Universität Stuttgart

Center of Excellence 627
Sonderforschungsbereich 627

Spatial World Models
for Mobile Context-Aware
Applications

neXus

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Preface

This report presents the activities of "Sonderforschungsbereich 627": Nexus, a Center of Excellence that has been established at Universität Stuttgart in January 2003. The scientific goal of Nexus is to conduct research with a long-term perspective in the field of large-scale spatial world models for mobile context-aware applications. This interdisciplinary research center, which is funded by Deutsche Forschungsgemeinschaft (DFG), currently involves more than 30 researchers from various disciplines, including computer science, electrical engineering, civil engineering, mechanical engineering, and philosophy.

The report summarizes the various activities of the center's first year, which was characterized by starting up its research projects, organizational infrastructure and laboratories. In the meantime, all research and non-research staff is on board, all research projects, including working groups fostering interdisciplinary research are well underway, and all our laboratories are almost entirely equipped. Although this took a substantial amount of our time, we could already make quite impressive progress in our research work, which is documented in many publications in leading journals and conference proceedings.

In order to intensify the collaboration with other research groups, the center organized three workshops, which all were very well received. In July, a workshop on context-awareness in Ubiquitous Computing took place at Universität Stuttgart. In conjunction with the official Nexus opening colloquium in November, an international workshop on Context-Aware Systems was held, which brought together more than 100 experts. Moreover, in December the center organized a workshop entitled "Mobile in Intelligent Environments", where various experts discussed methods to construct and analyze scenarios of mobile context-aware systems.

To demonstrate the potential of the investigated technology, the center's research projects developed a demonstrator system. This demonstrator was shown to a large audience at the 29th Int. Conf. on Very Large Data Bases, the Berlin-Symposium of the Gottlieb Daimler and Karl Benz Foundation „Total vernetzt - Szenarien einer informatisierten Welt", the Swiss NCCR MICS Annual Workshop 2003, the 49th Photogrammetric Week in Stuttgart, and the opening colloquium of the Center of Excellence.

Building up such an ambitious research center in a short time is fun, but it is also very strenuous. We could never have managed this without the dedication and the hard work by all our research and non-research staff members. We really appreciate their enthusiasm, creativity, and support to bring the center onto speed in such a short time.

Stuttgart, March 8, 2004

Prof. Dr. rer. nat. Dr. h. c. Kurt Rothermel
(Center Coordinator)

Participating Research Groups

Institute of Industrial Manufacturing and Management (IFF)

- Life Cycle Management Research Group
    Prof. Engelbert Westkämper

Institute of Communication Networks and Computer Engineering (IKR)
    Prof. Paul J. Kühn

Institute of Parallel and Distributed Systems (IPVS)

- Applications of Parallel and Distributed Systems Research Group (AS)
    Prof. Bernhard Mitschang

- Image Understanding Research Group (BV)
    Prof. Paul Levi

- Distributed Systems Research Group (VS)
    Prof. Kurt Rothermel (Coordinator), Dr. Christian Becker

Institute of Philosophy

- Philosophy of Science and Technology Research Group (WTTP)
    Prof. Christoph Hubig

Institute for Photogrammetry (IFP)
    Prof. Dieter Fritsch

Institute for Road and Transportation Science (ISV)

- Road Design and Construction Research Group (SuS)
    Prof. Wolfram Ressel

Institute for Visualization and Interactive Systems (VIS)
    Prof. Thomas Ertl, Dr. Daniel Weiskopf

Content

1 Vision

The proliferation of sensor technology, along with advances in wireless communication and mobile devices, allow for a promising class of applications - context-aware applications. These applications take into account the current situation of real-world entities, such as a user's current location, physical environment, or activity. Thereby, they are able to act upon and adapt to changes in the real world and select and present information depending on the application's physical context.

In the near future, a huge amount of context information will be captured by billions of sensors, being integrated into mobile devices or sensor platforms deployed in our physical environment. This information will be fed into spatial models building the foundation of context-aware applications.

For both economic and technical reasons, it is highly desirable for context information to be shared by a wide variety of applications. Therefore, we envision large scale and detailed spatial models of our physical environment. Those spatial models are generic and extensible in the sense that they can be used by a wide spectrum of context-aware applications. They include stationary objects, like streets, buildings, or rooms, as well as mobile objects, such as people, vehicles, or even tools in a Smart Factory. Furthermore, a spatial model may be augmented by virtual objects to associate real-world objects with information items like Web pages.

There will be a great variety of spatial models that may differ in various ways. For example, models may be of topographical or topological nature, support different levels of detail, or may cover different areas and aspects of the real world. They will be offered by commercial and non-commercial content providers and complement or even compete with each other.

We envision a federation of these spatial models leading to large scale spatial world models, which will offer a global and consistent view on the heterogeneous spatial information for a wide range of applications. This federation allows for complex queries, including position, range, and nearest neighbour queries. Moreover, applications can define and subscribe for predicates on the model state, which trigger event notifications when they become true. If the spatial world model is enriched by temporal concepts, applications can query not only the current model state, but also states of the past or even predicted ones in the future.

Spatial world models will typically be maintained in a highly distributed server infrastructure, similar to the World Wide Web today. However, with the emerging ad hoc networking technologies, we can assume that portions of the global model will also be managed in a peer-to-peer fashion.

2 Scientific Goals

The overall research goal is to develop methods and mechanisms for building, managing, and utilizing spatial world models.

We have identified the following dimensions along which the complexity of the subject of research evolves:

- **Modelled Objects** - the types of objects that are part of the model: geographic objects, mobile objects, virtual objects, objects that have dynamic state, and interactive objects.

- **Time Concepts** - the model only reflects the current state of the world or it provides a history and possibly a prognosis: spatial world models with and without time concept(s).

Figure 1:   Complexity Dimensions

- **System Architecture** - the underlying system architectures that are supported: infrastructure-based, infrastructure-less, and hybrid system architectures.
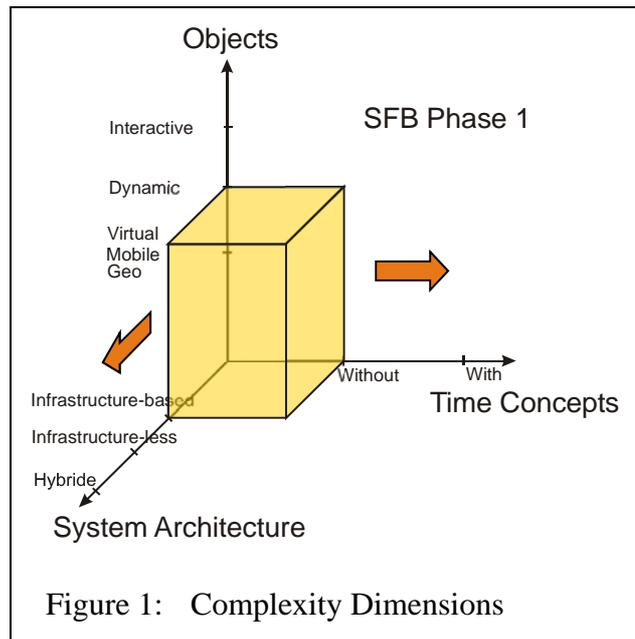
Figure 1 shows the complexity envisioned for the first funding period. Methods for modelling geographic, mobile and virtual objects are investigated, as well as objects with dynamic state, which are realized through the generic integration of sensor data. To provide a foundation for the second period of funding, some projects already investigate the modelling of time and the model management in infrastructure-less system architectures.

