



Research Results 2001



The opening of the House of the Future at Fornebu in Oslo was an important milestone in 2001. This is Telenor's new multi-disciplinary research laboratory – a unique arena for innovation and promotion of research findings.

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Introduction



Berit Svendsen, CTO Telenor
and Vice President R&D

It is a public policy objective to bring Norway further along the road towards an advanced ICT nation. This manifests itself through the expansion of new enterprises supplying ICT-based products and services, and through the use of ICT as a tool for making existing businesses and the public sector more efficient.

Telenor delivers voice calls, information, knowledge and entertainment to consumers via a broad spectrum of modern communications services. These services employ wireless and fixed platforms and networks. The sector is developing at breakneck speed, and new opportunities are created through major universal efforts into research and development in this field.

Telenor R&D's mission is to refine and make full use of our own research results as well as those of others, and to create commercial opportunities for Telenor at an early stage. The technical basis underpinning our activities is wide in its scope. Efforts are focused on three core strategic areas:

- Business models and technological strategy
- User-focused solutions
- Future networks and service arenas

Telenor R&D is playing an important part in planning the introduction of next generation broadband services in Norway.

This report summarises our R&D activities in 2001 and includes a complete list of publications. The practical work, including participation in a number of international projects within the EU and EURESCOM and with partners like Ericsson, Cisco and Sun, takes place under the auspices of ten research programmes. The programmes differ in their focus, but are all multidisciplinary in their composition. The projects are composed within and across programme boundaries.

We hope the R&D Report for 2001 will provide an insight and inspiration for a continuing commitment to ICT. Happy reading!

Berit Svendsen

The day-to-day work of Telenor reflects the global nature of telecommunications. R&D has extensive international commitments involving standardisation and research cooperation with organisations and selected alliance partners.

Today's telecommunications network would have been inconceivable without the detailed international contractual framework that underpins it, carefully constructed over the past hundred years. The original driving force was ITU, which realised the need for the standardisation of both technology and international agreements. Although the ITU continues to play an important role, the picture is nowadays more complex, with a number of standardisation forums.

Standardisation

R&D has responsibility for coordinating Telenor's international standardisation work. The bulk of this work continues to be channelled through ITU and ETSI, the established standardisation bodies, but IETF and other standardisation forums are growing in importance. The sector is clearly at a crossroads where formal standards have to give way. For instance, the expanding internet is standardised de facto by IETF.

International research cooperation

The majority of R&D's international activities take place in the context of the EU and EURESCOM research programmes. Under the EU's fifth framework programme R&D has been involved in 17 projects to date.

Through EURESCOM, R&D was involved in 14 projects in 2001. EURESCOM is now being wound up in its present form, but a new organisation is under discussion and is tentatively scheduled to be up and running by summer 2002.

Telenor opened an office in California in 2001, with a staff of two. Their work to date has focused on IETF and on building contacts with relevant players in Silicon Valley. R&D remains a member of MIT's TTT consortium.

Alliances

Telenor R&D has collaboration agreements with a number of businesses worldwide. The principal tie-up with BT has been somewhat diminished by restructuring and new operational constraints at BT's end. There is ongoing collaboration with Ericsson regarding Bluetooth, and interaction between HiperLAN and UMTS. R&D is also actively collaborating with Cisco through the FSN project. Collaboration with HP on further development/ demonstration of their CoolTown concept is under discussion.

Other partners include Sun, Microsoft, Alcatel, Bang & Olufsen, and Compaq.

Universities and colleges

Telenor has cooperation agreements with several Norwegian universities and colleges. Most of these relationships are coordinated by R&D, which has groupwide responsibility. The principal institutions involved are the Norwegian University of Science and Technology (NTNU), the University of Oslo (UNIK) and the University of Tromsø. In the economic sphere, Telenor has relationships with the Norwegian School of Economics and Business Administration (NHH) and the Norwegian School of Management (BI).

R&D in the EU programme IST

EMBRACE	Efficient Millimetre Broadband Radio Access for Convergence and Evolution	TORRENT	Technology for a Realistic End User Access Network Testbed
ODIN	Geographic Distributed Information Tools and Services for the Mobile Information Society	SANE	Sustainable Accommodation in the New Economy
SONG	Portals of Next Generation	TONIC	Tecno-Economics of IP Optimised Networks and Services
M3I	Market Managed Multi-Serviced Internet	YOUNGSTER	Young People creating Active Service On Context-aware Terminals
SAMBITS	System for Advanced Multimedia Broadcast and Information Technology Services	E-LIVING	Life in a Digital Europe
EYE-2-EYE	Fitness-for-Purpose of Person-Person Communication Technologies	STOLAS	Switching Technologies for Optically Labeled Signals
MEGA	Multisensory Expressive Gesture Applications	FLAWS	Flexible Convergence of Wireless Standards and Services
IPPA	Innovative Portable Pilot Assistance	SAVANT	Synchronised and scalable AV content across networks
CORAS CO	A Platform for Risk Analysis of Security Critical Systems		

