Proceedings of the 3rd German-Brazilian Workshop on Information Technology

edited by
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Proceedings of the
3rd German-Brazilian Workshop
on Information Technology

Berlin
December, 14th – 15th, 1995

edited by
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German-Brazilian-Cooperation
in Scientific Research and Technological Development
## Contents

**Foreword**

**Call for Participation**

**Programme**

**List of Participants**

### Data Base Technology
- **DoCAIA** - Support of Design and Development of Computer Applications in Industrial Automation
- **QUALIDADE** - Qualitative Reasoning in the Domain of Automated Diagnosis and Ecology
- Supporting Scientific Databases Using Object-Oriented Systems

### Formal Methods and System Design
- **GRAPHIT** - Graphical Support and Integration of Formal and Semi-formal Methods for Software Specification and Development
- **HARDY** - High-Accuracy Arithmetic Applied to Dimensional Metrology (GANA II)
- **PLENA** - Parallel and Flexible Environmental Analysis
- **ARTS** - Formal Approach to Real-Time Systems Development
- **InTec-SRE** - Innovative Technologies for Software Requirements Engineering
- **RIME** - Integrating Rigorous Methods in a Computer Supported Cooperative Environment

### Industrial Automation Technology
- **CIM-COOP** - A Cooperative Research in CIM Technologies Development and Transfer between Germany and Brazil
- **ANALYTICE** - Project and Analysis of Flexible Manufacturing Systems
- **OORTAC** - Object-Oriented Real-Time Automation and Control
- **BRIDGE** - Business Process Improvement using a Goal-Oriented Approach

### Computer Graphics and Signal Processing
- Adaptive Systems
- **BIOCOMP** - Computerized Procedure for Automatic Biological Analysis from Water Sample Images
- **VESIV** - Virtual Environment for Shared Interactive Visualization
- Coding and Enhancement of Speech and Audio Signals
- **VICO** - Development of a Visual Computing and Communication Platform

### Communication Systems
- **BROADBAND WIRELESS** - A Broadband Mobile Communication System for Universal Mobile Telecommunication Services
- MODP Multimedia ODP Platform for Cooperative Applications
Foreword

Information technology has traditionally played an important role in German-Brazilian cooperation in the scientific and technological sectors. While Germany is increasingly dependent on the application of state-of-the-art information technologies, Brazil is successfully securing for itself a place in the ranks of the leading software-producing countries, and - like Germany - it boasts a number of sound programmes for promoting information technology.

Against this background, scientific and technological cooperation projects are proving increasingly attractive, not least for the industrial partners on both sides. An important factor here is the growing practical orientation of the topics addressed.

To consolidate this process, a series of workshops have been held on a regular basis since 1993, offering a forum for the presentation of results, the conclusion of successful projects and the launching of new ones. The 1995 workshop was for the first time accompanied by an evaluation process. This was not only concerned with assessing the quality of the project work, but focused on the importance of industrial interests as well.

On the whole, a very positive view was taken of the project presentations and the ongoing project work. Where the response was negative, this was mostly due to an inadequate level of commitment by one or both of the partners to the orientation of the new programme.

The idea of focusing on five major areas of information technology was also seen as advantageous, and it will no doubt continue to produce first-class results.

The coordinators wish to extend their thanks to the ministries in both countries as well as to Forschungszentrum Jülich on the German and CNPq on the Brazilian side for their financial and administrative support. They are particularly indebted to Mrs. Birgitt Schmidt, Nikola Serbedzija and Jose M.V. Castilho for the preparation and execution of the workshop. They also want to thank once again all those who have contributed to the success of the workshop. They wish all project partners continuing success in their work and a fruitful collaboration between the two sides.

Stefan Jähnichen and Carlos Lucena

The Coordinators
Call for Participation

Workshop on
Information Technology:

Cooperative Research with Industrial Partners
between Germany and Brazil

Berlin, Germany, December 14th–15th 1995

Promoted by the German-Brazilian Cooperative Programme in Informatics

Cooperation between Germany and Brazil in the area of computer science has already entered its third successful decade. From previous person-to-person cooperation which involved mainly academic institutes the cooperation has grown to well established cooperative programme that includes industrial partners.

The Cooperative Programme will from now on sponsor research in computer science technologies that shall demonstrate their usefulness by solving concrete problems in strategic areas such as Ecology, Telecommunications and Advanced Automation.

The coordination envisages to build larger consortia made-up of groups interested in the same underlying technologies (independently of their institutional affiliation).

The purpose of this workshop is to present the state of the art of the current German Brazilian cooperation and to attract new possible partners both from industry and from academia to join existing or to propose new projects.

Topics

The strategic information technology areas are the following:

**Data Base Technology:**
Advance database and knowledge base management systems with special emphasis on their development and usage in practical applications; The use of systems as intelligent data management resources specially to support both design and applications and production control systems.

**Formal Methods and System Design:**
Specification and programming in general and in particular Cooperative design; Visualization techniques; Formal and semi-formal specification and design methods; Support for parallel and distributed processing; Software reusability; and Configuration management.

**Industrial Automation Technology:**
Development of a model for cooperative computer integrated manufacturing dealing with the process of economical rearrangement and adaption of small and medium-sized enterprises; Development of software tools for project and analysis of flexible manufacturing systems; Application of object-oriented concepts to the development of industrial automation and process control systems.
Computer Graphics and Signal Processing:
The combination of 2D images and 3D scenes; Image and signal analysis, including
object recognition; Models of complex systems for animation and simulation; Rendering
and visualization methods; User interfaces for image processing and visualisation.

In addition to contributions from the above areas the coordinators explicitly call for new
proposals. Proposers may also suggest strategic application areas different from the ones
given.

Participation
Each of the on-going projects should be presented by a status report (max. 3 pages, technical
description plus administrative data) and by a plan for the next two years (including both,
visits and technical contents).

New proposals are solicit. The project proposal should contain at least one German and
one Brazilian partner plus industrial partner or proposers should prove a strong industrial in­
terest. The new proposal should contain the following: 1° Title and Acronym; 2° Objectives,
Application Domain (1 page); 3° Partners' Names and Addresses; 4° Project Description In­
cluding Demonstration Project (2 pages); 5° Work Plan (1 page, with: detailed mile stones,
time schedules and expected results); 6° Travel Costs (with number, duration and purpose
of stays); 7° Descriptions of Partners' Expertise (0.5–1 page, each).

Proposals are to be submitted to one of the addresses below. Electronic mail
is preferred.

In Germany:

brazil@first.gmd.de or Birgitt Schmidt, GMD FIRST
Ruddower Chaussee 5, D-12489 Berlin, Germany

In Brazil:

castilho@inf.ufrgs.br or J. M. Volkmer de Castilho, UFRGS, Instituto de Informatica,
Caixa Postal 15064, CEP 91.501-970, Porto Alegre, Brazil

Deadline for Submissions: September 19, 1995
Notification of Acceptance: October 15, 1995

Workshop Chairmen

Prof. S. Jähnichen, TUB, Technical University of Berlin, Germany
Prof. C. Lucena, PUC, Catholic University of Rio de Janeiro, Brazil

German Organizing Committee: Brazilian Organizing Committee:

N. Šerbedžija, GMD FIRST, Berlin J.M.V. de Castilho, UFRGS, Porto Alegre
B. Schmidt, GMD FIRST, Berlin E. Costa, SOFTEX
Programme

**Wednesday, Dec. 13** – Hotel Berolina, Karl-Marx-Allee 31

20:00 Informal Get-Together

**Thursday, Dec. 14** – GMD Adlershof

09:00 Opening:
- Introduction, purpose of the workshop, introduction of the participants, introduction of the evaluation board, general remarks, future perspective

Ongoing Projects

Session 1 Data Base Technology:

09:45 1.1 DoCAIA - Support of Design and Development of Computer Applications in Industrial Automation
- J. M. Castilho, II/UFRGS
- T. Haerder, U Kaiserlautern

10:15 1.2 QUALIDADE - Qualitative Reasoning in the Domain of Automated Diagnosis and Ecology
- W. Roque, IM/UFRGS
- P. Struss, TU Munich

10:45 1.3 Supporting Scientific Databases Using Object-Oriented Systems
- G. Vossen, U Munster

11:15 COFFEE BREAK

Session 2 Formal Methods and System Design:

11:30 2.1 GRAPHIT - Graphical Support and Integration of Formal and Semi-formal Methods for Software Specification and Development
- H. Ehrig, TU Berlin

12:00 2.2 HARDY: High-Accuracy Arithmetic Applied to Dimensional Metrology (GANA II)
- Beatriz Franciosi, II/UFRGS

12:30 2.3 PLENA - Parallel and Flexible Environmental Analysis
- M. Endler, IME/USP

13:00 LUNCH BREAK

Session 3 Industrial Automation Technology:

14:00 3.1 CIM-COOP: A Cooperative Research in CIM Technologies Development and Transfer between Germany and Brasil
- H. M. Caulliraux, COPPE/UFRJ

14:30 3.2 ANALYTICE: Project and Analysis of Flexible Manufacturing Systems
- M. Tazza, CEFET-PR

15:00 3.3 OORTAC - Object-Oriented Real-Time Automation and Control
- C. E. Pereira, DEE/UFRGS
Session 4 Computer Graphics and Signal Processing:
15:30  4.1  Adaptive Systems  
       G. Richter, GMD/Sankt Augustin
16:00  BREAK
16:15  Evaluation Board Meeting
19:00  Dinner at Meistersaal, Koethener Strasse 38 (near Potsdamer Platz)

Friday, Dec. 15 – GMD Adlershof
New Projects
Session 2 Formal Methods and System Design:
09:00  2.4  ARTS - Formal Approach to Real-Time Systems Development  
         A. Haberer, DI-PUC/RJ
09:30  2.5  InTec-SRE : Innovative Technologies for Software Requirements Engineering  
         T.G. Kirner, DCS/UFSCar
10:00  2.6  RIME - Integrating Rigorous Methods in a Computer Supported Cooperative  
         Environment  
         C. Lucena, PUC-Rio,  
         S. Jaehnichen, TU/GMD Berlin
10:30  COFFEE BREAK
Session 3 Industrial Automation Technology:
10:45  3.4  BRIDGE - Business Process Improvement using a Goal-Oriented Approach  
         I. Morschel, Daimler Benz
11:15  3.5  ROBINSPECT: Research and Development of an Inspection Robot to Check  
         Construction Sites Structures  
         C. E. Pereira, DEE/UFRGS
Session 4 Computer Graphics and Signal Processing:
11:45  4.2  BIOCOMP - Computerized Procedure for Automatic Biological Analysis from  
         Water Sample Images  
         R. Guadagnin, DCC/UNB
12:15  4.3  VESIV - Virtual Environment for Shared Interactive Visualization  
         C. Kirner, DCS/UFSCar
12:45  LUNCH BREAK
13:45  4.4  Coding and Enhancement of Speech and Audio Signals  
         P. Noll, TU Berlin
14:15  4.5  VICO - Development of a Visual Computing and Communication Platform  
         L. P. Magalhaes, DEE/UNICAMP
Session 5 Communication Systems
14:45  5.1  BROADBAND WIRELESS - A Broadband Mobile Communication System for  
         Universal Mobile Telecommunication Services  
         G. Fettweis, TU Dresden
15:15  5.2  MODP Multimedia ODP Platform for Cooperativ Applications  
         V. Tschammer, GMD FOKUS
15:45  Evaluation Board Meeting
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Universität Münster
Aldo von Wagenheim
Universität Kaiserslautern/
UF Santa Catarina
Mathias Weske, Dr.
Universität Münster
Martin Wirsing, Prof. Dr.
Universität München
Data Base Technology
PROJECT REPORT

1. Research Area: Database Technology and Knowledge Base Systems

Title: Support of Design and Development of Computer Applications in Industrial Automation
Acronym: DoCAIA

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3. Objectives

DoCAIA's main objective is the development of tools and techniques to support design and development of computer applications in industrial automation, with special emphasis on applications supported by databases (DBs) and/or knowledge base (KB) systems.

4. Description

The following report describes the main activities executed and the major results achieved within the DoCAIA project, as part of the German-Brazilian Cooperative Programme in Informatics, research area Database Technology and Knowledge Base Systems. DoCAIA is being developed jointly by researchers of the Database Group of the Department of Applied Informatics of UFRGS, Brazil, the Database Research Group of Prof. Dr. T. Härder at the University of Kaiserslautern, Germany, and the Research Group on Database Systems and Knowledge-Based Systems of Prof. Dr. B. Mitschang at the Technical University of Munich, Germany. In the following, we briefly summarize all the noteworthy aspects that occurred during the last research period from (mid) 1993 to (end) 1995.

4.1 Local Projects on the German Side

On the German side we're doing research related to two implementation scenarios. One is the Non-Standard Database Management System (NDBMS) PRIMA and the other is the Knowledge Base Management System (KBMS) KRISYS. Here, we pursue a number of different research objectives each having some impact on the cooperation project.

4.1.1 PRIMA-Framework

The PRIMA Framework is a tool environment based on the NDBMS PRIMA as an integrated data repository system. Ongoing research pertains implementational issues of the PRIMA systems as well as on providing further framework services. Thus, version and configuration concepts are refined and (re)implemented (VStore), a model for cooperation control and design management is further conceptualized and implemented, and a component supporting tool integration and tool application (TOPAS) is realized. In those areas, there have been the following research activities:

- PRIMA (Prototype Implementation of the Molecule Atom Data Model) [Ge94].
- VStore (Object and Version Management System).
- TOPAS (Tool Integration into Design Frameworks) [BMM94, Ni95, HMNR95].
- CONCORD Activities [RMHGS94, HR95, HMR95, Ri94].
4.1.2 KBMS KRISYS

KRISYS is a KBMS prototype that provides powerful concepts for application modeling and processing, and supports overall means for efficient processing in a workstation/server environment. A first system prototype is completely operational, and several applications have already been developed with KRISYS, some of them in cooperation with our partner at UFRGS and industrial partners. KRISYS is also installed and in use at UFRGS and the Federal University of Santa Catarina in Brazil. This work is important for two main reasons. Firstly, because KRISYS is the common software platform of the DoCAIA project, and secondly, because this work broadens our knowledge and experience in KBMS and in knowledge-based applications. Main activities inside KRISYS are:

- Enhanced KRISYS Architecture [DMMT95].
- Semantic Integrity Issues.
- Multi-User KRISYS [Re95, RH94, RH95].

4.1.3 Industrial Partners

The before mentioned projects and activities are partially integrated into industrial cooperation activities:

- Concerning CONCORD and TOPAS activities, we are sharing research results and experiences with Daimler Benz AG, Forschung und Technik, Abteilung F3P, located in Ulm. Our cooperation partners are Dr. W. Käfer and M. Heimann as well as the Ph.D. students G. Sauter and J. Selten. The work reported in [BMM94] was done at the Pfaff AG (HTE) in Kaiserslautern.

- KRISYS was and will be used for all kinds of difficult modeling activities. From 1993 to 1994 we had a cooperation with the Raiffeisen Versicherungen e.V., located in Wiesbaden [ST95]. Currently, we are cooperating with the mechanical engineering company Keiper Recaro in Kaiserslautern. Cooperation topics are object-relational data modeling in technical areas, heterogeneous communication and workflow management in design and production processes.

- Further on, there is a continuing cooperation with IBM, Almaden Research Center and Database Technology Institute, in the basic areas of DB and KB systems. With our former colleagues Dr. N. Mattos and Dr. S. DeBloch, we are cooperating on specific KRISYS topics as e.g. constraint management issues, and on more general topics as e.g. SQL standardization efforts, since Dr. N. Mattos is the IBM representative for all SQL standardizations.

4.2 Local Projects on the Brazilian Side

4.2.1 STAR Framework

STAR's main goal is the development of an open software framework for the implementation of CAD environments for electronic systems design [WGF94]. The framework is being implemented on top of KRISYS. In this framework, there have been the following research activities:

- Version management.
- Configuration management [RWG94].
- Schema evolution [FGW94].
- Visual interface [MGW94, MG94].

4.2.2 TRANSCOOP

The project (Transactional and Cooperation Supporting Systems for Applications in Engineering, Industry, and Office Automation) aims at acquiring knowledge about possible behaviors of database applications in engineering as well as industry, and office automation, on the aspects of both their processing characteristics and how cooperative work among users takes place.
In 1994, a field study was carried out involving four software developing teams working for three software houses as to get more information about how the software development process really evolves in Brazilian companies. Relying on the results of the field study, a model supporting the description of software projects has been proposed which helps both identifying and implementing aspects of project management and cooperation control in the software engineering environment [IF95]. Furthermore, we are investigating methods and techniques that can help support the identification as well as resolution of language conflicts between humans in various phases of the software development process. In [Io95], an adapted methodology is proposed for automatic inference of most important concepts and ideas which are present in a piece of text and presents a software tool that might help humans identifying their language conflicts on the basis of that methodology. In addition, [Io95a] comments on the results of the field study in order to better understand the software development process as it really takes place in south-Brazilian software companies.

4.2.3 Design Methodology and Tools for Advanced Information Systems (AIS)

During the last year, we have concentrated on tools to assist and/or support some of the initial phases of database systems’ (DBS) design and development cycle. A prototype of a natural language processing system that could make text processing and extract simple E-R diagrams representing a first approach for the conceptual model of a DBS was developed. This work was published in at least two important national conferences in Brazil, and the prototype will be transformed in a software product by a Brazilian software house ("Develop Informática", established in Porto Alegre).

Some studies were done on conceptual models evolution, and "database redesign" (the restructuring of a database due to conceptual model modifications). A paper on the subject was accepted in the E-R 93 Conference, in Dallas, USA. A first prototype should be finished by September 1995. A group of three Ph.D. and two M.Sc. students is working on the subject "Intelligent Databases" (following the definition given by Parsaye and others). This is a very rich research field, we expect several important results. Another result of the project was a M.Sc. dissertation, which presented an extension to the Entity Data Base Model (Modelo E) to support (partially) the object-oriented paradigm. The proposed extension includes the notions of class, method, inheritance, delegation and encapsulation, among others, and the operations defined on the E Data Model were revised to implement the new concepts. In addition, a Ph.D. Thesis is being concluded with the main focus on the concept of versions of object-oriented databases. A multilevel architecture that incorporates version and configuration concepts is proposed, as well as the corresponding mechanisms needed. The results of this work [GS95, GS95a] may be applied to the E Data Model in future developments.

4.2.4 Industrial Partners

The project activities described before already include the relationships to their industrial partners. However, there are still industrial cooperation partners, especially to the TRANSCOOP project, to mention. The study of the software development process has been carried out in cooperation with three south-Brazilian software companies: ADP Systems, an information technology company belonging to the largest communication network (RBS Group) of South Brazil, SISPRO Data Processing, and Pensamento. We will now start investigating human interaction support and project management (workflow) in the fields of urban planning and environmental planning. Our industrial partners will be Metroplan (State’s Office for Urban Planning) and Fepam (State’s Office for Environmental Control).

5. Work Plan

The scope and purpose of our joint investigation is to provide adequate and practically approved concepts for computer applications in areas of industrial automation, thereby focusing on modeling, realization as well as consistency maintenance issues. As already mentioned, the cooperation is specifically directed to the fields of both advanced DBSs and KBMSs with special emphasis on their development and usage in practical applications. In particular, the project refers to aspects of
building and improving implementations of such systems in various environments, and in using them as intelligent data management resources specially to support both design applications and production control systems. The final goal of our joint investigation is the integration of several concepts of both approaches in order to define the basis of a new generation of systems capable of efficient and adequate object as well as knowledge management.

So far, our cooperation has lead to a number of joint papers: [CHIM94, RGMD93, RH94, RH95]. Furthermore, we have exchanged software systems, expertise, and experiences in the topics of research. Accordingly, we are planning to continue our cooperation by a number of joint activities. The work plan for the next two years period is given by the milestones categorized in the following:

- **Query processing in KRISYS:** During the past years, the conceptual and implementational issues of client-based query processing in KRISYS have been investigated. Future efforts will therefore concentrate on validating and augmenting the involved functionalities, e.g., query optimization, buffer management, and constraint management. These activities will be complemented by defining and establishing an adequate interface for KOALA, the query language of KRISYS.

- **Multi-user KBMSs:** Next, we start implementing our design using KRISYS. The main concepts for our implementation include: A transaction system for KBMSs, which is used in client/server environments, and handles nested transactions. This transaction system incorporates a new synchronization protocol, called LARS. Additionally, we are working on a recovery mechanism based on objects. Further on, these research results have to be refined and empirically evaluated in order to compare their gain to other approaches. For this purpose, we also intend to enter the field of system architecture, workload description, and performance evaluation for KBMSs.

- **VStore prototype:** After having refined the versioning and configuration concepts, we are currently reimplementing the object and versioning management system (VStore) on top of ObjectStore. Furthermore, the implementation of a graphical user interface has been started. VStore will be used as foundation of CONCORD.

- **CONCORD prototype:** As already mentioned, the CONCORD prototype will exploit VStore which is current realized. The CONCORD prototype will be implemented in three steps. The transaction layer is implemented. The implementation of the design-flow system (step two) and of the cooperation control facilities (step three) will follow as soon as the concepts, which are currently detailed, are validated and the most appropriate realization mechanisms (e.g. ECA rules, finite deterministic automata, scripts) are selected.

- **Realization concepts for activity management:** During the development of the CONCORD processing model, several inter-related aspects of activity management have been considered: Transaction management, design flow management, cooperation control, each related to one of the CONCORD layers and, thus, adapted to the special requirements of cooperative design applications. Besides the layer-specific aspects of activity management, the interplay of the corresponding management components is a crucial issue. This shows that an activity manager, on one hand, has to ensure the properties of a certain type of activities, e.g. design flows, but, on the other hand, also has to cope with external events, e.g. cooperation requests or transaction failures.

- **Modeling framework and tools for advanced or intelligent database systems:** A first version of a "Conceptual Model" for AIS, considering system's requirements like temporal, active, deductive, cooperative behavior for database systems, will be in use on the modeling of a set of AIS prototypes. A refined prototypical version of a tool to help in the requirements collection and conceptual modeling phases of AIS development will be available by the end 1996.

- **Studies on AIS architecture, development of AIS prototypes:** Proposals for architecture for AIS will be available soon. Besides industrial automation area, we are collecting requirements and working on the development of systems for Environment and Urban Control, for Petrography Analysis, and (a recent and growing trend inside the project) systems for Medical Informatics (to help the management of patients, drugs, diseases, etc., in the problem-prone Brazilian Public Health System). This work is attracting a lot of interest from State and Municipal authorities.
Intelligent information retrieval, and knowledge discovery in databases: Two M.Sc. Dissertations will work on the above subjects for the next 14 months. We expect interesting results by the end of 1996.

TRANSCOOP: We plan to develop research on human interaction’s influence in both project development and management covering three different environments: Geographic information systems (GIS) for urban planning, for environmental control, and the software engineering process. In all these studies, besides investigating both groupware and database support, we plan to study the adequacy of CONCORD for those applications.

STAR: Activities within STAR will proceed with the implementation of the already specified configuration and schema evolution managers, as well as the visual interface to the system.

Versions in object-oriented data models: The proposed model should be implemented on top of KRISYS to validate its functionality. Investigation must be done in order to evaluate the possibility of extending the data model of KRISYS with the version and configuration concepts.

This list of milestones reflects a considerable overlap of research investigations among the individual partner projects. These overlapping areas make up the basis of our joint project. The expected results are listed in the following:

1. Exchange of individual experience as well as expertise about both OODBMS and KBMS: This work will rely on the study of applications running on locally existing systems in each institution, e.g. VLSI-design application based on the STAR framework which relies on KRISYS, and investigation of PRIMA and the Model E implementation concepts.

2. Joint research work on specific system aspects: We will work together on concepts underlying both OODBMS and KBMS in order to enhance the ongoing research implementations: Modeling and managing both user cooperation and design evolution in engineering applications; Extension of KRISYS with appropriate concepts for multi-user workstation/server environments; Development of query processing and query optimization techniques for KRISYS.

Amongst the most important activities within such a geographically distributed project are the mutual visits that provide direct means to information exchange. In the last period, we had 4 visits to Brazil (Prof. Mitschang, August/Sept. 1994; Prof. Harder, Sept. 1994; F. Rezende, Sept./Oct. 1995; J. Zielinski, Nov. 1995-May 1996) as well as 3 visits to Germany (Prof. Iochpe, Aug. 1994 and Sept./Oct. 1995; Prof. Castilho, Dec. 1995). In the subsequent two years period of investigations, we plan six study/research missions per year:

- 1 mission of a Brazilian student for a period up to six months.
- 2 missions of Brazilian researchers for periods ranging from 14 days to 3 months each.
- 1 mission of a German student for a period up to six months.
- 2 missions of German researchers for periods ranging from 14 days to 3 months each.

6. Summary

With this report we hope to have shown that there are a lot of activities that guarantee for ongoing research within the DoCAIA project for the next two years. Although the project partners are geographically distributed, we always keep our joint work and scientific discussions running. Along with the move of Prof. Dr. B. Mitschang to the Technical University of Munich some changes had to be done w.r.t. the organizational structure of the project. Now there will be parallel and, of course, complementing activities on both German sides with special emphasis on concurrent engineering and parallel database query processing.

Although it is very difficult to keep the local projects and especially the local industry cooperation remaining, we so far could find enough time to discuss and exchange our experiences. This could have been done only by the travel funds of the German-Brazilian Cooperation Programme in Informatics to which we are very grateful.
Project Description: QUALIDADE

1 Title and Acronym

QUALIDADE - QUALitative reasoning in the Domain of Automated Diagnosis and Ecology

2 Objectives, Application Domain

The project QUALIDADE has two overall objectives:

- Contributions to the theoretical foundations of qualitative reasoning and model-based diagnosis
- the specification of techniques for particular applications such as ecological and environmental management support tools

These objectives will be achieved in developing tools for modeling and diagnosis, while working close to the application domain, which provides the challenges of the encountered complexities and the requirements for the usability of the tools.

The current focus is an application in the domain of hydro-ecological resource management support. The first goal is the development of an integrated model-based environmental decision support system with a specialization in hydrological ecosystems. More specifically, we aim at specifying and implementing a coherent framework for the tasks of

- model-building,
- situation assessment,
- monitoring,
- simulation,
- diagnosis and
- therapy planning,

that - in contrast to existing isolated and specialized computational systems - provides an integrated user interface and can exploit a coherent knowledge base for all tasks.

The modular structure of the knowledge is a central advantage in our approach, since we are able to separate representational issues and domain independent knowledge (formalized by computer scientists in advance) from the building of the domain knowledge base (with expert support), the later steps of a specific ecosystem description (which can be done by trained experts), and the actual use of the models in a specific monitoring situation, which then requires little knowledge about the underlying computational techniques.

Also the use of the system for similar tasks in the same domain requires only the replacement of a small and explicitly designated part of the knowledge base. The transfer for other application domains can be done with limited effort. The resulting software product is thus open to multiple exploitation possibilities. One might further extend a single module to a specialized full-scale application or continue to implement the proposed framework of an integrated decision support system. For a more detailed description of the architecture of the projected architecture refer to the section 4.1 Project Description.

We expect significant improvement of the Qualitative Reasoning techniques employed, since we face the challenges of large-scale real-world applications - in contrast to the many toy examples mostly discussed in the literature. Especially the methods for time-scale abstraction and spatial representation will receive valuable impulses, since the inherent complexity of the ecological systems under consideration and the reasoning with large-scale model libraries require a flexible and effective handling of the available knowledge.
3 Partners' Names and Addresses

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4 Project Description, Demonstration Project, Status Report  

4.1 Project Description

The basic architecture of the decision support system SIGMA is shown in figure 1. The plan is to design the common framework and the structure of the underlying knowledge base and then to implement the situation assessment module (SIGMA-S) and an initial model library in collaboration with experts engaged in a field study on a specific case study (see 4.2 Demonstration Project).

For the situation assessment module the basic components of the system have to be implemented, i.e. the knowledge base interface, the prediction algorithm, the model revision strategy and the user interface form a necessary foundation. The user has to be able to interactively enter observation data and hypotheses about the current state and development of the system, while being provided the consequences and possible contradictions as well as hints for the refinement of the ecosystem model and the situation description.

A more detailed description of the architecture and its use has been published in an article for the "ECOS journal" edited by DMAE, Porto Alegre ([Guerrin et al. 95]).

![Figure 1: SIGMA - The basic architecture and application context](image-url)
4.2 Demonstration Project

As a case study and a demonstration project for the applicability of the model-based approach to environmental decision support, we concentrated on a river in southern Brazil, the Rio Guaiba. The municipal departments are increasingly concerned with the pollution load that imposes severe restrictions on the use of the natural resources, e.g. in terms of drinking water supply. Also a petrochemical company that operates a large industrial plant upstream of the city of Porto Alegre is planning to invest in research of the possible impact of accidents on the plant or during shipment of chemicals.