The following research questions are addressed:

- Concepts for a generic modelling and application-specific extensions of spatial world models
- Methods for federated model management
- Mechanisms for integration, aggregation, and generalization of geographic data
- Concepts and protocols for model-based communication
- Security and privacy concepts
- Mobility models
- Methods for model presentation and interaction with the model
- Methods for capturing model information
- Consistency concepts
- Development of two example applications:
  - Management of smart tools in the "Smart Factory"
  - Navigation and orientation for the visually impaired
- Social aspects of spatial world models

3 Research Program

Communication & Security	Model Definition & Management	Presentation & Sensor Integration	Applications & Acceptability
Communication Platform Kühn, IKR	**Extensibility and Federation Concepts** Mitschang, IPVS	**Integration of Sensor Data** Fritsch, IFP	**Smart Factory** Westkämper, IFF
Model-based Communication Rothermel, IPVS	**Geo-data Integration** Fritsch, IFP	**Sensor Fusion** Levi, IPVS	**Navigation for Visually Impaired People** Ertl, VIS
Security and Privacy Kühn, IKR	**Location Management and Information Diffusion** Becker, IPVS Rothermel, IPVS	**Generalization of Spatial Data** Fritsch, IFP	**Acceptability and Social Aspects** Hubig, WTTP
Mobility Modelling Ressel, ISV		**Context-aware Presentation** Ertl, VIS Weiskopf, VIS	
Mobility and Security			
Modelling and Consistency			

The overall structure of the research program is composed of four research areas:

Research Area 1: Communication and Security: One focus of research are novel communication infrastructures that allow mobile clients to efficiently access model content any time, any place and to collect sensor data from stationary and mobile sources. Another focus is the question of how the communication mechanisms themselves can profit from those models. In particular, context-aware optimization techniques and model-based communication concepts are investigated. Also, the concept of multilateral security is studied in the realm of context-aware systems. Finally, research is conducted in fine-grained mobility models and scalable simulation of mobile objects.

Research Area 2: Model Definition and Management: The tasks of this project domain are to deliver the modelling and querying technology for spatial world models and to provide a scalable and open federation platform. In supporting the vision for comprehensive spatial world models, where data providers and data consumers are able to freely deliver and exploit model data, special emphasis is on extensibility issues. Based on the importance of geography and topology, the seamless integration of geo-referenced data sets defines a specific research focus. Similarly, the inclusion of a historic dimension enhances the usages of the spatial world models significantly and thus

defines another relevant research issue. Finally, highly scalable location management mechanisms in both infrastructure-based and infrastructure-less systems are subjects of research.

Research Area 3: Model Presentation and Sensor Integration: This research area investigates how model information can be visualized and how users can interact with the model, depending on device characteristics and user context. Also, context-aware sensor fusion and the integration of consistent sensor information into the spatial world model are another subject of research. Other research issues are methods for the automatic generation of large-scale geographic 3D models and the consistency issues associated with different representations of the same geographic object.

Research Area 4: Applications and Acceptability: Here, two different context-aware applications are developed, a so-called "Smart Factory" and a navigation system for visually impaired people. On the one hand, these applications will be used for requirement analysis and the evaluation of the proposed methods. On the other hand, they give a deep insight into how the corresponding application areas can benefit from the concept of context-awareness. Furthermore, from the beginning of our research we take into account acceptability issues. In particular, we will investigate the requirements for system features that have to be provided to address security and privacy concerns.

In addition, there are two interdisciplinary working groups that are concerned with research issues relevant to all of the above research areas:

- Mobility and Security
- Modelling and Consistency

3.1 Research Area: Communication and Security

3.1.1 Project: Communication Platform

Researchers: Bernd Gloss, Stephan Lück, Michael Scharf

In this project we focus on two different research fields. The first part deals with extensions of the communication platform. The main challenge there is to enable a mobile node to communicate efficiently in heterogeneous access networks [Kue03]. In the first year, we analyzed functions like access discovery that middleware components must realize in order to support communication in this always-best-connected scenario. We started to design a middleware component that discovers network accesses by analyzing physical layer information, such as signal to noise ratio. Furthermore, we studied the architectural concepts of a context-aware communication control and we prepared the performance evaluation of such mechanisms.

The second research focus is the performance of the Nexus architecture. A literature study revealed that there seems to be little related work on modelling the scalability of such complex systems. The performance evaluation of the complete architecture also requires the characterization of the individual components, e. g. by measurements. Therefore, this project depends on results of other projects. We completed an extensive study of the TCP behaviour in presence of delay variations in mobile networks. The results show that variable transmission delays may significantly degrade TCP performance. Finally, an important issue is user mobility modelling. We reviewed existing modelling approaches and studied their characteristics.

3.1.2 Project: Model-based Communication

Researchers: Susanne Bürklen, Frank Dürr, Martin Bauer

The focus of our research is twofold - in the areas of hoarding and geocast. In the hoarding-related research we investigated the selection criteria for information items to hoard, i.e. prefetch on a mobile device [BMR04]. In order to select those information items, we exploited the structure of the information and the context, especially the location where an information request was made. Based on log-file analysis, an information graph was constructed which allowed the optimization of the selection of information items with respect to user request patterns in a given geographic area, thereby taking into account the reading speed of users and the time a user spent on a given webpage in relation to its size.

A fine-grained location model was developed for geocast in order to allow the definition of target areas of geocast messages and receiver positions [DR03]. This model is based on the spatial inclusion relationship and forms a hierarchy of locations. Locations in this hierarchy can be addressed by hierarchical symbolic addresses denoting e.g. street names, and floor or room numbers. Locations are annotated with geometric extents, too, so geocast messages can also be addressed geometrically. Additionally, this hybrid approach allows the deliverance of geometrically addressed geocast messages to receivers with symbolically defined positions and vice versa, as well as addresses consisting of geometric and symbolic parts. Additionally, local coordinate systems and mobile target areas like the dining-car of a train are supported by the location model leading to a fine-grained addressing scheme for geocast. Finally, an efficient routing algorithm for symbolically addressed

messages was developed, which will be enhanced further to support geometrically addressed messages.