R&D in EURESCOM projects in 2001

P902	Sustainability and social impacts of ICT on Schools, homes, and communities	P1105	MobilUS: Next generation Mobile Information Services on UMTS
P903	Cross-cultural attitude ICT in everyday (working) life	P1106	E-commerce Impacts on Service and Network Operations and Management
P904	The impacts of telework on a sustainable social development and quality of life	P1110	Open Service Access: advantages and opportunities in service provisioning on 3G Mobile Networks
P910	Technology Assessment of Middleware for Telecommunications	P1113	The Tsunami IPv6 Project
P924	Distribution and Configuration Support for distributed applications	P1115	SALTAMONTES – Selected Quality of Services Provision in a Multi Protocol Label Switching/ Differentiated Services Internet
P1001	Europe-wide PKI model for Inter-TelCo applications	P1116	SCORPION – Scalable Optical IP Transport Networks
P1002	TALMUD – Technologies and Architectures for a Leap in Multimedia – database Deployment	P1118	Public Bluetooth Access: A promising Access Technology to Ubiquitous Computing Services
P1003	Exploiting the Always-on Concept	P1119	The Third Dimension – Human-Centred Approach to Designing New Mobile Services for Different Terminal Equipment
P1004	ICE-Commerce (Framework for Interoperable and Customised E-Commerce Solutions)	P1142	Biosciences and ICT – Two Worlds Growing Together?
P1006	DISCMAN – Differentiated Services – Network Configuration and Management	P1143	Perspectives for Future Work on IP QoS Issues
P1009	Armstrong IPv6 deployment – “A small step for IP but a giant leap for mankind”	P1144	The future CAMERA – Customers And Markets EURESCOM Research Activities
P1012	FASHION – Flexible, Automatically Switched, client Independent Optical Networks	P1145	4G – the next frontier
P1013	First Steps towards UMTS: Mobile IP – A European Testbed	P1146	GOLD – Getting OnLine communities to Develop
P1015	FREEHANDS – Fibre and Radio Enhanced Integration in Heterogeneous Access Networks for Delivery of broadband Services	P1147	DIRECT – The potential of peer-to-peer interaction
P1046	Local provision of Next Generation (NG) services	P1148	EXACT – Exploring ACTual ITC users and markets data
P1101	Always-On ‘Heterogeneous Services’	P1149	Impact of changes in enterprise software construction for telecommunications
P1103	Inter-Operator IP QoS Framework – ToIP and UMTS Case Studies	P1151	Always-On Security over ADSL
P1104	Analysis, problems and solutions – an overview		

This research programme develops sustainable business models that will strengthen Telenor's future position. This is done by analysing markets and competition, monitoring and analysing regulatory trends, and assessing the potential of technological developments.

Business models and strategy

The programme is heavily involved in broadband-related issues. A theoretical analysis of the challenges associated with competitive strategy has been carried out, and Telenor's competitors have been analysed. Knowledge regarding willingness to pay in the broadband market has been obtained by analysing surveys and conducting an experiment among participants in the VDSL pilot scheme. Key drivers have been identified.

In addition to work related to the roll-out of xDSL, techno-economic studies of the profitability of building the third-generation mobile network have been carried out. Business models for UMTS/WLAN have been designed. Pricing strategy issues relating to the take-up and use of new mobile services have been analysed. An analysis of the competitive situation in the Norwegian telecommunications market has been carried out, focusing in particular on regulatory issues. This analysis forms part of a wider project aimed at raising awareness of regulatory aspects throughout the programme.

Competitive arena

R&D is studying regulatory issues and the impact of increasing convergence on the opportunities for positioning open to various players. In particular, the programme has focused on the media sector, and on identifying and interpreting technological, market and regulatory trends that point towards new regimes for media distribution. On this basis, the programme has considered various strategies for content providers.

One specific area that the programme has focused on is the development of rights management systems – mechanisms that give the owner of the content control over its use, irrespective of the distribution medium. Within the programme general work on the development of the regulatory regime has been carried out, and R&D has acted as a consultant regarding mobile commerce, payment solutions and digital signatures.

Architecture and service quality

The programme has analysed efficient and flexible architecture for networks and services. The scope for pricing services according to network load, which provides the best usage incentives for costly resources has been investigated. Specific mechanisms and architecture were studied, leading to specific knowledge about how this can be achieved. A framework for managing IP services with guaranteed service quality where multiple players are involved has also been developed. This is being validated through specific schemes for providing IP telephony and UMTS services. The technical and business issues of relevance to players planning to offer commercial IP services with guaranteed service quality in future networks were analysed in a strategic study.

Over time, a variety of algorithms for producing good frequency plans for cellular networks has been developed and implemented, and these have now been supplemented by a new genetic algorithm.

The programme has investigated automatically switched optical networks and has drawn up solutions for traffic aggregation, resource management, network functionality and network architecture, and migration scenarios based on techno-economic analysis.

Full Service Network

In the *Full Service Network* project, evaluation and testing of the technological maturity for an IP-based platform has provided a basis for roadmaps of various degrees of functionality in a Full Service Network. R&D's contribution concerns the technical mechanisms and functionality of IP networks, realisation of services, security, and migration. R&D has also set up technological platforms for pilot schemes, and formulated a business plan and recommendations.

R&D led work on phase one of the *Common Service Framework* project, whose objective was to establish a common interface between different service platforms. The conclusion was that the technology is not sufficiently mature to allow implementation. Continuation of the work in the form of a pilot scheme and professional networking was recommended. R&D also contributed to Telenor's technological strategy and to UMTS standardisation.

How can Telenor help its corporate customers gain advantages in the market, and how can ICT solutions renew and improve public services, for instance through mobile solutions? These are the fundamental issues in our Professional Organisation research programme, which is based in Tromsø and Stavanger.

Public sector

The *DOSIT* project has developed a multimedia conferencing solution that allows members of the public to communicate with council officials via a distributed customer service office, the first of its kind in Norway.

Home-based Care has reached the end of its three-year project period. A mobile patient records and communications system for the home care service, Mobil Profil, was developed and tested in field trials by outreach nurses in real-life situations. The system operates via a wireless local area network covering parts of the town of Alta. The solution incorporates mobile electronic patient records, multimedia documents, and internal and external communications. The external communications function enabled the home care service to contact GPs, specialists and pharmacies to order or renew prescriptions, book appointments and make enquiries. Digital images of wounds were transmitted for documentation and assessment, and trial consultations with doctors were held by videoconferencing in patients' homes.

ICT in State Schools developed an alternative model for ICT skills development through trials in three districts of Troms county. Around 220 pupils were involved each year. The project has submitted proposals for stepping up the scheme to central government.

Travel and tourism

Sm@rt.Travel is a project to realise ICT-based services in association with selected partners in the travel and tourism sector. Two pilot services have been created: one tracks the position of the user, and the other builds on network-based road services. Around 15 technological demonstration services have also been set up, and the trends and barriers affecting new network-based services have been surveyed.

Sm@rt.FUNK is a project to provide disabled people with improved access to information and services in the

travel, tourism and transport sector. Working closely with users, the project has drawn up specifications for the pilot service, GAID.

