Description of thesis topics

Algorithms

The design and analysis of algorithms and data structures forms one of the core areas within computer science. The Algorithms Group performs fundamental research in this area, focusing on algorithmic problems for spatial data. Such problems arise in geographic information systems (GIS) and automated cartography, robotics, computer graphics, CAD/CAM, and many other application areas. Our research can be grouped into four closely related and partially overlapping areas:

Computational geometry. This field combines clever algorithmic techniques with beautiful geometric concepts to obtain efficient solutions to algorithmic problems involving spatial data. Computational geometry can be seen as the fundamental study of algorithmic problems arising in the application areas mentioned above.

I/O-efficient algorithms. Modern computer systems have an increasingly complex memory architecture, organized hierarchically registers, several cache levels, main memory, and disk (or other external memory devices). An effective use of this memory hierarchy is often essential to obtain the best performance. Our research in this area focuses on algorithms with provable guarantees on their I/O- and caching behavior.

Graph drawing. Networks play an important role in real life—think for example of road networks, computer networks, or social networks—and their mathematical counterpart, graphs, forms a central concept in computer science. To get more insight into a graph structure, it often helps to visualize it. The subarea within algorithms research studying the visualization of graphs is called graph drawing, and it is one of the focus areas of our group.

Algorithms for GIS and automated cartography. Spatial data play a central role in geographic information systems (GIS) and automated cartography, and there are many challenging algorithmic problems in these areas, often dealing with massive amounts of data. We apply our expertise in computational geometry and I/O-efficient algorithms to solve these problems in a rigorous way.

We offer thesis projects in all four areas. The exact topic of the thesis project is defined depending on the interest and skills of the students. Projects can range from purely theoretical projects to projects involving significant implementation and experimentation. For more information on the group and its projects, see

http://www.win.tue.nl/algo

Group leader: prof.dr. M. de Berg

Mark de Berg received an M.Sc. in computer science from Utrecht University (the Netherlands) in 1988. He received a Ph.D. from the same university in 1992, after which he became a permanent faculty member. In 2002 he moved to the TU Eindhoven, where he became a full professor and head of the TU/e Algorithms Group. His research area is algorithms and data structures and, in particular, computational geometry. In 2003 he obtained a prestigious VICI grant for his research from the Netherlands Organization for Scientific Research (NWO). He is (co-) author of two books on computational geometry, one of which has become the standard textbook in the area, and he published over 160 papers in peer-reviewed journals and conferences. He was on the program committee of numerous international conferences on computational geometry, on algorithms, and on computer graphics, and he is on the editorial board of three international journals.
**Visualization**

The mission of the Visualization group is the development of methods, techniques and tools that enable people to obtain insight in data via interactive computer graphics. Data Visualization exploits the unique capabilities of the human visual system to detect patterns and trends in imagery. The central research question is how data should be presented such that this process is most efficient and effective. Our approach in this area is characterized by the application of know-how from 3D computer graphics and geometric modelling and by an experimental approach involving fast prototyping, close cooperation with end users, and validation in practice. Scalability of methods is a key issue. Within the large field of Visualization we currently specialize in the following areas:

*Information visualization.* We study how large amounts of abstract data, such as trees and networks, can be visualized. Typical use cases are the visualization of the contents of a computer hard disk and the visualization of the structure of a large software system.

*3D interaction and virtual reality.* Visualization requires often interaction with 3D data and objects for interrogation and navigation. In cooperation with CWI we study how affordable desktop Virtual Reality systems (hard- and software) can be designed to simplify these tasks.

*Scientific visualization.* Scientific visualization concerns data from simulations and measurements, defined over geometric spaces. Within this area we study the visualization of fluid flow and architectures for flexible visualization.

