A Modelling Approach for Dependency Management: a case study

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ABSTRACT

Today’s technology driven supply chain environments demand management of a vast array of complex dependencies. These dependencies are described as policies, processes, systems, and accountabilities, with each requiring a mix of controls for their integration into the supply chain environment. Controls such as intra-organisational collaboration, mandatory training, decision frameworks, and compliance audits have been administered with varying degree of success through various programs, management practices and methods. Based on our case study findings this paper presents a case for adopting Entity Relational Diagrams as a method to identify, communicate and manage complex supply chain dependencies.
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Keywords: Supply Chain Management; Integration; Process Innovation.

INTRODUCTION

Technology plays a pivotal role in supply chain management (Fredendall & Hill 2001): a dependency that has increasingly grown since the late 1990’s. This dependency is attributable to a number of factors; the onset of ‘virtual organisations’ (Sander & Schechter 2002); a competitive need to integrate supply chain elements; and, the evolution of innovating technologies such as Just-In-Time (JIT), Electronic Data Interchange (EDI) and e-Business (Chang, Makatsoris & Richards 2004; Fredendall & Hill 2001; Ross 2004; Sander & Schechter 2002). The literature suggests that organisations have principally adopted technology solutions - notably automated real-time transactional processing and workflows - as their main strategy to achieve organisational integration and to optimise supply chain management (Chang, Makatsoris & Richards 2004; Fredendall & Hill 2001; Marshall & Rossman 1999; Ross 2004; Sander & Schechter 2002).

Recently it has been acknowledged that technology alone is not the primary innovator for effective supply chain solutions. Organisations require a mix of controls extending to: inter- and intra-organisation collaboration; mandatory training; decision frameworks; and, governance and compliance audits to ensure integration at all levels within the ‘supply system’ (Chang, Makatsoris & Richards 2004; Fredendall & Hill 2001). These controls are considered critical factors in cross organisational, integrated and automated business processes that provide seamless transparency within the supply system (Chang, Makatsoris & Richards 2004; Fredendall & Hill 2001). Integrated and automated processes are largely supported by decisions that are ‘real-time’, and executed at the transactional (machine or network) layer level using a mix of protocol format exchanges and algorithms (Chang, Makatsoris & Richards 2004).

Given the growing reliance on the contribution of virtual enterprises to provide streamlined supply system solutions, and less reliance on human interaction, it is paramount that technology supports organisational business strategies and their underlying policies. It is also important that business strategies are flexible to be compatible with technological advances, especially where policies (or business rules) are often used as triggers to automate and control supply system transactions (Blauwens et al. 2006; Iannoni & Morabito...
With increased reliance on autonomic communications, rule-based and ontology-based policies, the efficacy of high level business policy is paramount to the delivery of efficient and flexible machine and network solutions (Davy et al. 2006).

This paper presents the initial case study findings of a large Australian organisation heavily engaged in complex, supply chain activities. The findings suggest that many events (internal and external to the organisation) can significantly impact the organisation’s policies. Policies, in turn, are generally translated into business rules, operational procedures, and constraints or similar, at lower organisational levels resulting in a complex, hierarchical network of policy dependencies. Moreover, policies are linked to business processes, organisational units, organisational parties, (information) systems and databases, oftentimes in a number of different ways. The findings reveal an extremely complex network of dependencies, indicating that an assessment of the impacts of a specific change trigger is a far from trivial exercise. More disturbingly, failure to undertake this assessment comprehensively and accurately can easily lead to procedural anomalies, inconsistencies and, in extreme cases, chaos!

Whilst the wider literature emphasises the need for a cohesive approach to organisational interoperability, there is minimal explicit research on the importance of managing inter- and intra-organisational dependencies and controls. While some enterprise modelling methods acknowledge policy or constraints (controls) as a vital organisation element, these mappings have generally been restricted to only the highest levels of the organisation (Li & Williams 1994; PLAIC 2001). Consequently there is limited acknowledgement or understanding of policy, process, technology, and decision-making dependencies and their impact on the organisation. Investigation of the case problem confirmed the need to identify and understand these relationships. This research attempts to first, address these gaps, second, bring to light the significance of these dependencies, and third, present a solution to communicate and manage these.

