Building municipal wireless infrastructures

Feasibility study for SURFnet

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Hilversum, the Netherlands
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The story of Innodelphia

The municipality of Innodelphia understands that many low-income households cannot afford to connect to the Internet, but needs to reduce costs for mobile workers, and wants to be known as a high-tech city. It therefore decided to investigate how to address these issues.

Although DSL is widely available in the city, it appears that many low-income households cannot afford a fairly high quality DSL subscription to connect to the Internet. Politicians are aware of the fact that an Internet connection is important for low-income households because it gives them the opportunity to learn and study.

Innodelphia employs thousands of mobile workers – men and women who work outside of office environments and need information on the spot. The typical mobile worker in Innodelphia can be a parking officer, police officer, real estate inspector, or engineer. All these employees have UMTS subscriptions, which are fairly expensive. Some jobs could be done even better if wireless subscriptions were provided.

Innodelphia wants to create a climate in which businesses can experiment with offering new services to citizens. This offers the city a double benefit: it creates a climate that encourages businesses to locate in Innodelphia and the city’s residents receive innovative services provided by the municipality or these businesses. Innodelphia’s leaders are also aware that such services can benefit tourists who are looking for information on their beautiful city.

Innodelphia’s mayor and policy makers began to ask themselves: "How could we turn these opportunities into a great success?"

Low-income households need a cheaper alternative to DSL, mobile workers need a cheaper alternative to UMTS, and businesses need a way to reach users with their applications. What about finding an alternative technology for UMTS? Innodelphia’s leaders learned that ‘Wi-Fi technology’ enables wireless access and is available in devices like laptops, smart-phones and PDAs. Compared with UMTS, Wi-Fi is a much cheaper technology because it is license-free and less complex.

So Innodelphia conducted a feasibility study to see if Wi-Fi could be introduced in the city. The goal was to implement city-wide outdoor wireless coverage because mobile workers should be able to work at any place in the city and low income households are not concentrated in one particular area. The feasibility study showed that €10 million for a three-year period would be needed to achieve the goal. A large part of these costs are related to finding, preparing and renting locations for mounting equipment. Fortunately, Innodelphia owns many buildings and every lamppost throughout the city. So these costs could be greatly reduced. Moreover it appeared that many businesses, which would like to develop services, are willing to invest in the initiative. Because the availability of Wi-Fi would be attractive to students, the university and colleges in the city appeared to be willing to commit themselves to purchasing services for each of their students for a three-year period. Content providers showed interest in the network too because they would be able to provide end-users with information and services at any place and time.

Interest appeared to be high, and city leaders knew that the city itself was the key player. So Innodelphia set up a consortium to build and operate the network and sell data-transport services to service providers. The consortium has contracts with the city, service providers, universities, schools and companies. The service providers will be able offer services like Internet, VPN or camera surveillance. Competition among service providers will keep prices low and quality high.

Innodelphia is a fictitious city, and the scenario above is inspired by municipal wireless initiatives worldwide.
Executive Summary

Within the SURFnet community a need has been expressed to have wireless access outside the campus or educational buildings. Although demand is there, the existing outdoor wireless access methods cannot meet the demand at reasonable price levels. Therefore SURFnet identified the need to determine whether Wi-Fi technology - for blanket outdoor coverage - would be feasible. The city of Utrecht has been chosen for the feasibility study.

More than 400 cities in the United States of America and some cities in other countries are currently planning municipal wireless networks. The rationale for creating municipal wireless networks is mainly based on the need for development of innovative services for residents. Other benefits include cutting costs for Governmental processes and decreasing the digital divide. Some companies (such as Google) have made plans for municipal wireless in order to experiment with location-based services for example. In addition to establishing full city-wide coverage by installing outdoor equipment, some companies are examining nearly complete outdoor wireless coverage by applying “community building approaches” (Wireless Leiden, FON).

In the Netherlands, hotspot operators like KPN, T-Mobile and Mobilander have not expressed any interest in creating a municipal wireless network based on Wi-Fi technology. FON might organically grow into a community of wireless hotspots which approaches city-wide coverage, but this will not provide a managed service.

There are four approaches to creating municipal wireless access: city-wide roll-out of new infrastructure; concluding roaming agreements with hotspot providers; community building approaches; and hybrid approaches involving some combination of the other three. The four approaches were derived from the key parameters in the business case: the initiator's goal and ambition, the service level and quality, and the type of stakeholders.

SURFnet's community survey exposed a need for outdoor wireless access. However, SURFnet community users are not (or to very low degree) willing to pay for wireless services. For the city of Utrecht, a blanket municipal wireless network would cost €9.2 million for a 3-year period. There is no financial justification for creating such a network exclusively for the educational community. Acquiring and rental of access point locations is a large part of the total costs (28%). Such a municipal wireless network is only feasible with support of (local) government.

SURFnet has various options for facilitating the inception of a city-wide wireless network. One option is to establish demand aggregation on behalf of the educational community at large and other not-for-profit organisations. Another option is to participate in existing initiatives for outdoor wireless in the Netherlands or to try to (further) interest a city in municipal wireless.

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1 This approach proved to be successful for example in the SURFnet/Kennisnet project “Samen Snel op Glas” and the GigaMAN projects in Leeuwarden en Nijmegen that aim at creating municipal fibre infrastructures for the educational and not-for-profit sectors
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1 Introduction

Networks based on Internet technology have become a major phenomenon in the last decade. As computerised networks have existed since the late 60s, the focus has largely been on connectivity and bandwidth. The growth in demand for bandwidth within the higher educational community of the Netherlands is illustrative of this trend.

A major trend within internetworking for the last 5 years is that networks are becoming more ubiquitous. This results in more mobility, and therefore more flexibility in where and how people can access, e.g., scientific data, personal information, or the internet. But it also enhances the options for remote collaboration for teams that cannot always be at the same location. In particular, mobility technologies like GPRS, UMTS and the non-licensed solutions like Bluetooth, and Wi-Fi have contributed to this trend.

Scope

Within the SURFnet community the demand has been expressed (SURFnet survey 2006) for wireless access outside the campus or educational buildings. As there is already demand (as a function of price and quantity), the existing solutions can not fulfil the demand at reasonable price levels.

