White book for real high bit rate transmission

Poor english translation attempt …

Note:

This is a translation of the SYCABEL White Book. It has not been translated word by word. The idea is to give an English reader the essential content and therefore the French strategy and approach in the area of FTTX.

SYCABEL

SUMMARY

FOREWORD

Quick evolution of telecommunication technologies :

2002 : negotiation between operators and local communities for the mobile phone coverage of 3000 cities and villages.

2003 : government objective = ADSL coverage for 97 % of the French population before 2007.

2004 : ORTEL observatory notes big local differences between regions regarding unbundling and access to triple play services.

2005 : beginning of ADSL2+ (up to 8 Mbit/s) for subscribers near telecom exchange

2006 : 3G (UMTS) enough deployed → digital breakdown between high bit rate mobile phone customers.

2007 : high bit rate transmission provided by FTTx, and VDSL technologies will give new possibilities to regions equipped with optical fibres, but not to other regions.

In that way, the public authorities are fundamental players :
- government plan (28 october 2004),
- local authorities according to L 1425-1 article giving possibilities to regions to install their own optical networks where traditional operators are not present.

The SYCABEL guide brings to public and private French players, technical and economic information for the revival of rural areas,, social cohesion and a competitive environment.

The DATAR (French country planning organization) is pleased to present this guide.

Alain DUCASS

PRELIMINARY

Internet standardization, emergence of « all digital » applications in daily life, the role of media (very enthusiastic but not very well documented), the marketing messages of Internet providers and terminal manufacturers (modems, mobiles, …) contribute to give a confused picture about high bit rate transmission.

First we must state that sound, pictures, voice, data carried by networks are digital data expressed in terms of bit, bytes and their multiples (kilo, mega, giga, tera).

A bit (binary digit) is the smallest digital unit and has only 2 values : 0 or 1.

A byte includes 8 bits and defines the size of a data file.

The transmission capacity of networks and terminals is not expressed using bytes but using bit per second (bps).
When a data file is carried on a local or a world network 2 supplementary bits are necessary. It means that 10 bits are required for 1 byte.

In the case of a VDSL subscriber with 10 Mbit/s who wants to upload a pdf data file, the Web provider indicates for instance the following size : 20MB.pdf. In this case it means 20 Megabytes. For a 10 Mbit/s (corresponding to 1 Megabyte/s) VDSL network, the uploading time will be 20 x 1 s .

Notified data flow and real data flow :
Most specialists (ADOBE, REAL, etc…) consider that, with a 1 Mbit/s subscription, the real data flow is about a quarter of the notified data flow because the data flow is shared between subscribers and its quality depends on the activity of the other subscribers.
It means that the 20 MB.pdf data file will need 1 mn 20 s to be uploaded.

This short example shows that a transmission capacity indicated in terms of bps gives an apparently good performance whilst in reality this is not the case, Remember : www was meaning « world wide waiting ».

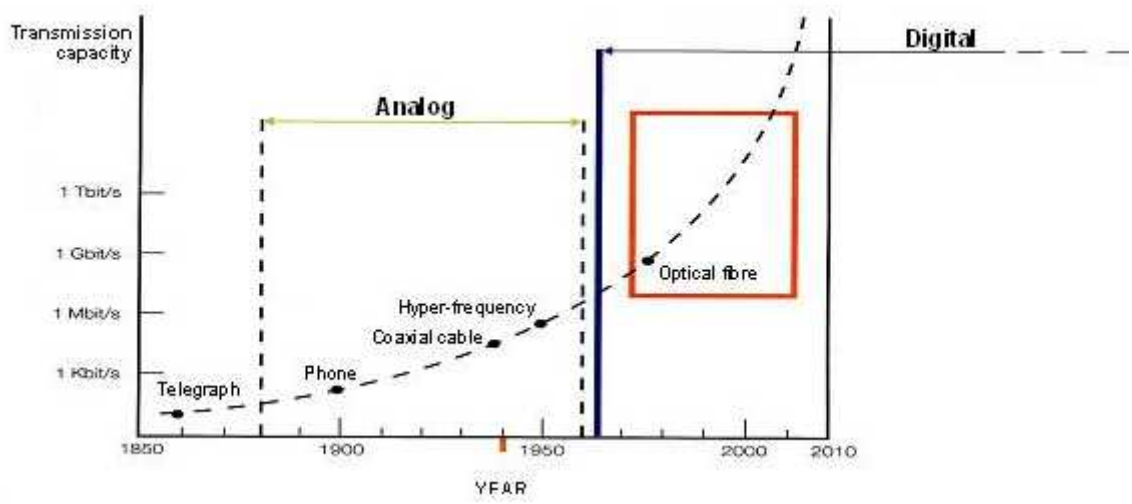
This reality explains why real high bit rate transmissions are needed both for individual susbcribers as well as for companies to decrease the cost of travel, to reduce intervention times, and to increase their productivity.

1. WHAT DOES « HIGH BIT RATE TRANSMISSION » MEAN?

This question is very important regarding economic and social aspects. In fact there is no standard defining what is a « high bit rate transmission » because this notion is constantly changing. For instance, in France, ADSL provides 128 kbit/s up to 8 Mbit/s (and then 15) depending on the location. In France these 2 values are actually considered as high bit rate transmission.
In Japan for instance, 4 Mbit/s (40 x the french data flow) are considered as the lower value acceptable for high bit rate transmission.

1.1 A evolving picture

10 years ago, everybody was happy with a 56 kbit/s modem. Uploading of big data files (pictures, video, …) was exceptionnal. The evolution of communications, the diversification of applications and the increases in bit rate demand have followed an exponential curve.



This evolution concerns all aspects of society.
For businesses this globalization of the economy means reduction of distances and a new set of needs (interactive video-conferences with data sharing in real time, home working, permanent access to information, …).

For the domestic consumer:, continuous learning, security of people and of goods, R&D, new applications (video games, video on demand, interactive teaching, video survey, data banks , ...).

We don't know what new tools will be created by these real high bit rate networks. New applications (not yet invented) will appear and will be developed and extended as has happened to the mobile phone in recent years.

To satisfy this increasing demand of data flow, all cable networks have moved towards higher capacities of transmission. This evolution means a change of support from copper cables dedicated to phone towards optical fibres having infinite possibilities.

1.2 A definition for all applications

It's important to define what « low, medium and high bit rate transmission » actually means. In countries having a strong position (Japan, Sweeden, USA) in terms of digital infrastructures the classification is the following :

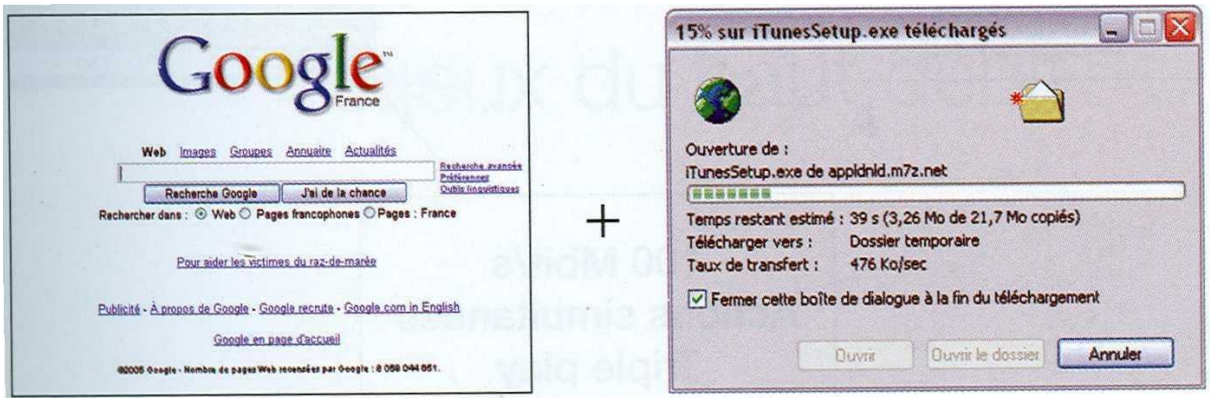
- low bit rate transmission : up to 1 Mbit/s
- medium bit rate transmission : 1 up to 10 Mbit/s
- high bit rate transmission : 10 up to 100 Mbit/s and more.

This classification is realistic ; We can't consider 512 kBit/s to be a high bit rate transmission because it does not provide satisfactory results for sophisticated application sharing, video on demand or high definition digital TV.
Traditional ADSL or coaxial cable provides asymetric flow : the reception (download) is favoured but not the upstream speed

For instance a 15 Mbit/s ADSL system provides only 1 Mbit/s upload capability.

1.3 Examples

With 1 Mbit/s we can upload relatively quickly videos and pictures but generally compressed and with poor quality. But this rate is too small for video streaming. So 1 Mbit/s is not enough for high bit rate transmission.

