Academic Networks GÉANT & RCTS

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***Abstract*—The Portuguese academic network is called RCTS (Science, Technology and Society Networks), being administrated and managed by the FCCN (Fundação para a Computação Científica Nacional). This core network is fully supported by optical fiber interconnections. The european academic networks, core networks that serve the academic community, all collaborate at the GÉANT association level in order to enable global interconnection.**

***Index Terms*—Core networks, academic networks, GÉANT and RCTS.**

I. Introduction

As part of the Course on Access and Core Networks, we were proposed to develop a research work, with information integration, analysis and technological characterization taking the GÉANT and RCTS networks as case studies.

To carry out the proposal the group had to make an intense research about the key concepts that surround the subject of academic networks. The concept of optical fiber and the technologies that made it the way it is today has an high meaning on the way we see the world. Fast transmission rates and low latency is becoming so widely important in the optical communications field as the need to improve them.

II. Theoretical Concepts

A. Optical Fiber

Fiber optics is the technology used to transmit information as pulses of light through strands of fiber made of glass or plastic over considerable distances. The optical fibers are about the diameter of a strand of human air and are capable of transmitting more data over long distances as well as faster data than other mediums [1] .

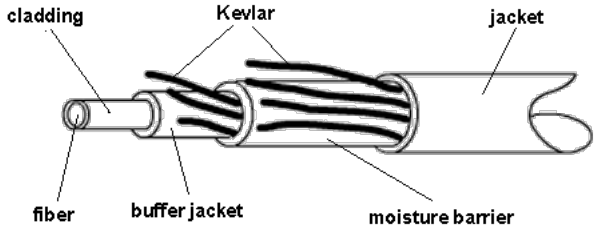

Fig. 1. Optical Fiber.

The optical fiber is constituted by the core, which carry the light and is the smallest component. Is usually made of glass and has a higher index of refraction than the cladding, the component surrounding the core. The index of refraction relation between the core and cladding dictates how much of the power transmitted is lost.

B. Ethernet

Ethernet is a family of wired computer networking technologies that are widely used in local area networks (LAN), metropolitan area networks (MAN) and wide area networks (WAN). It was first introduced in the market in the year 1980 and in 1983 it was standardized as IEEE 802.3.

The original Ethernet uses coaxial cables as the shared medium, whereas newer versions of Ethernet use twisted pair and fiber optics cables in conjunction with switches. Ethernet is currently capable of transmitting at a speed of 400 Gbps, with speeds of up to 1.6 Tbps being developed. [2] In a communication that uses Ethernet as the transmission protocol, the transferred data is divided into frames. The structure of a frame is represented in the following figure. [3]

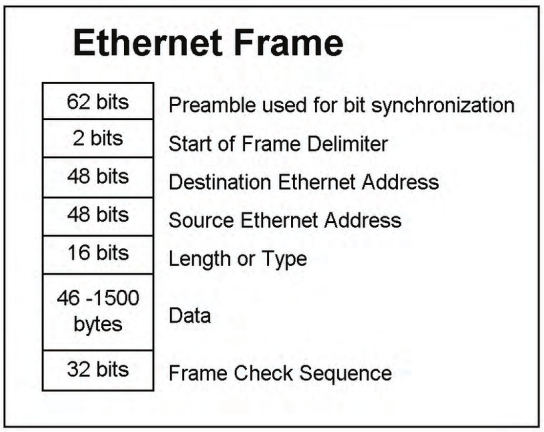

Fig. 2. Ethernet Frame.

Nowadays Ethernet is considered an essential technology for the good functioning of the Internet.

C. MPLS

MPLS (MultiProtocol Label Switching) is a protocol that emerged with the purpose to solve problems related to the quality of service and class of service. This protocol also has a very important role in routing, switching and forwarding traffic.

MPLS consists of labeling packets with fixed-length labels at the entrance of the network, which makes forwarding perform better than with long network addresses, which allows the avoidance of long routing tables. The routing, within the network, is done by exchanging labels.

This protocol represents a solution to reduce processing in network equipment and more efficiently interconnect networks of different technologies. In addition, it provides QoS, traffic engineering and VPN services for IP-based networks. Regarding real-time applications, it implements QoS that allows different types of traffic and prioritization of more fragile applications, in other words, it is a scalable network.

