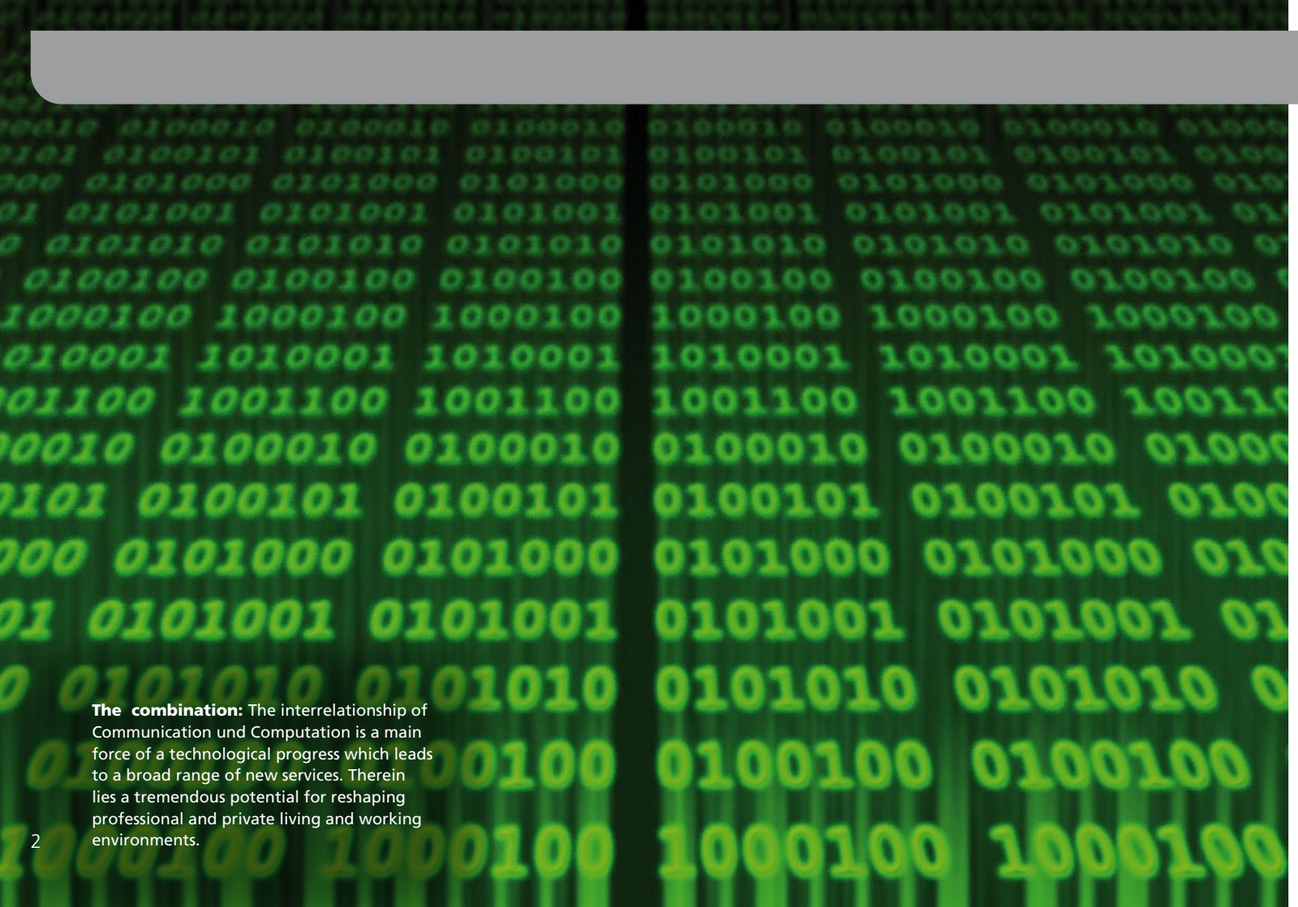
Karlsruhe Institute of Technology

Communication meets Computation

KIT FOCUS COMMPUTATION



The combination: The interrelationship of Communication und Computation is a main force of a technological progress which leads to a broad range of new services. Therein lies a tremendous potential for reshaping professional and private living and working environments.