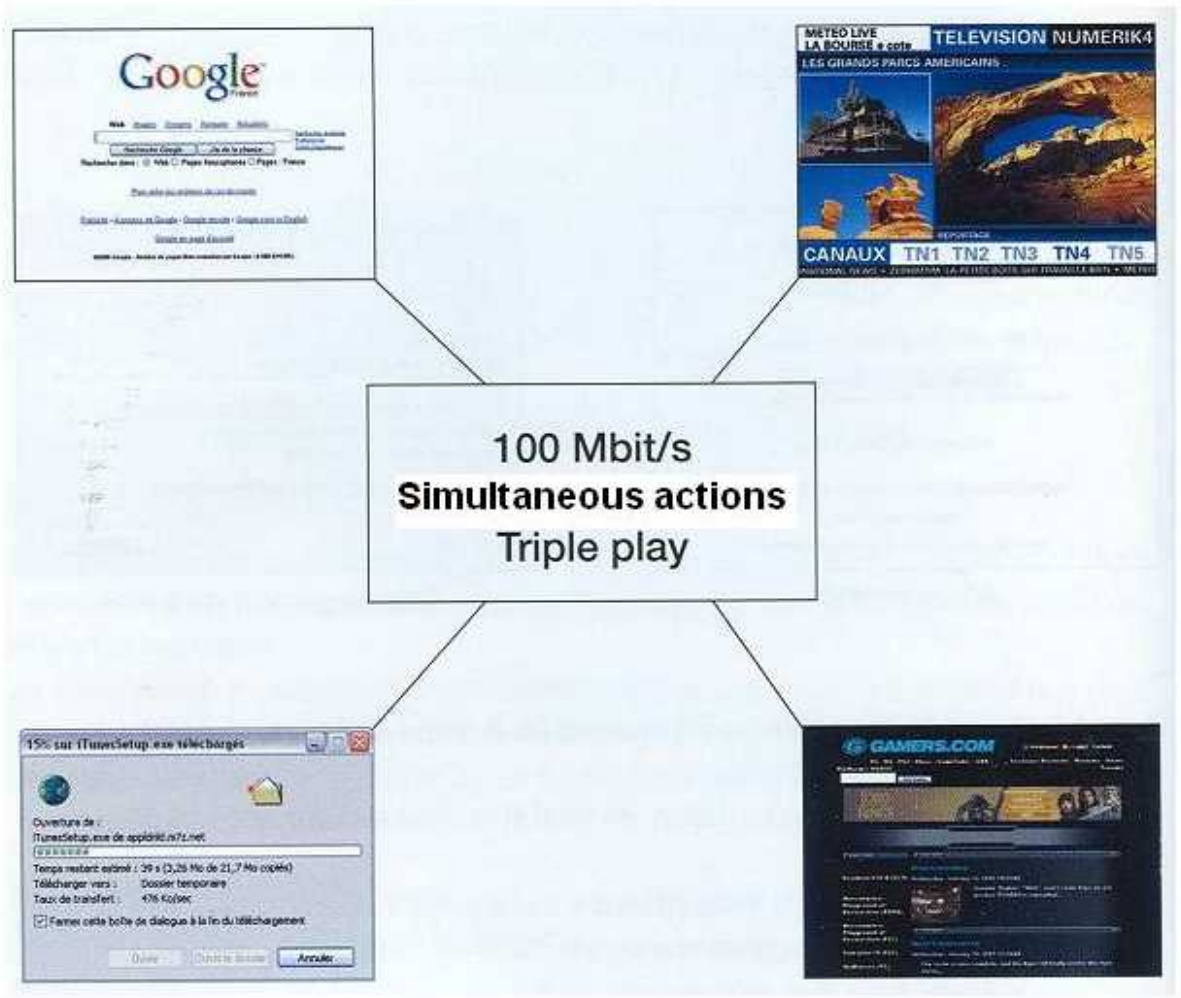


Internet access *Data uploading*

With 10 Mbit/s we can simultaneously have video on real time (TV, …) and data uploading.
This kind of service is common in Japan, Italy and Sweden and is under consideration in France.
10 Mbit/s are the lower limit for high bit rate transmission and correspond to digital convergence (triple play).

Internet access *Data uploading* *Interactive TV*

With 100 Mbit/s all applications currently known are usable simultaneously. This rate is considered as very high bit rate transmission today …. But not indefinitely.
Evolution of needs shows that in future 100 Mbit/s will be considered as high bit rate transmission.



2. « HIGH BIT RATE TRANSMISSION » THE CHALLENGE

High bit rate transmission is not only a technological innovation which allows a few specialist individuals the ability to web surf
Its development and extension are revolutioniizing the lives of everyone at all levels (professional, individual, social, cultural, …).
Purchasing from home a movie of DVD quality, taking part in a conference with people living in far-away countries without moving ……

2.1 New developments for health and social activities

Whilst still under experiment in France, applications which could offer good quality services for health to all regions are clearly of great interest

- ***Video-conference for patients:***

In the Franche Comté region, since 2001, the health of patients and victims of accidents has ben improved using video-conference. Some 500 costly transfers have been avoided.
During this period video-conference has generated a saving of 1 million Euros
The treatment of cancer by chemio-therapy has been rationalized and organized in the region providing a saving of 800 000 Euros

- ***High bit rate transmission for medical services :***

Operating on a patient located 6 200 km away is possible : In September 2001, in a 'World's First' French Professor Jacques Marescaux located in Strasbourg, operated on a patient located in the USA using a high bit rate transmission network coupled with the ZEUS robot developed by Computer Motion (California).

- ***R&D project : assistance to old people at home***

Population ageing, new policies for health, evolution of technologies … mean that assistance to elderly people at home becomes an important objective in terms of economic and social issues
The spread of Internet, the rate increase, the merge of tele-medicine contribute to the development of new projects for the quality of life of elderly and dependent people.

2.2 Optimization of R&D and teaching

Paris VII University exchanges teachers and Students with USA, KOREA, without leaving Paris. The teacher speaks to French students directly from New Jersey. The video presents a very good quality and the voice is perfectly synchronous using the RENATER network linking all French universities to other universities abroad. The teacher can see the French students live. The communication is perfectly bi-directional and the distance is forgotten ….

Teachers, students, R&D teams are using high bit rate transmission for application sharing in real time, data sharing, interactive communications, ….Courses are immediately available by streaming (VOD).

All these advantages provide cost savings (travel costs …) without affecting the quality of teaching. Simultaneous access to data banks, sharing of complex calculations between computers located around the world, real time exchanges, …. Provide greater efficiency and new possibilities not previously existing
The Renater network is an optical network offering generally 2,5 Gbit/s and 80 Gbit/s in the Ile de France region (around Paris). This network exists … it's not fiction ….

2.3 Local initiatives for a more competitive France

- ***No development without high bit rate transmission !***

Interview of Mr Philippe LEGRAND, Director of the « Manche Numérique » syndicate.

Manche Numérique (MN) shows that the Manche region wants to develop all digital infrastructures. All cities and villages, and the region itself have given the responsibility to this syndicate to manage this development.

MN pilots technical and political aspects, i.e. :
- best and long term solutions for high bit rate transmission and services offers,
- development of applications for the region.

We have selected the optical fibre as the best choice because technologies and bit demand move and increase very quickly and because we need a long term solution. In the next 15 years the optical fibre will be still the best medium ….

So we have installed 650 km of ducts and optical cables. Our syndicate is not allowed to supply services. So we bring the optical fibre everywhere towards existing buildings of operators in the cities. In rural areas we also install active equipment

The 1st step is almost finished (600 km installed). We are working on the 2nd step with an expected time of 15 years. An operator will ensure the maintenance and the extension of this network, install active equipment and sell bandwidth to service operators.
In the same time, the 3rd step begins : development of services, such as « intelligent home », …..

It was important to react for the region … If not, after 5 years our region would be out … So we needed a long term plan to anticipate the evolution of needs. All local communities have the same problem. Today 43 local authorities (departments) have the same strategy.
We have saved 13 million euro with the actual cost being 22 million euro. If we consider a final cost of 30 million euro amortized over 15 years, it represents each year only 0,66 % of the annual budget of the region. If we add all annual costs (using, maintenance, …) it represents a total of less than 1% to give to the region a structure for the long term. All risks and benefits are shared between the region and the private operators.

- ***High bit rate transmission everywhere, for everyone and for life !***

Interview of Mr Patrick WEITEN, Vice-President of the general coucil of Moselle.

Many parts of MOSELLE were not equipped, even with ADSL. The Moselle department includes both urban and rural zones. Political people from Moselle come generally from rural zones.(note – not sure if the meaning is correct here – political people?)
Moselle department (the biggest department of the LORRAINE region) has to merge with Vosges, Meurthe et Moselle and Meuse departments, with ALSACE region and with LUXEMBURG and GERMANY. Every day 60 000 people from the Moselle region go to work in LUXEMBURG and GERMANY.

The 2015 MOSELLE project has 2 objectives :
- to make the department attractive,
- to maintain its population

by developing a high bit rate infrastructure, with all means of communication (railways, highways, airports, …).

The Moselle department will be the owner of the network infrastructure.
1st step = political decision = no people at more than 15 km from the infrastructure → requires a loop of 600 km with optical fibres eventually completed with WiFi or other technologies.
Municipalities are in charge of the distribution network. For the less attractive zones (rural zones) it has decided to link all secondary schools (96). All industrial areas (56) have been also linked.
The intial loop of 600 km reaches now 924 km and each person of Moselle is at not more than 4 km from the optical fibre.
The budget was 83 million euro. 55,5 million euro was utilised on the infrastructure using, wherever possible, existing ducts or deployment along the roads (80 % of the network). Moselle department budget is 800 million euro/year. The amortization (ROI) time is 25 years, so the cost is only 2 million euro/year.
During the deployment along the roads we have buried several ducts for the future (to save money).
Now 30 cabled networks (public corporations or grants) are operating. More than 60 % of the population have 2 plugs (1 for TV, 1 for phone). Providers are now ready to distribute Internet on these networks after unbundling.
The deployment of the infrastructure will be finished in 2006.
We now have to think about services (video survey, local TV, links between administrations, links between secondary schools, universities, medical assistance for old people at home, cultural activities, data exchanges for entreprises….) and to link our network with Luxemburg and Germany.