Within the Freeband-project a non-blanket Wi-Fi coverage in student cities was piloted. Now, SURFnet wishes to explore and investigate whether using Wi-Fi technology for blanket outdoor coverage would be financially feasible. For the purposes of this feasibility study, an analysis has been conducted for the city of Utrecht and SURFnet’s community in the city of Utrecht.

Background

Municipal wireless networks (based on non-licensed radio frequencies) have received quite a bit of attention in the media in the last few years. Predominantly within the United States of America, it appears as if almost every municipality is either currently deploying or considering the roll-out of wireless infrastructure. In the Netherlands, this type of network has not reached the same level. The most plausible explanation is that the Dutch population already has other means of broadband access (through the ADSL or Cable infrastructure). In fact, an OECD report ranks the Netherlands as the country with the second highest penetration of broadband access. Another factor may be that the existing wireless (cell based) providers have had their focus on UMTS roll-out and creating a positive cash flow for this technology. There is also more resistance to municipalities spending public money on electronic infrastructures than there is in some other countries.

3 http://www.freeband.nl/
4 http://www.oecd.org/document/9/0,2340,en_2649_34223_37529673_11_1_1_1,00.html - Data2006
Although UMTS has been available in the Dutch market for over two years, it is hardly used within SURFnet’s community. Considering the pricing levels of over €50 per month, it is expected that the popularity of this solution within SURFnet’s community will remain low.

SURFnet is a community-oriented organisation providing services exclusively to institutions of higher education and research within the Netherlands. Exploiting a municipal wireless network for purposes other than serving its community is out of scope of SURFnet’s objectives and tasks as currently defined.

Hypothesis
For the purposes of testing assumptions and formulating recommendations on the project scope, the following hypothesis was developed:

**Municipal wireless networks are only financially feasible with the support of (local) government**

In this report a municipal wireless network is defined as a network that:

- provides Wi-Fi Internet services,
- covers a major part of a municipality,
- is available to the public or at least to the residents of the municipality,
- is accessible (at least) at locations outdoors, at ground level, and
- is accessible using regular consumer equipment, e.g. internal PDA, laptop or smartphone antennas.

Municipal wireless networks under this definition may be “not-for-profit” or commercial, and may be provided by commercial parties, government bodies, user communities, or combinations of these.

Structure of this document
With global initiatives on Wi-Fi networks across municipalities now a part of everyday life, the first part of this feasibility study explores the market for Wi-Fi services from both supply and demand perspectives. In Chapter 3, an overview of the supply side Wi-Fi initiatives at the national and local levels (Dutch country-wide as well as Utrecht city-wide) is presented. In addition, the demand for wireless network access from the higher education community is summarised in Chapter 3.

The basics of unlicensed wireless technologies and the different components required for wireless service are explained in Chapter 4. Furthermore, specific attention is paid to authentication in view of existing SURFnet guidelines and policies, which are linked to the *eduroam* standards. This chapter ends with a description of the cost build-up for a wireless network.
In Chapter 5 four different approaches for roll-out are identified and clarified. The various approaches range from a fully controlled city-wide roll-out to community build-up wireless services. The pros and cons of each approach are given.

The cost build-up of a city-wide wireless infrastructure includes upfront investments and operating expenses. In Chapter 6, the specific situation in the city of Utrecht is examined from a financial perspective.
2 Conclusions and recommendations

This study examines the feasibility of creating municipal wireless networks for the purposes of the SURFnet community. The following are the main conclusions drawn from the feasibility study:

- Municipal wireless networks are only financially feasible with the support of (local) government;

- For the SURFnet community alone, it is not financially feasible to create a municipal network. For the city of Utrecht, the total cost for a municipal wireless network for an operational period of three years would amount to €9.2 million;

- A significant part of costs involve acquisition and rental of access point locations. Costs can be reduced if local governments would make their property available for mounting equipment. Costs could be further reduced by partnering with commercial organisations like equipment manufacturers and Internet Service Providers. Aggregating demand, e.g., bringing together (semi-) public organisations like local government, universities and schools, can also help spread costs.

- In Utrecht, there is currently no municipal wireless network. Potential (semi-) public stakeholders have neither planned nor initiated the rollout of a municipal wireless network. However, some potential stakeholders are willing to participate if such an initiative were to be launched;

- While there is a need in the SURFnet community for outdoor wireless access, end-users and employees of organisations within the community are willing to pay very little or nothing for the service;

- Hotspot operators like KPN, T-Mobile and Mobilander have not expressed any interest in creating a municipal wireless network based on Wi-Fi technology. FON might organically grow into a community of wireless hotspots, which approaches city-wide coverage, but this will not provide a managed service;

- In the USA and other countries, municipal wireless initiatives are based on funding by, or in co-operation with, (local) government. Virtually all service providers involved in such municipal networks provide a paid service, often along with a free service sponsored by local government or by advertising.
The recommendations to SURFnet for creating municipal wireless networks are:

- Trying to find an interested city, or generate interest in municipal wireless by:
  - determining and identifying the “innovation rationale” for creating municipal wireless networks;
  - bringing (semi-) public and possibly commercial organisations together. Co-operation of the local government is essential;
  - initiating and scoping the process for demand aggregation on behalf of local educational organisations;
  - participating in the initiatives of communities in Groningen and Leiden in order to gain knowledge and experience in the establishment of municipal networks, and to experiment with the different SURFnet roles that could be applied.
Quick scan of Wi-Fi providers and Wi-Fi demand

3.1 Municipal initiatives in the USA

More than 400 cities in the United States of America are currently planning municipal wireless networks. This paragraph describes three different kinds of business approaches:

- not-for-profit organisations that deploy, own and operate the network infrastructure;
- not-for-profit organisations that outsource network infrastructure, and only provide wholesale services;
- community concept that uses wireless access to reach out to citizens.

