# A New Accounting Data Model

*by*

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# Declaration

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*Date:* 26 November 2003

# Abstract

This thesis investigates the design of the data model underlying accounting systems. Despite radical changes to business processes and enterprise information systems over recent decades, the data model used within accounting systems has changed little since the inception of double-entry bookkeeping over 500 years ago. Earlier studies have proposed alternative data models for accounting systems but these have not been adopted in practice. One reason for this is that they were not developed on the basis of accounting data representative of real world needs. This study uses empirical data derived from models of accounting transactions processed by actual organisations.

The motivation for this thesis arises from criticisms made about the inability of accounting systems to provide useful information to users and to support the business activities of organisations. However, there is very little empirical support for the criticisms which have been reported. Evidence gathered from users of accounting systems indicates that many of the criticisms have been overcome by contemporary accounting systems but some of the limitations which remain are a direct result of the design of the underlying data model.

A comparison of the models of manufacturing organisations with the alternative proposals for accounting data models shows that these alternatives are not sufficient for modelling the transactions of actual organisations. Recent developments in both financial reporting and enterprise information systems also confirm the need for a model which is able to accommodate changing user needs. This thesis uses an analysis of the accounting transactions from three organisations as the basis for the design of a new data model. The proposed data model extends the traditional recognition criteria to allow flows of a wider range of resources to be integrated into a single system as well as both past and future resource flows. Not only are some future flows used in the preparation of financial statements but their inclusion also permits the same system to be used for forward-planning. When combined with an explicit modelling of continuous resource flows, any need for end-of-period adjustments is removed and the constraints imposed by pre-determined reporting dates no longer apply. Problems concerning the choice of valuation basis and accounting method are avoided by designing the accounting data model to record resource flows independently of accounting choices. This makes the proposed model the first capable of supporting real-time reporting and allowing users to request financial reports based on their own preferred set of accounting policies.

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Last, but by no means least, is an acknowledgement of the love and support provided by my family and friends; especially my parents for providing me with such opportunities in life and my wife for her care and forbearance during the process.

# Dedication

*In loving memory of Mike*

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# Chapter 1

# Introduction

Accounting systems have been the subject of many criticisms over recent decades. These criticisms are largely concerned with the failure of accounting systems to support the information needs of users. This may not be surprising since accounting systems continue to be based on an underlying data model which originated over 500 years ago. However, despite recent developments in information technology and in enterprise information systems, the criticisms continue to be repeated. Either the authors of the criticisms are mistaken or there is a need for accounting systems to be redesigned to better meet the demands of their users.

The objectives of this thesis are to:

❖ review the literature regarding criticisms made of accounting systems and proposals for alternative accounting models;

❖ seek evidence regarding the contemporary validity of the criticisms made;

❖ identify the need for a new accounting data model from case studies of three manufacturing organisations;

❖ design and validate a new accounting data model which overcomes the limitations of existing alternatives.

The structure of this chapter is as follows. Section 1.1 outlines the motivation for the research reported in this thesis. Section 1.2 discusses the objectives of the research. An overview of the research approach adopted is presented in Section 1.3. The structure of the thesis is outlined in Section 1.4.

## 1.1 Motivation

The criticisms of accounting systems are likely to be associated with the signals reported by Elliott (1991, 3) of the "growing irrelevance of accounting" which included the growing gap between the CEO (Chief Executive Officer) and the CFO (Chief Financial Officer) and the comment that managers are running their companies with non-accounting data. Although computerised accounting systems may have reduced the time taken to prepare financial reports (especially financial statements), accountants continue to supply historical information which, in the information era, is not always sufficient for managers and owners (Elliott 1991). The popularity of enterprise resource planning (ERP) systems during the 1990's appears to have done little to quell the criticisms of accounting systems. Instead, ERP systems have had the effect of moving the focus away from the accounting system as being the central source of information within an organisation, to a position where the accounting records are a subsidiary part of an enterprise-wide information system updated with data captured by other modules. Thus, the "solution" to the problems which has been adopted in many organisations has been to sidestep the issue and relegate accounting to a repository for secondary data. This is very much like the initial reaction of auditors to computerised accounting systems; they avoided the system itself by auditing around it (checking inputs to the system and outputs from it). The continued use of a 500-year-old accounting model (despite the continued criticisms of it) in a system which has sought to support the re-engineering of business processes suggests that double-entry principles are both outdated and lacking in alternative solutions.

The failure of accounting systems to adopt new approaches is not caused by an absence of proposals for alternatives. The most prominent alternative is the REA accounting template proposed by McCarthy (1982). This approach is described in many accounting information systems textbooks (see, for example, Moscove *et al.* 1999; Romney and Steinbart 2000; Hall 2001; Gelinas and Sutton 2001) but has not been used to develop models of accounting systems for any actual organisations. This suggests that the alternatives proposed may not be suitable for the needs of accounting information users.

## 1.2 Research Objectives

An initial review of the current state of accounting systems suggests that they have reached a crucial time in their evolution. Accounting provides a fundamental element of the economic information about an organisation: it is concerned with recording details of the economic exchanges into which organisations enter. It fulfils a pivotal role in an enterprise information system by providing a means of relating the different flows of resources which comprise an exchange (for example, the outflow of inventory and an inflow of cash). Without the accounting system at the heart of an organisation's information system, there is a danger that these relationships between flows may not be recorded because the data may be captured by disparate systems. Thus, it is imperative that a new data model is designed to overcome the weaknesses of existing systems so that accounting can regain its ability to support user needs, and its declining importance within organisations can be reversed.

The main goal of this research is, therefore, to develop a new accounting data model. In order to justify and attain this goal, it is important to have a good understanding of:

- ❖ the problems experienced by users with existing systems;
- ❖ the constraints of existing systems;
- ❖ the information needs of users.

These are essential so that appropriate solutions can be developed and evaluated which not only overcome the problems with existing systems but also continue to fulfil the purposes for which they are used. It would be pointless to design a system which solves some problems only to create new ones. Thus, the research goal can be expressed in terms of the following objectives:

1.    what problems with accounting systems and proposals for alternative accounting models have been reported in the literature?

2.    what problems apply to contemporary accounting systems?

3.    what are the data requirements of an accounting system?

4.    how can a data model be designed to fulfil the data requirements and overcome the problems with existing systems?

## 1.3 Research Approach

The research approach adopted in this thesis is consistent with the following statement made by Sutton (2000, 7) that:

> "any research frame is appropriate if it adds to our perspective and knowledge of the subject matter. I generally adhere to a loose form of the grounded theory approach put forward by Glaser and Strauss (1967)."

Grounded theory is based on the premise that "theory should be grounded in empirical evidence, i.e. evolve from the data, rather than be developed *a priori* and then be tested" (Lye *et al.* 1997, synopsis). If a new design of an accounting data model is to be valuable it must be able to meet user needs. There may be a difference between the needs users *should* have and the needs which users *do* have. One of the roles of accounting research is to improve the methods adopted by accounting in practice; changes in the methods used may have implications for the accounting system due to changes in data requirements. However, a purely normative approach may fail to address the existing needs of users based on the methods currently adopted. Ideally, therefore, any new accounting system proposed should be capable of supporting current needs as well as facilitating (even encouraging) a move towards improved methods. There may be legal requirements for some current practices and so a system which is unable to support these needs may not be acceptable to users.

Grounded theory provides an appropriate basis for addressing the research objectives identified above. While evidence of problems with accounting systems can be revealed by a literature review (first research objective), this may not reveal the underlying causes of the problems and hence may not be suitable as a means of evaluating proposed solutions (fourth research objective). A full appreciation of the data requirements of accounting systems can best be obtained from an analysis of business processes and the reports required concerning these processes. Thus, the basis of the new accounting data model proposed by this research will be developed from a study of problems experienced by users (second research objective) and their data requirements (third research objective).

## 1.4 Overview of Thesis

This thesis has the following structure:

❖ *Chapter 2* reviews the criticisms made of accounting systems in the literature. These are synthesised into a set of nine aims for accounting systems and discussed in the light of other evidence which casts some doubt on the current validity of some of the criticisms made. Three goals are derived for future accounting systems.

❖ *Chapter 3* examines proposals for alternative accounting models: the REA accounting template, the Multiview Accounting System and REAL business modelling. The ability of these models to overcome the criticisms of accounting systems is reviewed.

❖ *Chapter 4* outlines the research questions which are addressed in this thesis and classifies them based on the research frameworks proposed by March and Smith (1995) and David *et al.* (1999).

❖ *Chapter 5* describes the research undertaken in relation to the research question (referred to as $RQ_{crit}$) which seeks indicative evidence regarding the contemporary validity of the criticisms of accounting systems reported in the literature. This research question provides further support for the need to design a new accounting data model.

❖ *Chapter 6* considers the research question (referred to as $RQ_{model}$) which addresses the needs identified for a new accounting data model. Data models for three manufacturing organisations are developed as the basis for the new design.

❖ *Chapter 7* describes the new accounting data model designed to achieve the three goals set for accounting systems.

❖ *Chapter 8* summarises the research findings and the limitations, and concludes with a discussion of the research contribution made by this thesis.

The structure of the thesis is illustrated in Figure 1.1.
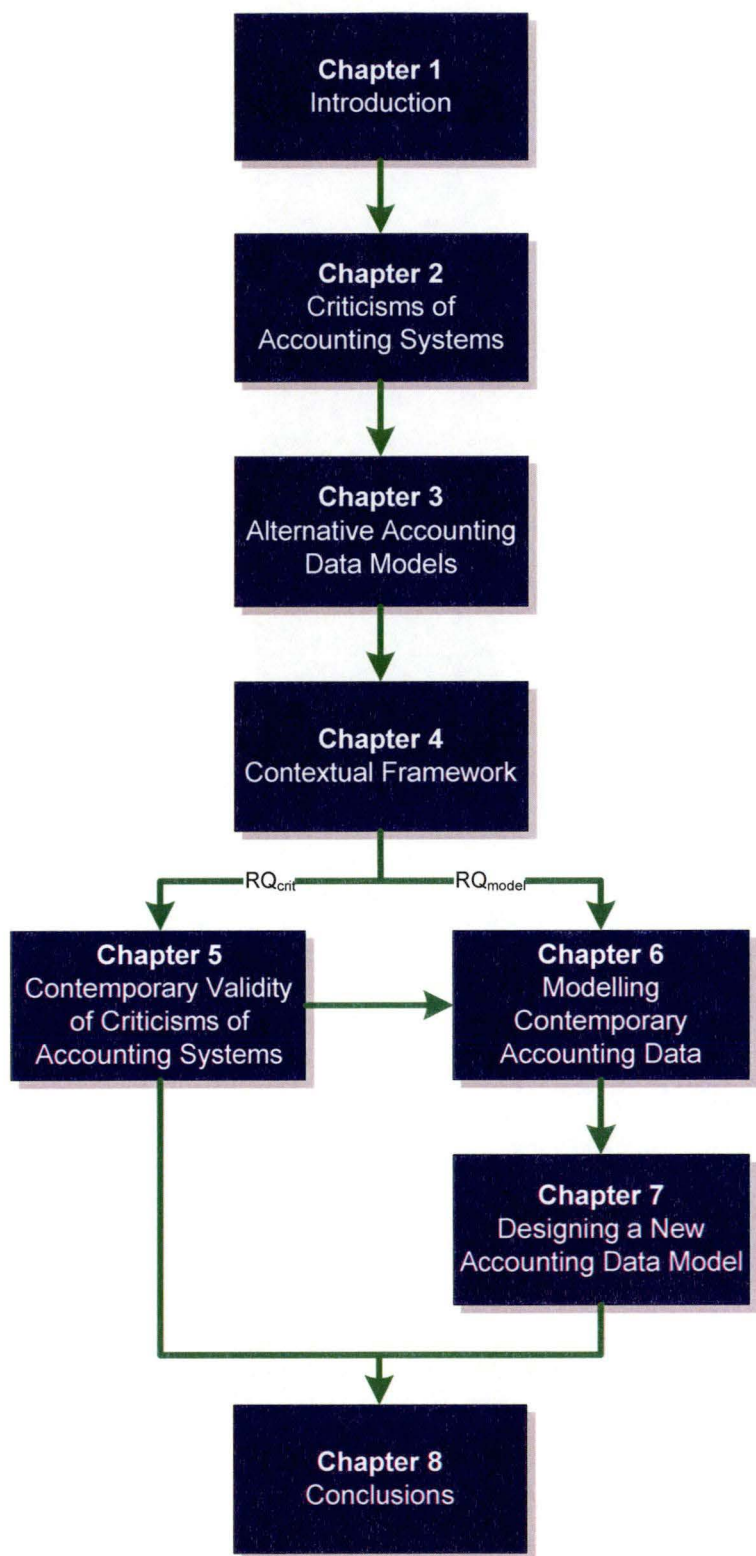
**Figure 1.1    Structure of Thesis**

# Chapter

# 2

# Criticisms of Accounting Systems

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This chapter reviews the most significant criticisms of accounting systems which have been made in the literature. Criticisms of accounting systems have been made from a wide variety of sources, both within and outside the accounting profession. Despite the age of some criticisms, they continue to be applied to contemporary systems.

The criticisms reported in this chapter have been categorised according to the nature of the problem being highlighted, but this also corresponds to a rough chronological sequence. Section 2.1 reports on the need for accounting data to be recorded independently of their use. Section 2.2 reviews calls for greater integration of related information systems. Section 2.3 considers problems which have been highlighted as a result of advances in technology, whilst Sections 2.4 and 2.5 describe issues relating to information usefulness and user choice, respectively. The criticisms described are synthesised into a set of aims for accounting systems in Section 2.6. Given the age of many of the criticisms, Section 2.7 seeks to compare the problems raised against existing evidence concerning the abilities of contemporary accounting systems to overcome them. A summary of the chapter is provided in Section 2.8.

## 2.1 Application Independence

A long-standing criticism of accounting systems has been that they do not record data in a form which is independent of their intended use. This means that the systems may be

unable to support all existing information demands and/or new applications which may arise in the future.

Goetz (1939) considered the major purposes of accounting to be:

* ❖ a systematic method for handling part of the day-to-day activities of the business enterprise;

* ❖ the accumulation, classification, and reporting of data according to rules imposed by governments;

* ❖ the preparation of reports for credit purposes;

* ❖ keeping track of equity interests;

* ❖ a tool of management.

Reports prepared for each of these purposes would apply sets of accounting methods appropriate to the specific task and which may be different in each case. To avoid variations in accounting methods having an impact on the accounting records, Goetz proposed that "an objective, historic record should be maintained, purged of opinion, estimate and other subjective data" (Goetz 1939, 156). Supplemental records to this *Basic Historical Record* would be maintained for the adjusting entries needed to prepare each type of report. Even though this predates the development of database theory, Goetz's (1939) proposal bears great similarity to the central database design objective of *application independence* which reflects a concern "with what the data is, rather than how it will be used" (Date 1995, 270).

Application independence in the design of accounting systems would help to ensure that data are recorded in a form which is suitable for multiple purposes and multiple users, and that it does not focus on a single task (such as the preparation of financial statements). This would reduce the need for multiple systems (and the consequential duplication of effort) to support user needs.

## 2.2 Integration of Information Systems

The tendency of accounting systems to focus on the preparation of financial statements as their sole task (see the discussion regarding application independence above) inevitably leads to the creation of multiple systems to satisfy the wide range of needs for accounting information. In particular, the demands of financial accountants for historical information

are quite different from those of management accountants who need future estimates. A system which could integrate such needs may enable information to be provided more efficiently and effectively, as well as better support needs which rely on both historic and future data.

The AAA Committee on Managerial Decision Models (AAA 1969) considered that "organizations and management can generally gain by combining the conventional accounting system and other data-gathering functions necessary for decision models" (AAA 1969, 53). Their call for an integrated information system came from concerns over problems of *data overlaps* and *information gaps* which might result from using multiple systems. It was also seen as being a focus for the coordinated provision of externally-generated data which are demanded by the decision models they considered.

The Committee was established to consider the implications of the *Statement of Basic Accounting Theory* (AAA 1966). This Statement identified the need for management information beyond that provided by the *conventional model*. The Committee defined the conventional accounting system as being one which "considers past data as the basic input, the chart of accounts as the basic classification model, and the financial statements as the basic output" (AAA 1966, 56). As a result of the managerial decision models considered, the Committee predicted that "accounting in the future will have to broaden the kinds of events which are recorded" (AAA 1969, 54) and that accounting information should be "multi-dimensional, encompassing both the past and projections of the future" (AAA 1969, 54). Their view was quite similar to Goetz's (1939) proposal for a basic historic record (see above):

> "New, less expensive data gathering, storage, and accessibility capabilities of computers will enhance the feasibility of having a system that essentially contains a library of raw data in as elementary, unstructured but well-defined form as possible, properly indexed for subsequent retrieval and stored so as to facilitate a wide variety of manipulation, classification, and aggregation. Such data may include many events which have not been traditionally recorded." (AAA 1969, 55)

In a similar vein, the AAA Committee on Non-Financial Measure of Effectiveness (AAA 1971) sought to break down the divisions between what is and is not "accounting" in relation to detection and recording systems. They regarded "the substantive question of 'what' is detected and recorded and 'why'" (AAA 1971, 189) as being far more interesting

than attempting to distinguish between accounting and non-accounting data. The Committee commented on the problem that "classification often results in an aggregation loss of certain detail" (AAA 1971, 193) and offered some support for the notion of a "generalised concept of an account" put forward by Colantoni *et al.* (1970, 38) which would support a wide variety of user needs including both financial and non-financial information. They also promoted the idea of using a single data bank as a repository for those events which are to be detected and recorded (AAA 1971, 191-197).

McCarthy (1980, 628) used these two AAA reports to identify four major defects in the conventional accounting framework in support of his entity-relationship accounting model:

1.    Its dimensions are limited.

2.    Its classification schemes are not always appropriate.

3.    Its aggregation level for stored information is too high.

4.    Its degree of integration with other functional areas of an enterprise is too restricted.

These criticisms were subsequently used in support of the development of the REA accounting model (McCarthy 1982, 554-555) and have been accepted and extended by other authors (see, for example, Armitage 1985; Andros *et al.* 1992; Hollander *et al.* 1996, 2000).

Although the information needs supported by each system may be distinct, the data captured by each are similar and related. Apart from efficiencies which may be gained from integrating systems (for example, a reduction in duplication of effort), there may also be benefits gained from creating links between the data items which may enable new information needs to be supported.

## 2.3 Application of New Technology

Some problems with accounting systems may be difficult or impossible to overcome for technical reasons. Thus, when new technology becomes available, further advances are made possible. However, the danger with new technology is that applications are not changed to take full advantage of the benefits available, but merely perpetuate the use of old methods.

Harper (1985) reported on the presence of the "stage-coach" effect in computerised accounts; that is "the tendency for the application of a new technique to comply with the quite irrelevant designs that related to the old technique" (Harper 1985, 152). In the case of computerised accounting systems, he was concerned that "the longer we retain double-entry accounts, the longer we will be failing to exploit the full potential opened by databases" (Harper 1985, 152). The radical redesign of accounting systems suggested by Harper would now be termed business process reengineering (BPR). The principles of BPR have been widely applied in many areas of organisations. The basic underlying rationale has been succinctly described by Hammer (1990, 104) as follows:

> "It is time to stop paving the cow paths. Instead of embedding outdated processes in silicon and software, we should obliterate them and start over."

The principles of reengineering proposed by Hammer (1990, 108-112) were:

❖ organise around outcomes, not tasks;

❖ have those who use the output of the process perform the process;

❖ subsume information-processing work into the real work that produces the information;

❖ treat geographically dispersed resources as though they were centralised;

❖ link parallel activities instead of integrating their results;

❖ put the decision point where the work is performed, and build control into the process;

❖ capture information once and at the source.

Andros *et al.* (1992) reported how IBM has included BPR principles in its development of new financial processes to overcome the "fundamental weaknesses" of traditional accounting methods. In addition to the four criticisms reported by McCarthy (see above) which were concerned with the organisation and storage of business data, Andros *et al.* (1992, 29) added a further four weaknesses which dealt with the way data are recorded, maintained and reported:

1. Recording, maintaining, and reporting information processes seriously limit the system's ability to provide timely information to decision makers.

2. Traditional processing methods tend to institutionalise antiquated, inefficient, and ineffective business processes.

3. Implementing and maintaining internal controls is costly, ineffective, and not performed in a timely manner.

4. Antiquated processing and storage methods are costly to maintain and operate.

To overcome these eight weaknesses, IBM adopted five solution concepts:

1.　Reengineering business and information processes.

2.　Developing event-driven solutions.

3.　Integrating processes.

4.　Integrating data.

5.　Realigning information systems ownership.

These concepts promote solutions which are based around integrated, enterprise-wide data models which incorporate both financial and non-financial data with data being captured at the time an event occurs by those responsible for that event. Andros *et al.* (1992, 31) reported the application of these solution concepts in relation to IBM's process for paying employees which was successful in terms of financial return, user satisfaction and improved decision-making.

Hollander at al (2000) also advocated an event-driven system to overcome the criticisms of traditional accounting information systems. They summarised the most significant of these criticisms as follows (2000, 101-104):

1.　The architecture captures data about a subset of an organisation's business events (the accounting transactions).

2.　Data are not recorded and processed in real time (i.e. as the business activity occurs).

3.　The architecture stores and processes only a limited number of characteristics about accounting transactions.

4.　The architecture captures and stores duplicate data in a highly summarised form.

5.　The architecture stores financial data to satisfy one primary view (perspective).

Thus, the benefits of new technology should always be analysed to identify how they can overcome problems with systems, rather than trying to fit old systems into new technology.

## 2.4 Usefulness of Accounting Information

Some limitations in accounting systems may affect the quality of the information they can provide. SAC 3 (AASB 1990) suggests timeliness and cost effectiveness as being potential constraints on the ability to provide relevant and reliable financial information.

New technology can provide opportunities for reducing the impact of these constraints and thereby enhance the usefulness of the information which can be produced.

Seddon (1991) believed that contemporary accounting systems already comprised many modules (or subsystems) used to capture a wide range of data about an organisation's activities. He did, however, raise concerns over the difficulty with which data from these modules could be integrated:

> "It may be difficult to use the data in the subsystem databases effectively. Even when interface programs exist the information they provide is likely to be very restricted. One has to rely on all the different subsystems and interface programs generating appropriate journal entries, and changes in accounting policy, even simple changes like a revision to the chart of accounts for the general ledger, will have implications for many different subsystems." (Seddon 1991, 6-25, emphasis in original)

He identified five problems with the "conventional architecture of computer-based accounting systems" (Seddon 1996, 2):

1. No knowledge of accounting rules.

2. Restructuring the chart of accounts is difficult.

3. No support for multinational reporting.

4. Account balances can reflect only one valuation system.

5. Continuous processes are treated as periodic.

He considered these problems to be symptomatic of accounting systems being designed to support the bookkeeping process more than the accounting process (Seddon 1996, 2). This provided the main justification used to support his research: the concern that the continued use of double-entry bookkeeping leads to unproductive ways of thinking (such as historic cost accounting) which are not useful for making economic decisions:

> "The balance in a general ledger account is constant, in money terms, until it is changed by a journal entry... However, market values are constantly changing, particularly in times of inflation, so accounting information may be more useful if values of assets and liabilities, and even balances in revenue and expense accounts are continuously restated." (Seddon 1991, 6-25 - 6-26)

For Seddon, therefore, a primary requirement of an accounting system was an ability to present accounting information adjusted for the effects of inflation. In recognition of the fact that there is no single valuation basis suitable for all types of decision, he advocated the need for the accounting system to support multiple valuation bases as well as multiple accounting policies so that the user is able to choose their own preferred combination.

Seddon's (1991) proposals have the potential to improve the timeliness and reduce the cost of financial information by both seeking to utilise data captured in other systems and also developing a system which more closely models the underlying data.

## 2.5 Choice for Users of Accounting Information

Particularly with the advances in technology, many business practices are being reoriented to provide a customer focus. That is, systems should be designed to support user needs rather than users having to accept whatever information is available from a system. Greater flexibility in the design and implementation of systems would allow users greater control over the information requested. Whilst developments such as XBRL (see, for example, Debreceny and Gray 2001) may provide users with some choice over the presentation of reports, choice over the content is dependent upon the data recorded by the underlying accounting system.

Cushing (1989, 30) analysed "the feasibility and consequences of implementing a database approach to corporate financial reporting". One of his conclusions was that database disclosure would change the focus of accounting standard-setting from resolving controversies over alternative methods of recognition, valuation, estimation, allocation and classification, to specifying which events should be recorded, which attributes of the events should be recognised, how attributes should be measured and (possibly) permissible forms of aggregation (Cushing 1989, 38). It would be up to each individual user to specify which accounting policies and valuation bases they wish to apply to the accounting data. Although Cushing was concerned with external reporting, the approach he discusses could be equally applicable to internal users.

The implementation of an approach such as that discussed by Cushing (1989) would also permit a broader definition of corporate accountability to be applied which could include events that are primarily non-financial in nature (Cushing 1989, 32). Such an approach may help to overcome the criticisms of accounting made by Elliott (1991, 2-3) who accused the "industrial-era accounting paradigm" of holding back the progress of accounting and causing the "growing irrelevance of accounting". For example, he reported that "managers are running their companies with nonaccounting data" and "strategic

management processes are omitting accountants" (Elliott 1991, 3). Whilst he does not lay the blame at the door of *accounting systems*, one of his recommendations is for systems which are able to provide "process measures in real time" (Elliott 1991, 6). Furthermore, Elliott (1992, 69-70) makes the following predictions in respect of "third-wave accounting systems":

- ❖ focus on *changes* in resources and processes;
- ❖ inclusion of intangible resources and obligations;
- ❖ greater concern with measuring the values created for customers;
- ❖ enabling rather than restricting;
- ❖ provision of information in real-time.

The final prediction was repeated in Elliott (1995, 121) where he also called for greater user choice in selecting the content, timing and format of reports.

The Australian Accounting Research Foundation (AARF) is pursuing a policy of harmonising its accounting standards with the International Accounting Standards. The main force behind the call for harmonisation is the increased globalisation of business (Howieson 1998, 4) and in particular the capital markets.

> "This is particularly relevant to an increasing number of Australian companies who now seek to raise finance on many world markets. Often this requires preparation of financial statements, at substantial cost, in accordance with a myriad of different rules." (Curran 1996, i, emphasis added)

Whilst not wishing to detract from the goal of a single, global accounting language, the rationale given above makes an indirect criticism of accounting systems. Given that the economic activities experienced and recorded by an entity are not affected by the destination of the financial reports, it is a concern that accounting systems can only convert these records into reports on the basis of different accounting rules "at substantial cost". It is possible that this is due to the need for a considerable amount of judgment and interpretation which is not easily automated. However, if this were the case one might also expect the preparation of financial reports under local accounting requirements to be an expensive and time-consuming process but there is no evidence that this is the case. The most plausible explanation is that accounting systems are only designed to efficiently handle a single set of accounting rules. A system capable of supporting accounting rules from other countries would, therefore, at least reduce the urgency of international harmonisation and global agreement on a single accounting language.

A system such as that considered by Cushing (1989) which allows users greater choice over the output generated and a greater integration of financial and non-financial events could also alleviate problems related to the lack of harmonisation of international accounting standards. It would, for example, remove the need for individual countries to specify acceptable accounting standards (especially valuation methods) and allow users of financial statements to make the selections for themselves.

## 2.6 Aims for Future Accounting Systems

It is not intended for the criticisms discussed above to be an exhaustive list of all those reported in the literature; preparing such a list would be a near impossible task. However, the criticisms included here reflect, in particular, those made by advocates of changes to accounting systems and provide the basis for the alternative accounting models proposed. It is worth noting that criticisms of accounting systems have arisen over a significant period of time and are still being made. Moreover, accounting systems seem to have been quite resistant to change if the recent repetition of long-standing criticisms is an accurate reflection of their current state. The considerable overlap between the authors referred to above is illustrated in Table 2.1 which synthesises the criticisms reported into a set of aims for new accounting systems. The following assumptions were made in preparing this table:

❖   The concerns expressed by McCarthy (1980; 1982) and Hollander *et al.* (2000) about the classification schemes used and the level of aggregation have been treated as relating to the single aim of recording data in a raw, objective form (Aim A).

❖   Seddon's (1991) comments about difficulties in making simple changes are assumed to reflect the cost of maintaining and operating the accounting system (Aim H).

❖   Both McCarthy (1980; 1982) and Andros *et al.* (1992) commented on problems regarding the integration of accounting systems with other areas of the business. This criticism has been incorporated into the aim of capturing both financial and non-financial data (Aim B) because they are seen as merely opposite sides of the same argument. Both these problems (integration with other systems and focus on financial data) can be resolved by either structuring the accounting system in such a

| Aims | | Goetz | AAA | McCarthy | Andros et al | Hollander et al | Cushing | Elliott | Harmon-isation | Seddon |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Record data in a raw (objective) form | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | | | |
| B | Capture both financial and non-financial events | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | | |
| C | Multi-dimensional record of events | | ✔ | ✔ | ✔ | ✔ | ✔ | | | |
| D | Encompass past events and future projections | | ✔ | | | | | | | |
| E | Process data more promptly (e.g. in real time) | | | | ✔ | ✔ | ✔ | ✔ | | |
| F | Support more efficient and effective business processes | | | | ✔ | | | | | |
| G | Improve implementation and maintenance of internal controls | | | | ✔ | | | | | |
| H | Reduce cost of maintenance and operation | | | | ✔ | | | | ✔ | ✔ |
| I | Support multiple valuation bases and accounting policies | | | | | | ✔ | | ✔ | ✔ |

**Table 2.1    Aims for New Accounting Systems**

way that it can be more easily integrated with other information systems or by designing the accounting system to act as a single information system incorporating

all of the data relevant to an organisation. The latter approach has been adopted by Enterprise Resource Planning (ERP) systems which have been widely adopted in recent years, especially by large organisations (O'Leary 2000). Whilst the integration of multiple information systems may be preferred by some users, it is contended that if a single system were designed then it would always be possible to divide it into a set of separate, integrated systems. However, the reverse does not necessarily follow: that separate systems can be integrated to form a single system. Thus, only the aim of capturing financial and non-financial data has been included here.

A system designed to achieve the aims set out in the table would overcome the most significant criticisms made against accounting systems. These aims are concerned with improving the following characteristics of the information which can be produced (the related aims are indicated in brackets):

❖ *Quality* (Aim G)

❖ *Variety* (Aims A, B, C, D and I)

❖ *Timeliness* (Aims E and F)

In addition, Aim H is concerned with reducing the costs associated with accounting systems.

## 2.7 Contemporary Accounting Systems

This review has revealed the long-standing and repeated nature of many significant criticisms made against accounting systems. Apart from documenting the urgent need for a new design of accounting system, it also begs the question of "if these criticisms are so significant, why have they remained unresolved for so long?" After all, these criticisms are still being reported (see, for example, Hollander *et al.* 2000). One answer to this question is that, as the criticisms are not usually supported by evidence of actual cases, the authors may be reporting non-existent or out-of-date problems (as the existence of ERP systems might indicate). The only article that refers to an actual case is Andros *et al.* (1992). However, this example relates to an administrative system handling employee disbursements and not to an accounting system as such. Both McCarthy (1978; 1980; 1982) and Seddon (1991) take normative views of the accounting world and base their research purely on accounting theory. Elliott (1991) provides only anecdotal evidence

from his experiences with real companies. Even the literature on international
harmonisation provides only indirect evidence of the failures of accounting systems. Thus
none of the criticisms made is supported by evidence drawn from an actual accounting
system and so it could easily be the case that many (or all) of the criticisms do not apply to
contemporary accounting systems.[1]

A typical accounting system in Australia is a computerised package.[2] These computer-
based systems are built as a series of modules. The most popular modules found by
Seddon *et al.* (1992) in their 1988 survey were Accounts Payable (92% of users) and
Accounts Receivable (78% of users). Whilst they also found that such modules were not
always integrated with the general ledger, all of the packages reviewed by Courtney and
Flippen (1995) and Commonwealth of Australia (1995) support their full integration. It is
likely, therefore, that a more current survey would reveal a much higher incidence of
integrated modules in use, especially for recent installations. The modules offered by
accounting systems cover a wide range of business functions. For example, purchasing
(100%), sales order processing, sales invoicing, inventory control (79%) and fixed asset
management (98%).[3] ICAA (2001) indexes accounting software under 12 broad functional
areas comprising a total of 53 separate capabilities. Although each package does not
support every area or capability, the index does serve to illustrate the wide range of tasks
for which contemporary accounting systems are being designed. Other recent evidence
can be found in the dramatic acceptance of ERP systems by businesses. For example,
Davenport (1998, 122) suggests that "the business world's embrace of enterprise systems
may in fact be the most important development in the corporate use of information
technology in the 1990s". O'Leary (2000, 3) reports on a 1998 finding that "a single ERP
system (SAP's R/3) is used by more than 60% of the multinational firms". Thus, the
evidence suggests that integrated systems are available and are becoming increasingly
popular.

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[1]  It is of no real interest here whether criticisms of accounting systems might have applied to previous
     accounting systems and it would be problematic to investigate in any case.
[2]  Seddon et al (1992, 100-101) found 99% of the companies responding to their surveys undertaken in 1988
     and 1989 were using a computerised general ledger system and 85% of the systems installed since 1980 were
     packages.
[3]  The percentages in brackets indicate the proportion of the packages reviewed in Commonwealth of Australia
     (1995) which offer this function.

The criticisms of accounting systems reported in the literature seem, prima facie, to contradict the nature of available systems and suggest that some of the aims derived from the criticisms may already have been achieved. A brief analysis of some reviews of accounting software offers some support for this proposition. Even without considering the advanced capabilities of ERP systems, there is considerable evidence that contemporary accounting systems have made major advances in many of the areas which are the subject of criticism. The evidence is presented below in terms of each of the aims identified.

A.   *Record data in a raw (objective) form.* With the integration of related modules into which source data are entered, and the storing of data in non-proprietary database management systems,[4] the ability to retrieve actual transaction data has been strengthened. In addition, Commonwealth of Australia (1995) provides sufficient information to identify 3 packages with over 1,000 customer sites which stored individual transaction details. This would, at least, make users less dependent upon the summarised information available from a general ledger.

B.   *Capture both financial and non-financial events.* It would appear that many software houses have addressed this issue by integrating a wide range of modules into their accounting systems. The existence of ERP systems is further evidence that accounting systems no longer focus solely on financial records but can include other functional areas such as order processing, fixed asset management, manufacturing and human resources.

C.   *Multi-dimensional record of events.* The mere existence of modules for inventory control and fixed asset management is persuasive evidence that contemporary accounting systems provide an ability to store non-financial data. Weber (1986) and Seddon (1991) provide additional evidence of systems which store volume data. The entry and reporting of non-financial data was one of the evaluation categories applied in Commonwealth of Australia (1995) and all the systems reviewed with over 1,000 customer sites offered this facility. In addition, at least 8 of the 15 popular accounting packages reviewed by Courtney and Flippen (1995)

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[4]   90% of all the packages reviewed by Commonwealth of Australia (1995) were implemented using a DBMS.

provided some facility for reporting inventory transactions on a unit (rather than monetary value) basis.[5]

D.   *Encompass past events and future projections.* No evidence has been found to suggest that contemporary accounting systems have moved away from the traditional accounting convention of recording only past events. However, the types of events captured by the accounting system has been extended to include many which precede the economic exchange of resources. For example, this is evidenced by the existence of sales and purchase order processing modules. But technically these are still not *future projections*, but merely records of past occurrences.

E.   *Process data more promptly (e.g. in real time).* Of the systems with over 1,000 customer sites reviewed by Commonwealth of Australia (1995), at least 75%[6] allowed the on-line recording of transactions. This suggests that it may also be feasible for these systems to be operated in real-time and certainly does not support the statement made by Hollander *et al.* (2000, 102) that "because accounting data are only captured and processed days, weeks, or even months after the event occurs, accounting information for decision making is always late".

F.   *Support more efficient and effective business processes.* This is a difficult aim for which to obtain support since the original criticism on which it is based was not specific about the failures of accounting systems. However, the reports of successful applications of BPR in practice and the growing popularity of ERP systems would suggest that improvements in business processes are not being thwarted by deficiencies in accounting systems.

G.   *Improve implementation and maintenance of internal controls.* This criticism was raised using an example of a manual administrative support system (Andros *et al.* 1992). It is possible that the mere process of computerising the system would have been sufficient to overcome this weakness since controls can be programmed into the system to be executed at the time of the action. This may even be in real-time and hence allow controls to be preventative. Without more specific evidence, it is

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[5]   The actual number may be higher because Courtney and Flippen (1995) were concerned with transactions being reported in date order and from a standard report (not one having to be constructed by a reporting module).

[6]   Insufficient information was provided for the remaining 25%.

possible that the popularity of computerised accounting systems has significantly reduced or eliminated the cause of this criticism.

H.  *Reduce cost of maintenance and operation.* This aim is also derived from Andros *et al.* (1992) and is not supported by evidence, especially from a computerised system. It is only possible to comment on this aim when alternative systems are available for which relative costs can be compared. Such an analysis should also be made on the basis of the total cost of ownership and not merely the costs of maintenance and operation.

I.  *Support multiple valuation bases and accounting policies.* All of the systems reviewed by Commonwealth of Australia (1995) were based around a chart of accounts and general ledger module. However, there is no evidence of these supporting alternative valuation bases or accounting policies. In fact, there is strong prima facie evidence to the contrary. The nature of double-entry bookkeeping is such that the general ledger balances are always kept in balance. Support for alternative valuation bases and accounting policies could lead to multiple values for a single accounting entry which would disrupt the self-balancing nature of the ledger. This is likely to be the case even with ERP systems; for example, Davenport (1998) provides an example of a system offering a choice of inventory policy, but this is a configuration selection not an individual user choice.

This brief analysis provides prima facie support for the concern that many of the criticisms made of accounting systems have been addressed (at least to some extent) by contemporary accounting systems. This is irrespective of the fact that some of the criticisms have been made subsequent to the evidence discussed. It is, therefore, important not to place undue emphasis on the criticisms as reported, but to have regard to the fact that they may not apply to contemporary accounting systems or that they may require further elaboration to ascertain their true nature. One of the main criticisms for which no conflicting evidence has been found relates to the support of multiple valuation bases and accounting policies (Aim I). Since Seddon made this comment based on a normative view of information needs, it is possible that the reason why contemporary accounting systems have not addressed this area is because of a lack of interest on the part of users. They may not want such information, they may not understand the information if they had it, or the need is such that alternative sources are adequate to satisfy such information needs.

## 2.8 Summary

This chapter reviewed the criticisms made of accounting systems in the literature and distilled them into nine aims (A to I) which reflect the goals of improving the quality, variety and timeliness of information produced and reducing their cost. Notwithstanding the concerns expressed above about the contemporary validity of the criticisms made against accounting systems, there is still evidence to support the contention that problems remain. In particular, no evidence was found to suggest that the criticisms concerning the integration of past events and future projections (Aim D) and support for multiple valuation bases and accounting policies (Aim I) had been overcome by contemporary accounting systems. This thesis will, therefore, consider further the aims of accounting systems as derived from the criticisms reviewed. However, the cost of maintaining and operating accounting systems (Aim H) is beyond the scope of this thesis. Cost should only be considered in conjunction with the benefits derived from incurring the cost. Until these benefits have been identified for a proposed system design, the cost is difficult to determine and irrelevant. The matter of cost is, therefore, left for future research, whilst this research will focus on overcoming the problems with contemporary accounting systems in order to achieve the benefits which may justify any cost involved.

Chapter 3 reviews alternative accounting data models which have been proposed to overcome problems with accounting systems. If these are able to achieve the aims and goals identified in this chapter then a new design may be unnecessary.

# Alternative Accounting Data Models

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The previous chapter found that significant criticisms have been made, and continue to be made, against accounting systems in both the academic and professional literature. A number of researchers have, therefore, designed alternative accounting data models to overcome perceived weaknesses in the double-entry model which underpins traditional accounting systems. The most established and documented proposal is McCarthy's (1982) REA accounting template. This model formed the basis for the development of REAL business modelling by Hollander *et al.* (1996). An alternative approach was adopted by Seddon (1991) in the design of his Multiview Accounting System. These three examples represent the main alternatives to traditional accounting systems proposed by the academic community and will be reviewed in this chapter to identify the extent to which they overcome problems experienced with contemporary accounting systems.

The three alternative accounting data models are discussed in chronological order in the following sections. Section 3.1 reviews the REA accounting template; section 3.2 discusses the Multiview Accounting System and section 3.3 examines REAL business modelling. In each case, the approach is considered in terms of its ability to act as an alternative to a contemporary accounting system. A summary of the findings is included in section 3.4.

# 3.1 REA Accounting Template

McCarthy designed a new semantic model for accounting phenomena to replace the double-entry model. This work originated from his doctoral dissertation (McCarthy 1978) which was outlined in an article in the Accounting Review (McCarthy 1979). A further article (McCarthy 1982) generalised the proposed framework into his REA accounting template and also extended the discussion of the design issues involved in modelling accounting events. Since that date he and other researchers have investigated the applicability of REA as an alternative to traditional accounting systems. REA represents the specification of a modelling template which can be used to design an accounting model for an enterprise.

McCarthy (1978) took the view that accounting should be an integral part of an enterprise-wide information system and, therefore, used by a wide range of different users. He divided users into three sections: external users, internal decision models and internal decision makers. He reviewed the information needs of each of these sections of users based on, amongst others, AAA (1969; 1971) and identified the following requirements for a new system (McCarthy 1978, 8-13):

- ❖   a record of more than just the monetary dimension of transactions;
- ❖   an increased flexibility in reporting and retrieval techniques;
- ❖   a reduction in the amount of information loss (caused by classification and aggregation);
- ❖   an enquiry facility for unstructured and unanticipated questions.

However, these needs would only be supported after satisfying the requirements already being provided by traditional accounting systems (McCarthy 1978, 128-130 and 157). This led him to develop a semantic model of accounting data (McCarthy 1978) which he later generalised into the REA accounting template (McCarthy 1982).

## 3.1.1 Design of the REA Accounting Template

McCarthy (1978) applied a top-down data abstraction process to develop an accounting data model for an imaginary retail enterprise called the Wilson Company. This entailed describing the accounting world in terms of entities, their relationships with each other and

their relevant characteristics. This was defined as being that part of the "real world" which it is necessary to maintain information about (McCarthy 1978, 72 and 158):

❖ the economic states of the enterprise (objects);

❖ the events occurring over time that alter those economic states (events);

❖ the people accountable for those events (agents).

The *economic objects* identified are similar to the notion of a *resource* to be found in Ijiri (1975, 51-52) except that they exclude claims (future assets). In fact, McCarthy (1982) uses the term *economic resource* in preference to *economic object*. An *economic event* is equivalent to a single increment or decrement in the notion of *exchange* defined by Ijiri (1975, 61); a complete exchange would normally comprise at least two *events*. The term is also similar to the definition of an *economic transaction* used by Mattessich (1964, 38). The concept of an *economic agent* also follows the definition from Mattessich (1964, 37). McCarthy (1982) adds the term *economic unit* to represent an economic agent who works for the enterprise. REA takes its name from the three primary components (Resources, Events and Agents).

The resulting entity sets for the Wilson Company example are shown in Table 3.1. The *Order* event was admitted "under an extended axiom of exchange" (McCarthy 1978, 160)

| *Resources* | *Events* |
|---|---|
| Cash | Capital Transaction |
| Equipment | Cash Disbursement |
| Inventory | Cash Receipt |
| | Equipment Acquisition |
| *Agents* | General and Administrative |
| Customer | Service |
| Employee | Order |
| Stockholder | Personnel Service |
| Vendor | Purchase |
| | Sale |
| Source: McCarthy (1978, 76) | |

**Table 3.1    Entity Sets for Wilson Company**

and so has been excluded from the following analysis. These entity sets were used to produce an entity-relationship (ER) diagram for the enterprise (see Figure 3.1)[7] and a set of relational tables implemented for the transactions of the Wilson Company. This structure includes three types of relationship:

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[7]   This diagram uses a different symbol for each type of entity to clearly distinguish between them.
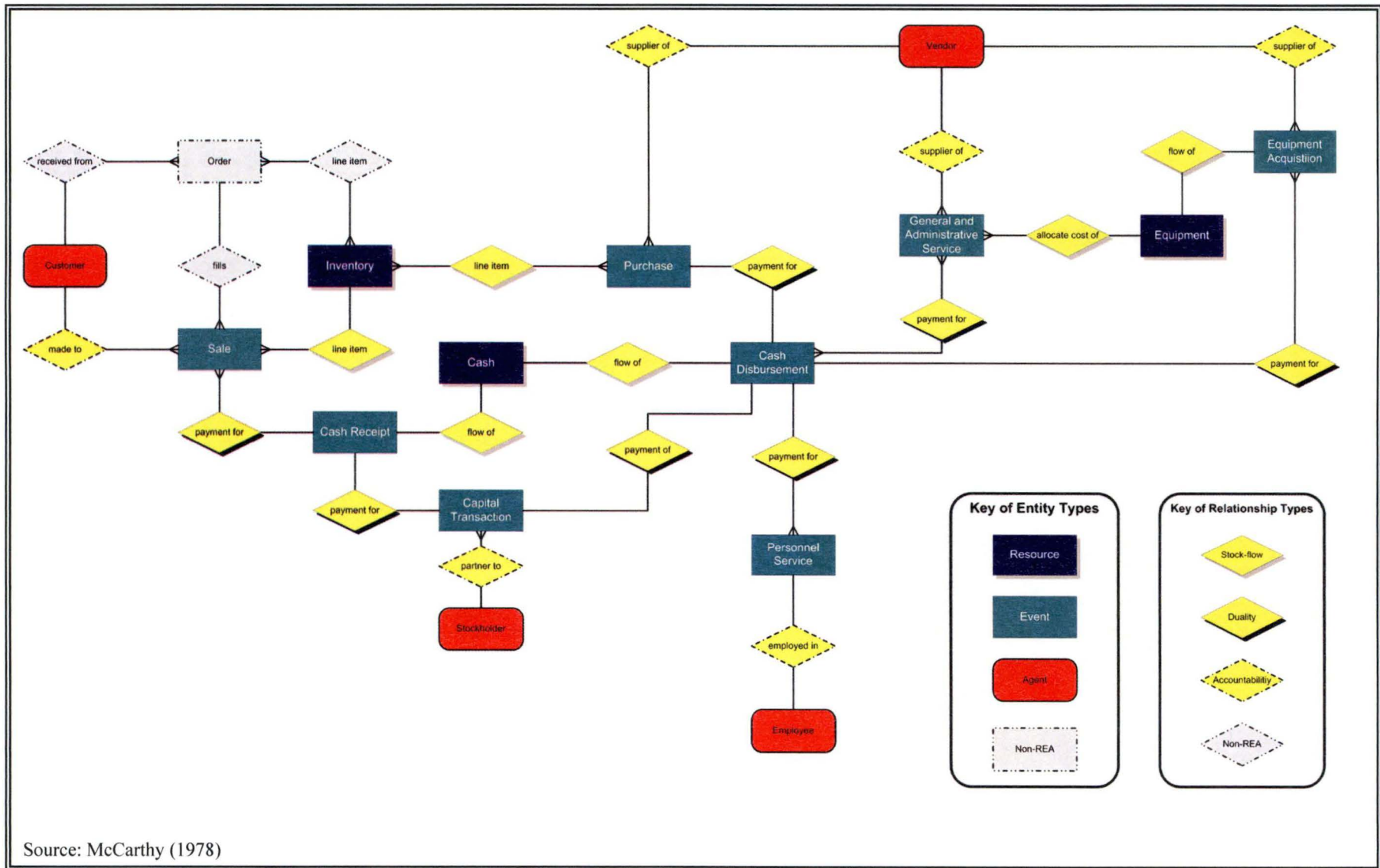
Source: McCarthy (1978)

**Figure 3.1    Entity-Relationship Diagram for Wilson Company**

❖   accountability relationship - an association between an *agent* and an *event*;

❖   stock-flow relationship - an association between a *resource* and an *event*;

❖   duality relationship - an association between a pair of *events*.

The relationships defined for the Wilson Company are summarised in Tables 3.2, 3.3 and
3.4.

```
            Customer ⇔ Sale
              Vendor ⇔ Purchase
              Vendor ⇔ Equipment Acquisition
              Vendor ⇔ General and Administrative Service
         Employee ⇔ Personnel Service
       Stockholder ⇔ Capital Transaction

Source: McCarthy (1978)
```

**Table 3.2     Accountability Relationships for Wilson Company**

| Resource | Inflow Event | Outflow Event |
|---|---|---|
| Cash | Cash Receipt | Cash Disbursement |
| Equipment | Equipment Acquisition | General & Administrative Service |
| Inventory | Purchase | Sale |

Source: McCarthy (1978)

**Table 3.3     Stock-Flow Relationships for Wilson Company**

```
   Capital Transaction ⇔ Cash Disbursement
   Cash Disbursement ⇔ Equipment Acquisition
   Cash Disbursement ⇔ General and Administrative Service
   Cash Disbursement ⇔ Personnel Service
   Cash Disbursement ⇔ Purchase
        Cash Receipt ⇔ Sale

Source: McCarthy (1978)
```

**Table 3.4     Duality Relationships for Wilson Company**

McCarthy (1982) considered the modelling design process in more detail than his earlier
works (McCarthy 1978, 1979). In this later paper he extended the accountability
relationship to include an economic unit involved in the control function and derived a
generalised REA accounting template as shown in Figure 3.2. The most comprehensive
model designed using this template is a teaching example using a fictitious manufacturing
company named *Ventura Vehicles* (David and McCarthy 1995). An ER diagram of this

example is shown in Figure 3.3. The entity sets and relationships for this model are summarised in Tables 3.5, 3.6 and 3.7. The Wilson Company and Ventura Vehicles models provide the most authoritative and comprehensive applications of the REA template and will, therefore, be used as illustrations for the discussion below.



Source: McCarthy (1982)
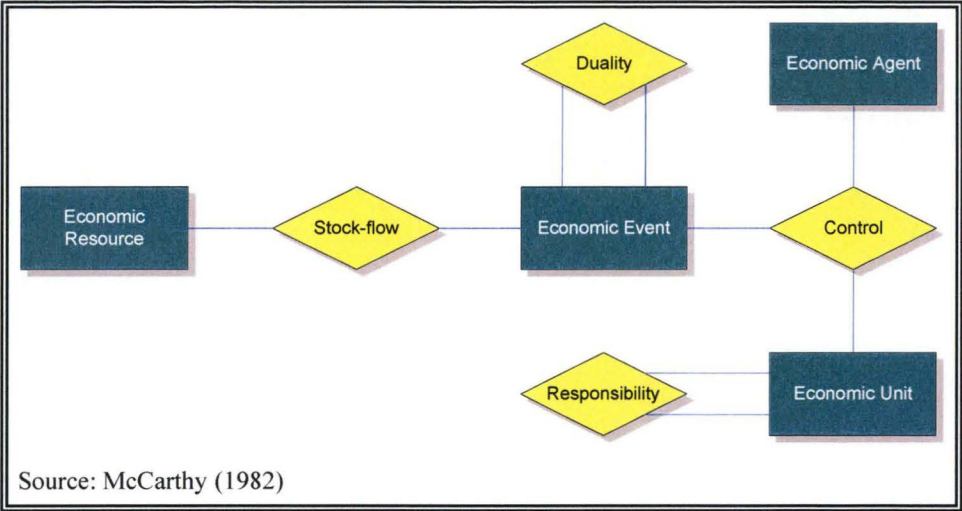
**Figure 3.2     REA Accounting Template**

| Resources | Agents |
|---|---|
| Cash | Accounts Payable Clerk |
| Finished Goods | Buyer |
| Fixed Assets | Cashier |
| Raw Material | Customer |
| | Employee |
| *Events* | Investor |
| Depreciation | Factory Worker |
| Cash Disbursement | Receiving Clerk |
| Cash Receipt | Salesperson |
| Employee Service | Shipping Clerk |
| Fixed Asset Acquisition | Supervisor |
| Long Term Debt | Vendor |
| Purchase | |
| Raw Material Issue | |
| Sale | |
| Service Acquisition | |

Source: David and McCarthy (1995)

**Table 3.5     Entity Sets for Ventura Vehicles**

Buyer

Raw Material Issue Type

Vendor · Purchase Order · Raw Material · Raw Material Issue · WIP Job · Finished Goods · Customer Order · Salesperson

Purchase · Department · Supervisor · Sale · Customer

Receiving Clerk · Factory Worker · Job Operations · Job Operation Type · Shipping Clerk

Accounts Payable Clerk · Cash Disbursement · Cash Receipt · Cashier

Cash

Fixed Asset Acquisitions · Supervisor · Service Acquisition · Long-Term Debt

Fixed Assets · Employee Service · Investor

Employee · Department

Depreciation

**Key of Entity Types**

Resource

Event

Agent

Non-REA

**Key of Relationship Types**

Stock-flow

Duality

Accountability

Non-REA

Source: David and McCarthy (1995)

**Figure 3.3    Entity-Relationship Diagram for Ventura Vehicles**

Cash Disbursement ⇔ Cash Receipt
Cash Disbursement ⇔ Employee Service
Cash Disbursement ⇔ Fixed Asset Acquisition
Cash Disbursement ⇔ Long-Term Debt
Cash Disbursement ⇔ Purchase
Cash Disbursement ⇔ Service Acquisition
        Cash Receipt ⇔ Long-Term Debt
        Cash Receipt ⇔ Sale

Source: David and McCarthy (1995)

**Table 3.6    Duality Relationships for Ventura Vehicles**

| Resource | Inflow Event | Outflow Event |
|---|---|---|
| Cash | Cash Receipt | Cash Disbursement |
| Fixed Assets | Fixed Asset Acquisition | Depreciation |
| Raw Material | Purchase | Raw Material Issue |
| Finished Goods | WIP Job | Sale |
| Cash | Cash Receipt | Cash Disbursement |

Note: the shaded cell represents a non-REA event

Source: David and McCarthy (1995)

**Table 3.7    Stock-Flow Relationships for Ventura Vehicles**

The components of the REA model may be divided into two areas. Firstly, the underlying economic reality is represented by the economic resource and economic event objects together with the stock-flow and duality relationships. Secondly, the accountability and control aspects of the accounting process are reflected in the economic agent and economic unit objects and the control and responsibility relationships. For the purposes of this thesis, the prefix "economic" to the terms resource, event and agent will be omitted for the sake of brevity. As a model of accounting systems, REA is naturally concerned with the economic activities of an organisation.

Applying the REA template in developing a model of an accounting system implies that the resulting model will have the following characteristics:

❖ each entity will represent either an event, a resource or an agent;

❖ each relationship will be of a stock-flow (between a resource and an event), duality (between two different event types), control (between an event, an agent and a unit) or responsibility (between two internal agents) type;

❖ each resource entity will have two related stock-flow relationships; one
representing an inflow of the resource and the other an outflow;

❖ each event is related to one other event by a duality relationship; one event
representing an inflow of a resource and the other an outflow;

❖ each event is related to both an agent and a unit as part of a control relationship;

❖ each unit may be related to another unit by way of a responsibility relationship.

A model which complies with these characteristics has been referred to as *full-REA* (Geerts
1993). However, McCarthy (1982, 565-575) identified a number of modelling issues
which may lead to a model varying from the full-REA specification. Evidence of these
variations can be found in both the Wilson Company and Ventura Vehicles models (see the
summaries provided in Tables 3.8 and 3.9 respectively).

---

**Events with no Associated Resource**
Capital Transaction
General and Administrative Service (excluding depreciation events)

**Events with no Duality Relationship**
None

**Events with no Associated Agent**
Cash Disbursement
Cash Receipt

**Events with no Associated Unit**
Model did not incorporate any economic units

**Non-REA Elements**
Order event

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**Table 3.8    Elements of the Wilson Company Model not Conforming to the REA
Accounting Template**

**Events with no Associated Resource**
Employee Service
Long-Term Debt
Service Acquisition

**Events with no Duality Relationship**
Depreciation

**Events with no Associated Agent**
Depreciation
Raw Material Issue

**Events with no Associated Unit**
Depreciation
Long-Term Debt

**Non-REA Elements**
Events: Customer Order, Purchase Order,
Other: Long-term debt, Department, Job Operation Type, Job
    Operations, Raw Material Issue Type, WIP Job

**Table 3.9     Elements of the Ventura Vehicles Model not Conforming to the REA Accounting Template**

*Duplication*

A model compiled by strictly applying the REA template would consist of two events, one agent and one unit for each resource defined. However, it is likely that some agents and units may be involved with more than one event in which case this duplication can be removed by combining references to any such entities. For example, the *Vendor* entity in both the Wilson Company and Ventura Vehicles models acts as an agent in more than one event (for example, the purchase and fixed asset acquisition events) and has been consolidated into a single reference. Thus REA models are likely to be simpler than a mere amalgamation of instantiated templates for individual events representing different resource flows.

*Redundancy*

In some cases a relationship may be omitted because it is already implied from other elements of the model. For example, the Wilson Company model does not include a control relationship between the *Cash Receipt* event and an agent because this can be

derived via the sale event associated by a duality relationship.[8] No such simplifications were made in the Ventura Vehicles model.

*Subtyping*

The term *subtyping* refers to the definition of entities which are part of another entity (see, for example, Date 1995; Halpin 2001). Subtypes are introduced by the process of *specialisation* which defines more specific instances of an entity type. The process of *generalisation* performs the reverse process by defining a general type for a set of entities. The instantiation of the Wilson Company model in McCarthy (1978) records depreciation with expenses (such as rent, cleaning and advertising). Whilst both can be viewed as subtypes of general and administrative expenses, they are distinguished by the fact that depreciation is a consumption of the equipment resource and is not associated with a cash disbursement event. Similarly share issues and dividends are modelled as subtypes of a *Capital Transaction*. In the instantiation of the Ventura Vehicles example, a supertype of *Employee* (with subtypes of *Accounts Payable Clerk, Buyer, Cashier, Factory Worker, Receiving Clerk, Salesperson, Shipping Clerk* and *Supervisor*) is used but other potential subtypes (for example, raw material and finished goods, customers and vendors) are not defined. In both models, the *Cash Receipt* and *Cash Disbursement* events may also be viewed as being supertypes because they incorporate cash transactions for a variety of transaction types (for example, customer payments and share issues are subtypes of the cash receipt event).

*Combining Events*

A strict application of the REA template requires every event to be linked to a resource via a stock-flow relationship. In some cases, however, the appropriate resource is not clearly identifiable as an independent object. For example, an advertising service could be modelled as being acquired and consumed, but being a *service* it may be distinguished from a *resource*. The unconsumed amount of advertising expenditure would usually be considered as either a prepaid or accrued commitment. In such cases McCarthy (1982,

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[8]    This also assumes that the sale event always arises prior to the cash receipt event, otherwise it would not be possible to record the source of cash receipts made in advance. The association between the *Sale* event and *Customer* agent is also redundant because it can be derived from the related *Order* event but this redundancy was not removed in the Wilson Company model (even though an order event must always precede a sale event).

572-573) suggests that the acquisition and consumption events be combined into a single event. In the Wilson Company model this approach has been applied to the *Capital Transaction, General and Administrative Service*[9] and *Personnel Service* events. In Ventura Vehicles, the *Employee Service* and *Service Acquisition* events are not associated with a resource and hence represent the events of both acquiring and consuming the related service. As a result of this process, it is possible for the number of events defined to be more than twice the number of resource entities.

*Degenerate Exchanges*

In a full-REA model each inflow event is associated with an outflow event via a duality relationship (and vice versa). However, there are situations where an event might arise in isolation. Ijiri (1975, 61) refers to these as "degenerate exchanges". As referenced by McCarthy (1982, 575), the FASB Statement of Financial Accounting Concepts 6 on the elements of financial statements (FASB 1985, para 85) recognises that some

> "gains or losses result from nonreciprocal transfers between an entity and other entities that are not its owners - for example, from gifts or donations, from winning a lawsuit, from thefts, and from assessments of fines or damages by courts. Still other gains or losses result from holding assets or liabilities while their values change - for example, from price changes that cause inventory items to be written down from cost to market, from changes in market prices of investments in marketable equity securities accounted for at market values or at the lower of cost and market, and from changes in foreign exchange rates. And still other gains or losses result from other environmental factors, such as natural catastrophes - for example, damage to or destruction of property by earthquake or flood."

In such cases no duality relationship could exist because only one event has occurred; it is merely the revaluation of a resource which arises without any compensating effect on another resource. The only example of a degenerate exchange in the Wilson Company and Ventura Vehicles models is the *Depreciation* event. McCarthy (1978; 1982) treated depreciation as the consumption (outflow) of an equipment resource but the consequential benefits arising from this flow are too indirect to be associated with it. The existence of degenerate exchanges may mean that an REA model would have fewer duality relationships defined than would arise under full-REA (as is the case with depreciation) or

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[9]  Except for the depreciation events which are included in the general and administrative services classification.

it may merely mean that not all instances of an event will participate in the duality relationship defined for that event type.

*Equity*

Records maintained on the basis of double-entry principles, and the balance sheet derived from them, remain in balance because the owners' interest is treated as being the residual (balancing) figure. As a balancing item the value of equity is, therefore, calculated as the net value of the event records. Thus the dual event for a degenerate exchange will be an inflow or outflow of equity. However, if information is required on the composition of the equity balance (for example, the split between capital and revenue reserves) it would not be appropriate to model all equity transactions as degenerate exchanges (i.e. just as a cash receipt event). It would also be necessary to identify the type of equity transaction. The Ventura Vehicles example does not model equity transactions but the Wilson Company model incorporated a *Stockholder* agent associated with *Share Issue* and *Dividend* events (treated as subtypes of *Capital Transaction* event). Thus REA-based models may need to include events which are not associated with a resource.

### 3.1.2 Extending the REA Accounting Template

Since its original conception, the REA accounting template has been the subject of further research work, by McCarthy and others. This work has explored the application of REA in different areas and provides further evidence of the completeness and appropriateness of the REA template in modelling accounting systems.

*Manufacturing Processes*

Denna and McCarthy (1987) described an implementation of an events accounting system for a simple, fictitious manufacturing enterprise modelled using the REA template. The conceptual model derived from the views which related to the manufacturing process highlighted a number of differences from the REA template. This model illustrates the conversion of raw materials into work-in-process and finished goods through the application of labour. It differs from the REA template in the following respects:

❖ the events involved in the manufacturing process have no associations with external agents;

❖ the labour operations involve multiple economic units (not merely one);

❖ a department entity is used to categorise economic units;

❖ a new entity type is created to record the standards (for example, target labour hours) against which manufacturing events may be evaluated;

❖ the *issue of raw materials* event does not participate in a duality relationship with any other event;

❖ the labour event is associated with two resources: work-in-process and finished goods;

❖ there is a direct relationship defined between two resources: work-in-process and finished goods.

The conversion process of a manufacturing enterprise is quite different from the accounting theory of economic exchanges upon which REA is based. Manufacturing represents a *transformation* process rather than an *exchange* process. It is, therefore, not surprising to find discrepancies between the resulting model and the REA template. The question (which is not addressed by Denna and McCarthy 1987) is what implications this has for the validity of a template purporting to be useful in deriving models of accounting systems.

*Non-Accounting Data*

The Wilson Company and Ventura Vehicles models both included additional entities which were not derived from applying the REA template.[10] This indicates the fact that it is possible to extend an REA model to incorporate other elements. Further work in this area was undertaken by Denna *et al.* (1990) who considered the integration of non-accounting data (such as marketing activity) and data from external sources (such as competitors' prices) with an events-based accounting system (using the REA template). Their illustration of how this might be achieved emphasises the need for information based on such data and raises the question of the extent to which a template focussing solely on the accounting data should be used to derive a conceptual model for an organisation's information system. Perhaps a wider perspective should be used in the initial design process. However, their conclusions do suggest that an accounting model based on REA

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[10] The non-REA elements have been highlighted in the entity relationship diagrams for these examples (see Figures 3.1 and 3.3).

can be more easily integrated with data from other sources than traditional accounting systems.

*Internal Controls*

Gal and McCarthy (1992) investigated the integration of internal controls into a conceptual model of an accounting system. A complete and consistent specification of a firm requires a system containing the following three elements:

❖ *declarations* of the firm's resource, event and agent entities;

❖ *procedures* which describe how the entities are processed into information for decision makers; and

❖ *constraints* which define how the firm's entities are permitted to evolve over time.



Source: based on Gal and McCarthy (1992)
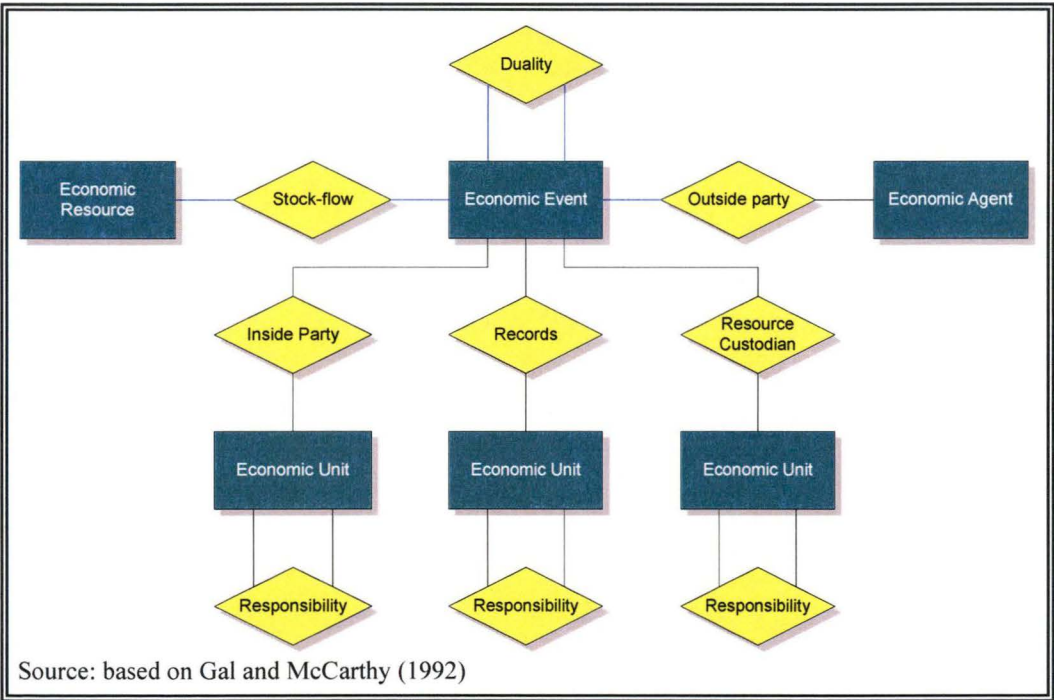
**Figure 3.4   REA Accounting Template with Internal Control**

The first two of these elements are already part of the REA template. In order to incorporate the third element two additional economic units were defined:

❖ the economic unit responsible for recording an economic event; and

❖ the economic unit charged with custody of an economic resource.

Thus, under this revised template, four economic agents are defined for each economic event as illustrated in Figure 3.4. These extensions to REA were necessary for the

accounting system to support the implementation of the rules proposed by Gal and McCarthy (1992) relating to internal control procedures.

*Exchanges*

The central object in the REA template is the event entity. Events are paired by a duality relationship to model the economic exchanges in which an organisation participates. The exchange itself, however, is not explicitly modelled in REA. This has a number of consequences. REA is based on the assumption that an exchange comprises two different event types. However, it is possible for exchanges to be more complex than this; a vehicle traded in for a new one would involve both an inflow and an outflow of a vehicle resource as well as an outflow of a cash resource. Such an exchange is not discussed in the REA literature, but would presumably require a duality relationship to be defined between every pair of events. In the example just given, this would lead to 3 duality relationships. In general, if an exchange involved $n$ event types, then $\frac{1}{2} \cdot n \cdot (n-1)$ duality relationships would need to be defined. Modelling exchanges, as proposed by Vickers (1995), would overcome this complexity by replacing the duality relationship between events with a relationship between each event and the exchange entity. Thus, only one relationship needs to be defined for each event to model an exchange.

The addition of an exchange entity would also facilitate extending the recognition criteria along the lines of Ijiri (1975, 68) to include consummated transactions even when none of the commitments has been performed (for example, purchase orders) and planned transactions (for example, budgets and forecasts). This would provide benefits in the modelling of such accounting items as bad debts and accruals (Vickers 1995).

*General Business Processes*

Denna *et al.* (1994) sought to test the whether the REA concepts could be generalised to the modelling of all (both accounting and non-accounting) business events. The conversion process was selected as an example of an area involving non-economic phenomena "outside the domain of accounting general ledger systems" (Denna *et al.* 1994, 46). Their models suggested the need for additional elements to the REA template; Figure 3.5 shows the generalised model of business events which they derived. This figure shows the following differences from the REA template:

Source: Denna et al (1994, 53)
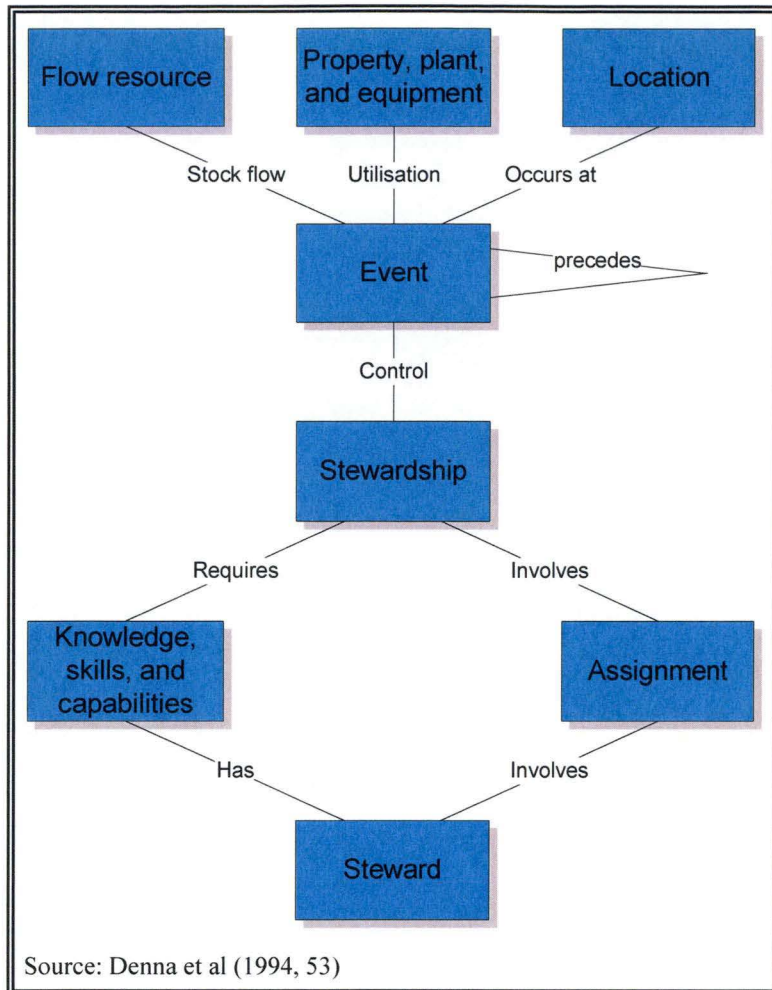
**Figure 3.5   Generalised Model of Business Events**

❖   processes (control events) are carried out through the execution of a sequence of detailed events; this sequence is modelled by an association between each consecutive pair of events;

❖   a single event might involve both an increment to a resource as well as a decrement to another resource and, thus, the duality relationship between events did not seem to apply at this level of detail;

❖   external agents were generally not involved in the conversion process and the control function of the internal agent may be executed automatically rather than by a person;

❖   the use of capital equipment is difficult to model as an economic event because of the arbitrary nature of measuring the deterioration which may have occurred; thus a *utilisation* relationship is used between an event and this type of resource rather than the standard REA stock-flow relationship;

❖　if an event location cannot be derived from the location of the participants or the
capital equipment used (for example, when the equipment is mobile), an explicit
location entity is required.

