A Model for Supplying Broadband Access to the Internet to Rural Areas in the Weser-Ems District

Case Study

A Model for Supplying Broadband Access to the Internet to Rural Areas in the Weser-Ems District

Content

1. Executive Summary

We will develop and describe a model to supply a broadband access to the internet in rural areas. The model consists of several phases of a generalized model, such as planning, developing and implementing phases. More over the operation and maintenance is described. Within the planning phase four methods to analyze are used and detailed in picture. These are: gathering information, analyzing requirements, feasibility study and approaches to supply rural areas with broadband internet access.

An application of the generalized model will follow in the next chapters. The basics are exposed in chapter 2 "Problem Statement" will be exerted particularly. We will take preparations for an opinion poll to investigate which broadband offerings already exist in the Weser-Ems District.With the help of a call centre the inhabitants´ statements will be queried. The company ju-DSL will accompany us to bring more and better broadband access to the internet for the residents. Throughout this case study we apply the developed general model in a planning and design phase, draw a conclusion, show the implementation phase and close with aspects of operation and maintenance.

2. Problem statement

In this chapter we design a theoretical model to show the possible ways to supply rural areas with broadband internet. The problem, which is to be solved, is the first respectively and the last mile. To solve this problem we developed a model with corresponding analyzing methods. The developed model is to be applied in the following phase. Hereby, the individual phases are (like described in the model) processed and the analyzing methods applied. The general model consists of four phases, which are displayed in figure 1. The individual phases are further subdivided and include analyzing methods.
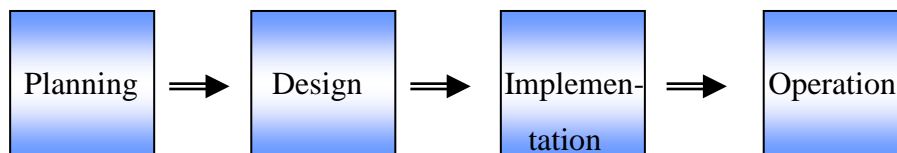

Figure 1: General model

The developed model is based on inquiries concerning the topic „Technologies for Broadband Internet"and information given to us by the company ju-DSL. Additionally, the compendium of the Fraunhofer-Institution for Communication Systems (ESK) was used as an inspiration. In a short review by Fraunhofer, the described paragraphs are placed in the planning phase. In the planning phase we developed several methods to gather information and enable a structured workflow. The first phase is the base for the following steps three and four. For the lack of practical experience the model cannot be thought through in every detail.

2.1 Planning Phase in General

In the planning phase information is gathered and processed in order to evaluate the practicability. Within the planning phase four methods of analyzing were used (figure 2).

2.1.1 Gathering Information

The first method within the planning method is gathering information. In this chapter information about the corresponding area and the demand for high speed internet is gathered and processed. As an overview figure 3 shows how the search for information is divided in the parts a) general information and b) concrete information.
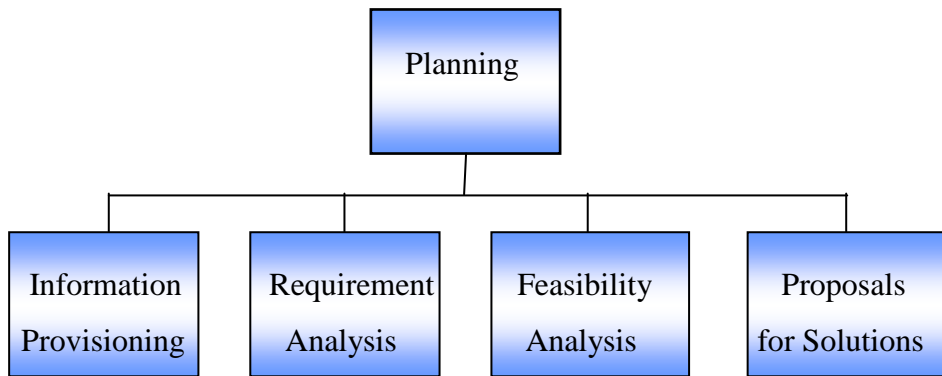
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Figure 2: Planning phase

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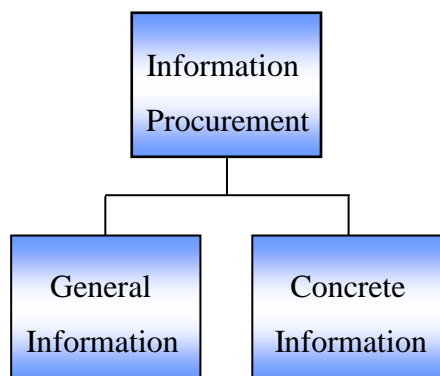
Figure 3: Analyzing the situation

The information search is similar to the analyzing of requirements. Each analyzing method is done from another point of view. For the starting point of gathering information, general information is used, which is further concretized (figure 4).
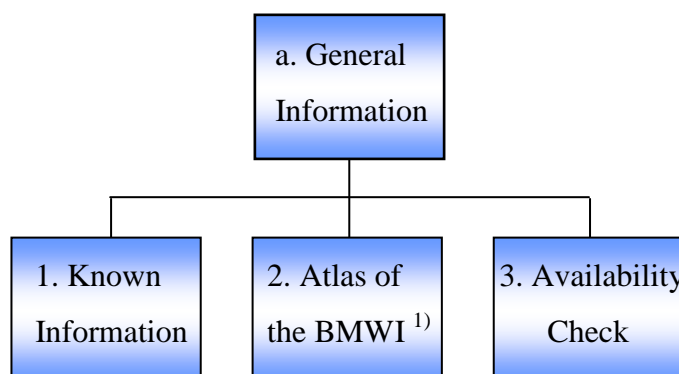
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Figure 4: General information

1) BMWI – Bundesministerium für Wirtschaft und Technologie (Federal Ministry of Economics and Technology)

a. General Information

1. Known Information

By known information we mean already existing information. These can come from case studies, current or finished projects or initiatives. If a project is already planned or is currently in process you can connect to it. As a participant of that project you have the chance to collect new information. This information regards the current plan and the current supply with broadband internet acces in the area. Also known information can refer to information you know from hearsay. These have to be revised and examined for correctness.

2. Atlas of the Federal Republic of Germany by Federal Ministry of Economics and Technology (BMWI)

Via the website of the BMWI (www.zukunft-breitband.de) you gain access to its Atlas of the Federal Republic. The atlas consists of maps which display the available technologies for each region. The information of that atlas is not exact enough to plan supply but it allows you to create an overview. The available technologies are given as percentages and the marked areas are, in rural areas, at least as large as a community or an administrative district. An example is given in figure 5.
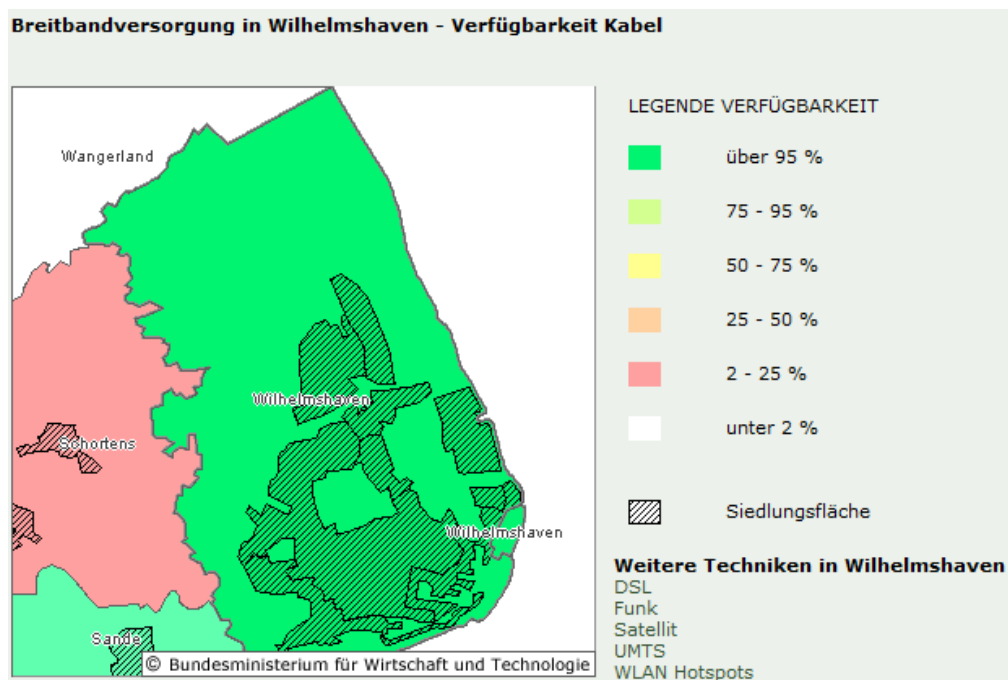

