ADIGE: Semantic Business Process Management for Smart Retail Environments

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ABSTRACT

We present the first system, called ADIGE, for the managment of semantic business processes in smart retail environments. Processes in ADIGE are modelled and maintained with the ARIS Business Architect tool, which makes use of a process assistance agent to support the process designer in the realization and adaptation of these processes with services at design time and runtime. The agent exploits means of semantic service selection and composition planning for this purpose. Executable processes can be registered at a smart retail management dashboard for certain events on objects which are monitored by an instrumented retail environment. This allows the retail store manager to get informed on and execute required processes that are recommended by the system in reaction to detected changes in the environment. The ADIGE system prototype has been successfully tested for common business processes in the retail domain in the innovative retail lab of a large European supermarket chain.

Categories and Subject Descriptors

H.5.m. [**Information Interfaces and Presentation**]: Miscellaneous

Keywords

Business Processes; Smart Environments; Semantic Services

1. INTRODUCTION

In instrumented environments like for smart factories [15] and smart supermarkets [9] the control and monitoring of the sensor-actuator network is usually decoupled from the management of relevant business processes. For example, the automated identification of a lack of goods on shelves in a retail store or in stock by an instrumented environment may require the store manager to execute the business process model designed for their reordering. However, there are no integrated solutions for adaptive process management in smart retail environments available yet.

On the one hand, many tools and systems for business process management (BPM)[24] support the service-based realization of process models [6, 8]. Since the availability and relevance of services for business process models can change at any time, there is a need for service-oriented process adaptation to such changes at design time and runtime. That can be realized with event-based semantic reselection and replanning of relevant services and the subsequent redeployment of the adapted process model [7]. In particular, external context parameters which are dynamically determined by an instrumented environment can be taken into account for a context-based generation, selection, and execution of required process variants of a process meta-model. However, despite tremendous advances in the fields of BPM, service-oriented computing and semantic technologies, to the best of our knowledge, no BPM solution is offering this functionality yet.

To this end, we developed the first system, called ADIGE, which exploits means of semantic service selection and composition planning to support the management and adaptation of service-based process models. Business processes are modelled and maintained in ADIGE with the ARIS (ARchitecture of Integrated application Systems) Business Architect tool. In particular, a process assistance agent proactively supports the process designer in his activity to implement business process models with services, notifies both designer and store manager on detected changes, and recommends respectively adapted process service plans at design time and runtime. The instrumented ennvironment is controlled and monitored by the store manager with a web-based interactive 3D management dashboard. Business processes can be executed in reaction to detected specific events in the instrumented environment. In ADIGE, process redeployment is not done automatically by default but requires a confirmation by the responsible person.

The ADIGE system prototype has been developed jointly with and tested for the adaptation of common business processes iun the retail domain, in particular for the semi-automated reordering of goods, in the innovative retail lab of a large European supermarket chain. Although the system has not undergone an extensive evaluation yet, but has been successfully demonstrated at the computer systems fair CeBIT, and is part of the innovative product portfolio of Software AG for a future release of the ARIS Business Architect tool.

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The remainder of the paper is structured as follows: The ADIGE system architecture is outlined in Section 2, which is then complemented with the description of an example application for semi-automated reordering of goods in a smart retail environment in Section 3. We discuss related work in Section 4, and conclude the paper in Section 5.

2. THE ADIGE SYSTEM

The ADIGE system facilitates the semi-automated adaptation of business process models to changes of the availability, performance, and relevance of services for business process models at design time and at process service execution time. For this purpose, the system comprises of the following main components (cf. Figure 1): The ARIS Business Architect tool, the process assistance agent, the process execution engine, and the smart environment managment dashboard.

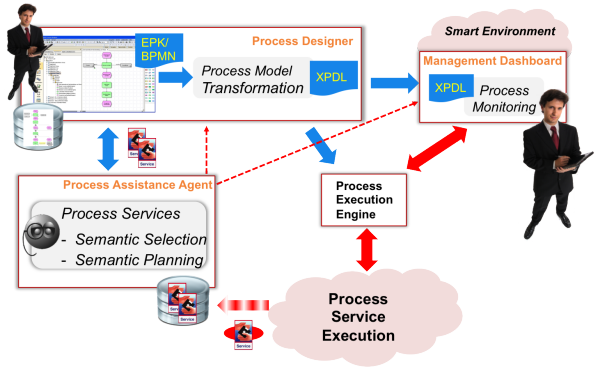

Figure 1: ADIGE system architecture

Semantic business process modelling and annotation. The ARIS Business Architect 7.2 tool of the ARIS Design platform facilitates the modelling of process models and their semantic annotation. Following the model-driven approach, process models on the CIM (Computational Independent Model) level are modelled in the EPC (Event Process Chain) notation, and in standard BPMN. In addition, the process designer can semantically annotate each task of a process model with concepts which semantics are formally defined in an ontology in OWL2. Classes of imported domain ontologies are used to annotate inputs, outputs, prerequisites and effects of a process task (cf. Figure 2)). The semantic annotation activity is supported by a dialog-based wizzard of the ARIS Business Architect, and the resulting annotation is stored together with the process model.