- ***An extraordinary tool for development !***

From Mr Alain GERARD, senator of Finistère department.

In the near future optical networks in the 21st century will be, like railways in the 19th century or like phones in the 20th century, a fabulous tool for development. The most

important is to have a good telecommunication infrastructure on time. An industrial area will disappear quickly if not equipped.

So we have decided to equip the city of Quimper and the surrounding region locally with a very high bit rate internet network. In the next 10 years no entreprise will be able to live without this type of network and if entreprises desappear it means the death of the region.
The region also wants to attract high tech entreprises.
Now the French power utility has installed wrapped optical cables on aerial power lines and all the region is covered with optical fibres.

2.4 The leisure market : exponential needs

- ***Uploading of twenty five holidays pictures with digital quality***

For instance 25 pictures taken with a standard camera (3 million pixels) need 25 x 800 kbytes → 20 megabytes = 200 Mbits.

The uploading time depends on the connection :

Connection type	Uploading time
100 Mbit/s	2 seconds
10 Mbit/s	20 seconds
1 Mbit/s	3 mn 20’
512 Kbit/s	7 mn
128 Kbit/s	30 mn

- ***Uploading of a movie with DVD quality***

For instance for a compressed movie of 7.18 Gbytes the uploading time depends on the connection :

Connection type	Uploading time
100 Mbit/s	48 mn
10 Mbit/s	8 hours
1 Mbit/s	16 hours
512 Kbit/s	1 day and 8 hours
128 Kbit/s	5 days and 8 hours

- ***A normal evening at home with Mr and Mrs DURAND and their 2 childrens***

Mr DURAND looks at a soccer match on the TV (in digital quality) → need : 4 Mbit/s.

Mrs DURAND looks at musical video clips using video on demand connexion → for 2 hours → 7 Gbytes meaning 9,7 Mbit/s during the viewing period. If she wants non stop during this time, it will necessary to upload the next 6 seconds of viewing before the end of the preceeding 6 seconds she is viewing. If a quarter of the theorical bit rate transmission is really available the real need will be 38.8 Mbit/s.

The 1st child calls by phone a friend living abroad. With VoIP we need only 64 Kbit/s (in fact 256 Kbit/s, if only a quarter of the bit rate transmission is available)

The 2nd child uploads music (3 Mbytes under MP3 coding for 10 songs) → with a 1 Mbit/s connection the uploading time will be 20 min.

So, the total need is :
4 Mbit/s (Mr DURAND) + 38,8 Mbit/s (Ms DURAND) + 1 Mbit/s (2nd child) + 256 Kbit/s (1st child) = 44 Mbit/s

The most important challenge is triple play, meaning all applications (voice, data, video, TV, …) simultaneously on the same infrastructure.

Applications are numerous and various when the capacity of transmission is very high, i.e . : video games, high definition TV, exchange of pictures and music (peer to peer), email, videophone, data sharing …. Only FTTH is able to achieve that with a capacity of 100 Mbit/s and more ….

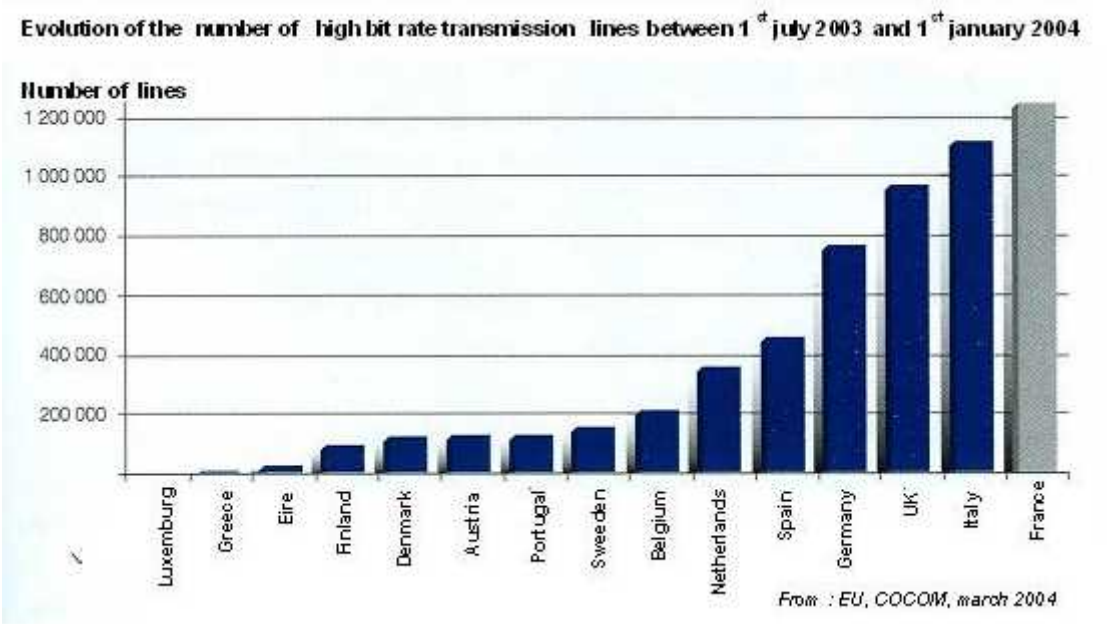
This migration towards FTTH needs intermediate steps such as ADSL using telecom copper pairs or coaxial cables (CATV). But these intermediate technologies are limited as explained before. With ADSL we can have only, in the best case, medium bit rate transmission.

We also have to distinguish major infrastructures where optical fibres are absolutely necessary and residential cabling where actual terminals are not adapted to optical networks at the present time. But the challenge is to bring the optical fibre progressively nearer the subscriber. Solutions exist to do that at the best cost and without affecting the quality of the infrastructure (see 5.1).

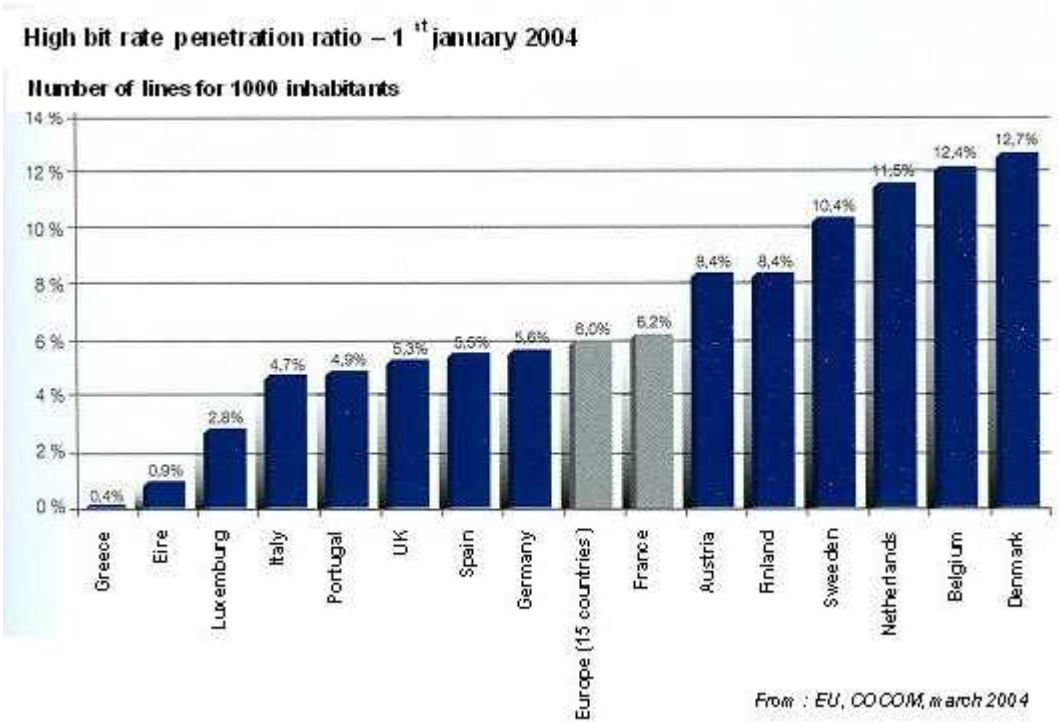
3. FRANCE POSITION IN THE CYBERWORLD

3.1 Evolution in France

During the 2 last years, when 128 Kbit/s and 512 Kbit/s were considered to be high bit rate transmissions, France had to make up for lost time to be at the same level as its economical partners for the development of high bit rate transmissions. Now France presents the best improvement in Europe.



Whilst this evolution is important, our country is just at the medium level in Europe and very late if compared to Belgium, Denmark or Austria.



- ***What high bit rate ?***

There no official definition for « high bit rate transmission ». Today in France there is some confusion between high bit rate transmission and ADSL.
In Korea, Japan, USA, Sweden and many other countries, the minimum for high bit rate is considered as 10 Mbit/s at least.
France has a few high bit rate networks and has mainly 512 Kbit/s networks. So the disparity between urban areas and rural areas is very important and many applications used abroad are impossible to use.
If we consider what is done abroad, 1 Mbit/s corresponds to medium bit rate. Today 10 Mbit/s are the minimum to have services offering the minimum quality.