Denna *et al.* (1994) recommended clarifying McCarthy's REA elements of economic agent
and economic unit by identifying the following new concepts:

❖　*Stewardship* - the roles played by those participating in an event may be defined
specifically for the type of event; for exchange events this may involve two
stewardships (for example, a customer role and salesperson role for a sales event)
but for conversion process events there may only be a single entity responsible for
executing the event.

❖　*Process Owners* - having responsibility for an entire process.

❖　*Participant* - someone or something that actually performs a stewardship.[11]

❖　*Supervision* - process owners were normally responsible for assigning participants
to stewardships.

❖　*Capabilities* - the skills and talents required to perform a stewardship.

Despite the obvious differences in the graphical representation of their generalised model
and the REA template, Denna *et al.* (1994, 53) conclude that "the essential characteristics
of the REA remain intact". However, as noted by Amer (1994) the removal by Denna *et
al.* (1994) of the duality relationship represents a significant departure from the REA
template in the specification of their model. If this is intended to be a generalised model of
business events which includes both accounting and non-accounting events, then their
conclusion is suggesting that the duality relationship is not an "essential characteristic" of
REA. However, the exchange of economic resources is fundamental to accounting and the
duality relationship in REA is the means by which the events representing the resources
being exchanged are linked. Without the duality relationship, the REA template would not
be able to match resources given up with resources acquired and would be unable to
perform essential accounting tasks (such as calculating accounts receivable). Subject to
this omission, the generalised model proposed by Denna *et al.* (1994) offers useful
suggestions for extending the REA template to a wider range of business events.

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[11]　It is assumed that the term *participant* (as used in the text) and the term *steward* (as used in the diagram) refer
to the same entity type.

*Business and Information Events*

David (1997) recognised that REA fails to provide a complete economic description of an organisation's business activities. It fails to reflect the interdependence of events which may arise in conjunction with the same activity. For example, if an enterprise provides a delivery service, the *Sale* event would give rise to events representing the consumption of a delivery van and the employment services of a van driver. David (1997, 10) refers to these interdependencies as *synergy* relationships. A more detailed analysis of a business's operations is likely to reveal additional activities which its management needs to "plan, monitor and evaluate". Denna *et al.* (1993, 47) define these as *business events* and this term is adopted by David (1997). Business events include economic events (as in REA), but also other activities such as processing sale and purchase orders. Finally, David (1997, 16) recognises the need for further events to take place in order to "capture, manipulate, or communicate information". These events are equivalent to the "information processes" defined by Denna *et al.* (1993). Information events do not signify any changes to an organisation's business activities, but merely represent the process of keeping records about these activities.

The proposals by David (1997) are similar to those of Denna *et al.* (1993; 1994) except that David (1997) seeks to extend the REA accounting template rather than replace it. She puts forward a new design methodology which starts with an analysis of economic exchanges using the REA template and then supplements the economic events in the resulting entity-relationship diagram with business events. Figure 3.6 reproduces the diagram from David (1997) which depicts the economic events for the revenue cycle of her Merchant of Venice example. The transformation of these economic events into business events is shown in Figure 3.7. In this example the single economic event representing the sale of silk is decomposed into two business events (take customer order and deliver order). Since the information events involve no new data (merely the capture, summary or reporting of previously identified data) they represent an implementation issue rather than a design issue (David 1997, 17). The strength of REA diagrams lies in the modelling of the economic and business events which give rise to the data. Hence, information events are not deemed appropriate for inclusion on the REA diagrams; it is only necessary to ensure that the data necessary to satisfy information requirements are captured.

Source: David (1997)
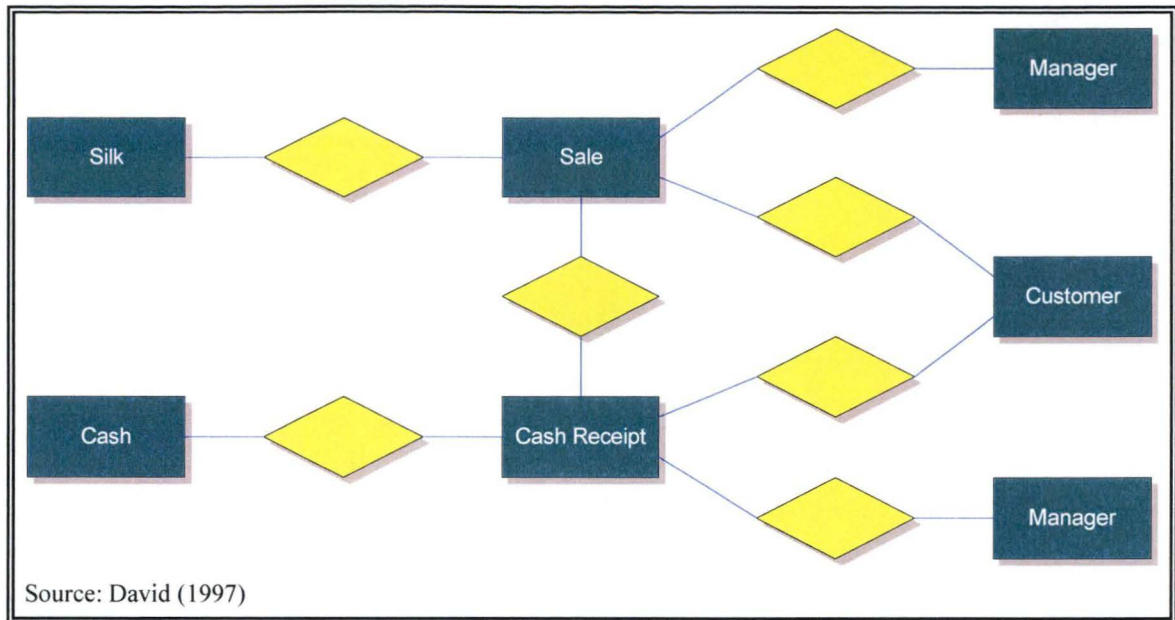
**Figure 3.6    Economic Event REA Diagram for the Merchant of Venice Revenue Cycle**



Source: David (1997)
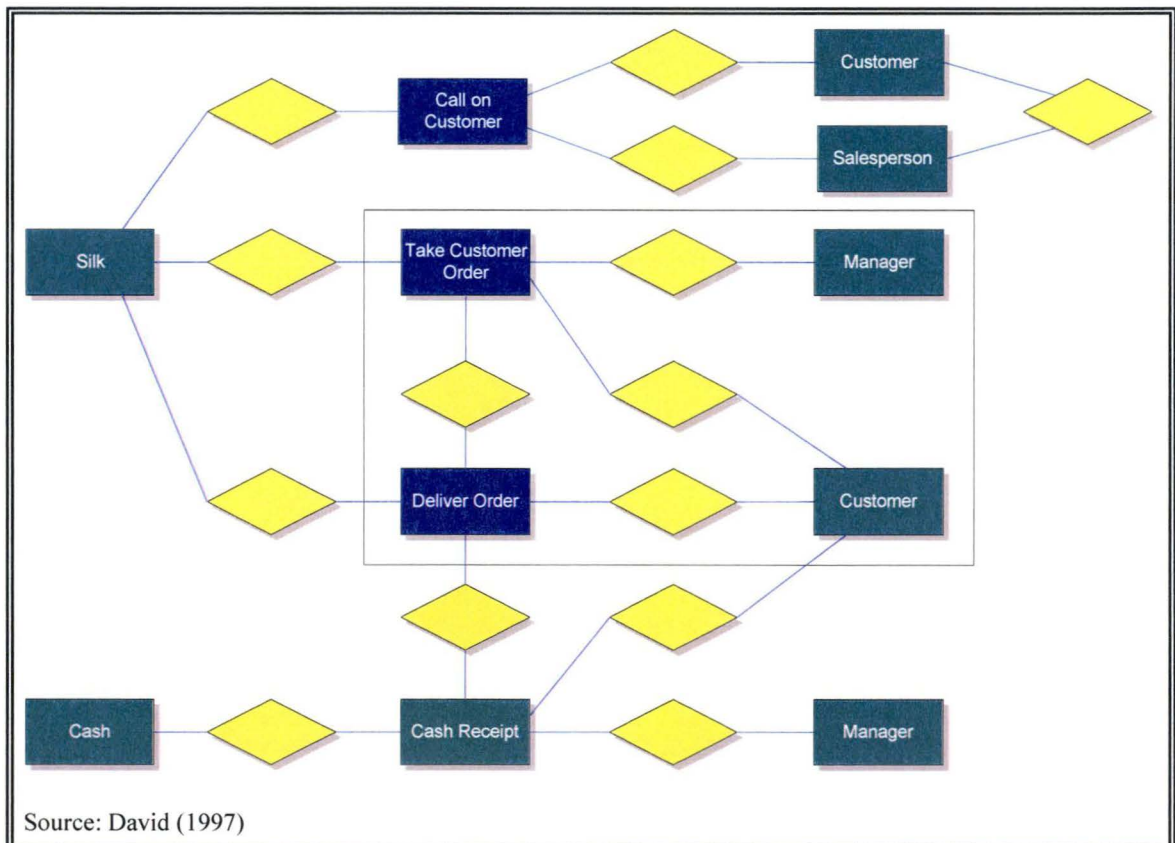
**Figure 3.7    Business Event REA Diagram for the Merchant of Venice Revenue Cycle**

*Enterprise Domain Ontology*

Geerts and McCarthy (2000) sought to extend the REA accounting template into an enterprise domain ontology: a specification of the phenomena which should be represented in an enterprise information system. Following Sowa (2000), they separate their ontology into two main categories: an operational infrastructure which conceptualises the economic phenomena and a knowledge infrastructure which conceptualises the abstraction of the economic phenomena. A detailed analysis of the proposed ontology is beyond the aims and scope of this thesis, but its recommendations for extensions to the REA template are of interest here.

Geerts and McCarthy (2000) add three new relationship types to the REA template:

❖ *Association* is a relationship which exists between two agents. This is a more generic version of the responsibility relationship which was included in the original template (McCarthy 1982). In addition the definition of economic agent is extended to include departments as well as people so that this relationship can describe an organisational structure. Another use for this relationship would be to describe the allocation of a sales representative to a customer.

❖ *Linkage* relationships describe dependencies between resources. For example, this may reflect the individual components of a product, or the existence of substitutes.

❖ *Custody* is a relationship between an internal agent and a resource. It reflects the exercise of control over the resource as proposed by Gal and McCarthy (1992).

None of these new relationships is involved in the recording of events, but they describe the organisational context in which the events take place.

The other extension put forward by Geerts and McCarthy (2000) is the modelling of commitments of resources, rather than focussing only on flows of resources after they have taken place. Their proposed solution is consistent with the first of the those suggested by Weber (1986); that is, a *Commitment* entity is created as a new type of event. The revised template is illustrated in Figure 3.8. The insertion of a Commitment entity also necessitates the addition of three new relationship types:

❖ a *reserves* relationship between a commitment and an economic resource;

❖ a *reciprocal* relationship between the commitments for the two resources which form part of the future exchange; and

❖    an *executes* relationship between a commitment and an economic event.



Source: Geerts and McCarthy (2000)
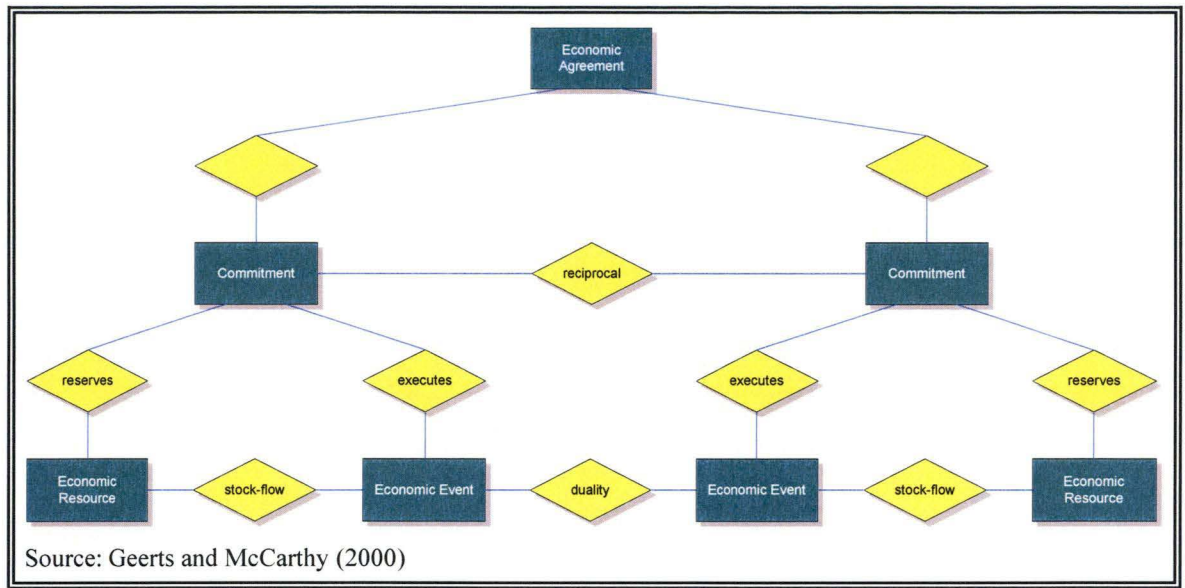
**Figure 3.8    Revised REA Template with Commitments and Agreements**

| *Numbers of Objects Required to Record an Economic Exchange Involving Two Events* | | |
|---|---|---|
| | **REA Template** | |
| | **Original** | **Revised** |
| Entities: | | |
| ❖    economic agreement | n/a | 1 |
| ❖    economic resource | 2 | 2 |
| ❖    commitment | n/a | 2 |
| ❖    economic event | 2 | 2 |
| ❖    economic agent | 4 | 8 |
| ❖    **total** | **8** | **15** |
| Relationships: | | |
| ❖    economic agreement-commitment | n/a | 2 |
| ❖    reserves | n/a | 2 |
| ❖    reciprocal | n/a | 1 |
| ❖    executes | n/a | 2 |
| ❖    stock-flow | 2 | 2 |
| ❖    participates | 4 | 8 |
| ❖    duality | 1 | 1 |
| ❖    **total** | **7** | **18** |

**Table 3.10    Comparison of the Original and Revised REA Accounting Templates**

Figure 3.8 also incorporates an *Economic Agreement* object.  This appears to be similar to the *Economic Exchange* object proposed by Vickers (1995) but Geerts and McCarthy

(2000) have not used it to remove the duality relationships between events. Thus, in their revised template both the duality and the reciprocal relationships are redundant since they can be implied from the association of commitments (and indirectly economic events) with an economic agreement.

The revised template represents a significant increase in the complexity of a full-REA model in terms of the number of entities and relationships which would need to be defined. Table 3.10 summarises the effect of the revision for a single economic exchange (comprising the exchange of two economic resources).[12] The effect would be even greater for more complex exchanges (involving more than two resources).

### 3.1.3　Wider Applicability of the REA Modelling Approach

Support for REA may also be derived from discovering other related areas in which the approach can be usefully applied. Grabski and Marsh (1994) considered whether the approach adopted by REA might be applicable to advanced manufacturing technology (AMT) information systems and the extent to which such systems can be integrated with an REA-based accounting system. An AMT information system differs significantly from a traditional accounting system in terms of the types of control and measurement adopted. Traditional accounting systems focus on feedback controls and quantitative, unidimensional measures (monetary values) whereas preventive controls and both qualitative and quantitative multidimensional measures are important to AMT systems. Adopting an REA approach should close the gap between these two types of systems because, amongst other things, REA sought to overcome the criticism that traditional accounting systems were not multi-dimensional. However, the implementation of preventive controls is more dependent upon the data entry being performed in real time rather than the nature of the underlying data model into which the data are being entered. Real time processing is already available in contemporary systems especially for modules such as sales order entry. Enterprise Resource Planning (ERP) systems also incorporate workflows such that the authorisation of transactions by the appropriate responsible person is controlled by the system.

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[12]　This table excludes the effect of the new *association, custody* and *linkage* relationships which are not related to exchanges.

| | **Increment Event** | **Decrement Event** |
|---|---|---|
| **Description** | Cooling the inlet gas | Heating the shell gas |
| **Components:** | | |
| ❖ Resource | inlet gas | fuel gas |
| ❖ Internal agent | gas regulator | fuel gas system |
| ❖ External agent | compressor | compressor |

Source: Grabski and Marsh (1994)

**Table 3.11    Events at Stage 1 of the Acid Gas Process**

Grabski and Marsh (1994) sought to apply the REA accounting template to the modelling of the continuous manufacturing system of a natural gas sweetening plant.  They divided the *acid gas* process into a series of stages, the first of which involved cooling the inlet gas through a heat exchanger.  This stage was analysed to separate it into its REA components: the resource which is incremented, the resource which is decremented, the events giving rise to these resource changes, and the inside and outside agents performing the events.  These are identified in Table 3.11.  This stage of the process can be described in words as follows (with the names of the resources underlined and agents written in italics):

> The cooling of the inlet gas is only achieved by allowing the shell gas to be warmed.  The pressure of the shell gas is increased using a *compressor* before being passed through a *regulator* to reduce the pressure and thereby its temperature.  This resulting reduction in temperature of the shell gas allows it to be warmed by the inlet gas, thereby reducing the temperature of the inlet gas.  The *compressor* is driven by an engine powered by fuel gas which is delivered to the engine through a *fuel system*.

The resulting REA model is shown in Figure 3.9.
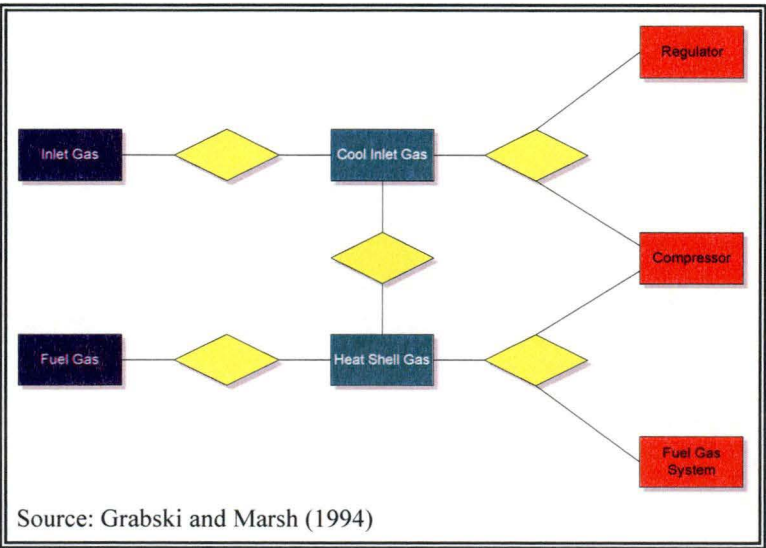


Source: Grabski and Marsh (1994)

**Figure 3.9    REA Model of the Cooling Inlet Gas Stage**

From their models of several stages of this manufacturing process, Grabski and Marsh
(1994) developed a generalised model for a single stage.  In doing so, they separated the
description of an event (the event type) from the instances of that event.  The diagram of
the generalised model in Grabski and Marsh (1994, 19) is not consistent with the tables
representing their full relational database implementation of such a model.  In particular,
the tables show a relationship between a resource and an event type and not between a
resource and an event as depicted in their diagram.  In addition, from the relational
database tables they presented (Grabski and Marsh 1994, figure 13), the agents appear to
be dependent upon the event type and not the event instance.[13]  The generalised model,
after making these corrections, is presented in Figure 3.10.



Source: Grabski and Marsh (1994)
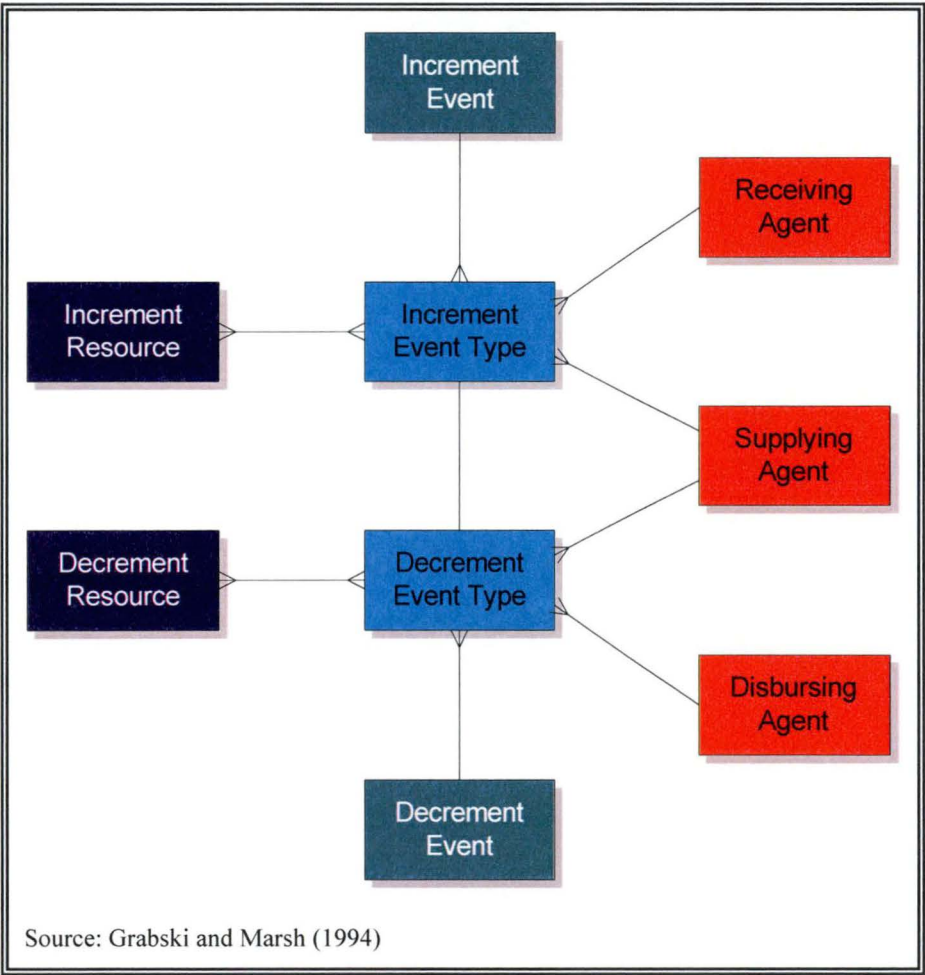
**Figure 3.10  Generalised REA Model for Stages in a Manufacturing Process**

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[13] The references to *disbursing agents* in the Increment Event table are assumed to be erroneous and should
instead refer to *supplying agents*.

The generalised model presented by Grabski and Marsh (1994) demonstrates that it is possible to represent a manufacturing process using a model which looks similar to REA. The only significant changes are that an object to describe the event types has been added and the "stock-flow" relationship has been extended to permit more than one resource to participate in an event. However, as discussed by Leech (1994), whilst it may be possible to conceive of a manufacturing process in REA terms, this does not mean that it is either natural or useful. The distinction between a resource and an agent is not clear, nor is the distinction between an internal agent and an external agent. For example, why should the compressor used to help cool the inlet gas be deemed to be an agent rather than a resource? Under REA, agents were a means of modelling the individuals or organisations participating in an exchange. Since a manufacturing process may be automated, Grabski and Marsh (1994) have redefined the term. They use the term "outside agent" to refer to the physical object which is used to generate the increase or decrease in a resource (for example, the compressor); whilst the "internal agent" is the physical object which facilitates the outside agent in performing this task (for example, the fuel gas system which delivers the fuel gas to the engine driving the compressor). To a large extent this distinction has been contrived to fit the REA template. The cooling of the shell gas is certainly achieved by a combination of shell gas, a compressor with an engine driven by fuel gas, a regulator and associated pipes. However, separating this physical system into a resource, and internal and external agents is not straightforward. For example, why does the shell gas used in this process not feature as a resource or an agent?

Another major difference between REA and the model developed by Grabski and Marsh (1994) relates to the nature of the events themselves. Under REA the events represent the inflow or outflow of economic resources and are related to reflect the economic exchanges of resources which take place. A normal business transaction would involve the increase in one resource in exchange for giving up another resource. Such exchanges are negotiated with the external agents to determine the amounts of each resource to be exchanged. Each exchange of a pair of resources may involve different sets of agents (for example, different customers and salesmen) and different levels of resource (for example, some customers may be given higher discounts than others). On the other hand, in the manufacturing process the increment and decrement events represent a physical process not an economic one. The exchange is based on the laws of nature and not on negotiations between the parties. Generally speaking, all instances of a particular event will involve exchanging

roughly the same levels of resources using the same "agents". This explains the inclusion
of event types in the generalised model. Furthermore, the events comprising the
"exchanges" of resources happen concurrently, unlike economic exchanges which may
extend over a long period of time (for example, a lease). Thus, the separation of a stage of
a manufacturing process into a pair of events is somewhat artificial as it is physically
impossible for them not to occur at the same time. The increment and decrement events
could be replaced by a single "exchange" or "process" object related to all the resources
consumed and generated by the stage as well as the "agents" which participated.

In summary, it is considered that the model of a manufacturing process produced by
Grabski and Marsh (1994) does not provide much support for the REA accounting
template, particularly in relation to accounting systems. Although both accounting and
manufacturing involve exchanges of resources which can be modelled in a similar way,
they are quite different in nature and there is no reason why a common framework is either
necessary or appropriate. The only link made by Grabksi and Marsh (1994, 17) between
an REA-based accounting model and their manufacturing model was relating an economic
event (a purchase) to a resource (electricity). This link is only dependent upon a common
recognition of resources between the two models and not, for example, on how the
manufacturing events are modelled. Adopting standard definitions for standard objects of
interest to multiple systems would facilitate the use of alternative approaches to modelling
manufacturing processes whilst still preserving the link to an REA-based accounting
system.

### 3.1.4 Contemporary Accounting Systems Based on REA

If contemporary accounting systems are based on the REA accounting template, then this
would provide support for the REA approach. Research in this area has been carried out
by Weber (1986) and David (1995).

Weber (1986) looked at how closely the order entry module of wholesale distribution
software packages resembled REA to discover the extent to which systems used in practice
were consistent with the REA template. He studied the data definitions of the order entry
module of 12 wholesale distribution software packages and found that REA was "a good
predictor of the high-level semantics to be found in the packages". However, Weber

(1986) also found additional elements in the modules which are excluded from the REA template because of its focus on traditional accounting phenomena. In particular, one package included a *Contract* object, which was a link between an economic resource and an economic agent. This falls outside the definition of an economic event in REA as it only represents a commitment of resources and not an exchange and, as such, there is no duality relationship. The two possible solutions to modelling "non-accounting" events proposed by Weber (1986) were:

1.     Define a new type of entity to represent "non-accounting events". These entities would not be associated by duality relationships and the stock-flow relationship would be replaced with a commitment relationship.

2.     The recognition criteria used to identify the types of resource changes which are included in the system could be modified to include commitments.[14]

It is not possible to derive any strong evidence in support of REA from this research because it was only concerned with a single type of event (a sales order) and did not, therefore, include any duality relationships which are a central part of REA. However, the work does suggest that the REA template is incomplete and provides some support for the extensions proposed by Geerts and McCarthy (2000) as discussed above.

David (1995) sought to evaluate accounting systems being used in practice against the REA accounting template. In order to carry out this work she required an operational definition of REA. Apart from providing the REA template and discussing some of the modelling issues, there is no clear definition of what constitutes an REA-based accounting system and how it would be distinguished from an accounting system which is not based on REA (a traditional accounting system). Thus, in order to evaluate contemporary accounting systems, David (1995) first sought to develop an operational definition of REA. She concluded that the following key characteristics provided an ability to differentiate traditional and REA-based accounting systems (David 1995, 19):

1.     support all critical events;

2.     store a detailed history of events;

3.     store the data in an integrated data repository;

4.     have the ability to retrieve and manipulate the data to meet users needs;

5.     process events as they occur;

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[14]     This is consistent with Ijiri's proposed extensions to historical cost accounting (1975, chapter 8).

6.    directed REA design and implementation (i.e. follow the REA accounting template);

7.    prepare financial statements without journal entries and a general ledger.

There are, however, a number of problems with this definition and its derivation.

In order to prepare the list of key characteristics, David visited eight US organisations in the pulp and paper industry and identified characteristics that differentiated the firms with the more sophisticated systems from those with the more traditional systems. The list, therefore, may be better described as representing the characteristics of an *ideal* accounting system rather than an REA-based system. The characteristics are not derived from the REA literature and hence cannot be seen as being part of any documented discussion of REA. For example, whilst the real-time processing of accounting events (item 5) provides the benefit of more up-to-date information, it does not appear to have been discussed in the REA literature as being a requirement; it is an implementation issue and REA is a modelling template independent of such matters. Thus it does not seem appropriate to describe it as a characteristic of REA or use it as part of the evaluation a system's degree of compliance with REA. Similarly, an "ability to retrieve and manipulate the data to meet users needs" (item 4) comes from undertaking a full requirements analysis and not just from using the REA template. A model based on REA may still be unable to meet user needs if a proper requirements analysis was not carried out. REA must be applied within a comprehensive systems design methodology, to ensure the quality of the outcome. It is also difficult to see the preparation of financial statements without the use of journal entries and a general ledger (item 7) as being a characteristic of an REA-based accounting system, for the following reasons:

❖    there is no evidence that a commercial REA-based accounting system could support the preparation of financial statements;[15]

❖    McCarthy and Gal (1983, 202) suggest that there would still be a need to prepare adjusting and closing journal entries;

❖    a general ledger can be considered to be merely a mechanism for accumulating totals for reporting purposes; for regular reports (such as financial statements) this

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[15]    None of the REA examples has been described as being representative of the complete set of business transactions which are the basis of the values which appear in a set of financial statements.

might reflect an efficient implementation and not the absence of an underlying semantic data model.

David (1995, 12) placed so much emphasis on the final item in the list that "firms that do not have a general ledger would automatically be placed at the REA end of the continuum".

Since none of the companies included in the sample used by David (1995) had an REA-based accounting system, her research provides no evidence of REA's ability to capture and process data from a real organisation. Nor, for the reasons outlined above, is it considered to provide an operational definition of an REA-based accounting system suitable for use in future research.

### 3.1.5 Summary

REA represents the most widely known alternative accounting model and is discussed in some Accounting Information Systems textbooks.[16] It is intuitively very appealing because its derivation is closely associated with accounting theory and the fundamental concept of exchanges of economic resources. However, there has been limited empirical research in this area. Although Geerts and McCarthy (2000) have incorporated some of the proposed extensions in their revised REA template, they do not discuss the reasons for omitting others. The lack of a clear operational definition of REA also makes research in this area problematic. Without a definition it is impossible to determine the value of proposed changes. There has also been a shift in emphasis since REA was first developed, from a template of an accounting system (McCarthy 1982) to a template of an enterprise information system (Geerts and McCarthy 2000). These subtle shifts which have occurred over time make the task of evaluation more difficult because the "target" is not stationary.

## 3.2 Multiview Accounting System

The objective of Seddon's PhD thesis in 1991 was to determine whether cost-effective, computer-based accounting systems can be used to generate better accounting information than existing transaction processing accounting systems (Seddon 1991, 1-3). The

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[16] For example, Moscove et al (1999), Romney and Steinbart (2000), Wilkinson et al (1997; 2000), Hall (2001) and Gelinas and Sutton (2001).

underlying motivation for his work, is that double-entry bookkeeping may lead to ways of thinking which are unproductive; for example, the perpetuation of historic cost accounting. Thus he sought to approach the design of computer-based transaction processing accounting systems from first principles (Seddon 1991, 1-5). This gave rise to his Multiview accounting systems incorporating the resources and exchange events (REE) model.

### 3.2.1 Design of the Multiview Accounting System

In seeking an answer to his research question, Seddon evaluated normative accounting theory regarding the information needs of users. He started from the assertion that the:

> "main objective of accounting is to provide useful information for economic decisions." (Seddon 1991, 2-3)

He also acknowledged that accounting was not the only source of information for decision-makers and that information is required by both internal and external users. From the literature, Seddon distilled three more specific objectives of accounting (Seddon 1991, 2-3):

- ❖ to provide management with information useful for planning and control;
- ❖ to provide external users with information useful for predicting the future cash flows and the earning power of a firm;
- ❖ to provide accountability information useful for contract monitoring.

Seddon then used empirical evidence to support two design principles for a new model of accounting systems. These were:

1. the ability to generate reports in inflation-adjusted/current-value terms (Seddon 1991, 6-1);

2. retention of data in machine-readable form as a corporate database for subsequent analyses (Seddon 1991, 6-18).

Existing systems fail to achieve these objectives because of the following weaknesses:

- ❖ the data in the subsystems may not be stored in a manner independent of the general ledger (or other subsystems) and the interface provided may restrict access to the data;
- ❖ conventional general ledger systems are intolerant of inflation; values stored are static and remain constant in money terms.

To overcome these weaknesses and to apply his design principles in achieving the objectives of accounting, Seddon proposed a solution comprising two components:

❖ a general ledger capable of recording formulae as values of transactions and account balances;

❖ an REE model which provides a rich view of the underlying transaction data.

Although these two components can be implemented independently of each other, the objectives are only likely to be achieved when both are present. An interpreter would also be necessary as an interface between the general ledger and the REE model in order to translate the logical view of the economic exchanges into one or more specific accounting interpretations of the exchanges for reporting purposes (Seddon 1991, 9-2).

Only part of the Multiview Accounting Systems is represented diagrammatically by Seddon (1991) so Figure 3.11 is an interpretation of how the descriptions and examples provided combine into a single system.[17] Objects from each of the three elements of the system (resources and exchange events model, formula accounting general ledger, and interpreter) are distinguished by the use of different symbols.

*Resource and Exchange Events Accounting Model*

Seddon (1991, 9-3) hypothesised that, according to accounting measurement theory, the recording of information about resources and exchange events would be both necessary and sufficient for the purpose of generating reports of income and wealth. His prototype REE model was proof of this proposition. His model "refines and extends" (Seddon 1991, 6-30) REA in two areas:

❖ REE uses "accounts" as a modelling primitive;

❖ a description of resources is included in order that their changing value over time can be modelled.

The basis of REE is Ijiri's (1975) causal double-entry approach. Seddon justifies his use of the "account" construct as a "useful way of describing relevant economic events" and to simplify the extraction of information from account-based subsystems (Seddon 1991, 6-30 - 6-31).

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[17] The diagram uses the ORM modelling method (Halpin 2001). This method is used for all the data models prepared in this thesis and a brief overview is included in Appendix B.

**Figure 3.11　Multiview Accounting System**
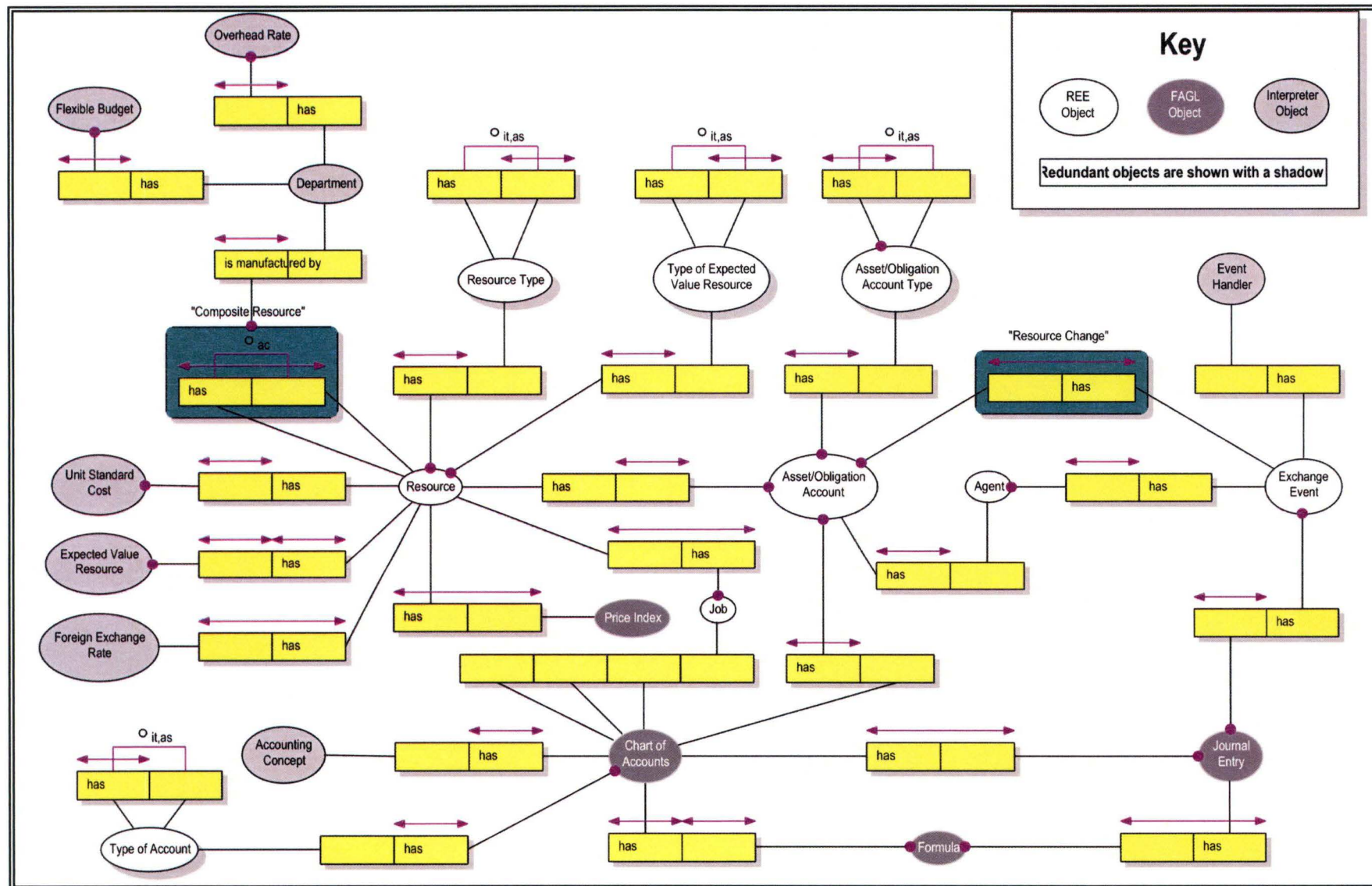
At the core of the REE model is a set of accounts representing the organisation's assets and obligations (AO). These are classified into a hierarchy of unconditional (current and non-current assets and obligations) and conditional (for example, sale and purchase orders) account types. Each AO account has an associated resource. Seddon (1991) uses two classifications schemes for resources:

❖ *Resource Type* which uses top-level categories of

  ✦ monetary resources (for example, cash, trade debt, loans)

  ✦ non-monetary resources

    ✧ tangible (for example, inventory, equipment, land)

    ✧ intangible (for example, labour services, goodwill)

❖ *Type of Expected Value Resource* which uses top-level categories of

  ✦ shrinking value resources

    ✧ tangible (for example, equipment and buildings)

    ✧ intangible (for example, labour services and goodwill)

  ✦ static value resources (for example, non-interest bearing cash, trade debt, inventory)

  ✦ growing value resources (for example, interest-bearing cash, loans)

  ✦ variable time derivative resources (for example, foreign currency)

Seddon (1991, 9-21) modifies the notion of resource from Ijiri (1975) to include future assets in order to maintain the balancing effect of exchanges. Future assets may be positive (for example, accounts receivable) or negative (for example, accounts payable and loans). For valuation purposes, Seddon (1991, 9-17 - 9-18) found it convenient to separate resources into three classes as illustrated in Table 3.12. This illustrates the integrated nature of the three elements of the Multiview Accounting System: exchange events in the REE model are used in the valuation of transformed resources, formulae supported by the Formula Accounting General Ledger (FAGL) are used to value resources consumed over time, and price indices maintained by the Interpreter facilitate the valuation of resources whose form does not change.

| Class of Resource | Example | Method Used for Valuation |
|---|---|---|
| Physical form does not change but value does | Shares, foreign currency | Price index |
| Both physical form and value change but resource is still considered to be the "same" | Machinery | Formula |
| Change in physical form is so great that resource must be reclassified | Conversion of raw materials into finished goods | Exchange events |

**Table 3.12    Valuation of Resources in the Multiview Accounting System**

*Formula Accounting General Ledger*

The general ledger system proposed by Seddon (1991) for the Multiview Accounting System extends traditional systems by permitting the journal entries and ledger balances to be calculated on the basis of a formula rather than being a constant value. As seen above, this is useful for valuing resources which are consumed over a period of time. Rather than posting a sequence of periodic journals to record depreciation, a journal containing a formula based on the date of purchase and the current date could provide the correct balance on a continuous basis. Similarly, the provision for doubtful debts journal might be posted as a given percentage of the value of the accounts receivable balance.

*Interpreter*

The Interpreter is the program which generates Formula Accounting journal entries from data in the REE database. Whilst the REE model captures details of the events, it is the task of the interpreter to translate them into appropriate journal entries for recording in the ledger. This is a procedural task using knowledge of each event type, a mapping between the Asset and Obligation accounts and the General Ledger accounts and an appreciation of related accounts (such as fixed asset and accumulated depreciation accounts). The valuation model to be applied is built into the Interpreter. The accounting treatment applied to each type of event is defined as a set of event handlers. This is similar to the processing that would be performed by a traditional accounting system when it offers input screens for the single-entry of common transaction types (such as a sales invoice which would automatically be posted to a sales account and a debtors account).

### 3.2.2 Analysis of the Multiview Accounting System

The Multiview Accounting System offers a very different design for an accounting system from the REA model. Although Seddon (1991) extends the types of transactions to include continuous events, an analysis of the complete model proposed highlights some concerns.

*Limited Scope*

A model's "completeness is only meaningful with reference to some specific goal"(Seddon 1991, 9-24). The sole aim of Seddon (1991) was to provide reports of income measurement and wealth; one of his design rules was that:

> "for inclusion in the REE model, data must be <u>necessary</u> for the Interpreter
> to generate its Formula Accounting journal entries." (Seddon 1991, 9-4,
> emphasis in original)

Thus, any basic attributes or relationships which might be defined for (or between) events, resources and agents would be omitted if they are not required for preparing journal entries. This is the same approach taken by traditional accounting systems and hence Seddon's solution will not overcome the reported weaknesses which relate to the limited ability of systems to provide multi-dimensional, disaggregated data suitable for supporting a wide range of information needs. If the system has only one form of report to support, a chart of accounts matching that format is a very efficient means of achieving the goal. However, the major disadvantage is the inflexibility that this yields, caused by the lack of independence between the data model and the processing model used to generate reports. REA sought to overcome this by concentrating on the design of the data model independent of any reporting requirements; provided the relevant attributes are captured by the model, arbitrarily complex reports should be possible. Seddon (1991), however, has designed a system for a specific purpose which severely limits the usefulness of his system and its ability to cater for the variety of, and changes in, reporting needs.[18] A useful consequence of this work, however, is a specification of the data requirements of current-value reports.

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[18]  For example, Seddon states that the preparation of a trial balance for accounting income and balance sheet reports is the "objective of the whole exercise" (1991, 10-2).

*Over-Specification of the Model*

The Multiview Accounting System is a model of the data necessary for the preparation of financial statements. Figure 3.11 illustrates the broad structure of the model as it is described in Seddon (1991) and from the examples used for his prototype system. A closer inspection of these examples, indicates that there are some elements which are not used or whose function could be replaced by a simpler construct. For example, each asset and obligation account is classified into a hierarchy of unconditional and conditional account types. Since conditional items are not relevant to the preparation of financial statements, the Interpreter does not generate journal entries for events related to these accounts. Apart from its use in filtering out conditional assets and obligations, the hierarchy is only used for two other purposes:

❖ to properly account for the cost of goods sold, sales tax and delivery charges when processing a credit sale event;

❖ to select the buy or sell rate for converting foreign currency according to whether the resource is an asset or an obligation.

At least in the examples used, the first purpose could have been achieved equally well by checking the *Class* attribute of the AO account since the class types sought all reside at the bottom level of the hierarchy. The second purpose appears flawed because the use of a buy or sell rate would depend upon the direction of flow of the foreign currency and not on whether it represented an asset or an obligation.[19] Thus, it would appear that the AO hierarchy is not an essential part of the model and could be removed without loss of functionality.

Like AO accounts, resources are also organised in hierarchies. The only use made of the resource type hierarchy is to identify resources which fall within the categories of monetary, equity, inventory and labour. The type of expected value resource hierarchy is used to identify resources subject to depreciation or amortisation. But this can also be ascertained from the existence of an entry in the `Expected Valued` table which specifies the depreciation method and rate.

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[19] For example, the buy rate would be applied to an increase in foreign currency holdings, whereas the sell rate would apply to a decrease. The opposite would apply to foreign currency obligations. This part of the model was not used by any of the examples provided in Seddon (1991).

The chart of accounts is organised into a balance sheet and profit and loss account structure but this is only used to identify profit and loss account balances when closing off the ledger at the end of a reporting period. A simple boolean field in the chart of accounts entries would be sufficient for this purpose.

Thus, the model contains a significant amount of detail which is superfluous to the defined purpose of preparing financial statements. For the manufacturing example this would represent a saving of about 25% of the database entries.[20]

*Accounts as a Modelling Primitive*

One of the advantages claimed for formula accounting can also be seen as one of its main drawbacks. Formula accounting:

> "imposes no restrictions on the accountant: <u>any real-world phenomena that can be recorded in a conventional accounting system can also be recorded in a Formula Accounting system</u>." (Seddon 1991, 7-32, emphasis in original)

Since constant-value journals are still permitted, it is true that formula accounting is an extension of traditional general ledgers. However, the statement makes the major assumption that conventional accounting systems provide sufficient flexibility for the accountant or, if not, that formula accounting is able to resolve these restrictions. Given his discussion of Ijiri's theory of accounting measurement and his support for a REA-like accounting model, it seems incongruous for Seddon to rely on a traditional general ledger structure for the preparation of reports. A chart of accounts, by definition, restricts the external view of the accounting events to a single form of analysis. Furthermore, it perpetuates the confusion of data capture and data processing. For example, an attempt to reallocate overhead expenses directly by formula results in a circular reference (Seddon 1991, 10-31). Such account transfers are artificial transactions created to cope with the excessively output focussed nature of a chart of accounts and have no place in a system designed to meet a multiplicity of reporting needs. The solution proposed by Seddon (1991) to support alternative sets of financial statements, was to maintain a separate

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[20]   This figure is calculated as the proportion of the lines in the Prolog file for the Manufacturing example (excluding blank lines and comments) which represent entries for the elements of the model which are not used or required.

general ledger for each. This seems a very extreme approach to adopt without seeking evidence that a more efficient solution is not possible.

*Use of Formulae*

The use of formulae for specifying transaction values and account balances is a useful concept, but its implementation does not provide the ability for extracting a trial balance for any selected date which would seem a natural extension of the idea. The balance information generated is always at the current date; back-dated reports excluding subsequent transactions are not supported.[21] In addition, the use of formula accounting journal entries could also be extended to the recording of services consumed which might be the subject of accrual or prepayment adjustments, although Seddon (1991) did not do so in his examples.[22] The only consideration Seddon (1991) gave to the problems of periodic reporting is in relation to the continuous valuation of assets and obligations and the closure of the profit and loss account; the allocation of consumption events is not discussed.

*Data Duplication*

Seddon did not design his Multiview Accounting System to replace existing subsystems; in fact he proposed to continue using these as the sources of the required data. Thus it is inevitable that data will be duplicated at least once. However, the design of his prototype system maintains multiple copies of the data: one in the REE model and one in each FAGL. A separate FAGL is maintained for each combination of valuation basis and accounting policy for which reports are required. The number of duplicate copies of the original data may, therefore, be quite large.

### 3.2.3 Summary

A major contribution of Seddon's work is the recognition that accounting systems record both discrete and continuous events and that accounting values are not static in nature but may change due to the passage of time. His proposed solution sought to separate the recording of the economic events from their interpretation using different valuation models

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[21] Implementing the FAGL as a view of the underlying transactions would permit trial balances to be extracted for any specified date by ignoring those dated after this time.

[22] The only indications of the period to which expense items apply are to be found in the narrative.

and accounting rules. The REE model is only concerned with "real" events from which the Interpreter is able to apply procedural rules to derive accounting adjustments such as depreciation.

Both the Multiview Accounting System and the REA accounting template include resources, events and agents as core elements. However, the former includes additional components which are not included in REA. The Multiview Accounting System organised resources and associated accounts into hierarchies to reflect their underlying nature. This domain knowledge is then used by the Interpreter component in applying appropriate accounting rules in the preparation of financial statements. Price indices are also included in the system to support valuation models based on current values.

A major weakness of the Multiview Accounting System is its narrow focus; it is designed solely for the preparation of financial statements. This is quite the opposite of the design of the REA accounting template which was designed independently of information (output) needs. Seddon (1991) recognised that organisations were already using a variety of subsystems to capture data regarding their business activities. This data would then be available for use in the Multiview Accounting System to avoid duplicating data capture. He did not investigate the option of designing a single, integrated system, or whether the data requirements of the Multiview Accounting System could be satisfied by collecting data from separate sources. An end result of this approach is the duplication of data across multiple systems, including duplication within the Multiview Accounting System itself. Although the example models used by Seddon (1991) were very limited both in terms of the numbers of transactions and the types of transaction, there is evidence to suggest that the system is over-specified; significant parts of the system were not used, or were used in a very limited manner. Further analysis with more data which are more representative of actual organisations may enable the system definition to be simplified considerably.

## 3.3 REAL Modelling

Andros *et al.* (1992) described the benefits derived from the reengineering of IBM's employee disbursement system. Although they included McCarthy's (1980) criticisms in the weaknesses they overcame, their application was not an accounting system but the administrative system by which employee expenses were reimbursed. Although this is

related to accounting since it involves the authorisation and payment of funds, it was not directly related to the recording and reporting of accounting transactions and was only concerned with one side of the economic exchange (the cash payment). It does not, therefore, offer a good insight into the application of REA principles to accounting systems. However, the work represents one of the foundations of REAL modelling as developed by Denna *et al.* (1993) and Hollander *et al.* (1996; 2000) which considers the wider area of modelling business processes. The term REAL is an acronym for Resources, Events, Agents and Locations. The first three elements are taken from McCarthy's REA accounting template. The fourth, location, was recommended as an extension to REA by Denna *et al.* (1994) which was discussed above.

### 3.3.1 Design of the REAL Modelling Methodology

Andros *et al.* (1992) extended McCarthy's criticisms of traditional accounting systems by adding a further four criticisms which were concerned mainly with the abstract nature of how an organisation's physical activities are represented in its accounting system. One of the authors' recommendations was that there should be a closer alignment between business and information processes. To prove the viability and value of event-driven solutions to accounting systems, Denna *et al.* (1993, 121-122) suggest two criteria. The first necessary (but not sufficient) condition was that they should address the weaknesses of traditional systems. The second was that they should enable organisations to meet present and future challenges.

Hollander *et al.* (2000, 11) view accounting as fulfilling the following essential functions:

* ❖ recording data about business transactions;
* ❖ summarising results of business activity into useful reports;
* ❖ providing assurances that the business is operating as intended and that the assets of the organisation are protected.

The accounting information system is the "infrastructure that supports the production and delivery of accounting's information products" (Hollander *et al.* 2000, 11). However, accounting transactions are only a subset of business events so Hollander *et al.* (2000, 12) suggest that the set of business events captured should be broadened to include other types of information needed by an organisation's *information customers*. They propose a model of business processes which includes all "strategically significant business activities and

essential characteristics about these business activities" (Hollander *et al.* 2000, 46). These essential characteristics consist of answers to the following questions:

- ❖ What happened?
- ❖ When did it occur?
- ❖ Who was involved and what roles did they play?
- ❖ What resources were involved and how much?
- ❖ Where did the event occur?
- ❖ What can go wrong during execution of the event?

The results of this analysis are graphically represented in a REAL model following the template shown in Figure 3.12.



Source: Hollander et al (2000)
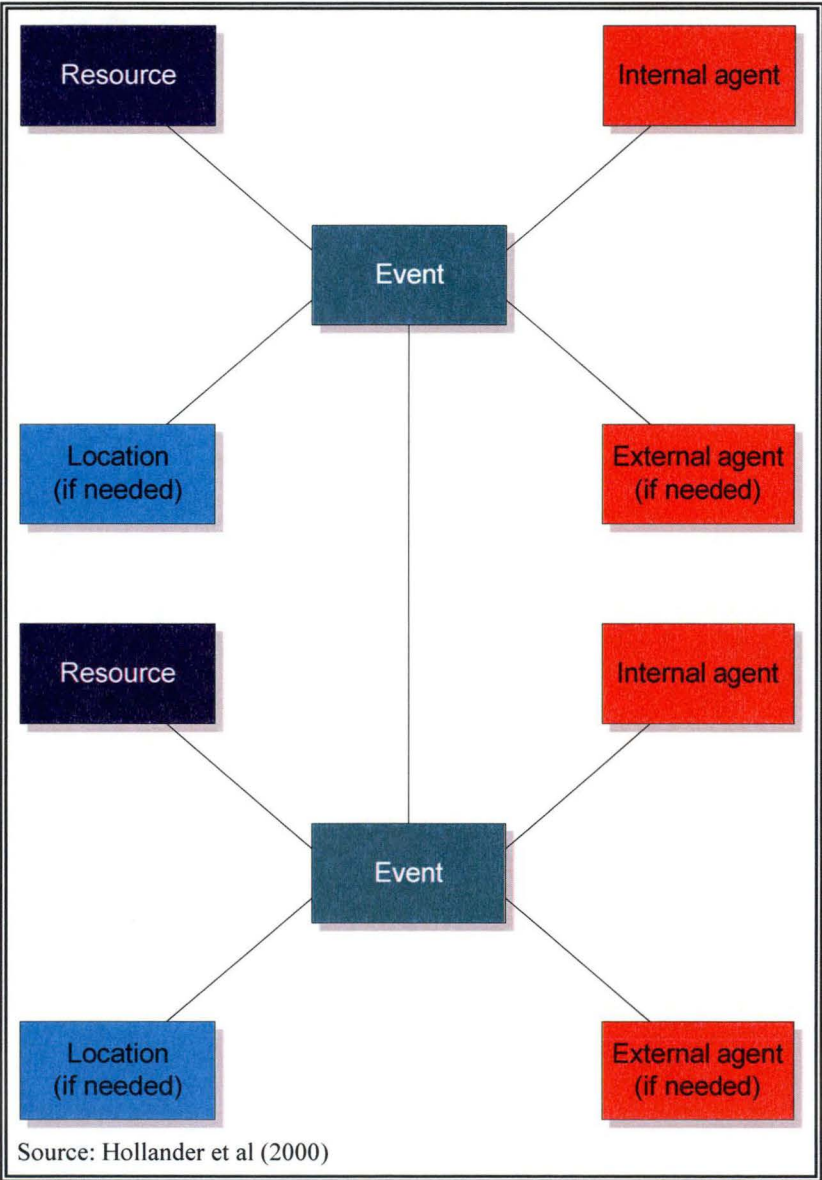
**Figure 3.12  REAL Template**

### 3.3.2 Analysis of the REAL Modelling Methodology

The REAL template bears many similarities to the REA template. For example, events have relationships with resources, internal agents, external agents and other events. However, many of these only appear similar on the surface; a closer look reveals fundamental differences between the two templates. Firstly, in a REAL model an event may be associated with more than one instance of a resource, internal agent and external agent. Under the REA template each event represented the flow of a single resource and was executed by one internal agent and one external agent. However, more importantly, the relationship between events in REA represented the resources gained and given up in an exchange (the duality relationship). A REAL model, on the other hand, is a process model (rather than a data model) and the relationship between events is included "to show the required sequence of events in a business process" (Hollander *et al.* 2000, 59). Some of these may correspond with a duality relationship but many will not. This is because a REAL model may include many non-accounting events. For example, the sample REAL model given for the sales/collection business process (Hollander *et al.* 2000, 269) includes the events of:

- ❖ call on customer;
- ❖ receive customer order;
- ❖ prepare shipment;
- ❖ deliver goods to customer;
- ❖ collect customer payment.

Only the last two events represent economic events and the duality relationship between them would not be captured by a REAL model unless they happen to occur consecutively. The design of a REAL model does not ensure that all duality relationships are captured and nor does it try to distinguish those which do reflect a duality relationship between events. Without a record of an organisation's economic exchanges, a system would be unable to prepare financial statements and hence it is not possible to describe REAL as a method for modelling accounting systems. It is, as the authors themselves describe it, a model of business processes and consequently it seeks to overcome the weaknesses of traditional accounting information systems by redefining the nature of the system. The effect on supporting existing information needs as a result of changing the focus of the system from economic events to business processes is not discussed.

A process model of business events is not considered sufficient for designing an information system which is to be equivalent to a traditional accounting system. The emphasis of Hollander *et al.* (2000) on modelling business processes appears to be derived from the evidence they present on organisations which have benefited from applying business process reengineering to their activities. They have then sought to align the information processes with the business processes on the implied assumption that this will create an information system able to support all the needs of its customers. Unlike the reengineering of the business processes which identifies the required outcomes and seeks to radically redesign the way in which they are achieved, the design of a REAL model is generated independently of any considerations of the information needs from the resulting system. Whilst one of the principles of reengineering proposed by Hammer (1990, 110) was to "subsume information-processing work into the real work that produces the information" this does not mean that the information system should be a model of the physical business processes. An information system can only be deemed useful if it is able to satisfy information needs of its users. The principles of reengineering would then recommend that the data capture required to support this information system be integrated with the business processes from which the data are derived. However, this is not the same as basing the design of the information system solely on the design of business processes. Data capture may benefit from an alignment of business and information processes, but this does not require the data model to be the same as the process model. One of the advantages of data modelling is that it can result in a conceptual model of an organisation's activities which can survive changes to the physical processes themselves. This is similar to the application of the "substance over form" rule in many areas of accounting regulations where the real nature of an arrangement is of less importance than its effect. Of course, if the information system is intended to report on the processes themselves rather than the outcomes of the processes, then this close alignment is inevitable.

The closeness of the names REA and REAL, which is caused by the fact that they have three object types in common (resources, events and agents), gives the appearance that the two models are quite similar. However, as has already been discussed above they are radically different types of models. REA is a data model of economic exchanges, whilst REAL is a process model of the events comprising a business activity. This distinction is clear from the different definitions for *event* in each case. REA refers to *economic events* which are defined as the inflow or outflow of an economic resource, usually as part of an

economic exchange as represented by associating a pair of events. REAL modelling, on the other hand, involves identifying the "strategically relevant events within a business process" (Hollander *et al.* 2000, 47). These events describe physical activities and their primary focus is not on recording the movement of economic resources. It is likely that most economic events in REA would have an equivalent process event in REAL since the movement of an economic resource would be expected to be strategically relevant. However, it is clear that a REAL model is concerned with far more of an organisation's activities than the narrower focus adopted by REA. Whilst all of the resources and events included in an REA model may be found in its REAL equivalent, the same is not the case with all of the REA relationships. For example, the responsibility relationship does not form part of the REAL template and the duality relationship between events is not modelled; the relationships between events merely describe their sequence in time. This also means that REAL models would not easily incorporate economic resources which are consumed over time rather than as a result of some physical process (for example, overhead expenses and depreciation).

The examples given by Hollander *et al.* (2000) imply that the categorisation of objects into the four types of resources, events, agents and locations is sufficient for the modelling of business processes. However, until information needs have been specified, it is not possible to conclude on the completeness of a model. There is no theoretical or practical reason why these categories should be exhaustive, and none is offered by the authors. Although these four types are probably the most important ones, they should not be seen as limiting the content of an information system. A system should include any object which is of assistance in meeting its objectives, regardless of its nature. For example, records of share prices or exchange rates may be maintained independently of whether an organisation has any events involving such resources. Of course, the same criticism may be levelled against REA which has yet to demonstrate conclusively that it is sufficient to support the information needs from traditional accounting systems.

As well as discussing the completeness of the object types used in defining a REAL model, the importance of these objects should also be questioned to ensure that they are not superfluous to the support of information needs. The event and resource type objects were derived from accounting theory by McCarthy (1982) in his development of the REA accounting template. Similarly, agents were added to reflect the parties participating in the

events. Hollander *et al.* (2000) added a fourth object type of location in defining their REAL models. Their notion of location is, however, somewhat unclear. An object is something about which the organisation wants to collect data. Thus, for a location to be adopted as an object, it must have properties (or attributes) of interest which need to be recorded and maintained in the information system. There are a number of attributes which could be relevant to a location; for example, market value, area, age, grid reference. However, the recognition of location as a separate object type would imply that such attributes are of interest merely because of the fact that an event took place there. It is contended that many "locations" of events may be places owned by the organisation (in which case they would be classified as resources) or owned by external agents (in which case they are attributes of agent objects). It is hard to find an example of a location object about which an organisation would want to capture multiple attributes which would not be more appropriately classified in a different way. The examples presented by Hollander *et al.* (2000) do not help to clarify the role and meaning of location in REAL models. Their REAL models of the sales/collection process, purchase/acquisition process and other business processes do not include any locations (Hollander *et al.* 2000, chapters 6-8). The closest object to a location is the inclusion of *Bank* in both the sales and purchase processes. However, this is both classified as an agent object and is also not related to an event (it is related to the cash resource). The only references to locations in these models appear in the logical structures presented for the acquisition/payment process where the location of an order is used as an attribute of the *Order Goods* event, The suggested values for location are "phone, fax or mail" (Hollander *et al.* 2000, 318) none of which is readily defined as a "location". Agent addresses (employees, vendors and bank) could be regarded as locations, but these are included as attributes of the agent object. The only use of location objects appears in the example introduced to describe the process of developing a REAL model. In the case of the sales/collection process for a retail store the cash register is defined as the location of a sale (Hollander *et al.* 2000, 54). For a small beekeeping operation the locations identified for its events were the organisation's store, the vendor's store, the supply barn and the field (Hollander *et al.* 2000, 67). In each of these cases, the locations selected are also resources of the organisation (or one of its external agents in the case of the vendor's store at which purchases take place). Thus, Hollander *et al.* (2000) provide insufficient evidence to support the need for an additional object type to record details of locations. Even though they acknowledge that locations need only be included

when they cannot be determined by referencing the event, resource or agents (Hollander *et al*. 2000, 54), the evidence they provide would suggest that location might be more appropriately defined as a new relationship type (between an event and a resource) rather than as a separate object. This is consistent with Wilkinson and Cerullo (1997, 206) whose view is that "locations are a special type of resource".

Hollander *et al*. (2000) recognise the need for their models of business processes to be able to support external financial reporting (Hollander *et al*. 2000, supplemental chapter E). They propose methods for calculating accounts receivable and gross sales as examples of how income statement and balance sheet items can be derived. However, these methods involve some rather limiting assumptions. For example, accounts receivable is calculated by subtracting the total value of customer payment events from the total value of sales events. Since the duality relationship is not modelled, this method uses an implied duality relationship between a sale and a customer payment. This assumption breaks down if a customer payment relates (at least in part) to an obligation which has not yet been fulfilled (for example, when payment is received in advance, or when the price paid includes the cost of installation which has not yet occurred). In addition, it assumes that cash payments are the only way in which a customer might repay their indebtedness to the organisation. In some cases this may be in the form of a contra against another transaction (such as when goods are purchased from a customer or when trading with other group companies). It is not clear whether the absence of an explicit duality relationship would permit the preparation of financial statements except under very simplistic conditions. In addition, since REAL models only capture events in real-time at best, they may lack any data on future expectations which are required in the preparation of financial statements (for example, when calculating accruals and provisions).

### 3.3.3 Summary

Despite stating that REAL modelling is an adaptation of McCarthy's (1982) REA accounting template, it is apparent that they are fundamentally different. REA is a data model of economic exchanges; REAL models are process models of business activities. REA is concerned with information (recording) events; REAL models capture operating (physical) events. When designing an information system to replace traditional accounting systems, it is the information events which are most important. Any model which does not

include the data necessary to satisfy the needs of its information customers would not be an acceptable substitute for an existing system. The first essential criterion proposed by Hollander *et al.* (2000) for evaluating an alternative solution was that it should overcome the existing criticisms. However, their focus on business processes and not on information needs makes it difficult to draw any conclusions on their achievements in this area. Whilst a process model can assist in managing an organisation's activities, a data model is also required to support the information needs of users. It is certainly possible that a REAL model may improve the quality of information at an operational (process) level, but it has not been shown that it remains able to provide information at a strategic level.

## 3.4 Summary

The most promising streams of research in relation to alternative data models of accounting systems are the REA accounting template and the Multiview Accounting System. A complete view of an accounting system is derived from combining different models. For example, Rumbaugh *et al.* (1991) uses an object model, a dynamic model and a functional model to fully describe a problem. Both the REA accounting template and the Multiview Accounting System are concerned with the data model (equivalent to the object model in Rumbaugh *et al.* 1991) view of accounting. REAL models, on the other hand, are process models; they are concerned with the processes or activities which occur in the organisation. Although most applications involve processes as well as data, the data element is more stable and all processes are contingent on the underlying data (Halpin 2001, 7). This research is, therefore, concerned with the accounting data model; process models of organisations are beyond the scope of this thesis. Hence, further consideration of REAL models is not appropriate.

The REA accounting template and the Multiview Accounting System offer solutions to different criticisms of existing accounting systems. There appears to be broad agreement on the basic entities required to support an accounting system; that is, resources, events and agents. There has also been no dispute over the proposed relationships between the entities, except for suggestions of additional relationships. The advantage offered by the Multiview Accounting System is the independence of the accounting data from accounting choices of valuation bases and policies. This was not a consideration in the design of REA and the example models developed include instances of specific accounting policies (for

example, depreciation and stock valuation). The Multiview Accounting System also models both discrete and continuous events; REA only models discrete events and so has to arbitrarily split continuous events into discrete parts in order to meet reporting requirements. The main disadvantage with the Multiview Accounting System is that it was designed for a single purpose: the preparation of financial statements. It also leads to a significant duplication of data because of the need to maintain a separate general ledger for every combination of valuation basis and set of accounting policies. Both models suffer from a lack of validation using realistic accounting data. Without more rigorous validation of the models, it is not possible to conclude about their completeness and their ability to perform the functions for which existing accounting systems are used.

Since both REA and the Multiview Accounting System were proposed, there have been significant developments in commercially available accounting systems. Many organisations have also installed enterprise resource planning (ERP) systems which integrate the accounting system with modules covering other business processes. Although these systems maintain a chart of accounts, one would expect that there has been plenty of time for any serious criticisms of accounting systems to have been addressed (especially given the age of many of the criticisms). This, therefore, raises the questions of whether alternative solutions to the criticisms have been adopted and, if not, whether the criticisms are actually important to users of accounting systems. If important criticisms remain unresolved, this may suggest that academic research has yet to fully prove the viability of its proposed solutions. It may also be the case that the research in this area has only overcome a subset of the problems which exist with accounting systems.

Both the REA accounting template and the Multiview Accounting System offer some useful insights into alternative approaches to modelling business activities. However, there is some doubt, prima facie, about the nature of the problems with contemporary accounting systems which need to be addressed. It is also not clear whether either of these alternative proposals is sufficient to replace existing systems. The research in this thesis will, therefore, first seek to clarify the problems experienced by users in order to provide a basis for the design and evaluation of new accounting data models.

# Contextual Framework

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Accounting information systems research is concerned with studying the representation of business activities. Since contemporary accounting systems are generally computer-based, this area overlaps significantly with information technology (IT) research. A number of authors have proposed research frameworks as an aid to identifying valid research questions. These are useful for classifying existing research and identifying research gaps which might lead to fruitful research projects.

The framework for research in information technology developed by March and Smith (1995) and the Research Pyramid proposed by David *et al.* (1999) are discussed in the first two sections. They are then applied to the focus of this research which is concerned with overcoming the criticisms of accounting systems. Two research questions are derived and classified using the frameworks with their inter-dependency being highlighted in the final summary.