Communication and Computation Research at KIT

Communication and Computation are inherently connected to technological progress which is transforming our world: We are surrounded by increasingly larger collections of intelligent embedded devices empowering a range of objects in our vicinity with capabilities to interact, to perceive their environment, and to adapt to dynamically changing requirements. An adequate response to these challenges depends on a deep understanding and an intelligent exploitation of communication and computation, or, to emphasize their interrelationship, of COMMputation.

KIT Focus COMMputation: mission and strategy

The KIT Focus COMMputation addresses the challenges of adequate management and control of complex technical systems.

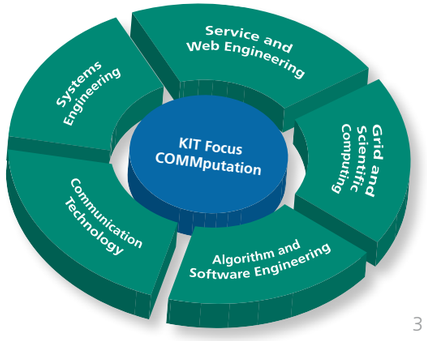
By combining the interdisciplinary expertise of researchers in informatics, electrical engineering and economics COMMputation focuses on concepts, architectures, methods, tools, and applications of information processing, communication technology, organizational and service-oriented principles, in order to enable their trustworthy, robust, and efficient operation.

The activities of the KIT Focus COMMputation are clustered in five topics:

- Service and Web Engineering
- Grid and Scientific Computing
- Algorithm and Software Engineering
- Communication Technology
- Systems Engineering

The knowledge triangle

Like the European Union, KIT emphasizes the knowledge triangle: Research – Education – Innovation. Its proximity to top-ranking research makes education and training at KIT highly attractive. At the same time, KIT uses its enormous innovative potential as a partner in cooperation with industry to ensure that excellent research findings are turned into commercially viable products in near real time.



TOPIC 1: Service and Web Engineering

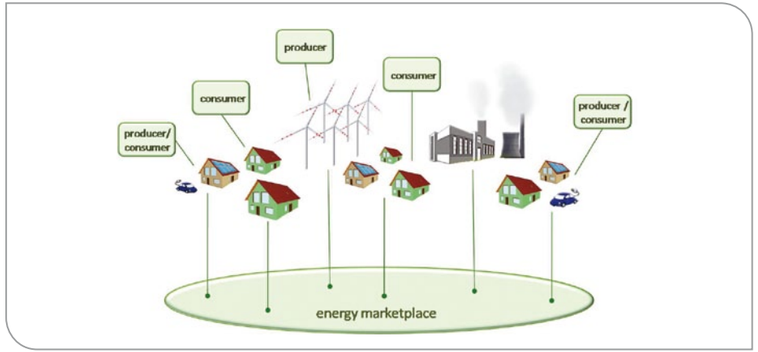
Service and Web Engineering: Building scalable solutions for the modern Web.

The Web has grown into a ubiquitous environment serving all aspect of modern business and life. Unlike in the early days of electronic commerce, today all forms of business exist in the Web, ranging from mobile commerce to social commerce to business networks. Most notably, people are increasingly connected through social networks and messaging services, which have reached an unprecedented scale. The growth continues even further, as new applications and new opportunities emerge.

Scalable solutions

Dealing with „Internet-scale" is one of the main challenges in the area of Service and Web Engineering. For all services in the Web, a scalable, dependable software architecture is a key component", says topic speaker professor Stefan Tai. Particular attention is given to cloud computing research and experimentation: the combination of virtualization technology, Web technology, service-oriented platforms and innovative applications gives rise to the next-generation of the Web.