Offshore

Future Production Fields has examined ICT as a tool for adding value when developing offshore fields in future, with regard to technology, individuals, working processes and regulatory authorities.

Virtual GeoNorge, or *Gullfaks PBL*, sets out to produce e-learning materials in geology using data from the Gullfaks field. Several universities and colleges are involved in the project. R&D has assisted Statoil in developing SCORM-compatible templates for publishing e-learning materials and assuring educational quality.

Other areas

ICT Potential in Fisheries surveyed the Norwegian seafood industry, its requirements for ICT products and services, and identified possible initiatives for Telenor.

A pilot project entitled *Automatic Reporting of Operational and Environmental Data in the Shellfish Industry* was conducted in association with Senja Skjell, and the opportunities and weaknesses were documented. Sensor systems and ICT can be used to monitor operational and environmental parameters in shellfish farming, and the weaknesses of existing technology.

The *NettLærR (Online Learning)* project aims to create an enduring, high-quality portfolio of online learning activities, to develop the infrastructure for the development, distribution and maintenance of e-learning, and to model structures, best practice and scenarios.

EURESCOM *P904* conducted an investigation into flexible working and quality of life among employees in Portugal, the UK, Iceland and Norway. The conclusion was that teleworking creates a more satisfied, loyal and efficient workforce. People who work at home for one or more days a week enjoy an improved quality of life overall, primarily due to greater control over tasks, greater flexibility and greater opportunity for concentration.

P1119 *The Third Dimension* focuses on users of new mobile terminals and telecommunications services, such as WAP, GPRS, UMTS and Bluetooth, to find out what they expect in terms of services, and how these services should be delivered. Two reports have been submitted. The findings show that adaptability is crucial to users – both adapting the services to different terminals and adapting the content to the user.

This research programme provides input to Telenor's efforts to devise business models for future media. R&D's role is to develop ideas for new services, and to demonstrate and describe how future media will be used in the private sphere, in public spaces and on the move. The programme had lead responsibility for making Telenor's House of the Future at Fornebu a reality.

House of the Future

The House of the Future, opened on 26 October 2001, is a research laboratory for studying the application of new media and communications technology in the domestic sphere, as well as a place for exhibiting new service concepts and ideas from R&D and its partners. A number of demonstrators are described below.

A person entering the house is identified by using a mobile phone employing Bluetooth technology. A Bluetooth-based electronic key to the house is also featured. A "smart" letter box distinguishes between letters and newspapers, providing different types of notification. Taking an artistic approach, the *Sense* project has researched the use of sensor technology for registering and transmitting feelings, to demonstrate how states of mind can control individual elements within the house.

To show that home surroundings can form part of our communications with the outside world, the house features a communicating lamp which, for example, emits red light when a message is received from someone very special. A demo entitled "Narrow or broad – getting together anyway" shows how young people use ICT across a range of media, and how to accommodate their desire to always be there for their friends, both physically and electronically.

For further information, visit the House of the Future website at www.fremtidshuset.com.

New media

Through the international organisation TV-Anytime, R&D has helped develop specifications for interactive TV combined with local storage. A video laboratory has been set up, to try out and experiment with new media technologies and standards.

New Media in the Public Arena is intended to provide strategic input to Telenor regarding service concepts for public viewing of digital content. The project has produced a specification for an electronic cinema solution, which is to be turned into reality at Fornebu, where it will serve as a research and presentation arena. R&D was involved in setting up the European Digital Cinema Forum and is working closely with the E-Cinema working group at Svenska Filminstitutet (Swedish Film Institute). A study entitled "E-Cinema – Introduction and early entry considerations" has been produced.

New Media on the Move has investigated whether – and how – an even spread of wireless zones providing mobile internet access (communication spots) can be used to offer content services despite limited availability, and whether such solutions may affect Telenor's business.

MATADOR

The *MATADOR* project (Medical Advanced Training in an Artificial Distributed Environment) sets out to develop and evaluate a network-based learning tool for use in training clinical staff in emergency medicine. The project is part financed through Nordunet2. Working closely with experienced physicians and surgeons, R&D has developed a clinical scenario and a demonstrator designed to raise awareness, both of the choice of clinical procedure and of communication within the team. In a pilot experiment, a group of medical experts tested and evaluated the MATADOR application.

