Institut für Parallele und Verteilte Systeme


Institute of Parallel and Distributed Systems

www.ipvs.uni-stuttgart.de
This year we will celebrate the 20th anniversary of our institute. IPVS, founded in March 1989, comprises the five scientific groups. Applications of Parallel and Distributed Systems, Image Understanding, Distributed Systems, Parallel Systems and Simulation of Large Systems plus an infrastructure group. From the very beginning IPVS was constantly growing. Currently more than 80 scientists as well as technical and administrative staff are working at IPVS, and 45 students are involved in our projects. Most of our projects are externally funded by industrial partners and funding organizations. From our current projects we would like to highlight a few: Members of the institute coordinate the Collaborative Research Center Nexus – Context Models for Mobile Context-Aware Systems (SFB 627) as well as the two Integrated Projects Replicator (Robotic Evolutionary Self-Programming and Self-Assembling Organisms) and Symbion (Symbiotic Evolutionary Robot Organisms) funded by the European Union. Moreover, we also conduct research in various projects of the Cluster of Excellence Simulation Technology (SimTech) and the Graduate School of Excellence for Advanced Manufacturing Engineering (GSAME).

While in 2008 our robot soccer team took a remarkable fourth place in the World Championship it was the winning team of the Robocup German Open in 2009. We congratulate the newly formed First Roboter Fußball Club (RFC) Stuttgart on this excellent performance.
During the past year members of IPVS (co-)organized again a number of scientific events, including First Workshop on Architectures, Services and Applications for the Next Generation Internet, July 17, Karlsruhe, ITPC (IBM Technology Partnership Center) Colloquium on Distributed Hierarchic Event Processing, November 6, Böblingen and First Workshop on Global Sensor Networks (GSN’09), March 6, Kassel.

Over the last 20 years numerous people contributed to make IPVS a successful research institution. In particular, we would like to mention our former colleagues P. Bastian, U. Baitinger, H.-J. Bungartz, A. Reuter and W. Strommer. Especially, the founder of the institute, A. Reuter, shaped the institute with his pioneering work and laid the foundations of its current structure, which has proven to be perfect over the years. Also our partners and friends in industries and academia supported us a lot in our projects and the progress of our research. Last but not least, without the dedication of our staff and students IPVS would not be there where it is today. Many thanks to all of them!

For the Board of Directors: Prof. Dr. rer. nat. Dr. h.c. Kurt Rothermel
Head of the Institute IPVS
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Organisational Structure

Management

Head of Institute
- Prof. Dr. rer. nat. Dr. h.c. Kurt Rothermel

Deputy Head of Institute
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Board of Directors
- Prof. Dr. rer. nat. habil. Paul Levi
- Dipl.-Inf. Michael Matthiesen
- Prof. Dr.-Ing. habil. Bernhard Mitschang
- Prof. Dr. rer. nat. Dr. h.c. Kurt Rothermel
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Information is understood as the lifeblood of today’s businesses. Hence, information management is about creating and enabling business by integrating, analyzing, optimizing, and storing heterogeneous types and sources of information throughout its life-cycle and in an effective manner.

Currently, the department for Applications of Parallel and Distributed Systems is conducting research in the following three working areas:

- **Data and Metadata**
  Fundamental prerequisites for any effective information management comprise efficient data and metadata management by means of enhanced database technology. Explicit metadata management further enables a semantic treatment, interoperability as well as a code generating approach as applied by model-driven engineering.

- **Content and Semantics**
  Content management defines the complementing facet of information management. Content is understood to be unstructured or semi-structured and thus demands for different storage, search, and management techniques as compared to the well-structured data management area. Approaches that bridge this gap try to address both aspects in order to get the best of both sides.
Information Systems, Applications, and Services
The above mentioned technologies enable the development of new techniques for information systems and associated applications, like process or product data management, message monitoring and retention systems, or context-based information systems. The service-based approach is seen as a next technology step towards enhancing flexibility.

The research activities of the department are best characterized by its current involvement in research projects as described further in the project description section below.

The department is proud to be involved in all excellence initiatives that are granted by the German research Foundation, DFG, to the Universität Stuttgart. This is on one side the Graduate School GSaME (Graduate School of Excellence for advanced Manufacturing Engineering), where the department coordinates all activities within the research cluster ‘Information and Communication Technologies for Manufacturing’. On the other side the department participates in the research area ‘Integrated Data Management and Interactive Visualisation’ as part of the Cluster of Excellence ‘Simulation Technology’ (SimTech).

Staff
Research Projects
www.ipvs.uni-stuttgart.de/abteilungen/as/forschung/projekte

BIA - Business Impact Analysis
Personnel: S. Radeschütz
Funded By: Universität Stuttgart
Duration: since 1.6.2006
For optimizing business processes effectively, a profound analysis of all relevant business data in a company is necessary. This project aims to develop an approach to automatically integrate a company’s process execution data and operational business data in order to enable a more informative and comprehensive analysis.

SRC: SimTech - Data Provisioning for Scientific Workflows
Personnel: P. Reimann, P. Janowski
Funded by: Deutsche Forschungsgemeinschaft (DFG)
Duration: 1.5.2008 – 30.4.2011
This project, embedded in the Cluster of Excellence “Simulation Technology” (SimTech), primarily aims at offering a consolidated data management and provisioning abstraction that is efficiently interfaced with simulation workflow technology and applicable to novel visualization techniques and simulation computations. All this is done to enable engineers and scientists to work on novel and challenging simulation applications in an integrative systems science.

SQL4WL - Optimization of Data Processing in Business Processes
Personnel: M. Vrhovnik, H. Schwarz
Funded by: Universität Stuttgart, partially IBM
Many workflow management systems allow for the tight integration of data management tasks into workflow models by means of language extensions. In this project, we develop concepts, control strategies and appropriate internal representations for the optimization of such data-intensive workflows.

Expose
Personnel: F. Kaiser
Funded by: Universität Stuttgart, partially Bundesministerium für Bildung und Forschung (BMBF)
Rating the similarity of two or more text documents is an essential task in information retrieval. A major challenge originates from the fact that two documents can have the
same topic or even express the same facts, while they use different wording to describe it. A sophisticated algorithm that aims to implement human understanding of document similarity therefore will have to use additional context information instead of performing solely syntactic comparison. In this project, we develop algorithms and strategies for calculating the similarity of text documents. They build on Concept Contexts that are derived from content and structure of the Wikipedia hypertext corpus.

Content Management as a Service
Personel: F. Wagner, A. Moosbrugger
Funded by: IBM
Duration: 1.6.2007 - 31.5.2009
Due to the vast amount of valuable semi-structured and unstructured information produced, processed and stored today, appropriate Enterprise Content Management (ECM) is a crucial task for companies. In this joint project with IBM and the University of Hamburg a service-based infrastructure for ECM is developed which can dynamically adapt to changing workload situations.

GSaME – Cluster E - Data Management and Information Provisioning in the Virtual Factory
Personnel: J. Mínguez, M. Jakob
Funded By: Graduate School of Excellence for advanced Manufacturing Engineering
Duration: 1.4.2009 - 31.3.2012
Information management in today’s digital factories shows a multitude of unconnected, heterogeneous information systems without effective integration of data except along a few standard processes. To successfully run the virtual factory, it is crucial to introduce a service-based information integration management that enables a flexible information provisioning.