The approach we have taken is based on the premise that any attempt to manage this complexity must be underpinned by some automated IT solution. Thus, the primary focus of this paper is on presenting a preliminary specification of a conceptual model that describes the key entity types (and relationships between these) involved in the case participant’s supply chain change management program. Since the core of the proposed model is represented in entity-relationship (ER) form Chen (1976), it can readily be translated into a relational database schema. Consequently, an instantiation of this database for a specific organisation and its processes (or part thereof) allows the automated derivation of all parties, processes, systems etc. impacted by a change initiative. The knowledge and data required to construct our conceptual model (and associated schema and database) has been extracted from a current case study, investigating change within the supply and logistics operations of a large Australian company.

This paper is structured as follows: a brief outline of enterprise modelling and modelling methods provide insight and justification for the implementation of the adopted modelling formalisms; the case study is
discussed with reference to the specific issues addressed in this paper and the chosen research method; and, finally, preliminary data analysis and initial findings are then presented to reflect the current research state.

**ENTERPRISE MODELLING & MODELLING METHODS**

Enterprise architecture (or enterprise modelling) is an accepted and accredited methodology that is considered the conduit to organisation interoperability. It is regarded as a key enabler for organisations to meet their objectives and to realise efficiency gains (Harrison & Varveris 2007). Enterprise modelling has been used extensively since the late 1970’s to simulate and optimise manufacturing and distribution systems (Weston 1998) and more recently to communicate, hypothesise and optimise organisational structures, business and decision processes, and information flows (Bernus & Uppington 1996; Koumpis & Roberts 2003; Vasiliu & Browne 2003). However, many organisations have found that implementing and sustaining comprehensive enterprise architectures can be cumbersome, time consuming, overly complex, and just too expensive (Bernus 2003a).

Enterprise modelling has evolved to include a plethora of modelling frameworks, any number of which may be adopted to conceptualise the enterprise (Bernus 2003b). Conceptualisation (or modelling) can take the form of multi-dimensional architectural views that reflect the organisation’s entities, relationships, controls, and resources (Bernus 2003a). An enterprise model can include - but is not limited to - various schemas or architectures detailing information flows, systems, business processes, resources, and decision points or centres (Bernus 2003a; IFIP-IFAC Taskforce 1999).

Enterprise modelling is underpinned by a sub-set of modelling methods and related standards (Dewhurst, Barber & Rogers 2001; Kosanke 2004; Noran 2004; Schmitt et al. 2004). Modelling methods are deployed to support a specific modelling requirement and are essentially the mechanics used to analyse and illustrate the enterprise (organisational) environment (Bernus 1999; Bernus 2003b; Williams 1994). Methods are assigned to modelling solutions in accordance with their respective standard or modus operandi (Dewhurst, Barber & Rogers 2001; Kosanke 2004; Williams 1994). For example, the Entity Relationship Diagram (ERD) is regarded as the foundation modelling method, developed in the 1970’s as a conceptual modelling aid for data base design (Chen, C, II-Yeol & Weizhong 2007). The ER modelling method has since evolved to become synonymous with ‘understanding real world phenomena’ using entities, attributes, and relationships to define the enterprise environment (Chen, C, II-Yeol & Weizhong 2007).

