

Summary of key findings

Legal form

The most common (but by no means the only) legal model for an NREN in the 'EU-15/EFTA' group of countries is an NREN which is a separate legal entity. This separate legal entity is controlled by the research and education community which itself is (largely) government funded.

NRENs that can operate with a certain amount of independence from government may have certain advantages, such as easier decision-making procedures and the ability better to attract and retain the needed staff. This may help to explain why this model is more common in countries where research networking has developed over many years and is now well-established.

In any case, NREN development requires the commitment of all major stakeholders, such as funders and users. A governing model that allows the participation of these stakeholders would seem to be the most appropriate; such a situation can be achieved in a number of different ways.

Users/clients

In the 2003 – 2005 period, NRENs in the new EU member states have shown a remarkable increase in the number of universities connected at **Gigabit speeds**. From a position close to parity with the

other EU members, they have taken the lead with more than twice the proportion of high-bandwidth connections.

The SERENATE study¹ recommended the promotion of Gigabit networking services. Gigabit connections can be seen as a necessary, though by no means sufficient, condition for a university to engage in high-end research and learning programmes.

The Compendium data suggest that the SERENATE recommendations on Gigabit networking are being implemented in many countries now. It seems that fibre-optic technology is allowing NRENs to leapfrog immediately to much higher capacities. Gigabit Ethernet is being introduced by many hitherto less developed NRENs and seems to make it possible, for the first time, to quickly address an important aspect of what was termed the 'digital divide' in Europe in the SERENATE study.

There is clear evidence that the connection of **secondary and primary schools** to NRENs and also the provision of support and application services to schools features high on the agenda in many countries. The commitment by EU heads of government in Lisbon in 2000 to making Europe "the most dynamic and competitive knowledge-based economy in the world" by 2010 is a common factor underlying this activity.

The **uptake of IPv6** is greater within EU/EFTA NRENs than in those of other countries. However, the situation varies greatly from country to country. Within NRENs of all types, the lead in IPv6 seems to be taken by the universities rather than research institutes. In the EU/EFTA NRENs, the respective figures are 15% and 5% take-up. In other NRENs, the mean figures are 3% and 1%, respectively.

IPv6 usage varies considerably from one NREN to another. While the usage by most NRENs is still less than 1% of total IP traffic, there are a few leaders, with levels of usage between 10% and 20%. Moreover, the growth in IPv6 traffic has been considerable, increasing by a factor of 14 from December 2003 to May 2005. As a proportion of total IP traffic, growth has been from 0.3% to 2.7%.

Network

The overall trend is that there is considerable **growth** year on year, with the new EU member states and the non-EU/EFTA countries to the fore in expansion. This trend is also visible when looking at core network size as defined in this Compendium. Growth in this area is never linear, but is always step-wise.

The Compendium shows that for most NRENs that are part of the GN2 project, the **external link** to GÉANT is by far the most important in terms of capacity. NRENs also often have peering

¹ SERENATE Summary Report p.6

arrangements at neutral Internet exchanges and many also have connections to commercial ISPs, but these do not have the same capacity as those to GÉANT. The situation is obviously different in the countries that are not part of GN2.

There are indications that more and more NRENs are switching over to **dark fibre** as the technology of the future, with the EU NRENs being in the lead. As well as providing NRENs with the ability to better control, manage and exploit their network infrastructures, dark fibre provides new opportunities to enable users to define their own dedicated end-to-end links across the network, and to do so within constant NREN budgets. In this sense, the uptake of dark fibre is to be commended where it is possible. Indeed, the procurement of the new GÉANT 2 network has endorsed this development and has provided a pan-European dark-fibre footprint, already linking fifteen countries in the first phase.

Regarding **core capacity** on the networks, the trend seems to be that in the more advanced countries, the core capacity will evolve to 10 Gb/s or multiples of that.

Traffic

Growth rates in the new EU member states and in non-EU/EFTA countries are clearly higher than those in the 'old' EU member states.

It seems that in the EU, **traffic growth** is slowing down. It seems that traffic is now determined more by (changes in) user demand, rather than by network capacity limitations. It is unclear if this trend towards slower growth will persist – new applications, for example in the Grids area, may change the picture. However, in that case growth will be driven by demand, rather than by changes in the network capacities. In any case, NRENs need to upgrade their external links from time to time in order to keep up with increasing demand.

