The ADEPT WfMS Project at the University of Ulm

Peter Dadam and Manfred Reichert
Faculty for Informatics, Dept. Databases and Information Systems
E-Mail: {dadam, reichert}@informatik.uni-ulm.de
WWW: http://www.informatik.uni-ulm.de/dbis

Introduction and Background

In the ADEPT[1] project [ADEPT] we are looking at different facets of advanced process-oriented information systems in conjunction with each other: Component-based application development, exception handling and flexibility issues, dynamic workflow changes, temporal aspects, workflow evolution, inter-workflow dependencies, man-machine interfaces, scalability, and WfMS architectures and implementation.

The roots of the ADEPT project go back into the year 1992, when the interdisciplinary research project "*Open Clinical Information and Database System for the Integration of Autonomous Subsystems*" (OKIS, 1992-94) started. The intensive discussions we had with the medical personnel and the investigations performed within the OKIS project have made clear to us that "passive", data-centric information systems alone are by far not sufficient to solve the pressing problems found in most clinical application areas. Being confronted with the presence of decentralized, autonomous information systems on the one hand, and the necessity to actively support even long-running, complex "processes" on the other hand, it became evident that this can not be achieved at reasonable costs and with the robustness needed by the use of conventional programming methods. Instead, we came to the conclusion that a system layer is needed that "knows" the processes to be supported and, therefore, can take care about the tasks coming up in the context of starting, stopping, and monitoring locally and remotely executing application components, of delivering data to these components at invocation-time, of taking care of their output data, and of performing synchronization and recovery when necessary.

Consequently, we shifted the emphasis of our conceptual work towards the design of a cooperative, process-oriented information system for the clinical domain (see [Kuhn94], [Kuhn94a], [Dada95]). To prevent ourselves from becoming too academic with regard to our research directions, we complemented our basic research work with the application-oriented project "*Use of Workflow Management Systems for Clinical Applications*" (1996-97). It was performed in tight cooperation with the Women's Hospital of the University of Ulm and with Siemens-Nixdorf Informationssysteme AG (which also gave financial support). The issue of this project was to analyze, to understand, and to document (and to optimize, where possible) in-depth all relevant processes from this hospital and to evaluate to which degree they could be supported by today's "high-end" workflow technology, in principle (see [RKD96], [DRK97], [RKD97], [RSD97] for more details). – Within this project we also developed a complete workflow-based application for the division "Day Clinic" of the Women's hospital (which performs minimal invasive surgery). This application was based on the commercial WfMS WorkParty of Siemens-Nixdorf. We completely replaced the standard screens of the WfMS by own user interfaces, which we especially developed for the usage by non-computer experts (see Fig. 1 as an example).

These experiences led to the insight that any serious attempt to develop an implementation platform for the clinical application domain must not only concentrate on isolated aspects of workflow technology but must try to look (as far as possible) at the overall picture. Our current research interests, and the research and development work in the ADEPT project, which reflect this thinking to a large degree, is outlined in the next section.

ADEPT – Current Research Interests

The current research interests within the ADEPT project can be summarized as follows[2].

1. **Component Ware:** Development of robust process-oriented applications based on software components. How far do we come with a "plug-and-play" vision for the development of process-oriented applications? How shall one implement the components (without knowing exactly, in which context they will be used) such that they can be easily integrated into a common user-interface, avoiding the typical "window on-top of window" style, for example? The screen in Fig. 1 from our clinial application integrates three different applications into a common interface: The left upper part gives access to the patient data,

[1] ADEPT = Application Development Based on Encapsulated Pre-modeled Process Templates
[2] The list reflects the work documented in 22 internal reports and research reports, 15 completed master theses, and 12 external publications related to this subject area up to date. – More external publications are currently under preparation.

the right half of the screen gives access to scheduling and calendar functions, while the left lower part represents the user's worklist.

2. **Robust Transactional, Process-Oriented Information Systems:** We concentrate on information systems which have to run stable and which are used by non-computer experts. Typically, in such systems users do not directly interact with the underlying WfMS (as they also do not directly interact with database systems today), but via application programs. Therefore, in general, we have to deal with application components which are called when executing a workflow step. This, in turn, means that the correct flow of data between them and the provision of parameter values at their invocation time must be analyzed, validated and enforced by the system. This becomes extremely important when deviations from the pre-modeled execution sequence shall be allowed at run-time (see next item).