## 4.1 Framework for Research in Information Technology

In developing their research framework, March and Smith (1995) separated the broad notion of science into two distinct "species": natural science and design science. Each species represents different activities and generates different products as summarised in Table 4.1. The four research outputs of design science represent building blocks for producing IT artifacts:

❖  *constructs* define the vocabulary of the domain;

❖  *models* express relationships between the constructs;

❖  *methods* use constructs and models to define the steps required to perform a task;

❖  *instantiations* are the operationalisation of the underlying constructs, models and
   methods.

| | **Natural Science** | **Design Science** |
|---|---|---|
| Aims | Research aimed at understanding reality | Attempts to create things that serve human purposes |
| Activities | *Theorise* - process of generating or proposing scientific claims *Justify* - testing scientific claims for validity | *Build* - process of constructing an artifact for a specific purpose *Evaluate* - process of determining how well an artifact performs |
| Products | Scientific claims in the form of laws, models and theories | *Constructs* - concepts with which to characterise phenomena *Models* - combinations of constructs used to describe tasks, situations or artifacts *Methods* - ways of performing goal-directed activities *Instantiations* - physical implementations intended to perform certain tasks |

Source: based on March and Smith (1995)

**Table 4.1    Natural Science and Design Science**

March and Smith (1995) view design science as being concerned with the building and
evaluation of these elements. Natural science activities then seek to explain the behaviour
of the artifacts produced (theorise) and gather evidence to support the explanations given
(justify). They argue that "both ... activities are needed to insure that IT research is both
relevant and effective". (March and Smith 1995, 251)

The March and Smith (1995) framework uses the distinction between research outputs and
research activities as separate dimensions for the categorisation of research. This is
illustrated in Table 4.2. Research in the *build* activity is judged on its value or utility to
users:

> "Building the *first* of virtually any set of constructs, model, method, or
> instantiation is deemed to be research, provided the artifact has utility for an
> important task... The significance of research that builds subsequent
> constructs, models, methods, and instantiations addressing the same task is
> judged based on 'significant improvement,' e.g. more comprehensive, better
> performance." (March and Smith 1995, 260)

| | | Research Activities | | | |
|---|---|---|---|---|---|
| | | Build | Evaluate | Theorise | Justify |
| **Research Outputs** | Constructs | | | | |
| | Models | | | | |
| | Methods | | | | |
| | Instantiations | | | | |

Source: March and Smith (1999, 255)

**Table 4.2     Framework for Research in Information Technology**

Once built an artifact must be evaluated against pre-determined criteria based on a particular task that the artifact is designed to perform; building an artifact merely demonstrates feasibility, it does not demonstrate improvements in effectiveness. The types of criteria suggested by March and Smith (1995) as being appropriate for evaluating each of the research outputs are summarised in Table 4.3. The second research activity, *evaluate,* is concerned with determining how well an artifact works and not with how or why it works. The latter aim is the purpose of the *theorise* activity; the validity of the theories generated being tested by the *justify* activity.

| **Research Outputs** | **Suggested Evaluation Criteria** |
|---|---|
| Constructs | Completeness, simplicity, elegance, understandability, ease of use |
| Models | Fidelity with real world phenomena, completeness, level of detail, robustness, internal consistency |
| Methods | Operationality (the ability to perform the intended task or the ability of humans to effectively use the method if it is not algorithmic), efficiency, generality, ease of use |
| Instantiations | Efficiency, effectiveness, impact on the environment and its users |

Source: based on March and Smith (1995)

**Table 4.3     Suggested Criteria for Use in the Evaluate Research Activity**

| Research Outputs | Research Activity by Research Paper[1] | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** | **O** | **P** | **Q** | **R** | **S** |
| Constructs | b | | | b | | e | | b | | | | b | | | etj | b | b | b | e |
| Models | b | | | | | e | | b | | b | | b | | b | etj | b | | b | e |
| Methods | b | b | b | | | | | b | | | | | | | | | | | |
| Instantiations[2] | | b | b | b | b | | b | b | b | | b | | b | | | | | | |

Key to Research Activities
b    Build
e    Evaluate
t    Theorise
j    Justify

Key to Research Papers

A.    McCarthy (1982)
B.    McCarthy and Gal (1983)
C.    Armitage (1985)
D.    Gal and McCarthy (1985)
E.    Gal and McCarthy (1986)
F.    Weber (1986)
G.    Denna and McCarthy (1987)
H.    Denna et al (1990)
I.    Geerts and McCarthy (1991)
J.    Gal and McCarthy (1992)
K.    Andros et al (1992), Cherrington et al (1996)

L.    Denna et al (1993, 1994), Hollander et al (1996, 2000)
M.    Dunn (1995)
N.    Grabski and Marsh (1994)
O.    David (1995)
P.    David (1997)
Q.    Dunn and McCarthy (1997)
R.    Geerts and McCarthy (1997)
S.    O'Leary (1999)

Notes
1.    The research papers have been ordered by date of publication and hence this only approximates the sequence in which the research work was carried out.
2.    The term *instantiations* has been extended to include prototypes for the purposes of this analysis.

**Table 4.4    Analysis of REA Research Using the Framework for IT Research**

| | Research Paper | Constructs | Models | Methods |
|---|---|---|---|---|
| A | McCarthy (1982) | Economic resource; Economic event; Economic agent; Stock-flow relationship; Duality relationship; Control relationship; Responsibility relationship | REA accounting model | Conclusion materialisation |
| B | McCarthy and Gal (1983) | | | Record sale; Accounts receivable; Cost of goods sold |
| C | Armitage (1985) | | | Production management requirements: job cost, idle time, outstanding material orders, delivery times. |
| D | Gal and McCarthy (1985) | Authority constraint | | |
| E | Gal and McCarthy (1986) | | | Accounts payable for inventory; accounts payable for services; Negative claims (accruals); Trial balance |
| H | Denna et al (1990) | External customer data | Extended REA data model | Age of outstanding sales invoices; Accounts receivable by customer |
| L | Denna et al (1993, 1994), Hollander et al (1996, 2000) | Location; Business event; Information process | REAL business process model | |
| N | Grabski and Marsh (1994) | | REA framework for the manufacturing process | |
| P | David (1997) | Synergy relationship; Information event | Business event REA | |
| Q | Dunn and McCarthy (1997) | Database orientation; Semantic orientation; Structuring orientation | | |
| R | Geerts and McCarthy (1997) | REA object Template; Task | Business process and task specification model | |

**Table 4.5     Examples of Build Research Activity in REA-Based Research (Constructs, Models and Methods)**

This framework can be used to classify existing research as a means of identifying topics for further study. For example, McCarthy (1982) proposed the REA accounting template which represented the building of constructs, models and methods. This paper did not perform any evaluation of these research outputs, but subsequent REA-based research has extended this original work in a number of directions. Table 4.4 summarises the research papers which have considered the REA accounting model[23] and categorises them using the March and Smith (1995) framework. This table highlights the fact that most of the work in this area has concentrated on the *build* activity, with very little evaluation. Tables 4.5 and

| Instantiation | | Research Paper |
|---|---|---|
| Small retail enterprise (based on Wilson Company) | B | McCarthy and Gal (1983) |
| | D | Gal and McCarthy (1985) |
| | E | Gal and McCarthy (1986) |
| | I | Geerts and McCarthy (1991) |
| | M | Dunn (1995) |
| Small manufacturing firm (K-W Manufacturing Co.) | C | Armitage (1985) |
| Simple manufacturing enterprise | G | Denna and McCarthy (1987) |
| | H | Denna et al (1990) |
| IBM's National Employee Disbursement System | K | Andros et al (1992), Cherrington et al (1996) |

**Table 4.6    Examples of Build Research Activity in REA-Based Research (Instantiations)**

4.6 identify the constructs, models, methods and instantiations which were built by each of the research papers summarised in Table 4.4. It is evident from Table 4.6 that most of the instantiations reported are based on simple, hypothetical enterprises and not on actual organisations or data derived from an analysis of implementations of accounting information systems. The only exceptions to this are the reports of IBM's National Employee Disbursement System (see, for example, Andros *et al.* 1992). However, this

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[23]    This analysis excludes those papers which have used the REA accounting model only as a basis for new research and have not sought to extend or evaluate REA itself. For example, Geerts (1993) which began the development of CREASY, and Chen et al (1993) which described SEAtool. The findings of such research does not provide direct evidence in support of REA in relation to its original, intended purpose.

system represents only a minor part of an accounting system: the completion, authorisation and processing of employee expense claims. So none of the instantiations reported to date can be said to provide supporting evidence of the validity of the underlying REA model. Moreover, the instantiations reported may not be sufficient to fall within the March and Smith (1995, 258) definition which is "the realization of an artifact in its environment". The example implementations of REA-based systems have not been applied to the environment for which REA was designed (the recording of business activities) but are only simple prototypes. They have been described here as instantiations because they are the closest that research in this area has come to implementing the constructs, models and methods proposed. The absence of the target environment, however, means that they only provide limited evidence of the validity of the underlying REA model as a basis for an alternative design of accounting systems.

Table 4.3 summarised the criteria identified by March and Smith (1995) for evaluating research outputs. Only some of these have been applied in evaluating REA research (see Table 4.7). For example, the differences found by both Weber (1986) and O'Leary (1999)

| | Research Paper | Evaluation Criteria |
|---|---|---|
| F | Weber (1996) | Conformance of entity-relationship diagrams for wholesale distribution packages to the REA accounting model |
| O | David (1995) | Survey instrument designed to identify whether accounting systems used by companies in the US Paper and Pulp industry: <br> ❖ have no chart of accounts; <br> ❖ support all critical events; <br> ❖ store detailed data about resources, events and agents; <br> ❖ store non-financial information about resources, events and agents. |
| S | O'Leary (1999) | Comparison of data warehousing schema with the REA accounting model and REAL business process model |

**Table 4.7    Criteria Used in Evaluate Research Activity in REA-Based Research**

suggest that the REA constructs and model may not be complete. David (1995) reviewed existing accounting systems against the REA accounting model but none was found to conform to it. Since there does not appear to be a true instantiation of an REA-based accounting system, it is very difficult to evaluate the ability of REA to perform its intended

functions; the simple case studies used in the prior research have not been developed
independently of the research.

Weber (1986, 500) noted that failure to find similarities between the REA accounting
model and existing systems would mean that:

> "either (a) the problems [which REA sought to overcome] do not exist or
> they are insignificant, (b) unresolved deficiencies still exist in the software,
> or (c) alternative solutions to the problems have been found."

However, REA-related research has only been subject to limited evaluation. Therefore, a
fourth possibility is that REA itself may fail to overcome the problems it sought to resolve
(whether, or not, existing systems have been successful in doing so). Unfortunately, the
need for further evaluation of the REA accounting model is not universally accepted. For
example, Haugen and McCarthy (2000) claim that

> "the REA model has been validated for correctness by peer review in the
> leading accounting journals, and accounting is among the most meticulous
> of business professions... REA is a superior accounting model, but its
> popular acceptance has been held back by the conservatism of the
> accounting profession".

Dunn and McCarthy (1997, 46) suggest that any new build activities in this area could not
be justified as advances unless they are evaluated against REA. Such propositions can
only be valid if REA itself has been fully evaluated. The above analysis of the REA
literature does not support this statement. In fact, the above review using the March and
Smith (1995) framework highlights that there are many gaps in the evaluation of REA
research which must be addressed if progress is to be made in this area.

## 4.2 The Research Pyramid

David *et al.* (1999) sought to develop a framework for classifying accounting information
systems research based on Sowa's (2000) *meaning triangle*. The meaning triangle
illustrates the three dimensions of knowledge representation:

❖ *objects* represent things which have a physical existence;

❖ *concepts* are mental representations of real-world objects; and

❖ *symbols* are the means by which we communicate our perceptions of objects.

These three constructs encapsulate the different ways in which the meaning of something
may be considered: the object itself, the mental interpretation (or experience) of the object

and the symbolic representation of the object which may be used as a means of communicating information about the object to others.

David *et al.* (1999) added accounting information systems (AIS) as a fourth construct, thereby extending the meaning triangle into a pyramid (see Figure 4.1). This pyramid was then used to categorise examples of existing accounting information systems research according to the combination of the pyramid's corners (constructs) which were addressed by the research questions. David *et al.* (1999, 15) considered it "impossible to study just one corner in isolation" and so the total number of possible categories used by them was 11.[24] This *Research Pyramid* was also used to suggest appropriate research methods based on the categorisation of the research questions.
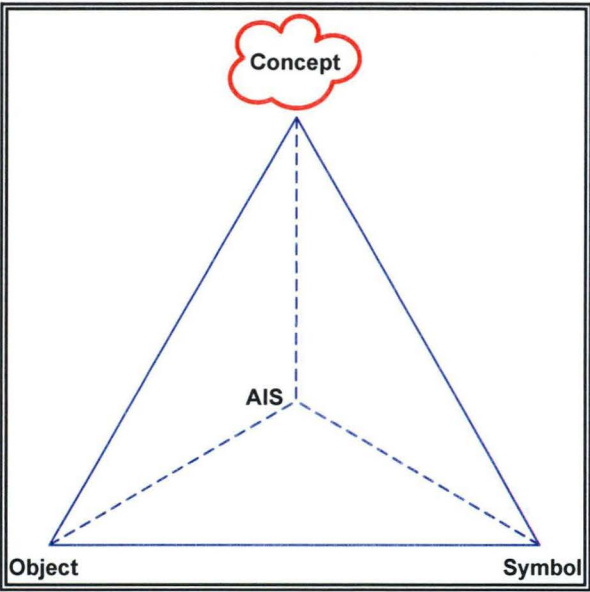


Source: adapted from David *et al.* (1999)

**Figure 4.1    Research Pyramid**

A review of David *et al.* (1999) highlights four areas of concern in relation to the application of the Research Pyramid to the classification of AIS research:

1.    The purpose of the fourth (AIS) construct.

2.    The classification of research.

3.    The valid research categories.

4.    The identification of appropriate research methodologies.

Each of these concerns is addressed in turn.

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[24]    6 involving a pair of corners, 4 involving 3 corners, and one involving all 4 corners.

### 4.2.1 The AIS Construct

The fourth construct (AIS) added by David *et al.* (1999, 12) represents "components of accounting information systems, i.e. a specific system implementation". Further insights into the intended meaning of this construct can be extracted from looking at how they used the dimension to classify research. Their examples of research which has AIS as one of its categories include (David *et al.* 1999, 15-24):

- ❖ evaluating systems used in organisations (e.g. how well they capture an organisation's events and meet the needs of its users);

- ❖ creating a system as a "proof of concept" for a new symbol set;

- ❖ the impact and importance of individual characteristics of systems (e.g. in terms of usage, availability, satisfaction or performance).

Thus, it would appear that to be classified on the AIS dimension the research should involve an implementation of an accounting information system, whether it be a real system being used in an organisation, or a prototype system.[25] If this is the case then a better term for this construct might be *Implementation of an AIS* since "AIS" is often interpreted much more widely.

Having defined the fourth construct, the next question to ask is "why it is needed?" According to David *et al.* (1999, 9):

> "Although Sowa's ... Meaning Triangle did not include information systems
> as a dimension, it is apparent that they are, in fact, related to each construct
> in the original model. By adding *accounting information systems* as another
> point in the Meaning Triangle, a Research Pyramid is created ... to guide
> research into how AIS interact with objects, concepts, and symbols."

To be worthy of inclusion as an additional construct, David *et al.* (1999) imply that AIS is something which cannot be represented by the existing constructs. It is possible, however, that information systems are "related to each construct" because they are an object about which knowledge can be represented using the meaning triangle. For example, an information system can be defined as a symbolic representation of physical objects. It might also be possible to consider an information system as an object in its own right, which might be represented symbolically in the form of a conceptual data model. This is consistent with Sowa's (2000, 193) linking of meaning triangles to represent Zachman's

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[25] This construct is similar to the concept of an *instantiation* in March and Smith (1995) as discussed in Section 4.1 and provides support for extending its definition to include prototype systems.

(1987) information system architecture (ISA) levels. At the top level are views of the world which are described independently of how they might be represented in a computer. The next level down considers implementation-independent descriptions, whilst the bottom levels describe how physical objects might be represented. These levels are consistent with those proposed by the ANSI/X3/SPARC Study Group on Database Management Systems (see Tsichritzis and Klug 1978) who broke down the architecture of a database system into three levels:

❖ *external level* - individual user views;

❖ *conceptual level* - community user view;

❖ *internal level* - storage view.

A linked set of meaning triangles for AIS research is depicted in Figure 4.2. The leftmost meaning triangle represents the external view of business activities as they might be captured in the AIS. The second meaning triangle represents a systems analyst's
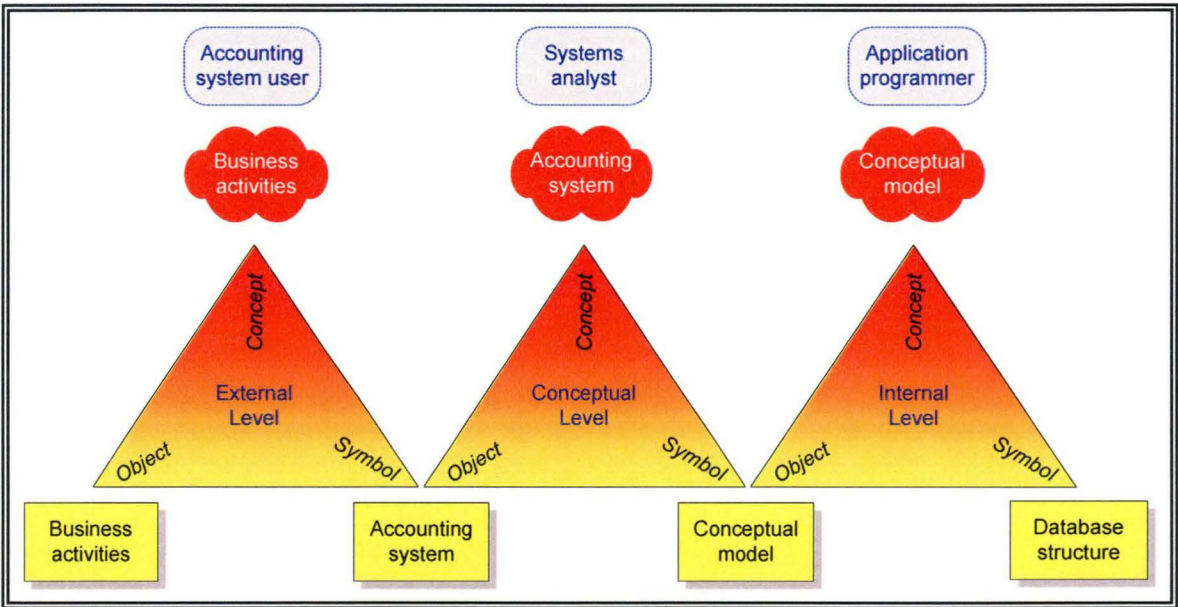


**Figure 4.2 Linked Meaning Triangles for AIS Research**

viewpoint of seeking to design a conceptual model suitable for representing the real world business activities. Finally the third meaning triangle considers a specific implementation of the conceptual model. As noted by Sowa (2000, 195),

> "Some symbols may refer to mental, fictional, or hypothetical objects, but the foundation of the system as a whole rests on solid ground."

This refers to the fact that at the external level is a physical object, but the symbolic representations of objects may themselves be viewed as objects at lower levels. For example, an accounting system may be seen by its users as representing the business

activities of an organisation, but to a systems analyst it is the object for which a conceptual data model is designed. Thus, the AIS construct proposed by David *et al.* (1999) does not appear to add anything new to Sowa's concepts, but is merely something which might be interpreted as being an object or a symbol according to the level at which meaning is being interpreted. It is possible that the AIS construct was invented in recognition of these levels because David *et al.* (1999) realised that there was an object between the physical business activities of an organisation and a conceptual model of those activities; this object being the AIS. Such an interpretation of their view would be consistent with the levels of the meaning triangle represented in Figure 4.2 in which the accounting system provides the "link" between the top two levels. Since the third level is concerned with implementation issues, it could be argued that this represents computer science research rather than AIS research. This provides a reason for only identifying the AIS as an additional construct and focussing on only two levels of knowledge.

A further concern with the inclusion of the *AIS* construct is that it is seems to be more closely related to the research *methodology* rather than the research questions which the Research Pyramid seeks to classify. This may result in the same set of research questions being classified in two different ways: one classification including the AIS construct and the other classification excluding it, depending upon whether the research involved an implementation of an AIS. Despite having identical research questions, the classification might be different. In this way, the AIS construct acts as little more than an attribute about the research and this extension opens the door to the inclusion of other potential attributes pertaining to the nature of the research, such as:

- ❖ the type of organisation (however this be defined);
- ❖ the type of AIS being used;
- ❖ the research strategy adopted (for example, questionnaire, case study, experiment, etc.).

The reasons underlying the selection of just a single factor are not made clear. The fact that a piece of research involves an implementation of an accounting system appears to be no more interesting than any other factor and its selection requires more justification.

Sowa (2000) considers the abstract representation of meaning; that is, not in relation to any particular subject. It represents a complete model; there is no need for any additional constructs in order to apply it. If, however, a fourth point were to be added, then one

representing the domain of discourse would complement the meaning triangle. The Research Pyramid could then represent the basis for classifying research for a particular area of knowledge. The *AIS Research Pyramid* would be used to classify research questions in AIS research. Other similar research pyramids could be defined for classifying research in other domains. For the purposes of this thesis, the AIS construct will be ignored.

## 4.2.2 Classification of Research

David *et al.* (1999, 15) sought to categorise AIS research on the basis of its research questions. The process of identifying the constructs of the meaning triangle (or Research Pyramid) which are addressed by a research question is made more difficult by the fact that the level at which the meaning of the constructs are being interpreted is omitted from the model. As seen above, something may be viewed as either an object or a symbol according to the nature of the research questions (level). For example (using mapping descriptions drawn from David *et al.* 1999), research which compares two symbol sets to evaluate the fit between the symbol and dimensions would consider an accounting system as an object, whilst research which examines how AIS influence organisational realities would treat accounting systems as symbols. This may explain some of the apparent inconsistencies in the classification of AIS research examples in David *et al.* (1999). For example, consider two of the research papers which have lead to proposals for alternative accounting models: McCarthy (1982) and Seddon (1996). The former work was classified into the *Object-Symbol* category, whilst the latter work was classified under *Symbol-AIS*. Both McCarthy (1982) and Seddon (1996) addressed questions about the symbolic representation of a set of objects. This explains their classification using the *symbol* construct. McCarthy (1982) was classified using the *object* construct because it outlined "how the objects should be represented in symbol form" (David *et al.* 1999, 15). This was also the case with Seddon (1996) but the *object* construct was not included in its classification which suggests some inconsistency between the two classifications.[26]

The description of how research examples were classified suggests a more fundamental concern. Looking into "how the objects should be represented in symbol form" implies

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[26] It is assumed that the *AIS* construct was included in the classification of Seddon (1996) because it constructed a prototype system to demonstrate the feasibility of the findings, whereas McCarthy (1982) did not.

that the research questions would be concerned with the *symbol* construct and not the *object* construct. The *objects* merely act as the subject of the research and are not the purpose of the research. To include both constructs would imply that all research concerned with the *symbol* construct would also be categorised under the *object* construct since there must always be objects for the symbols to represent. Sowa's (2000) meaning triangle is a means of representing knowledge; it is not possible for one construct of this representation to exist in isolation, all knowledge derives meaning from each of the corners.

The method of classification used is more consistent with focussing on the nature of the research (that is, the elements of the Research Pyramid which are involved in the research project) rather than solely on the research questions being addressed. For example, David *et al.* (1999) suggest that "all potential REA projects require the REA symbol set" and would, therefore, be classified using the *symbol* construct, seemingly without regard to the nature of a research project's questions. However, this supposition still fails to explain the inconsistent classification of McCarthy (1982) and Seddon (1996). Both these pieces of research involved accounting objects, and both had regard to user views yet the *concepts* construct was not included in their classification.

These apparent inconsistencies in the classification of research by David *et al.* (1999) make it more difficult for the framework to be applied by others.

### 4.2.3 Valid Research Categories

David *et al.* (1999, 15) contend that "interesting AIS research questions" can only be derived from edges or faces of the Research Pyramid; that is they cannot involve the study of just one corner on its own. Although, the most interesting questions may involve multiple corners, it is not made clear why research could not be isolated to a single corner. In fact many of the examples given by David *et al.* (1999, 15-24) are considered to involve research questions which only address one of the corners. Some of the mapping descriptions from David *et al.* (1999) for research examples involving only two constructs (an edge of the Research Pyramid) are listed below; the single construct (corner of the Research Pyramid) which such research questions might address is shown in brackets:

- ❖ Research "that develops symbols sets from the real world" (*symbol*)
- ❖ Research "that identifies effects of symbol sets on reality" (*object* or *concept*)
- ❖ Research "that examines how object characteristics are implemented in AIS" (*AIS*)
- ❖ Research "that evaluates how objects in reality influence people's mindsets" (*concept*)
- ❖ Research "that creates systems based upon symbol sets" (*object* or *AIS*)

David *et al.* (1999, 15) refer to examples which follow a single edge of the Research Pyramid as *primitive mappings* and note that they may be bidirectional:

> "For example, when looking at the Object-AIS primitive mapping, one could look at the extent to which an object set is represented by two different AIS (from Object to AIS), or one could look at the differential effects of using the two AIS on the object set (from AIS to Object)."

If a piece of research is only concerned with a primitive mapping in one direction, then it could be argued that the research questions in such instances would involve only one of the two corners. Thus, looking at the extent to which an object set is represented by two different AIS would lead to research questions which concern the AIS construct and not the object set which is being used as an input to the research process.

The conclusion by David *et al.* (1999) that no research can involve a single corner of the Research Pyramid may be related to the other concerns discussed above. The fact that all three elements of meaning co-exist at different levels, and the fact that the classification process appears to confuse the nature of the research with the research questions, may have contributed to this view. There is no clear reason why research should not be solely concerned with one corner of a meaning triangle, as with the evaluation of alternative symbol sets.

### 4.2.4 Identifying Appropriate Research Methodologies

In addition to using their Research Pyramid to identify research opportunities, David *et al.* (1999) also suggest that it can be used to provide guidance on appropriate methodologies. The four main research methodologies discussed are design science (or normative studies), field studies, surveys and laboratory experiments. The relationship between the research methodologies and the corners of the Research Pyramid is shown in Figure 4.3. Each column represents a different research methodology and each row a construct which appears at one of the corners of the Research Pyramid. In David *et al.* (1999) research

classifications had to include 2, 3 or 4 of the constructs. Thus each construct would participate in 3 classifications involving a pair of constructs, 3 classifications involving 3 constructs and 1 classification of all 4 constructs. The length of each of the bars in the figure represents the proportion of the combinations for each classification that a research methodology is proposed as being appropriate.[27] From the figure it is clear that the field study and survey methods are considered appropriate for all classifications. Laboratory experiments are appropriate for all classifications involving at least three constructs but only for pairs which involve the concept construct. Design science is only considered appropriate to research involving the concept construct if it is paired with the symbol construct and not as part of any other combination.
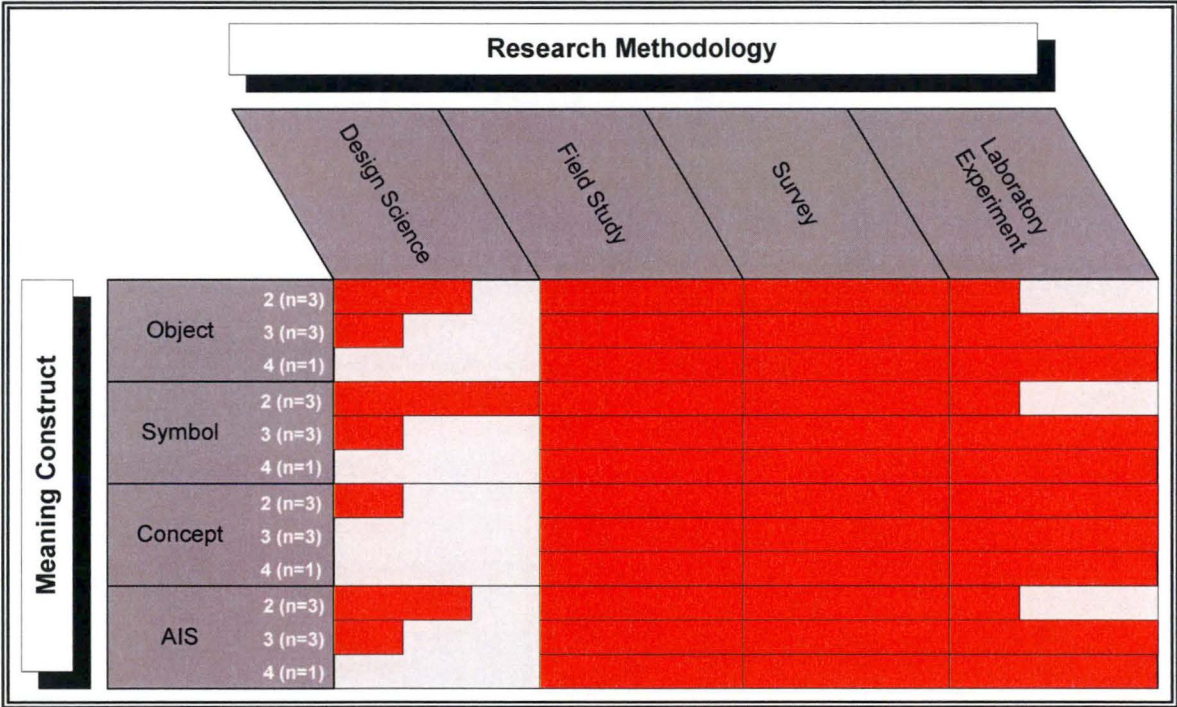


Source: based on David et al (1999)

**Figure 4.3   Appropriate Methodologies for AIS Research**

The usefulness of the Research Pyramid classification scheme in suggesting appropriate research methodologies is not clear. Since field study and survey research are suggested for every category of research, the Research Pyramid does not provide a means of determining the appropriateness of these research methods. Furthermore, although each category of research may suggest particular types of methodology, it is not clear that this relationship is between the category and the method or whether it might be more

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[27]   For combinations of 2 and 3 constructs the length of the bar is the number of instances out of a possible total of 3; for the single combination of all 4 constructs the bar will either be full length (100%) or absent (0%).

accurately represented as a relationship between each individual construct and a method. For example, laboratory experiments are more likely to be appropriate when wanting to measure user perceptions (the *concept* construct) whatever other constructs (or categories) might also be involved. This is consistent with the suggestions made by David *et al.* (1999) as illustrated in Figure 4.3. An association between design science and the symbol construct is also suggested by the figure but is less clear cut from the classifications made by David *et al.* (1999).

The difficulties in identifying appropriate methodologies may be linked with the confusion over the classification of research discussed above. Whether guidance based on the individual constructs (rather than the research category) would be more appropriate was not discussed by David *et al.* (1999) and is worthy of further investigation.

### 4.2.5 Summary

The meaning triangle is a convenient means of considering knowledge. As research is about extending knowledge the meaning triangle should provide an interesting way of classifying research questions. The extension of this approach into a Research Pyramid (as proposed by David *et al.* 1999) by adding AIS as a fourth construct appears to confound its use. It is considered more appropriate to extend it into a series of linked meaning triangles to represent the different levels of meaning. An accounting system (the proposed AIS construct) is then represented as the link between the top two levels of meaning triangle. When applying this framework it is important to focus on classifying the research *questions* (the knowledge dimension of the research) and to identify the level with which the research is concerned. Subject to these clarifications, the meaning triangle may provide a useful means for classifying research and will be applied to the research in this thesis. However, it is not considered appropriate to pursue the application of the Research Pyramid until further consideration and clarification of its application has been undertaken.

## 4.3 Focus of this Research

The literature review in Chapter 2 can be summarised in terms of 3 goals which a new accounting system would need to achieve if it is to overcome criticisms made against such systems. These goals were concerned with:

❖　improving the *quality* of information which can be produced;

❖　improving the *variety* of information which can be produced;

❖　improving the *timeliness* with which information can be produced.

Although these goals are related, initially each is considered separately.

### 4.3.1　Quality

The production of information from an accounting system involves a combination of many factors, starting with an initial system design (conceptual data model) and culminating in
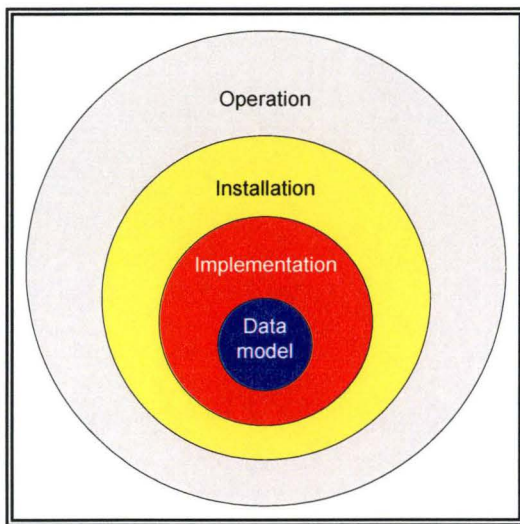


**Figure 4.4　Operational Context of Accounting Systems**

the operation of the system. Each factor may influence the quality of the information produced as illustrated in Figure 4.4. This figure identifies the following main contributing factors:

1.　*Conceptual data model.* Details of the business activities required to be captured in the accounting system can be expressed in the form of a conceptual data model. Not only should such models be independent of how they might be implemented but, since most accounting systems are packaged software written by a third party, they will not be based specifically on any individual organisation's business activities.

2.　*Implementation process.* Conceptual data models need to be converted to a lower level structure for implementation. Initially they are mapped to a schema for a selected logical data model (for example, relational, hierarchic or object-relational) and then into an internal schema for a specific DBMS. This process may necessitate changes or compromises being made to the conceptual design because

of limitations in the logical data model or DBMS, or in order to satisfy cost or performance targets. Furthermore, functionality provided by an implementation may not be accessible because of inadequacies in the user interface. Thus, some limitations in an accounting system may be introduced as a result of the implementation process.

3.   *Installation.* Accounting systems are installed within organisations; this physical, social and political context may influence the operation of the accounting system and lead to problems being experienced by its users. For example, a user may not be given direct access to the system but be expected to submit written requests in order to obtain reports or answers to ad hoc enquiries. Alternatively, the number of terminals able to access the accounting system may be limited and in short supply which may frustrate users.

4.   *Operation.* The ability of staff to use the accounting system will also influence the level of problems which arise. No matter how well a system has been implemented within an organisation, if staff do not have appropriate expertise or training, the system may not be set up and used appropriately to achieve the greatest benefits.

Figure 4.4 also shows the relationship between these factors. At each stage of the deployment of an accounting system, decisions may be taken and/or compromises made which restrict the quality of the information it is capable of supporting. Such restrictions cannot be circumvented by making appropriate choices at a later stage (an outer level); for example, no amount of training (*Operation* level) can overcome limitations introduced as a result of how the system was installed. Thus, the most crucial factor in improving the quality of accounting systems is the design of the underlying data model. No matter how good the implementation, installation and personnel, the quality of information provided will suffer if the data model has not been designed to capture and store the appropriate data.

### 4.3.2 Variety

The variety of information available from an accounting system is dependent upon two main factors:

❖   whether data captured are being appropriately stored;
❖   the range of data being captured and stored.

Data relating to an organisation's business activities may be captured by its accounting system, but it is not necessarily the case that these data are retained or that they are retained in this form. For example, the maintenance of an open-item sales ledger requires that receipts from customers be matched against the outstanding invoices. However, once they have been matched (and the amount outstanding for each invoice updated) the details of which customer payments were to cover which invoices are no longer required and may not be stored. Thus, reports on the average periods taken by customers to pay their invoices may not be available.[28] Other data may only be stored in an aggregated (or summarised) form so that detailed analyses are not possible. Such criticisms have been made of accounting systems based on double-entry principles.

In addition to not retaining all of the data relating to an organisation's business activities (or only doing so in a summarised form), the variety of information available from an accounting system is also influenced by the types of data which are included as part of the system. A criticism of accounting systems is that they are restricted to recording the financial aspects of transactions which affect an organisation's economic resources. There is evidence to suggest that many contemporary accounting systems also record non-financial attributes of economic transactions, and with the growing popularity of ERP systems accounting transactions are being integrated with data from other business activities. However, problems associated with the variety of information available may remain because:

❖ the integration of accounting and other data only occurs at a summary level;

❖ an incomplete set of non-financial details is recorded in relation to economic transactions.

Therefore, to ensure that access to a wide variety of information is maintained, it is important for an accounting data model to both integrate easily with data models used to capture other types of business activity and be extensible to allow the incorporation of other aspects of economic activities.

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[28] Or such reports may have to be based on a simplifying assumption such as "receipts pay for the oldest invoices first".

### 4.3.3 Timeliness

The timeliness of reports from an accounting system can be improved in the following ways:

❖ increase the processing speed of the equipment being used;

❖ maintain the data in the format required by reports;

❖ ensure that all data used as input to reports have been recorded.

The first solution is essentially a cost/benefit tradeoff similar to that faced by all other technological solutions and is beyond the scope of this thesis. The second solution is similar to the approach adopted by double-entry systems which maintains a summary of the effect of transactions on the accounting equation. This makes it very easy to generate a set of financial statements but can also limit a system's usefulness in supporting other information needs. Provided such summaries are not maintained at the expense of the detailed records of business activities, they can be a sensible compromise to adopt in order to reduce the costs associated with the first solution. Neither of these "solutions" will be relevant until all of the data required to prepare a report have been recorded in the system. Thus, the first priority in improving the timeliness of reports is to ensure that all the required data are available in a timely manner. In traditional accounting systems, the preparation of financial statements first involves the processing of end of period adjustments, so streamlining this processing is a useful first step for improving the timeliness of these reports.

### 4.3.4 Analysis

Although there are many different factors which impact upon the quality of information provided from an accounting system, improvements in information quality, variety and timeliness all depend in part upon the design of the underlying data model. Moreover, the design of the data model is of fundamental importance; it is difficult (or impossible) to overcome deficiencies in the data model by making changes elsewhere. The primary focus of this research will, therefore, be on the design of the accounting data model as an essential first step in overcoming problems with existing accounting systems.

The two main proposals for alternative accounting data models (REA and the Multiview Accounting System) were discussed in Chapter 3. Neither has been adopted for use in

actual accounting systems which provides prima facie evidence as to their unsuitability for the task. This may be for the following reasons:

❖  the alternative models fail to overcome a sufficient number of the problems with existing systems to make the change worthwhile;

❖  accounting software houses are unaware of the alternative models but would otherwise have adopted one of them.

Links between some of the authors of alternative proposals and organisations concerned with writing and implementing commercial accounting systems (such as IBM and Pricewaterhouse Coopers) together with the adaptation of models for use in other areas (such as data warehousing) suggest that the second reason (a lack of awareness of alternatives) is unlikely to be the cause of their lack of adoption. This, therefore, casts some doubt over whether the potential benefits can be derived from the alternative models proposed.

Neither of the alternative models was designed with all of the aims synthesised from the review of criticisms in Chapter 2 in mind. In addition, the review in Chapter 3 revealed that these models have not been subject to comprehensive evaluation. Both the failure to address all the problems with contemporary accounting systems and the lack of evidence to demonstrate that the proposals are capable of supporting the needs of actual organisations, may explain why neither model has been adopted in the production of a commercial accounting system. If long-standing and important criticisms of accounting systems still exist, this would suggest that the REA and Multiview Accounting System are unable to overcome them or that there are other problems associated with their adoption. Although the design of each model demonstrated improvements in the quality of the information it is able to provide, such benefits must be outweighed by other factors; otherwise they surely would have been adopted in practice.

The Multiview Accounting System fails to address the goal of improving the variety of information provided since it was designed solely for the purposes of producing financial statements. One of the design goals behind REA, however, was its ease of integration with other information systems. The absence of any actual accounting systems based on REA make the achievement of this objective difficult to prove but its conceptual design would greatly facilitate this process. The extensibility of the REA approach to allow the incorporation of other aspects related to the flows of economic resources is also in doubt:

the REA template consists of three elements with no guidance on how other types of related entity might be integrated. Moreover, the recent attempts (such as Geerts and McCarthy 2000) to extend the template to incorporate commitments provide some evidence of the difficulties which may be encountered in doing so. In this case, the extension resulted in a significant increase in the complexity of the template (for example, the number of different types of relationship was more than doubled) even though the new entity relates to the same economic phenomena as the components of the original template. Further extensions (such as the recording of flows on non-economic resources associated with exchanges) may further complicate the resulting REA model making it even more difficult to implement.

Both the REA and the Multiview Accounting System adopt the traditional convention of only recording historical data. Since many of the adjustments processed before financial statements can be prepared relate to future expectations (for example, accruals and provisions), neither of these models can necessarily improve the timeliness of such reports. On demand, real-time reporting, for example, would not be easily supported by these alternative models.

### 4.3.5 Need for a New Accounting Data Model

The above discussion indicates that the achievement of the goals to be addressed for improving accounting systems would necessitate the design of a new accounting data model. Existing accounting systems have unresolved problems which alternative proposals fail to fully resolve. The primary research question addressed in this thesis is, therefore:

> $RQ_{model}$    Can the criticisms of existing accounting systems be overcome by making changes to the design of the underlying accounting data model?

The criticisms of existing accounting systems relate to the eight aims (A to I, excluding H) identified in Chapter 2. The strongest evidence to support an affirmative response to $RQ_{model}$ would be to demonstrate its feasibility by designing such a model. This approach would generate research outputs in the form of constructs and models, and involve the build and evaluate research activities of the March and Smith (1995) framework. The external validity of the new data model is enhanced by basing its design on an analysis of data models developed from actual organisations and by testing it using independently

generated examples which were prepared as illustrations of other proposals for alternative accounting models. The research addressing $RQ_{model}$ falls within the second (conceptual) level meaning triangle with a focus on the symbolic representation of accounting data. This classification of $RQ_{model}$ is illustrated in Figure 4.5 using a combined form of the March and Smith (1995) and David *et al.* (1999) frameworks.
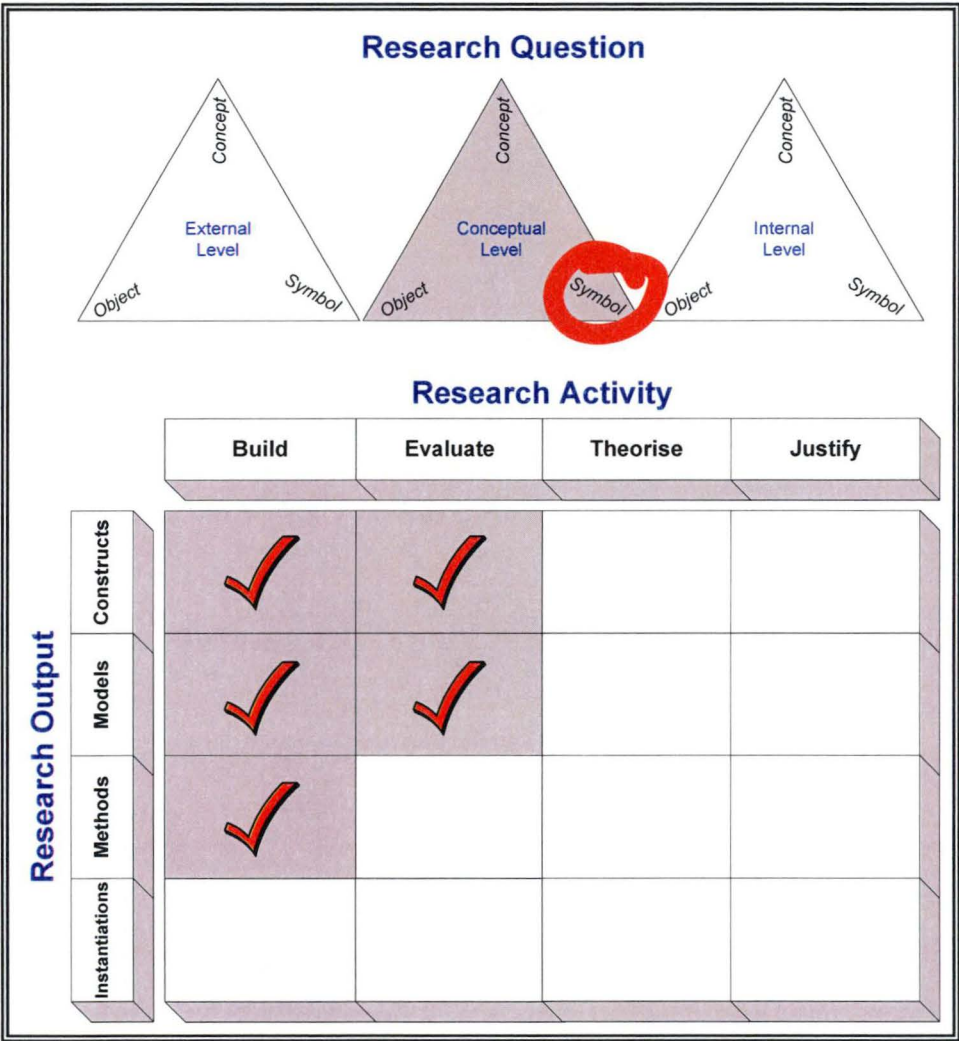


**Figure 4.5    Classification of $RQ_{model}$**

## 4.3.6  Contemporary Validity of Criticisms of Accounting Systems

A fundamental assumption of $RQ_{model}$ is that the criticisms which it seeks to address are valid. The criticisms have been derived from a review of the literature but none includes reports of evidence gathered from accounting system users. In the light of this, it is possible that:

❖    the criticisms are not considered important by users of accounting systems (including users of the information prepared from accounting systems);

❖ subsequent improvements to accounting systems have overcome the criticisms so they no longer apply;

❖ other unreported problems with accounting systems are experienced by users.

As a consequence, before seeking to redesign the accounting data model, it is considered prudent to seek some confirmatory evidence that resolving the problems identified has some value to users. Thus, the following initial research question will be addressed in this thesis:

$RQ_{crit}$   Are the criticisms of accounting systems reported in the literature representative of those experienced by users?

The objective of addressing this research question is not to derive a comprehensive list of problems associated with accounting systems. Since this question is being raised as a pre-requisite to the main research question, it is addressed only on a modest scale to find prima facie evidence of the continued validity of the reported criticisms and, at the same time, check that there are no significant omissions from the list. Subject to this caveat, the
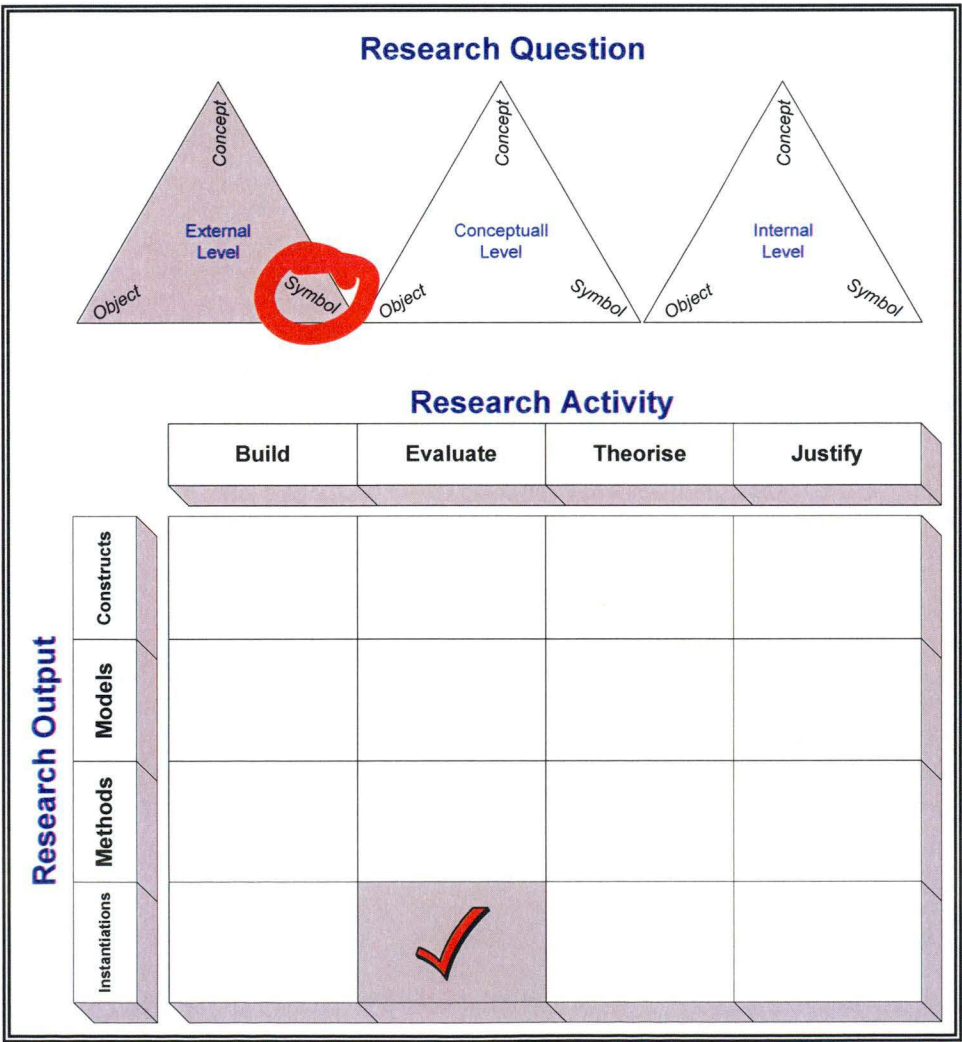


**Figure 4.6   Classification of RQ$_{crit}$**

research undertaken to address $RQ_{crit}$ can be classified using the March and Smith (1995) framework as relating to the evaluate activity on instantiations. The investigation of accounting systems as they are used in practice would place this research in the first (external) level meaning triangle with a focus on the symbol corner (the accounting system being the symbolic representation of the organisation's business activities). This classification is illustrated in Figure 4.6.

## 4.4 Summary

This thesis can be described as being concerned with research on information technology with accounting used as the universe of discourse to which the information technology is applied. Accounting systems have reached a crucial time in their evolution. The traditional systems based on double-entry principles are unable to satisfy the needs of present-day users and demands for the future. The growing popularity of enterprise resource planning (ERP) systems has seen the focus move away from accounting systems as the central information provider for an organisation to a point where the accounting records may remain at the heart of the information system but they are secondary to the other operational modules. The majority of accounting transactions are automatically generated from data entered into other modules and the accounting module may only be used for the specialised purpose of preparing financial statements (for internal or external users). Without the accounting module providing a pivotal role within the information system, there is a danger that relationships between the different elements of economic exchanges will be lost because they are recorded in separate modules. Unless changes are made to the design of the accounting data model, accounting will continue to be unable to support all of the needs of users for information relating to the economic activities of the organisation and the role of accountants will become increasingly less important, reduced to executing outdated methods on secondary data.

The main research question to be addressed in this thesis ($RQ_{model}$) seeks to apply the same transformation to the design of accounting data models as has been applied to the other modules within an ERP system. Recent years have seen the radical re-engineering of business processes and the information systems which support them. It is time for such changes to be applied to the accounting elements. This research, therefore, fits within the area of design science which "attempts to create things that serve human purposes" (March

and Smith 1995, 253). Such research is not concerned with theory which is the province of natural science, instead "design scientists produce and apply knowledge of tasks or situations in order to create effective artifacts" (March and Smith 1995, 253). The output from investigating $RQ_{model}$ should be new constructs and a new model relevant to the accounting domain which may be evaluated on the basis of the criteria outlined in Table 4.3. These outputs should also be positioned with respect to existing constructs and models to demonstrate the contribution they make (March and Smith 1995, 261).

$RQ_{crit}$ is investigated first as a precautionary measure to provide some limited reassurance that the problems being addressed by $RQ_{model}$ remain valid. An investigation of users' perceptions of their accounting system could easily form a completely separate topic of its own, but this has been resisted in this thesis which seeks to emphasise the design of the accounting data model. It is, however, a recognition of some concern with the literature in this area which does not attribute problems with accounting systems to particular users or contexts and which continues to reiterate criticisms made in the past on the untested assumption that the circumstances which gave rise to the original reports have not changed.[29]

If the results of investigating $RQ_{crit}$ find no support for problems with accounting systems, then it would not be appropriate to address $RQ_{model}$. Instead, such a finding would indicate the need to conduct more thorough research into user problems. This would provide a robust set of criteria which could then be applied in the evaluation of any alternative accounting data models which may be subsequently proposed.

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[29] It is recognised that it would be difficult to perform such tests in many cases since the underlying causes of the criticisms are often not reported.

# Contemporary Validity of Criticisms of Accounting Systems

From the analysis of criticisms of accounting systems (Chapter 2) and the review of alternative accounting data models (Chapter 3) it is evident that many important questions remain unanswered about the nature of the problems with accounting systems. Before attempting to design a new accounting data model it is important to be satisfied that the problems this task seeks to overcome are representative of those being encountered by users of contemporary accounting systems. The objective of the preliminary research question addressed in this thesis ($RQ_{crit}$ from Chapter 4), therefore, is to seek confirmatory evidence of users' experiences and problems with their accounting systems.

This chapter is structured as follows. Section 5.1 discusses the development of the hypotheses relating to $RQ_{crit}$. Section 5.2 describes the research method adopted with an analysis of the interviews provided in Section 5.3. The support for the research hypotheses is reviewed in Section 5.4 followed by a summary of the chapter in Section 5.5.

## 5.1 Development of Hypotheses

This chapter is concerned with addressing the following research question as identified in Chapter 4:

$RQ_{crit}$  Are the criticisms of accounting systems reported in the literature representative of those experienced by users of contemporary accounting systems?

The purpose of addressing this research question is to provide confirmation that there are problems with contemporary accounting systems which, it is argued, could be overcome by redesigning the underlying data model. The findings may fall into one of three categories:

1. problems reported by users of contemporary accounting systems are consistent with those reported in the literature;

2. problems reported by users of contemporary accounting systems are not consistent with those reported in the literature;

3. no problems are reported by users of contemporary accounting systems.

Findings in either of the first two categories provide more robust support for addressing $RQ_{model}$ than if it appeared that no problems exist with contemporary accounting systems (category 3). Pursuing $RQ_{model}$ in the third category would require acceptance that the third party reports of problems reported in the literature are both valid and current, and undermine the original arguments for addressing $RQ_{crit}$ in the first place. Under these circumstances it is considered that a more thorough investigation of problems with accounting systems should be made before any proposals for the redesign of accounting systems are developed. Otherwise there would be no firm basis on which to evaluate proposals for alternative accounting data models.

Chapter 2 summarised the reported criticisms into nine aims. These were as follows:

    A.    Record data in a raw (objective) form

    B.    Capture both financial and non-financial events

    C.    Multi-dimensional record of events

    D.    Encompass past events and future projections

    E.    Process data more promptly

    F.    Support more efficient and effective business processes

    G.    Improve implementation and maintenance of internal controls

    H.    Reduce cost of maintenance and operation

    I.    Support multiple valuation bases and accounting policies

Aim H is ignored for the purposes of this thesis because it was concerned with the issue of cost. The analysis of the reported criticisms in Chapter 2 found evidence to suggest that many of these aims may already be supported by contemporary accounting systems. Only aims D and I were not contradicted by other evidence. On this basis, the following hypotheses are put forward:

$H_{crit,1}$    Users of contemporary accounting systems are able to achieve aims A, B, C, E, F and G with their present system.

$H_{crit,2}$    Users of contemporary accounting systems are not able to achieve aims D and I with their present system.

Neither aim D nor I arises from criticisms made in recent years. However, the reason why it is not expected that they have been overcome by accounting systems is because they are not considered to be important by users; that is, there is no demand for such changes by the purchasers of accounting systems. In both cases, this may be due to the fact that users do not perceive any benefits to be gained from achieving such aims or it may be because users view them as being beyond the scope of accounting systems. The former reason is considered unlikely because:

❖    achieving aim D would benefit the preparation of budgets which is a common task in organisations; and

❖    achieving aim I would benefit organisations reporting for different regulatory agencies (for example, in different countries or for tax and accounting purposes) which would apply to many (or all) organisations.

Thus, the most likely reason why aims D and I would not be supported by contemporary accounting systems is because they are not seen as being compatible with such systems. The traditional method of recording accounting data and the training of users may have engendered a presumption that the achievement of these aims is not possible. This gives rise to a third hypothesis:

$H_{crit,3}$    Users of contemporary accounting systems use other systems to achieve aims D and I, and do not consider this to be due to weaknesses in their accounting system.

## 5.2  Research Method

An investigation of Hypotheses $H_{crit,1}$, $H_{crit,2}$ and $H_{crit,3}$ involves obtaining information from users about the problems they experience with accounting systems. Such information may take a number of forms:

❖    details of actual problems with accounting systems;

❖    user perceptions of problems with accounting systems;

❖    third party perceptions of problems experienced by others with accounting systems.

None of the criticisms reported in the literature is based on documented evidence obtained from actual users (although some imply that this is their source); nor are any of the

criticisms derived from instances of specific problems with an actual system. Instead, the criticisms reported in the literature are the perceptions of third parties either based on their knowledge of actual users and systems, or on a normative view about what accounting systems should do. As a consequence the reports of criticisms generally fall within the third category. It is, therefore, possible that some of the criticisms reported are not perceived as being problems by the users of the accounting systems. This would not necessarily mean that such problems have been falsely reported, but that users may have found alternative solutions to get around the problem and hence do not consider it to be a failure of their accounting system. Similarly, users may perceive problems with their accounting systems which may not be a consequence of the accounting system but a failure of its implementation, installation or operation. Thus, identifying problems with accounting systems is not a straightforward matter and as suggested by Percival (1993) it may be easier to "just ask them".

The term "accounting system" may be interpreted by users as referring to a wide variety of information systems. For the purposes of research hypotheses $H_{crit,1}$, $H_{crit,2}$ and $H_{crit,3}$ "accounting system" is defined as being that system used to record the accounting transactions which form the basis of the organisation's financial statements. Typically this system would also be used for preparing other reports but, to limit the review to a single system, the financial statements have been taken as the primary form of report derived from the accounting system and thereby used as the means of identifying this system.

In conducting this research another difficulty to overcome is that of identifying which problems are caused by the design of the accounting data model rather than the system's implementation, installation or operation. Each type of problem would be of interest to organisations, but this research is only concerned with those which are related to the quality of the underlying data model. Most computer-based systems today are too complex for users to have a good technical understanding of their operation. Thus, it is considered unlikely that users would be able to reliably identify the cause of any problems they report. This judgment would require a good understanding of the nature of the problem and the design of the accounting system being used. Obtaining evidence about problems with accounting systems is, therefore, considered to be a task which is most suited to a case study research method.

When seeking to identify the nature of problems with accounting systems, it is also possible that users themselves may not be aware of all the problems associated with their accounting system. What might be termed a problem caused by the design of the accounting system may be considered by a user as a constraint or just as "the way things are (or have to be) done". As noted in the commentary on Percival (1993) by Weaver (1993), it would be wrong to assume that a practitioner has the same conceptual understanding of reality as a researcher. For example, many users of a DOS-based computer system may not have raised the inability to multitask as a problem with their machine because they were not aware of the possibility. A "naive" user might believe that a computer can only perform one task at a time and hence its failure to do so is not seen as a problem with the machine but a physical limitation. On the other hand, users of a Windows-based computer system are quite likely to complain about software which does not run in multitasking mode. Thus identifying a more complete set of problems with accounting systems (including those which users may not perceive as problems with the system) requires more than "just asking them". Once again this implies that case-based research methods are appropriate. Evidence might be sought which demonstrates the need for users to work around the accounting system in order to achieve their desired results. For example, the use of a spreadsheet to analyse figures extracted from an accounting system might imply a failure of the system to support a required function. Alternatively, it may be evidence of a poor user interface (compared with a spreadsheet).

### 5.2.1 Research Strategy

The choice of research strategy is largely determined by the following three conditions (Yin, 1994, p. 4):

❖ the type of research question posed;

❖ the degree of focus on contemporary as opposed to historical events; and

❖ the extent of control an investigator has over actual behavioural events.

$RQ_{crit}$ is concerned with identifying *what* problems exist with accounting systems. The context is contemporary and there is no need for control to be exercised over behavioural events. Evidence can be obtained from recent sets of accounting records and reports which have already been prepared, so there is no risk that the researcher has influenced the events. Based on these responses, Yin (1994) recommends a survey as an appropriate strategy for addressing $RQ_{crit}$.
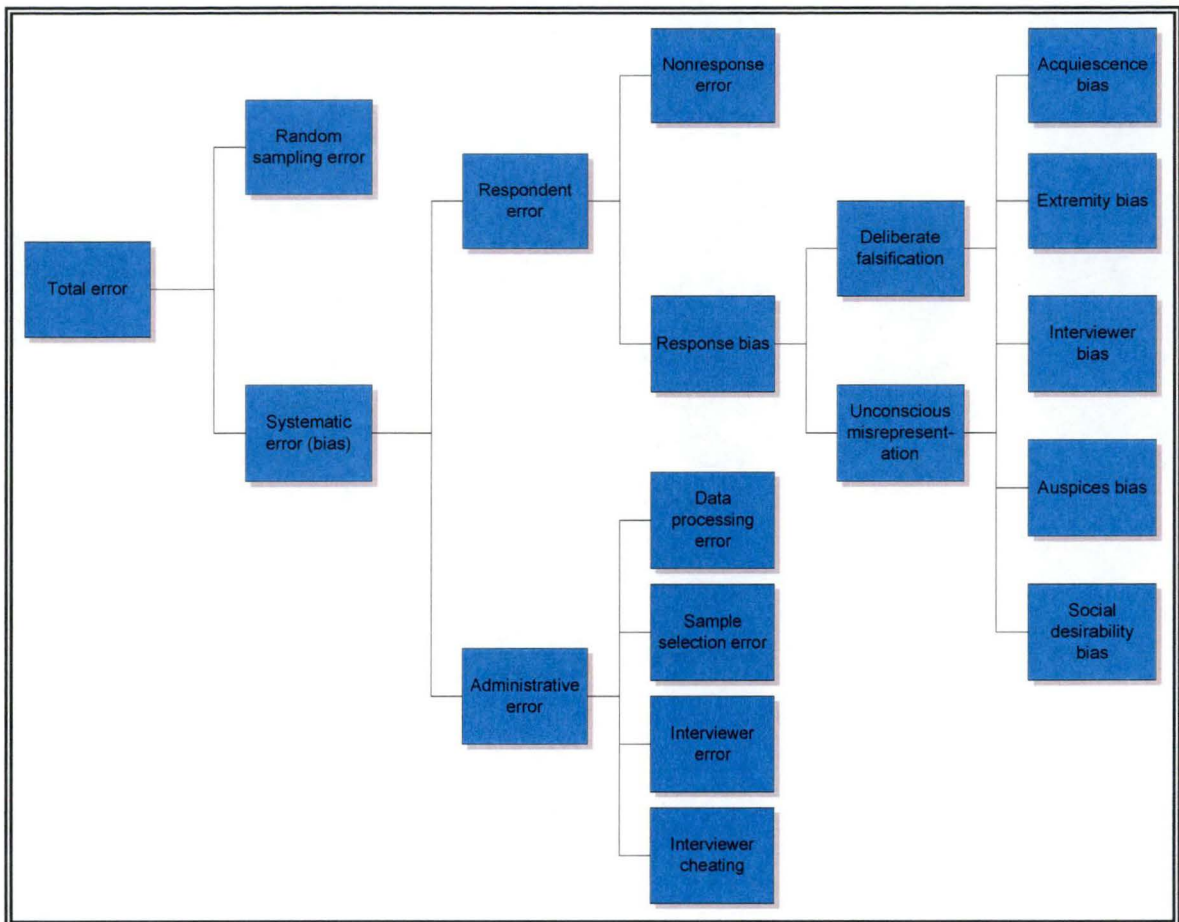
Source Zikmund (1994)

**Figure 5.1    Total Survey Error**

Since problems with accounting systems may arise for a variety of reasons and users may not be able to isolate those problems which arise as a result of the design of the data model, it is considered that in addressing $RQ_{crit}$ it would be appropriate to conduct the survey by personal interviews.  This approach has the following benefits:

❖    reduction in the misinterpretation of the questions being asked;

❖    respondent will gain a better understanding of the purpose and nature of the survey which may improve the quality of their responses;

❖    brief or unclear answers to standardised questions can be clarified at the time;

❖    increased likelihood of obtaining complete sets of responses.

The disadvantages of using personal interviews rather than some other form of survey method include:

❖    the interviewer time demanded by this approach means that a smaller sample will be used which is likely to lead to a smaller number of completed questionnaires;

❖ respondents are not anonymous (at least to the interviewer);

❖ responses may be biased by the demographic characteristics of the interviewer or the interviewing technique adopted.

When designing any survey it is important to consider the sources of potential error and seek to minimise their impact on the responses. The sources are summarised in Figure 5.1 and measures taken to minimise the risks are discussed below.

The subjects selected for interview were the Chief Financial Officer (CFO) of the sample organisations. The CFOs are in the best position to appreciate the problems and limitations of their accounting systems and the user needs that have been difficult (or not possible) to support. Where permission was granted, a substantial user of the accounting system was also interviewed to provide further evidence.

## 5.2.2 Survey Sample

Some problems with accounting systems may be specific to the industry in which the organisation operates. Since the survey method being adopted necessitates a small sample size, it was considered that all organisations should be taken from a single industry. This increases the comparability of the responses obtained and increases the likelihood of being able to generalise the findings if a subset of this sample is used to examine $RQ_{model}$. The manufacturing industry was selected for the following reasons:

❖ manufacturing is an important industry to nations for its capacity to generate wealth;

❖ it may be possible to generalise results from the manufacturing industry to the retail industry as retail is similar to manufacturing except for the absence of a conversion process between raw materials and finished goods (similarities also exist with the service sector);

❖ the most comprehensive examples using alternative accounting models involve manufacturing enterprises (see, for example, David and McCarthy 1995).

A 1997 directory of manufacturers produced by a State or Territory government within the Commonwealth of Australia was used as the source for the sample. The directory was compiled from responses to a questionnaire which was widely distributed throughout the business community in the State or Territory. The directory provides a range for the

number of employees in each organisation which was used as a proxy for size. A summary of the size of organisations in the directory is provided in Table 5.1.

| Number of Employees | Proportion of Companies |
|---|---|
| Less than 10 | 53.9% |
| 10-19 | 16.7% |
| 20-49 | 15.9% |
| 50-99 | 6.4% |
| 100-199 | 2.9% |
| 200-499 | 2.8% |
| 500-999 | 1.0% |
| 1,000 and over | 0.4% |
| *Total* | *100.0%* |

**Table 5.1    Size of Organisations in the Directory of Manufacturers**

It was considered appropriate to avoid small organisations as their accounting needs and systems are likely to be less sophisticated and less up-to-date. The smaller an operation, the more personal control can be exercised by management and the less dependence upon accounting reports. If smaller organisations have less sophisticated needs they are more likely to be well catered for by existing accounting systems and these systems are not likely to require replacement as often as for organisations with more complex needs. 13.5% of the organisations in the Directory had at least 50 employees and the sample used was selected from this subset. A sample size of 15 was chosen as being sufficient to obtain an impression of the range of problems encountered by users of accounting systems in the manufacturing industry. The organisations were not selected at random but on the basis of their willingness to participate as well as seeking to include a wide range of different types of manufacturing operation. For example, the final sample included organisations operating standard cost, job cost and process costing systems. Given the desire to conduct a personal interview with the Chief Financial Officer (CFO) and the fact that the findings to this research question are only intended to be indicative, this approach was considered appropriate and acceptable.

### 5.2.3 Questionnaire

The survey undertaken was based on personal interviews using a set of structured questions. These questions were designed to identify problems which might be related to the accounting data model. The problems reported in the literature were summarised into three goals in Chapter 4; these goals were concerned with the variety, quality and

| Summary of Question (Information Provider) | Related Goal |
|---|---|
| 1 Main users of the accounting system | |
| 2 Information not available | Variety |
| 3 | |
| 4 Change format of data before entry | Timeliness |
| 5 Duplication of data entry | Timeliness |
| 6 Change format of information produced | Timeliness |
| 7 Restructuring of system required | Quality/Timeliness |
| 8 | |
| 9 Alternative valuation bases | Variety |
| 10 Reporting dates | Timeliness |
| 11 Alternative accounting policies | Variety |
| 12 Five most important improvements | |
| 13 Other comments | |

**Table 5.2    Relationship Between Questions and Accounting System Goals**

timeliness of the information provided by the accounting system. The following shortcomings will detract from the achievement of these goals:

❖    unable to provide useful information;

❖    information provided requires further processing;

❖    data cannot be entered in their original form;

❖    data have to be entered more than once;

❖    changes in information needs or external events require significant changes to the data entry or the configuration of the accounting system.

In addition there may be constraints imposed by the accounting system which are not presently causing problems but which represent potential future problems. For example, support for multiple views of the data, in particular alternative valuation bases, accounting

policies or reporting periods. The questions prepared seek to elicit examples of these types of issues from the interviewees. The responses can then be analysed to determine whether they are consistent with any of the reported criticisms. A copy of the questionnaire can be found in Appendix A together with a slightly tailored set of questions for use with information users. The relationship between each question and the three goals of accounting systems is summarised in Table 5.2.

## 5.2.4 Minimising Survey Errors

Table 5.3 summarises the potential sources of survey error. Since the sample in this case is not large and was not randomly selected a limitation of the survey is that it may not be representative of the population. The results will be interpreted in this light. None of the organisations contacted declined to be involved in the survey and all interviews were completed in full. Thus, there can be no nonresponse bias in the survey. Deliberate falsification of responses is unlikely because personal interviews were conducted with senior personnel and responses were clarified with followup questions at the time to resolve any inconsistencies or misunderstandings. However, it is possible that respondents had no wish to admit to problems with their accounting systems as this might reflect badly on themselves or their colleague(s) who selected the system. This is likely to be most prevalent with organisations who have recently changed their accounting system. Acquiescence and extremity biases are minimised by asking open-ended forms of question; respondents had to make a statement rather than selecting an answer from a list. None of the respondents was known to the interviewer and pre-written questions were used to minimise the risk of interviewer bias. In addition the survey questions were given to three experienced accounting academics for comment and were revised on the basis of feedback given. A pretest of the questionnaires on three organisations did not suggest any further changes were needed and so these organisations were included in the final sample. Each respondent was provided with a summary of the purposes of the survey in advance and this was outlined at the beginning of the interview. It was also made clear that responses were completely confidential. These measures should minimise any auspices and social desirability biases. All the interviews were conducted personally and in all cases but one (who declined the request) tape recorded for later transcription of responses. Hence, the risk of administrative errors is minimised.

| Source of Error | Description |
|---|---|
| Random sampling error | Sample does not portray a representative cross section of the population because of chance variation. |
| Systematic error | A nonsampling error caused by an imperfect research design or a mistake in its execution. |
| Respondent error | Errors arising from the responses received from survey participants. |
| Nonresponse error | The statistical difference between a survey that includes only those who responded and a survey that also includes those who failed to respond. |
| Response bias | An error which occurs when respondents tend to answer in a certain direction. |
| Deliberate falsification | When respondents deliberately give false answers. |
| Unconscious misrepresentation | When a respondent is consciously trying to be truthful and cooperative, but provides a false response as a result of the question format or other stimulus. |
| Acquiescence bias | When a respondent has a tendency to agree with all the questions. |
| Extremity bias | When a respondent tends to use extremes when answering questions. |
| Interviewer bias | When a respondent's answers are influenced by the interviewer. |
| Auspices bias | When a respondent's answers are influenced by the organisation conducting the survey. |
| Social desirability bias | When a respondent's answers are influenced by their desire, either consciously or unconsciously, to gain prestige or to appear in a different social role. |
| Administrative error | An error caused by the improper administration or execution of a research task. |
| Data processing error | Errors that occur because of incorrect data entry, incorrect computer programming, or other error during the analysis stage. |
| Sample selection error | A procedural error caused by the improper selection of a sample. |
| Interviewer error | Errors caused by the failure of an interviewer to perform tasks correctly. |
| Interviewer cheating | The practice of filling in fake answers or falsifying interviews by interviewers. |

Source: Zikmund (1994)

**Table 5.3     Sources of Survey Error**

## 5.2.5 Survey Execution

The survey·included 15 different organisations and resulted in 22 interviews which comprises each CFO and a significant user in those organisations where access was given. Each interview was conducted by prior appointment. All respondents were sent an outline of the project in advance and this was reviewed at the beginning of each interview. The questions were asked in the sequence on the questionnaire; the examples were only given when the respondent required clarification. Interviews took 1-2 hours each. A copy of the questionnaire can be found in Appendix A. A summary of the biographical details of the interviewees is shown in Tables 5.4 to 5.8.[30]

| Years | Frequency |
|---|---|
| 30 - 39 | 12 |
| 40 - 49 | 6 |
| 50 - 59 | 4 |
|  | **22** |

**Table 5.4    Age of Interviewees**

| Years | Frequency |
|---|---|
| 5 - 9 | 4 |
| 10 - 14 | 6 |
| 15 - 19 | 5 |
| 20 and over | 7 |
|  | **22** |
| *Minimum* | *6* |
| *Maximum* | *30* |

**Table 5.5    Years of Experience of Interviewees**

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[30]   The number of years an interviewee had used their accounting system is used as a proxy for their familiarity
      with it.

| Qualification | Frequency |
|---|---|
| BBus | 5 |
| BCom | 9 |
| BEc | 3 |
| BSc | 1 |
| MBA | 1 |
| None | 3 |
|  | **22** |

**Table 5.6    Highest Tertiary Qualification of Interviewees**

| Qualification | Frequency |
|---|---|
| ACA/CPA | 13 |
| FCA/FCPA | 3 |
| ASA | 2 |
| ICSA | 1 |
| FNIA | 1 |
| None | 2 |
|  | **22** |

**Table 5.7    Highest Professional Qualification of Interviewees**

| Years | Frequency |
|---|---|
| under 5 | 7 |
| 5 - 9 | 13 |
| 10 - 14 | 1 |
| 15 - 20 | 1 |
|  | **22** |
| *Minimum* | ¼ |
| *Maximum* | *19* |

**Table 5.8    Interviewee Familiarity with Current Accounting System**

## 5.3 Analysis of Interviews

The problems identified from the interviews are discussed below under headings which relate to the aims of accounting systems based on the criticisms reported in the literature (see Chapter 2). Problems which arise from an organisation's choice not to install a particular module of its accounting system, or which could be resolved by upgrading their system, have been ignored.