Systematic ecosystem research will be carried out by the municipal department of water and sewage (DMAE) in the framework of a formal collaboration contract with the mathematical department of the federal university. There is a close interaction with ecologist experts, two of which are actively participating in university studies, possibly with the aim to obtain further degrees. Models of the phenomena will be developed and the overall architecture of the system and the user interface will be tailored to meet the needs of the resource managers.

4.3 Status Report

In the initial phase of the project, the contact with municipal and industrial partners and an outline of the collaboration has been established. Dr. habil. Peter Struss visited Porto Alegre in September 1993 to discuss the application domains and to facilitate the start of joint projects involving non-academic partners. The Rio Guaiba was chosen as the primary focus of the first phase.

September through November 1994, Ulrich Heller, a MSc student of Peter Struss, stayed in Porto Alegre to work on the modeling of the river. In interaction with the ecologists, the principles for a qualitative modeling approach were specified and a particular phenomenon, the repeated occurrence of local algal blooms in the river, was modeled. The tentative qualitative model is currently being tested for its predictive power and verified against real field data, that is obtained from the observation of the river. The modeling brought up several challenging representational issues in the modeling of spatial parameter distributions and the handling of widely separated time scales. Important impulses for spatial and temporal abstraction have been derived. The results of this work have been presented to the scientific community in the workshop "Artificial Intelligence and the Environment" at the International Joint Conference on Artificial Intelligence in Montreal, Canada, 1995 ([Heller et al. 95]). Ulrich Heller also participated in the talks with interested industrial companies. Particularly the Copesul company showed interest in a middle- and long-term collaboration with the university to examine the possible environmental impact of accidents during shipment of chemicals. Other possible research topics were defined.

In February 1995, Prof. Dr. Waldir Roque visited Munich and participated in the initial design of the projected decision support system SIGMA and presented the possible tasks proposed by the Copesul representatives.

In late 1995, a formal collaboration contract has been signed, specifying several possibilities for exchange of data and personnel between DMAE and the university in Porto Alegre. Two researchers from the municipal department are actively participating in research at the department of mathematics. The authorities are willing to make significant effort to obtain required measurements and observations.

References

[Heller et al. 95]

[Guerrin at al. 95]
5 Work Plan

In the next two years it is intended to design and implement the framework and the first module of the integrated environmental decision support system SIGMA. This is to be carried out in connection to field studies in the ecosystem chosen as a case study and demonstration project. The design will follow the basic architecture shown in figure 1. The modular structure of the knowledge base facilitates the incremental modeling and implementation approach. A careful planning for the systematic ecosystem research is necessary. The work will be structured according to the following work packages:

Work Package 1: Preparation of field studies (6 months, Porto Alegre)
Type and frequency of observations have to be determined and a measurement network will be set up. The aim is the early detection of algal blooms, so that selected occurrences will be monitored and examined in detail. The institute of mathematics in Porto Alegre will establish communications and interaction paths to the ecologists involved.
results: observation plan and framework for data utilization in form of a technical report

Work Package 2: Specification of SIGMA (6 months, Munich)
The framework of the SIGMA system will be designed, using the suggestions and requirements provided by the field researchers.
results: A technical report containing the system specification

Work Package 3: Algal bloom field study (6 months, Porto Alegre)
A close examination of selected occurrences of algal blooms and of the general situation and development of the river will be carried out according to the plans delivered in work package 1. Tentative models will be built to formalize and communicate the expert knowledge about the observed phenomena.
results: technical report with the field study results and a preliminary conceptual model of the system

Work Package 4: Implementation of the SIGMA framework and SIGMA-S (6 months, Munich)
The situation assessment module will be implemented in accordance with the specifications derived in the work package 2. The implementation will aim at providing testing and refinement possibilities early.
results: prototype implementation of SIGMA-S with documentation and manual draft

First milestone (end of 1996):
• Field study results, data and knowledge collection, preliminary conceptual models
• Documented prototype of SIGMA-S

Work Package 5: Model building (8 months, Porto Alegre)
In close collaboration of all participating groups (facilitated by mutual research visits - see Travel Costs), an initial model library of hydro-ecological phenomena with special focus on the algal bloom phenomenon will be built. A representation framework will be established and the transformation into operational models (for simulation and prediction) will be examined.
results: documented formalized models

Work Package 6: Refinement of SIGMA-S (12 months, Munich)
With the input from the model building phase (work package 5) and in interaction with the calibration phase (work package 7) the initial design and implementation of SIGMA-S will be refined to better meet the needs of the users.
results: revised prototype of SIGMA-S, extended documentation for inexperienced users

Work Package 7: Calibration and validation of the models (4 months, Porto Alegre)
The models derived in work package 5 will be calibrated using real field data. The comparison with the observed behavior will provide a validation of the predictions derived from the models.
results: revised documented model library

Second milestone (end of 1997):
• refined situation assessment module with user manual
• a model library for hydro-ecological phenomena, focused on algal bloom
• joint publication in the journal “Ecological Modeling”
• a workshop for the dissemination of the results, held in Munich on the topic of “decision support systems”
6 Travel Costs for 1996

- 1 short visit to Porto Alegre (2 weeks, initial phase):
  The first visit is used for a kick-off workshop with the Brazilian researchers and collaborators from the municipal department (DMAE) to derive a plan for the joint field studies. An analysis of the problems posed by the Copesul company will be carried out and concrete suggestions for possible feasibility studies and long-term contracts will be made.

- 1 visit to Munich (one month, during work package 4):
  One of the researchers actively participating in the field studies in Porto Alegre will be discussing the application requirements with the German team. She will receive additional training in the use of the modeling software and support tools.

- 1 visit to Porto Alegre (one month, during work package 3):
  A researcher from the Technical University of Munich will temporarily participate in the field studies and discuss the evolving design of the SIGMA architecture. The future of the industrial contacts will be determined after another careful evaluation.

- 1 short visits to Munich (2 weeks, final phase):
  The coordinators will discuss the progress and the perspectives for future work. Strategies for the employment, the exploitation and the dissemination of the obtained results will be agreed upon.

7 Description of Partners' Expertise

Dr. hab. Peter Struss joined the Technical University of Munich in 1992. He has been working in AI since 1978 and on research in QR since 1981 at Siemens Corp. Research and Development. A principle of his work is to always carry out and evaluate basic research in the context of concrete case studies.

Publications:


Prof. Dr. Waldir Leite Roque is currently a member of the Graduate Program Council and the vice-coordinator of the Graduate Program in Applied Mathematics (CPGMAP) at the Federal University of Rio Grande do Sul (UFRGS), Porto Alegre. He was previously a faculty member at the Mathematics Department of Brasilia University and the Informatics Department of Federal University of Santa Catarina, Brazil. He has been a visitor at the Institute for Informatics, University of Karlsruhe, at the Research Institute for Symbolic Computation (RISC) in Linz, Austria, and at ICTP/ISSIA in Trieste, Italy.

Publications:

WASA: Supporting Scientific Databases Using Object-Oriented Systems:
Status Report and Future Plans

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2 Objectives

The goal of this project is to develop a working environment for scientists in the natural sciences, exploiting the emerging computer science technologies of scientific databases, distributed object management, workflow modeling and management, and data and object brokering. Our major focus is on biological applications and applications of the geosciences. The development of a new and appropriate type of workflow management and database system for this domain, embedded into a carefully designed and equipped processing environment, would allow more efficient and better documented data manipulation, and enable end user access to existing domain specific data analysis procedures through an integrated user interface.

Since our initial proposal [1], the cooperation project has evolved from pure scientific data management to scientific workflow management. This development was triggered by our perception of the needs of scientists in academia and industry to control and document complex processes that characterize scientific work today, and is elaborated upon in the following sections.
3 Project Description

The results obtained to date involve the development of the WASA architecture for documenting and specifying scientific experiments, and the identification of another major area of application besides molecular biology – geosciences, where the same type of approach can be undertaken. (Section 4 elaborates on the project results.)

3.1 The WASA Environment

WASA (Workflow-based Architecture to support Scientific Applications) is a system intended to integrate database technology with tools existing in a scientific environment, to support the management of scientific experiments. This type of framework is nowadays considered essential to allow documentation, specification, and result sharing of scientific experiments, besides other aspects. WASA is centered around a workflow management system which takes advantage of an underlying set of database systems, to which it has access via a standard object broker interface. In the WASA architecture, experiments are specified as workflows with special properties ("scientific workflows"); through which WASA users (scientists) can specify, control, and simulate scientific experiments in different domains. One of the novel aspects of WASA is that it automatically supports the documentation of experiments, together with data used by such experiments. This allows scientists to share and reuse experiments which were developed by other groups. A detailed description of WASA can be found in [2].

3.2 Application of WASA to Biosciences: FAT-WASA

In recent years, progress in the biosciences largely depends on computer support. In particular, the need to store, retrieve, visualize and analyze biologically relevant data has led to the use of domain specific scientific databases. The support for data management in the biosciences today is considerable to help the daily work of biologists.

As discussed above, WASA goes beyond traditional scientific data management in that it supports the specification, controlled execution, and documentation of scientific experiments. Experiment management is of crucial importance for the biosciences since biological experiments usually have a complex structure and many researchers, devices, and protocols are involved in biological experiments.

In a recent paper, we investigate the bioscience application of DNA sequencing and focus on its process structure. We identify tasks, their interdependencies and internal structure. Tasks are progressively refined into manageable units that can be executed by humans or software tools, i.e., we describe DNA sequencing as a scientific workflow. We show how WASA can be tailored for DNA sequencing and discuss the support that FAT-WASA (Fragment Assembly and WASA) provides to the bioscience user [4]. The FAT-WASA architecture – a derivative of the generic WASA architecture – is given in Figure 1.

To evaluate the applicability of a business workflow tool to scientific workflow management, we implemented a FAT-WASA prototype using IBM's FlowMark™. Preliminary experiences are reported in [4]; a more detailed review appears in [3].

3.3 Applications of WASA in Geoprocessing

Geographic Information Systems (GIS, for short) are systems that manage geographic phenomena associated with their location on the Earth. GIS play a major role as a decision support tool for planning activities. Both in Germany and Brazil, GIS are now extensively used for environmental and urban planning.
Present GIS lack however several facilities which are required by users. Thus, there is a great demand for extending present GIS or developing new tools and techniques to support user needs. Within WASA, the main concern is that, in order to efficiently support GIS applications, one must experiment with new technologies, involving database systems, storage, data management and interface facilities.

Users need support to help record and specify new procedures in data collection, error correction and analysis. Several kinds of applications can be found where a common set of procedures is needed, but no automated support of these activities exist. Examples are the steps conducted by users in defining scenarios for analysis in environmental planning, or the preliminary procedures for data quality assurance. At present, we are trying to identify such subsets of procedures where the use of WASA would liberate users from routine work. As well, the documentation facilities of WASA would be extremely valuable in helping environmental and urban planners record their activities for subsequent justification of planning decisions.

3.4 Industrial Cooperation - Present and Future

The WASA architecture originated from a number of meetings with members of university institutes in several places, industry sites involved in biosciences, and, later, in geosciences. WASA is an answer to the major needs expressed in these meetings.

In details, the following requirements were identified as common to the two scientific domains under consideration:

- The need for an environment where scientific experiments can be documented, specified, and even executed and conducted within a single framework. This project is trying to meet this requirement by using the workflow approach, an emerging computer science paradigm for process and activity management.
- The need for tools and methodologies to model real-world phenomena, and to store them into scientific databases in an organized way which also reflects their temporal
features and possibly existing versions. This requirement, among other things, relates to data standards, reusability and data sharing, and to heterogeneous database system integration, all of which are addressed within the WASA project.

As a result of the first need, we have developed the WASA architecture and initiated tests on the specific domain of biosciences. In the continuation of this project we will proceed with tests on the domain of geosciences.

The industrial partners interested in this phase of the project were GENOMIC and INPE, both in Brazil. In particular, INPE is interested in using the framework for helping non-expert users develop appropriate procedures to collect and process georeferenced data and select adequate analysis procedures. It is hoped that this will decrease the overall cost in the use of GIS, since about 60% of the cost of developing applications in geoprocessing involves data specification and collection.

4 Project Results

The results obtained in the context of this project to date can be summarized as follows:

- Specification of a working framework, the WASA architecture, which integrates the emerging paradigm of workflow management into scientific applications; it makes intensive use of database technology and upcoming standards.
- Development of tests on a commercial workflow system to validate the feasibility of the architecture.
- Identification of industrial partners:
  1. GENOMIC in São Paulo (Biosciences)
  2. INPE, the Brazilian National Institute for Spatial Research (Geoprocessing)
- Results of testing a commercial workflow management tool showing its applicability and shortcomings in scientific applications.

During 1994 and 1995, there were 4 visits (two on each side) of one month each. These visits included, on each side, contacts with other partners within the Database Technology area. Another facet of this cooperation was the sending of a Brazilian student from UNICAMP to do a PhD under the supervision of Prof. Vossen. The following activities were conducted:

- 7 talks in Brazilian universities and research centers (Dr. Mathias Weske)
- 8 talks in German universities and research centers (Drs. Claudia Bauzer Medeiros and Joao Meidanis)
- visits and contacts with prospective industrial partners
- development of prototypes of object oriented applications by the PhD student

5 Work Plan and Future Work

5.1 Activities and Partners

Due to the results obtained in its first two years, and the needs identified in the industrial area, the project has acquired two industrial partners in the Brazilian side.
The following research and development goals are planned for the period 1996-1997:

- development of a prototype of the WASA architecture
- testing this prototype with procedures provided by industry
- development of data modelling and versioning solutions for specific problems posed by geographic database systems, provided by INPE
- testing these solutions on real data
- looking for new industrial partners using as lever the results obtained

5.2 Intersection with Other Projects

The results obtained will not be restricted to the specific interests of the industrial partners of this project. On the Brazilian side, there is an intersection of part of this project with a multi-institutional thematic (PRoTeM-CC) project of CNPq, in the development of tools and techniques for geoprocessing systems. This thematic project, called GEOTEC, involves several Brazilian universities, industries and government companies (among which Petrobras and Telebras), all of which have declared their need for solutions in specific problems in the domain of geographic databases. It is therefore foreseen that the results obtained in WASA will be applicable not only to its industrial partners, but can also be incorporated by other parties (for instance, the other partners in the GEOTEC project).

For the next two years, the following trips are planned (each about one month):

- 1996
  - two visits of Brazilians to Germany (Claudia B. Medeiros in January)
  - two visits of Germans to Brazil
- 1997
  - two visits of Brazilians to Germany
  - two visits of Germans to Brazil

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GRAPHIT
Graphical Support and Integration of Formal and Semi-Formal
Methods for Software Specification and Development

January, 1996

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  P. Castro
2 Objectives

The overall aim of this project is to bridge the gap between formal specification techniques developed in research projects and semi-formal or informal specifications used in industrial practice. The main idea to overcome these problems is to develop graphical support for formal methods in order to increase acceptance by practitioners and to provide means for integration of formal and semi-formal methods. More specifically suitable concepts are being developed to combine algebraic specifications, Petri Nets, and Graph Grammars with each other and with distinguished graphical components to be used by industrial partners.

3 Project Description

Techniques for the specification and development of software in industry must combine both an intuitive appearance and a formal basis in order to provide easy access, clarity in standard and marginal cases, and the possibility for formal analysis whenever this is required.

Unfortunately, most of the specification and development techniques which are used in practice today lack a formal basis. But such a basis is necessary for a clear problem description covering not only the standard but in particular also the marginal cases where errors are most likely to occur. Moreover, a formal analysis or correctness proofs for critical parts of software strongly require a formal basis of the description. On the other hand there is a clear need in practice for development techniques being intuitive and suggestive. Efforts should be directed to coping with the specified problem rather than with the specification formalism.

As already mentioned before the aim of this project is to bridge the gap between formal specification techniques developed in research projects and the semi-formal or mostly informal specifications used in industrial practice. To solve these problems we divided the project into the following three research topics:

- **Integration and adaption of formal and semi-formal methods**
  This topic includes the analysis of intuitive and semi-formal methods with graphical components which are used by industrial partners, and their integration with formal specification techniques.

- **Concepts and tools for the graphical layout of algebraic specifications**
  To increase the readability of specifications and make them (at least partially) understandable even for non specialists, graphical layout is of great importance. Graph grammars and Petri Nets have a natural graphical representation, and for algebraic specifications a corresponding extension was provided by [Rie93, Bar93]. However, these representations are still sometimes to complex to be used in the practice. The development of the case studies has shown that (graphical) shorthands are needed in many situations. That is, to bring formal methods closer to real applications, we must allow more flexibility in the representation.
  New software tools shall be developed based on the extended graphical facilities of modern computer soft- and hardware and the already existing tools dealing with algebraic specifications, graph grammars and Petri Nets should be integrated into the ACT-[CEW93] and PROSOFT-[Nun93] environments.

- **Combination of algebraic with graphical specification techniques**
  Combining algebraic specifications with Petri Nets [REP93] and/or Graph Transformations [LKW93] results in high-level specification formalisms with graphical components for the informal and formal specification of different aspects of software like data type and process parts in an integrated framework. The graphical components should provide increased comprehensibility leading to more reliable software.
4 Project Results

Research in the first year of the project has followed the outline which was described in the proposal for GRAPHIT [BBCE+94]. The progress with respect to the research topics and the results obtained up to now are described below.

Due to its character as a working group, the project supports the cooperation of the partners. Research on integration of semi-formal and formal methods was intensified by several bilateral visits of the partners as listed below:

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<tr>
<th>Visits from Germany to Brazil</th>
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<tr>
<td><strong>Names</strong></td>
<td><strong>Names</strong></td>
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<tr>
<td>J. Padberg (TUB)</td>
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<td>L. Ribeiro (TUB)</td>
<td>P. Castro (NUTEC)</td>
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To demonstrate and integrate the results of the research topics one workshop in Porto Alegre (Brazil) has been organized. Moreover three working group meetings took place in Berlin (Germany) where more aspects of the cooperation have been discussed and reports about current activities were given.

In the following we summarize our activities and results concerning the first two years of cooperation, taking into account the main research topics of GRAPHIT.

- **Integration and adaption of formal and semi-formal methods**
  
The first step towards integration of formal and semi-formal methods was the preparation of an overview paper about semi-formal methods used in industry "A survey on semi-formal approaches to software development" by R. Bardohl, A. Martini, J. Martins and L. Ribeiro. After presentation of a first version of this paper to the industrial partners during a workshop in Porto Alegre, it was decided that the paper deserved both an enhancement as well as an extension with the main aim at providing a fairly broad and easy to use reference for the subject by practitioners. The corresponding final version is in the state of final preparation.

  Furthermore, a master thesis was prepared concerning approaches of the integration of semi-formal and formal specification methods for software development.

  As a result of a visit of J. Padberg (TU Berlin) to NUTEC, Porto Alegre, a first attempt was made to integrate algebraic high-level nets with state-transition diagrams as used by NUTEC. Since the initial results were received with considerable enthusiasm by members of NUTEC, special attention to this topic will be given in further cooperational activities.

- **Graphical layout of specifications and tools**
  
  As a result of this topic a telephone system proposed by NUTEC has been specified using object-oriented graph grammars and object-oriented algebraic high-level nets [HKR95]. Additionally, the shipping software which was proposed by MSB has been specified using algebraic specifications. These specifications are visible with the GVT system [Bar95].

- **Combination of algebraic with graphical specification techniques**
  
  The work on this topic is divided into two parts. One part is concerned with the application of formal specification techniques to real problems of the companies MSB, Berlin, and NUTEC, Porto Alegre. The other part is concerned with the foundations of formal and semi-formal specifications and concepts.

  Applications: The following work has been done:
Specification of a telephone system proposed by NUTEC, Porto Alegre, using object-oriented graph grammars and object-oriented algebraic high-level nets [HKR95].

Specification of the shipping software proposed by MSB using graph grammars [EB94], object-oriented algebraic high-level nets [Rib94], and algebraic specifications [Bar95] including a modeling of transactions and the relationship between ER-diagrams and algebraic specifications.


Foundations:

Concerning this topic we have written the reports "An Outline of the Basic Elements of Category Theory" [Mar94], and "A Survey on Categorical Techniques in Computer Science" [Mar95]. The aim of both reports is to provide an comprehensible exposition of both basic categorical concepts and applications. Besides, the presentations, which took place in the GRAPHIT workshop in Porto Alegre, were also concerned with an exchange of knowledge between the partners.

Moreover, new research activities have been developed and are under consideration concerning foundational issues, which include true concurrency semantics for graph grammars [Kor94], specification of dynamic abstract data types [EL094], as well as concepts for structuring and refinement of nets.

Summarizing all the activities we can say that formal methods with graphical representation are suitable for precise documentation by practitioners in industry and a basis for correctness proofs and verification.

5 Work Plan

After having specified very different real problems using quite different formalisms, we have acquired considerable experience and knowledge that led us naturally to the following topics about the weak points of each of the formalisms used:

- In order to make the complex task of specifying real world objects intellectually manageable, the development of well-founded concepts for both modularization resp. structuring and refinement are strongly needed, specially for graph grammars and high level nets.

- Specifications carried out using graph grammars are weak concerning the visualization of the control flow of the system.

- Algebraic specifications, in the classical sense, are not always suitable to specify data bases or systems that have a natural implicit or underlying state. In fact, the whole state or the data base must be an input for virtually every operation of the system, making such specifications extremely hard to be read and understood.

- Classical Petri Nets are not suitable to specify distributed, complex states.

On other hand, each of these formalisms have also their strong points, e.g., algebraic specification for the specification of data types. Petri Nets for specifying the control flow of non-trivial systems and graph grammars for specification of distributed applications. Therefore, we intend in further activities within GRAPHIT to work on these problems in order to develop suitable integrated versions which are applicable by the industrial partners. For this, we point out that our partner NUTEC is at this moment highly involved in both, specifying and developing concurrent communication-based systems. Main aspects that must be taken into account in such software systems concern safety, reliability, data flow, concurrency, as well as real time and distributed
aspects. The variety of concerns involved may suggest a wide spectrum of “needed” techniques for both specification and development to cope with such a complex task.

Besides, one of the research topics at this moment in Prof. Ehrig’s group at TU Berlin is the development of well-founded concepts for the notion of “module” for graph grammars and Petri Nets that allows compositionality with respect to correctness and semantics, which are key factors for developing complex software systems in a “tractable” and reliable way. Besides, Prof. Daltro’s group at UFRGS has been already working for some years in the specification and verification of concurrent systems and more recently with real-time systems as well.

Therefore, one of our main aims is to see how far these concepts can be successfully applied in specification of concurrent communication based systems developed by NUTEC. Moreover, as pointed out above, different formalisms may be also suitable for specification of different aspects in different parts of the development process. Thus, we also intend to study the possibility to integrate in a coherent and structured way different formalisms. Such integration may allow transference of results and proofs among the different formalisms as well as the use of available tools for different formalisms as originally intended. Upon successful evaluation of results, appropriate training of NUTEC’s personnel could take place in order to provide mastering of all the concepts and techniques involved.

Summarizing the discussion above, we intend to continue our work in the following directions:

- Development of structuring techniques as well as refinement/abstraction concepts for graph grammars and Petri Nets.
- Analysis of the case studies in view of requirements from industrial partners.
- Development of well-founded concepts in order to integrate different techniques and formalisms according to the requirements of the case studies.
- Adaptation of the developed formalisms to practical applications using new graphical notations so as to extend, optimize and ease the application of such formalisms.
- Application of graph grammars for the specification of the Shipping System served by MSB.
- Correctness/verification of system specifications according to the case studies of MSB and NUTEC using graph grammars and algebraic high-level nets.
- Extension of the case study specifications.

Due to lack of time of industrial partners, some activities that were planned for the first two years had to be postponed. In particular, this includes the detailed analysis of the case studies and discussion, what may lead to new topics for further research.

5.1 Travel Plan

The following tables present our expectations concerning traveling activities within the project GRAPHIT for 1996.*

<table>
<thead>
<tr>
<th>Visits from Germany to Brazil</th>
<th>Visits from Brazil to Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instit.</strong></td>
<td><strong>Persons</strong></td>
</tr>
<tr>
<td>TUB</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The number of months is the total of all persons.
References


High-accuracy Arithmetic applied to Dimensional Metrology – HARDY

1 WORKGROUP

1.1 Partners

- Coordination:

  Dr. Dalcidio M. Claudio (coordination at UFRGS)
  Dr. Siegfried M. Rump (coordination at TUHH)
  José C. Paz da Silva (coordination at SENAI)

- Collaborators:

  Beatriz R. T. Franciosi (UFRGS)
  Carlos A. F. C. Alves (SENAI)
  João B. S. de Oliveira (TUHH)

1.2 Institutions involved

- Universidade Federal do Rio Grande do Sul (UFRGS)
  Departamento de Informática Teórica
  Pós-Graduação em Ciência da Computação
  Brazil

- Technische Universität Hamburg-Harburg (TUHH)
  Informatik III
  Germany

- Servicio Nacional de Aprendizagem Industrial (SENAI)
  Centro Tecnológico de Mecânica de Alta Precisão (CETEMP)
  Laboratório de Metrologia Dimensional
  Brazil
1.3 Some words about the industrial partner

The industrial partner is the Dimensional Metrology Laboratory at SENAI/RS. The SENAI/RS is one of a series of institutions with the same name, each one being supported by private industries from the state where it is located. In this sense, SENAI/RS is supported by private enterprises of the Rio Grande do Sul, a region comprising the extreme south of Brazil.

The aim of these institutions is the training of technical industry workers, that is, specialized technicians that apply rather sophisticated technologies in industrial environments.

The SENAI/RS supports technological centers in some interest areas of the funding industries. CETEMP is one of these centers, which works on the precision mechanics area. CETEMP has as main goal to assist the necessities of industries that work with computer-assisted design among machine makers, precision calibration as well as metal processing.

In the scope of this project, we intend to test the feasibility of the error-correction strategy that will be developed to reduce measurement errors. Doing so, new approaches can be quickly tested in practical work.

1.4 Partners expertises

**Dr Dalcidio Moraes Claudio**
Senior researcher, has been developing a semantical approach to information processing using interval theory. Since 95/June, he has been the UFRGS head of a cooperative project between UFRGS-SENAI/RS. This project aims is to use interval theory to solve some practical problems related of dimensional metrology.

**Dr Siegfried Michael Rump**
Senior researcher, has been developing scientific processing tools and methods oriented to high-accuracy computations, that is, ways to assure rigorous exactness for the results of computer programs performing extensive calculations. Extensive experience on the development of scientific processing tools.

**José Carlos Paz da Silva**
Member of the SENAI's technical staff with large experience on dimensional metrology aspects. Mr. Silva has been working with length, shape and position measuring machines. Experience on accuracy of coordinate measuring machines. Just a few years ago, the
SENAl bought a coordinate measuring machine from Zeiss Company and then it has been using to make possible the practical learning about this subject.

Beatriz R. Tavares Franciosi
Student at doctorate program at CPGCC-UFRGS supervised by Dr. Claudio. She has been developing research in scientific visualization of interval functions and also studying visualization, manifolds and simulation. This effort intends to take mature about the close-set concepts and techniques to built a succesfull visual environment design to interval functions.

Carlos Alberto F. C. Alves
Member of the SENAI's technical staff, production engineer, developing work in dimensional metrology applied to industrial processes. He has been taking practical experience at coordinate measuring machine supervised by Mr. Silva.

João Batista de Oliveira
Student at doctoral work at TUHH supervised by Dr. Rump. Has been working with new ways to achieve sharp bounds to interval functions, a theme probably necessary to the project. Has also worked in the representation of tri-dimensional data in interval form.

2 PROJECT GOALS

The main goal of this project is to take a reliable geometrical model from a real object obtained from a measurement machine. The difference from already available models is that the measurement error might be further reduced through the use of high-accuracy methods. So, this new model (or equivalently, the strategy of building a better model) will increase the operational effectiveness of the measurement machines at CETEMP.

The following tasks are foreseen:

1. to define the measuring uncertainty and the systematic error decrease through numerical correctness, in two-dimension measuring routines;

2. to plan the scientific visualization of the geometrical model including the related error tolerance for each object measured point;

3. to implement and test the designed plan to geometrical model visualization;

4. to define the measuring uncertainty in tri-dimensions and systematic error decrease;
5. to design an environment with a powerful visual communication which makes possible a visual exploration of the obtained geometrical model;

6. to implement and test the visual exploration environment to support measuring error from a geometrical model.

3 PROJECT DESCRIPTION

The technology of coordinate measurement is based in the recognition of points from an object. This is done by an optical instrument operating on the surfaces that constitute the object. This instrument is connected to a Coordinate Measuring Machine (CMM) and makes possible the construction of a geometrical model. The geometrical modeling is possible through the numerical processing of the measured coordinates from the CMM.

A CMM is a multi-purpose instrument able to measure a very large family of geometrical parameters. For each parameter there are many possible measurement strategies that are not standardized. Both, the measurement task and used measurement strategy, define the error amount which is introduced in the measurement system and the way it propagates in the hardware and software of the CMM.

These machines are vulnerable to geometrical or parametrical errors, which can produce important differences between the real object and the one represented by the geometrical model.

