Top-down assessment of core and metro networks

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NGPN

Next Generation Photonic Networks

This report presents the top-down assessment methodology and its application to the core and metro part of the network

Table of Contents

1. Reference Material

1.1. Reference information (documents, web sites, etc.)

www.ieee.org

www.ietf.org

www.itu.org

www.metroethernetforum.org

www.oiforum.com

1.2. Abbreviations

GSM	Global System Mobile
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
ITU	International Telecommunication Union
LAN	Local Area Network
MEF	Metro Ethernet Forum
MPLS	Multi-Protocol Label Switching
NGPN	Next Generation Photonic Networks, an activity of the IST Next Generation Networks Initiative
NNI	Network-Network Interface
OIF	Optical Internetworking Forum
QoS	Quality of Service
SNI	Service Node Interface
UNI	User Network Interface

WDM Wavelength Division Multiplexing

1.3. Definitions

All-optical network	Each connection through the all-optical network is totally optical. It means that there is no OEO (optical-electronic-optical) conversion at the intermediate nodes, the optical data signal is converted to electronic at the terminating nodes, only.
Circuit switching	A dedicated path (circuit) with a fixed capacity is switched through the network. The circuit is established during a set up phase. Set up and release may be done on request by the network management or by the communicating parties using signalling messages.
Opaque network	The optical paths through an opaque network are interrupted at intermediate nodes by optical-electronic-optical (OEO) conversion operations.
Optical network	In an optical network information/data is carried by optical signals. The dominant transmission medium of optical networks is optical fibre.
Packet switching	The information is switched or routed through the network in form of packets. Routing or switching of a packet is performed by the network nodes based on a destination address or a routing tag in the packet header.

1.4. Document History

Version	Date	Editor	Partner	Comments
1.1	14.08.2002	Ádám Kapovits	Eurescom	Draft including comments from Peter Stollenmayer, Eurescom
1.2	15.08.2002	Ádám Kapovits	Eurescom	Draft including comments from Sathya Rao, Telscom
1.3	15.08.2002	Ádám Kapovits	Eurescom	Further improved draft, ready for comments
1.4	31.08.2002	Ádám Kapovits	Eurescom	Accommodating comments from the reviewer, Hans-Martin Foisel, Deutsche Telekom

1.5	27.09.2002	Ádám Kapovits	Eurescom	Accommodating comments from Paul Vogel, Telscom

(Note: version number consists of two numbers, the one before the dot indicates major changes to previous versions —change of document structure, new sections, etc.—, the number following the dot indicates minor changes —correction of typing errors, changes to the wording…)

2. Objectives

The objective of this document is twofold:

1. to explain the methodology of the top-down technology assessment approach, and
2. to apply the top-down technology assessment methodology to the core and metro part of the network.

Chapter 5 will serve as a key input to the Deliverable D6 'Main conclusions' of NGPN and also to the overall conclusions of NGNi.

3. Top-down methodology

A top-down assessment methodology considers the general trends and tries to capture the big picture, as opposed to a bottom-up approach, where an inventory of the details, ingredients and necessary components is made and systematically analysed (Figure 1).