Boston

The City of Boston studied an initiative to roll-out a municipal wireless metro transport and first-mile Wi-Fi access network. The wireless network should contribute to Boston's goals to promote economic development and stimulate innovation, decrease the digital divide, and improve the quality and efficiency of City services. The City should identify a non-profit group of corporations to own and operate such a network rather than handing over the project to, e.g., commercial ISPs. The network should be designed to bring the signal up to the periphery of buildings. End-users, business or perhaps ISP should bring the signal from there to inside the buildings (using a bridge, for example). Several ISP's could compete to offer wireless services to end-users using the network from the non-profit corporation. The price that end-users have to pay is therefore not determined, but is predicted to be around $15 per month. Investments around $17 million should come initially from local business and foundations, not from public funding. However, the City of Boston grants access to locations like light-poles, traffic lights and city buildings. Construction of the city-wide network should start January 2007.

Philadelphia

Philadelphia studied the option to create a municipal wireless network to provide wireless access to its 590,000 households. The goals for Philadelphia were to:

- invest in the people of the city (by providing low cost Internet to low-income households);
- enable Philadelphia to be a competitive location (e.g., for businesses);
- enhance the experience for visitors (providing Internet for travellers), and
- deliver public services (e.g., for Philadelphia's mobile workers).

The City created a non-profit organisation, Wireless Philadelphia, whose task is to build the network by contracting out to private partners. The business model is a Co-operative Wholesale model. In that model, the network is open to all qualified service providers. In May 2006, the city council approved Wireless Philadelphia's $15 million plan to work with the Atlanta-based Internet firm Earthlink to spread a 135-square-mile wireless network over the city. The Wi-Fi service is initially set at an average upload/download speed between 0.75 and 1.25 Mbps. Earthlink Assisted WiFi (subsidised Wi-Fi for low-income households) will be sold at a net retail rate of no more than $9.95 per month. A regular subscription should cost $20.00 per month. Deployment is ongoing and full city-wide coverage is expected in early 2007.
Mountain View
Google covered all of Mountain View, California, with a free outdoor wireless service. Google took the initiative to build the network as part of their ongoing community outreach efforts. Google’s network includes 380 access points throughout the city, which has about 72,000 residents and covers a 12-square mile area. To acquire locations for Wi-Fi access points, Google partnered with local government, schools, library, and neighbourhood associations. A throughput of 1 Mbps both upstream and downstream is offered. Mesh technology is used to create the backhaul network for access points. The service is already in operation, however coverage is patchy.

3.2 Municipal initiatives outside the USA

UK-Norfolk
Norfolk Open Link is the first community municipal wireless network in the UK to provide free internet access for the public sector, the business community and the general public. The £1.1 million two-year project has operated since July 2006. The project aims to evaluate the impact mobile technology could have on economic development in Norfolk and the delivery of public sector services. This network is publicly funded. The project is not allowed to compete with commercial Wi-Fi services, so the access speed for businesses and the public has been set at 256 Kpbs, with public sector staff accessing at 1 Mbps. Each session has also been limited to one hour.

Macedonia-Skopje
As part of the first country-wide Wi-Fi-based Internet access network, a municipal network has been created in Skopje. Wi-Fi deployment for the city was initiated in early 2006 and was expected to be completed by the end of 2006. The project was initiated by local government and funded by USAID. It is owned and operated by On.Net, an in-country operating commercial ISP. Services are offered for home and business users. No free access model is applied. Access speeds of 256 Kbps up to guaranteed 1 Mbps (based on point-to-multipoint solutions) are offered. Monthly service fees range from €9.50 (limited data rates and usage) to over €1300 (for the guaranteed 1 Mbps / 1 Mbps point-to-point link).

Taiwan-Taipei
Taipei has one of the densest Wi-Fi city networks in the world (roughly 4000 hotspots, covering around 90% of the 2.6 million people). The service – called WiFly – is provided by a company called Q-ware Systems on a commercial basis. The Taipei government initiated the service back in 2003 with an RFP process. The contract included the option for Q-ware to use municipal facilities (like public buildings, metro-stations, lamp posts etc.). The objectives of Taipei’s city government for rolling out a municipal wireless network were:
- Service reengineering (creating better always-on services for residents)
- Process reengineering (cutting costs by tuning business processes with computer automation)
• Education reengineering (providing on-line distance learning services)
• Building an information infrastructure (providing communication services to all citizens)

The network is currently rolled-out and by the end of 2006, 90% of the city will be covered with WiFly services. At that time, there are plans to add voice services. Services are provided on a pre- and post-paid payment scheme. Price differentiation is applied for students, who can get an “all you can eat” rate plan for €6.00 per month.

France-Paris
Paris plans to offer visitors and residents free Internet access over Wi-Fi at 400 hot spots across the city, with the goal of city-wide Wi-Fi coverage by the end of 2007. A public tender will be launched in the fall of 2006. Wi-Fi providers will have access to municipal buildings and facilities. Global initiatives like FON are invited to participate, but further details are not available.

Belgium-Blankenberge
Since the beginning of July 2006 a city wireless mesh network has been available in the coastal city of Blankenberge. This wireless network is a joint private/business initiative. Free wireless access is available which features:
• limited bandwidth (128/64Kbps)
• restricted application access (web browsing and web mail, no P2P, instant messaging or VPN)
• and restricted access duration (every 5 minutes the browser is re-routed to an advertisement webpage)

Advanced service schedules are available in both pre- and post-paid subscriptions. These services will provide higher bandwidth (512/256Kbps) and have no restrictions on type of applications and access duration.

3.3 Hotspot providers in the Netherlands

3.3.1 T-Mobile
T-Mobile Netherlands is a mobile telecommunications operator providing mobile telephone, data and Internet services mainly in the licensed GSM and UMTS bands. Besides their mobile services, T-Mobile provides wireless services through their hotspot network in the unlicensed Wi-Fi band.

The T-Mobile hotspot network in the Netherlands is operated and owned by T-Mobile Netherlands B.V. T-Mobile Netherlands B.V. is a subsidiary of T-Mobile International. T-Mobile International is a wholly-owned subsidiary of Deutsche Telekom. In March 2004, T-Mobile acquired ViaWia, a wireless hotspot operator.
Target customer profile
T-Mobile Hotspot targets (international) business travellers who need broadband wireless services. Customers are reached in the Netherlands via T-Mobile HotSpot Partners Accor, BP Connect, Mc Donald's, Goudreinet, Regardz and WestCord Hotels.

