Discovering the Dynamics of Smart Business Networks

L-F Pau

ERIM REPORT SERIES *RESEARCH IN MANAGEMENT*	
ERIM Report Series reference number	ERS-2007-081-LIS
Publication	December 2007
Number of pages	5
Persistent paper URL	http://hdl.handle.net/1765/10732
Email address corresponding author	lpau@rsm.nl
Address	Erasmus Research Institute of Management (ERIM) RSM Erasmus University / Erasmus School of Economics Erasmus Universiteit Rotterdam P.O.Box 1738 3000 DR Rotterdam, The Netherlands Phone: + 31 10 408 1182 Fax: + 31 10 408 9640 Email: info@erim.eur.nl Internet: www.erim.eur.nl

ERASMUS RESEARCH INSTITUTE OF MANAGEMENT

REPORT SERIES
RESEARCH IN MANAGEMENT

ABSTRACT AND KEYWORDS	
Abstract	In an earlier paper ,was discussed the necessary evolution from smart business networks, as based on process need satisfaction and governance, into business genetics [1] based on strategic bonds or decay and opportunistic complementarities. This paper will describe an approach and diffusion algorithms whereby to discover the dynamics of emergent smart business network structures and their performance in view of collaboration patterns over time. Some real life early analyses of dynamics are discussed based on cases and date from the high tech sector. Lessons learnt from such cases are also given on overall smart network dynamics with respect to local interaction strategies, as modelled like in business genetics by individual partner profiles, goals and constraints. It shows the weakness of static "business operating systems", as well as the possibly destabilizing clustering effects amongst nodes linked to filtering, evaluation and own preferences.
Free Keywords	smart business networks, business genetics, network performance, SBN, dynamics
Availability	The ERIM Report Series is distributed through the following platforms: Academic Repository at Erasmus University (DEAR), DEAR ERIM Series Portal Social Science Research Network (SSRN), SSRN ERIM Series Webpage Research Papers in Economics (REPEC), REPEC ERIM Series Webpage
Classifications	The electronic versions of the papers in the ERIM report Series contain bibliographic metadata by the following classification systems: Library of Congress Classification, (LCC) LCC Webpage Journal of Economic Literature, (JEL), JEL Webpage ACM Computing Classification System CCS Webpage Inspec Classification scheme (ICS), ICS Webpage

Discovering the dynamics of smart business networks

Prof L-F Pau, Rotterdam school of management, POBox 1738, NL 3000 DR Rotterdam, lpau@rsm.nl

Abstract:

In an earlier paper ,was discussed the necessary evolution from smart business networks ,as based on process need satisfaction and governance, into business genetics [1] based on strategic bonds or decay and opportunistic complementarities . This paper will describe an approach and diffusion algorithms whereby to discover the dynamics of emergent smart business network structures and their performance in view of collaboration patterns over time. Some real life early analyses of dynamics are discussed based on cases and date from the high tech sector .Lessons learnt from such cases are also given on overall smart network dynamics with respect to local interaction strategies , as modelled like in business genetics by individual partner profiles ,goals and constraints . It shows the weakness of static "business operating systems", as well as the possibly destabilizing clustering effects amongst nodes linked to filtering , evaluation and own preferences .

INTRODUCTION

In a smart business network theory , one key attribute of the definitions is "quick connect- quick disconnect " which reflects more an intended characteristic than a design result sofar .In the business world reality , each node of such a network has different granularities , from project , to business unit , to a joint venture , where the nodes are self-organizing while they interact through different classes of business related exchanges and trades .But both the autonomous nodes and the relationships are evolving dynamically over time ,as a result of their local and global interactions .The events happening between two or more nodes as a result of the relationships have different time perspectives as well which altogether blur the notion of "quick connect-quick disconnect "; these different time perspectives while blended constitute the dynamics of the smart business network : some are lasting financial or IPR dependencies ,some are medium term business transaction processes, while finally some are real-time information exchange processes . The autonomy of the nodes is defined when each node determines its own behaviours rather than a fixed business process, and when they operate based on local information with no direct influence of any global information . his assumption of autonomy has to be made as long as a smart business network has not instituted governance rules, the time validity of which is an open question if there is "quick –quick disconnect "!
This leads to the aims of the present paper: (a) to discover the dynamics of emergent smart business network structures; this not only involves the topological changes in he network and the activities happening in it, but also addresses the changes in the nodes behaviours / profiles and possibly network performance (b) to model such dynamics in view of simulation, forecasting or estimation of parameters to be used in other analysis methods such as business genetics [1].