Figure 5: Atlas of the Federal Republic of Germany – Availability of Cable

In figure 6 information regarding DSL technology is displayed. One can see that the marked areas are large but the information is more exact than in figure 5. If availability is examined one can conclude that it is not possible to buy a DSL connection everywhere. The legend shows the availability of DSL.
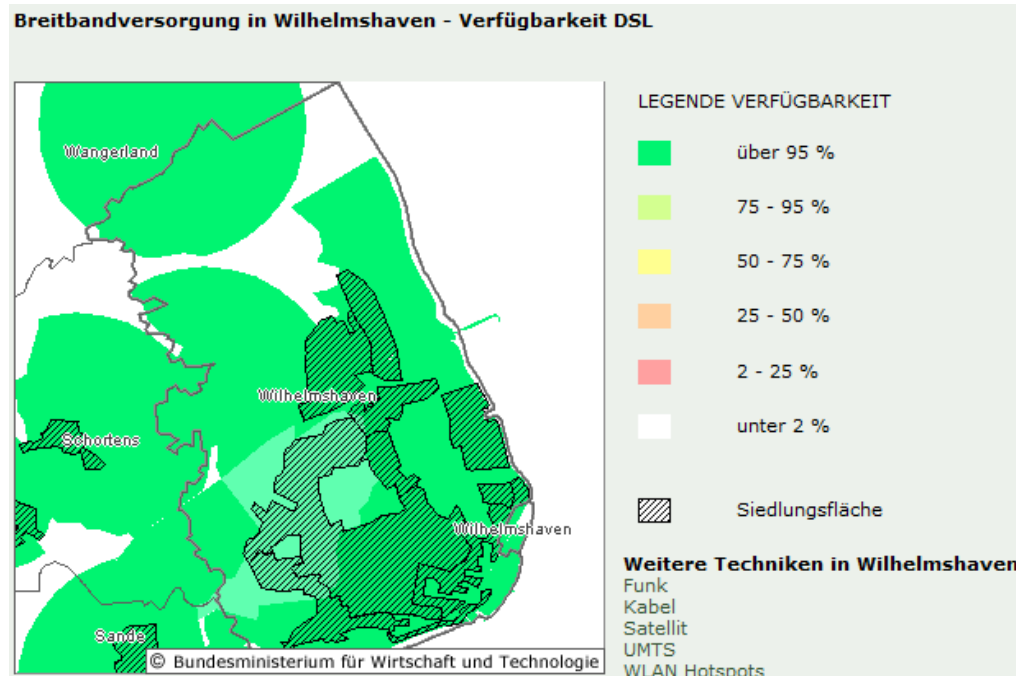

Figure 6: Atlas of the Federal Republic of Germany – Availability of DSL

3. Availability Check

Availability checks can be done on the internet sites of the different providers. The result is determined from the address and potentially the telephone number. If the availability check was positive the customer can get a DSL connection. If the customer sends an order form to the provider they will check which specific connection is possible, meaning that the information from the availability check could be wrong. The reasons rely on the network of the provider. A DSL access multiplexer (DSLAM) doesn't have the capabilities to provide a DSL connection for everyone. The transmission speed which is displayed during the availability check can differ from the effective speed. The possible transmission speed relies on used technology, e.g. the DSLAM can be up to 5.5 km away from the house connection (ADSL technique).

With the previously determined information a base has been created, which is specified in section b (see figure 7). Therefore four methods are available to be applied separately or together.
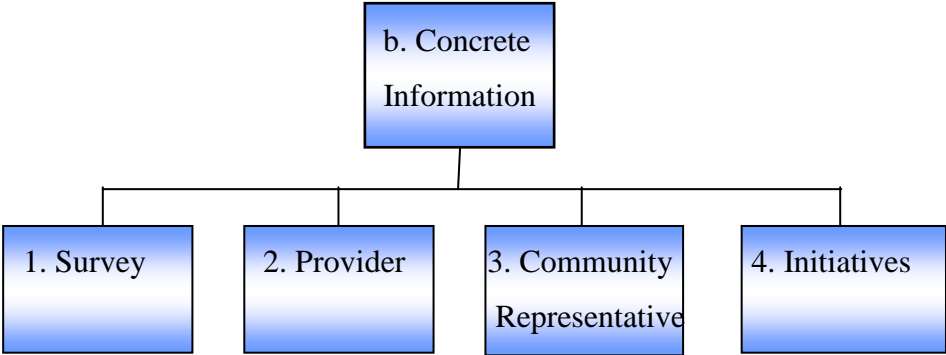
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   ┌────────────┐  ┌────────────┐  ┌────────────┐  ┌────────────┐
   │ 1. Survey  │  │2. Provider │  │3. Community│  │4. Initiatives│
   │            │  │            │  │Representative│ │            │
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Figure 7: Concrete Information

   b. Concrete Information

      1. Survey

A survey is suitable for getting an exact statement relating the area which is to be supplied. The advantage here is that such a survey can be done independent from the provider or other entities. A survey consists of three phases displayed in figure 8.
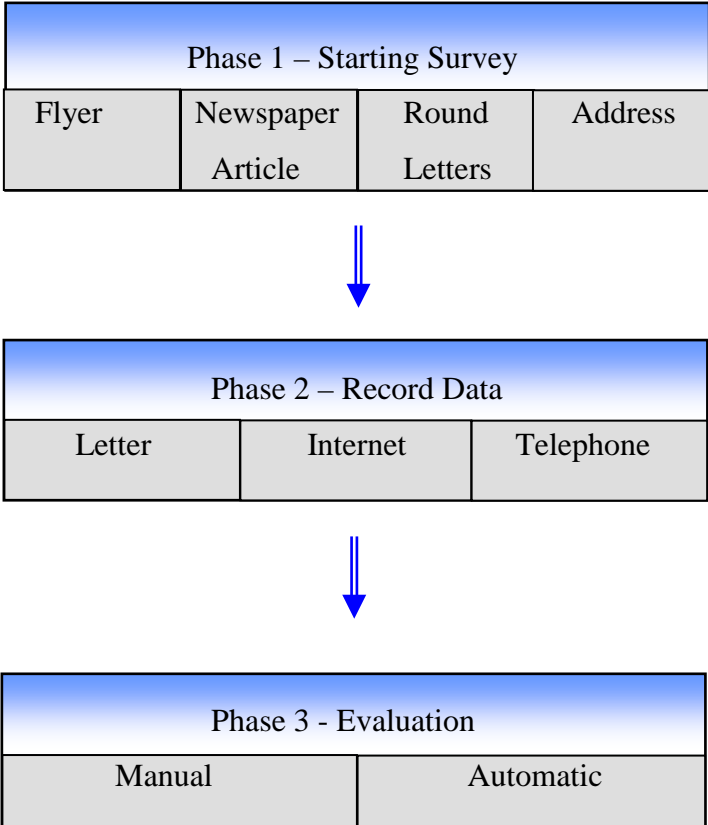
Phase 1 – Starting Survey			
Flyer	Newspaper Article	Round Letters	Address

⇓

Phase 2 – Record Data		
Letter	Internet	Telephone

⇓

Phase 3 - Evaluation	
Manual	Automatic

Figure 8: Processing a survey

In the first phase it has to be decided how the participants should be involved. Therefore you can use tools like flyers, newspaper articles, round letters but you have to depend on the reaction of the customers. Furthermore you do not know the number of participants, rather than if you directly talk to people on the street, via telephone or assembly. Processing the survey via telephone has a big disadvantage: people could feel harassed, thus do not participate and get a negative impression. Certainly if you speak directly to the customer you can provide further information. This information can answer questions about radiation and used technologies and can lead to a better impression and thus an agreeing customer. If the tools are available, the second phase starts, determining where the customer can get help and can get additional information. If you use the internet, only customers who already have an internet connection can participate. Additionally a website has to be written which has to keep private information in confidence. If people shall be able to participate via mail, you will have to explain the cause.

Another variant to participate in the survey is a telephone survey. With a telephone survey you have the opportunity to support a calling customer at technical issues and to lead him through the survey. The disadvantage here is that there are people who do not like to telephone and thus will not participate. As soon as the information is acquired it will be processed in phase 3. You can manually process it if there is not too much information, otherwise you should make use of software for data processing. Based on the information, you can give a concrete estimation concerning the availability of broadband internet. However this method for a concrete determination is depending on the inhabitants of that area.

2. Gathering Information from the Provider

This method for gaining data holds problems. The provider has to reveal concrete information about his network. This will show the business strategy to concurring companies and therefore damaging its ability to compete. Also it is the providers' nature to increase the number of its very own customers, thus improving its position. On the other hand, this would be the best method because the provider knows his network best and knows where the network needs development. By

cooperating with the provider, combined with new customers, this method definitely is possible.

3. Community Representative

   Yet another method is to talk to community representatives. A community representative is responsible for the interests of the citizen in his or her community and thus knows the local situation. Based on that, one can set up a contact. If no information about the current access to broadband internet is disposable, the community representative is able to gather concrete data (by e.g. using the survey method). The provider and the community will have economic profits from working together, thus processing regulatory affairs, e.g. setting up radio masts faster. The availability of broadband internet is more and more important for companies and private users and is a criterion for choosing a site, respectively the place of residence. A disadvantage is the dependency on the community's cooperation.

4. Initiatives

   The last alternative in this paragraph to gather concrete information is a method called initiatives. Of course, it is essentially based on the fact that an initiative for broadband internet was established in the respective area. That initiative can consist of members of the community or larger groups of people with the same interest. The benefit of an initiative is that they can access concrete data about their area very easily and therefore know which areas in the community cannot be connected to broadband internet. Additionally, the initiative can do supportive work.