One of such errors is related to the deviation of the coordinate system regarding the ideal reference coordinate system. The error is caused from deficiencies of the shape and orientation in the associated data and trails, because when the subsets get out alongside of the coordinates axes, they execute a translation motion perpendicular to the rotation and motion direction with a small angle, thus generating motions in non-orthogonal directions.

The trail deficiency effects are dependent of the measuring machine configuration, and they change from position to position with the motion of the machine. The translation motion can be perceived like rectilinearity deviation and the rotation deviation like slope deviation. Both deviations together describe the displacement sequence of a CMM.

To reduce these errors in the mathematical modeling the processing becomes much more complex because we need a connection rule for the spatial coordinates of each identified error. That is, we need methods to evaluate the error of a measurement, and this error depends on the position of the point to be measured, as well as the last movements of the machine.

The ideal situation is that one where can be able some correction for each point of the geometrical model generated, according to the spatial error processing (position, rectilinearity, orthogonality and slope).
HARDY project

This project intends to achieve the ideal situation described above. Then, the systematical geometrical errors of a CMM need be compensated in the mathematical model. A special kind of correction for each point, according to the spatial error processing (position, rectilinearity, orthogonality and slope) will be investigated.

So, there is a need of performing an error survey in different positions from the machine measuring space. Each point contains \( x, y, z \) values to make possible the spatial vector processing. In this way, the systematic geometrical errors of a CMM need to be compensated by special techniques oriented to high-accuracy geometrical model generation.

There is some planning solutions. One of these, will use an interval function generated from interpolation of a set of point positions. The construction details of this function will be presented in the following paragraphs.

For each point position will be associated an error according to their components of spatial error — position, rectilinearity, orthogonality and slope. These errors are measured from the calibration process of a coordinate measuring machine and they are connected with the different positions of machine reading.

The elements from the position set generated will be interpolated by special interpolation techniques. Then, a geometrical model will be construct and may be possible to visualized the expected residual error of the measuring process.

The theories and techniques to be use are based in works developed by [6], [1], [4] and [5], among others.

There are a few important contributions in the Hardy project. One of the scientific contributions regarding to the geometrical model generation with coordinate error correctness. Another is the technical development of the interval interpolation. The geometrical model and a graphical visualization will help to understand the error model.

At least two social contributions are to be emphasized: applied research in the dimensional metrology with direct industry connection to make possible the knowledge exchange, as well as the important contribution to make better the industrial processes.

References


4 PROJECT RESULTS

4.1 University-Industry Cooperation

A official agreement between UFRGS and SENAI/RS was established planning to exchange theoretical and practical knowledge about high-accuracy arithmetic applied to dimensional metrology. (official agreement period: April 1995 - April 1997)

4.2 Publications

- Some advances on slope evaluation. J.B. Oliveira, UFRGS, November 1994. (invited talk)


- Inclusion methods for real and complex function in one variable. D.M. Claudio, S.M. Rump, Revista de Informatica Teórica e Aplicada, volume 2, number 1, January 1995. p 125-136


- Evaluating to the Lipschitz constant for functions given by algorithms. J.B. Oliveira, S.M. Rump, Transactions on Mathematical Software. (to appear)

- A backward mode for slope evaluation and a remark on backward methods for interval variables. J.B. Oliveira, Revista de Informatica Teorica e Aplicada. (to appear)

- New slope methods for sharper interval functions and a note on Fischer's acceleration method. J.B. Oliveira, Reliable Computations. (to appear)
4.3 Potential new partners

Dr. U. Kulisch – University of Karlsruhe, Germany: academic staff member; theoretical background about interval arithmetics and related subjects.

Marcilia A. Campos – Univ. Fed. Pernambuco, Brazil: academic staff member; practical concerns about enclose of statistics and intervals.

Schott-Zeiss do Brasil Ltda, Brazil: industrial staff member; connection between technology developer and academic staff.

5 WORKPLAN AND FUTURE WORK

1. to define the measurement error as a function (of a 2-D and 3-D measurement region):
   - to achieve a position and geometrical error survey regarding a measuring plan of a CMM;
   - to define components in all measurement field;
   - to apply the correction on the coordinate measuring;
   - to test the generated model with the correction on the coordinate measuring;
   - to elaborate a correction strategy to be used in such machines. The strategy should be as fast and as simple as possible.

2. to design a methodology to visualize the measuring error associated with a coordinate measuring machine (errors maps);

3. to generate a reliable geometrical model from the measuring error information:
   - to design and implement a method visualization\(^1\) the geometrical model and the error occurred in the measuring procedure;
   - verification and validation of such method.

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<thead>
<tr>
<th>task</th>
<th>YEAR I</th>
<th>YEAR II</th>
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<tr>
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<td>3</td>
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\(^1\)scientific visualization, that means, many elements are combined to make up data visualization technology. Among them are animation, and resources ranging from simple graphics up to sophisticated rendering (computer images created to represent the surfaces of 3-D objects with shading and texture).
HARDY project

6 TRAVEL COSTS

• First year:
The main goals are knowledge exchange between partners, problem formalization and characterization of possible solution strategies.

Activities:
1. discussions about the problem formalization and the solution strategy;
2. bibliographic investigation;
3. visit a coordinate measurement machine industry (contacts with Zeiss have been established);
4. personal training;
5. know–how exchange about mathematics in industry;
6. visit the Dimensional Metrology Laboratory at CETEMP–SENAI/RS
7. lectures about the research subject

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<tr>
<th>From</th>
<th>To</th>
<th>Duration</th>
<th>Time</th>
<th>Activity</th>
</tr>
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<tbody>
<tr>
<td>Porto Alegre</td>
<td>Hamburg</td>
<td>30 days</td>
<td>1st semester</td>
<td>1,2,4</td>
</tr>
<tr>
<td>Porto Alegre</td>
<td>Karlsruhe</td>
<td>30 days</td>
<td>2nd semester</td>
<td>1,2,3</td>
</tr>
<tr>
<td>Hamburg</td>
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<td>30 days</td>
<td>1st semester</td>
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<td>Karlsruhe</td>
<td>Porto Alegre</td>
<td>30 days</td>
<td>2nd semester</td>
<td>1,5,6,7</td>
</tr>
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</table>

• Second year:
The main goals are knowledge exchange between partners, implementation strategy identify, scientific visualization design applied to coordinate measuring error visualization.

Activities:
1. discussion with the partner about the solution strategy and scientific visualization approach;
2. personal educational–training;
3. know–how exchange about mathematics in industry;
4. paper and technical report will be produced;
5. lectures about the research subject.

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<th>Duration</th>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>Porto Alegre</td>
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<tr>
<td>Porto Alegre</td>
<td>Hamburg</td>
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<td>Porto Alegre</td>
<td>30 days</td>
<td>2nd semester</td>
<td>1,4,5</td>
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</table>
Parallel and Flexible Environmental Analysis (PLENA)

1 Partner's Names and Addresses

Prof. Stefan Jähnichen (German Coordinator),
GMD-FIRST, Rudower Chaussee 5, D-12489 Berlin, Email: jaehn@first.gmd.de;
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Permoserstrasse 15, D-04318 Leipzig, Email: 100265.3000@compuserve.com;
Prof. Michael Hortmann,
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POBox 330440, 28334 Bremen, Germany, Email: michaelh@informatik.uni-bremen.de.

2 Objectives

The proposed project aims at investigating and developing methods and techniques to support the efficient execution of flexible environmental modeling, analysis and control systems. New parallel programming models, parallelization techniques and development support tools will be investigated and developed to enhance and speed-up a selected environmental modeling and analysis system.

3 Project Description

The proposed project aims at investigating and developing methods and techniques that support the development and the parallel execution of environmental modeling, analysis, and simulation systems. Such systems are becoming more and more important for estimating and detecting environmental pollution and supporting political and management decisions concerning the use of natural resources. The main emphasis of the project is on the development of parallel programming models and execution environments that support the development of efficient and flexible environment modeling, simulation and analysis systems. The project is organized in the following four lines of research (workpackages).

WP1: Environmental Modeling and Analysis. This part of the project is concerned with modeling, simulation and analysis of meteorological, chemical and dispersion processes
related to environmental pollution. Starting points are the current air pollution analysis system DYMOS[6], and work on parallel weather prediction models and parallel algorithms for partial differential equations done at the Department of Applied Mathematics at IME/USP.

One goal is to adapt the DYMOS system to the topographic, meteorological and social-economic characteristics of the city of São Paulo. A preliminary investigation shows that this adaptation requires some changes to DYMOS' mesoscale meteorological model, which does not provide accurate results for topographical irregular regions[5]. This adaptation will be done together with the Secretaria do Verde e Meio Ambiente of the city of São Paulo, which will provide the pollutant emission data and prepare it for the input to DYMOS. Another goal is to apply artificial neural networks for specific environmental control processes, which are characterized by the lack of suitable analytical models (e.g. water cleaning).

GMD: A. Sydow; IME/USP: S. Barros; SVMA: S. de Oliveira.

WP2: Parallel Programming Models. This part of the project is concerned with the development of parallel programming models and algorithms, the complexity and performance analysis of such models, and methods for parallelizing sequential applications. In particular, a theoretical model for the performance prediction of shared memory programs running on a virtual shared memory system on top of a distributed memory parallel architecture is being developed. Besides this, the DYMOS system is being analysed w.r.t. its current parallelization model and will be used to test the performance prediction model.

Parallelization of novel programming models, such as neural networks for distributed memory architectures is also being investigated. Special attention has been given to features inherent to the connectionist model, namely that numerous processing units are massively interconnected and operate in a synchronous mode.

Another line of research is the analysis and parallelization of algorithms in the area of cryptography. Here, the so-called Differential Cryptanalysis and the Linear Cryptanalysis are used to find the secret key with a time complexity lower than enumerating all the possible keys. This analysis uses a table of pre-computed characteristics, the computation of which has almost exponential complexity. Thus, the main objective will be the transformation of such sequential cryptoanalysis algorithms into efficient, parallel algorithms.


WP3: Support for Parallel Program Development. Parallel program development requires tools for problem dimensioning, program design, programming, execution, monitoring and debugging. The operating system PEACE[7] is a very efficient, highly configurable execution environment running on parallel architectures and on clusters of workstations. Based on experiences of the PEACE project, this workpackage aims at developing methodologies and tools supporting parallel program development on the PowerXplorer.

One of these tools is a performance prediction model currently being developed for the virtual shared memory system VOTE[1] running on PEACE. This model will be extended also to different parallel programming models and other execution environments. The second objective is to port (part of) PEACE to PARIX (the current runtime environment of the PowerXplorer). This allows the use of services that run on the top of PEACE (e.g. ROI, VOTE) on the PowerXplorer. Yet another line of research involves building monitoring instrumentation and data display facilities for the PARIX/PEACE operating environments.

WP4: Data Driven Modeling. Many technical applications in the environmental domain are related to dynamical processes which cannot be described explicitly by mathematical means, but can be characterized by numerous data and qualitative, heuristic knowledge. An example are water purification processes, where data can be gathered from control protocols of the past, and where fuzzy rules reflect the impact of internal and external parameters. Artificial neural networks have proved to be a valuable tool for data driven system modeling. Other methods from artificial intelligence can be used to process qualitative information, and to handle informal domain descriptions such as those found in some environmental control systems. The goal of this workpackage is to investigate artificial neural networks and artificial intelligence methods, and to develop integrated approaches which, on the base of heterogeneous data, can be used for modeling and control.

GMD: G. Kock; INCO: T. Becher; ICMSC/USP: A. de Carvalho.

4 Project Results

In November 94, IME/USP applied for a ITDC grant from the Commission of the European Communities (CEe) for the acquisition of a parallel distributed memory computer to support the PLENA activities. Among more than 200 proposals submitted worldwide, the PLENA-oriented proposal was selected together with aprox. 20 other projects and received a ECU 157.000 grant for the acquisition of a 16-node Parsytec PowerXplorer. With this machine, IME/USP now has better possibilities to contribute to the practical goals in PLENA and shall also benefit even more from the cooperation.

WP1: Environmental Modeling and Analysis. Mr. Oliveira (SVMA) visited GMD FIRST for one month (11/94). He analysed the DYMOS system w.r.t. the requirements for adaptation in São Paulo[5]. His analysis indicates that for an adaptation of DYMOS to the São Paulo conditions, one needs access to data on pollutant emission rather than pollutant concentration for the whole metropolitan area. Moreover, one has to include a tridimensional meteorological model into DYMOS which accounts for the irregular topography of the metropolitan and surrounding area. After the visit, Mr. Oliveira started organizing and preparing the meteorological and topographical data, as well as data on pollutant concentration in São Paulo for the DYMOS system. Peter Mieth (GMD) visited IME/USP in 10/95, where he gave a course on DYMOS and installed the system on the Parsytec PowerXplorer.

WP2: Parallel Programming Models. G. Kock visited IME/USP (2/95 - 5/95), where he worked with Profs. Endler, Song and Gubitoso on the parallelization of the neural network specification language CONNECT (developed at GMD FIRST). At the beginning, he gave a one week lecture on Theory and Applications of Artificial Neural Networks. This lecture was part of the regular IME summer program and served as a framework to identify connectionist structures which are suited for parallel implementation. Afterwards, the CONNECT compiler (generating C++ code) has been analysed w.r.t. the goal of transparent parallelisation. It turned out that unit parallelism can be realized by slight language extensions and simple modifications of the given code generation process. Training set parallelism also can be realized in a transparent way. The necessary extensions and modifications of the language and the code generation process, however, have to be studied in more detail. These results are documented in [4]. Finally, G. Kock visited ICMSC/USP, where he planned the future steps of the cooperative work in workpackage Data Driven Modeling.

WP3: Support for Parallel Programming. Marco D. Gubitoso visited GMD First (7/94 – 10/94). Together with Jörg Cordsen he developed several analytical performance
models for a virtual shared memory system (VOTE) running on the MANNA machine. The information obtained through the models was used on further development of VOTE. Jörg Cordsen visited IME/USP (8/95 - 10/95). In this visit, VOTE extensions were modeled for a SOR application and matrix multiplication. The SOR program was ported to PARIX and modeled in a similar way. The modeling techniques used on both visits will be generalized and adapted to other applications, e.g. DYMOS, and provide guidelines for software development under VOTE-PEACE and PARIX.

WP4: Data Driven Modeling. Dr. Gerd Kock and Prof. André de Carvalho have prepared a plan for the work to be started in 1996.

Joint Publications


5 Work Plan

WP1: Environmental Modeling and Analysis. The next steps will be the preparation of the topographic, meteorological and pollutant concentration data of São Paulo for input to the DYMOS system. This includes acquiring currently available data for regional time/space patterns of meteorological, climatology and air quality data, interpolation of the values in a virtual grid over the metropolitan area and the digitalization of the city map. Also, the mesoscale meteorological model in DYMOS (REWIMET) shall be reviewed and one will study the feasibility of the substitution of this model by a three-dimensional one, like GESIMA. Finally, with the aim of having an efficient parallel implementation of DYMOS on the PARSYTEC system, the current implementation will be analysed and alternatives will be investigated.

<table>
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<tr>
<th>Period</th>
<th>Activity</th>
<th>Result</th>
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<tbody>
<tr>
<td>01/96-05/96</td>
<td>preparation of meteorologic, topographic and air quality data; review of the meteorologic model for southern hemisphere</td>
<td>test use of DYMOS without pollutant emission data; report on change feasibility</td>
</tr>
<tr>
<td>05/96-7/97</td>
<td>acquisition of pollutant emission data; analysis of parallel performance of DYMOS</td>
<td>pollutant emission map; evaluation reports, SW enhancements</td>
</tr>
<tr>
<td>7/97-12/97</td>
<td>possible replacement of the meteorologic model in DYMOS</td>
<td>full operational use of the system for the São Paulo region</td>
</tr>
</tbody>
</table>
WP2: Parallel Programming Models. The next step is the implementation of unit parallelism into CONNECT. For training set parallelism, the language CONNECT has to be extended and a transparent implementation scheme has to be developed. With respect to parallel algorithms for cryptography, various complex parallel algorithms will be designed and implemented (on the 16-node Parsytec PowerXplorer) to reveal possible weaknesses of block ciphering algorithms against information leakage.

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<tr>
<th>Period</th>
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<th>Result</th>
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<tbody>
<tr>
<td>1/96-9/96</td>
<td>unit parallelism: PVM-based implementation; design of parallel cryptoanalysis algorithms</td>
<td>CONNECT generates par. code; design documentation</td>
</tr>
<tr>
<td>10/96-6/97</td>
<td>development of language and implementation concepts for training set parallelism; implementation of cryptoanalysis algorithms on the PowerXplorer</td>
<td>CONNECT extension report; tables of differential characteristics &amp; tech. reports</td>
</tr>
<tr>
<td>7/97-12/97</td>
<td>implementation of training set parallelism result evaluation and comparison</td>
<td>fully-parallel CONNECT joint publications</td>
</tr>
</tbody>
</table>

WP3: Support for Parallel Programming. Work will concentrate on performance models and runtime support for monitoring SPMD programs (for message-passing and shared memory paradigms). The main target of performance modeling will be the study of the DY-MOS application and the functional encapsulation of overheads in the current version. This would allow the customization of the model for different simulation scenarios (e.g. topography, level of detail, grid size, number of layers) and adapting the model for new algorithms, computing environments and simulation techniques. Modeling will concentrate on communication behavior and I/O contention, the two main potential sources of overhead. These will be studied in the context of several programming environments: VOTE (PEACE), PVM and MPI (PEACE and PARIX), the PARIX native library. It is not clear that a complete set of accurate models can be derived for all these programming environments, but it will be possible to develop guidelines for future SW architectures of DY-MOS. Performance modeling will be complemented by the development of monitoring instrumentation and data display facilities for the Parix/Peace operating environment. In particular, we will port the package Falcon [3] to Parix so we can experiment with thread-level monitoring and steering[2].

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<th>Period</th>
<th>Activity</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/96-6/96</td>
<td>porting Falcon runtime support for monitoring threads to Parix; detailed study of DY-MOS structure</td>
<td>real-time display of threads for DY-MOS; map of overheads and preliminary model</td>
</tr>
<tr>
<td>7/96-12/96</td>
<td>developing new displays for monitoring information &amp; detection for potential steering in DY-MOS; developing basic performance model of overheads</td>
<td>design &amp; performance report; functional encapsulation of overheads</td>
</tr>
<tr>
<td>1/97-7/97</td>
<td>integration of the analytical performance model with the Falcon steering support; analysis of new application programs</td>
<td>prototype: user oriented steering of DY-MOS, dynamic domain decomp.; guidelines: further parallelization of DY-MOS</td>
</tr>
</tbody>
</table>

WP4: Data Driven Modeling. The goal is to find out the limitations, when neural networks are applied to real world applications. The work will suggest ways to overcome these limitations by combining different techniques. As an example, control of water purification plants will be considered; this is of practical interest for the industrial partner INCO Systems GmbH. First, data and fuzzy rules are collected. Then, approaches for dealing with this information are studied, and a connectionist based system is designed and implemented as a prototype. The results have to be analysed and compared to other techniques.
<table>
<thead>
<tr>
<th>Period</th>
<th>Activity</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/96-9/96</td>
<td>study of approaches for data driven control</td>
<td>design; NN-based control system</td>
</tr>
<tr>
<td>10/96-6/97</td>
<td>development of a prototype</td>
<td>prototype; parameter evaluation</td>
</tr>
<tr>
<td>7/97-12/97</td>
<td>comparison with other techniques</td>
<td>report</td>
</tr>
</tbody>
</table>

**Planned Visits**

**A. de Carvalho** (GMD, middle of 1996, 6 weeks): Design of the connectionist system, analysis of the results achieved until then, definition of the next steps.

**M. Gubitoso** (GMD FIRST, July 1996, 4 weeks): The preliminary performance prediction model will be validated. An evaluation report will be produced.

**M. Endler** (GMD FIRST, middle of 1996, 4 weeks): Work on training set parallelism of CONNECT, and on the implementation of a Peace-like runtime support on the top of Parix.

**M. Hortmann** (IME/USP, middle of 1996, 4 weeks): Work with Route Terada's research group on the design and analysis of parallel algorithms for block cipher functions.


**M. Fabiunke** (ICMSC/USP, end of 1996, 6 weeks): The design of the connectionist system will be completed, and the practical application will be prepared.

**G. Kock** (IME/USP, end of 1996, 8 weeks): Work on the transparent implementation of training set parallelism. Language and parallel implementation concepts will be developed.

**J. Cordsen** (IME/USP, January/97, 4 weeks): In that visit the final encapsulation will be tested and the performance modeling of existing versions of Dymos will be started.

**T. Becher** (ICMSC/USP, beginning of 1997, 2 weeks): As an industrial partner his interest is to evaluate the current system development from the application oriented point of view.

**D.M. da Silva** (GMD, July/97, 4 weeks): She will work with the DYMOS and Peace Groups, for discussing and adapting the steering support to other parallel applications.

**References**


1. Motivation

ARTS is an ongoing three-year project contracted by EQUITEL with the Laboratório de Métodos Formais of the Pontifícia Universidade Católica do Rio de Janeiro (LMF-DI), and being developed in cooperation with The Imperial College of Science, Technology and Medicine of the University of London, the Ludwig-Maximilians Universität-München (LMU), and the Forschungsinstitute für Angewandte Softwaretechnologie (FAST).

A significant portion of software engineering activities consists of the construction of embedded and real-time systems, which have widespread industrial application. The economic impact of the automation offered by these systems is expressive. At EQUITEL embedded systems are a fundamental part of the company's basic technology. They are present from the built-in controls in telephone exchange centrals to transmission net managing applications. These systems compose their main products.

The advent of object oriented methods opened new possibilities for the development of high quality software systems. Due to their nature and characteristics, embedded and real-time systems benefit directly from the advantages offered by object orientation. Hence, with an appropriate programming system, it is possible to define the behaviour of objects when receiving different types of messages, specifying, for example, the treatment of exceptions, and the cooperative execution of tasks. However, current object oriented methods lack a formal base – a fundamental feature in safe, modern software development methods. They do not go beyond helping, often in a very efficient way, development and understanding of what has already been thought, but only up to exactly this point.

Existing methods do not provide the appropriate mechanisms to make inferences on the behaviour of the system under development, or to enable the user to prove the validity of certain assertions or the invariance of particular properties. If one mentally pictures an engineering process, one will realize that these inferences and proofs establish the difference between engineering and craftsmanship. The support of, for instance, both rational reuse and early prototyping, including early performance measures, requires formal principles and tools.

Let us analyse this subject a little further. The usual idea of a methodology presupposes a series of conventions, rules, restrictions, and uses, as well as a specific, often iconic, language. These tend to rule the development process, so as to expedite and organise the actions needed to produce an artefact that satisfies users' requirements. (Moreover, many of the existing methodologies offer mechanisms to help the user elicitate and describe such requirements.) Hence, by methodology we understand any kind of mechanism used to structure a mental construction. This structure can be given, for example, by the notation used to describe verification and validation rules and guidelines, and the principles that regulate the development process.

We have a clear example of such structure in the taxonomic differentiation between verification – answering the question “are we building rightly?” – which implies checking the correspondence between descriptions, and validation – answering the question “are we building
the right thing?” which implies determining whether the descriptions are still consistent with the empirical concepts.

Structuring implies mental economy; for example, when we divide the software development process into stages such as strategic modelling, requirements analysis, analysis modelling, design analysis, implementation modelling, construction, and delivery; and give each of these stages diagrammatic notations and how-to-do recipes, we are creating templates that circumscribe and focus our own constructive process. Divide-and-conquer is a type of structuring process. One thinks of one thing at a time, be that either a physical or a methodological thing; one thinks, for example, of objects and then of their interrelations. The constructive chain is described by guidelines; it is an intellectual process guided by general principles like information hiding.

The problem is that, without a formal representation of the objects, rules, and guidelines involved, this chain is nothing but a set of prescriptive and descriptive rules. Therefore, a methodology built upon that basis does not possess the “exactness” and “inferential power”, which are components of every engineering process.

This kind of prediction or explanation, which we accept as taking part in any engineering process, involves an underlying calculus with a well defined set of inference and deductive rules.

Doting a development system with similar inference and proof facilities is a fundamental step in the evolution from craftsmanship to software engineering.

ARTS' main goal is the definition of a new methodology, as well as a prototype of its support system, for the development of concurrent embedded real-time systems based on (and hiding from users' view) a formal level which allows software engineers better control over the process and the product being developed. This supplies, thus, a qualitative differential in the products created within ARTS, by means of the formal approach to specification, early prototyping with performance evaluation, validation, verification, continuous testing, enacting of diagrams and, in general, of heterogeneous system descriptions, automatic code generation, traceability, project optimization, reuse of constructive procedures and development components, and automatic generation of documents. Other goals pursued in its development are early prototyping with early performance evaluation and formally proved transformations guaranteeing correctness. The technological innovations thus introduced represent major breakthroughs in the field.

The technology adopted will allow significant quality and productivity gains in an area where technology has a fundamental role as a differential in the formation of costs and prices.

This formal approach serves as a basis for integrating the different diagrammatic notations of object-oriented development, particularly those diagrams modelling objects and classes and describing dynamic behaviour and interaction. Such semantic basis will render possible the maintenance of a level of inferences and proofs hidden behind the user level, which contains ordinary user-oriented notation.

Along with this intended methodology, support tools for the development and management of the corresponding object-oriented diagrams, including traceability, are being developed. Facilities as version control and a data base of classes are also being included. The tool suite, moreover, will support the development of use case analysis à la Jacobsson, diagrams for object interaction, prototyping, validation and animation of designs using rewriting tools, testing based on use cases, automatic code-generation from designs, and code optimisation by transformation tools. Support for the reuse of components is foreseen as well.

2. Why Combine Object Orientation with Formal Methods

Formal methods for software construction have been studied and developed for approximately 30 years. From Floyd's program verification with annotations, Burstall's and Darlington's 1965
program derivation calculus, the legendary CIP project at the University of Munich, headed by Bauer in the late 60s and early 70s, Dijkstra's predicate transformation method, and Hoare's logic; through functional programming calculi, such as Bird's and Meertens's, the one associated to Z language, semi-formal methods like VDM and wide spectrum languages like LARGE, algebraic specifications, and abstract data types, Sintzoff's design and programming calculus, and DEVA; to formal method support environments like RAISE, KIDS, PLATO and LOCOS, and modern relational calculi, like the Eindhoven group's and the ones based on well known extensions to relational algebra approach, such as the so called Munich and Rio approaches, and Möller's calculus, a long way has been trailed to show that the formal construction of programs is not only possible, but "healthy".

The problem has always lied in the creation of software development models or methods that can be used by working programmers. Wierstrass said, in the nineteenth century, that if a mathematician couldn't "leave home" and get the first person he meets to understand the theorem he has just proved, his work was worth nothing. Either times and habits have changed considerably, or we must admit that 30 years of efforts invested in the development of formal methods were of use only to entertain their creators and a handful of followers. The truth is that there is no visible possibility of getting a working programmer to know enough algebra or logic to understand this kind of method.

Fiadeiro and Maibaum state on a recent MODELAGE Project (Esprit BRA 8025) report that "the need to simultaneously manipulate different formalisms seems intrinsic to the area known as Software Engineering, particularly regarding modularity, reusability, and incrementabilitly". It seems evident that Fiadeiro and Maibaum referred to a different kind of "Software Engineering" from the one used, for example, in the Third International Conference on Software Reusability, which took place in Rio de Janeiro in November 1994. In the conference's proceedings there is no work referring to formal methods. Wirsing's work on reuse by means of signatures up to isomorphisms, for example, are completely ignored by working software engineers.

Fiadeiro and Maibaum go on to say, "... in this work we suggest an alternative focus... where different ways of modelling can be individually formalised in a mathematical framework - Category Theory, and the relations between them can be established by functors". It is hard to imagine a working software engineer routinely using Category Theory and proving properties of functors.

On the other hand, object orientation has gained the software production market. As Kuhn might have said, it is the "paradigm" of the decade. That is, besides possessing well-known qualities, object oriented programming methods have been widely accepted by the working software engineering community.

It is interesting to note that, like abstract data types, "objects" may be modelled formally. Inheritance, encapsulation, message passing, etc. can be easily modeled in various formalisms. The diagrams of methodologies in vogue can be considered as well formed formulae of a formal language and then mapped to theories in some given formalism. The behaviour of object-defined systems can not only be described, but also forecasted, by means of logic models. In short, it seems we have our hands on a way to deal with system and program construction, that can be formalised, and, unlike abstract data types, has already been accepted and come into fashion in "the real world programming market".

The original proposal of project ARTS is to combine object oriented analysis, project and implementation methodologies, along with their development processes and life cycles, with formal methods which render strictness to the development and safety to the forecast and derivations of validation experiments. The method proposed in ARTS consists of two levels: the user layer, which presents an ordinary object oriented methodology based on SYNTROPY [Coo94] extended with concepts as study cases with constructs appropriate to the development of real-time embedded systems and with a slight modification of its implementation model to allow automatic code generation from designs; and the formal layer, composed by an Object
Calculus (built upon a first-order modal action logic extended with deontic and a temporal operators), a Conditional Rewriting Logic Model à la Meseguer, and a Programming Formalism. A type of "correspondence rules" maps one layer on the other.