RELATED WORK

Research on social networks has been carried out for a long time, and aims primarily on analyzing relative positions of individual nodes and their corresponding roles and functions, with resulting characterization of network topology and evolution.In this context, centrality metrics based on the connection degree of any given node to others in an existing network, have been widely used [5], also in he context of smart business networks [11]. Sector specific analyses have been carried out, e.g. about systemic risks in the financial banking systems by varying he levels of capitalization, interconnectivity degrees ,and sizes of interbank exposures [2] . Small world high clustering and scale free topologies (where the distribution of connections follow a power-law distribution) have also been widely researched and popularized [6]; extensions have been made to transitive linking into an acquaintance network [7] as well as to epidemiological models [4] [8]. In social dynamic networks, a meta-matrix describes the relations between nodes with probabilistic attributes or agents are used [9] extending the seminal random graphs of Erdös and Rényi [10].

PROPOSED APPROACH

But such approaches have only captured partial aspects of the dynamics found in smart business networks .They do not reflect the sequential decomposition or recomposition of tasks , nor the "tiering" effect where some subgroups in the smart business network have higher probabilities of having relationships [2] and may also have comparable attributes such as size . It is necessary to address also the autonomous decisions, different time perspectives, the transaction processes, as well as constraints. The constraints are both time constraints attached to service execution, as well as resource constraints and minimum benefits. With such assumptions one can get a better understanding of how the smart business network evolves and could evolve over time, and on how better performance can be achieved based on certain local interaction strategies.

It is also assumed that all transactions between the nodes have the following steps: filtering, evaluation of the transaction, transaction fulfillment and propagation, and evolution of the node profile, as described below. The filtering splits the transaction request into one part which could be fulfilled by the node, and the remaining tasks .Next, based on its profile and the reward from that part of the transaction , the node will judge whether to accept the request and propagate the remaining subtasks to its neighbours .If the transaction request is declined, the relationship between the node and its partner node who sends the request is downgraded .Once the initial service leading to transactions has been completed in full , there is a reward to all the nodes who were involved in accomplishing the service ,and he set of relationships are strengthened . With the above mentioned model, a smart business network performance can be defined as the proportion of service requests which are finished, by the average relationship degree inside the network, and by average speed of execution.

SMART BUSINESS NODE PROFILE AND UPDATING

<u>Dynamic node profile</u>
Each node is characterized by a dynamic profile, which includes:
i.-the nodes ability to accomplish various tasks under certain constraints on each; the tasks are characterized by: quality level, cost, workload, execution speed
ii.-the cumulative rewards p (i, t) earned from past transaction interactions
iii.-degree of cooperation c(i) , which is a slowly changing parameter describing how often the node accepts partial transaction execution ; it can have a second parametric field to indicate if a high utility, such as profit margin, is required to accept tasks.
iv.-partnership degree d(i ,j,t) indicates for any pair of nodes the number of service executions both have been involved in ,adjusted for establishing new partnerships; a strong partnership facilitates future cooperation and reduces set up costs .
It should be emphasized that ii, and iv. are time- and service flow dependent.

<u>Extend or reduce set of interacting nodes</u>
The nodes with high cumulative rewards from ii. will consume some of these in establishing new relationships with new nodes in the smart business network. That is, node (i) will add a relationship to node (j) according e.g. to the following diffusion process:
$d(i, j, t+1) = k1 * p(i, t)$ (Eq. 1)
$p(i, t+1) = p(i, t) - d(i, j, t)$ (Eq. 2)
where $0<k1<1$ is a constant, and the above updates must be made, assuming autonomy, only for nodes j not involved in the current. service execution .If furthermore such nodes have refused to participate in this current service execution:

$d(i , j, t+1)= k2*d(i ,j,t)$ (Eq. 3)
where 0<k2<1 is a penalty coefficient .If the partnership degree d(i ,j,t) becomes lower than some threshold , the relationship will break .

Task acceptance rules

When receiving a transaction request, any node must not only filter it , but also decide whether not to accept it .Is assumed an extra cost of cooperation between nodes .His cost is low when the partnership degree is high ,and inversely he cost will be high if current partnership degree is low .Although the rewards from fulfilling the filtered tasks may be higher than the sum of the cost of executing these tasks , including cooperation costs , the node may still not accept the task based on an individual profit margin constraint .

