European Commission

Broadband: Technology overview

An overview of different wired, wireless and upcoming broadband technologies and a description of their advantages, disadvantages and sustainability.

Rural communities joined forces to bring fibre to Hamminkeln, Germany
fix-empty

Wired broadband technologies

A large range of communication technologies with different technical capacities are capable of providing high-speed internet to households. Wired technologies include copper cable (xDSL), coaxial cable (e.g. HFC), broadband over power lines (BPL) and optical fibre cable (FTTx).

Copper wires

Copper wires are defined as 'legacy telephone unshielded copper twisted pair', providing broadband connections by using xDSL-technologies, such as ADSL/ADSL2+ (max. 24/3 Mbps down-/upstream rate within max. 0,3 km efficiency range) or VDSL/VDSL2/VDSL2-Vplus/VDSL2 vectoring/G.fast (with vectoring max. 300/100 Mbps down-/upstream rate within 0,2 km efficiency range).

- **Pros:** They require relatively low investment needed for passive infrastructure (a copper telephone line is already present in most households) and are least disruptive for the end users.
- **Cons:** The high (download) speeds depend on the length of copper line. The xDSL technology is heavily asymmetrical: upload speeds are generally much lower than download speeds; this may hamper new services (e.g. cloud computing, videoconferencing, teleworking, tele-presence). Higher investment is needed in active equipment (with a life-time of 5-10 years). This may be an interim solution, yet the investment in fibre infrastructure would most likely only be postponed by 10-15 years.
- **Sustainability:** Newer copper-based technologies (e.g.: Vectoring, G.fast) can deliver higher speeds, but suffer from the same limitations. They demonstrate bridging technologies towards complete fibre optic cable infrastructures.

Coaxial cables

The classical cable connection would be the two wires of a telephone line (‘twisted pair’), most prone to disturbance effects such as interferences. Broadband internet via coaxial cable is usually offered to customers via the existing cable TV (CATV) network. The coaxial cable consists of a copper core and a copper-shielding coat. The TV cable networks are therefore much more efficient than the traditional telephone networks.

- **Pros:** This requires relatively low investment needed for passive infrastructure and is also least disruptive for the end users. This infrastructure offers slightly more opportunities to deliver higher broadband speeds than on telephone lines. Ultra-fast speeds are possible, if the infrastructure is properly upgraded and distances are kept short.

- **Cons:** The bandwidth is shared among several users reducing its availability during peak traffic periods of the day. The impossibility of unbundling makes service competition basically absent in the cable market; seldom present in the digital-divide areas. An interim solution to invest in fibre infrastructure would most likely only be postponed by 10-15 years as with copper wires.
- **Sustainability:** The implementation of new standards (DOCSIS 3.1, 3.1 full duplex) allows for higher bandwidths to end-users of up to 10 Gbps.

Broadband over power line (BPL)

Broadband can be delivered over existing low and medium voltage electric power distribution networks. BPL speeds are comparable to those of xDSL and coaxial cables.

- **Pros:** It is not necessary to deploy new infrastructure as existing power lines can be used. BPL has great future potential as power lines exist nearly everywhere.
- **Cons:** In low populated areas, the technology is only economically viable for the end user if 4 to 6 homes are equipped with transformers to make broadband available over power lines. Otherwise, end user prices for internet access surpass those for xDSL and coaxial cable solutions. There are technical challenges due to power lines being a very “noisy” environment and interference with high frequency radio communications and broadcasting.

Optical fibre

Optical fibre lines consist of cables of glass fibre connected to end-users’ homes (FTTH), buildings (FTTB) or street cabinets (FTTC). They allow for very high transmission rates of 100 Gbps and more within very wide (10-60 km) efficiency range. This is the most future-oriented solution, but requires high investment in passive infrastructure.

- **Pros:** Extremely high level of transmission rates and symmetry (Gbps and Tbps bandwidths possible), less susceptible to interference and hardly any power drop at larger distances to the distributor unlike DSL or VDSL and enough power reserves also for demanding multi-person households.
- **Cons:** High investment costs in passive infrastructure due to the high costs of civil engineering for excavation and piping; deployed infrastructure is not locatable and requires exact documentation.
- **Sustainability:** Next generation technology with capacities to meet high bandwidth demands expected in the near future.

