Discovering Business Networks in Virtual Marketplaces

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Abstract

Electronic markets are intrinsically social environments. Virtual marketplaces, populated by avatars and objects representing market players (both people and software agents), enable the observation and measurement of behaviours that is difficult (if not impossible) to perform in physical market environments. This paper presents the conceptual framework of the virtual marketplace – an electronic trading environment that amalgamates the representations of market players, supporting actors (e.g. information bots, data mining agents), product representations, transaction and communication systems, tools for accessing and presenting all contextual information - all of which support market operations. The paper discusses the design of the data sets collected in such environment that will enable the analysis and investigation of emerging business networks between the players, the data mining techniques that can be applied and the outcomes. Incorporating these techniques in the electronic trading environment can lead to electronic markets, which support the discovery of innovative business transactions.

Keywords

electronic markets, business networks, network mining, virtual worlds

INTRODUCTION

Markets are driven by knowledge and people. Knowledge leads to the recognition of opportunities to trade for mutual advantage. What gets organised in markets is not just economic exchange but human social relations (Fligstein, 2001). Innovation and market evolution come from the discovery of new opportunities (new knowledge), which are seized and implemented by people. Science and innovation are being increasingly recognized as social processes in which links are made between existing ideas across people and organizations, rather than with them (Goldenberg et al., 1999). Thus science proceeds through the interaction among scientists’ ideas in the form of reading and building of the ideas of others as reflected in citations, co-authorship networks. Markets operate through the interactions among market participants (market actors or players) within and between firms as is demonstrated by a large and fast growing body of literature and research (Anderson et al., 1994; Wilkinson, 2001; Wilkinson and Young, 2002). The underlying rationale of these research efforts was to understand the actions of the business partners and the longitudinal development of their relationship (Olkkonen et al., 2000). Relationships are a substantial part of structuring, evaluating and understanding messages in interpersonal settings (Duck, 1998). Business relationships (dyads) or sets of relationships (networks) are assumed to evolve as a result of interpersonal communication, which occurs situationally in communicative and cognitive processes between market actors. Aspects of interpersonal communication are important in attempting to understand issues such as long-term bonding, various forms of adaptation and the development of trust and mutuality in business relationships and networks. Relationships are connected. A change in one relationship affects positively or negatively others (chain effect). Relationships change and evolve over time. Connectedness of business relationships ties individual and companies into business networks. These networks interlink people, information and knowledge, and provide a vibrant structure for knowledge development and sharing. A business network is also an inherently social process in which both tacit and explicit dimensions are involved (Nonaka and Takeuchi, 1995; Brown and Duguid, 2000). In this context, new opportunities or ideas do not come from nowhere but result from the recombination of existing ideas (Fleming and Sorenson, 2001; O'Connor and Rice, 2001). The role and importance of relations and networks in markets and innovation is demonstrated in a large and fast growing body of literature and research (Ritter et al., 2002; Wilkinson and Young, 2002) and in recent working papers by researchers from MIT Sloan School of Management. This body of work shows that innovation and the evolution business networks stems from interactions that confront, links and stimulate ideas. In other words, innovation and opportunity discovery in traditional business environments comes from networks of interacting people at the workplace or in the pub. Furthermore, the exploitation of these ideas is through networks of interacting people and firms employing money, resources and technologies (Loudon, 2001). Innovation has consistently ranked among the most powerful drivers across different industries, according to the
Value Creation Index (VIC) of Cap Gemini Ernst & Young Center for Business Innovation in Cambridge, Massachusetts (CBI). The value drivers in CBI’s VIC are composed of quantitative data indicators. (Chan and Ho, 2002) have identified three criteria: it must engage a creative process, it must be distinctive and it must yield a measurable impact. The research in such complex interacting business networks and their dynamics is in its infancy (Bornholdt and Schuster, 2002). One of the reasons for it is that in conventional business environments tracking the complex data about the behaviour of individuals engaged in such networks, their interaction, and content creation and exchange, can be a difficult exercise, in terms of collecting and organising consistent data set(s) for further analysis.

