

3 Network

3.1 Core Capacity on the network

We have asked NRENs how they would describe their network in bandwidth terms. In other words, we have asked for the current typical core usable backbone capacity on the networks (in Mbit/s) (excluding backup links). By this, we mean the typical core capacity of the linked nodes in the core. Some networks do not have a core backbone, for example, because they have a star topology. In that case, we have asked for the maximum capacity into the central node of the network. Some NRENs have dark fiber with a very high theoretical capacity. In those cases, we have asked NRENs to tell us the usable IP capacity.

Note that many NRENs employ a range of capacities on their backbone. What may be considered the 'typical' leaves, of course, some scope for differences in interpretation between NRENs. Many NRENs provide maps of the topology of their backbone on their websites; more information about these maps can be found in the country-entries on the Compendium website.

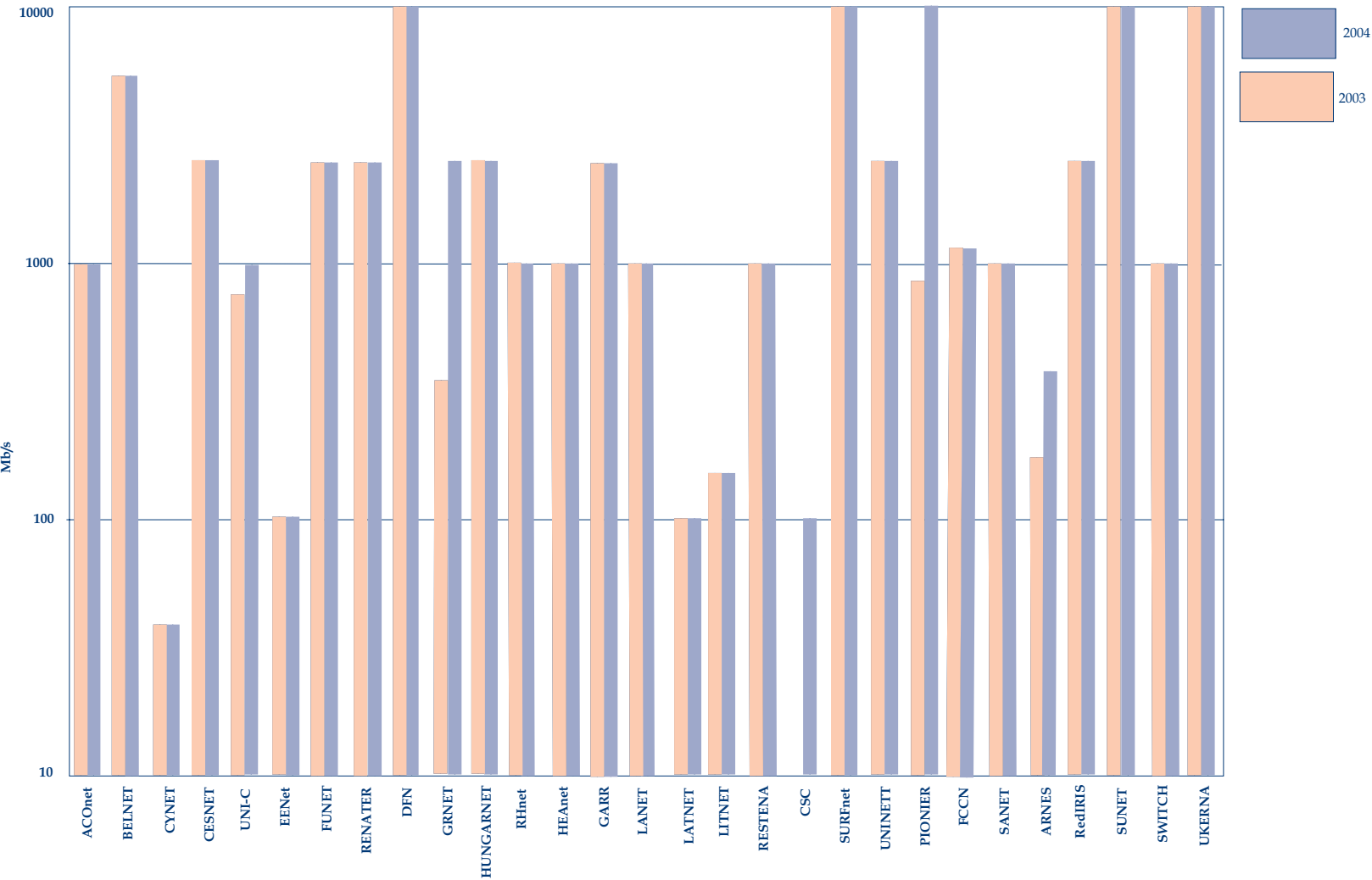
Graphs 3.1.1 and 3.1.2 give an idea of the evolution of network capacity from 2003 to 2004. For presentational purposes, the information is given in two graphs: 3.1.1 for the EU and EFTA countries, graph 3.1.2 for the other countries.

Note that the scales are logarithmic and not the same for the two tables!