### 5.3.1 Aim A: Record Data in a Raw (Objective) Form

All of the organisations visited appeared to be satisfied with the level of detail of the reports being generated from their accounting system; each transaction was maintained within the system for at least the current period. In some cases the records do not precisely reflect the underlying events. For example, a company's continuous manufacturing process had to be broken into discrete batches for recording purposes.

### 5.3.2 Aim B: Capture Both Financial and Non-Financial Events

The largest problem with capturing data about business events did not appear to be the accounting systems but the data collection methods. One organisation was investigating an electronic clock card system for employees, but was presently collecting this data manually and only entering summaries into the system. Another organisation had a sequence of manufacturing processes for which it was not practical to measure the quantity of product being transferred from one process to the next. Hence the analysis of the operations in this case was hindered by a lack of data caused by physical constraints and not the ability of the accounting system. Some organisations noted that it was difficult to predict in advance the information needs and ensure that the appropriate data are recorded. For example, information required by the Australian Bureau of Statistics is not known before the beginning of the reporting period. One company's parent requested an analysis of freight by mode of transport which required some manual analysis of invoices.

In some cases organisations considered it easier to use a spreadsheet to combine financial and non-financial data; for example, performance reports based on machine and labour hours.

### 5.3.3 Aim C: Multi-Dimensional Record of Events

The accounting systems in use were able to record multiple attributes (financial and non-financial) about transactions. Inventory systems maintain many details about items held and both the value and quantity of purchases and sales are recorded. Generally the coding structure permitted by accounting systems allowed different elements to be defined to represent different attributes of a transaction. Whilst this provided some flexibility it was not without its limitations; for example, the comments made by interviewees included the following:

❖ it is too complicated to change the coding scheme during a financial year;

❖ the same coding scheme is applied to all transactions but some components of the code may not apply to all types of transaction;

❖ codes tend to be long and some combinations are meaningless and need to be prohibited by the system.

These limitations were most apparent in relation to expense items which needed to be classified for different purposes. For example:

❖ to identify fixed and variable costs;

❖ to distinguish between claimable and non-claimable expenses in relation to one or more tax or other rebate schemes (such as fringe benefits tax, research and development, and bounty);

❖ to separate inventory and non-inventory purchases.

In addition, because the classification is being performed through the coding scheme, the introduction of new values for a component necessitates the creation of new sets of accounts in which to record transactions with these values. One organisation also complained of having to comply with a single coding scheme applied across all companies within the group.

Examples of cases in which details of transactions were recorded separately include:

❖ the rationale behind, and person requesting, expense allocations and other types of journal;

❖ transactions relating to holdings of foreign currency recorded in terms of that currency.

### 5.3.4 Aim D: Encompass Past Events and Future Projections

The organisations visited all used spreadsheets for the basis of their budgets. In some cases these budget figures were transferred to the accounting system for reporting comparisons, and in others the actuals were transferred to the spreadsheet from which reports were generated. There was no evidence of any integration of these two sets of data. Most organisations were operating sales and purchase order systems but these only captured the orders after they had been placed and hence were not concerned with projections.

### 5.3.5 Aim E: Process Data More Promptly

One of the main reasons behind the aim of processing transactions more promptly is so that reports can be generated on a more timely basis. The organisations visited were generally satisfied with the number of days needed after the end of the period before which financial statements could be finalised. The comment that the number of days had been significantly reduced over recent years was typical. However, it was still the case in each organisation that financial statements could not be prepared until period-end adjustments had been posted. This has two main effects:

- ❖ financial statements are not available on demand;
- ❖ the dates on which financial statements are prepared are regular and preset.

The adjustments include items such as:

- ❖ depreciation;
- ❖ prepayments and accruals;
- ❖ foreign currency gains/losses;
- ❖ profit attributable to the period for long-term contracts on the basis of percentage completions;
- ❖ reconciliations with systems which are not integrated with the accounting system;
- ❖ allocations of overheads and labour;
- ❖ effects of stocktakes performed to calculate material usages;
- ❖ levels of excise tax (fixed amount per unit sold).

The adjustments are necessary because the accounting systems do not understand the true nature of these types of transaction, or they are not recorded until after they have taken place but have an impact on the financial statements prior to this date. Although all of the

organisations had a regular (normally monthly) reporting cycle, there were a number of examples of instances when financial statements were required at other dates:

❖ joint owners with different year-ends;

❖ year-end dates for reporting in different countries may differ;

❖ a date other than the accounting year-end may be used when preparing reports for some regulatory agencies (for example, tax and payroll/FBT);

❖ a 52 week year may be used for some purposes and a calendar year for others.

In each of these examples, the accounting system was only used to prepare financial statements for a single set of dates and were adjusted manually for other dates.

One organisation also commented on the need for some flexibility over reporting dates in order to prepare comparable figures for prior years; for example, so that Easter is included in the appropriate comparative figures when trade is highly seasonal. Two other organisations commented on the need to prepare financial statements at other times for reasons of capital raising and the sale of the business. The end-of-period adjustment process reduces the promptness with which financial statements can be prepared, especially at ad hoc dates.

### 5.3.6 Aim F: Support More Efficient and Effective Business Processes

All of the organisations found their accounting system adequate for the preparation of financial statements. One organisation had implemented an enterprise resource planning (ERP) system to model more closely its business processes. The more complex the manufacturing processes (and required reports) the more sophisticated the accounting system which was required. At least for the organisations included in the sample, the accounting systems available commercially were capable of producing reports relating to their business activities. The limitations of these systems arise in relation to the flexibility with which such reports are produced as noted under the comments for the other aims. In addition, the degree to which the accounting system can model an organisation's business processes is dependent upon the ability to capture all of the required data. Some problems in this area were highlighted under Aim B above.

### 5.3.7 Aim G: Improve Implementation and Maintenance of Internal Controls

Very few instances of internal control problems arose from the interviews. All of the organisations used computer-based accounting systems which implemented some control over data entry. In fact, these systems may provide too much control; one organisation complained about the inability to change a transaction once it had been posted, even to correct its narration or reference.

### 5.3.8 Aim I: Support Multiple Valuation Bases and Accounting Policies

Although this aim was not commonly expressed as a problem by interviewees, there were numerous examples of cases where the lack of support for multiple valuation bases and accounting policies gave rise to additional work on the part of the information providers. For example, internal and external reports may be based on different valuation bases:

* ❖ production valued at standard cost for internal purposes but actual cost for external purposes;
* ❖ insurance valuations of non-current assets are based on market values rather than cost;
* ❖ taxation rules for valuing non-current assets differ from accounting rules;
* ❖ some non-current assets may be periodically revalued for accounting purposes;
* ❖ asset values may need to be reviewed to ensure that their net realisable value is not lower than their cost.

There were also instances where reports adopting different accounting policies were required:

* ❖ some organisations had to report under the rules imposed by different countries (for example, when joint-venture owners are from different countries or for foreign parent companies);
* ❖ recognition rules may vary according to the user (for example, sales may be recognised on shipment to the market or only after sale at the market);
* ❖ the capitalisation rules used to recognise non-current assets may vary for accounting and tax purposes.

The accounting systems of the organisations visited were only able to maintain records for a single valuation basis and set of accounting policies, although some were able to generate reports which restated non-current asset values for tax purposes. In general, the

required adjustments were performed outside the accounting system, either by hand or in a spreadsheet.

## 5.4 Support for Hypotheses

In general, all of the interviewees were satisfied with their accounting system. The problems discussed above were elicited from the interviews undertaken, but most arose from descriptions of their accounting process rather than being presented as problems. This was not unexpected. All of the accounting systems being used (including the ERP system) were based on double-entry principles. Since such systems are designed to maintain a single view of an organisation's financial transactions, their failure to support demands for multiple views would be construed by their users as a limitation of accounting rather than as a problem with the system. This is consistent with the responses obtained during the interviews.

To a large extent the interviews undertaken provide support for $H_{crit,1}$. The accounting systems in use by the organisations visited:

- ❖ retained details of the transactions recorded (Aim A);
- ❖ incorporated both financial and non-financial transactions (Aim B);
- ❖ recorded multiple attributes about each transaction (Aim C);
- ❖ enabled monthly reports to be prepared in a timely manner (Aim E);
- ❖ provided support for business processes (Aim F);
- ❖ supported the implementation of internal controls (Aim G).

However, some weaknesses in these areas were detected. It is possible that the flexibility with which accounting systems provide support for recording multiple attributes could be improved; for example, the coding schemes permitted can be difficult to change once implemented. Similarly, although the timeliness of reports had improved over recent years and was considered satisfactory, it remains the case that the accounting systems operate around regular, pre-determined reporting periods. Numerous examples were identified of situations in which financial statements at other dates were required for which a relaxation of this constraint would have been useful.

From the extensive literature on ERP systems (see, for example, Davenport 2000 and O'Leary 2000) and the limited sample used in this research there is evidence to suggest

that the more sophisticated and expensive accounting systems are better able to support an organisation's business processes. Those organisations with more complex manufacturing processes and wanting detailed management reports invested in more sophisticated packages (such as ERP systems) to support their needs; other organisations found simpler, cheaper accounting systems to be adequate for their needs. If anything it was problems related to data collection (for example, the practicality and cost) rather than the accounting system which seemed more critical. Some instances were found of accounting-related data being collected and processed using a spreadsheet. To some extent this represents a weakness on the part of their accounting system, but several of the organisations used spreadsheets for the formatting of their reporting packages in which case entering the data into the accounting system would have been unnecessary.

The evidence collected also suggests support for $H_{crit,2}$. Budgets and actuals could not be prepared from the same system: spreadsheets were generally used for preparing budgets with accounting systems only used to record past transactions (apart from end-of-period accruals which are subsequently reversed). Similarly, the accounting systems were only able to prepare financial statements on the basis of a single set of accounting policies, yet numerous examples were found which required the application of alternative accounting policies; for example, reporting requirements in different countries and reports for different regulatory agencies. Less demand was found for the support of alternative valuation bases (for example, none of the organisations prepared financial statements on a current cost basis) but several modifications to a strict historic cost basis were implemented manually; for example, to implement the "lower of cost or net realisable value" rule and the periodic revaluation of some non-current assets.

The organisations visited took the manual adjustment of financial statements for different accounting policies as a normal course of events and did not raise the issue as a problem with their accounting system. This is attributed to their training in the principles of double-entry which represents a method that only maintains a single view. It is also true that such adjustments normally only need to be made once a year and so the importance of this limitation of the accounting system is reduced. On the other hand, two organisations commented on a desire to have a much closer relationship between their budgeting system and their accounting system which records their actuals. Thus, it could be concluded that $H_{crit,3}$ is only supported for aim I and not for aim D.

## 5.5  Summary

It is important to remember that the hypotheses based on $RQ_{crit}$ were only tested on a small sample of organisations which were not randomly selected and so the evidence collected must be interpreted in this light. This preliminary research question sought only to gather an indicative impression of the problems with accounting systems in relation to the criticisms reported in the literature. However, even from this sample, it is clear that many of the criticisms made of accounting systems do not fully apply to contemporary systems. The range of data which accounting systems can record and the detail being retained is far greater than is implied by many of the criticisms which have been made. Future reports of criticisms would be more useful if greater detail were provided so that the precise nature and cause of the problem could be identified.

The main *limitations* found to remain related to aims D and I: the integration of data relating to past and future transactions, and the support for multiple valuation bases and accounting policies. They have been described as limitations because they were not raised as problems (or criticisms) by the users interviewed. This is considered to be a matter for education so that users are made aware that there are alternatives to the existing way of recording accounting transactions (based on double-entry principles) which may provide greater benefits (in a similar way that upgrading an operating system from MS-DOS to Windows allows computer users to become more productive).

Although many of the criticisms of accounting systems appear to have been addressed by contemporary accounting systems, it is not clear that the solutions adopted could not be improved upon. There is a limit to the imaginative ways in which a coding scheme can be used to allow the information required to be provided. One organisation incorporated production data valued at standard cost within the accounting system by using a special group of account codes which balanced to zero so as not to affect other reports. Similarly many of the end-of-period adjustments represent aspects of transaction types which cannot be fully modelled by the accounting system. For example, continuous events (such as depreciation) have to be divided into a set of discrete events for accounting purposes. Accounting systems fail to make other time-related judgments such that, for example, adjustments must be made manually to separate liabilities between current and non-current

at each reporting date. Group consolidations are also too complicated for many accounting systems and those being undertaken by the organisations visited were performed using a spreadsheet. Thus, there is further evidence that accounting systems fail to recognise the full nature of the transactions being recorded (including the relationships with other transactions) and, as a consequence, are unable to directly support all of the information needs of users.

The evidence gathered in response to addressing $RQ_{crit}$, therefore, provides indicative support for at least some of criticisms of accounting systems. This evidence provides support for investigating $RQ_{model}$ in an attempt to design a new accounting data model which is able to overcome the unresolved criticisms as synthesised into the following goals of an accounting system:

❖ integration of data relating to both past and future transactions;

❖ provide support for multiple valuation bases and accounting policies;

❖ fuller recognition of the nature of transactions.

# Modelling Contemporary Accounting Data

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The analysis of criticisms reported in the literature concerning accounting systems (see Chapter 2) and the lack of adoption in practice of proposals for alternative accounting data models (see Chapter 3) led to the formation of $RQ_{model}$ in Chapter 4. $RQ_{model}$ seeks to investigate the need for a new accounting data model to overcome the problems with existing systems. Addressing this research question was dependent upon first finding evidence to confirm the applicability of the reported criticisms to contemporary accounting systems. This was the subject of $RQ_{crit}$ and, as discussed in Chapter 5, supported the decision to address $RQ_{model}$.

This chapter sets out the hypotheses derived from $RQ_{model}$ in Section 6.1 and then outlines the research method adopted to test them in Section 6.2. This method involved developing models for three organisations. The models are described in sections 6.3, 6.4 and 6.5. The final summary in Section 6.6 provides a link between the models derived and the process of designing a new accounting data model which is the subject of Chapter 7.

## 6.1 Development of Hypotheses

Chapter 4 argued in favour of the need to address the following research question:

$RQ_{model}$      Can the criticisms of existing accounting systems be overcome by making changes to the design of the underlying accounting data model?

This need was supported by the findings in relation to $RQ_{crit}$ as discussed in Chapter 5.

Proposals for new accounting data models have been made before (see Chapter 3). However, a major limitation of these proposals has been that they were not developed on the basis of data from actual organisations, nor have they been validated using actual accounting data. It is likely that this is a contributing factor to the reasons why none has been adopted in practice. The development of new models on the basis of simple, example data do not provide sufficient evidence to demonstrate their ability to overcome criticisms of contemporary accounting systems whilst continuing to support users' needs in practice. As an analogy, a bicycle may be quite adequate as a means of transport around the vicinity of a relatively flat locale. However, if the means of transport is required to be used in a more complex environment (for example, one with hills, longer distances or poor quality roads) or is required to undertake more complex tasks (for example, transporting passengers or carrying luggage) then the design of the bicycle may prove to be inadequate. In addressing $RQ_{model}$, therefore, this research will consider the needs of actual organisations in an attempt to avoid this limitation.

The main criticisms of accounting systems which are to be addressed by $RQ_{model}$ are those identified in Chapter 5 following the investigation of $RQ_{crit}$. This investigation found that many of the criticisms had, at least in part, been overcome by contemporary accounting systems. The issues of concern which remain relate to:

❖ the integration of data relating to past and future transactions;

❖ providing support for multiple valuation bases and accounting policies;

❖ a more complete recognition of the nature of the transactions being recorded.

The benefits to be gained from a new accounting data model which overcomes these concerns include:

❖ closer links between data representing budgets and actuals;

❖ the ability to offer users a choice of valuation basis and accounting policies;

❖ a reduction in the number of adjustments required before financial statements can be prepared.

With regard to the last benefit above, if the accounting data model was able to fully reflect the nature of all the transactions relevant to the contents of financial statements, then it may also be possible to remove the need for any reporting adjustments, and thereby enable reporting on-demand which has been the subject of recent debate (for example, see Elliott 1995; Sutton 2000).

The main hypothesis in relation to $RQ_{model}$ is as follows:

$H_{model}$　An accounting data model can be designed which is capable of recording accounting transactions (including projected transactions) such that users can choose the valuation basis and accounting policies to be applied as well as the timing of reports.

This hypothesis is separated into three parts for the purposes of testing:

$H_{model,1}$　An accounting data model can be designed which integrates past and projected accounting transactions.

$H_{model,2}$　An accounting data model can be designed which records accounting transactions independently of the valuation basis and accounting policies selected for reporting.

$H_{model,3}$　An accounting data model can be designed which would support reporting on-demand.

## 6.2　Research Method

Whilst $RQ_{crit}$ was concerned with identifying *what* problems exist with accounting systems (see Chapter 5), $RQ_{model}$ seeks to determine *how* these problems might be resolved. In both cases, the context is contemporary and there is no need for control to be exercised over behavioural events as evidence can be obtained from accounting records and reports which already exist. Thus, based on Yin (1994), an appropriate strategy would be a *case study* for testing the hypotheses derived from $RQ_{model}$.

### 6.2.1　Research Strategy

March and Smith (1995) suggest that appropriate criteria for evaluating models are:

❖　fidelity with real world phenomena;

❖　completeness;

❖　level of detail;

❖　robustness;

❖　internal consistency.

Evaluations based on each of these criteria would be strengthened if the model was based on data collected from actual organisations. This puts further weight behind the selection of a case study approach.

A consideration of all the data recorded and information produced within an organisation would extend this research into areas which are beyond its scope. A positive view of the information needs of users is adopted rather than attempting to determine a normative perspective of what information users *should* be demanding. This does lead to the potential flaw that the model designed may only be suitable for supporting existing information needs but this danger is minimised by:

❖ focussing on financial statements which represent an information need common to all organisations and one which is unlikely to disappear in the short term;

❖ focussing on the data requirements of financial statements as the basis of the design for a new accounting data model and not the information content of these reports.

In this way it is expected that the model of the data being recorded by organisations should also be in a form suitable for supporting other information needs, albeit there may be additional data items which need to be added to the model to fully accommodate such needs.

For each case study, the transactions recorded by the organisation having an impact on the content of the financial statements (including data recorded outside of the accounting system) need to be identified. Accounting systems have a set of pre-defined, standard transaction types with their own data entry screens; for example, sale and purchase orders, and sale and purchase invoices. Transactions which do not fit into one of the pre-defined types are recorded using journal entries. Thus, to gather the data necessary to draw up a model of an organisation's accounting transactions, it is only necessary to analyse the standard transaction types used by the organisation and the journal entries processed. It is not necessary to analyse individual transactions for the standard types because the system will process them all in the same way. Journal entries, on the other hand, represent transactions which do not conform to any of the standard types. Each journal may represent a unique type of transaction and must, therefore, be examined individually to identify its underlying purpose so that such transactions can be modelled appropriately. Any additional data which are entered into other systems and used in the process of preparing financial statements also need to be identified.

### 6.2.2 Case Study Subjects

In order to increase the generalisability of any findings, three of the organisations included in the survey conducted to address $RQ_{crit}$ were selected as subjects for case studies to investigate $RQ_{model}$. These organisations were not selected at random. The primary selection criterion used was the willingness of the organisation to provide access to details of their accounting records. Organisations with different types of manufacturing process were sought so that a range of different structures of accounting system would be considered. The final selection included organisations operating standard costing systems and job costing. The inclusion of each organisation in the original survey sample already ensured that they were of a reasonable size (at least 50 employees).

### 6.2.3 Data Collection

The following data sources (using the most recently completed financial year) were used as the basis of the case studies:

❖ accounting system documentation;

❖ accounting transactions recorded;

❖ other working papers, including journal books;

❖ financial reports prepared;

❖ accounting personnel.

These data were used to identify the different types of transaction recorded by each organisation. The transaction instances are not relevant to the preparation of a data model; only the nature of each transaction in terms of its values and relationships with other entities. Thus, standard transaction types (such as purchases and sales) were identified first, followed by analysing journal entries for two separate months from the year being reviewed. The two months selected were the final month of the year and another month which did not fall at the end of a quarter. These two months were assumed to be representative of the typical monthly transactions as well as of end-of-year adjustments. This was confirmed by interview with the organisation's financial accountant after the analysis had been undertaken.

The details of the transactions identified were analysed to synthesise any common types (or duplicates) which may be present. Each type of transaction was modelled separately

based on its underlying purpose and its relationship with other transactions. The individual transaction models were then combined into a single accounting data model for each organisation. This process is described for each case study in Sections 6.3, 6.4 and 6.5.

### 6.2.4 Model Validation

The design of the data models was validated by conducting a further interview with the financial accountant from each organisation. These interviews were arranged by prior appointment. Each interviewee was sent a letter containing an explanation of the purpose of the interview (to confirm the fidelity and completeness of the model), a copy of the draft model and a copy of Appendix B which describes the modelling method used (ORM). An interview package was prepared consisting of a separate page for each diagram used as the basis of the model (see Sections 6.3, 6.4 and 6.5). This was used to explain the element of the model to each interviewee and ask for their views on its fidelity and completeness; space was provided for comments on errors and omissions.

After explaining each element of the model, interviewees were asked the following questions:

1.  Can you think of any of your accounting transactions which do not fit within the above elements?
2.  Are there any data used in the preparation of your financial reports which have not been included in this model?
3.  Has this model increased your understanding of the nature of the data underlying your accounting system?
4.  Can you think of any useful information which might be available from an accounting system based on this model which is not available from the existing system?

The models have been updated with any significant errors identified from this validation process. A summary of the bibliographic information collected from interviewees is presented in Table 6.1. In one case a change in personnel at the organisation meant that the model was validated with a different member of staff than the one who assisted with the original data collection. Although their experience with the organisation would be more limited, an independent view of the accounting systems is considered to add strength to the validation process.

*Age:*
        30-40 years (all)
*Highest tertiary qualification:*
        All interviewees had a business-related undergraduate degree
*Highest professional qualification:*
        All interviewees were members of the Institute of Chartered
        Accountants in Australia or CPA Australia
*Prepared financial accounting information as part of your work?*
        13 years (average)
        10 years (minimum)
*Prepared financial accounting information for your current firm?*
        8½ years (average)
        8 months (minimum)

**Table 6.1        Summary of Bibliographic Information**

These interviews provided assurance that the data models developed for each of the organisations fairly reflected the range of transactions which apply to their business activities. These models, therefore, provide a sound basis for designing an accounting data model which is capable of overcoming the limitations of existing models and of supporting the information needs of manufacturing organisations (at least in relation to the preparation of financial statements).

## 6.2.5 Data Models of Organisations

The three organisations used as case studies have been named Company A, Company B and Company C to protect their anonymity. A data model was prepared for each of the organisations using Object Role Modelling (ORM). This modelling method provides a richer and more expressive modelling scheme than entity-relationship (ER) diagrams and Unified Modelling Language (UML) class diagrams. One major reason for this is that ORM models are attribute-free (Halpin 2001, 355). Zachman comments on "ORM's incomparable ability to capture semantic intent and unambiguously express it graphically" (Halpin 2001, xiv). The data models of organisations are described in the three sections which follow.

## 6.3 Accounting Data Model for Company A

Company A manufactures building products. It is a wholly owned subsidiary which operates from multiple locations. For accounting purposes, it separates its activities between the different manufacturing plants and sales offices. Its accounting system is used to prepare a monthly reporting package containing a statement of financial position and a statement of financial performance including standard cost variances. This package also includes figures for budgeted performance but these are derived from a spreadsheet.

### 6.3.1 Transaction Types

The transactions being captured by the present accounting system for the preparation of reports can be categorised into the types listed below. Each transaction type has been allocated to a subsystem:

* ❖ *Purchases* - purchase invoices (including petty cash expenses) and payments (see section 6.3.2);

* ❖ *Inventory* - complete production batch of finished goods, transfer inventory between company locations, count stock, closing stock (see section 6.3.3);

* ❖ *Sales* - sales order, sales invoice, sales receipt, returned cheque, write-off bad debt, sales discounts, sundry sales adjustments (see section 6.3.4);

* ❖ *Payroll* - record time worked, record leave taken, payroll payments (see section 6.3.5);

* ❖ *Fixed Assets* - commission a new fixed asset, capitalise labour used to generate a fixed asset, depreciate fixed assets in use (see section 6.3.6);

* ❖ *Internal usage* - use of inventory and labour for expense or fixed asset purposes (see section 6.3.7);

* ❖ *Funds transfer* - move funds from one account to another (see section 6.3.8);

* ❖ *Other* - matching adjustments (for example, accruals and prepayments), calculation of production variances from standards, adjust previous estimates, correct miscodings, reclassify transactions, omitted transactions, reclassify balances, end-of-year transfers (see section 6.3.9).

The company's accounting system was analysed prior to the introduction of the Goods and Services Tax (GST) in Australia. Changes made since then to accommodate the GST have not been incorporated into the model. The main effects are that each transaction with a

party outside the company must have an associated GST element and a note made as to whether, or not, the amount can be reclaimed. The GST collected and paid (if reclaimable) can be treated like any other amount receivable/payable with the net balance being paid over on a regular basis.

### 6.3.2 Purchases

The accounting system is not used to record purchase orders. The first record of a purchase in the accounting system arises when a purchase invoice is received. A purchase item may be one of three types:

* *stock* (i.e. those products for which individual stock records are maintained to record movements);

* *fixed asset* (i.e. those items purchased for use within the business);

* *expense* (i.e. any items which are not itemised for inventory or asset purposes).

All purchases are related to a supplier entity; for sundry purchases (e.g. petty cash expenses) a special supplier entity may be used for which no other details are recorded.
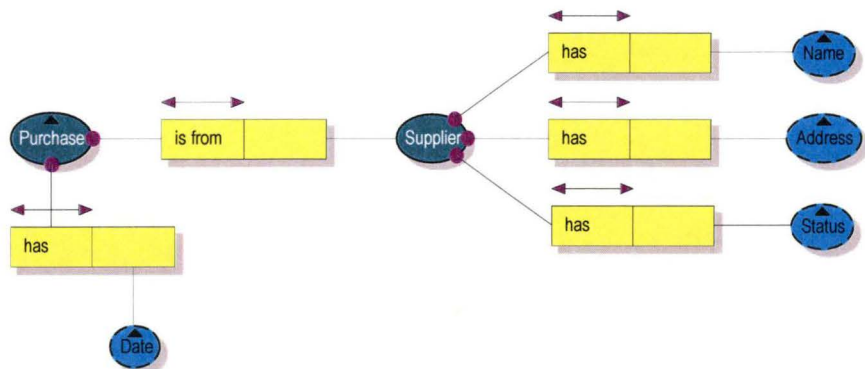


**Diagram 6.3.1   Modelling Purchases**

*Stock*

Each stock item is located in one of several warehouses operated by the company. All movements of stock, therefore, relate to a particular stock item in a particular warehouse. Thus the data model distinguishes between a stock item (the general description of an item) and a warehouse item (a stock item in a specific warehouse).
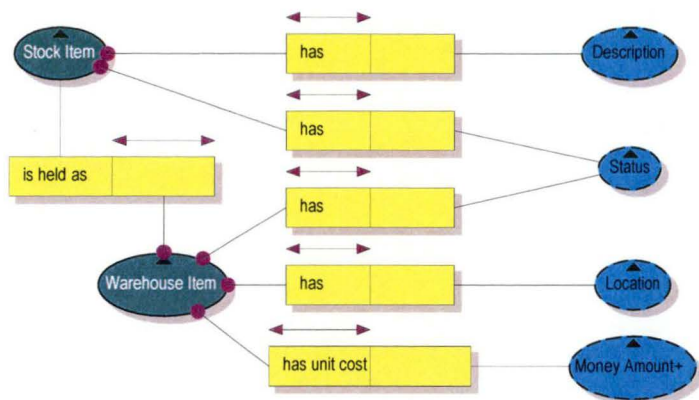
**Diagram 6.3.2    Modelling Stock Items**

A purchase may consist of a number of different stock items purchased for specific warehouse locations.
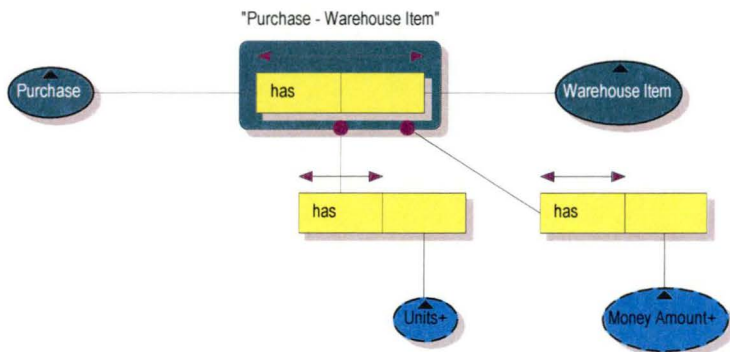


**Diagram 6.3.3    Modelling Stock Purchases**

The quantity of raw materials purchased is recorded outside the accounting system. Stock levels are only determined monthly on the basis of a physical count.

*Fixed Asset*

A purchase invoice may contain items which form a whole or part of a fixed asset (defined below) which is to be capitalised and depreciated over a period of time.
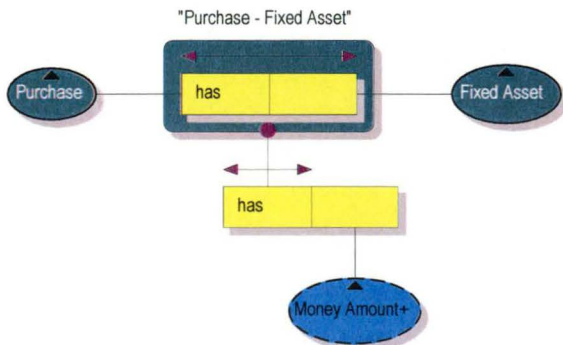


**Diagram 6.3.4    Modelling Fixed Asset Purchases**

*Expense*

The remaining purchases relate to the acquisition of items for which itemised records are not required either for inventory or asset depreciation purposes.



**Diagram 6.3.5   Modelling Expenses**

The *units* value is an optional specification of physical units relating to the expense, such as a weight or level of consumption (e.g. kWh). Specifying an account code provides a means of analysing the expenses into different categories for reporting purposes. The period to which the expense relates enables the value to be allocated (see discussion of matching below).

*Payment*

Purchases are normally paid for by electronic transfer, cheque or cash from a specific money account. This is represented by a *Payment* entity. Each payment may be for more than one purchase and each purchase may be paid for by more than one payment.



**Diagram 6.3.6   Modelling Purchase Payments**

*Intercompany Offset*

A purchase may be paid for by the parent company in which case the purchase will be associated with an *Intercompany Offset* entity rather than a *Payment* entity. The sign of the *money amount* value will identify whether the intercompany offset is an amount due to or from the parent company.



**Diagram 6.3.7   Modelling Intercompany Purchases**

### 6.3.3  Inventory

The inventory subsystem records the activities involved with those items held as inventory. This includes their usage, their movements and the reconciliation of the records with physical stock levels counted.

*Production*

Raw material inventory purchased may be used for the production of finished goods inventory. Production is recorded in daily batches. Each batch of production involves the consumption of quantities of warehouse items in order to generate quantities of other warehouse items. No attempt is made to identify the inventory consumed with specific items produced during the day's production. The number of machine cycles is also recorded as the basis for allocating overhead costs.
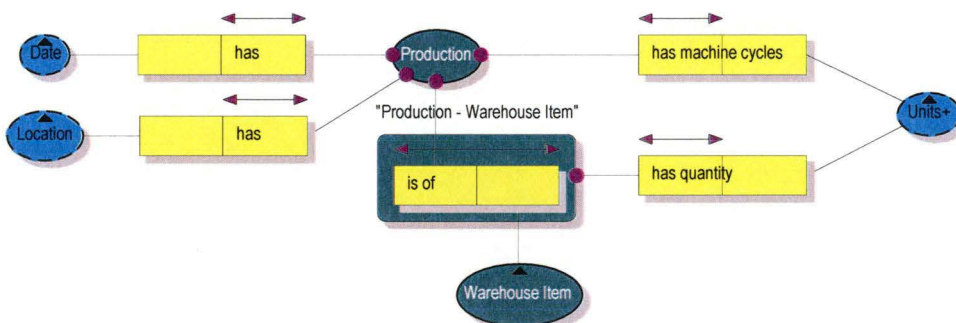


**Diagram 6.3.8   Modelling Production**

If the quantity value for a particular instance of a *Production - Warehouse Item* entity is positive, the warehouse item has been produced; if the value is negative the warehouse item has been consumed by the day's production process.

*Transfer*

It is often necessary to transfer inventory from one warehouse to another. The sign of the *units* value identifies whether the warehouse item is being transferred in or transferred out. A transfer out should normally be recorded first and a corresponding (offsetting) transfer in should exist once the transfer has been completed.
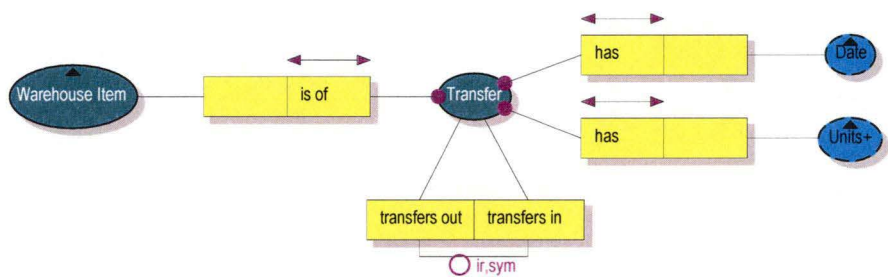


**Diagram 6.3.9   Modelling Stock Transfers**

*Stock Count*

Monthly stock checks are made to update the accounting records against the physical stock. The *units* value will record any adjustment required to bring the accounting records into alignment with the quantity counted.
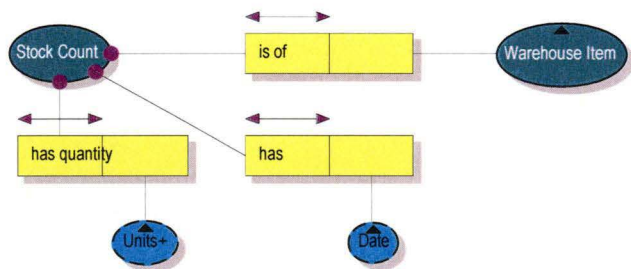


**Diagram 6.3.10  Modelling Stock Counts**

*Closing Stock*

The closing stock of each warehouse item can be calculated using a procedure and requires no additional data. The value will depend upon the quantity in stock (being calculated from the stock counts and/or the quantities purchased/produced and consumed/sold after adjusting for transfers between warehouses) and a choice of accounting policy (such as FIFO, LIFO or average cost).

### 6.3.4  Sales

The sales subsystem records the sales made to customers.  A single sale (represented by an invoice) comprises one or more sale items.  A sale item may be one of two types:

* ❖ *stock* (i.e. a warehouse item previously purchased)
* ❖ *sale charges* (i.e. charges made to customers such as hire of equipment or installation)

A customer account is created for most customers but for those purchasing items over the counter, the sale may be charged against a single 'Cash' account as no customer details are required.  A sales order can be viewed as being a sale for which no date has yet been set.
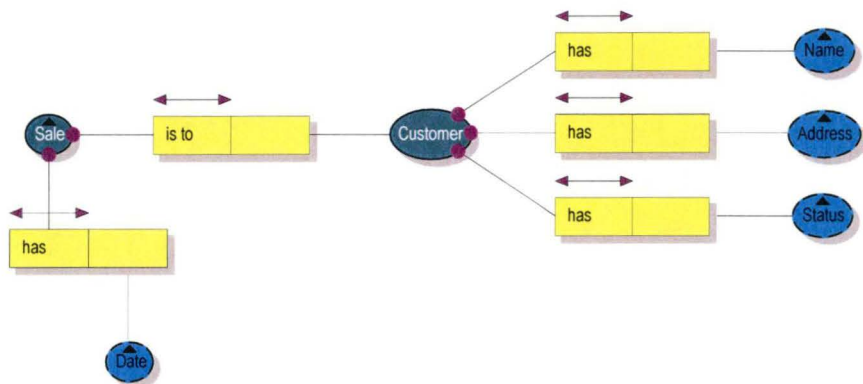


**Diagram 6.3.11  Modelling Sales**

*Stock*

The stock items sold are located in specific warehouses and hence the relationship involved is between the *Sale* and *Warehouse Item* (defined above) entities.  A sale may include more than one warehouse item, each item having a number of units and a selling price recorded.
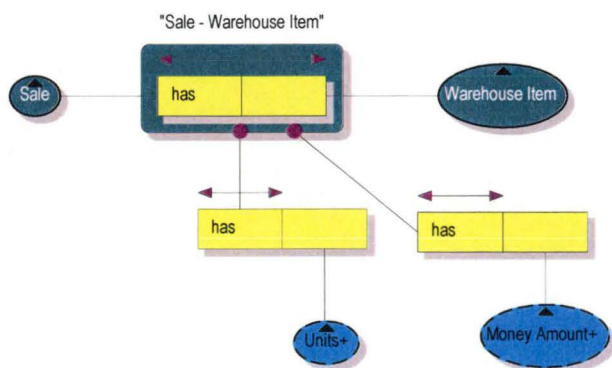


**Diagram 6.3.12  Modelling Sales of Stock**

*Sale Charges*

A sale may also include charges for the hire of equipment or pallets, or for the cost of installing the items purchased. Each charge has a description, a cost and an account code for the purposes of subsequent analysis.
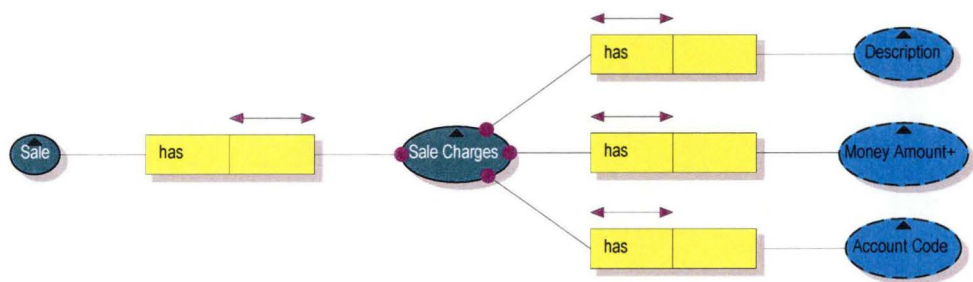


**Diagram 6.3.13 Modelling Sale Charges**

*Sales Discounts*

A sales discount can be recorded as a sales charge (see above) with an appropriate account code.

*Receipt*

Sales are normally paid for by cheque or cash which is placed in a money (bank or cash) account. Each receipt may represent payment for multiple sales.
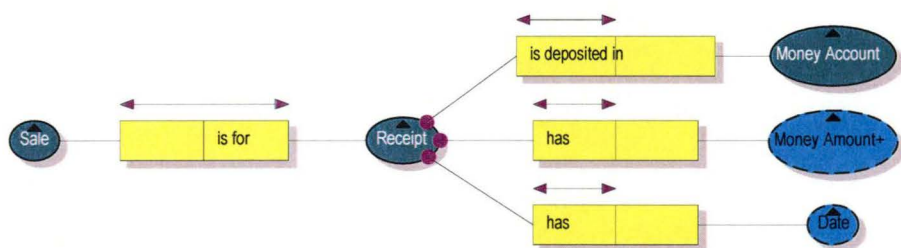


**Diagram 6.3.14 Modelling Sale Receipts**

*Returned Cheque*

A returned cheque can be recorded as a receipt with a negative money amount.

*Intercompany Offset*

A sale may be paid for by the parent company through the intercompany account. In this case the sale will be associated with an intercompany offset entity rather than a receipt entity. The sign of the *money amount* value will identify that the intercompany offset is an amount due from the parent company.



**Diagram 6.3.15 Modelling Intercompany Sales**

*Bad Debt Write-off*

When it is determined that a customer is not going to pay for a sale, then the debt is written off. In this case the sale entity will be associated with a *Bad Debt Write-off* entity to represent the amount of the sale which is being written off.



**Diagram 6.3.16 Modelling Bad Debt Write-Offs**

## 6.3.5 Fixed Assets

Some purchases will relate to items to be used within the business rather than being resold. These are normally referred to as fixed assets and, for accounting purposes, are expensed over their useful life rather than at the time of acquisition.
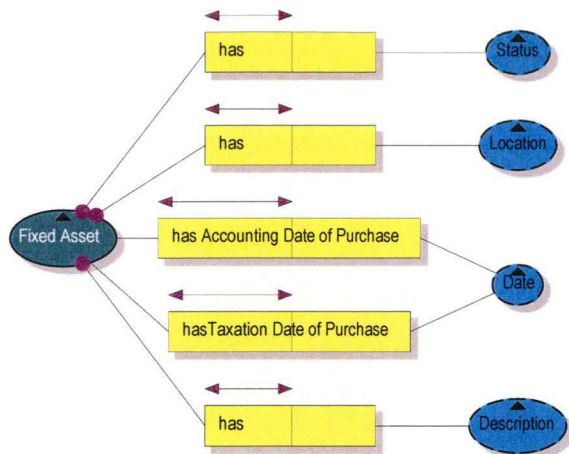
**Diagram 6.3.17 Modelling Fixed Assets**

In order to account for fixed assets, the system needs to record values which identify the accounting treatment to be adopted for accounting and taxation purposes. This is achieved by allocating each asset to a *Fixed Asset Class* and a *Depreciation Class*.
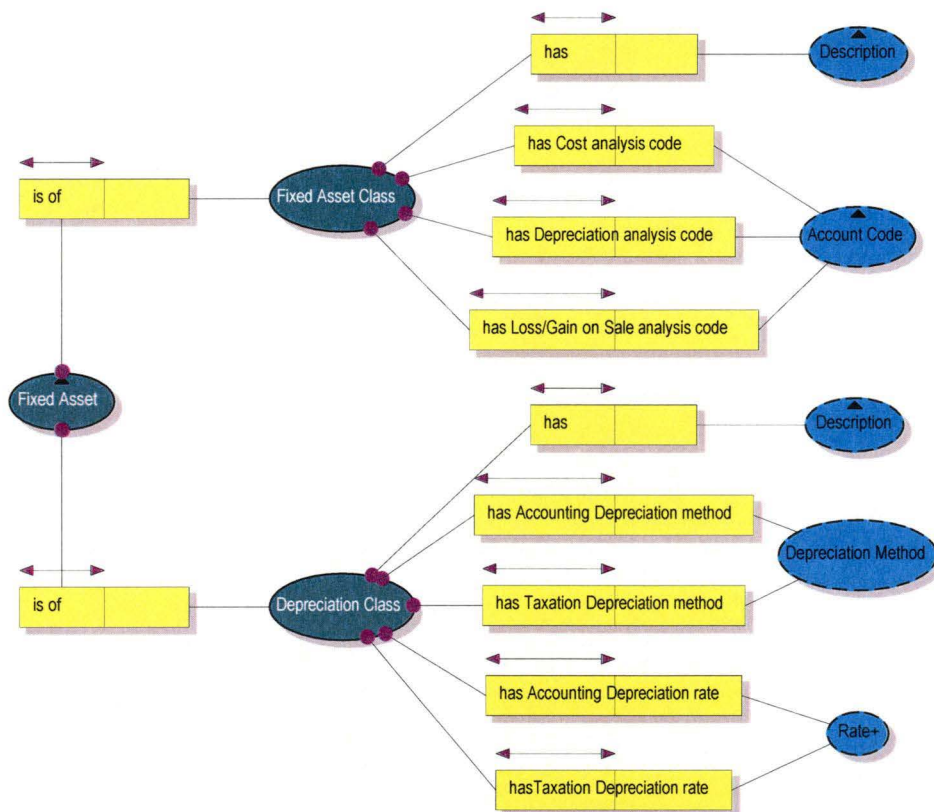


**Diagram 6.3.18 Modelling Fixed Asset Classes**

*Commission a New Fixed Asset*

A new fixed asset can be recorded as being commissioned by entering a date of purchase. A fixed asset with no date is deemed not to have been commissioned yet.

*Depreciate Fixed Assets*

Depreciation is an artificial accounting adjustment designed to allocate the cost of a fixed asset over the periods deemed to benefit from its acquisition. The data required to calculate the depreciation for any period (depreciation method and depreciation rate) are already recorded in the accounting system and so the value can be obtained by applying a procedure.

### 6.3.6 Payroll

The payroll subsystem records the time worked, leave taken and reimbursement of employees.
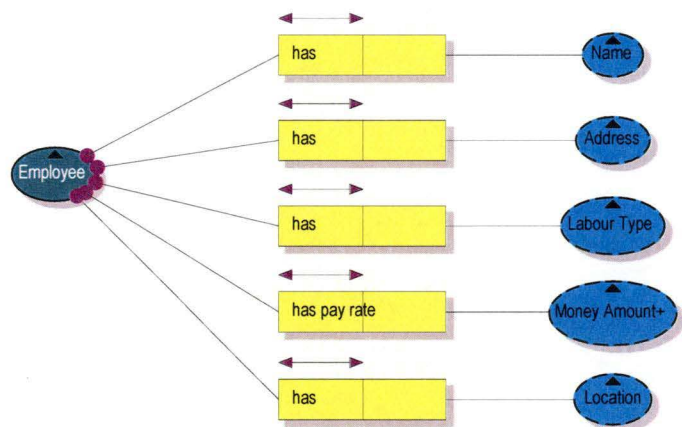


**Diagram 6.3.19 Modelling Employees**

*Time Worked and Leave Taken*

Employees are paid each period for the hours they have worked and/or for the leave (annual or long service) they have taken. On costs are not allocated on an individual employee basis, but are summarised by labour type for each periodic payroll.
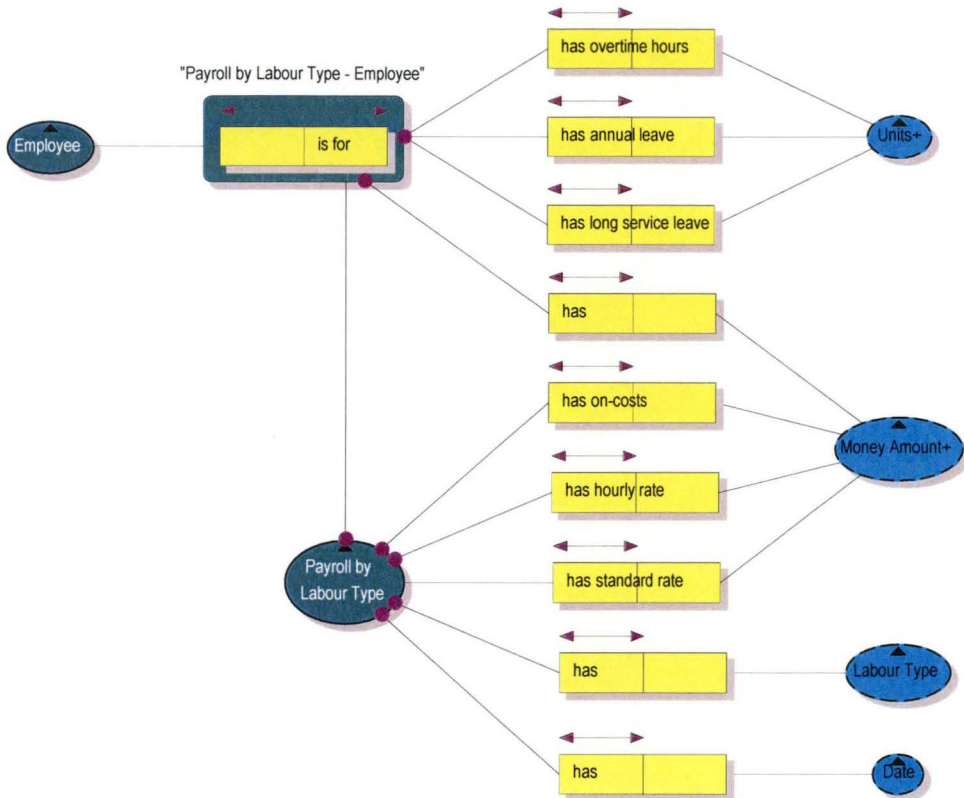
**Diagram 6.3.20 Modelling Payroll**

*Payroll Payment*

The payroll is paid by automated bank transfer, so the only accounting record required relates to the full amount of the payroll. The total net pay is paid to employees and any deductions and employer's contributions are paid to the relevant parties. The *Payment* entity is as defined above.
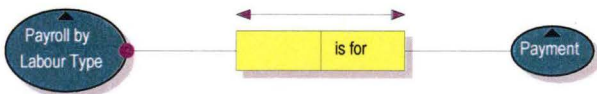


**Diagram 6.3.21 Modelling Payroll Payments**

### 6.3.7 Internal Usage

Some fixed asset costs included the use of items from inventory and employee time. The costs of such items need to be allocated to the fixed asset. Similarly, some inventory items were used for other internal activities such as marketing. The cost of these needs to be added to the appropriate category of expenses.

*Inventory*

The use of inventory in the construction of a fixed asset requires a relationship between a *Fixed Asset* entity and a *Warehouse Item* entity which has values of the date and the number of units used. Both of these entities have been defined above.

"Warehouse Item - Fixed Asset"

| Fixed Asset | is made using | Warehouse Item |

has | has

Date | Units+
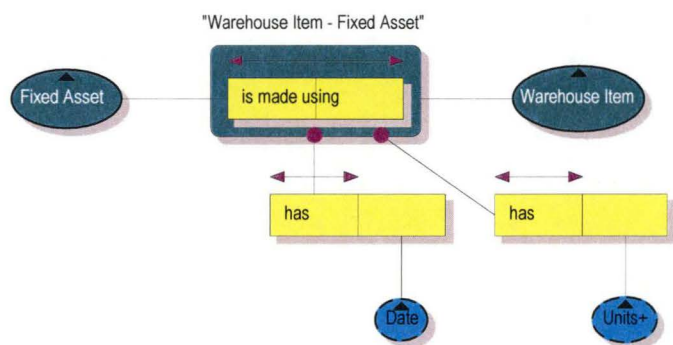
**Diagram 6.3.22 Modelling Capitalisation of Stock**

For those items used for internal expense purposes, a similar relationship can be established between a *Warehouse Item* entity and an *Expense* entity. Both of these entities have been defined above.

"Warehouse Item - Expense"

| Expense | consumes | Warehouse Item |

has | has

Date | Units+
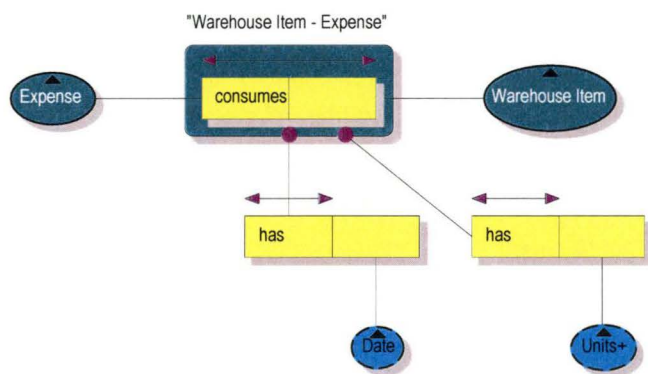
**Diagram 6.3.23 Modelling Expensing of Stock**

*Labour*

Labour time used to help construct a fixed asset is recorded using a relationship between the *Payroll by Labour Type* entity and a *Fixed Asset* entity. Both of these entities have been defined above. Note that the labour time is not attributed to a specific employee, but merely to a type of labour.

"Payroll by Labour Type - Fixed Asset"
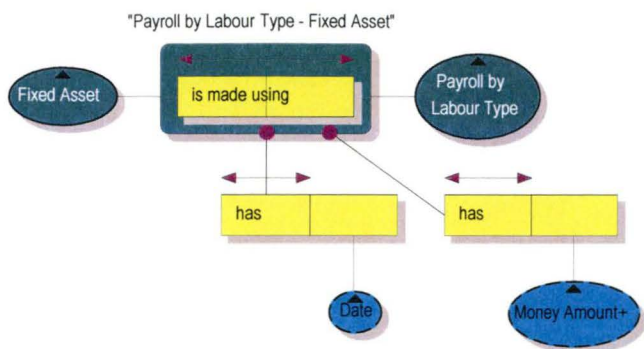


**Diagram 6.3.24 Modelling Capitalisation of Labour**

### 6.3.8 Funds Transfer

Several accounts (bank and cash) are maintained in which cash resources are held. It is
sometimes necessary to transfer funds between these accounts. This can be recorded as a
linked payment (withdrawal from one account) and receipt (deposit into another account).
The *Payment* and *Receipt* entities are defined above.
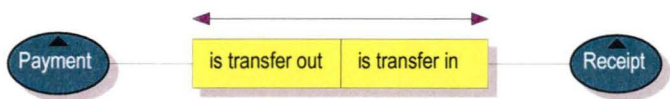


**Diagram 6.3.25 Modelling Funds Transfer**

### 6.3.9 Other

The accounting records included a number of journals for other sundry types of transaction
which are discussed below.

*Matching*

Journals at the end of each reporting period are entered to adjust the profit and loss account
for accrued and prepaid expenses. This is an accounting adjustment which seeks to
allocate expenses over the period to which they relate rather than at the time they are
incurred. This is part of the application of the matching concept. For prepaid expenses
this adjustment can be calculated from the *Expense* entities using the date values which
identify the relevant period. Since an accrual implies that the expense has not yet been
recorded, it is important to ensure that an *Expense* entity is created to record an estimate of
the expected expense. This may also necessitate the creation of other related entities (such
as a *Purchase*). These entities would be forward dated and hence clearly identified as

being future estimates. When the actual amount is known, the *money amount* value can be updated with this figure.

Another type of matching transaction recorded seeks to ensure that any *sales charges* to customers are properly matched with any corresponding expenses. For example, since most hire charges are refunded, an adjustment is made at the period end to remove any outstanding amounts from revenue (i.e. matched against the future refund). Similarly, charges for such items as installation must be matched against a sub-contractor's expense for performing this task. This requires a relationship to be established between a *Sale* entity and a *PurchaseExpense* entity.
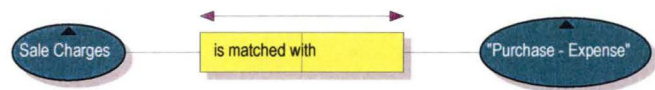


**Diagram 6.3.26 Modelling Matching**

*Standard Costing*

In order to prepare standard costing reports which show variances between the actual and standard usage of materials and labour, it is necessary to record the standard usage for each production item. Material and labour costs are not allocated to specific production runs (or batches) and so standard cost reports can only identify variances for a day's production. The standard quantities of materials used to produce other stock items can be recorded as follows:
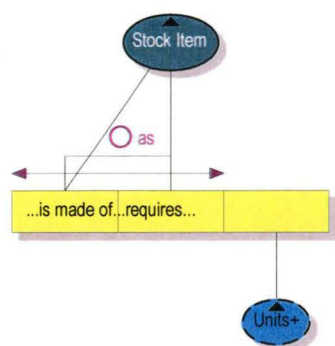


**Diagram 6.3.27 Modelling Standard Usages**

Standard costs of materials and fixed factory costs are also recorded for each warehouse item.
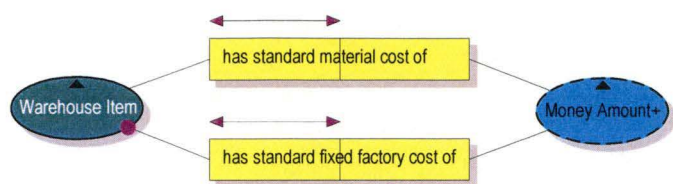
**Diagram 6.3.28 Modelling Standard Costs**

The standard costing data are required only for reporting purposes and represent estimates or targets set internally and are not based on actual transactions. It may, therefore, be considered part of a reporting system rather than part of the accounting data model as it is an "optional extra" only required if standard costing reports are to be prepared.

*Adjust Previous Estimates, Correct Miscodings and Reclassify Transactions*

These types of journal seek to update the accounting records with the effect of a change to a value previously recorded. As an alternative to recording a transaction which reflects the difference between the original record and the required record, it would be possible to directly edit the original entities and correct their values.[31] In this way no additional entities would be required unless the type of transaction changes in which case an entity may be replaced by one (or more) of another type (for example, an *Expense* entity may be replaced by a *Fixed AssetPurchase* entity).

*Omitted Transactions*

Rather than using a journal to record an omitted transaction, the transaction can be entered in the normal way just as it would have been originally had the omission not occurred. Hence there are no special requirements to handle omitted transactions.

*Reclassify Balances*

At the time of reporting some balances may be the opposite of what is normally expected. For example, the bank balance may be an overdraft. In such cases a journal is used to reclassify the balance under the appropriate section of the Balance Sheet. Since this is purely required for reporting purposes and can be encapsulated in a set of simple rules, this operation can be replaced by a procedure executed at the time of reporting.

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[31] For security purposes, this facility may be restricted to senior personnel and a log may be maintained of changes made.
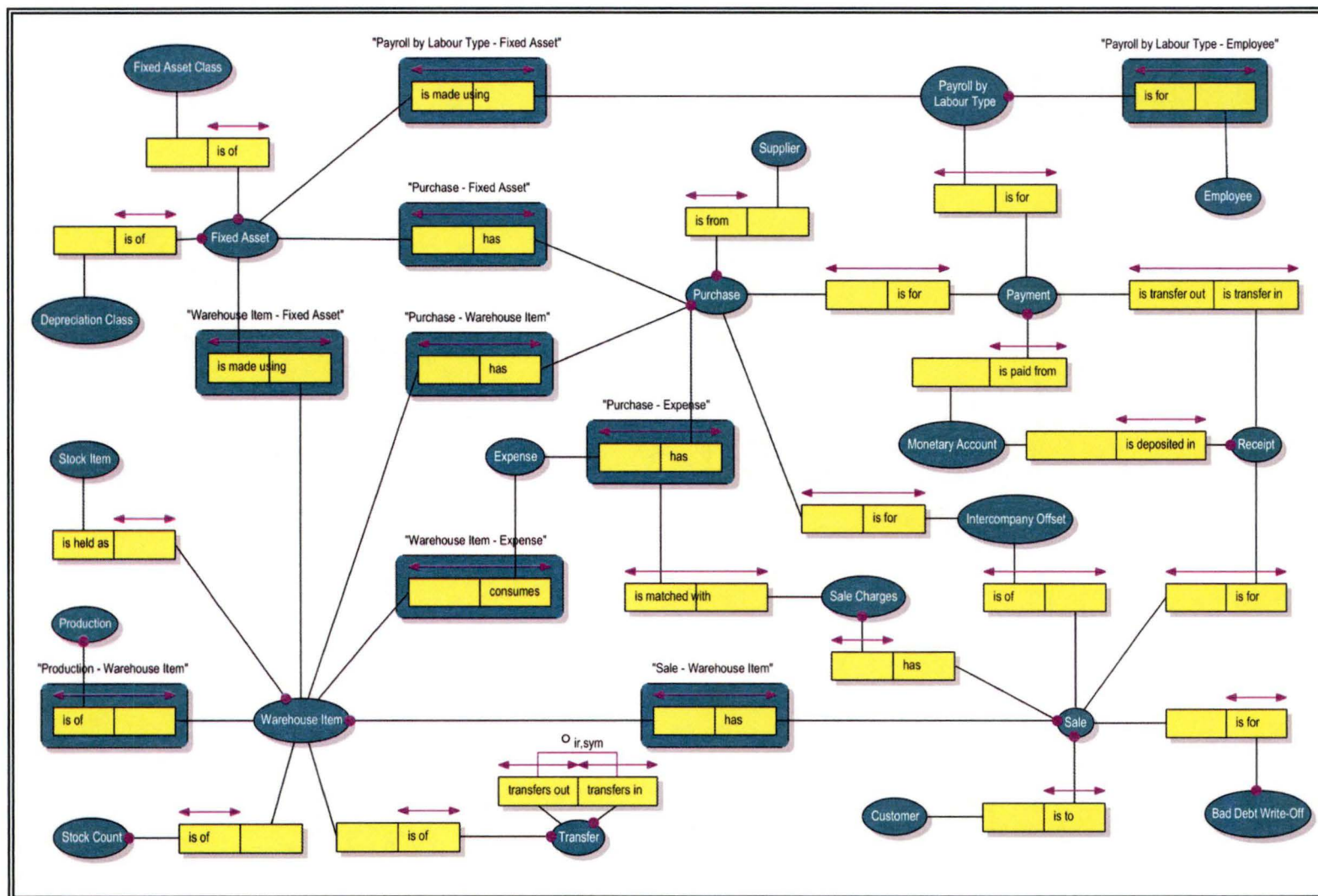
**Figure 6.1    Data Model of Accounting System for Company A**

*End-of-Year Transfers*

At the end of the year, profit and loss account balances are cleared and the profit is transferred to reserves. This is required so that the profit and loss accounts can accumulate the transaction values for the next year. Since these values can be obtained directly from the underlying transaction data when reports are required, the accumulation of balances during the year is not required and so neither are any end-of-year transfers.

### 6.3.10 Complete Model

The model extracts for each of the subsystems described above may be combined into a single data model of the company's overall accounting system. This is shown in Figure 6.1. For the sake of compactness, value objects have been omitted from this figure. In addition the standard cost data required for reporting purposes have also not been included since it is not necessary for the recording of the accounting transactions.

## 6.4 Accounting Data Model for Company B

Company B is a building company. It operates on a job-costing system, each building contract being a separate job against which the associated costs and billings are recorded. Customer requirements often change during the performance of a contract and so the system has to handle contract variations (change orders) including adjustments to the initial quotation and cost estimates.

### 6.4.1 Transaction Types

The accounting system for Company B comprises the following subsystems:

❖ job cost (see Section 6.4.2);

❖ expenditure, including payroll (see Section 6.4.3);

❖ sales (see Section 6.4.4);

❖ reporting adjustments (see Section 6.4.5).

The types of transaction recorded within these subsystems are generally straightforward: mainly direct expenses (including payroll and subcontractor costs), indirect expenses and

progress payments from customers.  The complications within the accounting system arise from the need for management information regarding the cost of each job.

Each of the subsystems is discussed separately below from which a model of the complete system is generated.

### 6.4.2  Job Cost

The job cost system tracks expenses and revenues in relation to individual contracts (or jobs).

*Jobs*
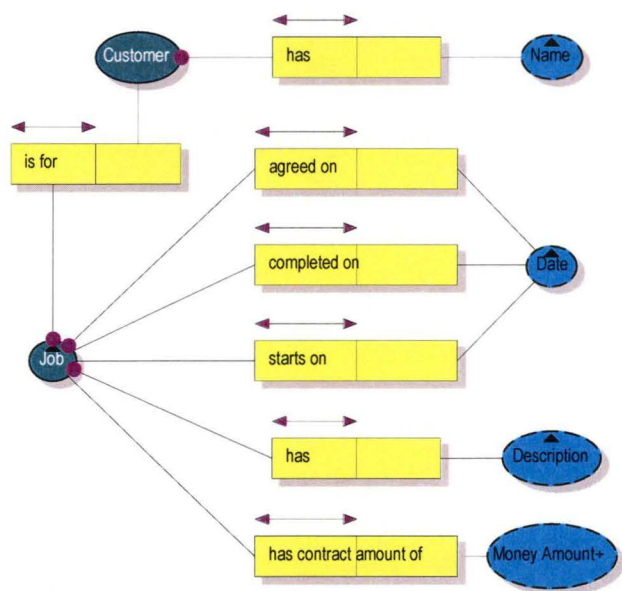


**Diagram 6.4.1   Modelling Jobs**

A *Job* comprises one or more *Phases*, with each *Phase* being divided into one or more *Categories*.  A phase is essentially a stage of the building process; phases are normally undertaken in sequence.  A category is a type of expense related to a phase.  When a job is agreed a budget is entered for each category of each phase.
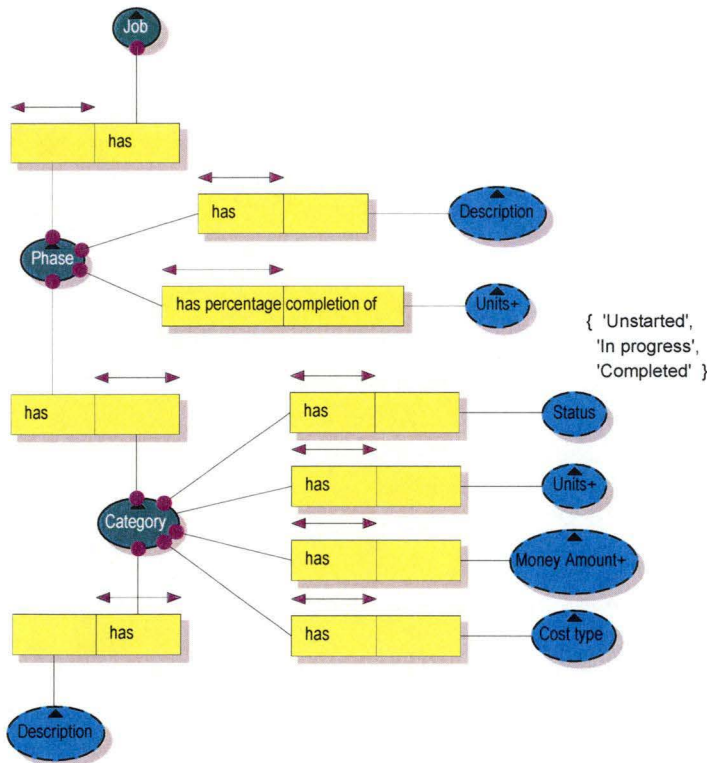
**Diagram 6.4.2    Modelling Job Phases and Categories**

The budgeted cost of a phase can be calculated by summing the values of its categories; in the same way the total budgeted cost of the contract (job) can be obtained by summing the costs of each phase.  The status of a phase is determined by the status of its categories: if all are "Unstarted" then the phase is also unstarted; if all are "Completed" then the phase is also completed; otherwise the phase status is "In progress".  The status of a job can be similarly determined from the status of its phases.

*Change Orders*

A *Change Order* arises when a change to a job is negotiated with a customer.  Each change order has one or more *Change Order Items* which record the effect of the change on the contract (job) value.  The status of the change order items would be updated as negotiations with the customer progress.
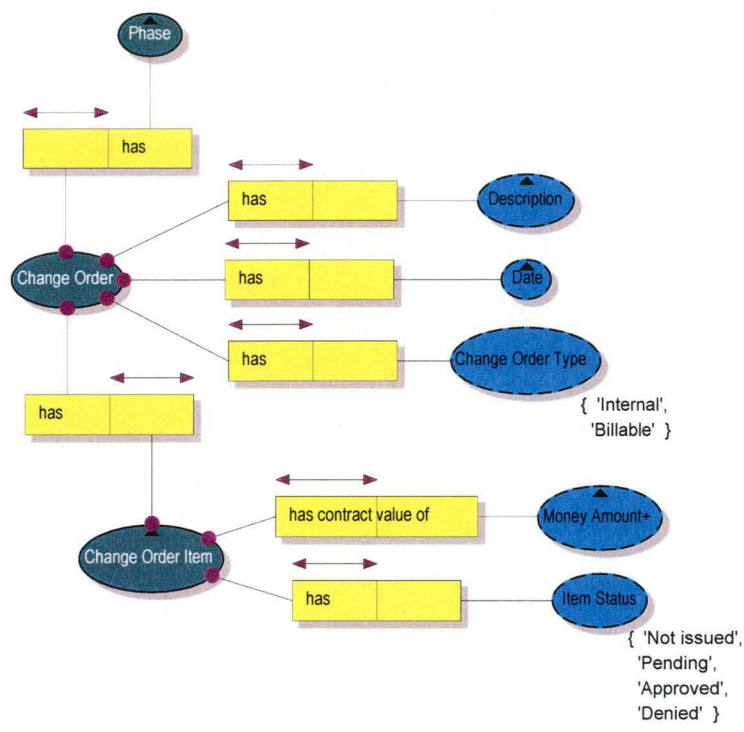
**Diagram 6.4.3    Modelling Change Orders**

Each change order item has one or more *Change Order Item Estimates* to record the adjustments to the categories affected (in both value and unit terms).
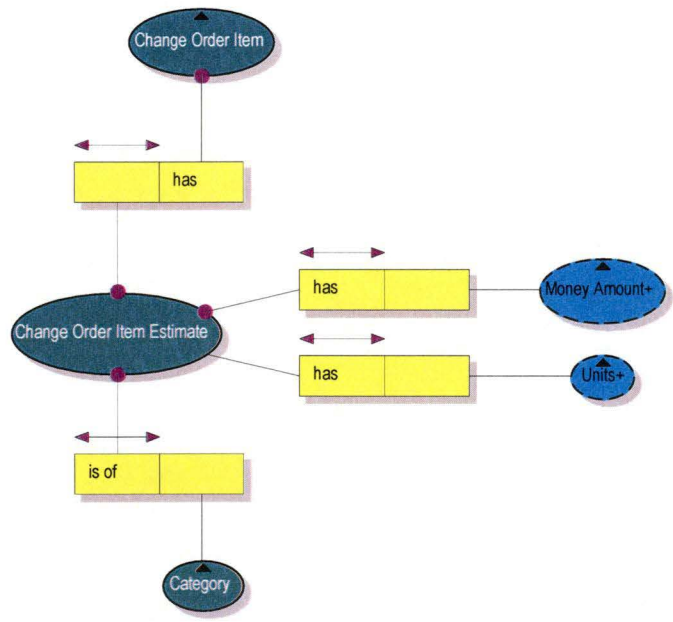


**Diagram 6.4.4    Modelling Change Order Item Estimates**

The existence of change orders means that an up-to-date contract (job) cost would be determined by increasing the value of each phase by the values of any related change order items which have "approved" status. Similarly, the latest estimated cost of a category can be obtained by including the values of any related change order item estimates.

