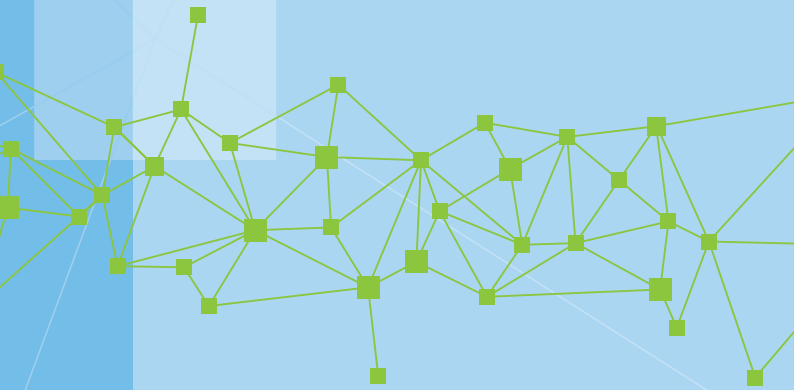
Universität Stuttgart
Germany

Collaborative Research Center 627

Spatial World Models for Mobile Context-Aware Applications



NEXUS

http://www.nexus.uni-stuttgart.de

Vision

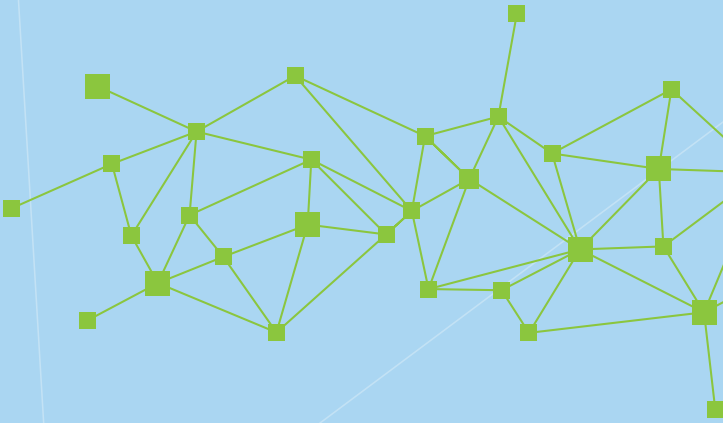
The proliferation of sensor technology, along with advances in wireless communication and mobile devices, allow for context-aware applications. Those applications take into account the context of real world entities, such as a user's current location, physical environment, or even activity. They are able to act upon and adapt to changes in the real world and select and present information depending on the application's context. Since almost all application domains can benefit from context information, we envision most applications to be context-aware in the near future.

Billions of sensors located in our physical environment collect a huge amount of context information. This information will be fed into numerous spatial context models building the basis for context-aware applications. The models may include stationary objects, like streets or buildings, as well as mobile objects, such as people or vehicles. The spatial models may differ in various ways, e.g., in topographical or topological nature, in different levels of detail, or in coverage of different areas and aspects of the real world.

For both economic and technical reasons, it is highly desirable for context information to be shared by a wide variety of applications. We envision - in analogy to the WWW - a World Wide Space, which provides the conceptual and technological framework for integrating and sharing context models. It is open in the sense that any commercial and non-commercial provider can "place" context models into this space. The collection of context models is federated and leads to a large scale context model, offering a global and consistent view on the context data. The federation allows for complex spatial queries, including continuous evaluation and stream-based processing. If the context 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. To protect context data, application-specific views can be defined for individually controlling model access. We envision the World Wide Space to be the common basis for future context-aware applications.

Research Objectives

The main research objective is to investigate methods to create, manage, visualize and use federated context models, which are the foundation of the envisioned World Wide Space. The context models under investigation are large-scale, highly dynamic, and complex in terms of the abstractions supported. In particular, the abstractions to be offered include stationary geographic objects, mobile objects, objects associated with dynamic state information, as well as virtual objects augmenting reality.
Moreover, the research will focus on innovative context-aware applications built on spatial context models. It is also investigated how the existence of those models affects the system-level concepts and mechanisms themselves.
Of particular interest is the quality of context, which impacts almost all areas of research in Nexus. The investigations focus on quality concepts and metrics as well as algorithms considering context quality.



Participating Research Groups

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

Institute of Industrial Manufacturing and Management (IFF)
Life Cycle Management Research Group
Prof. Dr. Engelbert Westkämper

