Connectivity and transfer activity semantics in net-like structures

J. Aaltonen, M. Saloheimo

University of Lapland of Research Methodology, Finland

Net-like structure is an useful abstraction that can be used to describe and analyze important characteristics of varying types of inter-connected agent topologies. For example, the economic markets, industrial networks and information technology based service provision paradigm share some interesting characteristics when reviewed from the perspective of the network wide connectivity, and agent activity semantics (e. g. business relationships, transactions or transfer activities). The theoretical backgrounds and practical considerations of utilizing net-like structure approach in business network research are outlined in this work.

1. Introduction

The evolution of IT has facilitated universal connectivity between different organizations (e. g. customers, suppliers and partners). The reach and richness of information has improved substantially and the execution of tasks is more rapid in inter-organizational context. Nowadays, there is not a strict tie between the goods/products and the information flows concerning them. Issues of connectivity and information transmission are critical for management and coordination of networked organizations [1]. Net-like structure is an useful abstraction that can be used to describe and analyze important characteristics of varying types of inter-connected agent topologies. For example, the economic markets, industrial networks and information technology based service provision paradigms share some interesting characteristics when reviewed from the perspective of the connectivity, and agent activity semantics (e. g. business relationships, transactions or transfer activities). The theoretical backgrounds of network analysis and practical considerations of utilizing net-like structure approach specifically in business network representation and relationship analysis research are outlined in this work.

2. Net-like structures

In general, a *net* consists of nodes that are connected with directed or undirected links. The *dynamics* of the network refer to the various interactions between the intra-, inter- and extra-network entities. Each network exists in a particular *environment*, which can be seen as a logical context that defines an operational and topological scope for the net in question. The structure of the net is additionally influenced by the *resources* that are available to the network nodes (or agents). They can be external to the nodes, or even to the network, and the resources (or assets) can be created, consumed, transformed or transferred between the nodes during the network activities. The *connectivity* or topology of the net thus depends on theses interactions, relationships, connections or linkages between the nodes of the overall structure.

It is proposed that the generic notion of a net-like structure can also be applied to organizational relationships and to information technology enabled business transaction patterns as well. As shown above (Table 1) the economic markets, industrial networks and information technology based service provision paradigms and architectures all share a common denominator; they can all be generalized and represented as net-like structures [5]. Below the basic characteristics of these varying net-like structure types are reviewed especially from the connectivity and relationships semantics perspectives.

Table 1

Mapping the elements of various net-like structures

Net-like structure element	Economic markets [2]	Industrial networks [3]	Service paradigm [4]
Environment	market	network	context
Nodes	participants	actors	services (agents)
Recourses	products and services	resources	capabilities
Dynamics	transactions / processes	activities	interaction
Connectivity	relationships, economic exchange: trust and power relations, information flows	actor bonds resource tiers activity links	composition, choreography, orchestration

2.1. Economic Markets

In general, an economic market can bee seen as the location where the supplier and customer meet. Reviewing the studies about economic markets and electronic commerce, some common structural elements can be identified. For example, according to Choi and Stahl [2], every market consists of three main components:

- the market participants (supplier, buyer, wholesaler, retailer);
- the products and services;
- the transactions and processes.

An interesting net-wide phenomena, for example in travel industry networks is the problem of *information asymmetry* between the market participants [6]. This is a specific connectivity characteristic of a net and it can be described as a situation where the other party of a transaction has more information than the other, and it is considered problematic because of its negative implications on trust and power balance based business relationships.

2.2. Industrial Networks

The industrial network approach is part of the marketing science and it has been developed by Industrial Marketing and Purchasing Group (IMP, www.impgroup.org) [7]. Driving force behind business networks and inter-firm networking is the focus on core competence. An enterprise should concentrate on value activities, which are part of its core competence and acquire other competencies/activities from other enterprises by cooperating with them. This outsourcing creates dependencies between enterprises. The value activities of different enterprises form together a value creation system, which provide an offering for the end customer [8].

As suggested above (see Table 1) based on the fact that industrial networks are a type of net-like structure, they can be seen from different perspectives:

1) as interaction,
2) as structures,
3) as positions and
4) as processes.

