AGENT-ORIENTED COMPUTING FOR BUSINESS PROCESS MANAGEMENT – WHAT, WHY AND HOW

Minhong Wang[1], Kuldeep Kumar[2] and Weijia Ran[1]
[1] *Division of Information & Technology Studies, The University of Hong Kong, Hong Kong*

[2] *College of Business Administartion, Florida International University, USA*

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Abstract: Agent-oriented computing has been addressed for seeking significant advances on complex process management systems. However, recent research on this problem is experience-driven, ad-hoc, and without a cohesive theoretical base. This study aims to examine the key problems and solutions for complex process management as well as the mechanism of why and how agent-oriented computing can be applied in developing complex process management solutions.

1 INTRODUCTION

Business process management (BPM) is regarded as a systematic approach to improving an organization's business processes. Most approaches to BPM use information technologies to automate business processes in whole or in part, through building business information systems that offer the right tasks at the right time to the right participant along with resources needed to perform these tasks. They help coordinate and streamline business transactions, reduce operational costs, and promote real-time visibility in business performance.

Traditional approaches to BPM systems use workflow technology to design and control the process through workflow engine (van der Aalst, et al., 2002). They follow a highly structured and predefined workflow model, and therefore are well suited to applications with standard inputs, processes, and outputs. However, business processes may change over time as a result of complex interactions, resource competition, abnormal events, and other sources of uncertainty. Against this background, a number of studies are seeking significant advances on process management approaches by applying various technologies.

Although there has been a proliferation of studies on agent-oriented computing technologies in BPM (Jennings et al., 2000, Wang et al., 2002), the key mechanisms have remained unrevealed, i.e. why we need them for BPM, and how to apply them in developing BPM solutions. Most prior research on this problem is experience-driven, ad-hoc, and without a cohesive theoretical base. There is only minimal work that examines the root of complexity of business processes, the need of effective approaches to complex process management, and how this need affects the requirements and solutions for business process management (Kumar et al., 2006). Unless we have appropriate understanding on these important issues, further advances on BPM solutions will be problematic.

2 HOW TO MANAGE COMPLEX PROCESSES

A business process is a collection of activities that consist of a series of steps performed by actors (machines or humans) to produce a product or service for the customer. Real-world processes are messier than the input-transformation-output view might suggest. They are best viewed as networks, in which a number of roles collaborate and interact to achieve a business goal. Based on this understanding, we examine the complexity of BPM problem, and address the key solutions to BPM in this section.

Decomposition of Complex Processes. Business processes are complex systems, made up of a number of interacting objects with dynamic behavior.

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The way we manage complexity is to decompose a complex system or process into smaller modules that can be designed independently, i.e. modularity. Modularity ensures easy maintenance and updates of complex systems by separating the high-frequency intra-module linkages from the low-frequency inter-module linkages, and limiting the scope of interactions between modules by hiding the intra-module relations inside a module box (Simon, 1981). In this conception, a business process can be defined as set of subsystems, which can in turn be hierarchically decomposed into further levels of detail corresponding to the organizational context.

How to decompose complex processes? "Task" has been selected as the basic module for building process management systems. A process can be decomposed into tasks, task into sub-tasks, and so on, through many layers in a hierarchy. With the increased extension of business processes from intra-organizational to inter-organizational scope, we need to deal with interactions within an organization as well as interactions across organizations in partnership. To reduce the complexity, we need to distinguish between inter- and intra-organizational interactions and deal with them by isolating one from another. We may propose "service" as a high level view of the building block of a process, where a process is composed of a set of services; each service is provided by an organization and can be further decomposed into tasks.

Flexible Coordination among Tasks. To manage complex interactions in business organizations, multiple actors, activities, resources and goals need to be coordinated. After decomposing a complex process into a number of task components, we need to coordinate various interactions between the components at different levels in a network hierarchy.

How to coordinate the interactions between the task components? The more stable and predictable the situation, the greater the reliance on coordination based on structured and specifiable schedules, such as coordination by plan and coordination by standardization; the more variable and unpredictable the situation, the greater the reliance on informal and flexible communication, such as coordination by feedback and coordination by mutual adjustment (Minzberg, 1979). Faced with increased uncertainties in dynamic environments, organizations must use more flexible coordination mechanisms to coordinate their processes. Flexible coordination is portrayed by less centralization in top management to facilitate bottom-up initiatives. The required mechanisms include flatter hierarchies, decentralized autonomy-based units and decision-based coordination, which are used for narrowing direct control and encouraging more mutual adjustment and coordination.

