Analysis of the Accessibility to Broadband Internet for the Weser-Ems District

Broadband to the Country
Case Study

EUROPEAN UNION
European Regional Development Fund

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The Interreg IVB North Sea Region Programme

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Content

1. Executive Summary

The Federal Ministry of Economics and Technology (BMWI) approved a broadband strategy at the beginning of 2009. The strategy includes providing broadband internet, which will cover large areas at the end of 2010. The next step of the broadband strategy: 75 percent of households are to get the opportunity to receive an internet connection with a transfer rate of up to 50 Mbps till 2014. For the Weser-Ems district, which is one of the most sparsely populated regions of Germany, being connected to the broadband internet is associated with obstacles. Compared to the rural area of the Weser-Ems district, broadband technologies in larger cities, e.g. Wilhelmshaven, is well developed. We refer to definitions around broadband and internet especially in Germany and describe the basically usable technologies for a broadband connection. We suggest a solution canopy from Motorola to supply the rural areas with broadband internet and give advice for implementing it in parts of the Weser-Ems district.

2. Problem Statement

The supply of broadband internet in the Weser-Ems district is available in some larger cities. In many rural areas people and also small and medium enterprises suffer from the lack of broadband internet. Either the people and enterprises, which need broadband internet, move towards the larger cities or it has to be brought to them. We abstract from social effects and repercussions. To prepare the next sections we now list some definitions around broadband and internet.

Last Mile/First Mile

The last mile is the view from the provider to the house service connection. Another view is the first mile, which symbolizes the private connection to the provider. Both refer within the telecommunication network to the part of the line which goes towards the house service connection also known as the subscriber’s line (TAL). The last mile is property of the established carriers. In Germany one of the established carriers is for example *Deutsche Telekom* for the landline. TAL can be rented by competitors for a regulated fee.

Fair User Policy

The *Fair User Policy* is a paragraph, which also appears in internet scales. Basically this paragraph is used with DSL-, cable-, and mobile services scales by each provider although the *Fair User Policy* has different characteristics and boundary values. DSL- and Cable providers barely use the *Fair User* Policy, which relies on the height of the boundary value. In the past if customers had loaded a high amount of data traffic the provider cancelled the agreement. For mobile internet up- and/or downlink speed would be limited or additional costs for the customer would occur. Compared to cable-bound technologies the limiting values are minor.

Definition of Broadband Internet

Generally speaking the term “broadband” is a synonym for a fast internet connection. There are different views from where the down- / uplink speeds of “broadband” begin. Nevertheless there is an official definition published by the Federal Ministry of Economics and Technology (www.breitband-niedersachsen.de). Since the beginning of 2009 broadband starts from 1 Mbps in downlink.

Some organizations and initiatives, who campaign faster internet, demand a definition for broadband internet between 3 and 6 Mbps. To advance the development of broadband internet connections as fast as possible some associations and federal states started initiatives, for example

„eco“(www.eco.de) and the Federal State of Lower Saxony (www.breitband-niedersachsen.de). Those associations provide information for internet providers and customers.

Significance of Broadband Internet

In our society a fast internet connection becomes more and more important. In some cases the availability of a fast internet connection is a criterion for companies before choosing the location or when looking for a place to live. Especially for companies broadband internet is important because more and more services and products are presented in the internet. Therefore villages, where no broadband internet is available, are less attractive.

Users of Broadband Internet

The internet community can be divided into three groups: The first is the group of commercial users. For those broadband internet is an essential reason to choose a location where broadband is available. As a commune you want to set up broadband internet to offer your location to companies. Commercial usage means high traffic in down- and uplink. The second group of users is of private nature. This group uses the web with different intentions, e.g. browsing, live-streaming, VoIP, video calls and online gaming. For these people high downlink and short latency are important. Uplink speed may be neglected. The third and last group is public administration. More and more forms and other administrative tasks can be done over the internet resulting in a growing significance of broadband internet for public authorities.

Digital Dividend

Analogically technologies have been used to transmit radio and television signals. With the conversion to digital techniques the frequencies used could be used more effectively. The released spectrum which is used is the UHF band from 790 to 862 MHz. These free frequencies will be referred to as the digital dividend. Within the digital dividend the frequencies from 790 – 814 and 838 – 862 MHz for the professional use of radio microphones are to be used. This is noted in the "general allocation of spectrum for wireless microphones for professional uses in the frequency ranges 790 - 814 and 838 - 862 MHz" by the Federal Network Agency.

This means that even 24 MHz remain free and a decision on the use of these frequencies is a must be. The World Radio Communication Conference has approved the use of the digital dividend for broadcasters and mobile providers. However, it is not possible to use the digital dividend for both application fields. Therefore it must be decided for what technology the vacated spectrum has to be used for. So far no authoritative basis for the use of the digital dividend has been established in Germany. An auction of frequencies in the digital dividend was held in spring of 2010.

The main advantage of the digital dividend is that the released spectrum is in the UHF band. This frequency range has the advantage of achieving a good geographical spread. Other positive characteristics of the UHF band are the penetration of buildings and that to line of sight between the transmitter and receiver is required.

The frequency of the digital dividend could be used to significantly increase the cell tower. In addition, a comparison is shown in figure 1. In the right part of the figure are cells with normal cellular UMTS frequencies shown. On the left is a mobile cell with frequencies where the UHF band is shown. The cost of mobile network operators can be reduced by larger cells. The decrease in network costs could be passed on to consumers.

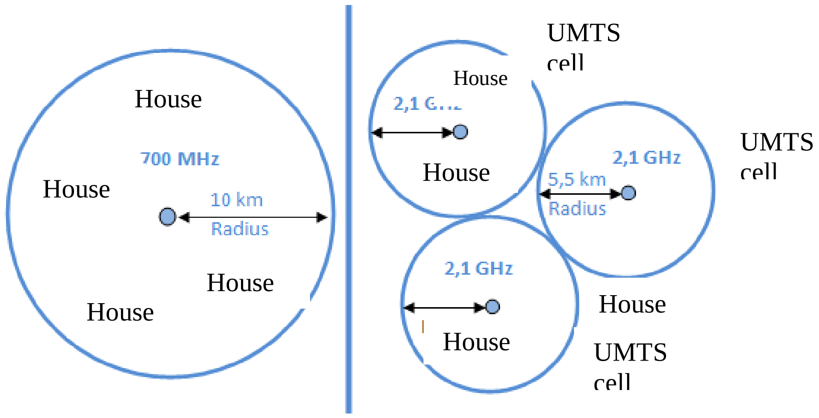

Figure 1: Size of a mobile communication cell (700 MHz und 2,1 GHz)

The Weser-Ems district which lies in the northwest of Lower Saxony is a mostly rural region. The number of inhabitants per square kilometer is 165. For this reason, the web is partially or poorly developed with no broadband internet. The affected areas are also known as white spots. For most large telecommunications companies rural areas are not economical enough to improve the network in the areas with copper or fiber optic cable and thereby creating a DSL infrastructure. Just the cost of earthworks would be immense. For this reason, an investment is usually avoided. Accordingly, technical solutions must be found to provide an alternative to DSL.

3. Alternatives

The broadband technologies can be divided into two groups. On the one hand the wired technologies these are: DSL, cable TV, power lines and fiber optic technologies. The second group includes non-wired technologies. These are: mobile communications, WLAN and WiMAX.

3.1 DSL Technologies

The most popular broadband internet technology is the Digital Subscriber Line (DSL). Before the word DSL there is sometimes another letter, e.g. ADSL or SDSL. The additional letter indicates the particular technique which has different properties.

