A new foundation for accounting:

Steps towards the development of a reference ontology for accounting

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A new foundation for accounting: Steps towards the development of a reference ontology for accounting

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Abstract:

This paper firstly reviews the need for a radical shift in the foundations and framework of accounting's conceptual scheme. It, secondly, proposes that the foundations of the new scheme should be a reference ontology. It outlines a process – ontological analysis – for building this and illustrates how it will work with some examples.

Introduction

The last century's revolutionary developments in information technology, particularly in computing, have led to many significant changes, and still continue to do so. There is the beginning of a recognition that they may well lead to a new accounting conceptual scheme[1]. There are proposals for changes afoot[2] – though what the final outcome will be is unclear. This purpose of this paper is to provide some insight into what the foundations of this new scheme will look like and an outline of a process for building it – the re-engineering of a reference ontology for accounting.

It firstly examines the nature of the changes. It explains how similar changes in the past provide an insight into what the accounting changes are likely to be. It explains why the changes are likely to involve both a significant precisification and a radical shift in the foundations and framework of accounting's conceptual scheme. (It also explains why the new foundations will probably provide a much better support for current and future business changes.)

It secondly proposes a process – ontological analysis – for systematically carrying out the first part of the radical shift – the re-engineering of the foundation to produce a reference ontology. It explains what this process is and why it is a suitable choice. It also illustrates how it will lead to the predicted radical shifts, taking the basic bookkeeping foundations of accounting's conceptual scheme as an example.

The work reported on here has been in gestation for some time. A first report was given in the Epilogue to (Partridge 1996), see §2 – *The accounting paradigm's debit and credit pattern*, §3 – *Accounting's ledger hierarchy*, and §4 – *Developing a new object-oriented accounting paradigm*. This drew upon almost a decade of commercial

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[1] Where this is the framework of concepts used by the accounting community to think about accounting.

[2] See for example, Geerts and McCarthy (2002) *An Ontological Analysis of the Primitives of the Extended-REA Enterprise Information Architecture* say on p.2 "many scholars consider it [the REA model] a more solid foundation for the enterprise information systems of the future than the traditional double-entry framework it attempts to supplant". Similar points are made in Walker and Denna (1997) *Arrivederci, Pacioli? A new accounting system is emerging.* and Andros, et al. (1992) *Reengineer your accounting, the IBM way.*

work re-engineering enterprise systems using the REV-ENG methodology[3]. This paper presents an updated perspective taking account of more recent work.

The current situation

The current focus in both academia and commerce is not on revising the accounting scheme, but trying to accommodate the raft of changes that are impacting it. A wider variety of business practices have to be accounted for and, with globalisation, there is a growing demand to find a common standard that can be accepted globally. These changes have, in large part, been enabled by revolutionary innovation in information technology. This is not the only change IT has brought to accounting. It has also led to a higher degree of formality and precision in the specification of the existing and new accounting procedures, which is needed for them to be implemented in computer applications. These changes have placed enormous pressure on both the accounting scheme[4] and the applications that support it.

Understandably, given this level of change, businesses (and academia) are putting a significant amount of effort into evolving the current accounting scheme to both accommodate it and facilitate its implementation in computing technology. Currently, this is only partially successful. It is proving difficult to implement the full scale of the changes in computer applications, in large part because they are leading to increasing, unmanageable, levels of complexity.

The changes seem to be outpacing the structure's ability to adapt. An indication of this is a general trend for businesses application architectures to move the original core accounting objects (ledgers and their movements) to the periphery – and use their own data structures to accounting for business transactions. It is, for example, now an architectural option to treat account movements and ledgers as a view (and only one of many) over the corporate data. This trend is particularly evident in emerging applications, such as ERP and CRM. There is a corresponding organisational trend, where the responsibility for producing the information for making financial decisions is in the hands of an IT department, independent of the financial function.

As a counter to this trend, there are initiatives within the accounting discipline whose aim is to make the fundamental changes needed to accommodate the kinds of information requirements that are at the heart of modern business applications in a form suitable for computing technology. A sterling example of this is the REA Ontology[5]. These initiatives are being driven by an appreciation of the problems that the current conceptual framework is presenting, along with an understanding of the business and computing requirements. Understandably, a number, including REA, have been influenced by practices in the computing field[6].

Asking what history can teach us

This paper suggests a different approach than these initiatives. It suggests that it makes sense to start by stepping back and asking what is driving this need for change and what the new conceptual schema will look like. Obviously, a prime driver for

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[3] Developed for the re-engineering of legacy systems.

[4] The idea that this needed to change is old. For example, Goetz (1939) *What's wrong with accounting* and Schmalenbach (1948) *Pretiale Wirtschaftslenkung, Band 2: Pretiale Lenkung des Betriebes* pointed this out over half a century ago.

[5] McCarthy (1982) *The REA Accounting Model*.

[6] For example, Table 3 in David, et al. (2002) *Design Science: Building the Future of AIS* lists the IT books that have influenced the design of REA.

change is the revolution in information technology, particularly the development of computing. However, to appreciate the extent of this one needs to recognise the extent to which the current scheme is a product of the old paper and ink technology. Then it becomes clear that the current scheme needs to be aligned with the new technology. The question then is: what form will this re-alignment take? Here studies of other similar historic re-alignments (revolutions) provide some clues. Studies in 'orality and literacy' and the 'philosophy and history of science' reveal the likely general characteristics of the shift and the new scheme.

Accounting - bookkeeping - based upon old technology

The emergence of accounting (and its conceptual scheme) is closely associated with the emergence of writing (an early information technology). Historians tell us that writing developed in Ancient Mesopotamia millennia ago to help people manage the accounts of the developing city-states[7]. They developed systems of budgeting and accounting for resources that both supported the emerging social structures and enabled more complex structures to develop.

The current accounting conceptual scheme has it roots in a more recent development. The introduction of printing in the late 15th century prompted a number of books on accounting[8] – describing various different systems. It also prompted Europe's standardisation on the one of these most suited to the then current technology – the system described in (Pacioli 1494)[9]. The influence of paper and ink technology is plain in most of the early book's text. For example, in Chapter 2, Pacioli writes "The businessman must then prepare his Inventory in the following way: First of all, he must *write* on a sheet of *paper* or in a separate *book* …". Similarly, in the system he described, the debit and credit entries were identified by their position on the *page*.

Pacioli's system also shows the constraints of this technology. One of its key features was the use of two books: the Journal to record the event and the Ledger to record the entries – hence its name 'double entry'. From the modern perspective of computing technology we can see this as constructing two different views over the same data[10]. The use of two books created the need to correlate the two views. Pacioli describes how this is done: "In the left margin, next to the [journal] entry place the page numbers where the debit and credit entries are to be found, the debit above the credit below. Immediately enter the debit and credit account in the index, each under its own letter. Cash will be placed under the letter C as follows 'Cash, page 1'. Place Capital also under C, 'Capital of my own, page 2'. In this way, continue entering in the Index all the debit and credit accounts under their respective letters, in alphabetic order. When this is done the accounts can easily be located in the Ledger." These operational details would be unnecessary in a modern computing system based upon views over data.

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[7] See, for example, Nissen, et al. (1993) *Archaic bookkeeping*.

[8] Littleton (1933) *Accounting evolution to 1900* on p.23 notes some of the early books: Account Keeping – Pacioli, 1494; Reckoning Book – Schreiber, 1523; Book Keeping – Gottlieb, 1531; Keeping the Reckoning called Debtor and Creditor – Oldcastle, 1543; Accounting Books in the Italian Manner – Ympyn, 1543; Double Bookkeeping – Schweiber, 1549; Keeping Books of Account – Mennher, 1550.

[9] The chapter *Particularis De Computis Et Scripturis* (Details of Accounting and Recording) in the book *Summa de Arithmetica, Geometria, Proportioni et Proportionalita*. The system is one that, as Pacioli noted, had been used by Venice merchants for hundreds of years. So printing was not a key factor in its development – just in the standardisation upon it.

[10] Goody (1977) *The domestication of the savage mind* p.89 notes that Pacioli's system is an example of the general problem of sorting lists within writing technology.

Another important 'design' choice was the number and kind of entries to include. The other accounting books published at the time showed alternatives. In Pacioli's ledger only a monetary entry is recorded – twice. Within the constraints of paper and ink technology, this greatly simplifies the process – an important information engineering consideration. However, as always, there are trade-offs. For example, this simplification led to the need to account for depreciation – as the value of the (unrecorded) stock changed.

This last constraint is a good example of what is practical within the old technology, but no longer necessary in the new computing technology. Hence, initiatives such as REA, recognising what modern computing technology has enabled, suggests the inclusion of the full range of entries.

Orality and literacy studies.

The introduction of writing had a far wider influence than just accounting, it enabled the emergence of radically different legal and religious systems – as well as the development of science. These radical shifts from oral to literate cultures – from speaking to writing (and listening to reading) – have been studied[11], as well as the later shifts due to the introduction of paper and printing. A constant theme in these studies is the way the changes in technology drive radical changes in the conceptual structure[12].

The shifts had two common features: a vast increase in the amount of information and the new technology's need for significantly increased formality and precision. These two features converged, in so far as the need to radically improve the way the increased volume of information was typically satisfied, though a significant increase in precision – particularly the introduction of more precise distinctions.

A classic case of this, often quoted[13], illustrates the emergence of a clearly marked distinction between metaphor and scientific statement. Around the time that Ancient Greek literate culture was being established, Empedocles claimed that salt water was the sweat of the Earth. Aristotle, a generation later, criticised this saying "Perhaps to say that is to speak adequately for poetic purposes – for metaphor is poetic – but it is not adequate for understanding the nature [of a thing]." This also illustrates the shift from oral cultures' habit of reasoning analogically (described in (Lloyd 1992)) to literate cultures more syllogistic reasoning. Deductive syllogistical reasoning works on the assumption that the premises are true and so is only practical if they usually are – and this only becomes generally feasible in a literate culture.