When the required data was gathered a new problem emerged: You will have to process the collected information. An approach to this was published in July 2008 by the ‚Broadband Initiative of Bavaria', called "Guideline for Mayors, Sponsors for Broadband and Communal Persons in Charge". The initiative led to a broadband portal in the internet, to which groups of interest can get access. Different groups can get different access rights to the stored information. Using the portal one can collect, process and administrate data.

2.1.2 Analyzing Requirements

The analysis of requirements is a technical point of view and also an analysis of the market on the topic of broadband internet connections. That means that some sort of specification for the customer is created. The specification can include following points:

a. Transmission Speed Down- /uplink

    The transmission speed is the main criteria of the specification. Here down- and uplink speed is determined which influences the usage of internet applications. The transmission speed shall be similar to DSL via cable.

b. Allowed Variability's in Transmission

    The transmission speeds which were determined in a) cannot be guaranteed to 100 %. There are times when the network is used to full capacity because many users are active. Additionally, users (e.g. companies with special contracts) can be preferred. Another reason for the non-availability can be the breakdown of network components, e.g. by the cause adverse weather conditions. That is why there can be variations in the transmission speeds even if they are part of the contract. Therefore, tolerable boundary values must be appointed. The speeds mentioned in the contract cannot be guaranteed, which is also conditioned by physical parameters of the connection.

c. Reliability

    A network consists of many components. The most important exist redundantly. Yet, components can have a blackout. Therefore, the provider has to make provisions to assure the functionality of his network. If wireless technologies are used, the distances and components can suffer from environmental impact. They might lead to malfunctions even if the network is stable and secured. For example, damage from lightning will very likely destroy a component.

    The agreements about the failure rate are extremely important for companies and their businesses because a network blackout would interfere with the companies´ business activities. The reliability and respectively the availability of the network is determined by the provider in the general terms and conditions. Information about the probability of a blackout is given by the manufacturer of the hardware

components. Included in the reliability is the amount of time needed for troubleshooting.

d. Reaction Time in the Case of a Network Failure

It has to be determined how much time troubleshooting is allowed to take, if the network is somehow malfunctioning. Hereby one has to differ between a problem by customers or if the malfunction is based on hardware which is in controlled by the provider. A breakdown of the providers´ hardware can lead to a blackout of larger parts of the network. This kind of malfunction is on highest priority for the provider. If the problem occurs on the customers´ side, it has to be fixed as soon as possible. A flexible field service can be established. Malfunctions occur from down breaking hardware, environmental impact or wrong configuration.

e. Telephone Connection

The DSL and cable provider offer tariffs, which replace the standard telephone connection of the *Deutsche Telekom*. Telephoning is realized via VoIP technology. It has to be decided, if there should be similar options to the ones the provider offers. If wireless technologies for the supply with broadband internet are used, it depends on the uplink speed if you can use VoIP. Additionally, the maximum latency of 150 ms has to be considered. According to the feasibility, the customer can choose between having an additional telephone connection or not.

f. Hardware

In this paragraph it has to be determined, what hardware is to be installed at the customers' location. There are components which provide the required functions to connect to the network. There are also components which have integrated services such as telephone and WLAN.

g. Monthly Fee and Service Charge

The monthly fee and the service charge shall be similar to the current market prices. As a reference, the tariffs of DSL and cable technologies are used.

2.1.3 Feasibility Study

In this analysis the technical feasibility of the respective area is examined. Therefore, the available techniques are examined regarding their benefits and their disadvantage in paragraph a). In the following part b) we verify if geographical data is required. The existing network infrastructure will be ascertained and described in paragraph c). For each individual technology it must be assured that present licenses are kept (see Paragraph d: Licenses). In the last paragraph e) links laws and permissions are examined. An overview for the paragraphs within the feasibility study is shown in figure 9.
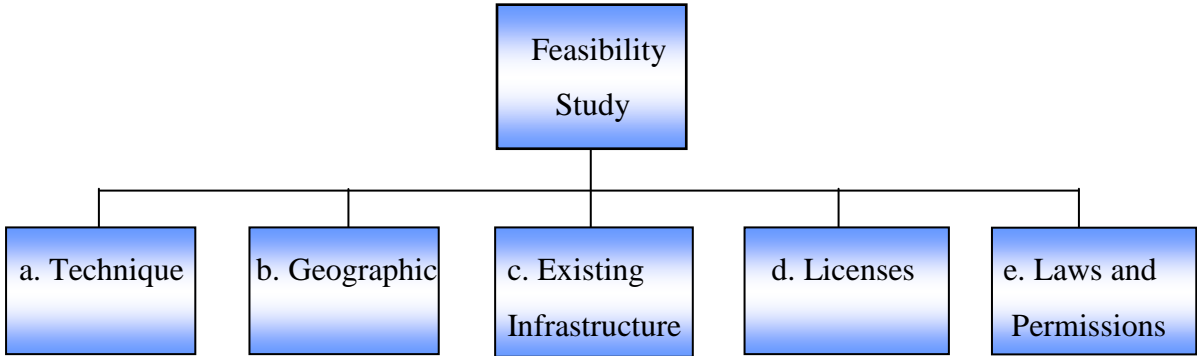
Figure 9: Feasibility Study

a. Technical Analysis

The technical analysis is subdivided in three parts (figure 10). In the first step we check which technology can be used to supply the area with broadband internet. After that examination the hardware which is to be used is selected. In this step we also consider possibilities where to place the hardware.
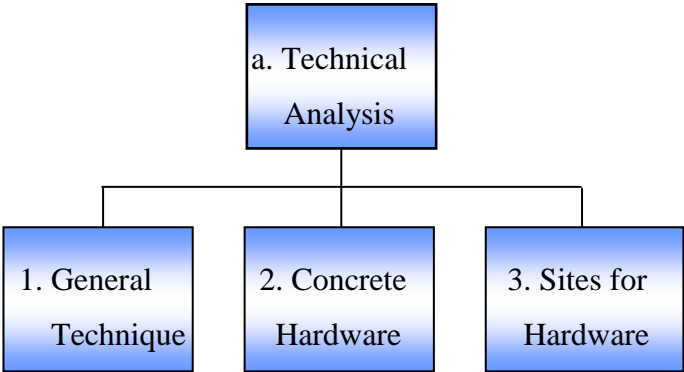

Figure 10: Technical Analysis

1. General Technique

In the first paragraph of the technical analysis it is determined, which of the possible technologies is reasonably functional for the supply of rural areas with broadband internet. The benefits and disadvantages are summarized in table 1.

Technique	Applicable	Reason
DSL	no	- high costs for a DSL-infrastructure (laying cables) - only slow development in rural areas
Cable-TV	no	- infrastructure of the provider mostly in cities.
Powerline	no	- slow performance - possibility of malfunction
Satellite	no	- no high transmission speed - high latency - many users have to share the bandwidth - high costs compared to DSL and cable
Mobile communication (UMTS)	no	- high costs - many users, low bandwidth - not well developed in rural areas
WLAN/ WiMAX	yes	- suits the first mile - low cost - new user can be connected fast
Motorola Canopy	yes	- suits the last mile - low costs - high traffic speeds possible - new user can be connected fast - proprietary standard

Table 1: General Techniques

To bridge the last mile in rural areas, radio technologies are preferred because no cable-bound infrastructure has to be set up. These technologies are used to solve the problem of the last mile or as a part of the network. That is because it is not economic to lay copper or fiber glass cables at sub surface because the costs for burying are higher than the costs for the material itself. Mobile communication technologies can be used as an addition to the internet connection. However UMTS with HSPA is, regarding costs and transmission speed, not comparable to DSL or cable. You must also have in mind that the providers did not develop their mobile technologies to its fullest in rural areas. Even in cities one will never reach full promised transmission speed of these technologies.

2. Concrete Hardware

The second part of the technical analysis is a task for the provider. They will select the adequate hard- and software for the customer. For the provider the hardware has to be determined to fulfill the strategy for the number of users, requirements, and the expandability. Additionally, the chosen technologies have to be kept economically and the network must be scalable for more users.

3. Sites for Hardware

In the last paragraph of the technical analysis, sites for the hardware have to be chosen. For the provider as well as for the customer different things are to be considered. If e.g. radio modules have to be installed on walls or public buildings, they may disturb the cities scope. If that is the case good ideas to hide the radio modules could be helpful, e.g. installing them on lanterns. This has the benefit, that the components can be connected to electricity without high effort (a problem could be loss of power during the switch off times). On the side of the provider, sites have to be chosen, e.g. sites for redundant hardware and intelligent network components.

b. Geographical Analysis

If radio-based technologies are used, the geographical analysis is an important part of the planning phase.

1. Sites of Radio Masts, Including Sending/Receiving Masts

The radio masts you want to use must be applicable to the technology and free to rent for own usage. If no masts are available, you have to set up your own. Radio masts have to feature a height, where the individual radio modules can connect via an optical line of sight. Additionally, you have to keep in mind the *Fresnel zone,* which means that not only physical objects can distract the signal within the distance between two models. If directional radio links are set up, more modules have to be installed at the same height to assure optimal signal strength.

2. Obstacles between Sender and Receiver

If the sending and receiving units need a quasi-optical connection, obstacles can cause problems. It is required to gather information regarding the maximal

height of trees and buildings in the area. The results have to be considered for setting up the radio masts. This also means that you have to develop an alternative if you are not able to establish a quasi-optical connection. One alternative could be using intermediate stations, such as hubs or repeaters.

c. Analyzing Existing Infrastructure

1. Supply Point (Uplink)

You have to find points, where the wireless LAN connects to a grid-bound network. The uplink needs to fulfill the requirements to supply the customer.