### 6.4.3  Expenditure

Expenses may be one of three types: direct (non-payroll), indirect (non-payroll) and payroll.  Estimates of expenses may be recorded for reporting purposes, prior to knowing the actual amounts.  Commitments may also be captured by the model in the same way.
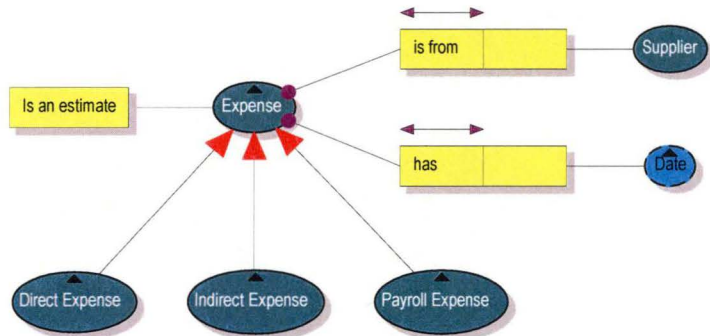


**Diagram 6.4.5   Modelling Expenses**

*Direct Expenses*

Each *Direct Expense* is incurred in relation to one or more categories of a job; its value would be attributed between each category.
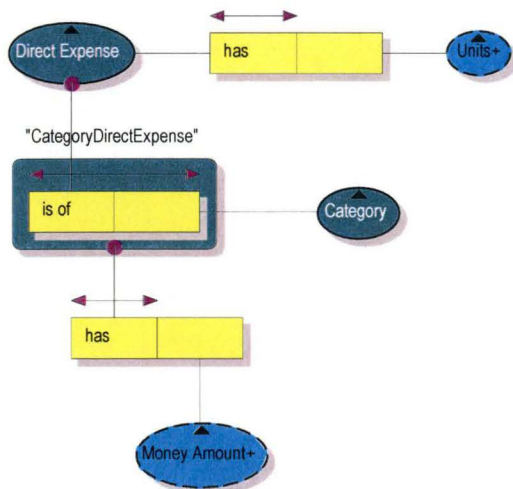


**Diagram 6.4.6   Modelling Direct Expenses**

*Indirect Expenses*

Indirect expenses are merely recorded with a cost type (e.g. general ledger code).  The total value of an expense (invoice) will be the summation of all the related *Indirect Expense* instances and *CategoryDirectExpense* instances.
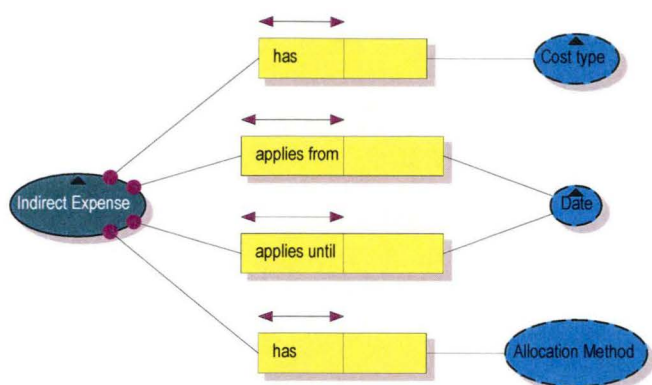
**Diagram 6.4.7    Modelling Indirect Expenses**

*Payroll Expense*

The amount of time worked by each *Employee* on each job is recorded on a weekly basis. This provides evidence of the number of hours incurred by each job (which acts as a basis for charging) as well as supporting the payroll calculations. The amount of leave (annual or long service) taken by each employee would also be recorded on a periodic basis so that entitlements can be updated and to perform a complete payroll calculation. Such hours are not attributable to a job. At the end of each pay period the chargeable and non-chargeable time recorded for each employee is used to calculate and record the payroll deductions.
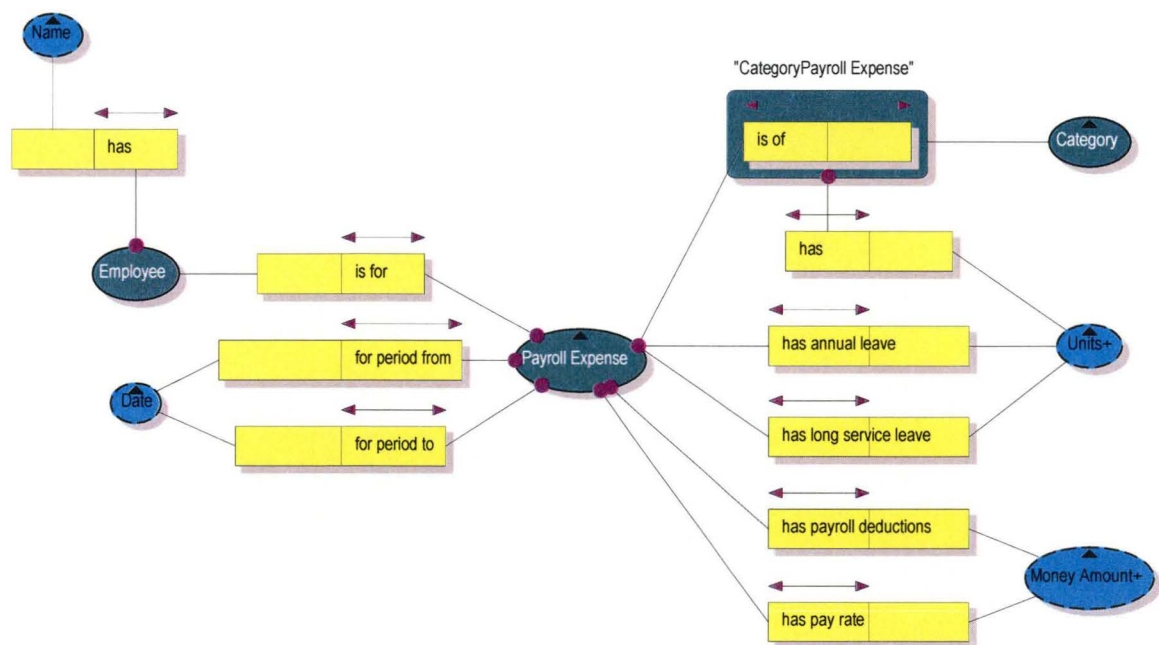


**Diagram 6.4.8    Modelling Payroll Expenses**

The direct labour hours are used as the basis for allocating overheads to jobs and thereby calculating the margin earned (see below).

*Payments*

Payments of expenses would be made from a bank account and may comprise multiple expense instances in each payment for any one supplier.
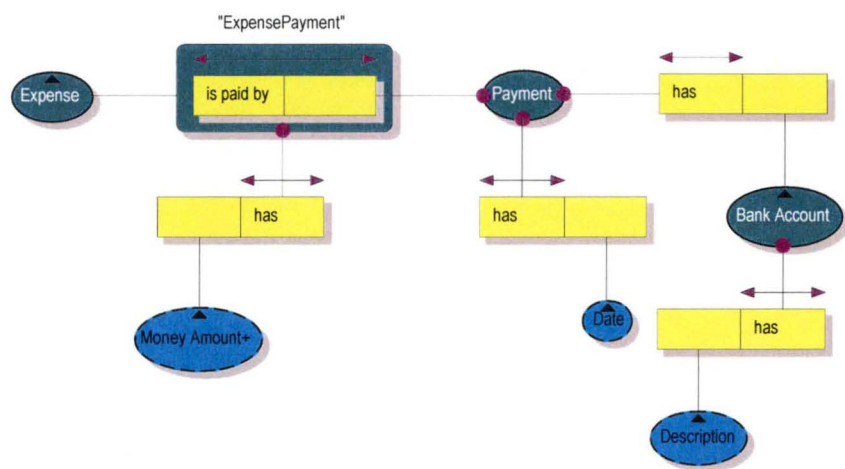


**Diagram 6.4.9   Modelling Payments**

### 6.4.4  Sales

*Progress Invoices*

Customers are billed according to the progress made on a job (subject to the terms of the contract).  A retention amount may be subtracted before an invoice is issued; this would be invoiced at a later date.  Credit notes can be treated as negative invoices.
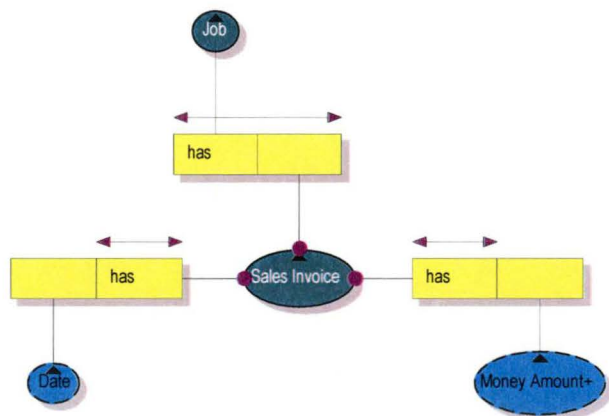


**Diagram 6.4.10 Modelling Sale Invoices**

*Receipts*

Receipts from customers would be banked and allocated against the invoices for which they are payment.
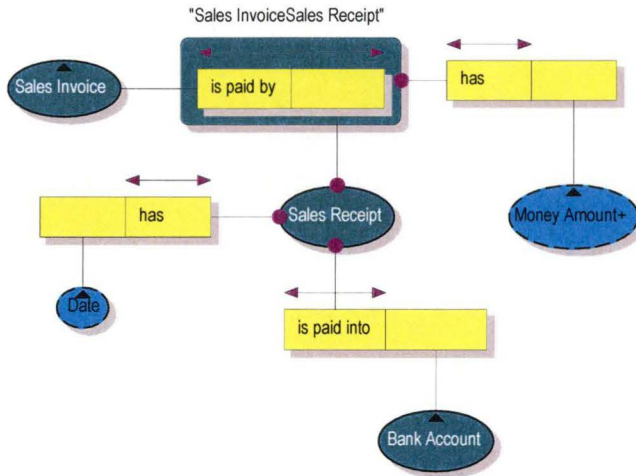


**Diagram 6.4.11  Modelling Sale Receipts**

## 6.4.5  Reporting Adjustments

*Prepayments*

The level of prepayments at any point in time can be calculated by applying the required allocation function (e.g. straight line) to the indirect expense instances.  (Each indirect expense is recorded with the period to which it applies.)  Depreciation is merely a longer-term form of prepayment and can be handled in the same way.

*Accruals*

Provision for expenses which have yet to be invoiced and/or paid for can be made by creating an expense instance for the estimated amount.  (Instances for estimated values would be marked as such.)  This value would be used in all reports and can be updated with the final amount when it becomes available.  Adjustments for accrued employee entitlements can be calculated from the length of leave taken (as recorded for the payroll expense) and the total accrued entitlement (based on an employee's start date and the contractual agreement).

*Payroll Tax*

The amount of payroll tax due on subcontractors' invoices can be calculated from the expense instances recorded. The *units* value would record the number of hours worked from the invoice which then forms the basis of the payroll tax calculation. Suppliers could also be marked as being subcontractors if required. The payroll tax expense can be added as an indirect expense.

*Margin*

Assuming that all costs to date and all expected costs to completion (or the latest budgeted total cost) have been recorded within the system, the degree of completion of a phase may be determined by comparing the costs incurred to date (sum the values of the *CategoryDirectExpense* instances for the phase and the *CategoryPayroll Expense* instances applied at the required unit rate) with the total expected costs (found by summing the values of the category instances for the phase as adjusted for any change orders). This proportion can be applied to the contract amount for the phase to calculate the margin earned. However, this calculation also requires the exercise of some judgment by the account manager and so a percentage completion value has been associated with each phase. The precise modelling of this area is left as an implementation issue to be resolved after a more detailed study of the company's operations. At present the calculation of margin is undertaken on a monthly basis.

*Empty Clearing Accounts*

Clearing accounts for allocating indirect expenses would not be required in this model. Their purpose can be achieved through procedures. The use of estimates for accrued expenses will automatically be corrected when the expense instances are updated with the actual values. The over- or under-charging of jobs with employee costs can always be calculated and treated accordingly. This includes the calculation of appropriate accruals and prepayments for employee entitlements.
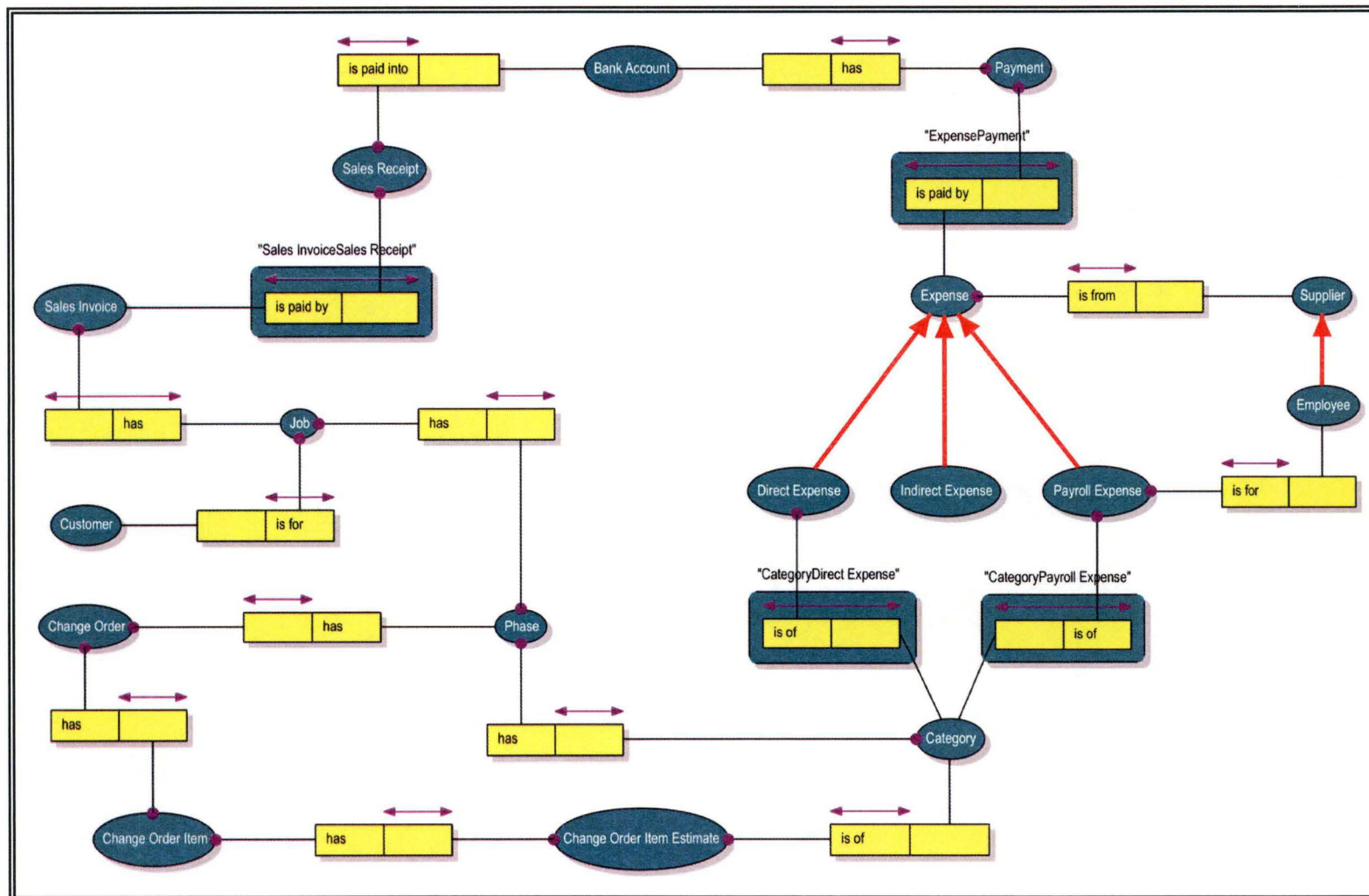
**Figure 6.2    Data Model of Accounting System for Company B**

*Capitalisation of Leases*

This adjustment affects only the presentation of reports and not the underlying records. It can, therefore, be implemented by an appropriate reporting procedure provided the necessary additional data have been captured.

### 6.4.6 Complete Model

The model extracts for each of the subsystems described above may be combined into a single data model of the company's accounting system. This is shown in Figure 6.2. Value objects have been omitted from this figure due to lack of space.

## 6.5 Accounting Data Model for Company C

Company C is a shipbuilder operating from a single location. It splits its business operations between two legal entities: Company C1 (Sales) is responsible for the sales and marketing of vessels and owns the plant and equipment, and Company C2 (Production) undertakes the manufacturing of vessels. A single, multi-company accounting system is used to record the transactions for both companies and to prepare quarterly management reports and financial statements.

### 6.5.1 Transaction Types

The transactions recorded in their accounting system include the following transaction types:

- ❖ expenses (see Section 6.5.2);
- ❖ labour (see Section 6.5.3);
- ❖ payments (see Section 6.5.4);
- ❖ sale of completed ships (see Section 6.5.5);
- ❖ sundry revenue (see Section 6.5.6);
- ❖ receipts (see Section 6.5.7);
- ❖ other intercompany transactions (see Section 6.5.8);
- ❖ other transactions (see Section 6.5.9).

Wherever possible costs are directly attributed to the ship for which they were incurred. Indirect expenses are allocated to the ships as part of a periodic overhead charge. Other transactions include intercompany transfers, transfers of money between accounts, foreign currency conversions, reporting adjustments and correction of mispostings. Each of these types of transaction is modelled in turn before they are combined into a complete data model of the accounting system.

### 6.5.2  Expenses

Expenses are represented by purchase invoices which have an associated supplier and date. Some expenses will be directly attributable to a particular ship (direct expenses) whilst others will not (indirect expenses). A single invoice may comprise both direct and indirect expenses. The operating company incurring direct expenses can be inferred, but for indirect expenses it must be explicitly stated. Each expense has an analysis code which identifies its type. If a ship is being built to order, the budgeted number of production hours for each ship is used to attribute profit over the construction period.
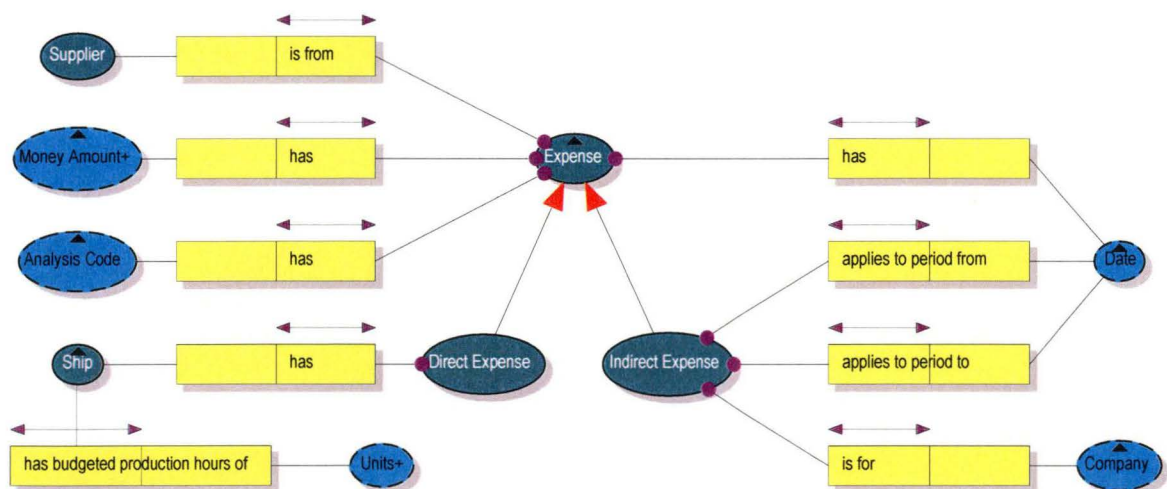


**Diagram 6.5.1   Modelling Expenses**

Indirect expenses are allocated over the period of time specified and classified according to the analysis code. This code may be used to represent a fixed asset or the allocation of overhead expenses across the period to which the services purchased relate.

### 6.5.3 Labour

Some basic details about employees are recorded which include their name and rate of pay.
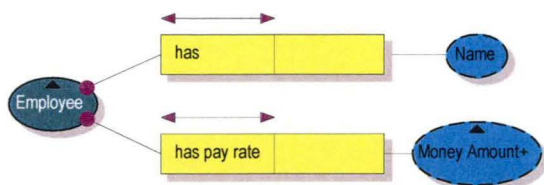


**Diagram 6.5.2    Modelling Employees**

Most employees use clock cards to record their working hours. These clock cards are used as the basis for preparing time sheets for the payroll calculations. Each productive hour worked may be assigned to the building of a particular ship so that labour charges can be allocated. Other hours may be recorded relating to annual and long service leave taken.
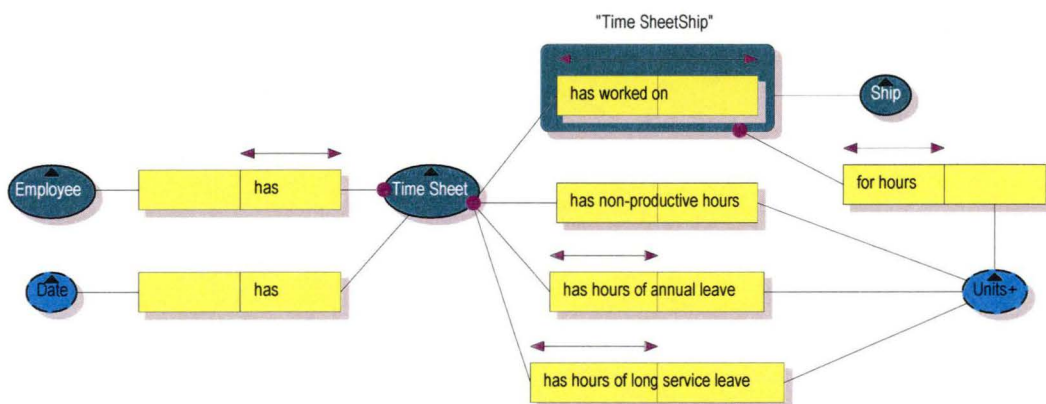


**Diagram 6.5.3    Modelling Labour Time**

### 6.5.4 Payments

Payments are made from money accounts (such as bank accounts or petty cash balances). An account may be operated in a foreign currency in which case this will be specified and periodic exchange rates recorded. The absence of an associated currency implies that the account is operated in Australian dollars.
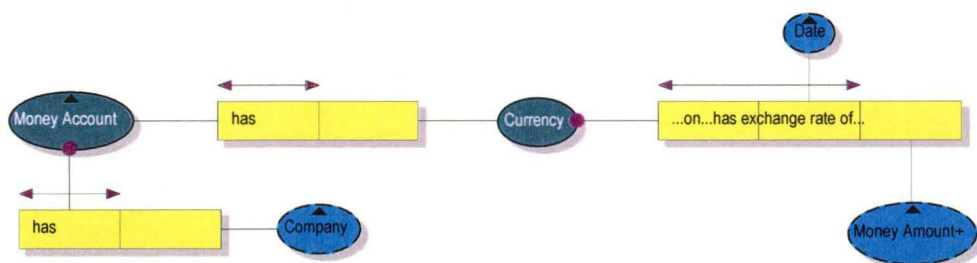


**Diagram 6.5.4    Modelling Money Accounts**

Each money account is associated with one of the operating companies and it is possible for one company to pay expenses relating to the other. The company for which a payment is being made can be identified from the related expense, whilst the company making the payment can be identified from the associated money account. A payment may relate to either an expense or a time sheet.
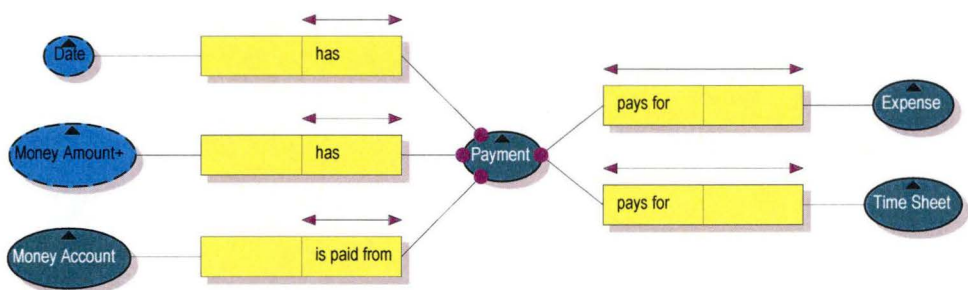


**Diagram 6.5.5   Modelling Payments**

### 6.5.5  Sale of Completed Ships

Until a ship is complete its costs are treated as work-in-progress in the books of Company C2 (Production) and once it has been completed it becomes finished goods. When a ship is sold its ownership is transferred from Company C2 (Production) to Company C1 (Sales) where its cost is matched against the sales revenue receivable by Company C1 (Sales). Since the transfer is made at cost, this complete transaction can be modelled as a sale; the details of the internal transfer can be calculated from the costs already recorded.
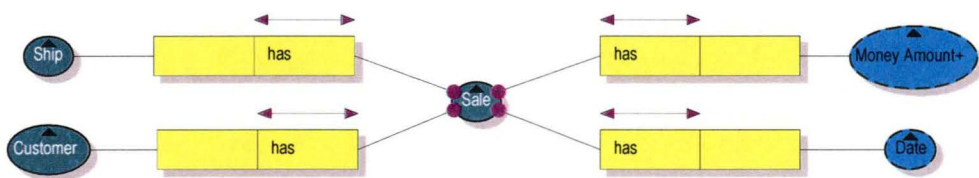


**Diagram 6.5.6   Modelling Sales**

After a ship has been completed and sold it is possible for further costs to arise. These may be recorded in Company C2 (Production) as a normal expense and will automatically be treated as being reclaimed from Company C1 (Sales) because the expense will become part of the ship's cost which is deemed to be the value at which it is transferred.

### 6.5.6 Sundry Revenue

Other forms of income are attributed to the appropriate company and classified according to one or more analysis codes. For example, the ships being built are eligible for shipbuilding bounty under the Federal Government's regulations. The bounty claims are based on the construction costs paid not just incurred. Paid expenses can be identified as being those which have related payments. Interest earned is another example of sundry revenue.
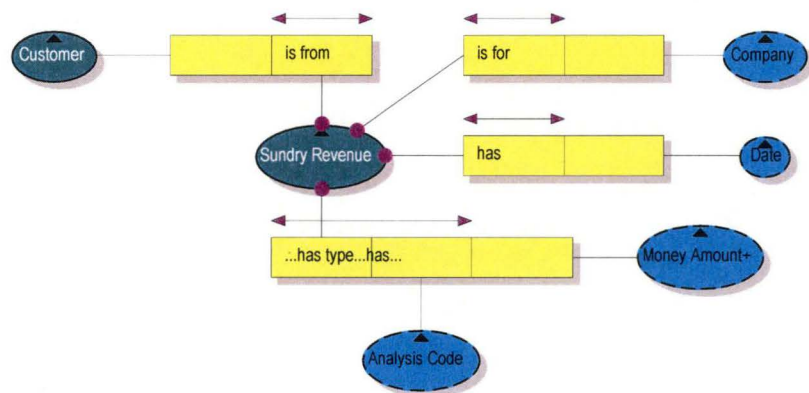


**Diagram 6.5.7   Modelling Sundry Revenue**

### 6.5.7 Receipts

Receipts from customers either in relation to sales or sundry revenue would be paid into one of the company's accounts.
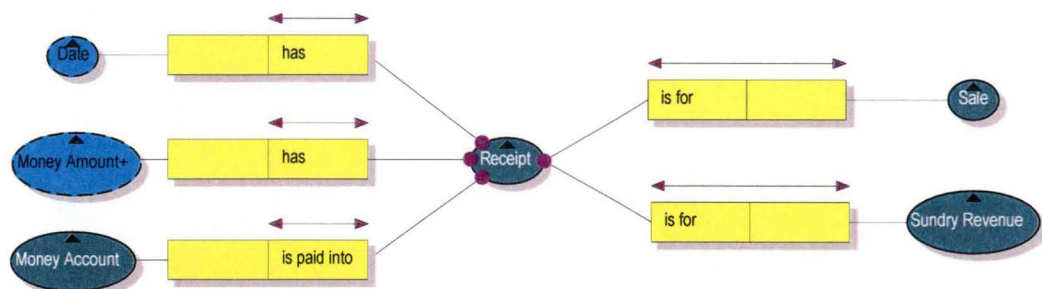


**Diagram 6.5.8   Modelling Receipts**

### 6.5.8 Other Intercompany Transactions

*Intercompany Exchanges*

In addition to the transfer of completed ships (see above), there are a number of examples of trading between the two operating companies. For example, since Company C1 (Sales) owns all of the fixed assets, rent is charged to Company C2 (Production) for their use. Such exchanges may be modelled as an expense/sundry revenue instance pair:

❖ expense incurred by Company C2 (Production) from a supplier of Company C1 (Sales); and

❖ sundry revenue received by Company C1 (Sales) from a customer of Company C2 (Production).

The only additional specification to those already outlined above would be to note that each of the operating companies should also be able to participate as instances of the *Supplier* and *Customer* entities. This can be achieved by combining suppliers and customers into a single super-type of *External Party* which would include the two operating companies.

*Intercompany Indebtedness*

Whilst no money need change hands when trading takes place between the two operating companies, the preparation of separate balance sheets will require the calculation of the net indebtedness. This may be achieved by summing the money values of the relevant transactions, which may include:

❖ expenses incurred by one company and paid by the other;

❖ sundry revenue received for one company but lodged in a money account belonging to the other;

❖ sales of completed ships;

❖ charges made between the two companies for such items as usage of equipment (represented by an expense in one company and sundry revenue in the other).

*Funds Transfer*

It may be necessary to transfer funds between the companies from time to time in order to reduce any net indebtedness between the companies. These transfers may be modelled as a pair of receipt and payment objects for the same money amount, where the money account for the receipt and payment for different *money account* instances, each account being associated with a different company.
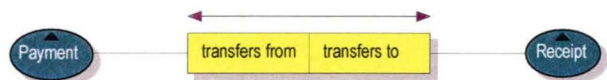


**Diagram 6.5.9   Modelling Funds Transfers**

Such transfers may also be used for moving funds between accounts operated by the same company.

### 6.5.9  Other Transactions

*Reclassify Transactions*

Expenses classified as repairs and maintenance in Company C2 (Production) may be reclassified as plant and equipment owned by Company C1 (Sales). This can be achieved by either correcting the original records to reflect the revised nature of the transaction, or by cancelling out the original expenses (by adding expenses with negative money amounts) and adding new expenses (for the same amount) to represent the plant and equipment. Any corrections to existing records could be restricted to authorised personnel and subject to an audit log for security purposes.

*Corrections of Mispostings*

In the existing accounting system, some transactions represent corrections to postings already made. For example, these might be to adjust previous estimates, correct postings to wrong accounts, remove duplications or cancel a cheque. In each case, these transactions can be handled by editing the original records to correct the appropriate values. Provided systems implement appropriate security restrictions and logs of changes made, correcting the original records is a simpler solution than adding new transactions to the system.

*Overhead Allocation*

Indirect expenses are allocated to ships on the basis of production hours. The level of
expenses and the number of production hours worked on each ship are available from the
existing model definition. A procedure can be written to perform the necessary allocation
for reporting purposes. There is no need for these adjustments to be reflected as permanent
entries in the system, particularly as the allocation basis used will be an arbitrary choice.
Treating it as a procedure would allow alternative allocation bases to be applied to the
same transactions if required.

*Accruals*

The current system posts accruals at the end of each reporting period for expenses not yet
recorded. This can be achieved by creating an expense for the anticipated item, even if the
money amount included is merely an estimate. The amount can be revised as required (see
discussion of corrections above) until the final amount is known (normally on receipt of an
invoice). In the case of accruing for workers' compensation, the adjustment could be
included in a procedure since the amount of this accrual is directly related to the level of
gross wages.

*Foreign Exchange*

When conducting transactions in foreign currency the money amount involved must be
converted into Australian dollars. In addition any foreign currency holdings will need to
be converted when determining the values of assets. The exchange rates at which these
conversions are made (for example, daily rate, average rate, closing rate) are a matter of
accounting policy choice and hence best incorporated into a procedure so that different
policies can be applied as required. This will be possible provided the required data are
retained; that is, the money amount expressed in its original currency and a series of
exchange rates covering the reporting period. The Australian dollar equivalent of any
foreign currency amount may then be calculated by applying the appropriate exchange
rate(s).

### 6.5.10 Complete Model

Each of the above elements can be combined to form a model of the complete accounting system for Company C. This is shown in Figure 6.3; value objects have been omitted for reasons of space.
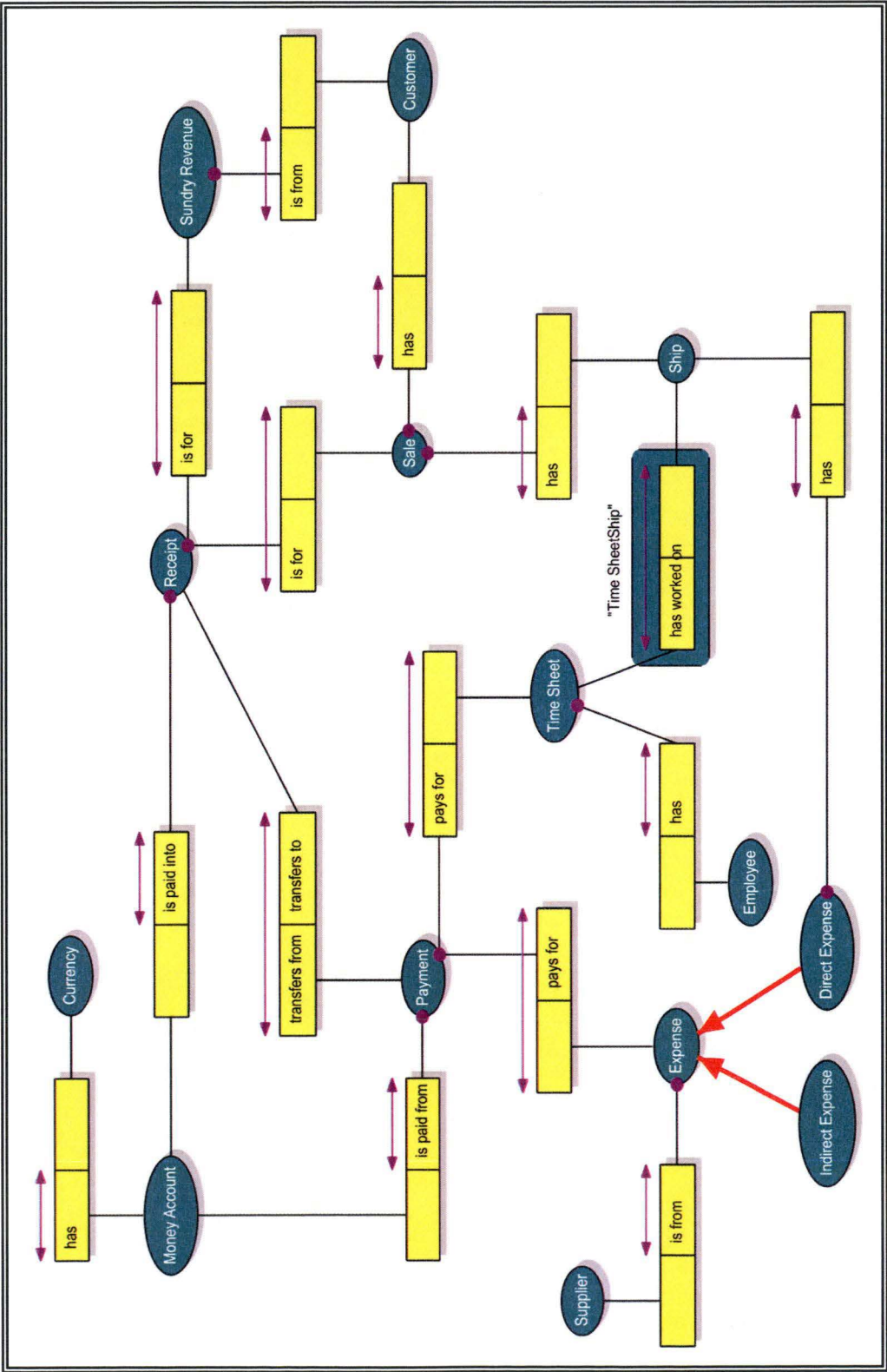


**Figure 6.3    Data Model of Accounting System for Company C**

## 6.6 Summary

The company models developed in this chapter highlight a wide range of transactions which arise in practice. The values appearing in financial statements are based not only on the flows of resources such as inventory (for example, from purchases and sales) and money (for example, from payments and receipts) but also the effects of accounting conventions such as:

- ❖ implementing periodicity through adjustments for depreciation and prepayments;
- ❖ providing for unrecorded transactions which relate to the past (for example, accruals);
- ❖ applying the matching concept between related transactions;
- ❖ recognising losses immediately (for example, valuing at the lower of cost and net realisable value);
- ❖ recognising income on long-term projects based on proportions completed;
- ❖ revaluing monetary assets and liabilities on the basis of current values (for example, calculating foreign exchange gains and losses).

To fully support the preparation of financial statements, a new accounting data model should be able to capture data relating to an organisation's business activities in such a way that these accounting concepts can be applied. Furthermore, the data model should be independent of the valuation basis and accounting policies so that different sets of financial statements can be prepared on the basis of alternative sets of rules to satisfy different user needs. The present use of journal entries for recording these effects is an indication of the inability of contemporary accounting systems to fully reflect the nature of the underlying reality being captured. The accounting systems used by the organisations participating in these case studies are not based on accounting data models which satisfy any of the hypotheses $H_{model,1}$, $H_{model,2}$ and $H_{model,3}$:

- ❖ none integrated past and future transactions ($H_{model,1}$);
- ❖ none recorded transactions independently of the valuation basis and accounting policies ($H_{model,2}$);
- ❖ all required period-end adjustments to be processed before financial statements could be prepared ($H_{model,3}$).

The models developed in this chapter can, however, be used as the foundation for redesigning the accounting data model so as to provide a better fit with the data needs of actual manufacturing organisations. This process is the subject of the next chapter. The accounting data model designed is then tested against the three hypotheses developed earlier in this chapter.

# Designing A New Accounting Data Model

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The models of accounting transactions being processed by organisations developed in Chapter 6 highlight some difficulties in the application of alternative accounting data models such as REA. This suggests the need for a new data model to be designed which provides a better fit with the complexities of the data requirements of actual transactions.

This chapter is structured as follows. Section 7.1 reviews the problems with the existing proposals for alternative accounting data models. Section 7.2 combines the analysis of the data requirements derived from the case studies reported in Chapter 6 with accounting measurement theory to derive the basis for a new accounting data model. A formal definition of the new data model is provided in Section 7.3 with a comparison against alternative proposals in Section 7.4. Section 7.5 describes the validation of the new data model and Section 7.6 summarises the findings.

## 7.1 Overcoming Problems with Existing Data Models

### 7.1.1 Duality and Non-Trivial Exchanges

The implementation of the duality relationship in a model based on the REA template is only clear for a "trivial" exchange involving only two economic events, as shown in Figure 7.1. In this case the sale event would be associated with a receipt event. The sale event represents an outflow of an inventory economic resource, whilst the receipt event is an

inflow of a monetary resource. Each is likely to be associated with the same external economic agent but if this is not the case, or if either event may occur first, then each event must be associated with the appropriate external economic agent.
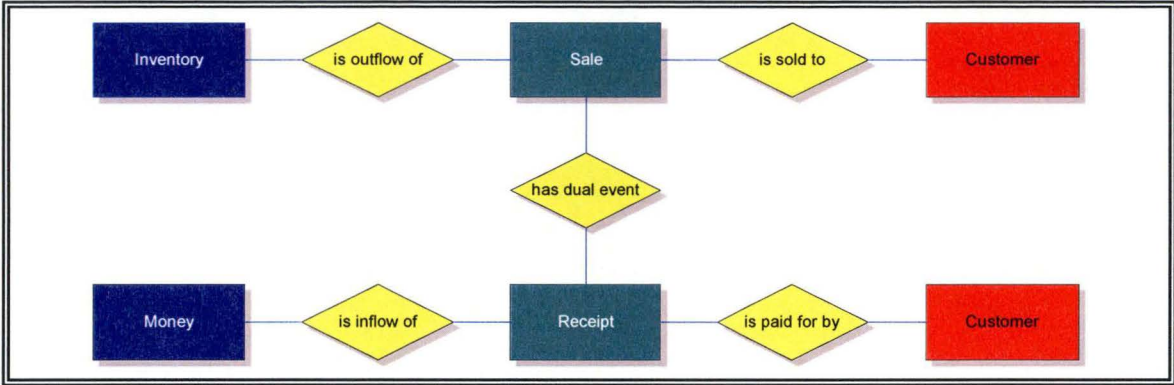


**Figure 7.1 Exchange with Two Events**

When more than two economic events are involved in an exchange it is necessary to ensure that the duality relationship is explicitly or implicitly defined between each of the events. If economic events are not recorded until they have taken place (as is the case with an REA model) and the sequence in which events occur is not pre-determined, then a duality relationship may need to be defined between each pair of events. This is illustrated in Figure 7.2 for a sale paid for in two instalments; one or both instalments may be paid prior to the sale and so there is no one event instance from which the duality relationships can be inferred. For an exchange involving $n$ events, this solution will lead to $\dfrac{n!}{2 \cdot (n-2)!}$ duality relationships being defined. Thus the number of duality relationships required to capture an exchange will grow at an increasing rate with the number of events involved.
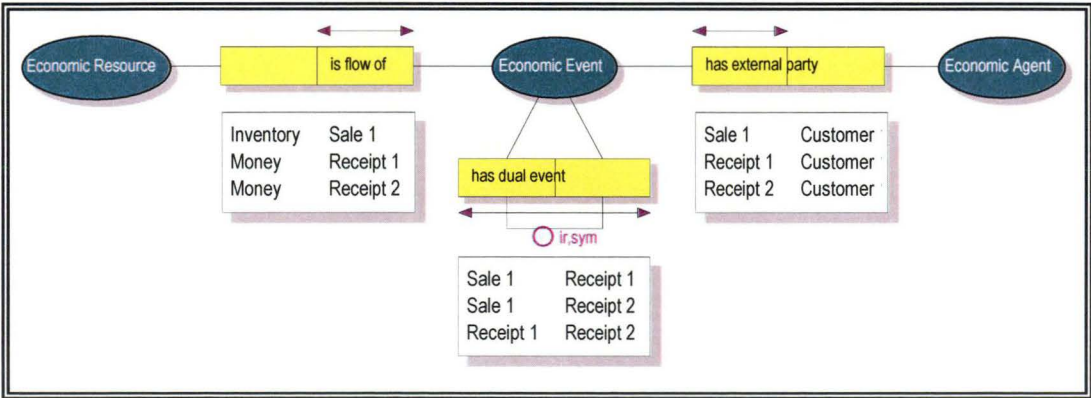


**Figure 7.2 Three-Event Exchange with Sample Population**

Another solution would be to associate each event with one other event from the same exchange and then repetitively follow the duality relationships defined to identify all of the

events which make up the exchange. This is illustrated in Figure 7.3 in which two steps are required to discover that *Receipt 1* and *Receipt 2* are part of the same exchange. The number of steps could increase as the number of events increases depending upon the structure of links used. For example, the duality relationships could be organised as a "daisy chain" (with each new event being associated with the last one), or in a tree-like hierarchy (with each new event being associated with any of the previous ones), or as a flat structure (with each new event being associated with the first one). The last structure may be the most efficient since they are only two duality relationships separating most of the events; only the first event is different in that it is directly associated with all of the other events.
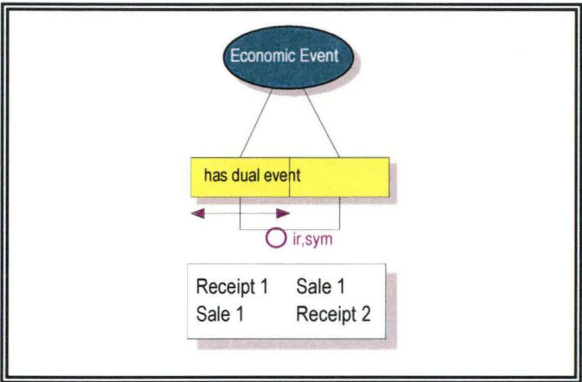


**Figure 7.3    Linked Duality Relationships**

The duality relationship is an essential element of a model of accounting transactions. However, the above analysis highlights the fact that the way in which it is represented within an REA model is not easily extensible for non-trivial exchanges. The problems encountered in implementing non-trivial exchanges can, however, be overcome relatively easily by introducing an additional entity which represents the exchange contract or agreement. Each event may then be associated with the appropriate *Exchange* entity as illustrated in Figure 7.4. This is quite similar to the flat structure of event entities discussed above, but has the added benefits of:
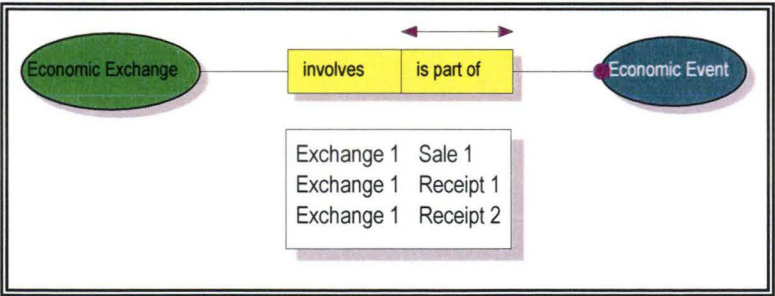


**Figure 7.4    Modelling Duality with an Exchange Entity**

❖  the same rules applying to all event instances; and

❖  there being no need to identify which is the first event for an exchange.

This construct is easily extensible for arbitrary numbers of events in a single exchange.
The duality relationships are replaced by an "exchange participation" relationship. Only
one participation relationship is required for each event.

## 7.1.2  Non-Economic Events

The *Exchange* entity proposed above performs a similar role to the *Production* entity in the
accounting data model developed for Company A (see Section 6.3). A production process
involves the concept of "exchange" except that it is a *physical* exchange rather than an
*economic* exchange. A set of ingredients is used as the input to a process which transforms
these raw materials into a set of finished goods. Given the numbers of different warehouse
items involved in the production process, it would have been complex to associate each
item to each other with a "duality" relationship. Instead, each item was associated with a
*Production* entity which represented the daily batch.

The relationship between the *Production - Warehouse Item* entities and a *Production* entity
is one of *participation*: it models those warehouse items which participate (as either inputs
or outputs) in the production process. Thus the REA duality relationship between
economic events has essentially been replaced with a *participation* relationship between an
*Exchange* entity and each event. In this new form, there is no reason why the relationship
should be restricted to economic events. It is possible for other events to be related to an
exchange in the same way. For example, this could be details of a call made to a customer
as part of the after-sales service. In the production process, events may be recorded to note
the number of machine hours used, or the volume of free resources (such as air and light)
consumed or the amount of effluent produced. The existence of non-economic events in
the information system should not affect the production of any reports which focus on the
impact of economic events; any non-economic events can simply be ignored. Thus, the
revised structure for modelling exchanges not only simplifies the recording of economic
events, but also enables a wider range of events to be captured.

### 7.1.3 Recognition of Events

Traditionally accounting systems have only recorded events after they have taken place and REA adopts a similar position. To mitigate the limitations of such an approach data models have been extended to accommodate other events. For example, contemporary accounting systems often incorporate sales and purchase order subsystems. Some REA models have included orders as separate events (see, for example, McCarthy 1978; 1982) and the latest extensions to the REA template (Geerts and McCarthy 2000) incorporates the concept of commitments which, in the case of sales and purchases, is equivalent to orders. In both cases the inclusion of orders in the information system results in new entity-types and new relationship-types being defined.

If an information system is to fully support the production of financial statements, then it must be able to capture expected future events. Some of the end-of-period adjustments made in the accounting systems of the organisations modelled, related to accruals for transactions expected to arise in the future. A simple example is an accrual for the annual audit fee. At the end of the financial year the audit will not have taken place but it would be quite legitimate to charge the cost of the audit against the income for that year. There was no provision for such a transaction in the original REA template, but with the revised version, an accrual could be modelled as a reciprocal pair of commitments as illustrated in Figure 7.5.[32]
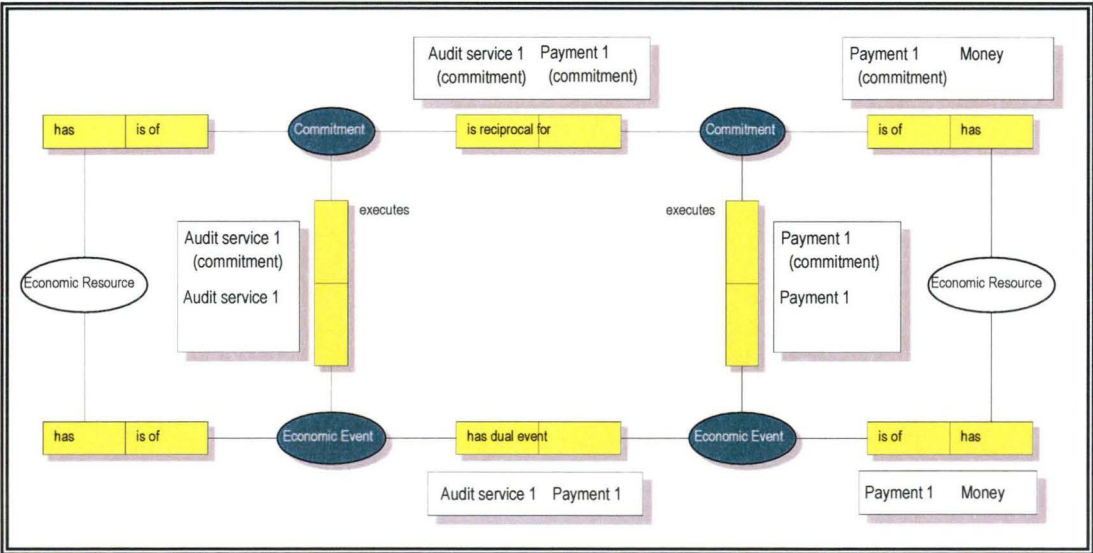


**Figure 7.5   Modelling an Audit Fee Accrual as a Commitment**

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[32]   Since this example involves the purchase of a service, it is unlikely that an economic resource would be associated with the inflow commitment or event.

A commitment represents the expectation of a future economic event, it is a stage through which an exchange moves between its original conception and its conclusion. As noted by Elliot (1992, 72), the events recorded "under the traditional accounting model are only a segment in a series of interactions, and those interactions are potentially useful in evaluating customer satisfaction". These interactions are listed in the first column of Table 7.1. If a separate entity were created for each of these customer interactions, then the data model would become very complex. An alternative solution is to treat the interactions as the evolution of single sets of entities. The second column of Table 7.1 illustrates how this could be implemented. Initial expressions of interest, quotations and orders can be modelled as "draft" exchanges. A draft exchange can be distinguished from an actual exchange by the date of its events; unconfirmed events may either be undated or use the future date when the event is expected to take place. Any negotiations regarding the sale would be recorded as changes to the draft exchange and once an order is firm and has been delivered then the appropriate transactions dates can be entered to remove the draft status

| Customer Interaction | Information System Representation |
|---|---|
| Advertising/promotion | |
| First contact/exploration | Create customer agent associated with a salesperson agent |
| Quotation | Create exchange entity associated with an undated sale event using initial quotation values |
| Offer | Update sale event with revised estimates |
| Counteroffer | |
| Acceptance (executory contract) | |
| Ship goods | Date sale event |
| Collect cash | Associate a receipt event with the exchange |
| Provide service/warranty | Associate appropriate non-economic events with the exchange |
| Replace/trade/upgrade | Initiate a new exhange sequence |
| Lapse | Remove association between customer and salesperson |

Source: based on Elliott (1992, 73)

**Table 7.1    Capturing Interactions in the Customer Interface**

of the exchange. In this way orders may be implemented without the need to introduce additional types of entity and relationship, thereby keeping the model simpler and easier to understand.[33]

The latest revision of the REA template includes reciprocal commitments (Geerts and McCarthy 2000). The method proposed above for recording a sale did not suggest the creation of a commitment for the money to be received in exchange for the sale. However, there is no reason why an exchange should not incorporate all of its associated events, including those expected to arise in the future. Furthermore, such an approach could provide useful additional information. For example, a receipt event could be created at the time of sale to indicate when it is expected that the customer will pay for the goods purchased. This data could then be used in the preparation of cash budgets. In the model for Company A (see Section 6.3), transfers of stock items between warehouses were captured by a *Transfer* event. Any unmatched transfers represented goods in transit. However, extending the model to include expected future transfers would enable the system to record the destination of the goods in transit and even their expected time of arrival. Similarly, production schedules could be entered as post-dated sets of *Production* and *Production - Warehouse Item* entities to indicate the expected production over the coming period. Thus, extending an accounting information system to incorporate both past and future events is a necessary prerequisite if it is to be able to generate financial statements but also offers many other benefits and opportunities.

### 7.1.4 Discrete and Continuous Events

End of period adjustments were also required by the companies modelled (see Chapter 6) to allocate transactions between reporting periods. Some of these adjustments were generated automatically, but others were calculated and entered manually. In either case the accounting system is processing what is essentially a continuous event by dividing it into a series of discrete events. This means that meaningful reports can only be prepared for the same periods as the continuous events have been divided. The company models overcame this problem by incorporating the continuous nature of such events. This was achieved in the Multiview Accounting System (Seddon 1991) by allowing formulae-based

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[33] Although this method involves the updating of existing entities, it would still be possible to obtain a history of a transaction by keeping a system log of changes. This is an implementation issue.

entries in the general ledger. However, this imposes a single allocation basis on the resulting reports. The models developed in Chapter 6 have avoided this by merely recording the data necessary to support a choice of methods. For example, an expense item such as an insurance premium would be recorded with the start and end dates of the period to which it relates. A procedure can then be applied to this data to allocate it to any period using whatever method is required (for example, on a simple time basis or in proportion to the sales level).

## 7.2 Designing a New Data Model

The inability of existing proposals for alternative accounting data models to support the transactions identified from real organisations indicates the need for a new data model to be designed (see Chapter 5). Unlike previous attempts, the design of the new data model will be based upon an analysis of transactions recorded by real organisations. This will improve the likelihood of the resulting model being able to undertake the same functions as existing accounting systems as well as overcoming their deficiencies (see Chapter 6) and achieving the goals set for accounting systems in Chapter 2.

### 7.2.1 Accounting Measurement

Ijiri (1975) identified three fundamental judgments required to carry out accounting measurement: control, quantities and exchanges. *Control* is the concept which identifies which resources will be measured in accounting (essentially those over which an organisation has some control). *Quantities* must be measurable for each class of resources so that comparisons can be made between alternative sets. Finally, *exchanges* are used to represent the changes in the levels of resources which occur over time. These judgments are incorporated into the Australian conceptual framework of accounting as embodied in the Statements of Accounting Concepts (SAC) issued by the Australian Accounting Standards Board (AASB) and, in particular, SAC 4 "Definition and Recognition of the Elements of Financial Statements" (AASB 1992). SAC 4 emphasises the stocks of resources rather than the flows which give rise to changes in the levels of stocks. However, since it is the flows which give rise to the stocks, the approach taken here focuses on the flows.

These judgments should form the basis of any accounting data model designed to support accounting measurement. However, the accounting data model need not be restricted to capturing flows of just those resources under the control of an organisation; they represent the minimum position, other resources could be included if they would provide useful information. Each flow of a resource forms part of an exchange for which a primary measurement must be recorded; for example, the number or weight of an inventory item purchased. Satisfying these three judgments should ensure that accounting reports can be generated.

### 7.2.2 Exchanges

An exchange is the most fundamental object of an accounting data model. It is the means by which flows of resources are grouped and by which values of non-monetary resources may be implied. For example, the value of inventory received can be implied from the monetary amount given in exchange. Exchanges are, therefore, represented by a set of one or more resource flows. This is illustrated in the following diagram.
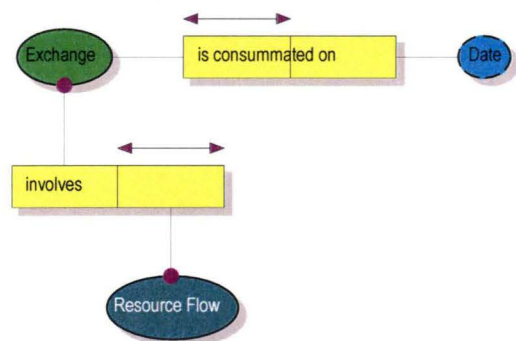


**Diagram 7.2.1    Modelling Exchanges**

Exchanges may be referenced by a unique *ID* and have a date to denote when they were consummated. Other details about the exchange may also be recorded as deemed appropriate.

### 7.2.3 Resource Flows

A *flow* entity represents a change in the level of a resource. The change may be an increase (an inflow) or a decrease (outflow). The same flow entity can be used to represent both inflows and outflows; the distinction being determined from the sign of the value of

the flow. An arbitrary convention is adopted which denotes positive values as being inflows of resources and negative values as being outflows.[34]

Another important distinction to make is between external and internal flows. An external inflow represents a resource which is received from a party external to the organisation; for example, the purchase of inventory from a supplier. An external outflow represents a resource which is surrendered to an external party; for example, the sale of inventory to a customer. Internal events are those which do not involve an external party; for example, the conversion of raw materials into finished goods. The distinction between external and internal flows is important in accounting for valuation purposes. External flows have a monetary[35] valuation attached to them as agreed between the organisation and the external party (for example, the selling price of goods and services). No such valuation exists for internal flows; any value placed on the flow of a non-monetary resource within an organisation is an arbitrary choice. Since the valuation of internal flows is subject to the user choice of an appropriate accounting policy, it is not appropriate for the accounting data model to record a monetary value for these flows. Instead, it should offer procedures by which their values may be derived using a range of acceptable alternative accounting methods so that the user may then select their preferred method.[36]

An external party is a person (real or legal) who is separate from the organisation. This definition would include suppliers and customers with whom the organisation does business. It would also include government agencies, such as the tax office. Employees would also be regarded as external parties because they contract with the organisation for the supply of their labour service and their wages and salaries represent monetary resources which are lost to the organisation. Thus, suppliers, customers and employees represent specific types of external party who may participate in an external flow of resources with an organisation and for whom different information may be recorded with the information system. For example, payment terms may be recorded for each supplier; customer details may include the name of the salesperson assigned to them; employee records would include pay details.

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[34] The opposite rule could have been used but it is not considered to be as intuitive.
[35] Money is assumed to be the medium of exchange when transferring resources from one party to another.
[36] Users may also be offered a choice of method for external flows if valuation bases other than historic cost are to be permitted.

A resource flow may be modelled as follows:
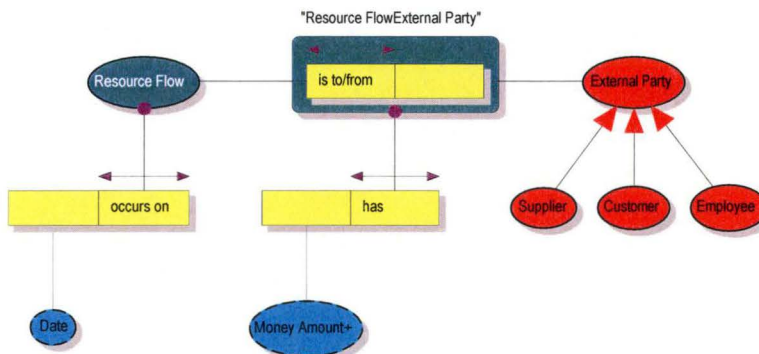


**Diagram 7.2.2    Modelling Resource Flows**

Each flow takes place on a specific date.  For external flows, the association with an *External Party* entity will have a monetary value attribute.  The *External Party* entity will capture general details about these people; data specific to a particular type of external party can be recorded by creating an appropriate subtype.  Potential external party subtypes include supplier, customer and employee; others can be added as required.

### 7.2.4  Fundamental Resources

An analysis of the company data models developed (see Chapter 6) reveals three main types of resources:

- ❖   *money* - monetary assets which are defined as "currency units (Australian dollars or units of other currencies) held, or claims to determined numbers of such units of currency.  These numbers will not change as a consequence of changes in prices, though the service potential they represent will." (AASB 1989);

- ❖   *inventory* - things which have a monetary value and for which acquisition and consumption flows are separately recorded;

- ❖   *service* - all other things having a monetary value.

Each of the flows modelled can be seen in terms of one or more of these resources.  Thus, the *Resource Flow* entity can be viewed as the supertype to *Money Flow*, *Inventory Flow* and *Service Flow* entities, as illustrated in the following diagram.
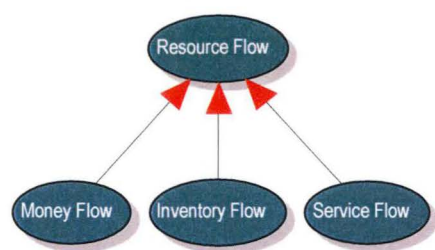
**Diagram 7.2.3    Subtypes of a Resource Flow Entity**

The modelling of each of these subtypes is described next.

*Money Flow*
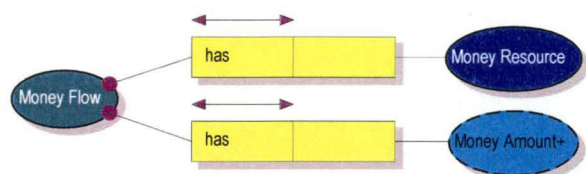


**Diagram 7.2.4    Modelling Money Flows**

The *Money Resource* entity identifies which monetary resource is involved (for example, which bank account) and the *Money Amount* value records the size of the flow.

*Inventory Flow*
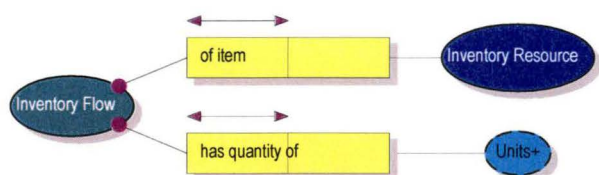


**Diagram 7.2.5    Modelling Inventory Flows**

An inventory flow is represented by a quantity of an inventory resource. The *Inventory Resource* entity is used to record details about each inventory item, such as its description, size and location.

*Service Flow*
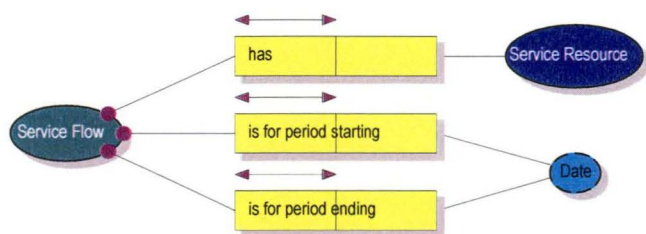


**Diagram 7.2.6    - Modelling Service Flows**

Since a service is not, by definition, separately identifiable, it is assumed to be consumed over a specified period of time. The *Service Resource* entity may be used, for example, to identify the nature of the service which can then be used for classifying the expense for reporting purposes. The method used for allocating the monetary value of the service over the specified period is not recorded; potential methods are encapsulated in procedures so that users may state their preference when requesting reports.

### 7.2.5  Modelling Exchanges

The above constructs represent the building blocks with which models of accounting transactions can be developed. Before applying them to actual transactions, some simple examples will be used to illustrate the procedure involved.

*Exchanges of Inventory Resources*

Consider the following transaction:

> On 3 January purchase order *PO379* for 10 units of inventory item *ABC* is sent to supplier *S001*. The price of *ABC* is $5 per unit. The complete order is received as expected on 7 January and payment is made in full on 20 January in line with the terms of sale.

This exchange involves an inventory flow and a money flow as depicted in the following diagram. The associated values are shown beneath each entity.[37]
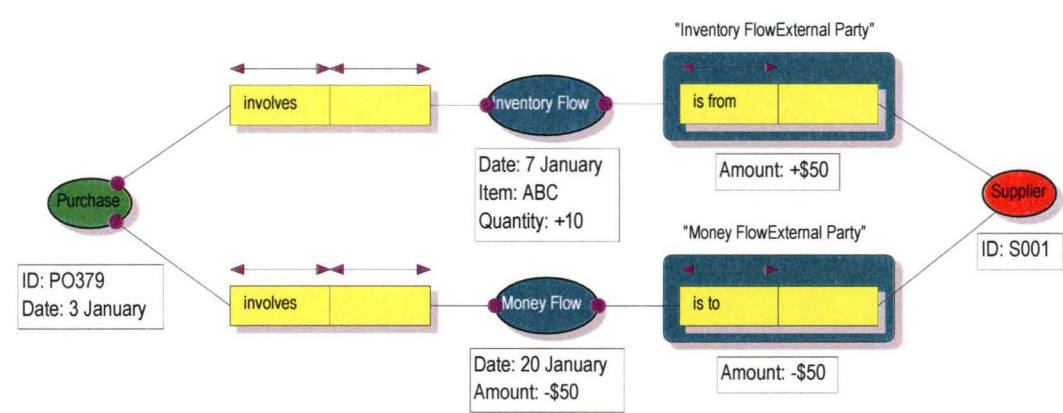


**Diagram 7.2.7   Example of an Inventory Acquisition Exchange**

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[37]   Note that subtypes inherit the values of their supertype.

On or before 3 January the details of the complete exchange shown above would be recorded in the accounting system. The interpretation of these objects will depend upon the date at which the observation is being made. For example:

- ❖ *On 1 January*: on the basis that the above details have already been entered into the accounting system, since the exchange has a future date it is assumed that it has not yet been consummated; it represents an expected purchase order.

- ❖ *On 5 January*: the exchange has now been consummated (the exchange date has passed) and so the objects represent an outstanding purchase order (since the inventory flow has not yet taken place).

- ❖ *On 10 January*: the order has now been received but payment has yet to be made and so the objects represent an increase in the inventory resource offset by a trade creditor (a commitment to a future money flow).

- ❖ *On 30 January*: the completed exchange has caused an increase in the inventory resource and a decrease in the money resource.

Not only does this model record the impact of the exchange it also provides forecast information as to when inventory is expected to be received and assists in budgeting for future commitments of money.

The same structure can be used to record more complex examples of purchases. A separate *Inventory Flow* entity would exist for each item ordered and a *Money Flow* entity would be added for each separate payment (for example, when paying in instalments). If the dates of flows are unknown, then either best estimates can be used or they can be left as null values to be entered once the data are available. The more complete the data which are entered, the better the forecasts of future flows which can be made from the system.

A sale of inventory can be modelled in a virtually identical manner. The same types of flow (inventory and money) will be involved but with values having opposite signs, and the external party being a customer rather than a supplier.

*Exchanges of Service Resources*

The purchase of services can be modelled in a similar manner to inventory resources. Consider the following example:

On 4 March notification is received from the insurance company (supplier code *S192*) that their property insurance for the year beginning 1 April falls due on 31 March. The annual cost is $5,000 which is paid on 26 March.

This exchange involves a service flow and a money flow as depicted in the following diagram.
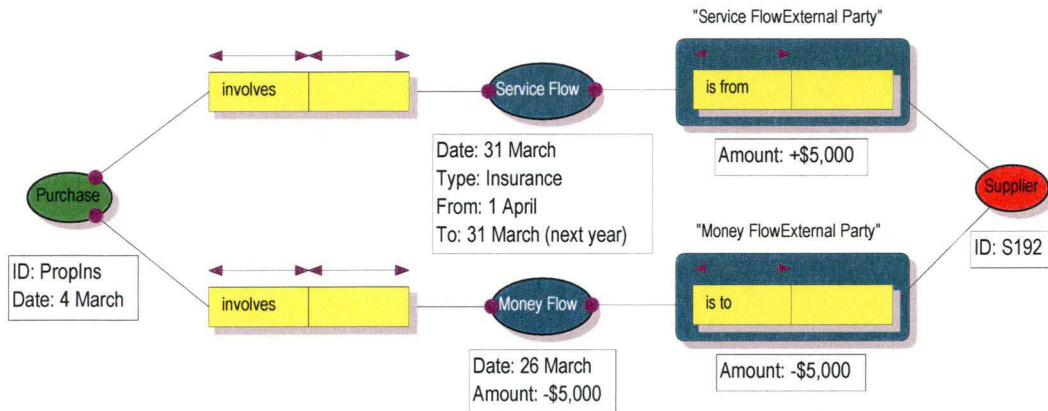


**Diagram 7.2.8   Example of a Service Acquisition Exchange**

The exchange could have been recorded before the notification was received on 4 February using estimated values, thereby assisting with any forecasting models. Once the details are known they can be used to update the objects accordingly. The date of the *Service Flow* entity represents when the amount payable falls due. The interpretation of this representation of the exchange depends upon the date for which this is being determined. For example,

- ❖ *On 6 March*: the insurance premium is not yet due and the period to which it applies has not yet commenced so the objects are of interest only for forecasting purposes.

- ❖ *On 28 March*: the premium has been paid but the insurance cover has not yet started; the decrease in the monetary resource (the amount paid) represents, therefore, a prepayment.

- ❖ *On 30 April*: the insurance cover has started and is continuing so the cost should be allocated between a deduction against income for the month of April and a prepayment for the remaining 11 months.

- ❖ *On 30 April in the next year*: the insurance cover period has finished and so the full amount of the insurance premium should be treated as an expense with no remaining prepayment.

The method used to allocate the cost over the period covered by the service is an arbitrary choice. Typically an insurance premium might be allocated evenly over the period, but procedures may be implemented to offer users a choice of methods when requesting reports (for example, costs may be allocated on the basis of sales rather than time). To record a service which provides a benefit at a particular point in time (rather than over a period) the *from* and *to* dates of the *Service Flow* entity can be set to the same value. Additional services purchased as part of the same exchange can be incorporated by adding further *Service Flow* entities. If the insurance is paid in multiple instalments (for example, monthly) then a *Money Flow* event is added for each instalment. The value of the prepayment at any point in time will be the difference between the value of the instalments still to be paid and the value of the unconsumed part of the service acquired. A "negative prepayment" represents an accrual.