Similarly, the Integration DEFinition (IDEF) standards comprises a suite of ‘special-purpose methods’ used to communicate various enterprise views and solutions, which includes, but is not limited to: function modelling; data modelling; and process modelling (Mayer, Painter & Lingineni 1995; Noran 2004). A more recent modelling method is Unified Modelling Language (UML), largely used as an object oriented software development tool, but has some limitations when applied to capturing business definitions (Noran 2004).
Method Engineering is a recent accepted modelling practice that is gaining momentum among academics and practitioners alike. It advocates the use of the subjects’ artefacts or methods rather than those predetermined by more traditional enterprise frameworks (Winter 2007). Method Engineering is essentially a design process whereby one or many processes or methods are used in order to develop the required solution (Winter 2007). A major benefit is that a practitioner need not analyse the entire enterprise objects or relationships, only those deemed relevant to solving the problem. From a practitioner and academic perspective, the preferred modelling method is essentially user choice, which should be taken in consideration of the task at hand, the modelling methods adopted by the organisation in question, and the resources allocated to the project (Noran 2004). Finally, some researchers have advocated a ‘horses for courses’ approach, whereby different formalisms are employed to model specific organisational aspects depending on their suitability (for one such proposal, see McGrath, 1997).

JUSTIFYING THE MODELLING METHOD

A major issue which had to be faced was that the case participant had a history of failure in enterprise architecture implementation, with the exception of process modelling, which was widely accepted throughout the organisation.

Enterprise modelling, in its traditional form, requires the commitment from management, unlimited access to appropriate resources and more importantly, time (Bernus 2003a). Given the complexity of the case the researchers could not guarantee these elements would be accessible for the duration of the project. In the early stages of this study the researchers undertook an evaluation of some of the traditional modelling methods to gauge their appropriateness to communicate or solve the problem. We found that traditional enterprise modelling frameworks, and more recent inclusions such as Service Oriented Architecture (SOA) and Business Process Reengineering (BPR), for example, fell short in their ability to show the relationship between policies and processes and related system and/or network instructions (Watters 2007). Taking an enterprise approach to organisational interoperability will enable organisations to establish and maintain a conduit between the enterprises, policies, processes, and supporting systems. These are considered essential elements in integrated supply chain systems (Chang, Makatsoris & Richards 2004).

Initial analysis of the case data revealed multiple instances of complex and duplicated processes and relationships, which the researchers considered could not be adequately simulated or sustained using traditional enterprise modelling methods. There were some positives found with existing organisational practices and it was considered that in our current project we could build upon this; for example, by using the Company’s existing artefacts to communicate and construct the solution (Winter 2007). Finally, the conceptual model to be specified in this project is, essentially, data-centric and it is widely-recognised that
ER modelling is ideally suited to this type of domain (Chen, C, Il-Yeon & Weizhong 2007). In addition, it was to our advantage because both researchers are skilled and experienced in ER modelling.

**CASE PARTICIPANT**

The case participant is a large Australian organisation heavily engaged in complex, supply chain activities. The organisation, which we refer to as the ‘Company’, is governed by a plethora of multifaceted, duplicated and often conflicting policies, which are controlled by both internal and external parties. This investigation focused on specific supply chain functions and brought to light the vast array of supporting systems and processes, policy domains, relationships, and controls that comprised the Company’s supply chain environment. The literature suggested that complex and/or bureaucratic organisations by their nature were susceptible to misaligned, conflicting, and duplicated policies or controls (Becht, Bolton & Roell 2002; Brown 2002; Chuter 2000; Drucker 1999; Searle 2006; Weigley 1993). This anomaly was reflected here where this Company had suffered poorly for a number of years in its attempts to respond in a timely manner to its external drivers (controls). Often this resulted in further inefficiencies than was previously the case with misalignment of its policies, processes, systems, accountabilities and responsibilities.

Analysis of the initial data suggested the extent of the conflict was recognised by stakeholders at the lower (operational) level of the Company but not at the executive level where the majority of the strategic decisions were fashioned. There was also evidence of minimal, or indeed the absence of, formal or informal feedback loops and authority roles within the Company’s organisational hierarchy. It was apparent that the Company’s basic management principles prescribed by Henri Fayol (1916), Luther Gulick (1937), and Herbert Simon (1946), as discussed by Shafritz & Ott (1987), were flawed. The consensus is that management anomalies will raise the occurrence of a reactive culture and reduce the level of proactive behaviour (Meryl Lewis (1983) in Shafritz & Ott (1987)).