SFB 627 – Project B1 – Homogenized and Virtualized Model Management
Personnel: A. Brodt, N. Cipriani, M. Großmann, C. Lübbe
Funded by: Deutsche Forschungsgemeinschaft (DFG)
In this project, the concept for managing and providing data of the Nexus world model is being developed. This concept consists of two main parts: The homogenization of the query processing, which integrates query-response, stream- and event-based inter-
action patterns, and the virtualization of the query processing, which allows for map-
ing the operators of a query to different execution nodes.

**SFB 627 – Project B5 – Dynamic, Time-Referenced Model Data**
Personnel: N. Hönle
Funded by: Deutsche Forschungsgemeinschaft (DFG)
The aim of sub-project B5 is to develop a history server that stores data histories from
spatial data streams. Our history server uses domain-specific pre-processing algorithms
to reduce the data volume. Furthermore a history warehouse with specialized opera-
tors to analyze spatial data histories will be developed.

**RADES**
Personnel: C. Dorda
Funded by: Daimler AG
Duration: 1.4.2002-30.9.2008
We are developing a generic approach for application integration by introducing an
abstract view based on model-driven software engineering approaches. A toolset- and
repository-based refinement of the abstract view supports developers to automate the
implementation of system integration landscapes.

**GIMMIC – Generic Integration Middleware for Mediating Informa-
tion Calls**
Personnel: R. Wagner
Funded by: partially IBM
Duration: 1.7.2001 - 30.11.2008
This project provides a generic integration middleware that allows to uniformly han-
dle and access existing and upcoming integration technologies. Integration compo-
nents like SQL wrappers and J2EE connectors can be seamlessly plugged into the me-
diating middleware and can be used by any client system.

**CEOPS – Cost-based, database-External OPtimization of query gen-
erating information Systems**
Personnel: T. Kraft, H. Schwarz
Funded by: partially Deutsche Forschungsgemeinschaft (DFG)
Duration: 1.3.2005 - 31.3.2009
The CEOPS project focuses on the cost-based optimization of generated sequences of
SQL statements. It extends the heuristic approach which has been developed as part
of the ORBIT project by a cost-estimation component. This cost-estimation compo-
Selected Research Projects

GSaME – Cluster E - Data Management and Information Provisioning in the Virtual Factory

Information management in today’s digital factories shows a multitude of unconnected, heterogeneous information systems without effective integration of data except along a few standard processes. To successfully run the virtual factory, it is crucial to introduce a service-based information integration management that enables a flexible information provisioning.

A Service Oriented Architecture (SOA) enables the factory’s information management to achieve a higher degree of flexibility and interoperability. Loosely-coupled services in a virtual manufacturing environment support flexible business process modelling methods by using service aggregation. Moreover, a SOA-based approach provides the required level of interoperability for the integration of the information systems needed for simulation, visualization and data analysis as used in the virtual factory that is a predecessor of what we ultimately call real-time factory.
The project “Data Provisioning for Scientific Workflows” is embedded into the Cluster of Excellence “Simulation Technology” (SimTech). The project goal is to provide a consolidated data management and data provisioning as well as data de-provisioning abstraction that is efficiently interfaced with scientific workflow technology and also applicable to novel workflow techniques and applications such as visualization and simulation computations. All this is done to enable engineers and scientists to work on novel and challenging simulation applications in an integrative systems science relieving them from tedious data management and workflow tasks as much as possible.
Research Focus

Image understanding denotes the multi-sensorial and knowledge based interpretation of situations, estimations of intensions and predictions of activities of the perceived objects. This division defines and develops distributed intelligent systems on macro- and microscopic scale:

- **Image Understanding**
  This scientific focus is devoted to the context based recognition of situations and the prediction of the behaviour of the detected objects. Such a cognitive interpretation of situations is usually distributed and has to be proved on consistency before it is transferred into a world model.

- **Multi-agent systems**
  Autonomous systems operate under self-control of their internal states, goals and actions and act usually without human interactions. Such systems are generally modelled by multiple agents. Representative applications are the development of autonomous cars and traffic management by these cars themselves.

- **Cognitive and evolutionary Robotics**
  Cognitive robots are provided with an elaborate cognitive architecture that cooperates closely with a controlling architecture in order to be able to act autonomous. This approach is a top-down proceeding to develop multi robot system like in RoboCup. On a microscopic level evolutionary robots are developed to investigate swarm intelligence.

- **Nonlinear dynamics and chaos theory**
  The dynamic of complex technical systems is usually nonlinear and therefore the behavioural prediction of such systems can only be done if a powerful simulation system is available. AnT (www.Ant4669.de) is a simulation system that supports a broad spectrum of analysis tools.
Research Projects
www.ipvs.uni-stuttgart.de/abteilungen/bv/forschung/projekte

CoPS – Cooperative Soccer Playing Robots Stuttgart
Funded by: Universität Stuttgart
Duration: since 1.7.2001
In 2008 our Multi-Robot-System was improved by implementing an arbitrary ball detection which enables the robot to detect any round ball given to it and to play soccer with it. In addition the robot hardware was redesigned with a four wheeled omnidirectional drive. Finally a reinforcement based strategy learning algorithm was implemented to adopt the team strategies during a match against another team on the opponents behaviour.
SFB 627 – Project C3 – Sensor-Supported, Context-Based Consistency Analysis  
Personnel: U. Käppeler  
Funded by: Deutsche Forschungsgemeinschaft (DFG)  
In subproject C3 concepts are developed for the evaluation of the quality of sensor data, in order to integrate indistinct measurements and inaccurate results into distributed environment models. Protocols and Metrics for the degradation of sensor data were developed to enable context aware applications to handle accuracy of context information.

SFB 627 – Project E3 – Distributed Situation Recognition Based on Evaluated Context Information  
Personnel: O. Zweigle  
Funded by: Deutsche Forschungsgemeinschaft (DFG)  
In subproject E3 we develop a distributed application-specific situation recognition based on evaluated context information. In 2008 we developed a situation recognition algorithm that is an extension to Bayesian networks. It integrates reinforcement learning methods to adopt continuously to Situations in the real world.

GOLEM – Bio-inspired Assembly Process for Mesoscale Products and Systems  
Personnel: S. Kernbach, F. Schlachter  
Funded by: European Community (EC)  
GOLEM is the acronym of a European research initiative to understand and investigate the use of bio-inspired bonds to self-assemble small components. The current research focus at IPVS consisted in the construction of a simulator capable of representing the behaviour of different DNA strands in a common environment. The objective of this simulator is to find feasible ways to perform perfect match self-assembly process.

Collective Microrobotics (SwarmRobot Project)  
Personnel: S. Kernbach, O. Kernbach, E. Meister, F. Schlachter, S. Popesku  
Funded by: Universität Stuttgart  
Duration: since 1.10.2004  
The main goal of this project is to develop a cheap, reliable and swarm-capable micro-robot that can be easily reproduced even at home. This robot allows building a large-
scale swarm system (100 and more robots) to investigate artificial self-organization, emergent phenomena, and control in large robotic groups.

SYMBRION - Symbiotic Evolutionary Robot Organisms
Personnel: S. Kernbach, O. Kernbach, F. Schlachter
Funded by: European Community (EC)
Duration: 1.2.2008 - 31.1.2013
The main focus of this project is to investigate and develop novel principles of adaptation and evolution for symbiotic multi-robot organisms based on bio-inspired approaches and modern computing paradigms.

REPLICATOR - Robotic Evolutionary Self-Programming and Self-Assembling Organisms
Personnel: S. Kernbach, E. Meister, S. Popesku
Funded by: European Community (EC)
Duration: 1.3.2008 - 28.2.2013
The REPLICATOR project focuses on the development of an advanced robotic system, consisting of a super-large-scale swarm of small autonomous mobile micro-robots that are capable of self-assembling into large artificial organisms.