Thesis projects are possible in each of these areas. The exact topic of the thesis project is defined depending on the interest and skills of the students. For more information on the group and its projects, see [http://w3.win.tue.nl/nl/onderzoek/onderzoek_informatica/visualization/](http://w3.win.tue.nl/nl/onderzoek/onderzoek_informatica/visualization/)

**Group leader: prof.dr.ir. J.J. van Wijk**

Jarke J. van Wijk received a MSc degree in industrial design in 1982 and a PhD degree in computer science in 1986, both from Delft University of Technology, both with honours. He worked at a software company and at the Netherlands Energy Research Foundation ECN before he joined the TU Eindhoven in 1998, where he became a full professor of visualization in 2001. He is cofounder of MagnaView BV, a company that aims at providing visual tools for large datasets, and is since 2005 vice-president scientific affairs. His main research interests are information visualization, visual analytics, flow visualization, and mathematical visualization. He has (co-)authored more than 100 papers, including many papers in prestigious venues such as ACM SIGGRAPH and IEEE Visualization. He has been paper co-chair for many international conferences in the area of visualization (including IEEE Visualization and IEEE InfoVis, and IEEE PacificVis 2010). In 2007 he received the IEEE Visualization Technical Achievement Award for his work on flow visualisation, and he received the Henry Johns Award 2009.
Databases and Hypermedia

The Databases and Hypermedia group concentrate on three aspects of data access and management: (a) the management of semi-structured and semantically linked data, (b) data mining technology for aiding information discovery, (c) user modeling, personalization and adaptive information delivery.

The work on the management of semi-structured (and linked) data concentrates on representing and retrieving information, using semantically meaningful metadata. It ranges from the study of XML, RDF and XMLand RDF query languages (XPath, XQuery, OWL) to concrete storage, indexing and retrieval technology to effectively and efficiently handle semi-structured data. This work has practical applications in Web-Information Systems, where we concentrate on the aspects of navigation and adaptation. We are currently in the process of hiring a new assistant professor to strengthen this research direction.

The work on data mining technology for aiding information discovery combines fundamental research into data structures and algorithms for data mining (to improve the performance of data mining processes) with application-oriented research into specific data mining problems like detecting concept drift and classifying without discriminating. The former has concrete applications in many areas, including detecting trends and fluctuations in industrial processes but also detecting a shift in customer interest in on-line shops and predicting sales in order to optimize (wholesale) store inventory. The latter has applications in e-business where business decisions based on patterns discovered through data mining must obey certain anti-discrimination laws. For the data mining work we also collaborate with the AIS research group in which the topic of process mining is studied (which is essentially data mining on process data).

The work on personalization and adaptation in information access and delivery concentrates on designing and implementing generic (models and technology for) adaptive information systems. This work has applications in e-culture, e-entertainment, e-learning and e-business. Personalization is the only way in which humans can continue to use the ever increasing amount of information that is available on-line. Personalization and adaptation not only help the human information consumer but also the providers who can to more targeted information delivery.

Projects in the group can be internal, research-oriented projects, and industry-oriented projects, and are defined in depending on the student’s interest. For more information on the group and its projects, see

http://www.win.tue.nl/dh/doku.php

Supervisor: prof.dr. P.M.E. de Bra

Paul De Bra studied mathematics and computer science at the University of Antwerp, where he graduated with "greatest distinction". In December 1989 he joined the Computer Science department of the Eindhoven University of Technology, where he heads the Database and Hypermedia Research Group. He performs research on different aspects of hypermedia systems and databases. Currently he is most active in the area of adaptive hypermedia and adaptive Web-based systems. He has been program chair of many important international conferences on hypermedia. He has been steering committee member for EdMedia, and is or has been associate editor and guest editor of several international journals. He is currently vice-president of UM Inc, the non-profit organization that promotes research on and development of User Modeling.
**Architecture of Information Systems**

The Architecture of Information Systems (AIS) research group investigates methods, techniques and tools for the design and analysis of process-aware information systems, i.e., systems that support business processes (workflows) in organizations. We are not only interested in these information systems and their architecture, but also try to model and analyze the business processes and organizations they support.