3.1.3   Project: Security and Privacy

Researchers: Andreas Gutscher, Christian Hauser

The focus of our research in the first year was twofold in the areas of pseudonymous communication and trust management. In the first part, it was evaluated how mobile IP-based communication affects privacy protection by an approach using multiple (virtual) identities per user. Therefore, the threats implicated by communication were explored and classified. Then, existing approaches for anonymous communication systems were evaluated regarding these threats. The outcome is, that no existing (proposed) solution protects sufficiently against all threats to the multiple identities approach. Moreover, we have worked towards a more formal representation and evaluation of these threats and we have found first protection approaches.

In the second part, it was explored how users can express ratings and trust relations for services and other users, how these can be exchanged and whether they can be used for estimating the properties of service providers. Initially, different existing models for expressing trust have been analyzed (in particular the Dempster-Shafer, Jøsang and Maurer models) and it has been evaluated, whether and how the trust opinions of different users can be combined and the resulting trust values of trust chains can be calculated. As none of these models satisfies the requirements, the design of a new model taking up several elements of the existing models has been started.

3.1.4   Project: Mobility Modelling

Researchers: Florian Bitzer, Bruno Arbter

In the first year, we specified traffic scenarios in Baden-Württemberg that we will investigate in our future simulations. In the long term, vehicle simulation within the superior road network shall be performed for the whole area of Baden-Württemberg, whereas for the pedestrian simulation we will concentrate on the campus of Universität Stuttgart. The latter includes the building of the Faculty of Computer Science. The output to the other projects in form of cross sectional data and especially the interconnection to the spatial world model was fixed as a main focus for the integration into the spatial world model of Nexus. In order to obtain the geographical context of road data for vehicles and to build data for pedestrians, we refer to the existing implementation of different cross-conflated geometry models in the spatial world model. An overview of the different kinds of traffic flow models in the pedestrian and vehicle simulation was performed.

One major problem in the field of microscopic simulation is the lack of comparability between different traffic flow models. Therefore we draw on a basic framework from the Institute of Transport Research at German Aerospace Center (DLR) that is based on two thoughts. First, it provides basic input and output functions needed in any kind of traffic flow model. The second idea is to supply a common test bed for different models. This test bed has to be extended and different models will be compared and evaluated [Res04].

3.2 Research Area: Model Definition and Management

3.2.1 Project: Extensibility and Federation Concepts

Researchers: Nicola Hönle, Matthias Großmann, Daniela Nicklas, Thomas Schwarz

This project focuses on the modelling, the management, and the further development of the spatial world model establishing the basis for the current project phase, as well as taking into account temporal modelling and reasoning for the next project phase. Also, it considers application scenarios, use cases [NGS03], and the overall architecture of the platform. The modelling is driven by two design goals: we want to cover all context information that is useful for applications and we still want to be able to process and manage the model efficiently. Since the spatial world model is the core vision of the Center of Excellence, nearly all other projects have requirements regarding the schema and the contents of the model. We lead the working group "Modelling and Consistency" and supervise several enhancements of the model, like sensor data, meta data, network infrastructure, or 3D data. Also, we analyzed existing geo-standards (e.g. from the OGC).

Concerning data management, we investigated the following three issues: the storage of local models on so-called context servers (including the integration of external data), the federation of the spatial models to the spatial world model, and the efficient representation and insertion of the data into the platform. For the integration of external data we built a web robot that searches Web sites for spatial content. Also, we integrated a spatial server that was built for the Georgia Tech's Aware Home into our platform using a semantic wrapper [LBB+04]. Regarding the federation issue, we developed efficient data structures for query processing and interfaces for plug-in of semantic operators processing model data. An efficient algorithm for the processing of federated k-nearest neighbour queries was developed, implemented, and evaluated (publication in review process). Also, we built a coordinate-system-independent java library for the representation of geo-spatial data [SHG+04].

3.2.2 Project: Geo-Data Integration

Researcher: Steffen Volz

Research activity in the first year mainly dealt with data modelling [FV03]. On the basis of a use case analysis, object classes for the representation of street data within the Nexus data schema have been developed. Then, rule-based mapping functions have been created in order to transfer data from the original formats (namely from Geographic Data Files (GDF), Authoritative Topographic Cartographic Information System (ATKIS), and Automatic Property Map (ALK)) into the spatial world model format. Thus, street data stemming from different sources could be represented in the common Nexus schema, leading to the problem of multiple representations in geographically overlapping regions. In order to handle the difficulties involved, a model to explicitly express the relations between multiple representations is being set up. This work is still in progress and in the near future, algorithms will be developed which aim at automatically deriving the relations and storing them in an XML-based format in order to facilitate the conflation and update of multiple representations on the federation level. The work is currently being documented and will be published in [VW04]. Regarding the topic of spatial data matching, a new algorithm has been developed for

street data that combines node matching with a line-tracking approach. The algorithm identifies junctions of different street networks with a high likelihood of correspondence by comparing strictly defined geometrical, attributive, and topologic parameters. The found pairs are defined as start points. They are used for an affine transformation to adjust the data sets. Basically, the whole network can be examined by running in each direction from any start point and comparing each incident edge and each adjacent node and again their adjoining features, and so on. After having identified all corresponding node instances, the algorithm merges these objects into one resulting representation.

3.2.3   Project: Location Management and Information Diffusion

Researchers: Tobias Drosdol, Dominique Dudkowski

During the last year our research was focused on the following aspects: extending the functionality of the existing infrastructure-based location-service and establishing a basis for data management in mobile ad hoc networks. Regarding the infrastructure-based location-service, we investigated the possibilities of supporting symbolic coordinates. This concept allows referencing a certain spatial location by a unique identifier (e.g. "Room 2.464"). In contrast to geometric coordinates, such a representation of location information does not imply any spatial relation (like the inclusion relationship) between two symbolic identifiers. In order to realize the service model of a location-service, which includes position, range and nearest neighbour queries, it is therefore necessary to explicitly define these spatial relations in so-called *location models*. An in-depth analysis of existing location models for symbolic coordinates has shown that no single model can be chosen without losing generality of the resulting location-service. This is caused by the complementary aspects covered by different approaches as well as the required trade-off between modelling effort and accuracy. As a consequence, we have developed a generic location-service architecture that supports arbitrary location models and thus allows choosing the appropriate model for each application environment. A practical evaluation of these concepts is currently under way.

Within the scope of data management in mobile ad hoc networks we focused on location management, consistency, and network partitioning. Our goal is to design data dissemination algorithms that are suitable for the realization of spatial queries. This work will serve as a basis for realizing a location-service in mobile ad hoc networks supporting the service model of the infrastructure-based location-service. For this purpose we defined a simple spatial context model and classified possible system parameters which impact the design of those algorithms. We also developed the first algorithms for range queries and are working on 1-nearest neighbour queries for mobile ad hoc networks. In the field of consistency, we have extended our notion of observation order consistency. This enhancement allows putting observations of *different* objects in order. We then designed a scoped replication algorithm supporting our definition of consistency. The consistent update diffusion algorithms [BHM03, RBH03] even support multiple observers and concurrent observations without relying on synchronized clocks. Regarding the phenomenon of network partitioning, we have proposed a comprehensive set of partition metrics that allow characterizing the partitioning behaviour of a mobile ad hoc network. Our results show that network partitioning has to be addressed even in scenarios comprising a large number of nodes [HDM04, HDM+04].

