2008

Integrating Collaboration into the Design of Complex Adaptive Systems

I. T. Hawryszkiewycz
School of Systems, Management and Leadership University of Technology, Sydney, igorh@it.uts.edu.au

Integrating Collaboration into the Design of Complex Adaptive Systems

I.T. Hawryszkiewycz
School of Systems, Management and Leadership
University of Technology, Sydney
igorh@it.uts.edu.au

Abstract

The paper stresses the need to emphasize social relationships in system design especially in systems that cross enterprise boundaries in a changing environment. The paper describes these systems as a new class of systems – complex adaptive systems. It describes ways to model collaboration networks in such systems both as the drivers of change and as indicators of knowledge requirements. The paper defines a blueprint that for integrating business activities, network and knowledge into models that exhibit the characteristics of complex adaptive systems. It includes examples to illustrate the models.

Keywords:

Social Networks, Collaboration, Design

INTRODUCTION

Collaborative relationships are becoming more important in many information systems, especially those that support the trend to business networks. The collaborative relationships within such environments indicate the kind of knowledge transfer that must be accommodated. This is further supported by evidence that greater value can be obtained through networking and collaboration within and between enterprises to create and deliver increasingly innovative products and services. The emphasis on collaboration is also expounded in research such as that of Evans and Wolf, who in their 2005 article to the Harvard Business Review describe the kinds of results that can be achieved by teams working together on focused goals. One case quoted as an example was where a supplier could quickly respond by supplying valves to a car manufacturer. When a Toyota plant supplying components burnt down, arrangements where quickly made with their suppliers to supply the parts and restore operations within 4 days of the fire. Although not commonly found in business the idea of bringing people together quickly to address problems is gaining attention. It sees evolving collaboration between organizational units that were sometimes seen as silos to collaboration across firms to form a business web.

Networking in large collaborative environments in almost all situations involves what are known as knowledge workers (Davenport, 2005, Chen and Eddington, 2005). These workers must quickly assess complex networking situations and respond to them. Efforts to reengineer the work of knowledge workers into prescribed forms have proven unworkable (Davenport, 2005). Studies have shown that knowledge workers are characterized by greater emphasis on continuously changing social connectivity and interactivity. Hence it is crucial to include social or work networking as a significant part of any modeling in system design. The models will thus cater for knowledge workers, who do not follow prescribed processes. On the other hand, knowledge workers require support to enable them to quickly change their social work connections to meet new and often unanticipated process requirements and quickly adapt to changing situations. They should be able to do so in a way that they can quickly comprehend how to adopt any new technology, and assimilate it in their work (Swanson, Ramiller, 2004).

Perhaps the clearest vision of the trend to what are dynamic organizations is what is known as Enterprise 2.0. It was introduced by McAfee (2006) in his article in the Sloan Management Review as a natural trend towards obtaining additional competitive advantage by using the new features available through Web 2.0. The characteristics of Enterprise 2.0 focus on innovation and the ability to create and protect new ideas. They also emphasize knowledge sharing and the support of relationships and networking that encourage such sharing. . It sees a business environment where collaboration extends from groups and individuals to organizational units and whole enterprises. The other dimension is client value and how enterprises can add to client value. This includes developing new products that are of value to clients, as well as the ability to deliver them, reduce costs and provide services around products that lead to raised client satisfaction. In this way, the business maintains a posture that is perceived as forward looking while at the same time taking actions within that posture that create value for clients. Often people speak of a vision when looking at ways to change a business.

Current design methodologies mainly focus on supporting individual units and often do not include ways to orchestrate collaboration between people in the different units. Most methodologies for information systems

design focus on prescribed processes. Some methodologies address limited forms of adaptive processes, as for example, Desai and others (2005) see support as providing agents to deal with exceptions. Still other (Zhang (2002), create their own methodologies that place greater emphasis on user analysis and communication in cross-organizational medical systems can lead to better acceptance of systems.

Our goal is to develop methodologies to design system like that shown in Figure 1. The system architecture integrates all activities in ways that enable knowledge workers to set up knowledge activities as the need arises. This includes integrating ERP systems, knowledge activities to present them to knowledge workers who interact through lightweight architectures to generate new knowledge. The architectures will be based on services provided in customizable and adaptable workspaces. These will be presented through the work context and encourage productivity and continuous innovation through better awareness of the entire process within the work context.