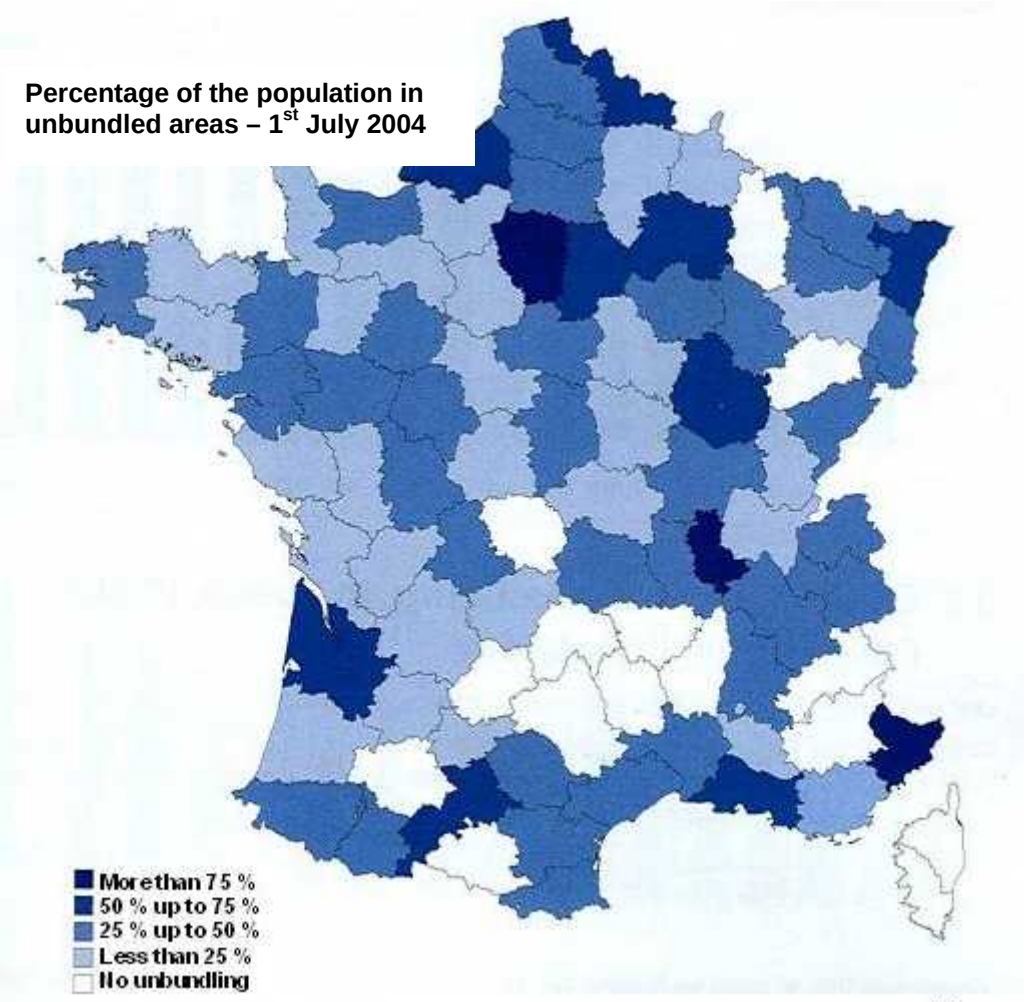
- ***What about France ?***

Studies from TACTIS and IDATE have shown that many areas in France are not covered with high bit rate communications. It seems that we have inverted the ratio needs / infrastructure. Advanced countries (Sweden, Denmark) are correctly covered for historical and practical reasons. With low population count and difficult physical communications during a long period each year, these countries (it's the same for Canada) are fore-runners for cabled infrastructures. In France cities have been the first to access to the internet at the expense of rural areas , even if access to internet for rural areas, is a good opportunity to provide services with added value.

The following map shows France unbundling in the Summer of 2004. Even if the traditional operator has only forgotten the Lozère department for ADSL, we can see big differences between areas in terms of bit rate coverage.

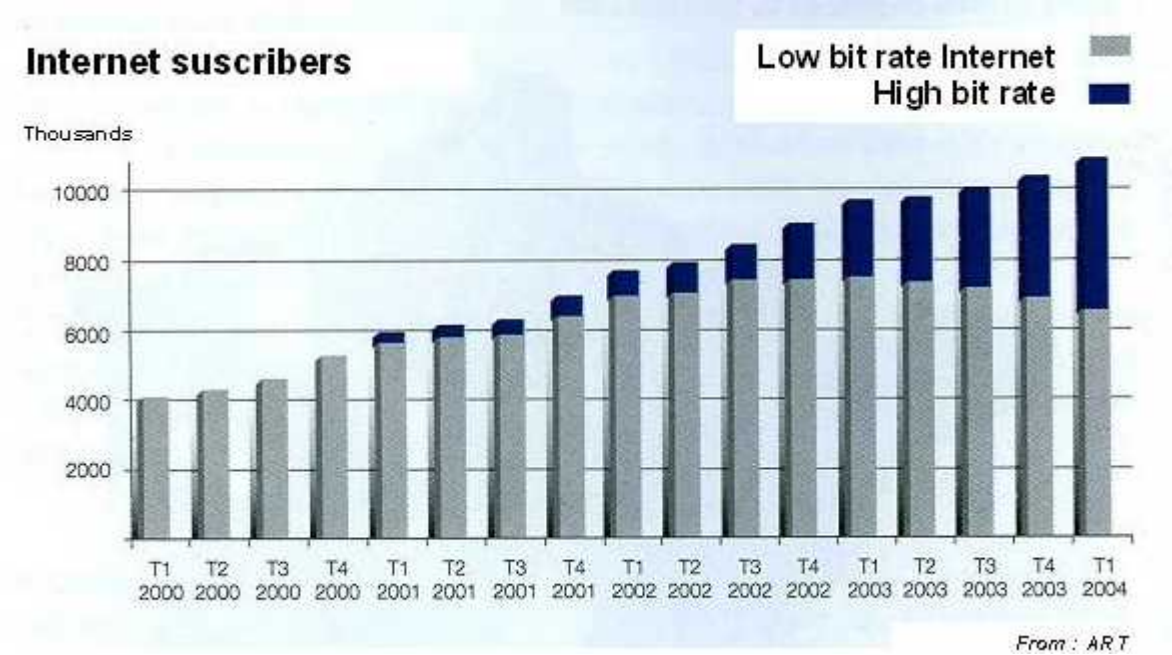
Between cities with 100 000 people or more and the rest of the country, the difference is very important. The digital breakdown is well known
This difference is worsened because the lower performance accesses are expensive. For instance in the Savoie department, a 512 Kbit/s subscription costs 36 Euros/month, and in Paris a 8 Mbit/s subscription is cheaper.
Access to high bit rate becomes the 1st priority for the management of the territory.

Percentage of the population in unbundled areas – 1st July 2004



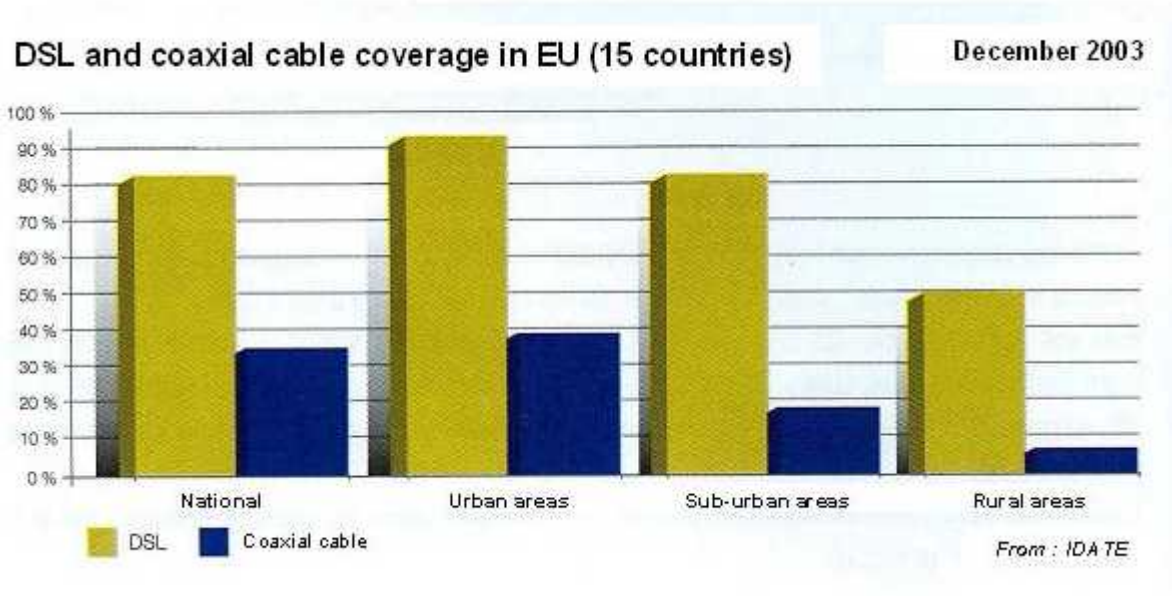
From : ART according to informations given by France Télécom about repartitors supplied to unbundling operators.

The number of high bit rate (according to the actual definition = ADSL) subscribers is given hereunder.