The two features are clearly at work in the current information revolution. There has been a vast increase in the amount of information and computing technology's need for significantly increased formality and precision[14] is well known. The introduction

[11] A good introduction to the subject is Ong (1988) *Orality and literacy*. A more recent introduction is Olson (1994) *The world on paper*. More specialised accounts include Clanchy (1993) *From memory to written record, England 1066-1307* and Eisenstein (1983) *The printing revolution in early modern Europe.*

[12] Olson (1994) *The world on paper* proposes, contrary to popular conception, that radical shifts in conceptual structure enable radical developments in technology. However, he accepts that the development in technology then go onto lead to further radical changes in conceptual structures.

[13] For example, Ibid.. p. 190.

[14] This distinction between formality and precision is useful. It is a technical distinction between the formality with which the representation is expressed and the precision with which it refers. This makes formality a property of the representation and precision a property of the relation between the representation and the represented. In ordinary language the meaning of these terms are not 'precise' and so other imprecise terms can be precisified to make the technical distinction. For example, Russell

of a more precise framework of distinctions has yet to happen for most conceptual schemes – including accounting.

History and philosophy of science studies.

One area where shifts in conceptual structure have been documented and studied extensively is science. This makes it a fruitful source of clues as to what the accounting revolution may produce. One particularly useful source is (Kuhn 1970), where he describes the nature of scientific revolutions.

He notes the importance of what he calls paradigms that fix a world view for the practice of normal science in a community. (We can see Pacioli's book as promoting the paradigm that underlies the current accounting conceptual schema.) He notes that as scientific theories evolve they tend to become more unwieldy, more complicated, less explanatory and less fruitful. For example, Copernicus wrote in the Preface to the *De Revolutionibus* that the astronomical tradition he inherited had finally created only a monster. (There are many parallels here with the current accounting schema – whose (monsterish) inadequacies have been detailed for decades.)

Scientific revolutions are a response to this. Historically, they often involve a breakdown of normal science and a return to fundamental questions, often ones that were 'settled' long ago. Einstein's re-opening of the debate on absolute and relative space between Newton and Leibnitz is a well-known example of this. They are usually a response to well-known inadequacies of a theory in the light of well-known data rather than to new experimental results – Copernicus, Newton and Einstein are good examples. (The questioning of Pacioli's restriction of the ledger to monetary entries is an accounting example of a well-known inadequacy.)

The response typically involves a radical shift in the underlying paradigm, which re-arranges the existing knowledge into a very different pattern – rather than introducing new elements. As Kuhn notes[15], this change is like seeing the same world in a different way and quotes other historians who have made similar comments. (Butterfield 1949), on pp.1-7, describes it as "picking up the other end of the stick", a process that involves "handling the same bundle of data as before, but placing them in a new system of relations with one another by giving them a different framework". (Hanson 1958), in Chap. 1, describes it as a change in visual gestalt: the marks on paper that were first seen as a bird are now seen as an antelope, or vice versa.

Kuhn also notes an important characteristic of the new paradigm, that in order to succeed it must be seen as much better than the old one. Often it is at the same time both simpler and more general than the old one. This may seem counter-intuitive. We might expect a more general theory to be more complex, but examination of revolutions such as Newton's and Einstein's show that they are both simpler and more general. And also, importantly, that they were more explanatory and more fruitful, suggesting new results.

Often the revolution produces a theory that is more precise, but not always. Copernicus is a good example of this. His theory was simpler and more explanatory – but not more precise (at least at the time Copernicus published it) than the Ptolemaic theory it was attempting to supplant.

(1923) *Vagueness* p. 153 uses precise to mean what I have called formal, saying a belief 'is accurate when it is both precise and true' allowing for the possibility of a false precise belief – in my terms, an imprecise formal representation.

[15] Kuhn (1970) *The structure of scientific revolutions* § The Response to Crisis, p.85.

Kuhn's paradigms were more than the bare conceptual structure – they included methods and applications. As he notes (p.41 (Kuhn 1970)) about the Cartesian paradigm: "As metaphysical, it told scientists what kinds of entities the universe did and did not contain: there was only shaped matter in motion. As methodological, it told them what ultimate laws and fundamental explanations must be like: laws must specify corpuscular motion and interaction."

This insight has been developed in studies of the styles of scientific thinking. These (for example (Crombie 1994)[16]) have identified general styles that transcend particular theories. An example of the kind of style that Crombie identifies is: ordering of variety by comparison and taxonomy. One reason for focusing on these is that they offer a more stable way of characterising the scientific enterprise than scientific theories. Clearly Crombie's 'ordering by variety' style has persisted through a number of changes of theory. This notion of style is used in a later section to characterise the nature of ontological analysis.

The probable characteristics of accounting's shift

These studies give us a picture of some of the probable general characteristics of the shift in accounting's conceptual structure.

- The alignment with the new information technology is going to require significant increases in precision.
- The current radical changes in information technology are likely to lead to equally radical changes in conceptual structure.
- The radical shift will start with the foundations of the conceptual structure.
- This shift in the foundations is likely to be a re-arrangement of what we already know in response to well-known inadequacies.
- For the new scheme to be successful it needs to be more general, simpler and more fruitful than the current scheme.

Identifying accounting specific details

This historical analysis gives us some general characteristics that we now translate into accounting specific details. It reveals that the core of the shift is going to be a re-arrangement of what we know about the accounting conceptual structure, including the elements of its foundation. We can pick these elements out to focus on. It also reveals that the re-arrangement is going to respond to well-known inadequacies. We can pick out some of the most salient of these inadequacies for the foundation elements.

The elements of the foundation

We know that the elements at the foundation of the current scheme are going to shift into a new arrangement. It is worth identifying what these are. At the core of accounting is bookkeeping and the basic elements of this can be identified even in the original Pacioli text. These are the foundations upon which accounting is built.

The obvious starting point is the accounting books: the journal and the ledger. Then there are the divisions in the books. Journals are divided into days and ledgers into

[16] See also Hacking (2002) *Historical ontology*. Esp. Ch.12 *"Style" for historians and philosophers*, where this is referred to as styles of reasoning.

accounts. Then there are the entries that are made in these divisions: journal entries and ledger entries. We could identify more elements, but these are sufficient to illustrate our analysis. To summarise, the (partial) list of elements is:

- Book:
  - Journal book,
  - Ledger book,
- Divisions
  - Days (journal)
  - Accounts (ledger)
- Entry:
  - Journal entry,
  - Ledger entry,

These are the elements that the new scheme has to ‘re-arrange’, showing them in a different light.

Well-known inadequacies

A straightforward way of identifying some well-known inadequacies of the current scheme is to compare it with the other competing schemes it originally triumphed over[17]. One such scheme is (Manzoni 1534) who notes that:

> “the four principal things appertaining to buying, selling, receiving, paying, exchanging, lending and gifts are:
>
> 1. The one who gives
> 2. The one who receives
> 3. The thing given
> 4. The thing received” [18]

There are a number of obvious differences between it and Pacioli’s scheme. Firstly, it recognises (as many other schemes at the time did) the non-monetary element of the transaction. This is now clearly recognised as a shortcoming of Pacioli’s scheme and is remedied, for instance, in the REA framework. Secondly, it explicitly recognises the parties to the transaction – what would, in the Pacioli perspective, be called the proprietor and the client. In Pacioli a single proprietor is implicit, the owner of the books, and the client is refered to indirectly as the ‘owner’ of an account across which the entries are posted. Over half a century ago, (Littleton 1933) noted (on p.51) a Manzoni-type approach was better: “The simple logic of the early Italian manner became much obscured when the conscious inclusion of the proprietor in every transaction fell into neglect.” Making the parties to the transaction explicit becomes essential when there is internal trading in which both parties are parts of the entity that is being accounted for (the Pacioli proprietor) – a point we return to later.

Increasing the precision of our understanding

There is a clear recognition in accounting of a need to represent the business sufficiently precisely. This is shown in the traditional accounting claim that the accounts represent a ‘true and fair picture’ of the business. In (Dunn and McCarthy

[17] Recall Einstein’s re-opening of the debate on absolute and relative space between Newton and Liebnitz.

[18] Translation from p.47 of Littleton (1933) *Accounting evolution to 1900*.

1997)'s analysis of the drivers for proposed accounting conceptual schemes this is called (on p.7) the semantic orientation – where "[t]he objects in this conceptual model are required to correspond closely to real world phenomenon."

The foundational elements identified earlier are concepts, which represent the business and its transactions – what can sensibly be called business objects. The historical analysis above suggests that the shift to a new scheme will set higher standards of preciseness. This implies that the new scheme will provide a more precise representation of the business objects than the current scheme. A useful first step towards this is to get a clearer picture of what the business objects, referred to by foundation (conceptual) elements identified earlier, are.

A clearer picture of the conceptual elements

Let us clarify the structure of relationships between the foundational conceptual elements identified above. The books originally were where the accounting data was stored – in both a journal and a ledger book. In modern applications, these are either tables on a database or views over them. Divisions are the way the data are divided in the books: the journal is divided by days and the ledger by accounts. Inside these divisions the entries are stored, journal entries in the journal's day divisions and ledger entries in the ledger's account divisions. Additionally the ledger entries are linked back to their corresponding journal entry. This structure is shown below in Figure 1.

