MULTI-AGENT SYSTEMS FOR BUSINESS PROCESS MANAGEMENT - OVERVIEW

Abstract:
Business process management systems are used in corporate environment to reduce their routine business and administrative work in order to improve business processes. This paper focuses on the multi-agent solutions for the business process management. The purpose of the paper is to describe the key concepts of the agent-based system design and to point out the main differences between agent-based and traditional business process management approaches.

1 INTRODUCTION

In the systems engineering sector, a process is a sequence of events that uses inputs to produce outputs. According to [3] the process management, based on a view of an organization as a system of interlinked processes, it involves concerted efforts to map, improve, and adhere to organizational processes. The Business Process Reengineering (BPR) movement of the 1990s emphasized technology as a key enabler of the process management and process change. As a result, information technology (IT) has steadily gained a prominence in the management suites of large enterprises. The Business Process Management Systems (BPMS) deployment provides a closer relationship between business process designers, and IT helps to reduce the gap between the business requirement and the final deployed solution.

The key concept of Business Process Management (BPM) is the convergence of technologies with process management theories. This convergence produces a new process design and implementation approaches that enable what Michael Hammer [6] terms the process enterprise. BPM solutions enable the process enterprise to measure and standardize processes and provide reusable processes that can be networked. This new breed of technology eases the task of changing business processes by separating the underlying applications from the business processes. Processes are no longer etched in stone once they are conceived. This inflexibility to support changing business processes was the bane of many business applications. [3], [10]

Previous works [1] and [9] describe BPMS as ideal for managing business processes which are well structured and where all logical paths can be fully predefined. However, not every business process is like this. Furthermore, the business environment is becoming more dynamic and volatile, and follows more complex processes. The existing BPMS have a number of drawbacks and limitations [9] and [14]. They need an improvement and changes. Therefore new approaches, which also include agent-based technologies, are rapidly emerging. The main advantages of the agent-based approach over more traditional counterparts such as management information systems, workflow management, and enterprise integration are those that it offers greater flexibility, agility, and adaptability. [5] Many research teams have introduced their own solution of the BPM systems using agent technology [2], [7], [9] and [12]. There are various approaches; each has its own particular enhancements and features.
of using the autonomous, collaborative and intelligent software agents with an agent-based system.

The purpose of the paper is to describe the key concepts of the agent-based system design and to point out the main differences between agent-based and centralized BPM approaches. This paper is structured as follows. Section 2 briefly informs about the BPM principles. In section 3 the intelligent agent description is presented. In section 4 and 5 we summarize the advantages and disadvantages of traditional and agent-based BPMS.

2 BUSINESS PROCESS MANAGEMENT

BPM is a systemic, structured approach to analyse, improve, control, and manage processes with the aim of improving the quality of products and services. From this definition, BPM has evolved into a management approach. Chang [3] summarizes these BPM principles:

- **Processes Are Assets** - functions or individuals do not produce value for customers. They might be responsible for a part of the overall work, but customers will not perceive value from standalone functions;

- **Processes Should Be Managed and Continuously Improved** – the management of processes entails the tasks of measuring, monitoring, controlling, and analysing business processes. These three tasks go hand in hand;

- **Information Technology Is an Essential Enabler** - in the new industrial engineering, business processes are the focus for an improvement, and IT is the key enabling tool. IT can provide real-time process information that is very important or BPM to accomplish its tasks of monitoring and controlling business processes.

BPM is characterized by these practices:

- **Process-Oriented Organizational Structure** – an organizational setup reduces the duplication of functions but still allows the organization to benefit from the process-focus one;

- **Appoint Process Owners** - a process owner is responsible for the performance of the process assigned. The process owner designs, deploys, and improves the process;

- **Top-Down Commitment, Bottom-Up Execution** - practitioners have found that the best way to implement BPM is to align it with the strategic goals of the organization;

- **Use IT to Manage Processes** - traditional systems implementation methodology is focused on functions and objects. Processes are relegated to a workflow which usually does not receive a major attention during the implementation;

- **Collaborate with Business Partners** - the management of business processes should not stop at the edge of the organization. Increasingly companies are getting more and more focused on what they want to perform in a house;

- **Continuous Learning and Process Improvement** - in the customer-centric economy, the competition is fierce and organizations have no choice but to continuously improve their current offerings and introduce innovative new offerings;

- **Align Employee Rewards to Process Performance** - employee rewards should be aligned to the performance of the business processes. This creates the situation
where workers only want to maximize their functional performance at the cost of collaboration with other functions;

- **Utilize BPR, Total Quality Management (TQM), and Other Process Improvement Tools** - BPM organizations can choose the proper tool for the appropriate situation. For incremental improvements, Six Sigma Define, Measure, Analysis, Improve, and Control (DMAIC) could be deployed.

