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Connectivity in the School Sector: NREN Survey Results for Access and Connectivity of Schools in Europe

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Executive Summary

With 50 million more children are enrolled in schools worldwide today then in 1999, more funding, and resources are required. According to UNESCO, $22 billion will be needed to ensure basic education by 2030 [UNESCO].

Information and communication technology (ICT) has become more affordable and have effectively embedded themselves into users' daily activity. However, neither universal access to Internet nor broadband has been achieved. In an increasingly connected world, those who fall behind on the technology adoption curve are at a great disadvantage. This sentiment is echoed most noticeably within the education sector.

Since 2003, the World Summit on the Information Society (WSIS) acknowledged the importance of schools connectivity and adopted a plan of action calling governments, "to connect universities, colleges, secondary schools and primary schools with ICT." This change was driven by the move towards greater availability of devices for students and the emergence of cloud computing for supporting online educational content and school administration software.

2017 SCHOOL SURVEY KEY FINDINGS

Trends in the increase of the number of schools connected to NREN networks were up 124%, to 26,982 schools, the highest growth since 2012.

NRENs connecting more than 62% of schools in their country.

***70%** of NRENs have peak traffic load of **1Gbps** and above.*

***83%** of NRENs expect traffic to grow over 11% for the next 3 years.*

***63%** of NRENs provide services beyond connectivity.*

This report presents an initial look at ICT use and internet connectivity in education, its main challenges, and work of GÉANT partners in primary and secondary schools with access to the internet. This document presents the key findings, especially with reference to school access and funding.

Access: There are major issues related to gaining high-quality access to broadband and technology infrastructure in schools. The issue is more profound in primary schools, and in all schools in rural areas. Many schools struggle to provide and maintain high-quality access to online resources/the internet compared to commercial organisations.

Funding: Many governments in Europe recognised the importance of ICT in schools, and have committed a portion of education budgets to modernise schools technology. However, the complexity of schools' funding makes it difficult, as there are various levels of administration involved in transfers of funds depending on the resource in question (school staff, operations, services, and capital goods). In addition, there are no harmonised funding mechanisms for provision of ICT in schools in Europe.

1 INTRODUCTION

1.1 Background

The Spanish National Research and Education Network (NREN), RedIRIS, is involved in a national project to improve connectivity to schools (primary and secondary education, ages 5-18). The aim of the project is to ensure that 18 000 Spanish schools will have connections of at least 100 Mbps. The project, with an estimated total budget of more than EUR300 M, includes:

- Funds for the deployment of WiFi and LAN networks in schools.
- Funds for access links provided by operators or regional research and education networks
- Funds to upgrade existing RedIRIS equipment, as the traffic from each of the 17 Spanish regions would be aggregated by the operators of regional Research Education Networks, and then passed to RedIRIS, which would provide them the global IP service for their users.

In response to RedIRIS, GÉANT conducted a basic NREN survey to gather and analyse NREN data on schools (primary and secondary sectors). The main areas of investigation included:

- The number of schools connected to an NREN's network.
- NREN regional network capacity and traffic load.
- Connectivity services offered by the NREN to schools.

1.2 Methodology

An invitation to take part in the survey was sent to the sig-msp@lists.geant.org mailing list, which targeted 39 GÉANT partners [SIG-MSP].

The survey ("School Survey") was built and developed using an online survey tool, Survey Monkey.

The survey was open for 4 months, and closed on 11 August 2017.

1.3 Survey Response

As per GÉANT's NREN Compendium data for 2016, 23 of NRENs provide connectivity to schools (primary and secondary). This yielded a 70% response rate (16 respondents) [COMPENDIUM].

1.3.1 Financial Resource on Education: European Trends

In 2017, total expenditure on education jumped by 7.9% to EUR895 billion, the highest level since 2012

Prioritisation of education and training from EU member states, was the major factor behind the rebound.

Figure 1.1 shows the relative expenditure on education, from the four main sources of expenditure: government, non-educational private source and international organisations.

In 2014, the contribution of government expenditure on education posted 82% to EUR730 billion. The spending in UK and Portugal ranged from just less than 72%, and up to more than 95% in Romania and Sweden.

The non-educational sources posted EUR158 billion (17%) across 33 countries in Europe, and international organisation was much lower. Italy, Spain, Portugal, and Cyprus had the highest contribution from private organisation than the rest of Europe.

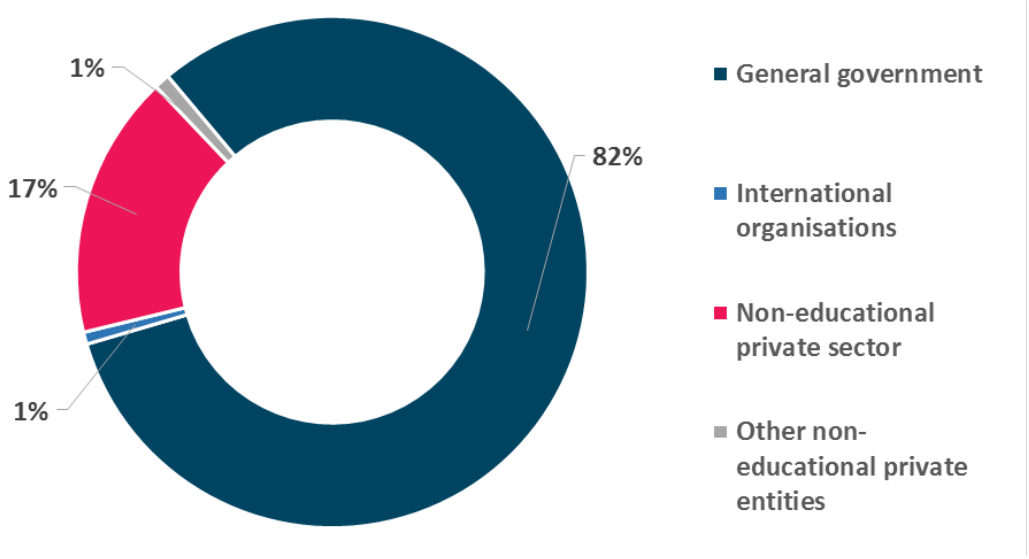


Figure 1.1: Distribution of educational expenditure by source, excluding early years education, 2014 [*Source: Eurostat Education metadata*]

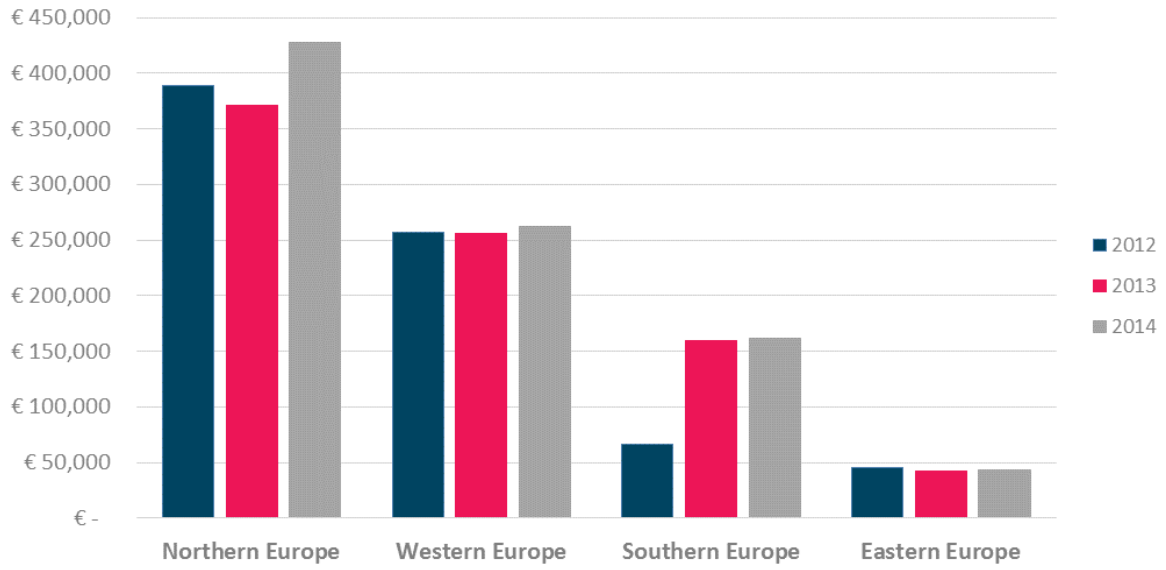


Figure 1.2: Total educational expenditure by region, excluding early years education, 2014 (EUR M) [*Source: Eurostat Education metadata*]

As seen in Figure 1.2, the highest growth was noticeable in northern Europe, where the total expenditure rose by 15% in 2014, to EUR428 billion, mainly driven by the United Kingdom. This was followed by Western and Eastern Europe, (2%), and the lowest amount was recorded in Southern Europe (1%).