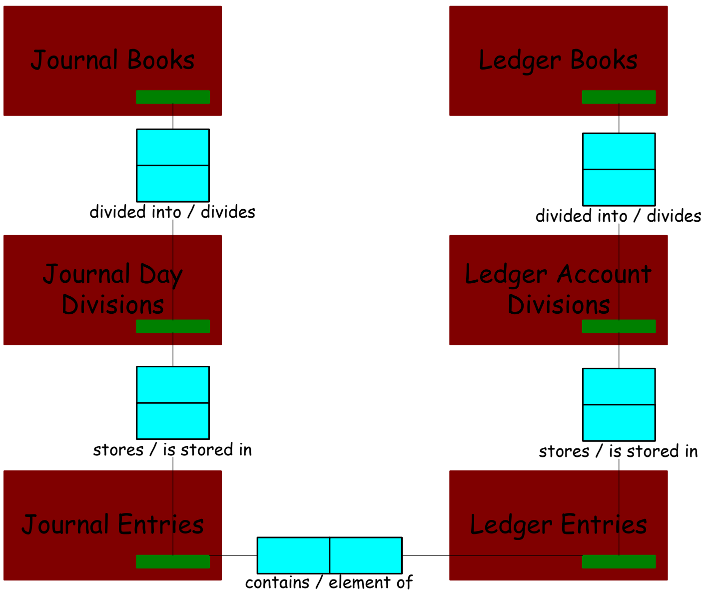

Figure 1 – The accounting foundational conceptual elements

These conceptual objects and their relations refer to and reflect the business objects and their relations that they account for.

Clarify our current understanding of the business objects

A necessary first step in developing a more precise understanding of the business objects, is to clarify our current understanding of what they are. As an illustration, we now make a simple analysis of what business objects are represented by the conceptual objects in Figure 1. This is not altogether straight-forward because although the syntax of the accounting procedure is clear, its semantics is less so.

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We start with the 'journal entries' as it is clearest what these refer to. These record 'business transactions'. The corresponding 'ledger entries' are the accounting representation of the relevant 'accounting movement' elements of the transaction. This implies that relation between the transaction and the movement, represented by the link between the journal entries and the ledger entries, is a kind of mereological part-of relationship.

It is less clear what the books and divisions' conceptual types reflect – they seem to be more mechanisms for organising the data than reflecting business objects. However, with a little analysis an educated guess can be made. The individual books can be seen as representing objects for a particular accounting entity. Notice that the notion of a book implicitly assumes the existence of an accounting entity. This helps to confirm the point noted in the earlier section on well-known inadequacies, that the scheme does not make explicit the role of the proprietor.

An individual journal book can be seen as representing the collection of business transactions to which the accounting entity is a party. The general journal book conceptual type can be seen as representing the collection of the individual 'journal book' objects (in other words, a collection of collections of business transactions) – a sub-type of business transaction types. Let's call this an Accounting Entity Transaction Type.

An individual ledger book can be seen as the collection of accounting movements for those transactions. Similarly, the general 'ledger book' conceptual type can be seen as representing the collection of the individual ledger books – a sub-type of the general account movement types. Let's call this an Accounting Entity Movement Type.

A similar manoeuvre can be made for the divisions. An individual journal division into a particular day for a particular accounting entity can be seen as representing the collection of transactions recorded on that day for that entity. (Notice that this implicitly assumes the existence of the type day.) This is a sub-collection of its corresponding Accounting Entity Transaction Type instance. Journal day division represents a collection of these day collections of transactions – whose instances will be sub-types of the instances of the general journal book type. Let's call this an A/C Entity Day Transaction Type.

An individual account division for a particular account for a particular accounting entity can be seen as representing the collection of movements that have been classified for that particular account for the particular accounting entity. This is a sub-collection of its corresponding Accounting Entity Movement Type instance. The general 'ledger account division' conceptual type represents the collection of these day collections of transactions – whose instances will be sub-types of the instances of the general journal book type. Let's call this an A/C Entity Account Movement Type. The division into accounts is based upon a variety of criteria that are not explicitly reflected in the structure of these foundation elements. There are too many of these to analyse and represent them here.

These business objects and their relations are shown diagrammatically in Figure 2 below, with a box surrounding the explicitly represented business objects.

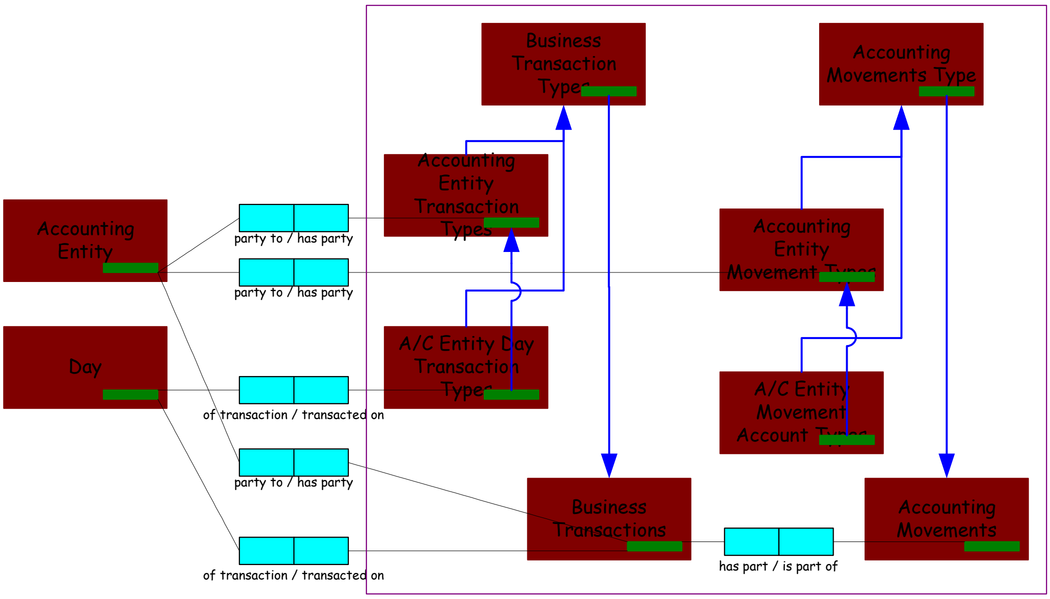

Figure 2 – Business objects represented by the accounting foundational conceptual elements

It is clear from the analysis reflected in this diagram that the transactions and movements are fundamental. The other explicitly represented business objects are collections of these transactions and movements grouped together on the basis of other objects – in the case of the accounts classification these other objects are not shown. Furthermore the movements are grounded in the transactions, they are aspects or parts of these transactions. In the light of this it is not unreasonable to relegate the collections from our foundational elements list and promote the objects upon which they are based – which give us this revised (partial) list of foundational business objects:

- business transactions,
- account movements,
- accounting entity, and
- day.

And their relations:

- Account Movement – part-of – Business Transaction,
- Accounting Entity – party-to – Business Transaction,
- Business Transaction – transacted-upon – Day.

A better idea of the kind of process

The studies of earlier revolutions in information technology tell us that there needs to be a significant precisification of the conceptual schema. The studies of scientific revolutions tells us that there is going to be a radical re-arrangement based upon what we know of its foundation elements. In this section, we try to develop a better idea of the kind of process that can help one make such a shift. There is an aspect of the nature of the underlying accounting objects that have a big influence on this. We examine this now.

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Socially constructed accounting objects

It is an aspect, not only of these accounting objects, but also of most business objects. These are of a different kind than ordinary everyday physical objects, such as trees and stones. Physical objects have an existence independent of us, whereas most business objects (including accounting objects) are dependent upon us.

Money is a good example of this. People have used many things as money, including cowrie shells. What makes these money is that those people accept them as such. Cowrie shells are certainly not intrinsically money, independently of the humans that use them. Similar things are true of languages and social institutions, such as marriage. The same is not true (at least not in the same way) of trees and stones. (Searle 1995) analyses this difference and describes these people-dependent objects as *socially constructed* and calls them *human institutions*.

Furthermore, the rules that characterise human institutions (to use Searle's name) work in a different way from the rules that characterise physical objects. Physical objects have rules (laws) that govern their behaviour, but cannot be said to know the rules. Stones do not have to learn the rules of gravity before they fall – it does not make sense to say they know and follow the rules, or that they can decide they do not want to follow them. Whereas people have to learn the rules that govern their human institutions. This can be quite arduous, as, for example, when someone has to learn a new language. It is also possible (in many cases quite easy) to 'disobey' the rules. Fluent language speakers can and do choose to make deliberate grammatical mistakes.

Most people are comfortable with notion that the conceptual structures of the law and accounting are socially constructed artefacts. However, with this notion often comes a couple of other assumptions that are not so well warranted which are relevant to our topic. Firstly, that these artefacts are solely the result of people following rules (even constituted by the rule following). This would imply, among other things, that developing a more precise picture of the artefacts would involve documenting the rules in people's heads. And secondly, that the accounting and legal disciplines (socially) construct their respective conceptual structures by specifying rules, which people learn and follow. This would imply that constructing a new scheme would just involve specifying rules. Then, if the first assumption is true, implementing it would involve people learning the rules and following them. If this were (completely) true then the lawyers and accountants faced with the task of constructing new conceptual schemes would have the creative freedom of engineers designing artefacts[19]. Though there are elements of truth in both these assumptions, I shall argue that they are mistaken in the case of the shift in foundational accounting objects.

Following rules

The first assumption seems, on the face of it, reasonable. Language is an archetypal example of a human institution. Consider someone who is learning a new language. When they try to speak, they have to laboriously consult the rules that they have been taught and are conscious of trying to follow them. Things are less clear for children learning their mother tongue. However, this can be explained, as Chomsky does in his account of Universal Grammar (Chomsky 1975). He reckons a child is able to learn grammar because he or she is already innately in possession of the rules of a universal grammar, though these are unconscious.