**Case Problem**

This research investigated specific functions within the Company’s supply chain environment, which were the subject of change. The aim was to identify the relationship dependencies and propose a solution for their management. The Company, for a number of reasons, had been unable to respond readily to change. This has inadvertently left the Company in a position of perpetual change: a state it has endured for over a decade. The Company’s core business activities comprise supply chain and logistics functions and much of the change was directed at the coal-face of these activities. Analysis of the data revealed anomalies within the company’s supply chain environment, which became stressed when these activities were subjected to change.
The archival material revealed that the Company had expanded over time and as a result its supply chain environment, together with its management practices, had become increasingly fragmented. There was an array of demarcation issues affecting these management practices: supply systems; enterprise and policy ownership; accountability and responsibility; training; and, contract management, to name but some. A major concern was that the Company’s strategic decisions were fashioned without cognisance of its core business: supply chain activities. It was also apparent that the Company’s supply chain stakeholders had little understanding of the necessity to communicate changes that may affect these functions. There were many instances where the inability to identify and manage supply chain dependencies set in play a domino effect of dysfunctional activities. Some examples are given in the section entitled ‘Process Diagram Findings.’

This paper presents the findings of the Company’s supply chain activity, Contract Procurement, which was the subject of change.

**CASE STUDY DESIGN**

In the absence of any relevant, related research or hypotheses an interpretivist research design was chosen as the appropriate approach from which to understand and resolve the research problem (Leedy 1997; Punch 2001; Williamson 2000). This study adopted a qualitative research approach to observe, explore, interpret and communicate a social environment and its dynamics for the purpose of proposing a solution to a known problem (Coghlan & Brannick 2001; Williamson 2000). Given the size of the Company and the magnitude and complexity of its supply chain activities, a multiple-case study was considered the appropriate method from which to understand the case problem and to develop the conceptual model. The study is being undertaken within the Company’s supply chain functions using each case as the object of analysis (Creswell 1998; Yin 1989). Case studies are valued for their focus on real situations and problems and are commonly used in organisations as a collaborative approach to implement change programs Coghlan & Brannick (2001), Schmuck (2006), Somekh (2006), and Williamson (2000), or to improve enterprise practices (Noran 2004). Taking this approach has enabled the researchers to collaborate and evaluate the findings on a case basis with the view to developing a conceptual model that can accurately assess the impact of a specific change trigger within the Company’s supply chain environment.

**Data Collection and Analysis**

Archival research and unstructured interviews were the chosen qualitative data collection methods because of their ability to provide an accurate and reliable account of what is happening in an environment (Creswell 2003; Myers 2006; Williamson 2000; Yin 1989). The interviewees, who were supply chain contract procurement subject matter experts, were asked to describe and comment on the contract procurement change process. That is, they were asked to describe the change process and any impact on the Company’s supply chain activities. The initial process described by the interviewees was identified as the ‘As Is’
contract procurement change process. The ‘As Is’ and ‘To Be’ nomenclatures are accepted enterprise modelling terms of reference (Bernus & Uppington 1996; Noran 2004). The interviewees were then asked to identify and resolve any practices within the contract procurement change process that, from their perspective, required improvement. That is, areas of conflict were identified in the ‘As Is’ contract procurement change process, which is shown at Figure 2, then remediated and reflected in the contract procurement ‘To Be’ change process Entity Relationship Diagram (ERD), shown at Figure 3.

The ‘As Is’ and ‘To Be’ processes are the outcome of analysis of the Company’s archival materials and in-depth interview data with the findings collaborated, refined, and validated at the point of each interview. This is a validation method that is widely accepted by qualitative researchers (Marshall & Rossman 1999; Williamson 2000). Data derived from both the archival materials and interviews have been administered in accordance with emerging patterns or themes Creswell (1998), and a ‘methods’ and ‘source’ triangulation approach has been used to validate the data, and to ensure its reliability (Creswell 2003; Punch 2001; Williamson 2000).