3.1.1 Structure and Functionality

The DSL technology uses existing telephone networks. This can be used as a traditional voice application and does not use the network at its fullest. For the separation of voice and data signals a splitter for the network operator and the customer is needed. On the part of the network operator, there is the digital subscriber line access multiplexer (DSLAM), which acts as a switching centre. The basic structure is shown in figure 2.

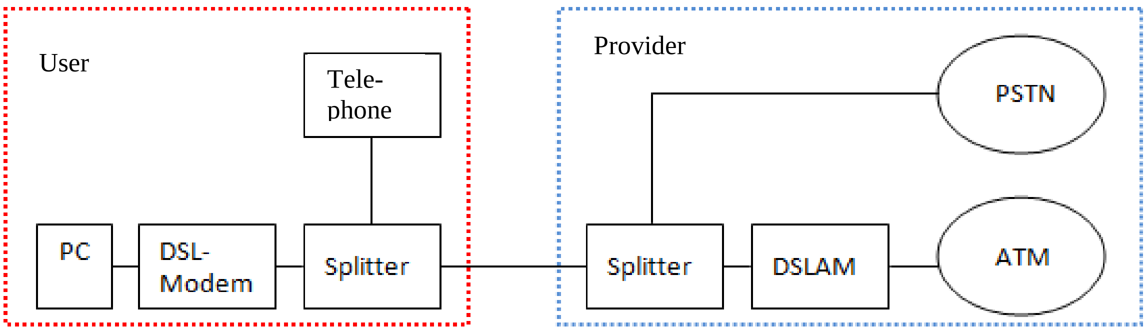

Figure 2: Structure of DSL

3.1.2 DSL Technologies

The prefix letter gives information to the characteristics of the DSL technology. Table 1 lists a variety of DSL technologies including their characteristics. An important parameter is that at higher speeds the maximum distance decreases to the house connection.

DSL technique	ADSL	SDSL	HDSL	VDSL
	Asymmetric DSL	Single Line DSL	High Data Rate	Very High Data Rate DSL
Uplink	640 kbps	1,544 Mbps // 2,048 Mbps	1,544 Mbps // 2,048 Mbps	1,5 to 2,3 Mbps
Downlink	8 Mbps	1,544 Mbps // 2,048 Mbps	1,544 Mbps // 2,048 Mbps	13 to 52 Mbps
max. range	2,7 to 5,5 km	2 to 3 km	3 to 4 km	0,3 to 1,5 km
where to use	Fast Internet, interaktive Videodienste, Multimedia	T1/E1 services, LAN- and server access	T1/E1, services LAN- und server access	Fast Internet, interactive video services, Multimedia

Table 1: DSL Overview

ADSL

In most cases when DSL is mentioned one talks of an ADSL connection or a further development of ADSL. The abbreviation ADSL stands for Asymmetric DSL. The "asymmetric" stands for different speeds in the downlink and uplink speed where by the uplink has much lower speeds than the downlink. ADSL is ideal for users who require a higher down than uplink speed. For most home users an ADSL connection is sufficient.

SDSL

Another common DSL technology is SDSL which stands for symmetric DSL and offers the same uplink and downlink speed. SDSL is used primarily for commercial purposes.

VDSL

Another DSL technology which has not been long on the market is currently offered (June 2009) only by the Deutsche Telekom as VDSL. In this technique, significantly higher uplink and downlink data speeds than ADSL are possible. However, the maximum distance from the distributor to the customer is limited from 300 to 1500 meters. In the VDSL technology primarily fiber optic technology is used. This technique needs to be brought as close to the house connection as possible (see Section 3.4 Fiber Glass Technology) so that only a few 100m to the VDSL modem must be bridged. A schematic setup is illustrated in figure 4.

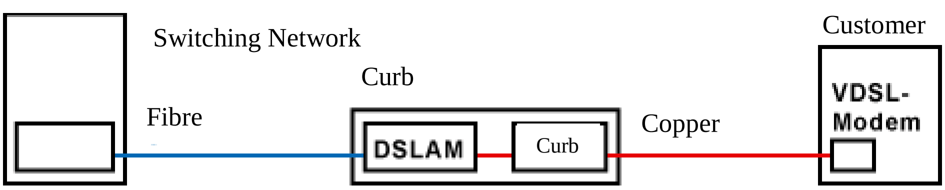

Figure 3: Schematic Structure of VDSL

The ITU has written the VDSL technology and has already designed a development. Figure 4 shows significant differences in terms of data rate and the unbridgeable distance. With the second generation of VDSL coverage and the maximum transmission rate are further increased. Another important advantage of VDSL2 is the compatibility with the ADSL technology.

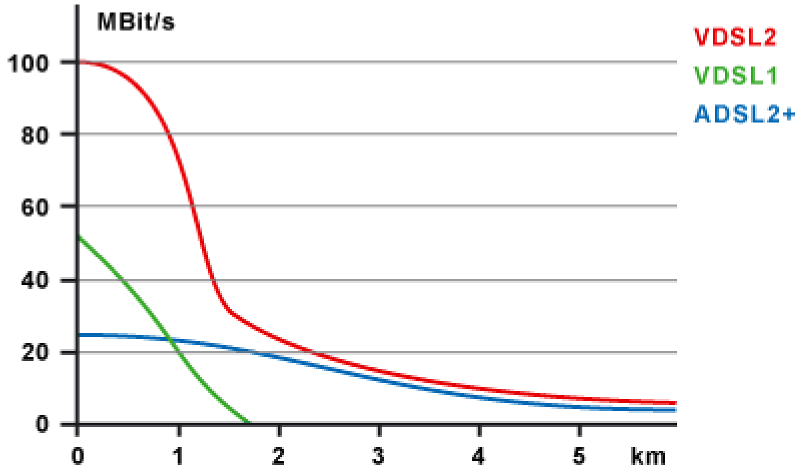

Figure 4: VDSL, Bandwidth/Range

VDSL is currently available in 50 major German cities. In Germany the largest supplier of VDSL is the *Deutsche Telekom*. They provide VDSL mainly in connection with entertainment packages, e.g. IPTV. Plans call for a further expansion of the VDSL technology. However, large investments to set up the fiber optic network must be made. Thus the VDSL technology will initially be available in larger cities. The VDSL setup will not happen in the near future in rural areas.

3.1.3 Benefits and Disadvantages

The DSL technology is well developed in urban areas. Currently the infrastructure for the DSL technology in rural areas is partly incomplete or virtually non-existent. To connect the affected areas with DSL technology to the internet would require high investments. For this reason the network operators build up their networks only slowly in rural areas. The main advantage is that this technology provides high downlink and uplink speeds (see (VDSL)) and low latency of 50 ms which allows low prices.

3.1.4 Providers and Prices

An overview over the current ADSL tariffs is shown in table 2. The prices and services of different providers were not considered.

Provider	Deutsche Telekom	1&1	Ewetel
Name	Call & Surf Comfort	DSL-HomeNet 6000	DSL Maxi
Downlink	6016 kbps	6016 kbps	6 Mbps
Uplink	576 kbps	576 kbps	512 kbps
Hardware	Speed port	Fritz!Box	Samsung SMT-G300 AVM Fritz!Box
monthly. Costs	39.95	29.99	29.95
Duration	24 month	24 month	24 month

Table 2: DSL Provider and Prices, April 2009

In Table 3 VDSL-tariffs of the *Deutsche Telekom* are shown. For the entertainment-packets, additionally DSL 16plus, meaning ADSL, is listed.

Tariff	downlink	uplink
DSL 16plus	10.000-16.000 kbps	800-1.000 kbps
VDSL 25	16.704-25.064 kbps	1,6-5 Mbps
VDSL 50	27.968-51.392 kbps	2,7-10 Mbps

Table 3: VDSL Tariffs, April 2009

3.2 Cable TV

The cable network in Germany is well developed. At the moment 18 million households have a cable connection available. Using the cable network, receiving television and radio signals is possible. Now, in addition, the cable providers offer internet connections using the cable network.