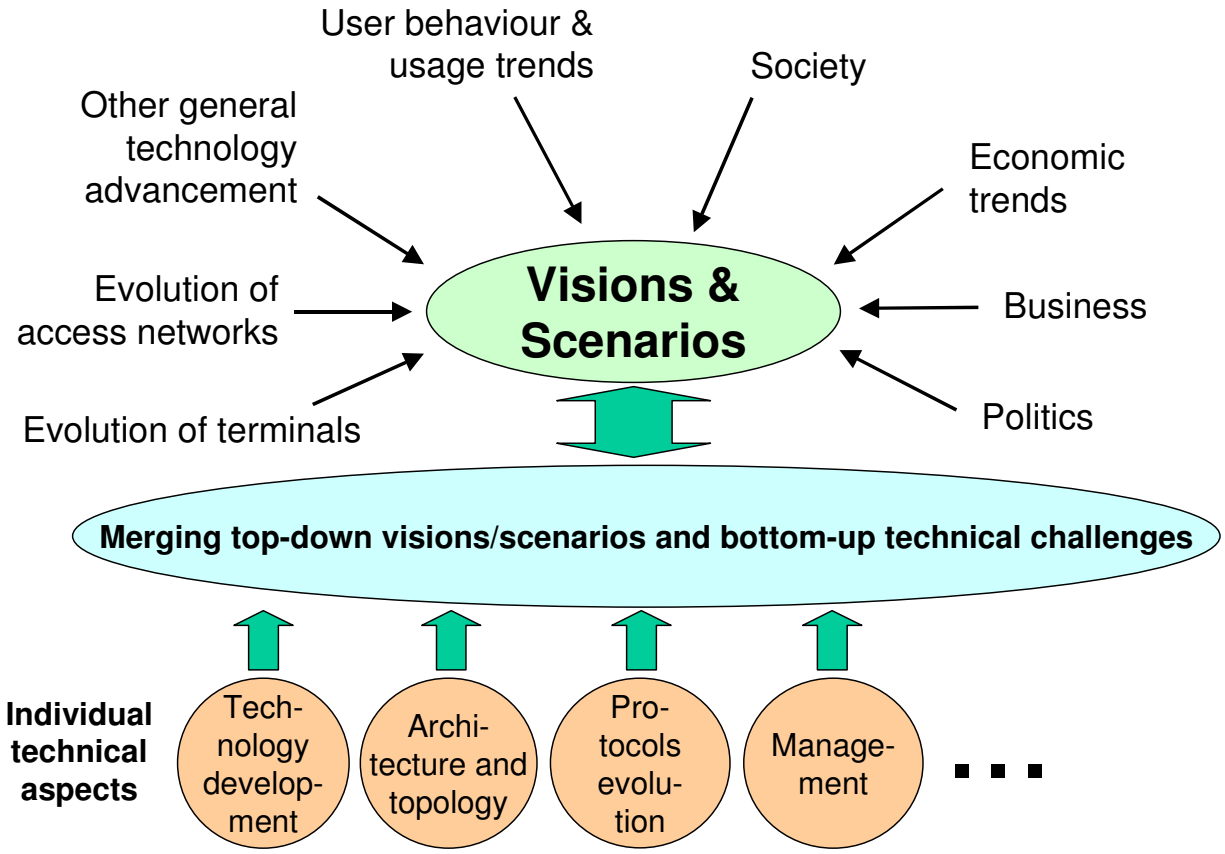

Figure 1. Top-down & bottom-up assessment methodologies applied to core networks

In a top-down assessment the subject of the analysis needs to be put into a broad context, to identify interdependencies. Therefore this document addresses social and economical aspects, besides the purely technical ones.

4. Core and metro networks in a broad context

Let's define core and metro networks through the role they play and the purpose they serve. **Core and metro networks carry data and information between the geographically separate access parts of the network to which customers/users and their devices are connected (Figure 2).** ***This implies that the future evolution of core and metro networks can not be discussed without considering the trends in user behaviour and usage that determines the evolution of the traffic to be carried, and also the evolution of the access network technology to which the core and metro networks need to interface with.*** **We do not expect the core and metro networks to change their role in the upcoming future.**

