BEYOND 3G RESEARCH:

Can the nordic and baltic countries (re)emerge among the world leaders?

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The development of Beyond 3G systems requires a multidisciplinary and user-driven approach. On the basis of its established research traditions and institutions, the Nordic and Baltic area could be a driver in advanced mobile and wireless systems. This role is likely to be very different from the one played by the region in the first generation and 2G systems based on standardised technology systems. In the Beyond 3G setting we will see solutions based less on specific technologies and more on interoperability and new business models.

INTRODUCTION

Europe has enormous knowledge and industrial assets as well as one of the world's largest markets. More than ever, partnering of Nordic and Baltic countries at a European level is needed to keep pace with soaring research costs and increasingly complex and interdependent technologies.

Increasing competition on a global scale, with the accelerated globalisation of markets and an ever faster pace of technological change, gives the Nordic and Baltic countries, as part of Europe, no other choice than to mobilise their resources and focus them on key elements of the value chain to attract investment. Development is driven by the interaction between technical and socio-economic changes, thus to lead progress in ICT, it is essential to improve innovation performance and address related socio-economic challenges.

On the technical side, progress and breakthroughs in ICT are driven mainly by continuous miniaturisation of electronic components and new integrated and embedded multi-functional systems. Performance and reliability of underlying electronic components and systems must be increased. Further, accelerated digital convergence of communications, computing and media technologies implies the need to make network and service infrastructures more stable, predictable, scalable and secure.

The increasing need for systems that can contextualise, learn and act autonomously is another research-driving factor. ICT systems need to be able to better learn from observation and experience, adapt better to the context in which they operate, and become more personalised and user friendly. An ever growing load of information and content and increasing demands for knowledge and skills require progress in the way we create and publish digital content and in the way we can effectively search for, discover and make use of it.

Mobile communications have evolved from a rare and occasional service based on expensive pieces of equipment used mainly by the business sector to an integrated part of daily life based on pervasive low-cost personal items. In many countries, mobile phones now outnum-

ber land-line telephones, and the mobile phone services portfolio is constantly expanding.

Mobile technology development during the last two to three decades has been one of the major trends in the massively changing ICT landscape. Mobile technologies enable mobility and flexibility in the use of ICT services and have changed relations in social life and production. Within this development the Nordic countries have been very visible as advanced markets and the Nordic mobile industry has been a prominent actor and driver. Mobile communication, however, increasingly embraces a range of converged services especially related to the development of wireless standards and the new generation of mobile technologies. This definitely challenges the role and position of the Nordic countries. A number of positions and strongholds acquired during the build-up of digital mobile technologies set the Nordic region apart from the rest of Europe. If the region can use this to create convincing next generation technology solutions, products and services, then it may be able to regain some of its position and emerge as an advanced market and actor in the 'beyond 3G' development. This potential could be reinforced by broadening cooperation to the whole of the Nordic and Baltic area.

HISTORICAL FACTORS FOR THE CONTINUOUS GROWTH OF ICT IN THE NORDIC COUNTRIES

Mobile communication started in the United States (US) in the 1940s with radio phones in cars. The next step was hand-held cellular radio devices – also based on analog technology – available since the beginning of 1980s.

In 1980, the mobile cellular era began, and since then mobile communications have undergone significant changes and experienced enormous growth (Ojanperä and Prasad, 2001). First generation mobile systems using analog transmission for voice services were introduced in the 1980s. Several standards were developed: Advanced Mobile Phone Service (AMPS) in the US, Total Access Communication System (TACS) in the United Kingdom (UK), Nordic Mobile Telephones (NMT) in the Nordic countries, Nippon Telephone & Telegraph (NTT) in Japan, and so forth (Ojanperä and Prasad, 2001). The mobile market during this era was obviously very fragmented with a variety of standards used in different countries.

With NMT, a joint development between Denmark, Finland, Iceland, Norway and Sweden, the Nordic countries acquired a prominent position for first generation mobile. While Swedish industry was the dominant partner, Finnish and Danish industries in particular, along with the incumbent operators in the five countries, were all involved as very active players in a mutual collaboration. The combination of high income with specific geographic and socio-economic conditions no doubt contributed to the development of the demand side of the mobile market.[1]

Because of market fragmentation, efficient harmonisation and interoperability/roaming were either a non-issue or at best a very complicated process. With the emergence of the Internal Market in the EU, this was seen as a huge problem for Europe. Driven by the need for a common standard and the creation of a single mobile market, the late 1980s saw the introduction of second generation systems using digital transmission and characterised by higher spectrum efficiency, better data services and more advanced roaming. In Europe, the 2G system was the Global System for Mobile Communications (GSM). Although the goal was a single mobile market, the result was still a fragmented one, although less so. GSM has had enormous success within and beyond Europe, even in countries where there are a number of other competing standards. With respect to optimal utilisation of frequency resources, digital technology uses transmission resources efficiently due to advances in both audio compression standards and digital modulation technologies.