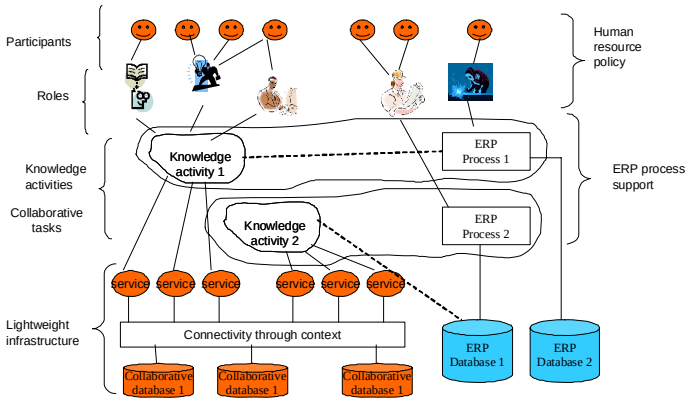

Figure 1: An Integrated Enterprise

This paper will define ways to model processes that emphasize social relationships and develop architectures that integrate social connectivity into the process context, rather than relying on individual workers to select individual services such as e-mail for each interaction. This paper addresses this issue by providing a blueprint for modeling such large and complex collaborations and elaborates on the techniques used to implement the blueprint.

CHARACTERISTICS OF COMPLEX ADAPTIVE SYSTEMS

In proposing new approaches, this paper sees the evolving systems as a new class of system and uses the generic term complex adaptive systems (Kovacs, 2005) to describe them. Such systems introduce new requirements on design methodologies. Complex adaptive systems are generally defined (Holland, 1995) as made up of many agents (which may represent cells, individuals, firms, projects) acting in parallel, constantly acting and reacting to what the other agents are doing. The control of complex adaptive systems tends to be highly dispersed and decentralized. The overall behavior of the system is the result of a huge number of decisions made every moment by many individual agents. Processes in such systems need to be equally adaptive and we refer to them as complex adaptive processes. Such processes introduce a new set of requirements for system modeling. Most of these come from complexity theory (Merali, McKelvey, 2006) and that of complex adaptive systems (Holland, 1995).

The criteria here include:

- The ability to self organize at local levels in response to a wide variety of external changes,
- The defining and quick establishment of self contained units that address well defined parts of the environment,
- Loose coupling between system elements and a control system to reorganize the structure to respond to external change,
- The ability to organize connections between units and support the changed connections and interactivity.
- The aggregation of smaller units into larger components with consequent changes to the connectivity and interactivity,
- The realization of simple interfaces between model components.

These then become the testable prepositions to show the validity of our models.

A BLUEPRINT

From the perspective of design theory (Gregor, Jones, 2007) the paper proposes a central blueprint for modeling complex adaptive systems. The blueprint is shown in Figure 2, and combines business activities, collaboration networks, and knowledge as the three basic constructs for any model. The blueprint defines the major system components emphasizing the importance of emphasizing social relationships in the design process. We combine the business activities with social networking as an integral part of the systems and seeing it as a link between the different activities. Such integration is seen by many (Prahalad, Krishnan, 2008) as essential in creating systems that support innovation. Firstly the business activities are seen as loosely connected and the connections can change over time. Similarly knowledge requirements are often the explicit databases found in most business systems. The knowledge requirements go beyond simple transaction databases but include records of social interactions integrated into the activities. They will be focused on the knowledge needs of roles within the social structure. Work patterns will provide a strong guideline for defining such social knowledge. For example, a leadership structure needs different knowledge to that in providing expert service or for brokering within a business network. Such work networks will provide useful patterns both for linking to business activities and for defining the knowledge requirements.

Network structures are also important for knowledge management. One important aspect of business process design is that of defining roles and responsibilities of people and the information and knowledge they needed to carry out the responsibilities. The other important aspect is the information and knowledge exchanged between role participants.

