Sonas Innovation

Report on

The Future of Research and Education Networking in Ireland

for the

Higher Education Authority

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Foreword

In the not too distant future, Vint Cerf believes the Internet will be the global language of equality, helping people communicate effectively no matter what their perceived level of ability. Cerf should know: he is one of the people credited with founding what became a universal language of network communication, the ‘Internet’.

In the 1980s, American academics were using an early version of the Internet to communicate between universities for research purposes. Their system, known as Transmission Control Protocol, helped standardise communications and allowed open links between researchers and staff.

While Cerf and others were working on developing these network protocols since 1971, the US government was starting to foster networks for universities, and fund their expansion to connect every university in the country.

Crucially, the US government’s willingness to invest in both research of the Internet and funding of a common platform for users is one of the reasons for America’s outstanding research driven economic progress.

Private industry is now fully responsible for the commercial Internet, yet the US government continues to be involved in cutting edge research of new technologies. Since 1998, the University Corporation for Advanced Internet Development (UCAID) has progressed in its aim of securing a robust platform for the future development of US and International Research.

Cerf believes that in Ireland’s case, the role of Government in pushing the capabilities of networking is critically important to research success. Given Ireland’s vision of becoming a world leader for ICT and Biotech research, the Irish state’s role in backing university network advancement, and flexibly partnering with the private sector, is essential.

If broadband access is made fully available to everyone involved in Irish education and research, their output and capability will achieve multiplier effects and perhaps Irish individuals can discover as did Isaac Newton: “If I have seen further it is by standing on the shoulders of Giants.”

Vinton G. Cerf
Terms of Reference

To examine current arrangements for funding and operating network infrastructure and access for higher education institutions and to make recommendations as to the best methods of providing appropriate levels of service to all client/users, taking account of funding available and the need to ensure value for money.

Background

HEAnet is Ireland's National Education and Research Network (NREN). In common with other European countries the NREN was set up to provide high quality national and international connectivity for staff, students and researchers in Ireland's higher education and research institutions.

Under the guidance of the Board of Directors, HEAnet has implemented a broadband, resilient national network with high-speed international links to the worldwide Internet. The network is managed by the central Network Operations Centre.

HEAnet Limited was set up as a not-for-profit organization.

Terms of Reference

1. Analyse current Higher Education networking infrastructure for HEAnet and ITnet with particular reference to:
   (a) The management and administrative structures of HEAnet Ltd as they relate in particular to ITnet
   (b) The respective customer bases of HEAnet and of ITnet and the services provided to such customers, including types of service and levels of delivery of same.
   (c) Capital and recurrent sources of funding for HEAnet and ITnet and costs of same, at present and into the future.

2. Consider current and future trends in Education and Research Networking infrastructure, taking into account the developing situation in the telecommunications market generally and with particular reference to the implications of the:
   (a) Establishment of a new Government VPN
   (b) DIT / IoTs Management Information Systems project

3. Make recommendations in light of 1 and 2 on the appropriate structures to deliver the most effective and efficient network services required by Universities and

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1 This report is not concerned with section 1 (a): The management and administrative structures of HEAnet Ltd as they relate in particular to ITnet. This is being dealt with under a separate report.
Institutes of Technology and other clients/users, taking account of the diverse needs of all clients/users and of the need to ensure that value for money for the Exchequer is obtained
1 Executive Summary

The 20th century was a period of dramatic technological and scientific breakthroughs and discoveries. Current economic conditions affect the image of the technology sector, yet the reality is that rapid innovations and advances have continued at pace. Research and Development success is critical to our economic future. Ireland has stated its ambition to become a world leader in ICT (Information and Communications Technology), and Biotechnology research, and large investments are being made in our research base.

National Research and Education Networks (NRENs) are now more than an operational platform for communications. They are the engines driving the pace of collaboration, innovation and discovery amongst scientists. The role of a National Research and Educational Network is critical to the achievement of stated national education and research goals. This is particularly the case in a market where there is less competition in the supply of broadband communications than exists in other countries.

Now that much of Ireland’s youth has grown up with technology as a tool, our Higher Education institutions should become places where information is always accessible in context, communications can be easily achieved with any corner of the world and intensive collaboration increases the pace of knowledge generation.

As will be seen, other countries have adopted policies for their Higher Education sector very similar to those adopted in Ireland. These countries have also built NRENs, and associated capabilities, that are an order of magnitude higher capability than those available in Ireland. In these countries, further investments are being made to deliver further next generation networks. Individual research projects in other countries are demanding the equivalent amount of 30 times the bandwidth an entire Institute of Technology currently uses in Ireland. International collaboration is a necessity in many science areas. A wave of technological innovation (including ubiquitous networking, information navigation) drove the initial development of the Internet. Another wave of technological innovation (including optical switching, grid computing, web services) is well underway. This time Ireland should be one of the leading countries.

Ireland possesses many European Headquarters of globally leading ICT companies. Yet these companies choose to conduct their research and development with universities in other countries where these networks exist. This needs to be changed if Ireland is to move up the value chain and increase the R&D activity in Ireland.

How can Ireland attract the world’s top researchers if Ireland does not have the world’s best information infrastructure? By comparison to any choice of investment by Government, technology investment in this sector will have a high long term return. This is now a particular urgency given the rapid advancement of technologies making the slipping of Ireland’s standing even more stark.
The Government has committed considerable resources to science as a key component of future economic growth. The profile of research has risen inexorably. “Moving up the value chain” is now clichéd. The business of Higher Education is undergoing massive transformation. The most information intensive activity in the State is that of Higher Education. This, however, seems disjointed with the lack of full scale Information and Communications Technologies (ICT) strategic implementation.

It is evident that good progress has been made in the provision of broadband to research and educational facilities, particularly in these last three years. Ireland is now firmly ‘on the map’ amongst peer NRENs in terms of basic capability. However, while significant international broadband has been delivered by HEAnet, the distribution of this broadband nationally and on-campus is of an order of magnitude lower capability than what it needs to be to ensure Ireland’s competitiveness. While the telecommunications market in Ireland has been a constraining factor during this time, there are now a number of factors that will allow the NREN to fully establish a solid foundation for globally leading information infrastructure in Ireland.

Increasingly, the private sector and the public sector need to work closely throughout each Higher Education activity. Flexible supply partnerships to deliver broadband, research collaboration, research direction and educational curricula input are all seeing the blurring of the edges between each sector. The most successful countries in the new economy will excel in these public private partnerships. This competence will grow in importance for Ireland’s NREN. The potential for a new vision has been very well received by both suppliers and researchers in the private sector.

A strategy on Information and Communications Technology (ICT) in Education and Research is urgently needed. The broadband information infrastructure, although a key enabler, is only a platform. ICT is fundamentally changing the nature in which learning occurs and the way discovery happens (through collaboration from increased communications, and knowledge from increased information availability in context). This is where the full value for any State investment will accrue.

A world class, fibre optic based robust infrastructure capable of meeting the future needs of all end user organisations in Ireland needs to be delivered. Having reviewed the findings from the consultation process, Sonas Innovation recommends that a single organisation be charged with the operational delivery of national research and education networking services for higher education in Ireland. HEAnet is well placed to undertake this role. This development of a world-class research and education network will ensure that Ireland can remain a competitive centre of excellence and innovation in the future.

Further recommendations are made that will establish Ireland on the way to achieving this stated ambition.
The following are the recommendations of the report:

**Recommendation 1:** A single organisation (NREN) be responsible for delivery of education and research networking services in Ireland. HEANet is well placed to undertake this role.

**Recommendation 2:** That a steering group be established to advise on policy and planning in relation to ICT in education and research.

**Recommendation 3:** A programme to upgrade and integrate the current NREN needs to be put in place. The quality of the network established needs to be of world class standard.

**Recommendation 4:** New partnerships with research and commercial entities need to be established.

**Recommendation 5:** While continuing to focus on core competences, the NREN should outsource those services and facilities that can be more efficiently provided by commercial providers.

**Recommendation 6:** The NREN Operator should market itself as a key partner in enabling research based projects in Ireland.

**Recommendation 7:** The NREN Operator needs to provide a broad range of services.

**Recommendation 8:** That the two distinct stakeholder groups, Education Users and Research Users, be reflected in the key performance indicators for the organisation. Ongoing International benchmarking needs to be conducted.

We are confident that should these recommendations be implemented fully, Ireland would have established one of the key foundations for ensuring the future competitiveness of the economy.
2 Introduction

2.1 Background

There are currently two educational networks in Ireland, namely, the Higher Education Authority Network, HEAnet, and the Institutes of Technology network, ITnet. Each serves its respective client bases. HEAnet is the exclusive provider of international connectivity to all Higher Education institutions.

These networks have emerged and grown from the demand by the end user organisations to have connectivity to similar organisations both nationally and internationally. Both networks deliver network connectivity, including Internet access, to Universities, Institutes of Technology and other various Government agencies on a national basis.

The activity of providing networking to education and research users is seeing dramatic change (including hospitals, libraries, schools, incubation facilities). Research capacity is seeing a major developmental drive, technology is becoming central to the delivery of education and furthermore the telecommunications market has become rapidly transformed.

The Lisbon agenda that has made commitments regarding the availability of networking technology itself is quickly evolving such that the need for connectivity grows apace with capabilities to deliver it.

This project involves the following distinct elements:
- Overview of HEAnet and ITnet
- Overview of NRENs in other countries
- Analysis of trends and basis for NRENs
- A review of possible NREN structures
- Analysis of related Government initiatives
- Make recommendations for the future

Further information on both HEAnet and Itnet is now provided.
2.2 **HEAnet**

2.2.1 History

The HEAnet was established in 1984 by the seven major and Dublin Institute of Technology (DIT) with seed funding provided by the Higher Education Authority. Its original remit was to promote the interchange of information electronically within the third level institutions in Ireland. A key role is the development of linkages abroad to ensure we are connected to research networks established at global level and allow Irish institutions participation on these.

Today, the HEAnet serves over 150,000 students and staff spread across 46 organisations within Ireland. The significant and growing costs of operating a national network that provides onward connectivity to the Internet are met largely from charges to members according to their level of usage, in addition to EU funding and funding for specific projects. The organisation provides all international connectivity to Higher Education institutions. Network build has been primarily achieved through Exchequer monies, and by way of asset grant from the Government by way of allocation of capacity through the International Connectivity Project (on Global Crossing’s network).

![HEAnet Network Diagram](image-url)

**Figure 2-1 HEAnet Network**

Report on Future of Research and Education Networking in Ireland
2.2.2 Organisation Structure

Initially directed by a voluntary Network Management Committee, HEAnet was incorporated in 1997 as a not-for-profit limited company run by a Chief Executive and full-time staff. The Board of Directors comprises primarily of representatives from third level institutions with a representative from the Higher Education Authority, and one from the Department of Enterprise Trade and Employment.

There are currently 12 staff employed by the HEAnet at their head office location in Shelbourne Road, Ballsbridge. This premises also houses the Network Operations Centre (NOC) which oversees the day to day operation of the network.

2.2.3 Network Overview

There are two main parts to the HEAnet network, the national backbone network and the international connectivity.

The main national backbone network consists of the following link capacities:

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<tr>
<th>Link</th>
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<tr>
<td>Dublin – Citywest</td>
<td>1Gbps + 1Gbps Backup</td>
</tr>
<tr>
<td>Dublin – Kilcarbery</td>
<td>1Gbps</td>
</tr>
<tr>
<td>Citywest – Kilcarbery</td>
<td>1Gbps</td>
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<tr>
<td>Citywest – Galway</td>
<td>1Gbps</td>
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<tr>
<td>Dublin – Galway</td>
<td>2 x STM-1 (155Mbps)</td>
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<tr>
<td>Dublin – Cork</td>
<td>2 x STM-1</td>
</tr>
<tr>
<td>Cork – Limerick</td>
<td>2 x STM-1</td>
</tr>
<tr>
<td>Limerick – Galway</td>
<td>2 x STM-1</td>
</tr>
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</table>

STM-1 = 155 Mbps = c. 3,000 times capacity of a 56kbps dial modem link
1Gbps = 1,000Mbps = c. 20,000 times capacity of a 56kbps dial modem link
Backup – Link for immediate availability should the other link fail
For international connectivity, HEAnet operates multiple high speed links to other networks. These are:

<table>
<thead>
<tr>
<th>Link</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GÉant (European Research Network)</td>
<td>2 x STM-16 (2.5Gbps)</td>
</tr>
<tr>
<td>INEX (Irish Internet Exchange)</td>
<td>2 x 1Gbps</td>
</tr>
<tr>
<td>JANET (UK NREN)</td>
<td>2 x STM-1</td>
</tr>
<tr>
<td>Global Crossing</td>
<td>1 x STM-16, using 622Mbps</td>
</tr>
<tr>
<td>Abilene (US)</td>
<td>1 x STM-1</td>
</tr>
<tr>
<td>StarTAP (US)</td>
<td>1 x STM-1</td>
</tr>
<tr>
<td>Teleglobe (General Internet)</td>
<td>1 x STM-1</td>
</tr>
</tbody>
</table>

Figure 2-3 HEAnet International Link Capacities

![HEAnet International Links](image)

Figure 2-4 HEAnet International Links
2.2.4 Network Services

The HEAnet network provides additional services to end users beyond that of pure connectivity. Some of the services provided include:

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRIS</td>
<td>Library management cataloguing system</td>
</tr>
<tr>
<td>PADDI</td>
<td>An all-Ireland architecture and design database</td>
</tr>
<tr>
<td>AKAMI</td>
<td>Localizes major information resources within HEAnet, thus optimizing their delivery to its users</td>
</tr>
<tr>
<td>Web of Science</td>
<td>Online resource giving access to journal information</td>
</tr>
<tr>
<td>Listserv</td>
<td>Supports over 420 mailing lists, with a total of 300,000 subscribers.</td>
</tr>
<tr>
<td>Net News</td>
<td>News feeds to end users</td>
</tr>
<tr>
<td>Multimedia Services</td>
<td>Video and Audio content delivery via multicast</td>
</tr>
<tr>
<td>IP Registry</td>
<td>HEAnet provides a local IP registry for RIPE, European IP Registry</td>
</tr>
<tr>
<td>IPv6</td>
<td>HEAnet has launched Irelands first IPv6 based network</td>
</tr>
<tr>
<td>Honeypot</td>
<td>This allows network security to be tested</td>
</tr>
<tr>
<td>Anti-Spam</td>
<td>Service to reduce the instances of Spam received by members</td>
</tr>
<tr>
<td>Video Services</td>
<td>Video Conferencing and Video Streaming</td>
</tr>
<tr>
<td>NTP</td>
<td>Network based Time Services</td>
</tr>
<tr>
<td>Software Mirroring</td>
<td>Hosting of Software databases</td>
</tr>
</tbody>
</table>

