Nordic Internet Infrastructure Development 1988–2007

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Abstract. In the development, introduction and spread of the Internet, Nordic researchers have had a pioneering and central role. Already in the 1970s Norway hosted and developed the first ARPAnet node outside North America. In the 1980s pioneers in the Nordic countries started national computer networks and joined forces into the Nordic academic network NORDUnet, developed and operated from the KTH Network Operation Centre, KTHNOC. Its DGIX (Distributed Global Internet eXchange) node became central in the global Internet in the mid 1990s, with about 40 Internet operators connected. NORDUnet played a strong role in European network cooperation and in spreading the net eastwards from 1990. We describe, analyse and reflect on the Nordic development 1988-2007 with details on the expansion into higher and higher capacities and services.

Keywords: Internet, Nordic Infrastructure, Net capacity, Net service

1   Introduction – Nordic Background

Norwegian pioneers contributed in the 1970s and early 1980s substantially to the development of Internet Technology, as described by Yngvar Lundh in [1] and by Pål Spilling in [2]. They already had the first ARPAnet node outside North America in 1973. Nordic researchers were also involved in other early networking experiments and in building infrastructure. Experiences of Computer Mediated Communication, including the KOM system, in the 1970s in Sweden, are described by Jacob Palme in [3]. Development of "Baby Networks", like videotext, in the Nordic countries and Europe in the early 1980s, is described by Tomas Ohlin in [4].

Fig. 1. Map over NORDUnet 1992 with KTHNOC at the centre

In the 1980s the spread and decentralization of computer power accelerated, especially with personal computers and graphic workstations. The computer centres lost their central role and most of them disappeared.

Swedish researchers became involved in Internet when the ban of non-NATO use of ARPANET based networks was lifted around 1980. Pioneers at KTH started building networks based on Ethernet and got a very central role in the development and operation of the Swedish university network, SUNET, as well as in the Nordic Academic network NORDUnet. In Denmark, Finland and Norway academic networks were also developed.

2   Computer Networks in the Eighties

In the beginning there were mainly packet switching networks using X.25 switches. An early international network in Europe was EUnet, European Unix Network. It was first announced in 1982 at the European Unix User Group conference. IBM supported a European version of Bitnet called EARN, connecting research centres using IBM computers. EARN became operational in 1985 and the Nordic countries were early members of EARN. Digital Equipment had

DECnet connecting their DEC computers. And then there were the Internet Protocols, TCP/IP, well established in the US through ARPANET and later CSNET and NSFNET, both supported by the National Science Foundation. Norway as a NATO member, had early Internet access via SATNET, but this was still limited to a few institution.

In parallel the "anarchistic" USENET, based on UUCP, the Unix-to-Unix-Copy Protocol, was spreading. If you had a Unix computer and knew someone with a Unix computer connected to USENET, you just had to establish an electronic connection (i.e. by a telephone line) and then you were on the net. The first Swedish "Internet connection" was established in April 1983 via USENET by Björn Eriksen, then working at ENEA, a Swedish information technology pioneering Company.

These different networks with their own protocols normally did not interconnect, but eventually some bridges were developed to open traffic between them, mainly email traffic.

3   NORDUNET from Project to Network

NORDUNET started as a community of Nordic Networkers in 1980, with support from Nordforsk, as a program and became a project for Network development with funding from the Nordic Council of Ministers during 1985-1991. The coordinator from 1985 and later director until 2005 of NORDUnet was Peter Villemoes. In an account of the first 25 years of NORDUnet (see [5]), Kaarina Lehtisalo writes: *By choosing to use the Internet protocol developed in the United States but not yet approved by the other Europeans, NORDUnet took a courageous step which later proved to be the right decision.*

Development of plans was rather slow in the beginning of the project. There were still several competing network protocols and solutions, but none that could serve all.

European networking policy had firmly focused on the OSI-model, Open System Interconnect. TCP/IP was excluded, as the political level wanted to develop the European industry in this area. Unfortunately the top-down approach of OSI development was much too slow to produce cost-effective communication solutions compared to the US Internet Protocols developed for ARPANET through a bottom-up approach. The Internet Engineering Task Force became the forum for developing these standards, proven by running code.

The NORDUnet project had a very concrete goal**:** to set up a working network for Nordic researchers as soon as possible. And it became more and more clear that the complex OSI model would take many years to deliver. So the only alternative was to base the services on existing technology. And the technology that had evolved recently was multiprotocol routers and long distance Ethernet solutions via Remote Bridges. It had made it possible to set up a wide area multiprotocol network. This was the new track that NORDUnet followed, though also

declaring that it would migrate to OSI when feasible. This never happened.