Transfer Unit 059 – Transfer Project TF2 – Economic Transformability in the Medium Sized Production Business
Personnel: O. Kernbach
Funded by: Deutsche Forschungsgemeinschaft (DFG)
In the interdisciplinary project a Factory Cockpit is developed. The cockpit includes all necessary parts for providing up-to-date information for managers. Furthermore the managers can play with prospective situations and evaluate them through simulations.

ANGELS - Anguilliform Robot with Electric Sense
Personnel: S. Kernbach, D. Sutantyo
Funded by: European Community (EC)
The aim of the ANGELS project is to design and build a prototype of a reconfigurable Anguilliform swimming robot able to split into smaller agents (and vice-versa), each equipped with a bio-inspired “electric sense” used both for recognition of objects and communication between agents.
OCiND - Organizing centers in non-smooth dynamical systems: bifurcations of higher codimension in theory and applications
Personnel: M. Schanz, V. Avrutin, B. Schenke
Funded by: Deutsche Forschungsgemeinschaft (DFG)

The behavior of dynamical systems in extended parts of the parameter space is often organized by only a few bifurcations of higher codimension, so-called organizing centers. By identifying these organizing centers one is able to explain not only 1D bifurcation scenarios but also much more complex 2D and 3D bifurcation structures. The focus of the project lies on the investigation of bifurcations with codimension-2 and codimension-3 in dynamical systems with a discontinuous system function, which are an important class of models, representing an adequate description of many applications from such fields as electronics, mechatronics, mechanics, nano-technology and robotics.

Selected Research Projects
www.ipvs.uni-stuttgart.de/abteilungen/bv/forschung/projekte

REPLICATOR - Robotic Evolutionary Self-Programming and Self-Assembling Organisms

SYMBRION - Symbiotic Evolutionary Robot Organisms
In former projects in the field of swarm robotics (e.g. I-SWARM) the main focus was on collaborative and coordinated behavior on a swarm level. The REPLICATOR and SYMBRION projects leap forward to the next step in swarm robotics by combining the advantages of swarms with the advantages of reconfigurable robotics. The aim of the projects is to have a high number of stand-alone robots which are capable of aggregation. Once they are aggregated, they can share communication, energy and computational power.

Mainly, the SYMBRION project focuses on bio-inspired approaches like artificial evolution and learning of symbiotic or-
organisms, while the REPLICATOR project focuses more on adaptive systems for unstructured environments. The synergies of both projects pushes the development of hardware, electronic and software. The two platforms share common characteristics and are able to build flexible and adaptive structures for both unpredictable and unsupervised applications.

**ANGELS - Anguilliform Robot with Electric Sense**

ANGELS is a fundamentally interdisciplinary project which involves three scientific communities: roboticians, biologist, and physicist. The aim of the ANGELS project is to design and build a prototype of a reconfigurable swimming robot able to split into smaller agents (and vice-versa). Compared to the present existing solutions for Autonomous Underwater Vehicles (AUV) exploration, ANGELS first exploits the advantages of the anguilliform swimming mechanism which is the optimal morphology that nature has found for solving the trade-off between swimming efficiency, agility, and morphological simplicity.

Moreover, ANGELS will develop new hardware and software for a bio-inspired sense that has not been extensively explored by robotics until now: the electric sense. On this point, a new promising sensor technology is introduced, that can be applied in environmental exploration and inspection where vision cannot be used. Additionally, underwater collective robot behaviour is also investigated.
Research Focus

The basic research philosophy of the department parallel systems is the analysis and optimization of the hardware/software system performance with the focus on the interaction of the different levels of the system design. This includes the technological level of the hardware platform, the architectural level of the design and the algorithmic level of the application. Concerning the applications the resulting hardware/software systems is domain specific which leads to very compact high performance systems for desktop applications or very power efficient and space efficient high performance systems for mobile and embedded applications. Prototypes are built to demonstrate the efficiency of the approach.

One selected application domain is the electromagnetic field simulation. The research on a hardware/software system for the acceleration of these simulations is funded by a DFG priority program since 2004. This work will be extended to hardware/software systems for the acceleration of iterative solvers of linear systems of equations. Another area of research is a hardware/software platform for sensor data processing funded by the Graduate School for Advanced Manufacturing at the University of Stuttgart. This work will be extended to data processing in embedded systems and further application domains. Although these hardware/software systems differ with respect to their application domains considerably, common basic building blocks on the architectural level and on the level of the hardware platform can defined and reused for very different application domains. On the algorithmic level it will be more sophisticated to identify common functions or building blocks with respect to performance gains over implementations on general purpose hardware. Modifications on the algorithmic level can be essential for high performance results. The collaboration with groups of other disciplines especially on the algorithmic level of the application will support the performance results of the hardware/software systems.
Before joining the University of Stuttgart, Prof. Simon worked in the field of high speed digital interfaces and VLSI design in general for several years in industry as well as in academia with his research group which is a sound basis for the hardware implementation of high performance hardware/software systems. The second field of research he covered during his time in industry and in academia are efficient hardware/software architectures in the application domain of digital signal processing. The optimization of the architectures was based on the interaction of the algorithmic and architectural level. In addition in the last 4 years he worked on the acceleration of simulation algorithms for light scattering.

In February 2008 the former department “Integrated Systems Engineering” was renamed as the department “Parallel Systems”. Parallelism with respect to architectures, algorithms and hardware devices has been a field of research since the beginning of VLSI design and computer architecture research. Nevertheless the applications for parallel systems like SIMD-coprocessors for e.g. image processing or high performance supercomputers based on parallel processors are limited in number or in significance compared to the general purpose processor market which has been based on sequential processor architectures for over 30 years. The saturation of clock speed improvements to approximately 3GHz (because of physical effects like power dissipation or timing issues) led to current microprocessor architectures with several parallel cores on a single chip in the last few years to obtain further performance enhancements. For the foreseeable future general purpose processor cores with 10 to 100 cores on a single chip will replace the performance enhancements obtained by the increasing clock rates of the past. This fundamental change to parallelism in the general purpose processor domain raises a large number of new questions and fundamental problems in research like how to handle the increasing computing performance of the cores compared to the limited increase of I/O-bandwidth. In addition low cost parallel general purpose processor cores will enable new high performance hardware/software systems with respect to the chosen application domain. These new opportunities are the basic motivation for changing the research focus and name of the department to Parallel Systems.
Research Projects
www.ipvs.uni-stuttgart.de/abteilungen/pas/forschung/projekte

High Performance Hardware Platforms
Personnel: M. Wróblewski, J. Hillebrand
Funded by: Universität Stuttgart
Duration: Unlimited
The goal of the work is the design of high performance hardware platforms based on reconfigurable devices, general purpose processors and graphics processing units for specific application domains.

Enhancement of the Effective I/O-Bandwidth of High Performance Systems
Personnel: A. Balevic, S. Simon
Funded by: Universität Stuttgart
Duration: since 1.9.2007
The increasing difference between the performance of processor cores and the I/O-baudwidth leads to limitations which can be overcome by improving the efficiency of the I/O-data. This efficiency enhancement is especially applicable in reconfigurable
hardware systems on the bit-level but can also be extended to the general purpose processor domain.