The annotated process models are then realized with semantic service plans that are generated by the process assistance agent, and eventually confirmed by the process designer. These service-based process models are transformed into an executable form in XPDL (Execution Process Description Language), which is then passed to a process execution engine. Executable processes that are supposed to be executed in case of specific events in the instrumented environment are also registered at its management dashboard. The process execution engine coordinates the execution of process services either at a central site, or at the local sites of service providers, and the process assistance agent gets informed about the performance and availability of services.

Semantic process service selection and planning. The

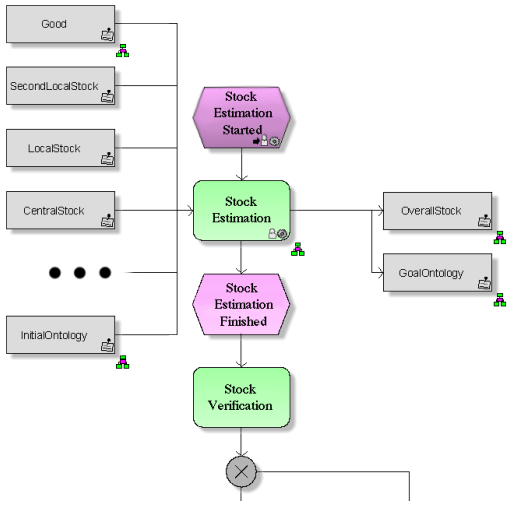

Figure 2: Semantic annotation of a process task (green) with concepts (grey) in the ARIS Business Architect

implementation of annotated business processes with services is supported by the process assistance agent which interacts with the ARIS Business Architect, and the process execution environment for this purpose. It makes use of the open-source tools iSeM [13, 12] and OWLS-XPlan2 [14] for a high-precision semantic selection and automated composition planning of services in OWL-S, respectively. The used semantic services are grounded in executable web services and registered by service providers in the service repository of the agent. The agent detects changes of the availability and performance of registered services, performs an automated replanning of the affected process service plans in reaction to these changes, and notifies both process designer and store manager on the availability of the respectively adapted business processes. The planning problem description in PDDL is generated by the agent from the process model annotation in OWL2, its initial and goal state ontology, and the set of registered semantic services in OWL-S. An example of a process service plan which satisfies all requirements that were specified by the process designer in the annotation of the process task "Stock Estimation" is shown in Figure 3. The signature variable bindings of chained services on the grounding level are set by the designer with the Business Architect wizzard. Generated process service plans are maintained by the agent for their potential re-use in future interactions with the process designer.

Whenever a new service, or service variant with changed parameters becomes available, the agent registers them in its service repository, and generates an adapted process service plan variant for each affected process model. It notifies the process designer and the store manager about the nature and benefits of the changed process models such as a potential speed-up of process execution. That supports both manager and designer in making their decision whether this adapted process shall be redeployed, or rather not. If the semantic annotation of business process models is changed, then the agent attempts to repair the affected service plans by means of semantic re-planning and re-selection of services. The process assistance agent has been implemented in Java using

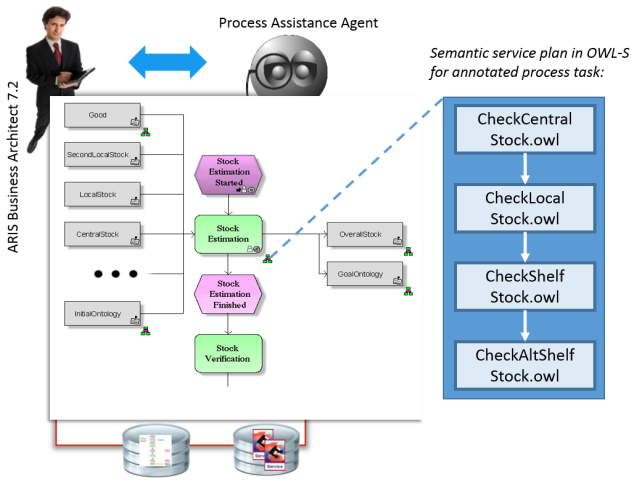

Figure 3: Agent-based realisation of annotated process task with a semantic service plan

the JADEX agent building environment.

Smart environment management dashboard. The ADIGE management dashboard (MaD) virtualizes the sensor-actuator network of an instrumented environment according to the dual reality paradigm [16] in a web-based interactive 3D visualization interface using XML3D[1]. In particular, business processes that shall be executed in reaction to the occurrence of events which are defined for objects in the environment, or that have been adapted by the process assistance agent during their runtime, are displayed aside the 3D view of the store. The MaD relies on a CEP (complex event processing) system which processes the monitored context and interactions with RFID-equipped objects in the smart environment, and detects events based on pre-defined patterns and context parameters. The store manager can use the MaD to specify ECA (event-condition-action) rules for the execution of service-based business processes with given context parameters. On the occurrence of certain context parameter constellations which are detected by the CEP, the store manager gets respectively notified, may confirm, and then observe the progress of the execution of the relevant process with his ADIGE MaD.