The interaction is fundamental in the industrial networks; the enterprises use interaction to conceive the ways to utilize their combined core competencies. The structure of the network is based on the value creation system, where the enterprises perform interconnected value activities. An enterprise has relative power and influence in network (position) and it is also expected to perform certain activities (role). Networks are in a constant process of change, which is induced or mediated by the enterprises in network. Networks are a result of a historic process; they have past, present and future [8, 9].

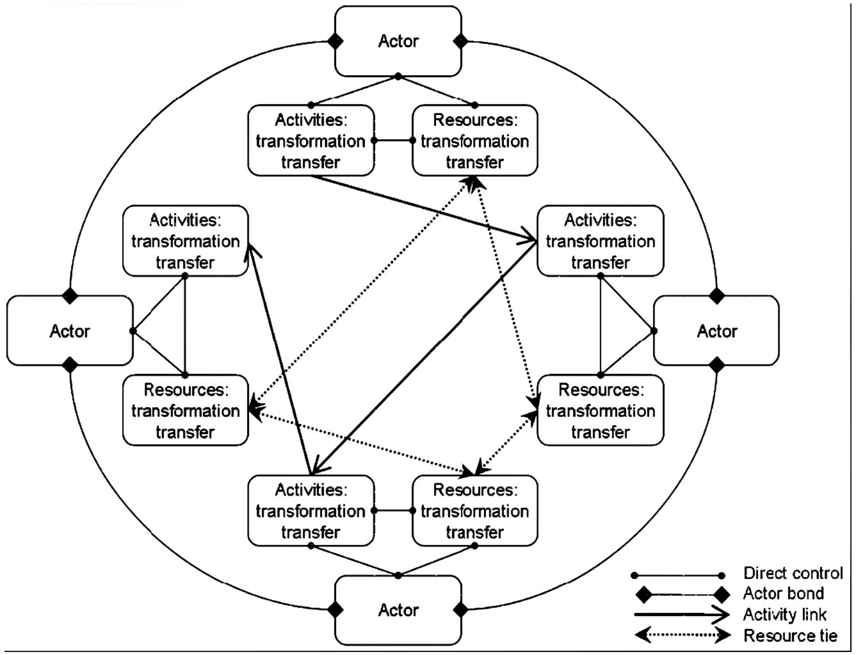

Fig. 1. Connectivity between ARA-based network elements (modified from [3, 10])

The Actor—Resource—Activity (ARA) model [3] of industrial networks contains the following elements:

1) actors,
2) resources,
3) activities and
4) relationships.

All the elements together form the network (see fig. 1).

The three basic elements (or variables) are related to each other by the following circular definitions:

- **actors** perform activities and/or control the resources and they can be individuals, groups of individuals, enterprises or groups of enterprises;
- **resources** are the means used and required by the actors when they perform activities. They have an unlimited number of property dimensions and they can be characterized by the actors controlling them and by their utilization in activities;

- **activities** occur when actors combine, develop, exchange or create resources. There are two types of activities: (i) *transformation activities* are controlled by one actor and through them resources are changed in some way, and (ii) *transfer activities* link the transformation activities between actors and transfer the direct control over a resource from one actor to another.

Actors in networks have relationships of interaction and interdependency. With relationships the actors are able to produce results that they cannot produce by themselves. In a relationship there are connections between actors in following levels:

1) activity links,
2) resource ties and
3) actor bonds.

Technological, administrative, commercial and other functions of different actors and connected by activity links. Resources of technological, material or informational nature of different actors are connected by resource ties. The actors themselves are connected by bonds, which affect the way they perceive self and others in network [10].

It is important to distinct the concepts of business networks and business nets. Business network can be seen as macro-level phenomenon, «industries-as-networks». At this level the network might be limitless fabric of actors and relationships. Business networks consist of many smaller business nets. These are created consciously for some defined purpose by group of enterprises and/or other organizations. The network has its goals, but also the members of it have their own goals. Members have agreed about the roles and responsibilities for network activities [8].