One of the projects related to the Topic Service and Web Engineering is called Advanced Context Technologies for Collaborative Enterprise (EU IP Active). Up to 2011, scientists have worked on increasing the productivity of knowledge workers. The goal was to convert tacit and unshared knowledge – the „hidden intelligence" of enterprises – into transferable, interoperable and actionable knowledge.



Aiming at additional values: The scientists analyze distributed and enhanced service scenarios.

Powerful and intelligent: Grid, Cloud and High Performance Computing form the seamless integrated working environments at KIT and are research and development aspects at SCC, the Steinbuch Centre for Computing.

TOPIC 2: Grid and Scientific Computing

High Performance Computing (HPC), Grid and Cloud computing form seamless integrated working environments at KIT. Demanding applications are in the domain of climate and environment, bio-technology, energy research and nano-computing. In these areas, models, algorithms and infrastructures have to scale with rapidly increasing computational demands and data volume but also energy-efficiency aspects.

"To realize an increased uptake of HPC, Grid and Cloud computing by scientific users an integration of compute resources and data management solutions in the scientific lifecycle and easy-to-use interfaces, portals and middleware solutions combined with powerful storage connections is needed", says topic speaker Professor Achim Streit. New mathematical models for numerical simulation and optimization with adaptive methods, as well as innovative solutions for 3D visualization of the scientific results are required. To realize these goals, the topic "follows an integrated approach from the mathematical models to the hardware infrastructure and develops suiting software services", adds deputy topic speaker Professor Vincent Heuveline.

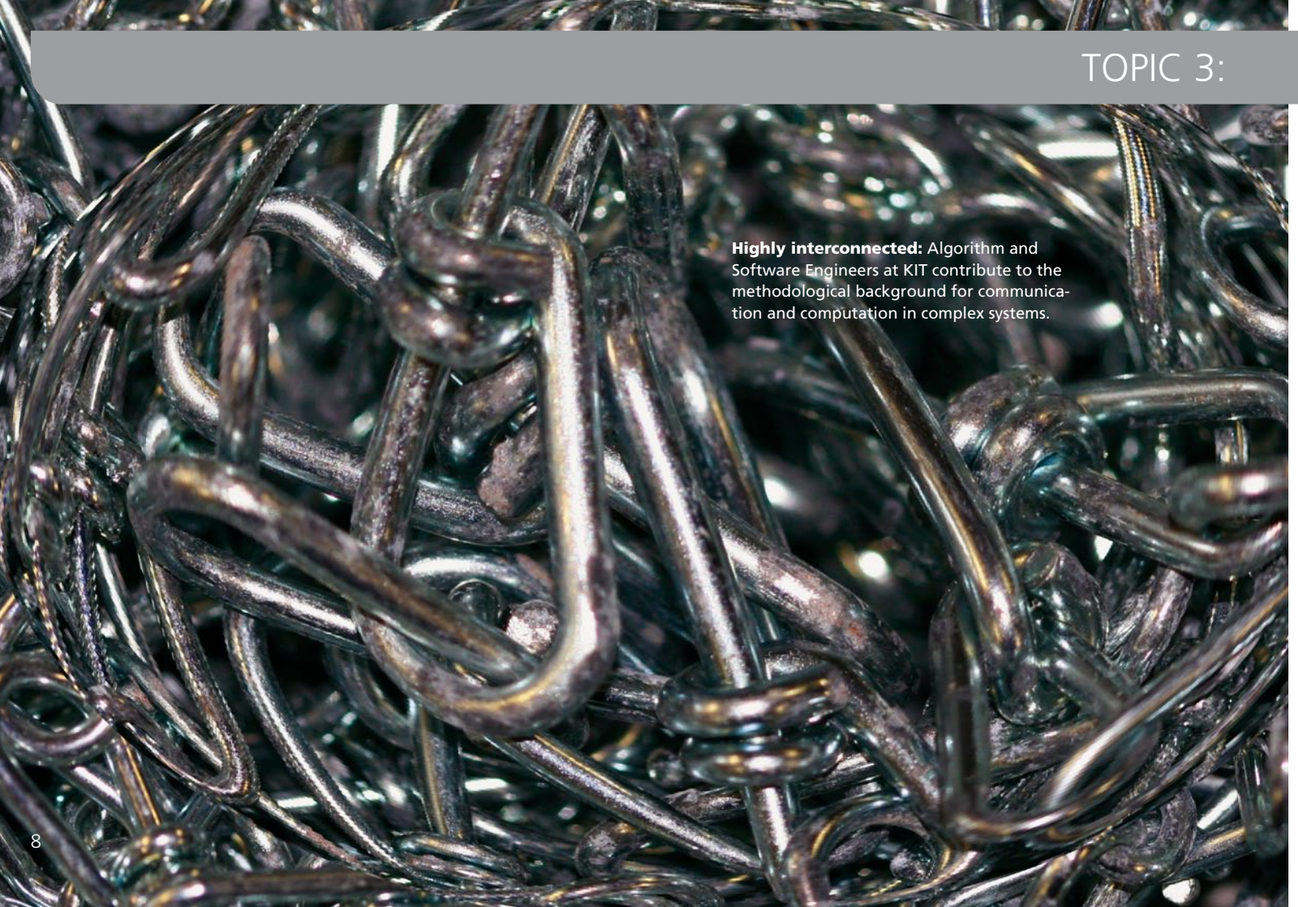
Major interest: the integration of Cloud services in a production environment.