3.2 In Europe : Luxemburg, Sweeden, Italy, Germany, UK

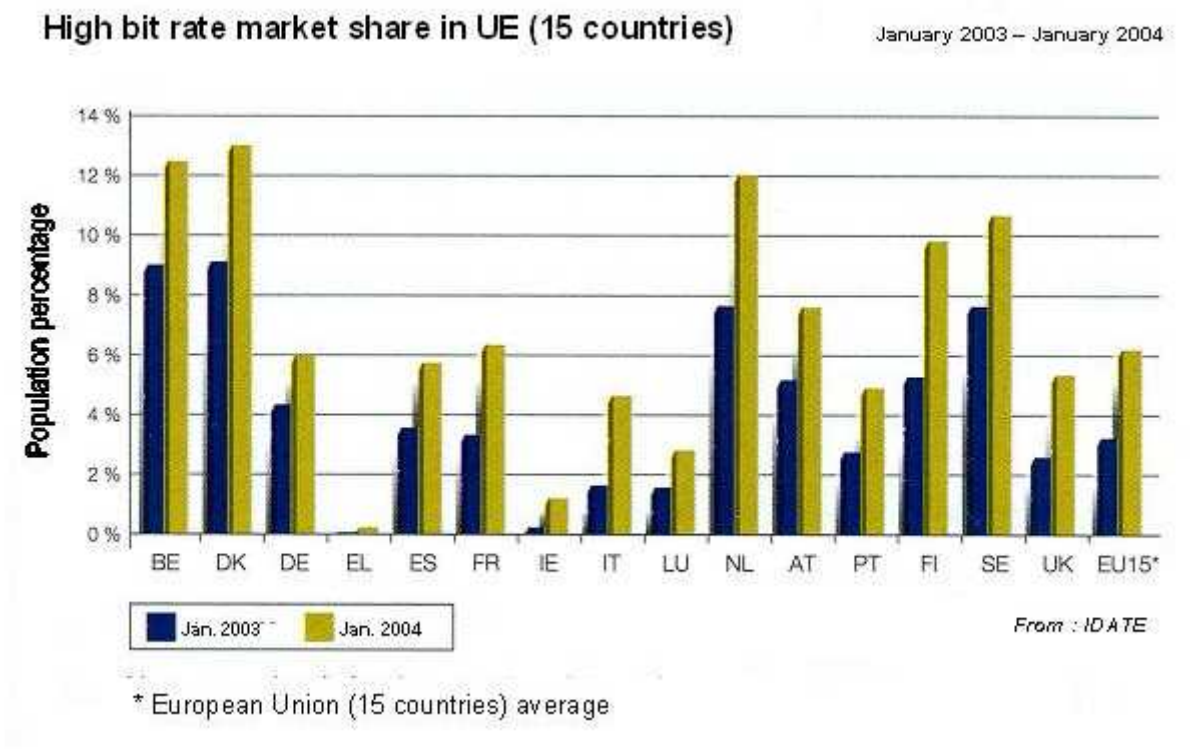
Tendancies in Europe : development of ADSL, slowing down of coxial cable, starting of FTTH. During the European Congress for Telecommunications in 2003, some information about DSL coverage was published (see hereunder) showing in urban and rural areas development of ADSL and slowing down of coaxial cable.



In this figure we consider :

- Urban areas : more than 500 inhabitants / sq km
- Sub-urban areas : 100 up to 500 inhabitants / sq km
- Rural areas : less than 100 inhanitants / sq km.

We can also compare the high bit rate ratio as actually defined in France (< 10 Mbit/s) with other European countries. This ratio corresponds to the percentage of people having access to the high bit rate versus the total population. This tool is frequently used to compare countries, but it does not have the same significance in all countries in terms of bit rate transmission. The European Union has published the following figure :



- ***In Sweden***

With more than 600 000 subscribers from 1 up to 10 Mbit/s, Sweeden was in the top position in the world.
Today more than 95 % of municipalities are linked to high bit rate.
The Swedish government has instigated several tens of FTTH projects for 200 000 homes linked with 100 Mbit/s and more.

- ***In Italy***

2 700 000 homes are connected to high bit rate but with a large range of technical solutions. For instance people living in the biggest cities can access services, audio services and Internet on a 10 Mbit/s optical network. 200 000 homes are today connected and the annual growth is higher than 10 %

.

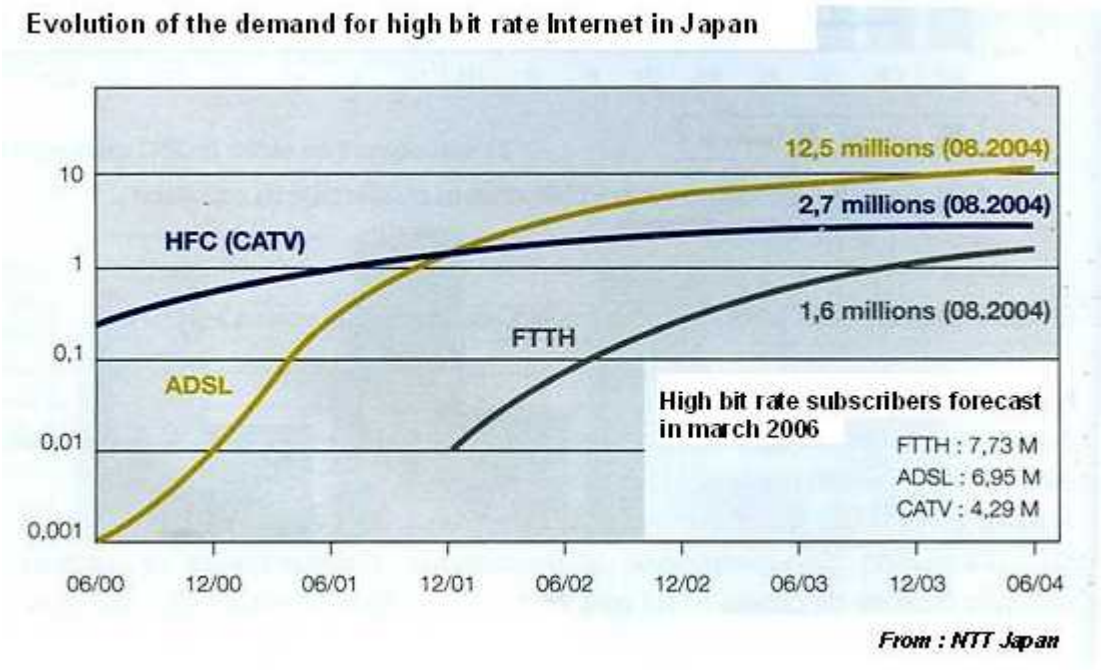
- ***In Germany***

5 500 000 homes have 1 up to 10 Mbit/s. ADSL represents 24 % of high bit rate solutions.

3.3 Around the world : Japan, South Korea, USA, …

- ***In Japan***

To reduce the difference with other industrial countries at the beginning of 2000, Japan decided to deploy high bit rate optical networks. With more than 1.6 millions 100 Mbit/s FTTH subscribers Japan is now the world leader. If DSL (12.5 million subscribers) and CATV (4 million subscribers) are still the most important, their evolution is slowing down. According to the Japaneese government, there will be 8 millions FTTH subscribers, 7 millions ADSL subscribers and 4 millions CATV subscribers in March 2006.



So, with 70 million km of optical fibre installed, Japan is now living in a FTTH world, providing 100 Mbit/s to most of its susbscribers for an extra cost of 10 Euro/month if compared to 10 Mbit/s ADSL.

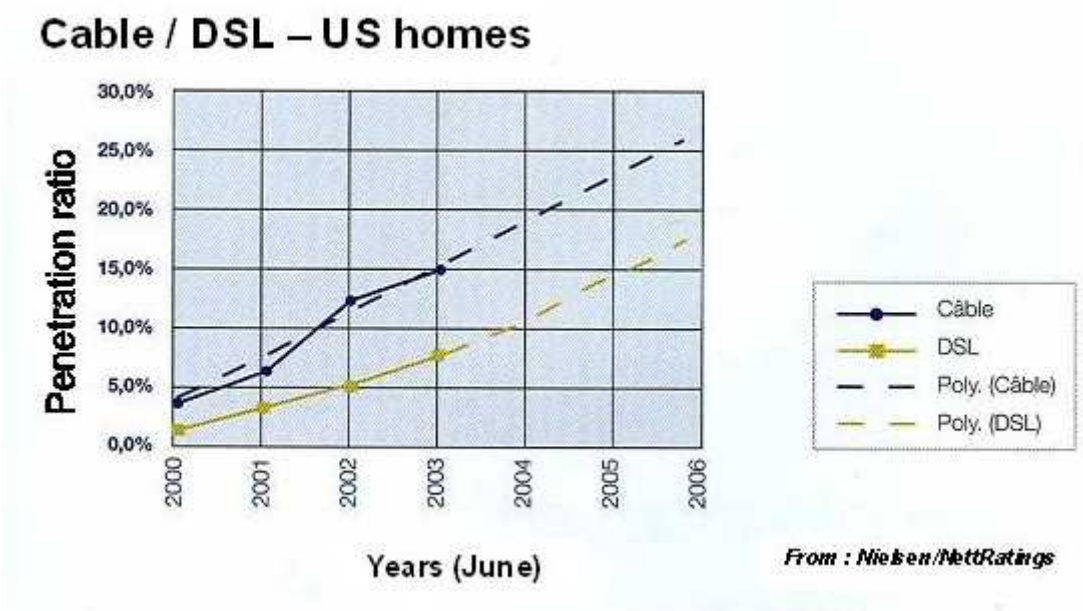
- ***In South Korea***

The government has instigated the deployment of a dense optical fibre network in this country of 48 million people. 61 % of the population is connected to the Internet. With more than 6 million high bit rate subscribers (including 4 million with ADSL, 2million with 20 Mbit/s VDSL and 500 000 with optical fibre), 95 % of connections are high bit rate transmissions.
For Mr Yong Kyung Lee (President of Korea Telecom), the target is 100 Mbit/s for each Korean in 2010.