Electronic market technologies are not only expanding further the scope and the border of these interactions, but are also offering significantly lower hurdles with collecting, organising and mining such data (Kohavi and Provost, 2001). The work presented in this paper is a framework for utilising the data, collected in virtual marketplaces based on the integration of 3D virtual worlds with their rich communication environment and multi-agent systems with their capability for market negotiation and transaction handling. The work brings to the front the role of communication between individuals in electronic marketplaces, focusing on the social or people networks as central to the recognition of opportunities and productive links among existing ideas and to their exploitation and implementation. The important question is how business relationships/networks start and evolve as a result of a “sequence of virtual interactions”; and how the beliefs of network participants change as a result of the evolution of the business network. The research builds on the state-of-art virtual marketplace, designed by researchers from the e-Markets group at the University of Technology, Sydney.

THE VIRTUAL MARKETPLACE

During the latter half of the 1990s great faith was placed in the future of e-markets that would establish a basis for free competition and so lead towards a perfectly efficient economy (Guttman et al., 1998). The initial hype has been replaced with some evidence to suggest that in an e-business environment traditional values—such as dealing with a preferred supplier even if better deals may be found elsewhere—will remain (Wise and Morrison, 2000). The transformation of financial markets that took place in the 1980s and 1990s provides a model for the emerging business-to-business (B2B) environment. There are theoretical grounds for believing that the “strategically weakest” buyers and sellers will migrate from fixed contracts to electronic exchanges, then the next ‘weakest’ will follow, and so on (Neeman and Vulkan, 2001). The assumptions on which this argument is based are that the agents involved are purely utility seeking; the argument does not allow for the ‘comfort’ of dealing with a reliable supplier, nor does it deal with economies that may be derived from matching predictable demands with supply. Market activities include trading orders to buy and sell, single-issue and multi-issue negotiations, requests for information extracted from market context. These activities are intrinsically social and situated. There is a number of ways to implement an electronic market as a computer-mediated market (Barbosa and Silva, 2001). Figure 1a shows an earlier implementation of a basic e-exchange, hooked to the Sydney Stock Exchange, designed by the authors. This virtual market supports the common trading mechanisms and in which every activity is managed as a constrained business process by a multiagent process management system. It offered players access to trading mechanisms, but no channels for communication and other interaction between them. When the electronic market was “hooked onto” real markets with the inherent unreliability of the Internet, one of the lessons learned and related to this project was about the need for additional interaction channels between humans and underlying software agents and directly between the humans. Given the optimism in the future of agents in electronic commerce and the body of theoretical work describing the behaviour of rational agents, it is perhaps surprising that the basic structure of the emerging e-business world is far from clear. The majority of Internet e-exchanges are floundering, and it appears that few will survive (Wise and Morrison, 2000). There are indications that exchanges may charge a negative commission to gain business and so too market intelligence. For example, the Knight Trading Group currently pays on-line brokers for their orders. One reason for the recent failure of e-exchanges is that the process of competitive bidding to obtain the lowest possible price is not compatible with the development of buyer-seller relations. The preoccupation with a single issue, namely price, can overshadow other attributes such as quality, reliability, availability and customisation. A second reason for the failure of Internet e-exchanges is that they deliver little benefit to the seller—few suppliers want to engage in a ruthless bidding war (Wise and Morrison, 2000). The future of electronic commerce must include the negotiation of complex transactions and the development of long-term relationships between buyer and seller as well as the e-exchanges.