In general, the smallest share of educational expenditure in 2014 was recorded for pre-primary education, with shares ranging from 5.7% in UK 5.7%, and 5.9% in Cyprus. Pre-primary education accounted for the lowest share of education expenditure, as the proportion of spending, post-secondary non-tertiary education was just under 8%.

Eurostat also reported expenditure on tertiary education in 2014 as generally higher, at a 37% share. Upper secondary (16–18-year-olds) and post-secondary, non-tertiary education (18+) typically accounted for the largest of the total educational expenditure, with lower shares recorded in Lithuania and Sweden, while higher shares were registered in Belgium and Italy {EUROSTAT].

1.4 Public Expenditure (Government Expenditure)

Public expenditure as a share of GDP is often used to assess government commitment to education (Figure 1.3). The highest public spending on education relative to GDP was observed in Sweden (7.1%), followed by Finland (6.8%), while relatively high ratios were also recorded among the northern EFTA members of Iceland (7.0%) and Norway (6.7%). Aside from Sweden and Finland, most countries reported ratios of public expenditure on education relative to GDP that were between 3.5% and 6.0%, with only Romania reporting below this range [EFTA].

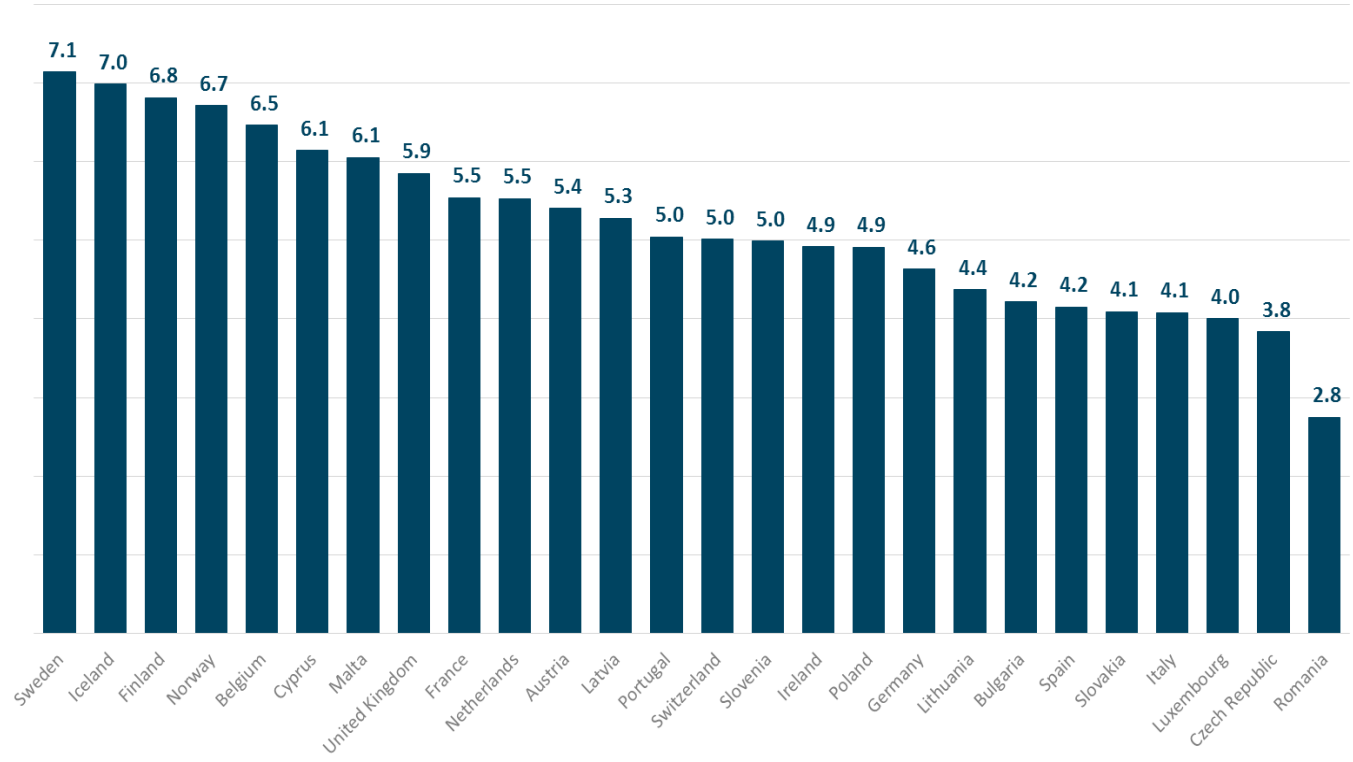


Figure 1.3: Public expenditure on education as a percentage of GDP, 2014 (excluding early childhood educational development) Note no data available for Croatia, Denmark, Hungary, Macedonia, Serbia and UK *[Source: Eurostat Education metadata]*

1.5 Capital Expenditure of Educational Institutions

Capital expenditure in Europe exceeded 10.0% of educational institutions' total capital and current expenditure, peaking at 19% in Latvia, followed by Estonia and Lithuania (15.2%; 14.3%). United Kingdom posted the lowest capital expenditure in Europe, at 3.3%. Nearly 50% of current expenditure in Europe is spent on teachers' pay.

Country	Capital expenditure	Current expenditure
Austria	834	16,955
Belgium	955	24,991
Bulgaria	180	1,577
Croatia	73	1,875
Cyprus	43	1,218
Czech Republic	-	-
Denmark	-	-

Country	Capital expenditure	Current expenditure
Estonia	-	-
Finland	822	12,703
Macedonia	-	-
France	10,464	118,606
Germany	10,631	131,307
Hungary	-	-
Iceland	-	860
Ireland	581	8,976
Italy	3,627	69,367
Latvia	251	1,066
Liechtenstein	-	-
Lithuania	251	1,506
Luxembourg	234	1,856
Malta	30	489
Netherlands	4,320	33,808
Norway	2,213	19,378
Poland	1,941	20,802
Portugal	375	9,265
Romania	192	4,008
Serbia	-	-
Slovakia	206	3,149
Slovenia	254	1,867
Spain	2,834	47,227
Sweden	1,500	27,242
Switzerland	-	-
United Kingdom	5,236	152,456

Table 1.1: Capital expenditure on education, excluding early educational development EUR (million), 2014 (ISCED 2011 levels) [*Source: Eurostat Education metadata 2014*]

GEO	Public Expenditure (EUR million)	Expenditure as share of GDP	Expenditure as share of GNI
Austria	17,836	5	5
Belgium	25,878	6	6
Bulgaria	1,804	4	4
Croatia	-	-	-
Cyprus	1,078	6	6
Czech Republic	6,008	4	4
Denmark	-	-	-
Estonia	-	-	-
Finland	13,991	7	-
France	118,496	6	6
Germany	135,393	5	5
Hungary	-	-	-
Iceland	904	7	7
Ireland	9,510	5	6
Italy	66,094	4	4
Latvia	1,248	5	5
Liechtenstein	-	-	-
Lithuania	1,597	4	4
Luxembourg	1,997	4	6
Macedonia	-	-	
Malta	510	6	6
Netherlands	36,660	6	6
Norway	25,241	7	7
Poland	20,190	5	5
Portugal	8,715	5	5
Romania	4,137	3	3
Serbia	-	-	-
Slovakia	3,106	4	4

GEO	Public Expenditure (EUR million)	Expenditure as share of GDP	Expenditure as share of GNI
Slovenia	1,861	5	5
Spain	43,011	4	4
Sweden	30,893	7	7
Switzerland	26,549	5	5
Turkey	-		
United Kingdom	127,667		6

Table 1.2: Main indicator for public expenditure on education, EUR (million), 2014 (ISCED 2011 levels, excluding early childhood educational development [*Source: Eurostat Education metadata 2014*]

2 SCHOOLS' FUNDING

The mechanism for schools' funding is not harmonised across Europe, with complex differences from country to country. There are various levels of administration involved in transfers of funds, depending on the resource in question (school staff, operation, services, and capital goods). For example, the contrasting diagrams from Poland and Sweden, below, demonstrate that there are more authorities involved in school funding in Poland than Sweden.