3.2.1 Structure and Functionality

To realize an internet or phone connection using this technique a return channel is needed which was not provided for the supply of television and radio. For this reason the cable provider must expand their networks enabling it to return data. To provide additional services over the cable network a frequency range becomes employed that is not used for television or radio programs.

In figure 5 the basic structure of the entry point of the cable operator is shown. The cable modem termination system (CMTS), as briefly mentioned, is the head station. This is the central point for merging television, radio and internet. From CMTS further distributing elements go in the direction of the customer, so-called hubs.

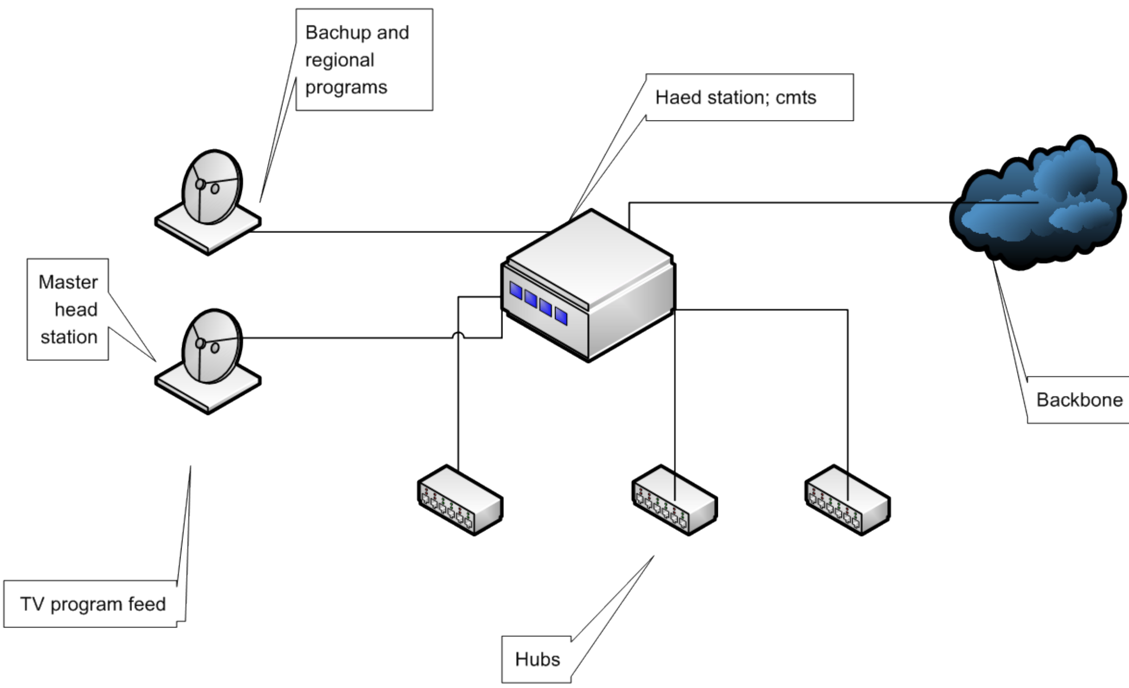

Figure 5: Structure of a Cable Network

From the hub (see figure 6) there is a bus topology connected to the customer. In this section the customer is known as the "cable". In necessary sections of the cable operator is a signal amplifier. On one hub up to 5000 customers can be connected. A major disadvantage is that all the connected clients share the available bandwidth.

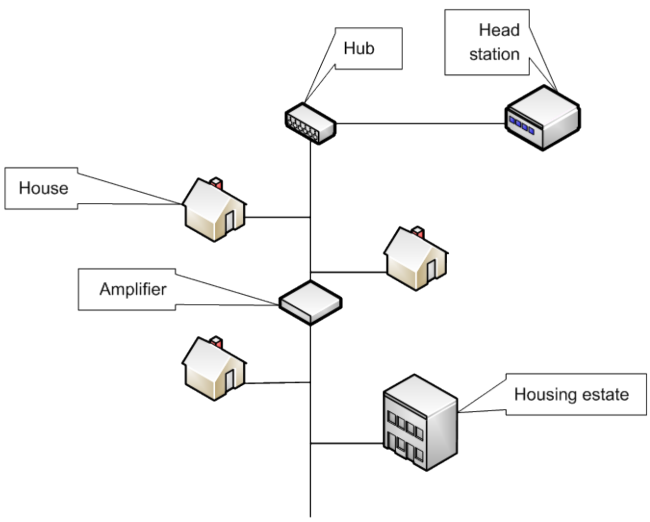

Figure 6: Structure, Hub Topology with Cables

In order to achieve a higher bandwidth the existing topology is changed to star or star with bus topology (figure 7).

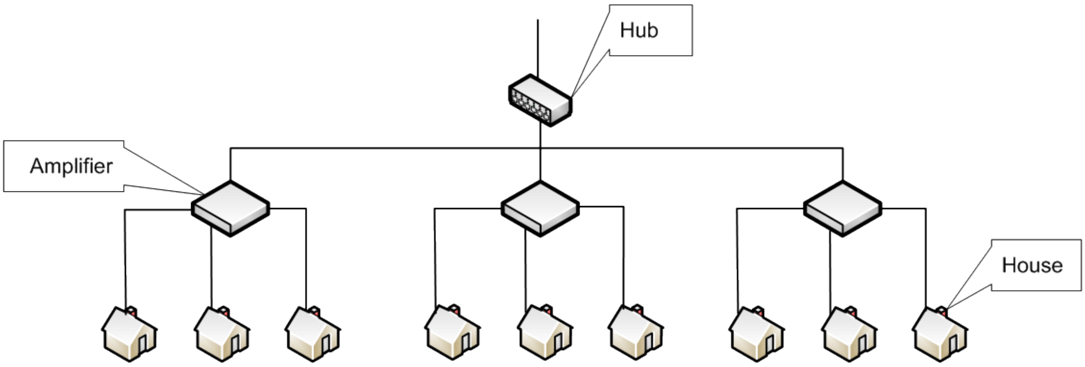

Figure 7: Structure, Hub Distribution

Another possibility to enhance the bandwidth is “net intelligence”. Bringing the head knot closer to the customer as shown in figure 8.

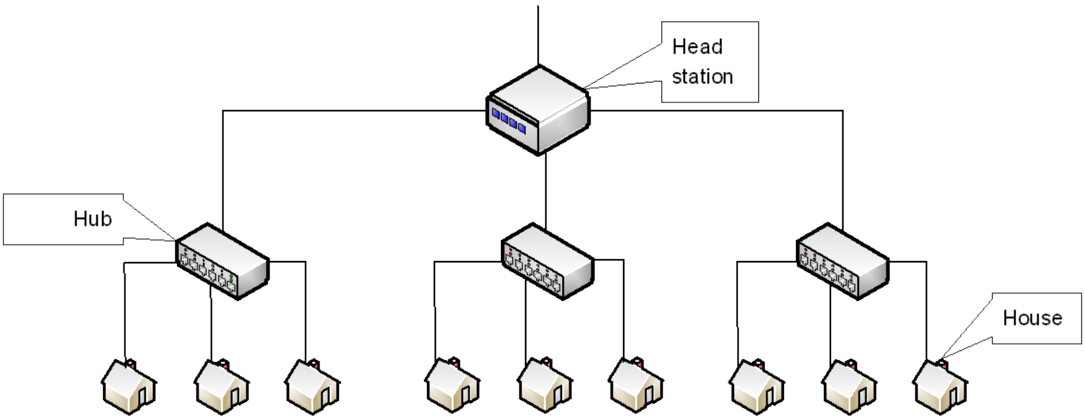

Figure 8: Central point cable

Required Hardware

The customer requires an antenna connection including a data-slot. In addition a cable modem is required. Connected to this cable modem is a PC or a router. The router is able to connect several computers. Connecting the TV or CD-Player stays unchanged.