Local selection / interaction strategy

Each node having accepted part of a transaction based on its filtering, it must decide which cooperating node to send the residual tasks to .Intuitively, the node will select a node with a high cooperative degree and a high partnership degree between them, that is choose h where (c (h) * d (i, h, t)) is maximum amongst all nodes not involved yet in the same service execution.

RULES FOR TASK FILTERING AND EVALUATION

Within the framework of the above model, a diversity of modular rules can be considered whereby the task filtering is carried out subject to applicable constraints, and whereby the rewards are recalculated .They influence both the list of tasks a node can finish, the costs involved, as well as the rewards level expected from greedy nodes with low cooperation degree.
Likewise a diversity of modular interaction rules for the selection of the cooperating nodes may be tested.

DISCOVERING THE DYNAMICS OF AN EXISTING SMART BUSINESS NETWORK EVOLUTION

In this case ,the incoming time dependent processes of service requests and task decompositions at each node have to be known , like the network topology over time , the constraints of each node and rewards at each node .On this basis, and given assumed initial values , one can estimate k1, k2 and c(i) (subject to numerical non under determinism) . Whereas traditional methods would yield centrality, clustering and connection metrics, this analysis provides the distribution of the cooperation degrees c (i). When real data are used, normally all service requests are treated as fulfilled (unless data exist for unfilled service requests), thus the proportion of accomplished services is one.

Even more interesting, one can estimate the degree of smart network stability which is computed based on the proportion of the changed partnerships of the nodes. Specifically, we define the degree of network stability as the ratio of the number of node partnerships which have not changed over a certain time interval, to the number of changed partners, this ratio being again multiplied by the difference in the total number of partners within the interval; the number of changed partners is itself the sum of the removed partners and the number of added partners.

In he context of three implementation cases ,the software environment which has been developped, and which serves to implement the discovery of the smart busines network dynamics , has an interresting organizational placement in the corporate audit function . The busines units initiating, or involved in, partnerships , only keep the track records (in BPM, ERP and order management systems) of single or repeated relationships. The accounting units do not have task fulfillment data .The audit function however keeps track records over varying relationships across different business units, and has matching data against both orders received and procuremnt expenses, besides having access to contractual details . .

SIMULATING THE SMART NETWORK DYNAMICS IN VIEW OF SELECTION OF PARTNER SELECTION RULES

Simulation is not the aim of this paper .However, one should state that the above model can obviously also be used for a simulation, as many other business process models , if inversely k1 , k2 and the c(i) values are assumed given ,besides basic smart business network starting configuration and process characteristics . In that case, alternative rules for filtering and evaluation can be tested to determine the most suitable in view of a diversity of goals, at either aggregated smart business network level or at the level of a given node. This simulation approach can with advantage be replaced by business genetics of [1] which add more depth to the profile updating equations 1-3 by attraction or repulsion processes. When simulation is applied, obviously the proportion of accomplished services becomes a meaningful network performance indicator.

RESULTS FROM DISCOVERY OF DYNAMICS

From carrying out the dynamics discovery process from three smart network data sets in the high tech area, and besides specific conclusions, some general lessons can be learnt.

First, dynamic context dependence is very high, meaning that no single node in the case smart business networks was or could apply the concept of monolithic "business operating system", envisaged as a time dependent scheduler with priority levels and fixed task allocation strategies, the design of which was shared between the nodes but running different scheduling tasks at each of the nodes. Indeed, each business partner got exposed sooner or later to the cumulated effects of filtering and evaluation by other nodes (even non directly cooperating). In this sense , the analysis shows that the dynamics are much closer to those in a communications network governed by signalling network and some business protocols, as conjectured in [10].
More specifically, k1 and k2 change a lot over time intervals; engagement levels k1 are high in the merging phase of a smart business network, then disappear to reappear later when some nodes drop out; penalty levels k2 are low when the smart business network is in an emerging phase as apparently the nodes forgive each other, but high in a mature phase. Cooperative degrees c(i) move from homogeneous distributions to islands, as predicted by business genetics , which means that actually different types of "business operating systems" would have to be considered as operating simultaneously .After long periods of interaction ,the smart network has high clustering and network stability is dynamically changing over time and with respect to local interaction strategies

Next, the "quick connect-quick disconnect" effect could not be analyzed precisely as here is latency built into the diffusion equations 1-3 and no data were available to quantify the node selection delays involved in the evaluation and selection .The only hypothesis which could be formulated was that total average service execution times stay higher than the minimum possible, just because those nodes who in sequence could achieve the minimum service execution time are just not in relationship, or not in good enough relationships to select each other.

