A transactions pattern for structuring unstructured corporate information in enterprise applications

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ABSTRACT

It is known that 80-85% of all corporate information remains unstructured. As such, many enterprises rely on information systems that cause them to risk transactions that are based on lack of information (errors of omission) or misleading information (errors of commission). To address this concern, the fundamental business concept of monetary transactions is extended to include qualitative business concepts. A Transaction Model (TM) is accordingly identified that provides a structure for these unstructured but vital aspects of business transactions. By highlighting how unstructured information can be integrated into transactions, the TM provides businesses with a much more balanced view of the transactions they engage in or to discover novel transactions that they might have otherwise missed. A simple example is provided that illustrates this integration and reveals a key missing element. This discovery points to a transactions pattern that can be used to ensure that all the parties (or agents) in a transaction are identified, as well as capturing unstructured and structured information into a coherent framework. In support of the TM as a pattern, more examples of its use in a variety of domains are given. A number of enterprise applications are suggested such as in multi-agent systems, document text capture, and knowledge management. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: *Conceptual Graphs; Knowledge Management; Multi-Agent Systems; Modelling; Patterns; Text Capture; Transactions; Resources Events Agents*

INTRODUCTION

The major benefit of adopting a structured model of a problem is so that such a model, by its inherent nature, draws out all the problem's relevant parameters from which its dynamics can be understood and its possible solu-

tions investigated more meaningfully. Contrast this with a written or spoken text discussion (such as word-processor documents, such as Microsoft Word documents, or emails for example). In such a form, ambiguities and obfuscations can occur easily. This 'natural language' interpretation of problems may be the most flexible and easily followed, but without at least a basis in some structured form it can be dangerously erroneous. Yet it is claimed that 80-85% of all corporate information remains unstructured (Seidman & Ritsko, 2004). It is thus worryingly easy to omit or misinterpret the salient issues of a given business problem. Consequently, enterprises miss valuable business opportunities. Or they undertake transactions that they have come to regret as the recent financial turmoil has only too clearly reminded us (Borio, 2008; Kramer, 2008).

The accounting discipline provides sophisticated models for capturing the problem dynamics of economic activity in a structured way (Zimmerman, 2006). Accounting recognises the concern that "if it can't be measured then it can't be evaluated". Accounting thereby offers the enterprise the tools it needs to capture and analyse otherwise unstructured data. Whilst we shall see that accounting too permits enterprises to omit or misinterpret the salient issues of a business problem, it offers a useful vehicle by which we may be able to capture unstructured information in a principled way – namely through the notion of transactions.

STRUCTURE THROUGH TRANSACTIONS

Drawing from our previous work, we now explore how transactions might provide structure to the unstructured (Hill, Polovina, & Shadija, 2006; Hill, 2007; Polovina, 1993a; Polovina, 1993b). In support of our view we can note that enterprise information systems (EIS) echo this underpinning concept (Groenewegen, 1993). These systems model the enterprise and process its business activity based on the concept of a transaction, be they through databases, accounting, financial/asset management, operational (e.g. payroll and pension), decision support systems or others. Again, these systems may only capture certain transactional elements of the domain that they represent. Accordingly, like accounting, these systems can omit or misinterpret the salient issues by making 'errors of omission or commission' (i.e. omit or misinterpret the salient issues of a business problem as we have described). We therefore return to accounting as our frame of reference.

In Accounting

In order to provide a structure for modelling transactions the traditional model of accountancy, the bookkeeping model, was developed in the Middle Ages (Lee, 1986). The principle behind this model is economic scarcity. In other words for every benefit a sacrifice has to be made. For example, the

benefit of a business owning its office is sacrificing £1,000,000 that could be employed elsewhere; a book prepared by its author researching a new exciting area in semantic understanding may have involved that author deciding against many complex yet important alternatives, such as the costs of, say, not participating in his or her growing family. These 'transactions' occur because the decision-maker makes an intuitive (hence unstructured) 'value judgement' that the benefits outweigh the costs. The bookkeeping model is simple but rigorous. Fundamentally, instead of recording one amount per transaction it records two: A 'debit' and a 'credit'. Moreover these amounts are complementary to one another; hence they 'balance' against each other. An accounting 'balance sheet' is merely the aggregate of all these debits and credits. The rigorousness derives from this principled 'double entry' structure so that each benefit is accounted for by a cost and vice versa. Hence every gain is matched to a sacrifice.

