Data, Ontologies and Decision Making
An Inter-disciplinary Case Study

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Keywords: Information Governance, Data Quality, Shared Knowledge, Decision Making.

Abstract: Several studies have highlighted the need for information governance in organisations and the importance of quality data in decision making. Especially when considering the increasing need for collaboration, data-sharing, and interoperability. Organisations are not immune to importance of information governance and given the recent spate of information- related disasters and accidents, information risk management has become all the more important and its link to corporate governance explicitly noted and mapped. Data driven organisations typically lack the structure to associate ontologies tagged with data and are unable to offer the rich semantics that sometimes can enrich a decision maker's worldview. Data documents need not necessarily capture relationships and ontologically there are unable to offer the rich semantics that the data can sometimes show. The value of data is enriched by the associated semantics and modern enterprise systems are inadequate in their capacity to capture this rich source of knowledge and its representation. This research borrows approaches from urban sustainability to understand domain ontologies and their implications in system design and subsequent improvement in the value of organisational information. It uses case studies to highlight ontology modelling and how such an approach can add value in an organisational context specifically in the domains of system design and information value chain.

1 INTRODUCTION

The traditional view of data management within organisations have stressed on the notion of the availability of quality data at appropriate levels of decision making, but little is known about the value of semantics in such decision making scenarios. The complexity of inter-organisational systems and speed at which decisions are made makes it hard to encode the semantics associated with data. Data documents typically available at the decision table are unable to cope with relationships among other documents and ontologically there are unable to offer the rich semantics that the data can sometimes show. The value of data is enriched by the associated semantics and modern enterprise systems are inadequate in their capacity to capture this rich source of knowledge and its representation.

2 DATA AND ONTOLOGY - THE PROBLEM

Ontology is concerned with beliefs about reality; that is, the values and assumptions which support our worldviews, whether explicitly or tacitly held. Ontology is then the framework of core values upon which we base our understanding of the world and as such represents taken for granted rules and relationships. A more specific use of the term considers the formalization of ontology into a structured and computer-useable manner, i.e. the applied or 'formal' ontology. The creation of formal ontologies typically starts with brainstorming and stakeholder activities designed to reveal implicit definitions and understanding and is gaining increasing interest as an important means to encode knowledge gained from a group, subject area, or domain in order to support knowledge sharing and increased communication (Teller et al., 2008; Cimiano et al., 2009; Rettinger et al., 2012; Dobson, 2012): "Ontologies include computer-useable definitions of basic concepts in the domain and the relationships among them and are increasingly valued because of the ever-increasing need for knowledge interchange" (Mounce et al., 2010, p. 40). The practice of formalising concepts has found particular relevance within the computer sciences

Dobson S., Sukumar A. and O'Brien T..
Data, Ontologies and Decision Making - An Inter-disciplinary Case Study.
DOI: 10.5220/0004616905630568
In *Proceedings of the 15th International Conference on Enterprise Information Systems* (IVM-2013), pages 563-568
ISBN: 978-989-8565-60-0
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and organisational studies and especially in relation to the semantic web (Brüggemann and d'Amato 2012). The application of formal the ontology in service design is described by Akkermans et al., (2004).

The underlying logic behind data aggregation is fixed in system design. For example, a balanced scorecard approach necessitates the aggregation of multiple performance dimensions which are directly determined by the values and world-views (ontological position) of those involved in system design. Whilst data invariably changes - knowledge is hard coded in the data structure. That is the domain knowledge belonging to those for whom the system is intended and/or helped design/commission the system. Integrating multiple domains does not necessarily (but may) require changes to data type and format, but will require knowledge structure to be extensible and changeable to reflect multiple perspectives. These are shared structures.

To address the interoperability of data and multi-sectoral communication, research needs to focus on formalisation of organisational ontologies (W3C). Organisational ontologies are beneficial for enhancing communication, cooperation and therefore 'metabolic' transaction (Teller et al., 2008). More importantly it is from these cross-domain (functional) conceptual models that we might start to move toward integrated systems- thus leading to an integrated organisational practice. This work requires conceptual models that are both semantically extensive, so as to embrace the many definitions and perspectives, as well as being extensible.