2. Mobile Radio Mast

It is to be determined, if you can co-use existing mobile radio masts. Therefore, the owner of the masts has to be identified. To install wireless components, even high towers or buildings, e.g. churches, are suitable.

3. Contracts

If you can co-use the existing infrastructure, contracts have to be developed which fit into the economic and technical system. If that is not the case, one has to consider to expand the existing infrastructure or to set up an own infrastructure. This especially concerns renting mobile radio masts. Instead, several radio modules can be installed on one building.

d. Licenses

It has to be reappraised if eventually licenses can be used or have to be considered. That can be the case with certain network components or software. The use of licensed frequencies in Germany needs allowance of the Federal Network Agency.

e. Laws and Authorization

If new mobile radio masts come in to account, many requests have to be filed and allowances gained. Obeying and considering laws is an important factor in the planning phase. From the technical point of view the maximal allowed transmission power is not to be exceeded. Setting up radio masts and the installation of radio modules can be regulated by law, e.g. mounting units are not allowed to be higher than two meters above the roof without suspension ropes.

2.1.4 Approaches

In this chapter different approaches are demonstrated to supply rural areas with broadband internet access. In the first approach ideas to improve the DSL structure are shown. Improving the structure depends on the major provider. The second approach makes use of the existing infrastructure of the area where no broadband internet is available. Therefore, a connection on the basis of radio technology to a place with a broadband connection is set up. The third approach involves using radio technology for bridging the last mile. This variant suits smaller companies which cannot set up a grid-bound network because of financial reasons. In the concluding part of the analysis the different approaches are evaluated.

a. First Approach

The easiest way would be to provide the area with a DSL infrastructure. To keep the costs lower for burying and thus for setting up the grid, a near starting point has to be found. That point can be located in a nearby town which has broadband internet. For this approach the main actor is a major provider, such as *Deutsche Telekom* or *EweTel.* To quicken the development of the network the town which is to be supplied can execute constructive work on its own which lowers the cost. For making the network infrastructure which is to be installed more economic contracts can be negotiated. Additionally, projects for the supply of rural areas can apply for subsidies on community state or federal level.

In the study of the *Fraunhofer Institute for Systems of Communication Electronics* you can see that the market offers DSLAMs for few subscribers. These components are suitable for smaller towns.

b. Second Approach

In the second approach the existing infrastructure in place is used. The existing infrastructure in place is appropriate for the DSL technology. If in the city the technology to connect to broadband internet is absent, it is possible to provide a radio link to provide the necessary bandwidth. The uplink can be done in a neighboring town that has broadband internet. The basic design for this proposed solution is illustrated in figure 11. The internet users in the city get a DSL connection over the local network.
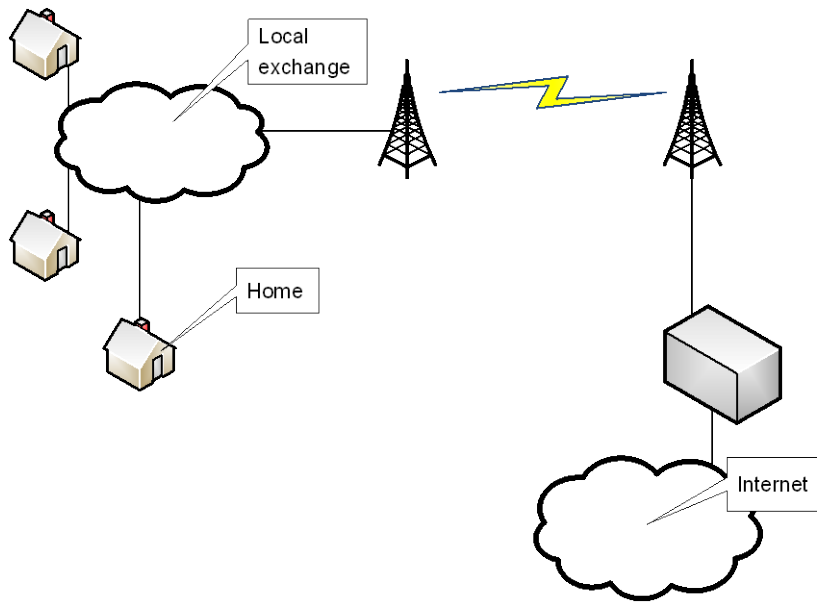
Figure 11: Second Approach

c. Third Approach

The third solution is based on wireless technologies and can be divided into two scenarios (figure 12 and 13). In the first scenario there is broadband internet access in the city with the help of wired technologies but for the majority of households in the village broadband internet access is preserved.
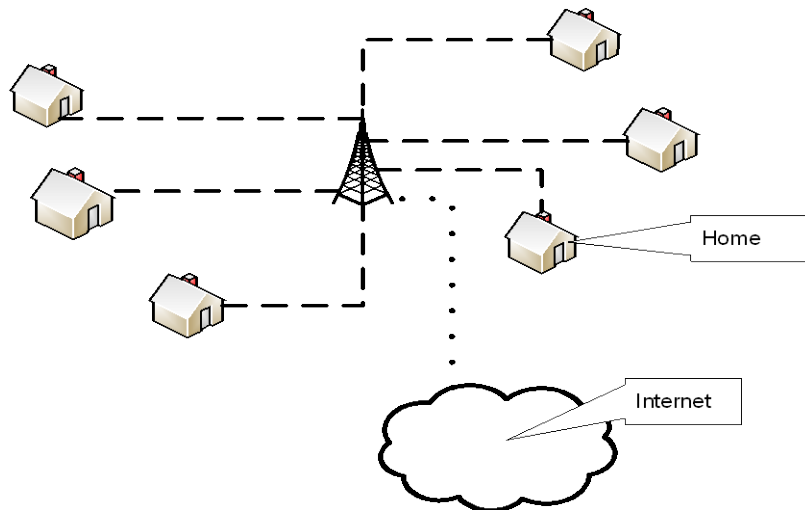

Figure 12: Third Approach, Scenario 1

To solve the problem a central sending and receiving unit is set up, which holds a connection to broadband internet. That unit can be installed on high buildings,

towers or mobile radio masts. From the site the modules can be aligned in that way that the customer will have the best connection possible.

In the second scenario there is no possibility to connect via cable-bound grid to a broadband internet connection. Thus one has to find a place which meets the requirements. For short distances neighboring towns are suitable. When place is determined, a directional radio link can be established.
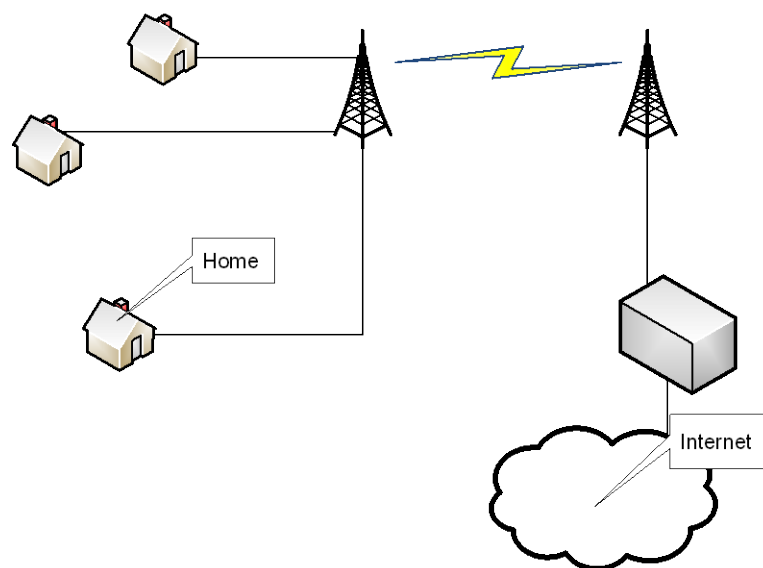

Figure 13: Third Approach, Scenario 2

Both variants include additional network components, if no quasi-optical line of sight between the radio modules can be established or the distance, which has to be bridged, is too high. In both cases repeaters are used.

For the whole *Weser-Ems District* no concrete conclusion can be evaluated concerning which approach suits the area best. For the cities in the *Weser-Ems District* which partially cannot be provided with broadband internet all introduced ideas are conceivable. A concrete solution depends on the existing infrastructure. For the rural areas in the *Weser-Ems District* where only few people live the third approach is most suitable. That is because the rural areas do not have an infrastructure for DSL or cable and therefore broadband internet access has to be provided. A fast economic solution would base on radio-based technologies like WLAN/WiMAX and Canopy by Motorola.