Different kinds of users, software engineers, process managers, project managers, documentators, testing specialists, theoreticians building and structuring distinct object theories will use the ARTS environment as a CASE specialised in their field. But the ARTS environment is much more than that. Any one of them will be able to view a system as one homogeneous and consistent whole, even though parts of it are only specified on the functional requirements level, others are represented only by analysis or project diagrams, and others are already completely implemented in an object language. The user is able to "exercise" his system by animating diagrams and executing code, make inferences on properties it will present once it is completely implemented, etc. This is done thanks to the set of representations of different parts of the system at various detail levels and their interconnections, and with the Design Description Language (DDL). Thes interconnections are implemented by relations such as the refinement one provided by object calculi and its connection via semantic based syntactic transformations hidden in the formal layer.

The originality of ARTS as a product lies in a property which common mechanisms have already had for many years. The formal arcanes of science are, in our everyday world, hidden under ingenious easy-to-use machines. Therefore, a driver and a mechanic do not need to know the "Carnot cycle" to use a motor. A biker does not need to know the gyroscopic torque which makes him keep his balance, knowing only that it is harder to do so when you are going slow than when you are going fast.

3. The Structure of the ARTS Environment

Figure 1 depicts the architecture of ARTS. In order to expose it more clearly, we shall divide this structure into three main components: its conceptual framework, its logical support system, and its physical support system, which can themselves be decomposed into a series of layers (in the vertical dimension) and levels (in the depth dimension). The ARTS architecture is software process centred, i.e., its constructive process can be canonised by, say, a project manager, and constitutes a kind of normative entelekia. Thus, from this canonisation, the application of each of the tools on the different levels is regulated (permitted or obliged) by such entelekia.

The greatest novelty introduced by the ARTS architecture abides in its conceptual framework, represented in it by the set constituted by three of its levels: the software process level, the user methodology level, and the formal level. Its peculiarity consists in the fact that formal semantics describing both the software development process and the diagrams and texts corresponding to the different stages and views of the constructive process are written in the formalisms in the formal level. As we see in the rear superior plane of figure 1 such formalisms are constituted by the Object Calculus, a Conditional Rewriting Logic, and a wide spectrum language built with DDL (a very high level Object Oriented Design and Programming Language) and C++.

Thus, for example, each step, from the first stammering thoughts about the description of a system and its strategic modelling to the outcome of the requirements analysis and the first stages of analysis modelling, may be mapped on the Object Calculus, so that the denotation of the description is preserved and refined throughout the entire analysis phase. The user sees and manipulates the usual texts and diagrams, but can, in a very early stage of the description, "ask
questions" about the system being described. Such questions usually concern the satisfaction of

certain properties and the verification of certain facts. On the Object Calculus and its underlying logic, these questions are well formed formulae, which are proved to be theorems if the properties they refer to are satisfied and the facts verified.

Once the descriptions refined by the user, by means of the notations available in the user level, are operationalised through the identification of actions and states, the semantics in the formalisms level can be transformed through suitable functors to a description in Rewriting Logic amenable of exercising by rewriting. The back and forth correspondence rules should provide an adequate mechanism of "parsing" and "pretty printing" diagrams in order to "translate", for instance, system exercising into diagram animation. Then, once the user has an appropriate mathematical expectation of the fitness of his system to the "modeled reality", the system description can be driven, through a series of refinements to a DDL description. Such translation can be methodologically carried out at the user level, so refinement, interpretation, implementation, etc., can be executed by manu habilis procedures based on the rules and guidelines of the methodology used. Unlike conventional methodologies, however, verifications
and validations are carried out at the formal level, by means of proofs involving the Object Calculus and the formal semantics of DDL. The extent to which these transformations can help in the passage from one description to another will depend on their properties. If, for instance, they are computable and their implementation has an acceptable complexity, the validation and verification of the result of a specific step might be carried out independently of user intervention, for these are satisfied by the constructive process itself.

Thus, verification (answering the question “are we building correctly?”), which implies checking the correspondence between descriptions, will be supported by the object calculi providing semantics to the different diagrams and annotations in the user level. This process is, as it should be, just one of the proofs in the formalism level of heuristically driven construction steps in the user level, or of formal derivations in the formalism level, which, in turn, can be understood by the user of the environment by means of their diagrammatic notation in the user level (as long as pretty-printing is provided).

Validation, i.e., answering the question “are we building the right thing?” is a different kind of process. It is obviously closer to the testing of scientific theories than to mathematical proofs. However, the two level structure of ARTS' conceptual framework (let us leave the software process level aside for a moment) provides here the same support to validation that the theoretical level gives to the testing of scientific theories \(\text{(Hem65)}\). By means of the formalisms level (always hidden by the user level) we can (a) infer certain properties of the real system being specified and then check them against its real behaviour or (b) formally prove facts observed in the real system.

Moreover, early prototyping is provided by exercising specifications and animating diagrams (by means of rewriting). It is interesting to note that, in order to be used as a prototype, a system doesn't necessarily have to be completely described in one formalism or have all of its components described at the same level of detail, in other words, it is not necessary that the whole prototype be in the same development stage for it to be exercised. This allows, besides the use of prototyping in a very early stage of development, the adoption of non staged life cycles. It is also possible to make early inferences on the complexity, and consequently on the efficiency of the software artefact to be delivered.
Translation back and forth from the user methodology level to the formal level can be an automatic process (provided the appropriate "cosmetic" information is stored, since, for instance, the same modal action logic based theory can be the semantics of different analysis or design diagrams). At some point the system will be described in the "operationally-oriented" segment of the object calculi. Then, the production of code, testing data and scenarios can be aided and automated by formal mechanisms, such as the transformational one.

An automatic code generator as described in figure 2 was delivered to EQUITEL in December 1995.

We can picture, by what has been exposed, a constructive process based on a series of descriptions in different formalisms and notations. Such descriptions, along with other objects like theorem provers and abstractions, form a type of semantic network whose relations are, for instance, denotes, is-denoted-by, refines, implements, abstracts-to, is-part-of, translates, and conservatively-extends. Figure 3 offers an incomplete and imperfect glimpse of such semantic network. Notice that there are other relations that can be thought of as pertaining to the level of the semantic network; one example of these are the relations linking different elements within diagrams 1 and 2.

The elements of this semantic network, the formalisms level with each of its formalisms and functors, the abstract representation of diagrams and methodological heuristics and steps in the user level, theorem provers, TXL transformational engine [Cor91, 92a, 92b], the mappings of the correspondence rules layer, etc. will be supported by the PLATO-like environment layer, which together with the concept of the Objects Hypergraph (not its implementation) form what we have earlier called the logical support system.
4. The Part of the ARTS Environment Development to be Supported by the GMD-CNPq Program.

The heart of the ARTS environment is constituted by an environment for the construction, structuration, and manipulation of theories. This environment should allow theories based on different logics, while the obviously needed common framework is represented by a network of
functors between the categories of the theories and logics involved. As we know, the general problem of dealing with functors between theories and logics using the institution approach still presents some open problems and, therefore, it is dangerous to intent, from the very beginning, to develop a general solution within a project like ARTS. Instead of this, we plan to develop appropriate solutions for each stage of the general project. In the current stage it will suffice to develop a theory manipulation environment for theories based on logics related by extension. As was the case in the PLATO environment (the LMF-DI's environment for theory manipulation [Sam95a, 95b], which is now in its third version) the theory manipulator of ARTS should deal both with flat and structured theories [Wir89, Wir91, Cen95]. Reasons for the importance of maintaining the structure, i.e., the term by means of which a theory was constructed are well known and can be found in the literature.

What is important to stress here is that all the operations between logics and theories can be calculated by means of operations on categorical diagrams as colimits (disjoint unions), pushouts, pullbacks and extensions. We should recall, at this point, that ARTS' environment will have as users software engineers, process managers, project managers, documentators, testing specialists and theoreticians; that all of them are used to communicating with the environment via diagrammatic notation, i.e., OO-methodologies diagrams, Petri nets, categorical diagrams, etc., and that, as we have previously stated, the diagrams of methodologies in vogue can be considered as well formed formulae of a formal language and that such assertion is valid for any consistent diagrammatic notation.

Hence, we have the opportunity of dealing with all of the diagrammatic notations in a regular and consistent form via syntax-oriented editors, both for textual information and for diagrams. In order to test the proposed approach, attribute grammars were used for describing OMT and Syntropy diagrams, as well as for categorical ones. Attributes can be divided into two species, those maintaining context information and those holding graphic-oriented information. These are needed not only for parsing and pretty-printing diagrams, but for decorate abstract syntax trees so that, by applying transformations on them, the graphic shape of diagrams will be changed mimicking the rewriting in formal descriptions made by the transformations corresponding to the refinement calculus and the like.

All kind of transformations within this environment will be done by means of TXL. The TXL programming language was created by James R. Cordy to allow the fast prototyping of language dialects [Cor92a, 92b, Cor91, Sri93]. The semantics of any programming language can be seen as being furnished by a translation of its syntactic sentences to another widely known language. We call this kind of semantic attribution Denotatio-Operational Semantics. The meta-language used in the formalisation of this type of semantics is transformational, i.e., a POST system instance. TXL expresses transformations through pattern matching and substitutions applied to parse trees of the languages being transformed. Both, source and object languages are inserted together into a larger language by means of grammatical constructors, thus creating a language called wide spectrum language.

TXL can be said to be a typed transformation language, for its strong use of grammar non terminal symbols as types. Compared to ICON or SNOBOL 4, the use of information about types makes TXL a more efficient transformation language, since the programmer can only write homomorphic functions/rules. This is one of the greatest advantages of TXL. Any program in TXL (as with most rewriting production systems) goes through three phases: Parsing, Transformation, and Unparsing (Pretty Printing). The first phase executes a top-down fully backtracking parser, which converts the input file into the appropriate tree. The transformational phase uses this tree as an input to the "main rule", and, by an iterative application of rules, converts it into a new structure representing a syntactic tree of the same input language. The third phase carries out an unpars (pretty printing) over the final structure, showing it in the form of strings. Therefore, the name Tree eXchanging Language is very appropriate.

Like PLATO, the new theory manipulation environment will mainly be a kind of object-oriented hypertext environment for constructing theory presentations, proving theorems, deriving
consequences, etc. The environment should allow the theoretician to begin by defining and constructing the logic which will underlay the theory he has in mind. For this, he should provide the formulae formation rules, the logical axiom schemata and the inference. Logics can be related to theorem provers. For first-order logic, for instance, we can have a system à la Hilbert or a calculus in natural deduction style, of sequents, etc. After doing that, or after simply choosing any of the already implemented logics, he can construct flat theories, representing, for example, data or object types, by entering its presentations, i.e., its alphabet and signature (consisting of sorts, function symbol declarations and predicate symbol declarations) and its extra logic axiom schemata.

Then, structured theories representing complex data or object types or systems, may be built from already constructed theories by means of category theory constructions. Theories can be linked not only with theorem provers, but also with symbolic formulae manipulators. Thus, proofs can be performed in a forward fashion (while deriving programs by calculation for instance), or backwards (depending on the features supported by the chosen theorem prover or symbolic formula manipulator).

The kind of "knowledge" represented by theory structure and construction history, along with links or "references" representing morphisms in general, which are introduced following the user constructive procedures, allow the environment to solve, with an acceptable complexity, some odd problems, such as the reuse of specifications by its signature and axioms up to isomorphism.

Using these facilities, the theory manipulator should permit, for instance, the calculation of the minimum theory used for a particular theorem proof or program derivation. It should maintain a record of "guesses" or "claims", i.e., statements included as holding in the current theory but without proof, so that the user is informed about missing proofs.

The theory manipulator should present to the theory engineer constructing object theories that will be used by the developer through his own interface, a textual and graphic interface which permits the construction of (and eventually the calculation expressed by) any categorical diagram. This interface is the one represented at the left hand side of figure 4.

Diagram "internalisation" and pretty-printing will, in every case, be conducted by syntax oriented graphic editors driven by suitable attribute grammars. Figure 4 represents the theory manipulator and it different interfaces, while figure 5 shows its internal structure.

The elements and relations forming the above discussed semantic network, those of the diagrams, semantic networks themselves, and, altogether, everything within the ARTS environment is an object or a relationship between objects. So, the whole environment, and particularly the conceptual framework and the theory manipulator, is embodied in a hypergraph of objects, on which we should be able to apply operations of abstraction, transitive closures of a given relation, etc.

Such operations and, generally, any reference to them or their elements, will be supported by an Hypergraph Manager Layer.

The core of the physical support system is a meta-CASE tool (based on the particular approach dealing with attribute grammars as described above) on an object oriented data base. The strict compliance to CORBA standards will allow the portability of this first version of the prototype of the theory manipulation environment, which will be delivered in 1996.

As a result of a task of comparison of existent Object Oriented Databases, and due to preferences of EQUITEL, we have chosen ObjectStore® as the database to store the object hypergraph. The ObjectStore® database provides high performance for applications such as net managing, and automation of processes that need to store data as objects.

The use we will make of it is different from the usual one on traditional database applications, such as payroll programs and simple order entry systems, for it deals with complex data.
models, interleaving a great quantity of small database operations with small amounts of computation over very complex data.

If every database operation required a significant per-operation overhead cost (such as the cost of sending a network message), overhead costs would become prohibitive. It is imperative that manipulation of stored data be as fast as possible. ObjectStore® was designed to minimise the overhead for pointer de referencing (object traversal), locking, network access, data caching, and disk access.
5. Short Bibliography


InTec-SRE: Innovative Technologies for Software Requirements Engineering

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3. Objectives

Requirements engineering consists of the early activities of the life cycle of software development. It includes problem analysis and requirements specification phases. Problem analysis involves learning the considered problem, understanding the needs of potential users, and outlining all the constraints on the solution. Requirements specification involves preparing a complete description of the solution system’s external behavior, often obtained by modeling that behavior. The result of these two phases is normally called as “requirements,” and is written on a SRS - Software Requirements Specification document.

A series of adequate technologies (including principles, techniques, languages and tools) are necessary to define software requirements. The overall objective of this project is to investigate, propose, test, and implement innovative technologies to improve the quality of processes involved in requirements engineering, aiming to obtain high-quality systems. In more detail, the following main goals are pursued: (1) Development and application of a goal-oriented measurement approach to evaluate requirements specification processes; (2) Obtention of new insights on the use and effects of existing requirements engineering methods and techniques; (3) Analysis of performance of inspection techniques as an instrument for the validation of SRSs; and (4) Development and extension of methods and tools to support the modeling and validation of requirements, including an environment for multiple views of requirements and a tool for fault detection in specifications.

The intended application domain covers as conventional systems as telecommunication, meteorology, and process-control systems. Many of the applications focused here involve real-time characteristics, that is, they have to perform their mission according with timing-constraints imposed by their environment. In addition, many of these applications have safety-critical characteristics, and must execute free of failure (or tolerant to certain classes of faults), to avoid catastrophic results. Consequently, the inclusion of special characteristics in methods and techniques are planned in the context of this project, in order to satisfy real-time and critical issues of some systems.

The project has high potential to be applied in the industrial context and both German and Brazilian groups intend to test, implant, and transfer its results to companies that are already participating in joint research with the groups or are being presently contacted.

4. Project Description

The focus of the project is on the development and use of a set of innovative, cost-effective technologies to support the software requirements engineering process. This includes techniques and tools for modeling and validation of requirements. In addition, as we are planning to test the potential effectiveness and efficiency of these technologies in real applications in the industrial context, a goal-oriented measurement approach will be studied, extended, and adopted. The main sub-projects to be developed are defined as follows:

4.1. Goal-Oriented Measurement in Requirements Engineering

There is an increasing understanding within the software engineering community that software cannot be produced with a standard approach, but it needs to be developed by approaches tailored to the goals and characteristics of particular projects. Consequently, we
need to systematically experiment with software methods, techniques, and tools, in order to understand their weaknesses and strengths, tailor them for the goals and characteristics of particular projects, and package them together with empirically gained experience to enhance their potential reuse in future projects. This generic approach is based on goal-oriented measurement and is very helpful in requirements engineering. An example of framework for it is the Goal/Question/Metric (GQM) paradigm [1].

In this project, we intend to exploit the goal-oriented measurement in requirements engineering, which is considered here as a background technology for performing the other sub-projects, especially as an aid for proposing a multiple view in requirements engineering and as a monitoring instrument for systematic inspection techniques for SRSs. The following steps are intended: (1) Study GQM paradigm; (2) Test the paradigm and its application in requirements engineering; and (3) Propose refinements and improvements in the paradigm.

4.2. Modeling of Requirements

Modeling is concerned with approaches to represent and describe all the static and dynamic aspects of the software being considered. This project includes not only the study of some existing methods, but also the development of a multiple views approach for requirements engineering.

4.2.1 Comparative Study of Methods

There exists a proliferation of methods and techniques for software specification, such as Structured Analysis, Statecharts, Object-Oriented Analysis, Petri nets, etc. Each one provides some unique characteristics that make it appropriate for the specification of certain aspects of requirements. It is important to stress that probably different methods are necessary to specify the requirements for a complex system (for example, a real-time, process-control system) completely.

The following activities will be performed in this sub-project: (1) Study some important methods and techniques, trying to identify similarities and differences among them, as well as identify their advantages and weaknesses; (2) Conduct controlled experiments, with systematic data collection, to validate our study, and demonstrate the effectiveness (or not) of the studied methods; and (3) Propose modifications and extensions in methods, aiming to fulfill the exigencies of the application domain or systems being considered.

4.2.2 Multiple Views in Requirements Engineering

Based on study and experiments on methods and techniques, as described in the previous sub-section, we intend to develop a requirements engineering environment that is independent of any particular requirements method or technique. This environment will allow the representation of multiple views of requirements and its creation will comprise: (1) Definition of a requirements metamodel, which can be used to represent different notations from different methods; (2) Implementation of a prototype tool; and (3) Testing of the model and tool in the specification of representative system cases. Tests in the context of software engineering courses in the two universities, as well as tests involving real applications in companies, will be performed.

4.3. Validation of Requirements

Validation is concerned with approaches to test the software and assure its high-quality. In this project, we will explore two essential, interrelated approaches for software validation, applied to requirements engineering, i.e., inspections and fault detection.
4.3.1 Systematic Techniques for Requirements Inspections

Inspections are one of the most promising quality assurance techniques that can be used in all stages of software development. Utilized from the very beginning of the software development, inspections will contribute for the definition of correct and complete requirements, and will support an adequate design in conformance with the requirements. Besides, the fulfillment of nonfunctional requirements, such as correctness, completeness, consistency, reliability, and performance, can be stated by inspections.

In this sub-project, we intend to get new insights on the use and effects of some inspection techniques, as well as to define and adapt techniques to real situations in companies. This will be performed by the following steps: (1) Study of inspection techniques with special focus on the role-based reading technique; (2) Test of the techniques in the industrial environment, with special emphasis on measuring their efficiency and effectiveness; and (3) Extension and improvement of the techniques.

4.3.2 Fault Detection in Requirements Engineering

Problems in requirements specifications represent a very significant part of all errors made in software development. Furthermore, the longer that these problems remain undiscovered, the more they cost to detect and repair. The correct functioning of systems implies in executions free of failure or tolerant to some types of faults. In general terms, failure is a deviation in the system behavior that makes it impossible to achieve its intended mission and can lead to undesired and perhaps disastrous consequences. Failure can be determined by faults, originated in system components and along the system development, and manifested during system execution. The early detection of possible faults is essential, due to high-complexity, elevated costs, and criticality level involved in many applications.

The primary goal of this sub-project is to develop a tool to validate system specifications by means of detection of different types of faults. This is based on results obtained in studies and experiments about inspections, described in the previous subsection, and will include: (1) Definition of a framework for the identification of faults; (2) Implementation of a prototype tool; and (3) Testing of framework and tool in the specification of representative systems examples in companies.

5. Work Plan

5.1 Activities

The participants will cooperate in the realization of the following activities, during the next two years:

(a) Preliminary studies and project refinement;
(b) Development of measurement programs for the evaluation of methods and techniques for requirements modeling;
(c) Application of measurement programs on requirements modeling in the industrial environment;
(d) Definition and testing of a metamodel for representing multiple views of requirements specifications;
(e) Implementation and testing of a tool for multiple views specifications;
(f) Development of measurement programs for the evaluation of inspections techniques;
(g) Application of measurement programs on inspection techniques in the industrial environment;
(h) Definition and testing of a framework for classification and detection of faults in software specifications;
5.2 Time Schedule

The activities listed above will be carried out according with the scheduling shown in figure 1.

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Figure 1 - Schedule of Activities

5.3 Expected Results

In summary, the two-years cooperation between the Department of Computer Science in the Federal University of São Carlos and the Fraunhofer Institute for Experimenta Software Engineering in the University of Kaiserslautern, will produce the following concrete results:

(a) Evaluation of different software requirements engineering methods, based on goal-oriented measurement programs, in industrial environments in Brazil and Germany.
(b) Development of an environment for multiple views in requirements engineering, and testing of this environment and the related metamodel in academic and industrial contexts.
(c) Evaluation of systematic reading techniques for requirements inspections in industrial environments in Brazil and Germany.
(d) Development of a tool for fault detection in requirements, and testing of this tool and the related framework for detecting faults in academic and industrial contexts.
(e) Common publication of results and presentations at international conferences.

To realize the described work plan, a high degree of interaction between the research groups is required. The interaction will be concretized through the Internet and by means of travels, which objective is: refine the project and discuss specific issues; evaluate the activities that are being conducted and the obtained results; conduct complementary bibliographic review; test methods and prototypes in German and Brazilian companies or institutions; implement, test, and integrate tool modules; and write monographs and papers reflecting the project. There are some trips between Brazil and Germany that are planned and will viabilize the development of this joint project.
In addition, the consecution of the intended activities and expected results is guaranteed by the partners’ expertise, which covers all the subjects involved in the project. German and Brazilian participants are supplementing each other in their profile and scientific objectives. The combination of the experimental approach based on goal-oriented measurement adopted by the German group and the background and results of the Brazilian group in requirements engineering, offers a great opportunity for a real breakthrough in this very important area of software engineering. The emphasis of both groups in this project is on applied research, and there is a strong confidence that very important results will be derived from this cooperation, from both the research and application points of view. The experience of the groups with industrial cooperation reinforces the relevance of the project and its expected results to really improve the quality of requirements engineering processes, and, consequently, to significantly increase the quality of software being developed and utilized.

Bibliography

German-Brazilian Cooperative Programme Proposal:
Integrating Rigorous Methods in a Computer Supported
Cooperative Environment (RIME)

C. Lucena, PUC Rio
S. Jähnichen, GMD-FIRST/TUB Berlin

September 1995

1 Objectives

The growing complexity of computer systems, especially software systems, in the last two decades calls for appropriate software development methods. Specifically, formal methods have been proposed as a way to leveraging software production and quality. However, despite many successful applications of formal methods in industrial problems, they have not been embraced by industry to any comparable extent. Quite the contrary, the state of formal methods could be characterized as a chronic crisis, at least with respect to their industrial relevance. We believe that a more modest approach to the integration of techniques at different levels of formalization into the system analysis and design process will lead to their swifter adoption. Therefore, we propose a more bounded adoption of formal techniques within a conventional framework. Currently, most conventional development frameworks used to develop and to maintain application systems have little room for formal method support. Usually they are monolithic, and impose only one particular methodology for their use.

On the other hand, support for cooperative work is becoming increasingly more important in software projects. Consequently, techniques for cooperative work should comprise not only different people working on the same project, but also different tools working on the same project, sometimes based on different methodical paradigms. For this we need a framework to support different views on documents in specific states of their development (system versions). We also need elegant user interfaces, including elaborated hypertext facilities. Such a framework plays an important role for a smooth integration of formal techniques and tools into the development process. Within such a framework, engineers should be free to use the tools they find most appropriate. The underlying idea is to build up such frameworks by decomposing modeling information of system requirements, analysis, design and code into fine grained repository items. These items later on can be aggregated and presented as interwoven result documents at different levels of formalization, up to running source code, by the use of tools for collection and presentation in the style of literate programming.

1.1 Application Domains

It is to emphasize that the important (and new) goal of this proposal is not the development of its tools or environments, but the way we intend to use them to achieve better gains from formal methods in real applications. The use of these tools in industrial applications is a fundamental part of this proposal. Application cases will be provided by our industrial partners, mainly in two areas: 1) safety critical applications, and 2) engineering systems. Safety critical applica-
tions are found in running projects involving — among other partners — the Daimler-Benz company.

Engineering systems are the main products of TeCGraf, a partnership between PUC-Rio and PETROBRAS, the Brazilian Oil Company.

These areas are important for our partners, and they offer relevant technical features. Safety critical applications need formal methods because they have to be checked on a very high degree of dependability, at least in parts. They cannot live with bugs other systems may bear and which are tested for some correct functionality only. For safety critical systems a formal specification has to include the description of what the system must perform and what the system must not do (constraints) as well.

Engineering systems are interesting because of their intrinsic mathematical contents. Many of these systems are based on a formalized model applying appropriate mathematical theories. This model exists in advance of the development of the final software solution. Nevertheless, many of the existing software systems do not exploit the mathematical model well enough due to restrictions of the basic system components and its configuration constraints.

2 Cooperating partners

- Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Departamento de Informática, Rua M. S. Vicente 225, 22453-900 Rio de Janeiro, Brazil, responsible for cooperation: C.J.P. Lucena, R. Ierusalimschy.

- German National Research Center for Information Technology (GMD), Research Institute for Computer Architecture and Software Technology (FIRST), Rudower Chaussee 5, D-12489 Berlin, Germany, responsible for cooperation: S. Jähnichen.


3 Project Description

The present proposal intends to integrate current work being developed in Germany and Brazil. This section gives a brief description of projects on both sides that could collaborate in the cooperation; it also indicates how this collaboration can take place.

ESPRESS: The German ESPRESS project aims at combining formal and semiformal methods in order to capture a structural, a dynamic and a functional view each by means of an appropriate notation. Methodology is to be provided for a distinction between the specification of the expected system behavior and additional safety constraints. Both parts of the specification shall be used to generate a sufficient test suite. The whole method shall be supported by tools working together within an easy-to-handle graphical user interface.

PIROL: PIROL aims at the development of a software engineering environment supporting different views on common information according to different categories like roles within the project, stage of development as well as different methods and notations. Also Computer Supported Cooperative Work (CSCW) is to be realized by PIROL. All this is achieved by the architecture of an environment framework that is based on a central repository containing information on the software product and on the software development process in a uniform structure, based on the object oriented paradigm.

Lua: Lua is an extensible procedural language with powerful data description facilities, designed to be used as a general
purpose extension language. Currently, Lua is being extensively used in production for several tasks, including user configuration, general-purpose data-entry, description of user interfaces, storage of structured graphical metafiles, and generic attribute configuration for finite element meshes.

ADV: The ADV (Abstract Data Views) model, which decomposes designs into objects (Abstract Data Objects or ADOs) and views of objects (ADVs), addresses issues such as abstraction, encapsulation, separation of concerns, coupling and cohesion. This model is supported by a logical theory that allows to reason about the properties of designs composed of a number of components. The process, which formalizes many of the notions inherent in design patterns supports the composition of ADO and ADV components into systems.

Cooperative Work: This Project is about a cooperation model which states the way team members access the documents of a project. It is the underlying model for a cooperative system, where developers concentrate on the application's domain, ignoring the aspects related to the cooperative process.

We envisage several points where future collaboration may start. The ideas of the projects PIROL and Cooperative Work form a solid conceptual and technical framework wherein applications like ESPRESS can be supported. The Cooperative Work model, based on roles participating in the software development process could be adapted to PIROL's underlying meta model, which supports cooperating work benches. Both projects seem to be well suited to improve the definition, instantiation, and enaction of process models. The ADV idea, on the other hand, fits well into the overall object-oriented analysis and design methodology which is supported by the PIROL SEE. Moreover, it can be used in the elaboration of embedded software systems based on case studies from industrial applications as in the ESPRESS project. Finally, PIROL can benefit from Lua as an extension language. In a longer term, we aim to design a development environment which could be used in realistic industrial projects, and not only in specially selected test-cases. This involves a strong premise, that all proposed techniques should have smooth integration with common techniques. It is very difficult to suddenly change a whole staff to something new. Moreover, they cannot have an initial negative impact on production levels, otherwise people will be reluctant to embrace them. Filling these premises, we will be able to experiment our proposals within TeCGraf.