A fixed asset may be recorded as the inflow of a service resource. What differentiates a fixed asset from other forms of service is generally the length of the period over which the benefit accrues (as recorded by the *Service Flow* entity). The recognition of fixed assets is an arbitrary accounting choice; for example, to be treated as a fixed asset, a service expense may have to provide benefits for longer than one year and cost more than a minimum amount (that is, be material or significant in size). Such recognition rules may be implemented as procedures provided the data on which they are based are recorded in the information system (for example, as values associated with the *Service Resource* entity).

Sales of services may be recorded in an identical manner, except with opposite signs on the values of flows. For example, looking at the same example from the perspective of the insurance company, the instalments received will be split between earned income and prepaid income according to the allocation of the annual premium over the period which has already passed.

### 7.2.6 Modelling External Exchanges

Each of the standard transaction types identified in the data models prepared in Chapter 6 can be modelled as an exchange comprising one or more flows. Those involving external parties are illustrated next.

*Purchases and Sales*

Following the examples discussed above, purchases and sales of both inventory and service resources can be modelled as illustrated by the following diagram.
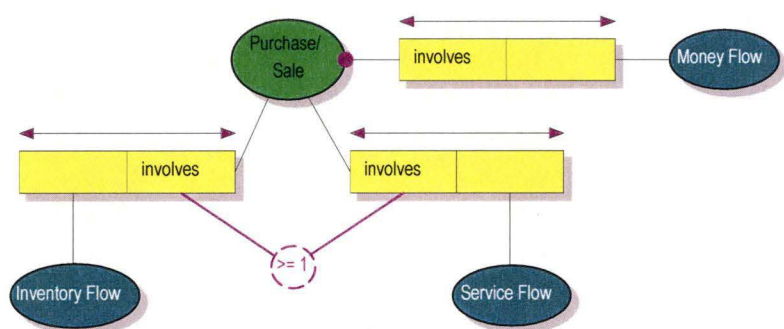


**Diagram 7.2.9   Modelling Purchase and Sale Exchanges**

A purchase or sale exchange comprises one or more *Inventory Flow* and/or *Service Flow* entities together with one or more *Money Flow* entities.  As an external exchange, each flow will be associated with an *External Party* entity.  Normally each flow would be associated with the same external party, but this is not a requirement of the model. Services may be supplied by one organisation with the cost payable to another; for example when a parent company pays a supplier on behalf of the whole group.  Thus, the same structure serves for both related party (inter-company) and arms-length transactions.

*Payroll*

One of the most complex transactions in the company models prepared related to the payment for labour services provided by employees.  This is partly because, unlike most other services, the actual amount of the service is calculated by the organisation which consumes it (subject to contractual agreements and government regulations).  For example, these regulations may guarantee periods of paid leave (annual and long service) and specify sick leave entitlements.  A payroll program will apply such data (including the hours worked) in calculating periodic employee payments.  A selection of the data requirements is used here to illustrate this transaction; the full extent of the data requirements for the payroll calculations is beyond the scope of this thesis.

As a form of service flow, labour services can be modelled as a subtype of the *Service Flow* entity as illustrated in the following diagram.
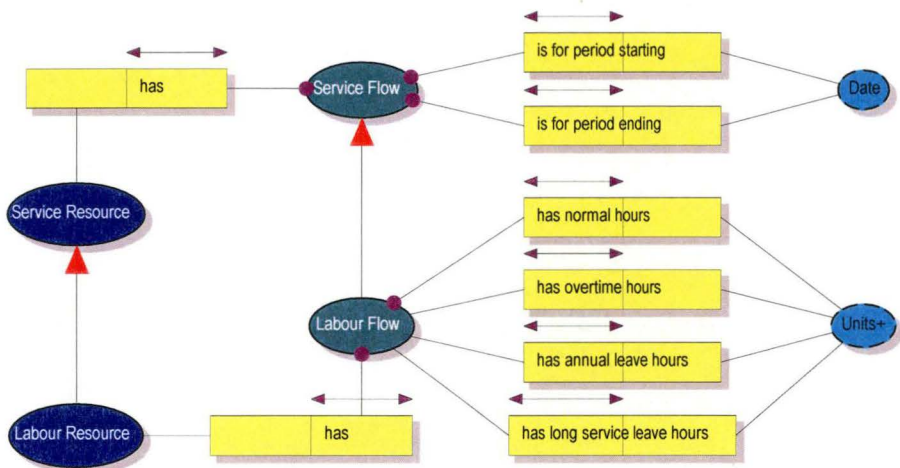
**Diagram 7.2.10  Modelling Labour Flows**

The payroll system applies this data for a specified period of time (for example, weekly, fortnightly or monthly) in calculating the payments due.  For a variety of reasons, legal and otherwise, not all of employees' monetary entitlements are paid directly to them.  Deductions may be made, for example, to cover tax, superannuation, union dues and medical insurance.  These amounts are paid directly to the appropriate agencies on behalf of the employee together with any additional contributions made by the employer.  The results of the payroll calculations can be represented as a subtype of the *Money Flow* entity as illustrated in the following diagram.
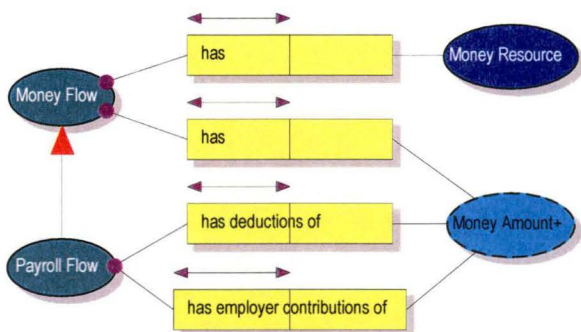
**Diagram 7.2.11  Modelling Payroll Flows**

The value of the *Money Flow* entity represents the amount payable to the employee (their net pay).  The totals of the deductions and employer contributions will be encapsulated in other *Money Flow* entities representing the payment of these amounts to the appropriate agencies.[38]

The two new subtypes can be combined to form a payroll exchange.

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[38]  Only the totals of deductions and employer contributions have been shown here; in practice there would need to be a separate value recorded for each different agency.
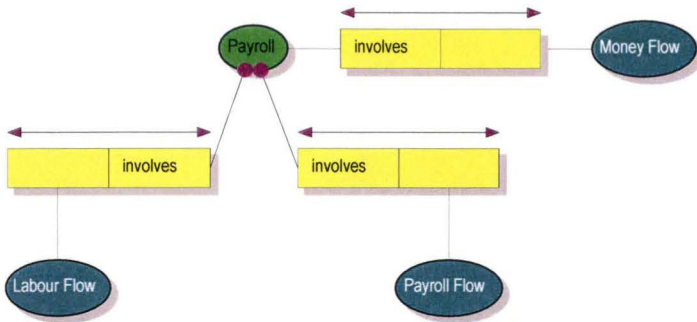
**Diagram 7.2.12 Modelling Payroll Exchanges**

A payroll exchange is represented by a combination of one or more *Labour Flow* entities and one or more *Payroll Flow* entities. The number of *Labour Flow* entities will depend upon the number of employees, the frequency with which labour time is recorded, and the length of a pay period. For example, if employees complete daily time sheets (over a 5-day working week) and are paid on a weekly basis, then there will be 5 *Labour Flow* entities per employee for each payroll exchange. These will be offset by one *Payroll Flow* entity for each employee together with one a *Money Flow* for each instalment due to those agencies for whom deductions have been made or employer contributions calculated. Since this is an external exchange, each flow entity will be associated with an *External Party* entity.

### 7.2.7 Modelling Internal Exchanges

The data models prepared in Chapter 6 revealed a number of transactions being recorded in the accounting system which did not involve external parties. These internal exchanges can be modelled in a similar manner to the external exchanges, but without any associations with *External Party* entities. Each of the internal exchanges identified will be discussed in turn.

*Money Transfer*

Most organisations hold their monetary assets in more than one "location". For example, they may have petty cash as well as several bank accounts. The movements of funds between these locations can be recorded by a simple set of *Money Flow* instances consisting of at least one outflow from one money account and one inflow into another money account.
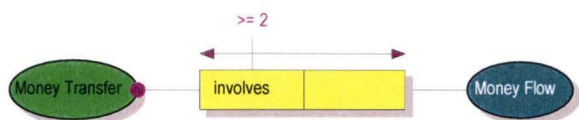
**Diagram 7.2.13 Modelling Money Transfer Exchanges**

*Production*

The production process involves the conversion of raw materials into finished goods (or raw materials for use in a subsequent production process). As such it can be modelled as a set of *Inventory Flow* entities, each different inventory item which acts as either an input to, or as an output from, the process being represented by a separate instance. This is illustrated by the following diagram.
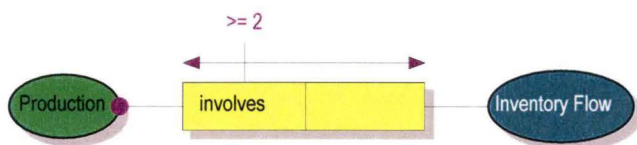


**Diagram 7.2.14 Modelling Production Exchanges**

It is assumed that a production process must involve at least one input and at least one output and hence a constraint has been specified that the exchange must comprise at least two *Inventory Flow* entities.[39]

*Inventory Transfer*

If the location is maintained as an attribute of an inventory resource, then its movement from one physical location to another will need to be recorded. This can be represented by a matched pair of *Inventory Flow* entities.
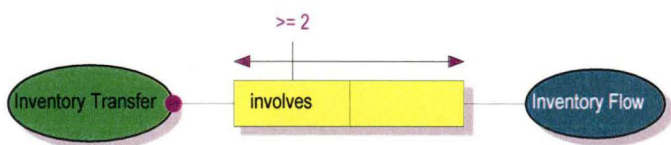


**Diagram 7.2.15 Modelling Inventory Transfer Exchanges**

The exchange should consist of at least one inflow and one outflow. The net flow of inventory items should net to zero or this constraint could be relaxed in order to allow for losses in transit. The only difference between the associated inventory resources should be the location attribute; the inventory is identical in all other respects. This exchange can be

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[39]    The additional restriction that there must be at least one inflow and one outflow is not shown on the diagram.

used to provide information about expected transfers and the destination of inventory in incomplete transfers as well as updating inventory records for completed transfers. Transfers of multiple inventory items can either be modelled as separate exchanges or combined into the same exchange.

*Inventory Count*

From time to time physical counts of inventory may be undertaken. These may identify differences between the levels counted and those recorded in the accounting system. These differences can be recorded as "one-sided" *Inventory Flow* entities as depicted below.
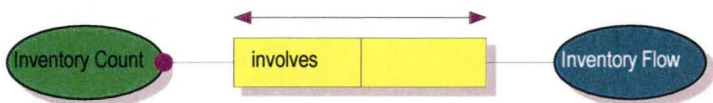


**Diagram 7.2.16 Modelling Inventory Count Exchanges**

The valuation of the gain or loss of inventory would be calculated using a procedure based on an appropriate accounting method selected by the user requesting the report.

*Internal Usage*

Whilst inventory is normally purchased for resale (or for the production of goods for resale) on some occasions inventory (including finished goods) may be used within the organisation itself. For example, a computer manufacturer may allocate some of its production for use by its own office staff. Such an occurrence represents the transformation of an inventory resource into a service resource as depicted in the following diagram.
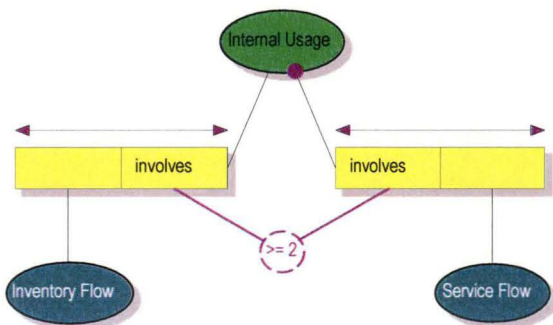


**Diagram 7.2.17 Modelling Internal Usage Exchanges**

The *Inventory Flow* entity would represent an outflow, whilst the *Service Flow* entity would be an inflow. The exchange will always involve at least two flows, one of which

must be a *Service Flow*. The above diagram has generalised this exchange further by including the possibility of the internal use of service resources as well as inventory resources. In particular this is used to record the capitalisation of labour services used in the production of a fixed asset. For such a case, the inflow would be a service flow associated with the service resource representing the fixed asset. The outflow would be represented by one or more *Labour Flow* entities for a specified time period with a negative number of labour hours. These flows would have the effect of reducing (offsetting) the labour costs charged to that period as a result of payroll exchanges. The same effect could have been achieved by directly allocating labour hours from the original external *Labour Flow* entities (comprising an external payroll exchange) to the internally generated service resource. This solution would be appropriate when the hours on employees' time sheets can be attributed to specific tasks.

*Bad Debt Write-Off*

A bad debt represents the view that no (or only part) payment will be received from a customer. Such a change in expectations can be recorded simply by updating the appropriate exchange which must already exist in the accounting system. The exchange will include one or more incomplete (future) *Money Flow* entities; the values of these entities may be modified to reflect the new expectations. In the case of a complete write-off, removing the entities from the exchange or reducing their values to zero would have the same effect (except that the latter would make it clear that payment was expected rather than the "exchange" being a gift). When evaluating a sale exchange, any imbalance between the value of the payments received (and any expected to be received) and the value of the goods and services sold can be assumed to represent the value of bad debts.

*Matching*

The matching of expenses and income is a fundamental accounting concept. Where resources are identifiable and inflows and outflows are recorded separately (as with the *Inventory Resource*) this matching process is straightforward. However, there are other cases where services are to be matched against income. Consider the following example which is based on an actual situation from one of the companies modelled:

> On 9 June customer *C991* paid in cash for 500 cartons of inventory item *10AD* at a price of $125 per carton plus a delivery charge of $250. The

delivery date is agreed at 16 June. All deliveries are undertaken by an independent freight company (supplier *S228*). They agree to deliver this order on the agreed date at a cost of $200. Their invoice is payable on 30 June.

This exchange can be modelled as a set of flows as illustrated in the following diagram.
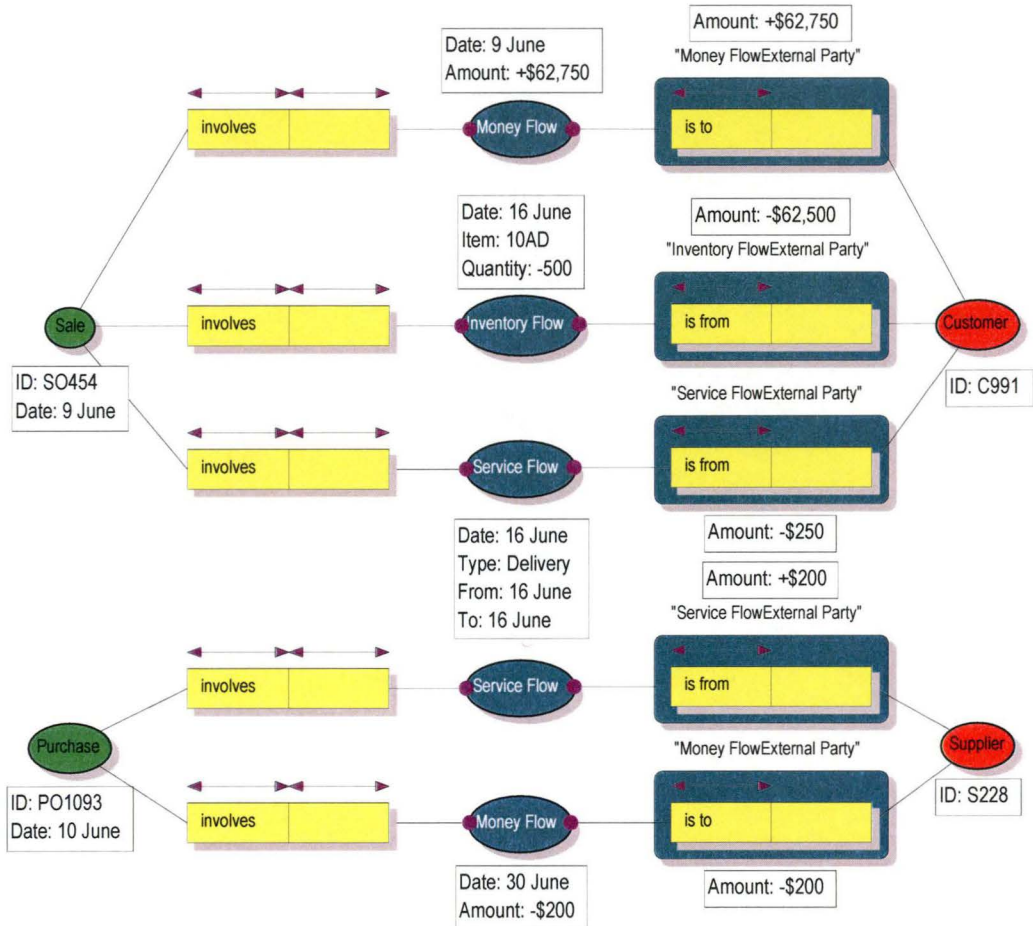


**Diagram 7.2.18  Example of Matched Resource Flows**

The two exchanges (a sale and a service purchase) would be created normally. Interpreting the sale exchange is performed as follows:

❖ *On 7 June*: no knowledge and records of this sale are available and so it does not appear in the accounting system.

❖ *On 10 June*: the sale has taken place but has yet to be delivered and hence is treated as an order. Since the customer has already paid the money flow must be treated as "revenue received in advance" (a current liability).

❖ *On 19 June*: the goods have been delivered and the sale is now complete; the cash received becomes sales revenue.

The service purchase exchange can be interpreted in a similar way:

❖ *On 7 June*: no knowledge and records of this sale are available and so it does not appear in the accounting system.

❖ *On 9 June*: the need for this service is now known but has yet to be negotiated with a supplier and so has not yet been entered into the accounting system (or only estimates have been entered).

❖ *On 10 June*: an agreement for delivery is made with a supplier and the exchange is recorded. Since none of the flows has yet arisen it does not affect the financial statements at this time.

❖ *On 19 June*: the delivery has now taken place and is treated as a cost of sale and a trade creditor.

❖ *On 1 July*: the supplier has now been paid so there is no longer a trade creditor. Instead the money resource is reduced by the outflow.

The matching of the service flows occurs automatically because their details are identical. In this case both the service sale and the service acquisition are attributed to 16 June; any reports prior to this date will exclude them from income and expenses whilst any reports after this date will fully include their value. The *Service Resources* associated with the service flows would provide the details necessary to classify the income and expenditure appropriately for reporting purposes. The main requirement is for the service purchase exchange to be recorded in the accounting system prior to the delivery date, otherwise any reports generated at this point in time will have no cost to match against the revenue generated from the delivery charge to the customer. This is only a concern if a financial statement is required during the intervening period (between the delivery and the recording of the service purchase exchange); once the exchange has been recorded, any back-dated reports produced will correctly include the matched resource flows.

*Foreign Currency*

All of the examples described above have involved money flows in a single currency. It is not uncommon for organisations to participate in transactions with organisations in other countries and have debts expressed in a foreign currency. Even trading within the same country may involve foreign currency values; for example, when the prices of global resources (such as oil) are quoted in another currency. No changes are required to the new accounting data model to accommodate alternative currencies. All *Money Amount* values are assumed to represent both the number of currency units and the currency in which

these units are denoted.  In the examples illustrated here, this is shown by prefixing each money value with a currency symbol (for example, \$50).[40]  For example, the following diagram illustrates the representation of the exchange of inventory resources discussed above (see Section 7.2.5) if the price quoted by the supplier was in Great British pounds (£) rather than Australian dollars (£2 each rather than \$5 each assuming an exchange rate of \$1=£0.40).
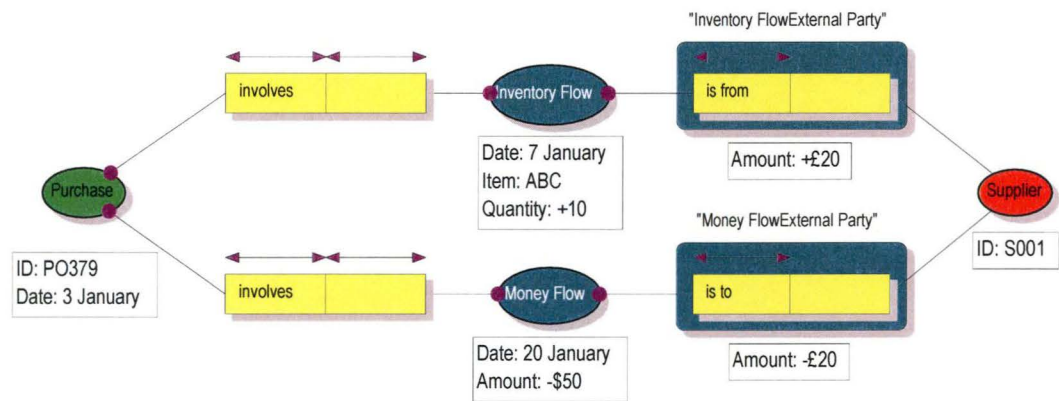


**Diagram 7.2.19  Example of an Exchange Involving Foreign Currency**

The only changes from the original example are that the values of the flows to the supplier are stated in pounds rather than dollars.  This exchange can be interpreted as follows:

❖  *On 7 January*: inventory is received and a trade creditor is reported with a value of £20  converted to its Australian dollar equivalent at the exchange rate for the date at which the liability is being stated.  Thus the value of the trade creditor (and, therefore, the cost of the inventory purchased) may fluctuate over the period before payment is made.  This would be reflected in changes to the amount of the *Money Flow* entity as this represents the Australian dollar equivalent of the amount payable.

❖  *On 20 January*: the supplier is paid by way of an international bank transfer direct from the organisation's bank account operated in Australian dollars.  The cost of transferring £20 to the supplier was \$50.  Since there are no further outstanding money flows for this exchange, the cost of the inventory can now be finally determined.  The actual cost attributed to the inventory is a matter of accounting

[40]  In practice a *Money amount* value may be divided into two separate values: the number of units and the currency.  It will also be important to ensure that unique representations of currencies are used.  For example, the \$ symbol could refer to many different currencies.  Codes such as AUD (for Australian dollars), USD (for US dollars) and GBP (for Great British pounds) as used in the banking industry provide one solution.

choice (codified as alternative procedures within the accounting system). For example, the cost might be taken to be the amount of the money outflow ($50), or it might be deemed to be the dollar equivalent of £20 at the time the inventory is received (7 January) with any difference from the actual outflow of $50 being treated as a gain or loss on exchange. The important matter is that the data required to implement the preferred accounting policy are captured by the accounting data model.

Additional data are required to implement foreign currency transactions in the form of the relevant exchange rates. If all translations were between Australian dollars and a foreign currency then the following structure would be sufficient to capture this data.
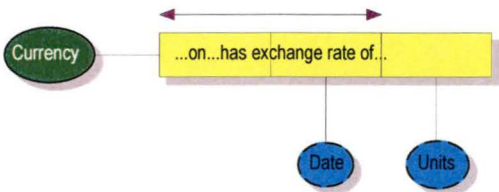


**Diagram 7.2.20  Modelling Exchange Rates**

Other translations could be made by using cross rates. Alternatively for a more comprehensive set of exchange rates, the structure could be extended as shown in the next diagram.
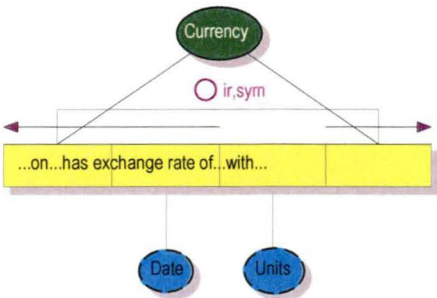


**Diagram 7.2.21  Modelling Cross Rates**

This would allow the exchange rate between any two currencies to be captured; cross rates could still be used for any which were not recorded.

At least for major currencies, exchange rate data should be readily available. One source, for example, would be to automatically download the data from the Internet on a regular basis. Exchange rates for missing dates can be estimated from the rates of the closest dates for which data are available.

The currency entity does not strictly form part of the accounting data model because it is only required for reporting purposes. Other similar cases would include share price data (for valuing shares held by the organisation, or valuing its own shares for financial analysis purposes) and other price indices as applied in current value accounting (for example, general and specific inflation rates).

### 7.2.8 Other Transactions

The transactions from which the company models were prepared are not completely exhaustive of all the types which might arise even in the manufacturing industry. Some of the more obvious omissions are discussed here to illustrate that the accounting data model proposed here can be easily extended to accommodate many new types of transaction.

*Sales Tax*

In July 2000 (subsequent to the time of the original data collection which formed the basis of the company data models in Chapter 6) Australia, in common with many other countries (such as the UK and the US) introduced a tax on sales of goods and services (GST). This system effectively makes every business a collector on behalf of the Australian Tax Office (ATO); GST must be added to the value of sales invoices and amounts paid to suppliers will include sales tax charged by them. The net difference between the GST charged and the GST suffered is paid to (or received from) the ATO after the end of the tax period. Consider the example above involving the purchase of property insurance (see Section 7.2.5). If sales tax is now chargeable on the premium at a rate of 10% the cost would rise to $5,500. However, the additional $500 would be recoverable from the ATO in the return due by 21 April. The complete exchange can then be summarised as illustrated in the following diagram.
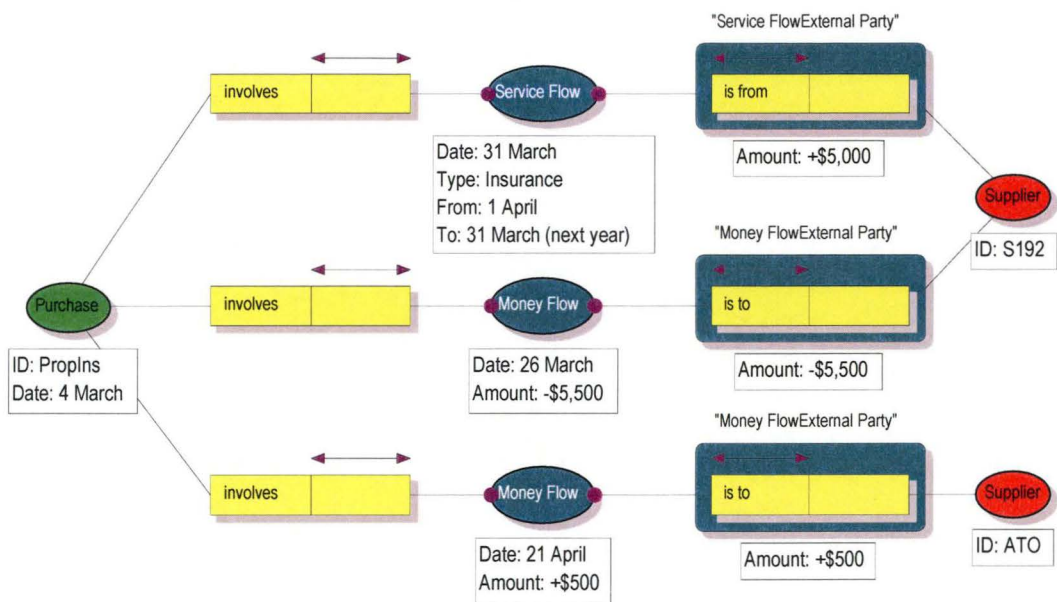
**Diagram 7.2.22 Example of an Exchange Involving Sales Tax**

The changes required are:

❖ the adjustment of the amount of the *Money Flow* instance to the supplier (from $5,000 to $5,500) to reflect the sales tax payable;

❖ the addition of another instance of a *Money Flow* to record the sales tax recoverable from the ATO 21 days after the end of the tax period.[41]

At the end of each tax period, the *Money Flow* instances due to the ATO on the next reporting date can be summed to calculate the amount of any payment or refund due. These instances may include outflows arising from sale exchanges as well as inflows resulting from purchases. Thus a single receipt or payment can be represented by one or more *Money Flow* instances each having the same date and external party values.

*Capital Flows*

None of the company models included transactions in relation to sources of long-term capital (such as equity and loans). These may also be easily incorporated into the new accounting data model.

A loan is essentially a series of *Money Flow* instances extending over a period of time. For example, an interest-only loan of $10,000 repayable in 10 years time could be represented

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[41] If a cash basis of accounting for GST is used, then the date of the money flow to the ATO will be based on the date of the money flow to the supplier rather than when the services are invoiced.

as an exchange involving two money flows: an inflow of $10,000 from the lender now and an outflow of $10,000 in 10 year's time. At any time during the period of the loan, a liability of $10,000 will be identified from the outstanding future outflow recorded in the accounting system. Interest is a service and can be recorded in the same way as other service purchases. Since the interest payments are known in advance they could all be incorporated into the same exchange (including the loan principal if desired). In this way, the accounting system is always aware of the timing of future interest instalments, and the interest can be properly accrued against the income for the period. A constant repayment loan can be recorded in a similar manner. Consider this example:

> A loan for $100,000 is negotiated on 1 August at an interest rate of 10% p.a. The loan commences on 31 August and is repayable in two equal annual instalments.

This loan can be modelled as illustrated in the following diagram:
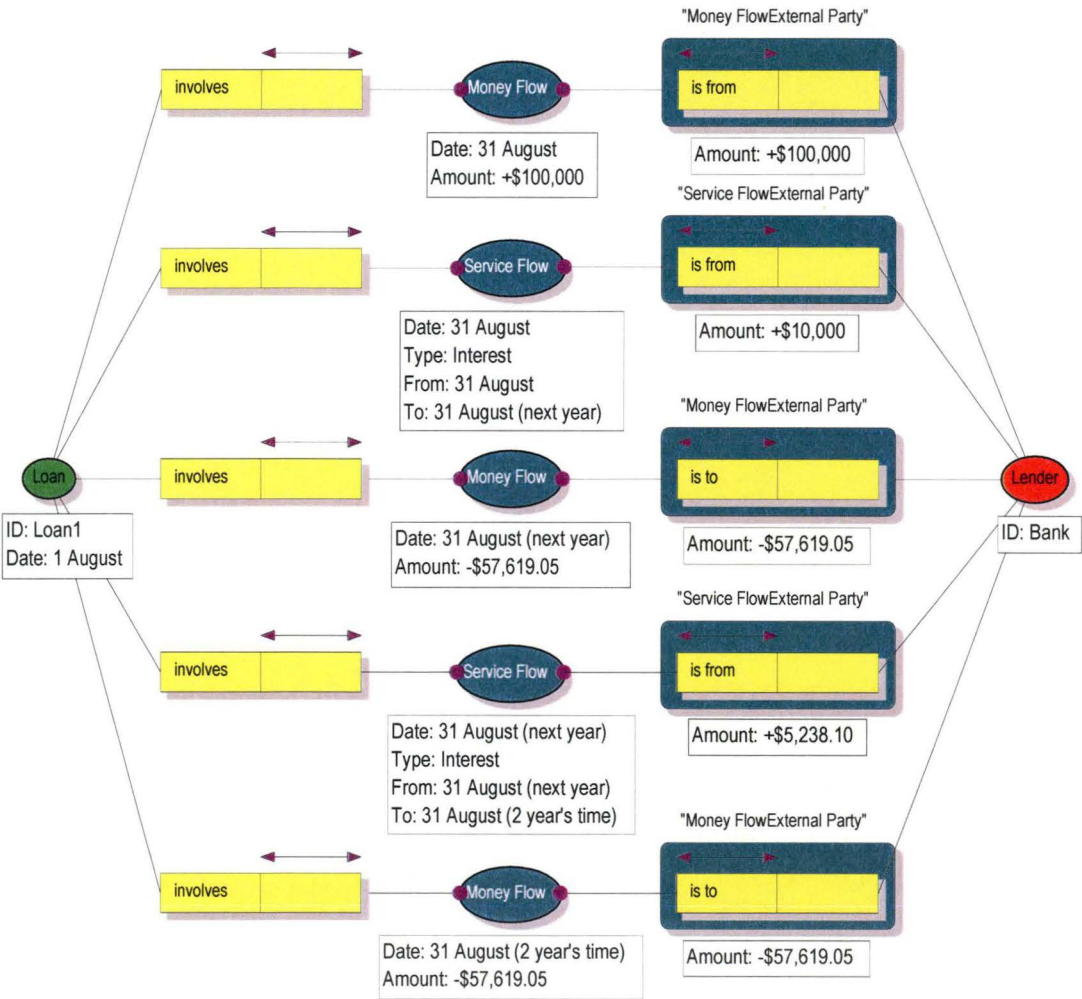


**Diagram 7.2.23 Example of a Loan Exchange**

This diagram shows the full impact of the loan on the organisation. The initial money flow represents the receipt of the funds from the lender. Then each year there is a service flow representing the interest payable on the loan and a money flow representing the instalment of the loan paid to the lender. The amount of the service declines over time as the principal is reduced. The amount of the instalments remains the same but the proportion representing repayment of principal will increase over time as the interest declines. The outstanding amount of the loan at any point in time is the net amount of any outstanding money flows and service flows. Thus, at 1 September next year, the outstanding balance is the final repayment due at the end of the second year ($57,619.05) less the interest which relates to the forthcoming year ($5,238.10). This gives a liability of $52,380.95.[42] A loan can also be modelled using a separate exchange for the money flows representing the loan principal with interest being treated like other purchases of services. The loan repayments would be the summation of all the money flows due to the lender on the same date (the principal plus the interest). In this way the interest elements of all the repayments do not have to be recorded until the period to which they apply, although the interest due will have to be calculated in order to record the flows of loan principal.

If interest rates change during the period of a loan, then the values of the future flows can be updated to reflect the new amounts due and costs of interest services. If the interest rate changes between repayments, the interest (service flow) for the period in which it occurs can be split into two: one representing the interest due up to the date of the change and the other for the interest due for the remainder of the period. This will allow interest to be properly allocated to the correct period for reporting purposes. These calculations could be performed automatically as part of the user interface designed when implementing a system based on the A:*xis* model.

Equity flows are quite similar to those of loans. The initial share issues represent money inflows which earn a return by way of dividends. Unlike loans, dividend payments do not represent the purchase of services (interest) but a share of surplus income generated by the organisation. It is, therefore, easier to model capital transactions separately from dividend

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[42]  Since the inflows and outflows of the loan exchange sum to zero, the balance could have been calculated by negating the net sum of the flows which have already taken place. However, it is preferred to base estimates of future liabilities on the data representing these expected flows. This will properly account for unbalanced exchanges.

transactions in the case of equity.  The share capital is like an indefinite, interest-free loan as illustrated in the following diagram.
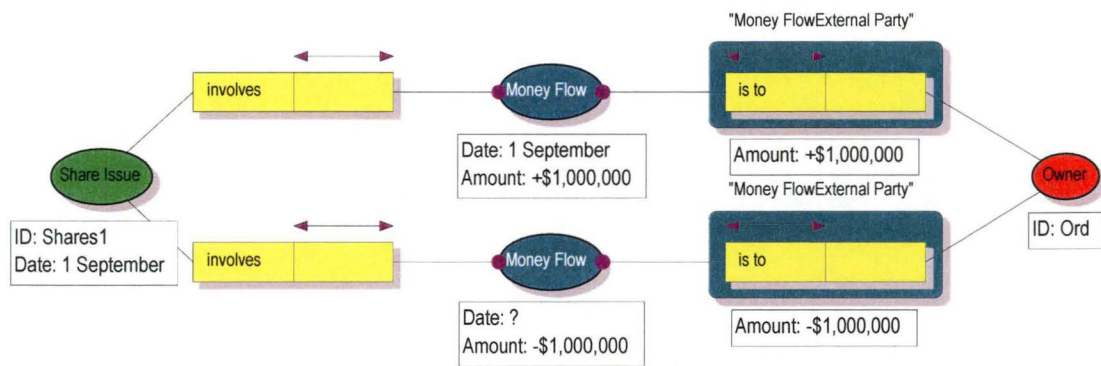


**Diagram 7.2.24  Example of a Share Capital Exchange**

The shares issued on 1 September represent an inflow of money which is repayable at some future, unspecified date (i.e. when the company is liquidated).  This future liability is represented by the existence of an undated (future) money flow for the negated amount of the share capital.  Dividends, on the other hand, represent unrequited distributions as show in the following diagram representing a dividend payment of $10,000 on 1 October.



**Diagram 7.2.25  Example of a Dividend Exchange**

For reporting purposes the value of equity on a balance sheet is essentially the balancing figure and so it is not important that the above exchange is unbalanced.  The data are useful only in ensuring that the balance of the appropriate money account is correctly reduced by the outflow and for analysing changes in equity over a period.

*Flows of Non-Economic Resources*

So far the new accounting data model being proposed includes only economic flows; that is flows which have an economic (monetary) effect on an organisation.  However, the model is extensible in that it can also incorporate other flows which arise as a result of an exchange.  Such flows can simply be ignored by report generators if they are not relevant to the content of the report.  Types of non-economic flow will depend largely on the nature of the organisation's business activities.  Gray *et al.* (1996) illustrate a variety of forms of

social and environmental reports, including an eco-balance prepared by Danish Steel

Works Ltd which

> "showed what inputs (materials supplied) had been converted into (finished
> goods, emissions, recyclable waste products and other waste products). The
> quantity of materials was reported in tonnes including water usage. The
> amount of electricity used was also reported" (Gray *et al.* 1996, 178)

A production process will be considered to illustrate how non-economic resources can be

integrated into the proposed accounting data model. In addition to the raw materials

(inventory items) which act as inputs to the process and the items produced as outputs, a

production process may involve other effects of interest such as flows of "free" resources

into the process and waste products produced by the process. The number of machine

hours taken may also be recorded as a basis, for example, of cost allocations. The

following diagram illustrates a hypothetical production exchange including non-economic

flows.
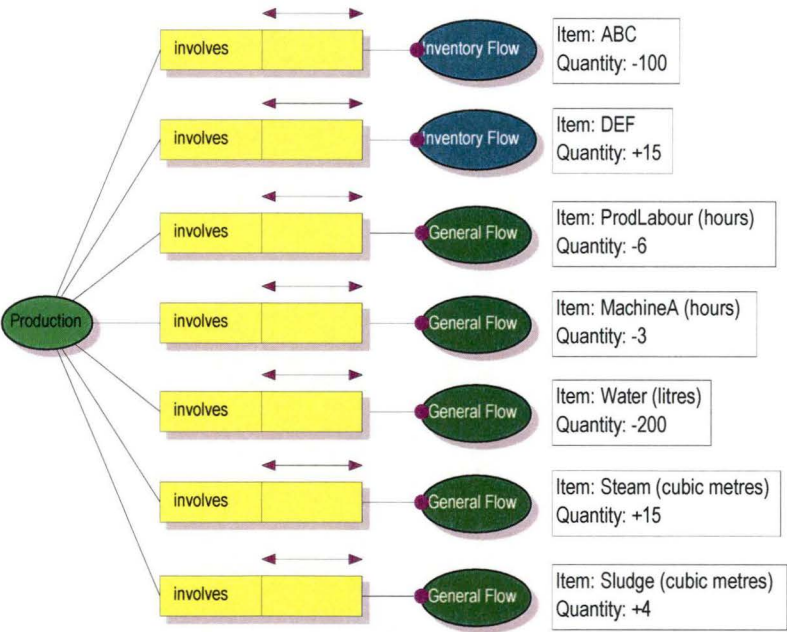


**Diagram 7.2.26 Example of a Production Exchange**

This diagram describes the production of 15 units of inventory item *DEF*. The process

requires inputs of 100 units of inventory item *ABC*, 200 litres of water, 6 hours of

production labour and 3 hours of time on Machine A. In addition to the units of *DEF*, the

process generates $15m^3$ of steam (which is released into the atmosphere) and $4m^3$ of sludge

(which requires disposal). Each of the non-economic flows has been denoted by a *General

Flow* entity to illustrate how other flows can be included. These entities, for example,

allow a description of what is flowing and by how much. The direction of the flow can be determined from the sign of the flow's quantity. The labour and machine hours are described here as general flows rather than flows of services because the economic flows have already been recorded (when the services were acquired) and their allocation against income is assumed to be on a time basis. However, for financial reporting some manufacturing costs will be attributed to the value of finished goods, but the method used is a matter of accounting choice which should be encapsulated in procedures so that the user can select their preferred method. The numbers of hours recorded in the general flows may be required in order to implement these methods.

If more detailed records of other flows are required, then an alternative solution would be to treat them as inventory items which have no cost. For example, the volume of water extracted from the local waterway could be recorded as an inflow, and its consumption in various production processes recorded as outflows (inputs); any water available for re-use or returning to the waterway could be another inflow (output) from the production process. Waste by-products which have to disposed of at a cost could also be recorded as inventory items with a negative selling price. For example, the 4m³ of sludge could be recorded as an inventory flow which is then "sold" (at a negative price) to the waste management contractor. The following diagram illustrates an example of such a sale.
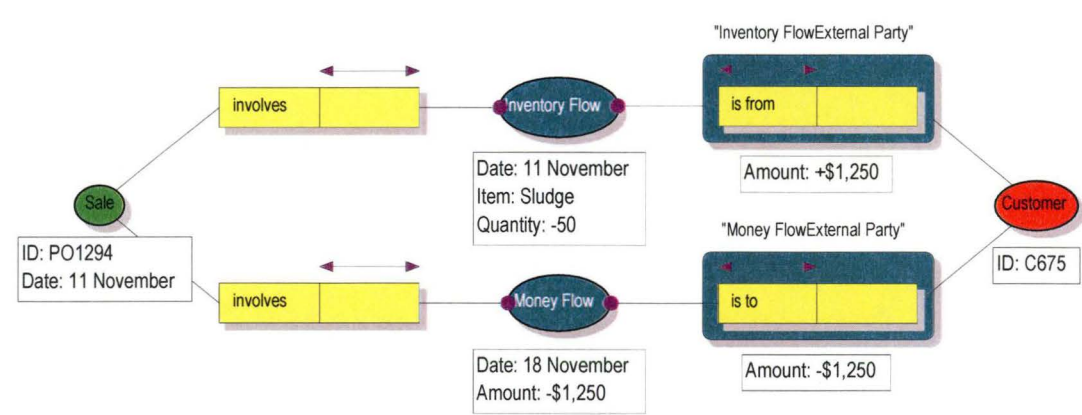


**Diagram 7.2.27 Example of a Waste Disposal Exchange**

50m³ of sludge is "sold" to the waste management contractor (*C675*) who is paid $25 per m³ for disposing of it. The cost of this sale would be attributed to the sludge and could, therefore, be included in the costing of the other items produced (in the same way that by-products which can be sold to generate revenue would be included). This example also illustrates the benefits from making no distinctions between purchase and sale exchanges

and between suppliers and customers. The disposal of inventory items may involve an inflow or an outflow of money, and external parties may act in both customer and supplier roles.

## 7.3 Generic Model Definition

The previous section has outlined a new accounting data model and illustrated how it can be used to record a wide range of business activities. It models these activities as sets of exchanges in which resources may flow in and/or out of the organisation. These flows may be of resources which have no economic value but which may be of interest to users. Flows to/from outside the organisation (external parties) are assigned a monetary value. Internal flows (those not involving external parties) are attributed values on the basis of applying accounting policies selected by the user requesting information from the system.

### 7.3.1 Exchange Models

The concept of exchanges arises in a number of different contexts not only with economic resources. For example, the *Law of Conservation of Matter* states that:

> "In chemical reactions, the quantity of matter does not change. The total mass of the products equals the total mass of the reactants." (Umland and Bellama 1999, 74)

Thus, ordinary chemical reactions are similar to a simple accounting exchange in which the amount given up is the same as the amount obtained, where amount is measured in terms of mass, money or money equivalent (such as inventory). However, in accounting this equality is not a law of nature and can be broken: accounting exchanges are artificially created and may not be balanced. For example, a bad debt implies that the monetary value of goods given up is not recovered in full. In addition the units of measurement used in accounting are not physical measures and hence are subject to variation. The prices of non-monetary assets can change without there being any physical change in the asset itself. Unexpected demand for a product can increase its price overnight and render a windfall gain to the owner. Although the values of monetary assets are fixed in terms of the number of currency units, the value of a currency unit is not constant (for example, for reasons of inflation or exchange rate fluctuations). Even "in nuclear reactions where the mass of the products is almost never equal to the mass of the reactants" (Umland and Bellama 1999,

806) some of the mass of the reactants is converted to energy. However, combining the *First Law of Thermodynamics*, "energy cannot be created or destroyed" (Umland and Bellama 1999, 197), with the *Law of Conservation of Energy* leads to the *Einstein Equation* ( $E = mc^2$ ):

> "total mass-energy before reaction = total mass-energy after reaction"
> (Umland and Bellama 1999, 807)

Thus a modelling approach suitable for recording economic exchanges may also be appropriate for other, simpler cases where the laws of nature place greater limitations on the forms that they can take. The general approach is, therefore, referred to as an e**x**change **i**nformation **s**ystem (xis), with the specific version designed for accounting systems given the name of A:*xis* (where the "A" stands for accounting). The approach may be adapted for other domains to generate additional versions of *xis*-based models.

### 7.3.2  *xis* Constructs

The basis of an *xis* model is an exchange entity which comprises one or more entities representing the flows of resources. As an information system, the date on which each flow takes place would be recorded as well as the size and direction of the flow. The general form of this model is shown in Figure 7.6.
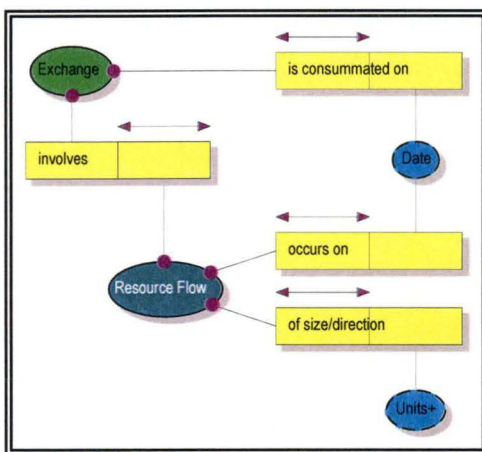


**Figure 7.6     General Form of an *xis* Model**

These constructs are defined as follows:

❖ *Exchange* - a process or activity which involves the flow of at least one resource. An exchange may take place instantaneously (all resource flows occur at the same time) or over a period of time (resource flows may take place in any order).

❖ *Resource* - an object of interest whose quantity can be measured and for which changes in quantity can be detected (at particular points in time, if not continuously). A separate entity may be defined to record details of resources but this is not essential if no additional details are required.

❖ *Resource Flow* - the change in the quantity of a resource, whether it be an increase or a decrease in quantity.

❖ *Date* - a time stamp which denotes the date and time that an exchange is consummated or a flow occurs. The date should be recorded using a level of precision which permits the sequence of resource flows to be determined and allows flows to be partitioned into two sets before and after a date specified for reporting purposes.

❖ *Units* - a numeric value representing the size of the flow measured on a ratio scale. The units should be appropriate to the nature of the resource being measured. The sign of the value indicates the direction of the flow; by convention a negative value represents an outflow and a positive value represents an inflow.

An *xis* model, therefore, comprises a set of such exchanges from which reports on the flows of resources can be prepared.

### 7.3.3 A:*xis* Constructs

An A:*xis* data model is an extended form of *xis* model designed for accounting (economic) exchanges. It is built using the basic *xis* constructs with subtypes defined for the *flow* and *resource* entities to meet the specific needs of the accounting domain. The general form of an A:*xis* data model is shown in Figure 7.7 (the values for previously defined constructs have not been repeated in this figure).
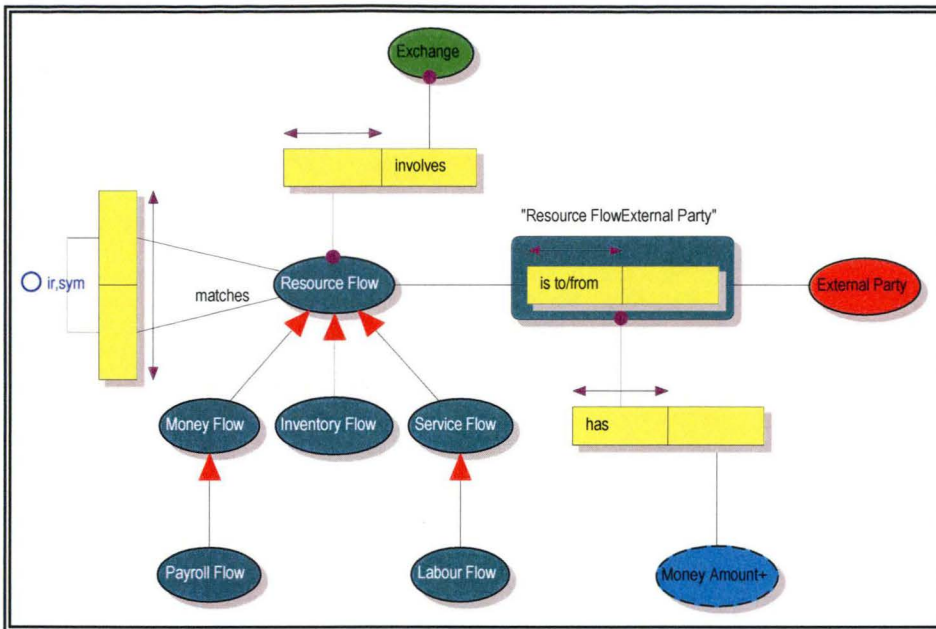
**Figure 7.7    General Form of an A:*xis* Model**

Accounting identifies three specific types of resource to which monetary values can be attributed: money, inventory and services.  The inclusion of other, non-monetary types of resources is optional.  Two types of resource flow are distinguished: flows to/from external parties and flows not involving external parties.  Examples of external parties include suppliers, customers, employees, owners and government agencies.  Money is used as the medium of exchange when trading with external parties and so each of these flows has a money value which can be objectively measured.  Definitions of the constructs added to form an A:*xis* data model follow in which references to "the organisation" mean the organisation whose exchanges are the subject of the A:*xis* data model and "party" includes real and legal persons and any other form of organisation which has a separate identity.

❖   *External party* - a party which exists independently of the organisation.  That is, it
     is someone other than the organisation itself, or a subdivision of the organisation.
     Examples of external parties include:

◆   *supplier* - a party from whom the organisation acquires non-monetary
     resources (other than as part of a contract of employment);

◆   *customer* - a party to whom the organisation supplies non-monetary
     resources;

◆   *employee* - a party from whom the organisation acquires labour services as
     part of a contract of employment;

◆ *owner* - a party who provides monetary resources for use by the organisation in return for rights to a share of the surpluses generated (such as a shareholder);

◆ *lender* - a party who provides monetary resources for use by the organisation on a temporary basis in return for interest payments (such as a financial institution);

◆ *borrower* - a party to whom monetary resources are surrendered on a temporary basis (such as a financial institution). On call amounts would not be included as these are still effectively under the control of the organisation.

Each of these examples may be defined as a subtype of the external party object.

❖ *External flow* - a resource flow between the organisation and an external party.

❖ *Money amount* - a quantity expressed in units of a specified currency.

❖ *Internal flow* - a resource flow which does not involve an external party but represents a flow within the organisation.

❖ *Money flow* - a resource flow involving the resource being used as the medium of exchange (normally units of currency).

❖ *Inventory flow* - a flow of a resource for which both acquisition and consumption flows are recorded (a discrete flow).

❖ *Service flow* - a flow of a resource for which acquisition flows are recorded but consumption flows are not measured but are instead deemed to occur over a specified period of time ( a continuous flow).

❖ *Labour flow* - a subtype of a service flow relating to the acquisition of labour services from employees, including those details of an employee's service necessary to perform payroll calculations.

❖ *Payroll flow* - a subtype of a money flow relating to the outflow of money to an employee in return for their labour services, including those details from an employee's payroll calculation necessary to determine the deductions made which should give rise to flows of money to other agencies.

❖ *Matching* - two or more resource flows may be matched for accounting purposes to ensure that they are reported in the same period.

Using these constructs, exchanges can be built to represent an organisation's business activities.

| Exchange Type | Flows | | Constraints |
|---|---|---|---|
| Purchase (inventory and/or service) | +<br>-<br>+ | inventory and/or service (supplier)<br>money (supplier)<br>money (ATO) | Must balance, except when applying standard costs where any imbalance will represent a price variance. |
| Sale (inventory and/or service) | -<br>+<br>- | inventory and/or service (customer)<br>money (customer)<br>money (ATO) | Shortfalls treated as bad debts. Excesses not permitted. |
| Payroll | +<br>-<br>- | labour service (employee)<br>payroll (employee)<br>money (ATO and other agencies) | Must balance. |
| Production | -<br>+ | inventory and/or service<br>inventory | Inventory outflows are normally valued on the basis of the value of the inventory inflows but, when standard costing is used, any imbalance represents a usage variance. |
| Inventory transfer | -<br>+ | inventory<br>inventory | Inventory items flowing in each direction should match in all respects except for location and possibly quantity. Imbalances treated as windfall gains/losses. |
| Inventory count | ± | inventory | Must not balance! Imbalances treated as windfall gains/losses. |
| Internal usage | -<br>+ | inventory<br>service | Balances because the values of outflows are based on the values of inflows. |
| Loan | +<br>+<br>- | money (lender)<br>service (interest)<br>money (lender) | Must balance. |
| Equity - share capital | +<br>- | money (shareholder)<br>money (shareholder) | Must balance. |
| Equity - dividends | +<br>- | service (dividend)<br>money (shareholder) | Must balance. |

**Table 7.2    Representation in an A:*xis* Model of Typical Types of Exchange**

### 7.3.4 Typical A:*xis* Exchanges

As already noted above, accounting exchanges represent flows of resources in which the money value of the inflows may not equal the money value of the outflows. It is necessary, therefore, to identify the type of an exchange because this will determine how any imbalances should be treated. The treatment of imbalances will depend upon the purpose and content of the report being generated. It may also be a subject of user choice. It is important to recognise that the accounting data model does not seek to interpret the meaning of any imbalances; it only permits their existence to be identified. It is left to reporting procedures to decide how such imbalances should be treated based, for example, on user choices, and the nature and purpose of the report. Table 7.2 summarises typical accounting exchanges, including those identified from the company models developed.

## 7.4 Comparison with Alternative Models

### 7.4.1 Comparing A:*xis* with REA

It is not surprising that an A:*xis* data model bears many similarities to the REA template as both seek to semantically model the same domain and are based on accounting theory (such as Ijiri 1975). The original definition of the REA template (McCarthy 1982) comprised 6 main elements: economic resources, economic events, economic agents, stock-flow, duality and control.

*Economic resources*

The REA definition of economic resources is based on Ijiri (1975) which requires resources to be under the control of the organisation, have utility and be scarce. This definition is further restricted to what Ijiri (1975) terms *present assets*. An A:*xis* data model relaxes the definition by removing the scarcity condition thereby allowing free goods to be included. The underlying rationale is that the model should permit flows of any resource in which the organisation is interested (the utility criterion) and are consequential to the business activities (the control criterion). Although free goods do not have any economic impact on financial reports, they may be of interest, for example, when preparing environmental reports.

Future assets are represented in an REA model by incomplete exchanges. In an A:*xis* data model, only the complete details of exchanges are recorded; future assets are represented by flows of resources recorded as being expected to occur at some future point in time.

Resource entities do not appear in the general form of an A:*xis* data model not because they are unimportant but because it is only their identification which is essential and not their recording. A resource flow must be for an identified resource, but if no details about this resource are required, then no resource instance need be created for it. In most cases it is expected that resource instances will be created. For example, descriptions, locations, selling prices etc may be recorded for inventory items. But the absence of a resource instance does not prevent many accounting reports from being prepared since they are summaries of movements in resources and not of the resources themselves.

*Economic events*

REA adopts the definition of economic events by Yu (1976); being changes in economic resources "resulting from production, exchange, consumption, and distribution". Economic events are similar to the *Resource Flows* of an A:*xis* data model. The more general term is preferred because the definition of resources is not restricted to economic resources, and the term "flow" is considered a better description of the purpose of the entity. The term "event" can be misinterpreted as implying that it occurs as a result of some activity, and not all activities give rise to flows of resources (for example, a sales call). There is otherwise little difference between REA's economic events and A:*xis*'s resource flows; both seek to measure changes in the resources identified as being of interest.

The REA template only recognises discrete events. Continuous events arising over a period of time, must be divided into a set of discrete events to be recorded. These sets of events must be designed to coincide with reporting dates to ensure that they are properly reflected in reports. An A:*xis* data model recognises that some resource flows do not arise at discrete points in time; for example the consumption of an insurance premium. In addition some discrete flows may not be considered significant enough to warrant being recorded as such, and so they may be treated as a single continuous flow over a period; for example, the consumption of items of stationery. Thus an A:*xis* data model distinguishes

between *Inventory Flows* (discrete) and *Service Flows* (continuous). Inventory flows represent both the acquisition and consumption of resources; service flows represent only the acquisition flow, the consumption being calculated by applying appropriate procedures to its data values. Finally, those flows of the resource which represents the medium of exchange (normally assumed to be money) are separately identified as *Money Flows*.

*Economic agents*

The REA template assumes that two parties participate in each event, at least one from within the organisation. Other research (for example, Denna *et al.* 1994) has already noted that there may be other parties of interest, such as the person recording the event, and the person responsible for the custody of the resource. Others are also possible, such as the person authorising an event. What is clear is that there may be a number of parties involved in an event, each of which may be of interest to record for reporting purposes.

Similar to the approach adopted with resources, an A:*xis* data model does not seek to be prescriptive about the modelling of internal and external parties. The level of detail included in a model should depend upon the information needs of users and, therefore, may be different for each industry or organisation. The aim of an A:*xis* data model is to be easily adaptable to fit specific needs, so only essential elements are included in its general form. External parties are included because of their significance to the application of accounting valuation bases and because it is likely that further details about these parties will be required (such as delivery or postal addresses). Internal parties can often be recorded as a simple value of an entity because nothing more than an identification is required.

There can be some difficulty in determining whether a party is internal or external or perhaps the same party can play both roles. This is most obvious when considering employees. An employee may participate in an event (flow) as an internal agent of the organisation (for example, the salesman) or as an external party (for example, a payment of wages). An A:*xis* data model avoids this dilemma by defining all parties, other than the organisation whose resource flows are being modelled, as being external parties. Subtypes of this entity allow different groups of external party to be differentiated and for parties to act in more than one role (for example, as both an employee and a customer). The recording of internal parties (those acting on behalf of the organisation) should be clear

from the nature of the relationship which has been defined. For example, a "records" relationship between a resource flow and an employee would represent an internal role. But when an employee acts in a "is to/from" relationship with a resource flow, then they would be acting as an external party.

In summary, an A:*xis* data model does not consider the inclusion of agents as any less important than REA, but it merely seeks to be less prescriptive about their inclusion. External parties are emphasised because of their importance from an accounting valuation perspective and not solely because of their participation in an event. Internal parties, where recorded, should be clear from the nature of the relationship with which they are associated.

*Stock-flow*

In cases where a resource entity is defined and has associated flows, then an A:*xis* data model will also incorporate the *stock-flow* relationship. However, they are only deemed necessary when a model design requires details of a resource to be recorded. A resource flow can be recorded without the need for a separate resource instance; the resource which is the subject of the flow can be identified purely by a unique code.

*Duality*

The duality relationship is used in REA to associate an inflow event with an outflow event. In an A:*xis* data model this is replaced by associating flows with an exchange entity through an *involves* relationship. It is effectively the same as a duality relationship except that the introduction of an exchange entity offers a number of significant benefits. For example, the duality relationship is best suited to exchanges involving pairs of events, otherwise can be difficult to implement. Since even the simplest sale or purchase can involve 3 events (for example, when sales tax applies) this makes the method quite restrictive. With the creation of an exchange entity, any number of flows can be added just as easily as a single pair. In addition it allows the model to be extended to include flows of non-economic resources.

*Control*

As discussed above, an A:*xis* data model makes fewer prescriptions about the inclusion of internal and external parties. However, their inclusion may be made on wider grounds than merely control. The associations between external parties and resource flows may capture those involved in undertaking, authorising and recording the flow.

*Responsibility*

This relationship in the REA template seeks to model the accountability of employees for their actions. This could be included in an A:*xis* data model as a ring fact type for the employee entity but it is not essential for financial reporting purposes and so is not included in the general form of the model.

*Commitments*

The original definition of the REA template by McCarthy (1982) was designed to record transactions only once they had occurred; orders were included as an extension to the template. The more recent enhancements to REA (see Geerts and McCarthy 2001) have incorporated the concept of *commitments* which can be used to reflect orders. These were added whilst maintaining the original structure intact. An A:*xis* data model takes a radically new approach by treating all resource flows (both past flows and those expected in the future) in the same way. All exchanges in a system based on the A:*xis* data model should be completely recorded using the best estimates of values known at the time. Thus, there is no need for different entities to be defined for commitments (orders) and sales; the only difference between them is the date on which the flow takes place (is expected in the future or was in the past). This distinction is easily made by inspecting the date associated with the flow. This approach also overcomes the problem associated with REA of distinguishing between incomplete exchanges (for example, an account receivable) and a complete but unbalanced exchange (for example, a bad debt). Because expectations of future flows are fully recorded in the system, this distinction will be clear. Furthermore, the system could be used not just for reporting on past events, but also on budgeting for the future.

*Summary*

The A:*xis* data model improves on the REA template by providing a more extensible structure for modelling business activities which is not restricted to past flows of economic resources. It broadens the outlook of the accounting system to other resources of interest and integrates future and past flows into a single system. The application of alternative accounting valuation bases and accounting methods are recognised by a clear identification of external flows and recognising both discrete and continuous types of resource flow. A:*xis* also implements the accounting concept of matching.

### 7.4.2  Comparing A:*xis* with the Multiview Accounting System

The Multiview Accounting System model was designed specifically for the preparation of financial statements and so is even more selective in the entities modelled than REA and also, therefore, an A:*xis* data model. It adopts the traditional convention of only recording past events (like REA) and only records balanced sets of events (unlike REA). In order to record an incomplete exchange, the Multiview Accounting System introduces obligation accounts to represent future assets. These only provide information about the value of an obligation, unlike an A:*xis* data model which can also report expectations on the expected date on which the obligation will be met.

The Multiview Accounting System provides a facility through its integrated formula accounting general ledger, to model both discrete and continuous events. The latter are achieved through specifying journal entries as time-related formulae. This has the same effect as the separately defined procedures used by an A:*xis* data model to value such events, but has the restriction that the choice of valuation method is made at the time the journal entry is recorded rather than by the user at the time a report is requested. To offer the flexibility of the latter approach, a Multiview Accounting System must maintain a general ledger for every combination of valuation basis and accounting policy which might be requested. Deferring the decision to permit user choice may make an A:*xis* data model less timely in preparing reports (because additional processing may be required), but it would also be possible for this to be reduced at the implementation stage by specifying that values based on the most common accounting methods be stored for future use. Thus, this matter is not considered further.

One of the other strengths of the Multiview Accounting System is that it recorded events independently of the valuation basis. It demonstrated the derivation of financial statements based upon current values as well as the revaluation of foreign currency holdings. This indicated the need for additional entities to be defined to support the application of these accounting rules. For example, price indices and exchange rates. This emphasises the importance of designing an information system on the basis of user needs because only then will the data requirements be evident. In addition, since user needs are constantly changing, a model design which is extensible is also important to enhance its ability to adapt to such changes. For example, an accounting system which is limited to recording economic events may be redundant if accounting recognition rules change to include other types of event. Whilst it is impossible to prove the adaptability of a model until the required change is known, the A:*xis* data model demonstrates its ability to adapt by extending the range of resources which can be recorded as well as incorporating data about future activities as well as the past.

## 7.5  Validating the A:*xis* Data Model

The function of a data model is to act as the foundation to an information system which is capable of supporting the information needs of its users. Ultimately a data model has limited value if it is unable to support user needs. The information needs from accounting systems are quite diverse. They will vary according to a number of factors which include the nature of an organisation's business activities, the performance indicators selected by the organisation's management and the regulatory framework(s) within which the organisation operates. Organisations often have unique information needs and so validation of the A:*xis* data model (or any other accounting data model) against all organisations' information needs is not possible. This thesis adopts the following validation approaches:

1.    A description of the procedures required to use an A:*xis* data model for accounting measurement (see Section 7.5.1).

2.    Independent confirmation of the completeness of the transaction types used as the basis for designing the A:*xis* data model (see Section 7.5.2).

3.  The development of a prototype implementation of the A:*xis* data model to prepare trial balances from independently prepared sets of example accounting transactions (see Section 7.5.3).

Such validation procedures should ensure wide applicability of the A:*xis* data model and demonstrate how individual requirements can be accommodated by the addition of further values, entities and relationships to support specific situations. The core *exchange-flow* relationship underlying the A:*xis* data model should be robust enough to accommodate such adaptations.

### 7.5.1  Using A:*xis* for Accounting Measurement

A trial balance represents the summary of an organisation's accounting transactions and forms the basis of financial statements. The process of preparing financial statements from a trial balance is an exercise in formatting and layout. This thesis is, therefore, primarily concerned with validating the A:*xis* model by applying accounting measurement theory to generate a trial balance from which financial statements may be prepared.

Statements of financial position and financial performance reflect the interlocking nature of accounting transactions. The statement of financial position represents the resources which are under the control of the organisation and the liabilities (including the owners' interest) used to finance them, and the statement of financial performance represents how the level of resources has been achieved through the business activities. Increases and decreases in the overall level of an organisation's resources are reflected in changes to the value of the owners' interest to maintain an equality between the value of resources and the value of liabilities. The trial balance summarises the information reported in both of these statements. It can be generated by evaluating the financial effects of each economic resource flow.

An example timeline for an exchange is shown in Figure 7.8. This timeline illustrates the
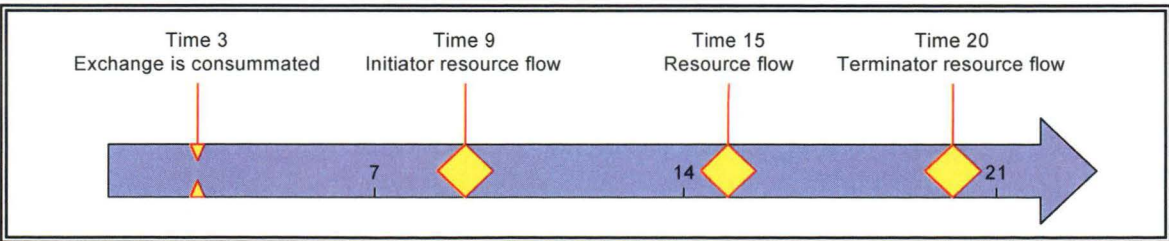


**Figure 7.8   An Exchange Timeline**

passage of time along the horizontal dimension (from left to right). The first occurrence is the consummation of the exchange: the establishment of an agreement to a future exchange of resources. Ijiri (1975) refers to the resource flow which occurs first as the *initiator* of the exchange and the final resource flow as the *terminator*. An A:xis exchange may be simple or compound (Ijiri 1975, 74) and hence any additional resource flows which occur between the initiator and the terminator may represent either inflows or outflows (or both). In addition, a degenerate exchange (Ijiri 1975, 61) may involve a single resource flow which would represent both the initiator and the terminator. The recognition criteria adopted in accounting (AASB 1992) mean that the promises of resources are only reported after the initiator has occurred; prior to that consummated exchanges are ignored. Once the terminator has occurred the full effect of the exchange of resources can be recorded; this may involve some application of valuation rules, which is discussed below. However, the period between the initiator and the terminator will involve evaluating promises of flows (referred to as future assets by Ijiri 1975). These would typically be classified as either debtors (future positive assets) or liabilities (future negative assets) for accounting purposes.

Since an A:xis data model implements Ijiri's three fundamental judgments "only a computational procedure remains in accounting measurement, a procedure that does not require any more empirical judgment" (Ijiri 1975, 69). This procedure can be included in an implementation of the data model to enable the preparation of financial statements. This will be illustrated here with respect to historical cost accounting but could also be applied to current cost valuation bases as illustrated by Seddon (1991).

*Valuation Rules*

Ijiri (1975, 75) specifies the following rules as being generally sufficient for recording the effects of simple exchanges on sets of resources:
1.     Quantities of resources are increased or decreased by the quantity obtained or foregone as part of the exchange.
2.     The values of monetary resources are equal to their quantity.
3.     The values of non-monetary resources given up as part of an exchange decline in proportion to the reduction in the quantity of the resource held.

4. The value of a non-monetary resource obtained as part of an exchange is equal to the value of the resources foregone.

These rules imply that the total value of resources can only change when an exchange involves an inflow of a monetary resource. There are also two circumstances in which these rules are not sufficient:

❖ when the initial resource set of an organisation contains only non-monetary resources;

❖ when an exchange consists solely of an increment to a non-monetary resource.

In each of these cases there is no historical cost value to impute to the non-monetary resource and so some other basis must be used. With compound exchanges involving increments to more than one non-monetary resource, it is necessary to allocate the value of the resources foregone between each of the non-monetary resources obtained. The basis for doing this may be derived from market values[43] or by applying an arbitrary allocation method (such as the net realisable value basis for allocating production costs to joint products).

*Future Assets*

The above valuation rules can only be applied when all the flows comprising an exchange

| Category of Exchange | Rule for Non-Degenerate Exchanges | Rule for Degenerate Exchanges |
|---|---|---|
| Exchanges involving monetary resources only | Treat the expected amount of the terminator as a receivable or payable. Recognise gains or losses (difference between the amounts obtained and foregone) as time elapses (rule 5 1) | Recognise gains or losses immediately (rule 5.2) |
| Exchanges involving monetary and non-monetary resources | See Table 7.4 below (rule 6) | |
| Exchanges involving non-monetary resources only | Impute the value of the resources obtained from the value of the resources foregone; use an estimate for the latter if this has not yet occurred (rule 7 1) | Recognise gains or losses immediately (rule 7 2) |

**Table 7.3    Rules for the Valuation of Future Assets**

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[43] The market value of a resource may not be a single amount but can be derived using a number of different approaches (for example, replacement cost or net realisable value). The term is used in this thesis in a general sense to refer to a value derived other than from the exchange entered into by the organisation. A more detailed discussion of alternative market values is beyond the scope of this thesis.

|  | Initiator is the non-monetary resource flow | Initiator is the monetary resource flow |
|---|---|---|
| **The resource foregone is a monetary resource** | The non-monetary resources are valued at the expected amount of money to be paid (rule 6 1) | Money paid is recorded as an advance payment until goods or services are received (rule 6 2) |
| **The resource foregone is a non-monetary resource** | The non-monetary resources are valued at the expected amount of money to be received (rule 6 3) | Money received is recorded as an advance receipt until the goods or services are delivered (rule 6 4) |

**Table 7.4    Rules for the Valuation of Future Assets in Exchanges Involving Monetary and Non-Monetary Resources**

have occurred and so the quantities of resources obtained and foregone are known. Additional rules are required for evaluating exchanges whose terminators have not yet occurred. Ijiri (1975, 79) classifies these exchanges into three categories. The rules to apply to each of these categories are summarised in Tables 7.3 and 7.4. Each rule has been given a number (following on sequentially from rules 1 to 4 described above) to aid future reference. These rules for valuing exchanges under historic cost accounting may now be implemented for accounting records maintained in an A:xis data model by considering examples of each of the different categories of exchange.

