The Database Group at University of Hagen (FernUniversitaet)

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1. Overview

The database area has been one of those areas of computer science which have very directly been driven by application requirements; this is true today in three ways: First, the users want more application specific support from the database, and they expect the DBMS to have more semantic application knowledge. Second, users want database support for new applications which are sometimes far from the traditional database applications and introduce completely new requirements as well as the need to smoothly integrate database technology with other advanced technologies (e.g. neural nets) in one application. Finally, the embedding of databases into interactive work environments - for instance, the use of databases in cooperative environments (computer supported cooperative work) - forces the database community to reconsider some of the traditional beliefs about databases.

The Database Group at Hagen University has felt these application pressures in various projects for quite a time. As a consequence the emphasis of our research has shifted from database core technology to application oriented research. Where the former research projects were mainly centered around concurrency control, recovery, distribution, and other "classical" database topics, the new research projects are concerned with the support of design environments, where design includes all activities of developing complex artifacts and, in addition, usually involves the cooperation of a variety of people. Design here includes areas like mechanical CAD, software engineering, VLSI-design, multi-media production and many others. A characteristic of design in all these areas is the use of a variety of heterogeneous tools which leads to complicated interoperability and integration issues.

A key motivating factor in our work on design-environments is concurrent engineering which certainly is one of today's major industrial challenges. For computer science it opens new problems, and at the same time it requires integration of different fields. The above mentioned new requirements for databases apply in prominent ways, including the issues of managing complex data, interoperability and integration, and support of teamwork.

The second research area is distributed learning environments. We are working towards systems that in future will offer, in an integrated way, computer based training and multimedia learning material, access to all sorts of information bases, communication facilities, conferencing systems, and simulation, experimentation and exercising environments. Such systems are not only important for the changing needs of university education (first of all continuing education), but also for industrial education and training systems, especially in geographically decentralized organizations. While this work is not a primarily database centered one, databases play a key role as the repositories for distributed hypermedia information.

Part of our work in this second research area involves developing advanced teaching material for computer based learning in computer science, and in cooperation with other faculties, in areas like mathematics, humanities, economy, and history.

The Database Group in Hagen, including the computer based learning group, consists of about 20 scientists and technicians. About half of these are financed by research and development contracts. A special unit is concerned with technology transfer and database testing for certain types of applications.

Closely connected to the Database Group is the *Institute for Automation, Production and Information Management*. This institute was founded by three different groups of Hagen University: an economics group with a special background in PPS, an automation group with the key area robotics, and our group. This institute acts as a platform for industry projects.
The research in the Hagen Database Group is not narrow focused but tries to address the multi-faceted problems of design and learning environments from different angles. The major projects are described in the following, together with the main members of the research teams. For each project, a small selection of publications is listed.

2. CAD-Framework

A framework provides an underlying software infrastructure for the realization of design environments. It provides services like data management, communication functions, design management support, common user interfaces, and it supports the integration of tools which altogether build the "integrated design environment". Both in software and in hardware design many efforts are being undertaken to define standardized interfaces, e.g. Portable Common Tool Environment (PCTE) and CAD Framework Initiative (CFI), and to develop commercially available products (e.g. SIFRAME).

Three main areas of the framework are discussed next.

2.1 Transaction and Configuration Management

Wolfgang Wilkes, Friedrich Kemper, Gunter Schlageter, Hans Streibel

Transaction Management in design applications has to support the cooperation of users where ever possible. Transactions in our system may be organized in a hierarchical way, and a transaction may be bound to a single user or to a team of users. Associated with a transaction is a local workspace, and the subordinate transactions are working on this workspace. The characteristics of transactions (e.g. allowable lock modes) can be determined individually for each workspace and thus adapted to the needs of the associated team. To support the cooperation among different designers and design teams, an additional lock allows concurrent write accesses to one object. Potential conflicts are resolved under the responsibility of the designers supported by communication protocols among the involved designers.

Our configuration management is based on a flexible versioning concept which can be adapted to the needs of the application by appropriately defining version graphs and version states. Design objects are related to their versions by means of an instance inheritance relationship by which the versions inherit the common properties from the design object. Also the relationship between a composite object and its components is described by the instance inheritance relationship which allows the transfer of interface data from the component to the composite object.

An actual research area is the investigation of different aspects of design objects: There is a need to distinguish between (a) a *description view* which mainly captures the direct relationships between a design object and its components, and (b) an *assembly view* which additionally represents the indirect relationships from a design object to its (indirect) components and corresponds to the physical assembly structure of an artifact. The description view is used mainly in the design phase for identifying the general structure of the design object. The assembly view is used mainly in the evaluation steps of the design phase and in the manufacturing phase for keeping track of specific properties of specific (physical) components. In principle, the assembly view can be build using the transitive closure of the component relationships in the description view, but it has to exist in its own right since the final version selection will often be done on the assembly view. Thus, if one component is used several times for the assembly of a higher level composite object, different versions of this component may have to be used. We materialize the assembly view as far as necessary, and we use "active relationships" to control the interrelationship between the two views.