Deployment methods

Wired broadband infrastructure deployment is a cost and resource intensive option. Reducing the costs will encourage investments in broadband roll-out and lower the threshold for market entry. This can be facilitated by accessing alternative infrastructures and utility networks and by using low-impact deployment strategies (e.g. trenching).

Installation in the ground (by trencher)

The open trench construction is a method for the deployment of supply and disposal pipes. The earth's surface is opened and a trench is excavated. For the laying of telecommunication lines, manual digging as well as construction equipment are used.

- **Pros:** The open trench construction is used in all topological scenarios and is generally feasible for all types of surfaces. The durability is very high and there is no restriction for the use of

pipes and components. Potential costs can be saved deviating from the regular depth, deploying in walking or cycling paths or using a trencher.
- **Cons:** Deviating from the normal depth increases the risk of possible cable damage in the course of construction and repair work of adjacent or overlapping infrastructures. The restoration of the surfaces is rather complex and the building environment is impaired by noise pollution and traffic disturbances. The method is costly and shows long construction times.

Trenching

A slit is milled into a road cover, an asphalt walkway or cycle path, in which microtubes are inserted and then immediately afterwards closed with a filling. A distinction is made between nanotrenching (up to 2 cm), micro-(8 cm to 12 cm), mini-(12 cm to 20 cm) or macrotrenching (20 cm to 30 cm) and the used cutting or milling technique.

- **Pros:** Trenching promises short building times and significantly lower construction costs. The process has a high construction output of approx. 600 m per day and leads to very little traffic impairments due to the rapid refilling of the road body.
- **Cons:** The milled slits can lead to damage in the asphalt surface in the form of cracks, settling or frost damage. The additional laying level in the road can make subsequent civil engineering work - particularly in the inner city area - more difficult and lead to longer and more costly constructions.

Horizontal directional drilling

The directional drilling technique allows laying trenchless cable protection pipes, e.g. used for crossing obstacles such as river, avenues (tree protection) and railways. A controllable pilot hole is carried out between two excavation pits. The effect of rotation, stroke and impact movements and liquefaction enables a propulsion at a wide variety of soil conditions. By means of a bentonite drilling fluid (drilling suspension), the soil is loosened and extracted (rinsed). After that, the drill head expands the existing channel.

- **Pros:** The method offers an alternative when open trenching is not possible (e.g. crossing of obstacles such as railways or rivers) or economically feasible.
- **Cons:** At low depth and loose grounds, the drilling suspension can escape at the surface during the drilling process (blow-out). Furthermore, control inaccuracies can cause deviations in the longitudinal gradient.

Drilling

This technology is a ground displacement process in which a pneumatically driven ground displacement hammer (rocket) is driven through the soil by compressed air. A protective tube is pulled into the created ground tube in the same operation. The technology is especially used for connecting buildings.

- **Pros:** Costs of excavation and restoration are saved, traffic restrictions or road barriers are often not necessary. The method saves time as pipes are fed directly with the rocket. It can be used even in extreme soils and at longer distances.
- **Cons:** The deployment depth must be at least tenfold the diameter of the rocket in order to avoid bulging of the terrain surface. It is suitable only for relatively short distances and cannot be used in bogs or very rocky soils.

Ploughing techniques

During the ploughing process, a deployment plough is pulled through the spoil with the help of a tractor. A flexible conduit (micro cable compounds) is laid in the resulting furrow, particularly suitable for direct ploughing.

- **Pros:** The procedure is comparatively inexpensive and allows the routing of long distances with little effort.
- **Cons:** It can only be used on unsealed surfaces and is therefore not suitable for asphalt roads.

Installation in sewer systems

An assembling robot is used in non-accessible ducts, whereas in walkable areas, the work is carried out by technicians. Routes are to be installed in such a way that the service and cleaning work of the sewer operator is not hindered and the safety is ensured at all times. The required space in the pipe system is minimal and does not represent a significant hindrance to the flow conditions. The respective operator can assess if this installation can be applied. Also the local situation regarding the state of the channel, clogging tendency, cleaning technologies, occupational health and safety aspects should be considered before the decision-making.