[19] A claim made in David, et al. (2002) *Design Science: Building the Future of AIS.*

Closer examination of specific cases shows that most rule following is unconscious. When someone has learnt a language properly, they are no longer conscious of consulting and following its rules. Similarly, practicing accountants and lawyers are typically not conscious of the rules they are following. The examination also reveals deeper problems with the rule-following account – it does not seem to fit the obvious facts. As Searle points out (on p. 127):

> "the structure of human institutions is a structure of constitutive rules ... the people who are participating in the institutions are typically not conscious of these rules; often they have false beliefs about the nature of the institution, and even the very people who created the institution may be unaware of its structure."[20]

Even when the beliefs are true, they are often inadequate by themselves for their purpose. As every system designer knows (and accounting system design is no different), experts typically cannot articulate the rules for tasks that they are meant to be following to a sufficient level of formality and precision. Even though they have no problem in actually undertaking the tasks precisely enough.

If we know these rules and are following them, it seems strange that we can so regularly have false beliefs about them. Particularly when this seems to have no correlation with our ability to follow them correctly. It also seems strange that we cannot articulate the rules to a level of accuracy that we must know to follow them properly.

The problem is in the assumption that we are always following rules. Searle articulates[21] the issue as a question about the causal role of the rules, which neatly distinguishes between the two extremes in the ways in which rules operate. Are there rules in our heads that are the cause of us following the rules – in other words, are the rules representations which we consult and follow? Or, at the other extreme, do these rule representations have no direct causal role – merely providing a description of the actions we take?

Neither extreme seems to fit all the evidence. As noted earlier, human institutions are clearly not completely governed by rules in the way physical objects are. But, on the other hand, neither are they completely subject to forms of rule following. There are a number of candidate explanations for this. A number of philosophers[22] (including Searle) have suggested that our more conscious rule following is grounded in natural propensities that operate at the level of neurophysiological (non-intentional) processes. This implies that the closer the rules are to the foundations, the less rule following is involved.

Irrespective of the chosen explanation, these facts have a clear implication for the process of precisification and re-alignment involved in shifting the conceptual foundation of accounting. Given the level of false and inaccurate knowledge there is

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[20] Searle (1995) *The construction of social reality*, p. 127. Gilbert (1992) *On social facts* makes a similar point.

[21] Gilbert (1992) *On social facts* p.127-8.

[22] Wittgenstein (1953) *Philosophical investigations* introduced the question of how we 'follow' rules and discussed natural dispositions. Kripke (1982) *Wittgenstein on rules and private language* revived the discussion more recently and it is now a lively topic. See also, for example, this point in Wright (1987) *Realism, meaning, and truth*, p.28 "… the path to understanding exploits certain natural propensities which we have, propensities to react and judge in particular ways. The concepts which we 'exhibit' by what we count as correct, or incorrect, use of a term need not be salient to a witness who is, if I may so put it, merely rational …".

of the rules that we are following, and the fact that we probably do not have representations of all or most of them (and where we do they are often insufficiently precise), it does not make sense to base the development of a more precise picture on attempting to document our knowledge of them. A better way is to re-examine what actually happens, what people and organisation actually do – taking into account any well-known inadequacies in the current descriptions. This is akin to the process of precisification found in natural science.

Constructing conceptual structures

It is part of the business of lawyers and accountants to construct new rules. New legislation and accounting standards are paradigm examples of these. There is definitely a creative element to this process in which the new rules are designed.

If may seem as if a similar process could be used for completely constructing a new conceptual scheme. That someone has to determine what the scheme should do and then develop the rules and structures that will give the desired result. This would be a design exercise in which the existing scheme does not have to play a part. In particular, there is no reason for the exercise to involve the re-arrangement of the foundational elements of the existing scheme.

However, the paradigm examples we started with are not the relevant part of the story for the exercise we are interested in – shifting the conceptual foundations. If one looks carefully at the legislation and standards, one can see that they are not specified to a level of formality and precision that would be adequate for a computer program – often not really specified at all. Furthermore, these foundations do not seem to be amenable to change by the stipulation of new rules and structures – they seem more to be a pre-condition to being able to stipulate them.

This second assumption founders on a similar problem to the first. It takes no account of the foundation of common understanding that operates at the level of our natural propensities or capacities. This paper suggests that a more fruitful approach to re-arranging the foundational elements is likely to follow the examples from natural science. To re-assess the arrangement of the foundational elements in the light of known inadequacies – bolstered by any new inadequacies found in the development of a more precise understanding.

Need a specific process

Though the forgoing analysis gives us some idea of the kind of process that is needed, it does not suggest a specific process. Current accounting practice does not have such a process, understandably, as it is not focussed on this kind of task. Some of the initiatives looking to revise the conceptual structure have looked to modern IT practices for their processes[23]. The process that this paper is proposing, ontological analysis, also comes from IT. Though it has ancient origins, it has recently been making a new life for itself in IT practice[24]. A good example of the type of analysis proposed is the REV-ENG methodology described in (Partridge 1996).

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[23] Table 3 of David, et al. (2002) *Design Science: Building the Future of AIS* lists the influences on REA, over half of which are IT related..

[24] It has been suggested that it has a role to play for some time. Mealy (1967) *Another Look at Data* said it was essential. Kent (1978) *Data and reality* makes a similar point. However, it was only in the 1990's that this significant work started being done.

Explaining ontological analysis

Ontological analysis fits the profile that has been built up of the kind of process that is required. However, the really only important criterion is whether it will actually help in shifting the foundational elements. Experience seems to show that it can be useful for this kind of task – and the next section illustrates how it might work.

Before we look at the details of ontological analysis, there is a need to explain what ontology is and how it is used. This is in part because it has always been, and still is, an esoteric discipline. It is also because of the novel way that this discipline is being harnessed and applied in IT, and now in accounting. The explanation starts by clarifying the use of some basic terms: firstly, ontology and semantics.

Ontology

Central to the ontological analysis approach is the traditional philosophical (metaphysical) notion of ontology – where this is "the set of things whose existence is acknowledged by a particular theory or system of thought."[25] Here the set of things is not just restricted to simple entities, it includes every type of thing that exists: for example, it can include relations and states of affairs, if these are deemed to exist.

This view was famously summarised by Quine, who claimed that the question ontology asks can be stated in three words 'What is there?' – and the answer in one 'everything'. Not only that, but tongue in cheek, he also said "everyone will accept this answer as true" though he admitted that there was some more work to be done as "there remains room for disagreement over cases."[26] Quine's glib description captures the common intuitive position in many disciplines, where it is unthinkingly assumed that the answer to the question "What is there – in this discipline?" will be the set of things that the discipline deals with.

This involves identifying the objects that the discipline's conceptual scheme is representing. There is substantial body of philosophical work that provides a framework for talking about the objects in this way. Good starting points are Quine's notion of ontological commitment[27] and Armstrong's notion of truthmaker[28]. In looking at the way a scheme represents its domain, we can ask what is the ontological commitment of this representation – what objects is it committed to saying exist. Similarly, we can ask what things make the representation true. In this way, one can clearly differentiate between how something is represented (the representation) and what is being represented (the ontology). These can be (and often are) quite different, and different schemes often have quite different representations.

Some care needs to be taken to distinguish this traditional metaphysical use of the word 'ontology' from one that has recently developed within Computer Science. Here an ontology is regarded as a "specification of a conceptualisation" (Gruber 1993) and is being applied to a wide range of things, including dictionaries. The Gruberian sense is similar in many respects to the notion of conceptual schema described in ANSI/X3/SPARC (Tsichritzis and Klug 1978). This is a representation of the conceptual perspective, and reflects how we conceive of the world – which is, in

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[25] E. J. Lowe in the Oxford Companion to Philosophy.

[26] In W.V. Quine's *On what there is* (1948), Review of Metaphysics, Vol. II, No. 5, reprinted in *From a logical point of view* (1961).

[27] See Quine (1964) *Word and object*.

[28] See Armstrong (1997) *A world of states of affairs*.

important ways, not the same as what our conceptualisation commits to existing in the world (or what things make the conceptualisation true).

This ‘conceptualisation’ sense of ontology does not give a fine-grained enough tool for the type of task discussed here. For example, it regards a conceptual scheme as simply an ontology – and so it cannot make sense of talking about the ontology underlying it[29]. Therefore, the ontological analysis we are discussing here will focus not on accounting’s conceptual structure but on the ‘the set of things whose existence it acknowledges’ – its (metaphysical) ontology.

Semantics

Along with the traditional philosophical sense of ontology there is a related notion of semantics – where this is the relationship between words (concepts) and the world – the things the words (concepts) describe[30]. This needs to be distinguished from the different, but related, sense of the word in linguistics where it means the study of meaning[31].

These notions of ontology and semantics are now used to describe two other useful notions – that of an ontological model and semantic divergence. These, in turn, are used to characterise the notion of a canonical scheme. Finally two other relevant notions are described: categorical ontology and epistemology.

Ontological model

An ontological model is a model that directly reflects the ontology. There is a simple semantics where each object in the ontology has a direct relationship with the corresponding representation in the model[32].

One of the characteristics of an ontological model is that the representations in it can be regarded as the names of the objects in the ontology – from a Fregean perspective as reference and no sense (from a Millian perspective as denotation without connotation). In (Marcus 1993), Ruth Barcan Marcus (explicitly following in the footsteps of Mill and Russell[33]) calls this ‘tagging’.

Semantic divergence

Semantic divergence occurs where an item in the representation does not map directly onto an object in the ontology. This is related to the notion of ontological model – in that these have no semantic divergence. Ontological analysis involves the development of an ontological model. It often starts by identifying and removing semantic divergences from an existing conceptual scheme.