3. **Exception handling / Flexibility:** The possibility to deviate from the pre-modeled task sequence at run-time is a must in clinical (and in many other non-trivial) application domains. In such environments it is either simply not possible to foresee and to pre-model all possible exceptional situations in advance or it would be an overkill to do so (see [DRK97] for details). Therefore, our research efforts concentrate on the support of ad-hoc deviations at the workflow-instance level during run-time (e.g., skipping/removing steps, introducing new steps, moving steps to another place, changing step attributes) without violating data consistency (see 2.), temporal constraints (see 5.), and robustness of the system. Data dependencies and the data-flow between steps are analyzed to decide which dynamic modifications can be granted and which have to be refused. Some details on this work item can be found in [ReDa97a] and [ReDa98]. This will also continue to be an important research area for us for the next future.

4. **Semantic Rollback.** We feel that this is a very important area, which will be one of the key factors for the success or the break-down of workflow technology. At this point, we have spent most time to understand and to solve the rollback problem (partial or complete cancellation/rollback of a workflow instance) in conjunction with dynamic workflow modifications (see 3). This includes, for example, issues concerning the correct adaptation of a workflow's internal state (marking of control edges, content of data slots etc.) as well as of its flow structure (e.g., when previously performed temporary workflow modifications shall no longer be present after the rollback; see [ReDa98]). Within the workflow application from the Day Clinic we have also investigated and prototyped how "recovery spheres" could be defined and supported by a commercially available WfMS (WorkParty in this case). Although interesting proposals have been made in the literature concerning these issues, the problem is not really satisfactorily solved so far.

5. **Temporal Aspects:** In a number of application areas (including the clinical domain) 'time' plays an important role. The support of deadline supervision solely is not satisfactory, especially in the context of dynamic workflow modifications. We, therefore, enhanced the capabilities of the ADEPT-WfMS by the support and supervision of deadlines, as well as checks whether minimal and maximal time distances between tasks, if specified, are kept. This allows us, for example, to infer the consequences for missing a deadline with respect to subsequent steps. Problems one have to deal with in this context include uncertainty, delays in the execution of tasks, and temporal inconsistencies (e.g., due to workflow modifications).

6. **Modeling / User Interfaces:** ADEPT offers very advanced concepts with respect to exception handling and dynamic workflow changes. A challenging question is how to express pre-modeled "exceptions" (i.e. execution alternatives), temporal constraints, and especially the facility for dynamic modifications to the workflow designer and to the end-user, respectively, such that they are really capable to adequately handle them. Several master theses have already addressed this issue and we expect it to remain an important area also for our future work.

7. **Workflow Evolution:** Propagation of workflow schema changes to running (and perhaps individually modified) workflow instances. Obviously, this requires a general framework for dynamic workflow changes and for change management [RHD98]. Work on this item has been started recently.

8. **Inter-workflow dependencies**: With this, we mean the specification of (global) dependencies "across" different (independently modeled) workflows and their enforcement at run-time. The goal is that some kind of "high-level" workflow scheduler supervises the execution of steps from different workflow instances and proposes desirable execution sequences for them (or refuses forbidden ones). The kind of application we have in mind here is the coordination of different examinations for the same patient; each of them is typically represented by an individual workflow instance, whereas some of these examinations or workflow steps respectively should be preferably performed in a certain order, however. Some details on this work can be found in [HeDa97].

9. **Scalability:** In general, as described above, we are mainly interested in the support of large-scale, enterprise-wide workflow applications. In such environments performance is a critical issue. At present, our research work in this area concentrates on reducing the network load by distributing the load induced

by workflow control onto several servers. During the execution of a particular workflow instance its control may migrate to a workflow server in another network segment in order to keep communication local within one network segment as far as possible. Some details on this work can be found in [BaDa97].

10. **WfMS Architecture and Implementation:** The main reason to look at different aspects of WfMS-based applications and application development is to understand the various interdependencies and contradicting architectural design goals. We have therefore started to design and to implement the ADEPT-WfMS which shall incorporate most of the aspects described above. The first version of the server component became operational in February 1998 and was demonstrated at the CeBit '98 fair.

These research and development efforts are complemented by research work done at or done in cooperation with the Daimler-Benz Research Center in Ulm on various aspects of concurrent engineering and design processes (cf. [OrDa95], [OrDa95a], [BeDa96], [BDS98]).

