BDI-Agents for Agile Goal-Oriented Business Processes

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ABSTRACT
Business processes are the core assets of enterprises. They turn the business potential into actual competitiveness on the market. To face the challenges posed by today's changing and uncertain business environment, traditional business process management (BPM) approaches are not sufficient anymore. This paper presents an approach to business process management, which leverages Agent Technology, especially BDI-Agent features to obtain agile business process behavior. This paper sketches the problem, describes the solution approach, and presents the experiences gained in a concrete case study in the domain of Engineering Change Management.

Categories and Subject Descriptors
I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *Intelligent agents Multiagent system.* H.4.1 [**Information Systems Application**]: Office Automation – *workflow management*

General Terms
Design, Experimentation

Keywords
Autonomous Agents, BDI Agents, Business Process Management, Goal-Oriented Business Process Modeling, Agile Business Processes.

1. INTRODUCTION
The definition of the core business processes is fundamental for any enterprise across all kinds of industries. The effective setup, execution and evolution of business processes have an essential impact on successful business operations. By definition a business processes consist of a set of activities, connected in a structured whole. Business processes describe the modes of operation of an enterprise in given situations.

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Business Process Management (*BPM* for short) subsumes all activities that an organization performs in order to create, maintain, control and evolve its business processes. BPM involves people, organizations and technologies [1], [2]. In addition, BPM can be carried out with varying levels of automation. Nevertheless we think that running business processes should be supported by modern information technology.

The past years in business where characterized by trends towards more flexible ways of working, shorter organizational reaction times and fully embracing market, business unpredictability, along with the increase in distribution and the need to preserve understandability despite more and more complexity. These trends show no signs of abating.

Compared to these challenges, the current status of BPM in most companies is inadequate: Business process models are modeled by graphical modeling tools. Unfortunately these "should-be" processes are usually only used to cover white walls in the offices. This is due to the fact that today's modeling tools support a very simple mind model behind modeling: processes are seen as long and fixed sequences of activities, which is far away from reality and from the challenges. The processes really executed are different from the ones on the wallpapers; "shadow" processes dominate the "official" ones. IT systems are built with the outdated "should-be" processes in mind; the process is mostly hard-coded with no explicit representation of the process. Thus the IT-Systems are outdated as they are rolled out. They are not understood or inflexible and hence misused by many users. Changes of the process and the supporting IT-systems are costly, imply the high risk of code modification, and always lag behind reality.

The main challenge is thus business process agility. Agility means not only to have process flexibility, i.e. the ability of the process to be adapted. An agile process should be able to pro-actively adapt itself quickly to a changing environment. This should be achieved both at modeling level, i.e. a changed process model should be transferred seamlessly into the supporting IT-system; and at execution level, when the executing process adapts itself to the current environment.

This paper presents *agile, goal-oriented business process management* as an effective approach to these challenges. The approach is based on agent technology, which offers methodologies and tools to meet the requirements mentioned above. The approach was successfully applied to a business process for engineering change management in the automotive industry.

This paper is organized as follows. Section 2 describes the major challenges of achieving agility in BPM, with particular reference to the domain of engineering change management. Section 3 presents the idea how Agent Technology is used in conceiving and realizing a solution for agile BPM. Section 4 presents details of the project agile change management (ACM; for short) and describes the experiences we have gained in applying the approach in a real-world business process. Lastly, Section 5 concludes the paper and gives an outlook on future work.

2. REQUIREMENTS FOR AGILE BPM

Compared to typical business processes, e.g. in call centers or financial services, managing engineering processes is even more challenging for several reasons [3]: First, they are long running processes. Designing a car takes many years and the next model of a large airliner is the result of nearly a decade of engineering and production planning. During this time period things change – what has been an up-to-date approach in the beginning may be outdated at the end. Second, engineering processes have to cope with uncertainty because of their mixture of creative tasks, collaborative work and repeating activities. This results in very complex processes with many alternative paths and sections that cannot be planned in advance. Third, some products became so complex that not all engineering tasks can be performed within one enterprise. This results in engineering processes which are partly executed by external partners. Managing such processes means to handle external engineering tasks without knowledge about "how" they internally work to provide their service.