The most direct and transparent models for funding school connectivity are ICT expenditures from the budget of the government ministry responsible for education. However, such ministries sometimes lack the funding to absorb the full cost of ICT equipment purchases and service charges. In such cases, the education budget could be increased or an allocation made from the central government. Another option is for a government to establish a universal service fund. Alternatively, instead of imposing a universal service charge, operators could provide Internet access in schools as part of a universal service obligation.

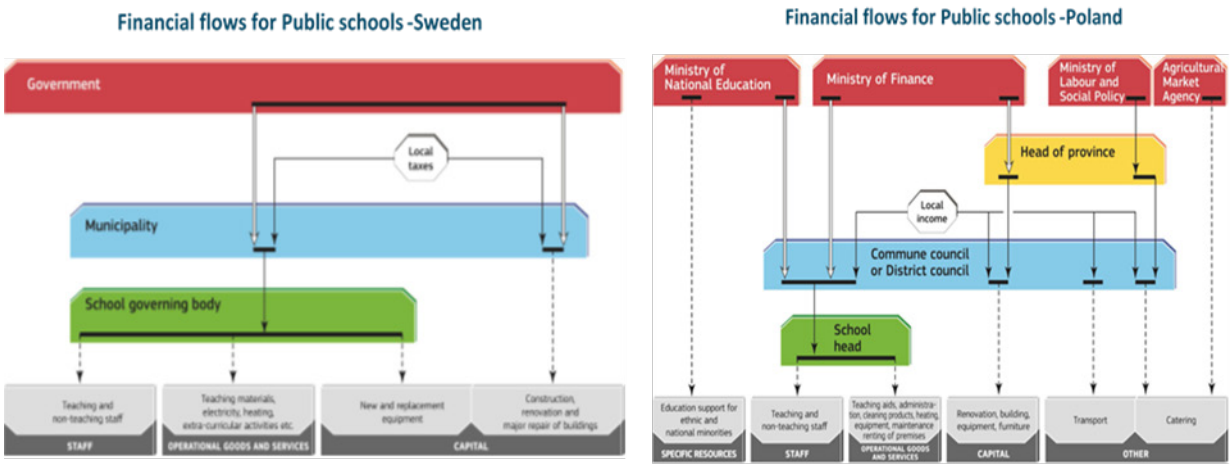


Figure 2.1: Financial flows for schools in Sweden and Poland *[Source: "Financing Schools in Europe: Mechanisms, Methods and Criteria in Public Funding" Eurydice 2014*]

GÉANT Partner	What is the funding model in your country for ICT expenditure in schools?
ACOnet	We don't know. It is rather diverse due to federal responsibilities and school autonomy.
ARNES	No response
HEAnet	Funding for ICT equipment in the school is generally the responsibility of each individual school, although the Department of Education provides grants every few years for schools to invest in ICT equipment.

Table 2.1: NRENs funding models for ICT expenditure within schools

GÉANT Partner	What is the funding model in your country for ICT expenditure in schools?
ACOnet	Our contractual partner is the Ministry of Education and the backbone connectivity (+ LIR and CERT services) from ACOnet for the EDUnet-connected schools is covered by a framework agreement with the Ministry and an annual flat rate.
ARNES	All services for schools (and other users) that ARNES provides are covered by regular national budget that ARNES gets from the Ministry (of Education & Research) as a non-profit public institute. This is also aided by specific project funding (e.g. purchasing dark fibre local loop to ARNES' schools backbone by the Ministry, which included communications equipment (routers, switches) at the school side) while we manage all of that.
HEAnet	The Department of Education funds 100% of connectivity to schools. In Ireland, secondary schools are connected at 100Mbps. The capital element for this programme was originally funded by the Department of Communications during the project rollout – 2009 pilot and a wider rollout in 2012–15, but it is now fully funded by the Department for Education.

Table 2.2: NRENs' sources of income for connecting schools

3 SCHOOLS' CONNECTIVITY

3.1 Connectivity Options

Connectivity options for schools have many requirements, including: the bandwidth required, the physical link to the internet provider, the upstream service provider and downstream distribution throughout the school. The amount of bandwidth required per school will vary, depending on its size (number of students and staff), the number of connected devices, and the location of the school. Therefore, it is not realistic to propose a common broadband speed for schools. An example from Ireland, below, is used to illustrate the setup of a typical school broadband network.

There are a number of technologies that facilitate a school's connection to the Internet. A school's connection should match its bandwidth requirements, based on the number of students. However, the location of the school will also influence provider choice, since the choice of technologies and/or data transfer speed becomes more restricted, in line with the distance of the school from urban areas. Wireless connectivity options such as ADSL are often used in remote areas, due to the unavailability of cabled technology.

2017 SCHOOL SURVEY RESULTS

The number of schools connected to schools jumped 124% to 26 982 schools, the highest growth since 2012. The surge to prioritise ICT use in education from many governments in Europe was the major factor behind the rebound.

Primary schools posted an increase of 130%,(10 587) and secondary schools posted an increase of 110% (4335) connections

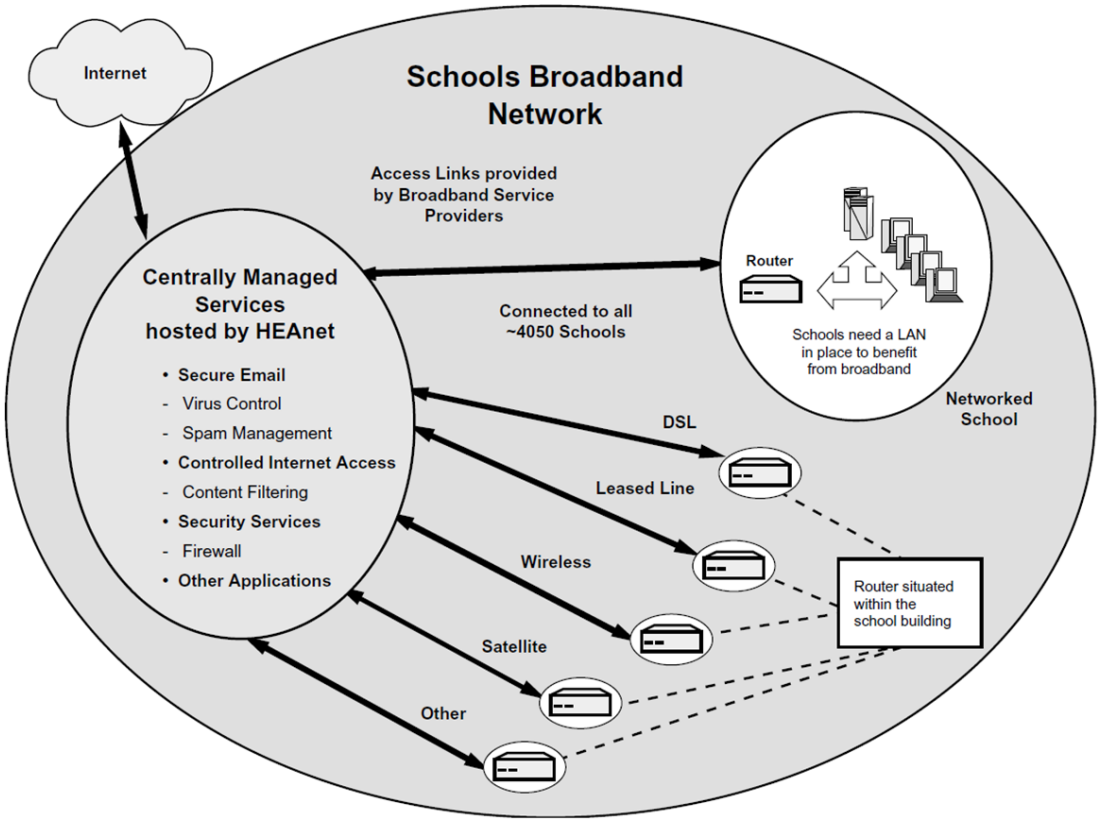


Figure 3.1: Schools' broadband network in Ireland [*Source: "The Schools Broadband Programme", National Centre for Technology in Education NCTE, 2004*]

3.2 NREN User Landscape

In recent years NRENs' user landscape has undergone considerable expansion. Many NRENs extend connections beyond universities and research institutions, to include hospitals, government departments and schools. There is an upward trend of connected schools, the latest Compendium data for 2016 indicated that primary and secondary schools represent the largest segment (65%), followed by research institute 17% [COMPENDIUM].