References[3]

[ADEPT] Please visit http://www.informatik.uni-ulm.de/dbis/f&l/forschung/workflow/ftext-adept_e.html for Information on the ADEPT research project and electronically available publications.

[BaDa97] Bauer, T.; Dadam, P.: A Distributed Execution Environment for Large-Scale Workflow Management Systems with Subnets and Server Migration. Proc. CoopIS 97, Kiawah Island, USA, June 1997, pp. 99-108

[BDS98] Beuter, T.; Dadam, P.; Schneider, P.: The WEP Model: Adquate Workflow-Management for Engineering Processes. Proc. European Concurrent Engineering Conference 1998, Erlangen-Nuremburg, Germany, April 1998

[BeDa96] Beuter, Th.; Dadam, P.: Anwendungsspezifische Anforderungen an Workflow-Management-Systeme am Beispiel der Domäne Concurrent Engineering. Ulmer Informatik-Berichte, Nr. 96-04, 1996

[Dada95] Dadam, P.; Kuhn, K.; Reichert, M.; Beuter, Th.; Nathe, M.: ADEPT: Ein integrierender Ansatz zur Entwicklung flexibler, zuverlässiger kooperierender Assistenzsysteme in klinischen Anwendungsumgebungen. Proc. GI/SI Jahrestagung, Zürich, September 1995, Mai 1995

[DRK97] Dadam, P.; Reichert, M.; Kuhn, K.: Clinical Workflows - The Killer Application for Process-oriented Information Systems? Ulmer Informatik-Berichte, Nr. 97-16,1997

[HeDa97] Heinlein, Chr.; Dadam, P.: Interaction Expressions - A Powerful Formalism for Describing Inter-Workflow Dependencies. Ulmer Informatik-Berichte, Nr. 97-04, 1997

[Kuhn94] Kuhn, K.; Reichert, M.; Nathe, M.; Beuter, T.; Dadam, P.: An Infrastructure for Cooperation and Communication in an Advanced Clinical Information System. Proc. 18th Ann. Sym. on Computer Applications in Medical Care 1994, SCAMC '94, Washington, 1994, pp. 519-523

[Kuhn94a] Kuhn, K.; Reichert, M.; Nathe, M.; Beuter, T.; Heinlein, C.; Dadam, P.: A Conceptual Approach to an Open Hospital Information System. Proc. 12th Int'l Congress on Medical Informatics, MIE '94, Lisbon, May 1994, pp. 374-378

[OrDa95] Ortiz, R.; Dadam, P.: Towards the Boundary of Concurrency. Proc. Concurrent Engineering (CE '95) - A Global Perspective, McLean, Virg., USA, Aug. 1995, pp. 191-201

[OrDa95a] Ortiz, R.; Dadam, P.: The Concurrency Model: Activating an Engineering Database Through an Integrated Product and Process Data Model. 6th Int'l Conf. and Workshop on Database and Expert Systems Appl ications, DEXA '95, Workshop Proceedings, London, UK, Sept. 1995, pp. 197-204

[ReDa97a] Reichert, M.; Dadam, P.: A Framework for Dynamic Changes in Workflow Management Systems. Proc. 8th Int'l Workshop on Database and Expert Systems Applications, Toulouse, France, Sept. 1997, pp. 42-48

[ReDa98] Reichert, M.; Dadam, P.: ADEPTflex - Supporting Dynamic Changes of Workflows Without Losing Control. Journal of Intelligent Information Systems, Vol. 10, No. 2, March/April 1998, pp. 93-129

[RHD98] Reichert, M.; Hensinger, C.; Dadam, P.: Supporting Adaptive Workflows in Advanced Application Environments. To appear in: Proc. EDBT Workshop on Workflow Management Systems, Valencia, Spain, March 1998

[3] Most of these publications are available electronically. Please consult our home page.