Issues in Accounting Transactions

However on deeper investigation the double entry bookkeeping model is unlikely to capture all these economic value trade-offs. Say the business in the first example above decides to sell its office. This transaction can be recorded easily by the elementary bookkeeping entries "Debit Cash £1,000,000, Credit Fixed Assets £1,000,000". The second, preparing the book, is simply too qualitative to be recorded by the bookkeeping model yet the author may want to know clearly about *all* the actual costs and benefits of such a transaction. This neglect on the part of the bookkeeping model is elaborated on below.

The threshold where the bookkeeping model may break down is perhaps lower than may be thought. Reconsidering the first example about the office, the value of selling the current office may be the purchase of cheaper offices for £500,000. The double entry would be "Debit Fixed Assets £500,000, Credit Cash £500,000". Now say, by spending the remaining £500,000 elsewhere, the business generates revenue of £600,000. On aggregate in the balance sheet the business's money worth then increases by £100,000 (Represented by the double entry "Credit Profit and Loss Account £100,000, Debit Assets £100,000"). However if the value of the current office is retaining key employees through a comfortable work environment then, as in the author example above, the bookkeeping model is inappropriate. Therefore the double entry bookkeeping model is easily liable to make significant *errors of omission*. Whilst this example may appear rather simplistic, it is well known that office relocations can have such dramatic adverse effects even though it 'saves money' and a whole industry has grown around this issue alone (Attwood, 1996).

Furthermore the bookkeeping model could mislead. Reconsidering the 'preparing the book' example the

value may be viewed as the more easily quantified cost of the author ceasing to conduct consultancy work at £2,500 a week instead. This revenue would have been recorded by the bookkeeping model on an ongoing basis. However the book might bring its author satisfaction of a deep desire for an enhanced reputation amongst peers. Unless this can be translated into a cash benefit the bookkeeping model would not record these judgements and thereby leave a 'loss' of £2,500. By choosing to author the book the decision-maker *qualitatively* has to justify, *against the grain of the bookkeeping model's assessment of value*, why that £2,500 has been forsaken even though this may the lesser value item. Therefore the double entry bookkeeping model, taken too literately, can also readily lead to significant *errors of commission*. Whilst once again this is a small example designed to illustrate the point, Claret describes a pertinent industrial scenario where the accounting system was dysfunctional to the information needs of the organisation, causing it to make the wrong decisions even though that organisation's operations director was acutely aware of the problem (Claret, 1990).

Resource Event Accounting/ Agents

The 'Resource Events Accounting' (REA) model recognises these familiar problems in accounting (Geerts & McCarthy, 1991; McCarthy, 1987). Notably, the 'A' in REA has since been updated to Agents giving 'Resource Events Agents' (Hrubý, Kiehn, & Scheller, 2006) as we will reflect in our later discussion. Whichever definition we care to choose we can note that REA, unlike the bookkeeping paradigm, attempts to capture the qualitative dimensions of economic scarcity. REA captures an exchange of resources based on the resources themselves unrestrained by superficial monetary measures. It drives to the heart of business transactions by recognising that "… the economic activities of an entity are a sequence of exchanges of resources - the process of giving up some resources to obtain others. Therefore, we have to not only keep track of increases and decreases in the resources that are under the control of the entity but also identify and record which resources were exchanged for which others." (Ijiri, 1967)

To achieve this, REA models are built using the following core concepts:

- **Resource:** any resource that is the subject of an exchange or transaction;
- **Event:** the activities that are required for a transaction to take place;
- **Agent:** a person, system or organisation that participates in the transaction.

Figure 1 depicts the original REA model in Hrubý's (Hrubý et al., 2006) use of UML (www.uml.org).