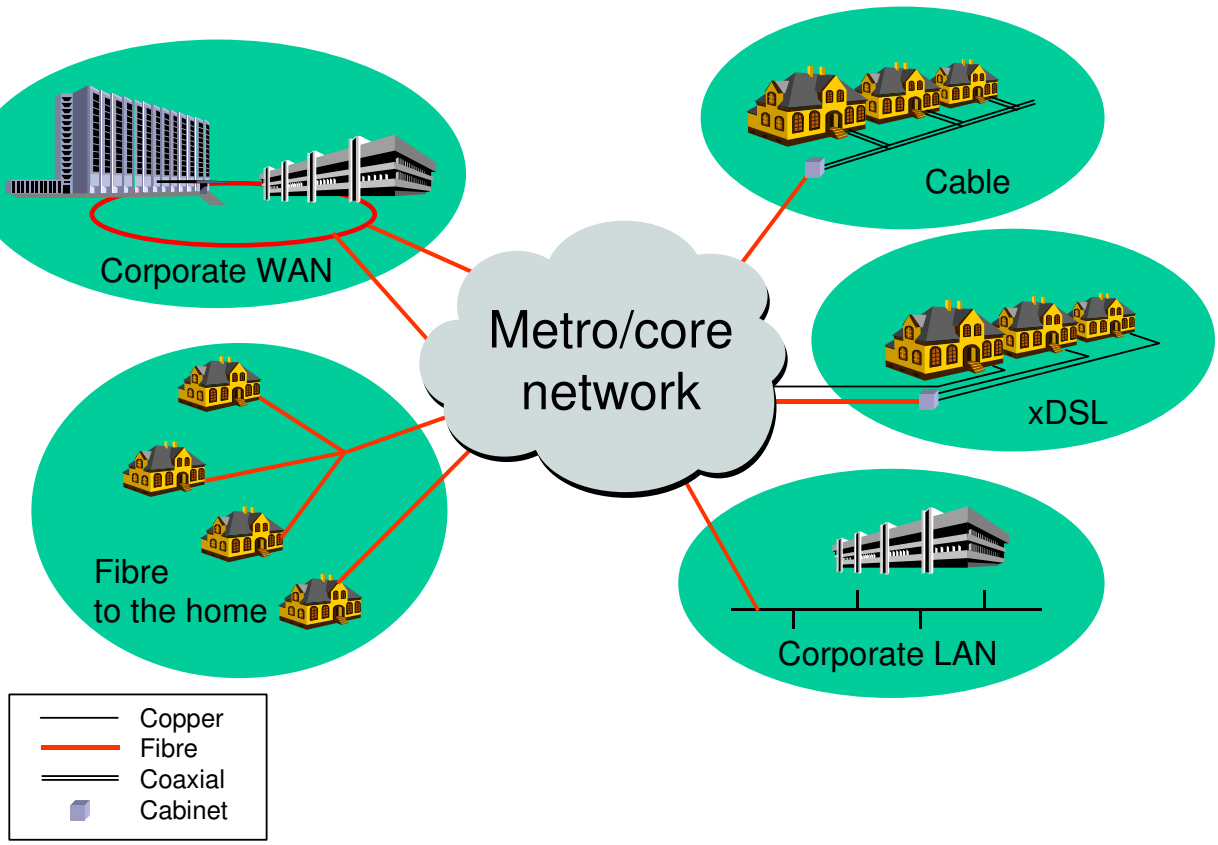

Figure 2. Metro/core networks interconnecting various geographical locations with different types of access networks (the access network examples shown are representative, but not exhaustive)

4.1. Access networks – the clients and environment of core and metro networks

Let's discuss first the access networks to which core and metro networks are interfacing. A few broad statements can be made in this regard. Evolution of the access networks will clearly have an impact on core and metro networks, and their evolution.

The boundary between access and metro/core networks becomes less significant.

In the light of recent developments one can expect a closer integration of access networks with the core and metro networks, in particular to support end-to-end control of connections, which users demand. There will also be a change/shift in the distribution of functionality across the access and core/metro networks. The change to packet based communication and the

consequently diminishing role of traditional switching and exchanges also supports the blurring of the traditionally clear demarcation between the access and core part of the network[1].

Same technologies for access and metro/core networks.

Regarding the technology, recently a clear cross fertilisation can be observed. Technologies developed for the core and metro network are making their way to the access part of the network, and the other way around, also. An example is Multi-Protocol Label Switching (MPLS), which was intended to support traffic engineering and QoS in the core network, but appears in more and more experts' vision of the future access networks. Another prime example is Ethernet that was originally designed for LANs, but is recently proposed by IEEE as a transport technology in the metro and core part of the network in its very high speed/bitrate (gigabit and 10 gigabit) variety. A third example is fibre optics and wavelength division multiplexing (WDM), which initially helped to multiply the capacity of core networks, but gradually make their way closer to the customers[2]. This process is expected to pick up speed as technology and processes evolve making industrialisation and mass production possible.

In conclusion, further technological cross-fertilisation is expected in the future between the access and core networks further decreasing the previously marked difference between access and core networks.

4.2. The basic enabling technology of core and metro networks

Core and metro networks are almost purely optical.

Regarding transmission fibre optics dominates core and metro networks. 99% of core networks is already optical[3]. The remaining 1% is satellite and point-to-point microwave used in well defined specific situations, usually in geographically remote areas, which are sparsely populated and have very rough terrain.

The enabling technology for core and metro networks is photonics with a progress similar to microelectronics.

[1] Exchanges were located and marked the boundary between access and core networks.

[2] Sometimes this goes unnoticed, but this is a steady process. For example the base stations of today's GSM networks are connected via fibre optics, and the number of those base stations steadily increases as the usage of the mobile network and bandwidth supported increases, and thus the fibre gets closer to the user.

[3] However, in the network nodes optical signals are still converted back to electrical ones and all processing is done in the electrical domain for the time being.