- **Pros:** Through the use of existing infrastructure, expensive and lengthy ground installations are avoided. The installation in sewer systems is a good alternative wherever traffic and environment impairments are to be minimised.
- **Cons:** The local situation needs to be properly analysed and possible obstacles resolved before the implementation of this technology. A disadvantage is that hitherto no house connections could be made. There are now different systems evolving for implementing house connection.

Overground installation

Optical fibre cables are laid over put-up wooden masts or existing street masts. This method is mainly used at connection routes on high and high voltage lines. It is particularly suitable for remote buildings outside the settlement area, for which other connections would not be economically viable.

- **Pros:** In comparison to the underground installation, the aboveground installation makes a cost-effective initial installation possible.
- **Cons:** The cable system is exposed to stronger external influences, which increases susceptibility. As the installation requires specially trained personnel and appropriate tools, the installation of the cables is therefore cost-intensive.

Wireless broadband technologies

Wireless broadband technologies include mobile radio solutions (e.g. HSPA, LTE), fixed radio solutions (e.g. WiMAX) and satellite solutions.

Antenna sites for wireless connections

A terrestrial wireless broadband connectivity is usually provided by WiMAX (up to 60 km efficiency range), Wi-Fi (up to 300 m efficiency range) or 4G/LTE/LTE Advanced (up to 3-6 km efficiency range) solutions. Further improvements will focus on new standards with additional features and the provision of additional frequency spectrums (5G).

Whenever the upgrade of the wired infrastructure is not possible, and funds for FTTB/FTTH are not available for a certain area, an option is to build infrastructure for terrestrial wireless broadband, mainly antenna sites for point-to-multipoint connections (e.g. WiMax, Wi-Fi, 4G/LTE).

- **Pros:** First mile wire connections are not needed. The infrastructure can be used for commercial mobile services as well.
- **Cons:** Since the bandwidth can be shared among several users, peak traffic periods of the day will reduce the available bandwidth for each user. Signal strength decreases fast with distance, and is affected by weather; disturbed line-of-sight may reduce signal quality. Interim solution: investment in fibre infrastructure will be necessary within 10-15 years.
- **Sustainability:** To access future NGA-services, bandwidth needs requires additional frequencies; however the available spectrum is limited.

Satellite broadband

Satellite Broadband, also referred to as internet-by-satellite, is a high-speed bi-directional internet connection established via communications satellites located in the geostationary orbit. The end customer sends and receives data via a satellite dishe.g. located on the rooftop.

- **Pros:** It requires low investment for passive infrastructure as regional backbone and area networks are not needed. It is easy to connect users scattered over a relatively large area (regional, macro-regional or even national).
- **Cons:** Limited total number of users can be covered in one region. Its inherently high signal latency due to the propagation time to and from satellite hampers certain applications. A relatively high investment for active end-user equipment is necessary. Bad weather and limited line-of-sight may reduce the signal quality. Data traffic is typically capped monthly or daily in current commercial offers.
- **Sustainability:** The available bandwidth especially depends on the amount of users that demand the satellite technology. Depending on further development potentials (e.g. transmission methods, satellite constellation), the technology will play a significant role in covering areas that are not yet connected otherwise.

Upcoming technologies

Next generation communication systems will most probably be the first instance of a truly converged network where wired and wireless communications will use the same infrastructure.

5G - converged networks

5G describes the next phase of mobile telecommunications standards beyond the current 4G/LTE. The fifth mobile radio generation is being developed on the basis of International Mobile Telecommunication-2020 Conference. 5G allows for an application end-to-end latency of 4 to 1 milliseconds, according to the International Telecommunication Union (ITU). The technology is capable of at least 10 Gbps upload and 20 Gbps download data transmission rates. Devices and applications will automatically select the network which best suits their needs. Industry and research expect a commercial roll-out of 5G in 2020. Read more about the latest policy developments concerning 5G in the EU.

- **Pros**: 5G offers improvements in coverage, signalling efficiency, transmission rates and reduced latency. Unlike in existing networks, 5G will include many different radio technologies – each optimised for a specific need (e.g. Internet of Things, critical communications, connecting cars, houses and energy infrastructures).
- **Cons:** Most of the current services are not yet in need of such high-speed data transmission

rates. This will change as new applications in need of enormous capacities develop.