In general, active relationships are used to control the "flow of activity" along relationships: if an object is related to another one by means of an active relationship, it will be triggered in case of specific events which occur on the other object. Active relationships can be used for the flexible integration of related systems, e.g. to integrate the materialized transitive closure of the composition hierarchy. In addition, the concept of active relationships will be used for several other applications, such as supporting active consistency control, automatic

change propagation, and the execution of complex design flows including the invocation of tools.

(1) Wilkes, W.; Klahold, P.; Schlageter, G.: *Complex and Composite Objects in CAD/CAM Databases.* Proc. 5th International Conference on Data Engineering, Los Angeles, February 1989.

(2) Kemper, F.; Wilkes, W.; Schlageter, G.: *Basic Mechanisms to Support Versioning in the Database Component of a CAD Framework.* Proc. 2nd International IFIP WG 10.2 Workshop on Electronic Design Automation Frameworks, Charlottesville, Virginia, November 1990, Elsevier-Verlag.

(3) Wilkes, W.; Kemper, F.: *Application of Indirect Components for Version Management in Design Databases.* International Conference on Data and Knowledge Systems for Manufacturing and Engineering, Hong Kong, May 1994.

(4) Bredenfeld, A.; Streibel, H.: *Complex and Cooperative Transactions for Design Environments.* JCF Project Report, Doc. No. JCF/GMD/006-01/30-Jun-94.

Funding and collaboration: The work on transaction and configuration management is funded by the Commission of the European Union in the ESPRIT project JESSI Common Frame (JCF). The work on design transactions is done in collaboration with the Research Institute "Gesellschaft fuer Mathematik und Datenverarbeitung (GMD)" in Bonn/St. Augustin.

2.2 Modelling and Use of EXPRESS Product Models

Wolfgang Wilkes, Thomas Kretzberg, Gerhard Scholz

A major goal of the development of standardized product models in the context of the ISO/STEP programme is to support the interoperability of various engineering applications. As a common basis the conceptual modelling language EXPRESS was defined and standardized and is now in wide use in the Engineering domain. In spite of these efforts in STEP, there continue to exist several other standards that are supplemented with an (in many cases re-engineered) EXPRESS model in the domain of electronic design automation. Since these standards and consequently their models cover overlapping application domains, it is highly desirable to identify their differences and commonalities. Our goal is to use a "core model" for describing the common aspects of different conceptual models. This core model can be seen as a common view of both underlying conceptual models, and in the case of EXPRESS models, we are using specific EXPRESS mapping models to describe the mapping from the underlying models to the core model and vice versa. The concept has been proved by constructing a core model for two existing conceptual models for electrical connectivity information, namely the EXPRESS models of EDIF (Electronic Design Interchange Format) and CFI (CAD Framework Initiative). Additional goals include the exploitation of the mapping information to generate conversion programs and the integration of the core model approach into an overall architecture for the interoperability of applications on heterogeneous databases.

Currently, EXPRESS is accompanied only with the very low level data access language SDAI (Standard Data Access Interface). Thus, it is not possible to mirror the complex structures which are normally found in product models in corresponding complex operations on the data. To support the use of EXPRESS data and to take the burden of a low level data interface from the application programmer we investigate mechanisms to (a) describe on a conceptual level the operational semantics of specific concepts which are captured in a conceptual model, and (b) to generate appropriate operations from these descriptions to enable application programmers to deal with higher level operations. A prominent role in this context plays the identification of different relationship types with specific corresponding consequences of operations for objects in the respective relationship.

(1) Scholz, G.; Wilkes, W.: *Information Modelling of Folded and Unfolded Design.* Proc. 1st European Design Automation Conference (EURODAC 92), Hamburg, September 1992.

(2) Scholz, G.; Wilkes, W.: *Specification of a Core Model for Netlist.* ESPRIT project 8370 ESIP, Document No. ESIP/FUHAGEN/004.1, October 1994.

(3) Scholz, G.; Wilkes, W.: *Interoperability Support by Integration of EXPRESS Models.* Proc. 4th International IFIP WG 10.5 Working Conference on Electronic Design Automation Frameworks, Gramado, Brazil, November 1994.

Funding and collaboration: This work is funded by the Commission of the European Union in the ESPRIT project ESIP. The work is done in

collaboration with the University of Manchester, the University of Paderborn (CADLAB), and with Siemens Nixdorf Informationssysteme (SNI).

