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A System of Systems approach to Managing Emergence in Complex Environments

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Abstract. Collaboration now plays an important role in many organizations. Many organizations often see collaboration as a given and provide a myriad of communication tools ranging from e-mail through workspaces to video conferencing. Assumptions are then made that these tools will be used in a productive manner. However, there are now many example of where goals are not achieved through ad-hoc use of technologies as collaboration is often not aligned to business practice, especially to changing business practices. This paper calls for an approach to align technology use to the enterprise practices.

The paper models enterprises as a system of systems where systems are closely integrated through collaborative spaces. These spaces change during system change. The paper provides a set of concepts to describe a system of system and shows how this can be used to align collaboration to the emerging business relationships. The proposed concepts, in contrast to existing methods, place greater emphasis on social structures. They support the idea of a collaborative architecture, which defines the alignment of social collaborative arrangements to business activities through the creation or rearrangement of collaborative spaces. The goal is to get away from traditional approaches in choosing the best pattern based on history, but to encourage design thinking through experimentation at the business structure level. The paper then describes the kinds of tools needed to support modelling based on these concepts.

Keywords: Collaboration, Agility, Modeling, Concepts for collaboration, Living Systems Theory

1 Introduction

The emerging trend in business and government systems is towards greater networking or what is sometimes called Enterprise 2.0 (McAfee, 2006). Network arrangements often include a number of organizations, who collaborate to jointly co-create products (Cova, 2008) or services. Apart from the trends, current literature does not look at the emergence and change of relationships that occur in networked organizations and their impact on collaboration. Emergence and change has been the characteristic of business practice for many years. Ciborra (1996) describes change at organizational level and develops the concept of a platform. He also identifies a trend to adopt existing patterns in most change decisions in contrast to the trend to design thinking (Martin, 2009) now emerging in practice. The idea of organization is now going beyond simply business units; it is also going into social communities, which themselves are increasingly seen as organizations. Ibrahim and Ainin (2013) describe the use of ICT in a Malaysian community. (Best, Kumar, 2008) describe how changing client behavior leads to the failure of a community where misalignment between practice and technology grows with changing community practices. In communities, as in many business organizations, there is greater emphasis on social structure (Pralahad and Krishnan, 2008) and collaboration. There are

increasing calls (Pisano, Verganti, 2008, Patel, 2012) for a more focused approach to create a collaborative architecture to align collaboration to the business process and avoid failure because of lack of collaboration.

The complexity that characterizes continual business change is here seen in a similar way to Merali (2006). It does not focus on mathematical solutions but ways to manage the continuous change in business relationships. The paper describes the set of modeling concepts that address these issues. The objective of this paper is to develop a model to encourage design thinking in social context by providing a platform, which focuses on collaborative structure within organizations. It brings together ideas from living systems theory (Miller, 1978, Lane and Swanson, 1993) and design thinking as a set of interacting spaces (Brown, 2008). The goal is to align the spaces to the collaboration that best fits the enterprise ways of working. This is in contrast to many current modeling methods, which focus on the technical structure and thus do not address the increasing role of social relationships in business system evolution.

2 Representing a system of systems

The paper proposes an open systems architecture to provide the semantics for emergence at the system level to define a number of classes of communicating system (Miller, 1978). An enterprise can then modeled in terms of the classes of systems and emergence can be described in terms of changing system structure.

- A group is a small number of people who have a well-defined goal. This may be a sales team, or a software team writing a program, or a temporary focus group working on a proposal. Thus groups usually address one function that requires one or two levels of decision making.
- An organization is something bigger and usually includes a number of groups. It may be a large business unit that develops and sells a financial product. It can include a number of groups as for example a product development group, a marketing group and a client relationship group.
- Organization is a generic term and organizations can include other organizations. Thus a bank can include a number of business financial units. The organizational level differs from the group level in that it has more than two levels of decision making.
- A community is a more loose connection of people. It may for example be a union within an organization. It may be a professional association, or a business group. It may be an association of people formulating a policy.

There are two more detailed levels. An activity is where a group engages in tasks such as to decide how to arrange a software module. A task is then something that is carried out in an activity such as ‘develop a program’.

Figure 1 illustrates these concepts with some simple examples of how the different classes of system can be composed into a system of systems. Figure 1 shows a sales group whose goal is to reach a sales target. This group is part of the sales organization that sets the targets. The sales organization is part of a business system that includes the manufacturing and sales organizations. The system of systems is the top-level of the semantics proposed in this paper.