The longer-established NRENs from the EU and EFTA countries are mostly **net exporters** of data, while the other NRENs are net importers. The pattern has changed over time. In 2002, there was a more uniform distribution of importers and exporters among the EU/EFTA countries. The new EU member states tended to have importer NRENs; only two out of nine were exporters. So the trend has been towards more net export of data.

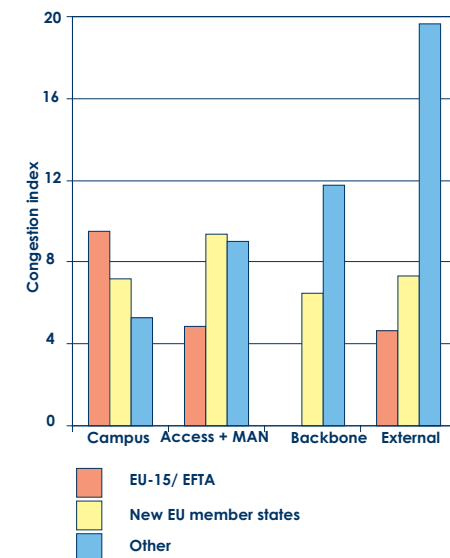
NRENs in the other countries, however, do not yet seem to follow this trend. In 2001, only one out of seven was a net exporter. In 2004, the proportion was more or less the same, at 2 NRENs out of 17.

In EU/EFTA countries, NRENs report relatively little **congestion** in the parts of the network that are within their domain of responsibility. Uniformly, they see no serious congestion on external circuits, virtually none in their core networks, and little

in the MAN or regional network. Any serious congestion, they report, is largely confined to access networks or, to the campus LANs of connected institutions.

The 'other' NRENs report that most congestion is clearly on external connections. In those countries, the restrictions imposed by low-capacity external connections mean that constraints at the campus and other levels are less apparent. It is to be expected that these constraints will show up as soon as the problems at other levels have been solved.

A 'congestion index' has been developed that summarises congestion by network level:



Services

There is an increased need for an **Authentication and Authorisation Infrastructure**. This is because:

- * Grid applications are being used by more scientists and due to the nature of Grids (typically distributed computers and resources in different geographical locations) authentication and authorisation play a key role.
- * Users travel much more and they demand to have their familiar environment, services and privileges available whenever they move from one site to another.
- * The network, although still improving, has reached a good level of stability, so that it is becoming easier to offer reliable services.
- * Various NRENs haven been developing AA tools over the past few years; these tools are now stable enough to look for inter-operability and to try to seek harmonisation.

Grid services are currently running in 15 out of the 27 EU/EFTA NRENs in the survey and in 5 out of the 16 NRENs from other countries in the survey.

Eight more EU/EFTA NRENs are planning to introduce such a service; a similar number of the NRENs from other countries have that plan.

NREN support is needed for running the service in the great majority of cases. Physics and chemistry are the most active disciplines, followed by biomedical applications and astrosience.

Funding

NREN budgets may fluctuate from year to year, because investments can vary considerably from year to year. NRENs have many different tasks and are organised in different ways. Some NRENs provide services only to the research or education communities in their country. Others provide additional services as well, for example, because they administer the country-code top-level domain or because they connect others who are clearly outside the research and education communities. There are also other reasons why comparisons are difficult:

- * Funding for regional and/or metropolitan area networks is handled differently in different countries;
- * In some countries, connected institutions pay for their line to the nearest NREN PoP, in others the NREN pays for this.

- * Some NRENs spend a large part of their budget to connecting secondary and primary schools, others do not.

When comparing current budget data with data from previous versions of the Compendium, it becomes clear that NREN budgets tend to be stable over time. There are fluctuations from year to year, depending on whether or not an important investment takes place during that year. But on the whole, the trend is that budgets stay relatively stable and that NRENs are able to deliver more bandwidth and more services for roughly the same amount of money.

The exception to this general trend seems to be the situation in the less developed NRENs. There, new possibilities for significantly upgrading international bandwidth (for example under the GN2, EUMEDCONNECT or SEEREN projects) seems to act as a catalyst for increased national NREN budgets.