OPERATIONS RESEARCH

Research Group

The sub-track Operations Research, which is a specialization in the track *Engineering Mathematics* of the Master *Applied Mathematics*, is supported by two research groups,

- Discrete Mathematics and Mathematical Programming (DMMP),
- Stochastic Operations Research (SOR),

both with a strong international reputation in fundamental research and education in the areas of Operations Research and their applications in Telecommunications, Logistics and Reliability. The two research groups are composed of experts in sub-areas of Operations Research such as queuing theory, scheduling, combinatorial optimization, nonlinear programming, graph theory, process control, probability theory, stochastic processes, timetabling and game theory. Research is concentrated in the Centre for Telematics and Information Technology (CTIT).

Research Field

Operations Research is the mathematical approach towards decision making under complete or partial information, with emphasis on the optimal design and operation of systems with scarce resources. This discipline covers modern and fast developing branches of applied mathematics, e.g.

- *Mathematical programming* deals with optimization techniques and includes linear-, nonlinear- and integer programming.
- *Dynamic programming* (deterministic and stochastic) is the mathematical theory for *subsequent* decisions (or strategies).
- *Discrete mathematics and graph theory* are important fields in the interplay between computer science and mathematics, and
- *Queueing theory* is the mathematical theory for systems in which jobs compete over scarce resources, and also includes inventory systems and fluid processes.

These fields cover a consistent theory and a broad arsenal of numerical methods. Applications arise e.g. in engineering, economics, and computer science.

Curriculum

The Master's program in Operations Research focuses on two aspects: fundamental research and a broad variety of modern applications. This is clearly visible in the Master's program that allows for an orientation towards mathematical aspects of Operations Research (academic research) or an orientation towards Operations Management (industrial career). Typical application areas include telecommunication systems such as wired and wireless networks and logistic processes such as in production, scheduling, timetabling, supply and inventory systems.

The Master’s program Operations Research allows for three orientations:

- Theoretical with emphasis on optimization models
- Applied with emphasis on logistics
- Applied with emphasis on telecommunications

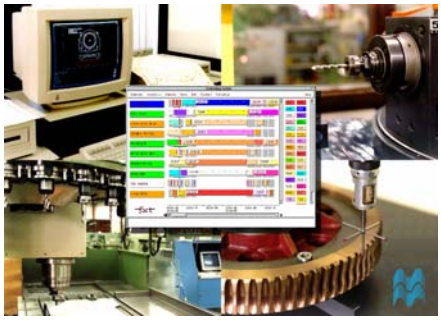
or a combination thereof. The two year program consists of courses (up to 90 ECTS), a practical trainee period and a final project, that are either university based (theoretical research) or company based (applied research). The courses consist of roughly 20 ECTS from the general mathematics curriculum, 35 ECTS specifically offered by the supporting research groups, and 35 ECTS from the application domains logistics and telecommunications.

Contacts with Companies

Industrial and (non)-governmental research contacts include Centraal Boekhuis, CQM, Ericsson, Essent, Holland Railconsult, Ikea, KPN, Lucent, NS Reizigers, ORTEC, Paragon, Philips, Royal Dutch Navy, Siemens, Tebodin, Thales, TNO, TPG Post, Vodafone, and Wehkamp.

Production Management

Current markets are characterized by a high product variety, short product life cycles, high quality requirements and short and reliable lead times. In order to remain competitive, companies are requested to respond flexibly to customer demand. This in turns demands for internal flexibility, the ability to rapidly introduce and manufacture new products, and to design flexible production system structures. High product stocks are undesirable, because of high interest rates and, in case of short product life cycles, high obsolescence risks. Research within CTIT on production management concentrates on design and performance analysis of manufacturing systems, capacity planning and inventory management, and shop floor scheduling and control.



Shop Floor Scheduling and Control

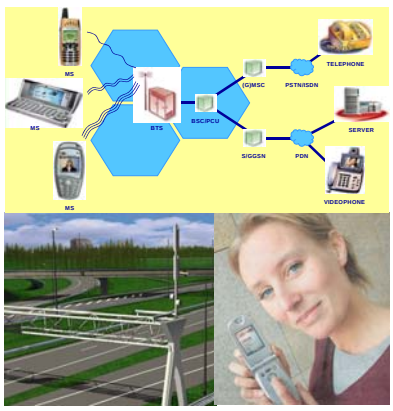
At the detailed shop floor level, important progress has been made in developing sound scheduling systems that are able to include most constraints as they occur in complex manufacturing systems. Examples include set-up times, equipment unreliability, multi-resource characteristics (e.g. machines, operators, cutting tools and fixtures at a CNC workstation) and complex capacity constraints. Research at CTIT concentrates on the development of intelligent shop floor scheduling and control systems that comprise automatic, close-to-optimal, due date scheduling algorithms for discrete manufacturing.

Manufacturing system design

Research on manufacturing system design concentrates on the performance analysis of systems in terms of effective capacity (throughput) and effective manufacturing lead times. This includes trade-off's between "make to stock" and "make to order", the selection of equipment, the design of product routings and the allocation of jobs to resources. Uncertainty of product and process characteristics is an essential element in any performance analysis method. Techniques employed are based on stochastic network analysis and discrete event simulation.

Telecommunications systems

Communication technology undergoes rapid changes because of the demands of modern industrial societies on the one hand, and the availability and low cost of computers and communication hardware on the other hand. The high performance standards motivate research on performance analysis of communication networks. Communications systems can roughly be divided into wireline networks (in particular related to the Internet Protocol, and its feedback-based flow-control mechanism TCP), and wireless networks. A common feature encountered is competition for limited capacity by services with different characteristics and requirements.



Capacity allocation in wireless networks

Performance problems arising in wireless systems such as UMTS, WLAN and ad-hoc networks are often due to the very limited availability of resources (spectrum), interference among simultaneous transmissions, the randomness of the quality of the resources (signal strength), and the mobility of users and therefore the changing network structure. Scheduling of resources is an important issue, where fairness of the resource allocation plays an important role. Another dominant research question is end-to-end routing and quality of service provisioning in multi-hop networks such as ad-hoc networks, where not only the location of the destination node may be unknown, but also the availability of intermediate nodes may change (a node may be moving or switched off). Such networks are typically modelled as random graphs.

The Master's program Operations Research provides a scientific attitude, combined with the necessary engineering skills to tackle problems in the broad area of Operations Research. Former students have been employed as mathematical engineers in consultancy agencies, industry, governmental organizations, or have pursued an academic career.