Stochastic Modelling and Simulation of Dynamic Resource Allocation

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1 Introduction

In contrast to computer systems, human behaviour is only predictable to a certain degree of probability. In semi-automated business processes human actors are guided by predetermined policies and regulations but retain the freedom to react to unforeseen events. For example, if an urgent prescription has to be dispensed by a pharmacist and the current pharmacist on duty is busy, it is likely that they would interrupt their current activity. The assignment policies in a model of this process should accurately define exception handling procedures in order to realistically simulate business processes. Other policies may require task assignment to the least-qualified person available to do the job if the people involved have different levels of access rights and qualifications.

Problem statement. It is difficult to accurately model and simulate the dynamic behaviour of humans in business processes without taking into account the following requirements: 1) access control; 2) dynamic (re)-assignment; 3) role promotion ; 4) resource assignment; 5) assignment policies; 6) process scheduling influenced by deadlines and priorities; 7) escalation handling; 8) probability of the resource performing/selecting tasks; 9) non-deterministic duration of tasks.

2 Proposed Solutions

A new modelling approach for human actors in business processes that replaces the rigid control flow structure with a more flexible rule-based approach is being proposed. A metamodel is used to define the abstract syntax influenced by Role-Based Access Control (RBAC) [9], whereas concrete syntax extends the UML notation of class and use case diagrams (R1). A Domain Specific Language (DSL) will be used to define the orchestration between participants and their corresponding roles and responsibilities in terms of standard organisational modeling [7] techniques for assignment of activities to resources in organisational structures (R3-5). Graphs will be used to represent system states and stochastic graph transformation will be used to model state changes with non-deterministic timing, such as the execution of a business action with a known

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average delay or the assignment of an actor to a role (R2,9). This allows us to model semi-structured processes, where actions are not chosen based on a fixed control flow but non-deterministically, influenced by deadlines, priorities and escalation events (R7-8). The operational semantics of stochastic graph transformation (GT) allows for simulation and analysis of dynamic reconfiguration (R2). The stochastic simulation will use probability distribution to predict the timing of operations, which will provide analysis facilities for gathering service level guarantee metrics and policy comparisons (R9).

At the same time the visual, rule-based approach provides an intuitive notation for structural changes. The approach also distinguishes between domain-specific and domain-independent GT rules. This enables specification of generic human resource allocation policies, which are defined using application conditions and constraints [6] (R5).

Current status of the PhD project. The syntax and semantics for the visual modelling language has been developed, which allows us to model human resources as part of business processes using a rule-based approach. The model will be implemented in an existing stochastic simulation GT tool [10] to validate performance aspects of the model, such as the probability for cases to finish within their deadlines, comparing different scheduling policies.

3 State of the Art

Standard business process modelling notations, such as UML or BPMN [8] do not address the dynamic assignment of roles to individual actors. BPMN represents business roles as participants, but is constrained by high-level concepts such as swimlanes to a static partitioning of activities, whereas WS-HumanTask and BPEL4People specify humans as part of service-oriented systems or processes by capturing task priority, assignment, and timeouts, and triggers appropriate escalation actions [1]. However, these xml-based languages lack visual representations suitable for domain and business experts and were not built with the intention of use in simulation engines.

There are various simulation approaches that are currently used in industry and research environments, which are based on the flow oriented style of modelling and provide functionality for modelling, analysis and design for business process management. Little-Jil [5] is a domain independent agent coordination visual language used for modelling and simulating process steps in a control flow manner. It captures key aspects of exception handling and deadlines; however its focus is primarily on the process step with very little on human resource allocation, whereas ADONIS [2] is a simulation tool that captures general aspects of resource allocation; however it is missing the requirements of escalation handling, deadlines, priorities, and assignment policies.

On the other hand, the rule-based modelling style has been used in agent-based systems to specify agent operations in a way comparable to the specification of our business activities [3]. While humans can be regarded as autonomous

agents, our approach adds the element of dynamic reassignment of human agents to roles as well as the modelling of non-deterministic timing of actions. This relation is explored in more detail in a previous paper [4]. In summary, none of the approaches completely satisfies the requirements laid out in Section 1.

4 Evaluation

The model will be evaluated in terms of usability, flexibility and scalability. Usability testing will be accomplished by experiments with computer science students developing models in the new language in comparison to existing languages using standard business process model examples. Scalability will be verified through simulation experiments on larger models, whereas flexibility will be verified by modelling experiments and analyzing their resulting models. The evaluation's test results would provide data on the models: ease-of-use, response to uncertainty and load impact. These results will be used to verify the correctness of the modelling approach and for future language improvements.

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