



Centrum voor Wiskunde en Informatica

Centre for Mathematics and Computer Science

Frontier research for practical applications

CWI is the national research institute for mathematics and computer science, located in Amsterdam, The Netherlands, at the Amsterdam Science & Technology Centre (WTCW). Since its foundation in 1946 the institute has acquired a prominent position in the research world.

CWI is a non-profit organisation, operating on a budget of 14 million EUR (70% basic funding from NWO, 30% from national programmes, EU programmes, and commissions). Its 210 employees include 160 researchers, 20 of them holding also positions as university professors.

The mission of CWI is twofold:

- to perform frontier research in mathematics and computer science;*
- to transfer new knowledge in these fields to society in general, and trade & industry in particular.*



CWI Research - some application areas

CWI carries out both fundamental explorative research and research with concrete applications in mind. Quantum computing is a fine example of the first. Some major application areas are detailed below.

Traffic

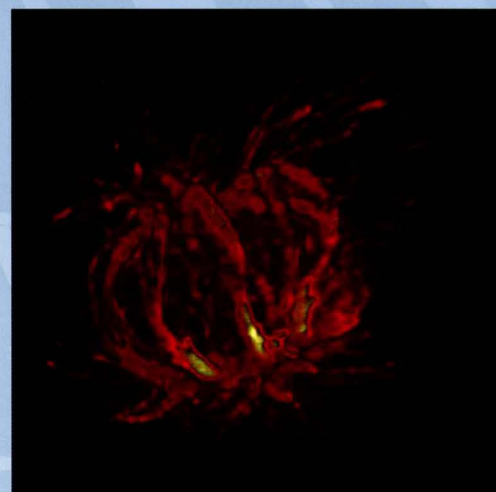
Traffic increases everywhere in density and in complexity. A scientific approach is needed to deal with the resulting problems. CWI developed a new tool for designing **railroad timetables** for Dutch Rail, which operates one of the world's most complex railroad systems. The resulting expertise and software is now being utilized on a European scale. Traffic in **telecommunication networks** is studied by developing and applying queueing theory for integrated services of voice, video, and data, each with different traffic characteristics and customer requirements. For **motorway networks** around urban centres there is a need for network control aiming at optimising travel costs for the users. CWI developed control measures for the Amsterdam ringroad and shares its expertise in an EU project.



Photo: Rijkswaterstaat, Meetkundige Dienst Afdeling Grafische Technieken, Delft: **Motorway network control**

Visual information

In understanding complex processes, visualisation is a most useful tool. CWI researchers have developed **interactive visualisation** tools and applied them to turbulent phenomena and the modeling of biological processes in cells. CWI developed software based on **graph visualisation** in order to get more insight into concurrent, distributed computation processes. Sending and searching **images across the Web** requires new ways of compression, transmission, indexing and retrieval. CWI focuses on 'multi-resolution' methods, including fractal, wavelet and morphological methods. Furthermore we use feature detectors to simplify and speed up queries in large, distributed **multimedia databases**, such as the Web.

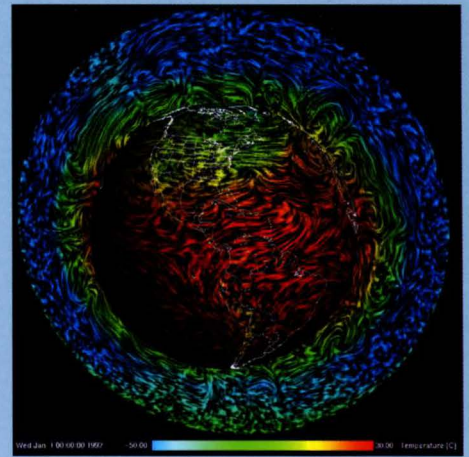


Source CWI: **Cell division during mitosis**

RSA-155 = 10941738641
= 102639592829741105

Natural systems

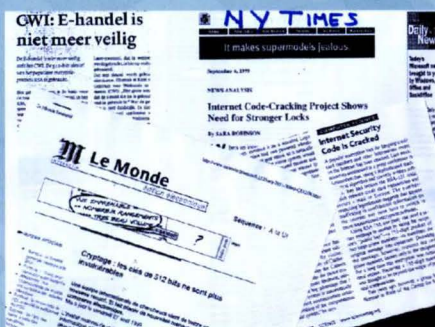
Pollution of air, water, and soil is still a major concern in our society. To learn more about long-term effects, CWI developed new methods to solve the very complex underlying equations. Applications include studies of smog formation, the spread of waste by rivers into the North Sea, and salt water intrusion into fresh water reservoirs. CWI's experience with computation of air flows around aircraft wings is now directed to computation of the optimal shape of **ship hulls**, by simulating a complete ship in free surface waves. This may lead to considerable energy savings. Furthermore CWI studies the mathematical equations underlying several **biological systems** and their numerical solution, often aided by visualisation tools. Examples include the development of neuronal connections in the nervous system and the growth of phytoplankton.