Hotspot coverage
In the Netherlands, T-Mobile operates around 700 hotspots at partner locations. For T-Mobile, the footprint objective to provide Wi-Fi access within a 7-minute drive, has been reached. T-Mobile is planning to expand business on existing hotspot locations.

Roaming
T-Mobile HotSpot and KPN HotSpots have a bilateral roaming agreement, so T-Mobile's customers can access 700 KPN HotSpots locations, in addition to T-Mobile’s own 700 hotspots. T-Mobile also has a roaming agreement with roaming provider iPass.

Rates (Excluding VAT, August 2006)

<table>
<thead>
<tr>
<th>T-Mobile Hotspot</th>
<th>Per 1 MB</th>
<th>€2.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per minute</td>
<td>€0.20</td>
<td></td>
</tr>
<tr>
<td>Vouchers</td>
<td>60 minutes</td>
<td>€5.00</td>
</tr>
<tr>
<td></td>
<td>30 days</td>
<td>€67.18</td>
</tr>
<tr>
<td>Flat fee (Wi-Fi incl. UMTS/GPRS)</td>
<td>1.8 Mbps / 384 kbps, per month</td>
<td>€58.40</td>
</tr>
<tr>
<td></td>
<td>384 kbps / 128 kbps, per month</td>
<td>€41.60</td>
</tr>
<tr>
<td></td>
<td>PDA / smartphone, per month (in combination with phone subscription)</td>
<td>€7.98</td>
</tr>
</tbody>
</table>

3.3.2 KPN
KPN is a telecommunications service provider that provides mobile and fixed telephone, data, Internet and television services. Their mobile services are offered mainly in the licensed GSM and UMTS bands. In addition to their mobile services KPN provides wireless services through their hotspot network in the unlicensed Wi-Fi band.
KPN HotSpots is a wholly-owned subsidiary of KPN. KPN HotSpots was founded in late 2003 as a result of KPN’s takeover of the wireless service provider HubHop. At that time about 100 hotspots were acquired. In April 2006 the number of hotspots totalled 700. In January 2006 KPN HotSpots acquired the fixed and wired Internet service provider for Schiphol Airport named Attingo.

Target customer profile
KPN Hotspots targets (international) business travellers with a need for broadband wireless services. Customers are reached in the Netherlands via location partners Netherlands Railways,
Van Der Valk, Delifrance, Hogenboom Vakantieparken, Jaarbeurs Utrecht, Landal, La Place, Douwe Egberts, TOTAL, Campanile and Q8.

**Hotspot coverage**
In the Netherlands, KPN Hotspots operates 700 hotspots. KPN Hotspots has no plans to create a municipal wireless hotspot network.

**Roaming**
KPN HotSpots and T-Mobile HotSpot have a bilateral roaming agreement. So KPN HotSpots customers can access 700 T-Mobile HotSpot locations, in addition to the 700 hotspots owned by KPN HotSpots. Roaming agreements have also been concluded with roaming providers Boingo, Trustive, Wings and iPass.

**Rates (Excluding VAT, August 2006)**

<table>
<thead>
<tr>
<th>KPN Hotspots</th>
<th>Prepaid / Subscription</th>
<th>Vouchers</th>
<th>Flat fee</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Per minute</td>
<td>50 minutes</td>
<td>31 days</td>
</tr>
<tr>
<td></td>
<td>€0.15</td>
<td>€4.82</td>
<td>€36.41</td>
</tr>
</tbody>
</table>

**3.3.3 Enertel Wireless**
Enertel Wireless is a wireless Internet provider offering services in the unlicensed Wi-Fi bands and licensed WiMAX band.
In May 2006, KPN acquired Enertel N.V. from Greenfield Capital. Enertel Wireless B.V., a 100% subsidiary of Enertel N.V., operates hotspots and owns a WiMAX license. The acquired hotspots from Enertel Wireless will be part of KPN HotSpots but the WiMAX license is not part of the take-over by KPN. In May 2006 Enertel acquired NauticNet, the Dutch market leader of nautical wireless Internet access. In June 2004 Enertel acquired wireless hotspot operator WinQ.

**Target customer profile**
Enertel Wireless targets mobile workers and consumers with a need for broadband wireless services. Besides providing hotspot services in public places such as restaurants, hotels and cafés, Enertel Wireless operates hotspots in such specific areas as marinas. Enertel focuses on acquiring individual hotspot locations rather than multiple locations via contracts with company chains.

**Hotspot coverage**
Enertel Wireless operates approximately 200 hotspots. Enertel Wireless and KPN are following their own business strategies for the time being.

**Roaming**
Enertel Wireless has a roaming agreement with the hotspot operator KPN in the Netherlands. Roaming agreements with roaming providers and non-Dutch hotspot operators exist between
Enertel Wireless and Trustive, Mach, WeRoam, PicoPoint, GBIA, E-Plus, Vodafone, iPass and Dekatel.

Rates (Excluding VAT, August 2006)

<table>
<thead>
<tr>
<th>Prepaid</th>
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<th>€1.62</th>
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<tbody>
<tr>
<td></td>
<td>60 minutes</td>
<td>€4.05</td>
</tr>
<tr>
<td>Month</td>
<td></td>
<td>€48.60</td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td>€243.00</td>
</tr>
</tbody>
</table>

3.3.4 Swisscom Eurospot

Swisscom Eurospot is a leading pan-European provider of high-speed Internet access and conference services for guests and clients of the hospitality industry. Swisscom Eurospot is a wholly-owned subsidiary of Swisscom, Switzerland’s largest telecommunications service provider.

Target customer profile

Swisscom Eurospot targets customers who visit well-known hotels, conference and convention facilities. Customers are reached via partner contracts with large hotel chains.

Hotspot coverage

In the Netherlands Swisscom Eurospot operates approximately 100 hotspots. Hotspots are available in well-known hotel chains like Best Western, Hilton, Holiday Inn, Intercontinental, Marriott, Park Plaza and NH.

Roaming

In the Netherlands Swisscom Eurospot has no roaming agreements with other hotspot operators. Swisscom Eurospot has a roaming agreement with the roaming provider iPass.

Rates (Excluding VAT, August 2006)

<table>
<thead>
<tr>
<th>Vouchers</th>
<th>30 minutes</th>
<th>€4.20</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2 hours</td>
<td>€8.40</td>
</tr>
</tbody>
</table>

3.3.5 Mobilander

Mobilander is an independent hotspot operator and wireless service provider. Mobilander is active in the Netherlands only.