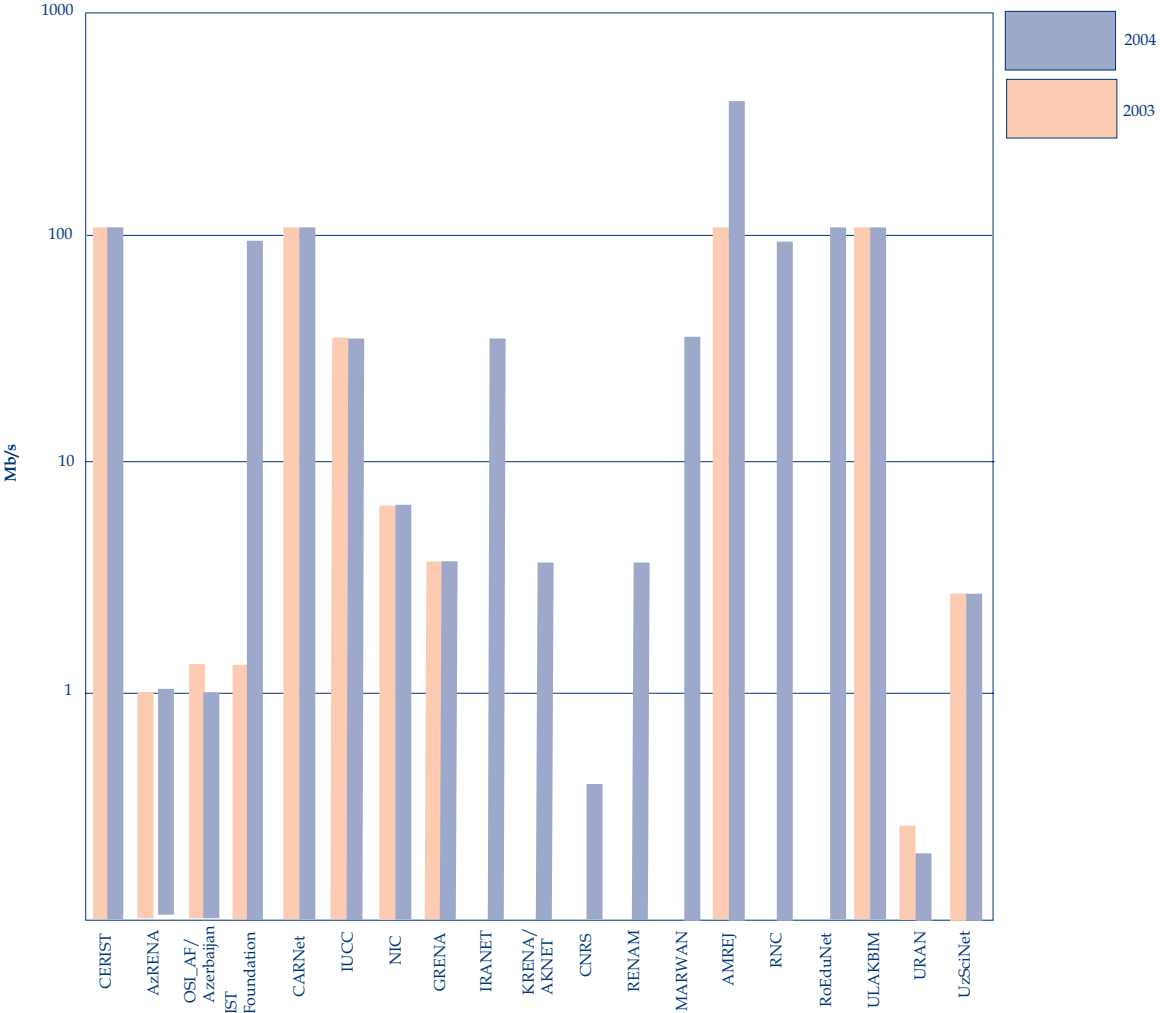
In a number of cases, the core capacity has stayed the same but the backbone itself has been extended (e.g., in the cases of GARR and UKERNA). For a more complete picture, see also the data in sections 3.2 and 3.3.

For a number of NRENs, we have data going back to 2001. Graph 3.1.3 gives the increase in core capacity on the networks between 2001 and 2004 for those countries (note again that the scale is logarithmic). In 2001, a number of countries already had a backbone of 2.5 Gb/s capacity; at that time, this was the highest capacity that was available. Some of those NRENs are still at that level. Others are now at the 10 Gb/s level. The largest increase was in NRENs that had a relatively low capacity in 2001 and that progressed since then to state-of-the art. Examples are PIONIER (Poland), that increased from 155 Mb/s to 10 Gb/s capacity, and SANET (Slovakia), that went from 4 Mb/s to 1 Gb/s.