Figure 2-5 HEAnet Services

2.2.5 Network Users

There are currently 46 organisations connected to the HEAnet network. Connected organisations include:

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Access Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Applications Office (CAO)</td>
<td>2Mbps</td>
</tr>
<tr>
<td>Department of Finance (CMOD)</td>
<td>2Mbps</td>
</tr>
<tr>
<td>Dublin City University</td>
<td>63Mbps</td>
</tr>
<tr>
<td>Dublin Institute for Advanced Studies</td>
<td>16Mbps</td>
</tr>
<tr>
<td>Dublin Institute of Technology (DIT)</td>
<td>64Mbps</td>
</tr>
<tr>
<td>Environment Protection Agency</td>
<td>512Kbps</td>
</tr>
<tr>
<td>Health Research Board Ireland (HRB)</td>
<td>2Mbps</td>
</tr>
<tr>
<td>Higher Education Authority</td>
<td>2Mbps</td>
</tr>
<tr>
<td>Irish Research Council for Science, Engineering and Technology (IRCSET)</td>
<td>1Mbps</td>
</tr>
<tr>
<td>Higher Education and Training Council (HETAC)</td>
<td>512Kbps</td>
</tr>
<tr>
<td>Institute of Technology Network (ITnet)</td>
<td>95Mbps</td>
</tr>
<tr>
<td>Organization</td>
<td>Bandwidth</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>NUI Maynooth</td>
<td>40Mbps</td>
</tr>
<tr>
<td>National Cancer Registry of Ireland (NCRI)</td>
<td>512Kbps</td>
</tr>
<tr>
<td>National College of Art and Design (NCAD)</td>
<td>10Mbps</td>
</tr>
<tr>
<td>National College of Ireland (NCI)</td>
<td>15Mbps</td>
</tr>
<tr>
<td>National Library of Ireland</td>
<td>512Kbps</td>
</tr>
<tr>
<td>National Qualifications Authority of Ireland (NQAI)</td>
<td>2Mbps</td>
</tr>
<tr>
<td>National University of Ireland</td>
<td>512Kbps</td>
</tr>
<tr>
<td>NUI Galway</td>
<td>60Mbps</td>
</tr>
<tr>
<td>Royal College of Surgeons in Ireland</td>
<td>15Mbps</td>
</tr>
<tr>
<td>Royal Irish Academy</td>
<td>512Kbps</td>
</tr>
<tr>
<td>St. Angelas</td>
<td>256Kbps</td>
</tr>
<tr>
<td>Trinity College Dublin</td>
<td>120Mbps</td>
</tr>
<tr>
<td>Teagasc</td>
<td>1Mbps</td>
</tr>
<tr>
<td>Tipperary Rural Business Development Institute</td>
<td>2Mbps</td>
</tr>
<tr>
<td>University College Cork</td>
<td>100Mbps</td>
</tr>
<tr>
<td>University College Dublin</td>
<td>125Mbps</td>
</tr>
<tr>
<td>University of Limerick</td>
<td>60Mbps</td>
</tr>
</tbody>
</table>

Figure 2-6 HEAnet User Organisations

### 2.2.6 Summary

HEAnet has a track record of achievement in delivering next generation networking for universities throughout its history. Down through the years, particularly as very little competition existed in the marketplace, and there was a dearth of network skill, HEAnet’s centralisation of skill and joint procurement efficiencies delivered high quality services and also value to its clients. As Ireland’s recognized NREN, HEAnet has been providing a range of services to its client base.

Its in-house approach to build and operation of its network has led to much competence being established. Innovative approaches, particularly regarding international connectivity have allowed for good progress.
2.3 *ITnet*

### 2.3.1 History

In 1991 the Institutes of Technology in Carlow and Cork collaborated on a project to provide connectivity to the European Advanced Research Network (EARN) via UCD. As the usage of this service grew, it became clear that other Institutes required similar facilities.

Funding was therefore sought from the Department of Education through Cork Institute of Technology to establish ITnet. It was established as an outsourced operation from the outset, with no permanent staff assigned. All international connectivity was to be sourced from HEAnet.

ITnet utilises the Eircom Business IP service, which is delivered via STM-1 (155Mbps) circuits running IP over ATM.

*Eircom Business IP service* - a high speed national network service  
*IP* - Internet Protocol, a standard for communications layer between applications and network transmission  
*ATM* - Asynchronous Transfer Mode, a standard for network transmission suited to converged voice and data

### 2.3.2 Organisation Structure

ITnet is prohibited as part of its definition from having any full time staff members. Currently, ITnet is managed by the Computer Department of Cork Institute of Technology and the Computer Department of Tallaght Institute of Technology.

### 2.3.3 Network Overview

The ITnet network is operated via the Eircom Business IP network. This service provides IP transport via the Eircom ATM network, delivered to each end user site as an STM-1 circuit. Traffic on these STM-1 circuits is currently limited to 34Mbps, but this can be easily upgraded.

International traffic is accommodated via a 95Mbps link between Tallaght Institute of Technology and HEAnet, which is shared amongst the 13 Institutes. At the time of writing this report, the link speed was due to be increased from 95Mbps to 270Mbps.

Network Management services for ITnet are provided by Lan Comms, a subsidiary of Eircom. Lan Comms is responsible for the day to day operation of the ITnet network,
performance management, tracking faults and liasing with Eircom for fault resolution. No service level agreement is in place.

2.3.4 Network Users

There are 13 Institutes connected to the ITnet network.

(Note that DIT is not connected to the ITnet network).

Figure 2-7 Institutes of Technology
2.3.5 Summary

ITnet has provided a good level of service to its clients within its given budget. Its budget is oriented towards efficient satisfaction of day-to-day needs of the computer departments of the Institute of Technologies. However, it has not been in a position to formally address forward-looking developments. As such, the network is not in a position to satisfy the needs of high-end researchers and educationalists using advanced ICT.

2.4 Conclusions

Findings here were of use not only to inform the report regarding current positioning, but also to understand the historic and cultural background to each organisation.

The table below is a summary of the findings relating to both ITnet and HEAnet:

<table>
<thead>
<tr>
<th></th>
<th>ITnet</th>
<th>HEAnet</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Institutions</td>
<td>13</td>
<td>46</td>
</tr>
<tr>
<td>Connection Speed</td>
<td>34 Mbps</td>
<td>256 kbps – 125 Mbps</td>
</tr>
<tr>
<td>National Backbone</td>
<td>155 Mbps</td>
<td>One @ 1Gbps Mostly at 155Mbps</td>
</tr>
<tr>
<td>International Backbone</td>
<td>95 Mbps (via HEAnet)</td>
<td>3.9 Gbps</td>
</tr>
<tr>
<td>Network Management</td>
<td>Outsourced, skeleton management internal</td>
<td>Mostly internal, technical support outsourced</td>
</tr>
<tr>
<td>Value added services</td>
<td>Some delivered on casual basis</td>
<td>Some delivered</td>
</tr>
<tr>
<td>ICT in Education, Research</td>
<td>None</td>
<td>Very limited</td>
</tr>
<tr>
<td>Forward building infrastructure</td>
<td>None</td>
<td>Very limited</td>
</tr>
<tr>
<td>Costs</td>
<td>€2.1m</td>
<td>€9.7m</td>
</tr>
</tbody>
</table>

Figure 2-8 Summary of findings regarding ITnet and HEAnet
3 Trends in Educational Research Networking

3.1 Introduction

Before looking at any recommendations that can be made with regard to National Education and Research Networking in Ireland, it is important to look at the reasons behind such a network. This section deals with the various drivers and trends in research networking, showing how it is vital for the success of any national economy to have a well-educated work force, a research enabling environment and a world-class educational infrastructure. Drawing on studies from Ireland and abroad, evidence is shown that supports the case for a national research and educational network.

3.2 Drivers in Education and Research

Ireland’s strategic investment in education and research can be closely linked to our subsequent economic success. Our Higher Education system has been a key driver of this progress.

The Higher Education Authority articulates the importance of education and research to our current economic positioning:

“Ireland needs to become an 'Innovation Society'. … Ireland needs to move from a situation where our economic growth relies, to a very considerable extent, on foreign direct investment and imported technology (an 'Investment-Driven' economy), to one where the basis for growth arises, to a much greater extent, from indigenous innovation (an 'Innovation-Driven' economy).”

HEA Chairman, Dr. Don Thornhill emphasised in a recent speech that building of capacity within the country is a key objective:

“We must have excellence in the classroom and in the research laboratory if our higher education institutions are to produce the type of graduates that are essential to lead future economic and social progress in this country.”

The role of education in general, and higher education in particular, in supporting the new economic model of the 1990s was recognized, as follows in the National Development Plan:

“There is a clear consensus that investment in education and training has a very high rate of return and that it accounts for a significant proportion of observed variation in economic growth rates around the world.”

The importance is further outlined by the IDA:
“Education is fundamental and central to the competitive position of all advanced societies.”

As Dr. Don Thornhill, HEA Chairman and Professor Roger Downer, Chairman, Conference of Heads of Irish Universities (CHIU) state:

“Nobody would now deny that education at all levels is central to economic, social and cultural well-being and a central part of self-development and personal empowerment. Worldwide, there is a growing demand for access to higher learning bringing forth new providers, new delivery modes and innovative methods of teaching and learning. The concept of lifelong learning is widely recognised, encouraging as it does a much greater diversity of the student body.”

Science Foundation Ireland in its report “Vision 2003-2007: People, Ideas and Partnerships for a Globally Competitive Irish Research System” Science Foundation Ireland in May 2003 has described:

“The last ten years have seen unprecedented growth and development within Ireland. This has been achieved through partnership with the European Union, strong historical ties to the United States, the skills of its well-educated population, and focussed Government policy. At the same time, science, technology, and knowledge-driven enterprises have become increasingly important to long-term economic success in a global society. To ensure that Ireland continues to benefit from its competitive advantages, the Government has, through the National Development Plan 2000–2006, made an unprecedented national commitment to support scientific research, technological development, and innovation.”

Figure 3-1 Growth in full-time Higher Education Enrolments
Figure 3-1 Growth in full-time Higher Education Enrolments illustrated that the quantity of students, which has been rapidly increasing over the last years, and is placing significant demands on our education and research infrastructure. Throughout this time, technology is starting to become pervasive in campus environments.

US Secretary of Commerce, Donald L. Evans captures the importance of technology in education environments:
“Successful development and deployment of these technologies in education and training could have a profound effect on American competitiveness and our standard of living. A world-class workforce is vital to the Nation’s ability to compete. But staying on top in today’s knowledge-based economy means Americans must have greater and more effective access to the knowledge and skills development they need to flourish as students, employees, and citizens in a rapidly changing world”

3.3 Evolution of National Research and Educational Networks

The communications industry has been undergoing rapid rates of change for the last decade in particular. Technology change and market change has been at breakneck speed. For example, the traffic on HEAnet has increased 16,000 times over a ten-year period.

Throughout this time, significant change has also been effected in the organisations providing and managing national research and educational networks. From the origins of the Internet, to continuing to push the boundaries of what is possible today, these organisations have globally been driving much of the change.

This change continues, and with the TeraGrid initiative in the US (described below), research networking continues to demand networks that are 16 times faster than those currently available.

3.3.1 Information Technology and Education and Research

It is no great exaggeration to say that information technology is fundamentally changing the relationship between people and knowledge. Society today is being reshaped by rapid advances in information technologies – computers, telecommunications networks and other digital systems – that have vastly increased our capacity to know, achieve and collaborate. These technologies allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavour in productive new ways, and to create communities that just a decade ago were unimaginable.

The rapid evolution of digital technologies is creating not only new opportunities for our society but challenges to it as well and institutions of every type are grappling to respond by adapting their strategies and activities.
ICT impacts:

- Administration
- Current R&D activities
- Next generations of “connected” R&D
- Learning
- Pedagogy
- Delivery of Education

Yet, in the most knowledge-based entities of all, the colleges and universities, the pace of transformation has been relatively modest. Although some areas such as research may have been transformed by information technology, other higher education functions have remained relatively unchanged. Teaching, for example, largely continues to follow a classroom centred, seat based model.

It should be noted that the central function of the higher education institution is the creation, preservation, integration, transmission, and application of knowledge. With this in mind, it remains to determine how best to apply the advances in technology to best use to assist the educational establishments to meet their demands.

Technology is identified by Professor Malcolm Skilbeck (who reviewed challenges facing Universities in a report to the HEA in 2001) as one of the key factors driving change:

“A progressive shift from formal, institution-bound teaching to technology-facilitated learning.”

Some institutions concerned specifically with the role of information technology and higher education include:

EDUCAUSE: (www.educause.edu) is a non-profit association whose mission is to advance higher education by promoting the intelligent use of information technology.

OpenCourseWare: (ocw.mit.edu/index.html) MIT OCW is a large-scale, Web-based electronic publishing initiative funded jointly by the William and Flora Hewlett Foundation, the Andrew W. Mellon Foundation and Massachusetts Institute of Technology (MIT). Its goals are to:

1. Provide free, searchable, coherent access to MIT’s course materials for educators in the non-profit sector, students, and individual learners around the world.