*Applying the Valuation Rules to an A:xis Data Model*

An A:xis data model identifies three main types of resource: money, inventory and service. Money clearly represents a monetary resource, and inventory and services are non-monetary resources. The valuation of monetary resources (rules 1 and 2) is straightforward since their unit of measurement is also the unit in which value is measured. However, as described above, when it comes to the valuation of non-monetary resources, the rules are more complicated. The values of non-monetary resources acquired are imputed from the value of the resources foregone (rule 4). When the quantity of a non-monetary resource is reduced, rule 3 assumes that the value of the resource declines in the same proportion. This is equivalent to the perpetual weighted average cost method. However, other methods which are used in accounting for valuing identifiable non-monetary resources (such as inventory) will impute different values to the amount foregone. Thus rule 3 should be viewed as just one example of the arbitrary rule which must be adopted in the valuation of reductions in non-monetary resources. The choice of methods includes first-in-first-out (FIFO), last-in-first-out (LIFO), average cost (using a

perpetual or periodic basis), last price and standard cost. The choice between those methods based on actual cost makes no difference if the resource held has all been acquired at the same price per unit or if it is all consumed at once. But if either of these conditions does not hold then the choice of method may affect the value imputed to non-monetary resources foregone.

Technically, Ijiri's (1975) fundamental judgment concerning *quantities* does not include services since (based on the A:xis definition of a service) they are resources for which a quantity measure is not being defined. This may be because a quantity measure is difficult to define (for example, advertising expenditure) or because it has been decided that recording quantities is not cost-beneficial (for example, items of stationery).[44] Therefore, rather than explicitly modelling the consumption flows, each service is treated as if it belongs to a unique non-monetary resource class for which a single unit of resource is acquired and which is deemed to be consumed over a specified period of time.[45] Thus rules 3 and 4 are applied to services as they are to inventory; the only difference is that the arbitrary rule adopted to estimate the amount of a service used up when applying rule 3 will be based on time rather than quantity. For example, possible rules which could be applied are straight line, reducing balance, double declining balance and sum of the years' digits.

At first glance the distinction between inventory resources and service resources appears to be similar to the distinction between current assets and non-current assets. Quantities of raw materials and finished goods inventories (current assets) are maintained and the cost of sales calculated by applying an accounting policy such as FIFO. Plant and equipment (non-current assets) are unique resources which are depreciated over time using an accounting policy such as straight line. However, as Ijiri (1975, 20-21) points out, it is quite feasible to apply either set of allocation methods to either type of asset. For example, a fixed asset may be considered equivalent to the acquisition of a quantity of units of service potential (as measured in terms such as hours of operation, or volume of production) which may then be consumed over time with a value imputed by applying a rule such as FIFO. Similarly, the economic value of each unit of inventory may not be

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[44]  Those resources for which quantity data is recorded are defined as Inventory resources in an A:xis data
      model.
[45]  For services foregone the reverse applies: only outflows of services are explicitly modelled.

considered to be constant in which case a method such as double declining balance may be more appropriate. Alternatively a "sum of the units' digits" method may be applied, where "units" refers to the units of measurement for the inventory resource in question.

The application of each of Ijiri's valuation rules in an A:*xis* data model is now considered for each rule in turn. These rules would be applied to each exchange for which the initiator has occurred; all other exchanges would be ignored for accounting measurement purposes. In addition, since an A:*xis* data model can incorporate an extended range of resource types, all flows of resources which do not fall within the accounting recognition rules (for example, free goods) are ignored. The rules described below represent just one possible set of rules which could be applied to the data captured in an A:*xis* data model; an implementation may choose to adopt different rules to satisfy different information needs (for example, valuation bases other than historical cost) or multiple sets of rules (for example, to comply with the regulations of different countries and/or different tax, professional and other regulatory bodies). It is important, therefore, that the data in an A:*xis* model are maintained independently of the application of the measurement rules being applied to the data.

*Rule 1* Quantities are recorded for money and inventory flows; inflows are represented by positive quantities and outflows by negative quantities. The balance of one of these resources at any point in time can be ascertained by calculating the net of the inflows and outflows which have occurred prior to that time.

*Rule 2* A separate quantity value need not be maintained for money flows because it is the same as the monetary amount of the flow.

*Rule 3* The value of outflows of inventory and service resources is based on the application of an appropriate accounting policy (such as FIFO or straight line).

*Rule 4* Inflows of non-monetary resources are valued on the basis of the value of the resources foregone. Where more than one non-monetary resource is acquired, the value of the resources foregone is allocated on the basis of market values (when the resources are acquired from external parties) or by applying an accounting policy (for internally generated resources).

*Rule 5* Outstanding money flows are treated as amounts receivable or payable. The amount of any imbalance between the value of the inflows and the outflows of a non-degenerate exchange is allocated over the period between the initiator and the terminator. The method used to perform this allocation will depend upon the

reason for the imbalance. For example, it may arise as a bank charge when transferring funds from one account to another, or it may be a foreign exchange difference arising from fluctuations in exchange rates, or it could represent interest payable on a loan. Apart from foreign currency gains and losses (which arise because of changes in the prices of monetary resources), any imbalances in the exchange of monetary resources may be removed by adding one or more service flows of an equivalent monetary value to represent the nature of the imbalance. Thus, these amounts are handled under rule 6 (see below). The modelling of degenerate exchanges of monetary resources can be avoided in the same way (rule 5.2).

*Rule 6* Any money flows are treated as payments in advance until such time as the flows of inventory or services have occurred (rules 6.2 and 6.4). Following rules 6.1 and 6.3, the non-monetary resources are valued at the value of the monetary resources exchanged (or expected to be exchanged). In practice, however, this value may be analysed in separate parts when an exchange takes place with an external party. For example, the monetary amount received from a customer in exchange for inventory foregone may be below an amount which could be expected (for example, the market value of the inventory) because of discounts given and/or non-payment of the account. Discounts given and taken may be modelled as service flows leaving any imbalances between the value attributed to the non-monetary resources and the expected value of the money flows as being bad debts (a failure of money flows to live up to original expectations).[46]

*Rule 7* Ijiri (1975) suggests applying a combination of rules 3 and 4 in the case of exchanges involving only non-monetary resources. This approach may be adopted for internal exchanges (for example, the production of finished goods from raw materials)[47] but for exchanges with external parties it is more likely that an amount closer to a market value will be attributed to the resources exchanged. For example, inventory foregone may be valued at the normal selling price and inventory or services acquired may be valued at the normal purchase price. Thus, an exchange involving the contra of an account receivable against an account

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[46]  An alternative is to model bad debts in the same way as discounts (as a service flow) thereby eliminating imbalances in this type of exchange.

[47]  Even here an alternative valuation basis (such as standard cost) may be applied.

payable will be treated in the same way as if the money flows to/from the external party had actually taken place. As noted by Ijiri (1975) this is a situation in which values other than historical cost may be needed. Whatever basis is used, the value imputed to any flows which have not yet occurred will represent an amount receivable or payable.

In this way, having captured the exchanges in an A:*xis* data model, it is possible to perform accounting measurement by applying a set of rules. When implementing such rules, information users may be given a choice of accounting policy to apply in the following areas, for example:

❖　the valuation of outflows of inventory (a quantity-based method such as FIFO) or services (a time-based method such as straight line);

❖　the valuation of internal inflows of inventory or services (for example, the value of resources foregone or standard cost);

❖　the treatment of foreign currency gains and losses (for example, imbalances in exchanges of monetary resources);

❖　the treatment of bad debts (imbalances in exchanges involving both monetary and non-monetary resources);

❖　the valuation of external flows of inventory or services which are exchanged for other non-monetary resources (for example, the use of cost or market value).

It is, therefore, important to ensure that the data requirements of the accounting policy choices offered to users are accommodated within the underlying data model as well as the data relating to the actual exchanges. For example, this will necessitate the inclusion of exchange rate data if any foreign currency transactions take place.

*Illustrations of Accounting Measurement Using an A:xis Data Model*

The implementation of the rules outlined above using an A:*xis* data model can be illustrated by examples of each type of exchange: exchanges involving monetary resources only, exchanges involving monetary and non-monetary resources, and exchanges involving non-monetary resources only.

Exchanges Involving Monetary Resources Only

The exchange illustrated in Figure 7.9 depicts the movement of funds from an account denominated in dollars to a sterling account.  The transfer was agreed with the bank at Time 2 at which time the exchange would have been recorded using the expected sterling amount to be obtained in return for the $1,000 being foregone.  At Time 5 when this exchange takes place the record of the exchange can be updated with the actual sterling amount obtained.  The value of this money flow in dollars (from Time 5 onwards) will be calculated using the current exchange rate; any difference between this value and the original $1,000 is treated as a foreign currency gain or loss.
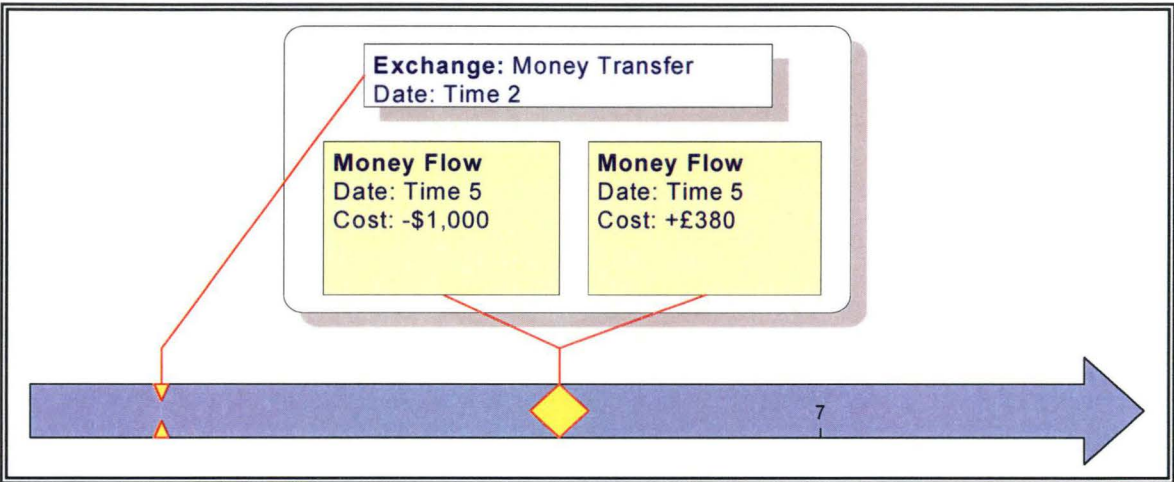


**Figure 7.9    Timeline for a Money Transfer Exchange**

This example ignores any transaction costs which would be recorded as an associated service flow; all imbalances are assumed to be due to currency fluctuations.  A similar approach can be used to value outstanding foreign currency money flows in other types of exchanges.

Exchanges Involving Monetary and Non-Monetary Resources

Inventory flows are modelled as discrete events.  The inventory flow is typically the initiator of the exchange with the terminator being a money flow.  For example, a timeline for a purchase of inventory is illustrated in Figure 7.10.  Until Time 8 (when the initiator occurs) this exchange would be treated as a purchase order and, therefore, ignored for financial statement purposes.  From Time 8 the quantity of inventory will be increased by 10 units and the value increased according to an appropriate accounting policy.  For most
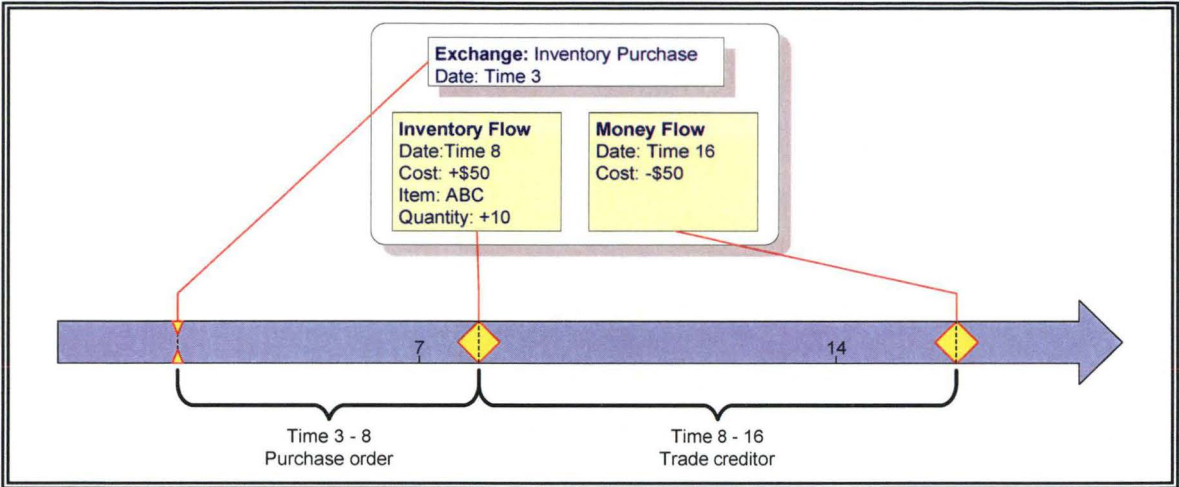
**Figure 7.10  Timeline for an Inventory Purchase Exchange**

inventory valuation policies the value will be equal to the expected cost of $50, but when a standard cost policy is adopted a difference may arise between the imputed inventory cost and the expected cost of the inventory flow (that is, a price variance).  Between Time 8 and Time 16 the inflow of inventory would be offset by the recording of a liability (trade creditor) to represent the promise of an outflow of money in the future.  This value would be derived from the amount of the expected money flow.  After Time 16 the inflow of inventory is offset by the outflow of money.

The sequence of resource flows could be reversed, in which case the outflow of money would be recorded as an asset (prepayment) until such time as the promise of inventory is fulfilled.  Two situations may arise in the treatment of incomplete exchanges involving flows of both inventory and money.  From the flows which have already occurred, the value of the money flows will either exceed the value of the inventory flows (in absolute terms) or vice versa.  In the former case, the excess would be treated as either an amount receivable or payable (depending upon the direction of the flows).  In the latter case, a receivable or payable would be valued on the basis of the expected money flows net of any other expected inventory flows.  If this amount does not equal the net deficit calculated from the flows which have already occurred then this implies an unbalanced exchange and the expectation of bad debts.  Since the expectation has already been recorded, it would be reasonable to recognise this loss immediately, although if future inventory flows are also expected, an alternative approach would be to allocate the loss between all of these flows.  Such a situation would only arise if an exchange involved inventory flows at more than one time and could be avoided if they were divided into separate exchanges.
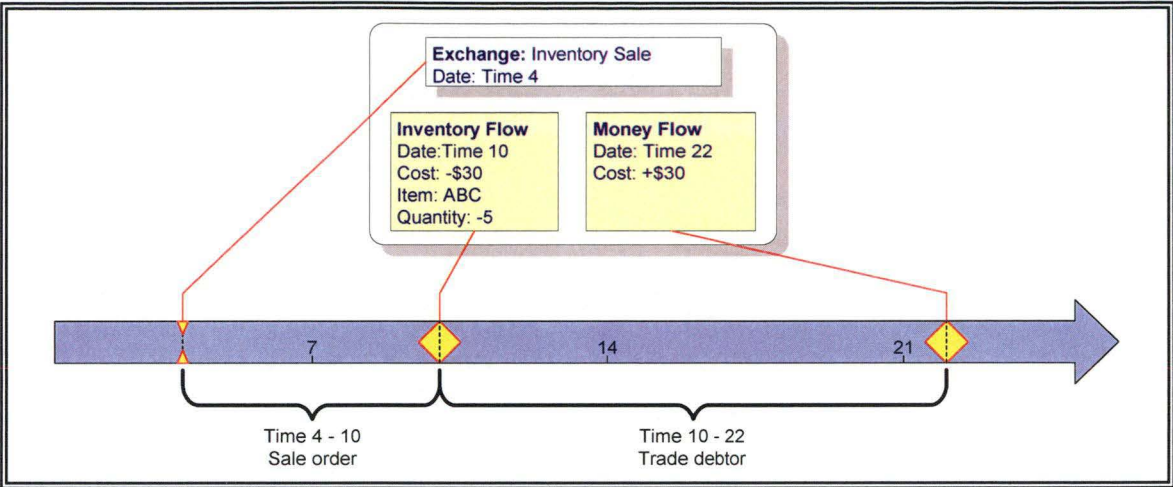
**Figure 7.11  Timeline for an Inventory Sale Exchange**

Exchanges involving the sale (outflow) of inventory would follow similar rules except that, if the inventory flow is to an external party, then an increase in total resources (profit) may be recorded.  For example, consider the sale illustrated in Figure 7.11.  For accounting purposes, the exchange is ignored until the initiator has occurred (Time 10).  The value recorded for the inventory flow is the sales value of the inventory being foregone which, therefore, represents the money value expected to be received in exchange (any difference between this value and the value of the money flows represents bad debts).  Once the inventory flow has occurred an amount receivable is recorded for the expected value of the outstanding money flow.  The inventory resource is reduced by the quantity sold and by a cost value determined by applying an appropriate accounting policy (for example, FIFO).  The imbalance between the reduction in the value of inventory (the cost of sales value) and the increase in the value of the future assets (the sales revenue value) represents the surplus (or deficit) made on the exchange.

The rules applying to exchanges involving service flows are similar to those outlined above for inventory flows.  The only difference would be that the valuation of the service flow may be calculated by applying a time-related allocation method.  In addition, a service flow may have a value at a time prior to what might be considered the time at which the exchange is consummated.  For example, services invoiced in arrears (such as power and telephone bills) may be entered as exchanges on the date of the invoice but may be allocated over periods prior to the invoice date.  In these cases the exchange is legally consummated by the original service agreements and the consumption of the services, but for accounting purposes it may be more practical and relevant to use the invoice dates.  Another example is an unplanned donation made during a period, the cost of which is

spread across the whole period (before and after the date of the donation) for accounting purposes.

Figure 7.12 illustrates an exchange for the payment of rent for the period from Time 7 to Time 14. The rental agreement is made at Time 5 with the rent being paid at Time 6. For the period between Time 6 and Time 7 this money flow represents a receivable amount
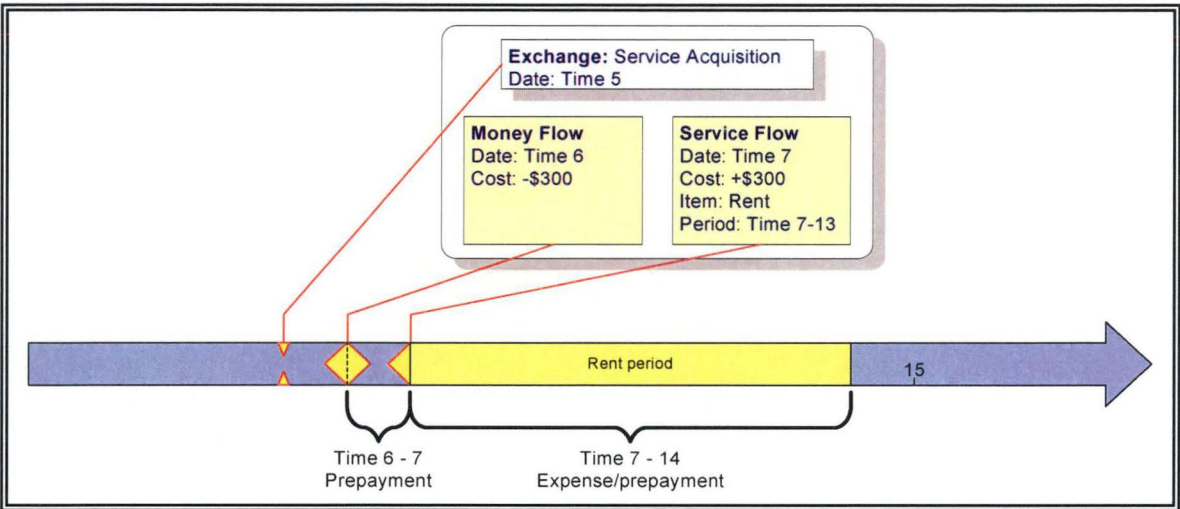


**Figure 7.12 Timeline for a Service Acquisition Exchange**

(just as it would have done had the outstanding flow been for inventory, as discussed above). After Time 14 the whole of the value of the service flow would be treated as an expense, but during the rental period the value would be allocated between receivables and expenses according to the point in time and the accounting policy adopted. Thus, unlike inventory, the value of a service flow is dependent on the time at which the value is being reported and on the selection of an appropriate accounting policy.

Exchanges Involving Non-Monetary Resources Only

When exchanging non-monetary resources for other non-monetary resources, a monetary value must be imputed (see discussion of rule 7 above). An example of such an exchange is when a purchase of inventory is "paid for" by way of other inventory as illustrated in Figure 7.13. The inventory purchased is treated in the same way as described above, the only difference is that the value of the trade creditor is imputed from the expected value of the inventory to be foregone rather than from a money flow. The treatment of any imbalance in such an exchange is a matter of accounting policy. For example, it may be treated as a windfall gain or loss or be used to reduce the value of the inventory obtained.
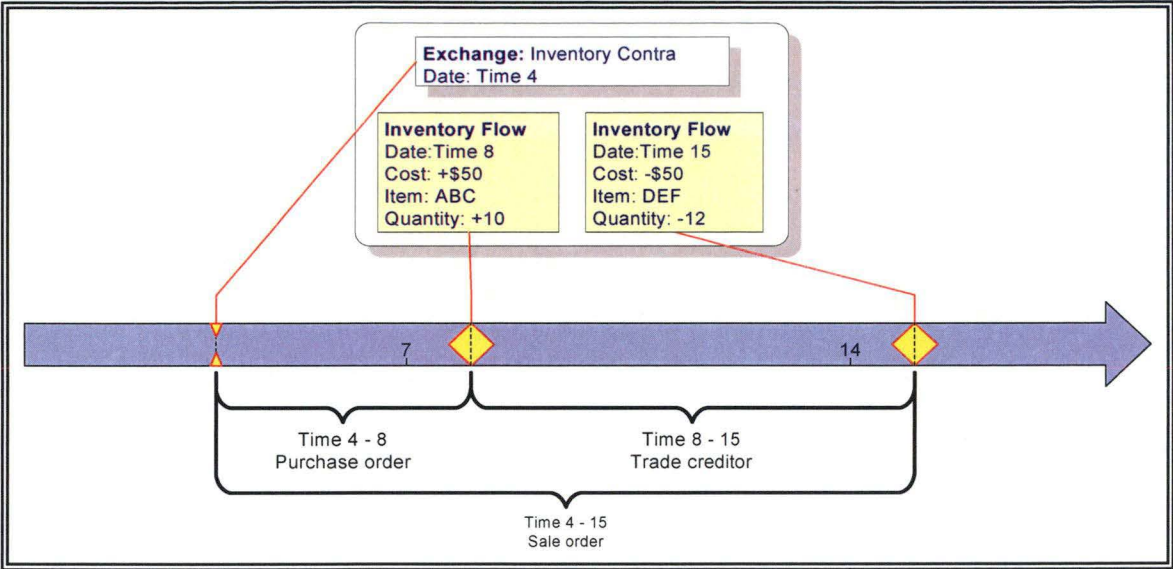
**Figure 7.13  Timeline for an Inventory Contra Exchange**

Production represents an example of an internal exchange of non-monetary resources. This is illustrated in Figure 7.14 which depicts a production process planned at Time 7 to take place between Time 10 and Time 12.  The production takes 10 units of inventory item
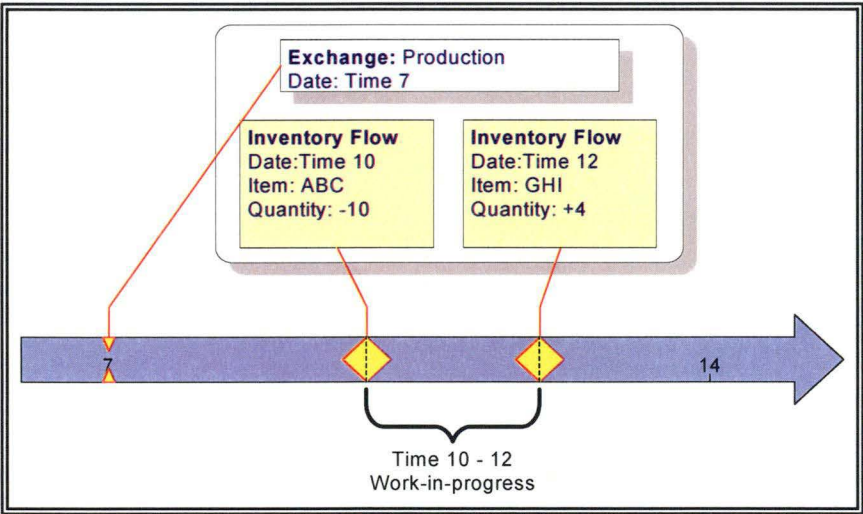


**Figure 7.14  Timeline for a Production Exchange**

ABC as an input and generates 4 units of inventory item GHI (which may either be a finished good or an intermediate product).  The value of the inputs is determined by applying an appropriate accounting policy (as used when inventory is sold).  During the production period this cost  represents work-in-progress.  After Time 12 an inventory resource of GHI will exist with a value determined from applying another accounting policy (typically this value will be the cost of the inputs to the process or a standard cost). When standard costing is used, the difference between the value of the inputs and value of

the outputs will represent usage variances. A production exchange may include service flows (including labour flows) as inputs as well as inventory flows.

## Reporting Issues When Using an A:*xis* Data Model

The discussion above demonstrates how an A:*xis* data model may be used to evaluate exchanges for the purposes of accounting measurement. By applying the above rules, a trial balance can be generated which lists the value of resources held and the revenue and expenses arising from the transfer of non-monetary resources to external parties. Since the exchange data have been recorded in an independent manner, a trial balance may be generated as at any point in time and by using any set of accounting policies for which the necessary procedures have been implemented. These choices can be offered to the user.

Some further reporting procedures may need to be applied to the trial balance generated before a set of financial statements can be prepared. For example, receivable amounts and payable amounts to the same external party may be offset against each other. The value of each resource held is represented by the net value of all the inflows and outflows which have occurred. Implementing this method, therefore, implies that a complete history of the flows for each resource is available. This can be avoided by adopting procedures which take a trial balance for the beginning of the reporting period and then applies the effects of each exchange which has arisen since that time (until the end of the reporting period). The opening trial balance used should have been created using the same set of accounting policies otherwise the complete history of exchanges will be required to calculate a consistent opening position. This method may also be used to improve the efficiency with which reports are produced from an A:*xis* data model, because it can avoid possibly lengthy processing of historical data.

Since details of past and future exchanges are maintained in a raw form and are independent of any accounting policy choices, reports may be generated from an A:*xis* data model for any point in time (past, present or future). As a result, it is important that a convention is devised to ensure that flows are accurately and consistently assigned to points in time within the level of accuracy demanded by reporting needs. For example, in the unlikely event that intra-day reports are required, both the date and the time at which a flow occurs would need to be recorded. For reports over longer periods, just a date may

suffice. Particular care must be taken with recording the periods over which service flows are deemed to be consumed. When only a date is recorded, the convention must specify whether this represents the beginning or end of the day. In addition, the specification of the service flows and/or the implementation of the allocation procedures may need to take into account non-working days and times. This is especially important if reports are required for short periods, when the effects of ignoring such details will be most significant.

### 7.5.2  Completeness of the A:*xis* Model

The A:*xis* model has been developed from a combination of accounting theory and three data models of manufacturing organisations. The generality of the model description suggests that it should have wider applicability than the three organisations modelled and the manufacturing industry. As a means of seeking confirmatory evidence of the completeness of the model, the professional opinion of two practising accountants was sought. These subjects had broad experience and so were in a position to consider whether the A:*xis* model might be capable of recording the types of transaction which arise in different types of organisation.

The process undertaken with each practising accountant was as follows:

❖ a brief background to the research was given;

❖ the purpose of the session was explained, in particular to emphasise that it was not designed to consider the advantages and disadvantages of the A:*xis* model but to try to identify any types of transaction which it would not be able to represent;

❖ a summary of the A:*xis* model was presented by describing its elements (exchanges, three types of resource flow and external parties) followed by illustrating the representation and interpretation of different types of exchange: inventory purchases and sales (including discounts, sales tax and bad debts), service acquisitions (including labour services), capital flows (loans and share capital), money transfers, foreign currency and production.

The presentation was pilot tested with a senior lecturer and a lecturer in financial accounting at an Australian University. Presentations were made to each of the practising accountants separately. They were conducted on an informal basis allowing questions and suggestions of other types of transaction to be addressed as they arose. Both of the

accountants participating in this process were a partner (or sole proprietor) in an accounting firm, members of the Institute of Chartered Accountants in Australia and held practising certificates. They were not selected at random but they were selected on the basis of their seniority and willingness to participate.

The results of these presentations were, in brief, that no transactions were identified which could not be captured by the A:xis model. However, a few interesting examples were raised which are worthy of future research. A summary of the findings follows:

❖ Both participants agreed that it would be better for the system to prohibit unbalanced exchanges so that the reasons for any "imbalances" are made explicit rather than being implied from the type of exchange. This would minimise the chances of fraudulent manipulation of the records and improve the overall level of control within the system.

❖ An implementation of an A:xis system should include controls which prevent unauthorised changes to records.

❖ It is important that, once a set of financial statements has been published, any changes to estimates which affect these values are actually reflected in subsequent financial statements rather than updating prior values. This can be achieved by saving sets of published financial statements, calculating the latest set based on all exchanges to date, thereby enabling the values for the latest period to be calculated as the difference between the two sets. Therefore, the financial statements may include exchanges which relate to the latest period as well as adjustments to prior periods. Separate analyses of each may be generated if required.

❖ The future is considered to be more important than the past so a major benefit of the A:xis model is its ability to incorporate future expected exchanges and flows. The future flows might be either those expected as a consequence of a specific exchange, or a budgeted total for a period. For example, budget figures could be included in an implementation of an A:xis system in such a way that these figures are reduced whenever an actual exchange is recorded so that the budget value automatically reflects the balance still expected to arise. For control purposes, the system should be able to distinguish between budget entries and those derived from actual exchanges.

❖ The method of recording and reporting SGARAs (Self-Generating and Regenerating Assets) was discussed with both participants. AASB 1037 (AASB

1998) values SGARAs on the basis of net market values.  In cases where active markets exist such information should be easily available.  Problems associated with the recording and reporting of SGARAs do not appear to be associated with the A:*xis* model, but with the general accounting issue of valuation.  These types of asset can be difficult to value regardless of the accounting system being used.  Support for valuing such assets in an A:*xis* model is a matter of identifying the data required to replicate the valuation method used and sources for this data.  The main effect of difficulties in obtaining the required data will be the frequency with which financial statements can be prepared unless some acceptable approximations can be made.  However, this is not a limitation unique to A:*xis* systems.

The evidence obtained from the practising accountants fails to refute the view that the A:*xis* model is capable of recording and reporting accounting transactions for all types of organisation.  Any limitations found were also common to all accounting systems.

### 7.5.3  Example A:*xis* Data Models

Authors of previous alternative accounting data models have devised simple examples to illustrate their proposals.  In particular the Wilson Company (McCarthy 1978) and REEFA Ltd (Seddon 1991).  Ventura Vehicles (David and McCarthy 1995) is a more detailed example of a model based on the REA template.  These examples will be used to demonstrate that an A:*xis* model is capable of supporting the same information needs and to highlight the enhanced features of the A:*xis* approach.  A prototype A:*xis* system built using Microsoft Access 2000 was used to reproduce the trial balance for each example;  a description of this prototype can be found in Appendix C.

*Wilson Company*

The Wilson Company is the only example of a model based on the REA template which has been published and for which suggested reports have been described.  It formed the basis of McCarthy's PhD dissertation (McCarthy 1978) and has been the underlying example to a number of academic papers since then (for example, McCarthy and Gal 1983; Gal and McCarthy 1985, 1986; Geerts and McCarthy 1991; Dunn 1995).  The Wilson Company represents a small retail enterprise for which transactions are specified over its first month of operation.  A balance sheet and income statement are derived at the end of

the month. The business events for this example can be represented in an A:*xis* data model as illustrated in Tables 7.5 to 7.10.

Table 7.5 identifies the exchanges recorded during the month. The event numbers from the original source have been used for ease of cross-reference.[48] Not all of the events from the REA model are represented in the A:*xis* model for the following reasons:

❖ sale orders are equivalent to expected future sales in an A:*xis* data model and hence orders and sales are not recorded as separate exchanges; the exchange number of the eventual sale has been used in the A:*xis* model, with any outstanding sale orders retaining the order event number;

❖ events representing payments to suppliers (exchange numbers 9, 12, 15, 18, 25, 27, 40, 42 and 44) or receipts from customers (exchange numbers 37, 38 and 41) form part of the exchange incorporating the original purchase or sale event;

❖ depreciation (exchange number 51) and closing inventory/cost of goods sold (exchange number 53) are automatically calculated and do not, therefore, represent exchanges in an A:*xis* model;

❖ revenue and expense accounts (exchange numbers 54 and 55) are not closed in an A:*xis* model so that reports can be generated for any required period using any set of accounting policies.

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[48] Flows would also be identified by a unique reference, but these have been omitted from the tables here.

| Exchange Number | Exchange Type | Consummated |
|---|---|---|
| 1 | Issue share capital | 1-Jun-1977 |
| 2 | Purchase equipment | 1-Jun-1977 |
| 3 | Purchase Truck | 1-Jun-1977 |
| 4 | Building rent | 1-Jun-1977 |
| 5 | Purchase | 1-Jun-1977 |
| 6 | Purchase | 2-Jun-1977 |
| 7 | Purchase | 3-Jun-1977 |
| 11 | Sale | 3-Jun-1977 |
| 13 | Sale | 4-Jun-1977 |
| 16 | Advertising | 8-Jun-1977 |
| 17 | Sale | 6-Jun-1977 |
| 19 | Purchase | 9-Jun-1977 |
| 20 | Sale | 3-Jun-1977 |
| 21 | Purchase | 10-Jun-1977 |
| 23 | Sale | 11-Jun-1977 |
| 24 | Transportation | 13-Jun-1977 |
| 26 | Payroll | 14-Jun-1977 |
| 28 | Cleaning | 15-Jun-1977 |
| 29 | Sale | 16-Jun-1977 |
| 30 | Purchase | 17-Jun-1977 |
| 32 | Sale | 18-Jun-1977 |
| 33 | Purchase | 18-Jun-1977 |
| 34 | Sale | 17-Jun-1977 |
| 35 | Sale | 19-Jun-1977 |
| 36 | Cleaning | 20-Jun-1977 |
| 39 | Sale | 19-Jun-1977 |
| 43 | Sale | 24-Jun-1977 |
| 45 | Sale | 24-Jun-1977 |
| 46 | Advertising | 27-Jun-1977 |
| 47 | Payroll | 28-Jun-1977 |
| 48 | Purchase | 28-Jun-1977 |
| 49 | Transportation | 29-Jun-1977 |
| 50 | Sale | 29-Jun-1977 |
| 52 | Payroll | 12-Jul-1977 |
| 56 | Dividend | 30-Jun-1977 |

Source: McCarthy (1978)

**Table 7.5     Wilson Company Exchange Instances**

| Exchange Number | Date | External Party | Product | Quantity | Value |
|---|---|---|---|---|---|
| 5 | 1-Jun-1977 | Oliver | A | 6000 | $12,000 |
| 5 | 1-Jun-1977 | Oliver | B | 2000 | $8,000 |
| 6 | 2-Jun-1977 | Williams | E | 20000 | $20,000 |
| 6 | 2-Jun-1977 | Williams | C | 3000 | $27,000 |
| 7 | 3-Jun-1977 | Smith | D | 600 | $6,000 |
| 11 | 5-Jun-1977 | White | A | -2000 | -$6,000 |
| 11 | 5-Jun-1977 | White | B | -1000 | -$5,000 |
| 11 | 5-Jun-1977 | White | C | -700 | -$8,400 |
| 13. | 6-Jun-1977 | Nelson | A | -1000 | -$3,000 |
| 17 | 8-Jun-1977 | Scott | E | -1000 | -$1,500 |
| 17 | 8-Jun-1977 | Scott | A | -2000 | -$6,000 |
| 19 | 9-Jun-1977 | Smith | D | 600 | $6,600 |
| 20 | 10-Jun-1977 | White | D | -1000 | -$15,000 |
| 21 | 10-Jun-1977 | Oliver | B | 2000 | $8,600 |
| 21 | 10-Jun-1977 | Oliver · | A | 2000 | $4,000 |
| 23 | 13-Jun-1977 | White | E | -2000 | -$3,000 |
| 23 | 13-Jun-1977 | White | A | -2000 | -$6,000 |
| 29 | | Jones | D | -300 | -$4,500 |
| 30 | 17-Jun-1977 | Oliver | A | 4000 | $9,200 |
| 30 | 17-Jun-1977 | Oliver | B | 2000 | $8,600 |
| 32 | 18-Jun-1977 | Jones | A | -1000 | -$3,000 |
| 33 | 18-Jun-1977 | Williams | C | 1000 | $10,000 |
| 34 | 19-Jun-1977 | Russell | E | -3000 | -$4,500 |
| 34 | 19-Jun-1977 | Russell | C | -1500 | -$18,000 |
| 34 | 19-Jun-1977 | Russell | B | -4000 | -$20,000 |
| 35 | | Howell | D | -500 | -$7,500 |
| 39 | 21-Jun-1977 | Howell | A | -2000 | -$6,000 |
| 43 | | Nelson | A | -3000 | -$9,000 |
| 45 | 26-Jun-1977 | Nelson | C | -800 | -$9,600 |
| 45 | 26-Jun-1977 | Nelson | E | -7000 | -$10,500 |
| 48 | 28-Jun-1977 | Williams | C | 500 | $4,625 |
| 50 | | White | E | -4000 | -$6,000 |
| 50 | | White | C | -500 | -$6,000 |

Source: McCarthy (1978)

**Table 7.6    Wilson Company Inventory Flow Instances**

| Exchange Number | Date | External Party | Value | Service Type | Period From | Period To |
|---|---|---|---|---|---|---|
| 2 | 1-Jun-1977 | Horvath | $2,400 | Furniture | 1-Jun-1977 | 31-May-1987 |
| 2 | 1-Jun-1977 | Horvath | $1,150 | Typewriter 1 | 1-Jun-1977 | 31-May-1985 |
| 2 | 1-Jun-1977 | Horvath | $1,150 | Typewriter 2 | 1-Jun-1977 | 31-May-1985 |
| 2 | 1-Jun-1977 | Horvath | $3,000 | Packaging machine | 1-Jun-1977 | 31-May-1996 |
| 3 | 1-Jun-1977 | Shore | $4,200 | Truck | 1-Jun-1977 | 31-May-1984 |
| 4 | 1-Jun-1977 | Green | $1,600 | Building Rent | 1-Jun-1977 | 30-Jun-1977 |
| 16 | 8-Jun-1977 | McKenzie | $500 | Advertising | 8-Jun-1977 | 8-Jun-1977 |
| 24 | 13-Jun-1977 | Hodge | $3,000 | Transportation | 13-Jun-1977 | 13-Jun-1977 |
| 28 | 15-Jun-1977 | Simmons | $300 | Cleaning | 15-Jun-1977 | 15-Jun-1977 |
| 36 | 20-Jun-1977 | Simmons | $350 | Cleaning | 20-Jun-1977 | 20-Jun-1977 |
| 46 | 27-Jun-1977 | McKenzie | $500 | Advertising | 27-Jun-1977 | 27-Jun-1977 |
| 49 | 29-Jun-1977 | Hodge | $4,000 | Transportation | 29-Jun-1977 | 29-Jun-1977 |
| 56 | 30-Jun-1977 | Conley | $1,000 | Dividend | 30-Jun-1977 | 30-Jun-1977 |
| 56 | 30-Jun-1977 | Brewer | $1,000 | Dividend | 30-Jun-1977 | 30-Jun-1977 |
| 56 | 30-Jun-1977 | Sullivan | $1,000 | Dividend | 30-Jun-1977 | 30-Jun-1977 |
| 56 | 30-Jun-1977 | Wall | $1,000 | Dividend | 30-Jun-1977 | 30-Jun-1977 |
| 56 | 30-Jun-1977 | Schwall | $1,000 | Dividend | 30-Jun-1977 | 30-Jun-1977 |
| 56 | 30-Jun-1977 | Delock | $1,000 | Dividend | 30-Jun-1977 | 30-Jun-1977 |

Source: McCarthy (1978)

**Table 7.7    Wilson Company Service Flow Instances**

| Exchange Number | Date | External Party | Value | Description | Period From | Period To | Normal Hours |
|---|---|---|---|---|---|---|---|
| 26 | 1-Jun-1977 | Wilson | $80 | Wages | 1-Jun-1977 | 1-Jun-1977 | 8 |
| 26 | 1-Jun-1977 | Jackson | $64 | Wages | 1-Jun-1977 | 1-Jun-1977 | 8 |
| 26 | 1-Jun-1977 | Johnson | $32 | Wages | 1-Jun-1977 | 1-Jun-1977 | 8 |
| 26 | 1-Jun-1977 | Harrison | $40 | Wages | 1-Jun-1977 | 1-Jun-1977 | 8 |
| 26 | 1-Jun-1977 | Taylor | $64 | Wages | 1-Jun-1977 | 1-Jun-1977 | 8 |
| 26 | 1-Jun-1977 | Adams | $48 | Wages | 1-Jun-1977 | 1-Jun-1977 | 8 |

Source: McCarthy (1978)

**Table 7.8    Wilson Company Labour Flow Instances (partial)**

| Exchange Number | Date | External Party | Amount | Exchange Number | Date | External Party | Amount |
|---|---|---|---|---|---|---|---|
| 1 | 1-Jun-1977 | Conley | $25,000 | 28 | 20-Jun-1977 | Simmons | -$300 |
| 1 | 1-Jun-1977 | Brewer | $25,000 | 29 | | Jones | $4,500 |
| 1 | 1-Jun-1977 | Sullivan | $25,000 | 30 | 22-Jun-1977 | Oliver | -$17,800 |
| 1 | 1-Jun-1977 | Wall | $25,000 | 32 | | Jones | $3,000 |
| 1 | 1-Jun-1977 | Delock | $25,000 | 33 | 23-Jun-1977 | Williams | -$10,000 |
| 1 | 1-Jun-1977 | Schwall | $25,000 | 34 | | Russell | $42,500 |
| 1 | | Brewer | -$25,000 | 35 | | Howell | $7,500 |
| 1 | | Conley | -$25,000 | 36 | 20-Jun-1977 | Simmons | -$350 |
| 1 | | Delock | -$25,000 | 39 | | Howell | $6,000 |
| 1 | | Schwall | -$25,000 | 43 | | Nelson | $9,000 |
| 1 | | Sullivan | -$25,000 | 45 | | Nelson | $20,100 |
| 1 | | Wall | -$25,000 | 46 | | McKenzie | -$500 |
| 2 | 4-Jun-1977 | Horvath | -$2,400 | 47 | 28-Jun-1977 | Wilson | -$800 |
| 2 | 4-Jun-1977 | Horvath | -$1,200 | 47 | 28-Jun-1977 | Jackson | -$640 |
| 2 | 4-Jun-1977 | Horvath | -$1,200 | 47 | 28-Jun-1977 | Johnson | -$320 |
| 2 | 4-Jun-1977 | Horvath | -$3,500 | 47 | 28-Jun-1977 | Harrison | -$400 |
| 3 | 1-Jun-1977 | Shore | -$4,800 | 47 | 28-Jun-1977 | Taylor | -$640 |
| 4 | 1-Jun-1977 | Green | -$1,600 | 47 | 28-Jun-1977 | Adams | -$480 |
| 5 | 6-Jun-1977 | Oliver | -$20,000 | 48 | | Williams | -$4,625 |
| 6 | 7-Jun-1977 | Williams | -$47,000 | 49 | | Hodge | -$4,000 |
| 7 | 8-Jun-1977 | Smith | -$6,000 | 50 | | White | $12,000 |
| 11 | 21-Jun-1977 | White | $19,400 | 52 | 12-Jul-1977 | Wilson | -$800 |
| 13 | 21-Jun-1977 | Nelson | $3,000 | 52 | 12-Jul-1977 | Jackson | -$640 |
| 16 | 8-Jun-1977 | McKenzie | -$500 | 52 | 12-Jul-1977 | Johnson | -$320 |
| 17 | 23-Jun-1977 | Scott | $7,500 | 52 | 12-Jul-1977 | Harrison | -$400 |
| 19 | 14-Jun-1977 | Smith | -$6,600 | 52 | 12-Jul-1977 | Taylor | -$640 |
| 20 | 21-Jun-1977 | White | $15,000 | 52 | 12-Jul-1977 | Adams | -$480 |
| 21 | 15-Jun-1977 | Oliver | -$12,600 | 56 | 30-Jun-1977 | Conley | -$1,000 |
| 23 | 21-Jun-1977 | White | $9,000 | 56 | 30-Jun-1977 | Brewer | -$1,000 |
| 24 | 13-Jun-1977 | Hodge | -$1,500 | 56 | 30-Jun-1977 | Sullivan | -$1,000 |
| 24 | 25-Jun-1977 | Hodge | -$1,500 | 56 | 30-Jun-1977 | Wall | -$1,000 |
| 26 | 14-Jun-1977 | Wilson | -$800 | 56 | 30-Jun-1977 | Delock | -$1,000 |
| 26 | 14-Jun-1977 | Jackson | -$640 | 56 | 30-Jun-1977 | Schwall | -$1,000 |
| 26 | 14-Jun-1977 | Johnson | -$320 | | | | |
| 26 | 14-Jun-1977 | Harrison | -$400 | | | | |
| 26 | 14-Jun-1977 | Taylor | -$640 | | | | |
| 26 | 14-Jun-1977 | Adams | -$480 | | | | |

Source: McCarthy (1978)

**Table 7.9     Wilson Company Money Flow Instances**

| Service Type | Depreciation Method | Scrap Value |
|---|---|---|
| Furniture | Straight line | |
| Typewriter 1 | Double declining balance | $50 |
| Typewriter 2 | Double declining balance | $50 |
| Packaging machine | Sum-of-the-years' digits | $500 |
| Truck | Straight line | $600 |

Source: McCarthy (1978)

**Table 7.10   Wilson Company Service Resource Instances**

The REA model for the Wilson Company records the hours worked by each employee over the two week payroll periods. In order to accrue the cost of wages for the last two days of the next payroll period (29 June to 12 July), the hours worked are split with the cost for 29-30 June being recorded as a separate event (number 52). This has the correct effect, but does not offer flexibility for generating reports for any other dates which might be selected by a user. To overcome this weakness, the complete payroll exchange for the next period would be recorded in an A:*xis* model (with the labour flows for each of the ten working days together with the expected payment due on 12 July). As an exchange for which the initiator has occurred, this exchange would be included in reports at the end of the month and an amount payable (accrual) automatically calculated based on the labour flows which have occurred. To enable the correct allocation of labour hours to the days on which they were worked, the hours for each employee are recorded on a daily basis. For example, Table 7.8 shows the entries for hours worked on 1 June. Similar instances would be added for each of the other 9 working days which make up the payroll payment made on 14 June (exchange number 26). Similar sets of instances would exist for each of the other payroll exchanges (exchange numbers 47 and 52). This approach ensures that the accrual at the end of the month is calculated as being 2 working days rather than $\frac{2}{14}$ of the total cost of the next payroll (which might otherwise be the result if labour flows are recorded on a fortnightly basis).

Some of the customer orders received by the Wilson Company are supplied in parts. Since the only distinction between orders and sales in an A:*xis* model is the date of the inventory flow (an order has a future or unspecified date), this situation would be implemented by initially recording an order as a single future sale which is then split in two as part of the order becomes satisfied. Orders would continue to be split until they have been completely fulfilled. If it is necessary to recreate the original order, the consummation date of each sale exchange may be sufficient to identify each element, otherwise a reference value may be recorded for this purpose.

An A:*xis* model includes more data regarding expense items (service flows) than a model based on REA. While REA assumes that expense items are charged against income at the time they are recorded (subject to any adjustments by separately recorded exchanges), an A:*xis* model explicitly captures the period over which an expense item is to be charged. For the purposes of this comparison, and in the absence of further information, the day of

the exchange has been used for most expense items. For the depreciable assets, however, the period has been deduced from the salvage values, depreciation methods and June depreciation amounts for each item (see McCarthy 1978, 107).[49] These data are captured by a Service Resource entity (see Table 7.10) from which the depreciation for the month of June can be calculated by applying an appropriate procedure. All other service instances would be allocated across the specified period through the application of a default method (such as straight line). Since the Service Resource instances consist of a proposed accounting policy to apply to each asset, it may be appropriate to make this entity available to users so that they may state their own preferences. Doing this for each asset may be too detailed, but assets could be assigned to a class so that users could select an appropriate depreciation method for each class of asset.

The undated money flow instances represent future promises for which the expected date is unknown. The initial issue of share capital is recorded in this way (exchange number 1). The receipt of funds from the sale of shares is offset by a promise to repay these funds at some future point in time. The other undated money flows represent amounts payable to suppliers or amounts receivable from customers. The explicit representation of debts in this way allows changes in expectations as to their size (for example, bad debts) to be recognised; in REA the full amount of unbalanced exchanges is always assumed to be due.

The prototype A:xis system extends the model based on the REA template by also:

❖   providing user choice of accounting policies;

❖   providing user choice of reporting dates;

❖   removing the need for period-end adjustments;

❖   providing future-oriented reports.

The A:xis data model also contains fewer entities: the eight different types of economic event in the REA model have all been encapsulated in the three different types of A:xis resource flow. This has a consequential reduction in the number of relationships defined within the model. Such simplifications to the model structure are of greater relevance when modelling more complex scenarios. All of the exchanges in the Wilson Company are with external parties and none is an exchange comprising only non-monetary assets. In the absence of any internal exchanges and exchanges of only non-monetary resources, this

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[49]   The depreciation for the packaging machine could not be reconciled with the data provided so the life of the equipment has been changed from 9 years to 19 years to resolve this.

example can only give a limited insight into the ability of REA to fully support accounting measurement.

## REEFA Ltd (Trading)

To demonstrate his Multiview Accounting System, Seddon (1991) included example transactions for a trading organisation called REEFA Ltd. These exchanges and flows have been represented in an A:*xis* model as illustrated in Tables 7.11 to 7.15. Exchanges have been numbered using the original event numbers for ease of cross-reference. The summary of exchanges in Table 7.11 excludes event number 5 (payment to supplier 1) because it is included as part of the exchange initiated by event number 2 (credit purchase from supplier 1). Otherwise the data captured by both systems are quite similar. The two main differences are:

- ❖ promises are not recorded as separate types of resource (or flows) but are represented by future-dated flows of the resource which is the subject of the promise;

- ❖ degenerate exchanges (such as the donation in event number 8) are modelled as service flows to enable the allocation of the flow to an appropriate reporting period and to provide descriptions.

Processing these exchanges using the prototype A:*xis* system produces the same trial balance as reported by Seddon (1991). The A:*xis* system, however, enhances the solution provided by the Multiview Accounting System by also:

- ❖ allowing reports based on different sets of accounting policy to be generated without also needing to duplicate the data;

- ❖ recording information about when future promises are expected to eventuate;

- ❖ reducing the number of transactions which need to be posted by combining future promises and actual resource flows into the same construct, distinguished only by the date of occurrence.

This basic example has no internal exchanges, but it does illustrate that there is an alternative method of implementing continuous flows of resources; rather than using a formula accounting general ledger, procedures dynamically generate values based on the raw data. It is this approach which simplifies the support for multiple sets of accounting policies: applying procedures on demand allows the selection of policies to be deferred until reports are requested by users.

| Exchange Number | Description |
|---|---|
| 1 | Issue shares |
| 2 | Purchase inventory |
| 3 | Sale of inventory |
| 4 | Purchase truck |
| 6 | Dividend |
| 7 | Wages |
| 8 | Donation |

Source: Seddon (1991)

**Table 7.11    REEFA Ltd (Trading) Exchange Instances**

| Exchange Number | Date | External Party | Product | Quantity | Value |
|---|---|---|---|---|---|
| 2 | 01-Feb-1990 | Supplier 1 | Widget 2 | 1000 | $2,000 |
| 2 | 01-Feb-1990 | Supplier 1 | Widget 1 | 1000 | $7,000 |
| 3 | 01-Mar-1990 | Customer 1 | Widget 1 | -500 | -$5,000 |

Source: Seddon (1991)

**Table 7.12    REEFA Ltd (Trading) Inventory Flow Instances**

| Exchange Number | Date | External Party | Description | Value | Period From | Period To |
|---|---|---|---|---|---|---|
| 4 | 21-Mar-1990 | Supplier 2 | 1990 Ford Delivery Truck | $36,500 | 23-Mar-1990 | 22-Mar-2000 |
| 6 | 1-May-1990 | Stock Holder 1 | Dividend | $600 | 32993 | 32993 |
| 8 | 1-Jul-1990 | Red Cross | Donation | $100 | 33054 | 33054 |

Source: Seddon (1991)

**Table 7.13    REEFA Ltd (Trading) Service Flow Instances**

| Exchange Number | Date | External Party | Description | Normal Hours | Value | Period From | Period To |
|---|---|---|---|---|---|---|---|
| 7 | 1-Jun-1990 | Employees | Wages | 200 | $500 | 32993 | 31-May-1990 |

Source: Seddon (1991)

**Table 7.14    REEFA Ltd (Trading) Labour Flow Instance**

| Exchange Number | Date | Money | External Party | Value |
|---|---|---|---|---|
| 1 | 1-Jan-1990 | Bank 1 | Stock Holder 1 | $75,000 |
| 1 | 1-Jan-1990 | Bank 1 | Stock Holder 2 | $25,000 |
| 1 | | | Stock Holder 1 | -$75,000 |
| 1 | | | Stock Holder 2 | -$25,000 |
| 2 | 1-Apr-1990 | Bank 1 | Supplier 1 | -$4,000 |
| 2 | | | Supplier 1 | -$5,000 |
| 3 | | | Customer 1 | $5,000 |
| 4 | | | Supplier 2 | -$36,500 |
| 6 | | | Stock Holder 1 | -$600 |
| 6 | | | Stock Holder 2 | -$200 |
| 7 | 1-Jun-1990 | Bank 1 | Employees | -$500 |
| 8 | 1-Jul-1990 | Bank 1 | Red Cross · | -$100 |

Source: Seddon (1991)

**Table 7.15    REEFA Ltd (Trading) Money Flow Instances**

*REEFA Ltd (Manufacturing)*

Seddon (1991) also provides a manufacturing example to illustrate the application of his Multiview Accounting System. An A:*xis* implementation of the data from this example is represented by the flows identified in Tables 7.16 to 7.24. The exchange numbers used have been taken from the original data for ease of cross-reference. In this example the production process in the Multiview Accounting System is modelled as a sequence of separate exchange events representing the allocation of inventory and labour resources to the production job and the outputs from the process. The two steps of Job 123 in this example are represented in an A:*xis* model as two exchanges. Each exchange records the resource inputs and outputs to the production step. The transfer of the output from step 1 to step 2 is modelled by transferring the items into and out of inventory. Thus exchange 3 (Job 123 step 1) represents the moulding of polyethylene pellets into bottles, whilst exchange 6 (Job 123 step 2) represents the packing of these bottles into cardboard cartons.

Only the first two inventory flows (see Table 7.17) represent exchanges with external parties. The remaining flows are concerned with the conversion of raw materials into finished goods and, therefore, represent examples of exchanges involving only non-monetary resources. A value for each of the resource inputs can be imputed from their purchase costs (using a selected cost-based accounting policy) with the value of the

outputs imputed from the value of the inputs. In this example, each step of the production process has a single output so problems of joint costs are avoided.

| Exchange Number | Description |
|---|---|
| 1 | Factory rent |
| 2 | Inventory purchase |
| 3 | Production (Job 123) - Moulding |
| 6 | Production (Job 123) - Packing |
| 12 | Factory wages |

Source: Seddon (1991)

**Table 7.16   REEFA Ltd (Manufacturing) Exchange Instances**

| Exchange Number | Date | External Party | Inventory Item | Quantity | Value |
|---|---|---|---|---|---|
| 2 | 1-Jun-1990 | Cash supplier | 20kg bag poly pellets | 500 | $20,100 |
| 2 | 1-Jun-1990 | Cash supplier | Cardboard carton | 2000 | $440 |
| 3 | 6-Jun-1990 | | 20kg bag poly pellets | -40 | |
| 3 | 6-Jun-1990 | | 1L bottle | 10000 | |
| 3 | 7-Jun-1990 | | 20kg bag poly pellets | 1 | |
| 6 | 7-Jun-1990 | | Cardboard carton | -825 | |
| 6 | 7-Jun-1990 | | 1L bottle | -10000 | |
| 6 | 7-Jun-1990 | | 12x1L bottle (carton) | 820 | |

Source: Seddon (1991)

**Table 7.17   REEFA Ltd (Manufacturing) Inventory Flow Instances**

| Exchange Number | Date | Description | External Party | Value | Period From | Period To |
|---|---|---|---|---|---|---|
| 1 | 1-Jun-1990 | Factory costs | Cash supplier | $1,000 | 1-Jun-1990 | 30-Jun-1990 |

Source: Seddon (1991)

**Table 7.18   REEFA Ltd (Manufacturing) Service Flow Instances**

| Exchange Number | Date | Description | External Party | Normal Hours | Value | Period From | Period To |
|---|---|---|---|---|---|---|---|
| 3 | 6-Jun-1990 | Moulding costs | | -79 | | 6-Jun-1990 | 6-Jun-1990 |
| 6 | 7-Jun-1990 | Packing costs | | -24 | | 7-Jun-1990 | 7-Jun-1990 |
| 12 | 6-Jun-1990 | Moulding costs | Employee M | 41 | $220 | 6-Jun-1990 | 6-Jun-1990 |
| 12 | 6-Jun-1990 | Moulding costs | Employee N | 42 | $225 | 6-Jun-1990 | 6-Jun-1990 |
| 12 | 7-Jun-1990 | Packing costs | Employee Q | 35 | $160 | 7-Jun-1990 | 7-Jun-1990 |

Source: Seddon (1991)

**Table 7.19   REEFA Ltd (Manufacturing) Labour Flow Instances**

| Exchange Number | Date | Money Account | External Party | Value |
|---|---|---|---|---|
| 1 | 1-Jun-1990 | Bank A | Cash supplier | -$1,000 |
| 2 | 1-Jun-1990 | Bank A | Cash supplier | -$20,540 |
| 12 | | Bank A | Employee M | -$220 |
| 12 | | Bank A | Employee N | -$225 |
| 12 | | Bank A | Employee Q | -$160 |

Source: Seddon (1991)

**Table 7.20   REEFA Ltd (Manufacturing) Money Flow Instances**

| Product | Standard Cost |
|---|---|
| 20kg bag poly pellets | $40.00 |
| Cardboard carton | $0.22 |
| 1L bottle | $0.29 |
| 12x1L bottle (carton) | $3.82 |

Source: Seddon (1991)

**Table 7.21   REEFA Ltd (Manufacturing) Standard Cost of Inventory Resources**

| Service Description | Standard Cost |
|---|---|
| Moulding costs | $5.00 |
| Packing costs | $4.00 |

Source: Seddon (1991)

**Table 7.22   REEFA Ltd (Manufacturing) Standard Cost of Labour Resources**

| Inventory | Flow Type | Standard Usage |
|---|---|---|
| 12x1L bottle (carton) | Inventory flow | $3.70 |
| 12x1L bottle (carton) | Labour flow | $0.08 |
| 12x1L bottle (carton) | Service flow | $0.04 |
| 1L bottle | Inventory flow | $0.16 |
| 1L bottle | Labour flow | $0.05 |
| 1L bottle | Service flow | $0.08 |

Source: Seddon (1991)

**Table 7.23    REEFA Ltd (Manufacturing) Standard Usage**

| Service Description | | Proportion |
|---|---|---|
| Transfer From | Transfer To | |
| Factory costs | Moulding costs | 60% |
| Factory costs | Packing costs | 30% |
| Factory costs | Office costs | 10% |

Source: Seddon (1991)

**Table 7.24    REEFA Ltd (Manufacturing) Cost Allocation**

In Seddon (1991) this example is illustrated using a standard cost accounting policy. Since standard costs are not directly related to the costs incurred price variances may arise. In an A:xis model these are represented by a difference between the monetary value of an inventory flow (which is based on the money which is foregone in exchange) and the imputed value of the flow from applying the selected accounting policy. The same approach is applied to labour flows to calculate a rate variance. The implementation of a standard cost accounting policy has additional data requirements. This can be achieved by the inclusion of details about the inventory and labour resources as shown in Tables 7.21 and 7.22. Usage variances arising from production exchanges can be calculated in a similar way: the standard usage of each input must be specified for each output. The total usage variance will be the difference between the cost of the inputs and the cost of the outputs (as all inputs are valued at standard cost). In this example, these data are specified as standard costs rather than being given in terms of units of each resource. Additional data must be specified if a breakdown of the total usage variance by class of resource is required. Table 7.23 shows the data used in the A:xis implementation of this example to

separate the total usage variance into its inventory, labour and overhead components for each step of the production process.[50]

Table 7.19 identifies the labour flows for this example.[51] Individual hours worked by employees are not charged directly to production, instead the labour flows are treated as an expense (exchange number 12) with hours consumed in each step of the production process being a reallocation of this amount. This is achieved by adding negative labour flows for the numbers of hours used in production with the same description and period details as used in the flow recording the hours worked. This solution can be explained as follows:

❖ the payroll exchange represents the acquisition of a labour resource which is recorded as a labour flow (or a set of labour flows) over the period for which the hours were worked.

❖ the consumption of a labour resource (as defined by its description and acquisition period) for production purposes is recorded as a negative labour flow to net against the original acquisition.

❖ any labour resource which is not reallocated remains as an expense charged to the period in which it was worked (equivalent to the idle time in this example).

In addition to the physical exchanges which are included in this example (and the calculation of price and usage variances from these), REEFA Ltd also has a policy of allocating its factory overheads between the moulding, packing and office departments on the basis of a 6:3:1 ratio. Seddon (1991) implements this as a separate event (number 0) consisting of a set of formulae using the balance of the overhead account as a parameter. In this way, all overheads charged to this account will automatically be reallocated as specified by these formulae. The data shown in Table 7.24 are used to achieve the same end result when preparing reports using an A:xis model. A procedure is written to make this adjustment in much the same way as an adjusted trial balance would be prepared manually. A specified proportion of a balance may be transferred from one service resource to another. It is not necessary for the sum of the proportions to equal 100%. If the order in which these allocations are made is important, a sequence number could be

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[50] Seddon (1991) only identified the overhead components of the usage variance; the inventory and labour elements for each of the production steps were not specified.

[51] The data in the example is flawed in the sense that employees have been recorded as working around 40 hours per day. This inconsistency has been ignored.

added to each entry. Alternatively an iterative procedure may be implemented which would also support circular allocations. The allocation of costs is a reporting procedure and so the addition of data relating to this matter should be distinguished from the core elements of the A:xis data model which capture the actual business activities of an organisation.

The prototype A:xis system reproduced the flexibility of the formula accounting general ledger (Seddon 1991) dynamically. This approach also enables support for multiple allocation models rather than just one. *Inventory Resource* and *Labour Resource* entities were included to capture details about the standard costs of the resources. Additional entities were also required to record data concerning manufactured inventory resources as well as cost allocations. These emphasise the fact that the specification of an A:xis data model only identifies the essential elements for accounting measurement but can be integrated with other objects as necessary in support of users' information needs.

*Ventura Vehicles*

The model of Ventura Vehicles (David and McCarthy 1995) was developed for teaching purposes and represents a small, start-up manufacturing company. The business activities for the company can be summarised into 61 exchanges as follows:

- ❖ 27 inventory purchases (including 6 outstanding purchase orders);[52]
- ❖ 8 inventory sales (including 2 outstanding sale orders);
- ❖ 7 transfers of funds between money accounts;
- ❖ a 5-year loan;
- ❖ 6 service acquisitions (4 expense items, 2 non-current assets);
- ❖ 7 weekly payroll exchanges;
- ❖ 5 production exchanges.

The details of these exchanges are encapsulated in their associated resource flows. A total of 410 flows are defined: 81 inventory flows, 153 service flows (including 81 labour flows) and 176 money flows. The labour flows include the hours worked by each employee during the weekly payroll periods as well as the re-allocation of some of this

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[52] Purchase orders for which the quantity received exceeds the quantity ordered have been treated as completely fulfilled and not as outstanding.

labour time to production. The service flows include the 60 monthly interest instalments on the 5-year loan.

The following differences between the REA-based model of Ventura Vehicles and the A:*xis* model are worthy of special comment:

❖ *Purchase Orders*

In the REA model separate entities are used to record details of orders and the resulting purchases. An order may result in one or more purchases. In the A:*xis* model records of purchase orders and purchases are combined. Orders are represented by undated (or future-dated) purchases. If an order is fulfilled by more than one purchase invoice from the supplier, then the flows can be reorganised into separate purchase exchanges to reflect this. Details of the original order can be recorded as values of the inventory flow entity if required.

❖ *Sale Orders*

The REA model adopts a slightly different approach for sales compared with purchases. Orders and sales are still recorded separately but there is effectively a one-to-one relationship between the two sets of entities. Thus orders fulfilled at different times are still treated as part of the same sale. The need for the separation is, therefore, even less clear in this case. In the A:*xis* model the sale orders and sales are combined with outstanding sales orders included as separate exchanges. Alternatively, the convention used in the REA version could have been continued by recording outstanding orders as future, expected inventory flows in partially fulfilled sale exchanges.

❖ *Loan*

Rather than creating additional entities to capture loan transactions, an A:*xis* model records a loan as an exchange involving of a series of money flows over its life. Interest is included as a set of periodic service flows so that the inflows and outflows of the exchange balance out. In the REA version, the interest element of loan repayments is recorded as an attribute of the cash disbursement event (which is ignored for other types of cash disbursement).

❖ *Services (Including Non-Current Assets)*

An A:*xis* model treats non-current assets and services in the same way, rather than as different types of event. The REA model does not make any provision for spreading the costs of services across the period to which they relate; they have either been recorded (and thus represent an expense) or they have not. Treating services as continuous flows (like non-current assets) allows this to occur without the need for end of period adjustments. In addition, the continuous nature of service flows is automatically recognised in an A:*xis* model without the need to record depreciation events as in the REA model. This also helps to overcome the restriction of reporting at pre-determined times only.

❖ *Inventory*

The REA model separates raw materials from finished goods whereas the A:*xis* model combines these into a single inventory resource. Whilst there are a few attributes which differ between the two entity types (such as selling price and default vendor), they are not considered sufficient to warrant separate entities being defined. It is possible that the differences arise as a result of an implementation compromise and that, in fact, both models view inventory and finished goods as subtypes of a common supertype. However, the present design of the REA model does not support the existence of intermediate products (ones produced for further processing rather than for resale).

Ventura Vehicles uses standard costing. All raw materials and finished goods are valued at standard cost with a price variance based on purchases. A usage variance is calculated based on the actual quantities consumed in production. These variances are the same as those calculated in the REEFA Ltd (Manufacturing) example above, but the two examples diverge in their approach to the calculation of labour variances. In Ventura Vehicles, hours worked by individual employees are allocated to production operations (rather than allocating hours of a particular type of labour). The standard cost of labour is specified for each individual operation involved in the production of finished goods. From these elements a total standard labour cost of production can be calculated with the difference from the actual cost being reported as the labour variance; the example does not split this variance into separate rate and usage components. No overhead allocations exist in the Ventura Vehicles example and so no overhead variances are calculated. The prototype

A:*xis* implementation of this example uses the following additional data to recreate the variance calculations:

❖ the standard cost per unit of each item of raw materials;

❖ the standard quantity used of each raw material in the production of a unit of each finished good;

❖ the standard number of hours and the standard labour rate per hour for each operation required in the production of a unit of each finished good.[53]

This also provides an example of how reporting data can be integrated with an A:*xis* data model.

The A:*xis* implementation of this example generates the same trial balance as the REA model, but offers additional advantages which include the following:

❖ the ability to generate reports as at any date;

❖ a clear separation of data elements relating to accounting policies (and, therefore, subject to choice) from those relating to the underlying business activities;

❖ an overall simplification of the model by reducing the number of different elements required to model the same underlying reality;

❖ support for new exchange types without the need to define additional entities.

The REA version of Ventura Vehicles comprises the following elements:

❖ *Resources* - raw materials, work-in-process jobs, finished goods, fixed assets, cash and long-term debt.

❖ *Events* - purchase order (including purchase order line-items), purchase (including purchase line-items), customer order (including customer order line-items), sale (including sale line-items), cash disbursement, cash receipt (including sales receipts), service acquisition, fixed asset acquisition, depreciation, employee service, raw material issue and work-in-process job operation.

❖ *Agents* - vendor, customer, investor and employee.

❖ *Other entities* - department, bill of materials, work-in-process job operation types.

These elements are reflected in an A:*xis* model using the following elements:

❖ *Exchanges* - used to record summary details of exchanges. These are similar to the purchase and sale entities in the REA model but an exchange entity is defined in an

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[53] This represents the data as specified in the original example but, given the calculations actually performed, only a standard labour cost per unit of finished good actually needs to be defined.

A:xis model for all types of exchange. This simplifies the capturing of associations between the individual resource flows which make up each exchange.

❖ *Resource flows* - the REA events are encapsulated into four types of resource flow: inventory flows, service flows (including labour flows) and money flows.[54] Purchase orders and customer orders are treated as expected, future inventory flows. The depreciation event is not required since fixed assets are treated in the same way as any other service acquisition (automatically allocated over time).

❖ *External Parties* - all participants in the resource flows are encapsulated as external parties. Subtypes may be defined if specific value are required for external parties which play particular roles (such as credit limits for vendors and customers). But the use of a single supertype allows external parties to fulfil more than one role (for example, as an employee, a customer and an investor) without the need to duplicate their details in instances of different types of entity.

❖ *Resources* - these entities need only be defined when additional data about resources are required. In this example, an *Inventory Resources* entity may be defined to record such values from the original example as a description, a warehouse location, a lead time and a selling price (for finished goods only).

❖ *Other entities* - these include the additional data required to implement standard costing (see above), departments (not required for the preparation of trial balances) and any details of allocation methods for specific services (for example, non-current assets) which differ from some default (such as straight line).

The A:xis implementation succeeds in simplifying the modelling of the events from the Ventura Vehicles example. The 12 different types of event from the REA model are encapsulated in a single supertype (resource flow) which has 3 subtypes (of which one also has a subtype). This reduction not only has a consequential effect on reducing the number of relationships defined between entities, but also removes the need to prescribe which types of event may be associated in a single exchange.

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[54] Payroll flows are not required in this example because no payroll deductions or employer contributions are specified.