Low Earth Orbit (LEO) Satellites

Satellites circulating closer to the earth (low earth orbit ranges from about 160 to 2000 km above earth) allow for better web performance, cover wide areas and enable affordable broadband access. Small, low-cost user terminals communicate with satellites and deliver LTE, 3G and WiFi to the surrounding areas.

SpaceX plans to put thousands of small, low-cost, disposable satellites into orbit (project Starlink). The satellites will orbit in three orbital shells (1.110, 550 and 340 km) to allow for faster internet service. SpaceX intends to provide satellite internet connectivity to underserved areas of the planet, as well as provide competitively priced service to urban areas. Testing of the technology started in 2018 and initial operation could begin from 2020/2021.

- **Pros:** Medium Earth Orbit (MEO) and Low Earth Orbit (LEO) satellites are featuring lower latency. They can cover wide areas and thus facilitate broadband coverage for very rural and remote areas.
- **Cons:** A big network of satellites launched in the orbit is necessary to cover wide areas/most of the planet. This in turn produces high costs for the supplying companies, also in terms of the controlling by the necessary ground stations of non-stationary flying satellites.

Internet Balloons

Internet balloons are sent up 20 km into the stratosphere. Specific software moves them up or down to find the right winds to direct them into position. Each balloon beams an internet connection down to antennas on the ground.

Project Loon is a network of solar powered balloons transmitting internet signals to ground stations, homes, workplaces or directly to personal devices using LTE technology. Balloons navigate in the stratosphere at an altitude of about 18 km, specifically designed to connect people in rural and remote areas.

- **Pros:** Internet balloons are capable of bringing internet access to the most remote parts of the planet. AI algorithms ensure that the balloons find and exploit the optimum wind flows to stay longer in the air.
- **Cons:** The enormous coldness adds to the nylon material of the balloon and makes it brittle. Lubricants become tough at these temperatures. The balloons are exposed to strong ultraviolet and cosmic radiation and marked pressure differences throughout their journey. Controlling by the necessary ground stations of non-stationary flying balloons is very challenging.

Light Fidelity (LiFi)

LiFi is a bidirectional, high-speed wireless communication technology. It uses visible light communication or infra-red and near ultraviolet (instead of radio frequency waves) spectrum. Light from light-emitting diodes (LEDs) serve as a medium to deliver communication. PureLiFi demonstrated the first commercially available LiFi system, the Li-1st. There are now a number of companies developing this technology.

- **Pros:** LiFi is 100 times faster than WiFi, reaching speeds of 224 Gbps. The technology is useful in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants without causing electromagnetic interference. Additionally, LiFi is expected to be ten times cheaper than WiFi.

- **Cons:** The technology only delivers communication over a short range. Low reliability and high installation costs are further potential downsides.

A comparison of the broadband technologies gives an overview and helps to choose the best technology.

Future trends and developments

Research and development increasingly focus on All-internet Protocol Network (AIPN). This allows to improve communication and data transmission via Internet Protocol (IP)-based network technologies and services that include internet telephony or VoIP (Voice-over Internet Protocol).

IP-based data packet transmission allows the development of innovative services and applications independently from the underlying network infrastructure. 5G is a typical example of the convergence of mobile communication and parallel existing broadband network technologies.

The complete conversion to network infrastructures based on the Internet Protocol (All-IP Migration) is the basis for a convergent service realisation in the Gigabit society and for the use of various combinations of individual network access technologies.

Recent developments involve network infrastructures to be complemented by all-optical-networks, which will allow application- and content-routing and switching.

A fourth strand of research includes the post-IP type of data transmission, which is characterised by:

- New architecture with management capability supporting multi-domain;
- New wireless-friendly (energy and spectral efficiency) protocols capable of supporting a variety of wireless networks, from very low power sensor networks to wide area mobile networks.

Existing and future transmission rates, innovative methods of data compression and improvements to transmission standards will meet bandwidth-intensive services and applications. It should be noted that the compression always causes losses in terms of quality of data (e.g. TV-formats, video conferences).