REA thus represents a powerful means of recording scarcity as more than a monetary measure. Without worrying about the significance of its 'dotted' part for now, Figure 1 reveals the fundamental links between an 'economic resource', which means some exchangeable item of value, and the parties which create the 'economic event' that causes the economic resource to be exchanged.

REA as Conceptual Graphs

In our work we have chosen to represent the REA model as Sowa's Conceptual Graphs (CG) (Polovina, 2007; Sowa, 1984). CG provide a powerful knowledge representation environment, whilst exhibiting the familiar object-oriented and database features of contemporary enterprise and web applications. CG capture the nuances in natural language whilst being able to be implemented in computer software. CG were devised by Sowa from philosophical, psychological, linguistic, and artificial intelligence foundations in a principled way. Furthermore CG is core to the recent ISO Common Logic standard (http://cl.tamu.edu/). All in all, CG are particularly attractive as they are built upon such a strong theoretical and wide-ranging base. A strong case therefore exists for capturing the REA model in CG (Gerbé, Keller, & Mineau, 1998; Hill et al., 2006; Hill, 2007; Polovina, 1993a; Polovina, 1993b).

We have accordingly transformed the REA UML model of Figure 1 into the REA CG model, Figure 2. This figure captures the duality in the 'dotted part' of Figure 1 referred to earlier. In other words, the 'cash receipt pays for the sale' in Figure 1 is really a shorthand to make that diagram concise. For instance 'party to' should also connect to 'cash receipt' because it is also part of the exchange. We therefore complete REA's representation in conceptual graphs by Figure 2, which reveals this duality in full.

Figure 1. The REA model in UML

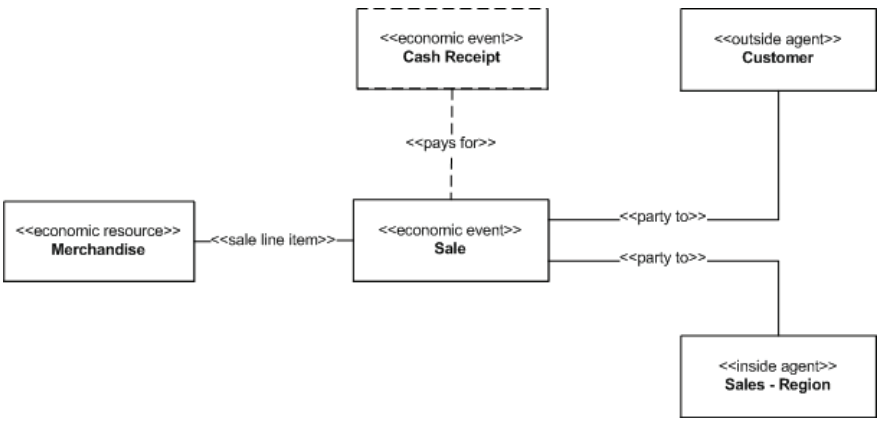
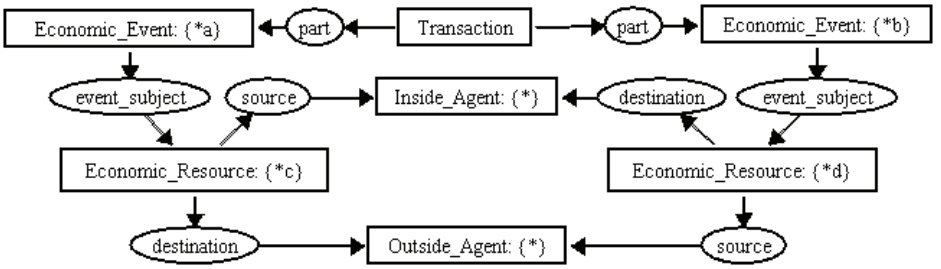


Figure 2. The transaction model



The Transaction Model

In Figure 2, which we shall now call the 'Transaction Model' (TM), both sides of duality are shown by linking the economic events to the same transaction. This, like REA, gives the same notion of balance as in the double entry bookkeeping model. As such it continues REA's capture of the essence of accounting by providing abstract constructs to model organisational transactions, including the bookkeeping notion of duality *and* drawing on the power of CG. The duality relationship permits two economic events to be represented as a mirror-image exchange of resources, thereby forming the basis of a transaction. As one value describes the benefit in the transaction, the other value depicts what had to be sacrificed for that benefit.