2.3 Intelligent Support for Design Processes

Wolfgang Wilkes, Michael Straube, Peter Buhrmann

By integrating various tools into a design environment, the management of the design process is becoming more and more important. A designer gets additional degrees of freedom in how to organize the design process. The goal of our work is to develop a "design consulting system" which provides the designer with additional information to support him/her in planning and executing the design process. This information can be based, for instance, on the experiences in previous design process executions or on analytical information provided by the tool vendors. The information is captured in several knowledge bases, and there exist several (knowledge based) systems that work together in providing information and advice to the designer. These systems and their (possibly different) evaluations of a given design situation have to be coordinated, taking into account information about the knowledge based systems themselves and their ability to solve specific problems. For this purpose, an "integration frame" is being developed which supports the cooperation of different design consulting components on the basis of a blackboard architecture.

(1) Straube, M.; Wilkes, W.; Schlageter, G.: *HANDICAP - A System for Design Consulting.* Proc. European Conference on Design Automation (EDAC94), Paris, February 1994.

Funding and collaboration: This work is funded by the Commission of the European Union in the ESPRIT project JESSI Common Frame (JCF). The work is done in collaboration with the University of Manchester, the Research Center for Computer Science (FZI) in Karlsruhe, and Siemens AG in Munich.

3. RODIN: Reuse of Design Information with Neural Networks

Andreas Scherer, Thomas Berkel, Gunter Schlageter

The great challenges for mechanical engineering of the nineties are the reduction of time-to- market and the optimization of the quality-standards. The main reasons are:

- to introduce quickly new and innovative ideas to the market,
- to react directly to changing legislation (e.g. updated environmental regulations) and changing consumer demands, and
- to guarantee high product quality over a long period of time.

In this project we make use of the fact that today's problem solving in design and production planning is characterized by the adaptation or variation of already existing solutions. This prevents the companies from expensive and time consuming development-from-scratch. The time consuming iterations between design-teams and teams related to other stages of the engineering process (e.g. production planning) can be minimized.

RODIN (**R**euse **O**f **D**esign **I**nformation with **N**eural networks) allows the designer to transfer dimensioning and machining information from a reference part to a new part. Using this functionality the designer can quickly verify whether the design of a part is correct using a tolerance analysis tool called ADAPT. A special focus of this project is on transforming the CAD data representation such that the resulting data can be used as an input for neural networks. The main task of the neural network is to detect structural similarities between two given geometries.

(1) Scherer, A; Berkel, T.; Schlageter, G.; Schultheiss, R.: *Using Neural Networks in a CAD/CAM Application.* In Lisboa, P.J.G., Taylor, M.J.: "Neural Networks: Techniques and Applications", Ellis Horwood, 1993.

(2) Scherer, A.; Berkel, T.; Schlageter, G.; Schultheiss, R.; Schulze Schwering, W.P.: *RODIN: Neural Networks in a CAD/CAM Application.* In Sodhi, R.S.: "Advances in Manufacturing Systems: Design, Modeling and Analysis", Elsevier, Amsterdam, 1994, pp. 437-444.

(3) Scherer, A.; Schlageter, G.; Schultheiss, R.; Schulze Schwering, W.P.: *RODIN: Connectionist Techniques in a CAD-System.* European Joint Conference on Engineering Systems Design and Application, Vol. 5, pp.115-122, 1994.

Funding and collaboration: This research is funded by the Ford Motor Company, and is done in close cooperation with the sponsor. The software developed is being integrated into a sponsor's system.

4. PREDICTOR: A Multi-Agent Approach for the Integration of Neural Networks and Expert Systems

Andreas Scherer, Gunter Schlageter

Due to the necessity to use different problem solving techniques in complex application problems the general interest in hybrid systems is a fast growing research area. For supporting the integration of intercommunicating hybrids this project uses techniques from *distributed AI* (DAI). Main advantages of this approach are the encapsulation of different paradigms, the separation of control and domain knowledge and the reduction of the complexity of individual problem solvers. Many concepts of distributed and federated databases turn out to be applicable in this environment.

In a case study we examined how neural networks can be embedded into distributed problem solving frameworks. In addition, applications of connectionist techniques in prediction were performed demonstrating the potential of neural systems in comparison to classical approaches.

(1) Dunker, J.; Scherer, A.; Schlageter, G.: *Integrating Neural Networks into a Distributed Knowledge Based Systems.* 124th Conference on AI, Expert Systems & Natural Language, Avignon, 1992.

(2) Scherer, A.; Schlageter, G.: *A Multi-Agent Approach for the Integration of Neural Networks and Expert Sytems.* In Goonatilake, S. and Khebbal, S. (eds.), Intelligent Hybrid Systems, John Wiley, 1994.

Funding and collaboration: Cooperation partner was WestLB (Westdeutsche Landesbank, a major German bank). WestLB also partially funded the project.