2.3. Information Technology Service Provision

In information system design, the service orientation has been the predominant approach to resolve the issues of IT-enabled business network operations during the past decade. It is a result of the emergence of enabling internet technologies like semantic web technologies, service oriented architecture (SOA), web services (WS) and XML-based information representations, and the general paradigm sift from monolithic and tightly coupled standalone application solutions to more loosely coupled distributed information system architectures.

In relation to the IT based business interactions, the SOA applies the lessons learned from commerce to the organization of IT assets to facilitate the matching of capabilities and needs. That two or more entities come together within the context of a single interaction implies the exchange of some type of value. This is the same fundamental basis as trade itself, and suggests that as SOAs evolve away from interactions defined in a point-to-point manner to

a marketplace of services; the technology and concepts can scale as successfully as the commercial marketplace [4].

3. Formalizing the Connectivity Semantics

The issue in traditional network studies (especially in business network contexts) is the multitude of different research approaches that produce incompatible research results and artifacts. Also, some of the widely used research methodologies itself are not that well suited to the examination of net-like structures. For example, business networks are conventionally researched by case study methodology. There are several challenges in this approach: 1) setting the boundaries of networks, 2) complexity of networks, 3) time dimension and 4) case comparability. The formulation of a well-defined research problem can be used to address some of these challenges and based on it the used conceptualizations, viewpoints and theoretical frameworks can be explicated and scoped [11].

3.1. Roles-Linkage Model

Business networks analysis can be simplified by representing the structure of the network in terms of two abstract constructs: roles and linkages. Roles are defined as distinct, technologically separable, value-added activities undertaken by firms or individuals in a given business network. The roles require different knowledge, skills and equipment. Linkages refer to ways of coordinating the dependencies between roles (table 2).

The complexity of business networks can be reduced by studying roles, not individual network enterprises. The focus on the technological separability captures the effects of technological change in the network. In practical terms, the network can thus be represented as a matrix in which the the roles and linkages are specified. The roles are located in the matrix axes and linkages are in the cells. The benefits of this model are the focus on few key constructs, excluding unnecessary details and reducing the complexity of analysis. It takes into account the interdependence management in network. The role-linkage matrix can be defined before any major ICT applications are implemented and be used as a basis for predicting changes in the roles and linkages in a business network [12].

3.2. Semantic Service Oriented Representation Model for Net-like Structures

In the view proposed by the original roles-linkage model, the linkage between nodes can be specified in mathematical terms as an unordered set (i. e. a tuple): $R_L = \{R_S, R_t, L\}$ where R_S is the source role, R_t is the target role,

Table 2

Linkage types between roles [12]

Linkage type	Description
Simple market exchange	Infrequent transactions Low levels of relationship specific investments Market mode of governance Terms of relationship negotiated case-by-case
Standard linkage	Frequent and routine transactions Relatively low levels of relationship specific investments Governed by standard contracts Terms of relationship stable for repeated transactions
Specialized linkage	Complex, infrequent transactions Significant relationship specific investments Governed by contingent contracts, arbitration and intermediation Complex but stable coordination mechanisms are set up
Customized linkage: alliance	Complex, frequent and long-term transactions Relationship specific investments Constant adaptation of relationship structures and processes Mutual committed assets Decentralized authority Complex bilateral and adaptive coordination mechanisms
Customized linkage: hierarchy	Complex, frequent and long-term transactions Relationship specific investments Constant adaptation of relationship structures and processes Centralized authority based on asset ownership Complex/Specialized coordination routines
Mandate	Not necessarily economic exchange relationships Influence through legal or professional authority Strong or weak

and the L simply represents the economic exchange linkage between the roles. However, as the linkage types in the above described model are only applicable to industrial networks and only consider the economic exchange patterns, the model should be extended to address more wider requirements of representing the connectivity semantics in net-like structures. In the here proposed extension of the model, the linkage element is thus abstracted to a more general structure that represents the connectivity between the roles and is thus a tuple:

$$L = \{E_e, C, T_a, S_r, R_f\},$$

where E_e is the original economic exchange typology, C is the connection coupling, T_a is the transfer activity, S_r is the service requirement, R_f is the