Research in this area -coupling data and organisational ontologies has been minimal, but there have novel approaches developed in other disciplines to study the problem of domain ontology. Here we present a case study that looks into the issue of urban sustainability. It specifically focuses on the formalisation of urban domain ontologies as an important step in understanding the pathways that can lead to an integrated urban practice. Lessons learnt from this case study can point to ways that can help us to better understand the value of data in organisational ontologies and in the overall performance of the organisation.

3 CASE STUDY

Urban areas and cities are described as the driving forces behind the global economy and are the largest contributors to national output, innovation and employment (Schauser et al., 2010). As such they are more than simply built form – cities are the culmination of inflows and outflows of knowledge, energy, materials and resources. Cities are dynamic spaces through which multi-level organization of transformation processes are performed. It is here that the three pillars of sustainability – the economic, social, and environmental - are most entwined, creating complex and multi-level inter-dependencies which serve to blur organizational and sectoral boundaries of concern.

Managing strategic change toward the sustainability of cities therefore raises key conceptual challenges, particularly within the context of multi-sectoral/ multi-stakeholder complexity. Planning measures need to be considered through a coherent framework capable of identifying complex inter-relationships and interdependencies - such as those existing between the numerous processes and services which support the economic, social, and environmental dimensions of urban areas. The dispersed nature of responsibility in managing aspects of urban systems, as evident for example in partnership approaches for the delivery of public services, forms an adaptive infrastructure which is often difficult to model in terms of impacts and longer term effects. Integrated Assessment (IA) is emerging as a city-wide approach to address such complexity and aims to identify the connectivity between all urban systems; whether natural, human, or technological (Hall et al., 2009; Dawson, 2011). Communities are key stakeholders within this information ecology. The European Union Community Strategy Guidelines 2007-2013 encourage an 'integrated approach' toward urban cohesion to support economic growth and job creation as well as support social and environmental goals. Integration of knowledge, information and data is a key concern in this context drawing upon two potential approaches broadly characterised by either replacement (i.e ERP - single system, transform existing systems and processes under one umbrella) or a more open architecture; extensible, configurable, connecting and translating.

The City Region Leadership Programme (CRLP) is a postgraduate certificate which aims to provide University-accredited learning to those in a position of leadership predominantly within the public sector. It was developed as a partnership between the two Sheffield universities (University of Sheffield and Sheffield Hallam University) and four major public sector organisations, Sheffield City Council (SCC), NHS Sheffield (NHS-S), South Yorkshire Fire and Rescue Service (SYFRS) and South Yorkshire

Police Service (SYPS). Its overall aim is to create innovative stakeholder-led collaborative learning opportunities, which enhance individual and organisational performance and economic outcomes in the region. The programme involves four modules of teaching and the approach presented here represents one component of a module on Customer Centric Services. The aim of this component is to challenge the individual to explore their tacitly held worldviews (ontological position) of services relevant to them with the aim of finding semantic commonalities and differences with representatives from different public services. The hope is that semantic connection may pave the way for actual connections between services and so the exercise aims to challenge and reveal both individual and also inter-organisational definitions of services.

The CRLP was initially developed for public sector services, but the course has demonstrated that benefits and value are created by cross-agency working and so now it has been fine tuned to develop broader partnership working between public, private and third sector organisations. The need for a collaborative approach to service design and delivery is acutely recognised in the CRLP module, 'Customer Centric Services'. Here, practitioners are encouraged to perceive how service user 'customers' might interact with services as interconnected parts of their journey and particularly to understand the role of customer involvement in the development and review of services. A key emphasis on this part of the CRLP is the process of building strategic alliances and partnerships to help configure future services. This requires a keen understanding of semantic definitions of core concepts which underpin service ontologies if new delivery partnerships are to be defined or old ones redefined. A learning exercise 'game' aimed at encouraging the collaborative processes of innovation and 'illumination' (Wallas, 1926) was devised to help render explicit these often tacit understandings of what services are - and more importantly, could be.