Awareness of Dynamic Environments. As a result of complex interactions, resource competition, abnormal events, and other sources of uncertainty, business processes are usually semi-structured or unstructured to the extent that there is an absence of routine procedures for dealing with them. Problem solving is then regarded as an interaction between the behaving organism and the environment under the guidance of a control system. A basic idea underlying this viewpoint is control of complex dynamic systems or situations based on situation awareness.

In a dynamic business process environment, there is a need for spontaneous decision and coordination of processes based on situation awareness. An exact execution order of activities is impractical, while the interaction or relationship between the environment and activities is more reliable in determining how to manage and coordinate tasks (Wang et al., 2006). In other words, we need to be able to coordinate the processes by sensing and comprehending the situations, determining responses to the situations, as well as taking initiatives to achieve business goals. The question of which task to execute and when to execute it is dependent on the current environment and underlying business rules rather than a static process schema.

Flexible Resources Coordination. The rise of Internet mediated e-Business brings the era of quick connected global business relationships into existence. Business networks that are temporarily integrated and driven by demands have emerged and operated for the lifespan of the market opportunity. Along with this change, a business process can be dynamically established by connecting or composing services together from different organizations through alliances, partnerships, or joint ventures. Attentions on business processes should be extended from task and procedure to resources discovery, selection and coordination (Wang et al., 2008). What is new in this flexible form is reliance on the idea of separating requirements from satisfiers (Mowshowitz, 1997). This separation allows for crafting process structures that enable management to switch between different resource options for implementing a process. The success of the model is highly dependent on the match between the requirements and satisfiers that deliver the services. One way to ensure this balance is to model the

integration or composition of business processes as a management problem which involves: 1) the separation of requirements from the means for realization, and 2) the dynamic selection and allocation of resources to requirements.

3 MECHNISMS OF AOC

What is AOC? Agent is some *actor* (performer) who on the behalf of a principal provides a service. The agent provides the service by receiving request of service from the principal. In performing or providing a service on behalf of a principal, the agent can ask other agents to provide it with the service, i.e. be the principal that asks other agents to perform the service. In this situation, the agent is a *broker*. In computer science, the term **"**agent" is used to describe a piece of software that acts for a user or other program in a relationship of agency. It denotes a software-based entity that enjoys the properties of autonomy, social ability, reactivity and pro-activity (Wooldridge, 2002). The key idea of Agent-Oriented Computing (AOC) suggests the delegation of tasks and responsibility of a complex problem and emphasizes autonomy and co-operation of agents to perform tasks in open and complex environments.

Why AOC for BPM? AOC represents an emerging computing paradigm that helps understand and model complex real-world problems and systems, by concentrating on high-level abstractions of autonomous entities. AOC is used to model and implement intelligent solutions to semi- or ill-structured problems, which are too complex to be completely characterized and precisely described. By using AOC, a complex system can be viewed as network of agents acting concurrently, each finding itself in an environment produced by its interactions with the other agents in the system.

AOC is applicable to a number of complex (dynamic, open, and interactive) domains like electronic commerce, manufacturing resource planning (ERP), supply chain management, project management, etc. It is particularly well suited for complex process situations that are not all known a priori, cannot all be assumed to be fully controllable in their behaviors, and must interact on a sophisticated level of communication and coordination (Wang et al., 2006).

For example, a typical supply chain faces uncertainty in terms of supply, demand, and process, etc. Moreover, business entities in a supply chain are highly interdependent in order to achieve coherence among them. A large number of interacting decisions may take place between different entities, most of which are impossible to foresee at design time. With mixed and often conflicting objectives, processes are sophisticated and difficult to manage using closed-form analytical solutions. Business managers have no way to deal with the situation, but fall back on whatever general capacity they have for intelligent, adaptive, goal-oriented action. The agent-based approach is directly applicable to this type of application domain.

4 HOW AOC WORKS FOR BPM

We investigate how AOC can be used to develop solutions of complex process management.

AOC for Decomposition of Complex Processes. Business processes display complexity because of interactions of their internal components and interaction of the process with its environment. The highly dynamic and unpredictable nature of business processes makes AOC appealing. A process can be decomposed into a set of tasks, task into sub-tasks, and so on, through several layers in a hierarchy. The tasks are then assigned to autonomous agents, each having specific goals to achieve and interact with one another to manage their autonomy and interdependencies. To deal with business processes across different organizations, "service" can be used as a high level view of the building block of a process. A process is composed of a set of services, each of which can be further decomposed into tasks.