By introducing the core principles and practices of BPMS, we are faced with the second important notion of the business process management - a Workflow Management Systems (WfMS). Workflow is defined as the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for an action, according to a set of procedural rules defined as workflow. So the workflow can be any business process, which consists of two or more tasks performed in a serial or concurrently by two or more people. The workflow should assure that the right people receive the right information at the right time. The workflow provides the following general information about the business process [5]:
- Individuals and teams needed to complete a task;
- Information and resources needed to complete a task;
- Dependencies and deadlines for the task completion.

3 INTELLIGENT AGENTS

A lot of research has emerged into the application of agents and agent-oriented concepts to help solve specific challenges faced by current industry WfMS solutions. The motivations for agents’ adoption in the workflow as discussed in [4] and [16] are as follows:
- Workflow domains typically involve disparate data requiring distributed components encapsulating local problem solving capabilities. Standard distributed WfMS applications tackle the inter-process communication aspects but fall short of dealing with the autonomous problem solving nature of the components involved.
- Workflow domains typically involve several discrete parts of an organisation structure working autonomously albeit interacting as and when required to achieve a common goal, an approach congruent with the agent paradigm.
- Agents can facilitate an intelligent management of resources and workload through the coordination and negotiation.
- Agents can provide the ability to deal with unpredictability through intelligent goal-driven autonomous decision-making, altering execution paths in order to achieve goals, including the possibility of learning capabilities.
- Agents can help ease interoperability and hence integration between components of a WfMS and even separate discrete WfMS instances given the naturally distributed systems architecture of multi-agent systems and the flexibility of semantic messaging as a more generic application interface than typical API-based approaches.

Yan, Maamar and Shen [16] also describe how some current WfMS solutions claim to leverage the power of agents in what the authors distinguish as “agent-enhanced workflow management”. In these approaches agents are used as a peripheral technology to the core workflow engine for tasks such as: personal assistant to human users, organising, filtering etc.; making some context-based autonomous decisions without
interrupting the human user; the generic interoperable interface for the integration
with other applications.

An agent is defined as a flexible software entity capable of performing an autonomous
action within the environment in which it is situated. In order for an agent to act
appropriately, it must determine the situation in which it finds itself. The full set
of actions available to an agent is described by Wooldridge [15] as its effectoric
capability. Choosing the appropriate action for this set is done at runtime based on
the decision making system employed by the agent. An important and prevalent aspect
of agent technology is the notion that typically no agent has full control of its
environment. Rather it maintains a certain (often limited) view of the environment over
which it can hold some influence. The natural consequence of this partial view is that
an agent often cannot guarantee an outcome for a situation within which it plays a part
as a result of performing its action. Agents must therefore be prepared for non-
deterministic behaviour within the environment and to adapt itself according
to the circumstances.

Most practical uses of agent technology involve not just a single agent, but multiple
agents working together in some collaborative way to fulfil a higher-level objective.
This constitutes a multi-agent system (MAS) and by nature represents a decentralised
distributed application environment where each agent maintains some level
of the control or influence in the environment [13], [15]. In MAS, each agent is aware
that it does not possess a global view of the problem and that it cannot solve the
problem by itself, thus relying on the interaction and coordination with others. It is
however still programmed to operate autonomously to compete for satisfaction of its
own self-interests, which it believes are benevolent to the goals of the overall group.
Fundamental to a MAS environment is this ability for agents to demonstrate social
interaction with other agents. As in human social contexts, how agents go about an
interaction, depends on their role and the relationship they have with the target agent.
These relationship categories as described by [11], [15] can include: peers or fellow
team members where familiarity and trust are already established; authority
relationships where one agent has more power or influence over another; coalitions
of agents within or across organisational boundaries with stricter rules of the
engagement in place to allow agent participation within a wider problem solving
initiative.

![Figure 1 – BPM Architecture (source: adapted from [2])](image-url)
The development of agent architectures represents one particular strand of the research operating under the Agent-Oriented Software Engineering (AOSE) discipline. It considers the practical implications of implementing agent systems, focussing on providing development toolkits and runtime environments that support the agent paradigm. Encompassed within agent architectures, there are considerations relating to agent lifecycle management; service provision; communication protocols and mechanisms among others, all of which are encapsulated away from the agent developer to facilitate an appropriate separation of concerns within the grander system architecture. Here we look at five broad categories of agent architectures: Deliberate, Reactive, Social, Mobile and Hybrid. [8]

4 TRADITIONAL INFORMATION SYSTEMS FOR BPM

An information system for BPM is a system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which are able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications. Such systems typically consist of the following components [14] (Figure 2): business process definition tools, business process servers, business process client applications and business process monitoring and administration tools. Business process definition tools allow you to define and map out the business process in the computer. The formalized build time business process, represented as a coordinated (parallel and/or serial) set of tasks that are connected for a common goal. Business process servers are the programs providing the run time execution of defined processes. They read the process definition and actually execute and track them. A business process client application is the software that the business participant uses to interact with the workflow. The software does not need to be the part of the BPM system. [5]