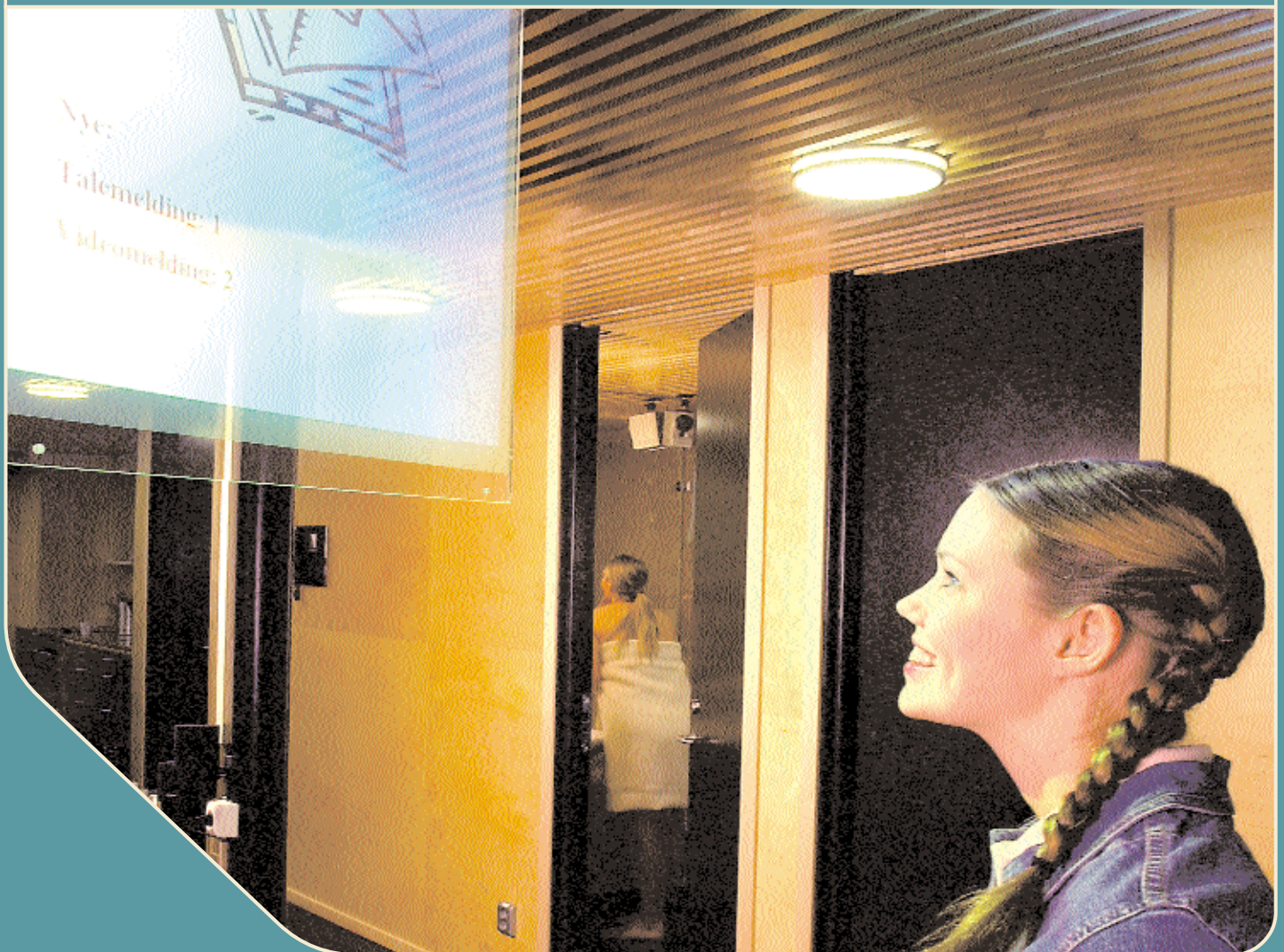
Groupwide projects

Future Media, through its video laboratory, has played a key role in the groupwide *FSN* and *HB@* projects, by setting up a video server for video-on-demand and broadcasting of TV channels, and by encoding large quantities of video material for video-on-demand. The project team has also assisted in conducting several large-scale field trials for *HB@*, by gathering and processing media usage data.

Playpen

In the *Playpen* project, R&D has produced a number of demonstrations of mobile services for the UMTS network, on behalf of Telenor Mobil. Much of this activity centred on products and services for multimedia transmission, and add-on functions to enhance the core functionality of mobile terminals. One example is BarFly, a prototype service that lets you choose a social venue on the basis of audio-visual data.

The mobile phone also serves as an electronic house key, identifying family members as they return home. Incoming messages appear as video messages on the big screen.



The distinction between what people do at work, at home and on the move is becoming increasingly blurred. There is a growing need for flexible solutions across traditional boundaries. Through user-driven research, the Flexible Communities programme aims to encourage knowledge, development and use of such services and products among Telenor's customers.

Nomadic working

Project Teleworking, a study of various aspects of teleworking, was completed at year-end. Over 30 businesses were involved in the project.

Nomadic Working in Norway analysed existing data sets, focusing on the use of ICT in working life. Businesses in 12 sectors were studied, and 63% indicated that they carry out a large part of their work outside the business. One in three managers expected teleworking to increase, especially in small to medium-sized businesses and the oil/gas, consultancy/IT and commercial sectors.

Using future mapping methodology, *Nomade 2007* devised three scenarios for nomadic working in Norway by 2007 and is discussing various forms of nomadism.

The EU project *SANE* is researching the interplay between workplace design, ICT and working methods, with a view to developing a model. Theoretical and practical parameters for the work have been established, and field experiments started in autumn 2001.

Nomadic lifestyle

The interaction between technology and users in the private sphere is of great interest. EURESCOM *P903* studied and compared 9,000 households in nine European countries, working through 36 focus groups, to provide a unique insight into how ICT is used today. *e-Living* (EU) is collecting data from 5,000 European households on a repeated basis, supplementing the snapshot provided by *P903*.

P1003 Always On focused on how telecommunications are used when technology and prices allow always-on functionality. The experiments showed that users were concerned about intrusion into their private life, but that the feature was popular and added value to a number of services.

Through pilot schemes, the *HB@* project tested the next-generation of broadband technology and services. R&D was involved in collecting and analysing users' experiences. A significant willingness to pay for the services was noted. The new possibilities offered by the high-speed internet, combined with always-on functionality, were quickly and actively taken advantage of. The project collected valuable feedback on innovative services and content.

Winnie, a joint project with Telenor Mobil on behalf of Samsung Electronics, focused on future UMTS terminals designed to meet the requirements of users. Four scenarios were developed and visualised in animated form, each illustrating the use of 3G services and terminals in a particular context.

Distributed communities and learning

EduAction has developed a new application for 3D learning environments. Team learning among pupils in network-based 3D environments is to be studied, with field trials taking place in early 2002. The trials show that interactive 3D environments have great potential for encouraging productive learning processes.

Telenor is starting a new drive to focus on education. In Project Education, we are contributing expertise relating to the professional implementation of ICT in schools. Research is focusing on new ways of addressing challenges at the interface between education, teaching methods and structures, and ICT. Experience from "best practice" schools has been catalogued.

In the *Knowmobile* project, R&D is working with HP, the Faculty of Medicine at Oslo University and InterMedia to test mobile services, terminals and networks for medical students in their practical work.

R&D is involved in a project entitled *ICT in Health and Education*, and has conducted studies in Nepal and Bangladesh. A business model focused on bringing e-learning and medical expertise to isolated communities has been developed in association with local content providers, and a draft plan for a long-term survey of ICT usage in two rural communities in the Himalayas has been produced. Letters of intent have been signed with local partners.