That these are common is evidenced by the ubiquity of semantic heterogeneity – a phenomenon much discussed in the database community. (Sheth and Larson 1990), on

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[29] Similar criticisms of the ‘conceptualisation’ approach are made by Barry Smith and Chris Welty in their introduction the *Proceedings of the international conference on Formal Ontology in Information Systems - 2001*.

[30] Or as Nelson Goodman put it in the Introduction to Quine’s lectures published as *Roots of Reference* – “… an important relation of words to objects – or better – of words to other objects, some of which are not words – or even better, of objects some of which are words to objects some of which are not words.”

[31] “Semantics – the study of meaning” from the Concise Oxford Dictionary of Linguistics, 1997.

[32] This is called *strong reference* within the REV-ENG Methodology described in Partridge (1996) *Business Objects: Re - Engineering for re - use*.

[33] Mill (1848) *A system of logic* and Russell (1919) *Introduction to mathematical philosophy*. See also ” Russell and Blackwell (1983) *The Collected Papers of Bertrand Russell*, Vol 8: p.176: “In a logically perfect language, there will be one word and no more for every simple object”.

p. 187, provide a description of it. They say that it is "… when there is a disagreement about the meaning, interpretation or intended use of the same or related data [in different databases]." But they note that "… this problem is poorly understood, and there is not even an agreement regarding a clear definition of the problem." From an ontological perspective it can be described as two semantically different representations of the same objects. Clearly, where there is semantic heterogeneity at least all but one of the representations must be semantically divergent.

Classic example of semantic divergence

There is a classic example of semantic divergence that is often used to illustrate it. This is data that represents the average family as having 2.4 children. In answer to the question 'How is this represented?' – the answer is as a family with children. The answer to the question 'What is being represented?' (or what is being ontologically committed to, or what makes the representation true) is quite different. It is not, as the outward form suggests, a family– but a relationship between a set of families and the numbers of members of the sets of children they have.

A more commercially relevant example is an indexical[34] representation such as a purchase or a sale. Where, for example, an organisation's trade is represented in its systems as a sale. But the same trade is represented in the counterparty's system as a purchase. It is only a sale or purchase relative to a party to the trade (and their system). The underlying trade whose existence these representations commit to (is made true by) is neither a sale or purchase in itself.[35]

A canonical scheme

An ontological model can be seen as a canonical representation scheme. The notion of a canonical form comes from mathematics, where it is defined in terms of the general notion of a normalisation procedure, which consistently transforms objects (for example, matrices) to a canonical form. This enables one to determine whether different forms are equal relative to the normalisation procedure and its canonical form. In relational database modelling there is also a well-known normalisation procedure that leads to a canonical form usually called the normal form.

Ontological analysis as normalisation

One can see that ontological analysis is a kind of normalisation process for representations that leads to a canonical form in the shape of an ontological model. This normalisation process strips the semantic divergences from a model – revealing an ontological model.

Categorical ontology

There is tradition that starts with Aristotle[36] of not only ordering the types in an ontology 'by comparison and taxonomy'[37], but also explicitly including, at the top level, the major formal categories of entities (what can be called, more pompously,

[34] Indexicality is a common source of semantic divergence. It is where the truth of an expression (representation) depends the conditions of its utterance. A classical example is the expression "I am here" – which is usually true, but will refer to different people and places on different occasions. This is clearly a way in which we use language (representation) and not a way in which the world is.

[35] This example, and indexicality, is described in a little more detail in Partridge (2002d) *What is a customer?*

[36] See Aristotle *The categories*.

[37] The example of Crombie's scientific style of analysis mentioned earlier.

the types of existence). As a matter of principle, all the various lower level types fall under one or other of these top level headings. Following (Thomasson 1999), let's call this a categorical approach.

A number of philosophers have distinguished this categorical approach that attempts to provide an overarching structure from a more piecemeal approach that considers things on a case by case[38]. They point out its advantages. For example, (Thomasson 1999) (on pp.115-6) notes a purely piecemeal ontology "can only provide a patchy view of what there is and a view that always risks arbitrariness and inconsistency." and (on p.117) "Approaching ontological decisions globally avoids the dangers of inconsistency and false parsimony that may result from piecemeal ontology."[39]

Computer science has picked up on the value of a categorical ontology. For example, John Sowa, in his latest book ((Sowa 2000) on p.51), states that "A choice of ontological categories is the first step in designing a database, a knowledge base or an object oriented approach."

Core accounting ontology

The ontology produced for the new accounting schema can be divided into a number of layers. At the top are the formal categories[40]. Underneath this is the core accounting ontology. A core ontology – as (Breuker, Valente et al. 1997) note – "contains the *categories* that define *what a field is about*." Where a "field is a discipline, industry or area of practice that unifies many application domains …". Determining the scope of core ontology and, in particular, the boundary between the top and core ontology, is a practical matter – and is guided, as Breuker et al suggest, by how much a candidate category helps to provide a unifying structure. The key point is that given a 'field' such as accounting there are core categories that help to "define *what [it] is about*."

Epistemology

There are two reasons why it is useful to introduce the notion of epistemology here. Firstly to clarify by contrast the notion of ontology and secondly because the new accounting conceptual scheme will need to have an epistemology built on top of its ontology – as indeed will almost any conceptual scheme. The examples of ontological analysis in the later sections help to illustrate this.

In philosophy, ontology and epistemology deal with two different questions, which result in two different ways of looking at and analysing the world. Ontology is concerned about what exists – whereas epistemology is concerned about what is (or can be) known by someone. For example, epistemology would attempt to explain how we can know about a particular type of thing, such as colours. Whereas ontology would be interested in what ontological type colours are.

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[38] As already noted this follows Thomasson (1999) *Fiction and metaphysics* (pp.115-6). Similar distinctions are made in: Williams (1966) *Principles of empirical realism* (see p.74) see the distinction between analytic ontology and speculative cosmology is made. Ingarden (1964) *Der Streit um die Existenz der Welt. 1. Existentialontologie* (pp.21-53) see the distinction between ontology and metaphysics. Similar points are made in the Introduction to Hoffman and Rosenkrantz (1994) *Substance among other categories*.

[39] Similar points are made in, for example, Körner (1970) *Categorial frameworks* and Collingwood (1940) *An essay on metaphysics*.

[40] In Partridge (1996) *Business Objects: Re - Engineering for re - use* this is called the framework level and an example of this for IT ontological analysis is given on pp. 276-8.

These two different approaches are both useful when specifying a system, particularly a computer application. A system (application) will make some ontological commitment – it will assume that certain things exist. These things are its ontology, which answers the question – what exists according to the system. The ontological model will represent this.

A system[41] will also have constraints on what it actually does (and can) know. These are described in its epistemology, which answers the question of what the system can (and must) know. In this context, an epistemology is always indexed to a knowing system. Of particular importance for operational applications is describing what it needs to know before it can do something. An epistemological model will represent this. The accounting conceptual scheme needs an epistemological aspect – it needs to describe what an enterprise's accounting system needs to know. Philosophical epistemology concerns itself with questions of belief, particularly the problems of false belief. Specifications of computer system ontology, and accounting conceptual schemes, seem less concerned about these.

One can regard the epistemology as looking at the world from the perspective of the system and what it knows and the ontology as standing back as describing the world that the system commits to from a perspective outside it. These two are interdependent. They deal with the same world, and mostly with the same things in the world. However, their different goals mean that they paint different perspectives of these – as the following examples show.

Examples

Let us assume, simplistically, that all humans are either male or female and that we are looking at a system that records humans' details including their gender. Then this system is ontologically committed to the existence of male and female types, which are sub-types of human and completely partition it. This is its ontology. However, we cannot guarantee that the system will always know a person's gender – so it has to deal with cases where it does not know the gender. So within the system's epistemology not all humans will be partitioned into male or female sub-types – in other words, within the epistemology the partitioning is incomplete. This gives us different, but equally valid, ways of categorising the world, illustrating how the approaches' different purposes can lead to different results.

Epistemology's purpose lines up quite neatly with one of the key requirements in specifying a computer application, clarifying what it must know and what it does not need to know. This makes documenting the epistemology an essential element of the specification of a system – though it is not usually called given such a grand name.

To see this, consider an insurance company that sells various types of policies. For its actuarial calculations, the company needs to know and so asks all its policyholders whether they are married and records the results. For its joint policyholders, it also needs to know, and so asks, whether they are married to each other and if they are, this marriage relationship is recorded. For its sole policyholders it does not need to know this information – so it does not ask or record it.

The system is ontologically committed to the existence of persons and their married states. It is also committed to the fact that persons in married states have a marriage

[41] In the case of a computer application this may be a network of applications, each with its own constraints upon what it can know.

relationship with each other: this is what being in a married state means. In contrast, from the company's epistemic perspective, knowing someone is married does not mean knowing their spouse and the marriage relationship. This is because for sole policyholders, the company can *know* that they are married, but not *know* who their spouses are and so cannot *know* their marriage relationships. Note that it may 'know' their spouses – because they are also policyholders – but not know whose spouses they are.

In current practice, the epistemic perspective plays a more prominent role in computer specifications because the current state of database technology means that only the epistemology (and not the ontology) is reflected in a company's database. In this example, the insurance company's database needs to be able to record persons that could be in a married state without having to record them having a marriage relationship. The fact that persons in a married state always have a marriage relationship cannot be recorded. This is why the use of the terms 'mandatory' and 'optional' and the cardinality constraints upon relations in database contexts are usually from an epistemic (not an ontic) perspective.