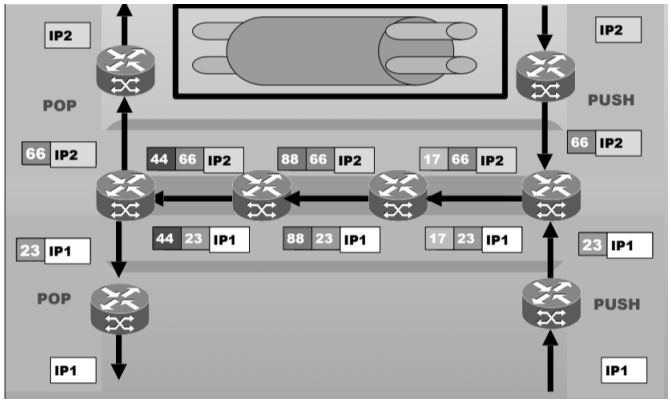

Fig. 3. MPLS Architecture.

The above figure corresponds to the MPLS architecture where it is possible to acknowledge the presence of 3 jobs for the MPLS Label Switching. These are **PUSH**, which corresponds to the process of label addition between the layer 2 and layer 3 header of the traffic packet. Other process is **SWAP**, where the backbone routers of the service provider is responsible for swapping the labels through the label switch path that is built between border routers. The last job is **POP**, which corresponds to the act of removing the outermost label from the packet. The last label that comes from swapping is removed with this process.

The main advantages of MPLS are its performance, network security, simplification of operations and its scalability.

Due to the fact that some more recent technologies do not rely on the packet header for information switching, which makes it impossible to verify the labels, GMPLS (Generalized MPLS) was developed.

D. SDH

SDH (Synchronous Digital Hierarchy) is a broadband time division multiplexing scheme with its systems being created in the late 1980s and early 1990s to replace the old PDH (Plesiochronous Digital Hierarchy) technology.

The main objective of these systems is to eliminate potential synchronization problems for big chunks of data and telephone exchanges. In order to achieve it, the data transfer rate had to increase substantially for a more flexible fiber optic based network infrastructure.

It is defined as a high-speed information transport system, capable of achieving rates of 2.5 Gbps, enough quantity to transmit 30240 telephone connections simultaneously. This technique operates at speeds of: 155 Mbps, 622 Mbps, 2.5 Gbps, 10 Gbps and the maximum transfer rate 40 Gbps synchronous. [5]

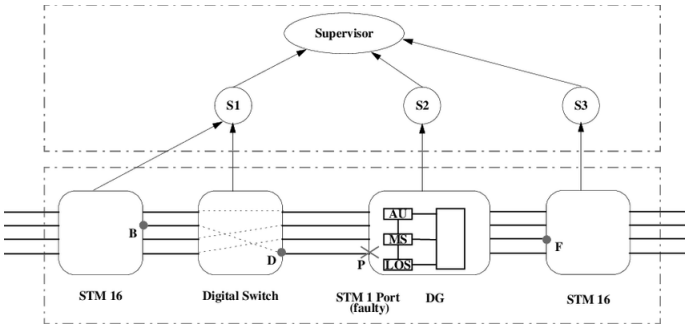

Fig. 4. SDH Network.

The synchronous mode in SDH allows low-order multiplex systems to be added and dropped from higher hierarchical levels. All this according to the standard that recognizes different hierarchies such as STM-1, STM-4, STM-16 or STM-64. SDH works with software running on the network and it usually uses Transaction Language protocols to transport network data between the terminal system and the equipment. In the end, it transports network data between SDH systems using embedded data communication channels. SDH also uses connections based on fiber optics cables, copper lines and satellite and directional radio links at the physical layer. [6]

Advantages of using SDH technology:

- Consistently uses more simplified multiplexing and demultiplexing techniques;
- Optical fiber bandwidth can increase without limit;
- Improved maintenance protocols with easy growth to higher bit rates;
- Good interconnection with various networks;
- Very popular in the field of telecom among networks and operators.

Disadvantages of using SDH technology:

- Complexity increased by directly adding and dropping lower rate signals that have been archived;
- Requires complicated SDH equipment to manage different traffic types and options;
- Provides a lower bandwidth utilization rate;
- It is largely software-based and vulnerable to cyber attacks.

E. WDM and DWDM

One of the most used technologies in optical fiber communications is WDM (Wavelength Division Multiplexing), a

multiplexing technique which consists in joining in the same optical fiber various light signals with different wavelengths. This technique operation is represented in the next figure.

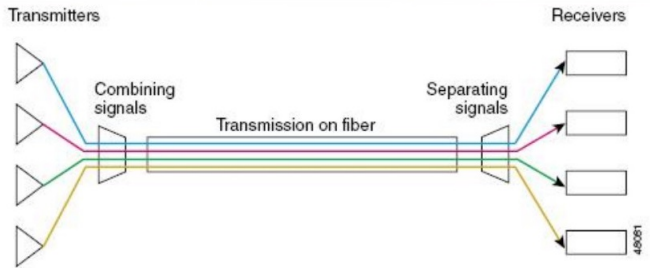

Fig. 5. WDM Technique.