In the Nordic countries, conditions that had promoted the growth of the first generation market also created advanced 2G/GSM markets, but it was early fixed line liberalisation that elevated the Nordic GSM markets above mainstream Europe. In the early 1990s, the

Nordic incumbent operators developed very strong cellular arms, which are still highly dominant on the GSM market. During the late 1990s the Nordic telecom regulators generally tightened surveillance on the incumbents to ensure that competition in mobile services was stimulated and that the incumbents did not receive any favours. The result was competitive markets with a high mobile penetration at a relatively early stage. An International Telecommunication Union (ITU) study in 2002 highlighted Denmark's leading European position in competition and pointed to four reasons for this: 1) early liberalisation of the telecom market, 2) technological innovation, 3) high general income levels, and 4) regulatory activity (ITU, 2002).[2]

The very competitive market could, however, be claimed to have worked against maintaining the Nordic position as a mobile pioneer in the 3G market as well. With respect to innovation and R&D in Beyond 3G, the Nordic position looks more promising for a variety reasons.

R&D AND LIBERALISATION

Telecom liberalisation generally resulted in the dismantling of operators' research and development departments, implying that operators were no longer among the primary actors in 2G. The equipment industry, including Ericsson and Nokia – a rising star at the time – took over in collaboration with universities. The significant positions of Ericsson and Nokia implied an important role for the Nordic area in 2G development. Even Denmark, without global level industrial mobile players, contributed to the overall development through advanced university research in collaboration with the global industrial players.[3] At Aalborg University, the Center for PersonKommunikation (CPK) research centre, in collaboration with local branches of the global players and SMEs, delivered some of the strongest antenna expertise at a worldwide level. The Danish Technical University commenced research focused mainly on backbone technologies and optical fibre technologies, and on integrated chip solutions for which functions and system knowledge are integrated, leading to single chip solutions, such as system-on-chip.

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2G systems evolved towards 3G systems with more advanced services at bit rates of 100 to 200 kbps for circuit and packet switched data. These evolved systems became known as 2.5G (e.g., GPRS, EDGE). 3G systems were established with advances in flexibility, data rates, the possibility to offer simultaneous multiple services for one user, and services with different quality of service.

Mobile network developments from 2G to 3G have been driven by developments in the equipment industry, but this time in a complicated international strategic set-up in which Japan, South Korea and also China have emerged as strong players, backing their respective 3G standard versions: WCDMA, CDMA2000 and TD-SCDMA. Ericsson and Nokia have favoured WCDMA, but the focus has been on making a difference globally and thus there has been little room left for a specific and marked Nordic role in a 3G market on its way to a potentially more fragmented state than the 2G market. The development towards 3G has primarily been driven by the lack of frequency resources for 2G to cope with the rapid development and penetration of mobile services and the need for new mobile services with varying demand on bandwidth foreseen by industry. These only emerged on the markets as manifest trends during 2006. Nevertheless, research institutions and industry have engaged in exploring solutions in mobile systems beyond 3G, and in this area Nordic countries are highly active.

THE ROLE OF UNIVERSITIES AND RESEARCH CENTRES IN ICT DEVELOPMENT

The importance of universities and research centres comprises a wide range of aspects (Varga, 1997; Segal Quince Wicksteed, 1985). Here we focus on the role of Danish universities in boosting R&D in 3G and Beyond 3G mobile communications in the region.

Even if Nordic research institutions have not been the driving forces in the development of 3G platforms, there has been a clear enhancement of mobile competencies by these institutions. It has been recognised that universities have a more direct and formal way of transferring ideas, knowledge and basic research from the university into industry practice. This began with various means of knowledge exchange, such as long-term university-industry research agreements, industry-financed contract research, or industry-sponsored university research centres. The Center for Tele-Information (CTI) (now known as the Center for Information and Communication Technologies – CICT) was an early example, set up as a joint venture between the incumbent telecom operator and the Danish Technical University (DTU) in response to demands for new multidisciplinary competencies among engineers in the new liberalised environment. This demand was formulated by industry/the incumbent, but also by the telecom regulator.