The basic enabling technology of core and metro networks is photonics. Photonics is expected to experience a similar progress as microelectronics. In the next 15 years the number of optical channels is expected to increase from the presently common 40-80 channels to 200 channels and the bitrate per optical channels is expected to increase from the presently common 2,5-10 Gbits/s to 40 and possibly 160 Gbit/s.

4.3. Functionality built into and provided by core and metro networks

Smarter optical layer rich in functionality

Parallel to the above outlined development of pure "volume" increase, the optical layer will become smarter, and the functionality implemented in the optical layer will also increase. (The optical layer will become more functionality rich.) For example in many instances protection is already realised in the optical layer.

Continuing reduction of network layers and elimination of functionality redundancy to increase efficiency.

In parallel to that the reduction of network layers will continue, which will lead to increased efficiency through reduced functionality duplication/redundancy.

Introduction of optical control plane makes core and metro networks more dynamic.

Finally, with the introduction of the optical control plane core and metro networks are becoming more dynamic and responsive to the changing demands already on the short term.

4.4. General trends in user behaviour and network usage

After the technology factors let us discuss some general trends influencing the user behaviour, the usage of the network and thus the traffic that needs to be transported. These include economic considerations and social trends, also.

High increase in packet switched Internet traffic.

In the last years the traffic volume increased very rapidly, mainly due to the fast spreading Internet. Currently about 38% of the EU population are connected to the Internet. The figures for the East European countries are much lower (e.g. only 3% in Bulgaria)[4]. Significant further increase is expected, as countries such as China and India are getting connected. This increase in volume is accompanied by a fundamental change in the nature of the traffic. The almost exclusively circuit switched voice traffic became first mixed, and by now it is heavily dominated by the packet based traffic of the Internet. As this trend continues networks need to adapt to this change – past circuit switched networks optimised to carry voice traffic need to change and be optimised for packet based traffic.

Content creation in the private environment will boost traffic.

A significant trend, which could be observed and will have a major impact on the traffic is the increased content generation capability at the edge of the network. Consumer devices capable of producing large amount of digital content, such as digital photo and video cameras appear on the market at ever decreasing price. End users are expected to share the wealth of information and content they create – the result of their creativity – with their peers. This will again change both the nature of the traffic, which is currently dominated by web browsing, and also the currently predominantly passive consumption of centralised content to a more balanced passive consumption and content creation. Thus IP traffic becomes more symmetric in all network domains.

Another trend influencing traffic evolution is online entertainment, online gaming. Virtual reality games can boost network traffic significantly. They also present different requirements towards the networks not only in terms of bandwidth, but also in terms of transmission delay.

Obviously, these trends, which rely on the buying power of the consumer and the quick adoption of new technologies are heavily influenced by the prosperity of the world economy. The new technologies will almost certainly have long reaching social impacts, also, that are often under-estimated and not sufficiently understood.

Finally, an example for unexpected, so called disruptive events that can have long reaching impact is the tragic terrorist attack on 11 September 2001. As a result of that, there has been a considerable increase in public security and surveillance increasing the volume of the traffic on the networks. In the course of 10 years, the timeframe of our study, it is very likely that there will be other disruptive events. Including their impact into the final picture is very difficult, because of their unexpected nature, but they will also shape the future in one way or another.

[4] Source: e-living IST project

4.5. The economy of core and metro networks

Another important aspect that needs to be analysed to properly understand what drives next generation photonic networks is the economy of core and metro networks. The main players need to be identified and also their motivation. So who are the players and what is their role? The following roles can be identified:

- Suppliers, vendors, equipment manufacturers
- Infrastructure operators
- Service providers
- Users
- Regulators and policy makers

Suppliers and vendors continuously innovate to gain advantage over their competitors.

The aim of infrastructure operators is to maximise the return on investment.[5] They would like to exploit their existing infrastructure to its full extent. They also aim at continuously improving their services for the satisfaction of their customers, in order to gain competitive advantage over their competitors and increase their market share.

Service providers offer all kind of services (home shopping, interactive video, video on demand, data storage, surveillance, etc.) to private and business customers using the network infrastructure. The services business will really flourish, once a truly broadband multiservice network infrastructure is available for a critical mass of potential customers.

Users would like to have better services at a lower price. In this case better service means more bandwidth, better (end-to-end) control and reliable Quality of Service (QoS).