This technique is performed with the objective of increasing the transmission capacity and, as a consequence, using the optical fiber bandwidth more appropriately.

This technology supports high-performance projects such as long distance learning and remote labs. It uses network technologies such as multicast, traffic engineering, quality of service, among others, offering a quality service with new technologies and high communication capabilities.

DWDM (Dense Wavelength Division Multiplexing) is a WDM technology where this systems can combine up to 64 channels on a single optical fiber. DWDM systems use wavelengths with channel spacings of 1.6 nm, 0.8 nm, 0.4 nm or even 0.2 nm. In addition, they have high transmission capacity per channel, reaching 1 Tbps in data transmission over an optical fiber.

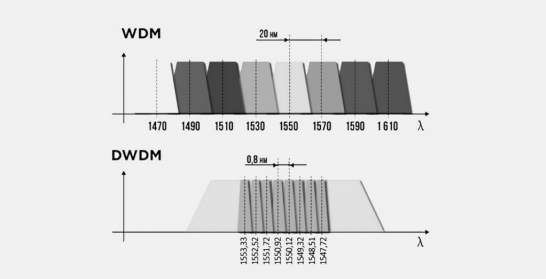

Fig. 6. DWDM Technique.

Currently, DWDM is mainly used in point-to-point connections. In this technology, it is possible for each transmitted signal to be at different rates or formats. In this way, the transmission capacity of DWDM systems can be expanded considerably and more easily.

III. Academic Networks

A. Motivation

With the emergence of telecommunications liberalisation in the late 1990s, GÉANT enabled the best minds across Europe and the world to work together on ground-breaking research activities and investigations that were previously not possible or very hard due to poorly built or unstable networks.

B. GÉANT Network

The GÉANT network connects research, education and innovation communities around the world, with secure, high-capacity networks. Responsible for the design, planning, construction and operation of large, high-performance networks that connect Europe's NRENs (National Research and Education Network) with each other and with other parts of the world with the goal to share, access and process high volumes of data generated by investigation and education communities and for testing innovative technologies and concepts. [7]

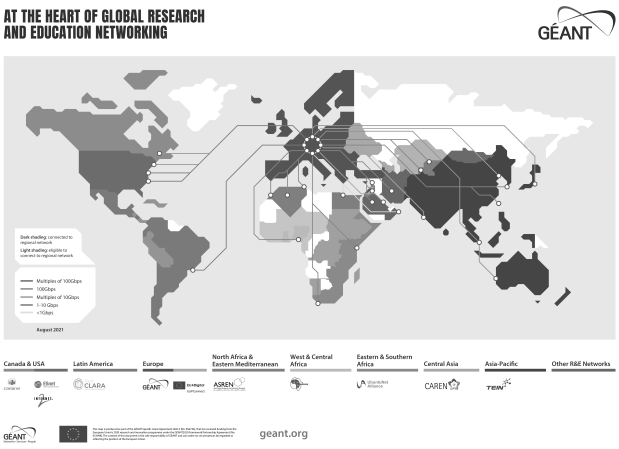

Fig. 7. GÉANT Global Connectivity.

GÉANT operates an advanced, high-performance network that provides cost-effective, highly available, high-capacity services tailored to and dedicated to research and education to Europe's NRENs. There are several network services as listed below.

- **Eduroam** - Service that delivers Wi-Fi access for research and educational purposes around the globe;
- **GÉANT IP** - This service provides high bandwidth, high speed international connectivity for academic users;
- **GÉANT VPN** - Service with increased privacy and control that helps building effective virtual teams across borders;
- **GÉANT Point-to-Point** - This service is special because it offers high-performance interconnectivity for the most demanding networking requirements;
- **GÉANT Open** - Service aiming to facilitate open collaboration across the globe. This service allows national research and commercial organisations to exchange connectivity efficiently and in a flexible manner.

1) Eduroam: Educational Roaming is a mobility service developed for the international education and investigation community. This service ensures secure internet access for students, teachers, researchers and institutional staff over the wireless network of the institution. This means that users can securely access with a normal login when visiting a home institution or other. Eduroam has uninterrupted Wi-Fi access and is considered safe all over the world.

Participating entities provide their users with the possibility of using their institutional account to access Eduroam network. This means that a professor or student from a Portuguese university can use his login and password credentials to connect to the Wi-Fi network of another university, whether this institution is Portuguese or foreign, as long as both ends belong to the Eduroam globe.