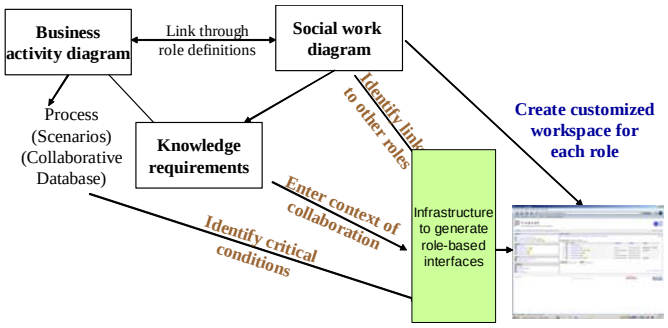

Figure 2: The blueprint for modelling adaptive information systems

The model components will then be mapped to technologies. The mapping will first define an infrastructure that can be used to generate workspaces specific to an application. It will then generate role based workspaces that can be dynamically changed as a situation evolves. The integration all process components and relationships relevant to a role into the one workspace space. Our research will follow systematic ways to convert models to an implementation as the form and function in Gregor and Jones (2007).

MODELING COMPONENTS

Our model is made up of three main parts. The business activity model comes from the concept of conceptual models in soft system methodologies and uses concepts that focus on collaborative work. The work networks draw on ideas of social work networking.

Business Activity Diagram

The business activity models are based on a conceptual model for collaborative systems (Hawryszkiewycz, 2005). The central points are the activities, which are on-going, and are connected through a context. The main concepts here are the activity, role, participant, and artefact. Figure 3 illustrates one instance of such model, which concerns evaluating an idea for a new product. Here there are four activities shown as clouded shapes. There three roles shown by Figures and four artifacts shown by the disk shapes. Any number of participants (not shown in this simplified diagram) can be assigned to each role. The model shows that the client and marketing manager interact in activity ‘analysis of marketing needs’ to develop a market report. Figure 2 illustrates the most fundamental parts of the model with more details found in (Hawryszkiewycz, 2005). The additional details include various discussion or interaction artifacts and ways to initiate events in one activity that are passed to roles in other activities.

The model semantics support dynamic changes to the model and the special characteristics of complex adaptive systems as:

- They allow activities to 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,
- New connections can be organized through events or shared discussions,
- Higher level activities can be created to aggregate the activities of existing activities.

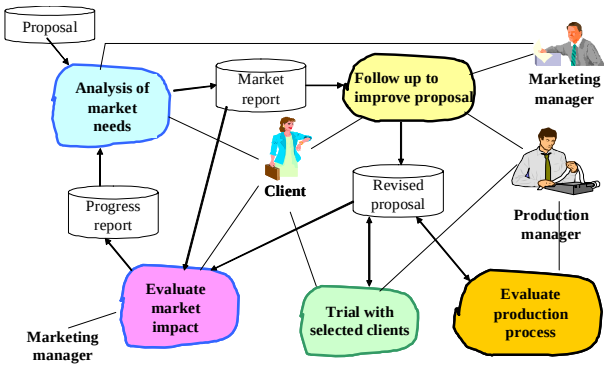

Figure 3: Business activity diagram

Collaboration Networks

This paper distinguishes between work and social networking. Work network shows the necessary communication in the business process. It focuses on peoples roles. Social networks on the other hand focus on people. Persons who take particular roles must communicate in the way defined by those roles. Figure 4 shows both the work and informal links between people in the organization. Such combinations are here called collaboration graphs. The roles are shown by black dots. The faces are individuals, who take on these roles. Thus n2 is a client and p1 is the production manager. The thick lines between the roles indicate work connections, which define the essential communication paths for the participants. The dotted lines show informal connections. For example p1 and n4 have an informal connection, which is not part of the work process.

Figure 4 provides a basis for modeling the relationships through identifying the interplay between the people. Figure 4 shows a collaboration graph where people take different roles in different activities and thus in this way share knowledge across activities.