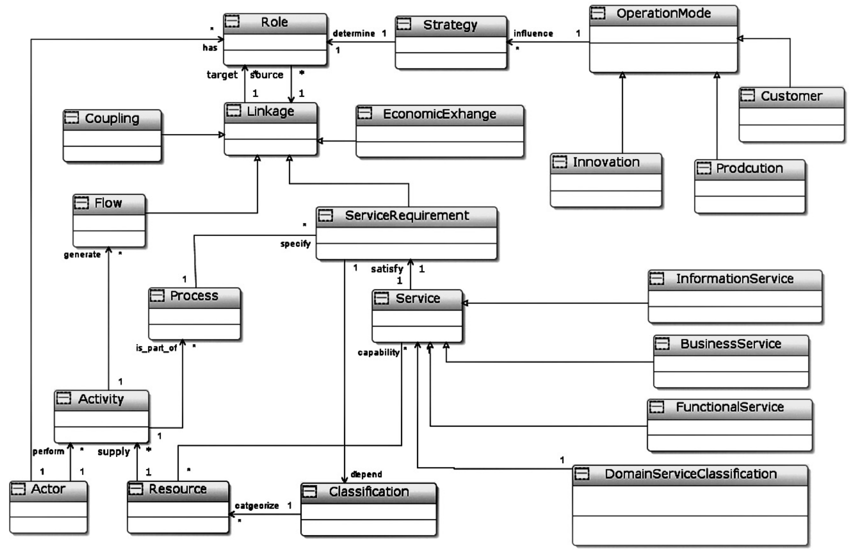

Fig. 2. Service oriented extension of roles-linkage model for business networks [5]

resource (information) flow. This model and an accompanying multidisciplinary conceptual research approach that addresses these problems has been developed as part of the information technology enabled business network research projects in the University of Lapland. The core of this approach is to provide a semi-formal representation framework to be used in the conceptual analysis [13, 14] of different research fields that examine the phenomena of the IT enabled connectivity especially in business networks (fig. 2) [5].

As already stated above, the complexity arising from the amount of nodes in the network can be reduced by identifying the network wide *roles* (Role) thru which the actors of the net are represented. Then the connectivity of the structure can be viewed by formally defining the type of *linkages* between the roles. The ARA based industrial network view (Actor, Resource, Activity) model is combined with the semantic resource classification model (Classification) [15] and the activities performed by the actors are part of business processes (Process) which generates information intensive flows between the network roles. The business processes specify the requirements (ServiceRequirement) for the network wide services (Service). The services can be categorized, for example following the Ontology Driven Service-Oriented Approach to enterprise Integration (ODSAI) model [16] to business (BusinessService), information (InformationService) and functional services (FunctionalService), or the service typologies can also be based on some industry sector specific domain service classification scheme [17]. The existence of an inter-organizational relationship means that there are business *transfer activities* (i. e. the exchange of knowledge, information or materials) between the different enterprises.

As an example of the above model, a business scenario in the travel industry CASEnetwork could be that that the accommodation service (Accommodation Services:Hotel) provider wants to send hotel capacity information to incoming tour operator (Organizing Services: ITO) based on their internal reservation information (Information Services:reservations), then this could be represented as a tuple:

$$R_l = R_s(Accomodation : Hotel), R_t(Organizing : ITO),$$
$$L(E_e(Standard), C(strong), T_a(send), S_r(Information), R_f(intangible : capacity))$$

Similar formalizations could be made for the other parts of the service oriented extension of the roles-linkage model, but this is to be elaborated in future research.

4. Conclusions and Future Research

In the future research, a more elaborate formal specification of the intrinsic nature and form of the connectivity characteristics in net-like structures could be achieved by utilizing the here presented and already existing models for inter-node exchanges [5, 14, 18] that they are based on. This will help in bringing the required expressive power and semantic clarity to fundamentally heterogeneous theoretical network analysis models and approaches. Additional benefit of this is, that the dominant paradigms in information technology (among others the service orientation and semantic technologies) and also the methods in the discipline of requirements engineering can be aligned with market and business network modeling techniques.