3. APPLICATION SCENARIO

The ADIGE system has not undergone extensive evaluation yet, but already tested in the innovative retail laboratory (IRL) of a large European supermarket chain for a few common use case scenarios in the retail domain. We briefly describe one of them for the semi-automated reordering of goods in smart retail environments. In the specific instrumented environment of the IRL, every product is equipped with an RFID (Radio Frequency Identification) transponder and the shelves with RFID antennas. This instrumentation allows the CEP of the ADIGE MaD to detect, in particular, out-of-stock (OoS) events, that is whether products of some type are present in shelves of the store, or not. Whenever customers remove products from a shelf, the RFID antennas attached to this shelf send events including those removals which are processed in the CEP module of the MaD. In fact, the MaD recognizes whenever the current count of products is below a given threshold, notifies the store manager about the fact that there is, for example, only one product of this type left in the store, and also displays the relevant business process for its semi-automatic re-ordering (cf. Figure 4).

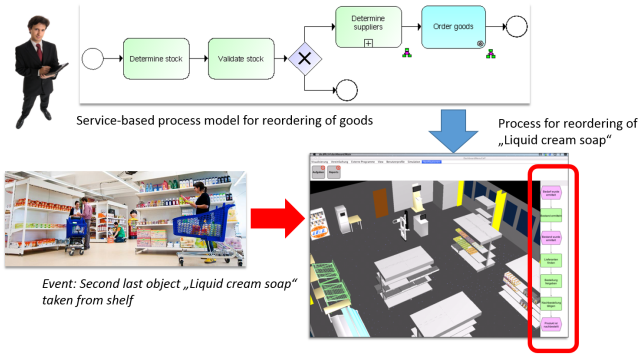

Figure 4: Simplified business process model and its event-based call for semi-automated reordering of goods by the smart environment 3D dashboard

This process has been designed and implemented with services with the ARIS Business Architect and the ADIGE process assistant agent (cf. 3). In our simplified example, the process task for estimating the overall stock comprises four services: Since the overall stock concerns the products in the shelf which, however caused the out-of-shelf (OoS) situation, the service plann checks for alternatives. These are, in this case, to look for the same product type at some different location in the same supermarket, the local, and the central warehouse. If there are enough products of the requested type available at other locations, notifications are sent to the supermarket staff in order to replenish the stock at the particular shelf with the out of stock product. If no products were found, however, the service-based process calls a service to search for suppliers of that type of product which are top-rated according to supermarket's guidelines, and rate their quality of service afterwards with an appropriate service of the same process model. The last task of the process model is implemented with a service that sends an order to the supplier with the best scores. The MaD gets informed by the process execution engine about and displays the execution progress to the store manager. If services become unavailable or a better performing service is registred, the process assistance agent immediately generates the respective alternative process service plan and notifies the tore manager about the changes. The store manager decides on whether the changed parts of the running process shall be replaced at runtime, or a full redeployment of the process is in order.

4. RELATED WORK

There are several initiatives and approaches to enhance business modelling standards and BPM systems with semantics [7, 23]. For example, reference architectures and frameworks for semantic business process modelling are proposed in [10] and [4]. Approaches to extend the standard BPMN and EPCs with semantic annotations are described in [1, 5, 17, 11]. An extension of ARIS for semantic BPM is presented in [20, 19]. Like in ADIGE, processes are designed

[1]http://xml3d.org

and semantically annotated with ARIS Business Architect, and then transformed into executable BPEL. Services for realising atomic tasks are selected during execution time according to the semantic annotations, though by use of a not state-of-the-art matchmaker. However, unlike ADIGE, the generation of service plans is not supported by this system, and the service selection remains opaque for the process manager. Also similar to the ADIGE system is the BPM research tool Maestro [2] which supports the realisation of semantically annotated business tasks with concrete services by means of automatic discovery and composition of services.

However, the ADIGE system mainly differs from the above mentioned works in particular in the following aspects: ADIGE (a) provides an agent-assisted realisation and adaptation of business processes with semantic service selection and planning in the ARIS Business Architect, (b) facilitates an event-driven selection and controlled execution of relevant business processes in smart environments, and (c) has been practically deployed in the innovative retail laboratory of a large European supermarket chain.

5. CONCLUSION

This paper presented the first system, called ADIGE, for the managment and adaptation of semantic business processes in smart retail environments. For this purpose, the system integrates the ARIS Business Architect tool with process execution engine, a process assistance agent capable of semantic service selection and composition planning, and a smart environment management dashboard. Processes are adapted to detected changes in the availability and performance of relevant services by means of semantic reselection and replanning of services. Retail managers get informed on and may control the execution of processes that are recommended by the system in reaction to detected changes in the instrumented environment. The ADIGE system prototype has not undergone an extensive evaluation yet, but successfully tested in the innovative retail lab of a large European supermarket chain. Ongoing work is concerned with the dynamic KPI-driven optimisation of process service plans and respective semantic data stream processing.

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