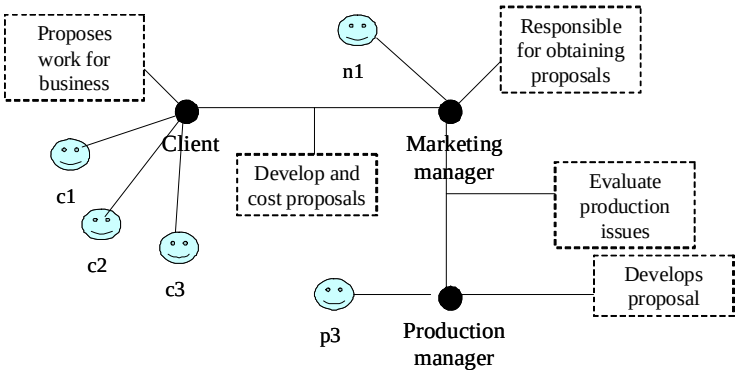

Figure 4: Collaboration graph

The links between the roles show that the way people assigned to the role interact or exchange information. This may be talking to each other, or exchanging notes or documents. The kind of information that must be exchanged as part of role responsibility is shown in the box linked to the link. Thus the requisition clerk informs the checker that the requisition is ready. The checker checks the requisition and sends it on to the supplier-manager, who selects the supplier. This is then passed to the expediter, who arranges delivery. The manager supervises the activities.

Our approach has been to use a combination of a modified rich picture and collaboration graph, and combine the two through roles that appear in both of these diagrams. It is assumed that work relationships include social interactions, as most people in formal relationships also exchange informal information. Hence it is not necessary to draw two lines between them showing both kinds of interaction.

The modelling method supports the earlier defined special characteristics of adaptive systems. The paper does this descriptively (Hevner, 2004) in the table below.

Table 1. Characteristics of Adaptive Systems

Special characteristics	**Modeling technique**
The ability to self organize at local levels in response to a wide variety of external changes,	Adding roles, participants and new artifacts to an existing activity. Creating a new discussion to include a distant member to provide new expertise to an activity.
The defining and quick establishment of self contained units that address well defined parts of the environment,	Creation of new activity. For example quickly creating a new team from existing members to address a special problem.
Loose coupling between system elements and a control system to reorganize the structure to respond to external change,	People assigned to roles in more than one activity. Events in one activity can be received in other activities, with new events added as required.
Ability to organize connections between units and support the changed connections and interactivity.	Set up events to pass notifications between activities. Share documents and discussions as for example contract development and requirements..
Aggregate smaller units into larger components with consequent changes to the connectivity and interactivity,	Create a new activity that shares artifacts with existing activities.
Realization of simple interfaces between model components.	This is achieved by defining role based interfaces that provide easy links to other roles and activities.

Process emergence here can include creation of new business relationships as for example extending the service to another client, or setting up a transient team to identify the cause of a complex fault.

EXTENDING TO DESIGN

Our goal is to develop design methods that are based on using patterns to construct systems. This follows the idea of patterns (Rizzo, 2006). It is proposed to identify typical class of application patterns and collaboration patterns and combine them into a workspace design. Ways of choosing activity patterns have been described earlier (Hawryszkiewycz, 2008). Here the activities are classified using the classification used by Davenport (2005), who distinguishes between transactional, integrative, collaborative and expert work. Each of these different kinds of activity then suggests the most appropriate workspace structure.

The different kinds of activities then suggest different collaboration structures. The paper suggests that such collaboration patterns can then provide the basic template or service that can be used to construct a working system.

Collaboration Patterns

There are a number of commonly found role structures that can be used as guidelines in design. They can then be used as standard patterns in design. An example is the leadership pattern shown in Figure 5. This is possibly the most often quoted role that is found in any business. The leader's responsibility is to define the tasks to be carried out within a team and monitoring task progress. The responsibility also includes motivating people to do the best possible in their work. Figure 5 shows alternate leadership structures, one with and one without delegation.