Each of these social systems is described as a lower level set of concepts. These are **roles**, shown by black dots, **artifacts**, shown as disk shapes, and **business activities** shown as ellipses. Links between roles indicate knowledge flows. The sales organization for example has a role sales manager whose responsibility is to ‘manage the sales program’. It also has a role ‘salesperson’ whose responsibility is to make sales. Figure 1 also shows collaborative group between the sales and manufacturing organizations. The concept boundary role boundary role is used to show social interactions across systems

System of Systems

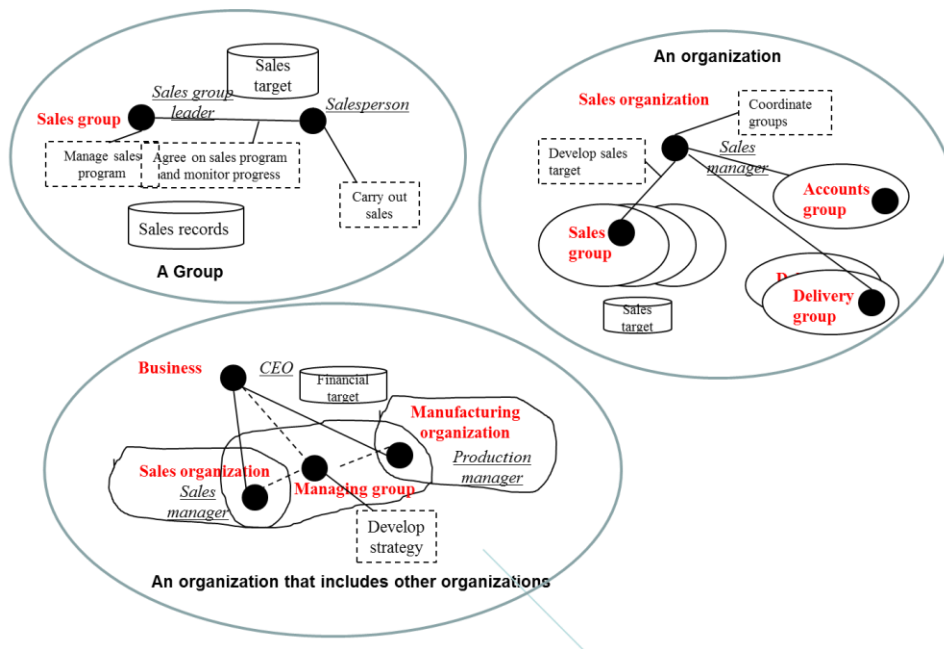


Figure 1 - Examples

An enterprise can also have internal communities, as for example a union, a professional group or a sporting group. All these systems must work together – hence the increasing emphasis on collaboration. There is also emphasis on social networking to support knowledge sharing within and between systems. The systems are now very likely to be **open systems**. That is systems that can respond to unanticipated inputs and can reorganize their activities.

Some readers may see a similarity to context diagrams as each system can be seen as a “process” in structured models. The major difference is that whereas modeling methods such as data flow diagrams focus on process and information flows the concepts here focus on social structures within the system given the more networked environments found in most business systems. There is also a difference in typical representations of organizational structure. Figure 2, for example, illustrates a traditional structure where a business is composed of a sales and manufacturing departments. An alternate representation based on a system of systems is shown in Figure 3.

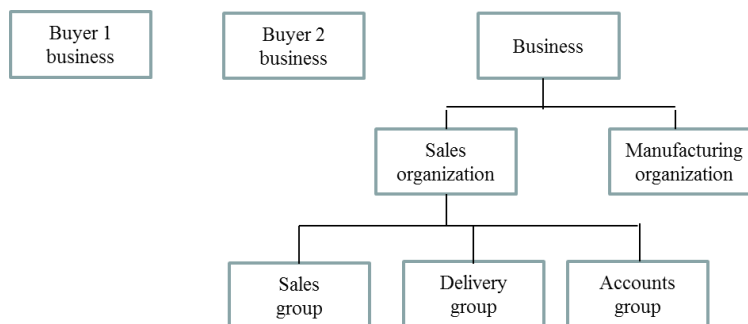


Figure 2 – Traditional Hierarchical view

In Figure 3 systems are seen as interlinked systems. Here the business is modeled as an organization. Sales and manufacturing are seen as organizations within the business. Collaborations in the structure can also be clearly shown. For example there are two collaborations created between the business and their buyer organizations. The connections are through boundary roles that exchange knowledge between systems and maintain alignment between them.