The research concentrates on formalisms for modeling and methods to discover and analyze models. On the one hand formal methods are being used, e.g., the group has a long tradition in Petri-net modeling and analysis. On the other hand, we are interested in modeling languages widely used in industry (EPCs, UML, BPMN, BPEL, etc.). In contrast to many other research groups we do not accept a model as an objective starting point, i.e., we also try to discover process models through process mining and check the conformance of models based on reality.

The AIS group tries to make research results accessible by providing (open-source) software. Notable examples are ProM (process mining and process analysis) and YAWL (workflow management). These implementation efforts illustrate that the problems of tomorrow’s practice are the driving force behind the development of new theory, methods, and tools by AIS.

The group offers master thesis projects on a variety of topics in this area. Examples topics are (i) modeling of (process-aware) information systems, (ii) development, prototyping, and evaluation of (process-aware) information systems, (iii) Process mining, (iv) Model transformation, (v) verification of models, and (vi) simulation of models. Many master projects are linked to some external organization. Examples are IBM, Pallas Athena, SAP, ING, Deloitte, AMC Hospital, Justice Department, ASML, Philips Medical Systems, Océ, etc. For more information on the group and its projects, see

[http://w3.win.tue.nl/nl/onderzoek/onderzoek_informatica/ais/](http://w3.win.tue.nl/nl/onderzoek/onderzoek_informatica/ais/)

**Supervisor: prof.dr.ir. W.M.P. van der Aalst**

Wil van der Aalst is a full professor of Information Systems at the TU Eindhoven having a position in both the Department of Mathematics and Computer Science and the Department of Technology Management. Currently he is also an adjunct professor at Queensland University of Technology (QUT) working within the BPM group there. His research interests include workflow management, process mining, Petri nets, business process management, process modeling, and process analysis. Wil van der Aalst has published more than 115 journal papers, 15 books (as author or editor), and over 230 refereed conference/workshop publications, and 40 book chapters. Many of his papers are highly cited, making him the Dutch computer scientist with the highest h-index (65). He has been a co-chair of many conferences and he serves on the editorial board of several journals.
Security
Research in the Security group spans two areas vital to the security of decentralized and embedded systems, and has its center of gravity in the intersection of these areas. The two areas are security policy specification & enforcement and security of embedded systems.

Policy Specification and Enforcement. While the Internet allows for a free exchange of data, the security boundaries needed to guarantee privacy and confidentiality have become the main obstacle to flexible cooperation within and between (virtual) organizations. The classical preventive access control mechanisms cannot cope with heterogeneous distributed systems and they have to be at least partially replaced by more elaborate trust management and compliance control systems. This is where SEC expertise lies: in the specification and implementation of policies for distributed systems.

Security of Embedded Systems. Securing networked embedded systems is particularly challenging because of their lack of computational and physical resources. In this area, SEC focuses presently on the security of mobile (e.g. smart-card based) systems; for instance in the PinpasJC project we are studying side channel attacks on smart cards. One of the challenges that embedded devices face is secure key storage. This issue is addressed by SEC’s research on Physical Unclonable Functions, a novel approach based on the extraction of randomness from the physical components of the device itself. Also in this area and closely linked to coding and crypto we have the project PinpasJC (on the analysis of smart card algorithms to identify possible side-channel attacks).