Institute for Natural Language Processing (IMS)
Theoretical Computational Linguistics Research Group (TCL)
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- **Applications of Parallel and Distributed Systems Research Group (AS)**
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- **Image Understanding Research Group (BV)**
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- **Distributed Systems Research Group (VS)**
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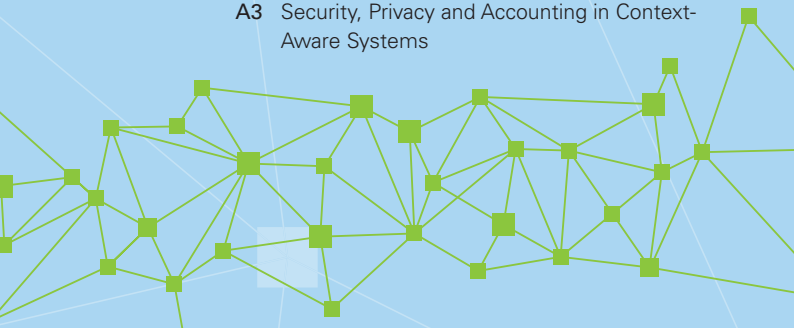
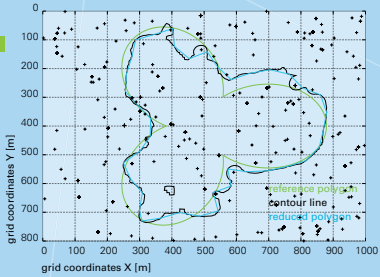
Research Program

Communication and Security

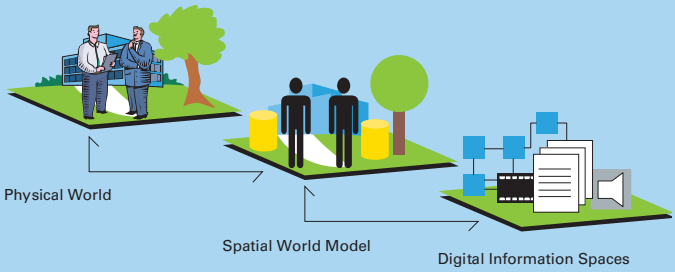
Communication mechanisms and security concepts are key building blocks of context-aware systems. Therefore, novel communication infrastructures are investigated that allow mobile clients to efficiently access spatial context models over heterogeneous networks, and which further use context information for the optimization and adaptation of communication processes facing changing situations. Moreover, context models enable new communication paradigms like context cast. With context cast, information can be distributed selectively among users or applications with a certain context, requiring special overlay networks and context-aware routing algorithms. Finally, multi-lateral security solutions for open context-aware systems are developed, in which not all involved parties can be considered trustworthy. The challenge is to fulfill both, privacy needs of users and security and accounting requirements of content and service providers.

A1 Context-Aware Communication Control
A2 Context-Aware Communication
A3 Security, Privacy and Accounting in Context-Aware Systems





Management of Context Models



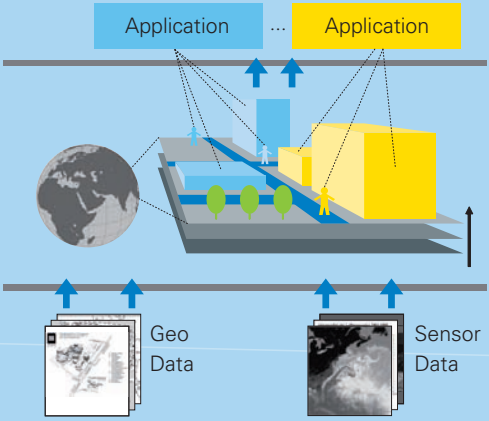
The challenges of this area are the modeling and provisioning of the federated context models. This includes different interaction methods (e. g., spatio-temporal queries, continuous queries, and event-based communication), archiving and data mining on historical context data, and a novel stream-based operator concept. This allows for a dynamic distributed query processing that offers a virtualization of the underlying sensors and context data providers, integrating dynamic data from sensors with other data sources. To efficiently find all data sources that are relevant for given information need, new concepts for distributed index structures are needed. Managing data histories of mobile objects is especially challenging, because their spatial relation changes over the time. The collected data histories can be used for predictions and in recognition of situations as well as for improving query processing. The management of context information will also be extended to hybrid system models that allow for a flexible integration of context management in mobile ad-hoc networks with infrastructure-based data grids.

B1 Homogenized and Virtualized Model Management
B3 Hybrid Model Management
B5 Dynamic, Time-Referenced Model Data

Model Interaction and Sensors

The acquisition and the presentation of context information are crucial for connecting the abstract context model to reality. Data in general and context information in especially has to be entered into the system and it has to be updated continuously to faithfully represent a consistent view onto selected parts of the model. Users need to interact with it everywhere and in an intuitive manner in order to benefit from the contextual information in novel ways. Projects in this research area deal with the acquisition of sensor data, with their consistency analysis, and with the context-oriented visualization of federated information providing advanced interaction mechanisms. Of special research interest are geographic data and the generalization of city models and an adequate and distributed visualization on mobile client devices. Metrics and valuation of heterogeneous sensor data are developed to integrate and to visualize uncertain measurements and inaccurate information in order to detect and resolve ambiguities and to retain data consistency and quality across the federated context model at various scales.