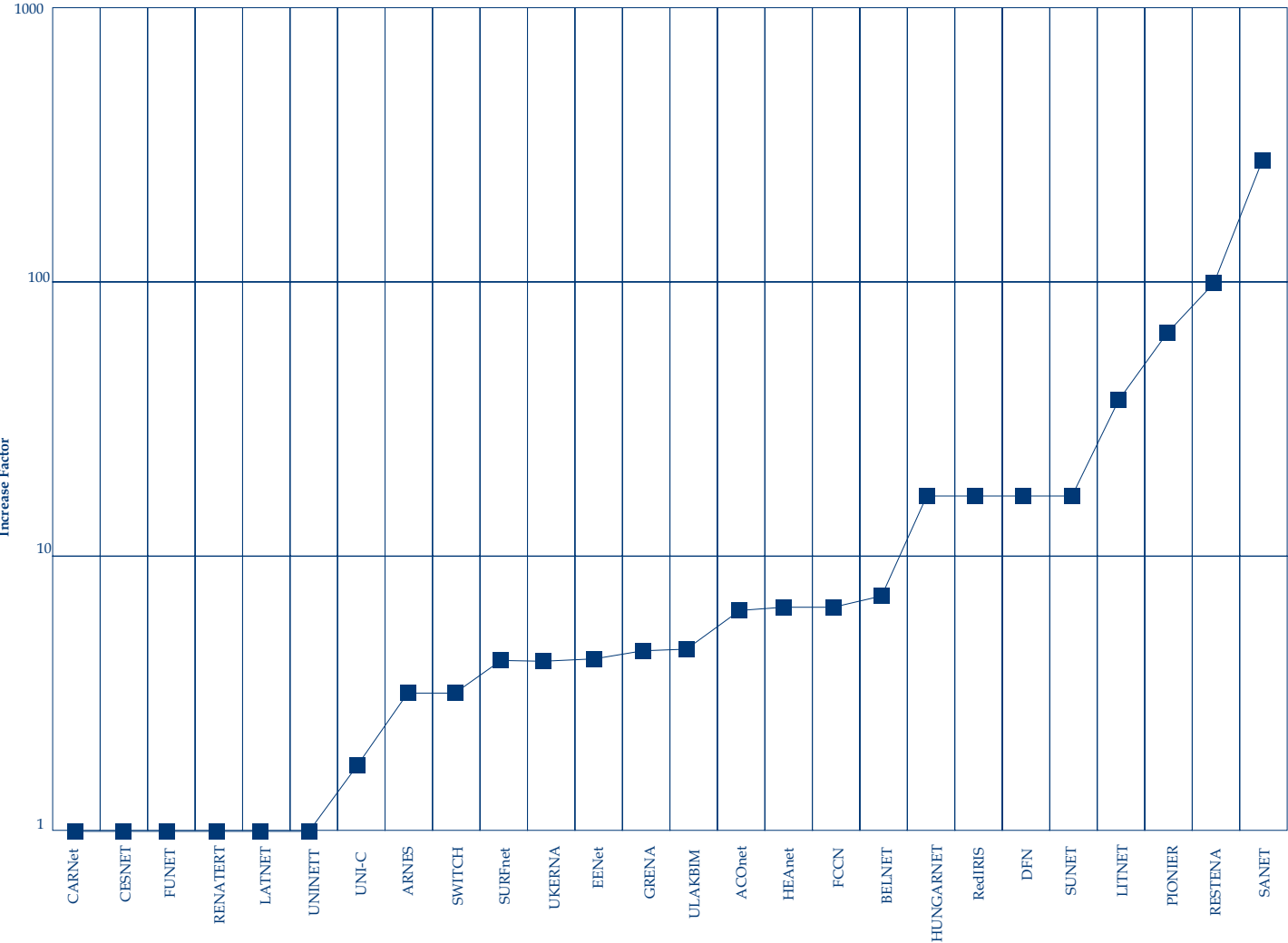
Graph 3.1.1 Core capacity on the networks, 2003 - 2004, EU and EFTA countries



Graph 3.1.2 Core capacity on the networks, 2003 - 2004, other countries



Graph 3.1.3 Core capacity on the network, increase factor 2001 - 2004



3.2 Expected change in the core capacity in two years' time

The following table gives the current core capacity (in Mb/s), the expected increase in two years' time and the expected (computed) core capacities for early 2006.

Note that, typically, the core capacity goes up in leaps, involving the change from one type of technology to another. Note also that it is not always easy to predict the evolution in core capacity. This is because this evolution depends on many factors, such as developments in technology and pricing and the availability of sufficient funds for investment. If one would compare the answers now predicted for 2006 with the predictions given last year for 2005, one would find differences in both directions; some NRENs now predict an increase that they would not have thought likely a year ago, while others have predicted a level of capacity for 2006 that is below what they predicted last year for 2005. The same is true when one compares the expectations for 2004 as formulated two years ago with the actual situation. The SERENATE studies that were published by TERENA in 2003 may have helped to make expectations more realistic (see <http://www.serenate.org>).

The trend seems to be that in the more advanced countries, the core capacity will evolve to 10Gb/s or even 20 Gb/s. This will also happen in many of the 'new' EU countries. Only some of the smallest countries (Cyprus, Malta, Iceland) seem to expect that they will not follow this direction – it is not clear whether this is because they see no need or because they lack the means. On the other hand, most of the countries in the Middle East and in the former Soviet Union expect that they will be unable to bridge the 'digital divide'.