Like REA, the TM comprises two *Economic Event* concepts, denoted by {*a} and {*b}. The transaction is complete when both economic events balance, which indicates that {*a} always opposes {*b}, representing debits and credits. The 'event subject' of these events are related to the two *Economic Resource* concepts, {*c} and {*d}, each having independent source and destination agents. Note that here we have refined the 'party-to' relations in the original REA model to 'source' and 'destination' relations to describe the actual movement of the resources. The *Inside Agent* and *Outside Agent* refer to the parties involved with the transaction. The Inside and Outside prefix denotes the relative perspective of the transaction for each party. The braces '{}' denote plurality, indicating that each concept can represent a number of aggregated resources, events or agents.

The TM allows us to support the computation of these qualitative concepts and capture hitherto novel transactions that would otherwise be a lost opportunity for an enterprise. Put simply, the TM has the ability to structure the previously unstructured aspect of transactions. As such it structures more of that remaining 80-85% of corporate information that we identified at the beginning of this discussion in a computer-based organisational memory. Accepting that the TM is a model of

the enterprise, it offers a common basis by which an enterprise's knowledge of itself and its environment can be accessed and manipulated across all its divergently encoded data, information and knowledge bases according to this fundamental pattern.

This generic TM with its generic concepts of 'Economic Resource', 'Economic Event' and 'Inside/Outside Agent' may be appropriately specialised to any quantitative or qualitative concept describing more specific items of interest. In Figure 1 the specialisations of 'Merchandise', 'Cash Receipt', 'Sale', 'Sales – Region' and 'Customer' are illustrated. Our simple but illuminating case study that now follows will show how we produce such a more expressive TM along the lines we have described.

A SIMPLE EXAMPLE: P-H UNIVERSITY

P-H University is a fictional higher education institution that has a student population of 15,000 and an annual turnover of £15m (15,000,000 British pounds). It specialises in technological subjects, with centres of excellences in certain areas. Due to uncertainties in government policy, students' preferences for non-technological courses, increased staff and equipment costs, and an increasingly competitive higher educational market it has a difficult year and is expected to remain so for the next two years. Indeed this year the university will make a loss of £1m.

The university's staff are concerned about keeping their jobs, not helped by the equivocal statements given by management who are in turn pressed by the financial statements that paint a grim picture. Consultants to the university have advised that the situation is cyclical, as there is an emerging trend by industry that wish to recruit technological graduates, as well as a significant increase in interest by schoolchildren in technology after a number of successful initiatives by government and industry. The university's management are nonetheless concerned that the university will not survive the current cycle, which they view as uncertain anyway, and has suspended all staff development and is seriously considering applying the same to the research budget for emerging researchers who do not yet generate income. The university is beginning to lose key staff who simply choose to leave, and risks losing credibility amongst its community and its profile in higher education overall. But by saving these costs a net surplus of £1m can instead be made, further increased by the salaries saved (allowing for pay-offs such as redundancy or other associated costs) of those staff leaving.

Many of P-H's staff are research active. This means they pride themselves on the quality of their research. 20% of the staff generate 80% of the research output. They bring in a substantial amount of research income that