- ***In USA***

40 % of the population is connected to high bit rate services, mainly using coaxial cables as opposed to Europe where ADSL solutions are the most widely used.

The following figure shows the future evolution of high bit rate in USA.



At the end of 2003, more than 300 000 homes were FTTH connected and several operators have decided to deploy all optical networks. The VERIZON project forecasts 1.7 million homes FTTH connected at the end of 2005.

- ***Don't forget China***

China has become the main supplier of manufactured products for developed countries, but also a big competitor for new technologies. Completely new companies with very rapid growth have appeared in the telecom business. The quick evolution of mobile phone (the most important one in Asia) shows that China will become a big competitor for high bit rate solutions in the near future.

4. A WIDE RANGE OF TECHNOLOGIES

Many technical solutions are available. But not all solutions are able to deliver high bit rate, secure transmission, with good quality of service and long term investment returns.

4.1 Wireless solutions

Several wireless solutions are available :
- radio local loop is mainly a metropolitan technology (MAN) linking an optical fibre trunk to the final subscriber
- WiMax can also be used for MAN
- Satellite is dedicated to particular cases
- Wi-Fi is mainly used for local networks (LAN).

- ***Radio local loop***

Like Wi-Fi, the radio local loop uses radio transmission. 2 bandwidth ranges are used :
- 26 GHz range
- 3.5 GHz range.

For operating at 26 GHz with 100 Mbit/s, antennas with direct view are necessary for point to point coverage.
So for 100 Mbit/s it is necessary to have many poles for use dedicated to the operator. This solution is not considered viable in terms of economy and environment impact.

4 Mbit/s per subscriber are possible if operating at 3.5 GHz.

Advantages :
- As for satellite this solution is interesting for the coverage of areas difficult to access.

Disadvantages :
- Low bit rate transmission
- No evolution possible
- Very expensive.

The radio local loop is a good solution only for small entreprises located in areas without any access to other solutions.

- ***WiMAX (Worldwide Interoperability for Microwave Access)***

WiMAX is a wireless broadband technology according to IEEE 802.16 standard.
As for WiFi the bit rate is distributed by radio from a terminal and the bandwidth is shared between the subscribers.

WiMax brings :
- broadband up to 75 Mbit/s to terminal and reaches 20 MHz (but generally regulation limits this to 10 MHz, so the maximum bandwidth is lower),
- coverage for mobile applications,
- a theoretical maximum coverage of 50 km (best case), but with low bit rate transmission (a few Mbit/s).

Practically, the coverage is 5km up to 15 km (depending on system used) and the mobility is limited to urban uses with a maximum car speed of 60 km/hour.
Even if, in some particular areas, the coverage ratio can reach 90 %, it is generally limited to 50 % in rural areas.

So WiMax is mainly a complementary solution to fixed and mobile access networks for areas with low population where the deployment costs of ADSL or FTTH are too high. WiMax cannot bring real high bit rate transmission as FTTH is able to.

- ***Satellite***

This solution uses satellites located 36 000 km above the earth. The new DVB-RCS standard proposes bi-directional communications (satellite ←→ subscriber). But as WiFi the bit rate is not symetrical, is limited and shared between subscribers in the covered area.

Advantages :
- interesting for the coverage of areas difficult to access.

Disadvantages :
- limited to 5 Mbit/s
- high cost subscription (about 150 Euros/month for 2 Mbit/s)
- many applications (videoconference, games on line, …) need high speed communication between the subscriber PC and the server. With 36 000 km between the satellite and the subscriber, the propagation time is important and not compatible for a good inter-activity.

- ***WiFi (Wireless Fidelity)***

WiFi is a wireless solution according to the IEEE 802.11 standard.
WiFi bit rate is distributed by radio from a terminal and the bandwidth is shared between the subscribers. The terminal itself is linked to an optical network. The confidentiality of information is not warranted and physical obstacles can create dark areas necessitating an increase in the number of antennas. Several WifI types are available as described in the table hereunder.

	802.11a		802.11b		802.11g	
Distance of coverage	1 m	120 m	1 m	60 m	1 m	60 m
Maximum bit rate (shared between customers)	54 Mbit/s	1 Mbit/s	11 Mbit/s	1 Mbit/s	54 Mbit/s	1 Mbit/s

Advantages :
With WiFi :
- it is possible to quickly increase the coverage towards the subscribers,
- there is no need to install a new cable if a new access point is required.

Disadvantages :
- shared bit rate transmission : If ten subscribers are simultaneously operating on a 802.11 b access point, they only have 300 Kbit/s each.
- there is no securitization of the network.

WiFi is mainly usefull for the capillarity of the networks, for example, hot spots applications (WiFi in public areas, such as railway stations, museums, bars, ….). however, Wifi is not interesting if it is not connected to a high bit rate network.

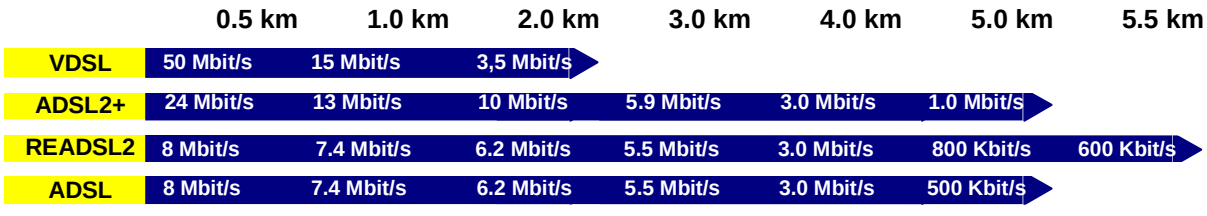
4.2 Cabled solutions

It is important to differentiate optical technologies from DSL technologies, mainly because their potential applications are different.

DSL technnologies using copper pairs or Internet using coaxial cables are only temporary solutions before the arrival of real high bit rate solutions. Generally, nobody would say that these solutions are able to offer extremely high bit rate transmission over long distance such as optical fibre. However for the last mile, these traditional copper solutions are adapted for the migration of existing networks towards FTTH.

- ***XDSL solutions***

When a signal is modulated up to the maximum level acceptable for copper cable the bit rate increases significantly (innovation of US Berkeley University in the years 90). But it means, for copper cables initially designed for a few Kb it/s, a resultant increase of the attenuation and a decrease of the bit rate as the length increases.
Therefore, as the distance between the subscriber and the POP (transition between copper and optical cable) increases, the bit rate decreases.
The figure hereunder shows, for the different DSL solutions and different distances (and attenuations of copper pairs), the different bit rate obtained (here, diaphony problems are not considered).



Theorical values

Advantages :
- The nearer the optical fibre is to the subscriber, the higher the DSL high bit rate .
- DSL technologies use existing cables (copper telecom cables).

Disadvantages :
- DSL technologies do not work without optical fibre being no more than 5 km from the subscriber.
- Asymetrical transmission (downstream higher than upstream).

DSL technologies are good, but temporary, solutions before the arrival of optical fibre solutions (FTTx) bringing bit rate transmission acceptable on the short term if the evolution towards higher bit rates is planned using optical fibres .

- ***Coaxial cable solutions (CATV)***

These solutions use existing coaxial cables dedicated for TV distribution. The optical network is extended towards the subscriber using coaxial cables. But, at the opposite of DSL technologies, cable is an arborescent network. So each subscriber has to share the bit rate with others.
Maximum bit rate is about 30 Mbit/s if the optical fibre is located at 1 km maximum from the subscriber.

Advantages :
- use of existing coaxial cable (mainly in big cities)

Disadvantages :
- cheaper than DSL solutions,
- shared bit rate transmissions.

Coaxial cables are installed for many years for TV distribution and are frequently used (for instance in USA). But as for xDSL solutions, coaxial cable solution depends on the distance between the optical network and the subscriber. The bit rate is always shared and limited by the number of subscribers connected at the same time.

- ***Power cables***

Carrier currents use power cables to transmit information. The theorical bit rate is about 10 Mbit/s. However, the power network configuration needs very expensive restoration. These technologies are very sensitive to interferences from surrounding equipment.
At each transformer 20 KV/220 V level, a high bit rate imput is necessary. From each transformer the bit rate is shared (power distribution = arborescent network).

Advantages :
- the support exists everywhere
- easy for indoor cabling (at least one plug/room).

Disadvantages :
- high cost of the power network restoration,

- necessity to bring high bit rate transmission at each transformer,
- interferences
- low bit rate transmission really distributed (a few Kbit/s) because the bandwidth is shared
- limited distances covered (attenuation of the network).

This kind of application is more suitable for the domestic environment. The higher the bit rate, the less is the interest of this solution.