Target customer profile

Mobilander targets consumers and mobile workers and especially students or employees of universities and colleges in the Netherlands.
Hotspot coverage
Mobilander operates approximately 40 hotspots in the Netherlands. Their goal is to become a wireless service provider; Mobilander has no ambition to fund further expansion of their hotspot footprint. Since December 2003, Mobilander has operated hotspots at important public locations in the larger Dutch cities.

Roaming
Mobilander has a roaming agreement with roaming provider PicoPoint and a 'one-way' roaming agreement with educational roaming service eduroam. Mobilander's customers, also being eduroam community members, are allowed to access Mobilander's hotspots using eduroam credentials.

Rates (Excluding VAT, August 2006)

<table>
<thead>
<tr>
<th>Mobility</th>
<th>2 hours</th>
<th>5 hours</th>
<th>24 hours</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer and business</td>
<td>€4.01</td>
<td>€7.25</td>
<td>€12.11</td>
<td>€28.31</td>
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<tr>
<td>Educational</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Month / 1-year contract</td>
<td>€6.08</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Month / 2-year contract</td>
<td>€4.82</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.3.6 FON
FON is a company that strives to establish a community of people that use and provide hotspot services through a social sharing model. FON is independent and was founded in December 2005. In February 2006, Skype, Google, Index Ventures and Sequoia Capital invested €18 million in FON.

FON's concept is to provide software and wireless hardware to share a fixed broadband Internet connection with other people through a wireless connection. There are two types of FON members called Linus and Bill. Non-FON members are called Aliens and pay for Internet access on hotspots owned by “Linuses” and “Bills”. If an Alien connects to a Linus hotspot, payment belongs to FON. Linus hotspot owners get free access to every Linus and Bill FON hotspot in the world as return. If an Alien connects to a Bill hotspot, payment is equally split between the hotspot owner and FON. Bill hotspot owners make profit when Aliens connect, so Bill's do not get access to the other FON hotspots.

Target customer profile
FON focuses world-wide on every person owning a fixed broadband Internet connection. FON community members are not actively recruited. The community grows on verbal advertising by the FON members themselves.
Hotspot coverage
There are about 2100 FON hotspots in the Netherlands because the Dutch FON community has 2100 members. The FON community grows at an unpredictable rate and at random locations. FON's vision is to create a community of one million people to reach global Wi-Fi coverage.

Roaming
FON has no roaming agreements with other hotspot operators or roaming providers.

Rates (Excluding VAT, August 2006)

<table>
<thead>
<tr>
<th>FON</th>
<th>FON community members</th>
<th>Others (Aliens)</th>
<th>1 day</th>
<th>5 x 1 day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Always</td>
<td></td>
<td>€2.43</td>
<td>€8.10</td>
</tr>
</tbody>
</table>

3.4 Wi-Fi coverage in Utrecht City

3.4.1 Hotspot service providers in Utrecht City
Five hotspot providers KPN, T-Mobile, Eurospot, Enertel and Mobilander offer outdoor wireless Wi-Fi services in Utrecht City. Private initiatives for public access to wireless Internet exists, like those at the Social Ground Coffee Company and in the Castle Stadskasteel Oudaen for a small number of locations.

Hotspots in Utrecht are mainly located in restaurants, public squares and shopping malls. KPN's hotspots are mainly located in the central train station, the Jaarbeurs, and at the Rabobank offices. T-Mobile's hotspots are mainly located at all McDonald's restaurants and several other restaurants. Eurospot's hotspots are mainly located in the well-known hotel chains like the NH Hotel and Carlton in Utrecht. Enertel's hotspots are mainly located at restaurants and bars and in the Hoog Catharijne shopping mall. Finally, Mobilander's hotspots are mainly located in City Hall, and public squares with outdoor cafés.

Figure 1 and Figure 2 provide an overview of the hotspot locations in Utrecht City and in the centre of Utrecht City respectively (dated August 2006).
Figure 1  Commercial Wi-Fi hotspots in Utrecht City

Figure 2  Commercial Wi-Fi hotspots in the centre of Utrecht City
3.4.2 Other Wi-Fi signals detected in the streets of Utrecht City

Today, many people connect a wireless access point to their fixed broadband connection. Wi-Fi signals transmitted from these access points are by nature not restricted to the in-home area. In fact, many wireless access points are detectable outdoors. Operators planning commercial hotspots treat the existence of those signals as interference to their service.

Groups of people called wardrivers try to make maps of such private access points. Using a laptop, Wi-Fi card, GPS and special software wardrivers drive through streets where the private networks are located. The data collected is uploaded to a central database. Wardrive-maps are shown in Figure 3 and Figure 4 for Utrecht City and the centre of Utrecht City respectively (dated August 2006).

![Figure 3 Map of private access points that are detected outdoors in Utrecht City](image_url)
Figure 3 and Figure 4 show a substantial number of access points. If the FON model is taken into consideration, the figures basically show the potential FON coverage.

3.5 Demand for Wi-Fi services from the SURFnet community and local potential stakeholders in Utrecht

In order to assess the potential business case, it is necessary to understand what the value of the solution for customers and users might be. To determine the value of a wireless network to the SURFnet community, information has been derived from SURFnet market surveys as well as interviews with local (Utrecht) potential stakeholders (University, Hogeschool, local government). The following conclusions are drawn from the information:

- SURFnet community users and customers express a need for wireless connectivity outside the campus or educational facilities (about 66% of respondents)
- SURFnet community users are willing to pay very little or nothing for wireless services (only 16% of respondents are willing to pay);
- The local government of Utrecht has not yet considered the benefits of having a municipal wireless network in place in the city;

SURFnet user research 2006 "SURFnet gebruikersonderzoek 2006"
• Hogeschool of Utrecht has no plans; however it is interested and might consider providing resources for both deploying and exploiting a wireless network;

• The University of Utrecht has a policy of not providing resources outside of their campus or locations for the benefit of its students and staff.
4 Technology and related cost elements

4.1 Principles of Wi-Fi

Wi-Fi is a technology standard that enables wireless broadband communication between mobile devices such as laptops, PDA’s, and some phones. Wi-Fi is common and widely installed predominantly in laptops. The name "Wi-Fi" is a brand owned by Wi-Fi Alliance\(^6\). Wi-Fi covers the IEEE 802.11\(^7\) specifications for Wireless Local Area Networks (WLANs).