Significant developments for mobile communications became visible at the European level during the 1990s as a result of ICT projects funded under the European Framework Projects, initiated in the 1980s. It was evident that international technical projects like these played an important role in improving competitiveness and strengthening Europe's position as a leader in mobile communications. This was also recognised by Danish governmental bodies, and in January 2004 the Centre for TeleInfrastruktur (CTIF) was established at Aalborg University with combined funding from Nordic and other industries, the Danish government, and the FP6 EU research programme.

Center for Information and Communication Technologies (CICT)

CICT is a continuation of the CTI, which was set up as an initiative of DTU and Tele Danmark (the incumbent telecom operator) with primary funding from these institutions in 1994. The idea was to provide a focal point for multidisciplinary research and training in the new field of 'tele-information'. The initiative was based on discussions with interested private and public parties within the sector, concluding that new technological and social tendencies within the area of telecommunications created new challenges to be addressed. It was recognised that these challenges could not be efficiently met with solutions from traditionally separated scientific disciplines.

In 2004 DTU decided to found CICT based on CTI's results in cooperation with industry. The Centre provides a focal point for multidisciplinary research and training in ICT applications. The principal aims of the centre are to determine and analyse the basis for new ICT applications; to analyse and develop ICT applications and the framework and strategies for their implementation; and to analyse and suggest policies and regulation related to emerging ICT applications, including the economic, social and cultural implications of their introduction. The CICT presently has approximately 35 employees.

Centre for TeleInfrastruktur (CTIF)

CTIF is a research centre with more than 130 employees organised into ten research groups, conducting research at the highest international level to enhance technological development in modern wireless communication technologies and telecom infrastructures. The CTIF maintains strong relations with industry for carrying out research and developing new types of networks, devices and services.

Future broadband networks, wired or wireless, need to adapt according to user demands. The vision therefore is to produce a knowledge base to meet the increasing need for reliable and fast access to broadband and connected services, for everyone, anywhere, at anytime.

The future will offer ubiquitous and unlimited-capacity communication networks. These could be defined as cost effective, re-configurable and flexible mobile and broadband network technologies, systems and architectures, including terrestrial and satellite networks. Convergence of different fixed, mobile, wireless and broadcasting networks and services spanning from the personal area to the regional and global area will play a major role, through the interoperability of wired and wireless communica-

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tions services and applications. Key focus areas for achieving this vision will be the management of networked resources, service re-configurability, and the complex networking of ad hoc intelligent multimedia devices, sensors and microchips, and personalisation. All this will require enhanced cooperation among industry players, the research community, and public authorities. This is the basic understanding and driving force behind the CTIF's activities and research policy.

CICT and CTIF

The two centres thus have different strongholds, but work within the same general area and complement each other. Combining their respective competencies, they are active in research and development of Beyond 3G and 4G technologies.

Among the various national and international research projects and activities in which they are involved, the EU-funded MAGNET Beyond project is particularly worth mentioning. This project is a continuation of the EU-funded MAGNET project, an Integrated Project type of instrument with CTIF as the coordinator and lead participant. The overall budget is around EUR 30 million, of which 10.2 million is funded by the EU and the rest by the involved industry corporations and SMEs. The impact of two consecutive projects of this magnitude led by Danish academic organisations has resulted in worldwide promotion of the possibilities of Nordic countries.

The project acronym stands for 'My personal Adaptive Global NET and Beyond'. Some of the main focus areas of MAGNET Beyond are user-centricity, personalisation and Personal Networks. The overall concept of MAGNET Beyond is shown in Figure 1.