Figure 3.2illustrates the results from the latest School Survey, in which 81% of NRENs responded they connect both primary and secondary schools. The number of schools connected doubled from 12 060 in 2015 to 26 982 in 2016. This growth was mainly driven by AMRES, RoEduNet, CARNET, and KIFU NIIF Program (Hungary), due to recent government funding.

The share of primary is considerably higher, 69%, in comparison to secondary schools, 31%, due to the greater number of primary schools.

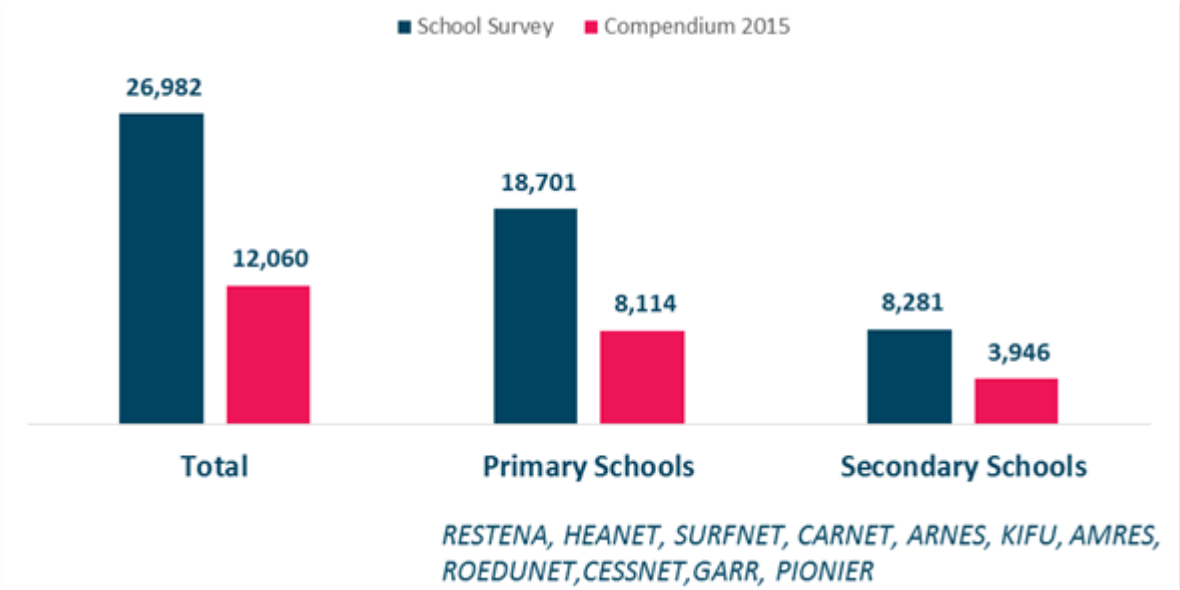


Figure 3.2: Schools connected to NREN networks [*Source: School Survey 2017; GÉANT Compendium, 2015*]

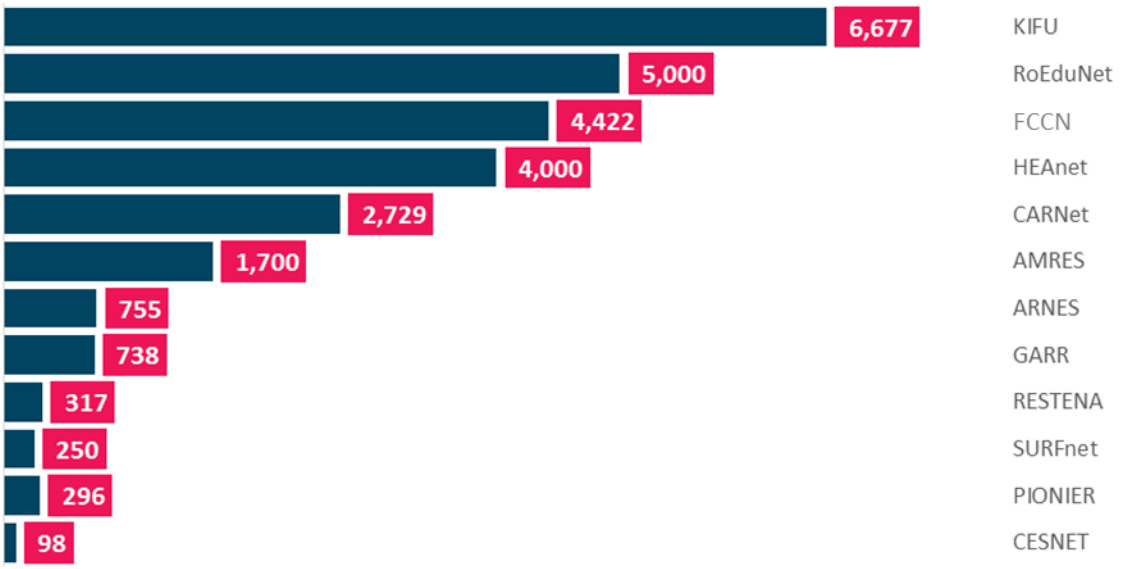


Figure 3.3: Total number of schools connected to NREN networks [*Source: School Survey 2017; GÉANT Compendium, 2015*]

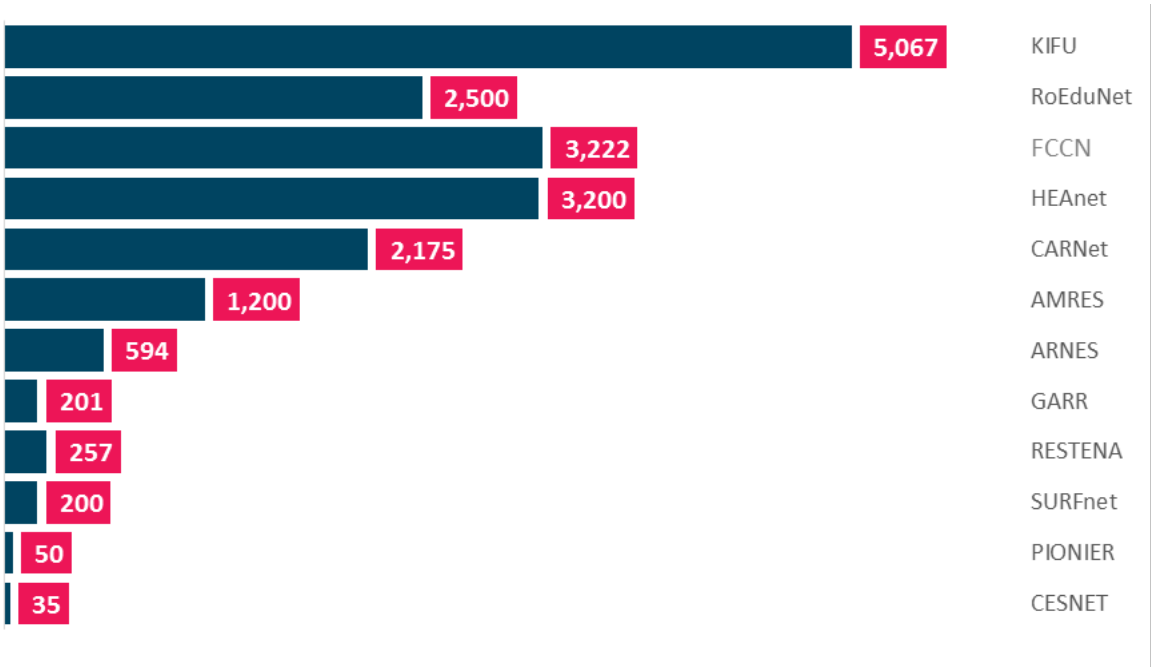


Figure 3.4: Number of primary schools connected [*Source: School Survey 2017; GÉANT Compendium, 2015]*