A typical Wi-Fi set-up consists of a wireless access point that is connected to a fixed network surrounded by multiple wireless clients. Clients can interact with the access point to gain access to resources such as the Internet or to each other, to exchange documents, for example.

Wi-Fi equipment operates in the 2.4 GHz and 5 GHz frequency bands, depending on the specific sub-standard. Sub-standards include:

- IEEE 802.11b that allows a data rate of 11 Mbps in total in the 2.4-2.5 GHz band;
- IEEE 802.11g where maximum speeds of 54 Mbps in total in the 2.4-2.5 GHz band are possible;
- IEEE 802.11g which allows the same speeds in the 5 GHz band.

The 2.4 and 5 GHz bands are part of the Industrial, Scientific and Medical (ISM) bands.

No license is needed for transmission of radio signals in the ISM frequency bands under certain conditions. Governments set those conditions. In Europe one of the limitations is that the total radiated power at the antenna does not exceed 100 mW\(^8\). So Wi-Fi operates in the unlicensed (but regulated) frequency bands, unlike GSM or UMTS that operate in the licensed (and regulated) frequency bands.

Transmission equipment for the unlicensed and for the licensed frequency bands must be certified. The certifying process checks, for example, whether equipment only generates radio signals in its assigned band and not on other frequencies. In the unlicensed frequency bands everybody is allowed to operate certified equipment, transmitting at frequencies in those frequency bands. The interference that exists because of third party certified equipment cannot be eliminated through regulation. In the licensed frequency bands, the license owner has exclusive rights to transmit radio signals at the frequency for which a license is provided.

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\(^6\) www.Wi-Fi.org

\(^7\) The Institute of Electrical and Electronics Engineers LAN/MAN group 11 standards committee

\(^8\) This figure refers to Effective Isotropically Radiated Power, the result of a hypothetical antenna radiating power equally in all directions. For an actual antenna with a gain in any direction, the power output has to be lower.
Wi-Fi technology is designed to transmit in an environment with a lot of potential interference. And, from the opposite perspective, the applied communication method used in Wi-Fi is designed to reduce interference caused by interaction with the Wi-Fi equipment itself.

Wi-Fi interference is introduced if two clients decide to transmit at exactly the same moment. The base station receives two signals at the same time, on the same frequency, with the same coding, so the transmission is void and will be ignored. For best performance, all clients should be able to receive each other's signals in order to limit the possibility of simultaneous transmission. This also applies to clients belonging to different networks, operating in the same area and same frequency. If these clients do not receive each other’s signals, the system will still work but the performance will be degraded. This issue is generally called the “hidden node” problem.

Interference between networks can be avoided by using different frequencies; however, the commonly used 2.4 GHz band only has three effectively different frequencies, so in a densely populated area with many private networks it will usually not be possible to find a frequency which is not already in use.

In licensed frequency bands, other, more effective transmission methods and power levels can be used, because interference is limited through license restrictions. Government provides licenses for frequencies in such a way that the possibility of occurring interference is limited. This is achieved by allocating individual frequencies to organisations for use within a specified geographic area, or by allocating frequency bands to specific applications with strict rules on when and how each station may transmit.

### 4.2 Principles of WiMAX and the comparison with Wi-Fi

WiMAX is a technology standard that enables wireless broadband communication between fixed stations. The technology can be used, for instance, to connect households to the Internet in areas where no fixed connection is available, or to provide backhaul for Wi-Fi hotspots. Therefore WiMAX can be seen as an alternative to DSL or cable. There is also a variant which enables support for mobile clients. The name "WiMax" is a term introduced by the WiMAX forum. WiMAX covers the IEEE 802.16 specifications for WLANs.

Today a typical WiMAX set-up consists of a wireless base station that is connected to a fixed network surrounded by multiple fixed-wireless clients. Clients can interact with the base station to gain access to resources such as the Internet. The base station decides which client may

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9 Although the European 2.4 GHz band allocates 13 channels, the signal is wider than a single channel so that there are only 3 non-overlapping channels.
10 In the Netherlands the Radiocommunications Agency or in Dutch "Agentschap Telecom" www.agentschapelecom.nl issues radio-licenses
12 802.16 is officially named by IEEE as WirelessMAN (Wireless Metropolitan Area Network)
transmit (following a scheduling algorithm), so it is not necessary for clients to receive each other's signals. The implication is that clients can be further away from the base station. This makes WiMAX the preferred technology for rural areas.

WiMAX equipment operates in the 2-11 GHz range or 10-66 GHz range, depending on the specific sub-standards. Sub-standards include, for example, IEEE 802.16d and 802.16e that allow communication with a data rate up to 70 Mbps in total in the 2-11 GHz frequency range. IEEE 802.16d is suitable for fixed-wireless applications and the IEEE 802.16e standard adds capability for full mobile support. The Dutch government has decided to assign the 2523-2667 MHz, 3.5-3.58 GHz, 24.549-25.025 GHz and the 25.557-26.033 GHz frequency bands for Wireless Local Loop (WLL) purposes. WiMAX is, amongst others, a WLL technology, so it can use these bands.

A license is needed for transmission of radio signals in the WLL frequency bands. For licensed WiMAX, radiation powers above 100 mW are allowed. This means that coverage is extended, but battery issues at the client side may limit actual useful range. The WiMAX IEEE 802.16e standard adds mobility requirements, including features to lower battery usage.