R&D was involved in *P1144 CAMERA*, which examined the need for customer and market-focused knowledge as a basis for developing competitive technical systems and networks.

The kitchen is the heart of the house and the family's gathering place. It is also an electronic communications hub – featuring traffic reports, electronic shopping lists, menus and cookery tips. The solution provides fully featured multimedia tools for working from home when required.



The future is wireless! This research programme is identifying and developing technological solutions and service concepts for future mobile communications, to ensure that Telenor has the necessary expertise to take advantage of the commercial opportunities.

The programme is extensively involved in international research and standardisation, primarily in the ongoing development of UMTS. We are also developing demonstrators to present product ideas and highlight our research activities.

Next-generation mobile systems

R&D has identified and analysed potential development trends in mobile communications in the period 2005–10. The overall issue has been how technology and markets will develop once UMTS has gained market foothold, and how Telenor should prepare for this. On the service side, R&D believes that mobile commerce, location-specific services and entertainment services will have the greatest growth potential. Mechanisms for stimulating this growth will include customisation of content to various media, open-interface service platforms, and functions for locating resources and addresses in various networks. R&D envisages a trend towards personal area networks of various kinds and wireless local area networks. New access networks are also likely to enter service, one example being cellular networks with around ten times the transmission capacity of UMTS. To utilise frequency resources and simplify the expansion of these radio networks, adaptive antenna and transmission technologies and self-organising radio networks will play a key role.

Radio access

R&D has developed a simulation platform for evaluating the use of various capacity-enhancing technologies in the radio access field, such as smart antennas. The aim is to ascertain the gain (e.g. an increase in the number of users) for each solution. A PC-based demonstration showing the use of smart antennas in cellular systems (UMTS) has also been developed. The application is based on measurement data from real radio channels. R&D was also involved in the COST programme entitled "Towards Mobile Broadband Multimedia Networks".

Services, platforms and quality

The aim is to develop user-centric services with customisable features, access to personal services regardless of geographical location and network access, context-based services accessible by users on the basis of geographical location, weather conditions, noise and light levels, and seamless access to peripherals. The bulk of this work has been conducted in a EURESCOM project led by R&D. The findings have been published in respected journals (Do Van Thanh et al.) and presented at international conferences.

R&D is also involved in an EU project seeking to establish acceptable values for user-perceived service quality on the basis of network-related and psychological parameters. The project has formulated guidelines for establishing parameters (such as delay, package loss, and package size) in different situations, methods for cost-benefit analysis of various services, and an evaluation method for both.

Networks and mobility

R&D has been studying various aspects of mobility once current technology (line switched) is replaced by IP-based solutions. One issue has been seamless mobility in a cellular network where all transmissions are by IP. We have investigated mechanisms for effective and scalable algorithms for seamless terminal mobility using IPv6, highlighting the security aspects and service quality management. One of our conclusions was that, in a multi-access architecture, it is unrealistic to seek to establish seamless internet telephony and, more generally, seamless real-time multimedia services.

Another topic is the optimum choice of access network in heterogeneous networks. R&D has devised a selection algorithm and demonstrated it in a scenario featuring UMTS and WLAN. The findings of this study have resulted in significant contributions to standardisation and research forums.

Speech technology

The development of compact mobile terminals with ever increasing data capacity has opened up new opportunities for value added services. For these services to be practicable, they will have to be easy to use. Speech technology, and speech recognition in particular, can be useful in many situations. On other occasions, pointing and pressing buttons is a more appropriate solution. R&D has therefore been studying the scope for combining both solutions. R&D has developed two PC-based demonstrations of the multimodal "Talk and Tap" concept.

A forward-looking phone company has to be able to offer products and services that are perceived as secure and technically sound. This programme is focusing on security in selected areas relating to the Internet, organisational structures, and 3G/4G mobile systems. In addition, the programme acts as Telenor's centre of expertise for risk analysis and risk management.

Security in distributed systems

The trend towards IP-based services and the opening up of Telenor's network to third parties presents new challenges in terms of security. To identify security flaws, R&D has conducted penetration tests on Telenor's servers and tested the security of a WLAN service. R&D is also monitoring developments in encryption technology, especially cryptoalgorithms.

R&D took part in EURESCOM projects focused on solutions for Public Key Infrastructure. A PKI model and interoperability requirements were formulated, and specifications drawn up for a pan-European testbed. Applications were tested in environments such as GSM, WAP, UMTS and mobile IP, and a profile for PKI certification policy was produced and coordinated with ETSI.

Issues surrounding Digital Rights Management and the distribution of creative works in UMTS-based networks were studied. The findings are also relevant to the distribution of creative works in other types of data network.

The *FSN Project* evaluated PKI/smart cards for access to broadband services. The project also covered distributed firewalls and IDS, VPN, and a new access server.

R&D also studied security in relation to alternative access technologies such as Hiperlan2, IEEE802.11x and Bluetooth. Various degrees of interaction were discussed. A demonstrator was developed to show the vulnerability of the "handling" system in WLANs.

The *Torrent* project is establishing a testbed for multi-service access networks. The objective is to propose an access solution for next-generation home-based networks, using agent technology. The service must allow negotiation of bandwidth, service quality and price between the end-user and the core network. R&D has

defined the security requirements for software and hardware. Specifications have been drawn up for a demonstrator, which will be tested.

Risk analysis

R&D works primarily on techniques for securing telecommunications networks, methods for risk management, and risk analysis. Seven analysis projects were carried out.

R&D studied how subjective expert opinions could be used as a basis for decision making in quantitative risk analysis where there is a lack of hard data. The results were implemented in an operational analysis tool.

The *CORAS* project has documented the state of the art in risk analysis and object-oriented modelling. To improve model-based analysis, R&D has identified the required modifications to existing methods and techniques. We have described the first step towards integration of semi-formal modelling techniques. Tests to be conducted in the telemedicine and e-commerce fields in 2002 have been planned in detail.