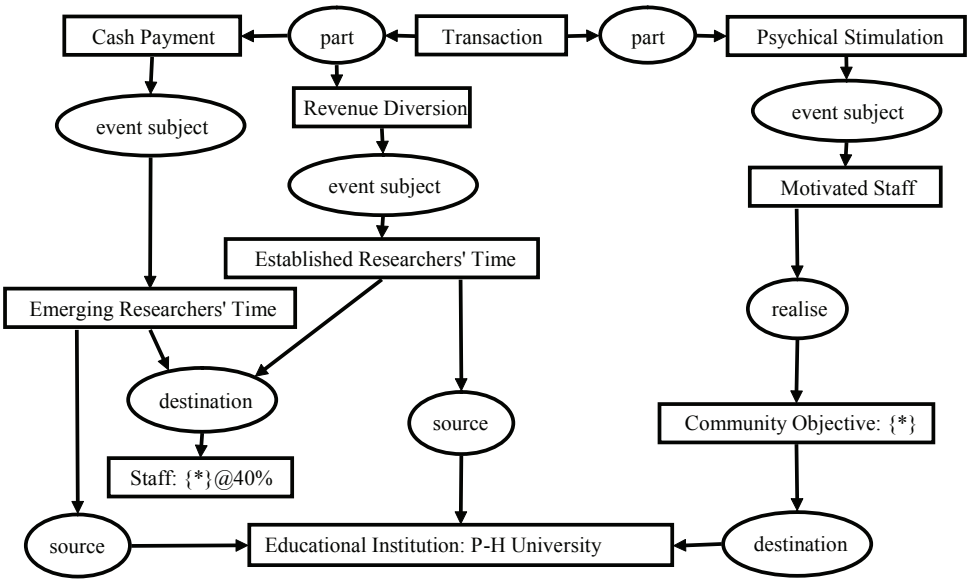
contributes £7m to the bottom line. A further 40% are emerging researchers contributing the remaining 20% of the research output but little that is income generating presently. It is this group that are most affected by the proposed research budget cut and although most of these staff are resigned to this fate, it will have a significantly adverse impact on their motivation. This will have an effect on P-H that presently cannot be calculated but is worryingly adverse. The other 40% of staff are interested in teaching only and do not contribute to research, but are already de-motivated by the loss of staff development. As many of them aspire to be research active, the loss of psychical enjoyment offered by this career path, like those already engaged in research is incalculable.

The university's Director of Research and representatives of the research staff meet to decide what the best course of action should be. They have distilled the situation as that captured by Figure 2, which is the specific TM for this enterprise. The basis of this CG was Figure 3, the generic TM that we have already encountered.

From this TM we can observe the following:

- The transaction reveals its validity through the costs being outweighed by the benefits of the university achieving its community objectives by undertaking this transaction. As we know the {*} in Community Objective above denotes a plural, thus stating that we are referring to community objectives.

Figure 3. View of P-H University scenario



- The balancing of these debits and credits denotes the exchange of resources but over and above the simple monetary aspects, thus in a conventional system this could not be captured leading to errors of omission or commission.
- The TM shows that *Cash Payment* and *Revenue Diversion* versus *Psychical Stimulation* are the two complementary sets of economic events that trigger the transaction. In CG theory they are hierarchical subtypes of *Economic Event*. The terms subtype (and supertype) are analogous to subclass (and superclass) in Object-Orientation (OO) (Fowler, 2004).
- The *event subject* relations (i.e. the states altered by the economic events) highlight the salient time and staff motivation resources (being subtypes of *Economic Resource*).
- The *source* and *destination* relations (i.e. providers and recipients) of the resources are the agents in the transaction. The subtype of *Inside Agent* in this scenario being the educational institution, with the *Outside Agent* being the staff involved as its corresponding subtype.
- The *{*}@40%* once again describes a plural of staff, but in particular the 40% who are the emerging researchers.
- P-H University is shown as a referent of *Educational Institution* (a subtype of *Inside Agent*), thus denoting it as a particular instance of the educational institution type. This corresponds to an object of a class in OO, or the value of a field in a database (Connolly, 2005; Fowler, 2004).