2.2 Design Phase in General

After the planning phase was executed successfully it is possible to provide broadband internet access to undersupplied areas. The design phase can be started. Here, the design phase will be relating to the third solution from the planning phase. The design phase can be subdivided in three parts (figure 14).
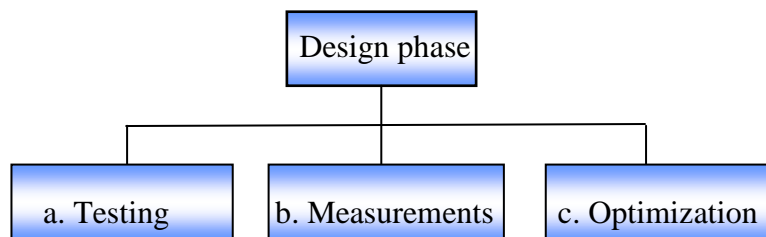

Figure 14: Design Phase

a. Testing

In the first paragraph of the designing phase, the experimental set-up, the selected approach is set up with the goal to experiment and draw conclusions. The third approach was selected. At first, the main radio mast is equipped with the basic hardware. In the next step, mobile radio masts can be used as temporary intermediate stations. To this station a directional radio link has to be established. This step makes it possible to find the best site for a radio mast. Afterwards, customers will be equipped with radio modules. After finishing the installation and configuration progress measurements can be taken in the next step.

b. Measurements

When all required components for the tests are installed, the first measurements can be taken. Following parameters can be tested: signal strength, bandwidth and distance. Additionally to the measurements it will be checked if other people already use licensed free frequencies.

c. Optimization

The results are used to determine the direction and suitable places for the radio modules. If, during the experiments it becomes apparent that the used components are

not appropriate other components have to be chosen and tested. For example, the established transmission path is not capable to provide the required bandwidth.

If the experiments turned out positive and if the requirements are met, the implementing phase can be started.

2.3 Implementing Phase in General

In the implementing phase all components for the developed solution are set up, stationary mounted and configured. Once again it must be differentiated between hardware for the provider and hardware for the customer.

a. Customer

On the customers´ side the hardware components have to be installed and configured. If radio modules have to be mounted at the customers place, a correct placement of that module is important. Eventually mounting equipment needs to be installed. This step can only be done by trained personal with appropriate measuring hardware. Also eventually a power line has to be drawn (according to the model). When the module is installed, it has to be directed to the radio mast. Radio modules also need a connection cable into the house, which can be drawn by the owner or an installer.

b. Provider

On the provider's side a network is set up or extended which makes it possible to provide broadband internet access. Therefore, the radio masts need to be equipped with the required hardware. Also an uplink has to be established that meets the requirements.

2.4 Operation and Maintenance in General

When the network is set up and customers are able to use broadband internet, the usability of the connection has to be assured. Therefore, a service must be established within the company which is responsible for repairing disorders. Disorders can emerge from defective hardware. Faults also can emerge in radio systems, if the quasi optical line is interrupted. This can happen by growing trees or other environmental impacts, e.g. thunderstorms.

Another task is to control and to inspect the network. For example, the load balancing is being monitored for a fast determination and the correction of network failures. Also monitoring enables the administrators to determine, if the uplink within the network is fast enough. The uplink can be reconfigured to meet new requirements.

The network can be expanded during operation to provide new customers with broadband internet access. Potential customers have to be informed about their possibilities. This can be done by setting up a hotline, a website or by holding information events. With the network expanding further, one has to keep in mind that the uplink needs to be sufficient and eventually the uplink has to be reconfigured to meet new requirements.

3 Alternatives

In this chapter the developed model is applied to the *Weser-Ems District.* The first step is to look for areas where no broadband internet is available. In the following the solution is to be determined to provide these household with broadband internet. This is done in cooperation with the company *ju-DSL. ju-DSL* is based in the town of Esens and aims at providing the East-Frisian people with broadband internet access. Further information about the company can be found on their homepage www.ju-dsl.de. For the purpose of cooperation people from the *Weser-Ems District* become connected to the network of *ju-DSL,* so they have an available broadband internet connection.

3.1 Planning Phase in Application

Within the planning phase all required information is gathered. There are areas to be determined, which do not have a broadband internet connection. After that the requirements for a possible approach are analyzed. At the end of the planning phase a ready-to-go approach should be available.

3.1.1 Gathering Information

At first, general information concerning the *Weser-Ems District* is gathered. As a result from researches in the internet it became clear that there are many small areas in the *Weser-Ems District* which are not provided with broadband internet access. In the following step we determine the available technologies for the *Weser-Ems District* with the help of the Federal Atlas of the BMWI. The Federal Atlas contains information to following technologies:

- DSL, Radio, Fiber, Cable, Satellite, Power line

Figure 15 is an excerpt from the Federal Atlas of the BMWI and shows a map of the *Weser-Ems District.* It displays information concerning the availability of the technologies: DSL, Cable, UMTS and Radio. One can see that the number of available technologies is highest in Wilhelmshaven and gets fewer in more rural areas, e.g. the town of Aurich and the county of Friesland.
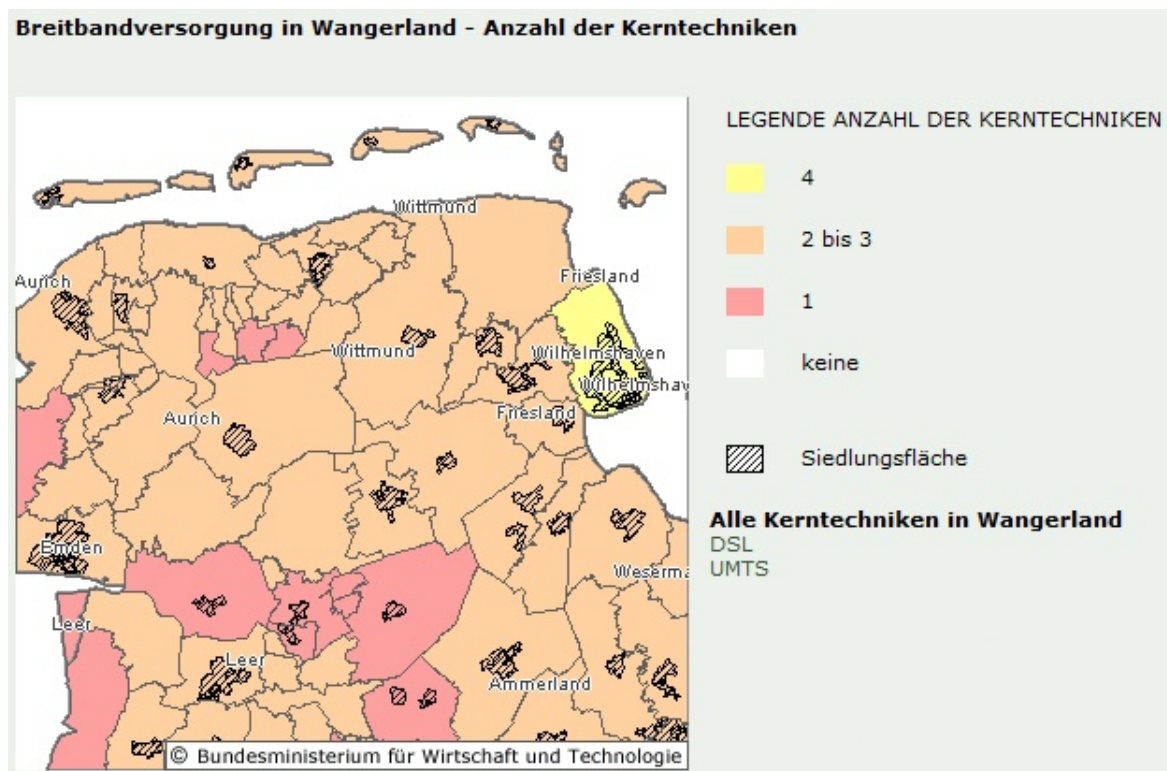

Figure 15: Federal Atlas – Broadband Supply in Wangerland

In figure 16, only information for the DSL technology is displayed. It is distinguishable that there are many areas which do not have the opportunity of being supplied with a DSL broadband connection. These areas are displayed in white. In cities like Wilhelmshaven or Wittmund DSL is available.
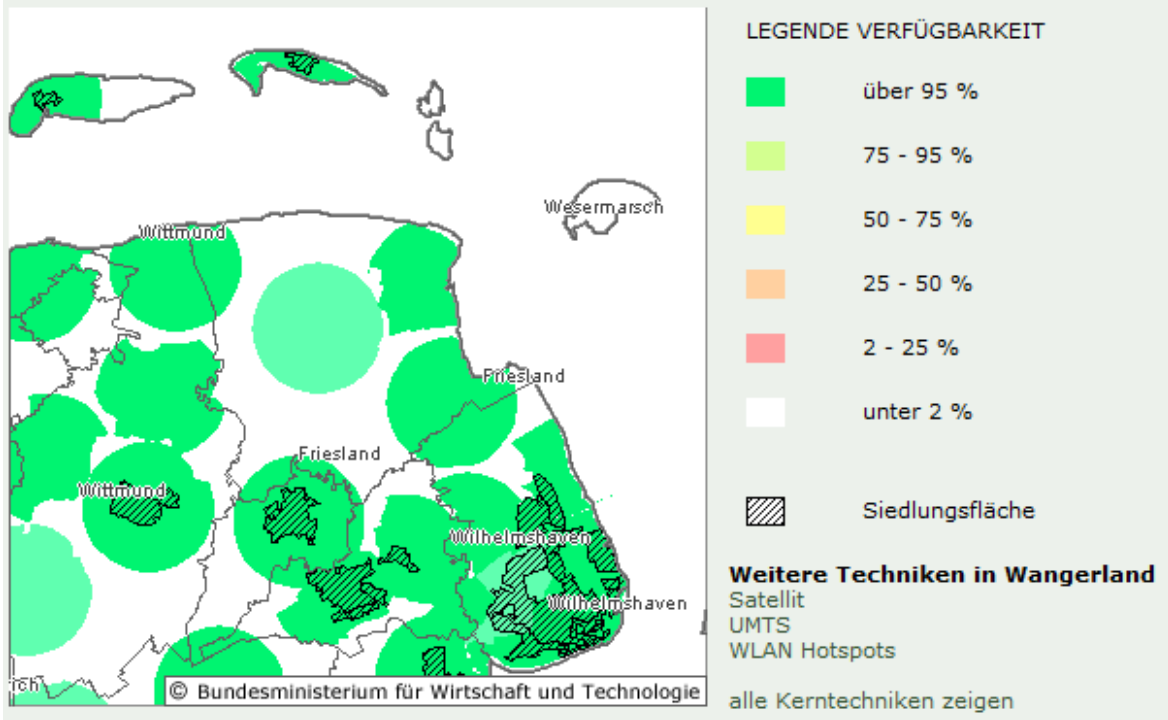
Figure 16: Federal Atlas, Availability of DSL