Instead a multiprotocol solution was used. It became known as The NOR-DUnet Plug, when Einar Løvdal presented it at the NORDUNET Conference in Reykjavik in September 1988.
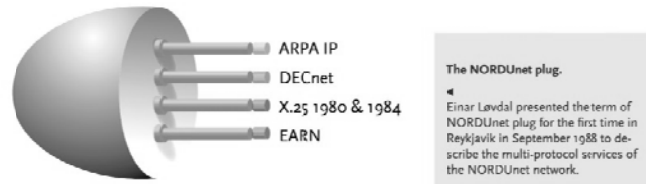

The NORDUnet plug.

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Einar Løvdal presented the term of NORDUnet plug for the first time in Reykjavik in September 1988 to describe the multi-protocol services of the NORDUnet network.

Fig. 2. The NORDUnet plug

Internet (ARPA IP) soon turned out to be the winner, and the role of the other network protocols gradually diminished in the Nordic countries. This process was much slower in the rest of Europe due to political reasons. But with TEN-34[1], TEN-155 and GEANT this changed and IP was accepted.

4   SUNET and KTH

The Swedish University Network, SUNET, started using the X.25 service from the Computer Centres, then added a dedicated DECnet network from 1985-1988. Hans Wallberg, who was in charge of SUNET development, found that X.25 as a bearer for the network became far too expensive, as traffic increased, and also much too slow. A 64 kbps line gave only 2400 bps effective capacity, the rest was overhead. A solution was then to move to a multiprotocol network over Ethernet in order to be able to serve all their different users with one network and to control costs. The networks that needed to be supported were X.25, DECnet, EARN and Internet. This required a coordinated effort in developing bridges between these networks. Some of that work was successfully done at KTH. This work, together with the experience from building a large Local Area Network using Ethernet and TCP/IP, gave KTH the task to set up and run the central node of the new SUNET. The new network became operational in mid 1988. Physically

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[1] TEN is Trans-European Network first at 34Mbps then at 155 Mbps. GÉANT is the pan-European data network for the research and education community.

it was implemented with leased 64 kbps lines using Vitalink Ethernet Translan Bridges and this way KTH could run the four different protocols over Ethernet, using the NORDUnet plug concept, Figure 2.

4.1 KTHNOC

When SUNET in 1988 decided to build its own dedicated multiprotocol network, KTH got the task to implement it and to operate the central node. A similar task was given by NORDUnet, to set up their multiprotocol network in order to link the Nordic Academic networks in Sweden (SUNET), Denmark (DENet), Norway (UNINETT) and Finland (FUNET), later also Iceland (RHnet). So the KTH Network Operation Centre was set up with Björn Eriksen in charge. And before the end of the year, the networks were operational and connected to the Internet at the John von Neuman Supercomputing Center in Princeton, USA. We were lucky to just miss the first significant Internet worm, Morris, which was spread on November 2, 1988, and caused considerable damage.
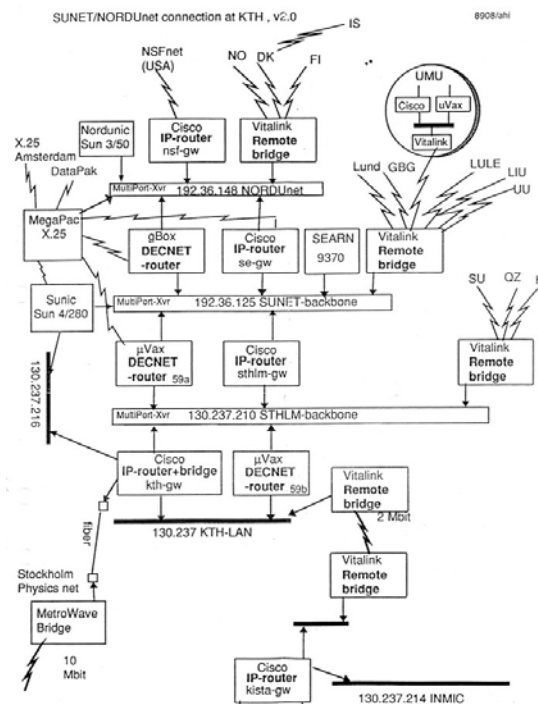