The authors have reconsidered their approach to the design of electronic markets. In their new approach, a marketplace is a real or virtual space populated by agents that represent the variety of human and software traders, intermediaries, and information and infrastructure providers. An electronic marketplace is a virtual space that amalgamates the representations of market players, supporting actors (e.g. information bots, data mining agents), product representations, transaction and communication systems that support market operations. Although, by its nature, market activities are distributed across borders and places, handling activities in one
“logical place” provides convenient mechanism for observing and collecting data about the behaviours, strategies and activities in the market. A high level view of the architecture of such e-market is illustrated in Figure 1b. This architecture has been adopted in order to address the above mentioned problems. The electronic market place have been redesigned as a multi-agent virtual world (Debenham and Simoff, 2001). The underlying implementation in this case is based on virtual worlds technology that integrate communication, interaction, negotiation and other exchange between actors in one place where the complete range of market activities is fully supported. Virtual Such architecture is capable to accommodate new emerging markets, perhaps as new e-market places, which will assist the observation and investigation of the the evolution of e-markets. The distributed e-market, populated with different e-market places is organised around the concept of an “universe”, populated with numerous “worlds”, respectively. E-market organised as a virtual place is a killer domain for the application of data mining methods. The technology of the three dimensional (3D) virtual worlds, initially developed as environments for computer games (hence, known also as 3D game engines) and interactive multimedia applications, are increasingly appearing among the distributed Internet-based information systems. The term “virtual world” refers to computer programs that simulate worlds and synthesise digital universes (Heudin, 1998). These worlds are constituted by representations, which may or may not be related to instances in the non-virtual world. Representation as a concept refers to all aspects of the appearance of objects, avatars, bots and other elements of the virtual world (Capin et al., 1999). The design and development of virtual worlds has focused on the implementation and rendering of the 3D models that provide the place infrastructure.

![Image](image1.png)

Figure 1. Examples of electronic markets.

The conceptual framework of the virtual marketplace is shown in Figure 2a. Technically the electronic market environment is a multi-agent virtual world (see Figure 2b), which integrates a number of technologies: (i) an electronic market kernel (Java-based), which supports the actual market mechanisms; (ii) a virtual world, concerned with all aspects of the appearance and interactions between market players, bots and other objects in the e-market place (based on Adobe Atmosphere); (iii) a variety of information discovery bots (Java-based), and; (iv) a multi-agent system, which manages all the market transactions and information seeking processes in the e-market as industry processes (built using the Australian JACK technology). This unique environment is devoted to the evolution of electronic markets, as a result of entrepreneurial action supported by the timely delivery of information drawn from the full market context. Entrepreneurship relies on both intuition and information discovery. All transactions, including information discovery requests are managed as heavily constrained business processes. The constraints include both process-related constraints (eg: time, value, cost) and player-related constraints (eg: preferences derived from inter-player relationships). The player-related constraints are based in part on a model of ‘friendship’ between the players—trust, support, communication, loyalty, understanding, empathy, and intimacy (Debenham, 2002). This work provides an understanding of the evolution of the most primitive business network involving just two players. On the other hand, the integrated virtual marketplace offers unique opportunity for collecting different data about the business operations conducted in such environment.

**Virtual interactions**

The concept of “virtual interaction” place a central role proposed approach. It refers to the interaction within the framework of the virtual market place. When players interact face-to-face, they use a wide range of nonverbal
signals that support the negotiation (and conversation, in general) process. These signals can create the positive (or negative) vibes between players and significantly influence the outcome of a negotiation or other business meeting, hence influence the evolution of a business network. Many of these signals are substantially different when people interact in a virtual marketplace. Since the virtual marketplace integrates virtual worlds technology controlled by a multi-agent system, there is a scale of representations, spanning from avatars, which represent human users, through a variety of information bots and data mining agents, to sophisticated animated negotiation agents. As a result, the interaction in such a place they include the interactions within the virtual worlds, market transactions, interaction with the information discovery bots and other objects in the virtual marketplace. The interactions in virtual worlds are summarised in Table 1 (Jensen, 2001).