Linking ontology to epistemology

It is important to understand how the ontology and epistemology link. One way of describing this is to widen the scope of the ontology to include the system that is the subject of the epistemology. This can pose some delicate problems and needs to be done carefully. Consider the first example. It may be tempting to regard the epistemological types as dealing with known instances – as perforce only these are instantiated in the model. This would suggest that the epistemology has known-male and known-female types – and possible an unknown gender type. However, it also makes sense to say that the system 'knows' the ontological types male and female, though it does not know all their instances – or, indeed, for all the known instances of human which of the gender sub-types they fall under. This second option is more attractive as our unreflective view of our own epistemology is that when we think of male or female sub-types we are thinking of the ontological variety, in other words, not just the males and females we know. Also, as it is possible for the system to know whether it knows, qualifying the sub-types with 'known' introduces the possibility of an endless regress with known male, known known male and so on.

Under the second option, the ontology would explicitly recognise the system and its knowing relationship with the male and female sub-types and their instances. It would also recognise that only some of the gender types' instantiation relations are known. Within the ontology the instances of human that are not epistemically classified by gender (in other words, whose gender is not known) would be marked in the ontology by there not being a known relation between the system and the instantiation relation. This explains why the epistemic partition is incomplete – it is representing the known instantiation relations rather than the complete set of instantiation relations. As this illustrates, in this simple example, the epistemological perspective can be seen as a filtered view of the ontology – only showing what is known. This filtering leads to apparent difference in structure.

From this brief outline it should be clear that our conceptual schemes need both an ontology and an epistemology. People sometimes need to be able to conceptualise that they know someone, who has a gender, but they do not know it. Insurance companies may need to know that if their policyholders are married that they have a married relationship with someone else – even if they do not know who the person is.

Unfortunately, due the constraints of current database technology, it tends to be the epistemology that is explicitly captured in the database.

Ontological relativity and paradigms

It might seem that discovering the ontology underlying a scheme is a straightforward matter. Most communities have a broad agreement about the majority of the objects in their domains. For example, professional accountants broadly agree what transactions and accounting movements are. This is because they share a common conceptual scheme. This would seem to imply that modelling the objects in their underlying ontology is straightforward.

Unfortunately, this consensus usually does not survive the rigour of an ontological analysis of the common conceptual scheme. Ontology needs a paradigm to fix its world view, and there are a variety of paradigms with major structural (architectural) differences – this is known as ontological relativity[42]. Much of the variety can be characterised in terms of meta-ontological, metaphysical choices[43]. These choices help to characterise what kinds of things can exist – and how they can exist. They dictate the top level categories into which the rest of the things that exist fall.

Most communities have not consciously fixed on an ontological paradigm. They would not understand the meta-ontological choices and have difficult in characterising the top level categories. The ontological analysis presented here in this paper is known as the business object paradigm, which is described in (Partridge 1996; Partridge 2002b).

Selecting an ontological paradigms

To justify the use of the business object paradigm, it helps to set out the basis on which its meta-ontological choices were made. For our purposes, a paradigm needs to be judged by its utility, the value of the ontologies that it helps the ontological analysis generate. This value is assessed against criteria adopted from engineering and science, which have characterised successful technologies and theories.

The technology-based values are:

- Useablility
- Applicablility
- Teachability

The science-based values are:

- Precision
- Simplicity and generality
- Fruitfulness
- Unity and Explanation

From the point of view of the foundational ontological paradigm and the new foundational (core) ontology for accounting the science-based values are more

[42] Quine (1969) *Ontological relativity, and other essays* introduced this term.

[43] See Partridge (2002a) *Note: A Couple of Meta-Ontological Choices for Ontological Architectures* and also Chap. 1 – *Meta-ontology* of Van Inwagen (2001) *Ontology, identity, and modality*

relevant. When considering the new overall accounting ontology and its overlaid conceptual scheme, the technology based values become more relevant.

Science-based values

Most people will have some general understanding of what the science values are. However, to avoid misunderstanding it is probably worthwhile to briefly confirm this.

Increasing (relevant) precision

Precision in this case means the accuracy with which the ontological model reflects the business objects. It is important to recognise that the goal is not exactitude, but to determine things to the relevant level of precision – as Aristotle said "it is the mark of an educated man to look for precision in each class of things just so far as the nature of the subject admits"[44]. And, as Charles Peirce and Bertrand Russell pointed out, our languages always contain an element of vagueness, so exactitude is an impossible goal.

It is also useful to make a distinction between the formality with which the representation is expressed and the precision with which it refers. It is possible to have a formal representation that is not particularly precise. However, it is more difficult to have a very precise representation that does not also have a high degree of formality. So increasing the level of precision is likely to also lead to an increase in formality.

Increasing simplicity and generality

To increase both simplicity and generality mere harmonisation is inadequate – it just increases complexity. Some level of revision is required. As David Lewis notes (on pp.133-5 (Lewis 1986)) "trying to improve the unity and economy of our total theory" involves "two things that somewhat conflict". Firstly, "to *improve* that theory, that is to change it", and secondly, "to improve *that* theory, that is to leave it recognisably the same theory we had before". As he notes, the first of these can, and does, lead to improvements that "correct" common sense. As he says, this may have some costs but these "must be set against the gains" within the overall scheme of things. And doing this is an important part of building a useful ontology.

As has been mentioned before, this may seem counter-intuitive but it is a trait of successful scientific theories. The classic scientific example is Einstein's well-known equation '$E=mc^2$'. This replaced pages of complex equations with a single line, and the 'improved' theory involved a new perspective that 'corrected' common sense.

Increasing fruitfulness

Unlike simplicity and generality, which can usually be seen directly in the ontology, fruitfulness is something that only becomes apparent in its application. Plato explained it metaphorically, describing it as carving nature at its joints. (Hilary Putnam, more prosaically, talked about cookie cutters and lumpy cookie dough.) Underlying this is the notion that fruitful theories capture reasonably accurately nature's underlying structure, in a way that goes beyond what is then known. This explains why they often 'work' in situations that were not envisaged when the theory was developed.

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[44] Introductory quotation headed 'A Warning' in Armstrong (1997) *A world of states of affairs*.

Unity and Explanation

Unity and explanation are more global than local features of the model. In a unified ontology, the individual local general patterns form part of a common global framework. The two are linked, as providing a unifying framework is also one aspect of giving an explanation. Another aspect is describing the causes (in the sense of Aristotle's four causes) – answers to the question 'Why?' in terms of 'Because …'.

Experience has shown that unity and explanation are useful in two main ways. Firstly, they make a model easier to comprehend. Secondly, they appear to be good indicators of fruitfulness. One apparent difficulty is that it is hard to give an exact measure for the level of unity or explanation, however this is no real problem as people find it easy enough to recognise this intuitively.

While the ontological model will explain to an extent what the objects are, it is not sufficient for human understanding. Typically it needs to be supplemented and supported with a certain amount of informal explanation.

The Business Object Paradigm

Ontological paradigms can be characterised in two different ways, by:

- the metaphysical choices they embody, and
- the styles of analysis they lead to.

As often happens at this very general level these two are inter-related – this will become clearer in the exposition below.

General characterisations

Before looking at the choices and styles specific to the business object paradigm, it is useful to examine a couple of characterisations that apply reasonably generally. One is a meta-ontological preference that informs the choices and the other is a style that applies to most ontological analysis.

A general meta-ontological preference for unifying entities

The general requirement for simplicity leads to this meta-ontological preference. A number of the meta-ontological choices involve a choice between multiplying or unifying entities. From the simplicity perspective, the concerns are wider than just inflating the number of entities, there is also a requirement to explain the relation between the multiplied entities. This does not exist for the unifying option, as they have been unified into a single entity.

Hence the general requirement for simplicity therefore leads to a preference, other things being equal, for a unifying option. This can be seen as a variety of ontological parsimony, much like Ockham's razor.

A general ontological style

Identity is of central importance to ontology. It is extremely useful for generating questions that help us to see what something is. Typically, the question will ask whether and why two names or descriptions refer to the same or different entities, or more generally, under what conditions two names of instances of a type refer to the same object.

Associated with identity is mereology; which looks at the whole-part relation. This can be seen as partial identity (Armstrong 1997): a part of something is partially identical to its whole. Mereology generates similarly useful questions about the partial identity of objects.

The specific metaphysical (meta-ontological) choices

The metaphysical (meta-ontological) choices help to determine the overall structure (architecture) of the ontology. Typically, these choices commit us to particular ontological categories. It also seems that these choices influence one another – that making one choice has architectural implications for the other choices. A major concern in constructing an ontology that these meta-ontological choices are made in a co-ordinated way, committing to a (reasonably) coherent set of ontological categories.

The meta-ontological choices

We now look at three of the meta-ontological choices, which are particularly relevant to the ontological analysis in the later sections:

- Minimal categoricity,
- Perdurantism, and
- Extensionalism.

All three are motivated by concerns for ontological parsimony.

Minimal categoricity

As part of a general preference for simplicity and ontological parsimony, the business object paradigm only commits to a minimal number of necessary categories for its objects. There are three main category simplifications that it adopts:

- Naturalism,
- Materialism, and
- Space-time-ism

Naturalism

The first simplification is what (Armstrong 1997) calls naturalism: "It is the contention that the world, the totality of entities, is nothing more than the spacetime system." This helps to enforce a useful rigour to the analysis, as one has to identify the objects in space-time – and cannot have recourse to abstract objects.

Materialism

A second simplification-unification is a single category for objects existing in naturalistic space-time – the material category. This obviates the need to have disjoint categories for form and matter. So the statue and the clay it is made of belong to the same single material category. Materialism and extensionalism (see below) imply that where descriptions of a statue and a piece of clay pick out the same spatio-temporal extension, they refer to the same object.

Unifying space-time and matter

A third simplification is the unification of space-time and matter. Space-time regions and its occupants belong to the same category. This and extensionalism (see below) imply that descriptions of a physical object and the space-time region it (completely) occupies refer to the same object[45].