Interested in the architecture and infrastructure of broadband networks? Get detailed information on network and topology, access types and the decision over the right infrastructure choice.

Follow the latest progress and learn more about getting involved.

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Latest

PRESS RELEASE | 15 September 2021
State of the Union: Commission proposes a Path to the Digital Decade to deliver the EU's digital transformation by 2030

The Commission has proposed this week a Path to the Digital Decade, a concrete plan to achieve the digital transformation of our society and economy by 2030. The proposed Path to the Digital Decade will translate the EU’s digital ambitions for 2030 into a concrete delivery mechanism. It will set up a governance framework based on an annual cooperation mechanism with Member States to reach the 2030 Digital Decade targets at Union level in the areas of digital skills, digital infrastructures, digitalisation of businesses and public services. It also aims to identify and implement large-scale

PRESS RELEASE | 12 March 2021
Commission welcomes agreement on the Connecting Europe Facility to fund greener, more sustainable transport and energy networks, and digitalisation

The European Commission welcomes the agreement reached by the European Parliament and the Council on the Connecting Europe Facility (CEF) proposal, worth €33.7 billion, as part of the next long-term EU budget 2021-2027.

PRESS RELEASE | 09 March 2021
Europe's Digital Decade: Commission sets the course towards a digitally empowered Europe by 2030

The Commission recently presented a vision, targets and avenues for a successful digital transformation of Europe by 2030. This is also critical to achieve the transition towards a climate neutral, circular and resilient economy. The EU's ambition is to be digitally sovereign in an open and interconnected world, and to pursue digital policies that empower people and businesses to seize a human centred, sustainable and more prosperous digital future. This includes addressing vulnerabilities and dependencies as well as accelerating investment.

PRESS RELEASE | 02 December 2020
Commission launches public consultation to gather views on improving fast broadband network rollout

Earlier this week, the Commission opened a public consultation, as part of the review of the Broadband Cost Reduction Directive, to collect views, until 2 March 2021, on incentivising the rollout of fast broadband networks, including fibre and 5G. The Directive, introduced in 2014, aims to enable fast electronic communications networks for people across the EU by reducing the related costs.

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Related Content

Big Picture

Broadband project planning

The Broadband planning section helps municipalities and other entities in their planning of successful broadband development projects.

See Also

Broadband: Financing public-private and private-run deployments

Investment efforts to finance public-private and private-run networks are made in cooperation between private actors who own existing infrastructure, and public authorities.

Broadband: Carrier models

Municipalities, municipal companies, joint ventures, and private companies can be involved in one, two or all three stages of broadband development.

Broadband: Actors in the value chain

The basic roles of Physical Infrastructure Provider (PIP), Network Provider (NP) and Service Provider (SP) can be taken by different actors.

Broadband: Access to infrastructure & service-based competition

Access to the broadband infrastructure is possible via different network nodes on the infrastructure and application level.

Broadband: Plan definition

The key to successful regional broadband development lies in defining a plan that includes goals, collaborations, and specific needs and stakeholders.

Broadband: Action plan

Broadband project plans help you map infrastructure needs, plan financing and deployment, monitor progress, find stakeholders, make the right choices and more.

Broadband: Basic business models

Choosing the right business model depends on the roles of the market actors in the broadband value chain.

Broadband: Investment models

Investment models present interesting involvement opportunities for a public authority that engages in regional broadband development.

Broadband: Main financing tools

The European Commission has a range of financing tools for high-speed broadband development projects across the EU.

Broadband: State aid

State aid for broadband may be necessary in some places where the market does not provide the necessary infrastructure investment.

Broadband: Network and topology

A broadband network consists of geographical parts. The topology of a network describes how the different parts of a network are connected. The most relevant topologies for the backbone and area networks are tree topologies, ring topologies and meshed topologies. For the first...

Broadband: value chain, actors & business models

Different business models are available to public authorities and other market actors in broadband development.

Broadband: Choice of infrastructure

Broadband networks require different infrastructure types based on different logistic, economic or demographic conditions. Use the questions to help choose.

Broadband: Technology comparison

A comparison of broadband technologies presents features of each solution and helps decisions on the best solution for different regions.