These areas overlap to a great extent and their intersection forms the core of SEC’s research: compliance control for distributed and embedded systems. SEC’s approach is to start from a concrete security problem and solve it by addressing the fundamental issues behind it. SEC’s strength lies precisely in the ability to understand deeply both the user’s concern as well as the theory behind it. There are many options for master thesis projects, both internal projects and projects in industry. For more information on the group and its projects, see http://www.win.tue.nl/sec/

Supervisor: prof.dr. S. Etalle

Sandro Etalle joined TU/e in October 2007, where he leads the group of Security of Embedded Systems. From 2001-2007, he worked at the University of Twente, where he still has a part-time appointment as professor of trust and risk management. His research interests include trust management, access control, policy compliance, intrusion detection and ICT risk management. Etalle has served on many program committee, including being chair for LOPSTR in 2004, ICLP in 2006 and IFIPTM in 2006. He was guest editor of international journals and is one of the founders of the IFIP working group on Trust Management and is a member of the Scientific Committee of the International School on Foundations of Security Analysis and Design. Etalle leads and participates to several national and international projects.
Software Engineering and Technology

The overall objective of the group Software Engineering and Technology is to develop methods and tools for time- and cost-efficient evolution of high-quality software systems: from inception, through development and maintenance, to phase-out. SET recognizes the importance of both legacy systems and state-of-the-art development methodologies such as model-drive software development driven by formal models, domain-specific modeling and generic tooling. Therefore SET will not limit its investigations to recent software development phenomena, but will also focus on a variety of other topics dealing with software migration, re-engineering and reuse. SET believes that it is of the utmost importance to integrate the daily software development practice with cutting-edge research and high-profile education. SET welcomes collaboration with industrial and academic partners that will foster a better understanding of the nature of software and software-related processes. The research of Software Engineering & Technology group is on software engineering in general, but with a strong focus on theory, methods and tools for maintaining consistency between models and code. SET has the following research themes:

Theory, methods and tools for model-driven software engineering. The ultimate goal of model-driven software engineering is increasing the quality of the resulting products and the reduction of development costs. The latter can be achieved by re-use of developed models, reduction of their maintenance, and application of software generation tools. Topics addressed in this theme are: generation of code from models, reconstruction of models from code, and analysis and transformation of models and code.

Verified software engineering. Topics addressed in this theme are: integration of specification language and programming language, consistent incremental development of specifications and code, correctness by design, and static and dynamic assertion checking.

Master thesis projects are possible in both areas, and can be done internally but also in an industrial context. For more information on the group and its projects, see

http://w3.win.tue.nl/nl/onderzoek/onderzoek_informatica/set/

Supervisor: prof.dr.ir. M.G.J. van den Brand

Mark van den Brand studied computer science from 1982 up to 1987 at the Katholieke Universiteit Nijmegen and he received a PhD from the same university in 1992. Since then he has been working at the University of Amsterdam, the CWI and the Hogeschool of Amsterdam, before becoming full professor and leader of the Software Engineering and Technology group at the TU Eindhoven. His research interest lies in the field of generic language technology, in area in which he has published many papers and where he has served on numerous program committees. He was keynote speaker at the Software Language Engineering (SLE2008) conference and he was three times guest editor of special issues of Science of Computer Programming devoted to academic software development.
Design and Analysis of Systems
The focus of the group Design and Analysis of Systems is on modelling and verifying behavior of systems and programs. Behavior must be understood as all possible actions that a system can consecutively perform during its lifetime. Computer-based systems are so complex, that it is impossible to program them without understanding how the different software components communicate, and what the responsibilities of these parts are. By modeling the behavior, these responsibilities are made explicit. Due to the complexity of the matter at hand, it is also non-trivial to get these behavioral models correct. For this purpose we use analysis techniques. Primarily, these are used to find flaws in the model, and ultimately these are employed to show that the modeled behavior satisfies all the requirements. For instance, a data communication protocol must not lose messages, and a firewall should under no circumstance let an intruder pass.