3.2.2 Benefits and Disadvantages

This technique benefits from the fact that cable networks are mostly found in congested urban areas. Therefore cable networks are roughly used to supply rural areas with broadband internet. The benefits of cable networks are high data rates (up to 26 Mbps), low latency (similar to DSL) and the costs. They are comparable with the technical details of DSL.

3.2.3 Providers and Costs

One of the largest providers for internet via cable is Cable Germany. An overview is compiled in table 4.

Tariff	monthly costs	downlink	uploadlink
Flat Easy 1000	9.90 €	1 Mbps	128 kbps
Flat Comfort	19,90 €	6 Mbps	460 kbps
Flat Deluxe Tarif	25.90 €	26 Mbps	1 Mbps

Table 4: Tariffs Cable, April 2009

The minimum contract period for all rates is 12 months. Depending on how well the network is expanded the actual speeds may vary. With a high number of users, i.e. a high utilization of the cable network, the transmission rate for internet users is significantly reduced.

3.3 Power Line

The power line technology uses the existing grid to transfer data resulting in the possibility to make internet available everywhere.

3.3.1 Structure and Functionality

Within the transformer house the signals from the Internet are fed and separated. Using the public grid the data is transported. At the customer's location data gets separated from the stream before the meter. After the electric meter the data is added again to the stream. The user needs a special power line modem. The basic structure is shown in figure 9.

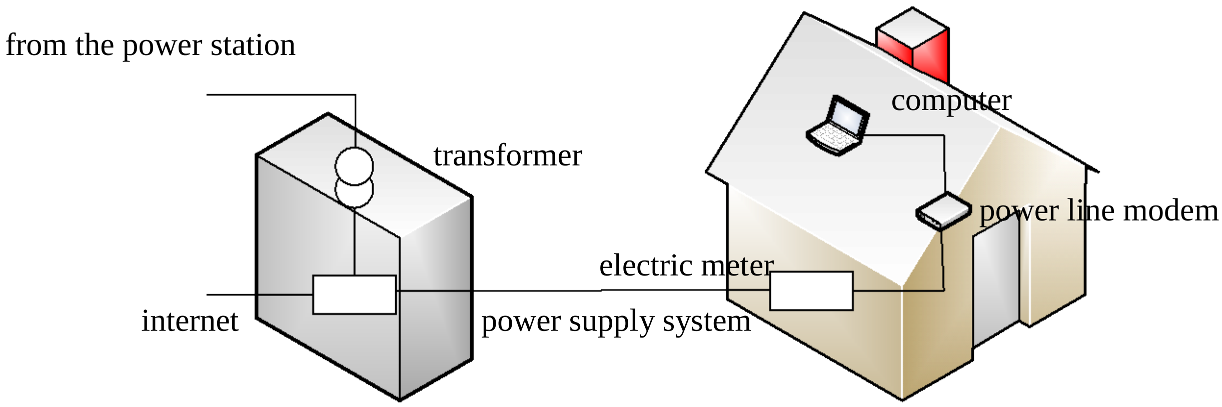

Figure 9: Structure Power Line

3.3.2 Current Projects and Providers

In Germany, Vype offers the power line technology in Mannheim and Hatzenbühl as the only provider. Tariffs are listed in table 5.

Tariff	monthly costs	included traffic	each further MB
VYPE Family	14,90 €	-	3,3 ct
VYPE Family 1000	24,90 €	1 GB	2,4 ct
VYPE Family 6000	39,90 €	6 GB	0,9 ct

Table 5: Tariffs Power Line, April 2009

The one-off connection fee is € 79.00. The duration of the contract is 12 months. According to Vype a typical transmission speed of 1 Mbps to the customer is possible although not guaranteed.

3.2.3 Perspectives

Shortly after the introduction of this technology major disadvantages became visible. A lot of users have to share the usable bandwidth of up to 2 Mbps. It also turned out that it is complicated and too expensive to get the existing problems under control. The biggest problem with the power line technology is the permanent impairment of long, medium and short wave reception. A variety of radio services have been compromised, for example air, maritime communications, military and amateur radio.

3.4 Fiber Glass Technology

The fiber glass technology is mainly used for backbone connections. Another application is the integration of larger businesses to the internet. Home computer users are currently not provided with fiber technology because the connection is very expensive. The advantage of this technique lies in the high transmission rates of up to 40 Gbps and the low attenuation in comparison to copper cables.

To use this technique a private house connection with fiber is necessary. If there are several apartments in the house the remaining distance to the customer can be bridged by the distributor with the help of copper wires. Using longer copper wire reduces the transmission speed. There are three types of fiber connections:

3.4.1 Fiber to the Curb / Neighborhood (FTTC/FTTN)

FTTC or FTTN describes a port that is located between a local exchange and the switching manifold. In a distributing element a signal converter is accommodated which converts the signals from the fiber optic cable to a copper cable. The FTTC connection is used for VDSL technology. In the cable distributors DSLAMs will be installed. 32 to 64 ports can be connected. The possible transfer speeds are given in Table 6.

	from	to
Downlink	25 Mbps	52 Mbps
Uplink	2 Mbps	12 Mbps

Table 6: Transmission Speed: FTTC

3.4.2 Fiber to the Basement (FTTB)

In this connection method the fiber will be installed to the building. In the building there is a signal converter that converts the signals into the existing copper cable. With a FTTB connection 8 to 16 Internet connections can appear. The downlink and uplink speeds are up to 25 Mbps.

3.4.3 Fiber to the Home (FTTH)

With this fiber optic connection the fiber is laid up to the end user. There are reachable transmission speeds in down- and uplink of up to 10 Mbps, 100 Mbps and higher. At the FTTH technology two topologies are used which are Ethernet Peer to Peer (P2P) and Passive Optical Network (PON). FTTH connections will grow in importance in the coming years. The research firm Heavy Reading conducted an analysis for European FTTH connections. According to this analysi, an increase from 2009 to 2013 of at least 16 million FTTH connections in Europe is expected. Currently there are approximately four million households that have a FTTH connection.

3.5 Satellite Technology

In some areas there is just one way to get a broadband internet connection: the satellite technology. To realize this technology, providers use the satellites of Astra and Eutelsat. The satellite technology provides two different ways to connect to the internet.

3.5.1 Structure and Functionality

The first possibility is shown in figure 10. The customer has two channels. The first channel is the channel by which the customer can send requests. This channel is realized with an analog modem or an ISDN connection. The second channel is the receiving channel which is realized with a satellite. Therefore a satellite dish which must be aligned to the satellite with a digitally fit for LNB (Low Noise Block Converter) is necessary. At the client side a DVB-card or a DVB adapter also is necessary.