Figure 2 – Conceptual model of centralized business process management system (source: adapted from [14])
The majority of current generation BPM systems pay a primary attention to business process tasks interdependences, namely, to the enactment sequence of the tasks. Existing systems provide a central workflow engine for a business process analysis and management, which monitors all events in the system. Such systems can be adequate only in situations where a business process is fully resourced and every conceivable outcome can be considered and controlled. Unfortunately not all business processes can be defined unambiguously. The real world business is a complex, continuously changing environment, so it is hard for centralized BPM systems to reflect real world changes adequately. Their structures suffer from a number of drawbacks and limitations, including [9] and [14]:

- Limited flexibility during process enactment;
- Inability to cope with dynamic changes in resource levels and a task availability. Existing systems tend to lack the necessary facilities to redistribute work items automatically as and when required;
- Inadequate exception handling, especially during the processing of decomposed items;
- Limited ability to predict changes, due to external events, in both the volume and the composition of work;
- Incompatibility of the systems components. The majority of existing BPMS consists of comparatively independent subsystems, which can hardly be linked to each other;
- Poor system accessibility and usability by the users;
- Inadequate representation of the real world business process that makes it difficult for users to work with this system (especially for BP participants that are not involved in the system maintenance), which in their turn leads to the situation, when the system is not used by the users, and it just represents a wider gap between the real world process and it’s computer representation;
- Usually the lack of performance, scalability and reliability.

5 AGENT-BASED BUSINESS PROCESS MANAGEMENT SYSTEMS

One of the possible decisions to eliminate the drawbacks of the traditional BPM systems is to involve agent technology in the coordination of business processes. An agent-based BPM system is a set of software components that meet the criteria to be considered as agents and are involved in managing the flow of work through a business process [14]. The idea of the agent-based BPM systems is to split a business process into groups in order to commit the coordination of this process groups to an autonomous software agent (Figure 3).
Business logic, explicitly defined to an agent by a set of business roles, is intended to show agent’s task and resource dependencies on other business process participants, which usually are agents too. Agents use business logic to plan their activities in order to achieve the goal of the concrete process participant. Communication protocols are implemented in order to allow an agent to synchronize their actions. The knowledge about the business process logic is distributed among participants of the process. Each agent acts according to his user goal, provides actual information about participant’s current tasks and deadlines. Intelligent agents should be able to plan their actions, make searches for achievements of alternative goal solution parts, explain own actions to the user and give advice.

5.1 ADVANTAGES OF THE AGENT-BASED BPMS

Here the authors sum up the main advantages of an agent-based BPM usage [1], [11]:
- The use of goal oriented, communicating autonomous agents, which also concerns about business logic, allows multiple solution paths to the business process goal to be achieved;
- Agent-based technologies allow greater flexibility and dynamism in the business process management system. Decoupling components of the system allows them to be swapped out, replaced, or even added to the system without impacting on other parts;
- It allows decentralized ownership of the tasks, information, and resources involved in the business process;
- Agent-based systems provide an access to the system, even if the system is physically distributed. They allow building highly decentralized, distributed systems, which corresponds to the real world situation, when the business processes in organizations are physically distributed;
- The use of autonomous agents provides a high degree of natural concurrency, when many interrelated tasks are running at any given point of the business process.
5.2 DISADVANTAGES OF THE AGENT-BASED BPMS

As mentioned in [9] the very nature of the agent paradigm leads to a number of problems, common to all agent-based applications:

- Agent-based systems have no overall system controller. It means that agent-based solution is not the best choice for managing business processes with a lot of global constraints to be maintained. The agent-based solution is not appropriate for domains in which global constraints have to be maintained, in domains where a real-time response must be guaranteed, or in domains in which deadlocks must be avoided;

- Agent-based systems have no global perspective. An agent’s actions are, by the definition, determined by that agent’s local state. However, since in almost any realistic agent system, the complete global knowledge is not a possibility, this may mean that agents make globally suboptimal decisions. This is one of the main issues that the agent-based business process systems managers should take care of;

- Users of the agent-based system usually face trust and delegation problems. For individuals to be comfortable with the idea of delegating tasks to agents, they must first trust them. Users have to gain confidence in the agents that work on their behalf, and this process can take time.

CONCLUSION

This paper looks through general theoretical questions about agent-based business process management. It gives an overview of the main concepts of BPM and figures a general conceptual model of the traditional and agent-based BPMS. The paper points out key properties of agent-based BPMS, sums up main advantages and disadvantages of such systems. The existing agent-based BPMS solutions, which have already been developed and applied as the solution of the real world problems, prove that the agent technologies are a highly perspective direction for future researches.

Bibliography references