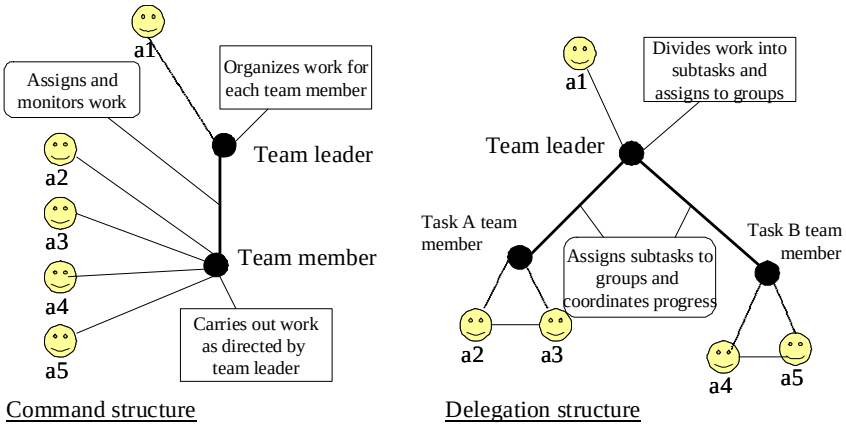

Figure 5: Leadership Role Pattern

Figure 5 shows the roles by black dots and example participants by faces. Two alternatives are shown in Figure 5. One is where the leader role, a1, assigns work to others in the team and maintains strong communication keeping track of the work.

The other is where there is some delegation of responsibility with groups of team members responsible for different parts of the work. Here the communication between the leader and the team exhibits lesser intensity because it focuses on monitoring and not frequent monitoring.

One following argument is that each such class of work requires a different collaboration patterns. Figure 6 indicates design knowledge in the forms of guidelines for choosing patterns. Thus for example a leadership pattern would be useful for management kinds of activities, whereas coordination is more useful for integrative activities.

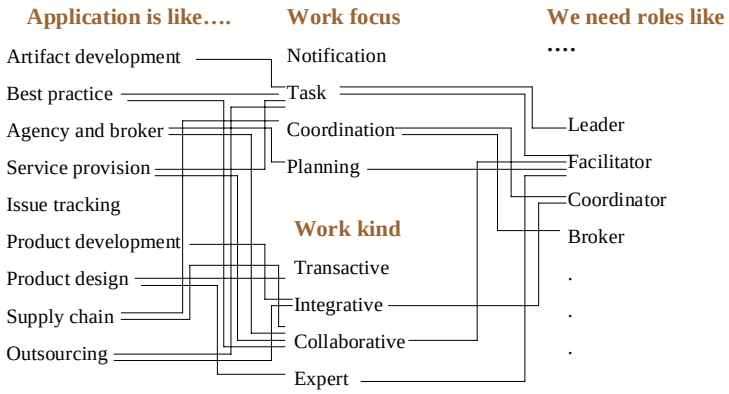

Figure 6: Design Knowledge for identifying patterns

DEFINING THE COLLABORATIVE INFRASTRUCTURE

We now combine the business model to specify collaborative requirements. The idea here is that once the relationships are identified in the collaboration graph we can easily use them to identify the technologies needed to maintain the relationships and capture any knowledge created.

Thus in Figure 7 we include all the roles in the collaboration graph. It then shows the interactions between the roles as the required services. The interactions are then used to identify the technologies needed to support them.

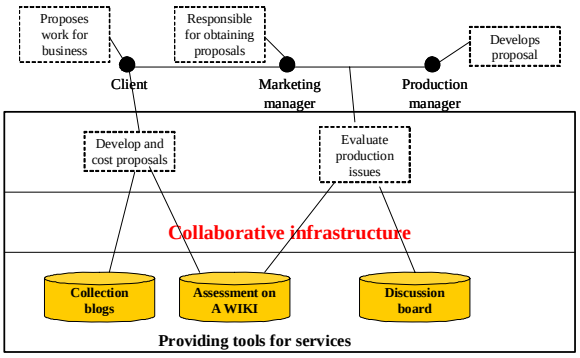

Figure 7: Converting to Web Technologies

DEMONSTRATION - OUTSOURCING

The next step is to draw the business activity diagram and identify the kind of collaboration that is to be supported. Figure 8 illustrates a business activity diagram. Here a global client outsources the provision of sales and billing applications to a technology solutions provider. The applications must be maintained in more than one country each with some special requirements. The technology solutions business in turn obtains the applications from the application provider and customizes them to the needs of the global client. The solutions provider also provides a customer service support for the client. Resolution of customer problems requires extensive communication between the various roles in the system to provide the necessary solutions.