2. Create an efficient, standards-based model that other universities may emulate to publish their own course materials.

The Futures Project: (www.futuresproject.org) The Futures Project is focused on stimulating an informed debate about the role of higher education in a new global society and the opportunities and dangers presented by a global market for higher education.
Developments in the global context are framed by the US National Science Foundation’s establishment of the National Partnership for Advanced Computational Infrastructure some five years ago. The following is how they themselves introduce their mission:

“The mission of the National Partnership for Advanced Computational Infrastructure (NPACI) is to advance science by creating an ubiquitous, continuous and pervasive national computational infrastructure: the Grid. This infrastructure for the 21st century builds on dramatic advances in information technology to enable distributed research by interdisciplinary teams. In the NPACI vision, researchers collect data from experiments and digital libraries, analyse the data with models run on a computing grid, visualize and share those data over the Web and publish the results for the scientific community in digital libraries”

Projects which have already shown scientific success include:
- Exploring Electrostatic Landscapes in Cells
- Cosmological Concordance
- The Perfect Omniguide for Light
- Modelling Hurricanes and Climate in Greater Detail
- Do Tectonic Plates Reach Mantle’s Bottom?
- Simulating Solar Storms
- Going with Boundary-Layer Flows
- Redesigning Jet Engines
- How to Predict a Protein’s Structure
- Clarifying Fluid Behaviour in Pores
- Salt Effects in Solutions of Peptides and Nucleic Acids
- Quantum Chemistry Calculations
- Testing the Standard Model

NPACI will build on success to date, focusing much of its energy on the launch of ‘TeraGrid’: “… NSF awarded $53 million to the San Diego Supercomputer Center (SDSC) and three other research institutions to deploy a unified grid with more than half a petabyte of disk storage, a 40-gigabit-per-second national optical backbone, and 13.6 teraflops of compute power. This facility will be integrated into an information infrastructure called the TeraGrid. It will be the most comprehensive ever deployed for scientific research, recognizing the critical role that grid computing will continue to play in science and engineering…”

NSF = National Science Foundation
40Gbps = 40,000Mbps = c. 800,000 times capacity of a 56kbps dial modem link
Teraflops = Measurement of computer power, A million, million floating point operations per second

TeraGrid represents the increasing reliance of research of increasingly varied disciplines on the best available technology to operate on a global basis.
3.3.2 The Case for a National Research Network

In its most recent report, the IMD² World Competitiveness Report listed Ireland in 11th place amongst the most competitive countries in the world. Two major contributors to Ireland’s fall from 9th place (from a high of 5th in 2000) were the costs of Internet connectivity (Ireland ranked 29th out of 29) and the number of people engaged in Research and Development (R&D) activities (Ireland ranked 18th of 29). While Ireland’s education system was highly regarded, it is necessary to ensure that all factors that contribute to Ireland’s competitiveness are aligned to increase the country’s ranking in the future.

![Figure 3-2 IMD World Competitiveness Report](image)

The 21st century will be the age of knowledge, with broadband communications as the key infrastructure, just as with industrialised age in the 19th century, rail was a key infrastructure. In the immature stages of the development of key infrastructure networks, when the demand is uncertain and a competitive market has not emerged, government investment plays a key role in establishing the embryonic networks.

In this context the significant points to be drawn from the history of the development of the Internet are

---

² World Leading Business School, based near Geneva
• The commercial Internet emerged from the research and education sector and will continue to be fuelled by the requirements of this sector (e.g. security, quality of service, transaction processing);
• Innovative and advanced services tend to be incubated on the national research and education networks prior to delivery on the commodity internet;
• Universities and Institutes are intense breeding grounds for business, industry, government and community consumers of bandwidth as their students graduate as network-literate and bandwidth demanding;
• The sector is a significant provider of services to the commodity Internet, which is growing in importance.

Universities and Institutes acting alone cannot meet the current and future requirements for bandwidth to address the current deficiencies and future demands from high-end research nor can the sector wide requirements be met by an ad-hoc or competitive approach.

The current and future needs for broadband capacity to support research and education must be addressed within an overarching strategic framework. The process for addressing these needs must be consistent with development of such platforms for the long term. Funding certainty into the long term is necessary for infrastructures with useful lives of over 15 years. This will be a huge improvement over the current scenario where funding uncertainty limits the capability to drive the supply market into competitive deals.
3.4 Economic Value of NRENs

Leadership in research and education networking can generate competitive advantage. As already outlined, Ireland has stated its ambition to do this.

Other countries have developed advanced education and research infrastructures to drive this process. The Netherlands’ policy is clearly outlined below:

“Gigaport is one of the world’s most advanced broadband networks for research, development and education. In 1998, universities and polytechnics announced that in order to conduct top-level research, they needed faster Internet connections with more broadband capacity. The pressure of competition has created the same need among a number of companies.

Gigaport is a project where the private sector and the public sector collaborated to generate a next generation network. Completing its 5 year project plan this year, another generation is under proposal to Government.

The third major party involved in innovation, the government, brought universities and enterprises together and set up an investment plan to which the government and business community both contributed substantial amounts. The results were impressive: a super-fast Internet connection that drew overseas businesses to the Netherlands. Intel came to the Netherlands to use the Amsterdam Internet Exchange; IBM expanded its R&D lab with next generation Internet services; and American and Canadian research institutes are cooperating closely with Dutch universities and all because of Gigaport, an innovation that gave the Netherlands an international edge.”

As networking technology is undergoing another stage of development, so will there be considerable foreign direct investment potential in being at the forefront of the next generation of research networking. Not to have such infrastructure will result in not embedding current high value companies in Ireland and loss of FDI investment.

3.5 Importance of Information Infrastructure to Research and Education

The role of ICT in the achievement of Education and Research objectives is of key importance:

“Information communications technology is playing a major part in current debates on new teaching and learning delivery systems. Therefore it is vital that we keep abreast of these developments especially in the crucially important context of lifelong learning.”
The Higher Education Authority has seen infrastructural investment as a necessary investment alongside funding Education and Research:

“The Programme for Research in Third Level Institutions (PRTLI) allocates funding on a competitive basis to third level institutions (including those outside the aegis of the HEA). The objectives of the programme are:

- facilitation of the strategic development of institutional research capabilities (infrastructural and programmatic);
- enhancement of the numbers, quality and relevance of graduate output;
- support of high quality inter-disciplinary and inter-institutional research.”

The business of Research and Education is fundamentally a knowledge activity. Information is and has always been a key ingredient of this knowledge. Technology is now allowing for information in context to allow for more dynamic and productive methods of learning and research. Ireland needs to not only excel in Education and Research, but now also in the methodologies which will transform its activities.

The Member of the EU Commission responsible for enterprise and information society, Erkki Liikanen, clearly recognises this interplay when the objectives were stated:

“By 2005 Europe should have:

- Modern online public services
  - e-Government
  - e-Learning
  - e-Health
- A dynamic e-business environment

Enabled by:

- Widespread availability of broadband at competitive prices
- A secure information infrastructure”

The recent economic success through a low cost business environment is not without threat from potential infrastructural deficit:

The Higher Education Authority have identified these threats:

“…we are already beginning to experience, through the emergence of constraints such as labour and skill shortages, cost inflation and stresses on infrastructural capacity, the limitations of undue reliance on this route for economic development.”
A prerequisite for Education and Research advancement and along with that economic success as outlined by this report is that we have a world-class communications infrastructure.

The strategy described by the Department of Education and Science in the report “Blueprint for the Future of ICT in Irish Education. Three Year Strategic Action Plan 2001 – 2003” clearly recognises the value of ICT in education. The Department of Education and Science are currently researching methods of delivering broadband into every school in Ireland. Experience from markets elsewhere shows that there will be many challenges in delivering full value from investment, and a central expert resource would be of immense value. The market will not be able to deliver this expertise alone until the modalities of delivery are established, defined and can be outsourced. The embedding of ICT in education will need to become a competence in itself if we are to compete with other nations.

### 3.5.1 Outreach Centres

Information infrastructure can allow higher education institutions to extend their capabilities beyond the boundaries of their campus. Education will continue to need personal tuition. There are challenges in the successful establishment of a remote node off the main campus with necessary reduced pedagogical human resources. This can be facilitated significantly through the pragmatic availability of enabling knowledge infrastructure to access specialist pedagogical resources effectively.

The role of technology in the enabling of greater access to information, knowledge and education is recognised by the Technical Working Group for the Higher Education Authority in their report “Technical Working Group on the review of outreach centers in Higher Education Institutions” in November 1999:

“In addition other imperatives are at work that justify greater attention to the role of telematics - the democratisation of knowledge, the demand for universal access to education, the decentralisation of social structures, the new awareness of the need for lifelong learning, the movements in support of rural and community development.”

Significantly, this report points to some challenges that still remain today:

“Where the effects are positive, one finds, all too often, that the cases cited are based on pilot programmes, address marginal activities, or are justified on the basis of a partial analysis of costs.”

Again, there is a strong case to be made in the centralisation of the competences in the use and exploitation of technologies in increasing availability of education.
3.5.2 Irish Education as an export

Ireland’s competence in education is currently a source of revenue for the exchequer.

As commented by the HEA Chairman, Dr. Don Thornhill addressing the Centre for Cross Border Studies on “International Education: A Capacity Builder for the Island of Ireland” in May 2003:

“Ireland has been relatively successful in attracting overseas students to study in Ireland. This activity is now a significant source of revenue.”

However, it is suspected that in volume terms, our numbers are quite low in comparison to countries on mainland Europe given our island status with less inter movement of population. The potential for growth here is very significant. Technology will allow for collaboration with overseas Educational Institutions such that Irish pedagogical capacity may be delivered remotely. This will be a highly scalable activity placing proportionately less demand on other educational infrastructural resources once ICT is leveraged effectively.

3.5.3 Research Collaboration

Research is becoming more collaborative globally. Networks of excellence are emerging with nodes distributed across the world. Seamless communications to allow for increasingly parallel activities on distributed information platforms is a necessary infrastructure for this activity.

For example, Science Foundation Ireland in its report “Vision 2003-2007: People, Ideas and Partnerships for a Globally Competitive Irish Research System” Science Foundation Ireland in May 2003 has stated its goal to have:

“Initiated centres, institutes and teams that established valuable research links between Irish research institutions and both Irish- and foreign-owned companies engaged in biotechnology or ICT research, including by attracting or substantially increasing the research and development (R&D) investments in Ireland of at least ten foreign-owned multinational firms and by producing at least five significant research collaborations between research institutions and indigenous companies.”

The US National Science Foundation in the US has identified this need in its research community (and has stated the US strategic goals to develop new generation of research network facilities). In the report by the Blue Ribbon Advisory Panel on Cyberinfrastructure “Revolutionizing Science and Engineering Through Cyberinfrastructure: Report of the US National Science Foundation.” in January 2003.

“Testimony from research communities indicate that many contemporary projects require effective federation of both distributed resources (data and facilities) and distributed,
multidisciplinary expertise, and that cyber infrastructure is a key to making this possible.\textsuperscript{xxiii}

A number of research institutions are currently undertaking such activity in the US as outlined by the National Partnership for Advanced Computational Infrastructure (NPACI) on their website:

“…the Network for Earthquake Engineering Simulations (NEES), the Space Physics and Aeronomy Research Collaboratory (SPARC), the National Ecological Observatory Network (NEON), the Grid Physics Network (GriPhyN), the International Virtual Data Grid Laboratory (iVDGL), and the High Energy Physics Collaboratory for the ATLAS project. Research mission agencies are also initiating similar projects, for example, the NIH Biomedical Informatics Research Network (BIRN), the Department of Energy (DOE) National Collaboratories Program, and the DOE program in Scientific Discovery through Advanced Computing (SciDAC). Relevant international activities include the UK E-science program, parts of the European Union 6th Framework Project, and the Japanese Earth Simulator.”\textsuperscript{xxiv}

It is clear given the nature of research that it will continue to have requirements for the most advanced networking technically available.

### 3.6 Impact of Research and Education Networking in the Regions

According to a recent Communication from the European Commission\textsuperscript{xxv}, the regional dimension of the University (including Institutes of Technology) is set to get stronger, given its essential role in the Europe of Knowledge, particularly looking ahead to enlargement.

The availability of networking in a region to cluster economic activity is recognised by the Council of Directors of Institutes of Technology in Report of the Expert Working Group. "Institutes of Technology and the Knowledge Society - Their Future Position and Roles” in May 2003

“The regional role of the Institutes is of a primary significance, their geographical location and industrial focus ensure that they are important stimuli for local industrial development, as well as magnets in attracting new investments projects to the regions”\textsuperscript{xxvi}

In a submission to the National Plan, the Council of Directors of the Institutes of Technology in a report entitled "Technological Education – the Key to the Competitive Knowledge Society" in 1999 described the institutes as:

“….strategically located throughout the regions to give maximum effect to national development priorities in the areas of human resource development, lifelong learning,
regional economic development, industrial training and skills upgrading, R&D, technology transfer, community, rural and tourism development."

ICT in regional education will allow for its participation at the highest levels of research and education globally, contributing to eliminating issues surrounding peripherality.
4 Case Studies of International NRENs

4.1 Introduction

A number of International countries were examined in their approach to provision of networking and ICT to their education and research sectors.

These countries were:
- Australia
- Canada
- Europe
- Sweden
- The Netherlands
- United States

Each of these countries will adopt differing approaches to their establishment of a National Research and Educational Network. These approaches will inform the analysis of the possible structures and the recommended structure for Ireland.

Detail from this research is included in Appendix 1.

4.2 Summary

All countries see their National Research and Educational Network to be of key economic importance and all have been investing significantly in recent years to extend the capabilities of their organisations. Networking is seen as an important part of the infrastructure. In some markets, 2.5Gbps are available to individual research teams and schools are being connected at 1Gbps.

Many of the issues in Ireland regarding the NREN and the state of the telecommunications market have been experienced elsewhere. In some countries, the NREN was an important factor in bringing about change to accelerate the provision of broadband regionally.

All countries have an established and focused strategy to ensure that their NRENs stay at the leading edge of technology. There was a consensus that there is a ‘chicken-and-egg’ relationship between provision of advanced infrastructure and the development of high value research and advanced educational methodologies.
4.3 Conclusions

Ireland is not unique in having a national research network. Much progress has been made, particularly in recent years in establishment of an excellent international connectivity infrastructure. However, as can be seen from the cases shown in this section and summarised in the table below, Ireland is falling behind in some areas.