4 Workplan

The RIME project is scheduled to run for three years:

1. The first year is dedicated to the participation of guest researchers of one country in the running projects of the other site and vice versa. By that procedure a smooth transfer of ideas can be arranged and the applicability of results can be proved. A common understanding of systems development shall be established by working on integration of the scientific partner's technology into a common software development environment framework. This platform shall be a technical basis for development of tool support for integrated engineering methods to be developed in RIME. In more detail the first year's workplan consists of:

   (a) Exchange of scientists of PUC-Rio and GMD/TUB-Berlin in order to gain a common understanding of concepts and technology, developed and used within currently ongoing industrial cooperations.

   (b) A technical result of this first year shall be the integration of Lua into PIROL (as a TCL/Tk replacement).
(c) A common cooperation model to be integrated into the resulting Software Development Environment shall be developed as well, according to the needs of current industrial projects of the partners.

2. The second year is mainly about conceptual work based on the local industrial cooperations. The main focus is the conceptual integration of traditional and object oriented development paradigms with more mathematically based ones. Tool support for combined methods shall be implemented on top of results of year one.

(a) The platform (or parts of it), developed in year one shall aid the local industrial cooperations and provide an easy to use and common platform for evaluation of the integrated methods, to be developed within this year.

(b) The ADV project's Abstract Data Views, developed at PUC, shall be merged with the Conceptual Objects of PIROL for the sake of a new methodological approach for systems development with increased formal reasoning and verification support.

(c) Work shall be done in the area of Domain Specific Systems Engineering and shall contribute to a certain level of genericity of the integrated methods to be developed. These methods and their easy specialization in the various project domains of the partners shall be prepared as well.

(d) In the second year first ideas for new projects shall be defined and set up. Proposals delivered to the national funding institutions should be based on common experiences of collaboration in the first year.

(e) The work to be done will be based on staff exchange like in the first year.

3. Ongoing work of collaboration in the old and new common projects should give the opportunity for all participating parties to collect sufficient conceptual and technical results to be integrated and evaluated within the collaborations of both institutions.

(a) Publication of work results on scientifically as well as industrially oriented events.

(b) Preparation and carrying out of an evaluation phase in industrial cooperations resulting in detailed reports on experiences and recommendations on technology transfer concerning:

- integration of formal and traditional engineering methods,
- application domain specific engineering paradigms supported by tools and a cooperation model agreed among the participants on a generic level and adapted within the cooperating partner's projects,
- preparation and proposal of further cooperation activities based on the results gained within RIME.

Results in detail

Each trip of participants should result in at least one detailed travel report. Moreover the outcome of year 1 – 3 should be common papers submitted to national or international conferences or workshops.

Results of 1. year: Experience reports reflecting common areas of interest and industrial applications.

Result of 2. year: Besides ongoing work reports there are descriptions and/or proposals of new common projects.
Result of 3. year: Definition of further coop­erations between PUC-Rio and GMD/TUB-berlin and their industrial partners in future.

5 Traveling: number of trips, duration, costs

Each site plans 2 – 3 one person-trips per year, duration between 3 month at least and 6 month at most.
Costs: USS 180,000 (USS 60,000 per year)

6 Partners’ expertise

PUC-Rio

The Pontifical Catholic University of Rio de Janeiro (PUC-Rio) is represented, in this project, by its Informatics Department. During the last five years, the Informatics Department has been improving its cooperation with the industrial and public sectors. In 1993 the Department created an institute called Instituto de Tecnologias de Software - I.T.S. (Software Technology Institute). Its main aim is to develop the relationship between companies and the University and to promote the development of software technology at PUC-Rio. Currently, ITS is completely auto-sustainable, and has a staff of more than one hundred people, among professors, assistant researchers, project managers, system managers, and programmers. It encompasses projects in areas like Computer Graphics, Formal Methods, Software Development, Data Base, and Multimedia, with partners like PETROBRAS (The Brazilian Oil Company), CEPEL, and IBM.

GMD FIRST

The Research Institute for Computer Architecture and Software Technology (FIRST) of the GMD has been established in 1983 to participate in the development of parallel computers. FIRST's forte is exactly the combination of the two disciplines, computer architecture and software technology, as well as the close feed-back obtained by applying these basic technologies to "grand challenge" problems.

FIRST's main objective is to conduct goal-oriented R&D, i.e., developments that yield tangible results - innovative parallel computers, operating systems, compilers, tools for the construction of correct software, expert systems for various applications, etc. The projects are typically at the leading edge of technology, aiming at the advancement of the state of the art. In this endeavor FIRST is cooperating with other research institutions and industry in Germany and other European countries.

TU Berlin

The Technical University Berlin (TUB) is represented in this project by the Department of Computer Science (TUB CS), Institute of Applied Computer Science, Software Engineering Research Group (SWT).

TUB fulfills its tasks in cooperation with academic, industrial and public sector partners in the national and international context.

Based on the results of research activities, prototypical application experiments are carried out in order to test new concepts and methods in practice and achieve synergy effects within the scientific community.

TUB CS is primarily concerned with basic research in information technology, structures of hardware and software systems, communication technology, applied computer science and nearly all other fields in computer science.

Keeping in mind public needs, TUB CS is engaged in trend-setting research and development by pursuing strategically important development lines in applications of computer science and information technology.

Industrial partners, mainly manufacturers and users of computerized equipment and problem-solving methods, benefit from TUB CS's R&D-activities which are ultimately profitable for the end user as well.

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The design of computerized systems adapted to man and satisfying criteria such as reliability, controllability, security, but also openness, maintainability and reusability, are the declared goals of TUB CS.

The Software Engineering Research Group (SWT=Softwaretechnik) works in the fields: software development in the context of parallel programming, incorporating formal methods into practical software development processes, software project and process support by software engineering environments (SEE's), the development of CASE tools and its integration, declarative programming languages as a means to increase productivity and software quality.

Most of the results have been achieved in the context of R&D projects where industrial and academic partners worked together. From that fact results a considerable technical and managerial experience.

References


Industrial Automation Technology
1 - Project Scope

The initial objectives of the CIM-COOP project was the development of a model for cooperative projects and technologies transfer. In the last years, the CIM-COOP-partners were involved in several cooperative research projects related to this cooperation. Up to now, we concluded some steps and the cooperation is much stronger than in the beginning. Because of these results, we decided to present and to adopt this project as a model for cooperation in research and technology development. This project started with a technology transfer, a training period and the transfer of a model in order to put the partners at the same level. Now we are working in an effective cooperative development of technologies in the areas of CIM and technical skilling.

The Cooperation started with the cooperation of only two research centers, COPPE-UFRJ and IWi-University of Saarland. The consortium growed by involving SENAI and nowadays it involves directly or indirectly several companies, regional centers of SENAI and universities in Brazil and Germany. This project looks for the modernization of brazilian industries and is planned to have several activities locally and in cooperation with foreign institutions, mainly the IWi-University of Saarland. This cooperation works in the planning and production control and organization, and its main goals are the technologies transfer and assistance and personal training. This way, we intend to create conditions for the implementation of a modern and competitive industry in Brazil.
This project was planned to be developed in several steps, as presented in the GMD-Workshop in Berlin (July, 1993). The first step was focused on the transfer of the "Y"-model for industrial integration to Brazil. This step was accompanied by the transfer of a prototype of an industrial plant which was conceptually developed under this Y-model. This step started with a training of a Brazilian team in Saarbrucken and was concluded with the installation of the prototype-plant in SENAI-RJ.

The next steps are the development of cooperative researches and the diffusion of the model and technologies all around the country, because of this, it was necessary the development of a model for this diffusion (presented in the GMD-Workshop in Rio de Janeiro - December, 1993). In resume, it is being done in the forms of seminars, courses, assistances, consulting and cooperative projects.

2 - Activities:

2.1 - Developed Activities

Up to now, it was developed a very long list of cooperative activities in the scope of this project. In the following some of them are presented:

- transfer of the Y-CIM-Model and its respective prototype
- integration of the CIM Model with other laboratories in SENAI and COPPE in order to mount a complete and integrated laboratory.
- technical skilling
- exchange of experience / visits of professors and researchers
- agreements with private companies that works with technologies related to the integration and industrial modernization.
- seminars and workshops in the area of Production Management and Control
- diffusion of technologies and models:
  - Publication of two books with the participation of the Nucleus Partners:
  - Publication of several international articles in partnership
  - Internal Courses (UFRJ)
  - External Courses (SENAI and Companies)
  - Consulting processes
  - Research to model the status of the Brazilian research centers in the area of automation and integration
  - Mounting a CIM laboratory in partnership with IBM in order to develop and test technologies.
Examples for the activities are:

* Simpósio Internacional de Manufacura Integrada Por Computador organized by COPPE/UFRJ, SENAI and IWi in Rio de Janeiro on November 3 and 4, 1994.

* Cooperatives seminars with industrial companies like:
  * With the companies SIMA SA and Symnetics SA, related to modelling and reengineering
  * With KSR company, related to CAPP
  * With FESTO company, related to technologies for automation and integration
  * Workshops and courses on CIM in different SENAI and other research Centers all around the country (more than 10 up to now)

* Participation and Presentation of CIM-COOP in the 11th ISPE/IEEE/IFAC international Conference on CAD/CAM, Robotics & Factories of the Future in Pereira, Columbia on August 28-30, 1995 (Including publication in the proceedings to the conference.)

2.2 - Activities in Preparation:

- research to model the status of the Brazilian industries in the area of automation and integration
- modeling industrial companies
- modeling universities
- several projects, courses, consulting and other diffusion activities in SENAI and other universities and companies, covering the whole national territory
- technical book discussing automation, integration and the Brazilian industrial competitiveness
- developing reference models for companies in different activities areas
- skilling courses using multi media technics

Future Activities planned:

- multi-medial skilling courses in the area of CIM
- post-graduation course in the area of technologies management
- consulting to companies
- South American Institute for technology development and transfer
- seminars and workshops in the area of Production Management and Control
- reference models for different industrial activities

3 - Travel Planning

For the next year (1996) there are planned 6 (six) travels of Brazilian professors/researchers to IWi in Saarbrücken and other cities in Germany and 4 (four) German professors/ researchers to Rio de Janeiro, all with a medium duration of 20 days each one, in order to exchange experience, to discuss the steps of the projects, to take part in international conferences and workshops.
4 - Resources

The CIM-COOP-project was supplied mainly by:
- Industrial partners
- CNPq: Conselho Nacional de Pesquisas
- Programas RHAECNPq e PCDT/CNPq
- SENAI: Serviço Nacional de Aprendizagem Industrial

5 - Partners:

5.1 - Brazilian Partners:

COPPE-UFRJ - Coordenação dos Programas de Pós-Graduação em Engenharia da
Universidade Federal do Rio de Janeiro
Programa de Engenharia de Produção,
Área de Avaliação de Projetos Industriais e Tecnológicos - APIT
Grupo de Produção Integrada - GPI

Coordinator: Prof. Dr. Heitor Mansur Caulliraux
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Fax: +55 21 290 6626
e-mail: Heitor@PEP.UFRJ.BR

SENAI - Serviço Nacional de Aprendizagem Industrial
Coordinator: Diolinda Xavier da Silva Prado
Av. Nilo Peçanha, 50 - Centro
CEP 20044-900, Rio de Janeiro/RJ - Brazil

Other Partners:
- Regional Departments of SENAI: RJ, MG, ES, SP, BA, PE, CE, PR, SC, RS
- Industrial Companies with formal agreements: IBM, Symetcs, Festo, SIMA
- Universities: UFPR, UFPE, UFMG, UFSC, UFRGS, UFES, Marigá, Londrina, PUC/MG, CEFET/MG
- Secretarias de Indústria e Comércio: Pernambuco e Minas Gerais
- STI - Ministério da Indústria e Comércio
- CNPq
5.2 - German Partners:

**IWi-Uni Saarlandes - Institut für Wirtschaftsinformatik an der Universität des Saarlandes**

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Altenkesseler Strasser 17, Geb. D2  
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Besides the nucleus partners, there are several German and Brazilian companies directly or indirectly involved in the project (see figure).

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**Figure: Nucleus Partners and Associated Partners in CIM-COOP**
6 - Expertise of the Nucleus Partners:

Brazil:

- **GPI - COPPE/UFRJ - Coordination for Post-Graduated Programs in Engineering of Federal University of Rio de Janeiro**
  
The Integrated Production Group - GPI is composed by professors, lecturers and researchers from the Industrial and Technological Projects Valuation Area (APIT) of the Production's Engineering Program at COPPE/UFRJ and from the Industrial Engineering Department of EE/UFRJ, where the main activities are related to the Modernization and Industrial Automation and Technical Culture areas.

This group had been working in cooperation with several partners, National and International ones, where it gets the domain of the technique to be transferred to the society in forms of lectures, meetings, books, projects and consulting. The results in the last years had been excellent.

In the APIT area, the group looks for the creation of a solid academic basis. With the creation of specialization area of Industrial Modernization in the Production Engineering Program (COPPE/UFRJ), it is being formed masters and doctors with inter-disciplinary knowledge (technology, strategy, organization and culture) that are able to analyze, project and manage automated production systems.

- **SENAI - National Industrial Apprenticeship Service:**
  
The National Department of SENA1 is responsible for coordinating of policies and norms laid down by the National Council, encouraging, integrating, guiding and even providing financial backing for the 27 Regional Departments, which are direct responsible for putting teaching programs into practice. SENA1 works with 600 operational units of its own, such as Technology Centers, Technical Schools, Professional Training Centers, Training Agencies, Operational Training and Mobile Centers. The Regional Departments act in close collaboration with industries in their regions, seeking to fulfill demands for skilled labor in accordance with local requirements.

Apart from the network of its own operational units, SENA1 plays an active roll in over 260 vocational training centers. SENA1's fund comes from monthly levies of all industrial companies and additionally from local and foreign grants. SENA1 itself finances projects that may range from teacher training to the construction and equipping of new operational units.

Germany:

- **IWi - Institut für Wirtschaftsinformatik (Institute of Information Systems) at the University of Saarland**
  
The objective of the institute is to contribute actively to the knowledge transfer between science and industry in applied electronic data processing. IWi has well-founded research results in the field of technology transfer and of the developing of qualification models. IWi has an interdisciplinary structure, an attached CIM-Technology-Transfer-Center, the realization of specialized seminars and congresses ("CIM within medium-sized enterprises"). The results of further current research projects which IWi is involved in could be used and integrated in the planned qualifying concepts for Brazil; in particular there are the following research projects that are most suitable in this connection: Developing of "Quality Information Systems - QIS" (project of BMFT) and "Creation of Interactive Teaching Software for Quality Assurance in small and medium-sized Enterprises based on multi-media technologies" (project within EU's COMETT II-programme).
1- TITLE

ANALYTICE: Project and Analysis of Flexible Manufacturing Systems

2- PARTNERS

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3- OBJECTIVES

The goal of the project is to develop a software tool for the project and analysis of Flexible Manufacturing Systems. In our context, Project means the definition of the structural and behavioral characteristics of a manufacturing system. Analysis means the numerical description of relevant performance parameters of the manufacturing system when operating under the restrictions imposed by the project.

4- PROJECT DESCRIPTION

The software ANALYTICE will provide functions for the project and analysis of Flexible Manufacturing Systems. Figure-1 gives the overall organization of the system.

The relevant parameters are those normally related with performance evaluation models: throughput, induced wait times, index of utilization for equipment, mean value of parts and pallets population in storage buffers. The restrictions imposed by a specific project alternative represent the system's invariant for this alternative: types and number of NC-machine-tools and material handling equipment, number of pallets, part families, layout, scheduling policies and control programs.

The environment for the TYPEs Data Base definition has been tested with the definition, simulation and inclusion of several equipment. Each inclusion implies the definition of a behavioral, geometrical and cinematic model. Several types of Robots, AGVs, AS/RS and Manufacturing and Inspection machines have been included in the Data Base.
Three relatively complex manufacturing workstations were modeled and analyzed in order to investigate the modeling limits of ANALYTICE at equipment level. The first workstation includes: a) one input and one output conveyor for pallets, b) one rail-car for transporting input pallets to a robot and from the robot to the output conveyor, c) the robot with manipulation functions, responsible for load/unload operations and d) a turning machine with automatic tool change. A second workstation model includes a) one human operator responsible for pallets manipulation, b) five input/output storage buffers, c) one rotational pallet changer and d) one inspection machine. The third workstation includes a) one human operator for loading/unloading of parts and for the activation of the assembly equipment, b) one screw machine and c) one press machine. The first is a hypothetical workstation. The second and the third are, respectively, models of the ACE-10 of DEA spa inspection machine and of the assembly Workstation E1 for Diesel motors at the BOSCH assembly line in Curitiba. The models of both workstations, embedded in the geometric model definition environment in ANALYTICE are shown in Fig-2 and -3.

Fig-1: general functional organization of ANALYTICE

Fig-2: a,b) geometrical model of workstation ACE-10 of DEA in ANALYTICE
The environment for the Project phase includes, beyond the equipment's recover functions from the TYPEs Data Base, functions for parts definition, part families and manufacturing cells identification, computation of the number of occurrences of machine and pallets types, layout definition and scheduling policies. The programs for parts and process plans definition and for part families and cells identification (Group Technology algorithms) have been integrated. The interface for layout specification is being implemented. The same interface will be used at workstation, cell and plant level. The first approach for layout definition is based on a strong user-system interaction. An automatic approach, where the layout alternatives are automatically generated is in a final stage of implementation. Specific programs for defining scheduling policies are in development stage. Preliminary results for testing strategies have been obtained using ANALYTICE for the definition of CLASSEs where the behavioral model is a timed Petri net representing a scheduling policy for a given problem. The quantitative analysis environment allows both the monitoring of equipment and the computation of performance parameters of a design alternative. Both functions reflect simulation results. At equipment level the user defines monitoring variables attached to and actualized in the behavioral model of the equipment. A graphical interface is responsible for the representation of status variable. At higher levels (workstation and manufacturing cells) the performance parameters are pre-defined (throughput, equipment's index of utilization, mean value of parts and pallets population at intermediate storage, induced wait times, production costs). The simulator has been exhaustively tested. Minor changes will be necessary due to the specificity introduced by workstation and cell levels.

Fig-4: a) definition of a process plan
b) example of output of a performance parameter (throughput x time)
Fig 4a shows the edition of a process plan. The process plan is defined as a directed graph with no loops, one source node and one sink node. A node represents a manufacturing state of the part. Arcs are labeled with the operation identification that lead the part from one state to the other. Fig 4b shows an example of the monitoring interface of ANALYTICE for performance parameters. In this specific case the number of pallets produced in a workstation by time unit is being displayed as a time function during simulation.

5. PROJECT RESULTS

Four graduate students have been sent to Europe for a two months program and one German specialist has been in Brazil for a six months period. The interchange program has been totally sponsored by CNPq.

5.1 Interchange Program from Brazil to Germany

Two students (Cesar A. Tacla and Hamilton K. Rokukawa) executed a two month visit program at the GMD/Sankt Augustin under the supervision of Dr. R. Durchholz. During the visit specific topics on formal specification techniques have been presented to the students: Compositional Data Objects and High level Petri Nets. Preliminary discussions over the application of the formalisms to the specification of some aspects of the system ANALYTICE (TYPE and CLASS definition, aggregation rules of equipment’s for higher level constructions definition) have been carried on. Two other students (Alvaro C. Matos and Alexandre P. Gallotta) visited industries, mainly in Germany and Italy, and universities in Germany, related with the topic of Flexible Manufacturing Systems. The goal was to establish a direct interaction with industries that use FMS technology or that are supplier of FMS equipment.

5.2 Interchange Program from Germany to Brazil

The overall goal of the six month assignment of Dr. Reiner Durchholz, GMD/Sankt Augustin, was to make available advanced methods of systems specification, in particular for use in a FMS specification environment. The selection of topics, illustrations and exercises was influenced by the requirements of the project, while the project received input from the methods considered.

6 WORK PLAN AND FUTURE WORK

6.1 Software Development and Applications

The planning for the next years includes tasks for the conclusion of the software, for modeling a real manufacturing cell and the organization of a continuous education program in new manufacturing technologies. Some details about the work are given in the sequel.

6.1.1 Conclusion of the software ANALYTICE

For the next year the major development tasks are related with the conclusion and integration of the code for the remaining steps in the project phase. The remaining steps are:

i): general
- integration of details of operational parameters definition at TYPE definition level.
- integration of the interface for costs definition at TYPE level.
- integration of the modules for the computation of the number of equipment occurrences for achieving given production volumes in given time horizon.
- specification, implementation and integration of the modules for scheduling policies definition.

ii): layout definition
- implementation of the aggregation rules of equipment for workstation definition
- implementation of the aggregation rules of workstations for manufacturing cells definition
- implementation of the aggregation rules of manufacturing cells for plant definition
iii): control definition
- implementation of the environment for control definition at workstation level. A control program at this level will be seen as control routines calls directed to the equipment aggregated to the workstation embedded in a sequence of flow control statements for parallelism in the workstation. The definition and execution of control programs for equipment level has been already tested and integrated.
- development of a communication interface for implementing VMDs (Virtual Manufacturing Devices) in the context of ANALYTICE. The aim of the interface is to switch from simulation to supervisory control of real manufacturing systems.

6.1.2 Development of a model for a real manufacturing cell

This task is related with data acquisition of the production activities of a real manufacturing system, its modeling using the ANALYTICE concepts and its simulation for model refining. In a second step alternatives for improving resource utilization will be analyzed. Preliminary industrial contact has been established with FURUKAWA, a local manufacturer of electrical products.

6.2 Proposed Interchange Program

The main objective of the proposed interchange program is to give practical international insight to Brazilian graduate students. The previous experience in this direction showed some inconsistencies due to the large amount of visits in a relatively short time.

Three long terms visits of Brazilian graduate students (about two month ) to a German institution, probably GMD/Sankt Augustin and IAS/Stuttgart for the continuation of the interaction on formal methods for the specification of FMSs. One long term visit of a Brazilian graduate student to an industry that either uses or is supplier of FMS equipment.
1 Title and Acronym:
Application of Object-Oriented Techniques to Real-Time Industrial Automation and Process Control Systems Development - OORTAC

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3 Project Goals
3.1 Application Domain
Industrial automation technology is a key issue both for industrialized and developing countries, despite the economical differences between them. Definitely, saves achieved by automation of technical plants concerning the reduction of personal costs are not so demonstrative for developing countries as they are in industrialized ones. However, for applications demanding very high-level of quality and precision, especially those that can (or should) not be performed by human beings due to safety reasons, automation is essential and plays a very important role. Moreover, with the internationalization of the markets, the consequent worldwide competition, and the increasing demand on high-quality but low-price products demand from modern industries a massive use of industrial automation in order to meet their customer requirements and be competitive. Because of this, modern industrial automation systems have achieved a high level of complexity that makes them almost intractable for humans. Next generation industrial automation systems tend to be even more complex, since these systems are expected to be very large, distributed, containing highly dynamic and adaptive behavior, having a long lifetime, and involving complex timing constraints.

There is a consensus that conventional techniques for developing real-time applications are not able to deal with such a complexity, mainly due to their poor abstraction mechanisms. Therefore, new techniques are required. This project proposes an object-oriented technique for dealing with such complex real-time applications.
3.2 Main objectives

This project focuses on the application of object-oriented concepts to the development of industrial automation and process control systems. The project's goals are manifold:

- to define a development process which cost-effectively produces high quality industrial automation systems, i.e. systems that are more robust, maintainable, reusable, etc. than those obtained using conventional approaches;
- to allow technology transfer in the field of industrial automation from Germany to Brazil and specially from academia to industry in both countries;

A secondary project's goal is to support the creation of Master and Ph.D. programs in the field of Process Control and Industrial Automation at the DELET-UFRGS, including:

- curricula definition;
- training for Brazilian scientists of the DELET-UFRGS, allowing a know-how transfer to be applied in the Post-Graduated Courses on Measurement and Instrumentation (and in the future Courses on Process Control and Industrial Automation);

4 Project Description

The aORTAC project focuses specially on problems related to the development of large and complex real-time industrial automation systems (for example, production control systems, robot control, etc.). The task of developing modern real-time systems cost-effectively, on time, fulfilling prescribed quality criteria, can only be satisfactorily met by applying apt system engineering approaches. All development phases, from requirements engineering through design, implementation, testing, until maintenance are covered within the OORTAC project. It is considered that these phases will be handled in a iterative way (spiral life-cycle). Each iteration cycle includes a progression through the same sequence of steps, for each portion of the products and for each of its levels of elaboration, from an overall requirements specification document down to the implementation of each individual program or hardware component. In order to handle all development phases a consortium of universities and some companies in Brazil and Germany has been built up. Each partner has as main research focus a different phase of the development of real-time systems. Hence, this cooperation project should promote a synergetic effect, allowing to combine the partner's expertise into a suited framework.

The approach proposed in OORTAC follows the core idea that, when developing an industrial automation system, before starting thinking on what hardware components, bus systems, etc. will be used, one has to fully understand the problem to be solved. Hence, a deep analysis of the automation problem to be solved is a must. In order to be cost-effective and to minimize waste of efforts, the analysis model is used as a starting point to the software and hardware structure. Additionally, special care is taken in chosen/defining the software and hardware structure, in order to ensure that it will be less subject to changes than the functional requirements usually are. Hence, application classes identified in the initial requirements engineering phase, evolve (in a gradual fashion) through each development phase to a stable representation form.

It is important to notice that the semantic of „object-orientation“ as used in the OORTAC project should not be understood as the use of an object-oriented language, but rather as a new way of thinking along the development process. One of the main advantages of the proposed strategy is to encapsulate information in manageable „chunks“ and to hide implementation and technology dependent oriented decisions from problem related ones, allowing the conception of more robust, reusable and maintainable industrial automation systems. For a more detailed description of the project's proposal readers are referred to the papers mentioned at the end of this project report.
5 Project Results

5.1 Technical Results

5.1.1 Object-Oriented Modeling of Real-Time Industrial Automation Systems

Within the context of Pereira's Ph.D. work at IAS under Prof. Lauber's supervision, an object-oriented approach to the specification of industrial automation systems was developed. This approach covers the so-called upper phases of an automation project and introduces the concept of active objects as a mean to smoothly map the structure and dynamics of the technical plant into the specification model. It also proposes concepts for a precise specification of timing requirements, allowing a formal checking of the specified timing requirements. Additionally, it allows a validation of the specification.

5.1.2 Low-Cost Distributed Hardware and Software Architecture

The analysis model is used as a starting point to the design phase, where a distributed hardware and software architecture are defined. Within the scope of the OORTAC's project, a distributed hardware architecture has been proposed. It consists of several low-cost processors (microcontrollers, PLCs, DSP processors, as well as personal computers) interconnected through standard protocols, such as fieldbusses (Proﬁbus, CAN). The architecture has been conceived to allow a smooth transition from the object-oriented speciﬁcation to a cost-effective implementation which guarantees that the speciﬁed timing requirements are fulﬁlled. Additionally, standard industrial communication protocols play a key role in the deﬁnition of open architectures for automation systems. Hence, interface drivers following the Proﬁbus-FMS and DP slave protocols (DIN 19245) have been implemented within the scope of OORTAC. An object-oriented model for interfacing object-oriented real-time programs with technical plant's components has also been deﬁned. This model is indeed protocol independent, since it deﬁnes an abstract communication class which makes message exchanging between objects totally transparent to programmers (a remote member function call is implemented, where objects' calls to member functions of other objects are mapped to real-time operating system messages exchanging between concurrent tasks).

5.2 Published Papers related to the OORTAC Project

A total amount of 16 papers have been published in several international conferences, which describes into details the overall OORTAC proposal.

5.3 Mutual Visits

Up to now, four visits have been implemented within the scope of the project:

• Prof. Dr. Halang (Fern-Universität Hagen, Germany) visited DELET-UFRGS for 1 month in November 1994. His visit was important for training the staff in Brazil, both from academia as well as from industry, in recent advances in the ﬁeld engineering of complex real-time systems. During his contacts with two Brazilian industrial partners were consolidated.

• M.Sc. Alceu Heinke Frigeri, an associate professor at DELET-UFRGS has visited the IAS-University of Stuttgart for 3 months, from January to April 1995. Mr. Frigeri, together with researchers from IAS have developed a case-study applying the concepts developed in the OORTAC framework. The obtained results were quite encouraging when compared to those obtained with conventional methodologies.

• Dr. Carlos Eduardo Pereira from DELET-UFRGS visited IAS, Daimler-Benz Research Center, Fern-Universität Hagen, and the FZI Research Center in Karlsruhe in July 1995. His visit was specially important to consolidate the contacts with Daimler-Benz (which resulted in the deﬁnition of the Bridge Project) as well as to build up the consortium that currently composes the OORTAC project.

84
• Prof. Dr. Rudolf Lauber visited DELET-UFRGS for one month in September 1995. During this visit, besides important technical meetings with our Brazilian industrial partners, some first contacts with researchers of the Analytice Project were possible. These contacts have shown that an effective cooperation between these two projects (both belonging to the Germany-Brazil Cooperation) can be started, since the approaches proposed are in several aspects complementary.