Nodes cluster rather fast as a result of service based interactions , again confirming the dislocation and merger process into sub-networks revealed by business genetics .Eventually the clustering coefficient stabilizes in the 0,15-0,20 interval .

The network stability increases with the number of nodes ,and then stabilizes .Also , from d(i ,j,t) values , it appears that his network stability could be improved in some cases or time intervals, if the selection process chose partners with high past cumulated rewards , while nodes that cooperate well in past activities may not provide a satisfying future cooperation ; similar results were found by [2] .

The question remains then about how network stability is in each of the smart network sub networks which have been clustered as a result of interactions? Are the risks not growing [10]?

REFERENCES

[1] L-F Pau (2006), Smart business network design and business genetics, Research report ERIM, Rotterdam school of management, Feb. 2006, http://hdl.handle.net/1765/7319 or http://repub.eur.nl/publications, forthcoming in Harvard Business review
[2] E. Nier, J. Yang, T. Yorulmazer, A. Alentorn (2007) , Network models and financial stability, J. economic dynamics and control, 31, 2033-2060
[3] P.Erdös, A. Rényi (1959), On random graphs, Publicationes Mathematicae, 6, 290-297
[4] F.Allen, D.Gale (2000), Financial contagion, J. Political economy, 108, 1-33
[5] P. Bonacich (1987), Power and centrality: a family of measures, Amer. J. Sociology, 92, 1170-1182
[6] S. Milgram (1967), The small world problem, Psychology Today, 2, 60-67
[7] H. Ebel, J. Davidsen, S. Bornholt (2002), Dynamics of social networks, Compl.Adapt. Systems, Part I, 8, 24-27
[8] M.Kuperman, G. Abamson (2001), Small world effect in an epidemiological model, Phys. Rev. Letters, 86, 2909-2912
[9] K.Carley (2003), Dynamic network analysis, in: Dynamic social network modelling and analysis: Workshop summary and papers, 133
[10] L-F Pau (2005), Smart business networks: architectural aspects and risks, in: Alexander Clemm , Olivier Feston (Eds) ,Proc. 9 th Intl IEEE/IFIP Conference on Information management (IM 2005) , Nice 16-20/05/2005 , IEEE Publications, Piscataway, NY , pp 151-155
[11] D. Braha, Y. Bar-Yam (2005), Information flow structure in large scale product development organizational networks, Chapter 8 in P Vervest, E.van Heck, L-F Pau (Eds), Smart business networks, Springer ,Berlin , 105-125

Publications in the Report Series Research* in Management

ERIM Research Program: "Business Processes, Logistics and Information Systems"

2007

India: a Case of Fragile Wireless Service and Technology Adoption?
L-F Pau and J. Motiwalla
ERS-2007-011-LIS
http://hdl.handle.net/1765/9043

Some Comments on the Question Whether Co-occurrence Data Should Be Normalized
Ludo Waltman and Nees Jan van Eck
ERS-2007-017-LIS
http://hdl.handle.net/1765/9401

Extended Producer Responsibility in the Aviation Sector
Marisa P. de Brito, Erwin A. van der Laan and Brijan D. Irion
ERS-2007-025-LIS
http://hdl.handle.net/1765/10068

Logistics Information and Knowledge Management Issues in Humanitarian Aid Organizations
Erwin A. van der Laan, Marisa P. de Brito and S. Vermaesen
ERS-2007-026-LIS
http://hdl.handle.net/1765/10071

Bibliometric Mapping of the Computational Intelligence Field
Nees Jan van Eck and Ludo Waltman
ERS-2007-027-LIS
http://hdl.handle.net/1765/10073

Approximating the Randomized Hitting Time Distribution of a Non-stationary Gamma Process
J.B.G. Frenk and R.P. Nicolai
ERS-2007-031-LIS
http://hdl.handle.net/1765/10149

Application of a General Risk Management Model to Portfolio Optimization Problems with Elliptical Distributed Returns for Risk Neutral and Risk Averse Decision Makers
Bahar Kaynar, S. Ilker Birbil and J.B.G. Frenk
ERS-2007-032-LIS
http://hdl.handle.net/1765/10151