<table>
<thead>
<tr>
<th></th>
<th>Ireland</th>
<th>AARnet Australia</th>
<th>Internet2 US</th>
<th>Canarie Canada</th>
<th>SurfNET Holland</th>
<th>Sunet Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Backbone</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
</tr>
<tr>
<td>National Backbone</td>
<td>Mostly 2 x STM1</td>
<td>~ 10Gbps</td>
<td>10Gbps</td>
<td>10Gbps</td>
<td>10Gbps</td>
<td>10Gbps</td>
</tr>
<tr>
<td>Access</td>
<td>125 Mbps</td>
<td>~ 2.5Gbps</td>
<td>~ 2.5Gbps</td>
<td>~ 1Gbps</td>
<td>1Gbps</td>
<td>2.5Gbps</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Provider Reliant 3</td>
<td>Fibre</td>
<td>Fibre</td>
<td>Fibre</td>
<td>Fibre</td>
<td>Fibre</td>
</tr>
<tr>
<td>Advanced Services</td>
<td>Emerging</td>
<td>Some</td>
<td>High Levels</td>
<td>High Levels</td>
<td>High Levels</td>
<td>Few 4</td>
</tr>
<tr>
<td>Staff</td>
<td>15</td>
<td>18</td>
<td>70</td>
<td>33</td>
<td>47</td>
<td>3 6</td>
</tr>
<tr>
<td>Budget</td>
<td>€11.8m</td>
<td>AU$31.4m</td>
<td>N/A</td>
<td>CA$27m</td>
<td>€17.7m</td>
<td>N/A</td>
</tr>
<tr>
<td>End Users</td>
<td>200,000+</td>
<td>800,000+</td>
<td>200+Universities</td>
<td>N/A</td>
<td>N/A</td>
<td>350,000+</td>
</tr>
</tbody>
</table>

Figure 4-1 Summary of NRENs Internationally

The national backbone in place is an order of magnitude less than that available in other countries. NRENs in other countries directly access fibre infrastructure, rather than leasing services from providers. This is seen in the community as allowing for much lower unit costs and greater bandwidth. It also provides for a good upgrade path in the future, ensuring service quality is maintained at world class levels.

Main areas where Ireland appears weaker:

- Less connectivity all the way to the desktop.
- Less engagement directly with research projects.
- Less engagement with the commercial sector.

Ireland can be proud of its achievements to date. Much of the capabilities of Ireland’s NRENs can compare to world leaders in some areas. Yet as has been shown, further initiative is needed to ensure it remains competitive.

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3 NRENs in Ireland use commercial service providers’ infrastructure, whereas in other countries examined, the NRENs access fibre infrastructure directly.
4 From research, outlined in Appendix 1
5 Day-to-Day operations of Surfnet are carried out by subcontractors, these are not included here
6 Sunet outsources most of its operations to University IT departments
5 Possible National Research Networking Structures

At the outset, this report sought to evaluate the potential ways that the communications needs of the user community could be provided for by way of a National Research and Educational Network.

For the purposes of this study users were assumed to be a distribution of large numbers of clustered users in centres distributed nationally around Ireland who are dependent on the use of a high speed network.

Assumptions were that users were engaged in the business of:

- Education
- Research

Other users would be in related activities (e.g. libraries, hospitals, schools). Needs are both between users directly connected to this homogenous network and also to other users on other networks (other national networks, and also the Internet).

5.1 Initial Review Findings

Options for the delivery of a network solution for given sets of users depend on a number of variables:

- The current need of the user base
- The future needs of current base and future base of Researchers
- The ambition to drive capacity in Education and Research
- The market readiness to provide solutions
- The willingness of the universities, Institutes & Government to not only provide the necessary infrastructure but to support R&D that depends on high speed connectivity

5.1.1 The Outsource Decision

Every industry is experiencing drastic rates of change. This is particularly the case in technology oriented and services based sectors. Propelling that change is the restructuring of global industries. As companies focus on their core activities and outsource most others, their success increasingly depends on their ability to outsource and yet control what happens in the value chain outside their own boundaries. In the 1980s, the focus was on supplier partnerships. As described by Cash, J.L., and Konsynski in the Harvard Business Review, “In today’s faster-paced markets, the focus has shifted to innovation, flexibility, and speed.”xxxvii
Michael Corbett, co-founder of The Outsourcing Institute, defines outsourcing in these words.

"Outsourcing is nothing less than the wholesale restructuring of the corporation around core competencies and outside relationships. It is being applied to every facet of the corporation and at every level. It is viewed as central to the rebirth of productivity in the American corporation. Outsourcing is no longer a novel business approach, but a strategy that must be embraced by firms if they are to compete successfully in today's economy."xxix

The NREN should determine what competences are necessary for the conduct of the business and which are absolutely necessary for achieving its strategic aims. In other words, which competences can be relied upon to help the organization to continue to achieve advantage for Ireland Inc. It should be noted that there is always a need, even if outsourcing, to retain in-house competence to efficiently manage the activities of the outsource partners.

Options are developed below (Options 2 – 5) which are approaches that should be taken in the context of the capability of the organisation and the state of development of the marketplace.

Decisions here will include:

- Which parts of the business can be outsourced to others?
- Who can it outsource these activities to?
- How will these be managed?
- How will the organisation retain a competence in the outsourced areas so that it can continue to have a competence in managing and specifying the contracts?
5.2 Options

The following five options were arrived at:

<table>
<thead>
<tr>
<th>Option</th>
<th>PROs</th>
<th>CONs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two networks - Universities and IoTs.</td>
<td>Possibly more aligned to need</td>
<td>Inefficient &amp; more costly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No future provisions</td>
</tr>
<tr>
<td>Outsource to telecommunications service provider</td>
<td>No organisation to manage – just service level agreement</td>
<td>Beholden to provider</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ICT Competences not retained</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Little future provision</td>
</tr>
<tr>
<td>Outsource to Univ. IT Dept</td>
<td>Good services fit</td>
<td>Performance may be difficult to manage</td>
</tr>
<tr>
<td></td>
<td>Good culture fit</td>
<td>Lower organisational competence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Little future provision</td>
</tr>
<tr>
<td>Network Services Company</td>
<td>More efficient procurements</td>
<td>Difficult to maintain user focus</td>
</tr>
<tr>
<td></td>
<td>Better development of network</td>
<td>Feature creep – services developing on network</td>
</tr>
<tr>
<td></td>
<td>Better services</td>
<td>independent of application and use</td>
</tr>
<tr>
<td></td>
<td>Network future provision</td>
<td></td>
</tr>
<tr>
<td>Research + Educational + Network Services Company</td>
<td>Objectives fully aligned with users</td>
<td>Culture of partner rather than supplier difficult to achieve</td>
</tr>
<tr>
<td></td>
<td>Better match of activity to business funding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ICT future provision</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5-1 Table of Options

Option 1: Two Networks

The first option is a slightly more distinct one than the next four, which are progressive in their stages of evolution. As such, it can be taken as a decision reasonably independent of the others.

From experiences in analogous circumstances the only justification over the long term for sustaining separate networks over similar geographies would be:

- Significantly different networking needs
- Cultural difficulties in integration of management
Technical efficiencies will be gained in the aggregation of assets such that core switching, etc. are shared.

Many functions in the operation of a network are highly scalable:
- Network Management
- Procurement Capability
- Ongoing Operations (troubleshooting, etc.)

Centralisation of these skills will allow for lower cost and / or increased quality of service.

Other economies of scale may be generated around the following activities:
- More significant negotiation power with suppliers
- Better utilisation of expensive core networking equipment
- Activities including stakeholder liaison, partnership development, etc. in common
- Dealing with the strategic R&D and intensive ICT enabled learning issues

**Option 2: Outsource to telecommunications service provider**

This scenario is where there would be a shell organisation would conduct procurements on a regularly efficient basis for the provision of an NREN by a private operator. All activities are thus outsourced: the network establishment, management and maintenance.

This approach would lead to a comparatively lower level of competence in the shell organisation as it would not be operationally engaged in the business of driving the capability of the network or the applications delivering value.

The evolution of technology in the service provider market in Ireland is such that this option is inextricably linked to a lag in performance versus our peers in Europe and globally.

While efficient costs would be achieved in the short term, the lack of a central control of the network would lead to the service provider achieving “lock-in” on the needs of the higher education institutions that would in the medium term quickly erode quality and cost competitiveness.

The ITnet network adopts this approach.
Option 3: Outsource to a University IT Department

This would allow for the outsourcing of management activities to one of the member institutions, which by contract, commits to Service Level Agreements with other member institutions.

Advantages here would be that there is a good fit between the provider organisation and its client / user base.

While the competence development potential level here is marginally better than Option 2, there is still a low level of such competence development as the business of running and developing the NREN is mixed with the day-to-day trials of operating campus IT services.

Option 4: Network Services Company

The Network Service Company option is that where the NREN focuses on a core competence of providing network solutions to its member base. It sees itself as a technology development company with the pure responsibility being within the domain of the network itself.

Other issues regarding the delivery of value from the investment in the network are seen to be outside its domain of control. The focus is providing the best network from end to end within the sphere of control of the NREN.

Advantages here are that the network competence leads to potentially more efficient procurements than the earlier options. The network quality will be higher than in earlier scenarios.

Some disadvantages include that as a supplier-type of relationship, it will continue to be difficult to ensure that the alignment with user needs is consistent. An internal focus may result.

The HEAnet network adopts this approach.

Option 5: Research + Educational + Network Services Company

The NREN activities here are inherently in the core of assisting in the provision of technology-enabled solutions for research and education itself. The NREN would encourage specific areas of research that are dependent on leading edge networks for success. It would encourage the adoption of technology in education to ensure that educational institutions are leveraging technology in general in the most efficient, and most useful way. Importantly, it does not compete with its member institutions, in that it
is a research and education enabler of its members rather providing such services directly itself.

The organisation is also in the business of providing world-leading network services to the member institutions, but this is seen as a full solution provision rather than a pipe to the door.

The advantages here include that the NREN would be seen to be fully aligned with its user base, and a common focus will be transparent. The value of the investment returned will be higher through accelerated improved performance in research and education.

Some disadvantages here will include that achieving the open partner relationships with its members takes some effort to achieve.

In this scenario it would work closely with the following bodies:

- The Higher Education Authority
- The Department of Education and Science
- The Department of Communications, Marine and Natural Resources
- The Department of Enterprise, Trade and Employment.
- Science Foundation Ireland
- DANTE
- Internet2
- Its user base
6 Customer Base Analysis

6.1 Research Users

As part of the process of gathering the needs of the users of the educational networks in Ireland, Sonas Innovation spoke with the Heads of Research in various organisations.

There were two main groups of researchers or heads of development questioned, those users of the HEAnet and those users of ITnet. The needs of both sets of users have traditionally been very different, however, as the Institutes of Technology migrate to provide more research facilities these needs will be seen to merge over the coming few years. In particular, the Universities have a larger requirement for very high capacity bandwidth owing to their roles in providing a significant amount of postgraduate research. Institutes of Technology, on the other hand, tend to concentrate more on the delivery of classroom type services and are only beginning to make inroads into the provision of postgraduate research. They do state that this type of postgraduate research is seen as a major growth area in the coming years and therefore their requirement for high capacity bandwidth is growing.

As regards the delivery of networking services, ITnet depends solely on the services offered by the commercial carriers, typically Eircom. While currently sufficient for the capacities required, this arrangement will not suffice into the future as the requirement for capacity increases exponentially. There is a need to provide infrastructure now as a platform for lower future costs that will provide a solid foundation for next generation services today and into the future as the technologies evolve. While the building of this infrastructure now is in advance of demand, this is necessary given the lead time involved in delivery.

6.1.1 HEAnet Users Responses

Vice Presidents of Research in HEAnet connected organisations were consulted on their research futures to identify their perceived link between research and information infrastructure.

Three responses were received from the seven Universities outlining their current and future research roles and requirements.

The most common issues raised in response to network facilities were:

- Video conferencing facilities supporting collaboration and real time data sharing
- Access to remote instruments
• Research into Grid Computing
• Transmission of imaging data
• Access to high performance supercomputers
• Accessing, updating and exchanging large databases
• Access to online scientific journals
• On campus facilities to distribute and access available bandwidth
• National and international collaboration facilities

In response to areas of research that require high capacity bandwidth, the main areas discussed were:

• Bio-informatics, biotechnology and biochemistry
• Creative media – video production
• Health informatics, remote diagnosis, real time medical information
• Grid computing
• Networking research – ICT, telecommunications
• Physics and material sciences
• Chemistry and pharmaceutical research
• Remote learning

6.1.2 ITnet Users Responses

The ITnet user community is slightly different today from that of the Universities in that there is less emphasis placed on research facilities. However, as the Institutes evolve, this emphasis is shifting to a model whereby post graduate research and development is becoming more and more important in the future of all Institutes.

Five responses were received from the Institutes of Technology, with all respondents indicating a growing requirement for high capacity networking requirements. The main areas requiring such services are:

• Creative media – video production, games technology
• Bio-informatics
• Lifelong learning
• E-learning
• Education of students overseas

Some Institutes consulted indicated that there is a strategic push to establish relationships in overseas markets such as China. This opportunity does not have the infrastructural costs of full-time on-campus students. ICT facilitated delivery would allow for a highly scalable model.

The delivery of e-learning course material is of prime and strategic importance to all the Institutes consulted. Many of the Institutes currently provide courses to Health Board staff on a regular basis, some on campus courses and some off-site courses. All believe that with the availability of high capacity bandwidth the cost of providing these types of
services could be reduced and their audience increased. However, a concern raised by respondents was the availability of Internet access in the community for users to participate in e-learning programs. One respondent commented that work was being done to allow users to access course material from their employers premises after standard working hours using the employers network connectivity, where this did not incur dial up charges.

### 6.1.3 Computer Services Responses

Responses were also received from the Computer Services Managers in both the Universities and Institutes. In all cases the role of the network is now a critical part of the operation of the relevant organisation with all staff and students having email and Internet access. This facility leads to better communications between students and teachers and ultimately to a better educational environment.

The main issues raised by the Computer Services Managers are:

- On Campus facilities
- Lack of additional services beyond basic connectivity
- Lack of high capacity bandwidth for researchers
- Lack of availability of services from local service providers (Eircom, Esat)

### 6.1.4 Summary

In summary, while some respondents are satisfied with the services provided by HEAnet and ITnet currently, there was an urgency to ensure that we are well positioned relative to other countries. There was consensus that ICT facilitated Research and Education is critical to their activity. However, there is a stark knowledge gap in practice (as to how outreach programmes may be conducted, eLearning delivery put in place, wireless on campus) As demands increase and organisations evolve the services required will need to grow at an exponential rate to keep pace. An NREN is necessary to achieve this as market forces in Ireland are not sufficient to enable the establishments to rely on the commercial service providers to meet the requirements.

A body of work also needs to be undertaken to ensure that high capacity bandwidth services can be delivered to the desktop and not just to the ‘front door’ of the organisations. This is particularly so in the case of the older universities and institutes.
7 Related Government Initiatives

7.1 Regional Broadband Programme

The Department of Communications, Marine and Natural Resources has partially funded local authorities to build communications infrastructure in regional locations in Ireland.