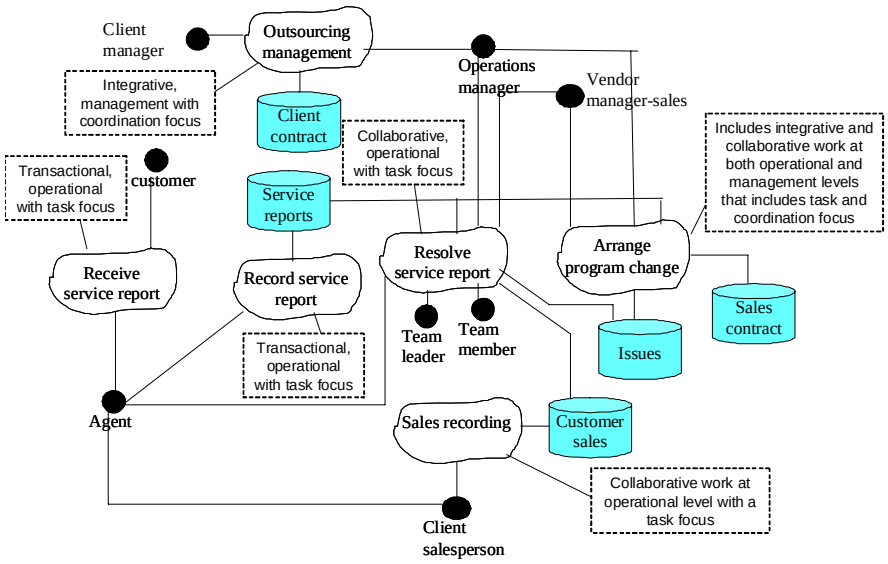

Figure 8: A business activity model in an outsourcing application

The corresponding collaboration graph is shown in Figure 9.

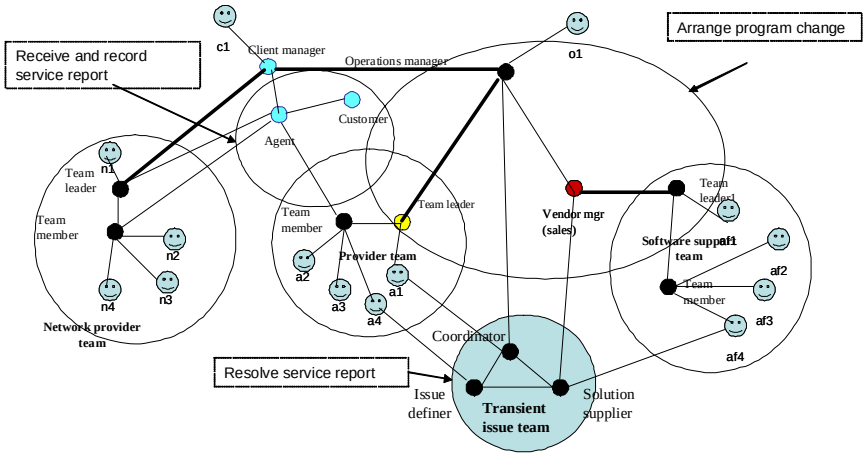

Figure 9: The collaboration graph

PRINCIPLES OF IMPLEMENTATION

The technical component has a two part role – infrastructure support and individual, support. The kind of infrastructure needed is primarily of a lightweight nature. Two alternatives are possible – an activity based conversion and a role based conversion.

In an activity based conversion business activity becomes a workspace. All the roles and artifacts in that activity become the workspace components. The interactions between the roles identify the communication services needed by the role participants.

In a role based conversion we look at the roles and place all the activities in which the roles participates in the workspace. Some earlier work [Hawryszkiewycz, 2007] described the kinds of lightweight workspaces for different kinds of activities, ranging from lightweight exchange to process support.

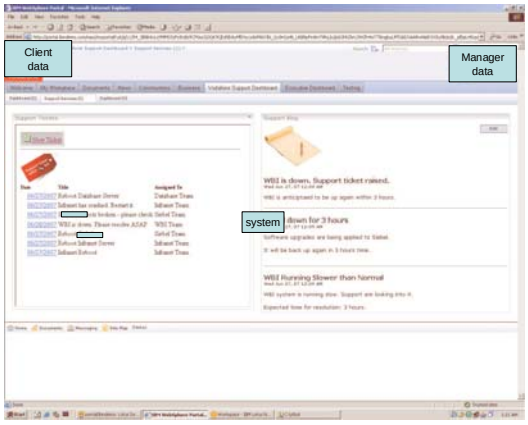

Figure 10: A role based interface

Each role in a role based conversion is to have a customized interface with access to a common context. The role responsibilities are identified from the business activity diagram. These activities are included in the role interface. The interface also includes access to all roles connected to the role in the work network to encourage informal interaction. The goal is to allow each role to have a role specific interface, as for example shown in Figure 10, (with some sensitive information blocked) with access to a common context. This context includes all the documents accessible to the project manager. The role responsibilities are identified from the social network analysis by identifying the activities of the role and presenting them in the role interface.