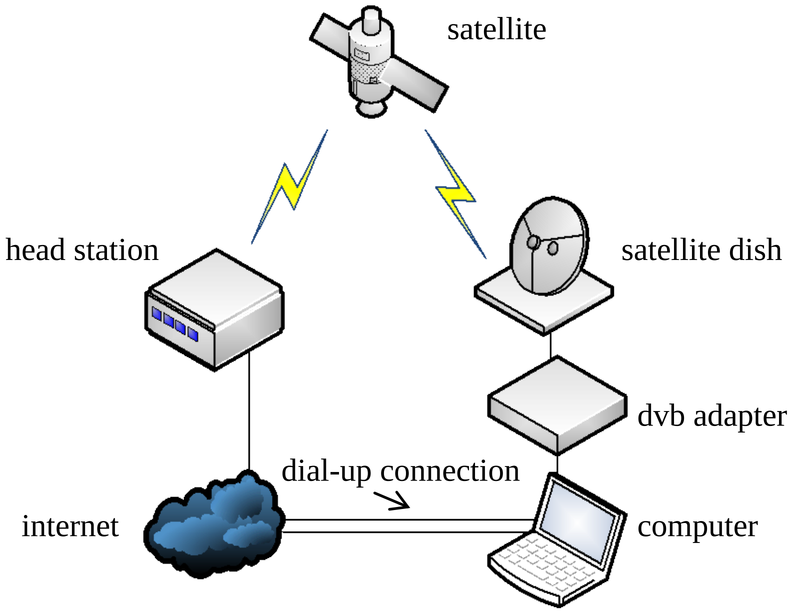

Figure 10: Satellite Connection Unidirectional

In figure 11 the second way to receive internet via satellite is shown. Characteristically, sending and receiving is handled via satellite dish. The used LNB has to be capable of sending and receiving data. The standard DVB-S2 is for receiving data and DVB-RCS for sending data in that second way of satellite internet.

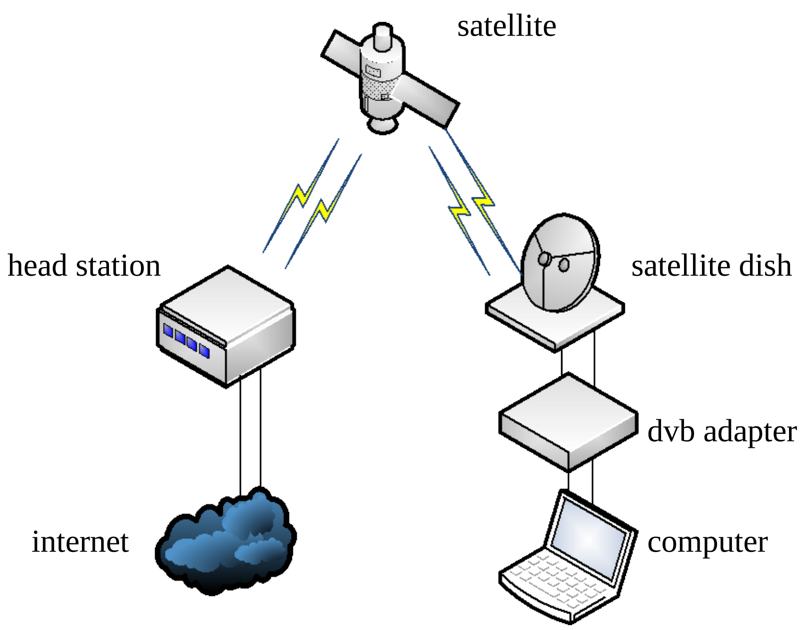

Figure 11: Satellite Connection Bidirectional

3.5.2 Benefits and Disadvantages

The advantage of this technology is the areal coverage. Theoretically, this technique is widely available. Instantaneous bandwidth is available from 1 to 2 Mbps. Over the next few years transfer rates of up to 10 Mbps are planned. Also prices will fall. This unidirectional technique deals with 24 months of contract period and 1 Mbps from about € 25 plus additional costs for the return channel is available.

A major disadvantage of this technique is that users must share the available bandwidth or a satellite transponder. Thus, this technique is not suitable for a large number of users. Another problem is the high maturities which amount to about 300-700 ms forth and back. Therefore this technique is not suitable for real-time applications such as VoIP and online games. Another disadvantage is the limitation of the data volume and the associated reduction in bandwidth. To install the satellite dish a precise alignment to the satellite is needed for which special skills and instruments are required. The dependency on the weather is another disadvantage of this technique.

3.5.3 Providers and Costs

In Germany there are two major providers that offer internet access using satellite technology with a return channel. These are the *Deutsche Telekom* and skyDSL. At *Deutsche Telekom* there is only the tariff "DSL via satellite" which is explained hereafter.

Traffic rates:

- Downlink up to 1024 kbps
- Uplink up to 128 kbps

Required Hardware:

- Satellite Dish
- iLNB
- Coaxial cable
- IP-Modem
- Sat Finder

Costs (April 2009):

- monthly payment: 39.95 Euro.
- Hardware: 99.95 Euro, additional 19.90 Euro for packing/sending
- Requirements: standard- or universal-connection of *Deutsche Telekom,* monthly from 17.95 Euro.

Contract length:

- 24 months

Another provider of satellite technology is skyDSL. They offer three different rates (downlink and uplink speeds) which are shown in table 7. The charges relate to a contract period of 24 months. Other options for the contract period can be selected, thus increasing the monthly cost. The costs of the return channel requirement are not included in table 7.

Tariff	Kind of tariff	monthly costs	Down-/Uplink	connection fee	skyDSL Box	PCI-Karte
skyDSL1000	Flatrate	24.90 €	1024/64 kbps	0.00 €	199 €	89 €
skyDSL2000	Flatrate	34.90 €	2048/64 kbps	0.00 €	99 €	0 €
skyDSL4000	Flatrate	54.90 €	4096/64 kbps	0.00 €	99 €	0 €

Table 7: Tariffs for Satellite Technology, April 2009

As mentioned above, the limits to reduce the bandwidth are set in the Fair User Policy. The preferences of users can be improved with the help of "gears”. However this leads to further costs. These higher speeds are not guaranteed. Since here the Fair User Policy plays an important role and the limit for the amount of data is 1.4 Gbyte, the Fair User Policy is partially quoted by skyDSL.

Extract from the Treaty on the Transfer Speeds

The transfer speed is dependent on the utilization of the satellite transponder. The range of 1024 kbps downstream and is 128 kbps upstream is not guaranteed. In times of high network bandwidth utilization depending on the volume of data of one individual user (considering a 30-day period) the available bandwidth can already be reduced gradually (Fair User Policy). The bandwidth limitation starts with a transgression of a total data volume of 1.4 Gbyte.

3.6 Mobile Communication Network

3.6.1 Evolution of the Mobile Communication Network

The first mobile network was the Advanced Mobile Phone Service (AMPS). It worked for analog and circuit-switched and was designed for voice transmission. From the second generation mobile telephony called Global System for Mobile Communications (GSM). The technology for transmission was digital but still circuit switched. For GSM expansion projects have been developed. They were HSCSD and GPRS. GPRS was the first technique that worked digitally and in packet-switched mode. With 2.75 G, EDGE was introduced and was used to improve the data transmission. The third generation of mobile networks is UMTS. From this mobile technology to internet via mobile connections is heavily marketed.

A summary of the development of mobile systems including their bandwidth is shown in table 8. From the third generation of mobile networks theoretical values are shown which can be achieved only partially under optimal conditions. From the third generation, mobile communications technology enables broadband internet access. For this reason the third generation networks and their accessories are described in another section.

Generation	Technology	Transmission	Bandwidth (max. down- u. uplink)
1G	AMPS	analog, line-switched	-
2G	GSM	digital, line-switched	14,4 kbps
2.5G	HSCSD	digital, line-switched	57.6 kbps
	GPRS	digital, packet-switched	53,6 kbps / 26,8 kbps
2.75G	EDGE	digital, packet-switched	220 kbps / 110 kbps
3G	UMTS	digital, packet-switched	384 kbps / 384 kbps
3.5G	HSPA	digital, packet-switched	14,4 Mbps / 5,8 Mbps
	HSPA+	digital, packet-switched	28 Mbps / 11 Mbps
4G	WiMAX	digital, packet-switched	up 75 Mbps, using 20 MHz-channels
	LTE	digital, packet-switched	up to 100 Mbps / 50 Mbps, using 20 MHz-channels

Table 8: Overview of Mobile Communication Cell

3.6.2 General Structure of a Mobile Network

In Germany there are four operators who build, maintain and further develop their networks. The network operators are: T-Mobile, Vodafone, E-Plus and O2. In a mobile network (see figure 12) there is a wired and non wired part.