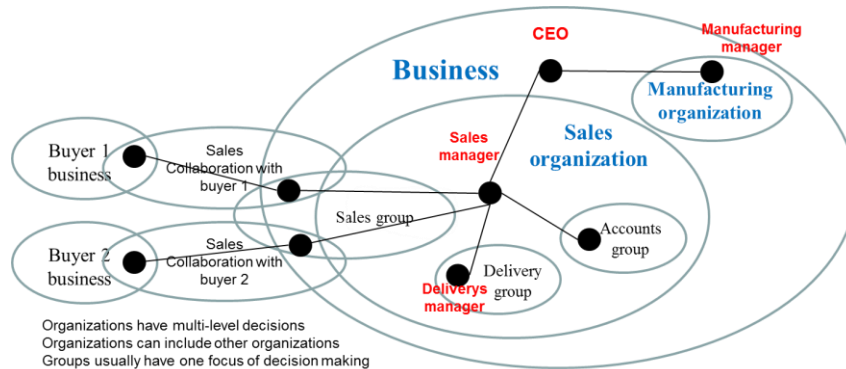


Figure 3 – An Open Systems View

3 Defining Semantics of Change

The premise in this paper is that change is primarily driven through actions of people occupying roles in businesses. It usually commences with some new collaboration that addresses a perceived opportunity. The organization structure thus changes as productive collaborative arrangements are identified and become part of normal operations. Change is modeled in the following steps:

- Change commences with the emergence of new collaborative group nominating boundary roles in each participating system. These become **virtual roles** within a collaborative group,
- Roles in existing systems are assigned to take on the responsibilities of the virtual roles,
- Self-organization takes place by rearranging information flows in line with the new responsibilities.
- Collaborative groups, if found effective can then become new systems that can be combined into the system of systems.

3.1 Example of Change – Emerging Network

Suppose two business managers, as shown in Figure 4, find that they can work together. One has the expertise in product development and outsources product installation to a variety of installers. The other is an expert in delivery and installation. By combining they feel they will add new value to their businesses. Partner A will be able to focus on creating innovative products while partner B will use their contacts to distribute these products.

System of Systems

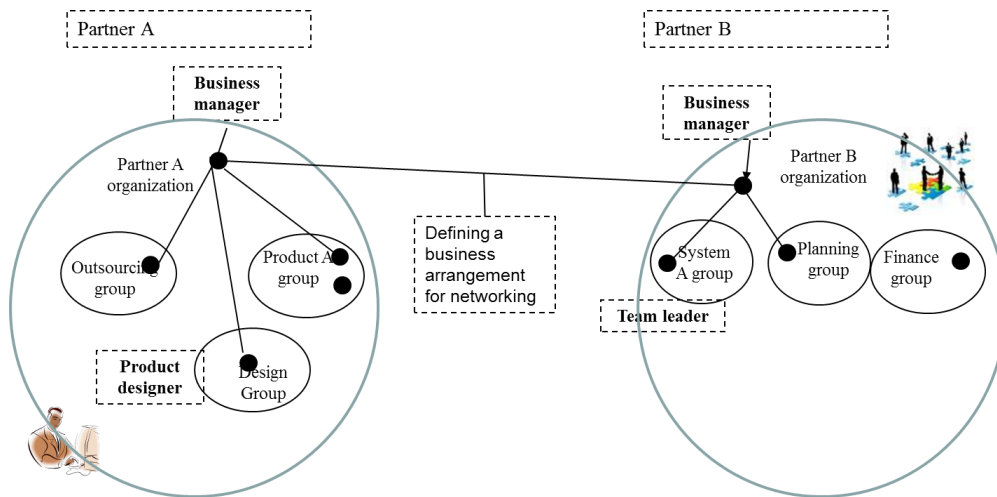


Figure 4 – Starting the Collaboration

In the initial stages the collaboration is simple – an interaction between the managers of two businesses who see some benefit in working together. Once agreement is reached a more sophisticated collaboration is proposed.