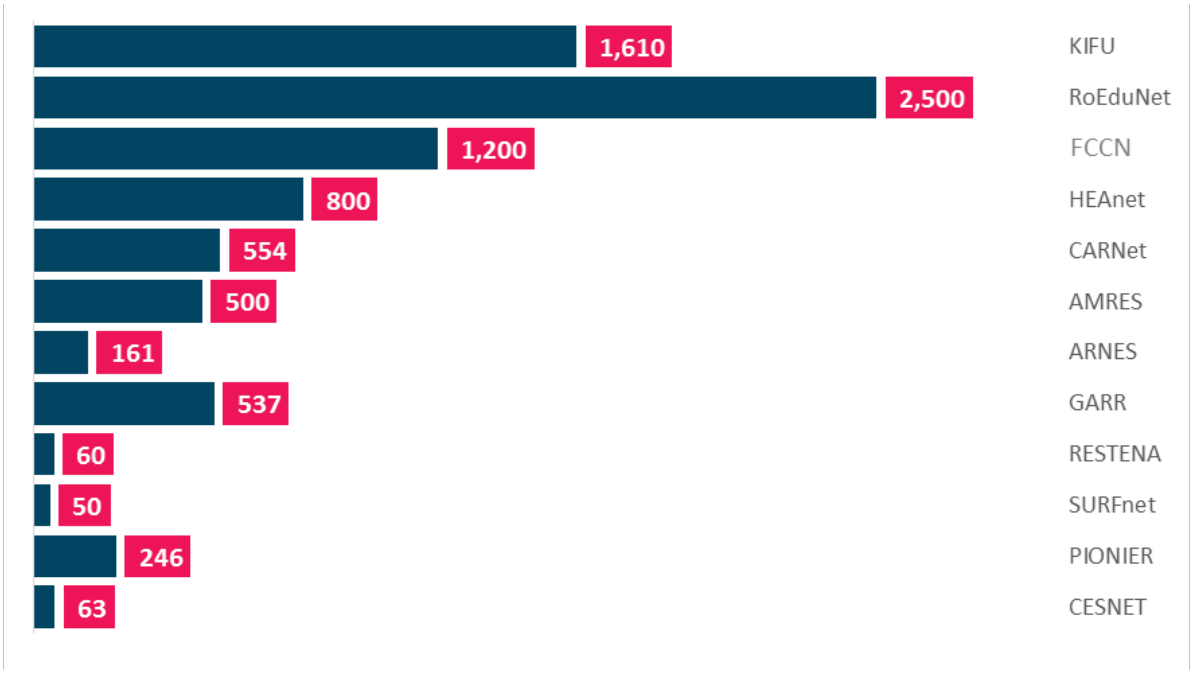


Figure 3.5: Number of secondary schools connected [*Source: School Survey 2017; GÉANT Compendium, 2015]*

3.3 NREN Market Share

2017 SCHOOL SURVEY RESULTS

The data showing a rising trend in number of schools connected to NREN Network

NRENs are connecting on average more than 62% of schools in their country

***GARR** posted the highest growth for secondary schools the coverage increased from 5% to 80-90%*

***45%** increase on RoEduNet market share for secondary schools*

RESTENA market share for primary schools increased from 80% to 100% coverage

The table shows the estimated market share for both primary and secondary schools. The overall market share distribution is comparable to the latest data from the GÉANT Compendium 2016.

69% response rate

	Schools Survey		Compendium 2016 Data	
	Primary Schools	Secondary Schools	Primary Schools	Secondary Schools
RESTENA	100%	100%	80%	100%
HEAnet	98%	100%	100%	100%
ARNES	74%	100%	90%	90%
GARR	10-20%	80-90%	1%	5%
ACOnet	90%		90%	90%
CARNet	75%	25%		
FCCN	73%	27%		
RoEduNet	25%	75%	50%	30%
SURFnet	8%		8%	8%
CESNET	1%	5%	1%	5%

Greater than 75%

Between 25-75%

Less than 25%

No data

Source: School Survey 2017, & Compendium 2016

3.4 Average Connection Speed and Traffic Load

Overall, the average connectivity speed to schools vary, ranging from 1Mbps up to 1Gbps. However, if we look at the results from the Compendium 2016 from NRENs who responded indicates that 1Gbps and above is typical capacity for connected Primary and Secondary schools

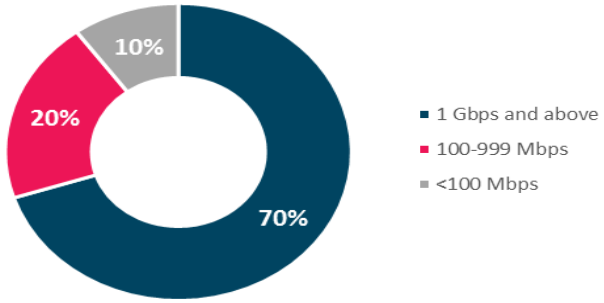
The graph below shows the peak traffic load to and from schools to the GÉANT network, and includes data from both primary and secondary schools. The largest source of traffic comes from Portugal, Ireland, and Croatia, where peak traffic was 2.5Gbps, 5Gbps, and 20Gbps, respectively.

2017 SCHOOL SURVEY RESULTS

70% *of NRENs have peak traffic load of* ***1Gbps*** *and above from schools to GÉANT– from GÉANT to schools*

83% *of NRENs expect traffic to grow over 11% for the next 3 years with the*

PEAK TRAFFIC LOAD FROM SCHOOLS TO NETWORK & TO SCHOOLS FROM NETWORK



	Average Connection Speed
AMRES, SURFnet, RESTENA, ARNES,RedIRIS	1 Gbps and above
CESNET,GARR, PIONIER, HEAnet, AARnet	100-999 Mbps
RoEduNet,CARNet,KIFU NIIF Program (Hungary), FCCN	<100 Mbps

Source: School Survey 2017

How is traffic carried?

We asked NRENs about how the traffic is carried. Is NREN who provides the local loops; is traffic carried to the backbone by regional RENs; traffic carried to the backbone by commercial providers? The table below shows the responses we had: 9% of NRENS provides the local loops, 18% the traffic carried to backbone by regional NREN, 27% traffic carried to the backbone by commercial providers, and 45% stated, they have a combination between commercial provider and local loops.

	How is the traffic carried?
GARR	A mix of the "NREN provides the local loops" and "Traffic carried to the backbone by regional RENs or local Universities
KIFU NIIF Program (Hungary)	Mostly commercial providers carry traffic to NREN backbone but tehere are same cases NREN has local loops
ARNES	NREN provides the local loops .more than 600 fibre LL owned by state, the rest carried to the bacbone by commercial providers, while ARNES manages CPE devices in both cases
SURFnet	SURFnet provides upstream IP only to commercial or public provider(s) that delivers ISP-service to schools
RoEduNet	Traffic carried by providers - project funded by structural funds
AMRES	Traffic carried to the backbone by commercial providers
FCCN	Traffic carried to the backbone by commercial providers
HEAnet	Traffic carried to the backbone by commercial providers
CESNET	Traffic carried to the backbone by regional RENs
PIONIER	Traffic carried to the backbone by regional RENs
CARNet	We provide local loops where possible (city where we have our own fiber) or we use lease line from providers

Table 3.1: How traffic is carried (by country) School Survey 2017

4 SCHOOLS NETWORK SERVICES

4.1 Overview (Network service requirements)

The GÉANT pan-European backbone network offers outstanding service availability and service quality for R&E projects and entities. GÉANT IP is an IP backbone network providing high bandwidth connectivity between millions of users through NRENs. The GÉANT IP service supports both IPv4 and IPv6 natively using a dual stack routing structure. By default, there is no bandwidth or performance guarantee between any communicating pair of addresses. It has been designed to provide general purpose IP transit services between participating NRENs and other approved research and education partners. Thus, the communication between two hosts is transited over the GÉANT IP if the hosts are connected by an NREN or other such R&E provider.