Through a series of practitioner workshops and developed as part of a leadership and management programme, formal ontology modelling is introduced as an important means to help build: a) an integrated understanding of sustainability as a multifaceted concept, and b) a conceptual framework from which to create better understanding of both the intended and unintended effects relating to service delivery in the longer term. The work here illustrates just one part of a necessarily holistic approach to the semantic understanding of city systems in order to support the integrated management of urban sustainable development. Whilst we must acknowledge the challenge in applying such a tool in practice any successes are likely to bring significant benefits to the sustainable management and development of cities globally. The dimensions of this are:

1) The formation of networks/ communities practice which are drawn together both by a common goal and vision, but more importantly a shared and explicit conceptual framework.
2) The creation of a conceptual framework (formal ontology) which fosters common understanding and aids cross-domain communication.
3) Integrated assessment of service delivery within the context of a complex urban system

The activity aims to encourage individuals to explore their own tacit understanding and definitions of concepts related to services. However by sharing these, inter-personal and inter-organisational variation is introduced through the connecting of sub-concepts.

For example, to rethink our definitions of public services, and achieve real collaboration through closer commonalities in values and understanding, we must consider how we define our assumptions and worldviews through language. However, common language does not ensure we share understanding, values or expectations and so conceptual modelling and the formalization of ontology is a key means to explore and reveal this.

The approach:

1. Each person begins by having their own service background in mind; then one person starts by writing down a word/concept related to their own service (for example: the Police service might write down the word 'safety')

2. The flip-chart paper is passed around anti-clockwise and the game progresses through many 'rounds' of the table. When it is a person turn, they must choose any word on the sheet and think of how that word might relate to their own service. They must write another word which they feel relates to one of those on the sheet and draw a line linking between them. The nature of the relationship is also indicated on the line. For example, a teacher playing the game may decide that children's well-being is a 'part of' safety. In this case the words 'children's well-being' would be written down and a line drawn to link this with 'safety'; 'part of' would be indicated on the linking line.

3. Each person has to add a concept relating to their own service and if possible draw and define its link to an existing one on the sheet. This should be quite rapidly done. If they cannot think of a link they must still write down a word/concept but it will remain floating, i.e. isolated.

4. When it is a player's turn, if they can see a connection to an isolated word they may choose to draw a link and define the link before taking their normal turn.

5. The process progresses for about 20 minutes - if there are numerous teams, the ones with the most connected words and fewest isolated words 'wins'.

6. At the end, each participant must write their service in the same coloured pen they used for the game. This acts as a 'key' when reading the results.

The purpose is to begin to reveal the ontological positions whilst also revealing your own. By colour coding this exercise, interesting themes start to emerge. For example, certain colours may regularly go together illustrating potentially stronger parallels or links in thinking. Alternatively, the presence of many isolated terms may indicate a difficulty in establishing commonalities within the team at a basic conceptual level. However, on the whole most people can see the relevance of words to their own service or profession and therefore links are most typically made - even if they are a result in slight semantic differences. Since any player may choose to link isolated terms before making their own move we may also observe which individuals/services appear to see the connections between others. Perhaps they already, or have the potential to, perform important brokering/intermediary roles between services.

In the example illustrated in Figure 1, the Police Service started the game with the word ‘Criminal’ to which a representative from voluntary sector associated this as a person with mental health issues. The professional from services related to Temporary Accommodation related Anti-Social Behaviour (ASB) to the word 'Criminal' and interestingly, the Environmental Services associate ASB with environmental quality. It is also evident from the larger number of red connections that it is the Voluntary Sector representative who can see the greatest number of cross-sectoral connections. Whilst these are just very brief snapshots of such an exercise it is possible to consider the value of this kind of approach in introducing departure (variation) from service-specific ways of perceiving the ontological/semantic relations between terms and concepts.

The service ontology which starts to emerge from this exercise is one formed from the shared perspectives of those around the table. For example, the links between ASB and environmental quality is an important dimension to be revealed and arguably only present because of the presence of the participant from Environmental Services.