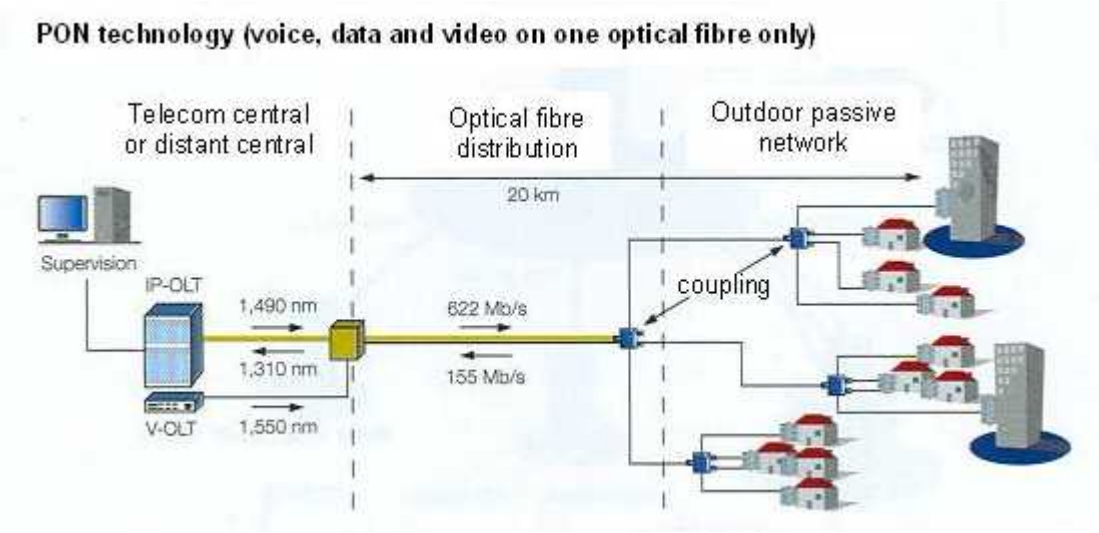
4.3 FTTH solutions

FTTH means optical fibre in subscribers' homes. So, at this step, there are no more temporary technologies (xDSL, coaxial cable, …) but only optical fibre.
Therefore bit rate transmission is symetrical (upload and download), not shared, and can reach from 10 Mbit/s up to several thousands of Mbit/s for each subscriber. If FTTH is very rare in France, it is expending very fast in other countries (Japan, Korea, USA, Sweden, ...).
An optical network includes optical fibre and active equipment dedicated for the modulation of the signal. The problem is easy to solve : the higher the bit rate and distances, the more the signal has to be amplified and modulated using inserted active equipment.

Several designs of networks are proposed :

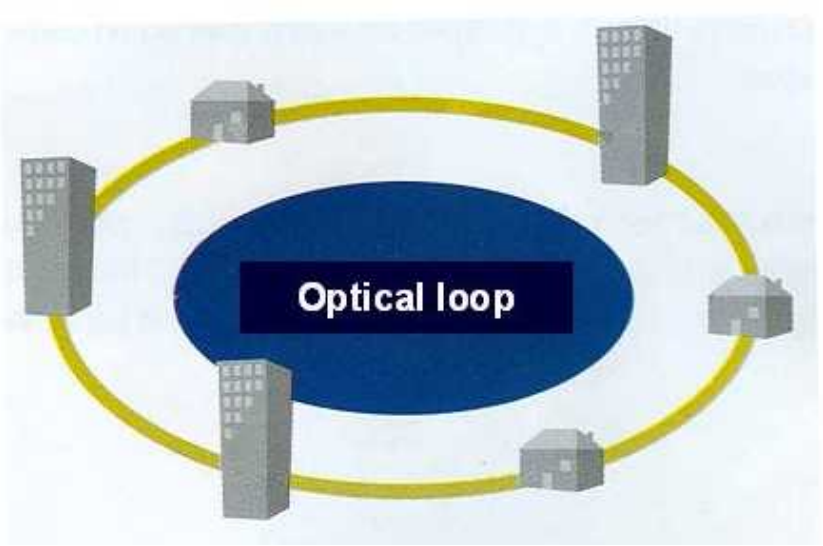
- ***Passive network : PON (Passive Optical Network)***

Nowadays, it is easy to cover a distance of 20 km without intermediary amplification. So the principle of passive networks is to use this possibility and to make cost savings for the last mile (no active equipment).
These networks having an arborescent architecture can deliver to each subscriber 10, 100 or 1000 Mbit/s. They are successfull in many countries.



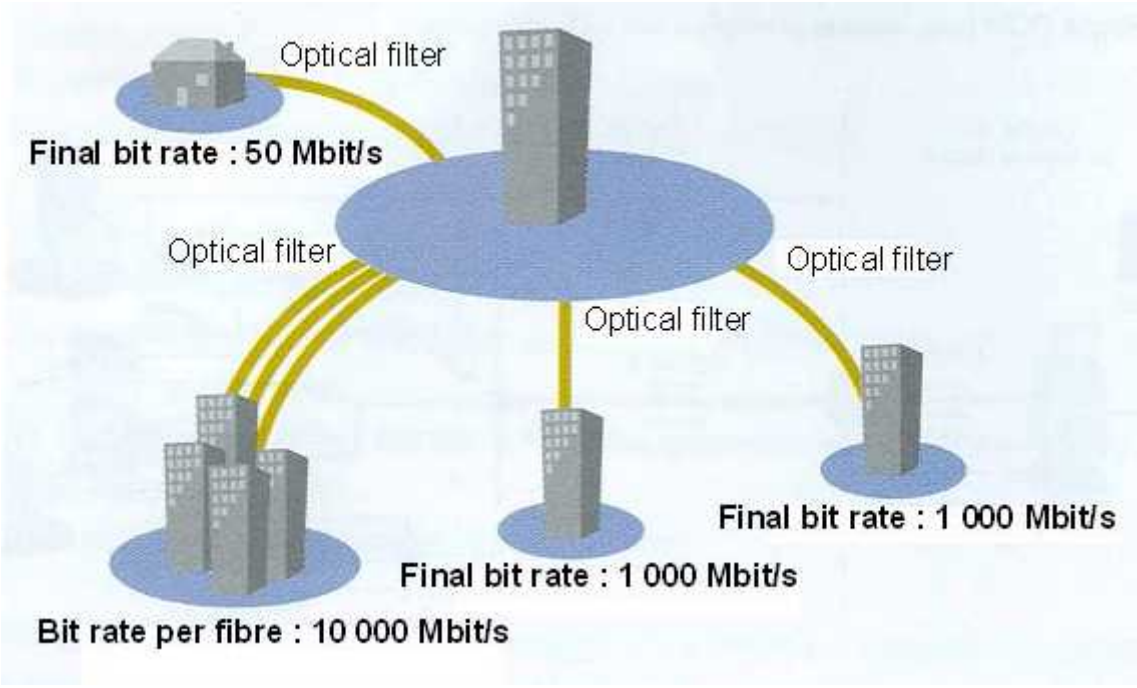
- ***Loop network :***

On a loop network, amplifiers and modulators are distributed in order to have high bit rate transmission in the loop (up to several millions Mbit/s). Each subscriber linked to the loop can access to a part of this bit rate (from 10 up to several thousands Mbit/s). Actually, loops are mainly deployed in professional areas (for instance in the Paris La Defense business offices). This design is very interesting because no more new network is required to connect a new subscriber.



- ***Star network :***

The principle is to bring at least one fibre to each subscriber. So each subscriber has its own dedicated optical fibre.



In fact, these 3 types of optical networks are frequently combined.

To summarize :
FTTH networks are the only network offering many advantages :
- long term behaviour and evolutive technologies for several tens of years,
- easy to modulate
- compatible with all applications
- adapted for triple play
- today a 48 O.F. cable is cheaper than a 56 pair copper cable.

Disadvantages :
- On the short term the investment is higher than for DSL technologies, mainly if important civils works are needed. But FTTH networks can be amortized over a very long period because of their very long term integrity.

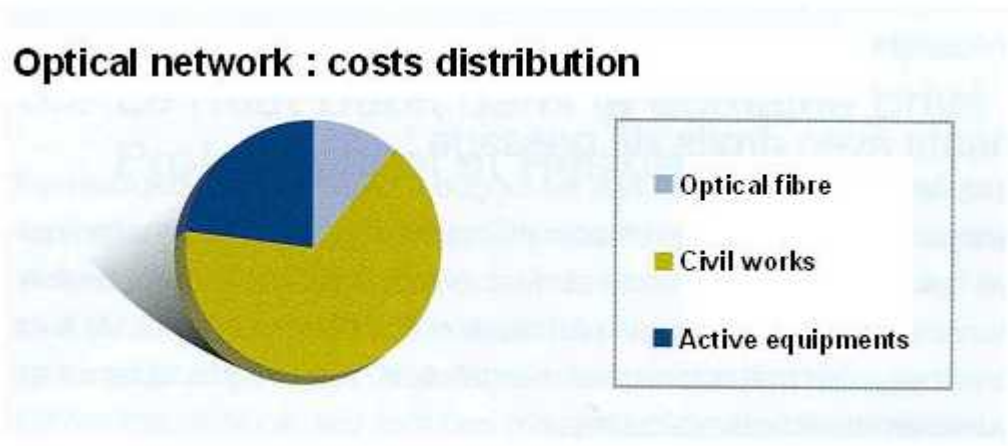
5. INFRASTRUCTURE: THE HEART OF HIGH BIT RATE TRANSMISSIONS.

There are two fundamental principles :
- There is no solution to bring real and evolutive high bit rate to the subscriber without optical fibre on long distances and offering real long term integrity,
- it is less expensive to install an optical cable than a copper cable (used for telephone and xDSL) or than a coaxial cable (used for TV and Internet).

5.1 Problems for deployment in public areas

- ***Civil works are an important consideration :***

The distribution of costs of a new telecom network is described herehunder.