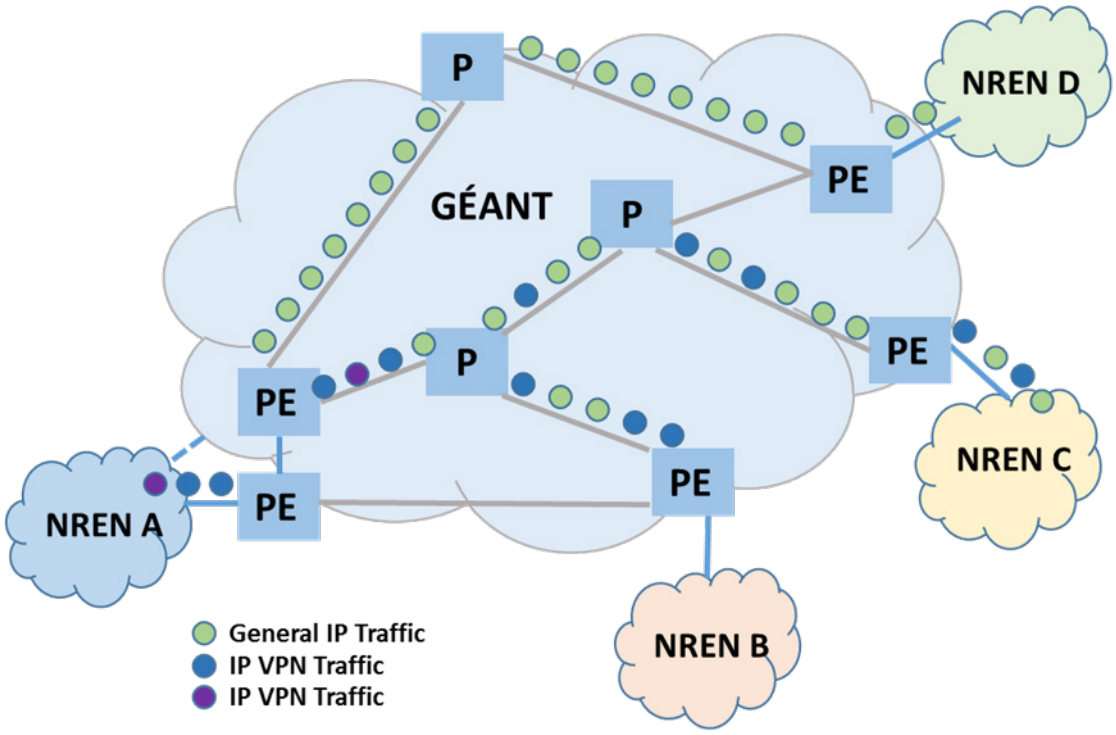


Figure 4.1: GÉANT backbone network

4.2 School Network Services

NRENs provide a broad portfolio of services to meet user need, from videoconferencing, virtual dedicated networks, web filtering, cloud services, security services eduroam, virtual hosting, and many other services.

4.2.1 eduroam in Schools

eduroam (education roaming) is the secure, worldwide roaming federated access service developed for the international research and education community, it allows students, researchers and staff from participating institutions to connect to the Internet when they are at their own campus or institutions, as well as when visiting other participating institutions.

Having started in Europe, eduroam has gained momentum throughout the research and education community and is now available in 89 territories worldwide. However, in schools eduroam is not widespread, only few schools have it available in contrast the number of schools connected to NREN network

According to the results from the Work Package 5 survey conducted by GÉANT for the Up2U project, only 10% (3 of 29 pilot schools who responded to the survey) of school principals declares that there is eduroam access at their school, and only 1 school declared that its students can authenticate to eduroam [Up2U].

eduroam is available within 1km from the 37% of the pilot schools, which clearly shows that students and teachers do not benefit from eduroam's potential. The issue could be further investigated in the scope of the Up2U project. At the first glance, it seems to be related to the weak popularisation of eduroam in the educational world, eduroam policies or legal issues rather than to the infrastructure limitations.

GÉANT Partner	eduroam	Security Services	Video-conferencing	Joint Procurement	Content Filtering	Others
AMRES	✓					
ARNES	✓					AAI with hosting of LDAP/IdP/IdM Hosting of CMS, LMS, video portal (VoD), email/webmail, FileSender ...
CARNet	✓	✓	✓		✓	
CESNET	✓	✓	✓	✓		Storage, virtual hosting, streaming, AAI
FCCN						
GARR	✓		✓			Public IP addresses and domain name registration. GARR-NOC and GARR-CERT are available to support the schools in case of troubles. In 30% of the connected schools GARR provides and operates the access router

GÉANT Partner	eduroam	Security Services	Video-conferencing	Joint Procurement	Content Filtering	Others
HEAnet		✓			✓	Web hosting, blogs, IP Addressing, VPN Remote Access, SMTP Relay
Jisc						
KIFÜ / NIIF	✓	✓	✓		✓	Web hosting, mail service
PIONIER						Provided cloud and application services as TV, access to digital libraries, etc.
RoEduNet	✓					
SURFnet	✓					

Table 4.1: Service matrix [*Source: School Survey 2017*]

4.2.2 Why eduroam is Not Widespread in Schools?

From the results we had from the School Survey, eduroam coverage in school is very low, so we contacted our NRENs in order to follow-up and understand the "why". Below are some of the responses we received.

GÉANT Partner	Why eduroam coverage in schools is very low?
ACOnet	Each school is responsible for its own IT infrastructure, mostly operated by teachers. Without the appropriate staff numbers, it is difficult to rollout services such as eduroam, and we (ACOnet) has neither a mandate nor capacity to provide WLAN or "eduroam as a service" to thousands of schools.
ARNES	Several reasons. One (not applicable for Slovenia) is that eduroam originally started as a service for universities (students) and there have been some reservations in different countries whether to include primary and secondary schools in the same federation at all (one of the issues being the age and the access policy). Another more practical issue is that building a wireless network on top of the internet connectivity requires additional funding and effort. And I mean any kind of wireless (cheap access points and improvised network), let alone the network which compiles with the technical (security, etc.) requirements of eduroam – this is generally expensive for schools, to the point they are reluctant to do it properly (not to mention the fact that not all schools are happy with the idea to have an "open" (freely accessible) network for pupils and they prefer to maintain restricted networks). Only in the last couple of years there are national incentives (and some funding, often using ERDF) to deploy WiFi (and perhaps enabling eduroam) in schools systematically (Slovenia, Croatia, Spain…)

GÉANT Partner	Why eduroam coverage in schools is very low?
HEAnet	While the Department of Education provides occasional grants to schools, they do not dictate what these grants must be spent on. There is no template for ICT equipment in schools and most schools procure their own wireless equipment. In addition to the above, there is no central repository of identities available in schools. Each school might run its own AD/LDAP server but these are not centrally managed. There is also no usable identity/learner ID assigned to Irish pupils.

Table 4.2: Responses to "Why eduroam coverage in schools is very low?"