Optimal Zone Boundaries for Two-class-based Compact 3D AS/RS
Yugang Yu and M.B.M. de Koster
ERS-2007-034-LIS
http://hdl.handle.net/1765/10180

Portfolios of Exchange Relationships: An Empirical Investigation of an Online Marketplace for IT Services
Uladzimir Radkevitch, Eric van Heck and Otto Koppius
ERS-2007-035-LIS
http://hdl.handle.net/1765/10072

From Closed-Loop to Sustainable Supply Chains: The WEEE case
J. Quariguasi Frota Neto, G. Walther, J.Bloemhof, J.A.E.E van Nunen and T.Spengler
ERS-2007-036-LIS
http://hdl.handle.net/1765/10176

A Methodology for Assessing Eco-Efficiency in Logistics Networks
J. Quariguasi Frota Neto, G. Walther, J.Bloemhof, J.A.E.E van Nunen and T.Spengler
ERS-2007-037-LIS
http://hdl.handle.net/1765/10177

Strategic and Operational Management of Supplier Involvement in New Product Development: a Contingency Perspective
Ferrie E.A. van Echtelt, Finn Wynstra and Arjan J. van Weele
ERS-2007-040-LIS
http://hdl.handle.net/1765/10456

How Will Online Affiliate Marketing Networks Impact Search Engine Rankings?
David Janssen and Eric van Heck
ERS-2007-042-LIS
http://hdl.handle.net/1765/10458

Modelling and Optimizing Imperfect Maintenance of Coatings on Steel Structures
R.P. Nicolai, J.B.G. Frenk and R. Dekker
ERS-2007-043-LIS
http://hdl.handle.net/1765/10455

Human Knowledge Resources and Interorganizational Systems
Mohammed Ibrahim, Pieter Ribbers and Bert Bettonvil
ERS-2007-046-LIS
http://hdl.handle.net/1765/10457

Revenue Management and Demand Fulfilment: Matching Applications, Models, and Software
Rainer Quante, Herbert Meyr and Moritz Fleischmann
ERS-2007-050-LIS
http://hdl.handle.net/1765/10464

Mass Customization in Wireless Communication Services: Individual Service Bundles and Tariffs
Hong Chen and Louis-Francois Pau
ERS-2007-051-LIS
http://hdl.handle.net/1765/10515

Individual Tariffs for Mobile Services: Analysis of Operator Business and Risk Consequences
Hong Chen and Louis-Francois Pau
ERS-2007-052-LIS
http://hdl.handle.net/1765/10516

Individual Tariffs for Mobile Services: Theoretical Framework and a Computational Case in Mobile Music
Hong Chen and Louis-Francois Pau
ERS-2007-053-LIS
http://hdl.handle.net/1765/10517

Individual Tariffs for Mobile Communication Services
Hong Chen and Louis-Francois Pau
ERS-2007-054-LIS
http://hdl.handle.net/1765/10518

Is Management Interdisciplinary? The Evolution of Management as an Interdisciplinary Field of Research and Education in the Netherlands
Peter van Baalen and Luchien Karsten
ERS-2007-047-LIS
http://hdl.handle.net/1765/10537

Detecting and Forecasting Economic Regimes in Multi-Agent Automated Exchanges
Wolfgang Ketter, John Collins, Maria Gini, Alok Gupta and Paul Schrater
ERS-2007-065-LIS
http://hdl.handle.net/1765/10594

Emergency Messaging to General Public via Public Wireless Networks
P.Simonsen and L-F Pau
ERS-2007-078-LIS
http://hdl.handle.net/1765/10718

Flexible Decision Control in an Autonomous Trading Agent
John Collins, Wolfgang Ketter and Maria Gini
ERS-2007-079-LIS
http://hdl.handle.net/1765/10719

Discovering the Dynamics of Smart Business Networks
L-F Pau
ERS-2007-081-LIS
http://hdl.handle.net/1765/10732

Performance Approximation and Design of Pick-and-Pass Order Picking Systems
Mengfei Yu and René de Koster
ERS-2007-082-LIS
http://hdl.handle.net/1765/10733

---

* A complete overview of the ERIM Report Series Research in Management: https://ep.eur.nl/handle/1765/1

ERIM Research Programs:
LIS Business Processes, Logistics and Information Systems
ORG Organizing for Performance
MKT Marketing
F&A Finance and Accounting
STR Strategy and Entrepreneurship