C1 Consistency and Generalization of 3D Geo Data
C3 Sensor-Supported, Context-Based Consistency Analysis
C5 Context-Aware Mobile Visualization



Applications and Acceptability

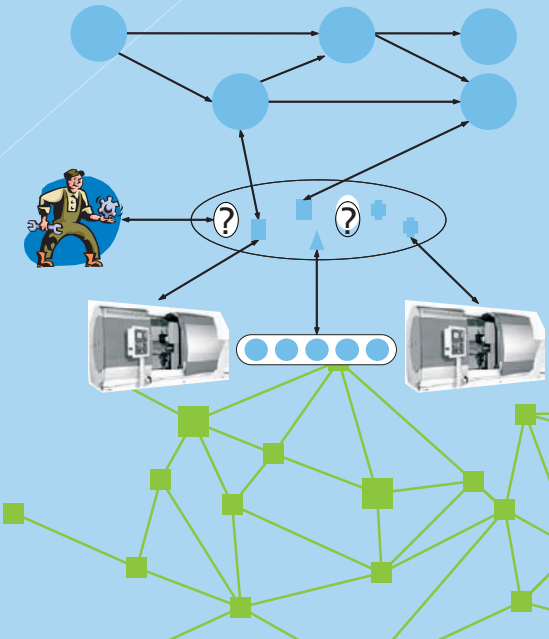
In this area, several context-aware applications are developed, to both validate the concepts of federated context models and to explore the potential of context-awareness in two given application domains. This work also gives a deep insight on the acceptability of context-awareness in applications. The research activities of the Smart Factory are oriented towards the homogenization of sensor information related to production and management fields and the improvement of communication between factory resources, as well. Context-based assistant systems are multi-purpose assistant systems which allow users with sensory handicaps and minor cognitive or physical disabilities a safe and independent mobility. All developments are accompanied by philosophical reflections and acceptability considerations, focused on security and privacy. Also, the economical aspects of mobile context-aware applications will be examined.

- **D1** Smart Factory
- **D2** Context-Based Assistant Systems for People with Sensory Handicaps
- **D3** Reflection and Evaluation

Application Support

This area focuses on the development of software architectures and development tools for context-aware applications, on the collection of context sensitive natural language information and on the recognition of complex situations. Main research is done in the field of model driven development tools to ease the development of context-aware applications, e. g. , by extending workflow modeling and execution technologies to the field of context-aware applications. With the help of semantic methods it must be examined how external data can be represented in the federated context model. Here, geographical data and natural language data are of special interest. Situation recognition should not only be accessible for certain predefined applications, but for every kind of application. The aim is the development of a reliable framework for distributed situation recognition.

E1 Context-Aware Workflows
E2 Semantic Methods
E3 Distributed Situation Recognition Based on Evaluated Context Information

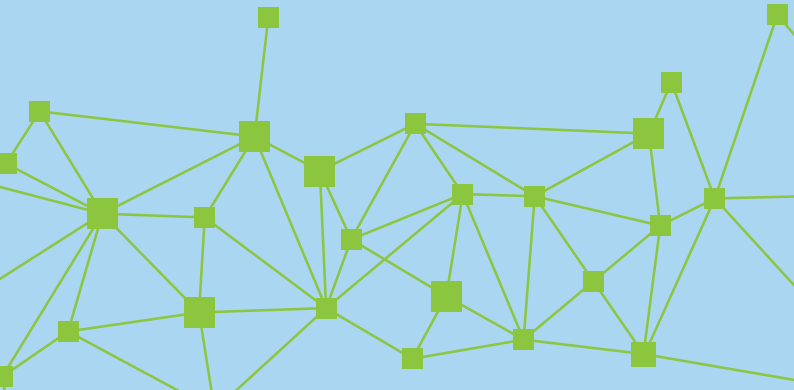


General Projects – Work Groups

Metrics and Valuation of Context The quality of context information may highly differ due to the heterogeneity of context information and the variety of approaches for context acquisition. This cross-cutting project aims at a reference model for assessing context quality.
This model has to incorporate the abstraction levels sensor data, observable context and situation as well as different aspects of context quality like degradation, consistency and trust.

Mobility and Security The working group coordinates the interdisciplinary research on mobility and security aspects. Both fields require intensive cooperation among the involved projects. Therefore, the working group organizes workshops and forms task forces to foster cross-project research and publications. Research topics include architectures for open context-aware systems, security and privacy solutions, and mobile communication issues.

Modeling and Consistency The topics of context modeling and support for application require common research and the thorough discussion of interfaces between several projects. Sample goals of this working group are the participation in the standardization process of 3D city models (CityXML), a concept for hybrid geographical/symbolical location models, or the provision of model-based approaches for application development.



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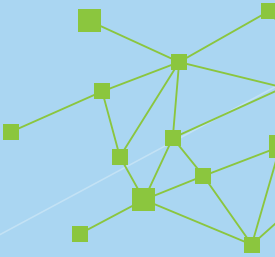
Facts

Funding	Deutsche Forschungsgemeinschaft (DFG)	
Project Periods	2000 – 2002	DFG Nexus Research Group
	2003 – 2006	Collaborative Research Center, 1st funding period
	2007 – 2010	Collaborative Research Center, 2nd funding period
Staff	66	



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