**WiMAX is not “better Wi-Fi”**

WiMAX and Wi-Fi technology are different technologies and each is applied in different situations. Some of the most important differences are:

- WiMAX is designed to be a backhaul or last-mile technology and Wi-Fi is designed to be a local access technology. Wi-Fi could be seen as an extension to DSL or cable and WiMAX could be seen as a substitute for DSL or cable;

- WiMAX is a far more complex technology than Wi-Fi, and in that sense Wi-Fi is more cost effective. Wi-Fi is also more cost effective because it is an unlicensed technology. WiMAX is currently a licensed technology, for which operators obviously have to pay. In theory, WiMAX can also be used in unlicensed bands, but with power levels as in unlicensed bands;

- Finally, and somewhat pragmatically, today's mobile clients are equipped with Wi-Fi technology. So, if fairly short-term access for mobile devices needs to be provided, Wi-Fi is the preferred technology for client access. WiMAX may be an option for the backhaul part of the network.
4.3 Components of access point locations

A typical municipal wireless network will consist of a large number of hotspots, each providing coverage to a limited geographic area. A hotspot typically consists of the following components:

- Physical location with space for the installation of equipment;
- Wi-Fi access point;
- Antenna structure;
- Cabling;
- Power connection;
- Backhaul (DSL, cable, Wi-Fi mesh, WiMAX).

To implement and operate a network of hotspots, the following main activities are needed:

- Planning and acquisition of locations;
- Contract management for location rental and backhaul;
- Installation of equipment, backhaul, power connection, antenna construction;
- Draft 'as built' documentation (such as documenting physical installation details, equipment types and serial numbers, cabling, antenna diagrams);
- Maintenance, change, fault and configuration management;
- User provisioning, authentication and authorisation;
- User billing (unless the service is free).

4.4 Coverage

The coverage of an access point depends on the environmental situation between the antenna of the access point and the client. Coverage will be limited if objects block the line of sight between the client and access points. In particular, objects containing water like wood, trees or even condensed water on windows will reduce the range considerably.

Coverage indoors will be up to 15 metres from the antenna location. If the antenna is placed outdoors, coverage will not be more than 100 metres from the antenna, assuming that there are no other Wi-Fi networks using the same frequency.

The density of access points depends on the environmental situation, the number of clients, the distance between client and access point, and radio-interference owing to the presence of other access points. Experts planning outdoor wireless networks need exact figures of the foregoing aspects. However a rule of thumb for cost calculations, based on desk research, is to assume a minimum density of 25 access points per square kilometre.

13 The absorption wavelength for energy of water falls within the 2.4 GHz Wi-Fi transmission band.
4.5 Multiple networks serviced by one access point

A network in the radio domain is identified with a Service Set Identifier (SSID). The SSID is known as the network name. Access points usually broadcast the SSID periodically to announce the presence of a network. The client side shows a list of available networks to connect to. Modern access points can service multiple networks, so that one access point broadcasts multiple SSIDs (as if there were multiple access points each broadcasting one SSID). Since every SSID represents a different network, authentication mechanisms and data flows can be completely separated from each other at the backhaul side of the access point. Even if only one SSID is used, data flows of different users can also be completely separated in the access point.

These concepts can also be referred to as the creation of wireless Virtual LANs, logically separated networks for different categories of users. For the latter, the authentication server provides information to the access point onto which VLAN users needs to be assigned. The authentication process is described in the next paragraph.

Authentication

Authentication is the process of verifying a person's identity electronically. The end-user is provided with a set of digital credentials. Given the fact that these credentials are known only to the end-user and that the channel used for communication of the credentials is trustworthy, a person can be identified as the expected person, to obtain access to a certain service or system. The type of authentication is mostly a business decision, since some authentication mechanisms are more secure but require special organisational or user activities.

For wireless Internet, one possible authentication method is a login web page where credentials such as username and password can be filled in. The username and password are verified in the database of the organisation where the end-user purchased the wireless service. In this model, access to the wireless network is unrestricted, but connections beyond the local network are blocked for unauthenticated users. This method is however vulnerable to malevolent acts such as session-hijacking.

For a more sophisticated authentication method, Port-Based Network Access Control based on IEEE 802.1x is widely used. The IEEE 802.1x authentication method uses the Extensible Authentication Protocol (EAP), which offers flexibility for (user-specific) authentication. Wireless clients first set-up a wireless connection with the access point. At this point the access point accepts no Internet traffic such as DHCP (for providing an IP address, Internet gateway

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14 It should be noted that web-based login is vulnerable to identity theft because after a user is logged on, an intruder could configure its hardware to appear to be the same user as the logged on user.
15 The IEEE 802.1x, named Port Based Network Access Control, is a sub-standard of the IEEE 802.1 Higher Layer LAN protocols.
16 The Extensible Authentication Protocol is defined in the IETF RFC 3748 (http://tools.ietf.org/html/rfc3748) and runs directly over the datalayer, so without using higher layers like the IP layer.
Instead, only EAP traffic is allowed. The client sends credentials to the access point and the access point redirects these credentials to the authentication server, which is usually a RADIUS server\(^{17}\). The credentials provided by the client are end-to-end encrypted by the selected EAP mechanism. The encryption thus takes place between the client and the authentication (RADIUS) server, providing a secured tunnel for whatever credentials used. The RADIUS server checks if the credentials are valid (EAP offers a flexible path to the client for whatever information is required) and instructs the access point to grant the client access if the authentication is successful. The traffic will then be encrypted, usually through WPA (Wi-Fi Protected Access). The encryption keys are derived from secrets created during the authentication phase. These secrets are only known to the client and the authentication server and are never sent through the air. After authentication and the initialisation of encryption the network allows non-802.1x traffic, if required, to a user-specific network (VLAN). At that point, a DHCP session can be started to provide the client with an IP address. After the DHCP session has completed, the client is ready for access Internet services.

To completely separate data flows at access point level, the RADIUS server needs to provide the VLAN with information using EAP. The access point must therefore be capable of using IEEE 802.1x.

### 4.6 Cost elements

For determining the expected cost of a city-wide wireless network, assumptions have to be made. Assumptions relate to the type of coverage desired, the access speed, the type of service and the expected users.

The basic cost elements for planning, implementing and operating a wireless network do not differ from other types of networks. The cost elements distinguished for the wireless network, consist of:

- **Access Points**
  The number of access points depends on the type of coverage (indoors or outdoors) and level of service (throughput and reliability). A rule of thumb points to a figure of 25 access points per square kilometre. If bandwidth consumption and/or users are high, or if there is a high level of interference, this figure could easily jump to 100 access points per square kilometre.