<table>
<thead>
<tr>
<th>Virtual Marketplace</th>
<th>Integrated Multi-agent system</th>
</tr>
</thead>
<tbody>
<tr>
<td>e-market place</td>
<td></td>
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<tr>
<td>interactions</td>
<td>market transactions</td>
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<tr>
<td>information</td>
<td>information mining bots</td>
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<td>requirements</td>
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<tr>
<td>H/H</td>
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<td>H-in-A/H</td>
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<td>O/H</td>
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<tr>
<td>VW/H</td>
<td>VW/H-in-A</td>
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<td>VW/VW</td>
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Table 1. Types of virtual interactions

Each of these interactions has a variety of nuances. The assumption in our research work is that such interactions can indirectly affect the evolution of business network structures. For example, in the “human-in-avatar and human” (H-in-A/H) interaction the human must adapt to the avatar’s specific movements, abilities and repertoire of expression. This also touches the pivotal question of identity — techniques for validating identity (for example, when it comes to financial transactions), multiple identities, visual appearance. The analysis of interactions between avatars (H-in-A/H-in-A) will look at how changes in the position of the avatars, movements, the distance between them and gestures used affect communication. In 2D virtual world, social attraction (i.e., liking) was found to vary with respect to the distance between the avatars, decreasing at middle distances and increasing at low and high distances (Krikorian et al., 2000).

MINING NETWORKS IN THE VIRTUAL MARKETPLACE

Uncovering the patterning of people's interaction has been the subject of social network analysis (Wasserman and Faust, 1994). It is based on the intuitive notion that these patterns are important features of the lives of the individuals who display them; hence the data sets for the analysis can be relatively small. Relational data mining (Dzeroski and Lavrac, 2001) has taken this idea further for examining large data sets that represent the relations among entities (e.g., acquaintanceship and friendship ties between people, links between places, things, web pages, events, and other organisational links). The data mining techniques for such data sets that will be

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considered in this project include probabilistic relational models (Friedman et al., 1999), Bayesian logic programs (Kersting and De Raedt, 2001) and relational probability trees (David and Jennifer, 2002).

The networks of virtual communities, supported by different collaborative virtual environments, the analysis of their activities in these environments and the diffusion of information in such communities play key role in the development of the discovery technology. Combining virtual communities with electronic business technology leads to the emergence of new business models and networks (Hagel III and Armstrong, 1997). From a data mining point of view, a virtual marketplace is a collaborative virtual environment where each player, whether a human or a software agent, is represented by an avatar, and they performed a variety of business activities. Some of these activities, like negotiation, information exchange, “gossiping” are happening in the virtual world part of the electronic marketplace. Generated complex data about interactions between players in different market scenarios, the corresponding transactions and information seeking strategies, reflect all aspects of market players’ behaviour and interactions between different players involved in electronic market scenarios. Recent works on identifying the “network value” of a person (node) within a social network structure of a business virtual community, based on person interactions and information diffusion (e.g. (Domingos and Richardson, 2001; Richardson and Domingos, 2002) showed the potential in utilisation the available data.

**Discovery networks in virtual marketplaces**

Our conceptual framework is shown in Figure 3. Business relationships are conceptualised through inter-linked activities and episodes to study their dynamics (Figure 3a) and is derived from (Olkkonen et al., 2000). Data collection, data set design, data mining, patterns discovery, representation of results and their utilisation is shown in Figure 3b in four major groups of inter-woven components, derived from (Simoff and Biuk-Aghai, 2001).

![Figure 3. Conceptual framework](image)

Relationships and networks are essentially formed by interpersonal communication processes, which are affected by their historical and structural contexts (eg, cooperation, conflict, social interaction, continuity, complexity, symmetry). At the bottom (under the timeline) in Figure 3a is shown the detailed data coming from the virtual world server logs, chat activities, documents exchanged, etc. Such data is aggregated into market “activities”. Similar analogy exist in the area of Web usage mining, were Web log data is aggregated to the level of page visits (including page entry and page exit), or user session level, where the data is aggregated per user visit to a site). Further levels of abstraction include episodes, transforming the behaviour patterns in episodes into relationships, estimating the “strength” of such relationships and deriving network structures from them. The network mining methods transform the flow of data into high-level static and dynamic patterns of knowledge and business network structures, through a series of increasingly abstract intermediate-level patterns. The methods and corresponding mining algorithms operate over information about the objects in the virtual marketplace and their specific configurations, namely information about the structures of the virtual marketplace, and the information about the actions that take place within that structure. The methodology presented Figure 3b includes collection of methods, discussed in more details below.