The researchers also drew synergies from enterprise modelling and systems design practices for the purpose of data collection, analysis, and to report the findings. For example, we chose modelling methods and systems analysis practices that supported the use of the subject’s artefacts rather than prescribing set criteria to presuppose a solution that may prove foreign to the Company, which would add little or no value. The initial findings outlined below are representative of one case and are reported here using a mix of textual and structured formats (diagrams/models). The aim is to communicate a visual and narrative explanation of the problem and propose a solution (Creswell 1998; IFIP-IFAC Taskforce 1999; PLAIC 2001; Williamson 2000).

PRELIMINARY FINDINGS: CASE ONE

The case findings are presented in the Company’s ‘As Is’ supply chain contract procurement change process and the proposed ‘To Be’ improved change process solution, with the latter discussed under the section entitled ‘Entity Relationship Diagram (ERD) ‘To Be’ Schema’. By mapping changes to the contract procurement process; that is, by asking what happens when a supply chain function is subjected to change, we were able to identify the objects or elements affected by the change process and the level of the impact. We could identify where within the organisation the change occurred and who was responsible for implementing that change. These phenomena were recognised as elements and interfaces belonging to the supply chain environment where it was apparent that there were interactions between these artefacts. The next step was to investigate their level of interaction.
The Context Analysis and Diagram

A context diagram is a high level systems analysis and design tool used, in part, to simulate the subject’s environment; specifically, its ‘characteristics’ or elements, interfaces, boundaries and key events (Burch 1992; Yourdon 1989). In this instance the subject is the Company’s supply chain environment, which comprises multiple objects or elements and interfaces that define its characteristics. Figure 1, the Contract Procurement Change Process Context Diagram, shows the objects and interfaces (controls) that impact, or are impacted by, the change process. The resulting knowledge has been used to identify the interfaces (relationships) and to define the level of impact. The instances of objects or elements are depicted as rectangles (see Figure 1), and their level of interaction or interfaces (controls) are simulated using arrowed lines. The sum of these instances has been defined as the Company’s supply chain environment.

Context Diagram Findings

The context diagram was used to define the scope of the problem. The analysis showed that the contract procurement change process may impact some elements within the supply chain environment, which is demonstrated using outward facing arrowed lines. There were instances where the situation was twofold whereby interfaces emanating from the supply chain environment and the contract procurement change process could control or be controlled by one another. This scenario is represented using a double headed arrowed line to reflect the dependencies between the objects. In a small number of cases the contract procurement change process was subordinate to the elements within the supply chain environment. This scenario is shown using inward facing arrowed lines.

From this exercise it became clear that a large proportion of dependencies or relationships within the supply chain environment required further investigation. Whilst the context diagram is an analysis tool that provides high level constructs from which to derive a deeper understanding of a given environment and its relationships, the degree of lucidity in terms of behavioural characteristics is better suited to the process diagram.

The Process Diagram

The process diagram (or process flow) is considered the next logical step in the systems analysis and design methodology (Burch 1992; Yourdon 1989). It is also widely used in enterprise modelling to better understand an environment and its relationships (Bernus 2003b; Noran 2004). The process diagram enables the designer to expand the context diagram to identify the type of interactions or flows between the elements. The elements and interactions depicted in the context diagram shown at Figure 1 were incorporated into a process diagram, which is shown at Figure 2: the Contract Procurement ‘As Is’ Change Process. A Business Process Cross Organisation Functional Relations diagram was used to explore the complexities of the
Company’s supply chain environment. This particular diagram caters for complex designs where multiple organisation levels and functions are required to accurately simulate the interfaces within the environment (Bernus 2003a). The organisation levels and functions that comprise the Company’s supply chain environment have been identified and shown in Figure 2.