Engineering change management (ECM) is one of the most crucial processes in engineering [4]. The process ensures that any change made to the product is documented, evaluated regarding costs, technical feasibility, compliance to laws and regulations, etc. Based on this detailed evaluation a decision is made, whether the change will be actually performed and implemented. Due to the big number of involved departments change management can be a long running, time-consuming process.

However for a certain class of changes (e.g. software bug fixes or minor changes) the "normal" process is too long and too complicated. Therefore a somewhat different process is needed to support this sort of change requests. Today this problem is handled by so called "light processes". But the demand for light processes tends to increase more and more. In addition any process variants have to be implemented by the supplier of the software and it takes some time to have a new process variant implemented. In the current Daimler ECM system more than a quarter of the changes run such a light process. Moreover often even a light process does not really fit the business needs. Today it is not possible to adopt a fitting process in time. Therefore this way of handling the engineering change process is not feasible any more.

Facing these challenges we think a new approach for modeling and executing business processes is needed. The approach has to

- support designing huge, complex processes
- decrease the effort for changing and maintaining the process model and IT-system by offering a seamless transfer of a process model into an IT-system and
- allow flexibility and agility in process execution through IT-systems.

We have found no commercial product that achieves these requirements in a satisfactory way. E.g. the ARIS tool suite [5] offers comprehensive modeling functionalities, but does not (yet) support the seamless building of an IT-System out of the process models. Approaches towards more flexibility of workflows, as described in [6], add flexibility on a rather low-level. They allow, e.g. to add or skip certain single steps in a workflow. But the overall process stays in principle the same.

We think that agent technology can offer better approaches and methods to meet the requirements stated above. Agent-oriented software technology was first introduced to deal with large-scale, distributed software systems, which are embedded in dynamic environments, and allow for the interaction of different partners.

3. USING BDI-AGENTS FOR BPM

3.1 From Agents to Agile Business Processes

Having the main challenge in mind to make business process agile, agent technology was our first choice to look for support. Multi-Agent Systems have presented the idea of agility in different application areas: flexible production control allows for agile behavior of the whole system facing changes and disturbances [7], system in logistics present an agile transportation planning [8], In the RoboCup [9] robots play football and act very flexibly and agile in their environment. Having this in mind, how can agent technology be used to support agile business processes?

In the BDI (belief-desire-intention) agent architecture an agent is described by its *beliefs*, i.e. the information an agent has about itself, its environment and possibly other agents; its *desires*, i.e. motivations of the agents that drive its course of action; and finally its *intentions*; i.e. the short-term goals that the agent wants to achieve, derived from its desires and external events, to which the agents wants to react. To achieve its goals/intentions an agent has certain plans how the goals can be achieved. Different plans are designed for different situations, which is described by the plan's context condition. A plan consists of certain actions/steps that have to be executed to achieve the corresponding goal.

The BDI architecture was first implemented by [10]. In an implementation the execution is as follows: The agent has to decide which goals it wants to follow next and which plan can be used to achieve the goal. To accomplish this, the agent introspects its goal base and extracts the goals which are not yet fulfilled; next it collects all plans from its plan base which could be used to fulfill these goals; finally it checks the current context (i.e. the current belief base) whether it fits to the context the plan was designed for. Performing the plan means to execute the single steps of the plan. These single steps can be: interacting with the environment, e.g. with the user of the system, performing some kind of computation, manipulating the own data base (belief base), or sending and receiving messages from other agents.

In section 4 we will describe how we have used this goal-oriented and context-aware execution of agent plans to allow for agile, goal-oriented business processes. But before that we will have a look at the relevance goals have in business process management and modeling today.

3.2 Goals in BPM

In day-to-day business operations, it is natural to set goals, decompose a goal into sub-goals, define or reuse plans, and routinely track and check the execution of chosen plans in order to detect problems as they occur (or even better before they do), and to take appropriate actions.

In business organizations there is an upper management level, which coarsely drives the more detailed project planning and tracking. Such a level gives clear direction without unnecessarily limiting the decisional power and the adaptation leeway of the finer-grained management operations.

It is thus natural for upper managers to be more concerned with (and express their views in terms of) what is to be achieved than how to achieve it. Operating at the goal level is a natural approach for such people with the core of the business process captured through goals and sub-goals independently of the actual activities.