Bibliography

1. *Parolini C.* (1999). The value net: A tool for competitive strategy. N. Y.: Wiley, 1999.
2. *Choi S. & Stahl D.* (1997). The Economics of Electronic Commerce. Indiana: Macmillan Technical Publishing.
3. *Hekansson H. & Johanson J.* (1992). A model of industrial networks. *Indiustrial Networks. A New View of Reality*, 1. P. 28–34.
4. OASIS (2006). *Reference Model for Service Oriented Architecture* (SOA Reference Model Technical Committee). 01.08.2006: OASIS.
5. *Aaltonen J.* (2007). Service oriented extension of roles-linkage model for travel business networks. In M. Saloheimo (Ed.), *Operative Network Integration: working papers from research project, University of Lapland, Department of Research Methodology Reports, Essays and Working Papers* 10 (pp. 166–181) Rovaniemi, Finland University of Lapland Press.

6. *Gratzer M.* (2003). Changes in the Travel and Tourism Industry Caused by the Internet — Competitive Advantage for the SME Accomodation Sector in Austria.
7. *Ford D.* (1990). Introduction: IMP and the interaction approach. In D. Ford (Ed.), *Understanding business markets* (pp. 10–27) Cambridge: Academic Press Limited.
8. Muller, K., Rajala A. & Svahn S. (2006). Tulevaisuutena liiketoimintaverkostot. Helsinki: Teknologiateollisuus ry.
9. *Easton G.* (1992). Industrial networks: A review. In B. Axelsson & G. Easton (Eds.), *Industrial networks: A new view of reality* (pp. 1–27) Routledge: London.
10. *Hekansson H. & Snehota I.* (1995). Developing Relationships in Business Network.: Routledge.
11. *Halinen A.* & Turnroos, J. (2005). Using case methods in the study of contemporary business networks. *Journal of Business Research*, 58, 1285–1297.
12. *Kambil A. & Short J. E.* (1994). Electronic Integration and Business Network Redesign: A Roles-Linkage Perspective. *Journal of Management Information Systems*, 10, 59–83.
13. *Aaltonen J., Rinne J. & Tuikkala I.* (2006). A Multidisciplinary Framework for Concept Evolution: A Research Tool for Business Models. In M. Maula, M. Hannula, M. Seppla & J. Tommila (Eds.), *ICEB +eBRF* 2006 *Frontiers of e-Business Research* 2006 (pp. 526–532) Tampere University of Technology and University of Tampere.
14. *Aaltonen J., Tuikkala I. & Saloheimo M.* (2007). Concept Modeling in Multidisciplinary Research Environment. In H. Jaakkola, Y. Kiyoki & T. Tokuda (Eds.), *Proceedings of the* 17*th European-Japanese Conference on Information Modeling and Knowledge Bases* (*EJC* 2007) (pp. 143–160) Pori Tampere University of Technology, Pori.
15. *Aaltonen J., Tuikkala I. & Saloheimo M.* (2007). Towards Semantic Resource Classification in Organizational Environment. In Lorna Uden, Ernesto Damiani & Giuseppina Passiante (Eds.), *Proceedings of the* 2*nd International Conference on Knowledge Management in Organization* (*KMO*): *New trends in Knowledge management. Workshop: Breaktrough results on the solutions and technologies for knowledge management* (pp. 183–187).
16. *Izza S., Vincent L. & Burlat P.* (2005). A Unified Framework for Enterprise Integration; An Ontology-Driven Service-Oriented Approach. In *Pre-proceedings of the First International Conference on Interoperability of Enterprise Software and Applications* (*INTEROP-ESA'*2005) (pp. 78–89) Geneva, Switzerland.
17. *Dogac A., Kabak G., Laleci S., Sinir A., Yildiz S. & Gurcan Y.* (2004). Semantically Enriched Web Services for the Travel Industry. *ACM SIGMOD Record*, 33, 3. P. 21–27.
18. *Saloheimo M.* (2007). Matkailupalveluja tuottavan perusliiketoimintaverkon roolit ja niiden valinen vuorovaikutus. In M. Saloheimo (Ed.), *Operative Network Integration: working papers from research project, University of Lapland, Department of Research Methodology Reports, Essays and Working Papers* 10 (pp. 166–181) Rovaniemi, Finland University of Lapland Press.