Mobility

ODMA is the name of an ad hoc network technology with the ability to increase the traffic capacity of each UMTS cell. R&D is examining the potential and limitations. We have developed a UMTS/ODMA simulation model, which has a modular interface and can thus also be used by others studying traffic patterns and radio resource usage in UMTS. Comparative simulations remain outstanding in the evaluation of the ODMA concept.

The *Mobile Learning* project takes trends such as online learning, mobile Internet, GPRS, UMTS, location-specific services, wireless networks and mobile terminals as its starting point. A pilot project was carried out.

The *Youngster* project is developing an open mobile multimedia platform that supports location-specific services. A user survey on mobile phone use, ideas on future services and disposable income was carried out among 700 young people in Southern Norway, and R&D has developed and demonstrated relevant applications.

R&D is taking part in the *Odin* project, which will present location-specific map-based services for mobile terminals, in cooperation with regional content and service providers. R&D is involved in developing the solutions for determining location. A Europe-wide distributed architecture for web services, interfacing with a GSM-based location server, has been implemented.

This research programme is working on issues at the interface between new interactive broadcasting services and PC-centred broadband services. One principal focus is the realisation of cost-effective broadband access solutions for “all” types of service. In 2001, as before, the bulk of our efforts focused on leading and taking part in the major groupwide project, *HB@*.

Another major challenge is in delivering services and content all the way to the end-user’s equipment. For both purposes, we have been working in particular on radio technologies. One reason is to make use of the extensive capacity in the 40 GHz band for which Telenor holds a licence, and another is to utilise new radio technologies for “personal” wireless access.

Through international cooperation, R&D has been involved in developing new forms of content via different media. Other projects have contributed to the digitalisation of the broadcasting networks, worked on mobile satellite communications, and carried out quality assurance testing of network elements and functions.

Popular and useful pilot project

“Dad, don’t ever let them take this out of the house!” That was the reaction from a young member of one of the 1,000 families who have been taking part in one of four pilot schemes in the groupwide *HB@* project.

The objective has been to develop and test profitable broadband access solutions for a combination of new TV- and PC-centric services aimed at the mass market. The four pilot schemes cover various technological combinations, tailored to different geographical circumstances and customer segments.

In Stavanger, 750 users were connected to Europe’s first and largest VDSL trial. In Oslo, Svolvær and Beito, the project used VDSL, LMDS in the 26 and 40 GHz bands, and digital terrestrial broadcasting networks combined with ISDN.

The pilot services were interactive TV, video-on-demand and electronic programme guides, coupled with high-speed internet access and ISDN phone services. In Stavanger, trial participants had access to 33 digital TV channels. The unique feature of the solution is that, in principle, users can “dial up” all kinds of content and programmes via a router-based network, while VDSL gives them access to up to three TV streams simultaneously.

The project ran across departmental boundaries within Telenor, and worked closely with content providers and pilot users. The main conclusion was that an adequate roll-out of broadband access will require hybrid network solutions. An extensive customer survey regarding willingness to pay was also conducted. The *HB@* project concluded as planned in 2001, but the pilot schemes are being continued by R&D and the relevant business units.

Marketing DVB standards

During the European broadcasting trade fair, IBC, in Amsterdam, R&D took part in a successful demonstration of the new standards DVB-MHP, MPEG-4 and MPEG-7 in use. The EU-sponsored *SAMBITS* project showed how conventional digital broadcasting services can be enhanced in combination with internet access and multimedia elements. Special reference was made to the findings in the concluding remarks at the conference, and representatives of the European Commission will now make use of the demo in marketing the DVB standards internationally.

Radio technology and service enhancement

During the IBC trade fair, R&D also took part in a presentation of two-way radio-based broadband access based on 40 GHz LMDS, under the auspices of the EU-funded *EMBRACE* project, which is led by R&D. As well as demonstrating a radio-based return channel, the project is working on planning methods and dimensioning criteria for the concept in use.

R&D has been actively involved in building radio-based access networks for Telenor subsidiaries in the Czech Republic, Slovakia and Russia.

Equipment testing

The Product Laboratory carried out a series of tests on equipment for Telenor’s networks. A number of shortcomings in relation to manufacturers’ specifications were discovered. Examples include interference in ADSL equipment, and network components for outdoor use that fail at temperatures lower than –5 °C.

The emotional aspects of communication can also be addressed. The House of the Future is able to sense the feelings of its inhabitants and adjust itself to their mood, using body sensors and biofeedback technology.



The information networks of the future will use internet technology. IP traffic is growing significantly faster than conventional phone traffic, and already exceeds it in volume in some areas. R&D is assisting Telenor in building network solutions that are optimised for IP traffic and can transmit data, text, images, sound and video.

R&D is working on solutions and infrastructure for a scalable, cost-effective IP-based network architecture, focusing on mechanisms, functions, network performance, network services, protocols, and traffic across administrative boundaries.

Traffic management

The *TrafHan* project is dealing with traffic management in IP-based service networks. The objective is to integrate all services, which has implications for traffic handling, transmission quality and availability. Results so far include an analytical model for calculating delays to priority traffic in low-capacity networks.

Expertise accumulated through TrafHan and EURESCOM projects has made a big contribution to the FSN project. P1006 *DISCMAN*, completed in March 2001, evaluated the available implementations of the DiffServ product and assessed the use of Traffic Engineering in a network. P1115 *SALTAMONTES*, which commenced in June 2001, is intended to produce guidelines for dimensioning, configuring, monitoring and controlling IP networks featuring service quality functionality.

IP via optical networks

P1116 *SCORPION*, which is dealing with IP via optical networks, is led by R&D. The project is seeking the optimum combination of IP functionality, GMPLS technology (Generalised Multi-Protocol Label Switching) and optical transmission networks for a scalable IP-based transmission network.

The *FONIP* project is studying the development of future generation optical transport networks for IP-based broadband traffic – in the light of expected progress towards an optical breakthrough and packet switching over the next three to eight years. The project is examining how the functionality of the optical network can allow optimum network utilisation through the introduction of technology that is currently still at the research stage. The objective is to ascertain how the development of fast optical switches and wavelength routers will affect functionality and performance, and hence influence network architecture, interaction and integration between optics and IP.