With current modeling techniques it is no problem to model the communication patterns of even the most complex systems. Using modal formulas most requirements can be formulated in a formal, precise way. Using one of the many existing process equivalences, it is very well possible to state the behavioral equivalence between implementations and specifications. So, in general, it is not really problematic (but sometimes hard) to formulate the properties that a system ought to have. The current technological bottleneck is our capability to prove that a requirement holds for a given model (the model checking problem) or that two processes are actually equivalent (the equivalence checking problem). The major research activity of this group is to increase the strength of the analysis tools. The core problem of the analysis of behavior is the state space explosion problem. There are so many states in which a system can end up, that it is generally impossible to explore these all individually. For this purpose, we must use so-called symbolic techniques to enable the verification. These techniques come from the realm of automatic reasoning, term rewriting and computer assisted theorem checking. Also, state space reduction techniques (abstract interpretation, confluence checking) are relevant to reduce the problem size.

The group Design and Analysis of Systems offers many interesting master thesis projects in this area. For more information on the group and its projects, see

http://w3.win.tue.nl/nl/onderzoek/onderzoek_informatica/ontwerp_en_analyse_van_systemen_oas/

Supervisor: prof.dr.ir. J.F. Groote
Jan Friso Groote studied at University of Twente (1983-1988) obtaining an engineering degree in computer science. In 1991 he obtained a Ph.D. degree at the University of Amsterdam. After having a tenure teaching position at Utrecht University in Philosophy, and being a group leader at CWI, he became a full professor at TU/e in software specification and analysis. His research has mainly been directed towards the development of mathematically sound and tractable behavioural specification and analysis techniques suitable to effectively deal with real systems (μCRL, mCRL2 and modal μ-calculus with data), an area in which he is one of the leading researchers world-wide. He has over 200 publications and he has been a member of numerous program committees. He is a founding father of the laboratory of quality software at TU Eindhoven University (LaQuSo).
System Architecture and Networking

Networking and distribution is at the heart of modern ICT systems. Embedded systems evolved towards networking more recently. While embedded computer systems originally just replaced mechanics, in the course of time we see programmable and communicating electronics in all kinds of equipment that surround us. The convergence of networking, user interfaces and embedded computing is usually called ambient intelligence. The System Architecture and Networking group studies ambient intelligence, i.e., networked embedded systems, from a few overlapping and closely connected perspectives.

Cooperative distributed systems. Distributed systems are increasingly developed as the composition of independent services. These services encapsulate functionality, resources and content, and they are composed in ways not known during their construction. This development results in a separation between functionality on the one hand and coordination, including management and control, on the other hand. We study distributed applications based on this concept from the perspectives of system architecture, service quality, service management and system design.

Predictable platforms. Predictable embedded systems require predictability of both platform and interconnect. This amounts to scheduling and resource management, as well as control of the installed software. For real-time scheduling we study applications of fixed priority scheduling with deferred preemption (FPDS), which is underlying many real-time connection technologies such as CAN and FlexRay; we combine FPDS with budget-based scheduling. In order to predict the behavior of a platform plus installed software we investigated how to specify the resource use of software components and how to predict resource properties of compositions. We studied both analytical and scenario-based approaches. As a sidestep of this work we have studied the quality of software architecture in an empirical way.

Embedded computations. With embedded systems growing more powerful and connected, the complexity of embedded computations has grown tremendously. Strict budgets of computation, memory and energy apply, and the challenge is to map these computations as efficiently as possible to a platform.

We offer master projects in all three area, often also in collaboration with industry. For more information on the group and its projects, see

http://www.win.tue.nl/san/

Supervisor: prof.dr. J.J. Lukkien

Johan Lukkien received his MSc in Mathematics and PhD from the Rijksuniversiteit Groningen. After a two-year leave at the California Institute of Technology, Pasadena he joined the TU Eindhoven, where is is currently a full professor leading the System Architecture and Networking group, with a research focus on resource-constrained networked embedded systems. Since 2008 he is also scientific director of the post-master Professional Doctorate in Engineering (PDEng) degree program in Software Technology. He is author of around 100 peer reviewed scientific publications, many of which were published in highly respected journals. Since 2005, he is the chair of the Networking Track of the IEEE International Conference on Consumer Electronics. He has developed strong collaborations with industry and European research parties and participated in a large number of national and international projects.