Table 3.2 Expected change in the core capacity in two years' time, EU and EFTA countries

EU & EFTA countries	NREN	Core capacity (Mb/s)	Expected increase in 2 years	Expected core capacity in 2006
Austria	ACOnet	1000	2.5 X	2500
Belgium	BELNET	5000	4 X	20000
Cyprus	CYNET	34	5 X	170
Czech Republic	CESNET	2500	4 X	10000
Denmark	UNI•C	1000	1.5 X	1500
Estonia	EENet	100	4 X	400
Finland	FUNET	2500	4 X	10000
France	RENATER	2500	4 X	10000
Germany	DFN	10000	2 X	20000
Greece	GRNET	2500	4 X	10000
Hungary	HUNGARNET	2500	4 X	10000
Iceland	RHnet	1000	2 X	2000
Ireland	HEAnet	1000	10 X	10000
Italy	GARR	2500	4 X	10000
Latvia	LATNET	100	10 X	1000
Lithuania	LITNET	30-622	4 X	155-2500
Malta	CSC	100	10 X	1000
Netherlands	SURFnet	10000	2 X	20000
Norway	UNINETT	2500	4 X	10000
Poland	PIONIER	10000	2 X	20000
Portugal	FCCN	1200	2 X	2400
Slovakia	SANET	1000	10 X	10000
Slovenia	ARNES	310	4 X	1240
Spain	RedIRIS	2500	4 X	10000
Sweden	SUNET	10000	none	10000
Switzerland	SWITCH	1000	10 X	10000
United Kingdom	UKERNA	10000	none	10000

Table 3.2 Expected change in the core capacity in two years' time, other countries

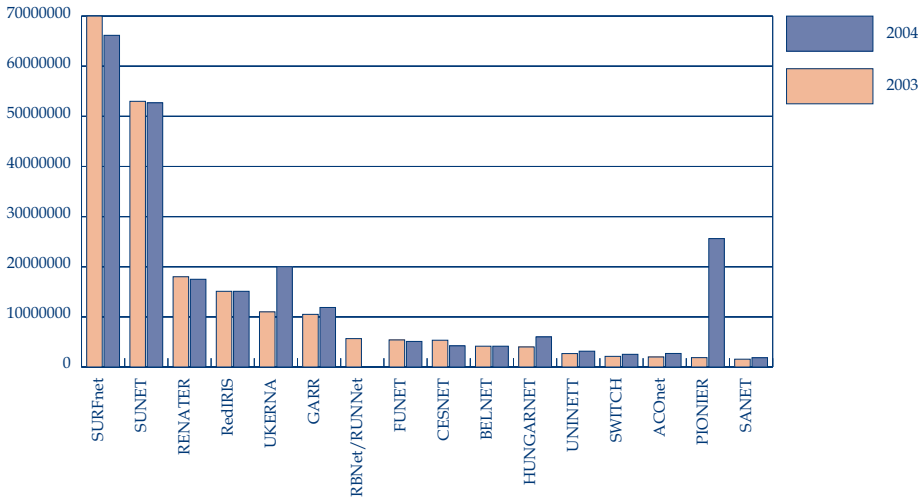
Other countries	NREN	Core Capacity (Mb/s)	Expected increase in 2 years' time	Expected core capacity in 2006
Algeria	CERIST	155	4 X	620
Azerbaijan	AzRENA	5	40 X	200
Bulgaria	IST Foundation	100	6 X	600
Croatia	CARNet	155	16 X to 64 X	6200
Georgia	GRENA	4	2 X	8
Iran	IRANET	56	35 %	75.6
Jordan	NITC	8	5 X	40
Lebanon	CNRS	448 Kb/s	2 X	0.896
Moldova	RENAM	4	10 X	40
Morocco	MARWAN	34	10 X	340
Romania	RNC	100	100 X	2500
Romania	RoEduNet	155	4 X	620
Serbia/Montenegro	AMREJ	500	2 X	1000
Turkey	Ulakbim	155	4 X	620
Ukraine	URAN	0.128	up to 100 Mbps	100
Uzbekistan	UzSciNet	2	2 X	4

3.3 Core network size

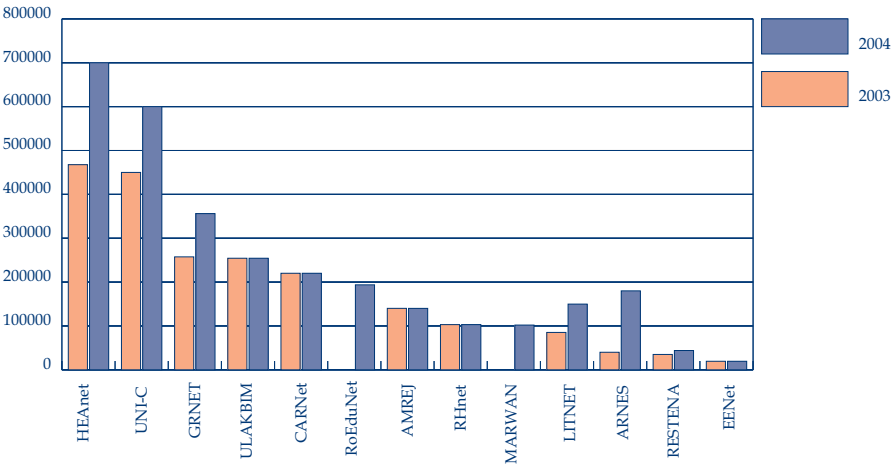
Like earlier years, we have asked NRENs to estimate the total size of their networks by multiplying the length of the various links in the backbone with the capacity of those links in Mb/s. The resulting unit is network size in Mb/s x km. As before, this question was difficult to answer for some NRENs. However, a number of NRENs have been able to provide more accurate estimates than in the past. This explains the difference in the value for SURFnet and SUNET. The graphs clearly show the advances made by the Polish network, PIONIER and by a number of the 'smaller' networks.