**Modeling and Simulation of Light Scattering Metrology for Nanostructured Surfaces**  
**Personnel:** L. Rockstroh, W. Li, S. Simon  
**Funded by:** Deutsche Forschungsgemeinschaft (DFG)  
**Duration:** 1.9.2005 – 30.4.2009  
This project focuses on the simulation of measurement techniques for nanostructure surfaces based on the coherent light of a laser. This project is carried out in collaboration with the light scattering metrology group of the Bremer Institut für Messtechnik, Automatisierung und Qualitätswissenschaften of the University of Bremen. The contributions of the parallel system group at the University of Stuttgart are the simulation algorithms of the light scattering for nanostructured surfaces and their acceleration by parallel hardware.

**A Sensor Data Platform for Monitoring Production Processes**  
**Personnel:** L. Rockstroh  
**Funded by:** Graduate School for Advanced Manufacturing, Deutsche Forschungsgemeinschaft (DFG)  
**Duration:** 15.2.2008 – 30.4.2012  
The focus of this project is a scalable hardware platform for sensor data processing in a production environment with emphasis on real time constraints and robustness.

**A Wireless Transmitter Concept Based on Sigma-Delta-Synthesizers**  
**Personnel:** K. Merkle – external  
**Funded by:** Bundesministerium für Bildung und Forschung (BMBF)  
**Duration:** 30.9.2007 – 30.3.2009  
In this external research project a circuit concept for a wireless transmitter is investigated which replaces the A/D-converter of a wireless transmitter in order to simplify the hardware concept.

**Acceleration of Algorithms for In-Process Measurement Techniques of Nanostructured Surfaces**  
**Personnel:** N.N.  
**Funded by:** Deutsche Forschungsgemeinschaft (DFG)  
**Duration:** 15.6.2009 – 14.6.2011  
In this project the algorithmic part of measurement techniques with respect to acceleration is examined which can be applied to nanostructured surfaces. The work is
carried out in collaboration with the Institute of Measurement Techniques of Bremen University.

**Acceleration of Simulations of Electromagnetic Wave Propagation in Biomedical Applications**

*Personnel:* M. Grégoire  
*Funded by:* Landesstiftung Baden-Württemberg  

In collaboration with the “Institut für Lasertechnologien in der Medizin und Messtechnik” at the University of Ulm the accelerated simulation of electromagnetic wave propagation in biological cells are examined based on the classical finite difference time domain (FDTD) approach and the discrete dipole approximation (DDA) approach.

**Selected Research Projects**

**High Performance Hardware Platforms**

The high performance hardware platforms used for the hardware/software systems are developed by the research group in order to have enough flexibility to balance computational performance and the required amount of memory. Board design with complex integrated circuits and high speed digital interfaces up to 10Gbit/s have to be implemented. An example for the target architecture based on reconfigurable devices which can be plugged into a PC is shown in the figure.
Research Focus

Partial differential equations as a result of continuum scale models are the backbone of natural and engineering sciences since many years – and still very exciting. The quest for compute power rises continually as models get always more sophisticated by including more physical processes and combining several scales in space and time. So-called multi-physics, multi-scale simulations as well as optimization are the current trends of the field. The simulation of large systems group focuses in the following areas:

► Discretization schemes for partial differential equations such as discontinuous Galerkin methods, Eulerian-Lagrangian type schemes and mimetic finite differences.
► Fast solvers for systems of linear equations, in particular parallel multigrid methods based on agglomeration.
► Development of scalable and flexible scientific software in order to support the simulation workflow from problem definition to interpretation of the results. In particular the group is actively involved in the development of the „Distributed and Unified Numerics Environment“ (DUNE).
► Application of the above-mentioned methods and software to problems coming from flow and transport in porous media as well as computational neuroscience.

In September 2008 Prof. Bastian accepted an offer of the University Heidelberg and during the winter semester the group step by step moved to Heidelberg. Prof. Bastian would like to express his sincere thanks to all colleagues at the IPVS for the excellent atmosphere and the fruitful collaboration which will continue to some extent within the SinTech cluster. The projects listed below will be continued in Heidelberg.
Research Projects
www.ipvs.uni-stuttgart.de/abteilungen/sgs/forschung/projekte

Adaptive Modelling of Coupled Hydrological Processes
Personnel: C. Engwer
Funded by: Bundesministerium für Bildung und Forschung (BMBF)
Duration: 1.10.2007 – 30.9.2010
This project develops improved methods for the simulation of coupled surface and groundwater transport.

Signal Processing in Large Neuron Networks
Personnel: P. Drouvelis, D. Popovic
Funded by: Bundesministerium für Bildung und Forschung (BMBF)
Duration: 15.4.2007 – 14.4.2010
Aim of this project is the extraction of 3D morphologies of neurons from electron microscopy data and the development of an efficient simulator for signal processing in networks of neurons.
Efficient Numerical Methods for the Simulation of Multiphase-Multicomponent Processes in Porous Media
Personnel: S. Marnach
Funded by: Deutsche Forschungsgemeinschaft (DFG)
Duration: since 1.1.2007
In this project we develop a mimetic finite difference method for two-phase flow in porous media with applications in CO2 sequestration.

DFG-Forschergruppe “Dynamic Capillary Fringes”
Sub Project 2 “Numerical Methods for the accurate and efficient simulation of multiphase multicomponent reactive flow in the capillary fringe”
Personnel: S. Liu
Funded by: Deutsche Forschungsgemeinschaft (DFG)
Duration: since 1.10.2007
This research group studies the hydrodynamics and reaction processes in the capillary fringe. The task of our group is the development of a model including hysteresis and air entrapment.

DFG-Exzellenzcluster „Simulation Technology“
Personnel: S. Müthing
Funded by: Deutsche Forschungsgemeinschaft (DFG)
Duration: since 1.12.2007
As a part of SimTech this project will develop a multi-physics multi-scale software infrastructure for numerical simulation based on the Distributed and Unified Numerics Environment.

Virtuelles Institut „INVEST (Inverse Modelling of Terrestrial Systems)“
Project 1 “Forward Model Development”
Personnel: J. Fahlke
Funded by: Helmholtz-Gemeinschaft
Duration: since 1.3.2008
This project develops 3D parameter estimation techniques for multiphase flows in porous media.
Research Focus

Many recently evolving computing applications are highly distributed and are deployed on several possibly heterogeneous devices. Conventional system and communication architectures cannot always fulfill the various demands of these new applications in an acceptable manner. The research activities of the distributed systems group address these challenges by concentrating on the communication technology aspects of new application areas. Our research interests are not limited to the abstract consideration of system aspects, but also include practical distributed applications. The current research activities of the distributed systems group are best characterized by its current involvement in research projects (cf. project description section). The research is centred on the following themes and groups:

- **Context-aware systems** – in particular mobile systems – utilize information about the physical world to adapt automatically to the context of users. Here, we investigate mechanisms for realizing large-scale distributed context models and mechanisms for supporting mobile context-aware applications. This research is done within the Collaborative Research Center Nexus (SFB 627).

- **Adaptive Communication Systems.** Distributed applications deployed on large scale need to cope with a high degree of network dynamicity because of changes to the set of participating processes, failures or mobility of processes. The focus of our research is to support robust and reliable applications by devising communications abstractions with the ability to dynamically adapt according to the availability of resources.