Mereological extensionalism

A natural extension of this category simplification is mereological extensionalism (see (Simons 1987) for more details), which is adopted. This is the principle that the sum of parts can only be a single whole. Where there is only a single main category, and so the whole and parts must belong to it, this makes sense.

Perdurantism - unifying the past, present and future

There is another type of simplification relating to time, which is not quite a category simplification. Physical objects, such as trees, stones and people, persist as individuals through time, despite changing. There is a meta-ontological choice to be made about how this is dealt with. A choice between regarding these bodies as changelessly extended in time (perduring through time) or changing as they endure through time[46]. The business object paradigm chooses to treat them as perduring through time – this is called a perdurantist position in contrast to the opposing endurantist position. From the perdurantist perspective, changes over time are regarded as different temporal parts of the object as having different properties.

This naturally leads to a position that deflates tense distinctions. Endurantists tend to argue that there is a difference between the future, present and past me – even with respect to the same time. So, the future-me tomorrow is different from the present-me when tomorrow arrives and the past-me after tomorrow. The perdurantist has no need for such a distinction – nor the problem of explaining how these 'me's are different but the same.

Extensionalism – categorical formal identity criteria

At the root of this is a proposal by Quine that greatly simplifies the analysis of identity. He suggested that identity is formally characterised for every entity by providing the top categories with criteria of identity. Hence his slogan (Quine 1969) that there is 'no entity without identity'.

Extensionalism is a way of characterising the formal identity criteria for the categories – in terms of their extension. The alternative is intentionalism, where two different objects can have the same extension, but be differentiated by their intension. This is discussed for types and elements below.

Extensional identity criteria for types

The extension of a type is the collection of objects that are instances of it. A straight-forward view of this only considers the actual objects that are instances of the type – and maybe even additionally restricts actual to now – that is, the present instances. Basing identity on this leads to problems, the classical illustration of which is a story of what happened when Plato defined humans as featherless bipeds – on the basis that the two types had the same 'actual' extension. In response, Diogenes plucked a

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[45] See Note 10 on p.76 of Lewis (1986) *On the plurality of worlds*, where quoting arguments from Nerlich (1994) *The shape of space*, he makes the same choice.

[46] The terms 'endurantist' and 'perdurantist' are taken from David Lewis's book *On the plurality of worlds.* (1986), where 'persist' is intended to be neutral with regard to the 'endure' and 'perdure' interpretations. For a more extended discussion of this choice see Partridge (2002a) *Note: A Couple of Meta-Ontological Choices for Ontological Architectures*.

chicken and offered it to Plato as an example of a human. A more sophisticated view takes the extension of a type to include all possible instances[47]. This is sufficiently fine grained to avoid these kinds of issues. It also provides a reasonably robust mechanism for determining identity, and partial identity. Where 'two' types have the same instances, the same extension, they are identical. Where two types have some instances in common, they are partially identical.

An intensional view is even finer grained than this. It would recognise two (ontological) types with different 'meanings', but the same extension. For example, it would regard equilateral triangle and equiangular triangles as different (ontological) types – even though they have exactly the same extensions. This intensionalist policy has a number of problems. It has a multiplier effect, increasing complexity. One would need not only more types, but also a need for structures /explanations to 'manage' the relations between types with the same possible extensions. For example, explaining why equilateral triangle and equiangular triangles necessarily have the same extension. This additional complexity does not seem to bring any apparent overall benefit. Of course, there are differences in meaning between the terms 'equilateral triangle' and 'equiangular triangle' – but these can be explained in semantical[48] terms – without burdening the ontology.

Extensional identity criteria for elements

Within the minimal categorical structure of the business object paradigm, all elements have a spatio-temporal extension. This provides us with an identity criterion. If elements have the same spatio-temporal extension, then they are the same. In less technical jargon, if two things are always in the same place at the same time, then they are the same. As (Locke 1690) pointed out[49] some time ago, if two things have different beginnings (or endings) they cannot be the same thing.

A classic example is the two names 'Morning Star' and the 'Evening Star'. Ancient astronomers at first thought these were two different planets. However as their observations became better, they realised that these were in the same places at the same times - that they were one thing, the planet Venus.

Styles of analysis

The paradigm's styles have, like scientific styles, emerged from successful practice rather than theoretically. The meta-ontological choices, particularly extensionalism, turn out to have a big influence on the styles of analysis – leading to a style called here extensional analysis. Experience reveals some styles successfully inherited from the general scientific store. An example is the style noted earlier, (Crombie 1994)'s 'ordering of variety by comparison and taxonomy' – called here categorical taxonomy. Another inherited style is his 'the deployment of experiment both to control postulation and to explore by observation and measurement' – called

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[47] Though this, of course, raises ontological questions about the nature of these possible instances' existence. See Lewis (1986) *On the plurality of worlds* for one position on this.

[48] Semantical in the philosophical sense – the relationship between words and objects. One place where this semantic explanation is done is Bealer (1982) *Quality and concept*.

[49] Book II, Chapter xxvii, 1 – XXVII – Of identity and diversity – "… When we see any thing to be in any place in any instant of time, we are sure, (be it what it will) that it is that very thing, and not another, which at that same time exists in another place, how like and indistinguishable soever it may be in all other respects: … [O]ne thing cannot have two beginnings of Existence, nor two things one beginning, it being impossible for two things of the same kind, to be or exist in the same instant, in the very same place; or one and the same thing in different places. That therefore that had one beginning is the same thing, and that which had a different beginning in time and place from that, in not the same but divers."

empirical investigation. These three styles and another called facet generalisation are described below.

Categorical taxonomy

An important part of building the ontological model is unearthing the underlying taxonomy. As noted earlier, this has been a standard approach since Aristotle. It involves identifying the major categories and organising the various entities into hierarchies under them. As a matter of principle, every entity has to fall into one or other of the categories. And care must be taken to ensure that it is placed into the correct category – that its ontological type is accurately identified.

Faceted generalisation

Facet generalisation is a key style delivering both simplification and generalisation. Aristotle's hierarchical analysis, and much taxonomic analysis since has used what might be called abstraction generalisation. This groups together lower level types under a single more general type – which is characterised by the common qualities of its sub-types. In this approach, there is a measure of generalisation, but the lower level types remain indispensable as they deal with the more specific characteristics.

In faceted generalisation, all the qualities of the lower level types are analysed for general patterns with the goal of characterising all of them under more general types – known as the lower level type's facets. Typically a smaller, simpler group of these higher level types/facets fully characterises the lower level types – giving a simpler, more general picture – rendering them, from one perspective, redundant. (Partridge 1996) calls this compacting and has several worked examples illustrating how it works.

Extensional analysis

As a result of the meta-ontological choice of extensionalism, the extensional analysis of objects corresponds to an analysis of identity both partial and total. This turns out to be a particularly fruitful style. The ontological analysis of the elements will map out their extension in relation to other elements, showing any overlaps. The choice also gives the taxonomic analysis of types an extensional basis: being a sub-type is extensionally equivalent to being a part[50].

This choice had lead to the development of a technique for modelling the relationships between spatio-temporal extensions called space-time maps[51] - there will an example later in the paper.

Empirical investigation

The ontological analysis has a strong empirical bent. Analysis typically starts with a close look at individual elements. As new general patterns are discovered, they are tested against their instances. Even the top levels are subject to empirical tests.

An important aspect of the meta-ontological choices is that they, typically, have no empirical consequences. One can think of these as ways in which the world is that, unlike empirical scientific claims, cannot be tested. Or, from another perspective, as

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[50] The mereology of types (classes) is described in Lewis (1991) *Parts of classes*.

[51] For more on these see pp.179-80 of Partridge (1996) *Business Objects: Re - Engineering for re - use*, which has an explanation and examples.

making choices about how we choose to organise what we know about the world. This may seem to suggest that we can make the choices without looking at the way the world is. But this is not so. The results of the choices are judged by how well they actually organise the world – on the basis of the values described earlier.

Experience has shown that the re-engineering of existing large applications provides a good empirical test. The data in the application system is regarded as a useful source of 'observations' which can be used to check the 'theory' embedded in the general pattern. Running the data against a proposed general pattern often shows up faults that are not easily found by human inspection.

Interlinked styles and choices

These various styles are interlinked and mutually supporting. For example, identity is linked to extensionalism as noted above. It is also related to ordering, in that the taxonomic ordering can be seen as delineating the mereology of the types involved – a sub-type is partially identical to its super-type as it shares some members.

How to re-engineer the foundations of accounting – an example

The ontological analysis presented here[52] focuses on a few simple transactions. It develops a more precise understanding of the business objects that are involved and in the process re-arranged the traditional perspective on them. This helps to illustrate the points that the paper has made so far.

This new perspective is *not* offered as the solution. It needs to be severely tested empirically before it can be regarded as such. This has been done to an extent, as the analysis here is informed by work that have been done and tested over the years. However, further empirical checking is essential, and no doubt this will lead to improvements.

The analysis focuses on the four foundational business objects and their three relations identified earlier, starting with accounting movements.

A core bookkeeping object – accounting movement

Traditionally an account movement is regarded as a movement across an account that either increases (a credit) or decreases (a debit) its balance. This can be illustrated with a simple transaction. Consider the purchase of a car for £10,000. Before the purchase the car is owned by Mr Smith and the £10,000 by Mr Jones. They make an agreement and, afterwards, the car is owned by Mr Jones and the £10,000 by Mr Smith. This would typically be accounted for in Mr. Smith's ledger with these two movements:

- Debit – Car Account - £10,000
- Credit – Cash Account - £10,000.

Two complementary movements would be made in Mr. Jones' ledger.

- Credit – Car Account - £10,000
- Debit – Cash Account - £10,000.

[52] For an analysis covering similar ground from a different perspective see the Epilogue of Ibid..