	Does your NREN provide eduroam wireless roaming?	Do you plan to increase the number of schools using eduroam over the next two years?	In how many schools is eduroam available?	Number of schools connected?
Arnes	✓	✓	100	755
RoEduNet	✓	✓	none	5000
CESNET	✓	✓	20	98
SURFnet	✓	✓	not known	250
AMRES	✓	✓	60	1700
GARR	✓	✓	very few	738
CARNet	✓	✓	approx. 50%	2729
KIFÜ / NIIF	✓	✓	1700	6677

Table 4.3: Responses to NREN eduroam coverage [*Source: School Survey 2017*]

Appendix A Case Studies – National Programmes

A.1 KIFÜ/NIIF Program (Hungary) /Sulinet + Project

In the past years the Hungarian school network complexly renewed (bandwidth, services etc.). As part of the development project NIIF/ Hungarnet introduced eduroam on more than 1700 primary and secondary schools. The Goal of Sulinet+ (School Network +) - Renewal of the more than ten-year-old infrastructure of the school network:

- **Development of network infrastructure**
  - Development of the end-point CPE
  - Increase capacity and reliability of the backbone
  - Build access network capacity in rural area where there is no other alternatives
- New services with Integrated Service management systems for schools
- T&I pilot to schools with WiFi
- Multimedia infrastructure pilot to schools
- Increase the available bandwidth by tenfold: “Schools at 100 Mbps”

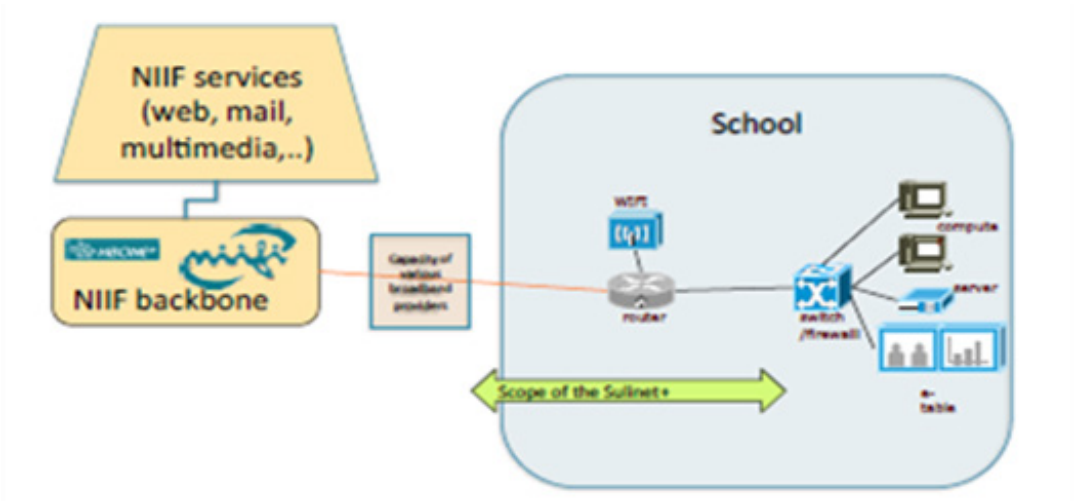


Figure A.1: Scheme of schools in NIIF/Hungarnet School network

School network methods

SDN for CPE and WiFi APs-Programmability/Automation:

- End point router development ~5500 high performance CPE with similar configuration.
- Abstract service interface in database.
- Automatically generated configuration and provisioned systems (CICI, DROPS tools) for routers and Access Points (APs).
- Initial eduroam pilot in 87 locations – huge success.

Federation as a Service (FedaaS) methods

Integrated T&I and eduroam for schools – FedaaS

Federated SSO authentication

- Institution identity: pupil/student, teacher, other educational staff
- Contract with the institution
- Up to date user database
- Physical take-care of WiFi Aps
- Local support person

NIIF responsibility

- Running the Access Points
- Running Radius infrastructure
- Running the user database
- Provide easy to use user interface for local administrator

Key findings:

- The eduroam CAT is a must for all the used platforms – including Windows Phone
- Intuitive user interface is important
- Mass management of users is required

Outcome

- eduroam at 1700+ service locations in Hungary
- Federated Identity for schools
- Automated provisioning system for routers and WiFi.

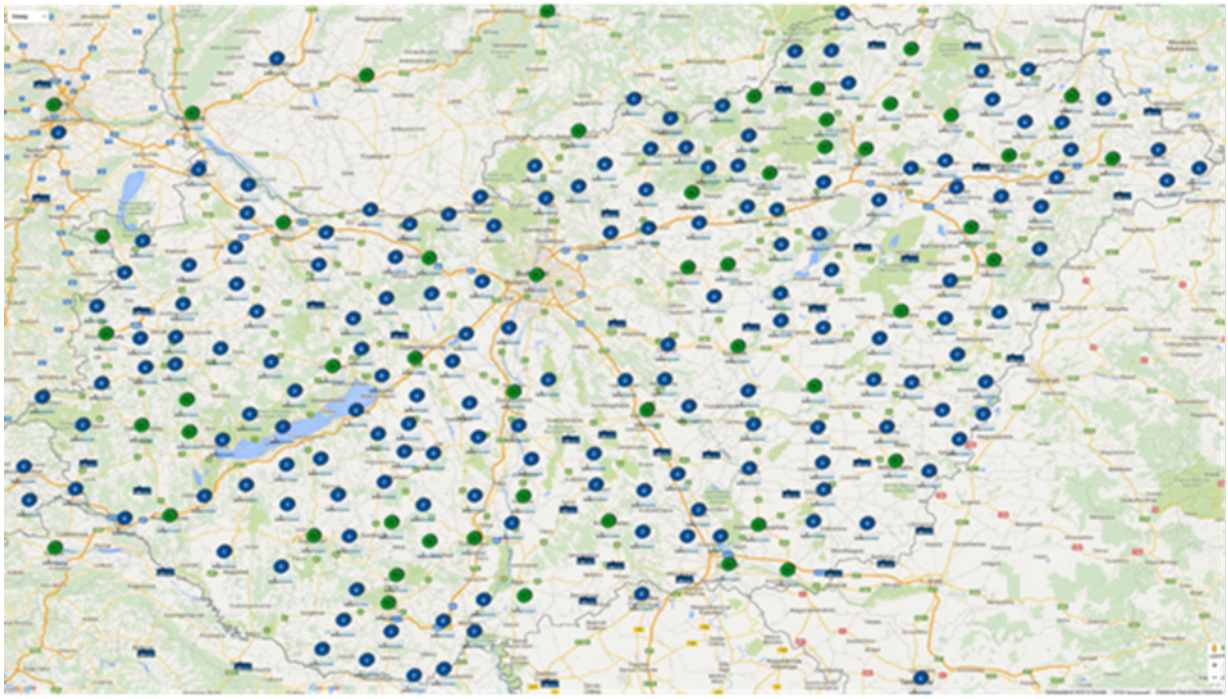


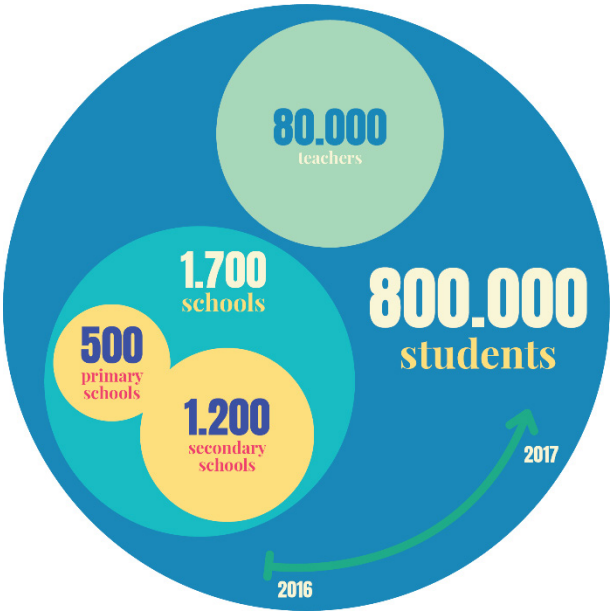
Figure A.2: eduroam service locations in Hungary (mostly in schools)

A.2 AMRES: Connecting Schools in Serbia

In 2003, the World Summit on the Information Society (WSIS) acknowledged the importance of schools connectivity, and adopted a plan of action calling governments "to connect universities, colleges, secondary schools and primary schools with ICTs". Since then, there has been an upward trend of connected schools to R&E networks. The latest GÉANT Compendium data for 2016 indicated that primary and secondary schools represent the largest segment (65%) and that, as of 2016, 33 NRENs connect schools to their network and five NRENs connect more than 90% of all primary schools in their countries [COMPENDIUM].