Moreover, for the occasion of the workshop in Berlin, Dr. Carlos Eduardo Pereira, who presented at the workshop the results obtained within the OORTAC project in the first two years, has visited IAS for two days. This visit was particularly important because it has allowed a direct contact with Prof. Göhner, Prof. Lauber's successor as Head of IAS. Since then, Prof. Göhner has officially joined the OORTAC project. He will continue Prof. Lauber's work on tool support to OORTAC.

5.4 Industrial Perspectives

Not only papers have been produced over the last two years. Due to the economical relevance of industrial automation to the competitiveness of industries from both countries, Germany and Brazil, contacts have been established with several industrial partners, which have demonstrated interest on the topics handled in OORTAC. From these contacts we could identify distinct types of industrial partners. In the so-called “suppliers group”, formed by companies producers of equipment for industrial automation, we could observe a clear distinction between two groups:

• large and traditional companies, such as AEG, Siemens, which offer complete (and usually monolithic) solutions to automation problems;
• small to medium-large companies (such as ALTUS and DIGICON), which usually offer components for industrial automation, such as programmable logic controllers, sensors/actuators, data acquisition boards, etc.

Companies belonging to the former group, as well as those companies which are users of automation technologies and components do have interest in new methodologies to industrial automation systems development. They are specially interested on topics like process optimization, where under process both “development process” and “production process” are meant. Companies from the second group are specially interested on topics like distributed automation systems and open architectures allowing the interconnection of several components from possibly different suppliers. Topics as standard bus protocols, standard programming languages for automation are a main concern. It could also be observed that the great majority of Brazilian companies active in automation belong to the second group. Within the scope of the OORTAC project we could start some cooperation with industrial partners belonging to both of the above mentioned groups. This has been possible specially due to the fact that the object-oriented paradigm has been proven to be very well suited both as a modeling concept as well as an architectural approach to implement distributed industrial automation applications. Among the industries which have demonstrated interest on the OORTAC's approach are: in Germany, FESTO DIDACTIC, AEG, Daimler-Benz Research Center, ETAS GmbH (Bosch), SWDatentechnik (software-house), and in Brazil, ALTUS Sistemas de Informática, Digicon, and Riosoft. It is important to mention that the great majority of Brazilian companies involved in industrial automation are small to medium-large ones. These companies have shown a special interest on the distributed architecture for industrial automation systems developed within the scope of the OORTAC project. Besides the company ALTUS, which has been an industrial partner of OORTAC since the start of the project, currently the company Digicon has

1 It is important to note that large companies from the first group usually also are interested on these topics, since users are increasingly demanding for open and distributed automation systems.
demonstrated interest on this topic. Related to the topic fieldbus, a new German partner has joined us in the OORTAC project: the Profibus Center of the Informatic Research Center - University of Karlsruhe. In addition, the Institute for Control and Real-Time Systems of the University of Hannover, headed by Prof. Dr. Gerth, has also joined the OORTAC project. This institute has developed a micro-kernel Real-Time Operating System (RTOS-UH) that directly support the time primitives of the PEARL language and which is tailored to run on low-cost microcontrollers (MC68x11 from Motorola) boards. In cooperation with this institute we will adapt the RTOS-UH kernel to Intel microcontrollers, which is the main processor family in use by ALTUS and DIGICON. The main goal is to have an real-time operating system, running on microcontrollers, which supports the communication between the active objects defined in the specification phase. It will build upon the already defined uniform software interface to the communication system (independently of the hardware and protocols used).

6 Workplan (detailed milestones, time schedule, and expected results)

6.1 Technical Activities:

milestone 1: to build up, in cooperation with the industrial partners ALTUS and DIGICON, a technical plant prototype at UFRGS to be used as the basic "test environment" to test the whole development cycle proposed and compare the results with other approaches. The intended technical plant will consist of a net of PC-compatible computers (running QNX and MS-DOS), microcontroller based controllers, PLC (from ALTUS and DIGICON), some "industrial components" (sensors/actuators and small robots) and a Modular Production System (from FESTO Didactic KG, Germany). Dr. Pereira will apply to a Grant of the German DAAD in order to obtain financial support for purchasing the technical plant.

milestone 2: to finish the implementation of the PROFIBUS-DP protocol in a net of microcontroller-based boards. With the help of the Profibus-Center we hope to have this protocol full implemented and tested (including compatibility test) by June 1996. This milestone will be carried on by DELET-UFRGS and ALTUS with support of FZI.

milestone 3: development of low-cost automation components, such as microcontroller-base boards running object-oriented real-time operating systems

milestone 4: in parallel, we will start the adaptation of RTOS-UH to our microcontrollers and PLCs, using the PROFIBUS-DP as the communication protocol. With this real-time operating system, it would be possible to easily implement our object-oriented real-time approach, based on active objects, since the management of the threads are guaranteed by the operating system.

milestone 5: to focus on strategies to allocate the active objects obtained at the specification level to the components of the distributed automation architecture. Special care is to be paid to ensure that the implemented automation system will fulfill the specified timing requirements. Moreover, different alternatives to configure the final automation system (using different processors and protocols) should be analyzed and compared, considering aspects as cost, performance, reliability, and so on. In this topic we will have the cooperation of another German institute, the Fernuniversitat Hagen in the person of Prof. Dr. Wolfgang Halang

milestone 6: it will be investigate how existing programming standards for industrial automation applications, such as the IEC-1131 standard, can be taken into account in the OORTAC project. This milestone will be carried on at the Fern-Uni Hagen.

milestone 7: to integrate OORTAC and ANALYTICE approach
6.2 Time schedule

notation: D: DELET; S: STUTTGART, H: HAGEN; K: KARLSRUHE; N: HANNOVER; A: ALTUS

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6.3 Travels.

1996:

• From Germany to Brazil (3 visits):
  ⇒ 1 Researcher from Profibus-Center (FZI-Uni Karlsruhe) will visit DELET-UFRGS during 1-2 months, to help in the definition and implementation of the distributed architecture for real-time industrial automation systems.
  ⇒ Prof. Wolfgang Halang (Feruniversität Hagen) will visit DELET-UFRGS during 1-2 months, to help in the definition of an object-oriented design strategy for mapping the active objects obtained at specification level to a distributed automation structure. Special care will be taken in order to obtain a solution with deterministic behavior, in order to ensure that timing requirements will be fulfilled. For that purpose the multimedia course developed at Hagen (which employs PEARL90) will be used.
  ⇒ Prof. Göhner will visit DELET-UFRGS during 1 month (?), to help in the definition of an object-oriented design strategy for mapping the active objects obtained at specification level to a distributed automation structure.
• From Brazil to Germany (1 visit):
  ⇒ 1 Researcher from DELET-UFRGS will visit the Universities of Stuttgart, Karlsruhe, and possibly of Hagen during 2-3 months, to continue the work on the definition of an object-oriented design strategy for mapping the active objects from the specification to the distributed automation structure, that guarantees the fulfillment of timing requirements.

1997:

• From Germany to Brazil (2 visits):
  ⇒ 1 Researcher from the University of Stuttgart will visit DELET-UFRGS during 1-2 months, to work on aspects related to milestones 1 and 5.
  ⇒ 1 Researcher from a German Partner will visit DELET-UFRGS during 1-2 months, to work on aspects related to 4, 5, and 6.
• From Brazil to Germany (2 visits):
  ⇒ 1 Researcher from DELET-UFRGS will visit the University of Hannover and the Profibus-Center (FZI-Uni Karlsruhe) during 3 months, to work on the integration of the whole automation system defined in the scope of OORTAC.
  ⇒ 1 Researcher from DELET-UFRGS will visit the University of Stuttgart during 2-3 months, to work on aspects related to milestones 6.

In addition, Alceu H. Frigeri from UFRGS will develop his Ph.D. thesis at the Fernuniversität Hagen, supported by a grant from DAAD, working on topics closely related to the OORTAC project. His work will surely intensify the long-term cooperation.
1 **Acronym**: BRIdGE

2 **Title**: BUSINESS PROCESS IMPROVEMENT USING A GOAL-ORIENTED APPROACH

3 **Partners**
The partners involved in BRIDGE are well experienced in the topics covered by that current proposal, in international collaborative work, and are renowned for their research and commercial activities e.g. in the field of

- software process improvement (Daimler-Benz Research Center - Department Software Engineering),
- reference models for industrial enterprises in the area of business process engineering (University of the Saarlandes - IWi),
- reuse practices and simulation of business processes (University of Stuttgart, IAS),
- object-oriented technology (UFRGS).

4 **Objectives**
The overall goal of the BRIDGE project is to provide means for industry to easily adapt itself to changes in the customer requirements, in order to enable it to compete effectively world wide. Emphasis will be put on an integrated approach to improve business processes and to develop tailored business IT-systems on the basis of new generation technology.

BRIDGE aims to establish a balanced correlation between business processes and IT, which presents following characteristics:

- integrated methodology to model and improve business processes as well as to develop business IT-systems
- goal-oriented improvement of business processes and attached IT-systems (both analytical and simulation tools like ARIS)
- taking advantage of object-oriented techniques to model business processes and to implement complex business systems
- reuse of process models (reference models) and of related software components (*componentware*)
- customer involvement by modeling, evaluating, and introducing business processes
- design and implementation of a business tools engine, which enables the integration of existing business engineering tools through an adequate data exchange as well as a workflow support.
5 Project Description

The business processes involved in BRIDGE come from the development of technical systems, namely from the systems development area (embedded systems) at the Mercedes-Benz do Brasil (MBBRAS).

The BRIDGE project will be primary application driven. This will be achieved by a closed coupling to real business processes for capturing their characteristic requirements and for evaluating and demonstrating the project results. The following steps will be covered:

1. capturing typical characteristics of an existing business process and of existing business IT-systems;
2. determining the needed technology to improve those processes, tailoring or extending it according to the user requirements when necessary;
3. describing measurable improvement goals to be achieved, deriving the measuring instruments (e.g. metrics), planning the activities and resources to fulfil the goals, and continuously evaluating the progress.
4. experimenting the „improved business processes“ in a pilot project, which includes a technical business process (embedded systems). Intention is to test the adequateness of the technology proposed and to evaluate the impact of that technology on the IT environment;
5. analysing the results of the previous experimentation and refining the methodology accordingly, aiming to enhance the reusability by packaging the models and knowledge into a reusable experience base, making them reusable for future process improvements.
6. „packaging“ the results and introducing the improved processes to the consortium partners.

Our main approach is based on following fundamental ideas:

- scenarios are a simple, natural way to identify business processes. A customer is a user of a company, and he / she uses the company through a business process.
- object orientation is an excellent way to clarify the inner workings of a company - its processes, services, resources - and how those things depend on each other.
- the business model of the redesigned company and the requirements model for the information system must be seamless. This is achieved by pairing object-oriented business engineering and object-oriented software engineering, which work in harmony.
• a smooth migration to future business practices should be based on a sound measurement-based engineering technique, which is transparent and understandable by the end-users.

• the reuse of products and processes contributes to faster adaptions and modifications in case of change in the user requirements.

That approach will be realized by combining two techniques, namely ARIS and QIP (Figure 1). ARIS is an integrated methodology to develop information systems on the basis of business processes. The Quality Improvement Paradigm (QIP) is an empirical method to improve processes in general, which uses intensively existing knowledge of the process. BRIDGE will tailor that methods aiming to increase the efficiency of existing business processes.

Figure 1 The integrated methodology in BRIDGE

The main results of this approach will be:

• the adaptation and extension of the used methods on the basis of the business processes

• to define a sound business engineering technique to improve business processes

• reuse of processes and products
6 Work Plan

6.1 Project Breakdown

BRIDGE is decomposed in 4 workpackages:

![Diagram of workpackages]

**Figure 2 Work Plan**

6.2 Workpackage 1000: Characterization

Goal of this workpackage is to capture typical characteristics of an existing end-user business process and of the existing IT-systems.

**Deliverable 0:** Business and IT Characterization

6.3 Workpackage 2000: Preparation of Technologies

In this workpackage the needed technology to improve the business processes will be determined. An evaluation of different techniques to support business engineering, software development, reuse and human modeling will be conducted. Goal is to perform an analysis of different techniques and to propose an integrated methodology to do business improvement and software development by taking human aspects and reuse as important factors for the business success.

**Deliverable 1:** Framework for Business Improvement
**Deliverable 2:** Software Process Model
**Deliverable 3:** Reuse Techniques
6.4 Workpackage 3000: Applications

The improvement of selected business processes will take part at this workpackage. At first a tailored definition of the needed framework (techniques) and platform assessment will be conducted. The second step is to perform the improvement activities through the definition of an ideal process, of the goals to be achieved and to derive the measurement instruments to follow the progresses. After the improvement step, the development of the attached IS support must be conducted. This workpackage completes with the evaluation of the used techniques and when needed, with their adaption and extension. That phase must be conducted directly by the users, who understand and utilize daily that processes. The preparation for reuse of processes and products will be conducted in that phase too.

Deliverable 4: Framework and Platform Assessment
Deliverable 5: Applications Execution
Deliverable 6: IS Development
Deliverable 7: Documentation of the Validation
Deliverable 8: Reuse Documentation

6.5 Workpackage 4000: Package

The developed techniques and strategies developed in BRIDGE must be disseminated to the users in the consortium. The publication of the results is another important step in that workpackage.

Deliverable 9: Results: methods, tools, process description
Deliverable 10: Introduction Guides

7 Project Organization

It is recognized, that a supportive management is a key factor for the success of a project. By geographically dividing it in regional management units, the communication and the coordination will be facilitated and be more transparent (Figure 3).
The Project Managers will be responsible for the overall co-ordination of BRIDGE. They will manage the project management board. Such meetings will take place annually.

Each Activity Leader is responsible for the coordination of the ongoing activities in BRIDGE. The regularity of such meetings depends on the complexity of the activities, and should be defined before the beginning of the respective project work. Some of the work packages must be conducted directly on site (at MBBRAS or at DBAG).

Regularly the partners in BRIDGE will produce different project reports, depending on the status and involvement in distinct activities:

- **activity reports**: each Activity Leader reports about the ongoing tasks from the view of his company;
- **project reports**: it reports about the project status, from its applications, from each partner and from the finished and ongoing activities. The overall Project Manager will be responsible for it.

The BRIDGE partners will take advantage of modern techniques and tools to support unified groupware structures, which combines distributed document database functionality with security layer mechanisms, existing messaging systems, meeting tracking, and workflow automation facilities, aiming to monitor activities (e.g. Lotus Notes).

On the basis of the meetings described above, BRIDGE plans 4 travels for the 2-years project duration, 2 Germany-Brazil and 2 Brazil-Germany. For the partner involved, it is planed a 4 weeks duration stay for conducting research and transfer activities on site.

Additionally, BRIDGE will encourage an intensive personal exchange in form of doctorate programs in the areas covered by that proposal (that foments are independent of the travel cost described above). A implementation of such a co-operation will be discussed during the project execution.
Computer Graphics and Signal Processing
Adaptive Systems

Project Report prepared by
P. M. Engel and G. Richter

Workshop on
Information Technology: Cooperative Research with Industrial Partners
between Germany and Brazil

Berlin, Germany, December 14th—15th 1995

Promoted by the German-Brazilian Cooperative Programme in Informatics

1 Title and Acronym

The cooperation project “Adaptive Systems: An AI Approach for Real-Time Computing” or Adaptive Systems, for short, is included in the strategic information technology area Computer Graphics and Signal Processing and addresses the application area Advanced Automation.

2 Partners’ Names and Addresses

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Responsible for the cooperative project: Prof. Dr. Paulo Martins Engel
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Responsible for the cooperative project: Dr. Gernot Richter
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3 Objectives

Tools and environments for the design and simulation of adaptive systems are the short-term goals of cooperation. In the long run, joint research on various aspects of adaptive systems like neural networks, reflective statistics, adaptive control or fuzzy control will be performed.

Adaptive systems based on neural networks are designed to solve function approximation tasks. They estimate input-output functions without a mathematical model of how outputs depend on inputs. Adaptive solutions are of great interest in situations where the behavior
of a system is difficult or impossible to model. Applications in the areas of remote sensing, image analysis, in industrial quality control and in adaptive robotics will be investigated.

A further kind of adaptive systems are systems that are supposed to act intelligently in the real world that is imperfectly perceived and incompletely known. The construction of such systems calls for radically new methods for design and implementation. The processing of sensory information and the generation of appropriate actions must possess a degree of reactivity and adaptability, comparable to that shown by biological systems acting in the real world.

A typical application is controlling a two-arm robot with a visual system that receives input from several cameras. The robot tasks involve in general controlling the arms for collision-free manipulation of objects lying on a workbench, guided solely by visual information about the external scene and the technical description of actuators and sensors. Basic sub-tasks that must be performed in order to achieve such goals include pick-and-place operations and the exchange of an object from one arm to another. The system gradually learns to produce better plans and smoother and quicker movements as the surroundings and task descriptions become more familiar. In the cooperative project applications with manipulators and vehicles are intended to be investigated and implemented.

4 Project Description

A central objective of this cooperative project is to establish a set of common tools to be shared with both groups for the study of adaptive systems (AS). Currently, two major systems are operational at GMD which can serve as testbeds for cooperative research (and have already been investigated in the framework of this project). In addition, several research results from UFRGS are available for extending these systems.

- An object-oriented environment for simulation of neural network architectures: SESAME (Software Environment for the Simulation of Adaptive Modular Systems). This system is very flexible allowing simulations of several neural network architectures. Considering the experience of the Brazilian group with other neural network architectures, it was decided that the expansion of the simulation modules of SESAME will begin with the neural architecture known as Learning Vector Quantization (LVQ).

- A heuristics-based approach to intelligent robot control: JANUS. The first version of JANUS works in simulation. The real robot system is currently comprised of one NiKo manipulator (a further manipulator will shortly be added). The visual sensory system is under construction. The development of the JANUS system relied heavily on experiments and testing in simulation. The simulation environment RoboWorld, also developed by the AS group, allows the experimenter to model the scene of a robotic work cell. The work cell for JANUS consists of two NiKo arms situated in a work-space containing cuboidal objects. Each arm has eight joints and a gripper. All JANUS functions are executed in the same way in the simulated as in the real world. Thus the manipulation of objects, the acquisition and reuse of planning and motor knowledge is the same for both simulated and real arms. Experiments show that motor learning leads to significant improvements in execution of tasks, even when they are quite different.
At the UFRGS, an environment for intelligent processing of multispectral images by Self-O rganizing Maps was developed, that allows the testing of new simulation modules to be incorporated in SESAME. Moreover, advanced studies in new learning techniques of neural networks and in neural-fuzzy hybrid systems form the main contribution of the group of the UFRGS to the common tools. We list below the current research results at the UFRGS that are relevant to this cooperative project.

- A modular neural system for automatic processing of multispectral images: IRENE. This system supports the different steps of the multispectral image processing. A cubic Kohonen Feature Map is applied for the unsupervised clustering of the original image pixels in different classes (pseudo-colors). With the help of the clustered image, a training file can be produced and used to train a Self-Organizing Map (SOM) during the supervised training process known as Learning Vector Quantization - LVQ. In a final step, all pixels of the original image are classified by the trained SOM, receiving a pseudo-color corresponding to the proper class. The experience with IRENE will allow the extension of SESAME by a LVQ-module.

- Attentional Mode Neural Network (AMNN): a new approach for real-time self-learning. The Brazilian group developed a new concept of adapting a neural-network on-line, while it actuates in its environment. The Attentional Mode Neural Network (AMNN) implements this concept and represents a new solution for real-time self-learning. First simulation results on autonomous guided vehicles (AGV) and in the control of a manipulator arm demonstrated the good applicability of the AMNN. It is planned to develop an AMNN based controller with an interface to RoboWorld.

- An environment for development of applications of fuzzy systems. This environment supports the project of fuzzy controllers for different applications. A prototype of this environment is being validated through applications of linear and non-linear systems. The experience gained with this development is useful to expand the common tools of this cooperative project.

5 Project Results

Phase 1 (July 94 to July 95):
Environment for the design and simulation of several neural network architectures, including related statistical methods. Toolbox for the simulation and visualization of robotic scenes.

Important Milestones:
- Evaluation of the existing design and simulation tools at GMD and UFRGS started last year (visit Paulo Martins Engel at GMD, July 94).
- The design and simulation environment for neural network architectures SESAME and the simulation environment for robotic applications RoboWorld where transferred to UFRGS (lectures, installation, adaptation, visit Thomas Sudbrak at UFRGS, November 94).
- As a first step towards offering a public domain package for robot simulation experiments the toolbox of RoboWorld was prepared for use outside the JANUS application (visit Ana Paula Lüdtke Ferreira at GMD, February – May 95).

Phase 2 (July 95 to July 96):
Validation of the design and simulation environment for neural network architectures through
applications. Continuation of research on adaptive robot control.

**Important Milestones:**
- A new LVQ module adapted from the NN simulation system IRENE from the UFRGS was integrated into SESAME (visit Rodrigo Vanini Nunes at GMD, July – October 95).
- Lectures about adaptive systems and control in open environments, evaluation (continued) of the existing design and simulation tools (visit Gernot Richter at UFRGS, November 95).
- Lectures about the Attentional Mode Neural Network and its applications in adaptive systems (visit Paulo Martins Engel at GMD, February 96).
- Research activities and experiments based on the shared environments will be started and their results will be exchanged.
- RoboWorld will be adapted to allow for the simulation of an autonomous guided vehicle (AGV) and its environment.
- A behavior based sensorimotor controller of two manipulator arms to operate in open environments will be investigated at UFRGS using and modifying the adaptive control system JANUS.

6 Work Plan and Future Work

- Comparative experiments using SESAME for multispectral image processing. The performance of SESAME for image processing will be evaluated through comparative experiments with classical techniques.

- A neural-fuzzy controller for an autonomous guided vehicle (AGV) will be developed. The Attentional Mode Neural Network and an adaptive controller based on fuzzy logic (Fuzzy Knowledge Based Controller – FKBC) will be considered as the potential techniques for implementing an AGV. Typical tasks, like trajectory tracking with obstacle avoidance will be simulated to validate the prototype. RoboWorld will be used to model the scene of the AGV environment.

- The JANUS prototype was developed in a simulated world, but was originally designed for control of a technical robot system. As soon as the visual system is successfully implemented the real hand-eye system will be used for further research on heuristics-based motor capabilities and flexible methods for processing sensory information. Researchers from UFRGS are expected to perform advanced studies using and modifying the control system according to their needs and in close cooperation with GMD's AS group. Their research on intelligent robotics is expected to progress the flexibility of the system both in sensory perception and in motor control, in particular with respect to real-time aspects.

- A prototype of a controller of a manipulator arm based on AMNN will be developed and simulated with RoboWorld. The performance of this controller will be investigated through real-time experiments with a NiKo robot arm.

**PS:** Profs. Lucena and Jähnichen informed us on January 26, 1996, that the review team of the German-Brazilian Workshop decided that the project *Adaptive Systems* should not be continued in 1996.
1. TITLE AND ACRONYM

Computerized procedure for automatic biological analysis from water sample images - BIOCOMP

2. PARTNERS’ NAMES AND ADDRESSES

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FAX +49 / 9131 / 303 801

c) Industrial partner
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Brazil

3. OBJECTIVES

This is a proposal of a new project submitted to the present cooperation between Germany and Brazil, that will require two years to achieve the following objectives.

3.1 General objective

To improve the quality of water for human purposes in order to prevent the occurrence of health problems resulting from inadequate water, according to standards of the World Health Organization.

3.2 Specific objectives

a) Development of a computerized image processing tool for automatic visual analysis of aquatic organisms.
4. PROJECT DESCRIPTION

4.1 Motivation

The increasing of the population under high rates, as well as an expressive migration from rural areas to the greater Brazilian cities, implies a special attention for a safe availability of water for human purposes with an adequate quality. The conventional procedure to detect microorganisms consists in visual counting of identifiable species existing in adequately prepared samples based mainly on size and form (See example of images in the next page). Such a process allows both quantitative and qualitative detection of micro-organisms and zooplanktons. It requires most of the working time of the technical personnel. This activity so reduces the available time for data analysis and discussions about biological questions. In order to improve the procedures concerning the counting of microorganisms one requires the utilization of a system for automated recognizing of images oriented to the present context. The automation of image recognition has been significantly developed in last years, despite of being restricted to specific knowledge domains. The improvement of equipment performance enables the practical use of formerly achieved theoretical results. The plan for development of a computerized support for water analysis has resulted through cooperation between the Department of Computer Science and the Department of Zoology in the University of Brasilia, the Department of Pattern Recognition (Informatics 5) in the University of Erlangen-Nuremberg and the Brasilia Water and Sewage Enterprise (CAESB). The present project concerns initially software development, but it is oriented for the future conception of a hardware platform, that will embody the automation of the whole water analysis procedure. The potential users of the results of this project are the public institutions, that provide water for human purposes as well as enterprises that need to control the quality of water for other specific uses.

4.2 Attributions

The project will be performed by a work group with researchers from UnB and University Erlangen-Nuremberg, biologists from CAESB and BS an MSc students in Computer Science. They will be assigned to the following:

Researchers from UnB:
- Coordinating the project activities in Brazil
- Advising the system developers about the computational methods and techniques to be applied;
- Providing the technical resources for system development.
Researchers from Uni. Erlangen-Nuremberg:
- Coordinating the projects activities in Germany;
- Proposal of methodologies concerning pattern recognition for the project;
- Organizing contacts with German researchers and enterprises, that are engaged with the interest areas of the project;
- Assignment of researchers for eventually necessary activities to be performed in Brazil.

Biologists from CAESB:
- Providing the images to be processed during the project development;
- Providing specialized knowledge about water analysis to enabling software development;
- Performing practical tests for validation of the computational procedures.

Examples of images with microorganisms

Daphnia (400 times increased)

Diaphanosoma (40 times increased)
4.3 Relevant experience

The following topics may be presented at this point as scientific experience of the Department of Computer Science of UnB:

a) Project "Implementing the Laboratory of Computer Vision"
This project made it possible to install the main equipment configuration for researches on Image processing. A budget of 35,000 Mark was approved by DAAD and GTZ for equipment purchase in 1992. Two workstations, a video camera and a laser printer from this acquisition have been widely used up to now.

b) Project "FRIEND - user-FRIENDly Environment for image uNDERstanding"
During a three months stay in Uni. Erlangen-Nuremberg in 1993, Prof. Guadagnin proposed the basic structure for a research platform on Image Processing. Such proposal has started the development of the platform in RISC architecture. Presently many procedures are available for an user friendly image processing, that are widely used for teaching and research purposes.

c) Project "Pre-processing and detection of geometric properties"
Procedures for detection of localization and area calculation after a series of pre-processing actions were developed and are available in platform FRIEND. Such procedures will be particularly useful for the present project.

d) Project "Instructional system for modeling, visualization and animation of three dimensional objects"
This project was approved by FAP-DF (Foundation for Research Support in Federal District) at 1994. It included the acquisition of equipment (about 30,000 US dollars) and software development for image processing and computer graphics. The first results were presented as final project of BS students at June and December 1995.