For presentational purposes, three graphs are presented, for countries with different network sizes.

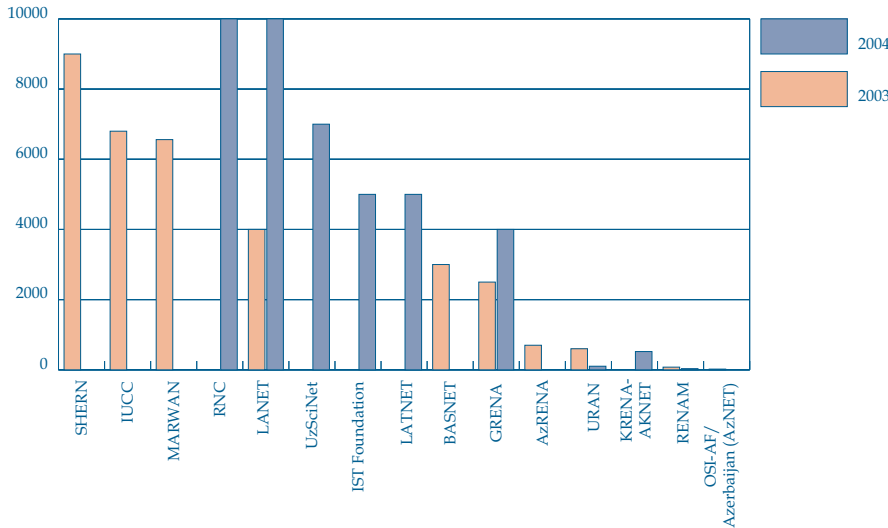
Graph 3.3.1 Core Network Size 2003 - 2004: > 1M Mb/s x km.



Graph 3.3.2 Core Network Size 2003 - 2004: > 10,000, < 1 M Mb/s x km



Graph 3.3.3 Core Network Size 2003 - 2004: < 10,000 Mb/s x km



3.4 Capacity of the highest link

Many countries are now linked at the highest capacity currently offered by the GÉANT network, 10 Gb/s. Some networks have several links of the same capacity. Table 3.4.1 lists the highest links and their capacities, for January 2004.

of those NRENs between December 2001 and January 2004 (note that the scale is logarithmic). The highest increases were in Croatia and Portugal, which both went from 17 Mb/s to 1244 Mb/s. Many others went from 2.5 Gb/s to 10 Gb/s.

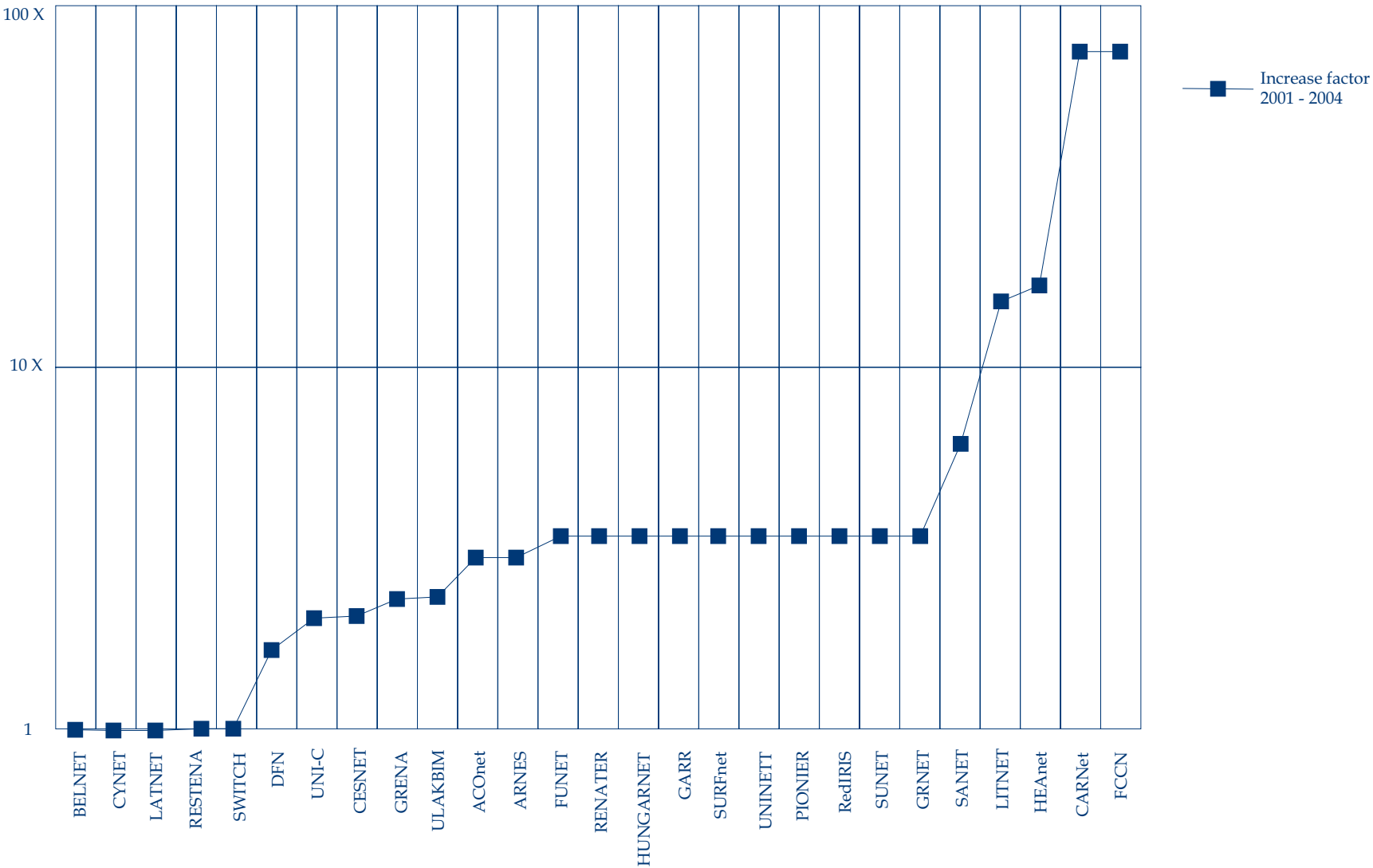
For a number of NRENs, we have data going back to 2001. Graph 3.4.2 gives the increase in the highest external links