AOC for Flexible Task Coordination. To coordinate the interactions in dynamic situations, flatter hierarchies, decentralized autonomy-based units and decision-based coordination are required, where AOC is directly applicable. AOC supports decentralized control and asynchronous operations by a group of autonomous software entities, which are able to perform decision-based coordination of their activities. In complex process management, it is impossible to predefine all activities and interactions at design time. Instead, we define the goal or role of each agent, based on which a set of rules can be specified for governing the behavior of the agent in dynamic situations.

AOC for Awareness of Dynamic Environment. The complexity of business processes comes not only from interactions of their internal components, but also from interactions of the process with its environment. To manage business processes in a dynamic environment, we need to be able to

continuously perceive the environment, and make real-time decisions on the process. Agent-based software entity is able to sense and interpret the situations and determine appropriate actions upon the situations based on predefined rules or knowledge. Moreover, AOC supports prediction of future state of the environment for purpose of proactive actions. Different from passive response to current events, proactive behavior has an orientation to the future, anticipating problems and taking affirmative steps to deal positively with them rather than reacting after a situation has already occurred. It refers to the exhibition of goal-oriented behaviors by taking initiatives (Wang et al., 2006, 2002).

AOC for Resource Coordination. A business process can be dynamically established by connecting or composing Web services provided by different organizations over the Internet. However, it is a complex problem to search appropriated services from a large number of resources as well as schedule and coordinate them under various constraints. The complexity arises from the unpredictability of solutions from service providers (e.g. availability, capacity, and price), and constraints on services in a process (e.g. temporal relationship, time and cost constraint). To deal with the problem, AOC can be used for coordination based on distributed decision making. In process integration, decision and coordination among services can be modelled as a distributed constraint satisfaction problem, in which solutions and constraints are distributed into a set of services and to be solved by a group of agents (brokers) on behalf of service requesters and providers. Finding a global solution to the integrated process requires that all agents find the solutions that satisfy not only their own constraints but also inter-agent constraints (Wang et al., 2008). In this situation, the special type of agent works as an intermediary between service requester and service provider, coordinating on behalf of two parties regarding service requirements, qualities, costs, and other constraints.

5 CONCLUSIONS

This work has investigated the rationale for developing solutions to complex process management by using agent-oriented technologies. The main problems and key solutions for complex process management are examined. Meanwhile, the mechanisms of Agent-Oriented Computing, together with its relationship with BPM systems development are clarified. Based on this, we present a clear picture on why and how Agent-Oriented Computing technology can be applied to developing process management systems, especially in complex situations. This work will benefit professionals, researchers, and practitioners by guidelines and methods for designing and developing technical solutions to complex business process management.

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REFERENCES

Jennings, N.R., Faratin, P., Norman, T.J., O'Brien, P., & Odgers, B., 2000. Autonomous Agents for Business Process Management. *International Journal of Applied Artificial Intelligence*, 14 (2), 145-189.

Kumar, K., & Narasipuram, M.M., 2006. Defining Requirements for Business Process Flexibility. *Seventh Workshop on Business Process Modeling, Development, and Support*, CAiSE 2006

Mintzberg, H., The Structuring of Organizations, New Jersey, Prentice Hall, 1979

Mowshowitz, A., 1997. Virtual organization. *Communications of the ACM*, 40 (9), 30-37.

Simon, H.A., 1981. *The sciences of the Artificial*, MIT Press, Cambridge, Massachusetts, London, England.

van der Aalst, W.M.P., & van Hee, K.M., 2002. *Workflow Management: Models, Methods, and Systems*, MIT press, Cambridge, MA.

Wang, M., & Wang, H., 2002. Intelligent Agents Supported Flexible Workflow Monitoring System. *Proceedings of the14th International Conference on Advanced Information Systems Engineering (CAiSE)*, Toronto, *Lecture Notes in Computer Science*, Springer-Verlag, 2348, 787-791.

Wang, M., Liu, J., Wang, H., Cheung, W., & Xie, X., 2008. On-demand E-Supply Chain Integration: A Multi-Agent Constraint-Based Approach. *Expert Systems with Applications*, 34(4), 2683-2692.

Wang, M., & Wang, H., From Process Logic to Business Logic - A Cognitive Approach to Business Process Management. *Information & Management*, 43(2), 179-193.

Wooldridge, M., 2002. *An introduction to multiagent systems*, England, J. Wiley.