- **Self-organizing software systems.** A self-organizing software system is able to adapt its structure to changing environmental conditions to optimize its operation. This is especially important for systems that do not allow manual maintenance due to their scale and dynamics. Here, we investigate new mechanisms and concepts for the self-organization in such systems.
Sensor Networks. Wireless sensor networks have been proposed as a way to unobtrusively gather real-world data. They consist of small networked devices equipped with sensors. The focus of our research lies on the software architecture and algorithms needed to deal with the increasing complexity of those systems. During this reporting period the Distributed Systems Group successfully organized three remarkable events in the context of Future Internet, Global Sensor Networks and Complex Event processing (cf. Section 2.6) involving participation from both industry and academia. Especially, the IPTC colloquium on Complex event-processing, which also marked the official beginning of the DHEP project, has drawn a lot of attention beyond the participants including the press.

Furthermore, the Global Sensor Grid project has started in May 2009. It is part of the German Cluster of Excellence on Simulation Technology (SimTech) at the Universität Stuttgart integrating six research areas to leverage the synergies of their isolated simulation approaches and enable an integrative systems science.

Besides the presentation of Nexus papers and demonstrators at various prestigious scientific events (cf. Section 2.6), Nexus prototypes developed by the Distributed Systems group were presented at two public events. First, at the Science Day (Tag der Wissenschaft) a novel context-aware instant messaging system was presented that enables users to address participants based on their current situation. This demonstrator was received very well by the visitors including groups of industry representatives and the rector of Universität Stuttgart Prof. Ressel. Second, in February 2009 Ralph Lange and Frank Dürr arranged a workshop on tracking moving objects for grammar school pupils who showed great interest in the concepts and practical implementation of novel mobile services.

In February 2009, Dr. Wolfgang Blochinger joined the Distributed Systems Group. As technical coordinator he is going to support the Collaborative Research Center Nexus.
ALLOW - Adaptable Pervasive Flows
Personnel: K. Herrmann, H. Wolf, C. Hiesinger, S. Föll
Funded by: European Community (EC)
ALLOW is a European research project funded under the 7th Framework Programme. Its objective is to develop a new programming paradigm for human-oriented adaptable pervasive applications. The core concepts of the project are Adaptable Pervasive Flows (APFs). APFs are employed for modeling the activities of the users involved in a pervasive application. This model is then used for adapting the environment to the user and his current needs.
AWARE - Platform for Autonomous Self-deploying and Operation of Wireless Sensor-actuator Networks Cooperating with Aerial Objects
Personnel: K. Herrmann, M. Gonzalo
Funded by: European Community (EC)
Duration: 5.6.2006 – 4.6.2009
AWARE is a European research project funded under the 6th Framework Programme. Its focus is to develop a platform for enabling the cooperation of autonomous aerial vehicles with ground wireless sensor-actuator networks, comprising static and mobile nodes. Especially in disaster relief scenarios, the AWARE platform will permit operations in areas that are difficult to access and that do not provide a communication infrastructure. This is achieved by combining diverse sensor systems. The distributed system research group is involved in the development of a respective middleware platform.

Cooperative Application-Level Services in Wireless Mesh Networks
Personnel: J.A. Briones
Funded by: Deutscher Akademischer Austausch Dienst (DAAD)
The project deals with the development of algorithms that support cooperative applications in Wireless Mesh Networks. The current focus is on algorithms which implement Publish/Subscribe and adapt to the variable network conditions in Wireless Mesh Networks. Furthermore, these algorithms need to perform also efficiently on infrastructure-based networks in order to facilitate the deployment and integration of applications that operate at the Internet scale.

DHEP – Distributed Heterogeneous Event Processing
Personnel: B. Koldehofe, B. Schilling
Funded by: IBM
Duration: 1.3.2008 – 28.2.2010
The DHEP project explores new ways in order to increase the scalability and availability of existing complex event processing technology. The project aims at developing a highly interoperable framework that enables distributed event processing over heterogeneous networks and heterogeneous event correlation technology. Furthermore, the project researches on adaptive operator placement strategies that account for the heterogeneity of involved correlation nodes.
Global Sensor Grid
Personnel: K. Herrmann, B. Koldehofe, A. Benzing
Funded by: Cluster of Excellence Simulation Technology
Duration: 1.5.2008 – 30.4.2011
The Global Sensor Grid project is part of and funded by the Cluster of Excellence Simulation Technology (SimTech). Its goal is to connect and integrate the growing number of wireless sensor networks together with other sensor data sources into a so-called sensor grid. This provides simulations access to real-time data collected by a huge number of sensors and efficient means to control the data gathering process.

EMMA - Embedded Middleware In Mobility Applications
Personnel: K. Herrmann, N. Ayllón Martin
Funded by: European Community (EC)
Duration: 1.5.2006 – 31.10.2008
EMMA (Embedded Middleware in Mobility Applications) is a Framework 6 European research project in which an embedded middleware platform is developed that supports wireless cooperating objects. Such objects may encapsulate arbitrary sensors in the automotive and logistics domain and enable these sensors to interact in a uniform way. This provides new ways of cooperation, e.g. between the different subsystems of a car, between cars, and even between cars and a road-side infrastructure.

NET - Network Emulation Testbed
Personnel: K. Herrmann, A. Grau
Funded by: Deutsche Forschungsgemeinschaft (DFG)
The NET project is building an emulation testbed for running evaluations of real software systems. New concepts of node and time virtualization are used on a computer cluster to achieve a versatile emulation environment that uses the cluster’s resources optimally and runs emulations in minimal time.

3PC - Peer-to-Peer Pervasive Computing
Personnel: K. Herrmann, S. Schuhmann
Funded by: Deutsche Forschungsgemeinschaft (DFG)
The 3PC project is funded by the DFG and investigates software architectures, algorithms, and protocols that support the adaptation of pervasive computing systems. Distributed applications are modeled as components and complex applications may be composed and adapted automatically through the middleware platform developed in this project.
Project A2 in the SFB Nexus researches context-aware communication paradigms based on the Nexus world model. In particular, we investigate overlay networks and context-based routing mechanisms to disseminate messages. During the last year, we focused on a temporal addressing, i.e. past and future contexts, while protecting the clients’ privacy.

Project B3 of the SFB 627 investigates mechanisms to efficiently acquire and manage dynamic context data in hybrid system structures where infrastructure-based and infrastructure-less ad-hoc networks are integrated. For the acquisition of data cheap and simple RFID-based sensors are used together with mobile nodes with integrated RFID readers that read sensors and communicate the readings.

This project focuses on management of dynamic context information – particularly moving objects’ trajectories. In the last year, we proposed several protocols for real-time transmission of trajectory data from moving objects to remote databases optimizing communication costs and storage consumption [LDR08, LFDR09]. Besides, we developed the Distributed Trajectory-based Index (DTI) for efficient processing of trajectory-based queries in space-partitioned moving objects databases [LDR08b].

Within the SFB 627, this project focuses on the recognition of meaningful high-level situations based on available context information. For example, the current activity in a room (like a meeting or a lecture) could be inferred from ambient sensors. In particular, we investigate how current AI methods can be efficiently distributed over available
network nodes to increase accuracy and timeliness of recognition with low resource consumption.

**SpoVNet**
Personnel: B. Koldehofe, G.Koch, A. Tariq
Funded by: Landesstiftung Baden Württemberg

SpoVNet’s goal is to meet the requirements of the next generation Internet by providing QoS-aware communication which can be deployed on heterogeneous devices and networks. At the IPVS, event service overlays are investigated that use cross layer information to meet QoS requirements. While many event services focus only on event notification, SpoVNet’s event service also supports the correlation and composition of events.

**OID - Optimized Information Discovery in P2P Overlay Networks**
Personnel: F. A. Memon
Funded by: Universität Stuttgart
Duration: since 1.12.2006

This project deals with the optimization of complex queries in P2P overlay networks, with main focus on multi-attribute range queries. Given a set of queries that have been previously monitored in a P2P overlay network, the goal is to optimize the search index for these queries. Such an optimization leads to significant improvement in overall system performance in terms of scalability.