The cable technology (see figure 17) is only available in larger populated areas, e.g. Wilhelmshaven. In the county, it is not possible to use cable technologies because the appropriate cable network is missing.
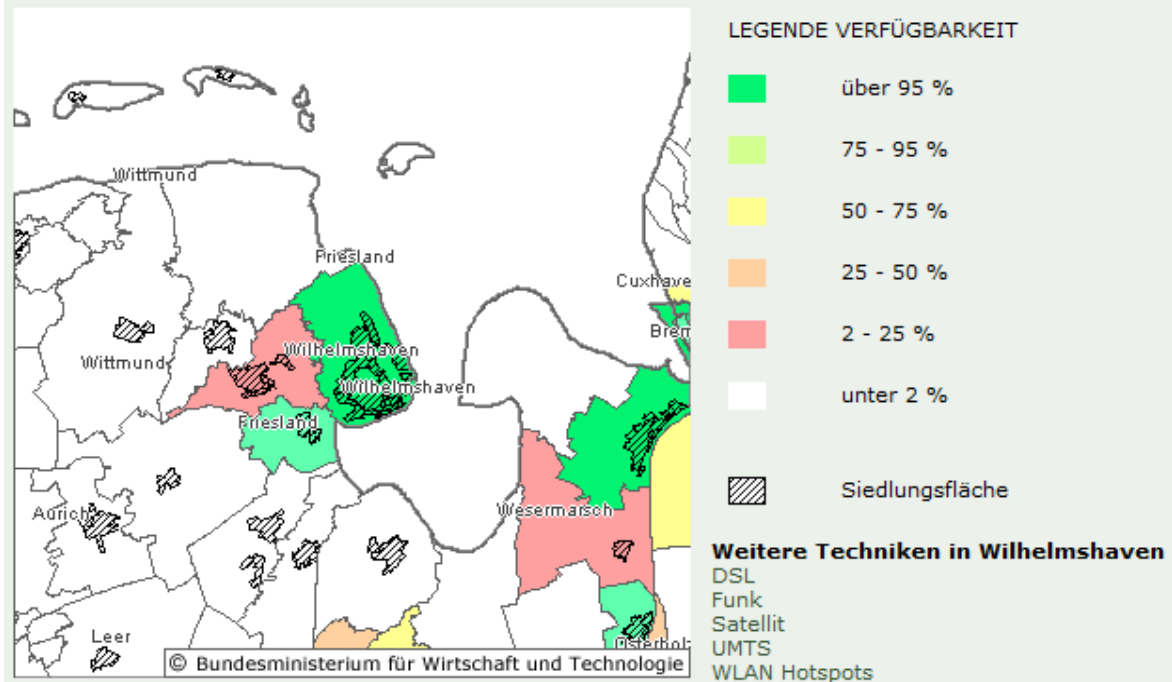

Figure 17: Federal Atlas – Wilhelmshaven – Availability of Cable Technology

The UMTS technology (see figure 18) is, according to the Federal Atlas, partly available. The graphic displays no information, if the UMTS additions HSDPA and the HSUPA are used in the areas.
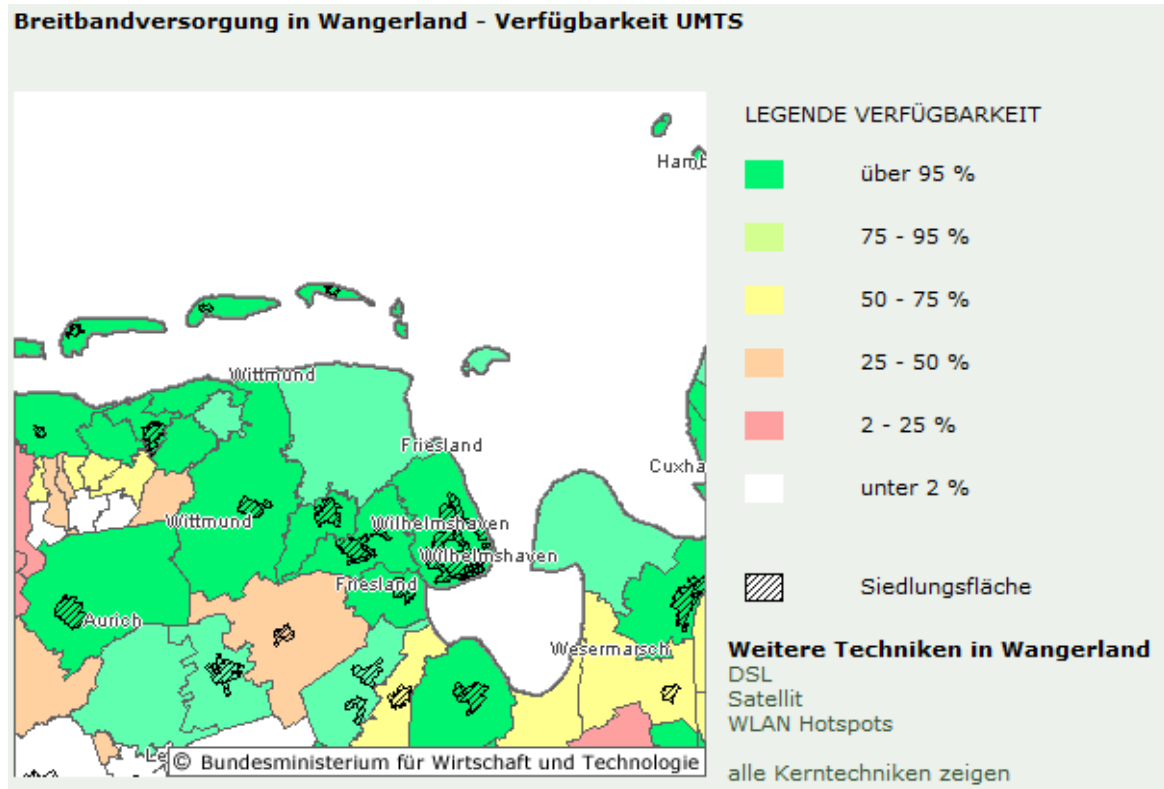

Figure 18: Federal Atlas – Wangerland – Availability of UMTS

The information from the Federal Atlas is not very exact. This is due to the large displayed surfaces, e.g. the whole area to Wilhelmshaven is indicated as above 95%. But even in areas which are marked green there are places, where the according technology is not available. For the percentage specification about the availability see caption. In figure 18, the coverage of the Wangerland with UMTS is assured to 95%. Where the missing 5% are is not indicated. For other technologies similar details are given.

In the next step, for the determination of the real availability of DSL, concrete places and streets are randomly chosen, which do not have broadband internet. As a first step, *Google Earth* was used to take a closer look at the places which are indicated as „no broadband available"in the BMWI. The determined places are recorded at the website *www.dasoertliche.de*. The results of the search were enlisted with the DSL check of the *Deutsche Telekom*. The process was done several times with different streets for one town. The gained data is used as a basis for the next step: distributing flyers.

The graphical design of the flyers was supported by the Faculty of Media Design of our UAS. An important point for the design was to fill it with information. Also the flyer should draw the attention of the citizens. Following these criteria we designed the flyer. The distribution is done via the centre of distribution of the *Wilhelmshavener Zeitung*. After receiving the flyer people could sign up telephonically. For the survey a call centre in the UAS in Wilhelmshaven was established. The call centre was coordinated and the call agents used a flow chart for a target oriented and equal cycle of each call.

After finishing and processing the data we recognized that only 38 calls came in to 7980 distributed flyers, which is less than 5 per mill. The reasons for the marginal participation can only be assumed. Perhaps, combining the flyers with the survey was not effective or appealing enough. Another reason could be a lack of interest or missing initiative of the affected persons who are not able to get a broadband connection. The gained data was enlisted in the tool *Magic Maps Tour Explorer Deutschland* for reviewing. The black triangle in the map excerpt (figure 19) represents the main radio mast of the company *ju-DSL*. The red circles represent the participants of the survey who use transmission speeds less than 1 Mbps. The yellow depictions show users with a bandwidth up to 2 Mbps. Green circles show users with a connection more than 2 Mbps.