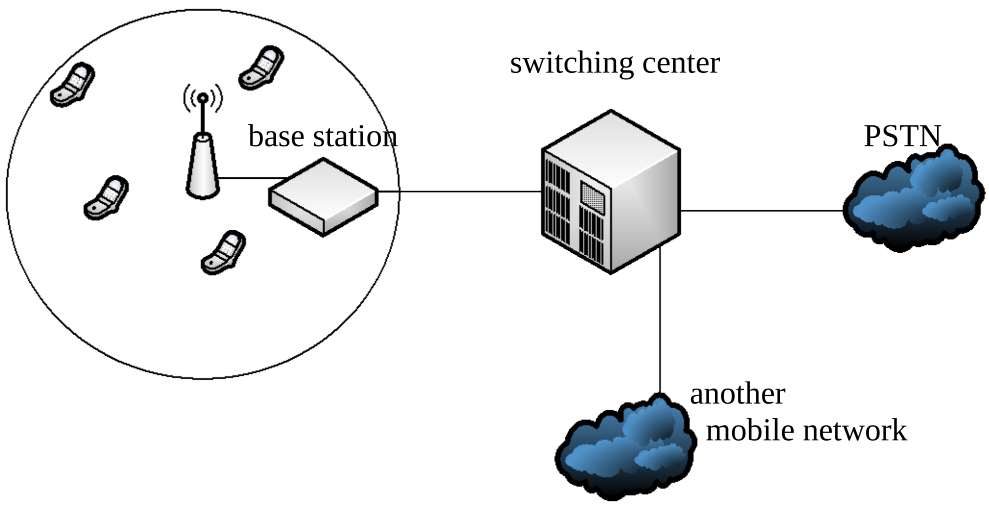

Figure 12: Structure of a Mobile Communication System

The central unit is the exchange. It establishes the connection between the base station, fixed line and mobile networks. The connection lines between the different networks can be realized by radio if no cable solutions are available. The network which connects to the base station is of particular interest. The upgrade of current hardware in the base station is connected with a little effort since the base station will be updated with software updates while connecting to landline causes higher costs because they require newer hardware.

3.6.3 UMTS

Universal Mobile Telecommunications System or UMTS is part of the 3rd mobile generation. With this technique it is possible to distribute the bandwidth dynamically in one radio cell. A high number of users in a cell decrease the bandwidth of each user. The peripheral region of a cell can be fraught with problems for users of UMTS since it decreases the quality of the reception. The access technique that is used in UMTS is Wideband Code Division Multiple Access (WCDMA). The cell can reduce the data rate at high utilization or the range of the radio cell.

UMTS supports the multi-call functionality. This feature allows you to use multiple connections simultaneously. So it is, for example possible to take phone calls and surf the internet. For three users in a cell each user has an approximate transfer rate of 128 kbps which is comparable to a bundled ISDN connection.

3.6.4 HSPA – High Speed Packet Access

HSPA is an additional protocol to UMTS. HSPA is further divided into two different protocols (see figure 13). The first protocol is High Speed Downlink Packet Access (HSDPA) and defines downlink in the mobile communication network. The second one is HSUPA (High Speed Uplink Packet Access). It defines the uplink.

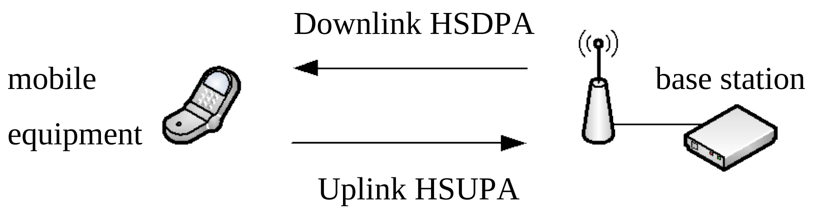

Figure 13: HSPA

With adding HSPA to UMTS it became possible to use the base station more efficiently. Also the answering time, in other words the latency, was shortened. HSPA is available in several upgrades. An overview is listed in table 9. In the first upgrade only HSPA is implemented. From the second upgrade HSDPA and HSPUA are added.

Technology	Year	Downlink	Uplink
UMTS	2004	384 kbps	64 kbps
HSDPA 1. Upgrade	2006	1.8 Mbps	384 kbps
HSDPA 2. Upgrade with HSUPA	2007	3.6 Mbps	1.8 Mbps
HSDPA 3.Upgrade with HSUPA	2008	7.2 Mbps	3.6 Mbps

Table 9: UMTS with HSPA Upgrades

Assuming a theoretical downlink of 7.2 Mbps with HSDPA shared by 15 users in one mobile cell each user has a downlink speed of approximately 480 kbps.

3.6.5 HSPA+ / HSPA Evolution

HSPA+ or HSPA Evolution is a development of HSPA. HSPA+ enables an improved usage of the frequencies which makes higher traffic rates possible. To use HSPA+ new end-hardware is required. On the side of the provider the base stations have to be equipped with newer technology. Theoretical stats are listed in table 10.

Specification	HSDPA (Downlink)	HSUPA (Uplink)
HSPA+ Release 7	28.0 Mbps	11.5 Mbps
HSPA+ Release 8	42.2 Mbps	11.5 Mbps
HSPA+ Release 9	84 Mbps	11.5 Mbps

Table 10: Overview HSPA

3.6.6 Providers and Costs

One provider for UMTS including HSPA is O2. In well developed areas HSDPA is also available with HSUPA. O2 as a mobile network provider offers four different tariffs (see table 11):

Tariff	monthly costs	included traffic volume	further MB	Timing pulse
Standard	-	-	-	60/60
Internet-Pack-S	€5.00	30 MB	50 ct	commenced 10 KB
Internet-Pack-M	€10.00	200 MB	50 ct	commenced 10 KB
Internet-Pack-L	€25.00	unlimited	-	commenced 10 KB

Table 11: Tariffs UMTS, April 2009

In the standard tariff one minute costs 0.09 €. The Internet-Pack-L, the so-called flat rate, includes a Fair User Policy. For O2 this means to slow down the traffic in both directions to 64 kbps if the customer uses more than 10 GB of traffic.

3.6.7 LTE - Long Term Evolution

Long Term Evolution (LTE) is part of the fourth generation of mobile communication and is again a further development of UMTS and HSPA. LTE is meant to use the freed frequencies from the digital dividend. The technology shall further improve the main criteria of UMTS and HSPA meaning to increase the transmission speed and decrease the latency.

Parameters

With LTE it is possible to use the frequency spectrums of 1.25 MHz, 2.5 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz. Accordingly LTE can be adjusted to the existing frequencies. It is also possible to make the frequency bands of UMTS usable for LTE. At 20 MHz channel bandwidth it is possible to allow up to 100 Mbps in the downlink and 50 Mbps in the uplink. If to this LTE technique the MIMO antenna technology is added data rates of up to 300 Mbps are theoretically possible.

In the future mobile communication networks not only the transfer speed but also the latency are important. Concerning LTE the latency shall be less than 5 ms from mobile to landline. There are also economic benefits for the operator. Using LTE, up to 200 active users can be provided with a channel bandwidth of 5 MHz. LTE is also capable to cooperate with GSM and UMTS. This results in lower costs for network operators in the establishment and expansion of their networks and lower operating costs of mobile cells.