4 CHALLENGES AND CONCLUSIONS

Working together therefore also requires a level of cognitive shared understanding starting from the very semantic framework through which we communicate ideas. The above example is a means to help reveal shared semantic knowledge in practice. Shared understanding is not fixed and so ontological structure underpinning data sharing needs to be open, shared, and changeable to reflect emerging and future uses of information across domains. The design of enterprise wide systems often do not facilitate this, their environment is around modelling a holistic solution for distinct operations. An ERP approach typically encompasses an organisation's Financials, Human Capital Management, Operations and Corporate Services.

This is a comprehensive approach whereby efficiencies and productivity are gained through seamless integration of functions. Whether on premise, or in the cloud - a company's processes and data governance are ideally aligned, or optimised, to match ERP system requirements. The underlying ontological structure is determined by the structure of the system and reconfiguration can be complex and problematic. System design methodologies in future must also recognise this inherent difficulty and for an organisation to achieve its true potential, an effort to incorporate the underlying ontological structures can lead to improved decision making and can reflect a phenomenon where value addition in relation to data can be realised.

Ontology modelling can ruffle feathers in view of system designers but it is important that design of systems carry this component where shared understanding and assumptions can be accommodated. Data enters organisational boundaries but conversion to information and an increase in its value can be achieved by accommodating shared semantic knowledge.

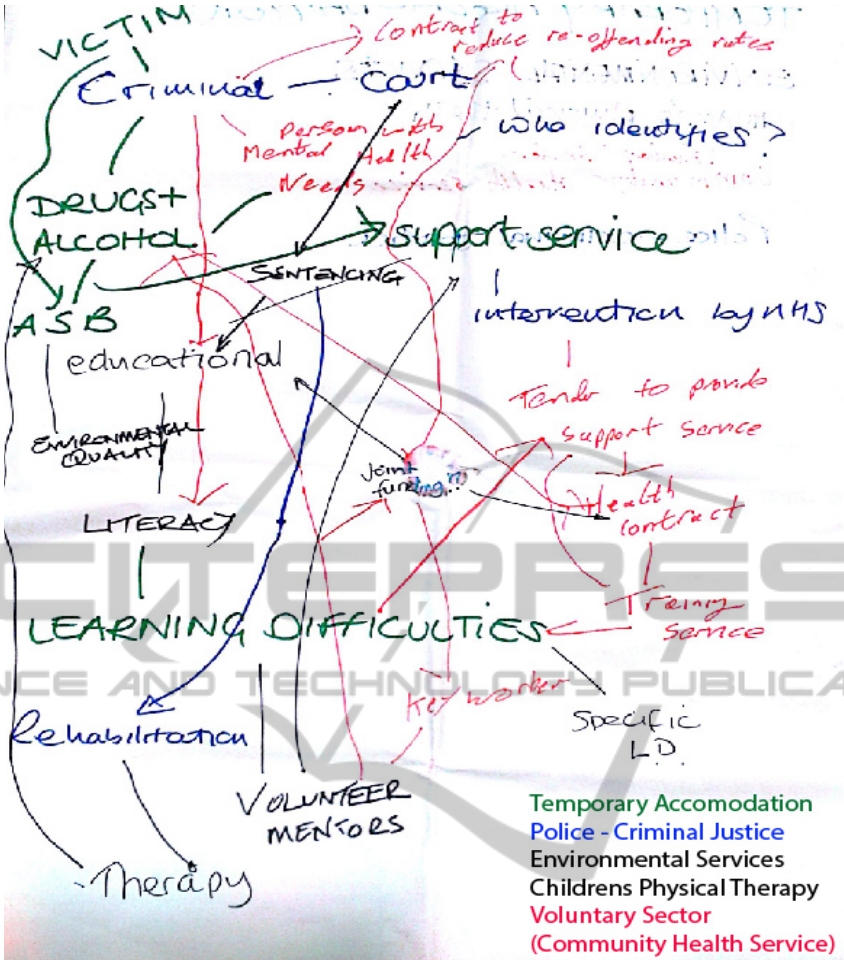

Figure 1: Example concept map.

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