3.3 Research Area: Model Presentation and Sensor Integration

3.3.1 Project: Integration of Sensor Data

Researcher: Darko Klinec

In order to provide intuitive methods and interfaces for interaction between Nexus users and the spatial world model, this project concentrates on two different approaches. On the one hand diverse sensor elements and positioning sensors are of interest and on the other hand image sensors, which are capable of object identification and position estimation if a model of the environment is available. In the sensor related research, additional sensors for the Nexus test bed have been analyzed, especially positioning sensors for indoor areas. New concepts for sensor integration and data fusion have been investigated in order to provide improved position information. For the identification of real-world objects in images we implemented an algorithm based on a general Hough transformation. The search algorithm uses information of the object silhouette, which is calculated by fusion of sensor and model data. The identification of the object position in the image is preparatory work for the following image to model registration and image based positioning. For the image based positioning process we extended the spatial resection algorithm to line features as input data. Based on automatic line extraction and photogrammetric spatial resection, a co-registration of image and model data can be provided [KF03]. The determination of corresponding image and object lines currently works in semiautomatic mode, as these features must be matched by an operator to run the spatial resection. In experiments we have shown that the accuracy of our line feature based approach is comparable to the common use of the spatial resection, which uses points as input data.

3.3.2 Project: Sensor Fusion

Researchers: Georg Kindermann, Uwe-Philipp Käppeler

The objective of this project is to enrich the spatial world model with dynamic information about the real environment acquired by different, distributed sensors. To provide as accurate and consistent information as possible, the data from different sources has to be evaluated, processed, and fused considering the context of the process of acquiring. The focus in the first year was on developing a software architecture for a sensor fusion agent.

Our approach consists of a local spatial model storing the local, restricted view of such an agent and different data processing elements reading from the model and writing derived data back. The focus of our design was to achieve a maximum degree of scalability and extensibility, which allows an easy integration of new data sources and evaluation algorithms. The local spatial model consists of two parts, one holding the externally acquired data and the other holding the locally derived data, which also includes a local plausibility rating.

Data processing elements provide the functionality to derive information, which is written back to the data container. Fusion objects are special data processing elements, which combine data from different sources and different abstraction levels to derive additional or more accurate information. It is the task of control objects to select (start and stop) and configure appropriate data processing elements depending on the current situation and objective with mechanisms provided by the framework. This also includes for example additional plausibility checking and the acquisition of

additional information from the spatial world model in case of a rare condition of doubt, which is not needed for normal functionality. To be able to access information from a fusion-agent in a Nexus conform way it is implemented as a Nexus context server with an appropriate communication interface. To sum up, we developed a flexible sensor fusion architecture with a two-part local spatial model and the capability to realize reactive, situation dependent behaviour [BKL+03].

3.3.3 Project: Generalization of Spatial Data

Researcher: Martin Kada

The research during the first year started with the analysis of shortcomings of the 3D generalization approach for building data as described in [Kad03]. The approach depends heavily on finding valid symmetries inherent to the model in order to generate high quality models during their simplification. Because of large errors that are introduced during data acquisition, these symmetries can usually not be found by using solely threshold values. It was therefore investigated if better results can be obtained in two passes. In the first pass the symmetries are conventionally found utilizing small threshold values and are then modelled in a graph structure. By logical reasoning, more building symmetries are then found in the second pass. This work is still in process and will be the main focus in future work.

Another topic was the incorporation of the generalization algorithm in real-time visualisation of urban landscape models. [KRW+03] describes how prominent building models can be simplified in a level-of-detail approach to speed up rendering. In [HK03], the need of building generalization for location based services is presented. [Kad04] shows the realization of a completely textured building model that is ready for visualization purposes.

3.3.4 Project: Context-aware Presentation

Researcher: Mike Eißele

The long-term goal of this project is to support an easy integration of Augmented Reality (AR) applications in Nexus. To this end, we have developed a client-server-based system that allows us to support a number of clients with different graphical output capabilities. With this setup we can support interactive 3D-renderings on a wide range of devices reaching from PDAs or Smartphones up to high-performance graphics workstations. We have also integrated some basic data visualization techniques to visualize data values stored within the Nexus spatial world model.

To overlay this abstract information with real objects, using an AR-display, we have integrated an orientation sensor. With the additional information of the user's position we are able to achieve first results in displaying real world objects with overlaid virtual information. For an easy calibration and location without a positioning system, a technique has been developed where the user spots multiple, known reference points and the system estimates the user's location based on these [KEW+03]. Currently we are investigating user interaction on mobile devices and AR applications using orientation information as an additional input.

3.4　Research Area: Applications and Acceptability

3.4.1　Project: Smart Factory

Researcher: Lamine Jendoubi

The focus of our research was the definition and structure modelling of smart production environments, e.g. smart factories [BJR+03, WJ03].

In other research projects, the Stuttgart model of adaptive, changeable, and virtual enterprises has been formulated. With respect to this model, a new perspective with the usage of context-aware computing was investigated, which allows the collection and distribution of information and knowledge at all places of work in manufacturing. The production environment continually changes towards more flexible structures trying to keep up with increasing product variation and decreasing batch size. Following new technological enhancements in production engineering, advanced organization tools have to be provided in order to keep the benefit.

The approach is a dynamic system that manages production fluctuations using decentralised communication and information support. Using a model of the Smart Factory spatial layout, sensor integration and communication structures are developed. This leads to a decentralized system, which uses intelligent manufacturing equipment in order to accomplish a highly flexible production. As a result, a minimum in complexity, costs, and time consumption is achieved. In the first period of the project, the potential and architecture of smart factories based on wireless communication and location technologies were defined with a focus on management of mobile objects in the production environment.

By means of experimental evaluation and cognoscente workshops, a new tool management system was designed using context-aware computing to create a model of the environment in order to form an optimization basis. Not only the communication structure was designed but also a screening, an evaluation, and optimization of the needed enabling technologies has been completed. Together with the design and 3D- modelling of a standard shop floor and the necessary objects in the environment we showed that a smart tool container can be built during the next year.

3.4.2　Project: Navigation for Visually Impaired People

Researchers: Dr. Andreas Hub, Joachim Diepstraten

The basic idea of this project is to allow object identification for the blind and to improve their indoor navigation abilities using local sensor information in combination with environment models. In agreement with the scheduled task, the first year of our research was mainly focused on integrating sensors and to create a 3D model of the current computer science building.