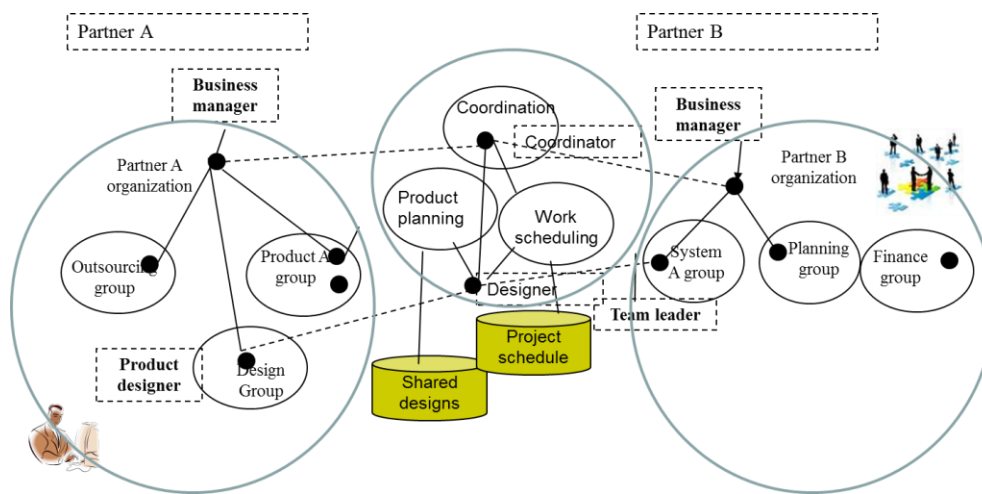


Figure 5 – Communicating Systems – An overall architecture

This, as shown in Figure 5, follows the same steps as the previous example but on a larger scale.

- The two businesses together create a collaborative organization through which they communicate.
- The collaborative organization has its own roles and levels. There is a coordination group, a work scheduling group and a product planning group. There are two roles, the coordinator and designer with specific responsibilities in the collaboration
- Virtual roles are created in the collaborating organization. There are a number of roles (shown by the black circle). Each role is assigned a responsibility and dotted links

between roles indicated how roles in the two businesses are assigned to the virtual role.

- People assigned to the virtual roles collaborate in carrying out their formal duties. Hence for example the product designer role is responsible for new product design for partner A whereas the team is responsible for developing the product for partner B.

4 Design Space for Modeling

The modelling method described here is implemented on the open modelling platform at the University of Vienna. The method known as MelCa allows models to be set up from different perspectives and maintains cross references between models as allowed by the open modelling platforms. The modelling concepts used in the model have been described earlier (Hawryszkiewicz, 2005) and support collaboration. The main concepts are a role (shown by a circle), artefact (shown by the disk shape, and activity (shown by the ellipse). New objects can be easily added to the model and rearranged as needed giving the flexibility to use alternate modelling options.

The basic principle used in the model in Figure 6 is to show each system as an aggregation of level in the square box. They must also create a collaborative environment where they can leave together. There is flexibility in rearranging systems, adding new components, and linking systems through collaborative spaces. The tool is highly interactive and supports design experimentation by providing the ability to quickly rearrange systems and collaboration between them. A more detailed application can be found in Yoo (2011).