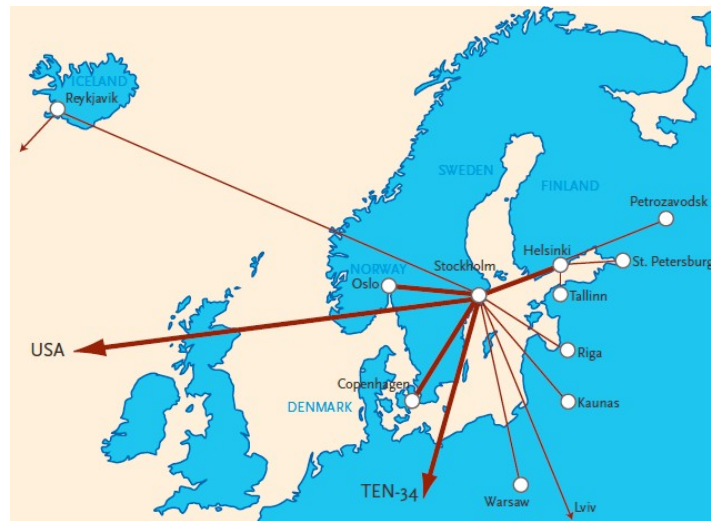**Fig. 3.** The three backbone networks STHLM, SUNET and NORDUnet in 1989

Fig. 4. The NORDUnet network in 1997

4.2 Root-server

The staff at KTH developed and demonstrated a high level of competence regarding the Domain Name System, DNS, and NORDUnet was the first network outside of the US that was given the responsibility to run one of the Root Servers needed for the top level of the DNS. It **was** named nic.nordu.net. In 2001 it's operation was transferred to Netnod by NORDUnet.

4.3 Swipnet

When Björn Eriksen joined KTHNOC he brought with him a number of EUnet customers, who at the beginning presented a marginal load, but grew and needed a new home. The Telecom Operator Tele2 took the challenge and started an IP-service, called Swipnet, and got a head start over the competition. Televerket started their IP-service TIPnet six months later.

4.4 Domain Name Registration

The Internet explosion from 1993 onwards put pressure on the domain name registration for the Swedish top domain **.se**, which was run by Björn Eriksen at KTHNOC. With suddenly 20.000 new domain names per year, this was not suited for a one-man show, so Björn handed over the responsibility of

.se to the Swedish Foundation for Internet Infrastructure, IIS, 1997.

IIS has grown considerably since then and is a serious player in supporting Internet development and spreading useful information on current Internet issues.

4.5 DGIX and KTHNOC-POP

With the rapid growth of Internet and internet traffic, the need for exchanging traffic between different networks and operators grew. Normally you set up direct lines with all the operators, with which you need to exchange traffic, but this turned out to be much more expensive as the number of nodes grew. That is why neutral Interconnect Exchanges were set up. The DGIX, (Distributed Global Internet eXchange) node was an early exchange of this kind set up at KTHNOC in 1995, as a central node in the global Internet, connected with about 40 Internet operators.

Many operators needed to house their equipment close to the DGIX switch and so the KTHNOC-POP (Point of Presence) evolved. By 1997 security concerns over KTHNOC as a possible single point of failure led to plans to duplicate the DGIX node. A separate foundation was formed to ensure more redundancy and expansion in the node activities, and Netnod was started for that operation. Even the academic networks in NORDUnet built in redundancy at the end of the 1990s, as the users had become dependent on continuous access to the network.

SUNET-155 was such a network, this time using 155 and 622 Mb/s capacity from the Swedish Rail Company, Banverket.

5 Ebone

The rapid development of Internet in the Nordic region was seen as an example for some networkers in Europe. RIPE was a coordinating organisation for IP in Europe, where staff from KTH participated. Bernhard Stockman made an inventory of all separate data links to the US and suggested, that with a European backbone network for IP it would be feasible to get much better service to the US at the same cost. So a consortium was set up, KTHNOC became the Operations Centre in 1992, and the network was called Ebone92. In September 1992 the initial European IP backbone with 256 kb/s links was completed and in operation.

The network was upgraded to 512 Kb/s in 1993, to 2 Mb/s in 1994, to 34 Mb/s in 1996, to 155 Mb/s in 1998 and to 2.5 Gb/s in 1999. Upgrades were done to meet the growing demand when lines were full.

Ebone was sold to GTS in 1999, bought by KPNQWEST in early 2002, but went bankrupt in mid 2002, as a result of the glut in international fibre capacity. For an insightful and detailed account of European networking development 1980-1999, given by Olivier Martin, see [6], from which we cite an example of protocol orthodoxy: *Peter Villemoes (NORDUnet) almost became an outlaw*

after the historic RARE Networkshop that took place in Trieste (Italy) in May 1989, i.e. only one month before the first RIPE meeting, and where some "eminent"
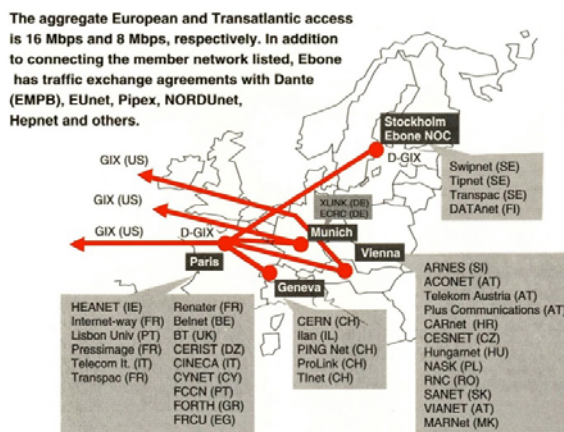

Fig. 5   Ebone – European Backbone 1995

members of the RARE CoA (Council of Administration) stated that, as long as they would be in charge of their emerging national networks, these would "under no circumstances whatsoever" run the "infamous" Internet protocols.