4.4 Human resources

a) University of Brasilia
1 researcher in Image Processing
1 researcher in Biology
1 systems analyst
1 biologist with Computer Science background
1 Computer Science student
1 Biology student

b) University Erlangen-Nürnberg
1 researcher in Image Processing

c) CAESB
3 researchers in Biology
### 5. WORK PLAN

#### 5.1 Milestones

<table>
<thead>
<tr>
<th>N.</th>
<th>MILESTONE</th>
<th>MONTHS</th>
<th>EXPECTED RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Surveying on the state of art</td>
<td>2</td>
<td>Description of existing theoretical and practical work concerning the project objectives.</td>
</tr>
<tr>
<td>2</td>
<td>Evaluation</td>
<td>1</td>
<td>Critical analysis of the survey, including indication of directives for prototype development.</td>
</tr>
<tr>
<td>3</td>
<td>Prototype development</td>
<td>4</td>
<td>Documented prototype version of software for water samples analysis.</td>
</tr>
<tr>
<td>4</td>
<td>Test and adjusting</td>
<td>2</td>
<td>Tested and adapted prototype version of software accordingly to real data.</td>
</tr>
<tr>
<td>5</td>
<td>Implementation</td>
<td>2</td>
<td>Installation of prototype version of software in CAESB equipment for water analysis.</td>
</tr>
<tr>
<td>6</td>
<td>Concluding evaluation</td>
<td>1</td>
<td>Concluding report about the achieved results. Training plan for prototype utilization.</td>
</tr>
<tr>
<td>7</td>
<td>Looking for a German industrial partner</td>
<td>2</td>
<td>Agreement with a German industrial partner as participant in the project.</td>
</tr>
<tr>
<td>8</td>
<td>Evaluation</td>
<td>1</td>
<td>Critical analysis with directives for system development.</td>
</tr>
<tr>
<td>9</td>
<td>Statement of requirements</td>
<td>1</td>
<td>Description of performance indicators and other requirements to assure efficacy of the system.</td>
</tr>
<tr>
<td>10</td>
<td>Development</td>
<td>4</td>
<td>Documented software for water samples analysis.</td>
</tr>
<tr>
<td>11</td>
<td>Test and adjusting</td>
<td>2</td>
<td>Tested and adapted software according to real data.</td>
</tr>
<tr>
<td>12</td>
<td>Implementation</td>
<td>1</td>
<td>Installation of software in CAESB equipment.</td>
</tr>
<tr>
<td>13</td>
<td>Concluding meeting</td>
<td>1</td>
<td>Report about results and potential users. Proposal of a dedicated platform, that will deal with image input and storing, image processing and output of results from automatic analysis. Design of a prototype for a laboratory structure. Training plan for system utilization.</td>
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</table>
5.2 Work travels

<table>
<thead>
<tr>
<th>N.</th>
<th>SCHEDULE</th>
<th>PURPOSE</th>
<th>PARTICIPANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feb./96</td>
<td>Visit to Uni. Erlangen-Nuremberg and others research and applications concerned institutions to: a) Theoretical and practical information collection; b) Statement of methodological and technical requirements for the prototype; c) Tasks assignment to project participants.</td>
<td>Prof. Guadagnin, Prof. Cavalcanti, 2 biologists from CAESB</td>
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<td></td>
<td>2 weeks</td>
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<td></td>
<td>Germany</td>
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<tr>
<td>2</td>
<td>Jul./96</td>
<td>Discussion on theoretical subjects to: a) Statement of prototype features; b) Statement of feed-back measures.</td>
<td>Prof. Guadagnin / Prof. Cavalcanti, 1 biologist from CAESB</td>
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<tr>
<td></td>
<td>2 weeks</td>
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<td></td>
<td>Germany</td>
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<tr>
<td>3</td>
<td>Dec./96</td>
<td>Evaluation meeting to: a) Visiting the CAESB laboratory; b) Workshop for presentation and discussion about the implemented prototype.</td>
<td>UnB and CAESB, project people, 2 researchers from Uni. Erlangen-Nuremberg</td>
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<td>2 weeks</td>
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<td></td>
<td>Brasilia</td>
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<tr>
<td>4</td>
<td>Feb./97</td>
<td>Visit to Uni. Erlangen-Nuremberg to: a) Detailing of project action in 1997; b) Divulgation of achieved and expected results for potential industrial partners.</td>
<td>Prof. Guadagnin, Prof. Cavalcanti</td>
</tr>
<tr>
<td></td>
<td>2 weeks</td>
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<td>Germany</td>
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<tr>
<td>5</td>
<td>May/97</td>
<td>Visit to German partner and industrial partners to: a) Reviewing the system requirements; b) Discussion with industrial partner.</td>
<td>Prof. Guadagnin / Prof. Cavalcanti, System developer, 1 biologist from CAESB</td>
</tr>
<tr>
<td></td>
<td>2 weeks</td>
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<tr>
<td></td>
<td>Germany</td>
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<td></td>
</tr>
<tr>
<td>6</td>
<td>Sept./97</td>
<td>Visit to UnB and CAESB for: a) Detailed discussion about the system features; b) Statement of feed-back measures.</td>
<td>UnB and CAESB, project people, 2 researchers from Uni. Erlangen-Nuernberg</td>
</tr>
<tr>
<td></td>
<td>2 week</td>
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<td>Brasilia</td>
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<tr>
<td>7</td>
<td>Dec./97</td>
<td>Concluding meeting for: a) Workshop for presentation and discussion about the implemented system; b) Training plan for system users; b) Discussion and proposal of further actions.</td>
<td>UnB and CAESB, project people, 2 researchers from Uni. Erlangen-Nuernberg</td>
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VESIV: VIRTUAL ENVIRONMENT FOR SHARED INTERACTIVE VISUALIZATION

Prof. Dr. Claudio Kirner  
Prof. Dr. Paulo Cruvinel  
Prof. Regina Borges de Araujo  
Prof. Ildeberto de Genova Bugatti  
Prof. Antonio Carlos Sementille

Prof. Dr.-Ing. José L. Encarnação  
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Darmstadt - GERMANY

1. TITLE

"VESIV: VIRTUAL ENVIRONMENT FOR SHARED INTERACTIVE VISUALIZATION"

2. PARTNERS

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Participants:  
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Dr.-Ing. Volker Kühn  
Dipl.-Inform. Klaus Böhm  
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Participants:
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Graduate students

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3. OBJECTIVES

The integration of computers, innovative computer devices and high speed networks has allowed collaborative work among geographically dispersed experts (either by a local or a wide area network) without physically moving from one place to another (telepresence). This has been achieved through meetings in a virtual environment. Medical systems to support collaborative diagnosis, Project Supporting systems for decision making in an organization etc. are only a few examples of existing collaborative systems. In both examples above, interactive visualization of objects is of fundamental importance.

The objective of this project is the development of a distributed virtual environment, which allows shared interactive visualization among remotely located participants discussing common interest problems. This environment aims to provide a quite realistic visualization of objects permitting immersive and not immersive interaction with those objects. Moreover, the system should support the simultaneous visualization of different views of an object as well as the animation and graphics of performance analysis of the simulations being executed.

The project intends to be applicable in several scientific and technological areas as a support for discussion and resolution of problems among remotely located professionals, in a common collaborative environment. An area will be selected and an application will be elaborated and its results evaluated.
4. PROJECT DESCRIPTION

The project comprises the development of a distributed virtual environment driven towards the visualization and animation of 3D objects in real time. Every node of the system will receive a description of both the object and the simulation. The object will have two representations: a simplified one to be used in the virtual environment system and a more detailed one for the visualization process. The handling of the simplified object will produce manipulation commands (primitives) which will drive the local and remote visualizations. The animation follows the same scheme: the local simulator sends commands to the remote simulators, using dead reckoning for the object repositioning process.

The project will have four main modules: support for the distributed system, virtual reality, visualization, and simulation and animation.

The module for the distributed system support will be responsible for the production of an integrated and transparent communication environment over a heterogeneous network. Platforms like PVM and CORBA will be taken as an alternative to be used in this module.

The virtual reality module will produce a virtual environment driven to the manipulation of 3D objects and to the control of the simulation/animation, using innovative as well as conventional I/O devices. This module will use a language for the description of both the objects and the virtual environment as well as a set of primitives for the object manipulation. It will have also a set of control actions for the simulation and animation primitives.

The visualization module will use a language for the description and manipulation of 3D objects. The manipulation of the objects will be driven by the primitives received from the virtual reality module. This module will allow simultaneous visualization of multiples views, as well as the use of head-mounted displays.

The simulation/animation module will have primitives for the simulation control and animation. The simulation control primitives will be issued by the user. The animation primitives will be used by both the user and the simulation.

The modules will be replicated and distributed across the network nodes. The description of all the objects of interest in an interactive shared visualization will be multicasted to all of its participants. The project will be based on MuSE and GIVEN projects being developed by the German group, using the experience of the Brazilian group in the field of parallel and distributed computing acquired through the development of a distributed dataflow machine in the Centaur Project of Parallel and Distributed Computing.

5. WORK PLAN

5.1 Activities

The participants will be involved with the following activities during the next two years:
a. studies and project refinement;
b. development of the support for the distributed system;
c. development of the virtual reality module;
d. development of the visualization module;
e. development of the simulation/animation module;
f. integration of the developed modules;
g. elaboration of an example for test;
h. testing of the system in a local network;
i. testing of the system in a wide area network;
j. final documentation and project evaluation.

5.2 Time Schedule

The activities listed above will be realized according to the following time schedule:

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5.3 Work Partitioning between the Two Groups

Both groups will work in cooperation so that the members will interact and develop the modules together. Meanwhile, based on the specific expertise of each group, each one will anticipate in the project with different emphasis.

Both groups will share the responsibility for the development of the virtual reality module and the visualization module. The German group will be responsible for the simulation/animation module and the Brazilian group will be responsible for the distributed system support and testing of the system in a local network. The other activities will be carried out through the interaction of the members of both groups.

For the development of the project, a high degree of interaction among the members of the two groups will be necessary. This interaction will be realized through the Internet and trips for the two groups involved. The trips will be used for studying, consulting, developing, and testing of the project, and writing of papers related to the project.
5.4 EXPECTED RESULTS

The expected results are as follows:

a. develop a product as well as a scientific/industrial application;
b. narrow the relationship between the two groups involved and with industry;
c. enlarge experience in the area for the two groups;
d. publish and present articles with the obtained results in related conferences and/or workshops.

5.5. PARTNERS EXPERTISE

5.5.1 Research Group in Germany

The Computer Graphics Center (ZGDV) in Darmstadt, Germany, is a public-funded non-profit research organization which was established as an European platform for application-oriented training, research, and development in the field of computer graphics. Jointly supported by the Technical University of Darmstadt (THD), the Fraunhofer Society (FhG), and numerous companies and institutions, the ZGDV research and development work concentrates on computer graphics and related areas of information technology, and graphics applications.

The ZGDV conducts applied contract research in medium- and long-term projects requiring complex infrastructures, technical support and professional project management. Most of the work carried out by the ZGDV is industry driven research and development. As a link between scientific research and business practice, the ZGDV contributes considerably to the technology transfer between universities and industry. In addition, the transfer of knowledge and experience among industrial, trade, and research groups is realized by joint R & D projects.

Through this knowledge transfer from research to practical applications, the ZGDV contributes to the technological advantage of trade and industry. The ZGDV is involved in European Community projects (e.g. DELTA, CTZS2, RACE, ESPRIT, France Animation 2000) and has produced significant results in these projects.

In the field of virtual environments, the ZGDV conducts research and development in the area of virtual environment toolkits, advanced hand gesture recognition based on neural networks, data visualization in virtual environments and multi-user virtual environments.


5.5.2 Research Group in Brazil

Most of the members of the research group in the Computer Science Department at UFSCar have been developing research in parallel processing, computer network and distributed systems for a long time in the Centaur Project of Parallel and Distributed Computing. In this context, a distributed dataflow machine was developed, involving several graduate works. Recently they are working with virtual reality and computer graphics. These people have experience related to
the project acquired through post-doctoral, Ph.D. and M.Sc. activities, and the development of projects, whose results are in publications of papers in related conferences. Besides, most of the members are associated to graduate programs in computer science, advising M.Sc. thesis and Ph.D. dissertations.

In the field of scientific and industrial cooperation, the city of São Carlos maintains a high technology center which is being developed with the support of the university. To stimulate the interaction of the university and the industries, the UFSCar has a technology transfer center named Foundation for the Institutional Support (FAI) which makes easy this interaction.

6. SELECTED PUBLICATIONS


Coding and Enhancement of Speech and Audio Signals

I. Introduction

Current and future digital communications assumes a robust transmission of the audio component at low and very low bit rates. One goal is a significant bit rate reduction for the audio component to provide an acceptable quality and complexity depending on network characteristics, potential applications, etc. Main quality parameters are coding distortions, bandwidth, and dynamic range, typical signal classes are telephone speech, wideband speech, and wideband audio signals all of which differ also in listener expectation of offered quality. The quality of 8-kHz sampled telephone-bandwidth speech is acceptable for many services. Higher bandwidths (wideband speech) may be necessary to improve the intelligibility and naturalness of speech. High quality audio coding including multichannel audio will be necessary in advanced digital TV and multimedia services. The conventional digital format for these signals is PCM, it often serves as reference in codec quality evaluations.

We have seen rapid progress in source coding techniques for these signals. Linear prediction, subband coding, transform coding, as well as various forms of vector quantization and entropy coding techniques have been used to design efficient coding algorithms which can achieve substantially more compression than was thought possible only a few years ago. Recent results in speech and audio coding indicate that a good to excellent coding quality can be obtained with bit rates of 1 b/sample for speech and wideband speech, 2 b/sample for audio. Expectations over the next decade are that the rates can be reduced to at least 0.5 and 1 b/sample, respectively. Such reductions can only be reached by employing sophisticated forms of adaptive noise shaping controlled by psychoacoustic criteria.

Bit rate reduced digital representations of source signals not only allow the use of digital channels more efficiently, they can also be made less sensitive to channel impairments than analog representations if source and channel coding are implemented appropriately. Bandwidth expansion has often been mentioned as a disadvantage of digital coding and transmission, but with today's data compression and multilevel signaling techniques, one can actually reduce needed bandwidths, compared with analog systems.

Recently a number of overview papers have covered speech and audio coding in more detail [1 - 6]. It is obvious that the use of our knowledge of auditory perception helps minimize perception of coding artifacts and leads to hearing-specific coders which perform remarkably successfully. Worldwide source coding standards are evolving, it is obvious that such standards are beneficial for consumers, service providers, and manufacturers.

Digital transmission is affected by channel-induced bit errors, and bit-rate-reduced representations of a speech or audio signal are typically very sensitive to channel errors. In addition, the speech or audio signal may be affected by background noise prior to source coding. Such background noise may play a significant role in mobile radio applications, and it affects

1Technische Universität Berlin, Germany
2Universidade Federal da Paraíba, Brazil
• the subjective quality of the digitized speech or audio signal
• the application and performance of speech recognition and speaker verifications algorithms.

II. Bit Rate Reduction: Motivations, Requirements, and Achievements

Although high bit rate channels and networks become easier accessible, low bit rate coding of speech and audio signals has retained its importance. The main motivations for low bit rate coding are the need to minimize transmission costs or to provide cost-efficient storage, the demand to transmit over channels of limited capacity such as mobile radio channels, and to support variable-rate coding in packet-oriented networks. In addition, in audiovisual communications there is the need to share capacity between the audio and the video component.

Basic requirements in the design of low bit rate speech or audio coders are firstly, to retain a high quality of the reconstructed signal with robustness to variations in spectra and levels. Secondly, robustness against random and bursty channel bit errors and packet losses is required. Thirdly, low complexity and power consumption of the codecs are of high relevance. Additional network-related requirements are low encoder/decoder delays, robust tandeming of codecs, transcodeability, and a graceful degradation of quality with increasing bit error rates in mobile radio and broadcast applications.

All of these partly conflicting factors have to be carefully considered in selecting a speech or audio coding algorithm for a given application.

III. Signal Delivery

Delivery of digital audiovisual signals is possible over terrestrial and satellite-based digital broadcast and transmission systems such as subscriber lines, program exchange links, cellular mobile radio networks, cable-TV networks, local area networks, etc. For example, in narrowband Integrated Services Digital Networks (ISDN) customers have physical access to a number of relatively low-cost dial-up digital telecommunications channels. Also of high interest are Integrated Voice/Data Local Area Networks [IEEE 802.9] which can cope with real time constraints. They provide a high bandwidth packet service (P channel) and a number of full-duplex isochronous digital channels (B, C, and D channels), similar to ISDN channels. Finally, in mobile communications, the ultimate goal lies in ensuring an exchange of every information with anyone, anywhere, and anytime at low costs using handy devices [7 - 8]. The end of this century will see third generation mobile communications, in specific the ITU-R Task Group 8/1 defined Future Public Land Mobile Telecommunications Systems (FPLMTS). Its projected European standard will be the Universal Mobile Telecommunication System (UMTS). It will include a wide range of services including (subsets of) ISDN and Broadband-ISDN, both circuit- and packet-switched. Additive noise and signal fades are major sources of distortion. Powerful error protection measures are needed for robust transmission of signals. In the case of deep fades, the effects are similar to that of cell losses. Interpolation strategies may be applied.

IV. Research Goals

The project has three goals:

(1) to contribute to the development of algorithms for medium-rate source coding and error-robust digital transmission of speech and audio signals over future digital networks

3 International Telecommunications Union, Radiocommunications Standardization Sector, formerly called CCIR
(2) to develop or improve algorithms for speech enhancement

(3) to apply or adopt given speech recognition and speaker verification algorithms to medium-rate decoded speech as input.

The overall goal of this project is to study the importance of various components of a complete speech communication link and their interdependencies. These components (source coder, speech enhancement systems, digital channel, speech recognition and speaker verification algorithms) are or will become available at the sites of the two institutions involved, but they may have to be modified and improved.

First Goal: Medium-rate source coding and error-robust digital transmission of speech and audio signals

Digital coding at high bit rates is dominantly waveform-preserving, i.e., the amplitude-versus-time waveform of the decoded signal approximates that of the input signal. The difference signal between input and output waveform is then the basic error criterion of coder design. Waveform coding principles have been covered in detail in [10]. At lower bit rates, facts about the production and perception of speech and audio signals have to be included in coder design, and the error criterion has to be in favor of an output signal that is useful to the human receiver rather than favoring an output signal that follows and preserves the input waveform. Basically, an efficient source coding algorithm will (i) remove redundant components of the source signal by exploiting correlations between its samples and (ii) remove components which are irrelevant to the ear. Irrelevancy manifests itself as unnecessary amplitude or frequency resolution; portions of the source signal which are masked do not need to be transmitted.

The dependence of human auditory perception on frequency and the accompanying perceptual tolerance of errors can (and should) directly influence encoder designs; noise-shaping techniques can shift coding noise to frequency bands where that noise is not of perceptual importance. The noise shifting must be dynamically adapted to the actual short-term input spectrum in accordance with the signal-to-mask ratio and can be done in different ways.

In the project we shall concentrate on encoding of speech and audio signals with two bandwidths, 3.4 kHz and 7.0 kHz. We will make use of available coding structures which allow for variable bit rate coding at rates of 4, 8, 16, and 32 kbit/s. The coding algorithms will deliver a high quality of the decoded speech with robustness to variations in voice spectra and levels. Our main interest is to analyze and optimize the robustness of such coders against

- random and bursty bit errors
- cell or packet losses
- bad frames in mobile radio.

The research will be based on available software platforms for speech and audio coding and for the modelling of various digital channels.

In the project we will use the Embedded ADPCM algorithm [ITU-T G.727] which supports speech transmission over packet-oriented transmission networks at switchable bit rates of 16, 24, 32, and 40 kbit/s. At low bit rate we will apply code-excited linear predictive coding (CELP) algorithms [9,10].
Second Goal: Development or Improvement of Algorithms for Speech Enhancement

In the project algorithms for speech enhancement will be used both at transmitter and receiver:

- In digital communication systems the speech signal will be degraded by \textit{transmitter-based} background noise, in particular if hands-free microphones are used in mobile radio applications. Such noise can be reduced by a significant amount if speech enhancement systems are being employed. Such systems are adaptive filters which have the disturbed speech signals of one or more as its input. In the case of microphone arrays a delay-and-sum beamformer can be used which compensates the different time delays of the microphones and sums the resulting delay-compensated signals. The sum of the speech signals is then filtered with an adaptive Wiener-Kolmogoroff filter. In the project we will apply available speech enhancement algorithms to speech signals degraded by \textit{transmitter-based} background noise.

- If errors occur on the digital channel a number of \textit{receiver-based} error detection and error concealment techniques can be applied.

One of the goals is to study the achievable increase in subjective quality.

Third Goal: Application/Adaptation of Given Speech Recognition and Speaker Verification Algorithms

In the project we are also interested in the performance of given speech recognition and/or speaker verification systems

- if these systems are based at the receiver and hence have to operate with decoded speech as input (the decoded speech may also be affected by channel errors)
- if speech enhancement systems are part of the communication link.

As mentioned before, the overall goal of this project is to study the importance of various components of a complete speech communication link and their interdependencies.

V. Main Phases of the Project

The cooperation is planned for a three-year period, its main phases are:

1. Generation of data bases
   (speech signals, noise sources, channel error patterns) 6 months
2. Speech coding (analysis and selection of promising algorithms) 4 months
3. Transmitter-based noise reduction 8 months
4. Receiver-based noise reduction 6 months
5. Speech recognition systems 6 months
6. Optimization of complete communication link 6 months

The Institut für Fernmeldetechnik, TU Berlin, will provide necessary simulation platforms for speech coding and noise reduction. It will also provide an interactive simulation package, called SIGVID, which has been implemented for simulations of coding algorithms, signal generation, signal analysis, and digital transmission links.
VI. References


1 Project Title and Acronym

Development of a Visual Computing and Communication Platform — VICO

2 Objectives and Application Domain

The project put emphasis on the specification and modeling of a system for animation, modeling, analysis and visualization of acquired and simulated data.

The initial goal of the project is the establishment of a reference model, called *Visual Imaging Reference Model* (VIRM), to handle the issues associated with the integration of computer graphics, computer vision, image processing, and communication technologies. This model is based on levels of information representation, transformation between levels, communication facilities and advanced interaction devices and techniques. In addition to the model, the architecture of a *Visual Computing and Communication Platform* (VICO) will be specified.

Application Domains for this technology are found in many areas of knowledge, such as earth’s science, medical imaging, biology, and others. See also [2].

3 Partners’ Names and Addresses

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Brazil
4 Project Description and Application

In recent years, despite the increasing computer power, the development of a large number of applications was not viable because of the huge amount of input data being approached. This holds especially for those applications where the data acquisition and the data visualization play a major role, such as meteorology, medicine, biology, and chemistry.

Although the new generation of general-purpose computer graphic workstations is able to process large amounts of data, there are still deficiencies to be solved especially regarding the acquisition of input data and the display of output data.

In the search for better tools for display, acquisition, manipulation, and communication of data, more and more the basic techniques derived from the areas of Computer Graphics (CG), Computer Vision (CV), Image Processing (IP) and Communication are being addressed in order to support those bulky data applications. Thus the integration of CG, IP, CV, and Communication is a present and actual necessity.

Among the many reasons for integration the following ones can be cited:

- Fusing multisensor information: The creation of a single model for data acquired from several different input devices. It should take into account the IP and CV functionality for feature analysis and model registration and the CG functionality for display and manipulation of data.

- Many algorithms for IP, CV, and CG are based on techniques of image-formation and model building. Models for shading, reflection, camera geometry, motion blur, and texture are examples of the commonality within the different areas.

- The CG pipeline can be seen as a forward modeling in the sense that from a given model data can be visualized and manipulated. The inverse problem of deriving such a model from acquired/observed data is much more difficult. One approach for the solution of the inverse problem is the repeated use of the CG pipeline as a forward modeling (simulation) and CV and IP techniques to match the observed data with the modeled data.

Many applications, although concerning to totally different domains, have much in common with respect to the handling of different types of input and output information (e.g. the same input and output devices and data type), and consequently duplicated efforts can be eliminated or reduced within an integrated solution.

Furthermore, in general there is no connection between the input and output pipelines. The proposal of an integrated model needs the bridging of the communication gap between the pipelines in order to allow the data interchanging. Thus, the data representation within the pipelines have to be conformed to allow this interchanging. The use of existing
and forthcoming data interchange and communication standards may be considered in conforming the data within the pipelines. It could also allow to extend the local system borders to include new input and output devices.

Earth's Science is an application domain in which the consideration of an integrated model will strongly increase the user's ability to understand, analyze and investigate the volume of data generated by the sensing devices and/or by numerical simulations. This increase is a consequence of using tools for:

- data enhancement, feature extraction, reconstruction of geometry and structure (tools derived from IP and CV),
- visualization and interaction with the recovered models, and evaluation and simulation based on the models (tools derived from CG and animation).

Examples of tasks that should be supported by a platform dedicated to earth's science studies are:

- transfer of observational data (also image data) acquired by remote-sensing instruments to the analysis center;
- time and space interpolation of scattered observational data allowing the determination of variables that are not directly observed;
- combination of data from different sources into a meaningful information-context;
- representation of multidimensional data, to capture as precisely as possible the physical variables (such as temperature, humidity, pressure, etc. in a agrometeorological application);
- conversion of observational and/or interpolated data into (pseudo) color images or volumes, to facilitate the qualitative interpretation;
- dynamic visualization of complex processes, such as storm simulation, to help the understanding and reinforcement of the causal interconnections of the data;
- the interactive steering by the earth scientists, in order to permit them to "play" with their data sets and pursue interesting physics at the pace of their own thoughts.
5 Activities and Workplan

The first phase of the common activities in the context of this Project was summarized in the paper *Towards a visual computing and communication reference model* [16]. It presents the VIRM model and describes the three data pipelines which relate Computer Vision, Computer Graphics, and Interfacing data.

This first phase was followed by the establishment of a common knowledge concerning the different areas related with the task. The Internal Report [15] describes the main results of this work.

In the last two years of the cooperation the following exchanging of researchers has taken place:

- March 94: Workshop in Campinas for Project definition (participation of J. L. Encarnação, R. Strack, F. Seibert, A. Hildebrand);
- October-November 94: Campinas, visit of A. Hildebrand and W. Mueller. Results of the activities concerning this period are described in the report [15];
- August-September 95: Campinas, visit of U. von Lukas. In this period the distribution aspects of the VICO platform were analyzed [17].

The next two years of the cooperation will be dedicated to evaluate the main aspects of VIRM. Particularly, the following topics are being considered:

- Computer Vision pipeline:
  - determination of depth image based on shape from shading and shape from contour techniques;
  - depth image segmentation;
  - reconstruction of 3D models based on segmented depth images;
- Computer Graphics pipeline:
  - visualization of simulated data;
  - techniques for image animation and simulation;
- Interfacing pipeline:
  - techniques for 3D interaction;
• Communication:
  
  - standards for exchange of multimedia data.

Furthermore, the VIRM will be evaluated in regard to its usage for an application scenario that will be chosen after the identification of a potential user.

At the Brazilian side the described tasks are also related to post-graduation projects.

6 Planned researcher interchanging

For the next two years, sponsored by ProBrAl, six travels from Brazil to Germany and three from Germany to Brazil are scheduled.

7 Description of Partner’s Expertise

The activities in the area of Image Computing at the Department of Computer Engineering and Industrial Automation - UNICAMP, begun at the seventies. Since then many activities have been developed in the different fields of Computer Graphics, Image Processing, Computer Vision, and Animation.

In the area of Computer Graphics high-quality rendering algorithms based on the scanline, ray-tracing, and radiosity techniques were implemented and has been continuously improved [5] [4]. A Geometric Modeling System based on a B-rep Model, including facilities for Manifold and Non-Manifold objects were developed and implemented [14]. Algorithms for animation by kinematics and dynamics are also available. Parallel architectures for image synthesis have been studied and solutions for high-quality animation [3] has been proposed. Some efforts were also done concerning Graphic Standards, specially based on GKS [6].

Image Processing and Computer Vision areas included works on the fields of medical imaging, digital processing of documents, volumetric visualization, and contributions to the extension of the Khorus Platform [10].

In the field of Computer Vision the following activities are being developed: camera calibration, image editing and coloring, parallel processing, low and high-end segmentation, and reconstruction techniques (shape from X) [13].

The GRIS at Technische Hochschule Darmstadt, founded in 1970, has developed a large experience in the areas of computer graphics and imaging since that time.

For the area of computer graphics both applied research and the development of various applications have been carried out. This includes e.g. applications in the field of scientific
visualization, geometric modeling, simulation, graphical information systems, multimedia systems, etc.

For the area of imaging this includes various projects like the establishment of a kernel system for imaging, called apART [11] [12], a system for the segmentation, matching and reconstruction, called SMART [7], and basic research for the establishment of new image processing algorithms. Besides these activities the experience in the field of imaging covers the design of image interchange formats since 1987, when the first trials and approaches for the transfer of colored raster pictures [8] have been attempted and published by staff members.

GRIS has been also involved in the work of international standardization of computer graphics for more than 10 years. The head of the institute of IGD, Prof. J.L. Encarnação, professor for computer graphics at the Technical University of Darmstadt, and co-workers have coined major parts of the Graphical Kernel System GKS [9].

The staff of Darmstadt has been working in geometric modeling, especially cellular modeling schemes, form feature interaction and geometric reasoning. Research has also been carried out in the context of user interface design for geometric modeling systems. In connection to research activities in the area of neural networks various applications have been developed in the field of image and gesture recognition in remote sensing, medicine, and virtual environments. Other activities are related to the processing and visualization of environmental data.

References


Communication Systems
1. Title and Acronym

Title: A Broadband Mobile Communication System for Universal Mobile Telecommunications Services

Acronym: Broadband Wireless

2. Application Domain

The field of mobile communications has shown a tremendous growth in the last ten years. Nowadays there are several types of mobile services which have achieved significant penetration, namely: paging systems, cordless phones, private mobile radio and wireless LAN's. However the service which has shown by far the largest development is that of cellular telephony.

Analog cellular phone systems were put in place in several places of the world during the 80's. Some examples of these systems are the North-American AMPS, the British TACS, the Scandinavian NMT and the German C-NETZ. They operate either at 450MHz or 900MHz. Although these systems, due to the cellular concept, had a much bigger capacity than the previous mobile radio systems, they quickly became overloaded. Meanwhile a second generation of cellular systems was being developed. These efforts resulted in the GSM system in Europe, the D-AMPS in the U.S. and the PDC in Japan. All these systems use TDMA technology as access method to the radio channels. More recently another system with apparent great capacity potential was developed using spread spectrum technology, the CDMA which is the basis of TIA IS-95 recommendation. All these systems use digital coding of speech and have a much better control and network structure.