**UP2P - Uniform Peer-to-Peer Protocols for Heterogeneous Networks**
Personnel: B. Koldehofe
Funded by: Deutscher Akademischer Austausch Dienst (DAAD)

The project on uniform peer-to-peer computing (UP2P) is a research cooperation between the IPVS and the University of Lisbon to establish and intensify cooperation between young researchers and Master Students in Germany and Portugal. The goal is to identify overlay structures that can be deployed at low cost over heterogeneous networks, for instance over ad-hoc and infrastructure networks.
Selected Research Projects

DHEP – Distributed Heterogeneous Event Processing
The objective of the DHEP project is the investigation of high performance and scalable complex event processing in the context of business and manufacturing solutions. Complex event processing is a technology which allows correlating basic events to complex events closely aligned with the semantics of business processes related to the events. Traditionally, complex event processing has been done in centralized systems. In order to ensure scalability with increasing number of data sources and sensor data, distributed event processing has gained attention recently. The DHEP project aims in overcoming a major obstacle in the deployment of current approaches in the context of business applications by considering event correlation over heterogeneous networks and correlation engines.

The framework allows the efficient processing of events without touching the processing systems, such as correlation engines, themselves. Therefore, the user is free to utilize any needed event processing technology and system setup, while the DHEP framework will ensure the communication and interoperability of the networks components. Moreover, a major goal of the project is optimize the event processing in the present network by using self-adapting rule placement strategies taking the heterogeneity of the underlying correlation technology into account. The DHEP project is funded by IBM Deutschland as part of the IBM Technology Partnership Center (ITPC). It involves researchers from both the IBM lab and the IPVS.

Global Sensor Grid
The Global Sensor Grid project is part of the Cluster of Excellence Simulation Technology (SimTech). SimTech gathers researchers from six areas to leverage the synergies of their isolated simulation approaches and enable an integrative systems science. Interdisciplinary intersections are covered by research networks formed across these areas. This project is part of the network that covers integrated data management, workflow and visualization to enable an integrative systems science.
The goal of the Global Sensor Grid project is to connect and integrate the upcoming huge number of sensors and sensor networks in a common middleware. Numerous data sources can then be shared by a wide range of applications. Especially, the provision of measurements with low latency for real-time simulations presents a new challenge in this context. To handle the enormous amount of and provide efficient access to data generated by the sensors, robust and scalable algorithms will be developed based on the concept of distributed stream processing. New mechanisms provide the simulations with the ability to dynamically change the set of data sources and the quality of service provided by the Global Sensor Grid.

SFB 627 - Project B3 - Hybrid Model Management

The objective of project B3 is to efficiently manage dynamic context data in hybrid system structures where infrastructure-based and infrastructure-less networks are integrated. Beyond the support for geographic location models, we further aim at the support of symbolic and hybrid location models as a base for the context management system. Recently, we investigated mechanisms for efficiently collecting and storing sensor readings in hybrid system structures. These mechanisms are based on a scenario with simple and cheap RFID-based sensors and mobile devices like mobile phones with integrated RFID readers. In our system, mobile nodes cooperatively read sensors installed in the environment as they pass by and transmit the data to a server infrastructure. To achieve quality requirements in terms of sensor value timeliness and efficiency in terms of communication cost and energy consumption, we developed several algorithms for coordinating update operations. According to one algorithm, mobile nodes form an ad-hoc network for the cooperative management of requested update times to meet the desired update interval and to avoid
redundant sensor reading and collisions during read operations. The figure depicts a simple example for a coordination task handled by the algorithm. This figure shows five nodes, N1 to N5, moving from left to right, and a sensor R. Node N5 reads sensor R in the top part of the figure and, since duplicate reading is not required, allows node N4 to pass by the sensor in the bottom part without reading. When nodes N1 and N2 get into read range, only one is actually required to read the sensor. Besides the decentralized coordination algorithm, we also developed a complementary algorithm that exploits infrastructure-based coordination [WDR09]. In cooperation with other projects, we developed an extended architecture for the Nexus system [LCG+09] including components for context model management in hybrid systems.
Context-aware applications consider 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. We envision that in the near future many applications will be context-aware. Context aware applications fundamentally rely on context models. Typically, these models include stationary objects, like streets or buildings, as well as mobile objects, such as people or vehicles. Sensors located in our physical environment collect detailed context information which is fed into spatial context models.

The Collaborative Research Center 627 “Nexus”: Spatial World Models for Mobile Context-Aware Applications has been established at the University of Stuttgart in January 2003 and is funded by Deutsche Forschungsgemeinschaft (DFG). Nexus is headed by Prof. Rothermel from IPVS and consists of 17 research projects including 7 projects from IPVS. The center’s multidisciplinary research activities focus around the vision of a World Wide Space, which we envision to be the common base for future context-aware applications. Specifically, the World Wide Space provides the conceptual and technological framework for integrating and sharing context models at a global scale. In analogy to the World Wide Web, independent providers of context information can “place” individual models into this space which are federated into a global and consistent view on the context data. Particularly, quality aspects of context play an important role in almost all areas of research in Nexus. These investigations focus on quality concepts and metrics as well as algorithms considering context quality.
In 2008 and 2009, researchers of Nexus presented their work on numerous conferences. Among others, prestigious scientific events, such as the International Conference on Mobile Data Management (MDM ’08), the Annual International Conference on Mobile and Ubiquitous Systems (MobiQUITous ’08), and the ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems (ACM GIS 2008) can be addressed.

To demonstrate the potential of context-aware systems we have designed a number of prototype systems which we presented at various major conferences such as PerCom 2009 (IEEE International Conference on Pervasive Computing and Communications) and MiNEMA (Middleware for Network Eccentric and Mobile Applications) 2008 workshop, collocated with the EuroSys 2008 conference in Glasgow.

Moreover, the results of the latest research of Nexus were presented at two public events. On June 21, at the Science Day (Tag der Wissenschaft) a novel context-aware instant messaging system was presented that enables users to address participants based on their current situation. This demonstrator was received very well by the visitors including groups of industry representatives and the rector of Universität Stuttgart Prof. Ressel who did not miss the opportunity to send and receive a couple of contextual instant messages using our system. Besides this instant messenger, the guests used the Nexus Explorer to visualize the processes and context-models of the Nexus Smart Factory.

On February 20, Ralph Lange and Frank Dürr arranged a workshop on tracking of moving objects for grammar school pupils interested in the computer science study course. After an introductory to the conceptual and technical background of mobile object tracking, the pupils tried out a prototypic implementation of the latest remote trajectory simplification algorithm [LFDR09] and improved the visualization of the objects’ movements in Google Earth in a brief programming tutorial.

Brief descriptions of the IPVS projects that are part of Nexus can be found in the department sections of this report.
Scope

The group “Infrastructure” is responsible for all tasks referring to the administrative and technical management of the IPVS. At the time the institute had been founded, the responsible persons decided to join the administrative as well as technical resources in one department to create a skilled and efficient support team for the institute.

The department acts today as a service provider for the five operational research groups of the institute. Project coordination, administrative management and information technology support are the major areas of responsibility.

Project Coordination: The main focus comprises the support of the acquisition and management of national as well as European collaborative research activities in basic and applied research for all the other departments. Among others the administrative and financial management of the Collaborative Research Center 627 – Nexus is settled here since 2003. Since 2008 the administrative coordination of three collaborative projects funded by the European Community has been added. These tasks as well as the management of the department itself, the organization of workshops and conferences or the publication of reports are being taken up by the project coordinator.