Transmission Technology

The LTE technology introduces new encoding procedures. There are different encoding methods for the downlink: OFDMA and for the uplink: SC-FDMA. Both techniques are based on the orthogonal frequency division multiplexing (OFDM) technology. This technique divides the available frequency band into smaller bands or channels. The individual carrier signals are orthogonal. This has the advantage of avoiding interference. One disadvantage arises from the coding effort produced by many channels.

MIMO Antenna Technology

Another technique using LTE is the so called Multiple Input/Multiple Output (MIMO) antenna technology. It is used with the WLAN standard 802.11n. Figure 14 shows the principle structure of MIMO. In the upper part of the figure is a single input/output shown. The sender as well as the receiver needs antennas. In the lower part of the figure the MIMO technique is shown. For MIMO receiver and sender have multiple antennas. This technology increases the traffic rate and the transmission quality.

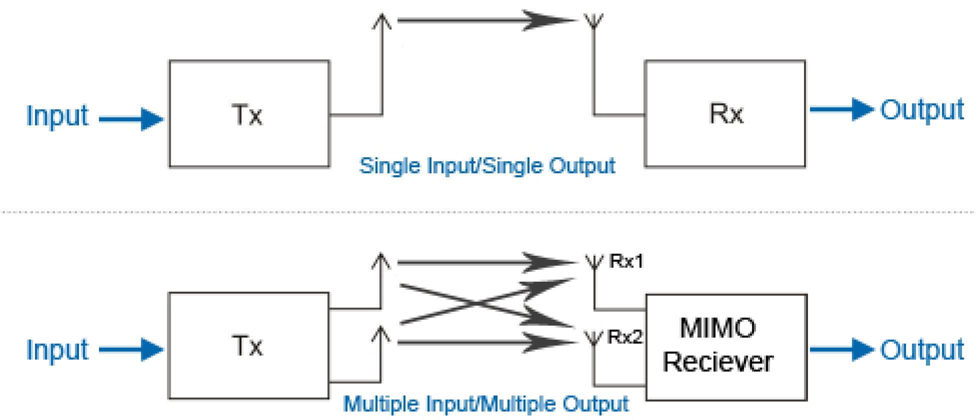

Figure 14: MIMO-Technique

3.7. WiMAX/WLAN

The WLAN technology (WLAN - Wireless Local Area Network) was defined by IEEE (Institute of Electrical and Electronics Engineers) in the 802.11 standard. Also the IEEE defined 802.16 (WiMAX). WiMAX is short for Worldwide Interoperability for Microwave Access and is a wireless technique for a Metropolitan Area Network. WLAN and WiMAX were developed simultaneously. Table 12 shows a comparison of those technologies and their technical attributes.

	WLAN	WiMAX
Propagation	local are wireless network	regional wireless network
Range	ideally 3 to 6 to km but normally 30 to 300 m	theoretically up to 50 km under conditions of LOS, in buildings 600m
Specification	802.11 b max. bandwidth up to 11 Mbps 802.11 g max. bandwidth up to 54 Mbps	802.16-2004 for static receiving 802.16 e for mobile receiving with cell phone or notebook
Max. transmission rate	theoretisch 54 Mbps, in der Praxis zw. 1 bis 14 Mbps	theoretically 109 Mbps with 28 MHz channel width normaly apprx. 20 Mbps
Quality of Service	not optimised for VoIP / videostreaming	VoIP and videostreaming optimised
Frequency range	2400 – 2485 MHz 5150 – 5350 MHz 5470 – 5725 MHz	2500 – 2690 MHz 3400 – 3600 MHz 5725 – 5850 MHz

Table12: WiMAX/WLAN

3.8 Motorola Company

The Motorola Company developed an own portfolio named Canopy. With the help of that technology they realized wireless broadband networks. The benefit of using Canopy is that Motorola products are perfectly adjusted to one another. Canopy is capable to realize point to point and point to multipoint (see Figure 15). It is possible to supply areas with broadband internet which did not have DSL yet. Net traffic rates can be up to 300 Mbps. Canopy is allowed to use the frequencies 2.4 and 5.4 GHz in Germany.

If a system is developed with the Motorola Canopy technology it consists of three main components which are shown in figure 16. If a connection to the internet is not locally available one can connect to a different location where internet is available, bridging the distance with a radio link system. Therefore Canopy technology, e.g. backhaul modules will be used. Another key component in the Canopy system is the access point. This allows the user access to the Internet.

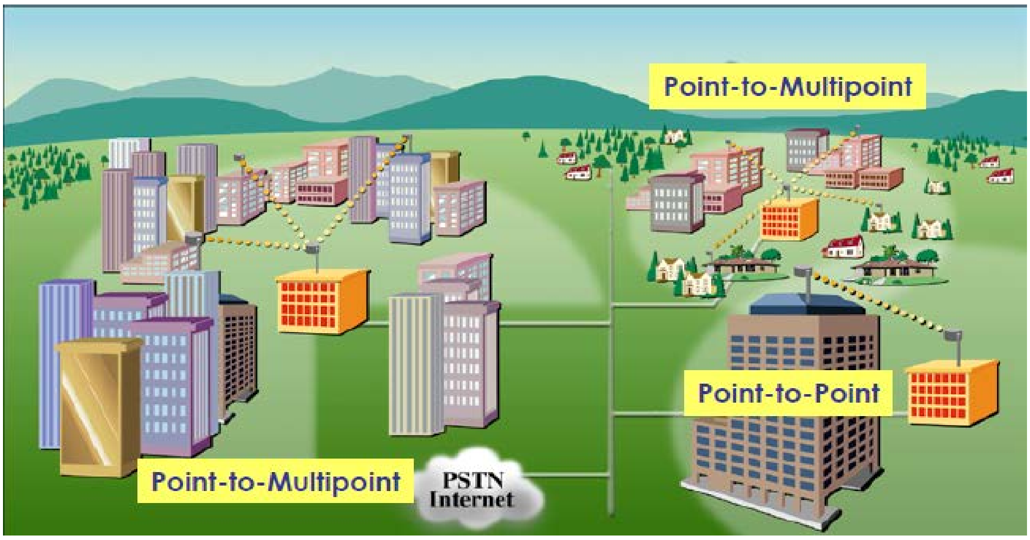

Figure 15: Canopy Connections

Six access points can be connected to form a cluster with one another to achieve a 360° coverage. Households need to be supplied with a subscriber module to connect with an access point and thus joining the Internet.

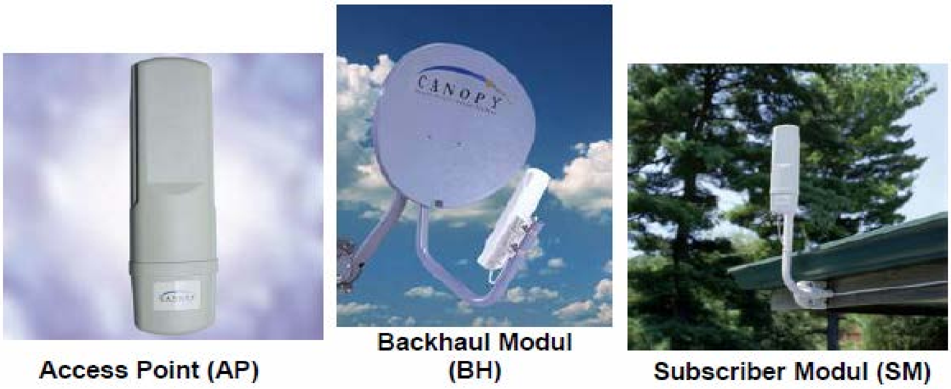

Figure 16: Canopy Components

Figure 17 shows the basic structure. On a mast an access point cluster is mounted which is connected to a wired internet connection. In addition there is a cluster management module that controls tasks for the network. Between users and access points is a point to multipoint network. With an access point cluster with six access point modules can achieve up to 200 subscriber modules.