As described recently by the Department of Communications, Marine and Natural Resources in the “Broadband Newsletter” in February 2003, Improved telecommunications infrastructure is a critical component in the continuing development of e-commerce and in the attraction and retention of foreign direct investment in Ireland. It is also critical to the competitiveness of indigenous industry. The Regional Broadband Programme aims to establish broadband service availability to many urban areas within Ireland, through the construction of carrier-neutral, open access Metropolitan Area Networks (MAN). These project will consist of metropolitan fibre optic cable and ducts with co-location space available on an open-access basis. xxx

19 towns have been selected as part of this programme:

- Athlone
- Ballina
- Carlow
- Carrick-on-Shannon
- Clonmel
- Cork City
- Digital Hub/Liberties area in Dublin
- Dungarvan
- Galway City
- Gweedore
- Kilkenny
- Letterkenny
- Limerick City
- Manorhamilton
- Mullingar
- Portlaoise
- Roscommon
- Tullamore
- Waterford City
- Wexford
A competitive process will begin to select the entity that will manage these networks on behalf of the State.

Once in place, these networks could potentially provide resources to develop the Educational and Research network. The Department of Communications, Marine and Natural Resources would be happy to explore any such opportunities when the management entity is in place. This should be in place at end 2003.

This may become an excellent platform for the development of world-class NREN capabilities in Ireland.

It is noted that an productive level of cooperation has already been established whereby HEAnet use 16 STM-1s from the International Connectivity Project, and two fibre pairs on ESB’s national network.

### 7.2 Government Virtual Private Network (VPN)

The Department of Finance has established a contract with Irish service providers to allow for communications services to all public entities at preferential rates. This allows for access to high speed networking services for all Government users. This Government VPN has significant geographical coverage.
The network is a Virtual Private Network (VPN) that means that users have dedicated links, or ‘pipes’ within the carrier network, or ‘large pipe’. This allows for a high level of security, high performance of network (by comparison to those which are commercially available), and full management by the service provider.

The Department of Finance sees two distinct requirements being catered for by NRENs in Ireland:

- Day-to-day education
- High-end research projects

From an expenditure point of view, it does not see a need for the State to be involved in capital subvention for the first need, which is already being provided for by the marketplace. The second need, however, where not provided for by the market is recognised to potentially require capital subvention. The general perspective would be that even assets such as dark fibre could be accessed on a current expenditure basis.

This approach is further highlighted by the history of the Government Telephony Network (“GTN”). At the time of establishment of this network, the service providers were not in a position to supply services to cater for the needs of the Government, and as such provisions had to be made to intervene and create its own private network. There was proof of money saving over the period of operation that justified the capital investment required. This network is now not used.

The market today is seen to be at a more advanced stage of development and through experience on the ground, CMOD expect that today’s communications needs are well catered for under the Government VPN. For example, ITnet’s network is largely based on the Government VPN.

However, it would be willing to accept that the next generation of services are not currently planned for under the VPN and should there be requirement for this it needs to be put in place separately. Access to underlying fibre may be done on a lease basis unless there are compelling savings to purchase. Co-utilising communications equipment should be evaluated where possible to reduce capital expenditures.

It is understood that HEAnet’s role is to provide for needs of Higher Education Institutions in a way that the market cannot. Such needs, as described above would include research projects whose communications needs are not available in the marketplace commercially. This is much in line with the experience in other countries, where commodity Internet traffic is separated from the Research and Education traffic in the National Research and Education Network.
7.3 **Institute of Technology Management Information System (MIS) Project**

“An Chéim” – Collaborative Higher Education Information Management is an initiative by the Department of Education and Science to allow for:

1. The provision of applications for the management of student, academic, library, financial, and HR information, to the Institutes of Technology

2. Development of a common standard design for all applications

3. Rolling out the applications on a joint project basis with the Institutes

4. To provide a foundation for the centralised provision of applications into the future

The roll-out of this project involves 60 sites with 24 said to be live.

While each of the above activities are reliant on network infrastructure for operations, the fourth activity which is in the process of evaluation is extremely heavily reliant on availability of quality network infrastructure. Full redundancy and resiliency of network architecture would be advised to ensure critical activities are not affected by a communications failure. Traffic from the users to the application servers is expected to be significant, and network load planning should inform the chosen architecture. Should application servers require decentralisation for any reason, communications with database servers are likely to require extremely intensive use of network resources.

“**Redundancy**” – dual components on a network which represent a single point of failure should outage of the component occur

“**Resiliency**” – dual routing of key trunks for transfer of communications to the other trunk should one trunk fail

In the current configuration, the network load is not expected to require special provisions apart from those delivered for other education / research uses.

The Conference of Heads of Irish Universities in their report “Technology Foresight & the University Sector” in April 2000 identify key savings that could be made in the adoption of ICT in administration. It may have opportunities for extension to universities to deliver further return on investment. An NREN could play a key role in actual delivery of this return on investment.
8 Future Options for NRENs in Ireland

There are a number of available structures to deliver the most efficient and effective network services required by Universities and Institutes of Technology and other users, taking account of the diverse needs of all users and of the need to ensure that value for money is obtained.

The structures are outlined, the options for delivery of appropriate structures are described and recommendations are made on which options should be pursued and how.

8.1 Findings of Study

The salient findings in the course of this project are set out according to each of the following perspectives:

General Environment

- The activities of education and research are becoming more globalised and more competitive internationally
- The effect of technology on education and Research is becoming pervasive
- The service provider market has evolved rapidly in commodity service provision but there is still an important role for NRENs to maintain a driving force in advanced service delivery & an awareness of international trends, and trends in R&D
- Timely availability national broadband infrastructure (to be put in place to allow demand to grow) is a key government objective
- Irish investment in globally leading research has seen a significant increase in recent years. This is critically dependent on connectivity.
- Capital for public infrastructure investment is less available than in recent years

User Perspectives

- Most users are satisfied with the quality of basic network and levels of service provided
- Some cases exist where research is being impeded by lack of sufficient connectivity
- Most users very interested in an education and research platform of excellence and recognise this to be of key value
- Consideration could be given to widening the access policy by HEAnet such that campus companies and links to commercial research partners can be delivered
- Research currently requiring advanced services is limited (due to the unavailability of necessary infrastructure)
- The network that originated as a research tool is now an operational necessity
- Institutes of technology are evolving to embrace more research programmes
- Education needs are currently of a different order to research needs (ICT adoption has been slower to date)
A national centre of competence for technology enabling education and research would be essential for the sector.
  o Administration
  o Education
  o Basic R&D
  o Strategic R&D requiring high speed access

**Stakeholder**

- Levels of network enabled research in Ireland have fallen behind leaders groups
- NREN excellence is critical if Ireland is to maintain competitiveness and generate a return on R&D investment
- Needs to be more clarity on investment and returns (there is not the general understanding of importance of this investment to the economy)

**ITnet and HEAnet**

- Major advances have been made in recent years by both HEAnet and ITnet in their respective roles
- Culture of collaboration is clearly required
- General consensus that one organisation would be better
- HEAnet and ITnet have significantly different approaches to service delivery options
- Inconsistent past funding limits future planning

### 8.2 Future Options

Considering the current and future trends in education and research networking, and the developing environment generally, the following are the delivery options. These options are according to a Low, Medium and High level of ambition

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>All NREN activities outsourced to a private operator and selected member’s IT department</td>
<td>Most commodity activities are evaluated against market capabilities regularly. Some piloting of future capability occurs</td>
<td>The NREN is seen as a key driver of change in the higher education sector and within the telecommunications marketplace. Relentless demands drive the rate of service provider innovation.</td>
</tr>
<tr>
<td>Network provides generic access to commodity internet and other commonly available online resources</td>
<td>As with Low, but with some centralised services with commonality across the user base. While we are represented in the global activity, Ireland is seen as a</td>
<td>Key research projects are located in Ireland significantly due to the</td>
</tr>
</tbody>
</table>

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No centralised resource exists and key technology requirements are hampered by lack of knowledge and funding for development. follower rather than a leader.
Can access independent funding resources (e.g. FP6)
Some benefits of technology adoption emerge through user determination and momentum.
Key competences continue to be fragmented.

information infrastructure and support available. New areas of Research competence are established.
Ireland among leaders Europe in ICT intensive research.
Partnership between NREN and researchers generates significant funding wins.
Ireland is international reference for the effective use of technology in education and research.

Figure 8-1 Future Options Grid

### 8.3 Costs

Capital and recurrent sources of funding were reviewed within the limitations of the information provided. For the purposes of a direct comparison, it should be noted that the user base and services delivered by each network are significantly different in delivery and therefore costs cannot be directly compared.

From information provided by HEAnet and ITnet, the following are the annual costs of providing their respective services:

<table>
<thead>
<tr>
<th>Network</th>
<th>Cost</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITnet</td>
<td>€2.1m</td>
<td>(13 Institutes of Technology)</td>
</tr>
<tr>
<td>HEAnet</td>
<td>€9.7m</td>
<td>(46 organisations + International Connectivity)</td>
</tr>
</tbody>
</table>

Each approach to service delivery is different and is not compared here. For example, should dark fibre be required (as elaborated in recommendations), a dedicated NREN national transmission infrastructure will be imperative.

Government MANs could provide local access infrastructure to most of the higher education institutions, and national transmission assets will be required to best leverage these opportunities. For example, within Cork city, UCC has over 20 separate campus sites, and providing high speed connectivity between these sites to date has proved difficult. The Government MAN project could provide fibre optic paths to each site.
Opportunities will also lie with the semi-state bodies Bord Gais, ESB, and Iarnrod Eireann as well as private operators to collaborate and provide resources.

While a detailed cost breakdown was not available, our analysis showed that there should be significant savings in the aggregation of resources in common:

- Hardware (e.g. core routers)
- Operational Resource (e.g. network management, support, administration)
- Service Development (e.g. video conferencing, email for life)
- National transmission (Intercity links)
9 Recommendations

Based on the findings of this report, Sonas Innovation makes the following recommendations to the Higher Education Authority. The recommendations should be viewed jointly and form a contiguous set addressing the terms of reference. Implementation of recommendations will require careful planning and change management.

9.1 Recommendation 1

A single organisation (NREN) be responsible for delivery of education and research networking services in Ireland. HEAnet is well placed to undertake this role.

Almost all developed countries and most developing countries have what is described as a National Research and Educational Network (NREN). An NREN provides an essential combination of expertise, leadership, innovation, infrastructure and service necessary to maximise economic outcomes of a nation’s research and development in a wide range of fields beyond those of networking and telecommunications technology. It is essential that Ireland continues to develop and evolve its NREN facilities in a coordinated manner to ensure that it remains competitive in the global arena.

There should be one organisation responsible for the delivery of high speed networking services to all higher educational establishments in Ireland. This organisation’s responsibility should be to provide connectivity to all those end users in the Higher Education sector and all future end users that would be entitled to use such services. Access to all should be a key principle.

This NREN should deliver services uniformly to Universities and Institutes of Technology, with services tiered according to level of need.

HEAnet is the recognised NREN for Ireland and provides a range of services to its clients, including:

- National connectivity
- International connectivity
- Sourcing external funding for operations
- Value-added services

HEAnet is well placed to continue to secure the competitiveness of Ireland’s research infrastructure into the future.

ITnet serves current needs of the Institutes by providing their national network connectivity, utilising HEAnet for international connectivity. ITnet has not had the
mandate to provide services in a forward-looking way to ensure that leading researchers and educationalists have access to world class information infrastructures and associated technologies.

High levels of joint effort will be required to reach Ireland’s stated levels of ambition. From consultation, it is apparent that many strong competences are already in place. In the establishment of a truly national NREN, investment will deliver better returns should this be considered and executed with both the University and Institute of Technology customer bases jointly taken into account. The NREN should adopt a forward-looking mandate which would address the particular requirements of both customer bases. Inclusiveness of all available resources will be important for the optimal outcome from this process.

The network operated should be developed as a ‘private network’ serving the research and education communities associated with the higher education sector. This network should allow all Irish researchers and members of educational organisations to be full participants in collaborative research as well as the development and use of innovative applications and services. There may be other areas where the NREN could add value, for example in the management of a broadband network for schools.

The role of the National Research and Educational Network provider should be to:

- Provide a platform for the development and use of advanced network services by the research and education community in Ireland
- Enable Irish researchers participate in collaborative national and international research projects and access global datasets, including access to advanced computing, grid services and remote instruments
- Provide infrastructure to provide the development, sharing and delivery of innovative online education content and applications nationally and internationally
- Provide / facilitate cost effective access to all organisations regardless of geographic location
- Provide leadership, direction and expertise via a strategic and coordinated approach to support Irish innovation

Subsequent recommendations establish a basis for the mandate for this NREN.

**Recommendation 1: A single organisation (NREN) be responsible for delivery of education and research networking services in Ireland. HEAnet is well placed to undertake this role.**
9.2 Recommendation 2

That a steering group be established to advise on policy and planning in relation to ICT in education and research.

It is recommended that a small, flexible group be established with a strong mandate that would dynamically work with all stakeholders to further development of ICT in education and research. Opportunities may emerge where full exploitation would be improved by this steering group’s efforts.

The steering group would perform the following functions:
- Coordination with multiple Departments / Agencies in relation to ICT
- Aggregating government resources for the NREN / other entities
- Over viewing policy implementation

The case for investment and overseeing value delivered is common to primary and secondary educational establishments. There will likely be overlap with the activity of delivery of infrastructure and services, such that it is necessary that a group can manage this overlap and realise any potential cost savings to the State.

A key role would be to benchmark relative to other countries how Ireland is performing.

The key stakeholders The Higher Education Authority, The Department of Education, The Department of Finance, The Department of Enterprise Trade and Employment, The Department of Communications, Marine and Natural Resources and Forfás and its agencies should form part of this body.

Recommendation 2: That a steering group be established to advise on policy and planning in relation to ICT in education and research.
9.3 Recommendation 3

A programme to upgrade and integrate the current NREN needs to be put in place. The quality of the network established needs to be of world class standard.

Ireland’s NREN is significantly behind competitor countries in some important aspects and will not achieve proper returns on R&D investments unless a world-class information infrastructure is in place.

Government policy in the promotion of broadband should be leveraged, with a national next generation network increasing competition in the marketplace. Suppliers may be interested in pledging resources to such an initiative.

The NREN should pursue a policy of utilising dark fibre in its national network. As a result of such a policy, unit bandwidth costs will become dramatically lower in the short to medium term. In a vertically integrated service provider marketplace, separating assets from services delivered generates large efficiencies in scale. Dark fibre will allow for maximum use of infrastructure by different sets of users.

