Design Method Requirements for Agile System of Systems

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ABSTRACT

The paper defines the need for new and innovative methods for business analysts to analyze and design systems in the emerging agile environments. The paper goal is to provide models for business analysts to identify collaborative arrangements needed to sustain collaboration within continually evolving business environment. The paper begins by describing the characteristics of the emerging environments and the requirements of new design methodologies. It focuses on ways to manage complexity, process integration and emphasis on social structures needed to respond creatively to changes in the environment. The goal is to create an architecture that encourages the emergence of new collaborations in response to changes in the environment and can easily accommodate process change. The collaborative architecture defines the collaborative arrangements and responsibilities to make the collaboration sustainable.

The paper develops a framework to describe business networks as a system of systems and ways to model collaboration between the different systems. The paper then proposes living systems theory as the framework for identifying the relationships of business units of different organizations and the messaging structure to support emerging collaboration between the business units. The paper illustrates a way to model a system of systems using living systems theory. It combines this theory with open modelling to show ways to manage complexity, process integration and collaboration. It then describes the kinds of tools needed to support the modelling and illustrates with an example of its use. It uses process outsourcing that involves a number of partners and suppliers as an example.

Keywords:

Collaboration, Agility, Modeling, Living Systems

INTRODUCTION

The emerging trend in business and government systems is towards greater networking or what is sometimes called Enterprise 2.0 (McAfee, 2006) where emerging business networks are increasingly complex and dynamic in nature. Network arrangements often include a number of organizations, who collaborate to jointly co-create products (Cova, 2008) or services (Vargo, 2008). The common characteristic in business networking is to create collaborative environments that foster creativity and
innovation. There is greater emphasis on social structure (Pralahad and Krishnan, 2008) and collaboration with increasing calls (Pisano, Verganti, 2008, Patel, 2012) for a more focused approach to align collaboration to the business process and for new collaborations to emerge as the business process changes. They suggest that what is needed is a collaborative architecture. Patel (2012) defines factors that lead to successful collaboration based on a lengthy study that involved a number of cases. Increasingly the environment is seen as one where a number of systems need to work together as a system of systems that combine to reach a network goal.

Such trends to more agile and increasingly socially oriented environments are calling for new development methodologies to design information systems that support such networks. The lack of such methods often leads to ad hoc development of systems. It focuses on issues such as emergence of new business activities, or self organization and ways to quickly respond to environmental change. The increasing complexity of this environment requires systems to increasingly deal with unanticipated events. Naranayan and others (2011) note that the increasing complexity makes it difficult for firms to realize the full benefits of networking.

The paper proposes that living systems theory (Miller, 1978) can provide a framework for modeling a system of systems and shows that this theory can represent their complex relationships and ways to model collaboration between them. It draws on complexity theory (Merali, 2006) to identify the kinds of business dynamics to be supported and extends it with concepts needed to include system integration. It begins by defining the characteristics exhibited in the new environment and the challenges to be met by modeling methods. It then shows how models based in living systems theory can meet these challenges. It then shows how agility is achieved through support for emerging collaborations that can quickly respond to change while existing business units self-organize to participate in the emerging collaborations.

**EMERGING CHALLENGES AND REQUIREMENTS FOR SYSTEM METHODOLOGIES**

The emerging networking environment is characterized by:

**Increasing Complexity** - Complexity is here as defined in similar way to Merali (2006). It does not focus on mathematical solutions but ways to manage the continuous change in business relationships. It focuses on issues such as emergence of new business activities, self organization and ways to quickly respond to environmental change. It requires managing communication in process integration to maintain awareness in teams in collaborating businesses to constructively contribute to the network.

**Social Structures for Creativity and Sustainability** - Increasing focus on collaboration requires greater attention to social structures to ensure that collaboration is both effective and sustainable. Sustainability in their sense requires the establishment of common ground. It focuses on structures that go beyond ad-hoc collaboration but introduce a more formal structure of roles and relationships that define business arrangements.

**Changing requirements** - Complexity and changing social structure result in continually changing requirements. Jarke and others (2011) call for greater emphasis on designs based on an evolving architecture. This paper emphasizes emerging architecture where collaborations can emerge to
respond to change. (Pisano, Pergatti, 2008) call for greater alignment of collaboration to the business process.

**REQUIRED FOR MODELING METHODS**

The paper describes ways that living systems theory can be used to address the challenges.

**Requirement 1 - Managing complexity especially support of emergent collaboration**

The focus is not on the mathematical theory of complexity but on basic principles such as emergence, reorganization or response to change. The paper shows how living systems theory provides a way to model emergence through the creation of new collaborative environments and continuous reorganization of working units.