The *IPON* project is a strategic technological study in which expertise from several projects has contributed to producing a roadmap of technological and network solutions for the optimum, cost-effective integration of IP/MPLS with underlying transmission networks.

Other projects

Other research projects have dealt with architecture for performance measurement and monitoring on the internet, how self-similarity in data traffic is affected by network architecture, and topology and migration of IPv4 to IPv6, mobile IPv6 and migration mechanisms.

R&D has delivered some important findings in its projects on behalf of Telenor Networks. Studies of optical multi-channel systems have shown that, in the event of orthogonality between the optical channels, there will be a gain of 6 dB on the budgeted output. This gain can be utilised in the form of increased range or a quadrupling of the number of termination points in a distribution network. We also performed numeric simulations of the effect of polarisation mode dispersion in 40 Gbit/s transmission, based on measured parameters in Telenor's fibre-optic network. The aim was to ascertain whether the fibre-optic infrastructure is good enough for future capacity upgrades.

Young people are quick to adopt new technology and often use it in surprising ways. Multimedia terminals allow them to be permanently in touch with their friends, and to interact with friends on homework and leisure activities.



Open service platforms allow services to be realised irrespective of the underlying network technology and operated across different networks. This reduces development costs, opening up new business opportunities in the national and the global market.

Programme for Advanced Telecom Services (PATs)

This research programme is based in Trondheim, taking advantage of its proximity to the Norwegian University of Science and Technology (NTNU) to collaborate closely in the telematics and data technology departments. Work on PATs accelerated in 2001. R&D made an experimental open service platform available to a service laboratory at NTNU. Together with NTNU and industry partners, we are using new methods and techniques to produce and evaluate prototypes of advanced telecom services. The goal is to create the broadest possible basis for students and researchers to study hybrid services running on various terminals, servers and networks. The core components are in place, and 17 NTNU students have developed a number of services.

PATs has done much to raise the international profile of Trondheim as a research centre, and to foster new relationships with industry partners.

Platform for value added services

For several years now, R&D has been responsible for delivering services and new components to the *GIN* (Gateway to Intelligent Networks) production environment, which serves a large part of Telenor's traffic in value added services, with the InTouch service as the biggest user. R&D developed the core of this service, and a multi-user version was delivered in 2001. GIN is living up to expectations as a fast, simple, scalable and reliable platform. Traffic has now reached one million messages daily.

GIN was the first step towards open service platforms. The *NIPS* project has produced a modern service platform with functions tailored to the market served by Telenor Link (call centre solutions). The volume of deliveries to GIN and NIPS has increased to such an extent that in November 2001, a dedicated company – GinTel – was set up to take responsibility for this work. Nine researchers from Telenor R&D are the entrepreneurs behind the venture.

Mobile information services and international projects

R&D has been involved in a number of international projects dealing with mobile information services (2.5G and 3G systems) and how service platforms can support these effectively.

P1002 *TALMUD* has been studying technology for data storage and retrieval as a key component of advanced services and multimedia applications. The project has developed an architecture that supports storage, management and retrieval of multimedia content. The results are currently being assessed by P1105 *MobilUS*, which is studying information services for nomadic working and lifestyle. One core issue is how information can be presented to users with maximum accuracy, when bandwidth, terminal equipment and availability will vary. The project will provide valuable experience of how mobile services can be realised in a UMTS network.

P1110 *OSA Assessment* is focusing on open interfaces in service platforms. The project is evaluating the standards defined by the Parlay Group and 3GGP OSA, and products from five suppliers. Various mobile services are being studied in order to review the standards and products, and to identify the new features needed by the services. The findings will have implications for future platforms supporting UMTS.

Work on concepts for future middleware and web-based service platforms and frameworks continued in 2001. Key aspects are operation, scalability and reliability with a view to real-time applications, and P910 showed how these can be addressed using middleware.

P1004 *ICE* studied an e-commerce solution based on components and modification – as an alternative to “complete” software packages from leading suppliers. The project catalogued and detailed the e-commerce services and components that small businesses currently or may in future require. The project set out a framework for e-commerce, backed up with various demonstrators.

This research programme, started in 2001, is examining the usage patterns, platforms and technology typical of spontaneous network communities that interact with or without limited central resources. The aim is to develop concepts and prototypes that can be developed into products.

A network community is defined as a group of individuals forming a social community based on common interests, where the communication takes place electronically. The network of players is usually loosely connected, has a flat structure, and is typified by direct communication between participants, with no or limited involvement by central bodies.

Network communities can develop via all available and suitable networking technologies. The technology best suited to flat structures is known as peer-to-peer computing (P2P). The subject area ranges from networking technologies such as ad hoc networks, to platforms with P2P features and the understanding of social networking theory. Other key concepts are smart environments, and spontaneous detection of resources and social groups associated with the location.

Peer-to-Peer Computing

This R&D project has been pursuing three complementary, interdisciplinary initiatives to shed light on the subject from different specialist perspectives.

The first is ad hoc network technologies. Nodes that are constantly on the move require efficient and robust routing protocols to facilitate connectivity at network level. Links are established and broken, and routes between nodes have to be quickly re-established.

In the field of P2P software infrastructure, key issues have been how to locate, exchange and navigate the resources, when these are coming and going spontaneously in a non-centralised environment. These resources may be people, data, terminals or information. In particular, the programme has started looking at social navigation with direct and indirect interaction. A related technique for navigation that is being looked at is the behaviour of biological systems (ant behaviour).

In the third area, information interaction, R&D believes the degree of absence of authority will vary. The main focus has been on what will be the driving forces behind the new patterns of cooperation.

The project has established a testbed using handheld PCs that act as routers for one another (bandwidth Napster). The design is a pure IP network in which the routing protocols are capable of handling extremely dynamic environments. The same pocket PCs may be points of access and gateways to the internet and web servers. R&D has demonstrated streaming, resource detection and resource sharing via this network. The demonstrator has been documented, and the results will be published internationally in 2002. In addition, the project studied the scalability characteristics of ad hoc networks using a "Small Worlds" approach. These results have been published.