“Dark Fibre” refers to the optical strands which are the core infrastructure over which high speed broadband may be delivered. Having access to the fibre directly ensures an upgradeable platform and reducing unit costs

In establishment of the national network, partnerships with other Government bodies (e.g. Libraries, schools, local authorities) should be put in place to drive economies of scale in securing network assets in regional areas. (e.g. joint procurement programme)

A pragmatic approach to network buildout and ICT adoption should be undertaken. This will capture any synergies with other private and public initiatives. The possibility of Ireland becoming a showcase should be emphasised in encouraging private partners to participate in such a leading project.

Key partners, the Department of Communications, Marine and Natural Resources and Comreg, should ensure that the availability of dark fibre be pursued with infrastructure providers (e.g. MANs project, ESB, Bord Gais, Iarnrod Eireann, etc.).

In the earlier stages, those institutions whose research and education would most benefit from large-scale activity should be targeted. For example, those projects whose activities would require access to higher order bandwidths should be selected first.
The table below outlines a possible phased approach to the delivery of high speed networking services in Ireland. In each instance the delivery of dark fibre infrastructure is assumed to provide bandwidth services at 2.5Gbps and above.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Timeframe</th>
<th>Issue</th>
<th>Effects</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Immediate</td>
<td>Current bandwidth preventing certain projects being commenced</td>
<td>Bio-Tech, Networking Research</td>
<td>Identify main Universities with high speed networking requirements Provide dark fibre links to these sites (initially only possibly 4 or 5 sites). Collaborate with IDA on FDI R&amp;D cooperation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>End University links need to be rescaled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 2</td>
<td>6 months</td>
<td>New services and research projects commencing</td>
<td>Common MIS platform Video Conferencing Voice over IP Telecoms Research network Additional research fields</td>
<td>Expand reach of dark fibre network to encompass additional sites using metro networks Investigate outsourcing possibilities of certain services</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 3</td>
<td>12 months</td>
<td>Research links with commercial enterprise</td>
<td>Gigabit access to desktops Wireless access on campus Elearning / Outreach Testbed capability established</td>
<td>Expand dark fibre network to include all member institutions with high speed requirements Continue outsource possibilities Investigate schools involvement in network</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 4</td>
<td>On going (2005 – onwards)</td>
<td>Ireland established as R&amp;D center of excellence</td>
<td>Research central to Irish economy</td>
<td>NREN now world-class, covering all educational establishments</td>
</tr>
</tbody>
</table>

Figure 9-1 Phased Deployment Approach

**Recommendation 3:** A programme to upgrade and integrate the current NREN needs to be put in place. The quality of the network established needs to be of world class standard.
9.4 **Recommendation 4**

**New partnerships with research and commercial entities need to be established.**

HEAnet has significant resources that would be valuable to the research sector in establishing research-industry partnerships. These should be exploited in collaboration with other relevant stakeholders.

The private sector would be interested in a vision where research, commercialization and excellent information infrastructure were driven by a Government programme to excel in chosen activities. For example, delivery of health and education services over broadband networks would attract significant interest.

For example, Ireland’s world leading position in the pharmaceutical industry can be leveraged in the development of collaborative research programmes with higher educational establishments.

Productive partnerships and excellent infrastructure will draw new investment, and future growth for the economy.

**Recommendation 4: New partnerships with research and commercial entities need to be established.**
9.5 Recommendation 5

While continuing to focus on core competences, the NREN Operator should outsource those services and facilities that can be more efficiently provided by commercial providers.

The type of high-end services required from an NREN are generally not available from the marketplace so must be provided by the NREN Operator. A key role for the NREN is to constantly push the capability of the marketplace for delivery of next generation services.

As a result of this, the NREN Operator should constantly review its position within the marketplace and concentrate its efforts on the delivery of such high-speed facilities and their ancillary services which the private market do not see as commercially viable.

For example, it may be more efficient to have first line helpdesk services provided by a third party operator, thereby allowing the NREN Operator to devote all its resources to its core competency. This would be of particular value in the event of operating a 24x7 helpdesk facility.

Recommendation 5: While continuing to focus on core competences, the NREN should outsource those services and facilities that can be more efficiently provided by commercial providers.
9.6  **Recommendation 6**

The NREN Operator should market itself as a key partner in enabling research based projects in Ireland

HEAnet in particular has valuable resources in place, and has made good progress in pushing the capabilities of research projects. However, feedback from researchers has indicated a lack of visibility or clarity of these resources and capabilities. While IT department audiences are well served, relationships need to be built with leading researchers and educationalists. For example, a regular newsletter covering innovative uses of next generation networking in a number of research domains could be issued.

As part of this role, and in ensuring that the infrastructure provided is sufficient to meet the requirements of the end users, it is necessary that the NREN Operator be involved in and aware of the research programs running or commencing in Ireland.

This will ensure that the objectives and goals of the NREN Operator are clearly and specifically aligned with those of the wider research community.

**Recommendation 6:** The NREN Operator should market itself as a key partner in enabling research based projects in Ireland
9.7  Recommendation 7

The NREN Operator needs to provide a broad range of services

While HEAnet complemented by ITnet provide a good level and range of service currently, the remit and range of services should be kept under review and extended where appropriate.

In addition to the delivery of high speed networking services, the NREN Operator should provide a wide range of network-based services. These services would be defined and delivered based on actual and projected education and research enabling technology needs. Examples could include:

- Gigabit to the desktop
- On-net video conferencing (e.g. remote lecturers)
- Telecommunications research

The NREN should work with end user organisations to encourage the availability of high speed networking throughout each campus, i.e. “Broadband to the desktop”.

Education users planning activities including outreach programmes, international collaborations or curriculum delivery and eLearning initiatives, would see the NREN operator as a source of valuable national expertise.

Recommendation 7: The NREN Operator needs to provide a broad range of services
9.8 Recommendation 8

The two distinct stakeholder groups, namely education users and research users, need to be reflected in the key performance indicators for the organisation. Ongoing International benchmarking needs to be conducted.

Initially the role of the NREN in Ireland was to provide a tool to allow for collaboration between researchers that were geographically dispersed. As it has evolved however, the role of the NREN has become critical to the day-to-day operations of the end user organisations to which it connects.

In order to ensure that the NREN is focused on the most effective and efficient methods of providing services and facilities to its defined user base, it is necessary that regular measurements can be made to validate its efforts. While it is outside the scope of this report to recommend the actual methods and measurements required, it is necessary to state that a system needs to be put in place that can allow such measurements to be made.

**Recommendation 8: That the two distinct stakeholder groups, Education Users and Research Users, be reflected in the key performance indicators for the organisation.**
10 Appendix 1 – International Case Studies

10.1 Introduction

To put the current infrastructure in Ireland in perspective, this section outlines briefly the efforts of those countries that are considered to be world leaders in the provision of research and education infrastructure.

10.2 Australia

Overview

AARnet Pty Ltd (APL) (http://www.aarnet.edu.au) is the company that operates Australia's Research and Education Network (AREN). It was initially formed in 1989 as an initiative of the CEOs of the major Universities and in 1999 was incorporated as a not-for-profit organisation. The shareholders are 37 Australian universities and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

AARnet provides high-capacity leading-edge Internet services for the tertiary education and research sector communities and their research partners. AARnet serves over 800,000 end users who access the network through local area networks at member institutions. AARnet delivered in excess of 440 terabytes of traffic to members in 2002 with a demand growth continuing to exceed 50% per annum. The service is cost-effective with reductions in base unit costs of around 20% per annum in recent years.

AARnet has been effective in making representations to government on policy, legislation, strategy and programs to improve the telecommunications facilities and services available not only to the education and research sector but also to the whole Australian community.

Research and Education Network

AARnet delivers high-capacity, cost-competitive Internet based network services to the tertiary education and research sector and partner organisations as detailed in the APL Access Policy. The AARNet2 network provides an incubator for development of advanced network infrastructure and applications with access to the global Research and Education Networks in North and South America, Europe and Asia.

The end-user client base comprises more than 800,000 staff and students of universities and research organisations where the AARnet network plays an integral role enabling them to:

• collaborate and interact in more effective ways;
access and provide information for teaching, learning, research and administration; and
participate in alternative and more flexible modes of course delivery.

During 2001 AARnet deployed its first international capacity by acquiring 310 Mbps of capacity from Sydney via Hawaii to Seattle. This provides access to the advanced research and education networks of many countries including North America, Europe, Japan, Taiwan, Asia and South America.

In 2002, AARnet was the prime motivator in implementing GrangeNet which provides a high capacity research network of 5 Gbps from Brisbane to Sydney and 10 Gbps between Sydney, Canberra and Melbourne.

AARnet has also worked with local Regional Network Organisations throughout Australia to achieve high capacity metropolitan and regional networks.

As of the end of 2002, the AARnet organisation comprised 14 staff.

**Funding**

Initially, AARnet was funded via the Australian Research Council, a Government agency. Today, AARnet receives all its funding through end user charges. However, it should be noted that a submission has been made to the Australian Government to enable additional funding to be received to allow the network evolve to a world-class infrastructure. Previously, the Australian Government has taken the position that the market place could meet the requirements of research networking.

**Grangenet - GRid And Next GEneration Network**

GrangeNet (GRid And Next GEneration Network) is a 3-year program that will install, operate and develop a multi-gigabit network to support grid and advanced communications services. The program started on 1 March 2002.

The Consortium Members are responsible for the management of the GrangeNet program. GrangeNet is 'open' to participation of organisations, communities of interest and individuals consistent with the objectives of the program.

The GrangeNet network comprises 10 gigabit backbone linking Melbourne, Canberra, and Sydney and 5 gigabits into Brisbane. A range of advanced services is available to users.
Services
The network and its management are designed to support the deployment and use of advanced communications services on GrangeNet. GrangeNet will be a test bed for a new generation of services aimed at supporting advanced and grid services as well as virtual organisations and user communities.

GrangeNet will be part of the global research and education network through access to the 300Mbps capacity via AARNet2 to the global research and education networks.

Advanced Communications Services
The following working groups will be established initially as an extension of the activities of AARnet working groups:

Quality of Service (QoS) Service
- Trial router traffic management options that allow traffic to be prioritised as it passes through the network
- Demonstrate at least 3 categories of service quality: Premium (highest priority), Best-Effort (standard priority) and Scavenger (lowest priority)
- Develop an environment where traffic can be tagged by a user on-demand, and the request is immediately checked for authorisation and is properly accounted and billed

Next Generation Internet Protocol service (e.g. IPv6)
- Install gateway routers to tunnel IPv6 traffic across the GrangeNet IPv4 backbone

IPv4 refers to the original numbering protocol for Internet Protocol, a communications standard. It became a limit to the numbers of computers connected, at 4.2bn hosts. IPv6 allows for an extended
range of numbering, and more devices connected. Will become important with proliferated computing devices.

- Demonstrate a typical suite of applications and services running IPv6 natively on GrangeNet tails and tunnelled across GrangeNet
- Route IPv6 natively across GrangeNet with a view to turning off IPv4 services on GrangeNet

**Traffic Engineering Service (eg MPLS, to allow fast switching and traffic tunnelling technology for a variety of protocols)**

- Identify the extent to which MPLS can be enabled not just across the backbone but also down to individual edge networks such as campuses, as well as regional and international networks
- Enable MPLS services across GrangeNet routers to allow for various types of traffic to be tunnelled across the backbone
- Configure MPLS services to demonstrate rapid-failover to other routers, fibres or wavelengths in case of a network failure

(`MPLS = MultiProtocol Label Switching, allowing for a number of channels on one IP pipe`)

**Multicast service (to deliver traffic from one/many-to-many)**

- Enable multicast on the backbone routers and demonstrate some standard multicast applications including audio, video and whiteboard tools
- Demonstrate large numbers of simultaneous multicast streams, such as during Access Grid events
- Demonstrate high-performance multicast services to multiple GrangeNet sites.

Other working groups that are expected to be established during the Project include:

- Security
- Access, Authorisation, and Accounting
- Measurement and Monitoring
- Caching and Content Distribution

**Grid Services**

The following working groups will be established initially as an extension of the activities of APAC and its partners:

**Distributed Computing**

Grid middleware will be installed to allow applications to be executed across multiple distributed computing systems at the APAC partner sites. A demonstration of the package NIMROD-G (from DSTC and Monash University) operating on Globus middleware is planned.

**Collaborative Visualisation**

Visualisation software will be installed on virtual reality systems at the APAC partner sites to enable collaborative working across two or more systems. The
applications will involve such tasks as engineering design, presentation of computational models and simulations, and product assessment. A demonstration of such applications is planned.

**Cooperative Environments**
Access Grid nodes will be initially installed at four APAC partner sites. Installations at other sites will be considered, subject to the expansion of the GrangeNet network and available funds. The Access Grid nodes will be used for meetings, workshops and seminars between the sites. The nodes will be part of the international Access Grid which currently has over 70 nodes.

The major demonstrations will involve participation in international events and conferences (specifically the SC (high-performance communications and computing) conferences in the USA).

**Digital Libraries**
Software will be installed at the APAC National facility to support user access to large-scale sets of scientific and technical data. A demonstration of Web-based access to one or more large-scale data sets (e.g. in astronomy, bio-informatics) using Grid middleware is planned. It is expected that the data sets will support Australian participation in international research projects (e.g. virtual observatories, international virtual data grid laboratory).

Grid services to allow remote large-scale instruments (e.g. electron microscopes) to be accessed across GrangeNet are also expected to be investigated.
10.3 United States

Overview
Internet2 (http://www.internet2.edu) is a consortium being led by 202 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet. Internet2 is recreating the partnership among academia, industry and government that fostered today’s Internet in its infancy. The primary goals of Internet2 are to:

- Create a leading edge network capability for the national research community
- Enable revolutionary Internet applications
- Ensure the rapid transfer of new network services and applications to the broader Internet community.

Figure 10-2 Internet 2 GigaPoPs
Background – The Origins of the Internet
NSFnet was established in 1988 as a Not-for-profit, funded originally by a grant from the NSF. It was located in the State of Michigan with management being conducted by Merit (www.merit.edu). Partners who jointly undertook responsibility for NSFnet operations included MCI, IBM and Michigan State. Private partners made contributions in kind amounting to $25-50m each over the years. The interest was to be associated with a new endeavour to allow for breakthroughs in the development, and use of high speed networking which was not otherwise possible. Funding was of a long term nature with a mid term review provisioned. The executive committee met every other month.