Administrative Management: The management joins the resource management (personnel and finances) of the institute’s budget as well all third party collaborative projects. In particular the daily financial accounting transactions, purchases, personnel administration, travel arrangements and much more are performed.

Information Technology Support: The IT support (Computer Lab) is responsible for the daily operation and maintenance, as well as planning and purchasing the central IT resources of the institute. Several hundreds of computer systems ranging from laptops and PCs up to compute servers and clusters are managed by the Computer Lab.
The local network and the connection to the faculty-wide net is also being administered. Additionally all the required basic software services in a heterogeneous OS environment are provided.

Staff
## Teaching

<table>
<thead>
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<th>Category</th>
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<td>Number of Diploma Thesis</td>
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<td>Number of Master Thesis</td>
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<td>Number of Student Thesis</td>
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The Institute participates in the following study programs:

**Diploma in Computer Science:** Computer science generally uses formal (mathematical) and engineering-based methods to solve problems. Both software and hardware systems form the focus of the program, both as research objectives and as tools.

**Diploma in Software Engineering:** This course is oriented towards the everyday tasks of software developers and managers in industry. Students learn how to specify, design, and implement software systems, and are introduced to software project management and quality assurance. Large projects and team-work are essential aspects. This course, which is unique in Germany, has been awarded a national prize and been given an excellent rating by an international evaluation team.

**Msc. in Information Technology:** This is an international master program. Information Technology stands for enabling technologies like hard- and software design, electronic and photonic components, computer and communication systems, communication networks, multimedia, traffic and process control systems. It further stands for innovative solutions in areas like mobile/fixed communication, Internet, automotive and industrial automation.

**Bsc. in Information Systems:** The ubiquity of information systems and communications systems in today’s economy makes it necessary to have a profound understanding of the interrelationships between business processes, organisational design and the use of IT. Teaching methodological expertise and professional competence for analysis, design and implementation of IT solutions is the primary aim of the program. Basics in mathematics and statistics are part of the program as well as classes in social sciences, economics, business administration and computer science.

**Msc. in Information Systems:** The program offers a high number of special courses and course clusters in social sciences, economics, business administration and computer science to deepen the topics introduced in the Bsc. program.
Dissertations
and
Postdoctoral
Qualifications
Dissertations

Lachenmann, Andreas
Cross-Layer Framework for Sensor Networks

Supervisors: Prof. Rothermel, Prof. Marrón

Cross-layer interactions are often used in wireless sensor networks. They help to optimize energy consumption, deal with memory limitations, and consider the special properties of wireless communication. However, cross-layer interactions have the disadvantage of negatively affecting desirable properties of the software design like modularity and reusability. In the extreme, applications consist of a monolithic piece of code that is hard to develop and impossible to maintain. Therefore, this thesis investigates different approaches to address the negative side-effects of cross-layer interactions. In particular, it develops a framework that pursues three different strategies.

First, it tries to preserve modularity and increase reusability by decoupling components that exchange data. This strategy is realized by TinyXXL, a programming abstraction for cross-layer data exchange. This part of the framework has been created based on an analysis of cross-layer interactions in existing applications. With some compile-time optimizations TinyXXL can reduce both energy and memory consumption compared to an application built from reusable components. Using Neidas, a novel neighborhood data sharing algorithm, it offers a comprehensive system for data exchange among the layers of a single node and with neighboring nodes.

Second, the framework relaxes one of the constraints that often lead to cross-layer interactions and, thus, decreases the need to apply them. Specifically, it includes ViMem, a flash-based virtual memory system that helps to reduce memory limitations and tries to optimize the memory layout.

Finally, the third strategy is to partially move energy concerns into the system software. For this purpose the framework includes Levels, an abstraction to specify optional functionality which allows to accurately meet a user-defined lifetime goal. If necessary, Levels deactivates functionality in order to reach that target lifetime. Furthermore, it includes a distributed algorithm that helps to provide a constant application quality over the total network lifetime.
**Lammert, Robert**

Programmiersprachen- und Entwurfskonzepte bei der Entwicklung von Simulationswerkzeugen mit Anwendungen im maschinellen Lernen und Planen

**Supervisors:** Prof. Levi, Prof. Leymann

Within this dissertation, the development of the AnT 4.669 simulator, its architecture, and the influence of some concepts of programming languages, especially during the design phase, were presented. By means of the AnT 4.669 simulator a scenario was developed and investigated, where planning in the state space was coupled with reinforcement learning (RL). Many concurrently (and, if required, bidirectionally) processed plans are hereby considered as the population of an evolutionary algorithm (EA). As a consequence, the learning process can be accelerated, as each individual is able to make a contribution which improves the RL strategy. A major benefit of this approach is that RL enables explorative behaviour, possibly leading to an optimisation of the overall system. The scenario also demonstrates that not only static, i.e. time-invariant, but also dynamic, i.e. time-variant (in this case periodically occurring) targets are suited to reinforcement learning.

**Rajaie, Hamidreza**

Distributed Architecture for Mobile Robots

**Supervisors:** Prof. Levi, Prof. Roller

This work originates from the context of the RoboCup project at the Institute of Parallel and Distributed Systems at the University of Stuttgart. The focus points of the thesis are as follows:

- Development of a distributed software architecture for the processing units of mobile robots.
- Design and development of different mobile robot platforms with distributed control architecture which can participate in the RoboCup world competitions. These robots have been used as test platforms for the proposed software architecture.
- Development of a distributed simulator architecture for the mobile robots.
Regele, Ralf
Cooperative multi-robot path planning by means of heuristic priority adjustment

Supervisors: Prof. Levi, Prof. Dillmann

This thesis introduces a new highly dynamic algorithm for a distributed, cooperative path planner. The core idea of the approach is the heuristic adjustment of priorities based on cooperative negotiations between the robots. It is especially designed to be applicable in systems with high numbers of robots, where the usability of centralized approaches is limited due to their complexity. The developed CoDy (Cooperative Dynamic)-algorithm provides a very robust solution for the general multi-robot coordination problem by delivering a deadlock-free path planning for all participating robots and was tested successfully not only in simulation but also using real multi-robot systems. Even complex situations like mass crossovers multiple intersections or situations with narrow bottlenecks could be handled.

Postdoctoral Qualifications

Schwarz Holger
Query-generating Systems: Applications, Implementation and Optimization Concepts

Supervisors: Prof. Mitschang, Prof. Freytag

Many information systems generate queries in order to access data in heterogeneous data sources. In this thesis, we discuss various aspects of query-generating systems. In the first part, we focus on important properties of such systems, like flexibility, adaptability and maintainability. Furthermore, we discuss the main strategies to generate queries and how they influence the architecture and characteristics of the resulting system. In the second part, we provide an in-depth analysis of approaches to optimize generated queries. This covers traditional query optimization and multi-query optimization as well as the optimization of heterogeneous data management tasks that are connected by complex control flow.
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Events
First Workshop on Architectures, Services and Applications for the Next Generation Internet

http://www.spovnet.de

On the 17th of July the SpoVNet project organized the First Workshop on Architectures, Services and Applications for the Next Generation Internet that was held in Schloss Karlsruhe. The workshop intended to provide a platform to familiarize and share ideas, trends, and approaches to the Next Generation Internet and attracted more than 40 participants from academia and industry. The program covered challenges and vision, initiatives and approaches as well as services and applications for the Next Generation Internet. Four invited speakers from industry and research institutions, Jürgen Quittek (NEC), Tanja Zseby (Fraunhofer), Wolfgang Kellerer (DoCoMo), and Udo Pletat (IBM) addressed in their presentations problems and approaches, traffic monitoring, heterogeneity in wireless networks and event-processing in the context of distributed manufacturing systems. Moreover, three talks by Oliver Waldhorst, Sebastian Mies, and Boris Koldehofe highlighted how SpoVNet addresses the transition towards the Internet of the next generation.