Table 3.4.1 Capacity of the highest link, January 2004

EU & EFTA countries	NREN	Link	Capacity
Austria	ACOnet	VIX	2000
Belgium	BELNET	GÉANT	2500
Cyprus	CYNET	GÉANT	40
Czech Republic	CESNET	NetherLight	2500
Denmark	UNI•C	NORDUnet	5000
Estonia	EENet	Tallinn Internet eXchange	1000
Finland	FUNET	NORDUnet	10000
France	RENATER	GÉANT	10000
Germany	DFN	Peering IX	4000
Greece	GRNET	GÉANT	1244
Hungary	HUNGARNET	GÉANT	10000
Iceland	RHnet	RIX	1000
Ireland	HEAnet	GÉANT	2500
Italy	GARR	GÉANT	10000
Latvia	LANET	LIX	100
Latvia	LATNET	GÉANT	34
Lithuania	LITNET	GÉANT	622
Luxembourg	RESTENA	GÉANT	155
Netherlands	SURFnet	Abilene, CA*net and other networks via MANLAN; CERN; GÉANT; StarLight	10000 each
Norway	UNINETT	NORDUnet	10000
Poland	PIONIER	GÉANT	10000
Portugal	FCCN	GÉANT; Gigapix- Portuguese Exchange Point	1244 each

Country	NREN	Link	Capacity
Slovakia	SANET	ACONET + VIX; CESNET + NIX; SIX	1000 each
Slovenia	ARNES	Slovenian Internet Exchange	1000
Spain	RedIRIS	GÉANT	10000
Sweden	SUNET	NORDUnet	10000
Switzerland	SWITCH	GÉANT	2500
Other countries			
Albania	ANA	GRNET/SEEREN	2
Algeria	CERIST	Teleglobe	34
Azerbaijan	AzRENA	DESY/DFN Germany	2.5
Azerbaijan	OSI-AF/ Azerbaijan	Azerbaijan IXP	10
Bulgaria	IST Foundation	GÉANT/SEEREN	18
Croatia	CARNet	GÉANT	1244
Georgia	GRENA	GÉANT via DFN; SMS Internet	2
Iran	IRANET	opentransit	48
Israel	IUCC	GÉANT	310
Jordan	NITC	Commercial Internet	8
Kyrgyzstan	KRENA-AKNET	Hamburg-DESY (Germany)	4
Romania	RNC	Commodity through peering BUHIX, RONIX	200
Romania	RoEduNet	GÉANT	622
Russian Federation	RBNNet/RUNNet	NORDUnet	622
Serbia/Montenegro	AMREJ	GRNET (SEEREN)	34
Turkey	ULAKBIM	TTNET	465
Ukraine	URAN	IX-UA; KARnet	100 each
Uzbekistan	UzSciNet	DESY/DFN Germany	2