Lesson from Full Outsource Attempt
Given the state of development of the market for the commercial provision of communications services, it was expected that there was no further need for Government involvement. As such, in 1998 there was a transfer to private industry. While the industry found the existing network and revenues to be beneficial in the building of significant backbone internet networks, there was a degradation in service to the higher education users. Commercial providers were not able to perform to NSFnet levels of service. Simply the demands that were placed by the research and education users were too much on the leading edge for the reliance on a private operator to provide a sufficient service. As a consequence, the NSF started to fund a VBNS (Very High Speed Backbone Network Service) to provide advanced networks to high end research users. Thereafter, Internet2 was launched as described herein.

Campus Driven Approach
The Government was funding upgrade programmes for Universities to install technologies on campus, and part of this funding was diverted by the Universities towards Internet2. Thus there was a high state of readiness in terms of campus technology deployment for the exploitation of the wide-area network connectivity of Internet2.

Funding
The organisation benefited from philanthropic grants from a number of private sources. For example, Quest donated fibre (lit and dark), Cisco provided routers. Current sources of funding are almost entirely non Governmental. This is probably a reflection of the fact that uniquely, the US educational system relies heavily on other sources of funding and as such can retain a high level of independence from Government. It was commented that from comparison to experiences in other countries, it is questionable whether this funding model is possible elsewhere given the unique philanthropic culture, particularly in the high-tech and educational sector in the US.

Research Activities
A core focus of the Internet2 organisation is to drive the levels of research in areas that require high end network connectivity. The vast majority of Internet2’s staff are focused on these areas. Activities include finding research, hosting showcase events and allowing for collaboration between research users.
Internet2 focuses activities to promote usage in chosen areas of research including:

- Network Performance
- Security
- Middleware
- Applications

Separate Asset Company
In April 2003, a new company called Fiberco was set up. The concept behind Fiberco is to help provide inter-city dark fibre to regional optical networks with the benefit of a national-scale contract and aggregate price levels. The responsibility for actually lighting this fibre will rest with the regional networks.

A secondary objective here is to ensure that the U.S. research university collective maintains access to a strategic fibre acquisition capability on the national scale for future initiatives. Internet2’s sense is that the fibre market is tightening up as the telecom survivors have been gobbling up the fibre assets for sale in a liquid market.

Fiberco has been established as a limited liability corporation with membership open to non-profit organizations. At present, Internet2 is the founding member. Fiberco has executed two agreements with Level 3 Communications that 1) provide it with an initial allocation of over 4,000 route-km of dark fibre anywhere on Level 3’s national footprint and 2) set the ongoing costs for fibre maintenance and equipment co-location. Fiberco was drawn to the Level 3 facility because of its homogeneous national presence and the company's aggressively open fibre interconnection policy with other entities (both for-profit and non-profit). In addition, Fiberco has the ability to acquire additional fibre strands at the same price levels over the next three years. It intends to make segments of this fibre available (by means of contract assignment) to all the regional optical networks serving higher education that have developed recently and those that are emerging in the United States.

“Dark Fibre” refers to the optical strands which are the core infrastructure over which high speed broadband may be delivered. Having access to the fibre directly ensures an upgradable platform and reduced unit costs.

“Co-Location” a neutral venue where owners of competing communications assets connect their networks together to enhance mutual connectivity of their end users.
10.4 Canada

Overview

CANARIE (http://www.canarie.ca) is a not-for-profit corporation that is positioned as “Canada's advanced Internet development organization”. Its mission is to accelerate Canada's advanced Internet development and use by facilitating the widespread adoption of faster, more efficient networks and by enabling the next generation of advanced products, applications and services to run on them.

CANARIE has already succeeded in enhancing Canadian R&D Internet speeds by a factor of almost one million since its inception in 1993. The organization has also funded numerous advanced Internet applications projects, providing some 500 companies with the opportunity to achieve business success through innovation.

CANARIE also intends to act as a catalyst and partner with governments, industry and the research community to increase overall IT awareness, ensure continuing promotion of Canadian technological excellence and ultimately, foster long-term productivity and improvement of living standards.

Background

Within Canada there are 10 Provinces, each with independent government. As such, the structure is quite analogous to the overall European structures in terms of the CANARIE operation. DANTE (described later in this chapter) would be the equivalent entity in the European context. The scale of some of the Provinces is significant. In Ontario there are 30 universities and, for example in Toronto, there are over 50,000 students.

Industrie Canada established the CANARIE organisation in 1993. A partnership with the main carriers was put in place. It initially emerged as an Internet academic toy. Awareness and importance grew in time with the evolution of technology and its uses. Now it has evolved to support research networking which is seen as of critical economic importance. 10 regional networks now connect to CANARIE.

Various programs of Government funding saw the development of the network itself, and also the research programmes administered by the organisation.
Research and Education Network

The commercial cost of the Internet is now so low that universities now buy direct from providers. Costs available now go to Ca$10 (€6.3) per Mb per month. CANARIE does not carry commodity Internet. Its traffic is now exclusively directly related to specific research and education uses and applications. Connectivity to international networks is another important part of what CANARIE provides.

Research Activities

Other areas of focus for CANARIE include the promotion of the following development and research which promotes the use of networking:

- Distance Education
- Video Conferencing
- GRIDs
- Digital Libraries

*GRIDs refer to a computer architecture where processes and tasks can be very highly distributed between a number of participating computed systems. These computing GRIDs have been shown to have the potential of outperforming the largest supercomputers.*

The CANARIE organisation has a majority of its staff working on advanced applications as compared to network operations. Programmes are run for academia and companies to conduct research that may lead to commercial products. Project areas that the organisation has and continues to promote include:

- To develop innovative applications for high performance networks
• To use high performance networks to evaluate and test new modalities of instruction, E-business and health delivery.
• To extend the capabilities of the Internet in new and unique ways.
• To encourage the definition and implementation of innovative solutions that allows users to control, manage, partition and advertise Lightpaths across the CANARIE network.
• To encourage projects that will accelerate the development of advanced E-business applications and services.
• To support research and applications development in the area of interactive media, and stimulate the development of advanced networked content.
• To encourage research and development projects that will accelerate the adoption and implementation of advanced telehealth applications and services, assisted by advanced networks.
• To encourage the development and use of broadband networks in education and training.

“LightPaths” Configurable route of transfer of communications traffic over an optical network where intelligent routing choices are made at junctions of various routes, (or nodes)

**Industrial Focus**

CANARIE allows for a reasonably open Access Policy to its network. This allows for commercial organizations as well as educational institutions to participate in research activities. A basis for this is that discounts in the educational sector are the same as commercial discounts. This allows for more commercial participation in the business of education and research.

**Approaches to Infrastructure Development**

In the establishment of a research infrastructure common to higher education institutions across the country, the Provinces have adopted different approaches. For example, British Columbia, Ontario and Quebec have acquired dark fibre. They have been able to rationalise the cost of bandwidth as a result. However, New Brunswick pursued an approach to co-invest with a commercial service provider. In some cities, the local authorities own conduit (including Montreal and Quebec). Power utilities are becoming aggressive in the marketplace such that access to fibre and other infrastructure is becoming more widely available.

“Conduit” or ducting – the physical piping through which optical fibre can be installed.

Much collaboration is driven by the research and education organizations in order to achieve its goals. For example, when RISQ (the regional organization in Quebec) want to build, it will do so through collaboration – e.g. school board, community groups, hospitals, will then work with alternative carriers to deliver the network. In Halifax, a private organisation built an infrastructure with the Universities as an anchor customer on 20 year agreement. Spare strands of fibre will allow them to sell on capacity to others later. RISQ had to raise money and then build. This build (if only 300km) threat made other asset owners trade assets at fair prices.

**Organisational Evolution**
CANARIE state that they want to put themselves out of business. Joint procurement (the initial basis for the organization) is not needed when the market has developed to a sufficiently mature state. While commodity Internet services are now seen to be available competitively in the marketplace, the next wave of services (which they call the 3rd wave of the Internet) still requires Government intervention to develop for the benefit of the Research and Educational sector.


10.5 Sweden - SUNET

Overview
SUNET (from Swedish University Computer Network) (http://www.sunet.se) is the organisation for the national higher education and research network of Sweden. It is used by researchers, teachers, students, and administrative personnel in 32 universities and colleges throughout Sweden. Some central government museums and external organisations are connected to the network.

The NREN (National Research and Educational Network) in Sweden saw its beginnings around 1980 where a University Research networking project established some X.25 links. This grew into a network between the main Universities and allowed for operational communications. In 1989 the current organisation was formed. In the earlier years, the Swedish Government contributed a high proportion of costs, while now the Universities themselves contribute most of the operational costs. The latest upgrade programme was completed recently and went into service in October 2002. The network is built with 10 Gbit/sec DWDM connections in a redundant infrastructure, connecting PoPs (Point-of-Presence) in 22 cities, nationwide, using redundant 2.5 Gbit/sec connections as access towards the universities.

"X.25" – a packet based communications protocol (as is IP) in use as primarily business communications networks. This was one of the earlier infrastructures on which applications such as e-mail emerged.

"DWDM" – Dense Wavelength Division Multiplexing"

"10 Gbps" - 10,000Mbps = c. 200,000 times capacity of a 56kbps dial modem link

In Sweden, the culture in the sector is that the Universities are fairly stand-alone with most of the power devolved. As such, the evolution of the NREN in Sweden was brought about primarily out of the collaboration of the Higher Education Institutions rather than by any intervention by a central Government body.

Homogeneous Services
All universities connecting to the network get access to the same service. This is a 2.5Gbps flat access offering. Internal analysis showed that lower tiered services do not work out to be much cheaper to provide to the user community. Management is simplified and savings are generated from the homogenous network design. The core network backbone operates at 10Gbps (previous network was scaled at 655Mbps backbone with 155Mbps access).

155 Mbps = STM-1 = c. 3,000 times capacity of a 56kbps dial modem link

High-End Network
Dark fibre is provided between universities in metropolitan areas, while a lit service connects these cities into the national network. Each city has a Point of Presence (POP) for interconnection of the local fibre rings and the national wavelengths (also redundant
and diverse. Dual routers are provided at the POP, with dual access pipes to each user point. 100% uptime has been the experience, even though individual elements of the network has had many outages since go-live.

“Fibre rings” – Fibre is normally constructed in a ring fashion to allow for traffic to reroute within the ring automatically in any path should there be a breakage at any point.

“Wavelengths” – The individual colours of light which act as communications channels aggregated within an optical fibre, allowing for multiple channels on each fibre. (This technology referred to earlier as Dense Wavelength Division Multiplexing)

“Routers” – Equipment placed at the junction of routes to allow for intelligent decisions regarding the further direction and treatment of incoming communications.
Figure 10-4 SUNET Sweden Network
Virtual Organisation
SUNET itself employs no staff. The University of Umeå is paid for time spent by the chief architect and nominal head of the virtual organization.

Operations are outsourced to a University Computer Department. The operational contract is held by the IT in Stockholm. 20 full time equivalents are assigned.

Funding and Charging Structures
Total funding is 120m Swedish Krona\(^7\) (or €13m) per year, of which university clients provide the majority. The Government contribution is in the order of 35m Swedish Krona (€3.85m) / year. These levels were at 90% in 1990 – 1993 while this has now reduced to 30%.

Charging structures relate to the overall revenue of the University subscriber (this is a useful measure, as it compares well to overall usage / traffic to within a 5% tolerance)

Research Activities
Few applications are provided over the network. There is an FTP archive, and white pages (which are under-developed).

\textit{FTP} – \textit{File transfer protocol}, a standard application allowing for the transfer of computer files through a network.

\textit{White Pages} – \textit{Online Directory archiving contact information}

Some conferences are conducted throughout the year on topics related to research involving or requiring networking.

Support of research is not a core part of the organisation. The organisation provides some capacity to researchers engaged on a research project into IPv6. This, however, is not a significant activity.

\(^7\) At time of writing, 1 Swedish Krona was worth approximately 11c
10.6 Europe – DANTE

Overview

DANTE (http://www.dante.net) provides a Europe-wide network connecting each national research and education network. Since its creation in 1993, DANTE has been responsible for four consecutive generations of European research networks, and is active in the ongoing development of European research networking. DANTE is owned by a number of European research networks and has "Research Association" status in the UK. It plans, builds and manages international networking services on their behalf. The pan-European research network enables European scientists to compete on an international stage by providing them with a world-class backbone that offers the bandwidth and the Quality of Service required for research and development activities at this level. It represents the basis for the introduction of 'virtual laboratories' and 'virtual institutes' in Europe.

DANTE itself does not support research but members are funded through the Research Programmes.
Evolution of European NRENs

Given DANTE’s position at the centre of NRENs in Europe, it has a unique perspective of each country’s positioning and future evolution.

Each NREN typically provides the following range of services:
• Commodity Internet
• University-to-University connectivity
• Research Project-to-Research Project connectivity

Today the National Research and Educational Network organisations provide raw connectivity to its member institutions. In the future the focus will increasingly be on quality of service delivered.

There will be a culture change required in the NREN organisations to ensure that there is follow-through and consequently that there is value generated from high speed networking at the educational and research levels. This will manifest itself in the spawning of application adoption driving network usage.

**Outsourced approach versus an NREN entity**

In DANTE’s experience (from an interview with Dai Davies, Managing Director of DANTE):

“The market does not supply advanced services to researchers. There is a need for Governments to ensure the delivery of these advanced services to the educational and research institutions”

This refers to the important of a Government backed NREN continually pushing the supply market for the most advanced services.

“Countries in Eastern Europe recognise the economic value of networking for research and education and countries such as Slovenia are making great progress.”

This outlines how there is a threat from other countries with relatively advanced Education and Research may be able to leapfrog other more developed countries.

From DANTE’s experience in other European countries, their view is that Ireland would want an NREN rather than attempting to allow the private sector to take entire responsibility.

DANTE here refers to their view that Ireland would benefit from centralising resources and building up expertise.

“Funding needs to be consistent to allow for value to be generated. Policy setting and implementation needs to be separated.”

This will be important for feeding into the proposed funding models for the entity.
10.7 The Netherlands – SURFnet

Overview

SURFnet (http://www.surfnet.nl) is the national computer network for higher education and research in the Netherlands. SURFnet connects the networks of universities, colleges, research centres, academic hospitals and scientific libraries to one another and to other networks in Europe and the rest of the world. There are in the order of 200 members.