6   Internet Engineering Task Force

Many of the Nordic Internet technicians made important contributions to the IETF (Internet Engineering Task Force), where protocols and other standards were discussed and decided by the most competent Internet developers in the world. Several Nordic participants even acquired the position of chairperson in technical expert groups.

The 33rd IETF conference was held at Grand Hotel in Stockholm in July 1995 with KTH and NORDUnet as hosts. Just in time for the conference, the first transatlantic 34 Mb/s connection was put into operation to serve the high profile demand of the IETF members. It was no small feat to get this link established and credits go to Peter Löthberg for seeing it through.

7   Eastern Connections

In the early 1990s, NORDUnet received new friends from the East, described in [5], and in the map in Figure 4.

After the dissolution of the Soviet Union the US ban on exporting technologies to the Eastern Bloc countries was lifted.

The new Baltic states – Estonia, Latvia and Lithuania – were building information infrastructures and were interested in setting up data networks. Nordic networking specialists came to establish close working relationship with networkers in the Baltic countries. An IP connection was established between the Polish research network NASK and Copenhagen in 1991, and by the end of the year NASK was fully connected to the Internet.

In the early 1990s NORDUnet established networking collaboration with the Russian research networks. In 1994 there were three Nordic connections to Russia: from Helsinki to St. Petersburg, from Helsinki to Petroskoi and a connection from UNINETT in Norway to Apatity, the scientific centre of the Kola Peninsula. Since 1995 RUNet (RUssian interNet) has been NORDUnet's closest Russian collaborator and has continuously upgraded the connection.
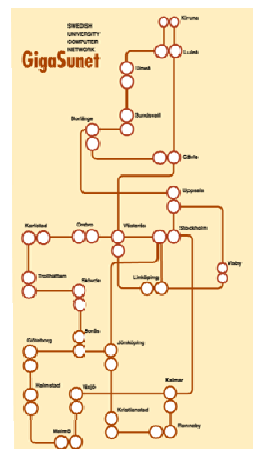
8   GigaSUNET and Optical Networks

SUNET was upgraded to a Gigabit network in 2002, fully redundant with links and equipment. Core network was made up of several rings of 10 Gigabit, linked in a redundant way and with dual 2,5 Gbit links to each University, see adjacent Fig. 6. Link provider this time was Telia.

The redundant design of both SUNET and NORDUnet proved to be very useful when KTHNOC was relocated within campus to a better and more secure facility in 2004. The move was done during full operation and no failures did occur.

When dark fibres became a feasible option for academic networks, both SUNET and NORDUNet carried out studies of possible solutions. Separate calls for tender were sent out, and as a result of the evaluations, a common solution was arrived at as being the most beneficial. New optical network, OptoSUNET and OptoNORDUnet were planned for implementation in 2007. The requested services from KTHNOC were rather limited both in scope, level and time-frame, and required much less development tasks. KTH did not see this as a suitable complement to academic activity any longer, and consequently turned down the offer and instead negotiated for an orderly and competent handover, which was carried out in the first four months of 2007.

Thereafter KTHNOC was closed down, after 19 years of intense activities, and SUNET and NORDUnet had optical networks with their own operations organisation, NUNOC.

9 Reflections and Conclusion

The quarter century period 1980-2005 was extremely dynamic in development of computer communication infrastructure, when most of the world became interconnected. Researchers and technicians in the Nordic universities were very much involved as early pioneers and developers, not only for their own countries but also for the whole world.

This central role was a result of technically gifted and socially devoted staff, open and non-rigid environments, trust and economic support from the universities, intense cooperation and very good contacts with pioneers in North America.
During the pioneering time it was necessary to combine development of the technology and infrastructure with daily operation of the networks. The development was obviously a task for universities.

When the principal university organisations financing the network in 2006 decided to ask only for part of the operations and no development, we were quite sceptical, but realized that only service provision is not a business task for universities.

Nonetheless the current leading role in Internet infrastructure of the Nordic countries, for most functions in society, is very much the result of the contributions from the academic world.

We, and the new generations in the academy, have the responsibility to influence the development, use, practice and spread of the Internet to preserve integrity and openness and equal access.

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