ITPC Colloquium on Distributed Hierarchic Event Processing

http://itpc.informatik.uni-stuttgart.de

On the 6th of November the DHEP project was introduced in a colloquium organized in the context of the IBM Technology Partnership Center (ITPC). The colloquium was held in the development laboratory of the IBM and involved 70 participants. In his talk on “Complex Event Processing in a Complex World” Kurt Rothermel emphasized the need for solutions based on distributed complex event processing in order to cope with high event rates and avoid bottlenecks of centralized solutions. Moreover, Udo Pletat (IBM) offered examples for using complex event processing in the industrial context and highlighted the importance of scalable complex event processing. Finally, Boris Koldehofe and Björn Schilling presented the approach taken within the project towards providing a highly scalable event correlation framework that can exploit heterogeneous event correlation technology. The event has drawn the attention of Computer Zeitung who reported about the event in their issue of December 15th.
First Workshop on Global Sensor Networks (GSN’09)

http://ipvs.informatik.uni-stuttgart.de/vs/gsn09

On the 6th of March Klaus Herrmann and Boris Koldehofe organized the First Workshop on Global Sensor Networks which was held in Kassel and collocated with the conference on “Kommunikation in Verteilten Systemen” (KIVS’09). The goal of the workshop was to gather researchers and practitioners working in relevant fields in order to share ideas, challenges and visions on Global Sensor Networks as well as to foster new cooperation. The workshop attracted 25 participants from academia and industry coming from four different countries (Germany, France, Switzerland, and Netherlands). Seven accepted papers, two of which came from industry (Micromata and Siemens), covered important topics related to global data processing, security, and overcoming the heterogeneity of sensor nodes. In a final wrap-up and vivid discussion the workshop participants exchanged their view on many challenges of GSNs, such as dealing with high data volumes and delay, the challenge of actuation in GSNs, the appropriateness of current overlay networks in GSNs, building federations and hierarchies of GSNs, security and privacy, data prediction, the relation of GSNs and the Internet of Things, as well as testbeds and applications. A report of the event can be accessed from the workshop homepage. Furthermore, a continuation of the workshop, possibly as part of cooperation with other activities in the field, is currently in planning.
Professional Activities
## Professional Activities

### Memberships

**Avrutin, Viktor**
- SICC (Italian Society for Chaos and Complexity)

**Herrmann, Klaus**
- ACM

**Hillebrand, Jürgen**
- EuMA (European Microwave Association)

**Koch, Gerald**
- Gesellschaft für Informatik
- IEEE

**Koldehofe, Boris**
- ACM

**Levi, Paul**
- Gesellschaft für Informatik
- Faculty Council
- Board of Directors IPVS
- IFAC
- Admission Committee Infotech
- Examination Committee Infotech
- Director FZI Karlsruhe
- Informatik Verbund Stuttgart

**Mitschang, Bernhard**
- Faculty Council
- Board of Directors of IPVS
- Head of Institute (temporarily)
- Deputy head of collaborative research center 627
- Head of Gemeinsame Kommission Wirtschaftsinformatik
- Director of GSaME Cluster ‘Information and Communication Technologies’
- Principal Investigator at GSaME
- Principal Investigator at SimTech
- Leitungsgremium der GI-Fachbereiche Datenbanken und Informationssysteme
- IEEE SMC Technical Committee on Computer Supported Cooperative Work in Design

**Rothermel, Kurt**
- Erweitertes Leitungsgremium der GI-Fachgruppe “Kommunikation und Verteilte Systeme”
- Faculty Council
- Board of Directors of IPVS
- Scientific Council of IZKT
- Head of SFB 627 (Nexus – Spatial World Models for Mobile Context-Aware Applications)
- Münchner Kreis

**Schanz, Michael**
- Gesellschaft für Informatik
- DPG (Deutsche Physikalische Gesellschaft)
- SICC (Italian Society for Chaos and Complexity)

**Simon, Sven**
- Faculty Council
- Board of Directors IPVS
- VDE
- Informatik Forum Stuttgart (infos)
- Deutscher Hochschulverband

**Program Committees**

**Dürr, Frank**
- First International Conference on Intensive Applications and Services (INTENSIVE 2009)
- Seventh IEEE International Conference on Pervasive Computing and Communications (Percom 2009) – Work in Progress Track
Großmann, Matthias
▶ The Sixth International Conference on Ubiquitous Intelligence and Computing (UIC-09)

Herrmann, Klaus
▶ SAKS 08 Workshop über Selbstorganisierende, Adaptive, Kontextsensitive verteilte Systeme
▶ PERADA workshop on Pervasive Adaptation held at SASO 2008
▶ PerAda Special Session on Adaptation Strategies for Pervasive Adaptation at the IEEE Congress on Evolutionary Computation (CEC) 2009 in Trondheim, Norway

Kaiser, Fabian
▶ EC-Web 2008: 9th International Conference on Electronic Commerce and Web Technologies, September 1-5, 2008, Turin, Italy

Koldehofe, Boris

Mitschang, Bernhard
▶ Twelfth East-European Conference on Advances in Databases and Information Systems, ADBIS, 2008
▶ 24th International Conference on Data Engineering, ICDE, 2008
▶ 7th ACM International Workshop on Data Engineering for Wireless and Mobile Access, MobiDE, 2008
▶ 11th Int. Conference on Computer Supported Collaborative Work in Design, CSCWD, 2008
▶ 24th Brazilian Symposium on Data Base, SBBD, 2009
▶ 10th International Conference on Mobile Data Management: Systems, Services and Middleware, MDM, 2009
▶ First International Workshop on Quality of Context, QuaCon, 2009
11th Int. Conference on Computer Supported Collaborative Work in Design, CSCWD, 2009
13th IFAC Symposium on Information Control Problems in Manufacturing, INCOM, 2009

Rothermel, Kurt
- WEWSN 2008, Workshop on Energy in Wireless Sensor Networks to be held in conjunction with DC OSS 2008, June 14, 2008, Santorini Island, Greece
- AmI 08, European Conference on Ambient Intelligence, Nov 08, Nürnberg, Germany
- ICDT 2008, Third International Conference on Digital Telecommunications, June 29 - July 5, 2008 - Bucharest, Romania
- ICPP 2008, International Conference on Parallel Processing, September 8-12, 2008, Portland, Oregon, USA
- MSN 1008, The 4th International Conference on Mobile Ad-hoc and Sensor Networks, 10 - 12 Dec 2008, Lake View Hotel, Wuhan, China
- PerCom 2009, Seventh Annual IEEE International Conference on Pervasive Computing and Communications, Galveston, Texas, March 9-13, 2009
- 16. GI/ITG-Fachtagung KiVS, March 2-6, 2009, Kassel, Germany
- CommVe, The 1st International Workshop on Concepts of Massively Multiuser Virtual Environments at the , March 5, 2009, Kassel, Germany

Schwarz, Holger
- X Brazilian Symposium on Geoinformatics (GEOINFO 2008). Rio de Janeiro, Brazil, December 2009
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