As foundation for the orientation assistant for the blind a sensor module was developed, that can be handled by a blind user like a flashlight and can be used for searching tasks within a three-dimensional environment. In the basic version this sensor module consists of a stereo camera, a loudspeaker, and a small keyboard. By pressing the key, inquiries concerning object characteristics, position, orientation, and navigation can be sent to the local sensors, or in the near future to the

Nexus federation. After successful evaluation these inquiries are acoustically answered over a text-to-speech engine. A portable computer module is attached to the sensor module connected via WLAN to the Nexus federation. Also, a provisional differential WLAN set-up is used for the two-dimensional positioning in the building until the final WLAN system of the building is made available. For security reasons the sensor module was equipped with a light and detachable blind man's stick, so that only one hand is necessary for both using the mobile orientation assistant and the blind man's stick. This development should facilitate the adaptation phase for blind persons into this new technology, without missing the safety feeling, that only can be obtained using a blind man's stick.

In parallel to the integration of sensors a detailed three-dimensional model of the computer science building was created. An OSGViewer was implemented on the portable computer module, which makes real time navigation possible with the model of the building. The sensor module was extended by a digital compass and an inclination sensor. To determine the height of the sensor module, experiments with an ultrasonic sensor were conducted. First usability tests show that further optimizations are necessary regarding the hardware and software ergonomics [HT03, SDW+03].

3.4.3   Project: Acceptability and Social Aspects

Researchers: Jessica Heesen, Oliver Siemoneit, Dr. Klaus Wiegerling

Since April 2003 - the start of the technology assessment project in the Nexus Center of Excellence - we have focused our work on the following points [Hee03a, Hee03b, Hee04, Hub03a, Hub03b, Hub03c, Hub03d, Hub04a, Hub04b, Sie04, Wie03, Wie04a, Wie04b, Wie04c, Wie04d]:

- Possibility of technology assessment with regard to the value pluralism in modern society by focusing the preservation of freedom for the acting subject.

- Since ubiquitous and pervasive computing is a technology in development, the technology assessment must be based on the evaluation of scenarios. It is necessary to analyze scenarios of ubiquitous and pervasive computing and to adapt the results to Nexus.

- Investigation of different scenarios of mobile and context-aware systems and their categorization. In December 2003, we organized the workshop "Mobil in intelligenten Welten", in which we discussed with various experts methods to construct and to analyze scenarios of such mobile and context-aware systems.

- Definition and reflection on important terms and concepts of the Nexus project, such like privacy, safety, security, confidence, consistency, mobility, and orientation.

At the conference „The unifying aspect of culture" in Vienna we organized a special section on "Virtualisation of Space, Perception and Culture" and gave some lectures, in Munich we gave some lectures on the Conference "Wirtschaftsethik und Globalisierung" (Globalisierung der Technik und ihre wirtschaftsethische Bedeutung; Globale Objektivierung in informierter Handlungsumgebung). Furthermore we consult the BMWA (Bundesministerium für Wirtschaft und Arbeit) and the DLR (Deutsches Zentrum für Luft und Raumfahrt) on their project „ambient intelligence".

3.5 Working Group: Mobility and Security

Group coordinators: Prof. Dr. Paul J. Kühn, Christian Hauser

The working group "Mobility and Security" aims at coordinating the work to be done in these areas. In order to gain a consistent level of knowledge in these areas, some tutorials were held at the beginning. Their titles were: "Mobilitätsverwaltung in Kommunikationsnetzen", "A Meta-Model and Framework for User Mobility in Mobile Networks", and "Security".

After that, each participating project presented itself with special focus on mobility and security/privacy aspects. Based on the herein identified joint problems, four subgroups (SG) were established in which the actual work is performed:

1) "Mobility Modelling": This SG coordinates the different mobility modelling activities.

2) "Communication Infrastructure": This SG coordinates requirements for the communication infrastructure and the boundary conditions of the infrastructure.

3) "Authorization Systems": This SG explores an access control and access rights management for the project. This is needed in several projects.

4) "General Security": This SG cares about a holistic view on security. Besides the technical security requirements, we defined the terms in this area. Moreover, security as being provided by Nexus is explored, e.g., the gain on security for visually disabled persons.

3.6 Working Group: Modelling and Consistency

Group coordinators: Prof. Dr. Bernhard Mitschang, Daniela Nicklas

In the working group "Modelling and Consistency", the contributions of the different projects to the central topics modelling and consistency are being coordinated. In the first meeting, the working group established five subgroups (SG) to cover the different working points.

- SG "Geo-Data and Topological Models"
- SG "Network Infrastructure"
- SG "Sensor Data"
- SG "3D Data"
- SG "Consistency"

The SG "Geo-Data and Topological Models" first gathered the requirements of all Nexus projects with respect to the integration of external standards. They analyzed different standards and compared them to the Nexus environmental model. For the representation of topological information, a model enhancement for so-called heavy-weight relations was developed and is currently documented in a technical report. In cooperation with the SG "3D Data", concepts for modelling the level of detail of model data were discussed.

The participants of the SG "Network Infrastructure" work on the modelling of communication and network infrastructure of the Nexus. With their model enhancements, access points and wireless networks can be queried and detected by mobile devices. This work is also currently documented in a technical report.

The work of the SG "Sensor Data" is twofold: they model both sensors (as physical or virtual entities that provide real-world data for the platform) and sensory data (observations that are made by sensors). For the latter, meta data (like accuracy or timestamps) play a important role. After a thorough analysis, the "Observation and Measurements" standard, proposed by the OGC, was chosen to be integrated in the spatial world model.

The SG "3D Data" focuses on the coordination of the modelling of 3D data. It currently analyzes the GML 3.0 standard for its suitability to represent three dimensional models and scenes.

In the SG "Consistency", the members discuss the problem of consistency and inconsistency throughout the platform. In the first year, terms and definitions for different states and levels of consistency were discussed, defined, and are currently being documented.

The results of this working group are reported in: [BBH+03, RBB03, RBB03a, RBH03, RDD+03, RFM+03]

3.7   Infrastructure and Demonstrator

In this project, different indoor positioning systems for the Nexus test bed were analyzed with respect to the requirements of the different projects. As a result of this analysis, two indoor positioning systems will be installed. A coarse-grained WLAN-based system that provides position information with room granularity covering several rooms, and a highly accurate system covering a single room. These systems will be used for instance to track the positions of tools in the "Smart Factory" scenario and for the development of navigation aids for visually impaired people. Additionally, an Everywhere Display and a Spatial Audio System for the "Smart Room" were acquired to provide proof-of-concept services for the spatial world model.

As part of the Nexus demonstrator, a student project developed a new application based on the Nexus platform. This application can be used with mobile devices like Notebooks and Personal Digital Assistants. Its functionality includes queries for spatial objects managed by the Nexus platform, navigation, and the visualization of spatial objects in form of maps. This application is the foundation for a Nexus-based information system for the campus of Universität Stuttgart. It will be used to evaluate and demonstrate the Nexus platform. The Nexus demonstrator was presented at several events, e.g. at the Berlin-Symposium of the Gottlieb Daimler and Karl Benz Foundation „Total vernetzt - Szenarien einer informatisierten Welt", the 29th International Conference on Very Large Data Bases (VLDB) 2003 [NGS03], the Swiss NCCR MICS Annual Workshop 2003, the 49th "Photogrammetrische Woche Stuttgart" 2003, and the opening colloquium of the Center of Excellence.