5. CSCW in Design-Applications

Silke Mittrach, Peter Buhrmann, Gunter Schlageter

The goal of this research project is to extend typical design and planning methods with concepts of computer supported cooperative work (CSCW). The project examines, develops and prototypically implements the basic mechanisms which are required to effectively support semantically rich forms of cooperation among designers managing a common task.

A main task is to integrate coordination management with traditional database-technology. The techniques discussed so far in the database community, mainly centered around new transaction concepts, are not sufficient for real-life design-applications. Among other things, our coordination management includes special lock-conventions supporting different forms of user-cooperation, and special methods to allow concurrent data-access (like negotiation with consideration of group structures).

To extend the support of teamwork to the whole process of planning, the next research step is to integrate coordination in and between different design-phases. The idea is to introduce more flexible work-flows. The effect, for instance, is an early feedback from experts of later design-phases giving confirmation, corrective recommendations, or warnings.

Funding and collaboration: The project has been funded by the German Research Council (Deutsche Forschungsgemeinschaft), and is funded by the State of Northrhine-Westfalia in the framework of the joint research effort "applications of artificial intelligence". Cooperation partners are the Universities of Aachen (Prof. Jarke), Bonn (Prof. Cremers), and the Fraunhofer Institute Dortmund.

6. Laboratory for Databases

Thomas Berkel, Frank Lenzen, Hans Streibel

The Laboratory for Databases was founded to support the technology transfer between university researchers and the industry. A basic function is to evaluate the whole range of existing database technology: relational and object oriented systems, commercial systems and research prototypes. Evaluation is done by a testbed developed by the Database Group. Based on broad practical experience the laboratory cooperates with external partners to solve practical problems. Currently, projects and consulting is being done in the areas of medical information systems, production planning systems and document management in multimedia systems. To give an impression of the kind of technology transfer the project Old Synagogue is briefly described:

The Old Synagogue is a historical and political documentation centre situated in Essen. The life of

Jews especially during the national socialist system is documented. Photos, videos, letters, written and spoken interviews form a large multitude of multimedia documents. To preserve the historical value of the material, it has to be stored safely. Advanced retrieval and presentation techniques are required to use the documents in exhibitions, for historical and political research, and for education purposes.

The user needs to investigate which (type of) database technology can offer the required support for the handling of the multimedia documents. Two database development environments were used: one around the relational system Oracle, the other with the object oriented database system Ontos as the main component. From the design to the implementation of the application, we investigated the support offered by the different tools. The resulting two prototypes are now the subjects of a variety of testing activities: performance tests, applicability of different object oriented analysis and design techniques, media specific retrieval mechanisms, etc. The described project is the starting point for a new project titled "Jewish Life in Europe" which will build up a potentially distributed multimedia database which will provide access to the documentation of five European documentation centers and museums via telematic services.

The laboratory started an industry oriented seminar programme for database administration. Supported by the European Community in the COMETT programme, the seminars provide knowledge on database management in a broad and vendor independent fashion.

Funding and collaboration: The laboratory was financed by the State Northrhine-Westfalia. It has been cooperating with BASF, Ford, Lufthansa and other industrial partners as well as with museums.

7. Laboratory for Interactive Learning and Information Environments

Eberhard Heuel, Uwe Manthey, German Nemirovski, Gunter Schlageter, Victor Sirotin, Juergen Feldkamp

The laboratory is working on the use of information and communication technology, especially multimedia and hypermedia, for training and education purposes. Research and development activities are focused on evolving innovative communication and distribution systems for flexible and distance learning and information environments. The laboratory has carried out a large number of projects addressing the technical, the didactic/perceptive, and the economic implications of computer based learning, training (CBT), and information gathering.

A long-term project has been the design, development, use and evaluation of CBT-courseware for qualified continuing education in computer science. Sponsored by the Federal Ministry of Education and Science, the laboratory has designed appropriate authoring tools and has developed until now a unique library of CBT applications, available to students of the university, but also to companies and private persons. The programs are based on a hypermedia architecture that guarantees a highly individual and flexible training approach. They include a large number of standardized tools to allow easy navigation, annotations, etc., and they offer self tests and simulation of the learning topics in electronic laboratories. Similar applications have been developed for mathematical topics, putting main investigation efforts in the specification of generator mechanisms and in concepts for interactive performance behaviour and feedback analysis.

The present research and development projects are tackling large-scale learning environments using widely available communication networks with access to large libraries of learning and information material, databases, tutorial services, mailboxes, etc. The embedding of all these projects in a profiled distance learning institution, i.e. the FernUniversitaet (distance teaching university), makes sure that any result, prototype or application, will be tested and evaluated in real educational environments on a large scale.

Funding and collaboration: The startup phase of the laboratory has been financed by the German Ministry for Education and Science and by the State Northrhine-Westfalia. Cooperation partners are various museums and publishers and the University of Graz. Addison-Wesley, Bonn, is distributor for the developed courseware material in the computer science area.