Currently there are studies under way to improve the radio interface, provide better radio resource allocation, more efficient mobility management and network structure. These improvements should make a decisive contribution to the implementation of the third generation systems. These systems are presently known as UMTS (“Universal Mobile Telecommunications System”) or FPLMTS (“Future Public Land Mobile Telecomm System.”) and should accommodate the requirements for higher capacity service integration and universal personal telecommunications (UPT). The UMTS should also provide a seamless connection between the mobile and fixed network environments. Due to the characteristics of radio communications, broadband services (e.g., video) will not be feasible for universal coverage. These services will have to be accommodated by a system operating at much higher frequencies, 60 GHz for example. The propagation characteristics limit the range of these systems to small local areas and most likely will lead to a separate radio network sharing the transport infrastructure with the UMTS. The development of a broadband mobile system is the subject of this proposal.
3. Partners

Universities

Center for Telecommunication Studies, Pontifical Catholic University, Rio de Janeiro, Brazil (CETUC-PUC/Rio);
Researchers: Prof. J. Roberto Boisson de Marca (Brazilian Coord.); Prof. Glaucio L.Siqueira; Ms. Ana Lucia A. Pinheiro
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Endowed Chair for Mobile Communications Systems, Dresden University of Technology;
Researchers: Prof. Gerhard Fettweis (German Coord.); Volker Aue, M.Sc.E.E.; Dipl.-Ing. Jürgen Deißner.
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Industrial Partners:

Equitel (Brazil)
Contact: Mr. Roberto Fischer
Equitel has about 3,000 employees. About 300 are working on the development of transmission and switching equipment. During the project Equitel will support CETUC with computational and measurement equipment. Equitel also partially supports twelve students in all levels (doctoral, master and undergraduate) and four members of the faculty.

Siemens AG (Germany)
Contact: Herr H. Blankenfeld
Siemens AG will help conduct field trials in Brazil. Siemens AG will also provide training to researchers of CETUC.

Alcatel SEL Forschungszentrum, Abt. ZFZ/S
Contact: Dr. Bostelmann, Lorenzstr. 10, 70435 Stuttgart, Germany
Alcatel SEL will be a sounding board during the project.

4. Project Description

The objective of this project is to perform studies and develop techniques necessary for the implementation of a 60 GHz mobile system which is easy to install. Although in the future bandwidths of 2 Mbps and above will be desirable, here, a more modest rate, around 500 kbps will be the target. Specifically the following activities will be performed:

- indoor channel characterization for microcells operating at 60 GHz;
- determination from measurements of the parameters required by the models;
- study of multiple access and modulation techniques which take into account both services to be offered and the characteristics of the 60 GHz channel;
- study of channel equalization and interference rejection techniques for the mobile channel at 60 GHz;
- study of appropriate network architecture and protocols for the target services and future interworking with the fixed broadband network and the UMTS;
Indoor Channel Characterization and Determination From Measurements

A deterministic model obtained from measurements of the indoor channel forms the basis for investigating, studying, and defining modulation and multiple access techniques. So far little data and channel models are available for the 60GHz band. Intensive measurements of the 60 GHz indoor channel will be taken in various scenarios. It is the goal at this step to understand the behavior of the channel and to acquire sufficiently enough data to define channel models.

Study of Multiple Access and Modulation Techniques

Our broadband systems will allow for video transmission (picture phone), image and graphics transmission, high data rates (up to WLAN). These services impose high demands on designing the air-interface for such systems.

The services can be characterized by an extreme heterogeneity in terms of bit rate, bit error rate (BER), burstiness, and allowable cost. Voice, e.g., can be transmitted at bit rates at the order of 10 kbps, and cope with BERs up to 1%. Voice transmission, however, needs to be continuous and long delays between transmitting and receiving ends cannot be tolerated. Computer data on the other hand requires very low BERs at high bit rate often for a short period of time. Short delays can usually be tolerated.

A terminal, which is capable of voice transmission only, must permit to be produced at low cost versus modems for higher data rates are allowed to cost more. A modulation scheme which also allows for multiple access must take these parameters into account. Todays cellular systems assume equal demands of each user on the channel. In addition, the modulation techniques used are designed to match the characteristics of the 900 MHz channel. Here, we will develop a multiple access scheme which will allow for transmitting the anticipated services, and which suits the behavior of the 60 GHz channel.

Channel Equalization and Interference Rejection Techniques

The mobile channel is characterized by multipath and Doppler. An equalizer employed at the receiver can compensate for these effects, and thus can improve the performance of the system. In modern telecommunication systems thermal noise is not the main source of interference. The interference usually originates from other users of the same cell accessing the channel at the same time or from neighboring cells. Interference rejection schemes have been developed for different modulation techniques. For our system, different equalizers have to be tested, and a new interference rejection technique has to be developed. Here, it is the task to find an optimum approach to effectively compensate for any distortion caused by the channel and multiple access interference.

Network Architecture and Protocols for the Target Services

In this part of the project we investigate network architectures and protocols to meet the needs for transmitting services with magnitude differences in bit rate and burstiness over a common channel. These studies include media access control (MAC) and mobility management (MM). The network architecture will be designed such that it targets services and future interworking with the fixed broadband network and the UMTS.

Development of a Demonstrator

In order to verify our results we will implement a demonstrator which will consist of a transmitter unit and a receiver. At first we will propose a baseband or IF implementation. The demonstrator will consist of a programmable signal generator which will produce the signal at an intermediate fre-
quency of 2.5 GHz. The signals will be fed into a fading generator simulating the 60 GHz channel with the parameters obtained from measurements scaled to 2.5 GHz. The receiver of the demonstrator will consist of a signal analyzer, a mixer, and a transient digitizer/recorder. The acquired data will then be used to test the algorithms and to demonstrate the performance of the system.

5. Work Plan

The above figure illustrates the work plan. The milestones have been described in the previous section. The project is assumed to end after a four year period. The project starts with obtaining measurements at 60 GHz and investigating multiple access techniques. Building channel models from the measured data will start half a year later. Channel characterization and modeling will be done at CETUC-PUC in Brazil. Both tasks will take one-and-a-half years. The issue of multiple access and modulation will be studied by the Dresden University of Technology group. This group will also take channel equalization and interference rejection into account as soon as the channel models are available. These tasks are assumed to last two years. Both groups will jointly work on the network protocoling issue with the beginning of the third year, and both groups will work on building a demonstrator. The project ends after four years.

6. Travel Cost

Two trips Brazil-Germany-Brazil and two trips originating in Germany per year. The duration of each trip should be three weeks. The approximate cost of each trip is US$5000.00, giving a total of US$20000.00 per year.

7. Description of Partners

CETUC group

Prof. J. Roberto Boisson de Marca received the Ph.D. in Electrical Engineering from the University of Southern California, Los Angeles, in 1977 and is currently Vice-President of International Affairs of the IEEE Communications Society. Prof. de Marca is a former President of the Brazilian Telecommunications Society and Director of the Brazilian National Research Council. He has twice served as Scientific Consultant of the AT&T Bell Laboratories, where he is work led to a
patent in the area of robust speech coding. Prof. de Marca is a Fellow of the IEEE.

Prof. Glauco L. Siqueira: He received his Ph.D. from the Electronic and Electrical Engineering Department, University College, in 1989. His Thesis was on the use of millimetric wave band (55 GHz) for mobile communication systems. For the last 12 years have been working on radio propagation experiments and channel characterization and modelling for digital radio point-to-point systems, rain attenuation and, specifically, on mobile radio systems. From the work on 55 GHz band, great deal of experience have been gathered and some papers have been published, mainly on AP and VT IEEE Transactions and VTC and URSI Conferences.

Research at CETUC includes and addresses the following topics:
• mobility management in cellular networks;
• simulation of CDMA systems;
• packet access methods (variations of PRMA, TRAMA, etc.)
• dynamic channel allocation for TDMA systems;
• combined adaptive power control and dynamic channel allocation;
• indoor propagation measurements;
• network structures for integration with ATM nets for multimedia applications;

CETUC (Centro de Estudos em Telecomunicacoes da Universidade Catolica do Rio de Janeiro) is one of the two largest university research groups in Brazil. It was founded 30 years ago and since then has established a tradition of close cooperation with the Brazilian industry and operating companies. CETUC has today 23 faculty members doing research in different aspects of communications like, optical devices, microwaves, antennas, propagation, image and speech processing, satellite communications, ATM networks and wireless communications. Undergraduate students are studying DCS-1800 and DECT, acquiring expertise which will be helpful in future field trials in Brazil.
CETUC also participates together with Computer Science groups in the formal specification of some protocols which are part of the IS-95 specification.

TU-Dresden group

Prof. Gerhard Fettweis received the Dipl.-Ing. degree in Electrical Engineering and the Ph.D. degree from Aachen University of Technology (RWTH) in 1986 and 1990, respectively. From 1990 to 1991 he was with IBM Almaden working on signal processing techniques for disc drives. From 1991 to 1994 he was with TCSI, Berkeley, CA in the personal communications division. Since September 1994 he holds the Mannesmann Mobilfunk Chair for Mobile Communications Systems at Dresden University of Technology, Germany. His current research interests include multi-mode wireless systems, multimedia over wireless communication links, and signal processor design for wireless communications. Dr. Fettweis is currently the Communications Society Representative in the IEEE Solid-State Circuits Council, and serves as associative editor of the IEEE Transactions on Circuits and Systems II.

Volker Aue is a research assistant working towards his Ph.D. at the Endowed Chair for Mobile Communications Systems. He helped getting the chair started. Volker received his MS in electrical engineering at Virginia Tech, VA, USA in May 1994. In May 1993, he joined Virginia Tech's Mobile and Portable Radio Research Group (MPRG). In his MS thesis, he investigated how time-dependent adaptive filters can help reject multiple-access interference and other interference in direct-sequence CDMA systems. His current research interests are multi-carrier systems, and
Jürgen Deißner is a research assistant working towards his Ph.D. at the Endowed Chair for Mobile Communications. He started studying electrical engineering at Dresden University of Technology in 1989 and worked several times as a practical trainee at Siemens AG, Munich, T.L.P. SA, Lisbon and TCS GmbH, Dresden in the field of switching and CCS #7 signaling as well as optical networks planning. In his diploma thesis he investigated the signaling amount of intelligent networks (IN) and future universal personal telecommunications (UPT) services at the Alcatel SEL Research Centre in Stuttgart. Now he is concerned with multimode mobile terminals and network operator aspects of a future multimedia mobile communications systems.

The objective of the Endowed Chair for Mobile Communications Systems at the Dresden University of Technology is to promote a research team with the goal to add to the advancement in wireless communications technology by working on industry relevant next generation problems. Thorough fundamental research as well as close industry cooperation are key to the success of projects.

Wireless/mobile communications is driven mainly by three branches of industry, namely network operators, system houses, and semiconductor manufacturers, with each branch having a different viewpoint of solving problems. Based on the three viewpoints the research team is divided into three groups, each group identifying itself with one industry branch. It is viewed as important that the different viewpoints are addressed in the research work, to ensure that the results have practical relevance and significance. The chair therefore welcomes industry contacts and partnerships to help meet this objective.

The chair was founded in September 1994 by an endowment of Mannesmann Mobilfunk GmbH, Düsseldorf, Germany.

Lab equipment is available at the Endowed Chair for Mobile Communications Systems. When it comes to demonstrating the behavior of the overall system, the chair will have all the hardware necessary for the demonstrator (signal generator, signal analyzer, etc.). Workstations including simulation software (Cossap, Matlab, etc.) are available for carrying out this project.
Multimedia ODP Platforms for Co-operative Applications (MODP)
V. Tschammer, M. Mendes

1. Project Outline

The project objectives are joint research, education and know-how transfer, co-ordinated development of software prototypes, and joint publication of papers in the area of telecommunications and open distributed computing.

The project has been started in January 1996, and has a planned duration of three years. The consortia includes PUCCAMP\(^1\) and UNICAMP\(^2\) from Brazil, and TU Berlin\(^3\) as well as GMD FOKUS\(^4\) from Germany. The persons co-ordinating the project in both countries are named in a separate section at the end of this paper.

2. Project Objectives

The project objectives are manifold. Main aspects are joint research and development, education and know-how-transfer, exchange and joint development of papers and publications.

2.1. Joint research and development

Joint research and development will concentrate on open distributed platforms for co-operative applications. We will particularly consider distributed object-oriented technology and will develop domain-oriented software for the telecommunications application area and selected open distributed systems. There, consortia like OMG and TINA-C are specifying generic platforms including basic functionality and domain-oriented services and facilities. The latter are to be developed in close co-operation with special task forces and leading research institutes which make proposals for specifications based on their experience in testing, developing, and applying such services and facilities in pilot applications. Contributions to the consortia's work is also encouraged.

FOKUS is a full member of OMG and is developing such functions in various national and international projects. FOKUS is also engaged in various standardisation activities, including the DIN-ODP group. Close interaction with the Brazilian institutes will give them the possibility of sending staff to participate in these projects as well as co-ordinating their own research and teaching activities with these developments. Additionally, FOKUS will get the opportunity of outsourcing project activities to Brazilian sub-contractors. In this way Brazilian institutes and staff will get the chance of participating directly or indirectly (as subcontractors or by sending staff) in various bi- and multi-lateral European projects as well as industry co-operations between TU Berlin, FOKUS, and partners.

Typical subjects of joint research and development will be:
- definition of an architecture for multimedia, object-oriented platform profiles for different application areas, including telecommunications, public administration and finances.

\(^1\) Pontificia Universidade Catolica de Campinas, Instituto de Informatica
\(^2\) UNICAMP Campinas, Fac. de Engenharia Eletrica, DCA
\(^3\) TU Berlin, Inst. für Software u. Theoretische Informatik Offene Kommunikationssysteme
\(^4\) GMD Forschungsinstut für Offene Kommunikationssysteme Berlin
• development of object-oriented software development tools, particularly those for configuration management,
• investigation of structures of management information systems - decision support systems (MIS-DSS), concentrating mostly on the object and process architecture.

2.2. Education and know-how-transfer

This aspect includes the exchange of staff between the Brazilian and German institutes, and the development of joint papers and publications. We plan the following activities:
• visits of Brazilian professors and PhD-students for the purpose of part-time participation in research projects and for the bilateral co-ordination of FOKUS-projects and a FAPESP-project already running at Campinas,
• visits of Brazilian professors and PhD-students for know-how-transfer which will assist them in updating and finalising the contents of master courses and lectures currently introduced in their home universities,
• visits of Brazilian PhD-students for the purpose of 'sandwich promotions' in related technology areas, such as telecommunications, open distributed processing, co-operative management etc.,
• visits of German professors and senior researches for the purpose of talks, tutorials, and part-time participation in the educational activities at the Brazilian universities,
• bilateral visits for research co-ordination and joint development of papers and publications etc.

3. Justification and Exploitation

As described above, the project is justified from an organisational as well as from a technical point of view. The project partners will continue their existing partnership, intensify their co-operation and harmonise their research and development activities.

There is already a broad history of co-operation and joint activities between the named Brazilian and German institutions. These - still ongoing - activities include sandwich promotions, visits of Brazilian professors and senior scientists with active engagement in German projects, tutorials of German professors and scientists at Campinas, a joint FAPESP-project, and joint papers. The proposed project will give the needed support for continuing and intensifying these activities.

Regional industry, particularly the small and medium size enterprises (SMEs), will profit from this co-operation: There is an important industrial zone in the environment of Campinas with a significant potential in exploiting the technology related to the project. There are already multilateral activities between the universities and enterprises, and most of the PhD- and master-students are already employees of those enterprises situated near to the Campinas universities.

Thus, a commercial as well as intellectual exploitation is possible. Commercially, the project will allow exploitation of software prototypes by telecoms and software houses. The prototypes will be based on wide-spread platforms, such as Microsoft COM, UNIX, Internet, and CORBA, and, therefore, will be ready for use in most environments. Intellectual exploitation seems to be even more important, as it allows Brazilian scientist, engineers, and programmers to become deeply involved in modern technology which makes them fit for participation in innovative projects, and allows SMEs to work more independently from large multi-national enterprises, based on their own educated staff.
4. Technical Aspects

4.1. Distributed object-oriented platforms

The project will concentrate on the domain-oriented aspects of open distributed object-oriented platforms. The generic functionality will be taken from the OMG specifications, and related products, such as ORBIX, will be used for testing, demonstration and education, as well as for the basis of further developments. Techniques related to the telecommunications domain will include multi-media, co-operative work and management, and information and decision support for public administration and finances. This will probably result in specific configurations and profiles of existing OMG services and common facilities as well as in newly developed domain-oriented facilities.

4.2. Component integration and re-use of software

Open distributed systems in general, and telecommunications in particular heavily rely on the re-use of existing components, i.e. legacy software, and the dynamic composition and integration of applications and services from pre-fabricated software building blocks. Run-time and development support for these techniques is still in its growing state, and investigations, tests, and specific developments are still necessary in order to make these techniques more mature, useable, and accepted.

The project will work on related models, application structures and interfaces which are to support these objectives.

4.3. Platform and application interoperation

The interoperability of platforms and applications is still in an infancy state. Approaches proposed by the OMG and others, e.g. Microsoft, for platform interoperability are to be tested, structures for application interworking are to be developed, e.g. meta object models, federated service types. The project partners will start and later intensify work on platform and application interoperability, including activities such as:

- definition of a common development environment supporting the portability and exchange of developed software components,
- participation in interoperability and interworking projects, such as the 'interworking trader project' including partners from Europe, Australia and America,
- proposals for joint projects for the development of domain-oriented support environments, such as the TINA-DPE, based on multi-domain or interoperating platforms, as for example the BERKOM/IDMIS or the Microsoft/COM and OMG/ORB interoperation proposal.

5. Technical Details

As indicated, the project's technical aspects are manyfold, and subprojects with specific background, technical approaches, and detailed planning of workpackages, timing, and resources will be necessary. As an example of the various projects which are to be undertaken within the framework of MODP, the following subproject PAgE is briefly described. It will be set up as a new project, starting in the first quarter of 1996, and is to work in the area of distributed object-oriented platforms.
5.1. Prototyping of an Agent Facility Environment (PAgE)

Agents have evolved as a new problem-solving paradigm, suited to a wide range of problem domains. They are known under different names, such as Intelligent Agents, Software Agents, Autonomous Agents, Intelligent Objects, Softbots, Knowbots, etc. Agent may be considered as a kind of meta-objects, also characterised by state and behaviour. Unlike objects, they have goals and work proactively to achieve them. There could exist a great variety of agents, e.g. user interface agents, database agents, calendar agents, mail agents, news agents, management agents, and the number of products, projects, and new applications is continuously growing. The study of agents presents a unique opportunity to integrate many significant results from various research areas. Agents also give us the opportunity to put technical results directly in the hands of the end users.

The project aims to the development of an agent facility environment prototype based on the OMG/OMA architecture. The integration and operation of the facility within the CORBA services and COREA facilities are to be investigated. Mobility of agents will be an important issue, in a second stage, and concepts of intelligent agents are to be exploited.

Several application domains will be analysed in order to allow the specification of user scenarios to be used during the project, as requirement specifications for analysis and project. Later, they will be used for the prototype validation.

The following application areas will be considered:
- telecommunication services,
- distributed heterogeneous information systems,
- management information systems and decision support systems,
- workflow applications.

PAgE will develop a generic distributed support environment for the construction, deployment, and execution of agents. This support environment is to be developed above CORBA using CORBA services. In the course of this development, new CORBA facilities and services may be proposed.

To successfully incorporate both, purpose-built and pre-existing systems, a top-down is needed to allow the definition of the overall requirements for different application domains, and a bottom-up approach is needed to look at the capabilities of existing systems. The project PAgE will address both approaches.

For the installation and validation of the support environment, two application environments are primarily considered: Interconnected LAN environment with workstations and ORB support, and Internet environment with WWW integration.

The PAgE project is to have a duration of 24 months and will involve professors, and researches from PUCAMP, UNICAMP, FOKUS and TU Berlin.

6. Organisation

6.1. Timing

Roughly spoken, the first year, specifically the first 6 months will be dedicated to a detailed project plan, mostly concentrating on the platform architecture, the object model, and the architecture for MIS-DSS-applications. The 2nd year then will elaborate the concepts, architectures, and structures and will start defining the platform facilities, the configuration management services, and the cooperation support services. This will be continued and finalised in the 3rd year.
6.2. Resources

Project resources are required for travels between Brazil and Germany and vice versa. In the 1st year the project partners plan:

- 2-weeks-travels of German project leader and colleagues to Campinas (US$8,000)
- 1-month-visit of Brazilian project leader to Berlin (US$4,000)
- 1-month-travel of Brazilian professor to Berlin (US$4,000)

In the 2nd year the following visits are useful:

- 2-weeks-travel of two German professors/researchers to Campinas (US$4,000)
- 1-month-travel of one researcher from UNICAMP to Berlin (US$4,000)
- Two 2-month-visits of PhD-students from PUCCAMP to Berlin (US$14,000)

For the 3rd year the following travels and visits are planned:

- 2-weeks-travel of two German professors/researchers to Campinas (US$4,000)
- 1-month-travel of one researcher from UNICAMP to Berlin (US$4,000)
- Two 2-month-visits of PhD-students from PUCCAMP to Berlin (US$14,000)

Total travel expenses: US$60,000

6.3. Participants

PUCCAMP: Prof. Dr. Manuel de Jesus Mendes (Brazilian Project Leader)
Dr. Mauricio Prattes, Dr. Juan Coelho, 4 PhD-Students

UNICAMP: Dr. Mauricio Ferreira Magalhaes (Deputy Brazilian Project Leader)
Dr. Ivan Marques, Dr. Ellery Cardoso

TU Berlin: Prof. Dr. Ing. Radu Popescu-Zeletin (German Project Leader)

GMD FOKUS: Berthold Butscher, Gerd Schürmann
Dr. Volker Tschammer (Deputy German Project Leader)

6.4. Reports

Each year of project work will generate a project report on the technical progress and the organizational aspects. Thus reports are to be delivered on:

- December 1996
- December 1997

and the final report will be delivered on December 1998.
Joint German-Indonesian Seminar on R&D Activities using the MPR-30
Jakarta, August 19-21,1985
GERMAN-INDONESIAN COOPERATION
ISBN 3-89336-011-5

Joint German-Indonesian Seminar on Public Acceptance, Waste-Management, and Nuclear Safety
Jakarta, October 7-9,1986
GERMAN-INDONESIAN COOPERATION
ISBN 3-89336-012-3

VIIIth German-Yugoslav Meeting on Materials Science and Development Ceramics and Metals
edited by Drago Kolar, Marija Kosec and Johanna Krawczynski
Brdo pri Kranju, May 18-21,1987
GERMAN-YUGOSLAV COOPERATION
ISBN 3-89336-001-8

Proceedings of the Fourth Workshop on Two-Phase Flow Predictions
edited by M. Sommerfeld and H. Zeisel
Erlangen, October 21-23,1987
GERMAN-YUGOSLAV COOPERATION
ISBN 3-89336-002-6

IInd Workshop on Process Automation
Darmstadt, November 2-6, 1987
GERMAN-YUGOSLAV COOPERATION
ISBN 3-89336-003-4

Ist German-Yugoslav Meeting in the Framework of the Bilateral Project Development of Innovation Structures in Yugoslavia
edited by G. Bräunling and V. Matejić
Pilvice, September 5-7,1988
GERMAN-YUGOSLAV COOPERATION
ISBN 3-89336-024-7

Proceedings of the 8th Winter School on Proteinases and their Inhibitors: Recent Developments
edited by E. Auerswald, H. Fritz and V. Turk
Tiers, March 8-12, 1980
GERMAN-YUGOSLAV COOPERATION
ISBN 3-89336-020-4

Second German-Greek Workshop on Materials Research for Information Technology
edited by G. Kaiser and H. Wenzel
Jülich, May 22-23,1989
GERMAN-GREEK COOPERATION
ISBN 3-89336-018-2

Seminar Fertigungsplanung und -steuerung
zusammengestellt von Burghild Wienecke-Toutaoui, Rolf Albrecht
Split, 7. und 8. Juni 1989
GERMAN-YUGOSLAV COOPERATION
ISBN 3-89336-025-5

IXth German-Yugoslav Meeting on Materials Science and Development Emerging Materials by Advanced Processing
edited by Wolfgang A. Kaysser, Jutta Weber-Bock
Hirsau/Stuttgart, April 16-19, 1989
GERMAN-YUGOSLAV COOPERATION
ISBN 3-89336-026-3
Bilateral Seminars of the International Bureau

1. IInd German Yugoslav Meeting in the Framework of the Bilateral Project
   Development of Innovation Structures in Yugoslavia
   Innovation Management
   Plitvice, October 18 – 20, 1989
   edited by Vlastimir Matejíc
   GERMAN-YUGOSLAV COOPERATION

2. IInd Workshop on Plasma and Laser Technology
   Cairo, February 21 – 28, 1990
   edited by E. Hintz
   GERMAN-EGYPTIAN COOPERATION

3. Seminar on Emissions and Air Quality
   Thessaloniki, October 9, 1990
   edited by N. Moussiopoulos, D. Kaiser
   GERMAN-GREEK COOPERATION

4. 5th Workshop on Two-Phase Flow Predictions
   Erlangen, March 19 – 22, 1990

5. IInd Workshop on Plasma and Laser Technology, Volume 2
   Cairo, February 21 – 28, 1990
   edited by Ph. Mertens, B. Schweer (1991)
   GERMAN-EGYPTIAN COOPERATION

6. 2. Brasilianisch-Deutsches Symposium für Naturstoffchemie
   herausgegeben von G. Habermehl (1991)
   DEUTSCH-BRASILIANSCHE ZUSAMMENARBEIT

7. 3rd German-Greek Workshop on
   Materials Research for Information Technology
   Thessaloniki, September 26 – 27, 1991
   GERMAN-GREEK COOPERATION

8. Egyptian-German Springschool and Conference
   Particle and Nuclear Physics
   Cairo, April 11 – 19, 1992
   GERMAN-EGYPTIAN COOPERATION

9. Seminar on Monitoring and Modelling in the Mesoscale
   Thessaloniki, September 27, 1991
   edited by N. Moussiopoulos, G. Kaiser (1992)
   GERMAN-GREEK COOPERATION

10. 3rd Workshop on Process Automation
    GERMAN-SLOVENIAN COOPERATION

11. Course on Medical Aspects of Nuclear and Radiation Accidents
    Cairo, April 11 – 16, 1992
    GERMAN-EGYPTIAN COOPERATION

12. Egyptian-German Springschool and Conference
    Particle and Nuclear Physics, Volume 2: Contributed Papers
    Cairo, April 11 – 19, 1992
    GERMAN-EGYPTIAN COOPERATION
13 Indo-German Workshop on High Pressure Technology-Engineering
Pune, January 3 – 4, 1992
GERMAN-INDIAN COOPERATION

14 6th Workshop on Two-Phase Flow Predictions
Erlangen, March 30 – April 2, 1992
edited by M. Sommerfeld (1993)

15 3rd Workshop on Plasma and Laser Physics
Ismailia, October 3-7, 1993
edited by Ph. Mertens (1994)
GERMAN-EGYPTIAN COOPERATION

16 Utilization of the Low Active Waste Incinerator Facility (LAWI) for Research and Development Work
Cairo, December 11 – 12, 1993 (1994)
GERMAN-EGYPTIAN COOPERATION

17 8th SIMCER International Symposium on Ceramics Biomaterials – Special Meeting of the Project EUREKA 294
Rimini, November 10 – 12, 1992
edited by I. Stamenković, J. Krawczynski (1994)
GERMAN COOPERATION with the University "Sv. Kiril i Metodij", Skopje

18 Conceptual Approaches to the Support of Industrial Research and Development in Slovenia
Ljubljana, November 10, 1993
edited by M. Komac, J. Krawczynski (1994)
GERMAN-SLOVENIAN COOPERATION

19 German-Egyptian Seminar on Environmental Research
Cairo, March 21 – 23, 1994
GERMAN-EGYPTIAN COOPERATION

20 1st Slovene-German Seminar on Joint Projects in Materials Science and Technology
Portoroz, Oct. 2 – 4, 1994
GERMAN-SLOVENIAN COOPERATION

21 Conceptual approaches for an industry-related promotion of research and development in Croatia
Workshop Proceedings, Zagreb June 28/29, 1994
GERMAN-CROATIAN COOPERATION

22 German-Egyptian Seminar on Science Policy and Management
Cairo, April 8 – 9, 1995
GERMAN-EGYPTIAN COOPERATION

23 Indo-German Workshop on Antiinflammatory Drugs from Natural Sources
Jammu Tawi, 10 – 11th April 1995
GERMAN-INDIAN COOPERATION

24 German - West Sumatra Seminar on R&D Management and its Role for Industrial Development
Bukittingi, West Sumatra, Indonesia, November 28 – 30, 1994
edited by D. Nentwich (1996)
GERMAN-INDONESIAN COOPERATION
Bilateral Seminars of the International Bureau

25 Indo-German Workshop on Technology Development and Transfer
   New Delhi, February, 7th – 10th, 1995
   GERMAN-INDIAN COOPERATION

26 Proceedings of the 3rd Workshop on Information Technology
   Berlin, December 14th – 15th, 1995
   GERMAN-BRAZILIAN COOPERATION