4 Professional Activities

4.1 Nexus Related Scientific Events

4.1.1 Workshop "Ubiquitous Computing"

On July, 23, about thirty researchers from various German universities participated in a Nexus workshop on context-awareness in Ubiquitous Computing, which took place at Universität Stuttgart. Various research groups working on problems related to Ubiquitous Computing were invited to discuss current trends in this area.

Prof. G. Müller and M. Kähmer (University of Freiburg) presented their work on ad hoc authentication in Ubiquitous Computing environments using common context information of mobile devices. F. Dürr and J. Hähner (Universität Stuttgart) proposed a lattice-based location model for fine-grained heterogeneous geographic addressing and an algorithm to replicate data in mobile ad hoc networks with respect to the global temporal ordering. Prof. M. Mühlhäuser, J. Kangasharju, G. Austaller and E. Aitenbichler (University of Darmstadt) discussed an approach to building context-aware applications. Prof. S. Fischer and C. Buschmann (University of Braunschweig) presented a software architecture for radio-based mobile systems, and finally, Prof. C. Lindemann and O. Waldhorst (University of Dortmund) discussed concepts of peer-to-peer computing in mobile ad hoc networks and presented a distributed lookup service supporting mobile applications.

4.1.2 Opening Colloquium of the Center of Excellence

More than hundred guests participated in the opening colloquium of our Center of Excellence on November, 14. Keynote speaker Prof. J.P. Hubaux from École Polytechnique Fédérale de Lausanne gave a talk on how mobility can increase security in wireless ad hoc networks and how cooperation between nodes can be fostered by micro-payments. He presented research activities, which are focused on mobile wireless networking and computing, with an emphasis on wireless ad hoc networks, multi-hop wireless LANs, and sensor networks.

Prof. Rothermel, coordinator of the Center of Excellence, introduced trends in technology, discussed the characteristics of context-aware applications and spatial models based on a small scenario, as well as the vision and scientific goals of the Center of Excellence. Finally, the Nexus researchers and participating students presented their demonstrator.

4.1.3 Workshop on Context-Aware Systems

In conjunction with the opening colloquium, the international workshop on context-aware systems took place at Universität Stuttgart and was attended by about one hundred guests. In two sessions, researchers of the Universities of Stuttgart, Saarland, Munich, Lancaster and the EML Heidelberg gave presentations on context and interaction, as well as about system aspects of context-aware systems.

In his talk about context and user adapted mobile interaction, R. Malaka from EML Heidelberg introduced some aspects of mobile human-computer interaction (HCI). He presented user adapted and location based services for pedestrian navigation systems and discussed mobile context-adapted user interfaces. A. Krüger from Saarland University talked about situated interaction in instrumented spaces. He described how users can be provided with intelligent support by addressing new challenges for the hardware, the modelling and the inference components of the environment. As an example he focused on an adaptive shopping assistant system that utilizes plan recognition to silently identify the actual user task. In this system, Radio Frequency Identification (RFID) sensory is used to observe the shoppers actions, from which the plan recognizer tries to infer the goals of the user under consideration of context information on products and user interests. A. Schmidt from LMU Munich gave a talk about enabling new ways in human computer interaction using context. Based on examples of explorative research in the area, the talk outlined steps towards a new interaction paradigm for context-aware and Ubiquitous Computing: The availability of rich context information and comprehensive world models will allow new ways of human computer interaction. Using context and interaction of the user in the real world, he proposed the notion of implicit human computer interaction to allow transparent forms of interaction. In his talk about building context-aware systems for the real world, A. Friday from University of Lancaster, UK, presented the experiences gained in engineering context-aware systems for deployment in the real world. He then moved on to explore how to generalize from this work to architect a reusable middleware for context-aware systems based on recent work, where context was used as the engine to drive dependable autonomous systems built from reusable components. Finally, D. Nicklas and S. Volz from Universität Stuttgart presented the Nexus platform and discussed the complexity and consistency of context models in Nexus.

4.1.4 Workshop "Mobil in Intelligenten Welten. Szenarien - Visionen - Trends "

On December 11/12, 2003, a workshop with various experts on the topic of scenario-based reflection and evaluation of ubiquitous and context-aware IT-Systems took place at Universität Stuttgart. Besides the theoretical basis of how to create scenarios and the experience yet made with the scenario-method in its practical use, they also discussed first results of technology assessment in Ubiquitous Computing. The main goal of the workshop was to get an overview of the various scenarios of usage of the technologies in question, to systematize them and to investigate in the possibility of their realization. Questions, whether these trends are also desirable, are subject to a further workshop we plan to run in fall 2004.

Various experts of different research groups were invited to the workshop (e.g. groups of Prof. Dr. Friedemann Mattern, Institut für Pervasive Computing, ETH Zürich, Prof. Dr. Günter Müller, Institut für Informatik und Gesellschaft, Universität Freiburg, and Prof. Dr. Elgar Fleisch, Institut für Technologiemanagement, HSG St. Gallen). Andreas Köhler of the EMPA, St. Gallen presented the methodology and first result of their study for the Swiss parliament „Das Vorsorgeprinzip in der Informationsgesellschaft. Auswirkungen des Pervasive Computings auf Gesundheit und Umwelt". Dr. Karlheinz Steinmüller and Prof. Dr. Horst Geschka, both well-known experts on future research, spoke on the theoretical basis of the scenario methods and analysis as a means of technology assessment. Prof. Dr Gerald Steinhardt (expert on psychology and technology, Vienna) and

Prof. Dr. Johannes Weyer (expert on sociology and technology, Dortmund) criticized and commented each talk out of their perspective and thereby guaranteed a fruitful discussion.

4.2 Committee Memberships

The Nexus researchers were involved in the organization of the following events:

- 49th Photogrammetrische Wochen Stuttgart, 2003 (General Chair)

- 2nd Int. Conf. On Pervasive Computing and Communications (PerCom 04), 2004 (Demo Chair)

- Context Modelling and Reasoning Workshop (CoMoRea 04), 2004 at the 2nd Int. Conf. On Pervasive Computing and Communications (Organizer)

- Middleware Support for Pervasive Computing Workshop (PerWare 04), 2004 at the 2nd Int. Conf. On Pervasive Computing and Communications (Co-Organizer)

- System Support for Ubiquitous Computing Workshop (UbiSys 2003), 2003 at the 5th Annual Conf. on Ubiquitous Computing (Co-Organizer)

- 29th International Conference on Very Large Data Bases (VLDB), 2003 (Publicity Co-Chair)

- Tutorial "Context-Aware Computing" at the 5th Int. Conf. on Mobile Data Management (MDM 04) 2004 (Invited Tutorial)

- Session "Virtualisation of Space, Perception and Culture" at the Conference "The unifying aspect of culture" 2003 (Co-Organizer)

4.3 Dissertations

Leonhardi, Alexander
"Architektur eines verteilten skalierbaren Lokationsdienstes". Faculty "Computer Science, Electrical Engineering and Information Technology", Universität Stuttgart, 2003.