SURFnet ensures that the Dutch institutions for research and education have at their disposal an advanced communication infrastructure with high-quality international connections. As a result, SURFnet is ahead of the market. SURFnet's policy is aimed at retaining its position among the leading international research networks.

Figure 10-6 SURFnet Network

Continual Evolution

Iterations of technology are introduced on a regular, planned basis. Each iteration of technology invested in the network assumes a name. The current network in usage by all members is called SURFnet5. Institutions connect into this network at 1Gbps or 10 Gbps. SURFnet6 is now being planned which will allow for wavelength switching.

“Wavelength” – The individual colours of light which act as communications channels aggregated within an optical fibre, allowing for multiple channels on each fibre. (This technology referred to earlier as Dense Wavelength Division Multiplexing)
The national research network is not the only thing to be renewed. The international connections to other networks in North America, Asia and Europe will be extended and enhanced. A third important component besides enhancing the backbone and the international connections is improving access to the network for member organisations and their end-users. To this end SURFnet will apply new fixed and mobile connection technologies such as ADSL, GPRS (high speed data via GSM) and fibre optics.

**Organisation**

Stichting SURF (SURF Foundation), the parent organisation, is the responsible Dutch (cooperative) organisation for institutions for higher education and research in the field of network services and information and communication technology. Stichting SURF has two subsidiaries, or daughters, which join forces in specific areas: SURFdiensten and SURFnet.

![Figure 10-6 SURFnet Organisational Relationship with Government](image)

SURFdiensten bv (SURF Services). SURFdiensten grants institutions for higher education and research SURF-licences for a wide range of ICT products - such as software and hardware - at very favourable conditions.

SURFnet bv operates the networks and promotes, delivers solutions to its users and is the forward looking network technology expertise unit. It employs in the order of 30 staff.

**Operations**

Operations of the network are outsourced to 2 university IT departments: One manages the network and the other manages the applications delivered such as streaming.

**Funding**

The structure of the funding is separated according to its two core activities, and core competences:

1. Day to Day operations
2. Forward looking Initiatives
The first source of funding is purely from the universities. These funds are in the order of €20m per year.

The second source of funding is from SURF Foundation which currently contributes in the order of €15m per year for the forward-looking initiatives.

**Innovative delivery – Pump priming Broadband delivery**

In parts of The Netherlands where dark fibre is not available, SURFnet partners with other not-for-profit organisations to jointly purchase fibre assets and delivers service into these areas.

**Netherlight**

Netherlight is another network exclusively used for research purposes. It is an advanced optical infrastructure and proving ground for network services optimized for high performance applications. Operational since summer 2001, NetherLight is a multiple Gigabit Ethernet (GigE) switching facility for high-performance access to participating networks and will ultimately become a pure lambda switching facility for wavelength circuits, as optical technologies and their control planes mature. NetherLight’s international connectivity includes dedicated lambdas to the StarLight facility in Chicago and to CERN in Switzerland (10Gbps provided by Global Crossing).

Researchers use the NetherLight facility to investigate novel concepts of optical bandwidth provisioning and to gain experience with these techniques. In particular, researchers are investigating different scenarios on how lambdas can be used to provide tailored network performance for demanding grid applications. Important issues are: how to get traffic onto and out of lambdas; how to map load on the network to a map of lambdas; how to deal with lambdas at peering points; how to deal with provisioning when more administrative domains are involved; and, how to do fine-grain, near-real-time grid application-level lambda provisioning.

“Lambda” = Wavelength – The individual colours of light which act as communications channels aggregated within an optical fibre, allowing for multiple channels on each fibre. (this technology referred to earlier as Dense Wavelength Division Multiplexing)

**Gigaport**

To remain in the lead SURFnet keeps improving its infrastructure and developing new applications, ensuring faster and better access to new Internet services for its users. SURFnet is an important partner in the GigaPort project, the national project involving the development of the next generation Internet in the Netherlands.
GigaPort entails the development of one of the world's most advanced communication networks. It will function as a proving ground where businesses can do pre-competitive research for new applications.

The approach with regards to industry partnering is interesting: “GigaPort aims to unlock the potential of next generation Internet by demonstrating the value of its applications in various industries.” Partners include non-ICT companies conducting Research and Development.

Sectors identified include:

- Construction and Civil Engineering
- Financial Institutions
- Media
- Transport and Logistics

**Gigaport Next Generation**

A Gigaport Next Generation has recently been put to the Dutch Government for consideration.

This project will have huge opportunities to generate another wave of economic advantage for the country.
10.8 Conclusions

Ireland is not unique in having a national research network. Much progress has been
made, particularly in recent years in establishment of an excellent international
connectivity infrastructure. However, as can be seen from the cases shown in this section
and summarised in the table below, Ireland is falling behind in some areas.

<table>
<thead>
<tr>
<th></th>
<th>Ireland</th>
<th>AARnet</th>
<th>Internet2</th>
<th>Canarie</th>
<th>SurfNET</th>
<th>Sunet</th>
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<td></td>
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<tr>
<td><strong>Backbone</strong></td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
<td>&gt; 10Gbps</td>
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<tr>
<td><strong>National</strong></td>
<td>Mostly</td>
<td>10Gbps</td>
<td>10Gbps</td>
<td>10Gbps</td>
<td>10Gbps</td>
<td>10Gbps</td>
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<tr>
<td><strong>Backbone</strong></td>
<td>2 x STM1</td>
<td>~ 10Gbps</td>
<td>1Gbps</td>
<td>1Gbps</td>
<td>2.5Gbps</td>
<td></td>
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<tr>
<td><strong>Access</strong></td>
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<td>~ 2.5Gbps</td>
<td>~ 2.5Gbps</td>
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<tr>
<td><strong>Provider</strong></td>
<td>Reliant8</td>
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<td>Fibre</td>
<td>Fibre</td>
<td>Fibre</td>
<td>Fibre</td>
</tr>
<tr>
<td><strong>Staff</strong></td>
<td>15</td>
<td>18</td>
<td>70</td>
<td>33</td>
<td>479</td>
<td>310</td>
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<tr>
<td><strong>Revenue</strong></td>
<td>€11.8m</td>
<td>AU$31.4m</td>
<td>N/A</td>
<td>CA$27m</td>
<td>€17.7m</td>
<td>N/A</td>
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<tr>
<td><strong>End Users</strong></td>
<td>200,000+</td>
<td>800,000+</td>
<td>200+</td>
<td>N/A</td>
<td>N/A</td>
<td>350,000+</td>
</tr>
</tbody>
</table>

Figure 10-8 Summary of NRENs Internationally

The national backbone in place is an order of magnitude less than that available in other
countries. NRENs in other countries directly access fibre infrastructure, allowing for
much lower unit costs and greater bandwidth.

Main areas where Ireland appears weaker:
  o Less connectivity all the way to the desktop.
  o Less engagement directly with research projects.
  o Less engagement with the commercial sector.

Ireland can be proud of its achievements to date. Much of the capabilities of Ireland’s
NRENs can compare to world leaders in some areas. Yet as has been shown, further
initiative is needed to ensure it remains competitive.

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8 NRENs in Ireland use commercial service providers’ infrastructure, whereas in other countries examined,
the NRENs access fibre infrastructure directly.
9 Day-to-Day operations of Surfnet are carried out by subcontractors, these are not included here
10 SUnet outsources most of its operations to University IT departments
11 Appendix 2 – NREN Innovations

11.1 NREN Innovations – Internet 2

Internet2 establishes new organization to support regional fiber optical networking initiatives
May 2003

Internet2 announced that it has established the National Research and Education Fiber Company (Fiberco) to support regional fiber optical networking initiatives dedicated to research and higher education.

Fiberco supports the Internet2 community's goals of developing and deploying advanced network applications and technologies, and complements existing Internet2 network infrastructure by providing a means for acquiring, holding, and distributing fiber optic network assets. Fiberco helps Internet2 meet a critical objective by facilitating the ongoing development of regional optical networking initiatives around the country. The assets allocated by Fiberco are expected to enable testing of a wide variety of highly advanced network applications, including uncompressed high-definition television quality video, remote control of scientific instruments such as mountaintop telescopes and electron microscopes, collaboration using immersive virtual reality, and grid computing.

Fiberco's initial assets include over 2,600 miles of dark fiber acquired from Level 3 Communications, Inc.
11.2  **NREN Innovations – UKLight Optical Network**

£6.5 million UKlight optical network announced in the UK

May 2003

JISC announces UKLight, a £6.5 million major international networking initiative. A new multi-million pound initiative will ensure that Britain can retain its position as a world leader in research. HEFCE (Higher Education Funding Council for England) is investing £6.5 million in an initiative known as UKLight, which will put the UK on the global optical networking stage.

UKLight is an international collaboration between JISC and SURFnet, based in the Netherlands. The UK will join several other leading networks creating an international experimental test bed for optical networking. These include StarLight in the USA, SURFnet in the Netherlands (NETHERLIGHT), CANARIE (Canadian academic network), CERN in Geneva, and NorthernLIGHT bringing the Nordic countries onboard. UKLight will connect JANET*, the UK’s research and education network, to the test bed and also provide access for UK researchers to the Internet2 facilities in the US via the StarLight initiative. The management of the programme will be provided by UKERNA (the UK Education and Research Networking Association), who manage JANET on behalf of the JISC.

Recent worldwide advances in networking technology are enabling a transition to the next generation optical network that will make available ultra-high bandwidth to its users. These developments will radically transform the landscape of the information economy and present new facilities and opportunities to both the network research and development communities and to those responsible for service provision and delivery. Researchers whose work relies upon fast and efficient computer networks will be able to stay at the forefront of their research, particularly in areas such as particle physics, radio astronomy, and high-performance computing.

Professor Peter Clarke, Particle Physics Research Group, University College London comments that "UKLIGHT is excellent for the UK. We now have a real opportunity to be at the forefront of developing new ways of networking needed to meet the requirements of education and research in the next decade. UKLight will enable e-Science applications in a way we have only dreamed of up until now. This news heralds a new era of International network research collaboration based upon this global test bed".

"UKLight will provide a leading-edge networking capability that is critical for supporting the emerging requirements of the computational sciences," adds Steve Corbató, director of backbone network infrastructure for Internet2, the advanced networking organization led by U.S. universities. "The growing ensemble of optical networking initiatives in the U.K., the U.S., and elsewhere around the world will enable communities of researchers to collaborate on distributed experiments and simulations and to share results in ways that have not been possible to date."
11.3 **NREN Innovations – World’s Largest Customer Owned Research Network**

World's Largest Customer Owned Research Network announced
December 2002

Toronto, Ontario - The formation of one of the world's largest optical research and education networks took a step forward today as the Optical Regional Advanced Network of Ontario (ORANO) and BellCanada announced a $25 million contract to deliver optical fibre and equipment for the Ontario Research and Innovation Optical Network (ORION), which spans 3,700 kilometres and will link Ontario's major educational institutions and research facilities. "ORION will transform the way Ontario researchers and organizations collaborate with each other and their colleagues around the world," said Dr. Ross Paul, president of the University of Windsor and Chairman of ORANO, which owns and operates the network. "ORION brings, for the first time, access to the world's top high-speed research networks to all regions of the province," he said.

The agreements announced today conclude discussions between ORANO, Bell Canada and a group of allied companies, including Hydro One Telecom, Nortel Networks, Cisco Systems and several regional telecom providers. This arrangement enables ORANO to build and maintain its own broadband fibre network infrastructure.

ORION will link 21 communities across Ontario. Laid end-to-end, ORION's total optical fibre would stretch to 8,200 kilometres, the equivalent of one fifth of the Earth's circumference, making it one of the largest and most powerful research networks ever built. No other fully-owned and operated research network matches the size and scope of ORION.

"This agreement represents the ideal model for an effective public and private sector partnership that highlights made-in-Ontario technology and expertise to build a network that will soon make its mark around the world," said Jim Flaherty, Ontario's Minister of Enterprise, Opportunity and Innovation.

"The vision for ORION comes directly from the Ontario Jobs and Investment Board Report and it is a critical component of our Government's Innovation Strategy, to ensure Ontario strengthens and maintains its position of global leadership in research and development," he said.

"We're proud to be part of this unique public-private partnership to deliver the ORION network. It's through partnerships like these, with government and the private sector, that we can give Ontario's colleges universities and research institutions the technological advantage necessary to remain at the forefront of research and innovation and the pursuit of knowledge," said Terry Mosey, President, Bell Ontario.
ORION brings high-speed optical networking capacity to users at levels comparable to or greater than the most advanced research networks in the world, and provides critical high-speed gateways to other research and education networks such as CANARIE's CA*net 4, Internet2 in the US and the Internet.

Two individual strands of fibre-optic cable, which ORION has acquired for 20 years, form the physical backbone of the network, inter-connecting each of the network's 22 points of presence. The network will offer optical wavelength capacities at 10 Gbps, scalable to 320 Gbps, using technology incorporating Dense Wave Division Multiplexing (DWDM) transmission capabilities and Layer 3 routing architecture to support real-time and high bandwidth applications such as IP multipoint videoconferencing and grid computing.

"Nortel Networks is committed to providing scalable and cost effective networking solutions to our enterprise customers," said Brian McFadden, president, Optical Networks, Nortel Networks. "We are pleased to be a part of this project, supplying our optical solutions that will help position ORION to offer innovative services, such as Gigabit Ethernet, to the research community."

"Cisco has always looked to research networks such as ORION as sources of innovation in the use of networking technologies," said Pierre-Paul Allard, President of Cisco Systems Canada. "ORION will help drive productivity in Ontario by serving as an enabler for advanced research in science, health, and education. Cisco Systems Canada is proud to play a role in this important project."

"Hydro One Telecom is pleased to support this initiative with the use of its optical fibre network and by facilitating the connectivity to regional and municipally-based fibre network providers across the province," said Joan Prior, CEO of Hydro One Telecom.

Member institutions are currently developing proposals for projects that are now possible because of ORION, which include advanced applications involving biotechnology, grid computing and real-time collaborative research in several scientific disciplines. The Ontario Ministry of Enterprise, Opportunity and Innovation and Ontario's SuperBuild Corporation are ORION's primary funding partner, with an investment of $32.3 million. The federal government has invested $3.4 million through CANARIE, Canada's Advanced Internet Development Organization, which operates CA*net4. Additional private and public sector investments over the next three years will bring the value of the ORION project to over $78 million. It is anticipated that ORION will be fully operational by Spring 2003.
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