**Process Diagram Findings**

Figure 2 reveals that much of the activities arising from the contract procurement change process is concentrated at the Company’s operational levels, which are those activities performed at the branch levels and below. Changes to the contract procurement process affected various functions across the supply chain environment. We also found that formal organisational consultation and feedback surrounding the change process occurred at the strategic level, only, where high-level decisions are fashioned then delegated for implementation as Company policy. At the operational level (branch and below), where policies become processes, there appears to be more consultation; albeit, ad hoc and generally it is a forced reaction to change: reactive rather than proactive behaviour. There was also a distinct absence of formal feedback loops within the operational levels, and the strategic and operational levels. Inadvertently there were various groups within the Company making decisions or taking actions that ultimately affected the supply chain environment, often with insurmountable outcomes.

For example, at one point, the finance group interpreted and promulgated the new financial guidelines as part of intended improvements to the Company’s contract procurement process. After consideration and action by the finance directorate, shown in Figure 2 and labelled ‘Interpret System Changes’, a change request was forwarded by them to the Company’s Information, Communication and Technology (ICT) group to implement the finance system changes. However, an unforeseen consequence of this was that users of the supply system were unable to raise invoices through the purchasing (finance) system and, hence, could not complete their orders. While workarounds were found to overcome the changes, these were temporary solutions, which usually resulted in users having to undertake a manual upload of the data then retain a paper trail for audit purposes. Some of these workarounds have been in place for two years or more, which has raised the workloads for supply system users and lowered workflow efficiencies. In some instances, the finance system changes have triggered a major rebuild of the supply system, which has cost the Company millions of dollars.

In summary, key findings reflected in the ‘As Is’ process diagram shown at Figure 2 include:

- changes to the contract and procurement process resulted in supply system changes and in some cases there was a requirement to implement new supply systems, which were consequently managed as projects;
• supply system changes were authorised (or not) without notifying the supply chain stakeholders leading to misalignment of supply processes and other support systems;
• conflict between existing supply chain processes with the new contract procurement policies resulted in stakeholder confusion, which led to productivity loss;
• new training requirements were not advised nor were they available, making it impossible to promulgate the new process requirements;
• contract change requests initiated to accommodate new policy requirements incurred considerable costs;
• no consultation with stakeholders at the operational level prior to policy development and/or implementation resulted in supply chain anomalies; and,
• no provision was made for stakeholders to be notified of implemented or pending policy changes or new policies.

Although the process diagram shown at Figure 2 defines the cross organisation function interactions that comprised the contract procurement change process, there are limitations in the process diagram tool to accurately depict complex relationships. Relationships are simply dependencies, which are defined in terms of the subject’s business rules or constraints (Bernus 2003b; Burch 1992; Mayer, Painter & Lingineni 1995; Simsion 2001; Yourdon 1989). To capture the complexities of these unique relationships an ERD or IDEF (1/1X) (or similar) tool is required. As previously discussed, the choice of tool is essentially user choice (Noran 2004). For reasons already explained the ER method was chosen as the tool to better understand the complexities of the Company’s supply chain relationships.

Entity Relationship Diagram (ERD)

The ERD is a tool used in systems analysis and design to determine the uniqueness of the objects or elements and their behaviour or relationship status (Burch 1992; Chen, P 1976; Simsion 2001; Yourdon 1989). That is, there may be mandatory relationships or specific conditions attached to each element. Mandatory relationships or relationship types essentially capture an organisation’s business rules. To better understand the complexities of the Company’s contract procurement change process dependencies, the researchers developed a relational schema using the elements and interactions defined in the Figure 2 process diagram. Data from the Company’s textual materials and the interviewees ‘To Be’ process improvement descriptions were incorporated into this schema. The combination of this data has been normalised to first and second normal form (1NF and 2NF); meaning, the entity or objects are mutually independent and unique because their respective composition (attributes) are dependent on each other (Burch 1992; Chen, P 1976; Simsion 2001; Yourdon 1989). Key attributes or unique identifiers were then assigned to each entity within the schema to distinguish between a combination of values or variables within the relationships (Burch 1992; Chen, P 1976; Simsion 2001; Yourdon 1989).
The normalisation process is essentially an exercise undertaken to understand the data in terms of the subject’s environment. In this instance it is about managing and communicating complex relationships through a logical schema of the environment. 1NF and 2NF reduces the instances of duplicate elements, combines like attributes (descriptors), and basically rationalises relationships. Figure 3, the Contract Procurement ‘To Be’ Change ER diagram simulates the Company’s ‘To Be’ improved contract procurement change process, which is presented here in 2NF. The schema offers a logical approach to addressing gaps within the Company’s existing management practices by identifying and applying conditions (business rules) to the process flows. The rules as they apply to this schema are represented as follows:

- 2NF subsumes 1NF – i.e. if the schema is in 2NF it is also in 1NF;
- 0 is a null mandatory relationship (may or may not);
- = means there are many instances in this relationship;
- an arrow head line indicates a mandatory relationship (must be, or must have); and,
- the entity’s unique identifier is listed as ‘ID’.

**Entity Relationship Diagram (ERD) ‘To Be’ Schema**

Here we present in dot point form a limited explanation of the schema using the element or the entity labelled ‘Process’ and its relationships as the example:

- a process must belong to a specific function but a function can have multiple processes. The rule here is that a process can only belong to one higher function but a function can comprise multiple processes;
- a process may or may not be controlled by multiple constraints (policies) and a constraint may or may not control multiple policies. The rule is to identify the policy instances that constrain a process and vice-versa;
- a process may be supported by none to many training programs and a training program may support one or more processes. The rule is to identify the training programs that support a particular process;
- a process may be supported by none to multiple contracts and a contract may be linked to multiple processes. The rule is to identify the contracts that support any number of processes; and,
- a process may be supported by none to multiple systems but a system must support a process. The rule is that a system cannot exist without supporting processes and those processes should be mapped against the supporting system or vice-versa.

The benefit of defining and communicating the Company’s business rules as shown in Figure 3, is that we know in advance of a change program that processes must be grouped by function and; consequently, if there are any changes made to a function we are aware that there will be a cascading effect on all related processes. Similarly, we know that systems must support a process; therefore, when there is a system change
we know there is likely to be an impact on those processes. In the constraint (policy) relationship example, when a policy changes we can see that this might impact on a related process. Maintaining a schema of the Company’s supply chain environment will provide a robust and logical change management tool.

**FUTURE DIRECTION**

We propose to extend the ER schema to include other attributes that uniquely describe the elements using artefacts drawn from the Company’s textual materials or existing data sources. The next step will be to rationalise the schema to 3NF and 4NF to ratify functional dependencies (Chen, P 1976; Simsion 2001). Taking this approach will allow unique, multiple instances of data such as many-to-many relationships to be identified as a single data record. We then propose to develop a database that will provide ongoing management of the Company’s supply chain environment by implementing additional business rules or relationship constraints, as defined in the ‘To Be’ schema. Once the database is populated it will be evaluated against its ability to record and report relationships and anomalies within the Company’s supply chain environment. The benefit to the Company will mean Stakeholders will be fully aware of any impending conflict within the supply chain environment and; therefore, will be better placed to manage change.

**CONCLUSION**

The case study findings illustrate that supply chain environments are comprised of complex relationships that require identification, communication and understanding to ensure they are adequately managed and integrated within the supply environment. Given the profundity of supply chain relationships, failure to recognise these dependencies may result in a domino effect of dysfunctional activities. Through the case problem and its findings we have logically discussed and evaluated the appropriateness of modelling methods to simulate and manage supply chain dependencies. The merits of these findings presents a case for adopting ER diagrams to identify, communicate, and manage these dependencies. The benefits of using this modelling approach have been captured in this paper and the future direction of this research will provide further innovation to supply chain management.

**REFERENCES**


Winter, R 2007, 'Relevant Rigour-Rigorous Relevance', paper presented to ACIS 2007, USQ Toowoomba QLD, 5-7 December.


Figure 1: Contract Procurement Change Process Context Diagram
Figure 2: Contract Procurement ‘As Is’ Change Process
Figure 3: Contract Procurement ‘To Be’ Change Entity Relationship Diagram (ERD)