Model adaptation

Scientific computing at KIT in general deals with model adaptation: the complexity of the considered application may impose the cascadic treatment of hierarchical models. KIT researchers work on the accurate and efficient computation of the value of techniques based on automatic model adaptivity.

Optimization

Improving the management of HPC resources, Grid and Cloud computing with optimized protocols, network and resource usage is another research topic KIT scientists are working on. One of their main efforts is to help scientists to share common resources.



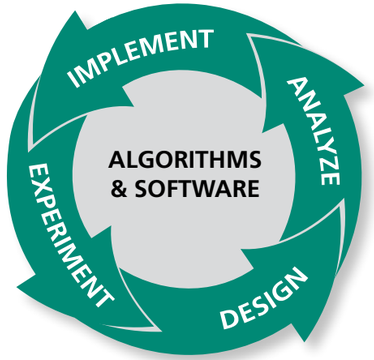
Highly interconnected: Algorithm and Software Engineers at KIT contribute to the methodological background for communication and computation in complex systems.

TOPIC 3: Algorithm and Software Engineering

The topic Algorithm and Software Engineering essentially contributes to the methodological background for communication and computation in highly interconnected systems. Given the increasing use of complex software systems which have to operate with predictable performance and reliability in all kinds of different applications domains, ranging from eHealth and eGovernment to classical banking and insurance applications and from logistics and production control systems to telecommunications and energy systems, it becomes clear why the engineering of algorithms and software is such a crucial challenge. Such systems are building on rather heterogeneous and dynamically changing hardware infrastructures with limited network connectivity.

Predictable properties

The arising challenges, says topic speaker Professor Dorothea Wagner, "can only be mastered with new algorithms as well as new software architectures". Therefore, the main contribution of the scientists in algorithm and software engineering to the area of COMMputation is primarily methodologically: Algorithm and software engineering provides efficient and effective algorithms and software architectures with predictable properties. One example is the priority programm "Algorithm Engineering", funded by the German Research Foundation (DFG): There, the KIT scientists develop a circuit driven by falsifiable assumptions which includes outline, analysis, implementation, and experimental evaluation of feasible algorithms. Using realistic models, they make this structure suitable for applications.