*Summary*

The prototype implementation of an A:*xis* model was able to process all of the transactions from the four examples considered above which were developed by the authors of alternative accounting models. Furthermore, identical trial balances were generated from simpler models: apart from some additional reporting objects (such as details of service resources and standard costs), the business activities were all encapsulated by the exchange and resource flow (including subtypes) constructs compared with the more complex models originally designed for the Wilson Company (see Figure 3.1), Ventura Vehicles (see Figure 3.3) or the Multiview Accounting System used for REEFA Ltd (see Figure 3.11). In each case, the A:*xis* model also deferred the choice of accounting policy to allow users a choice at the time of reporting.

The comparisons of A:*xis* with examples developed for REA and the Multiview Accounting System has demonstrated that it is capable of supporting the same information needs as these alternative models. It also illustrated additional benefits which can be derived from adopting the A:*xis* model.

### 7.5.4 Methods Required to Support an A:*xis* Data Model

The prototype of an A:*xis* model (see Appendix C for further details) built to verify its equivalence to the examples developed for the REA accounting template and the Multiview Accounting System, also provides an insight into the types of methods which would be required to support its implementation. The suggested methods are included in the Unified Modelling Language (UML) class diagram shown in Figure 7.15.[55] The methods are considered for each class in turn.

*Exchanges*

When implementing the rules for accounting measurement the main questions about exchanges are concerned with:

 ❖  whether the exchange's initiator has occurred (*Initiates_On*);

 ❖  whether the exchange's terminator has occurred (*Terminates_On*);

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[55]  ORM is an approach to data modelling and is not concerned with implementation details such as methods. Hence a UML class diagram is used here.
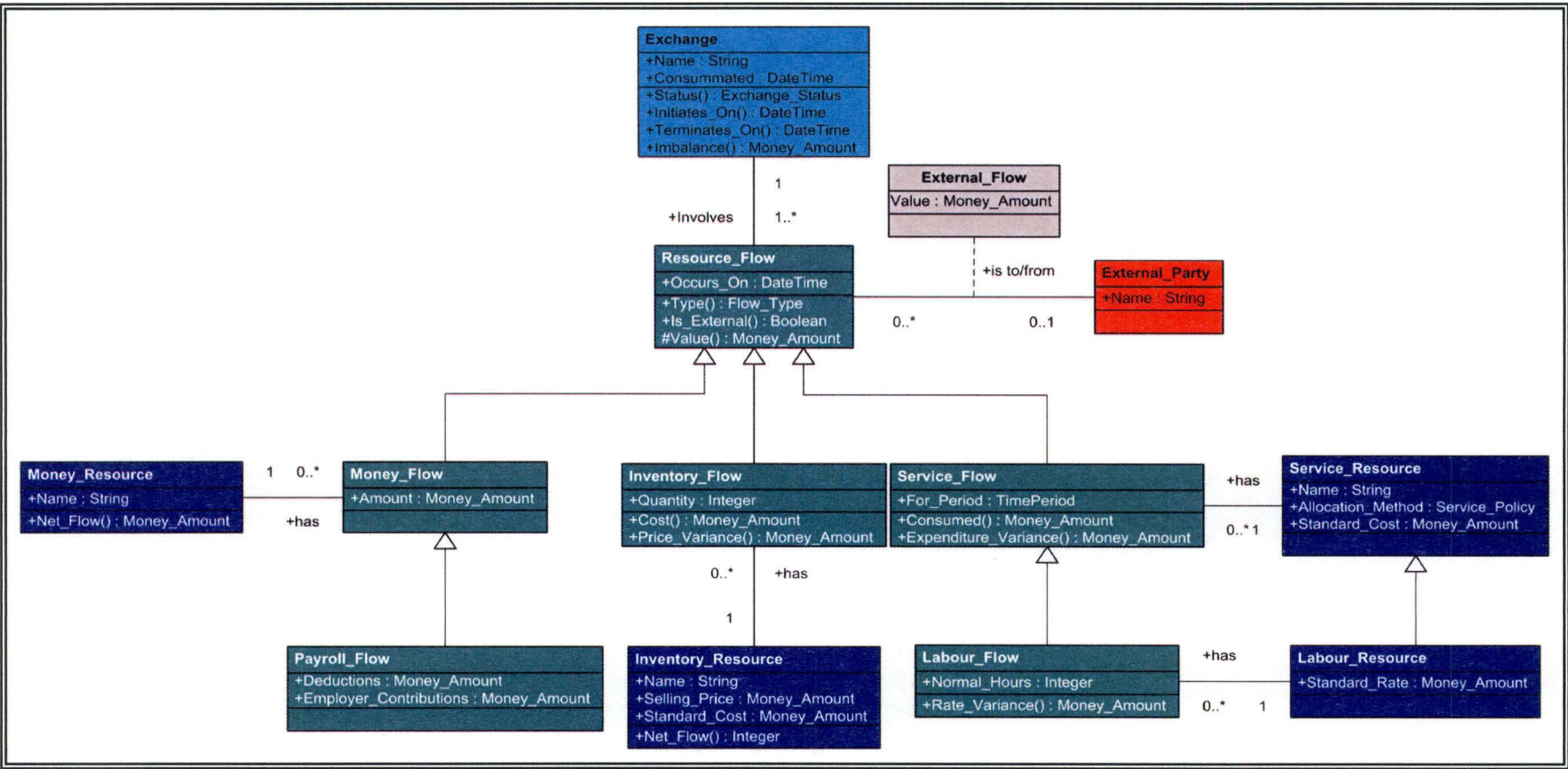
**Figure 7.15  UML Class Diagram of an A:*xis* Model**

❖ the level of any monetary imbalance between the inflows and the outflows

(*Imbalance*).

Each of these questions can be encapsulated in a method defined for the exchange class (as named in brackets above). The class diagram includes an additional method called *Status* which identifies whether the exchange occurred in the past, has yet to occur (future) or is in progress (present). This method is merely a convenient means of identifying the relative position of the reporting time to the time of the exchange's initiator and terminator; that is, is the report time prior to the initiator (a future exchange), after the terminator (a past exchange) or between the two (a present exchange). The method may, therefore, be implemented using the *Initiates_On* and *Terminates_On* methods which have already been defined.

*Resource Flows*

An economic resource flow must be one of three subtypes (money, inventory or service) and may also be a subtype of one of these (payroll or labour). The *Type* method provides a means of identifying the type of any resource flow. The association between a resource flow and an external party is optional so the *Is_External* method provides a convenient mechanism for determining whether such an association has been defined for an instance of a resource flow. For accounting measurement purposes each resource flow is assigned a monetary value. This may be based on the value agreed with an external party or it may be imputed from the application of a selected accounting policy. Any differences between external values and imputed values must be dealt with appropriately by reporting procedures. For example, such differences may arise because of price variances when adopting standard costing methods. The implementation of this method will vary according to the type of flow. For this reason *Value* is defined as a protected method in the superclass; each subclass will inherit the method and define their own implementation of it.

Inventory is a non-monetary resource for which both inflows and outflows are captured. Those outflows of inventory which represent sales to external parties will be valued on the basis of selling prices. For these flows, a *Cost* method is defined to enable a cost for the inventory foregone to be derived which may be used to ascertain the profit (or loss) made from the exchange. This method would apply a selected accounting policy to determine

the cost of the inventory. For inflows of inventory any difference between this cost and the value of the resource flow may be interpreted as a price variance. This would arise, for example, when a standard costing method is being applied. A method may also be defined to calculate a similar variance for labour flows (a rate variance) since a quantity figure is available for these flows in terms of a number of hours.

Since service flows are measured only in monetary terms and may be continuous in nature (provide benefits which extend over a period of time), the accounting treatment of these flows requires a method to divide them between periods. The *Consumed* method specified for the *Service_Flow* class may be used to determine the amount of the flow which can be attributed to periods prior to the report date; with any balance, by definition, applying to the period after this date. This allocation would be made on the basis of a selected accounting policy.

*Resources*

Some methods are defined for specific types of resource. For example, acquisition and consumption flows are recorded for both money flows and inventory flows. The *Net_Flow* method calculates the net of the inflows and outflows of these types of resource allowing the remaining balance to be determined. Accounting reports often seek to classify resources on bases which may require additional values to be recorded to support this. For example, unconsumed services may be classified as prepayments or different categories of non-current assets depending upon the nature of the service, its cost and its duration. Accounts receivable and payable may be classified as either current or non-current according to the length of time between the report date and the expected time of the flow. Typically, money flows expected to occur less than 12 months after a report date are treated as being current. Classifications may also be based on the nature of an exchange or the role being played by an external party. For example, finance provided by an external party would be treated as share capital if the flow is received from an external party in their capacity as a shareholder and as a current or non-current liability otherwise. These types of classification operations may be encapsulated in additional methods.

*Summary*

The methods described above represent the types of calculation required to generate a trial balance in the prototype A:*xis* system developed for validation purposes (see Section 7.5.3). These methods are required to implement the accounting measurement rules which transform data relating to business activities into accounting reports. As a result, such methods also provide a mechanism for maintaining the underlying data independently of the accounting policies which are applied in the production of reports. The *Exchange* and *Resource_Flow* classes are used to capture the basic accounting data, whilst the *Resource* classes (*Money_Resource*, *Inventory_Resource*, *Service_Resource* and *Labour_Resource*) provide additional data to support reporting requirements (such as standard costs and accounting policy choices). The *Resource* classes may, therefore, be seen as part of the interface between users and the accounting data. In order to offer some choice in the preparation of accounting reports, users may be permitted to specify values for some attributes of these classes.

### 7.5.5 Implementing Systems Based on the A:*xis* Data Model

Even though contemporary accounting systems record transactions using double-entry, in many cases transactions may be recorded using a single entry approach because the opposite entry can be derived from the type of transaction. For example, a credit sale will always be balanced by an entry to debtors. A similar approach can be applied when implementing an A:*xis* model through the use of *exchange templates*. A template may be set up for different types of exchange which would allow users to enter the required values. For a standard sale, a template would consist of one (or more) inventory flows and a money flow.[56] Since both models seek to record the same sets of events, the same visual appearance for the user interface could be used. An A:*xis* may allow additional detail to be recorded, but default values can often be derived from the system. In the case of a sale, the data relating to the inventory flows would be similar to a double-entry system. However, rather than recording the amount receivable as a debtor, the A:*xis* model would record a future, expected money flow. The date when an amount receivable is expected to be received is not normally entered in a double-entry system at the time of a sale. This would

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[56] Further money flows may be added if, for example, payment is expected in instalments. Some money flows might be defined automatically, for example, the sales tax payable to (or reclaimable from) the ATO.

be equivalent to leaving the future money flow undated in an A:*xis* system. Alternatively, an expected date of receipt could be entered by the user along with the other sale details or it could be estimated from the credit terms offered and/or the customer's payment history. Thus, it may not be necessary to extend the user interface for an A:*xis* system to permit additional data items to be entered as suitable default values may be available.

Recording some exchanges in an A:*xis* model can appear more complicated than in a double-entry system because the former seeks to record details about the complete exchange at the time it is consummated rather than over its life. For example, rather than just recording a loan as a liability, an A:*xis* model would add a money flow for each of the repayments and service flows for each interest element. These would all be entered into a double-entry system over the life of the loan so an A:*xis* system does not require additional entries, merely a change in the time at which they are entered. In the case of a loan, just entering the amount borrowed, the term, the frequency of repayments, the interest rate and the type of loan (for example, equal instalments or interest only) would be sufficient for an accounting system based on the A:*xis* data model to generate the appropriate set of money flows for this exchange automatically. It may also offer a facility to recalculate these values whenever interest rates (or other terms of a loan) change.

Thus, any apparent complexity in recording business activities in an A:*xis* model may be reduced by designing an appropriate user interface when implementing a system. As discussed above, this interface could be quite similar to ones used by contemporary accounting systems and, since identical reports can be produced, it is possible for users to be unaware of the change in the data model underlying their accounting system. However, users may notice a change in the range of reports available and the ability to delay the specification of reporting requirements until a report is generated (rather than before the data are captured).

Of course, continuing with a similar user interface as those typically used in contemporary accounting systems is not mandatory. There are opportunities arising from the change in the data model to design new ways of visualising the data being recorded. If accounting systems are to take advantage of the ability of the A:*xis* model to incorporate flows of non-economic resources, then some changes to the interface will be essential. Figures 7.16 and 7.17 illustrate two ways in which the underlying nature of an exchange could be depicted.
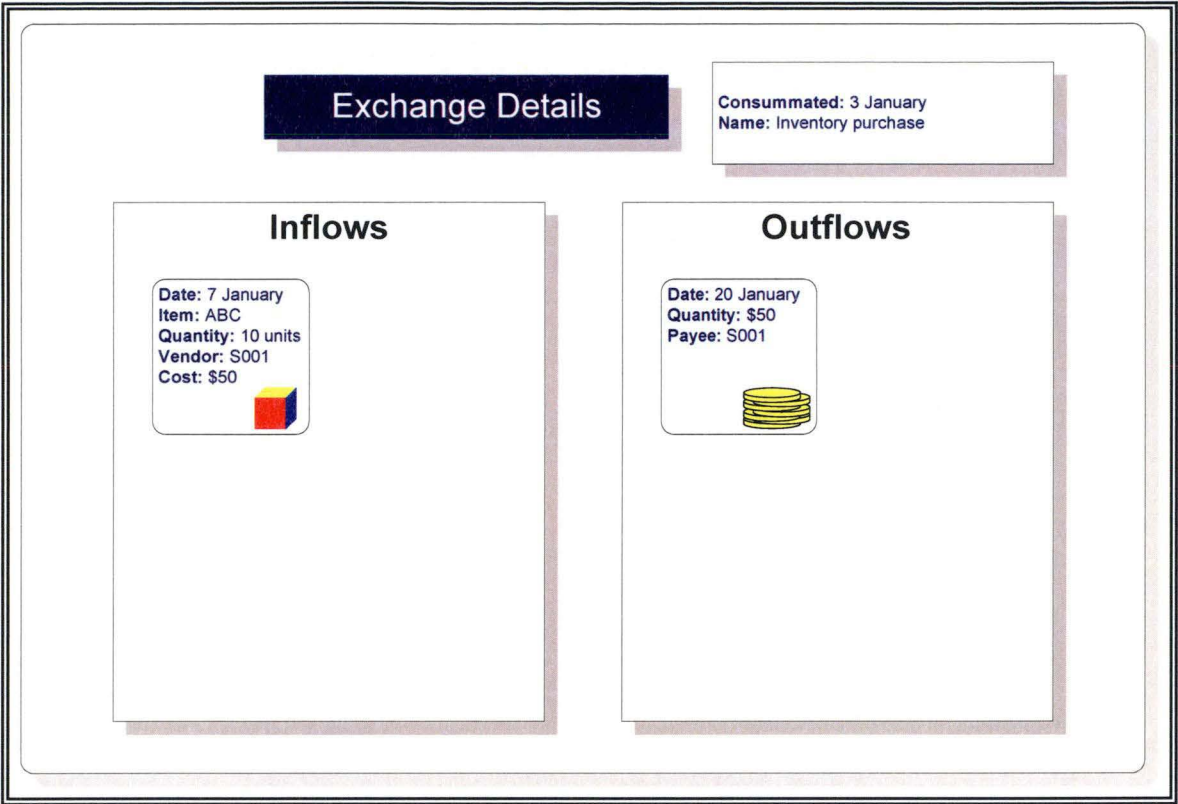
**Figure 7.16  Visualisation of an A:*xis* Exchange (Compact Version)**

The same exchange is illustrated in both figures: the purchase of inventory.  Types of flow are differentiated by an appropriate icon; in this case a cube represents inventory flows and a pile of coins is used to represent money flows.  Figure 7.16 displays the exchange as two sets of flows: inflows and outflows, whilst Figure 7.17 also emphasises the timing (and sequence) of the flows.  Other visualisations are also possible and, since the underlying data model is identical in each case, they are interchangeable: different views of the data may be used for different purposes or different users.  For example, data entry of large volumes of exchanges may be more efficiently performed using a view which is less graphical and more text based; whilst complex types of exchange may be easier to describe graphically.  The choice of user interface is a decision which can be deferred to the implementation stage of the development of an accounting system, but the closer fit of the data model to the organisations's business activities should permit the user interface for an A:*xis* system to be more intuitive.  Further consideration of the implementation stage is beyond the scope of this thesis and is the subject of future research.
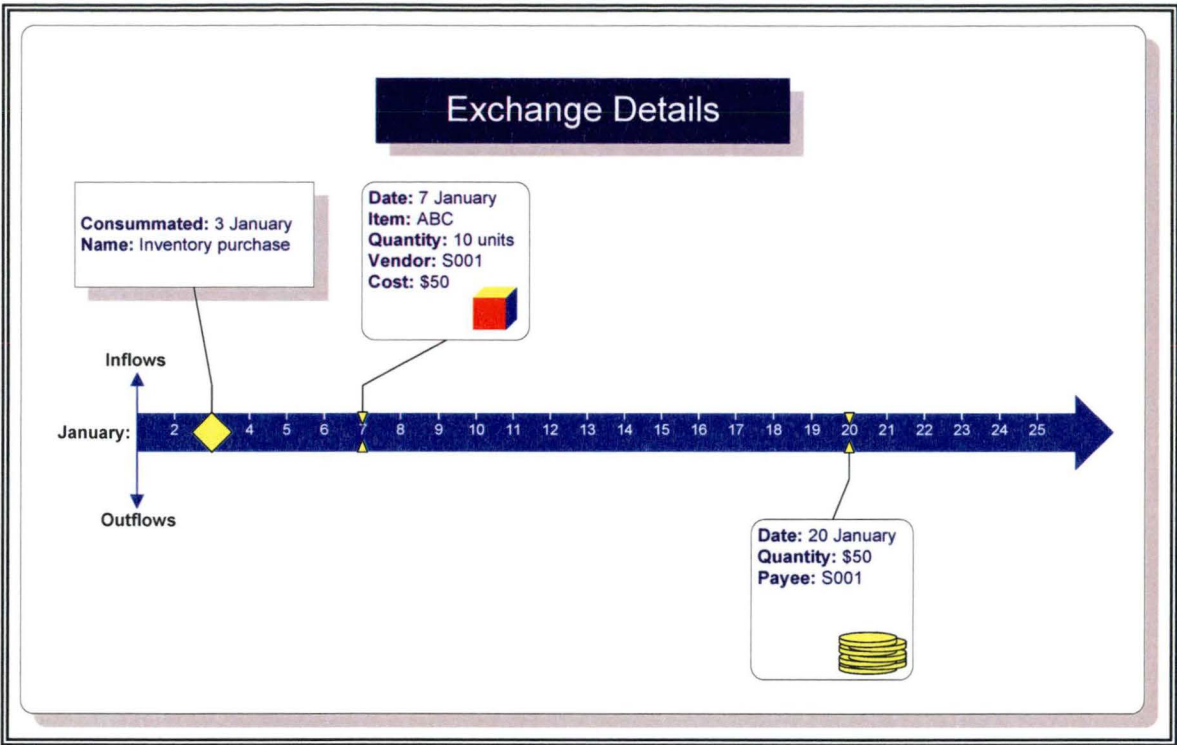
**Figure 7.17  Visualisation of an A:*xis* Exchange (Timeline Version)**

## 7.6  Summary

This chapter sought to design an accounting data model which would overcome the outstanding criticisms of accounting systems and which proposals for alternative models have failed to resolve.  In particular, it was hypothesised that a new accounting data model could be designed which:

❖   integrates past and future accounting transactions ($H_{model,1}$);

❖   records accounting transactions independently of the valuation basis and accounting policy choices ($H_{model,2}$);

❖   would facilitate reporting on-demand ($H_{model,3}$).

The A:*xis* model developed in this chapter was built on the basis of accounting data models for actual organisations (see Chapter 6) and provides support for each of the above hypotheses ($H_{model,1}$, $H_{model,2}$ and $H_{model,3}$).

An A:*xis* model comprises three main constructs: exchanges, resource flows and external parties.  Resource flows may be economic or non-economic.  There are three types of economic resource flow: money flows, inventory flows and service flows.  Labour flows are defined as a subtype of service flows and payroll flows are defined as a subtype of

money flows. The external parties construct is a supertype representing all persons (including legal persons) other than the organisation for which the resource flows are being recorded. Thus, subtypes of external parties include suppliers, customers, employees, lenders and owners. Any individual person may participate in more than one role (subtype); for example, an employee may also be a customer or an owner. Further subtypes of each entity can be defined as required.

At first glance the A:*xis* model looks similar to the REA accounting template. Resource flows in A:*xis* are similar to the economic events in REA, and the external parties in A:*xis* are similar to the economic agents in REA. Dunn and McCarthy (1997) propose the following three core features to differentiate the REA accounting framework from other accounting models:

❖   its database orientation;

❖   its semantic orientation;

❖   its structuring orientation.

A:*xis* conforms to each of these core features; it satisfies the three conditions of a database orientation (Dunn and McCarthy 1997, 36), it is a semantic model, and it provides a means for structuring a complete enterprise model. However, there are significant differences between an A:*xis* model and REA:

❖   *Conceptual model*

Whilst REA is defined as a template which can be applied to design conceptual models of accounting systems, A:*xis* is a complete conceptual model of an accounting system. The definition of REA is, therefore, closer to the notion of a construct than a model; it is a building block used to represent an economic event with instructions on how such blocks should be joined together (by way of duality relationships) to build a conceptual model. A:*xis* has synthesised the different economic events which may arise in practice into three types of resource flow and used the exchange construct as the mechanism for associating related flows.

❖   *Perspective*

The primary focus of REA is on economic resources; an economic event represents an inflow or outflow of an economic resource. An A:*xis* model focuses on exchanges; an exchange comprises one or more resource flows.

❖ *Recognition rules*

REA adopts the traditional approach of only recording economic events once they have taken place. Thus, a sale order describes a non-accounting phenomenon (Dunn and McCarthy 1997, 37-38). An A:*xis* model provides a consistent basis for modelling both past resource flows and future expectations of resource flows. Under this approach a sale order represents an expectation of a future flow of an inventory resource. The only difference between a sale and a sale order is its timing; a sale has already taken place and a sale order is a sale which has yet to occur.

❖ *Domain*

The REA accounting template only includes *economic* events. By focussing on exchanges, A:*xis* provides a structure in which resource flows of any type can be included (flows of non-economic resources would just be ignored when preparing financial statements, for example). This approach also extends to being able to model both economic exchanges and non-economic exchanges.

❖ *Fidelity*

A strength of the A:*xis* model is that it has been derived from case studies of accounting data recorded by actual organisations. This is unique to proposals for alternative accounting models. Although no instantiation of an A:*xis* model using actual data exists (in common with the proposals for other alternative accounting data models) a prototype using independent accounting examples and expert opinions of practising accountants provide greater assurance of the fidelity to accounting phenomena for an A:*xis* model than for any other existing proposal.

March and Smith (1995) suggested criteria for use in evaluating research outputs (see Chapter 4). For constructs and models, these criteria were:

❖ *Constructs* - completeness, simplicity, elegance, understandability and ease of use;

❖ *Models* - fidelity, completeness, level of detail, robustness and internal consistency.

The completeness of the A:*xis* constructs proposed is evident from the validation undertaken to confirm the completeness of the A:*xis* model although they are, at the same time, incomplete in the sense that the specification of the constructs only includes the minimum requirements to support accounting measurement (other properties may be added to satisfy additional purposes). In comparison with other accounting data models, it is considered that the A:*xis* model provides a simple and elegant solution to the modelling of

accounting phenomena. The constructs are closely related to concepts in accounting theory and to the nature of the accounting function; this should make them more understandable and easier to use. A set of rules was described for interpreting exchanges captured by an A:*xis* model which emphasises its internal consistency and robustness for performing accounting tasks. Further evaluation of the A:*xis* constructs and model is the subject of future research.

# Chapter

# 8

# Conclusions

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The main goal of the research in this thesis was to redesign the data model used by accounting systems in order to overcome criticisms expressed by users and to enable users to support new demands being requested of them. Although problems with the use of accounting systems may have a wide variety of causes, this research has focussed on the design of the accounting data model. The accounting data model is considered to be fundamental to resolving the problems with accounting systems because it is critical to ensuring that the needs of users (including future needs) can be met. Contemporary accounting systems continue to be based on a data model whose origins date back over 500 years. If the data required to support information needs have not been captured by the accounting system then no amount of effort addressing other aspects of accounting systems can overcome this failure. Thus, redesigning the accounting data model is an essential first step in improving the quality of accounting systems.

This chapter is structured as follows. Section 8.1 summarises the main research findings. Section 8.2 outlines the limitations of the research. Section 8.3 discusses areas for future research. The conclusions presented in Section 8.4 include the contributions and implications of the research.

# 8.1 Research Findings

This thesis considered two research questions: $RQ_{crit}$ and $RQ_{model}$. $RQ_{crit}$ sought indicative evidence concerning the problems being experienced by users with their accounting systems. This evidence provided additional justification and evaluation criteria for addressing the main research question, $RQ_{model}$, which sought to generate a new design for the accounting data model.

### 8.1.1 Criticisms of Accounting Systems

The literature in this area offers conflicting views on the ability of accounting systems to support user needs. On the one hand criticisms dating back many years continue to be made against accounting systems yet, on the other hand, the impact of advances in technology are reporting significant improvements in systems (for example, the advent of ERP systems).

$H_{crit,1}$ proposed that contemporary accounting systems are capable of achieving the aims relating to:

- ❖ recording data in a raw (objective) form;
- ❖ capturing both financial and non-financial events;
- ❖ capturing multi-dimensional records of events;
- ❖ processing data more promptly;
- ❖ supporting more efficient and effective business processes; and
- ❖ improving the implementation and maintenance of internal controls.

The evidence collected indicated that contemporary accounting systems have already addressed these criticisms and so hypothesis $H_{crit,1}$ is supported. There was, however, evidence that the solutions to these criticisms adopted by contemporary accounting systems are more restrictive than necessary. Redesigning the accounting data model will lead to an enhancement in the ability of accounting systems to achieve the above aims; for example, improvements in the integration of financial and non-financial attributes relating to resource flows. It is not possible to be conclusive about the continued applicability of these criticisms without more information about their precise causes; such details were not given by the authors reporting them.

The second hypothesis, $H_{crit,2}$, proposed that contemporary accounting systems are not capable of achieving the aims relating to:

❖ combining past events and future projections; and

❖ supporting multiple valuation bases and accounting policies.

The evidence collected provided strong support for this hypothesis.

Hypothesis $H_{crit,3}$ went further in proposing that users would not consider the inability to achieve these aims to be a weakness of their accounting system. This hypothesis was only supported by the evidence collected in relation to the inability of accounting systems to support multiple valuation bases and accounting policies and not in relation to the need for better integration of past and future data.

A further limitation of accounting systems was identified as a result of the data gathered; that is, the failure of accounting systems to capture a complete view of the underlying reality. This limitation manifested itself, in particular, in terms of the manual adjustments required in order to prepare reports (such as financial statements) and the difficulties of preparing reports for arbitrary periods of time. One cause of this is the failure of contemporary accounting systems to fully recognise continuous flows of resources, requiring instead that they be subdivided into a sequence of discrete flows.

The evidence collected in addressing $RQ_{crit}$, therefore, confirmed that contemporary accounting systems were able to overcome many of the criticisms reported in the literature. However, there is evidence that some problems remain which hinder the ability of accounting systems to fully reach their potential to satisfy the demands placed upon them. These remaining problems conflict with the approaches adopted by contemporary accounting systems: a focus on past (not future) events, applying accounting policy choices when data are entered, and concentrating on a single view of the data. The evidence, therefore, provides support for addressing the second research question, $RQ_{model}$, which seeks to redesign the accounting data model as a means of overcoming the weaknesses of contemporary accounting systems.

### 8.1.2  Adequacy of Proposals for Alternative Accounting Data Models

The task of designing a new accounting data model may be avoided if existing proposals for alternative approaches are capable of fulfilling all the needs of accounting systems including those which contemporary systems fail to support.  The analysis of the REA accounting template and the Multiview Accounting System concluded that they would not be sufficient for this purpose.  For example:

- ❖ neither model incorporates future projections;

- ❖ REA does not maintain a separation between the data pertaining to business activities and the accounting choices made; the Multiview Accounting System achieves this but only by maintaining a general ledger for every combination of these choices;

- ❖ REA does not model continuous events;

- ❖ neither model considers the matching concept.

These weaknesses added further support to the need for a new accounting data model to be designed.

### 8.1.3  Redesigning the Accounting Data Model

This thesis proposed a new accounting data model to overcome the weaknesses of contemporary accounting systems which existing alternative proposals of accounting models fail to resolve.  In particular, it was hypothesised that a new accounting data model could be designed which:

- ❖ integrates past and future accounting transactions ($H_{model,1}$);

- ❖ records accounting transactions independently of the valuation basis and accounting policy choices ($H_{model,2}$);

- ❖ would facilitate reporting on-demand ($H_{model,3}$).

The A:*xis* model was designed to address these three hypotheses.  It provides a means of modelling accounting phenomena in terms of constructs representing exchanges, resource flows and external parties.  Each resource flow is represented by one of three subtypes: money, inventory and service.  Further subtypes were defined to support payroll calculations (a labour service flow and a payroll money flow).  The identification of external parties enables external and internal exchanges to be distinguished which is

important for accounting measurement purposes. The model represents an improvement over accounting systems based on double-entry principles because it:

❖    extends the recognition criteria to include flows of non-economic resources (as well as flows of economic resources), future resource flows (as well as past flows) and continuous resource flows (as well as discrete flows);

❖    separates the data representing business activities from those elements which are used in generating reports for users.

The A:*xis* model achieves the three goals reflected in the hypotheses. It integrates future projections of resource flows with records of past resource flows ($H_{model,1}$). The model captures the data relating to exchanges of resources together with any additional data required to implement alternative valuation bases and accounting policies so that users can select their preferred accounting interpretation of the underlying business activities at the time of requesting a report, rather than prior to the data collection ($H_{model,2}$). The A:*xis* model is a closer representation of an organisation's transactions which relegates the function of end-of-period adjustments to a set of procedures, thereby enabling reports to be prepared at any time ($H_{model,3}$) subject to the currency of the data entered into the system. Thus, these three hypotheses are supported. Moreover, the A:*xis* model goes beyond the three goals. For example, it is not restricted to the modelling of flows of economic resources. The definition of the resource flow entity seeks to avoid being too prescriptive so as to facilitate the extension of the model to incorporate any other information concerning exchanges which may be of interest. The model should, therefore, be capable of supporting non-financial forms of reporting such as an eco-balance statement as found in some sets of 'Green Accounts' (Gray *et al.* 1996). Its future orientation also opens up opportunities for a closer integration of the budget/planning systems with the accounting records of past transactions.

## 8.2 Limitations

Criticisms of accounting systems have been used as the basis for devising the aims of a new accounting data model. These aims are based on the limited details of criticisms provided in the literature and on a sample of users interviewed in actual manufacturing organisations which were not randomly selected. Whilst steps were taken to minimise any sources of bias in conducting the interviews (see Section 5.2.4), the use of this research

method with such a small sample is a limitation. The list of criticisms may, therefore, not be exhaustive and it is not possible to confirm how widespread the criticisms identified are. However, given the disparate nature of the sources used (AIS literature, reviews of accounting systems and 15 different manufacturing organisations), it is considered that the aims of accounting systems and the experiences of users identified are fairly representative of those experienced across the manufacturing sector in Australia. On the other hand, since $H_{crit,3}$ is based solely on the evidence gathered from the survey, the support for users not recognising problems as being weaknesses of their accounting systems is less strong than the support for the other related hypotheses, $H_{crit,1}$ and $H_{crit,2}$.

The A:*xis* model has been developed on the basis of the case studies of three manufacturing organisations. These three companies were selected from the non-random survey sample (see above). The selection was not made randomly but companies with different types of manufacturing process were selected (see Section 6.2.2). The results do provide strong evidence that the A:*xis* model is capable of supporting the information needs of these three companies as well as any others which have similar business processes. But the usual limitations of external validity and the case study method apply (see, for example, Yin 1994), so extending these conclusions to other manufacturing organisations and other industries may be problematic. In this research, however, the consistency of the model with accounting theory and the additional validation of the model undertaken with practising accountants strengthens the support for concluding that the A:*xis* model would be suitable for a wide range of organisations.

A further limitation is that no instantiation based on the A:*xis* model exists. This thesis is concerned with the analysis and design stages of systems development (see, for example, Gelinas and Sutton 2001); the implementation and operation stages are beyond its scope and are a subject for further research. However, a prototype system was built and tested using accounting examples devised by other authors independently of the A:*xis* model. This prototype is described in Appendix C and, in itself, provides greater assurance as to the validity of the A:*xis* model than for any other proposal for an alternative accounting model. It has not been used to test examples which adopt current cost valuation bases. However, given the definition of Seddon's (1991) Multiview Accounting System, this should be a straightforward process requiring the addition of entities representing price indices and revisions to the procedures to incorporate the appropriate calculations.

## 8.3 Future Directions

The ambitious nature of, and far-reaching consequences of, the research reported in this thesis inevitably leaves a plethora of future research opportunities both to further the findings of this research and also to explore the consequences of these finding for other areas. Some of these opportunities are discussed briefly in this section.

### 8.3.1 Applicability of the A:*xis* Model

Further research is needed to provide additional evidence to support the view that an A:*xis* model is capable of supporting the information needs of users from a wide range of types of organisation. Such work includes:

- ❖ preparing data models for manufacturing organisations using different types of costing system; for example, process costing and activity-based costing (ABC);
- ❖ preparing data models for organisations in industries other than manufacturing;
- ❖ testing the model using valuation bases other than historic cost;
- ❖ specifying the data requirements and procedures to support all of the Australian accounting standards, including more complex cases such as self-generating and renewable assets (SGARAs) and financial instruments (see, for example, AASB 1998, 1999);
- ❖ extending the model to support the demands of other regulatory bodies within Australia and from overseas;
- ❖ testing the suitability of the model for supporting operations management decisions (Verdaasdonk 1998);
- ❖ proving the completeness of the A:*xis* model as an encapsulation of the rules of accounting measurement.

### 8.3.2 Implementing the A:*xis* Model

Building an instantiation of an A:*xis* model would provide further evidence of its ability to support the information needs of users. Undertaking this development involves the following steps (Halpin 2001, 404):

❖ map the conceptual model to a logical schema; for example, relational or object-relational;[57]

❖ generate an internal schema for a specific DBMS (for example, Microsoft Access or SQL Server);

❖ create external schemas (for example, forms and reports);

❖ enforce security levels; and

❖ populate the database.

Research in this area would provide:

❖ guidance on the choices of implementation compromises (for example, relational mapping procedures);

❖ methods for improving the efficiency of A:*xis* implementations (for example, controlled redundancy and algorithms used to execute accounting rules);

❖ a definition of a standard interface such that methods supporting different reporting requirements can be shared across all A:*xis* systems.

Contemporary accounting systems comprise a set of modules covering functional areas (such as purchasing, sales and production). Although an A:*xis* model seeks to record all aspects of an exchange, the data capture could be delegated to specialised subsystems. This could also involve defining subtypes of the three basic types of resource flow (money, inventory and service) to support specific tasks. For example, a sales subsystem may be supported with a "sale of inventory" resource flow subtype which adds values relevant to the sales function. The A:*xis* model may also be extended with rules relating to business processes to control, for example, the workflow procedures involved in carrying out the sales function (from initial customer contact to delivery of an order). Research work in this area could address such questions as:

❖ what additional definitions of resource flow subtypes and other entities are useful and under what conditions?

❖ how should subsystems be interfaced using an A:*xis* model as the core?

❖ how can business process rules be integrated with an A:*xis* data model?

Several authors have proposed object-oriented approaches to accounting systems (see, for example, Burch 1991, Kandelin and Lin 1992, Murthy and Wiggins 1993, Marland 1994,

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[57] Some data modelling tools implement mapping procedures to automate the conversion of a conceptual model into a DBMS; for example, Microsoft VisioModeler and Microsoft Visio Enterprise.

Adamson and Dilts 1995, Roohani and Sutton 1997, and Geerts and McCarthy 1999) and there has been some development work in the area of business objects (Haugen 1998). The most promising lines of research in this area are considered to be those which seek to develop objects from a conceptual model of the universe of discourse (such as an A:*xis* model) rather than creating objects based on an arbitrary classification scheme. There remain many issues to be resolved. For example, can business activities be recorded by a standardised object in a form which is independent of any of the participating parties? If so, it might be possible to use the accounting record as the means of communication between parties. A purchase order could be sent to a supplier as an instance of a forward-dated inventory resource flow entity. Acceptance of an order could be communicated from a supplier by returning this instance updated with any changes to values such as the delivery date or cost. This mechanism could be used to integrate a value (supply) chain model with an organisation's accounting records thereby providing further benefits from using the A:*xis* model.

A further research area related to an object-oriented approach concerns the implementation of accounting rules. These rules could be implemented as methods of the relevant objects. But accounting rules do not necessarily treat each instance as being independent occurrences. For example, the value assigned to a particular outflow of inventory is generated from applying an arbitrary rule (such as FIFO) and is not independent of other outflows (a change in the sequence of flows, or in the quantity of a flow, can affect the values assigned to other flows). It is also the case that accounting is often not concerned with the value of individual instances (especially given the arbitrary nature of some values) but only the total value of two sets (before and after a reporting date). This can often be simplified to calculating the value of one group as the value of the total population is often known, making the other set equal to any remainder. Thus, it may be more appropriate to associate methods with a reporting object than with the resource flow objects.

The A:*xis* model enables changes to be made to the content and timing of information. This suggests that it may be time for the accounting profession to review its choice of accounting policies in the light of the advances in accounting information systems which offer the potential for new and improved methods. Opportunities also exist for changes in the content, format and frequency of financial reports. Research in this area also includes

identifying what limits should be placed on choices offered to external users to protect the confidentiality of details in the accounting records.

### 8.3.3 Using the A:*xis* Model

The implementation of accounting systems based on the A:*xis* model brings with it an opportunity to review the manner in which users interact with the system and how accounting data are represented. Since the A:*xis* model captures the same data as a contemporary accounting system and can prepare the same reports, it would be possible to implement an A:*xis* system whilst keeping a similar user interface and reproducing the same double-entries (in the form of dynamic reports). However, a new conceptual model of accounting opens up opportunities for changing the education and training of users of accounting systems to realign their view to one which is closer to the actual business activities. For example, Chapter 7 included two possible visualisations of accounting exchanges which may represent more intuitive views of the business activities being recorded. Of course, changing the visual appearance of accounting exchanges is just one small part of what could be a more fundamental paradigm shift in accounting education.

One of the benefits of the A:*xis* model is its ability to support multiple valuation bases and accounting policies. This enables such choices to be offered to the user at the time reports are requested. However, it would probably be impractical for users to make these choices for each individual exchange or resource type. Hence, research is required to investigate what sorts of choices users find useful and how these choices might be specified. For example, such accounting choices could be implemented as enhancements to XBRL (eXtensible Business Reporting Language) which is proposed as a language for communicating financial information.

### 8.3.4 Extending the A:*xis* Model

The A:*xis* model is a specialised type of *xis* model designed to represent accounting exchanges (see Chapter 7). The core features of all *xis* models are the exchange and resource flow elements. A broad definition of a resource is deliberately used so as to accommodate any flow participating in an exchange which may be of interest to the information users. Thus, *xis* models are designed to be extensible. This can be seen by the

way in which the entity concept (Ijiri 1975) has been relaxed so as to permit the incorporation of non-economic flows of resources which are not under the control of the organisation (see Chapter 7). Such flows would be ignored in the preparation of traditional accounting reports. However, it may be varied for other reporting purposes (such as environmental accounting). This requires further research into the types of other resource flows which may be of interest to users and how they can be integrated into an A:*xis* system.

The entity about which reports are generated may also be varied. For example, extending the A:*xis* model with details of related companies (direct and indirect) would allow group accounts to be generated. Similarly an option might enable employees to be defined as being internal parties so that statements of value added could be prepared. Research in this area would include investigating how to implement such extensions, in the form of a method which identifies whether, or not, a resource flow is with an external party.

The A:*xis* model as presently defined is a deterministic model. However, some accounting rules adopt a probabilistic approach. For example, the recognition of an asset in SAC 4 (AASB 1992) involves identifying whether it is *probable* that future economic benefits will eventuate. Such rules could be modelled by incorporating an expected probability into each future resource flow. This would also assist in the calculation of provisions, such as for doubtful debts. Bad debts represent those flows which are assumed to have no probability of occurring, whereas a doubtful debt provision is made against those debts which might become bad debts at some future date.

## 8.4 Conclusions

In this thesis, a new conceptual model has been designed for accounting, to replace the double-entry principles which have formed the basis of accounting systems for over 500 years. This research, therefore, has implications for every organisation and information user. If the A:*xis* model is adopted, the change has wide-ranging and far-reaching consequences; for example:

❖ changes in accounting education at all levels;

❖ a demystification of accounting to make it more understandable to non-accountants;

❖ a change in the role of accountants to focus less on data capture and data processing, and more on providing information and expert opinion;

❖ an empowerment of individual users (both external and internal) to make choices about the content of reports requested;

❖ a customer-driven focus to the provision of assurance services in the light of the empowerment afforded to users (see Elliott 1995).

These changes reflect a radical shift in the role of accounting: at present most accountants are probably not even conscious of alternatives to double-entry systems. This lack of awareness may be the result of the education process and, in particular, of a failure of users to understand the distinction between classificational double-entry and causal double-entry (Ijiri 1975). The A:*xis* model continues to recognise the "cause-and-effect relationships among the changes in ... resources" (Ijiri 1975, 84) but overcomes the weakness of contemporary accounting systems which primarily focus on a dual classification of exchanges.

The call for the changes outlined above are not new: concerns about deteriorations in the position of accountants as the key information providers within organisations have been expressed for some time (see, for example, Elliott 1991, 1992; Hollander *et al.* 2000; Sutton 2000). "The challenge to academic accountants is to invent the third-wave accounting paradigm and produce the graduates who can function effectively in the third-wave organizations they will be joining" (Elliott 1992, 85). This thesis represents a response to this challenge and overcomes a number of the weaknesses of previously proposed solutions. The recent development of ERP systems has seen the accounting function relegated to a ledger update procedure (see, for example, Gelinas and Sutton 2001) rather than as the axis around which an organisation's information needs revolve. Each module of an ERP system may be a rich source of information about the flows of specific types of resource, but it is the accounting data model which can provide a means of relating these flows with each other (in the form of exchanges). Thus, the A:*xis* model can play a key role in overcoming the weaknesses of contemporary accounting systems and better support the information needs of users both in the present and into the future.

# Survey Questions

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This appendix includes a copy of the questions used when conducting structured interviews in relation to $RQ_{crit}$. The questions asked to the Chief Financial Officers (information providers) were varied slightly when interviewing information users. The examples given in italics were only used when interviewees required some further explanation. See Chapter 5 for details.

## A.1 Questions for Information Providers

1.    Who are the main users of information generated from the accounting system.
2.    Can you think of any examples of recent situations in which the accounting system was unable to provide the information requested by a user (either within the organisation or outside)?

   *Example: the accounting system aggregates sales according to the product type but users have requested analyses of sales by market, customer and invoice value.*

3.    Do you know of any information which is not available from the accounting system but which you believe would be valuable to users?

   *Example: a list of those sales made in the last six months which were not paid for within the permitted credit terms.*
   *Example: the effect of alternative methods of allocating overheads.*

4.    Are there any business activities whose observed values have to be transformed in some way (or other procedures or calculations applied) before they are suitable for recording in the accounting system?

   *Example: a posting summary to allocate overheads across different expense accounts.*
   *Example: calculation of home currency values for foreign transactions.*
   *Example: calculation of bad debt provision based on level of debtors.*
   *Example: calculation of goodwill.*

5.    Are there any business activities whose details (or partial details) must be entered more than once into the accounting system?

> *Example: accruals and prepayment details are entered separately from the original transaction.*
> *Example: fixed asset details are entered separately for depreciation calculation purposes.*

6.  Do you apply any transformations (or other procedures or calculations) to information generated by the accounting system before it is passed to a user?

> *Example: accruals-based reports must be adjusted to prepare a cash flow statement.*
> *Example: information must be exported to produce reports in a form which is easier to understand (e.g. graphs) such that changes to the underlying data does not automatically update these reports.*

7.  Have there been any occasions when a change in the information required by a user has necessitated alterations to the way in which data are recorded or processed by the accounting system?

> *Example: changes to the costing system cause expenses to be accumulated in different accounts.*

If so, how much time was spent making the changes? Were any costs incurred (other than staff time)?

8.  Have any recent external events had an effect on the way in which data are stored in, or information is prepared from, the accounting system?

> *Example: an accounting standard requiring segmental reporting requires a more detailed chart of accounts to be devised.*

9.  Has there ever been a need to provide information under alternative valuation bases?

> *Example: recoverable amount (AASB1010 - Accounting for the Revaluation of Non-Current Assets).*
> *Example: net present value (financial instruments).*
> *Example: deprival value (public sector).*

If so, was the accounting system able to provide this information?

10. Have you ever been asked to prepare financial statements at a time other than the end of a reporting period?

> *Example: to provide information for the bank manager.*
> *Example: prepare a prospectus for in response to a takeover or capital issue.*

If so, did this create any difficulties?

11. When did you last change (either voluntarily or involuntarily) one of your accounting policies? Please describe any problems encountered in adjusting your accounting system to cope with this change? Was the change made at the end of a financial year? If so, was this done to avoid additional problems from making the changes in the middle of a financial year?

12. What are the five most important improvements that you would like to make to your accounting system?

13. Do you have any other comments to make regarding the ability of your accounting system to meet your organisation's needs?

## A.2  Questions for Information Users

1. What is the main information you receive from the accounting system and what are the main purposes for which it is used?

2. Have there been any situations in which you were unable to obtain the information that you wanted from the accounting system?

    *Example: sales analysis by market, customer or invoice value.*

    *Example: overheads by type of expense, behaviour (variable or fixed) or business process.*

3. Is there any information which you would prefer to receive but have not requested because you think that it is not available (or would be too difficult to obtain) from the accounting system?

    *Example: a list of those sales made in the last six months which were not paid for within the permitted credit terms.*

    *Example: the effect of alternative methods of allocating overheads.*

    If so, please describe the nature of this information.

4. Is all of the information you use from the accounting system available by the time you would most like to have it?

    *Example: financial statements are not available soon enough after the end of the reporting period.*

    *Example: cash balances to support decisions on money market placements.*

    If not, what is the effect of such delays?

5. Is all of the information you use from the accounting system provided as regularly as you would like?

    *Example: financial statements can only be prepared at the end of monthly reporting periods.*

    If not, please describe the nature of the information and the desired regularity.

6. Have you ever encountered problems in requesting changes to any of the information that you receive on a regular basis?

    *Example: new method of allocating overheads required a significant amount of time to implement and since previous months could not be adjusted it could only be done at the beginning of the financial year.*

    If so, please describe these problems and their effects.

7. Please describe any transformations (or other procedures or calculations) which you apply to the information you receive from the accounting system before it is in the form that is used?

    *Example: if separate sales ledgers are maintained for each division, the overall balance owed by a customer must be calculated by summing each of the individual balances.*

8. Can you think of any external events which have changed the content or format of the information you receive from the accounting system?

    *Example: intangible assets are now included in our financial statements but they tend to be ignored in our internal decision-making.*

    If so, have these changes affected the way in which you use the information provided?

9. Do you ever require information from the accounting system based on alternative valuation bases?

    *Example: replacement cost*

    *Example: market values*

    If so, was this available?

10.     How often do you need to change (voluntarily or involuntarily) the accounting policies used to generate the information received from the accounting system? Can this be done at the time required?

> *Example: stock valuation method*
> *Example: depreciation method*

11.     Do you have any other comments to make regarding the ability of your accounting system to meet your organisation's needs?

# Object Role Modelling

The models presented in this thesis have been described using object-role modelling (ORM). ORM is based on extended NIAM and provides a graphical notation for preparing data models. Object-Role Modelling is so-called because it views the world in terms of objects playing roles. Facts are assertions that objects play particular roles. According to Halpin and Bloesch (1998) ORM is the most popular fact-oriented approach to data modelling. ORM provides a much richer description of a data model than other approaches such as Entity-Relationship (ER) modelling.

This appendix provides a summary of the ORM notation used in the models presented in this thesis.

## B.1  Basic Elements

An ORM diagram is comprised of the following basic elements:

*Entity:* an object (thing of interest) which is described

*Value:* an unchangeable object that is identified by a constant; numeric values (for which arithmetic operations may be performed) are denoted by adding a plus sign to the end of the name

*Predicate:* a fact describing roles played by entities and values (relationships); in this case involving two roles but it may be one or more



*Role connector:* roles are linked to the object which plays the role by means of a role connection line



Multiple instances of an object type in an ORM diagram are indicated by a small triangle inside the object type.

## B.2  Basic Constructs

| Extract of Conceptual Schema | Description |
|---|---|
|  | Employee has a name |
|  | Employee works for a department |

## B.3  Constraints

A mandatory role is denoted by a filled circle at the point where the role connector joins the object.  Uniqueness constraints are denoted by double-headed arrows across the top of the role for which the value must be unique (that is, the value may only occur in only one relationship of this type).  These are illustrated by the following examples:
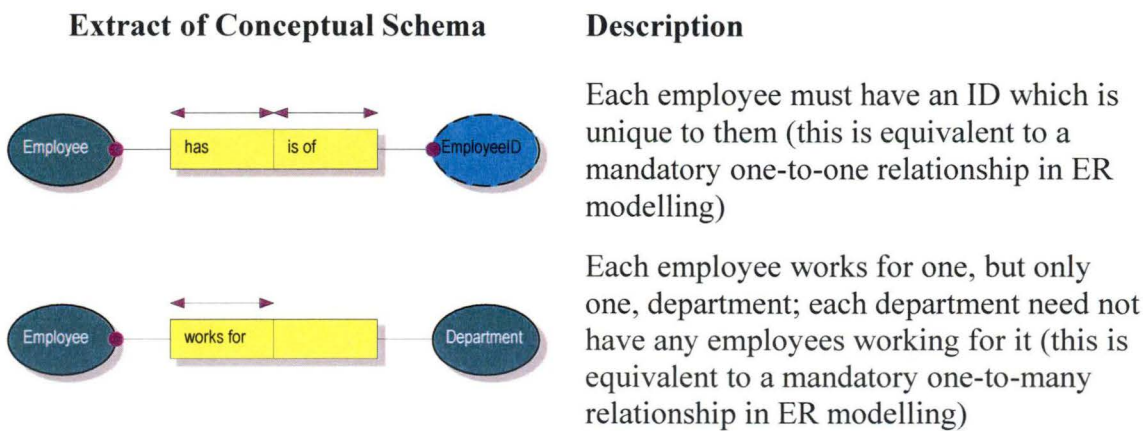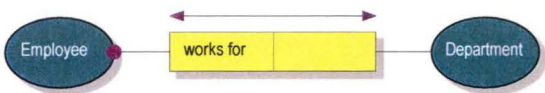
| Extract of Conceptual Schema | Description |
|---|---|
|  | Each employee must have an ID which is unique to them (this is equivalent to a mandatory one-to-one relationship in ER modelling) |
|  | Each employee works for one, but only one, department; each department need not have any employees working for it (this is equivalent to a mandatory one-to-many relationship in ER modelling) |

| **Extract of Conceptual Schema** | **Description** |
|---|---|
|  | Each employee works for one or more departments; each department need not have any employees working for it (this is equivalent to a many-to-many relationship in ER modelling) |

A frequency constraint specifies the number of times a role can be played by an instance of an entity. This type of constraint is illustrated by the following examples:
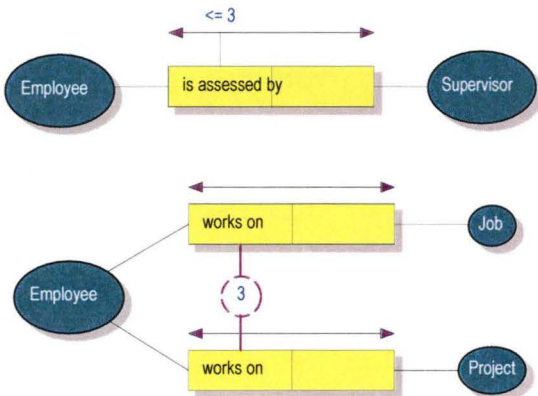
| **Extract of Conceptual Schema** | **Description** |
|---|---|
|  | An employee is assessed by at most 3 supervisors |
|  | An employee works on a total of exactly three jobs and projects |

The values of an instance may be constrained to a specified list as illustrated in the following example:
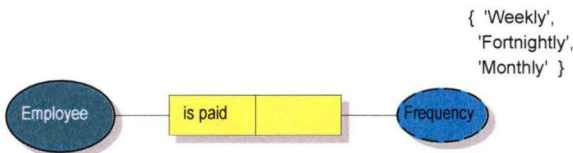
| **Extract of Conceptual Schema** | **Description** |
|---|---|
|  | An employee is paid either weekly, fortnightly or monthly |

Ring constraints may be applied where two roles in a predicate are played by the same object type. These are denoted by a ○ symbol followed by the type of constraint as listed below:

| Code | Kind | Example |
|---|---|---|
| ac | Acyclic | No cyclic relations. If A is related to B, and B is related to C, then C cannot be related in the same way to A |

| Code | Kind | Example |
|------|------|---------|
| as | Asymmetric | No symmetric relations. Prohibits A from being related to B in the same way that B is related to A. For example, if A is the supervisor of B, then B cannot be the supervisor of A. |
| ans | Antisymmetric | When A and B differ, prohibits A from being related to B in the same way that B is related to A. If period A includes period B, and A is not equal to B, then B cannot include A. |
| it | Intransitive | No transitive relations. Prohibits direct connections across a chain of two connections. For example, if floor A is just below floor B, and floor B is just below floor C, then floor A cannot be just below floor C. |
| ir | Irreflexive | No reflexive relations. Prohibits an object instance from playing two roles in the same relationship instance. That is, no instance can bear the relationship itself. For example, persons cannot be their own parents. |
| sym | Symmetric | Relation is symmetrical. Requires A to be related to B in the same way that B is related to A. For example, if A is the sibling of B, then B must be the sibling of A. |

An example of a ring constraint follows:
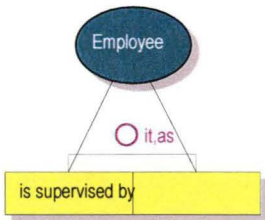
**Extract of Conceptual Schema**　　　**Description**



Each employee may have a supervisor but an employee cannot be supervised by someone that they supervise, and a supervisor is not also the supervisor of any employees supervised by those he/she supervises.

## B.4  Subtypes and Supertypes

A subtype is an object type which is part of another object type. Conversely a supertype is an object type which has one or more subtypes. They are depicted as follows:
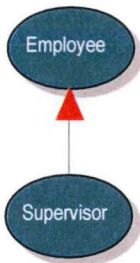
**Extract of Conceptual Schema**          **Description**



A supervisor is a subtype of employee; that is supervisors are a specific type of employee

## B.5  Nested Object Types

A nested object type involves treating a relationship between objects as an object in its own right.  An example might be where an employee has a different supervisor in each department in which they work as shown in the following illustration.
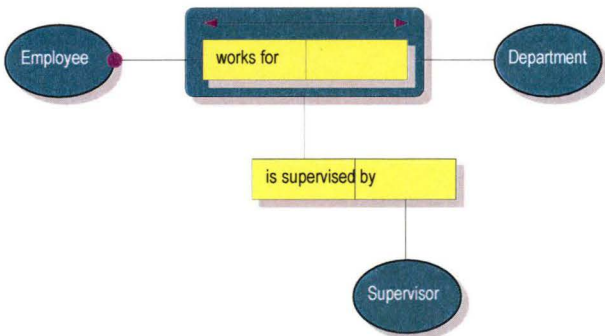
**Extract of Conceptual Schema**          **Description**



An employee may work for more than one department, and may have a different supervisor in each

# Prototype of an A:*xis* System

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⋮
⋮
∎

One of the methods adopted to validate the A:*xis* model was to illustrate how existing, independently-developed accounting examples would be modelled. These examples were discussed in Section 7.5.3. To confirm that these models could be used to generate the same information as in the original example, a simple prototype of an A:*xis* model was developed using Microsoft Access 2000. This prototype is described in this Appendix.

The prototype model has been only designed for the four example models discussed in this thesis; it is not intended to represent a generic implementation of the A:*xis* model suitable for actual organisations. It does, however, serve to illustrate the feasibility of the A:*xis* model and highlight issues which need to be addressed when it is implemented.

This appendix is divided into two sections. Section C.1 describes the derivation of the database schema from the A:*xis* conceptual model. Section C.2 outlines the procedures implemented to generate the trial balances for each of the examples.

## C.1 Relational Mapping

The process of mapping from ORM to a relational database schema is discussed by Halpin (2001). For the purposes of this prototype, the A:*xis* conceptual model (see Figure 7.7) was mapped into a set of relational tables without consideration for the efficiency of the resulting schema. Each entity was mapped to a separate table; the *separation* method (Halpin 2001, 428) was adopted for implementing subtypes whereby a table is created for the supertype with subtype specific-facts contained in separate tables. The

*ResourceFlowExternal Party* nested entity type was not mapped to a separate table, but incorporated into the *Flows* table (Resource Flows entity); null values in the *ExternalPartyID* and *Value* fields signify the absence of this relationship for a specific instance. The database schema is depicted as an entity-relationship (ER) model in Figure C.1.



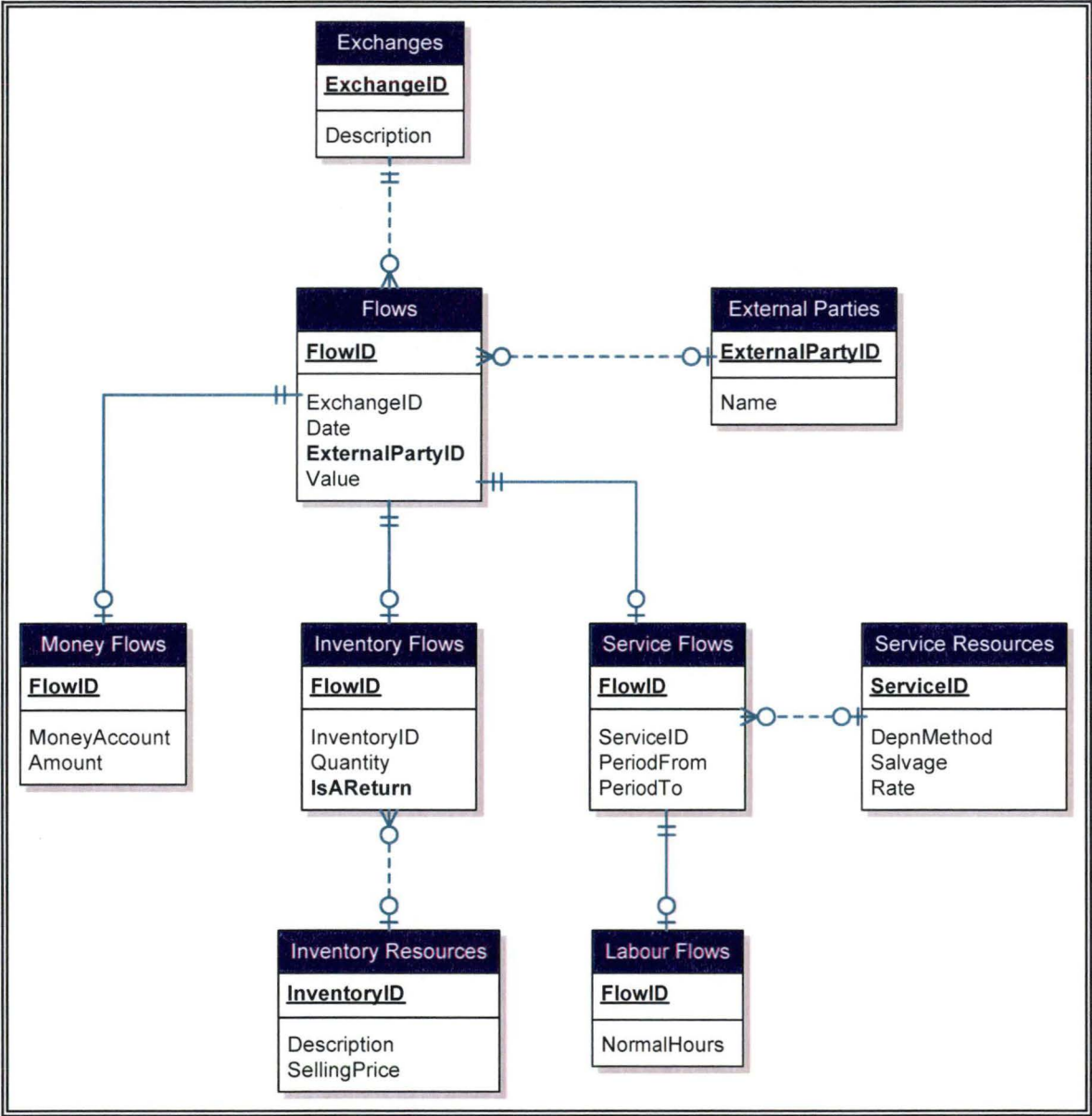**Figure C.1   Entity Relationship Diagram of Prototype A:*xis* System**

Fields have been added as unique identifiers for each of main constructs: exchanges, resource flows, external parties, inventory resources and service resources. None of the examples modelled using this prototype included detailed payroll data and so there was no need to include tables for labour resources or payroll flows in the schema. In addition,

there was no need for a money resources table. The service resources table was used to record depreciation details for non-current assets.

Tables were added to the schema to capture standard cost information (for both inventory and labour) where this was used by an example. Since the examples specify this data in different formats, these tables were adapted to accommodate the data as presented and the procedures updated to take account of such changes and the method adopted by the original author for calculating variances. These tables form part of the data required for reporting purposes and not the underlying business activities and so have not been included in Figure C.1.

## C.2 Procedures for Financial Reporting

The rules for applying accounting measurement to data in an A:*xis* model were defined in Chapter 7. The basic task is to ensure that each resource flow has a value attached to it. This may be represented by a value specified as part of an external flow, or it may be determined from the application of an accounting policy. In order to defer the choice of accounting policies to the time of reporting, procedures are used to determine the appropriate values. For the examples documented in Chapter 7, these procedures offer the following choices to the user:

- ❖ reporting date;
- ❖ inventory policy;
- ❖ time allocation basis.

The following choices of inventory policies were implemented:

- ❖ first-in-first-out (FIFO);
- ❖ last-in-first-out (LIFO);
- ❖ weighted average cost (perpetual);
- ❖ weighted average cost (closing);
- ❖ standard cost;
- ❖ last price.

Continuous resource flows were allocated over time on a straight-line basis unless otherwise specified by an appropriate entry in the *Service Resource* table. The choices of allocation method implemented were:

* ❖  straight line;

* ❖  reducing balance;

* ❖  double-declining balance;

* ❖  sum-of-the-years' digits.

A number of different approaches can be adopted when allocating values across a period of time. In order to accommodate those adopted in each of the examples tested using this prototype, the following choices of time allocation basis were offered:

* ❖  daily;

* ❖  monthly;

* ❖  annual;

* ❖  Seddon's approximation.

The differences between each choice are not significant but it was deemed necessary to implement them so that the trial balances from the examples could be precisely reproduced. Essentially the choice offered concerns how costs are allocated to arbitrary periods of time. The daily basis treats each day as the basis of the calculations so, for example, a straight line method will allocate the same amount to each day, and a reducing balance method will allocate an increasing amount to each day. A consequence of this is that a straight line allocation will not result in equal values being attributed to each month (it will vary according to the number of days in the month). Using the monthly basis overcomes this by allocating to months first; the value for an incomplete month will be calculated as a proportion of the value for the complete month. The annual basis performs a similar calculation on the basis of complete years. Seddon (1991) used an approximation to the daily method based on each year having 365¼ days.

The preparation of a trial balance in the prototype comprised the following steps:

1.    Obtain values for the reporting parameters (reporting date, inventory policy and time allocation basis).

2.    Value each resource flow (at least all those participating in an exchange which has been initiated at the requested reporting date).

3.    Allocate continuous flows to the periods before and after the reporting date.

4.    Apply any required classification procedures (for example, to separate long-term and short-term debts).

The procedure adopted for valuing resource flows is described by the pseudocode in Figures C.2 and C.3. Essentially these implement a recursive procedure for valuing

exchanges by valuing each of their resource flows. Due to the sequential nature of some of the methods for valuing inventory (for example, FIFO and LIFO), all flows for a particular type of inventory resource were valued at the same time as the first.
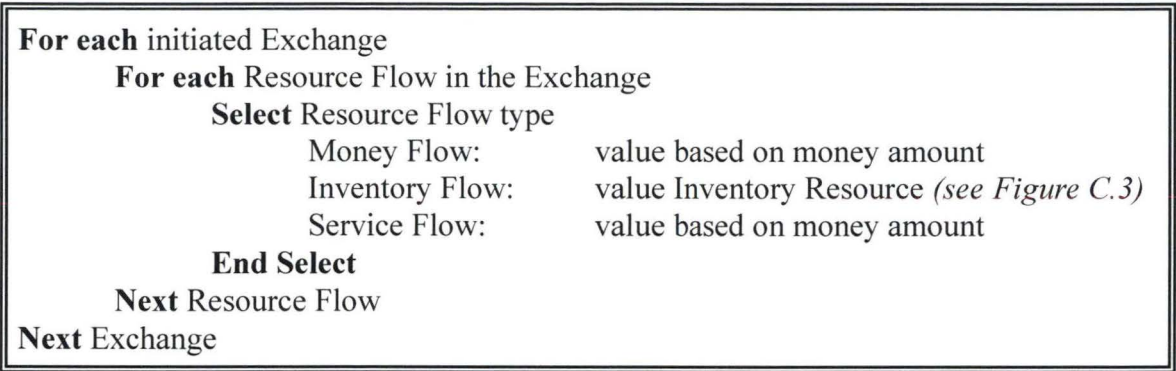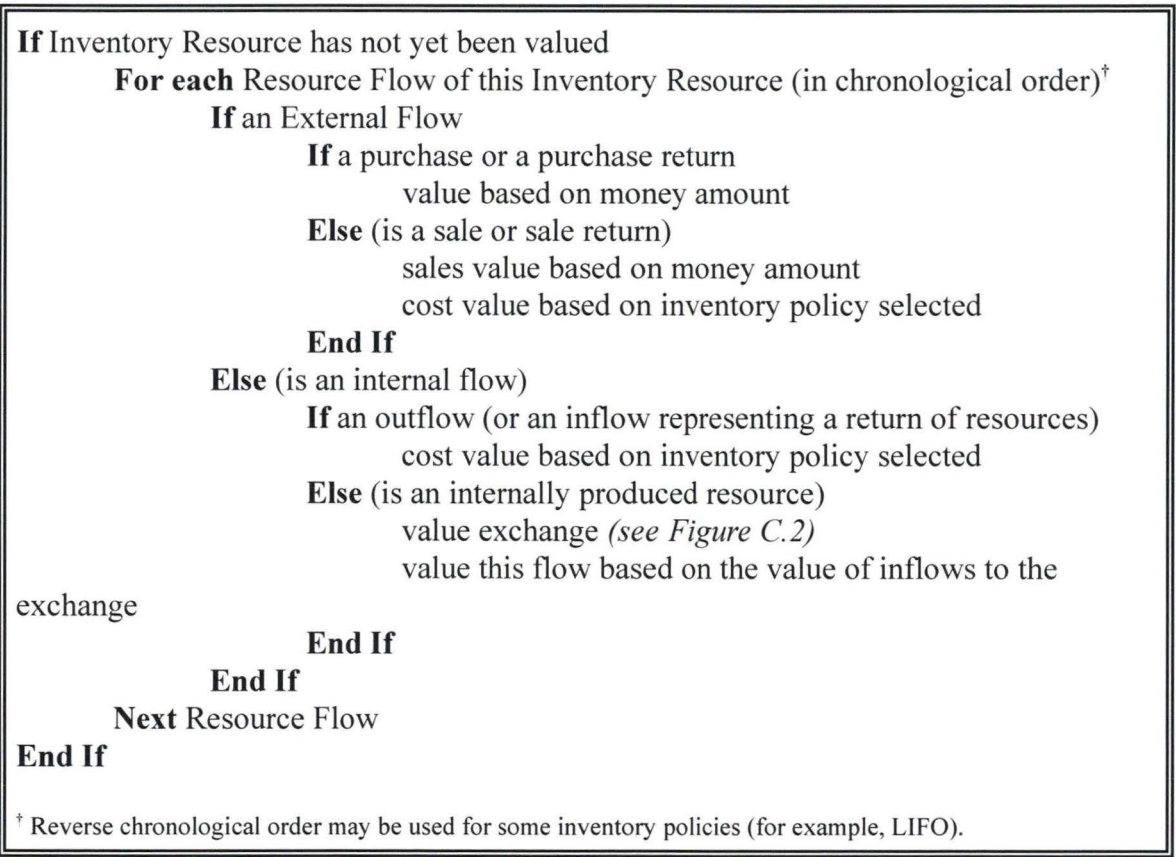
```
For each initiated Exchange
        For each Resource Flow in the Exchange
                Select Resource Flow type
                        Money Flow:         value based on money amount
                        Inventory Flow:     value Inventory Resource (see Figure C.3)
                        Service Flow:       value based on money amount
                End Select
        Next Resource Flow
Next Exchange
```

**Figure C.2   Procedure for Valuing Exchanges**

```
If Inventory Resource has not yet been valued
        For each Resource Flow of this Inventory Resource (in chronological order)†
                If an External Flow
                        If a purchase or a purchase return
                                value based on money amount
                        Else (is a sale or sale return)
                                sales value based on money amount
                                cost value based on inventory policy selected
                        End If
                Else (is an internal flow)
                        If an outflow (or an inflow representing a return of resources)
                                cost value based on inventory policy selected
                        Else (is an internally produced resource)
                                value exchange (see Figure C.2)
                                value this flow based on the value of inflows to the
exchange
                        End If
                End If
        Next Resource Flow
End If
```

† Reverse chronological order may be used for some inventory policies (for example, LIFO).

**Figure C.3   Procedure for Valuing Inventory Flows**

These descriptions of the procedures involved in valuing the resource flows identify the following issues which had to be resolved:

❖   A distinction must be made between outflows to customers and outflows to suppliers; the latter being treated as purchase returns rather than sales. The

*IsAReturn* boolean field included in the inventory flow table is used to distinguish between these two cases.

❖ The valuations of different types of resource are inter-related; for example, the value of internally generated resources are based on the values of resources given up as part of the exchange. Thus, the adoption of a recursive solution method provides a convenient mechanism for managing this complexity.

A further procedure was used to implement the allocation of continuous flows based on the alternative methods allowed (see above). Finally, the only classification procedure implemented was used to determine whether a future resource flow was long-term or short-term on the basis of a user-specified period.

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