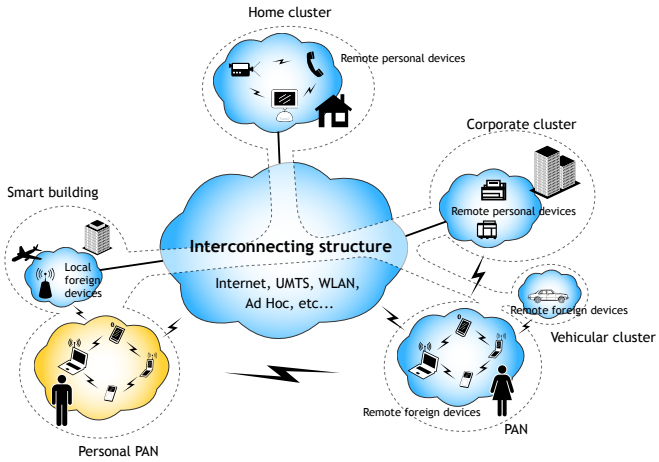

Figure 1: Concept of MAGNET Beyond
Source: IST Project MAGNET Beyond

Personal Networks (PN) potentially comprise all of a person's devices capable of network connection in the real or virtual vicinity. This requires major extensions of the present Personal Area Network (PAN). PNs are configured in an ad hoc fashion, as the opportunity and the demand arise to support a person's private and professional applications. These applications may run on a user's personal devices , but also on foreign devices. PNs consist of communicating clusters of personal digital devices, possibly shared with others, and connected through various suitable communications means. Unlike PANs, with a limited geographical coverage, PNs have an unrestricted geographical span, and may incorporate devices into the personal environment regardless of their geographic location. In order to extend their reach, they need the support of infrastructure-based and also ad hoc networks.

MAGNET Beyond is not only about developing advanced technology; the project aims to improve the quality of life for users by introducing new technologies that are better adapted to their needs. This research makes environments smarter, more responsive, and more accommodating to the needs of the user, without jeopardising the privacy and security of the individual. A unique feature of MAGNET/MAGNET Beyond is the integration of user requirements, which play a determining role in the development of the new technologies. This is primarily a result of the close collaboration between the CICT and CTIF.

FURTHER NORDIC UNIVERSITY-INDUSTRY INTERACTIONS

The CICT/CTIF collaboration has resulted in a number of further initiatives, including several that use and enhance the Nordic dimension. A prominent example is NordICT.

NordICT

The NordICT initiative is a network established to enhance collaboration between industry and universities in the Nordic and Baltic region within ICT.

As discussed above, Nordic research institutions have a strong track record

in mobile and wireless communication, based on close relations between industry and universities, mostly along national lines. Communication systems are, however, becoming extremely costly to develop, and the underlying research questions are correspondingly becoming very complex. It is already very difficult today for the universities in the rather small Nordic/Baltic countries to deal with the full range of research questions that need to be answered as a basis for a modern communication system. Completely new research questions are increasingly becoming relevant, with an ever higher degree of complexity and associated costs. Industry – and society – want to know about the user requirements of these new systems, the associated system requirements, and how this translates into business models.

Developing these competencies requires mobilising resources at a level that cannot be met by any of the individual countries. But with NordICT, it could be possible to contribute to mobilising the necessary resources in a focused and collaborative effort among universities in a new approach towards research development, knowledge sharing and networking. NordICT has been established to provide a platform for this effort.

CONCLUSION

It is argued that Beyond 3G mobile communication systems will comprise a more diverse set-up, consisting of a variety of heterogeneous systems working together in more or less transparent ways. They will be fully seamless with an emphasis on secure mobility, leading to a need to rethink the mobile access structure and the business models involved. It is likely that there will be room for smaller and medium-sized players in the various markets for devices, applications and services.

Development of such systems requires a multidisciplinary and user-driven approach. On the basis of its established research traditions and institutions, the Nordic and Baltic area could be a driver in advanced mobile and wireless systems. This role is likely to be very different from the one played by the region in the first generation and 2G systems based on standardised technology systems. In the Beyond 3G setting we will see solutions based less on specific technologies and more on interoperability and new business models. This calls for strong industry-university collaboration, and as shown above, there is already a well-established network upon which to base the (re)emergence of the Nordic and Baltic area in a prominent position in future mobile research. ●

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[1] *In Finland, Norway and Sweden geography has been seen as a crucial factor promoting mobile growth. A small population spread over a large landmass made fixed-line connections difficult and costly. NMT was a convenient alternative and although costly for the individual, many could afford it. In Denmark, without the extremes of terrain, the easy availability of mobiles (NMT) spurred the uptake.*

[2] *There are certainly differences between the Nordic countries, but the characterisation as advanced and competitive is substantiated in, for instance, a 2006 report from the Nordic telecom regulators, 'Competition and regulation in the Nordic mobile markets' (Nordic National Regulatory Authorities, 2006).*

[3] *This puts Denmark in the top rank for telecom sector innovation amongst European countries (Telestyrelsen, 2003; Skouby et al., 2003).*