The meeting thus has the information presented in a structured way that enables them to recommend that the 'top 20%' are allowed to divert some of their revenue generating activities (hence the term 'revenue diversion') to mentor the other 'up-and-coming 40%'. This 40% in turn has managed to retain a research budget, which the director knows that the university's governing board will ratify. The top 20% have the research income generating activities from which they can sustain their existence. The meeting agrees that this provides the most conducive environment to motivate the staff (who are thus more appreciative of the difficult environment), sustain the university in the present difficult climate and grow it in the future according to its community objectives. The university will show a net loss of £0.5m (500,000 British pounds) but this is now considered the optimal worthwhile investment for achieving its community objectives whilst retaining its sound financial management.

Missing Agent?

Whilst we accept that the P-H case study makes a number of assumptions for the sake of simplicity of this illustration, a careful examination of even this simplified example reveals that the

P-H TM is missing one key aspect. If we look again at *Community Objective* in this TM (Figure 3), we see that it lacks a source, and in the generic TM (Figure 2) every economic resource has a source and a destination. It is evident that this requirement is needed as part of balancing this transaction. Thus we have captured a potential error of omission – there is a stakeholder in our transaction that we have not explicated! Who might this 'new' outside agent be? We might accept that this agent may not need to be explicated as it is immaterial; it's likely however that given P-H's emphasis on satisfying its community objectives it would be useful to explicate who is supplying this economic resource (being its supertype) that P-H is enjoying as a destination. It forces P-H to consider it and bring it into its model. The meeting decides that agent is *Society*, reflecting the role that the community plays in P-H's transactions. It would not have been captured in its existing (accounting or otherwise-based) information system, and left implicit in any natural language description, but it is in the structure of the TM.

TOWARDS A TRANSACTIONS PATTERN

In our experiences with the TM and applying it in a number of domains, we have found such phenomena occurring in each of them. We are therefore of the view that we have identified a new pattern in accordance with the expectations of software design patterns (Fowler, 2003; Gamma, Helm, Johnson, & Vissides, 1995). Our experience has ratified the ongoing work of the REA community's business patterns, and complemented it with a CG-based TM (Hrubý et al., 2006). We summarise some of these experiences as follows.

Community Healthcare

We identified and explored a TM for the complex realm of home-based community healthcare services to frail and disabled people. This domain provides a complex set of challenges for UK Local Authority Managers. Defining the agents was an involved process and there was a continual temptation to introduce redundant resources, thus contributing to high levels of cost (errors of commission). Through the TM we were able to identify the relevant agents in a hierarchical way, and identify a new *Purchase Agent* role that had hitherto prevented progress on this work (error of omission) (Hill, 2006; Polovina & Hill, 2005).

Emergency Healthcare

The provision and management of emergency care consumes considerable economic resources, which must be balanced against the potential increase in lives lost. One of the challenges of this domain is to identify the key performance indicators (PIs) that have a direct influence upon the monetary balance sheet, in order that they can be

managed appropriately without the PI measures themselves losing sight of the economic resources they are meant to measure (e.g. an unacceptable loss of lives for saving money in hard-pressed budgets). In this case the TM identified problematic qualitative concepts and enabled measures to be derived to simplify the management of these difficult issues. As such, the PIs for qualitative measures became indexes rather than the objects (economic resources) in themselves thus avoiding errors of commission (Hill et al., 2006).

Learning Environments

Mobile learning (or m-learning) presents new opportunities for learners to interact with materials using their smart phones or personal digital assistants. Analysis with the TM highlighted how this particular mode of learning raised the tensions between study-time, employment and leisure time that typical m-learners experience. As such the TM enabled learners to make an informed judgement about the costs (e.g. time sacrificed) and rewards (e.g. psychic or career benefits of qualification) in place of an ill-considered surface level desire that leads to their dropping out and wasting their energies (errors of omission and commission) (Hill, 2007).

Early Requirements Elicitation

The combination of a rich, lucid modelling notation, foundations in formal logic through CG and the TM has been adopted as a means of capturing and expressing ontologies at a very early stage of preliminary requirements gathering. Since the population of a TM requires concepts to be specified, it also follows that this approach also serves to identify types and their associated hierarchical relationships, thus forming the ontological basis for a domain such as those applied to above. We developed an approach that we referred to as Transaction Agent Modelling (TrAM) as a pre-early (or 'embryonic') requirements technique for multi-agent systems and the enterprise applications that can be built upon them (Hill, 2006; Hill et al., 2006; Hill, 2007; Polovina & Hill, 2005).