Graph 3.4.2 External connections, increase factor 2001 -> 2004



3.5 External connectivity: total external links

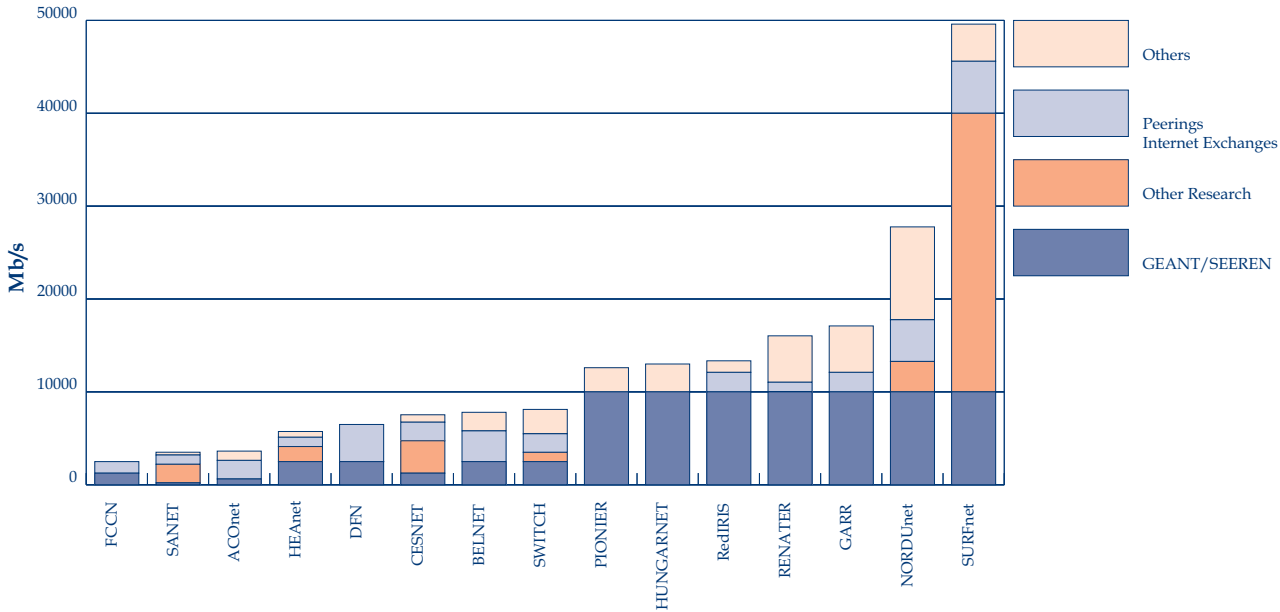
NRENs have been asked to list all of their external connections in January 2004.

The Nordic NRENs (FUNET of Finland, RHnet of Iceland, SUNET of Sweden, UNINETT of Norway and UNI-C (Forskningsnettet) of Denmark) share their external connections through NORDUnet. Therefore, the data for NORDUnet has been given in the graph below, instead of the data from the individual countries. Several Nordic NRENs have national peering arrangements in addition to the NORDUnet arrangements. In January 2004, UNI-C of Denmark had a connection of 5 Gb/s to DIX, the Danish Internet Exchange; FUNET of Finland had a connection of 2 Gb/s to Ficix, the Finnish Internet Exchange; RHnet of Iceland had a connection of 1 Gb/s to RIX, the Reykjavik Internet Exchange; and UNINETT of Norway had two connections of 1 Gb/s each to Norwegian Internet Exchanges.

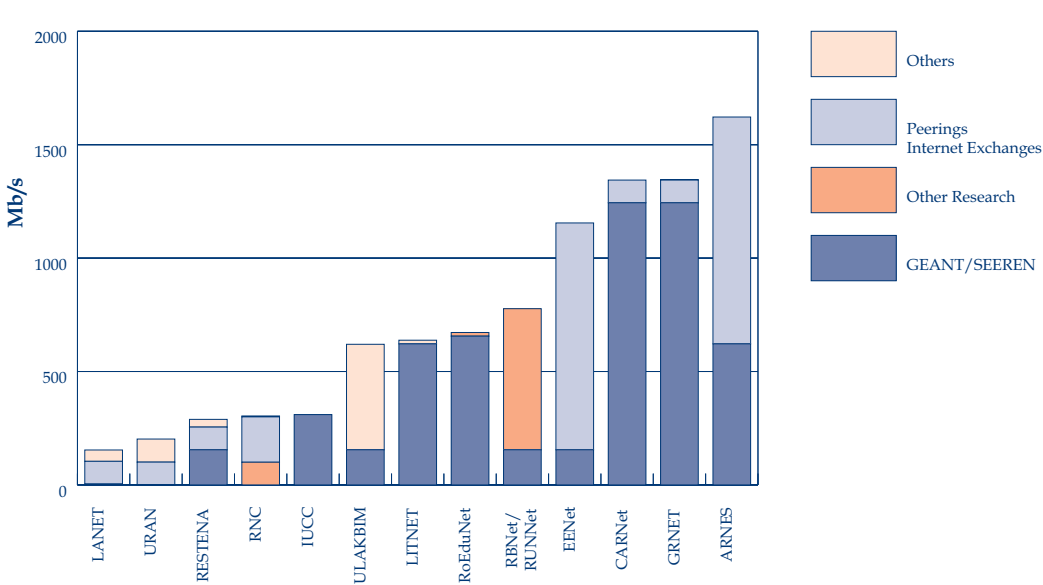
Several NRENs have backup connections for their connection to GEANT or to NORDUnet. These backup links have not been counted. Connections to CERN, Abilene and StarTAP have been grouped as ‘Other research’, because these connections are essentially for research traffic only.

For presentational purposes, three graphs are presented.