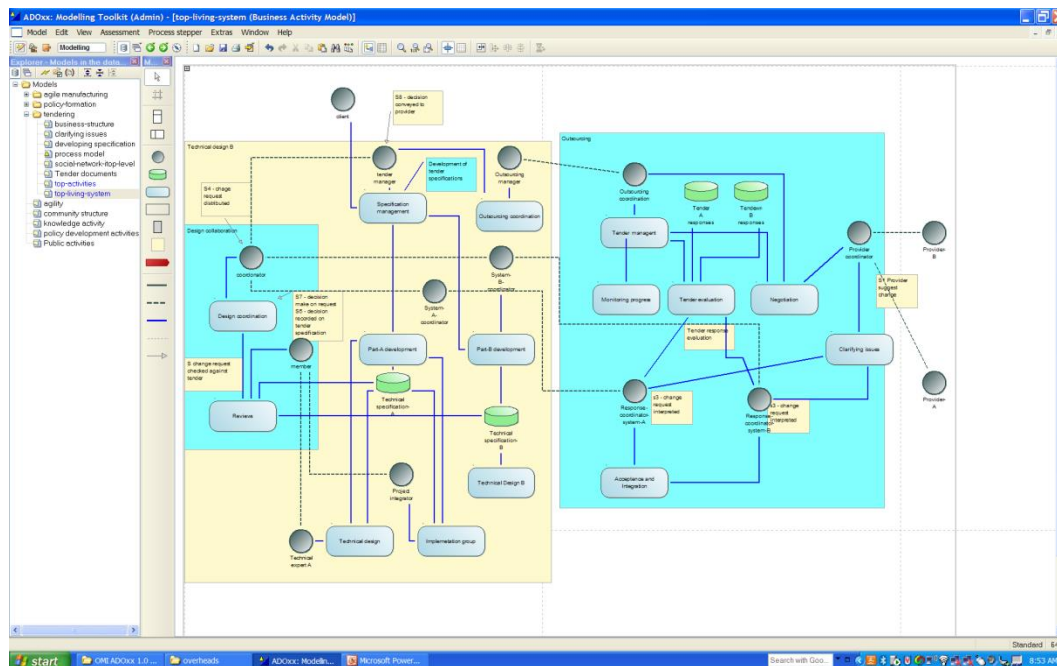


Figure 6 – A representation of business networking using MelCa

5 Implementation issues – creating platforms

Implementations combine objects to create the collaborative systems using adaptable workspaces. An example of a workspace is shown in Figure 8. Beginning with collaboration

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(Hawryszkiewicz, 2005) which supports the concepts described earlier. Knowledge workers can self-organize their work in a system by creating new roles or artifacts and rearranging responsibilities for working on the artifacts. They should also be able to create interaction spaces to pursue new and evaluate.

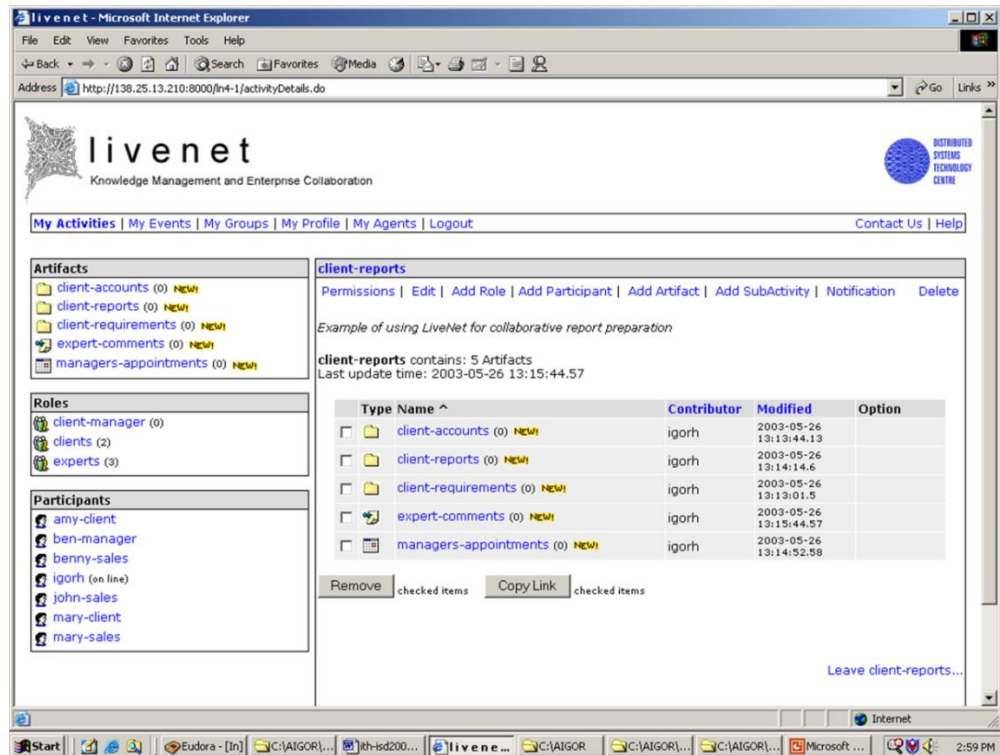


Figure 7 - A working platform

6 Summary

The paper defined the new characteristics of emerging complex systems and the challenges to be met by new methodologies that will help business analysts to deal with complexity and issues of integration of collaborating businesses. The paper defined a set of concepts to manage change using living systems theory (Miller, 1978) as its framework. The paper then identified the kind of tools needed to support the open modelling method and illustrated with an example.

The semantics focused on emergence, self-organization is simply managed by creating collaborative environments as needed. Process integration is also supported through collaborative environments where people assigned to roles that are linked to roles in the collaborative environment. The future work here is to use the semantics to propose services based on social media to quickly adapt social networking to emerging business structures.

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