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Analysis of virtual interactions between avatars.
These methods examine the relationships between avatars over time in the 3D virtual marketplace including:

- the virtual body language used by the avatar and how changes in position, movement, distance and gestures affect communication;
- the dynamics of the spatial and psychic distance of avatars (the methods in the 3D virtual marketplace extend the work of Krikorian et al., 2000);
- changes in avatar representations.

Such interaction can indirectly affect the evolution of business network structures. “Human-in-avatar/Bot” and “Bot/Bot” interactions are concerned with the characteristics of avatar behaviour that can trigger agent actions and vice versa. Our assumption is that bot(s) (through their behaviour) can become significant part of an evolving business network in a virtual marketplace. By introducing measures of interaction intensity we attempt to examine the impact of “virtual” social attraction on the evolution of business relationships.

Analysis of interpersonal text communication

The transcripts of Human/Human communication (whether text-based, or sound that can be converted into text-based form) are key component of the interaction data. The analysis techniques are based on the research in the analysis of design communication in virtual design studios (Simoff and Maher, 2000).

These methods combine a set of algorithms which analyse chat transcripts in business interaction in a virtual marketplace. A utterance or action is the unit for the utterance dynamics analysis, i.e. patterns in utterance sequences (Simoff and Maher, 2000). Within each utterance, the content of that utterance is analysed both in terms of text statistics (e.g. length, size of words, number of emoticons), and semantic analysis. The content analysis is based on the semantic network techniques implemented in TextAnalyst².

Analysis of other activities and transactions

Relationships are patterns of interaction (or can be detected as so) including creation of a relationship, activities generating or resulting from relationships and changes in network structures influenced by a relationship. These events may occur infrequently, hence standard statistical methods may not be feasible, instead methods such as comparative narratives can be used (Abell, 2001). Based on that approach we identify patterns of interactions leading to particular kinds of relationships (e.g. the presence of trust/distrust, respect/disrespect, appreciation or frustration) as player actions, capabilities and values are shaped by their history of interactions. We seek sequences of events that produce the relationships observed, not just the assortment of events that have occurred. The techniques include (i) interaction mining (sequences of “events”, described as a set of predicates (e.g. (Zaki, 2001)); (ii) mining interaction outliers (outliers can reveal key points of interaction that will change relationship development).

Patterns identified by the network mining algorithms are evaluated using a number of measures of (i) diversity (density, richness) of cliques; (ii) interestingness and impact of a node, clique or network; (iii) surprisingness of a change in a network; (iv) novelty of a network configuration. and similarity (including measures that emulate human perceptive similarity). These measures assist in interpreting the relevance of the patterns to the evolution of business networks and innovation. The measures are based on variations of respective measures in (Hilderman and Hamilton, 2001).

CONCLUSIONS AND FUTURE WORK

This paper presented a framework for analysis of the data collected in integrated electronic marketplaces based on virtual world technology. The incorporation of methods and information technologies discussed in the paper will lead to the extension of an electronic marketplace in order to support the investigation of the evolution of business networks. These business networks are expected to form as a result of conducting business operations in the virtual marketplace. This will provide fundamental insight into the operation of the next generation of market. Little is known on how entrepreneurs operate in electronic market places, although the capacity of the vast amount of information that will reside in those market places, and on the Internet generally, to assist the market evolution process is self-evident. E-markets are in themselves a fruitful arena for hunting entrepreneurial opportunities—witness the proliferation of new market forms and players and the characterisation of the new network economy as an “opportunity factory”. The opportunity arises to leverage the rich flows of information in and around e-markets, and between the players in them. The collection of techniques, presented in integrated form in this paper aim to facilitate the discovery of potentially profitable opportunities and thereby stimulate the innovation in business, and the evolution process in business networks.

² http://www.megaputer.com

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REFERENCES


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