Color	Downlink	Technologies
Red	< 1 Mbps	Analog-Modem, ISDN, DSL-Light
Orange	<= 2 Mbps	DSL
Green	> 2 Mbps	DSL

Table 2: Legend to the Results of the Survey

In the next step it was checked if the determined places can be supplied via the *ju-DSL* network. The analysis shows that the towns of Dunum and Ochtersum can be connected to the network. At the time of the analysis the whole town could not have been supplied. Parallel to the survey, *ju-DSL* established a smaller radio mast in Dunum and Ochtersum.
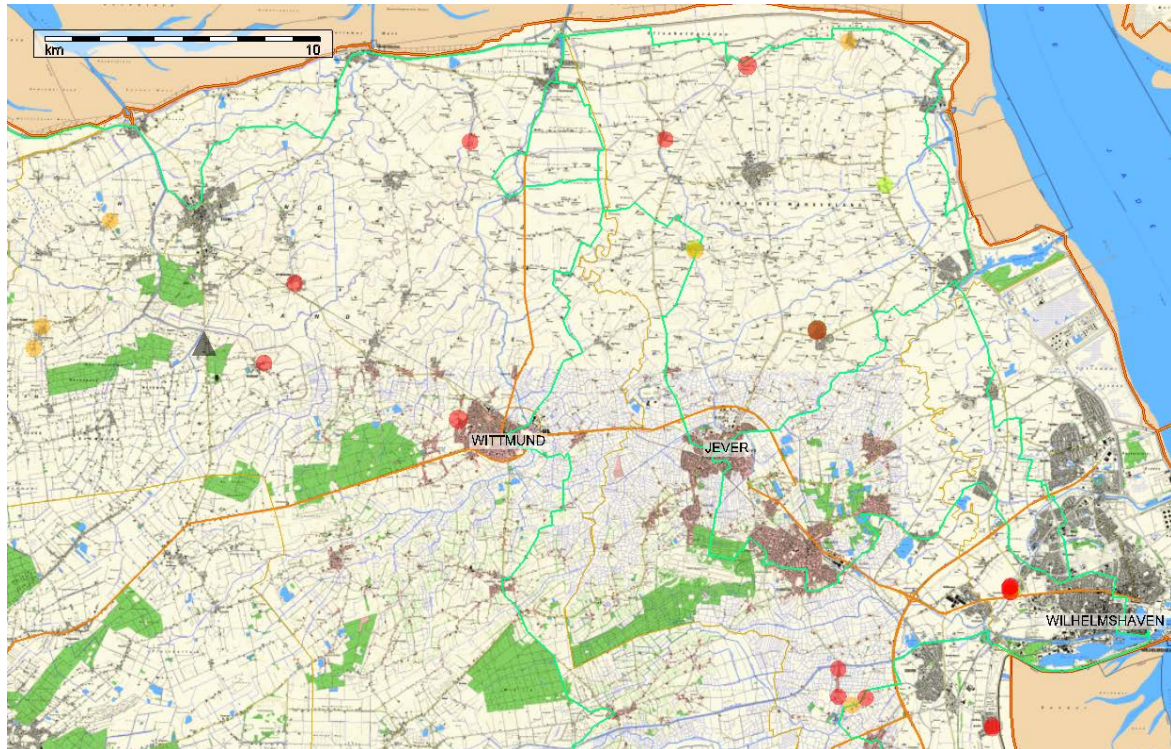
Figure 19: Results of the Survey (Magic Maps Tour Explorer Deutschland)

3.1.2 Analyzing Requirements

In this chapter, the requirements from the customer's point of view are to be determined. As a foundation the DSL technology is used. The required information for this chapter came from the General Terms and Conditions of the German DSL-provider "1und1". Additionally, the tariffs of *ju-DSL* are considered for analysis of requirements. The requirements are only corresponding to tariffs for private customers.

a. Transmission Speed for Down- and uplink

The transmission speed for down linking should be at least 1 Mbps. To use most of the internet applications, 3 - 6 Mbps (downlink) is recommended.

ju-DSL offers the following tariffs (Table 3):

Tariff	Downlink	Uplink
city 1000	1000 kbps	128 kbps
city 2000	2000 kbps	128 kbps
city 3000	3000 kbps	128 kbps
city 6000	6000 kbps	128 kbps

Table 3: Tariffs of ju-DSL, June 2009

The transmission speed for the uplink can be expanded up to 256 kbps, 512 kbps or 1024 kbps. For the upgrade further costs occur.

b. Allowed Variations within the Transmission Speeds

The transmission speeds of the tariffs are to be installed as "maximal" speeds and cannot be guaranteed by *1und1* and *ju-DSL* because the bandwidth is distributed dynamically to each user.

c. Reliability

The DSL-provider *1und1* declares a technical availability of 97% for the DSL connection. The offered hotline has 98% (annual mean). *ju-DSL* provides a „guaranteed stability" and availability of at least 97.5% .

d. Required Time to React to Malfunctions

The provider *1und1* includes a guarantee to eliminate faults in their general terms and conditions. They guarantee to repair malfunctions of the connection within two days. *ju-DSL* solves most of the problems within one or two days. If the problem has to do with the quasi optical line of sight, eventually trees have to be cut down. If that is the case, the owner of the tree has to be determined and the request to cut it down has to be filed. This can be a reason for the delay of the fault clearing.

e. Telephone Connection

In many areas it is possible to obtain a landline connection from *1und1*. Thus, a landline connection of the *Deutsche Telekom* is needless. A landline connection is required for the installation of a DSL connection. In comparison, an internet connection from *ju-DSL* does not require a landline connection. It is up to the customer whether he wants to have such a connection or not. Huge additional costs appear for a landline connection from *Deutsche Telekom* or *EweTel*.

f. Monthly Costs and Service Charge

In the tables 4 and 5, the prices for the *ju-DSL* tariffs are displayed. The service charge is 149.00 € *1und1* does not charge their customer.

Tariff	Price
city 1000	19.90 €
city 2000	24,90 €
city 3000	29,90 €
city 6000	34,90 €

Table 4: Tariff Prices ju-DSL, June 2009

Uplink-Expansion	Additional Price
256 kbps	+ 5,00 €
512 kbps	+ 10,00 €
1024 kbps	+ 15,00 €

Table 5: Prices, Expansions ju-DSL, June 2009

For an equal contract with *1und1* a customer of *ju-DSL* pays 44,90 € monthly based on a duration of 24 months. That is a difference of 14.91 € If you compare the 44.90 € with a similar contract with satellite technology, the fee is low. Thus, the offers from *ju-DSL*, which are offered with *Motorola*'s Canopy technology can compete with the tariffs with the DSL offers. The bandwidths and tariffs are reconcilable with broadband internet connections.

3.1.3 Feasibility study

The technologies WLAN/WiMAX and the portfolio Canopy of *Motorola* are up for debate.

    a. Technical Analysis

Ju-DSL decided to use *Motorola*'s Canopy. For this reason, in the further text only the Canopy technology will be analyzed. The information about Canopy is based on experience from the cooperation with *ju-DSL*.

1. General Technology

The technology developed by *Motorola* contains several benefits. A great advantage is that the portfolio offers all components needed for a *wireless broadband network*. As there are:

- Access Points
- Subscriber Module
- Management Module
- Backhaul

The Canopy technology offers modules for point-to-point and point-to-multipoint connections. With various modules and configurations it is possible, to design the radio network to own requirements. For the components, the customer (ju-DSL) asks the reseller who determines the appropriate components, regarding to the requirements:

2. Concrete Hardware

The company *ju-DSL* uses following modules of the Canopy technology:

(1) Access Point

- Motorola Canopy 5400APDD Motorola Canopy 5.4 GHz

(2) Subscriber Module

- Motorola Canopy 5400SMDD Motorola Canopy 5.4 GHz

(3) Canopy Backhaul

- Motorola Canopy PTP 58600 Integrated - Wireless Bridge
- Motorola Canopy 5400BHDD PTP54100 Lite 5.4 GHz
- Motorola Canopy 5400BHRFDD PTP54100 Lite 5.4 GHz Backhaul - Reflector

(4) Cluster Management Module (CMM)

- Motorola Canopy 1070CKDB Motorola Canopy CMM Micro

For the central administration and organization, the Linux based Router OS Software by *Mikrotik* is used. The currently used Software is the Router OS 3.13. For network management, software called *The Dude* also by *Mikrotik* comes into operation.

A GPS antenna is connected to the Cluster Management Module (CMM). The whole network gets synchronized with the aid of GPS and the CMM. The CMM includes a network manager which is accessible and configurable via browser. Additionally you can access the CMM via cable (RJ-45 slot). The CMM has eight RJ-45 slots. On six of them access points or backhaul modules can be connected. The connected modules will be powered via network cable. *Motorola* developed its own specification for providing power based on power over the Ethernet (PoE) is not sufficient. *Motorola* offers special power supply units, so called PIDUs.

The RJ-45 Port is connected to the *Mikrotik s*erver, which is in turn, connected to the Cisco router. The Cisco router is the last component in the network. It connects to the internet. With the aid of the access points that are connected to the CMM, point-to-multipoint-routes are set up. Therefore, backhaul modules come into operation. They are capable to offer bandwidths up to 150 Mbps, depending on the Motorola license. The exact bandwidth decreases with increasing distance between the modules. If the remote station is directed and configured, access points are installed. Off this point, point-to-multipoint is possible. Eventually hobs have to be installed, too. A hob consists of a subscriber module and an access point. The subscriber module receives radio signals from the distant access point and forwards them to the connected access point, which transmits them out. The radio direction of the subscriber module and the access points are in opposite directions.