Facing the challenge: The core of Algorithm Engineering is a cycle driven by falsifiable hypotheses.

Integrating point of view: The interdisciplinary composition of Communication Technology covers aspects like robustness and security as well as self-organization and energy efficiency.

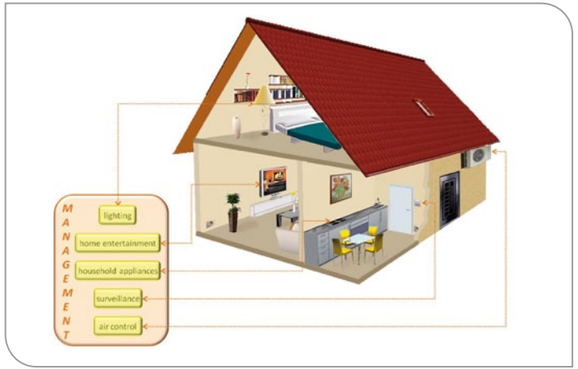
TOPIC 4: Communication Technology

Communication technology research includes distributed systems, communication methods, protocols, architectures and ontologies, as well as methods and tools for evaluating communication software and theory.

Research covers application fields within communication technology such as wired media, wireless networks, optical communication, high-frequency communication, wireless ad-hoc networks, internet of things, under water communication, and car-to-x communication. Within these fields scientists are addressing current hurdles to progress such as the inexorably increasing number of communication partners at constantly higher densities or communication in the terahertz ranges, and researching new solutions for improving quality such as communication with strict demands on dependability, security and real-time behaviour, as well as the autonomous self-organization of communication networks.

Controllability of systems

Topic speaker Michael Beigl says: “Making communication technology a ubiquitous resource is central requirement for many critical services, with tremendous ramifications for how we conduct business as well as how we live our private lives. With this in mind, improving controllability and dependability of these communication modalities while enhancing performance are central topics within COMMputation”.



New areas: Communication Technology becomes relevant in an increasing number of complex surroundings.

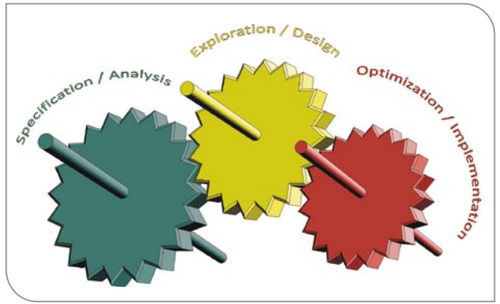
The Scientists have achieved substantial results through their involvement in major research projects funded by the European Union, the German Federal Ministries, the German science foundation and through cooperation with industrial entities and laboratories.

Appropriate methods: Systems Engineering includes formal techniques as well as technologies.

TOPIC 5: Systems Engineering

Systems Engineering deals with appropriate scientific methods for specification and analysis, exploration and design, as well as optimization and implementation of technical systems. This includes the necessary formal techniques – both mathematical and algorithmic – and comprises various kinds of heterogeneous system technologies, among others electronic, optical and mechanical.

Therefore, theoretical studies, methodologies, and the development of new concepts for architectures and computer aided tools for complex heterogeneous systems are needed, for example in communication and infotainment, robotics and automation, medical systems, automotive, and mobile or ubiquitous domains. These concepts have to be based on mechanics, electronics, and software.



Organic future: The scientists try to tame complexity in technical systems by providing appropriate degrees of freedom for self-organized behavior adapting to changing requirements of the execution environment.