Source CWI: **Global atmospheric models**

The Web

CWI has been involved from the very beginning in the development of the Internet and the World Wide Web. The institute was the **first non-military Internet site in Europe** and acted for several years as the gateway between the USA and Europe. It created the **domain registration** system for The Netherlands, which is extensively used abroad as well. CWI actively participates in several activities of the **World Wide Web Consortium**. Apart from image processing and retrieval, CWI research focuses on the following Web applications: **Python** - an interpreted, interactive, object-oriented language (comparable to Java), the specification language **SMIL** for multimedia authoring; **style sheets** for special purposes such as serving handicapped people; and **XHTML** - a bridge between HTML and the far more flexible and extensible XML. SMIL and XHTML were developed in W3C Working Groups to which CWI made crucial contributions. Coding techniques to protect Internet traffic rely on the difficulty to retrieve large prime numbers from their product. CWI explores the fastest **factoring methods** to determine the coding's safety limit. The factoring of RSA-155 was world news.



Source CWI: **Internet security**

70527421809707322040357612003732945449205990913842131476349984288934784717997257891267332497625752899781833797076537244027146743531593354333897
72054196573991675900716567808038066803341933521790711307779 * 106603488380168454820927220360012878679207958575989291522270608237193062808643

Software engineering

A typical industrial or governmental organisation maintains millions of lines of old programming code. **Renovation of this 'legacy' software** is economically very important, and in most cases also the only way out. With its extensive knowledge of mathematically rigorous construction methods, CWI develops practical renovation tools and languages. Another point of worry is the risk of calamities due to **errors in software systems**, such as the exploding Ariane rocket in the mid-nineties. This can be prevented by the **verification of software** built into physical devices (**embedded software**). CWI checked the control software of a railroad yard and of video devices. Quite another field of interest is the study of emerging markets like **E-commerce**, with many interacting agents and largely unknown behaviour. CWI develops evolutionary methods based on natural principles like 'survival of the fittest' to explore such systems.

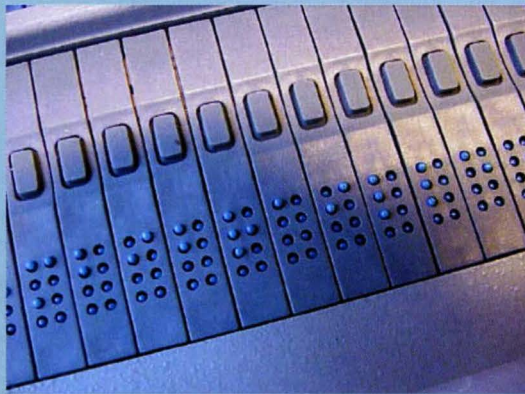


Photo: ESA: **Software should be error-free**

Frontier research, knowledge transfer

CWI performs fundamental research on themes which are derived from societal needs and are continuously renewed. This ranges from explorative areas like quantum computing to concrete questions like optimal railroad timetables. There is close cooperation with **academia, industry, and knowledge and financial institutions**. CWI participates in the **Telematics Institute** and the **WTCW** (Amsterdam Science & Technology Centre). Results are made available through publications, lectures, staff mobility, contract research, and the creation of **spin-off companies** based on results of CWI research. An active policy which started in the 1990s, has led to ten such companies in fields including datamining, software improvement, and several aspects of the Web (security, design, multimedia, animation). CWI also organizes an annual networking event for the Trade & Industry sector.

W3C



Internet accessibility for impaired people



Photos: Stichting Bartiméus

International cooperation

A substantial part of the research is performed in international collaborative frameworks. CWI participates in **fourteen EU projects** in ICT and related areas. It also plays an active role in the World Wide Web Consortium (W3C), defining Web standards in several Working Groups. The **W3C Office in The Netherlands** is managed by CWI, and the institute hosted the Ninth International World Wide Web conference in Amsterdam. CWI is a founding member of the European Research Consortium for Informatics and Mathematics (ERCIM) and keeps a prominent position in it. The objective of **ERCIM** is to promote research in information technology and related mathematics in Europe, and to intensify contacts between research organisations and industry. At present leading research institutions from thirteen European countries have joined ERCIM, representing over 7000 researchers.



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