Strong growth in connected users

Connecting schools to the AMRES network has always been part of their founding idea and connectivity for some schools has already been provided. In 2016 this project started to connect all primary and secondary schools to AMRES. In 2017, 95% of all schools were connected, the rest of schools will be connected in 2018.



Schools that are connected to the AMRES network:

- 10% are using dark fibre (including 1G optic cables to gymnasiums)
- 85% are using DSL with a speed of 20Mb.
- The remainder are connected via mobile network, especially schools in rural and mountainous areas of Serbia.

Figure A.3: Schools connectivity within the AMRES network

Initially, all primary and secondary schools will be connected to the AMRES network with the speed currently available and then to continually increase the speed when needed.

Organisational impact

Within the schools, there is rarely any dedicated IT staff. That means that in many cases AMRES provides additional support on how to connect to the network.

There has been an increase of the administrative work, the number of contracts to be signed and paperwork in general. New policies, new processes and relevant training provided to the external and internal staff

e-education and Wi-Fi for schools

Taking on the role as connectivity provider for all Serbian schools, AMRES is further participating in two pilot projects**:** E-education and Wi-Fi for schools. These projects are leveraging experience gained as a connectivity provider.

- E-education: AMRES provides the technical infrastructure for a newly tested Software for the School Information Systems (to provide information such as online class attendance, test results, reporting for parents). This pilot is run by the Ministry of Education, Science and Technological Development and currently 100 schools are participating in this pilot with plans to increase the total number to 200 schools by the end of the year.
- Wi-Fi for schools: this relates to rolling out wireless networks in about 40 schools. The pilot is limited to provide Wi-Fi access to teachers in the first instance. Also BYOD (*Bring Your Own Device*) scenarios are being tested to enable Wi-Fi access to more users and a wider community.

Both pilot projects target different schools with different technical set ups. This allows AMRES to assess the most suitable infrastructure set-up, providing, for example. insight whether symmetric links are sufficient or if fibre would be required to provide such services to all schools.

eduroam is one of the services in the planning phase to be rolled out to schools. Technical feasibility is being assessed, with an initial limitation to access for teachers only.

Bridging the digital divide

Students and teachers connected to AMRES are able to access a high-speed and resilient network, share their knowledge and learn with other users from the community using the latest standards and services.

Key findings and results

- At the end of 2017, there are 1700 schools now connected to AMRES network, representing almost 95% of all primary and secondary schools.
- The number of all users that connect to AMRES network has grown from a few hundred to 1.2 million today.
- AMRES operates an IT Support Center and runs four main Service Centres: in Belgrade, Novi Sad, Niš and Kragujevac.
- Schools located in distant rural areas, small towns and also cities are now able to connect with users from other countries.

Figure A.4: AMRES connectivity map

A.3 Ireland HEAnet: 100Mbps Broadband National Programme

Schools connectivity in Ireland gone through several phases since 1997, the first policy on ICT in education led to the technology integration in schools and grant was provided to schools to purchase computers and establish internet connections. The program resulted in all schools having an Internet connection by 2001. However, the connection speed to schools were slow and there were challenges with maintenance and technical support.

In 2005, the Schools Broadband Programme was launched to overcome and address these issues. The programme was a joint project between the government and the Telecommunications and Internet Federation of the Irish Business and Employers' Confederation. The total costs of the project, including the fixed and recurring costs through June 2008, were estimated to amount to around €30 million. Under this initiative:

- All primary and secondary schools would have an Internet connection of at least 512kbps.
- HEAnet was appointed as a network managers of the centralised Schools Network.

Arising from the government's 2009 Next Generation Broadband report, the 100Mbps Post Primary Schools Project marked the next stage for Ireland's vision of developing its schools as world-leading centres of digital education:

- The project called for some 700 post-primary schools in Ireland to be provided with broadband at speeds of at least 100 Mbps.
- The project commenced in 2010 with a pilot that drew participation from 78 schools with each county in the country represented by at least one school. Following a positive evaluation of the first pilot, the remaining schools were connected from 2012 to 2014
- As of September 2014, almost 750 post-primary schools were covered by the Schools 100 Mbps High-Speed Programme; those schools that have not yet secured the benefits of 100 Mbps connections will do as gradually as they are transitioned off of the Broadband for Schools Programme.

Following the successful completion of the third and final phase of the project in 2014, a team consisting of the Department of Education and Skills (DES), the Department of Communications, Energy and Natural Resources (DCENR), HEAnet and PDST Technology in Education manages both the Schools Broadband Program and the 100 Mbps Post Primary Schools Project.

The project has been funded primarily by DCENR (capital costs of around €11 million and €11 million for current costs for the years 2012-2015), with additional backing from the European Regional Development Fund (ERDF) and DES (remaining current costs estimated to be some €16 million up to 2015 and responsible for ongoing annual costs into the future

- HEAnet was designated by the Government to oversee maintenance of the new network, supported by ESB Telecoms, which will continue to provide backhaul from regional locations to Dublin.

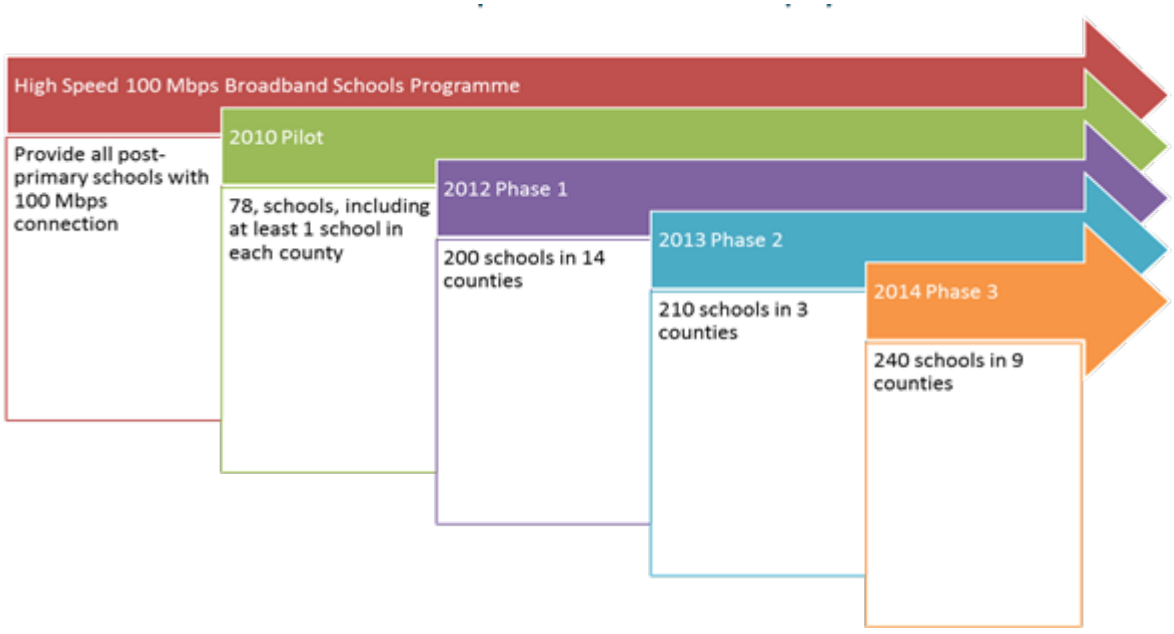


Figure A.5: 100 Mbps Broadband Schools Deployment in Ireland

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Glossary

AP	Access Point
BYOD	Bring Your Own Device
CERT	Computer Emergency Response Team
CPE	Customer-Premises Equipment
EFTA	European Free Trade Association
FedaaS	Federation as a Service
GDP	Gross Domestic Product
ICT	Information and Communications Technology
ISCED	International Standard Classification of Education
LAN	Local Area Networks
LIR	Local Internet Registry
MSP	Management of Service Portfolios
NCTE	National Centre for Technology in Education
NREN	National Research and Education Network
SDN	Software Defined Networking
SIG	Special Interest Group
T&I	Trust and Identity
Up2U	Up to University
WSIS	World Summit on the Information Society