These movements are representing the business situation described above. The question is what objects do they commit to existing. Within the business object paradigm, these objects will exist in space-time and we can map their extension.

Consider the car[53]. Before the agreement it was owned by Mr. Smith and after the agreement it is owned by Mr Jones. We can see this as two different ownership states of the car. The £10,000 has corresponding ownership states. The agreement terminates the first state and creates the second state. These are diagrammed in the space-time map below.

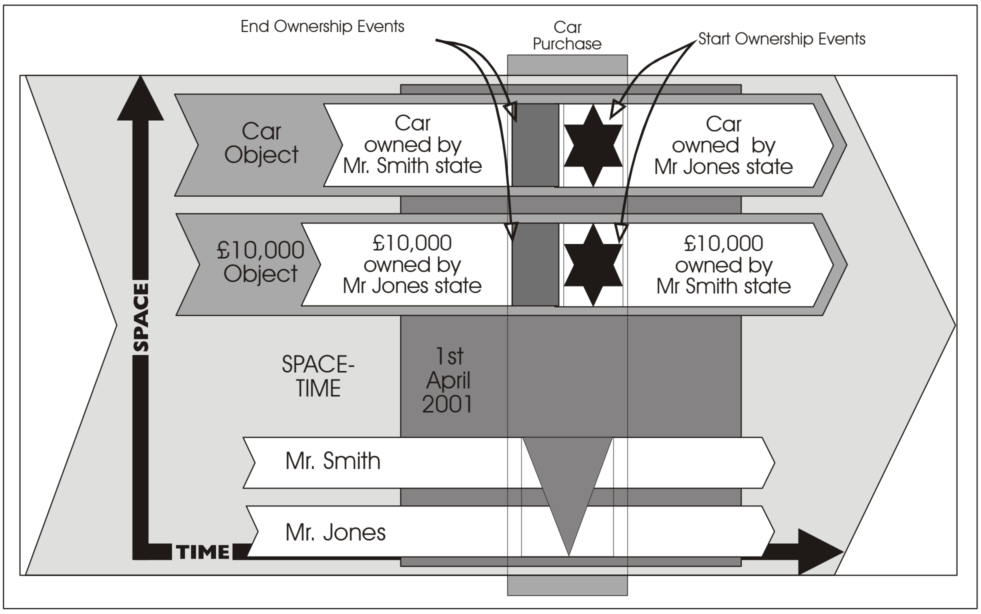

Figure 3 – Ownership state events space-time map

This gives us a different perspective on the situation. The closest thing to a movement would be the physical passing over of the £10,000. However, this physical movement is not enough in itself to change ownership. The money could be handed over for counting without any change of ownership taking place. The ownership of a car normally changes without it physically moving at all. The objects that most closely correspond to the debit and credit are the start and end events of the ownership states. There are four of these:

- End – Mr. Smith's car ownership state
- Start – Mr. Jones' car ownership state
- End – Mr. Jones' £10,000 ownership state
- Start – Mr. Smith's £10,000 ownership state

There is a reasonably direct correspondence between the cash account movements and the £10,000 ownership state events. The correspondence with the car ownership events is distorted by the ledger using the cash valuation amount rather than the car (asset) directly for entries in the car account. This illustrates that the events give a more accurate picture that the accounting movements. However, a look at Figure 3

[53] This analysis has been simplified for exposition. It assumes that the transaction deals with the object itself rather than its property/ownership rights. This simplified analysis can be seen as a first step towards a more precise understanding.

helps us to see why, within the confines of a paper and ink technology, the more accurate picture might not be practical.

Notice also the similarities between the events and the four entries described by (Manzoni 1534) in the extract quoted earlier. And that, like them, the events are explicitly linked to both the proprietor and the owner. This new way of looking at the business situation resolves these two well-known inadequacies[54].

The ontological analysis does not take a particular participant's perspective. However, one can build an epistemology on top of this ontology that takes either Mr. Smith or Mr. Jones' perspective. This would leave us with their two ownership events – a picture much closer to Pacioli's.

A core bookkeeping object – business transaction

Traditionally the business transaction has the accounting movement as parts or aspects. Ontological analysis maps the extension of the example business transaction. It shows that the transaction contains all four ownership events – reconfirming that the relationship between a business transaction and the ownership events as mereological – whole-part. But this cannot be all the transaction is. A key element of the transaction is the agreement of the parties, Mr. Smith and Mr. Jones. These agreement activities can be seen as temporal slices of the two parties – and are shown as such in Figure 3's space-time map.

A core bookkeeping object – accounting entity

Pacioli implicitly identified the proprietor (the accounting entity) as the owner of the books. Manzoni and the other sixteenth century writers on accounting explicitly identified the two parties to a transaction. The ontological analysis has identified the activities of the parties as a (mereological) part of the transaction. This gives a straight-forward mereological explanation of the parties' (including the accounting entity's) relationship to the transaction. This is clear in a simple business transaction involving two people – as diagrammed in Figure 3. However, there is a complication that shows up when one starts mapping the extensions of parties that are organisations, and a further complication that arises with large organisations.

Organisational parties to the contract – organisation mereology

Consider a business transaction entered into by a company. The agreement activity is undertaken by someone in the company – acting on behalf of the company – and this activity is part of the transaction. Yet it is the company – and not the person – that enters into the agreement. It appears that responsibility is assumed by the whole for the part's activities.

Now consider a business transaction entered into by a division of a large company. The agreement activity is undertaken by someone in the sales department of the division. Following the same pattern as the first example, we can identify the division as the party responsible for the agreement. But a similar pattern appears if one asks whether the overall company is responsible for the division's agreements – the answer is yes[55]. This gives us a hierarchy of parties that are involved in the transaction

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[54] Partridge (1996) *Business Objects: Re - Engineering for re - use* p.418 describes the explanatory value of this new perspective in terms of Aristotle's causes.

[55] Assuming the division is not a subsidiary, but a part of the overall company.

through the activities of a single common part[56]. The traditional ledger cannot represent this situation as it implicitly assumes a single proprietor and a single counterparty.

This assumption of a single proprietor places other restrictions on what can be represented. For example, it cannot represent business transactions between two parts of the proprietor in the proprietor's ledger. When one division enters into a transaction with another, the proprietor is not a party to this, so it cannot be represented in its ledger.

These two restrictions can be explained in terms of the ledger being an epistemology that shows the perspective of the proprietor. From this perspective, only the proprietor's involvement in a transaction is relevant, the rest of the hierarchy of parties is not – similarly transactions that do not involve the proprietor are also not relevant. Within the constraints of paper and ink technology it may make practical sense to settle on a single perspective – with more modern computer technology, it does not.

A core bookkeeping object – day

The third foundational business object on our list is day. Traditionally days are periods of time and the relationship with a business transaction is determined by the day upon which the business transaction was made. An ontological analysis of day, requires a general ontological analysis of time periods – this can be found in Ch. 17 – Re-engineering Time of (Partridge 1996). Here a time period is a time slice of the whole universe – for the relevant time period. Days are time slices that start at the beginning of the day and finish at the end of the day. This gives us an extensional explanation of the relationship between days and business transactions – it is mereological. Business transactions are part of the day. One can see this in Figure 3 – where the day object '1st April 2001' is shown.

There is an element of epistemic practicality in this. It is an epistemic decision that the system will only *know* the day that the transaction took place rather than the exact time period in which the business transaction actually took place. There is, in principle, no reason why one should not choose a different standard period, and, for example, record the hour or the minute within which the business transaction is made. This may not have been practical with paper and ink technology but has surely become feasible with modern technology. A more modern epistemology of business transactions would need to be able to account for knowing when the transaction took place with finer granularity. In practice, many enterprise systems do this – recording the time of the transaction. The current constrained accounting systems only 'see' the day. Similar comments apply to the monthly and yearly cycles within which the accounting systems operate.

A re-arranged view of things

The brief examples given here show how taking an ontological view gives us a different, more precise, view of the familiar foundational objects. Accounting movements become ownership events, which are components of business transactions, which are, in turn, parts of days. A single proprietor is shown to be merely one aspect of the transaction – which can involve a whole hierarchy of

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[56] Partridge (2002d) *What is a customer?* notes how every element of this hierarchy is a customer of the counterparty to the transaction.

organisations. It also shows how the process can naturally resolve well-known inadequacies within a more precise framework. If there were more space, it would be possible to also illustrate how the process leads to more general, simpler patterns.

The way forward

This is only a glimpse of what the new scheme may look like. It is probably only a first step towards the final scheme. Some relevant work is documented elsewhere. (Partridge 2002c) has a reasonable analysis of the mereology of organisations and (Partridge 2002d) has an example of how this may be applied.

The notion of business transaction requires more work. Its intentional nature needs more of an explanation, especially an account of why it is revisable. Also the full variety of patterns of business transactions needs to be accommodated.

The notion of asset also requires more work. The example simplified matters by considering the underlying physical object. The business transaction is actually in the property rights – and this needs to be analysed further.

The notion of valuation requires more work. This will need a general account of modality – as valuations typically consider what something would be worth if one sold it.

Summary

When a substantial undertaking is proposed, it is important that people have some understanding of what the result is going to be, why this is needed and how it is going to be arrived at. This paper has aimed at making these points clearer.

It has briefly reviewed why the emergence of computing technology has created a need for a radical shift in the foundations and framework of accounting's conceptual scheme. It has recommended a reference ontology as the goal of an early stage in this process – the shift of the foundations and recommended ontological analysis as a process for producing this. It has given a brief explanation of what ontology in general is and what this process is in particular. It has then used the basic elements of bookkeeping to illustrate how ontological analysis works and how it leads to radical different views of well-known phenomena and provide an initial view of what would lie at the core of the reference ontology. Taken together these give a good basis for understanding the nature of the undertaking.

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