The project also contributed the "Universal Remote Control" to the House of the Future. This is a handheld PC with a middleware and application structure that makes it possible to control and manage a number of functions in the house. The main focus of the design development work was on information interaction and user interface.

Findings that are to be followed up in particular are the studies concerning the scalability of ad hoc networks, the scope for finding routes in spontaneous networks using dumb agents, and the link between geographical location and peer-to-peer middleware. The main theme will continue to be navigation using handheld terminals in smart wireless environments featuring interaction with resources that appear spontaneously.

At international level, the programme was involved in P924, relating to the Java platform, P1009 and P1113, specialising in IPv6, and last but not least, P1147 *DIRECT – The Potential of Peer-to-Peer Interaction*, in which R&D played a leading role. The programme contributed to international standardisation through IETF, mainly in the areas of IPv6, mobile IP and ad hoc routing.

The programme has also made contributions on service platforms to the FSN project, to Telenor Mobil's strategic planning work concerning service platforms, and to the groupwide IPv6 strategy.

Incubator

The Incubator is designed to assist new business start-ups resulting from R&D's research and works closely with Telenor's new venture departments. Protection of technology through patenting forms a key part of the work.

Company start-ups

Octaga AS, established in June 2001, is a product of R&D's research into applied media technology. The company's mission is to develop products using distributed 3D virtual reality technology, either in cooperation with leading businesses wishing to add 3D capabilities to their existing products, or through all-new products marketed by Octaga itself. On the basis of experience with the DOVRE research tool, the Octagon product range is currently under development. This will comprise a core server technology, with spin-offs tailored to particular market segments and areas of application. Transport will be the first segment to be targeted, and product development work will be conducted in association with leading players in the Scandinavian market. The technology is based on open standards and will support formats such as MPEG4. Octagon will be the first client-server technology to support MPEG4 streaming and interactivity in multi-user applications. Telenor has a 55% stake in the company.

GinTel AS was set up in November 2001. For some years, the R&D centre in Trondheim has been developing and supplying intelligent network platforms and components, and advanced production services for telecoms networks. These include products for integrating landline and mobile networks, third-party solutions, and advanced call handling (e.g. distributed call centre solutions). The majority of these products were developed on behalf of Telenor group companies, and this part of the business has now been hived off to form GinTel. The company is to specialise in consultancy services and product development of advanced services for next-generation networks such as UMTS. The company will operate in a competitive, international market, and GinTel is aiming to be one of the first to provide advanced services based on the OSA and Parlay standards. Telenor has a 60% stake in the company.

Xymphonic Systems AS was established in December 1998. The company's mission is to use patented technology to support interaction on documents and other shared resources. The company will sell software developed in-house, as well as licensing the technology to other software manufacturers. A beta version of Xymphonic Composer for MS-Word was released in December 2001. The company's business plan has been revised, and there were two small share issues in 2001. The company also obtained both a development subsidy and an incubator grant from the Norwegian Industrial and Regional Development Fund (SND). Xymphonic Systems has become an Oracle partner and is in negotiations with Oracle regarding closer cooperation on marketing and technological development. Telenor has a 43.15% stake in the company.

Fazet was set up as an incubator project in autumn 2000. Activities in 2001 involved drawing up a business plan as a basis for establishing a company to provide a full package of communication and information services without itself owning any network infrastructure. The project has developed a service concept centred on a virtual PA designed to serve mobile users in the Scandinavian corporate market. The project has close links with Telenor's core business and was transferred to Telenor Innovasjon in autumn 2001. The aim is to set up a company in spring 2002.

Licensing

Telenor holds one patent for the MPEG4 multimedia standard. Together with 18 other companies (including Microsoft, Motorola, France Telecom, Sony, Toshiba, Sharp, Philips) Telenor has set up a patent pool, which is to license out the rights of the patent holders. The consortium is working to have a licensing programme up and running during the first three months of 2002.

Future com Business

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Abbreviations

3D	Three-dimensional	MHP	Multimedia Home Platform
3G/4G	Third and fourth generation mobile systems	MIT	Massachusetts Institute of Technology
3GPP	Third Generation Partnership Project	MPEG	Moving Picture Expert Group
		MPLS	Multi Protocol Label Switching
ADSL	Asymmetric Digital Subscriber Line	NFR	The Research Council of Norway
BT	British Telecom	NHH	Norwegian School of Economics and Business Administration
COST	Committee on Science and Technology	NTNU	Norwegian University of Science and Technology
DRM	Digital Rights Management		
DVB-MHP	Digital Video Broadcasting – Multimedia Home Platform	ODMA	Opportunity Driven Multiple Access
ETSI	European Telecommunications Standards Institute	P2P	Peer-to-Peer Computing
FSN	Full Service Network	PAN	Personal Area Networks
GIN	Gateway to IN	PATS	Program for Advanced Telecom Services
GMPLS	Generalised Multi-Protocol Label Switching	PKI	Public Key Infrastructure
GPRS	General Packet Radio Service	SCORM	Shareable Content Object Reference Model
HiperLAN	High Performance Local Area Network	SNF	Institute for Research in Economics and Business Administration
HB@	Hybrid Broadband @ccess		
IBC	International Broadcasting Convention	TTT	Things That Think
IDS	Intrusion Detection System	UMTS	Universal Mobile Telecommunications System
IETF	Internet Engineering Task Force	UNIK	Center for Technology at Kjeller
ICT	Information and Communication Technology	VDSL	Very high speed Digital Subscriber Line
IN	Intelligent Networks	VPN	Virtual Private Network
IP	Internet Protocol	VR	Virtual Reality
IPv6	IP version 6	WAP	Wireless Application Protocol
ISDN	Integrated Services Digital Network	WLAN	Wireless Local Area Network
IST	Information Society Technology		
ITU	International Telecommunications Union	xDSL	(x) Digital Subscriber Line
LMDS	Local Multipoint Distribution System		