Subscriber modules are components, which are installed at the customers place. They can be mounted on walls, on the chimney or special devices. To the subscriber module a network cable is connected which has the function of data transfer as well as supplying the module with power. The subscriber module is used as a modem and is connected to the computer or a router (even with WLAN). If a router comes into operation, several computers may be connected.

Process for Directing the Radio Modules
At first, it has to be checked if new customers can be connected to the network of *ju-DSL*. If that is the case, connecting the customer is possible within one day. If new areas become accessible, at least ten customers have to subscribe to make the components profitable. To make new areas accessible *ju-DSL* generally needs three to four months. If the required minimum amount of customers is available, *Google Maps* is used to determine the distance to the customer and check for obstacles. After this step an employee verifies the line of sight. If a quasi optical line of sight is possible, the customer becomes connected to the *ju-DSL* network.

The modules of the Canopy series have tools with which it is possible to align the modules. The backhaul modules can be switched in a configuration mode. If this is active, a signal tone as a function of the signal strength can be heard. All modules

have in common that they can be configured through the browser. In addition, measured values can be read out from the web interface. You can read the signal strength, jitter and the distance to the access point. It is possible to access the modules from any location, if it is connected to the network. In this way it is possible to determine whether there are problems with the modules.

3. Hardware Locations

The first stage of the network expansion of ju-DSL, the CMM and the server were housed in a switchbox near the main radio mast. The main radio mast is also the uplink to the network. The uplink is a synchronized connection with a bandwidth of 10 Mbps in the downlink and uplink. In further development steps CMM and a redundant server in the network will be installed.

b. Geographical Analysis

1. Locations of Radio Masts

A mobile radio mast in Uplengen has been rented. From this location the surrounding towns were connected to the internet. The main radio mast of *ju-DSL* is located between Dunum and Ochtersum and is displayed in figure 19 as a triangle.

2. Obstacles between Sender and Receiver

Possible obstacles between the mobile radio masts were determined with the help of *Google Maps*. The height of the radio modules is 55 m. This height is enough to overcome the trees and buildings in the region.

c. Analyzing Existing Infrastructure

Uplink

The uplink to the *ju-DSL* network takes place at the main radio mast (figure 19). Next to the switch box at the main radio mast is a fiber distributor to which ju-DSL is connected.

Mobile Radio Mast

The analyzing of available mobile radio masts took place before the cooperation with *ju-DSL*.

Contracts

Pre-contracts were signed with the customers so that *ju-DSL* obtains a certain security. The pre-contract is followed by a real contract, given that the customer can be connected to the network of *ju-DSL.*

d. Licenses

The used Canopy modules are sending on license free frequencies. *Motorola* holds license packages with costs. Using a higher license you can achieve higher bandwidths. We do not know how the frequencies and the licenses are associated. For the mounting of Canopy modules to objects certain regulations apply. The fixing points are not allowed to reach a height higher than two meters above the rooftop. If you have to mount the modules higher, steel ropes must be used to reinforce and guarantee the stability. Mounting on fixtures is required, if the subscriber module is not able to establish a quasi optical line to the access point.

e. Laws and Permissions

If trees are disturbing the quasi optical line of sight, the owner of the tree must be determined. If that is done and permission is available, the tree can be cut down accordingly. *ju-DSL* owns a lifting platform in order to solve those problems.

3.1.4 Approaches

ju-DSL realized the third approach with both variants (see 2.1.4 Approaches). The used components are already described in 3.1.3 Feasibility Study.

3.2 Design Phase in Application

a. Test Setup

The company *ju-DSL* has a trailer and a small van which allow test runs. The trailer and van are equipped with a retractable mast in which wireless modules can be located. If a town wants to test the technology and the internet connection of *ju-DSL*, the mobile masts come into use. The mobile tower gets connected to the ju-DSL network. The subscriber modules are temporarily mounted at the customers sites.

b. Measurements

Measurements are made by the Canopy modules. Using a web browser the modules can be accessed and configured via IP-addresses. Also the web browser can be used to read out the values. You can read the signal strength, distance and bandwidth. For the backhaul modules there is a configuration mode for alignment. Switching in that mode on and off is also done via web browser. If the configuration mode is on, the module starts to beep. With the help of the beeping and the reading of the measurements the backhaul modules are aligned.

c. Optimization

For a better reception to the subscriber, modules can be plugged into so-called passive lenses. These increase the signal strength of the module. The lens is used by *ju-DSL* when the distance between access point and subscriber module is more than three km or if the signals are absorbed by e.g. trees or buildings.

4. Conclusion

Since the beginning of 2009 the accessibility to the internet developed very well. An important part for the accessibility to broadband internet was contributed by the *German Federal Ministry of Economics and Technology* (BMWI) with its broadband strategy. Even though the goal of the BMWI is not accomplishable the topic of broadband internet was discussed in public. For example, different information portals from the federal level, the federal states and communities were set up on the internet. Also projects for broadband internet are financially supported by the federal, state, and community levels.

During the investigation for the case study, the contact with *ju-DSL* was established. After a personal chat the cooperation between *ju-DSL* and the University of Applied Sciences in Wilhelmshaven was agreed and *ju-DSL* agreed to give out information about the used technologies and methodology. For a concrete statement about the factual supply of broadband internet a survey was done. Therefore, a flyer was distributed and a flow chart for a call center developed. The amount of participants was much less than expected. The obtained results where analyzed and discussed with *ju-DSL.* The discussion resulted in the knowledge that some persons soon can be connected to the network of *ju-DSL.*

Parallel to the survey a model for the rural supply with broadband internet was developed. The developed model shall allow a structured methodology to provide broadband internet to rural areas. In the following part the model was practically processed. For the practical part *ju-DSL* actively helped to install and configure radio modules. Also we obtained know sequences within *ju-DSL.* It appeared that the methodology is not well-structured yet. That is because the company is young and in it's in its early organization and needs to collect experiences. Customers, who formerly could not get a broadband connection, were able to be connected to the network of *ju-DSL.* Now the customers own a broadband connection with 3 Mbps downlink and 128 kbps uplink.

5. Implementation

5.1 Implementation Phase

For example, a radio link to the town of Uplengen was installed and configured. ju-DSL had at that time already rented a portable radio mast in Uplengen. The directional radio link was established at first with the software program Google Earth to determine the distance between the city and the main radio mast in Uplengen. The analysis pointed out that the distance, which is to be bridged is about 40 km. The directional radio link shall be in a range between 16 to 18 Mbps. With this information ju-DSL approached the dealer for the Canopy components. The module that meets these requirements is the Motorola Canopy PTP 58.600 module. For the next step we determined landmarks via the program Google Earth, which were intended for the coarse alignment. The two backhaul modules were installed on the mobile phone masts at a height of 55 m and roughly aligned.

For the alignment the PTP 58600 module was switched in a configuration modus. That allowed the module to beep. The better the reception of the module was the faster it beeped. Additionally, the signal strength and the bandwidth were read out on a laptop. The laptop was connected to the module via network cable. Using the IP address of the module it could be reached via web browser. After the maximum was configured the module was switched back in its operation mode. That process was done with both PTP 58600 modules. After the fine

adjustment the directional radio link was able to provide a bandwidth of 28 Mbps. That topped the requirements of 16 to 18 Mbps.

In the area of Uplengen 60 pre-contracts with customers were signed. These will be connected after the application date to the network of *ju-DSL* is completed. The first connected customer was a partner company of *ju-DSL*. The partner company brings the products of *ju-DSL* to the market. For the customer in Uplengen it was determined at first if a line of sight to the customer is possible. That was the case. As a next step it was checked where the network cable coming from the subscriber module is to be drawn and where it is possible to bring the cable into the house. Because the customers' rooftop was not furnished it was easy to run the cable near the chimney. To the chimney a mounting fixture for the subscriber module was attached. The subscriber module was connected to the mounting fixture. In the attic a router was placed (without modem). The modem input of the router was connected to the subscriber module and between router and subscriber module a lightning protector was installed. For the correct installation of the lightning protector an electrician was in charge.

After configuring the subscriber module and setting up the customer's account, the connection to the customer was tested. The customer had a downlink speed of 3 Mbps and an uplink speed of 1 Mbps.

5.2 Operation and Maintenance

For operating and maintenance *ju-DSL* set up a suppression agency. The suppression agency can be reached via telephone or email. During the cooperation with *ju-DSL* a malfunction at the customer´s receiver occurred. The customer could use his internet only partially. An employee drove to the customer to determine the details about the problem. At first it was tested if the subscriber module and the computer of the customer did function correctly which was the case. Based on the measured values the possible malfunction was determined: the distraction was based on a grown tree with a thicker crown as it had been when the connection was set up. For the disturbing trees the road maintenance staff is in charge. The malfunction could not be repaired. At first a permission to cut down the trees had to be obtained from the road maintenance.

The existing network is expanded step by step.   Till now 60 pre-contracts were signed in the area. During the network expansion the demand for broadband internet connections already

gets determined. According to the new amount of customers the uplink becomes upgraded to a higher bandwidth. Which bandwidth is bought from the provider *EweTel* is not yet decided.