The Eduroam service is built on the industry's most secure authentication and encryption standards. It is a safe technology that protects the privacy of users.

2) Technologies: The GÉANT network not only provides high-bandwidth connectivity throughout Europe, but also serves as a testing ground for new technologies. This was the first hybrid network deployed internationally, combining routed IP and switched infrastructure. This allows the network to provide general traffic alongside virtual network paths for projects such as the Large Hadron Collider that specifically require dedicated bandwidth, security and flexibility.

GÉANT supported native IPV6 since 2002 and multicast IPV6 since 2004. It is involved in network research in areas such as carrier classe network technology, photonic switching, federated network architectures and virtualisation. A major network migration program was completed in 2013 where users could be offered multiple 100 Gbps connections, with the core network supporting 500 Gbps and a neetwork designed to support rates up to 8 Tbps.

Over 1 petabyte of data is already being sent daily over the GÉANT backbone network.

3) Participants: The GÉANT project is a collaboration of 41 partners, including 38 european NRENs (Portugal included) and NORDUnet, which represent the nordic countries. In the next segment of this article the Portuguese NREN is represented in detail.

C. RCTS

RCTS was created by FCT (Fundação para a Ciência e Tecnologia) which is the portuguese network enitity reponsible for providing the scientific and academic community a quality platform that allows its users to collaborate and commuinicate with each other. With more than 33 years of history, the network has gone through several phases and changes in the technologies used.

In 2004 optical fiber was first introduced into the network, which allowed better transmission rates as well the arrival of more people. The network connects to the rest of the world via a link to the European network GÉANT. This connection was made possible due to the use of fiber optic technologies, in particular two connections were made to the spanish network (RedIRIS), in Valença do Minho and Badajoz. [8]. The following image shows the current map of the fiber connections in the RCTS network.

Currently, RCTS provides several services to its users, including:

- **Eduroam** - Service that delivers internet access for research and educational;

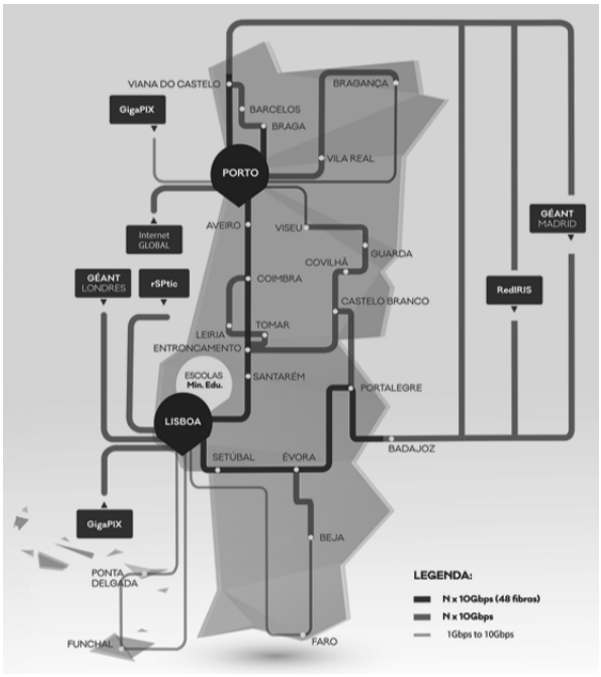

Fig. 8. RCTS Optical fiber links map.

- **Estúdio** - This service provides the community a place that offers high-level equipment for the production of content for educational, scientific, cultural or artistic purposes;
- **RCTS CERT** - This service aims to provide an effective response to computer security events originating or targetting the RCTS network;
- **RCTS Fibra** - This service provides the option to create networks with ficber optic connections depending on the needs of the institution;
- **RCTS Plus** - This services offers users access to highly reliable and safe virtual private networks (VPNs);
- **RCTS IP** - This service provides the scientific and academic community with the bonding between the Portuguese network and the different academic networks around the world;
- **VideoCas** - This service ensures an option with good quality for the transmission of events in real time to the whole world, through the internet.

IV. Conclusion

This study has presented the key concepts behind academic networks and the way they are connected. From start to finish it gives a perspective of the needs and the whys the global academic network needed to be implemented. First the European perspective where the GÉANT association emerge and then a particular case, the portuguese academic network.

RCTS is therefore considered a fundamental piece in Portugal for the scientific and academic community. Without it, it would be impossible to have the current level of collaboration between students, teachers and researchers that makes progress possible both at a scientific and academic level.

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