**Requirement 2 - Process Integration**

Process integration within business partners and their clients become an important issue especially in ensuring effective collaboration (Fathianathan, 2009) and leading to networking sustainability. It also requires strong process integration (Fathianathan, 2009) between activities in collaborating organizations and that this has a positive impact on firm performance, which in turn requires greater emphasis on collaboration (Fathianathan, 2009). Process integration goes beyond transaction exchange but focuses on collaborations towards a common goal.

**Requirement 3 - More emphasis on collaboration and creativity**

The emergence must continually create social structures for organizational creativity (Chang, 2011). This includes special roles such as connectors (Patel, 2012) or brokers (Sheate, 2010). Pisano and Verganti (2008) similarly suggest that a collaborative architecture is needed. Chang (2011) calls for greater structure in the communication needed to support creativity. Nguyen and Shanks (2009) for example distinguish between product creativity, process creativity and people creativity. The paper extends living theory with open modeling concepts to model the collaborative architectures suggested for creativity.

**Requirement 4 - Sustainability – make collaboration sustainable**

The paper now shows how living systems theory can provide the framework that meets these requirements.

**LIVING SYSTEMS AS A FRAMEWORK FOR REPRESENTING OF SYSTEM OF SYSTEMS**

Living system theory (Miller, 1978) provides a theoretical basis for developing the collaborative architecture. Living systems define layers of social systems each of contribute to sustainability. These levels are:
Society as a whole, communities within the society such as local communities, professional groups, sporting associations, that makes up society as a whole.
Organizations such as corporations
Groups in organizations
Activities in groups

Living system provides a basis for modeling business collaboration between businesses and within businesses. Figure 1 illustrates the basic principle of modeling using living systems.

The modeling principles adopted here are:

- Each partner is one living system.
- Each partner, partner A and partner B, is composed of a number of layers which are here seen as systems, Figure 1 shows some examples of layers for each partner, as for example partner A has a design group, outsourcing group and product group.
- Each system has a responsible role, shown by the black circle, which carries the responsibility work its work. In some cases this is the business manager. In other it may be a product designer or team leader.
- Each role is assigned some responsibility and links between these roles indicate that people assigned to the roles interact 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.
• The two living systems together create a collaborative environment through which they communicate. The collaborative environment is itself a living system with its own levels. The next level here for example is coordination and the next product planning and work scheduling.

• The collaborative environment has its own roles and levels. There is a coordination activity, a work scheduling activity and a product planning activity. There are two roles, the coordinator and designer with specific responsibilities in the collaboration. These roles are taken by people each partner as indicated by the dotted lines. Thus the business managers of both partners jointly coordinate the collaboration.

Living system theory goes beyond what appears to be a hierarchical structure but also includes definitions of information and material flows between the systems.

**APPLYING LIVING SYSTEMS THEORY**

A set of steps that can be followed by an analyst are:

• Identify the current operating units and model them by living systems,
• Define the collaboration environments and their goals,
• Define the boundary roles,
• Define the detailed collaboration processes.

This process is illustrated in the following example. It begins by describing the modelling using manual models and then shows a tool used for modelling a tendering process. The model that is developed is shown in Figure 2 through the following steps.

• First model the businesses in the business network. This includes the tendering organization that places tenders on behalf of its clients. The tendering organization is composed three groups, namely, the specification management group, the outsourcing group and outsource acceptance. The specification is developed by two design groups, design group A and design group B. Model the organizations that respond to tenders. In this case only two are shown. There can of course of any number of such organizations. It is assumed that these have a tender management group and a development group.
• Define the boundary roles, shown by the black dots,
• Identify the collaborative environments within and between the organizations. These are shown by square boxes and include:
  o collaborative environments within the tendering organization. One is to support collaboration between the different design groups (labelled A). The other is to support collaboration in arranging information for outsourcing (labelled B). The actual outsourcing is labelled C and called outsource management. It now includes provider organizations.
  o collaboration between the tendering organization and providing organizations. There is a collaborative environment at the contractual level (labelled D). The collaboration labelled E and G are during development where issues may need to be clarified. Those labelled F are acceptance test.
• Define the goals of each collaboration. For example collaboration A is to maintain consistency between the design parts. Collaboration B is to create a specification suitable for including in an outsource document. These collaborations especially those between businesses can be specified as part of a contract.

• The collaborative environments include roles needed in collaboration. These roles are taken be people from the collaborating system. The collection of collaborative environments is the collaborative architecture.

• Boundary roles have responsibilities to facilitate collaborations.

When each of the living systems and their collaborative environments are put together then we have a model of a system of systems. A more detailed design should then look at the detailed structure of each environment.