4.4 Publications

[BBH+03]
Bauer, Martin; Becker, Christian; Hähner, Jörg; Schiele, Gregor: ContextCube - Providing Context Information Ubiquitously. In: Proceedings of the IWSAWC Workshop at the 23rd International Conference on Distributed Computing Systems Workshops (ICDCS 2003); Providence, Rhode Island, USA, 2003.

[BHM03]
Becker, Christian; Hähner, Jörg; Marrón, Pedro José: Consistent Update Diffusion in Sensor Networks. In: GI/ITG KuVS 1. Fachgespräch „Drahtlose Sensornetzwerke"; Berlin, Germany, 2003.

[BJR+03]

Bauer, Martin; Jendoubi, Lamine; Rothermel, Kurt; Westkämper, Engelbert: Grundlagen ubiquitärer Systeme und deren Anwendung in der "Smart Factory". In: Gronau, Norbert (ed.); Krallmann, Hermann; Scholz-Reiter, Bernd (ed.): Industrie Management - Zeitschrift für industrielle Geschäftsprozesse; Bd. 19(6); 2003, 17-20.

[BKL+03]

Buchheim, Thorsten; Kindermann, Georg; Lafrenz, Reinhard; Levi, Paul: A Dynamic Environment Modeling Framework for Selective Attention. In: Proceedings of the IJCAI-03 Workshop on Issues in Designing Physical Agents for Dynamic Real-Time Environments: World Modeling, Planning, Learning, and Communicating; Acapulco, Mexico, 2003.

[BMR04]

Bürklen, Susanne; Marrón, Pedro José; Rothermel, Kurt: An Enhanced Hoarding Approach Based on Graph Analysis. In: Proceedings of the 5th IEEE International Conference on Mobile Data Management (MDM 2004); Berkeley, California, USA, 2004.

[DR03]

Dürr, Frank; Rothermel, Kurt: On a Location Model for Fine-Grained Geocast. In: Dey, Anind K. (ed.); Schmidt, Albrecht (ed.); McCarthy, Joseph F. (ed.): Proceedings of the Fifth International Conference on Ubiquitous Computing (UbiComp '03) ; Seattle, WA, USA, 2003.

[FV03]

Fritsch, Dieter; Volz, Steffen: Nexus- the mobile GIS environment. In: Peter Farkas (ed.): Proc. of the first Joint Workshop on mobile future and symposium on trends in communications; Bratislava, Slovakia, 2003.

[HDM04]

Hähner, Jörg; Dudkowski, Dominique; Marrón, Pedro José: A Quantitative Analysis of Partitioning in Mobile Ad Hoc Networks. Accepted for publication (extended abstract) in: Proceedings of the Joint International Conference on Measurement and Modeling of Computer Systems (Sigmetrics - Performance 2004); New York, USA, 2004.

[HDM+04]

Hähner, Jörg; Dudkowski, Dominique; Marrón, Pedro José; Becker, Christian: Partitioning in Mobile Ad Hoc Networks. In: GI/ITG KuVS 2. Fachgespräch „Drahtlose Sensornetzwerke"; Karlsruhe, Germany, 2004.

[Hee03a]

Heesen, J.: Ethik und Ethos der privaten Homepage. In: Thomas Hausmanninger (Hg.): Handeln im Netz. Bereichsethik und Jugendschutz im Internet (Schriftenreihe des ICIE Bd. 2). München: Fink 2003, 131 – 150.

[Hee03b]

Heesen, J.: Orte des Dialogs: in den Massenmedien, im Internet und in einer „intelligenten" Umgebung. Forum Medienethik 2/ 2003, Schwerpunkt: Dialog als Schlüsselbegriff medialer Kommunikation, 32 – 41. (In abgewandelter Form in: Trans. Internet-Zeitschrift für Kulturwissenschaften 15/ 2004 (inst.at/trans/15Nr/inhalt15.htm), Schwerpunktheft: INST (Hg.): Das Verbindende der Kulturen.)

[Hee04]

Heesen, J.: Technik als Mission: Wie Vereinte Nationen und G8 die digitale Spaltung überwinden wollen. In: Rupert M. Scheule/ Rafael Capurro/ Thomas Hausmanninger (Hg.): Vernetzt gespalten. Der Digital Divide in ethischer Perspektive (Schriftenreihe des ICIE Bd. 3), München: Fink 2004.

[HK03]

Haala, Norbert; Kada, Martin: Generation and application of virtual landscape models for location-based services. In: Proceedings of Geo Sensor Networks; Portland, USA, 2003.

[HT03]

Hub, Andreas; Teufel, Harald: Messung von wahrgenommenen Farben in realen Szenen und Vorausberechnung von Objektfarben in verschiedenfarbigen Umgebungen. In: Rahman Jamal, Hans Jaschinski (ed.): Virtuelle Instrumente in der Praxis, Begleitband zum Kongress VIP 2003, 11-14.

[Hub03a]

Hubig, Ch.: Globalisierung der Technik und ihre wirtschaftsethische Bedeutung. In: Jahrestagung der Ausschusses Wirtschaftsethik der Deutschen Gesellschaft für Philosophie, 2003.

[Hub03b]

Hubig, Ch.: Selbstständige Nutzer oder verselbstständigte Medien – Die neue Qualität der Vernetzung. In: F. Mattern (Hg.): Total vernetzt. Szenarien einer informatisierten Welt, Berlin/ Heidelberg/ New York: Springer 2003, 211-230.

[Hub03c]

Hubig, Ch.: „Intelligente" Handlungswelten – Eine neue Herausforderung für die Medienethik. In: D. Klumpp (Hg.): Next Generation Society, Talheimer 2003, 360 – 373.

[Hub03d]

Hubig, Ch.: Wissensmanagement und Kommunikation in der E-Economy – Zum Widerstreit zwischen Rationalisierung und Kompetenzerweiterung. In: Frank, U. (Hg): Wissenschaftstheorie in Ökonomie und Wirtschaftsinformatik. DUV-Verlag 2003, 188-202.

[Hub04a]

Hubig, Ch., Intelligente Netze: Wirtschaftsethische Fragen der Homogenisierung und Diversifizierung. In: Koslowski, P./Lütge, Ch.(Hg): Wirtschaftsethik der Globalisierung. Heidelberg 2004 (i. D.).