The total cost of an optical network is mainly linked to civil works and installation.
Different solutions are available for optical fibre cable installation and have been implemented for cost installation optimization.

They are suitable for all installation environments :

- ***Aerial cables :***

Aerial installation is a good solution to reduce significantly installation costs. Existing infrastructures such as power lines (several hundreds of thousands km of extra-high, high and low voltage aerial power lines) and such as telecom lines can be used, mainly in rural areas.

- ***Installation with civil works:***

Most frequently , works have to be made to install cables underground. Different techniques are possible :

→ Installation in burried ducts
- Resistant and very usefull, ducts are compatible with all types of ground and can make it easier for future re-interventions.
- Most of the cables installed in urban areas are laid in ducts : these existing ducts can be re-used for optical cables.

→ Direct burial
- Interesting for low cost and fast installation in rural areas.

→ Micro-trenchs or grooved trenchs
- Trenches with a few centimeters depth and width are made in the ground to allow installation of optical cables. These new technologies in the civil works domain are suitable for rapid, low cost deployment in rural and urban areas without damage to the environment. However all civil works companies are equipped to do that.

- ***Installation with rights of way:***

Sewers, underground, water pipes, gas pipes, etc …. Installation with rights of way consists of using existing infrastructures for a quick and low cost deployment with the minimum of environmental impact. In this case, optical cables have been optimized for the different methods of installation and appropriate laying techniques have been adapted or developped (for instance laying robots).

Several types of rights of ways can be used :

→ Sewers
- all houses are linked to sewers in urban areas
- reduce the need for major civil works
- suitable for fast installation

→ Water pipes and gas pipes
- exist on a large scale
- with optical fibre → possibility of permanent survey of pipes (leakage survey, …)

→ Aerial power lines
- all houses are linked to low voltage power lines in rural areas
- reduce the need for major civil works
- suitable for fast and low cost installation

→ Rivers and canals
- low cost installation
- large areas covered (the european fluvial system is very important)

→ Transport infrastructures (highways, railways, underground).
- these infrastructures cover a large part of Europe
- no need of specialized civil works.

These deployments are not expensive and have no negative impact on the environment. They are more and more used, mainly in urban areas where civil works costs are higher. Their impact on road trafic is lower than with traditional civil works.

5.2 High bit rate transmission in the private domain : professional cabling and home cabling

The responsability of telecom operators is limited to the deployment of high bit rate networks in the public domain (near houses, plants and offices). Knowing that the quality of the service is linked to the lower bit rate at the subscriber, it is important today to ensure the continuity of high bit rate transmission in the private domain.
Different technologies and standards exist :

- **For professional use :**

For more than 20 years, companies consider that information exchange are fundamental and essential for their development. Applications are more and more complex and now include high definition video and very high data transfer. The LAN infrastructure is evolving with several international standards available.

- **For residential use :**

Generally not taken into account but fundamental for the good quality of services delivered to subscribers, the multimedia residential infrastructure has to be on level terms with the public domain network and needs standardization. For home cabling video services have become the principal application used which require more and more bandwidth, significantly higher than those required for the telephone.

We have seen before (see Point 2) all expectations and promises given by high bit rate communications in terms of economy, culture, social and health. It is interesting to present the technical evolutions for high bit rate advantages that are available to the home subscriber.
The following information has been extracted from the « Multimedia House » document (SYCABEL – November 2004).
Among these technologies we have :

- Wireless
- Carrier currents on low voltage power lines
- Cables (telecom copper pairs, coaxial cable, optical fibre).

- **Wireless**

Solution used for the extension of an existing wired network providing advantages of mobility, but not suitable in many cases, such as :

- covered areas that may be limited by obstacles (walls, metallic elements, trees, …)
- many different systems of wireless communication not all compatible with others requiring dedicated devices (DECT, WiFi, … ;)
- limited use (risks of traffic jam + risks of electromagnetic disturbance)
- no proven innocuity of electromagnetic radiations (waiting for EMS report during 2005).

However if the emitting power is limited, jumpers can be suppressed without any health risk or for the communication security.

- **Carrier currents**

All existing low voltage power outlets can be used, however the bit rate is limited and not compatible with simultaneous transmission of several analog or digital TV channels in the UHF/VFH band.
This technology is also very sensitive with electromagnetic disturbance.

- **Coaxial cable**

Good for all TV applications and probably for the majority of the others, however it is not easy to install and not very well adapted for voice transmission.

- **Optical fibre**

The best support providing the highest possibilities (bandwidth, size, immunity against electromagnetic disturbance, ….).
In the future it will replace all other cabled systems … however it will only become highly efficient when all equipment arel designed with optical interfaces.

- **Twisted copper pairs**

Today with high quality twisted copper pairs, it is possible to transmit several analog or digital TV channels in the UHF/VFH band. So, at the present time, it is the best solution for home cabling. High bit rate cabling gives an added value to buildings and can be extended using wireless solutions on short distances.
Standardization brings security to customers.
For home cabling, the new NF C 1500 and UTE 90483 french standards define new requirements concerning installation (minimum number of outlets per room, star designed network) for access to high bit rate and quality levels (« grades ») of transmission, as described hereunder. Triple play is possible. Similar standards (i.e. EN 50173 and ISO/IEC 15018) are under study in various international committees.

Application	Grade 1	Grade 2	Grade 3	Grade 4 (*)
Telephony (analog)	●●●	●●●	●●●	⛔
Digital telephony (RNIS) and Internet	●●●	●●●	●●●	IP
High bit rate Internet	●●●	●●●	●●●	●●●
Household local network @ 100 Mbit/s	●●	●●●	●●●	●●●
Video and digital TV broadcasting (using telecom wires)	●	●●	●●●	●●●
High bit rate household local network @ Gigabit/s	⛔	●●	●●●	●●●
TV broadcasting (analog and terrestrial digital) VHF / UHF	⛔	●	●●●	●●●

●●● *Recommended*	●● *Adapted*	● *Minimal*	⛔ *Not adapted*
IP *Only for voice transmission on networks designed for Internet protocole (IP voice)*		**(*)** *Applicable only to optical fibre cables*	

6. SYCABEL RECOMMENDATIONS

Two cases can be considerd:
- green fields areas with no existing telecom network
- existing telecom networks.

6.1 Areas without existing networks

It is important to extend optical fibre as close as possible to the subscriber to access high bit rate transmissions. Curtailing the optical network a few kilometers before the subscriber using temporary solutions (DSL, for instance) does not have technical or economic justification. The optimium way is to deploy FTTH.
FTTH brings long term behaviour, security and is not more expensive than temporary solutions (DSL, …).
In these areas, civil works are the main cost of the deployment whatever the cabled solution installed. A directory letter from the french Minister of Transport and Equipment (january 2005) to Prefects recommends the use of existing ducts in order to facilitate negociations between operators and local authorities and to optimize costs deployments of new optical infrastructures.
Building of the network needs a signifcany amount of manpower and therefore can create local jobs for installation, maintenance and exploitation.
When the network is operating, its owner (local authority, etc …) can benefit quickly with regards to investment returns : added value with the multiplication of applications, with new services, news entreprises …. This network can provide all the necessary tools for the maintenance and development of economical , cultural and social activities.

6.1 Areas with existing networks

Large cities frequently have an existing local optical network (MAN) and use alternative solutions to provide bit rate in the last mile.
XDSL and coaxial cables solutions are temporary solutions when networks migrate towards high bit rate transmissions.
In the short / medium term, it will be necessary to bring the optical fibre to the subscriber (FTTH). But it is possible to migrate using successive steps to increase the bit rate transmission, bringing the fibre nearer and nearer to the subscriber.

For instance :

Distance between subscriber and optical fibre	Solution and performance
5 km	ADSL – 1 Mbit/s per subscriber
3 km	ADSL2+ – 5 Mbit/s per subscriber
2 km	ADSL2+ – 8 Mbit/s per subscriber
Less than 1 km	VDSL – 54 Mbit/s per subscriber

Other solutions are also used (PON network, coaxial cables for the last meter, …).

In order to begin the 21st century in the best condition, it is important to have infrastructures on equivalent levels taking into account the following criterias :

- optical loops sized for the migration to FTTH,
- optical fibre nearer and nearer to the subscriber
- preparation of a financial plan over several years to prepare network migration
- existing homes, plants and offices to be upgraded (new buildings are supposed to be according to new french standards) with evolutive pre-cabled infrastructures
- opening all regulations and laws encouraging infrastucture investments (coverage of the territory, pre-cabling of new buildings, restoring of existing buildings, …).
- wide-scale promotion of high bit rate applications and of associated technologies considered as a good catalyst for economic development.

CONCLUSION

The growth and development of economies is not only linked to highways and TGV, but also to an efficient communications networks including very high bit rate networks for all up to the subscriber home.

If compared with all existing technologies available, optical fibre is the only one real option to achieve high quality and unlimited bit rate access for professionals and individuals alike.

Contrary to current opinion, FTTH investment is very important and is the only option to provide long term behaviour and evolutivity for several decades.
It will provide support to telecom industries and dynamism to local economies.

FTTH is the infrastructure needed for France for :
- the development of access to culture, education and services,
- a better security of the population and of the territory,
- social and industrial innovation,
- disparition of enclaved areas,
- and tomorrow, to warranty its economical growth and influence in Europe and in the world.

SYCABEL white book aims to highlight that high bit rate communications are necessary : 5 – 10 – 100 Mbit/s everywhere and for everyone between 2005 and 2010 (see BEFFA report).

It is a strategic stake for France and for Europe.