The modeling satisfies requirement 1 as it is possible to create new living systems and link it to existing systems using collaborative environments. At the same time structures in the organization can reorganize by redefining their role responsibilities to participate in the emerging collaborative environments. Emergent new collaborations can gradually move towards new organizational units as responsibilities are transferred to the collaborative environment with roles being occupied by new personnel. The organization structure thus changes as productive collaborative arrangements are identified and become part of normal operations.
PROCESS INTEGRATION THROUGH COLLABORATION SPACES

A responsible person can create a collaboration space. The owner can invite people from other systems to participate in the space and provide them with access to any artifacts in their system. The design steps here include:

- Defining roles and their responsibilities in each collaboration,
- Assign the roles to roles in the business units,
- The model semantics support dynamic changes and the special characteristics of complex adaptive systems as:
- Collaboration be reorganized through changes to roles, artifacts,
- New activities can be easily set up and linked to existing activities through roles and artifacts,
- The activities are loosely coupled through their roles,

This requires additional concepts for use by the analyst. The concepts described here are chosen to model collaborative systems (Hawryszkiewycz, 2005). 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. Figure 3 illustrates an application of these concepts to some of the collaborative environments (A and B) shown in Figure 2. It shows three business units (Design Group A, Design Group B, Outsourcing Collaboration) and two collaborative environments (Design Collaboration to ensure consistency of design and outsourcing collaboration to prepare the design into a specification. Figure 2 shows a collaboration role ‘design coordinator’ which is taken jointly by the managers of design groups A and B and the design leader in specification management.

Figure 2 is indicative only and would include more detail. This detail is difficult to manage manually and a modeling tool, MelCa, which is described later in the paper.
This satisfies requirement 2 as now it becomes possible to integrate systems through their roles. It is also possible to create new collaborations as needed through supporting collaboration structures.

**CHOOSING SOCIAL STRUCTURES**

The social structures depend on the whether collaboration is synchronous or asynchronous. In synchronous environments the collaborative environment is supported by continuous interactions between people assigned to the assigned to the collaborative roles in the different business units. The roles are formalized in the sense that they must carry out the role responsibilities. In asynchronous environments it becomes important to define processes to be followed in collaboration. The chosen processes are chosen to contribute to creative environments (Chang, 2011). Modeling should give insights on ways to address (Engelsman, 2011) and ways to continually restructure working arrangements to meet emerging demands. This section of the paper illustrates how living systems theory provides the concepts to model systems in this environment. One approach is to use the concept of thinkLets (Kolfshoten, 2006). Each of the collaborative activities can be based in a thinkLet. Living systems provides a way to do this through the following information subsystems:

S1- A subsystem to receive new messages.
S2- A subsystem to interpret messages created within the social system,
S3- An analysis to see the relevance of the messages and classify them
S4- Distribution for further processing
S5- Storing any useful information
S6- Analyzing message for their effect on the current context
S7- Making a decision on any action that is needed to respond the message
S8- The decision is encoded into a form that is understood by the recipient

Messages provide a generic basis for defining the transfer of information and knowledge between social systems at any of the living systems levels or between living systems. The messaging is used to identify ways to develop the collaboration to sustain change over extended periods of time. They can be used in structuring collaborative activities to ensure successful outcomes, as for example defining the activities expected of each role as guided by thinkLet chosen for that activity. A typical scenario for collaboration A here is to ensure that a change in the design of one part is consistent with other parts. The example here is:

- The design coordinator receives a message (S1) about a design change
- The design coordinator interprets the information into a form used in the enterprise
- The impact assessor decides on the message importance (S4) and sets up an assessment group (S6).
- The assessment group composed of design leaders decide what to do (S7)
- The specification leader sends decision to relevant design team managers (S8)

![Figure 4 – A sequence of information subsystems in process Integration](image)

MANAGING THE MODELING PROCESS

The modelling method described here needs a modelling tool to support it. In this part we describe the characteristics of the tool and a possible implementation. 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. Figure 5 shows the way MeICa can be used to create a living system representation in more detail. The basic principle used in the model in Figure 5 is to show each layer as an activity. Each living systems is shown as an aggregation of level in the square box. Each business then is seen as a living community. They must also create a collaborative environment where they can leave together.

![Figure 5 – Living system representation of business networking](image)

The structure of the activities now goes into detail of the responsibilities of roles and ways to foster creativity.

Figure 5 also illustrates the use of living system information flows to ensure any transactions or messages are correctly managed. It shows a suggestion made by provider for a change or improvement to the specification. It then shows how this passes through the system.

**SUMMARY**

The paper described the challenges to be met in designing a system of systems. It defined the new characteristics of such 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 proposed living systems theory as a way to model such systems and illustrated with a modelling method and an illustrative example. The goal is to develop a collaborative architecture to define the information flows and responsibilities in business collaboration.
The proposed modelling method satisfies the challenges described earlier in managing complexity, process integration and emphasis on collaboration and creativity. The 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. Creativity is supported by providing the ability to create information flows and group structures found in creative teams.

The paper then identified the kind of tools needed to support the open modelling method and illustrated with an example.

REFERENCES