Research-Informed Learning and Teaching

Given the issues discussed thus far, it is not surprising that learning about the designing of robust, expressive software for the enterprise is a perennial challenge for students too. Relating the research into the TM to our own teaching, learners have been more able to make tangible links between the notion of business transactions and the needs of robust systems specification. Using a number of case studies that relate to healthcare, financial services and manufacturing, the TM has enabled learners to consider enterprise architectures that focus on the business rather than the technology. At the outset it forces them to consider the 80-85% of unstructured information as well as the 15-20% that

they see as the being the total problem with the serious levels of errors of omission and commission that can entail. The TM drives them to consider use cases for enterprise applications at the kite (business) level rather than the sea (system) level view (Fowler, 2004), and that reflect the balance the stakeholders and their transactions with the enterprise e.g. like the P-H case demonstrated. These 'transactional use cases' are rather unconventional compared to mainstream approaches, and together with the TM enable students to engage on a path of enquiry around the real issues in contemporary architectures for enterprise applications as we have described (Biggs, 1999; Houghton, 2004).

CONCLUSION

In our quest to identify how enterprises may be able to structure the vast majority of their information to enable them to engage in the right transactions, we have explored and demonstrated the relevance of REA and its effectiveness through the TM expressed in CG. Furthermore our experiences with the TM across a number of domains had identified a transactions pattern that can be applied across other domains too. The TM assists in identifying the agents in transactions from the TrAM embryonic requirements process, to build more accurate multi-agent systems for business applications. The TM has also provided our students with an educational experience so that they will be the much better informed enterprise architects of the future.

As well as all the above, we envisage that the transactions pattern may be incorporated into enterprise applications in a number of ways. One other avenue is that contemporary knowledge management systems, being the current vehicle by which unstructured information is captured and categorised, refer to the TM as the basis of their taxonomies to categorise content according to the business fundamentals of economic resources, economic events and inside/outside agents. Corporate decision makers would then be able to draw upon these systems to check existing transactions or to seek novel transactions for their enterprises. A further avenue might be to employ the natural language capabilities of CG to capture the text from documents, and map their content into TMs. This process would instantly structure this content, as well as identify missing aspects of the transaction e.g. a missing outside agent. Industrial examples using CG such as Sonetto already exist (Sarraf & Ellis, 2006), but as yet have no TM categorisation added into them. Whilst there is no doubt more work to be done to fully evaluate the validity of our approach, we foresee that the TM will become an inherent part of future architectures for enterprise applications.

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Simon Polovina is a senior lecturer in computing at Sheffield Hallam University, UK. He has six years of industrial experience as an accountant. His research interests are in Smart Applications, particularly in capturing the 'qualitative' dimensions of business transactions and business processes. These dimensions (e.g. 'quality of life') don't lend themselves to be measured in monetary terms, but need to be factored into software tools that can usefully support business decisions. Polovina's PhD addressed The Suitability of Conceptual Graphs in Strategic Management Accountancy. *Conceptual Graphs (CG) are a knowledge-based modelling language that is a key component of the recent ISO Common Logic standard (ISO/IEC 24707:2007). Polovina has, using CG, helped devise a 'Transaction Model' (TM) that can provide a qualitatively-rich specification for Enterprise SOA or multi-agent systems. Simon was the General Chair for the 15th International Conference on Conceptual Structures (ICCS 2007):* Knowledge Architectures for Smart Applications. *Polovina has expertise in SAP, Java, object-oriented analysis and design for enterprise & Web technologies, conceptual modelling of businesses as multi-agent systems, and interaction design. He has published widely.*

Richard Hill has published peer-reviewed articles internationally in the field of autonomous agents and has developed an approach to developing multi-agent systems based upon the notion of business transactions. His interests include agent-oriented software engineering, enterprise information systems and service oriented architectures.

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