Self-organization and adaptivity

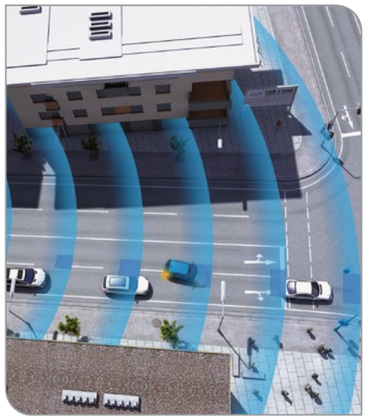
One of the topic's relevant research issues is the investigation and realization of self-organization and adaptivity: In the future, computers are to work on the basis of several self-x features like self-optimizing, self-restoration, self-explanation or self-protection. One example is the program "Organic Computing", funded by the German Research Foundation (DFG): The KIT scientists aim at systems which are aware of their own capabilities and the requirements of the environment, in particular with respect to human needs.

Trustworthiness, security and system design

Another important field of research is trustworthiness, especially as far as safety-critical systems are concerned, systems, which may have strong effects on society, economy or environment. Security and hard real time constraints at all levels of system design are further aspects.

The KIT Focus COMMputation

The KIT Focus COMMputation is a combination of more than 100 individual projects with a total of approximately 600 staff members. Scientific coordination and strategic planning of the Focus are the responsibilities of a Steering Committee and a Scientific Assembly.



Current members of the Steering Committee are Professor Wilfried Juling as KIT Board Member, Professor Hartmut Schmeck as Scientific Spokesperson, Professor Dorothea Wagner as Deputy Spokesperson and Topic Spokesperson Algorithm and Software Engineering, Professor Achim Streit as Topic Spokesperson Grid and Scientific Computing, Professor Stefan Tai as Topic Spokesperson Service and Web Engineering, Professor Marc Weber as Topic Spokesperson Systems Engineering, Professor Michael Beigl as Topic Spokesperson Communication Technology and Dr. Holger Marten as Representative of Academic Staff.

In their projects, KIT scientists cooperate closely with universities and research institutions from all over Europe and beyond. In two interdisciplinary research training groups, funded by the German Research Foundation (DFG), young scientists prepare themselves for a scientific professional life and at the same time experience scientific autonomy at an early point of their career.

Moreover: Sketching and realizing intelligent solutions for effective communication which is based on effective and efficient computations, working out scenarios like smart houses, smart cars, or smart shops, the researchers in the KIT Focus COMMputation are a much sought-after partner for industry. An outstanding example is the foundation of the Karlsruhe Service Research Institute KSRI as a joint initiative of KIT and IBM. One of its characteristics is an innovative „industry-on-campus“ concept: IBM researchers work side by side with KIT scientists. Together, they want to plough through a field with a promising future: the use of scientific methods for the development and management of services.

www.commputation.kit.edu

Karlsruhe Institute of Technology (KIT)

Karlsruhe Institute of Technology (KIT) is the merger of Forschungszentrum Karlsruhe, member of the Helmholtz Association, and Universität Karlsruhe (TH). KIT has a total of about 9000 employees and an annual budget of EUR 730 million.

The merger into KIT gave rise to one of the biggest research and teaching institutions worldwide, which has the potential to assume a top position in selected research areas. It is aimed at establishing an institution of internationally excellent research in natural and engineering sciences, outstanding education, promotion of young scientists, and advanced training. KIT closely cooperates with industry as an innovation partner. It is a leading European energy research center and plays a visible role in nanosciences worldwide. KIT focuses on the knowledge triangle of research, teaching, and innovation.

Imprint

Karlsruhe Institute of Technology (KIT)
Public Relations and Marketing (PKM)

Kaiserstraße 12
76131 Karlsruhe, Germany

Tel. +49 721 608-45680 or
+49 721 608-22861
E-mail info@kit.edu
www.kit.edu

Editor Klaus Rümmele

Photography Markus Breig, Christian Hirsch, Andreas Kamper, Lukas König, Bianca Pagliosa, Markus Stark, Gabi Zachmann (composition), car2car forum, photocase.de, pixelio.de, pixelquelle

Cover Wilfrid Schroeder

Design, Layout Eva Geiger (SCC-PPM)

Printing Wilhelm Stober GmbH, Eggenstein

November 2011