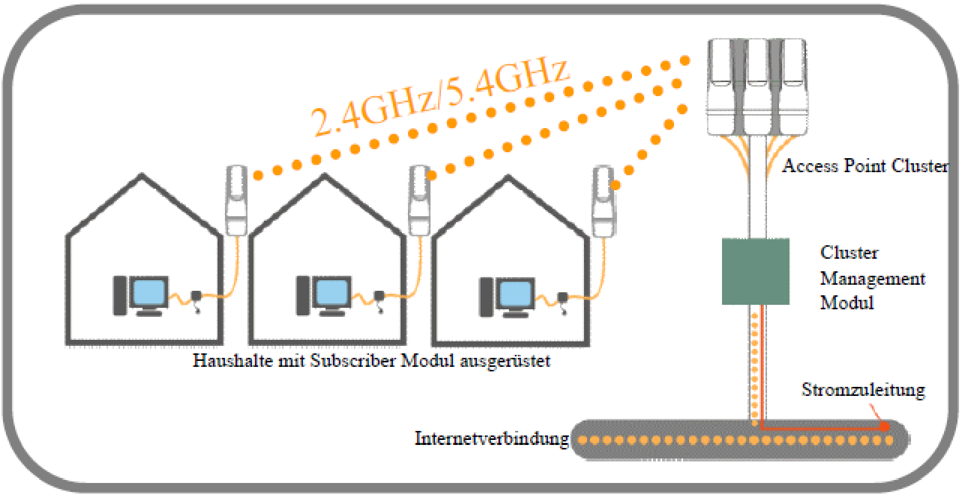

Figure 17: Canopy Distribution

If no communication is available at an access point cluster the distance to a location where internet is disposable can be bridged via a radio link system (see figure 18). Motorola offers backhaul modules to deal with the distances.

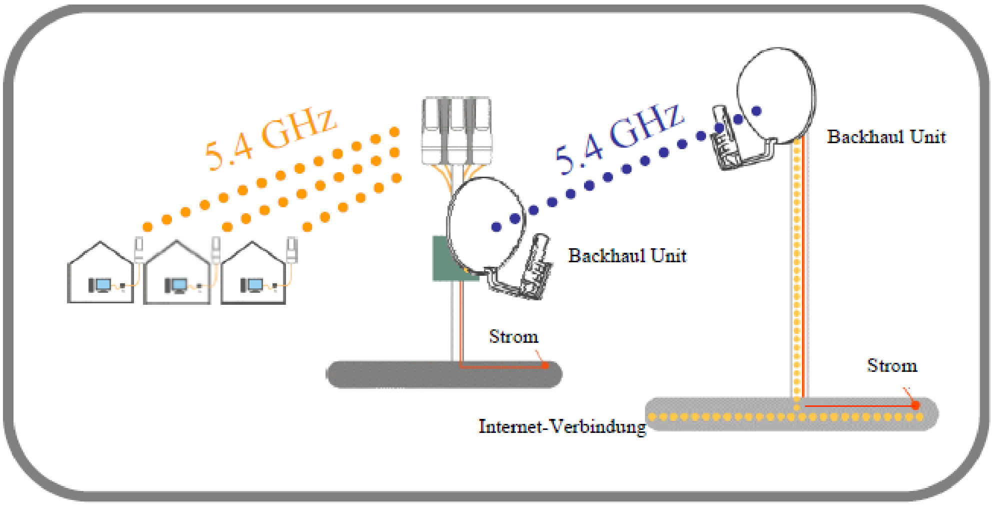

Figure 18: Canopy Radio Link System

In radio linked systems three possible types of lines are distinguished which are shown in figure 19. They lie between the transmitting and receiving stations.

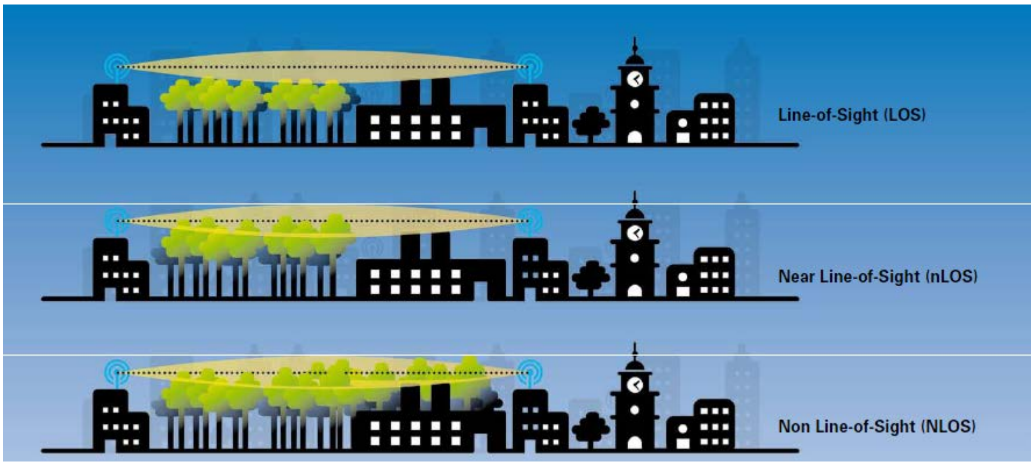

Figure 19: Possible Radio Link Directions

For the best connection direct visual contact is necessary. An alternative description of direct visual contact is line-of-sight (LOS). If minor obstructions are between the station, it is called near Line-of-sight (nLOS). If there are major obstructions, e.g. trees or buildings between the stations it is called Non Line-of-sight (NLOS). The worse the line of sight between the stations is the worse are the range and transmission rate.

4. Conclusion

Though this case study is meant as an overview of accessibility to broadband internet access we will favor a specific broadband technology for supporting rural areas in the Weser-Ems district. Our proposal does not mean that other technologies are rejected for an operation but it is best fitted where we do not find the application respectively the permanent support of DSL, cable-TV or fiber in the next, let us say, five years. The power line technology has large disadvantages for instance a lot of users have to share the usable bandwidth of up to 2 Mbps and the permanent impairment of long, medium and short wave reception. Even satellite technology has the major disadvantage that users share the available bandwidth of a satellite transponder. So this is not suitable for a large numbers of users. Moreover users suffer under high latency periods so that this technique is not convenient for real time applications. WiMax / WLAN are not appropriate for rural areas. Mobile communication networks up to the 2nd generation and UMTS standards cannot supply internet access with broadband quality from about 1 Mbps and more in the downlink, higher generation are not spread throughout the country.

In summary we select the Canopy connection as our solution. Broadband internet is possible, the costs need not to be higher than the costs of other technologies. In fact the costs are lower, customers can be supplied in less than five or six months and the connections can be implemented by a well-known local or regional small or medium enterprise.

5. Implementation

The implementation of the proposed solution will be described in a general model. This model contains a planning phase, a design phase, an implementing phase and a section called operating and maintenance. In a second step the outlined phases are applied which is detailed stated in the case study “A Model for a Broadband Supply to the Internet in Rural Areas of the Weser-Ems District”.

At first information concerning broadband supply to the Weser-Ems district is gathered. Afterwards requirements from the customer’s point of view are to be determined. A feasibility study is then in debate. The design phase covers a test setup, measurements and optimization. Subsequently a radio link from the rural area to test the broadband access has to be installed and configured. In the rural area which is tested a number of pre-contracts were signed and the customers will be supplied with 3 Mbps in downlink and 128 kbps in uplink. For operating and maintenance a suppression agency is instituted.

These statements are based on studies and research carried out in the summer and autumn of 2009 in the laboratory for communications and transmission technology of the University of Applied Sciences in Wilhelmshaven and resulted in a bachelor's thesis.

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