SUMMARY

This paper introduced the idea of complex adaptive systems as generic to model current large scale collaborative network environments. It developed a blueprint for modelling such systems. The blueprint emphasized three main components, business activities, social structures and knowledge. The paper then described modelling techniques that integrate business activities and social work networks. The paper then proposed principles of implementation that convert the models to either activity based or role based workspaces and illustrated with an application to process outsourcing.

REFERENCES

Chen, A., Edgington, T. (2005): "Assessing Value in Organizational Knowledge Creation" MIS Quarterly, Vol. 29, No. 2, pp. 279-309.

Davenport, T. (2005): "Thinking for a Living" Harvard Business School Press.

Desai, N, Mallya, A., Chopra, A., Singh, M. (2005): "Interaction Protocols as Design Abstractions for Business Processes" IEEE Transactions on Soiftware Engineering, Vol. 31, No. 12, December 2005.

Evans, P., Wolf, B. (2005): "Collaboration Rules" Harvard Business Review, July-August, 2005, pp. 1-9.

Gregor, S., Jones, D. (2007): "The Anatomy of a Design Theory" Journal of the Association of Computing Machinery, Vol. 8, Issue 5, pp. 312-335.

Hawryszkiewycz, I.T. (2005): "A Metamodel for Modeling Collaborative Systems" Journal of Computer Information Systems, Vol. XLV, Number 3, Spring 2005, pp. 63-72.

Hawryszkiewycz, I.T. (2007): "Lightweight Technologies for Knowledge Based Collaborative Applications" Proceedings of the IEEE CEC/EEE2007 Conference on E-Commerce Technology, Tokyo, July 2007, pp. 255-264.

Hawryszkiewycz (2008); "Designing Business Activities to Facilitate Knowledge Sharing" Proceedings of the 2008 Symposium On Collaborative Technologies and Systems, Irvine, May 2008, pp. 32`1-330.

Holland, J. (1995): "Hidden order: How adaption builds complexity" Cambridge Perseus Books.

Kovacs, A.I., Ueno, H. (2004): "Towards Complex Adaptive Information Systems" Proceedings of the 2nd International Conference on Information Technology and Application.

Livenet – http://livenet4.it.uts.edu.au

McAfee, A.P. (2006): "Enterprise 2.0: The Dawn of Emergent Collaboration" MIT Sloan Management Review, Spring 2006, pp. 21-28.

Merali, Y., McKelvey, B. (2006): "Using Complexity Science to effect a paradigm shift in Information Systems for the 21st. century" Journal of Information Technology, 21, pp. 211-215.

Morgan, G. (1986): "Images of Organization"., SAGE Publications, Beverly Hills, California.

Oates, B.J., Fitzegrald, B. (2007): "Information Systems Journal, Vol. 17, No. 4. October 2007, pp. 421-449.

Prahalad, C.K., Krishnan, M.S. (2008): "The New Age of Innovation" McGraw-Hill.

Rizzo, A. Pozzi, S., Save, L., Sujan, M. (2006): "Designing complex socio-technical systems: A heuristic schema based on Cultural-Historical Psychology" Proceedings of the 2005 annual conference on European association of cognitive ergonomics, pp. 71-81.

Swanson, E., Ramiller, N. (2004): "Innovating Mindfully with Information Technology" MIS Quarterly, Vol. 28, No. 4, pp. 563-583, December 2004.

Zhang, J., Patel, V., Johnson, K., Smith, J. (2002): "Designing Human Centered Distributed Information Systems, IEEE Intelligent Systems, September/October, 2002, pp. 42-47..

COPYRIGHT