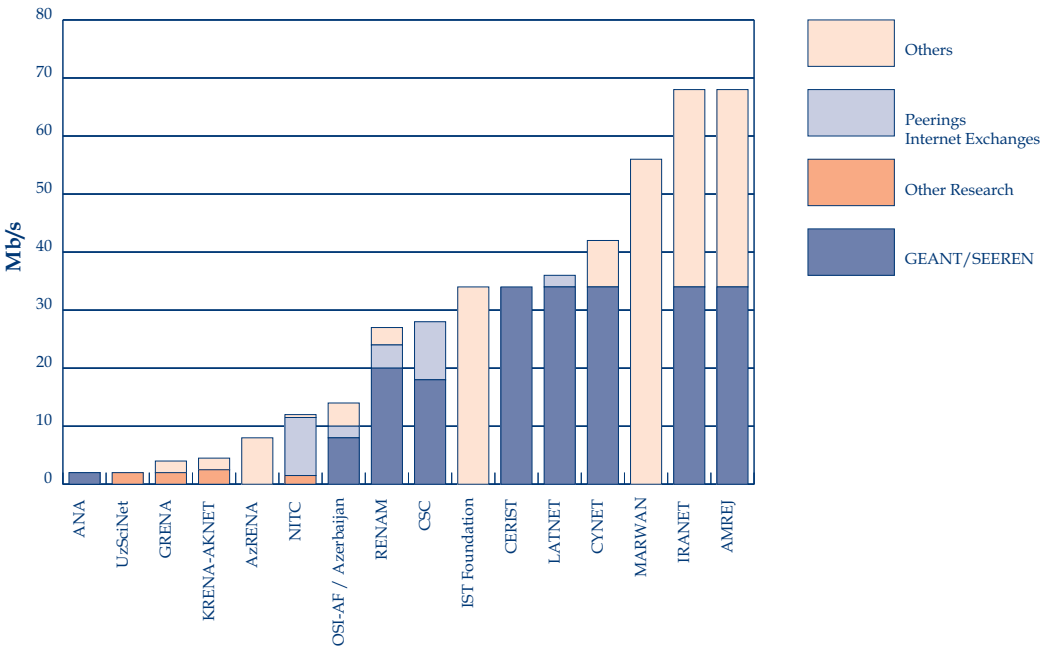
Graph 3.5.1 External connectivity > 2.4 Gb, January 2004



Graph 3.5.2 External connectivity > 100 Mb, < 2400 Mb, January 2004



Graph 3.5.3 External connectivity < 100 Mb, January 2004



3.6 Some network characteristics

The following table gives data about a few key network characteristics: the number of PoPs on the network and whether or not NRENs have or plan to get IRUs¹ or their own dark fibre.

Some NRENs own dark fibre or have IRUs and can decide themselves what technology and what speeds to use on it. In order to document this, we have asked NRENs if they currently have IRUs or own dark fibre, or if they plan to get it during the coming year. We have also asked approximately what percentage of their backbone is dark fibre, in Km, in point-to-point distances .

Whether or not owning IRUs or dark fibre is interesting for an NREN, of course, depends very much on the national situation, for example, regarding regulations and pricing. The table shows that owning dark fibre or IRUs is becoming an interesting option for NRENs in many different countries.

[1] IRU stands for 'Indefeasible Right of Use'. This is the effective long-term lease (temporary ownership) of a portion of the capacity of a cable. See, for example, <http://whatis.techtarget.com> for more information.

Table 3.6 Some network characteristics

EU & EFTA countries	NREN	Number of PoPs	Have dark fibre	% of backbone
Austria	ACOnet	8	no	
Belgium	BELNET	15	no	
Cyprus	CYNET	1	no	
Czech Republic	CESNET	11	yes	85
Denmark	UNI•C	8	yes	10
Estonia	EENet	18	no	
Finland	FUNET	14	yes	1
France	RENATER	30	no	
Germany	DFN	27	next year	
Greece	GRNET	9	no	
Hungary	HUNGARNET	56	no	
Iceland	RHnet	12	no	
Ireland	HEAnet	7	next year	
Italy	GARR	28	yes	
Latvia	LANET	1	yes	80
Latvia	LATNET	16		
Lithuania	LITNET	16	next year	
Luxembourg	RESTENA	8	yes	70
Malta	CSC	1	no	
Netherlands	SURFnet	25	yes	50
Norway	UNINETT	40	yes	
Poland	PIONIER	22	yes	60
Portugal	FCCN	2	next year	
Slovakia	SANET	20	yes	100
Slovenia	ARNES	27	yes	25
Spain	RedIRIS	20	no	
Sweden	SUNET	23	yes	
Switzerland	SWITCH	13	yes	90
United Kingdom	UKERNA	8	no	

Other countries	NREN	Number of PoPs	Have dark fibre	% of backbone
Algeria	CERIST	4	yes	50
Azerbaijan	AzRENA	6	next year	
Azerbaijan	OSI-AF/Azerbaijan	4	next year	
Bulgaria	IST Foundation	10	no	
Croatia	CARNet	21	yes	5
Georgia	GRENA	16	yes	10
Iran	IRANET	6	yes	20
Israel	IUCC	2	yes	5
Jordan	NITC	1	no	
Kyrgyzstan	KRENA-AKNET	25	no	
Lebanon	CNRA	5	no	
Moldova	RENAM	11	next year	
Morocco	MARWAN	16	no	
Romania	RNC	9	no	
Romania	RoEduNet	40	next year	
Serbia/Montenegro	AMREJ	1	yes	10
Turkey	ULAKBIM	3	no	
Ukraine	URAN	12	yes	1
Uzbekistan	UzSciNet	15	yes	1