When moving to detailed planning in business or project management, there is usually more to the plan than just its tasks and structure. At the very least, the expected objectives of the plan need be stated, and also, in many cases, the initial requirements. Moreover, additional information such as resource and time consumption is also often attached to a plan.

Although the goal-orientation seems quite natural to the area of business process management the modeling of the actual business processes (i.e. plans) is nowadays not linked to the goals. In the widely used business process modeling suite ARIS [5] it is possible to describe business goals, but there is no direct link to the model of the actual processes.

There are some approaches to address this neglect. In [11] the relation of business goals to business activities is described with the aim to build up an object-oriented business process model. A Goal/Means-Hierarchy is defined, where Means are linked to object methods, representing business activities. Input and output of the activities is described to get the execution sequence of the activities. In [12] the authors define a formal framework to relate goals derived from requirements specification to the business processes modeled in BPMN (business process modeling notation), an emerging OMG (object management group) standard for business process modeling [13]. The linking of goals and processes is twofold: A first link between a goal and an activity in the process model, states that the goal has some effect on the activity (this may be an achievement effect, but also an obstructing effect.). A second link states whether the activity satisfies the goal or how it satisfies the goal. Nevertheless, the relation of goals and processes and especially how they are working together in process execution remains unclear in both cases.

We think that this missing link from business goals to executable processes and process steps can be filled by agent technology.

Although the coupling of agent technology and business process management is not new, existing approaches (e.g. [14], [15]) focus on agents' communication and cooperation (and mobility) abilities to support the process execution. Single tasks are modeled as services and agents offer and use these services in executing the process. Moreover different types of agents are used for the implementation of a workflow system [16]. Goals do not play any role in the sense of business goals in these approaches.

Closest to our idea is the work of Georgeff, realized in the Agentis platform [17]. Agentis uses the BDI architecture for business process modeling and management. Nevertheless the main focus is to use agent plans as business process, no explicit modeling of goals is done.

4. GOAL- & CONTEXT-ORIENTED BPM

4.1 Plans and Goals to Express Processes

Inspired by agent technology and the concept of goal orientation and decomposition the main ideas behind our modeling approach are (i) to have a modular process model that describes the single steps of a process (sub-processes, activities) separate from the goals of the process and the different contexts in which the process can be executed; and (ii) to have different modeling levels, for the different parts of the process model. This modular, goal- and context-based process model can then be executed as an agile process, by considering current goal and context when determining the next step in the process, just as realized in the BDI agent architecture. The agent can be seen as an assistant or guide of the user who is responsible for "driving" a task through the process. Since the agent can perform a lot of routine work for its "boss", it can take over the role of a "process driver" on behalf of the user.

An additional effect of using this goal-oriented approach is the separation of the statement of *what* the desired system behavior is, from *how* the behavior is performed.

The process modeling consists of several steps: First the goals that have to be fulfilled by the process are identified and gradually refined by sub-goals. Goals can be operational goals, defining the actual outcomes of the process or more general goals, concerning time, cost and quality that have to be obeyed by the process. These two kinds of business goals result in two types of goals: *achieve goals* are used to model the operational goals of the process; *maintain goals* are used for those goals, the agent will monitor during process execution.

Next the different possible contexts of the process are described by means of *context variables*. These variables describe certain aspects of the process environment that will influence the process execution.

If no more sub-goals can be defined for a goal at the next level the different ways to achieve or maintain a sub-goal, i.e. the plans have to be defined. For each plan a condition has to be defined stating the condition in the process context, when this plan will be used to fulfill its corresponding goal. Maintain goal also have a *maintain condition* that has to be true all the time. The corresponding plans for these goals are called as soon as the condition becomes false. Any conditions refer to the context variables and their possible values.

As a result the final model of the business process will consist of one or more goal hierarchies, a list of context variables (with their possible values) and a set of plans with conditions linked to sub-goals. In the next section a process modelling for an engineering change management process will be explained in some more detail.

4.2 Modeling the ECM process

We have used this modelling approach for the engineering change management process of Daimler AG. We started this project, now called "agile change management" (ACM) in 2005 with a