[Hub04b]

Hubig, Ch., Künstliche intelligente Umwelten - über die Veränderungen unseres Wirklichkeitsverhältnisses. In: Lienen/ Kaufmann/ Bruppacher (Hg.), Kanalisation bis Handy - Verbreitungsbedingungen technischer Innovationen in der Gesellschaft, 2004 (i. D.).

[Kad03]

Kada, Martin: 3D Building Generalisation and Visualisation. In: Fritsch, Dieter (ed.): Proceedings of Photogrammetric Week '03; Stuttgart. Germany, 2003.

[Kad04]

Kada, Martin: Hardware-Based Texture Extraction for Building Facades. 20th Congress of International Society for Photogrammetry and Remote Sensing; Istanbul, Turkey, 2004.

[KEW+03]

Klein, T.; Eissele, M.; Weiskopf, D.; Ertl, T.: Simulation, Modeling and Rendering of Incompressible Fluids in Real Time. In: Workshop on Vision, Modeling, and Visualization (VMV'03); Munich, Germany, 2003.

[KF03]

Klinec, Darko; Fritsch, Dieter: Towards pedestrian navigation and orientation. In: Proceedings of the 7th South East Asian Survey Congress (SEASC'03); Hong Kong, 2003.

[KRW+03]
    Kada, Martin; Roettger, Stefan; Weiss, Karsten; Ertl, Thomas; Fritsch, Dieter: Real-Time Visualisation of Urban Landscapes Using Open-Source Software. In: Proceedings of ACRS 2003 ISRS, Busan, Korea, 2003.

[Kue03]
    Kühn, P. J.: Location Based Services in Mobile Communication Infrastructures. Invited Paper in: Australian Telecommunications Networks and Applications Conference (ATNAC'03), Melbourne, Australia, 2003.

[LBB+04]
    Lehmann, Othmar; Bauer, Martin; Becker, Christian; Nicklas, Daniela: From Home to World - Supporting Context-aware Applications through World Models. To appear in: Proceedings of the Second IEEE International Conference on Pervasive Computing and Communications (PerCom'04); Orlando, Florida, USA, 2004.

[NGS03]
    Nicklas, Daniela; Grossmann, Matthias; Schwarz, Thomas: NexusScout: An Advanced Location-Based Application On A Distributed, Open Mediation Platform. In: Proceedings of the 29th VLDB Conference, Berlin, Germany, 2003.

[RBB03]
    Rothermel, Kurt; Bauer, Martin; Becker, Christian: SFB 627 - "Nexus" Umgebungsmodelle für mobile kontextbezogene Systeme. In: Molitor, Paul (ed.); Küspert, Klaus (ed.); Rothermel, Kurt (ed.): it - Information Technology. Bd. 45(5), 2003.

[RBB03a]
    Rothermel, Kurt; Bauer, Martin; Becker, Christian: Digitale Weltmodelle - Grundlage kontextbezogener Systeme. In: Friedemann Mattern (ed.): Total vernetzt - Szenarien einer informatisierten Welt, 2003.

[RBH03]
    K. Rothermel, C. Becker, J. Hähner: Consistent Update Diffusion in Mobile Ad Hoc Networks. Technical Report 2002-04; Universität Stuttgart, 2002.

[RDD+03]
    Rothermel, Kurt; Dudkowski, Dominique; Dürr, Frank; Bauer, Martin; Becker, Christian: Ubiquitous Computing - More than Computing Anytime Anyplace?. In: Proceedings of the 49. Photogrammetrische Woche; Stuttgart, Germany, 2003.

[Res04]
    Ressel, Wolfram: Modeling and Simulation of Mobility. In: 1st International Workshop on Intelligent Transportation (WIT 2004); Hamburg, Germany, 2004.

[RFM+03]
    Rothermel, Kurt; Fritsch, Dieter; Mitschang, Bernhard; Kühn, Paul J.; Bauer, Martin; Becker, Christian; Hauser, Christian; Nicklas, Daniela; Volz, Steffen: SFB 627: Umgebungsmodelle für mobile kontextbezogene Systeme. In: Proceedings Informatik 2003, GI Lecture Notes in Informatics; Frankfurt (Main), Germany, 2003.

[SDW+03]
    Stegmaier, Simon; Diepstraten, Joachim; Weiler, Manfred; Ertl, Thomas: Widening the Remote Visualization Bottleneck. In: Proceedings of IEEE Int. Symposium on Image and Signal Processing and Analysis (ISPA'03); Rome, Italy, 2003.

[SHG+04]

Schwarz, Thomas; Hönle, Nicola; Grossmann, Matthias; Nicklas, Daniela: A Library for Managing Spatial Context Using Arbitrary Coordinate Systems. To appear in: Workshop-Proceedings (CoMoRea Workshop) of the 2nd IEEE International Conference on Pervasive Computing and Communications, Orlando, Florida, USA, 2004.

[Sie04]

Siemoneit, Oliver: Ubiquitous Computing – Neue Dimensionen technischer Kultur. In: Trans. Internet-Zeitschrift für Kulturwissenschaften 15/ 2004 (inst.at/trans/15Nr/inhalt15.htm), Schwerpunktheft: INST (Hg.): Das Verbindende der Kulturen, 2004.

[VW04]

Volz, S. and Walter, V.: Linking Different Geospatial Databases by Explicit Relations. 20th Congress of International Society for Photogrammetry and Remote Sensing; Istanbul, Turkey, 2004.

[WJ03]

Westkämper E.; Jendoubi L.: Smart Factories-Manufacturing Environments Of The Future. In: 36th CIRP International Seminar on Manufacturing Systems, Prof. H.Bley, Saarbrücken, Germany, 2003, 13-16.

[Wie03]

Wiegerling, K.: Kriegsmedien und Medienkriege – Zum Verhältnis von Krieg und Medien. In: Grimm, P./ Capurro R. (Hg.): Krieg und Medien – Verantwortung zwischen apokalyptischen Bildern und paradiesischen Quoten? Stuttgart, Germany, 2003.

[Wie04a]

Wiegerling, K.: Virtualisierung der Wahrnehmung. In: Trans. Internet-Zeitschrift für Kulturwissenschaften 15/ 2004 (inst.at/trans/15Nr/inhalt15.htm), Schwerpunktheft: INST (Hg.): Das Verbindende der Kulturen, 2004.

[Wie04b]

Wiegerling, K.: Kultur versus Globalisierung – Zu ethischen Konsequenzen informationstechnologisch disponierter Globalisierungsstrategien. In: Scheule, R./ Capurro, R./ Hausmanninger, Th.: Vernetzt gespalten. Die Digital Divide in ethischer Perspektive. München 2004.

[Wie04c]

Wiegerling, K.: Globale Objektivierung in informierter Handlungsumgebung. In: Koslowski, P./Lütge, Ch.(Hg): Wirtschaftsethik der Globalisierung. Heidelberg, Germany, 2004 (i. D.).

[Wie04d]

Wiegerling, K.: Mobilität und Orientierung. In: Concordia 2004 (i. V.).