[RKD96] Reichert, M.; Kuhn, K.; Dadam, P.: Prozeßreengineering und -automatisierung in klinischen Anwendungsumgebungen. Proc. GMDS '96, 41. Jahrestagung, Bonn, Sept. 1996, S. 219-223

[RKD97] Reichert, M.; Kuhn, K.; Dadam, P.: Optimierung und Unterstützung von Leistungsprozessen im Krankenhaus - Perspektiven, Erfahrungen und Grenzen. Proc. 20. Deutscher Krankenhaustag und INTERHOSPITAL/INTERFAB 97, Juni 1997, S. 668-682

[RSD97] Reichert, M.; Schultheiß, B.; Dadam, P.: Erfahrungen bei der Entwicklung vorgangsorientierter, klinischer Anwendungssysteme auf Basis prozeßorientierter Workflow-Technologie. Proc. GMDS '97, Ulm, September 1997, S. 181-187

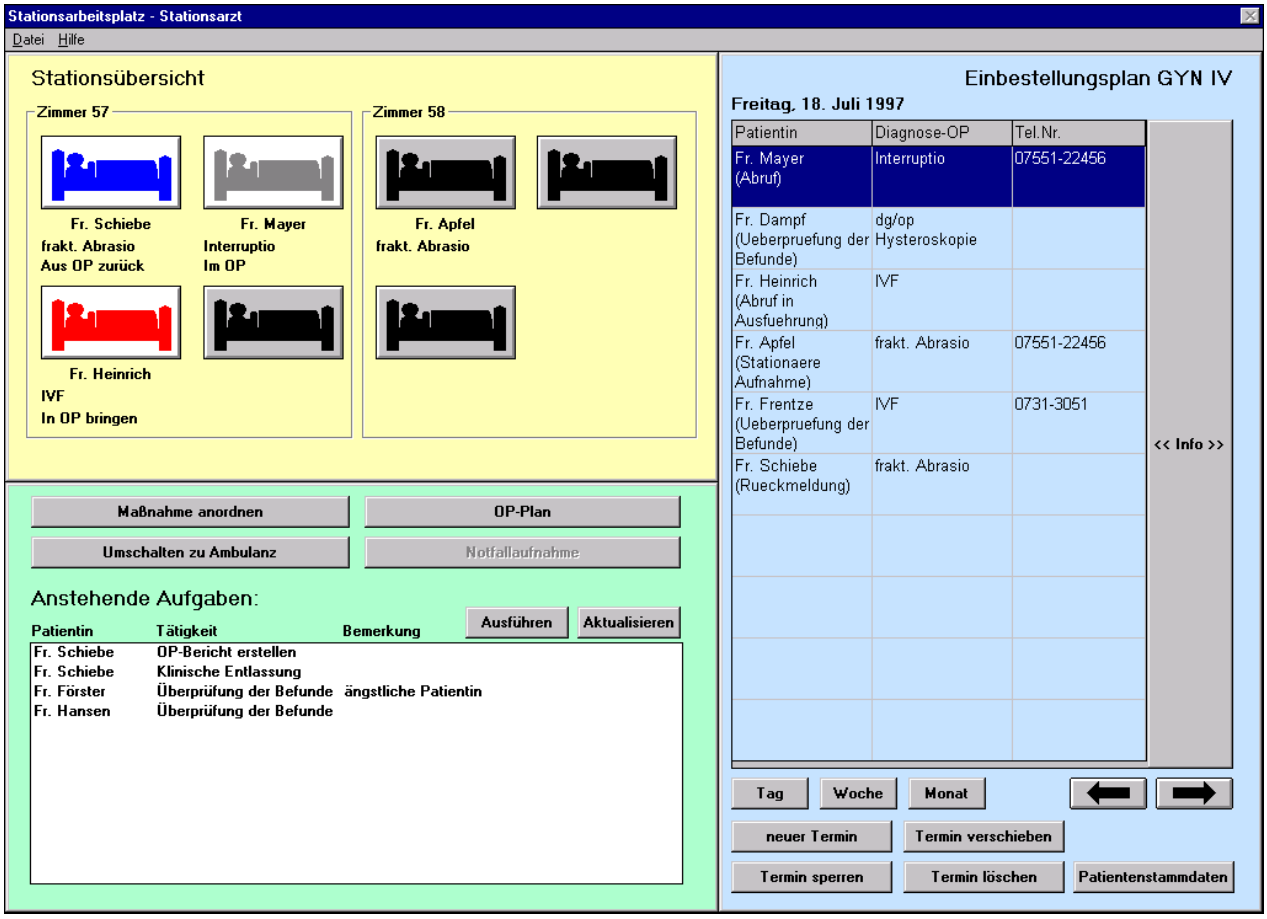

Fig. 1: A User Screen of the Day Clinic Application