Regulators aim at ensuring competition that serves the market, the users, the whole economy and the interest of the society. Policy makers are interested in the overall healthiness of the economy and progress of the society.

In our opinion there are two issues that demand special attention:

- Standardisation
- Regulation.

[5] Right now in the case of IP traffic transport service it is a challenging task to realise any profit.

Regulation and Standardisation need special attention:
Too many uncoordinated standardisation activities with different interests hinder progress
Regulators need to be cautious and only intervene if society values suffer

In telecommunications standardisation is vital. Since it is unlikely that one operator connects all users and information sources standardised solutions are needed to ensure interoperability. At present there are too many standardisation bodies involved and interested in the standardisation of core and metro network solutions. These include ITU-T[6], IETF[7], IEEE[8] (regarding Gigabit Ethernet), OIF (Optical Internetworking Forum[9]), MEF (Metro Ethernet Forum[10]) and more (our list is not exhaustive)[11]. Some of these are well-established standardisation bodies with a long history, whilst others are new. The convergence of the telecommunications and informatics industries (historically having separate standardisation bodies with responsibilities not interfering) is responsible to a large extent to the present confusing situation. Emergence of new standardisation bodies and fora is a natural outcome of evolution and progress, but the present divergence hinders future progress. Close co-operation should be established to speed up development of standards.

The role of the regulator is also very important. Regulators serve as a referee and should intervene when other fundamental values of the society suffer as a result of free market and competition, or if free competition is hurt. Regulators need to be very cautious and conservative in their approach, since their action could not only be beneficial, but can also be damaging[12]. In this regard one could safely conclude that the core and metro part of the network is subject of free competition in most part of Europe and also in the World.

[6] www.itu.org

[7] www.ietf.org

[8] www.ieee.org

[9] www.oiforum.com

[10] www.metroethernetforum.org

[11] Unfortunately, many of these standardisation bodies serve as a lobbying vehicle. They were snatched by one vendor (or a group of vendors), or another, and the sole purpose of these companies is to use the prestigious logo of the body as a marketing and sale argument. This also means that often there is no communication between these bodies ('camps'), as it is not in their interest. On the contrary, the interest of the vendors is to pursue their own ideas and marginalise the others.

[12] Often the regulatory actions have both positive and negative effect, and the different players view them according to their own interest.

5. Evolution of core and metro networks and roadmap to next generation photonic networks

When do technologies change? Technologies get phased out and replaced when a new technology is mature enough and offers significant advantages over the old one. This could be richer features, better performance or lower cost, or both. All of these features must be met for deployment of new technology equipment.

The main characteristics of the evolution will include:

- *Increasing total bitrate per fibre – increasing number of channels and higher bitrates per optical channel*

- *Smarter and more functionality rich optical layer*

The functionality implemented in the optical layer will increase. In many instances protection is already realised in the optical layer, which was previously provided by the SDH layer.

In parallel to that the simplification of the protocol stack will continue, which will lead to increased efficiency through reduced functionality duplication/redundancy.

- *More dynamic and responsive core networks*

With the introduction of the optical control plane core and metro networks will become more dynamic and responsive to the changing demands already on the short term.

- *Closer integration of core and metro networks with access networks*

Core and metro networks will be more closely integrated with the future access networks in order to support the end-to-end control of connections.

- *Less difference between access and core/metro networks*

Future access and core/metro networks will become more alike. This 'convergence' is due to

  - The changeover to IP and disappearance of local exchanges, the traditional demarcation between core and access

  - Use of similar technologies, including

    - Fibre,

    - WDM,

    - MPLS, and

- Ethernet.

- Increasing reach of the access network due to the adoption of fibre

  However, functionally there remains a distinction/difference between access networks and core/metro networks. Access networks will still perform the basic traffic aggregation, whilst core and metro networks will further aggregate and groom the traffic, but at a higher level.

- *Industrialisation of optical switching and storage*

There are some promising ideas, research and experimental results in this regard, but they need to be brought into production networks. We expect that this will take another 10 years.

- *Steadily improving planning methods and network optimisation tools*

In the past network operators invested significant efforts into developing and improving network planning methods and optimisation tools. As a result of that significant advances were made and the utilisation of networks improved. In the future we expect further incremental improvements to be achieved.

<To be completed with main findings from Deliverables D3, D4 and D5 of NGPN.>

6. References

[1] e-living list IST projects, www.....

www.oiforum.com

www.ietf.org

www.ieee.org

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www.metroethernetforum.org