- **Sites for mounting access points**
  The number of sites depends on the number of access points and the wireless technology applied (e.g. mesh). Site acquisition is expensive and unpredictable

\(^{17}\) A RADIUS server (Remote Authentication Dial In User Service) provides for an AAA service (authentication, authorisation and accounting). One authentication method based on distributed RADIUS servers is *eduroam*. 
(consider the cases of cellphone operators). In some situations, public property such as light poles may be available, subject to the co-operation of the local government.

- **Backhaul, including the Internet uplink**
  The number and capacity of uplinks will differ depending on the type of access point technology. If access points without mesh technology are applied (like in traditional hotspot networks), there will be as many Internet uplinks as there are access points. If mesh technology is applied, a shared uplink (overbooking of e.g. 1:10) could be used. An option for the uplink bandwidth is connecting to the fibre infrastructure of SURFnet; (however, there may be an issue with splitting commercial traffic from educational traffic in order to comply with SURFnet's acceptable use policy)

- **Datacentre, back-office and IT support systems like element managers, AAA, billing, roaming 3rd party, trouble ticketing**
  In order to provide services (either wholesale or retail), systems need to be implemented. These business support systems and operations support systems, including licensing, configuration, customisation and integration, can quickly run up to six-digit upfront investments. These costs do not depend so much on the number of access points as on the service provided (from free of charge with no call centre, to flat rate, up to differentiated service and price plans for both retail and wholesale customers).

- **Customer care and network of operations centre**
  These costs also depend on the type of services like best effort, service levels and guarantees.

- **Management and organisation**
  Sales, marketing, finance, legal, human resources

All these elements relate, to a certain extent, to both capital expenditures as well as operational expenses and will be part of the network life cycle\(^\text{18}\). In case of integration of a network into an existing environment, elements such as *eduroam* costs for integration need to be included.

Some ratios such as costs per access point or cost per site may be derived from these elements. These ratio elements are given below (Appendix A provides some values).

**Cost per access point**
- Procurement (one-off)
- Installation (one-off)
- Configuration (one-off and recurring)
- Maintenance/On-site support (recurring)

\(^{18}\) A life cycle has the following phases: plan, design, implement and operate / improve
Cost per site
- Acquisition/Survey (one-off)
- Rental/power (recurring)

Backhaul
- Installation (one-off)
- Rental (recurring)

Operational Support Systems and Business Support Systems
- Procurement/Licences (one-off)
- Implementation/Integration (one-off)
- Maintenance (recurring)

Services
- Network of Operations Centre/customer care
- Overheads
5 Approaches for realising municipal wireless access

There are various approaches towards creating municipal wireless access. Each approach has its advantages and challenges as regards service level and quality, coverage, investments, recurring costs and revenues or benefits. We have identified four basic approaches for creating outdoor wireless networks:

- city-wide roll-out of new infrastructure;
- concluding roaming agreements with hotspot providers;
- deploying municipal wireless access by community building;
- a hybrid approach combining elements of the above.

These approaches should guide initiators in deciding which approach is the most suitable given their situation and targets.

The four approaches were derived from the following starting points:

- the initiator's goal and ambition for realising an outdoor wireless network;
- the service level and quality versus the available (financial) resources;
- stakeholders who can be suppliers, buyers or both.

5.1 City-wide roll-out of new infrastructure

In section 3.1 examples are provided of municipalities that decided to roll-out a city-wide wireless infrastructure.

A business case for the initiator and one for the organisation responsible for the network

If the local government or any other public or semi-public organisation (like a school or university) takes the initiative for municipal wireless, basically two different business cases can be distinguished. They are the business case of the initiator and the business case of the organisation that will be responsible for realising the plans. Aspects for these two business cases are given below.

- From the local government perspective, the business case will be:
  - in financial terms, cutting costs for mobile workers;
  - in social terms, addressing social issues such as the digital divide;
  - in indirect-financial terms, enabling the development of innovative services;
  - in task-oriented terms, improving the quality of tasks.

- From the perspective of the organisation that will be responsible for the network, the business case will be:
  - in financial terms, achieving break-even if only non-commercial organisations participate; and making a profit if commercial organisations participate as well.
Municipal wireless is based on social, economical and indirect economical arguments
An initiative of this kind is driven by political, economical and indirect economical arguments. Typical objectives to develop a municipal wireless strategy are to provide Internet for households that cannot afford a DSL connection, to cut costs on mobile working, to stimulate innovation, or to provide government services to citizens. Several organisational models exist for deploying and operating municipal networks. Section 3.1 describes three organisational models.

Support from (semi-) public organisations is necessary for making a sound business case
Acquiring and maintaining locations accounts for a large part of the investment and recurring costs. In all existing initiatives, the business case is made financially attractive because of the support of local governments. They provide direct financial support by financing the network or indirect financial support by making property available for installing access points.

An additional financial source could come from private investors. These investors could be attracted if non-commercial stakeholders like the government, schools or universities commit to buy services for a specific volume and period. Such stakeholders are often referred to as anchor tenants.

Service level and quality of the service can be fully customised
The organisation that carries out the municipality’s plans offers network connectivity to customers (wholesale and retail) such as Internet service providers who provide Internet access to end-users, or security companies that could provide camera surveillance for end-users. The technology and architecture can be chosen in such a way as to meet any requirements on such aspects as bandwidth and authentication, thus providing full customisation of the service level.

If the service is to be sold as a wholesale product, quality should be carefully determined because companies depend on the network for bringing their services to end-users. Service quality is proportional to the number and locations of access points, the backhaul capacity, proactive network monitoring and fault resolution, and maintenance.

Because access points (being part of the wireless infrastructure) can be planned accurately, wireless access can be obtained at any desired location. In most cases, the wireless infrastructure will be planned for outdoor access, but in some cases it will also be planned for indoor access, which means that many access points will need to be installed and therefore many locations will have to be acquired.

19 Google's argument to roll-out a city-wide wireless network is an indirect economical one: to experiment with location-based services and to reach out to their end-users.
Summary

City-wide roll-out of new infrastructure: advantages, disadvantages and remarks from the perspective of the organisation that is responsible for the network

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Customised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of service</td>
<td>Customised</td>
</tr>
<tr>
<td>Service level</td>
<td>Customised</td>
</tr>
<tr>
<td>Investments</td>
<td>High</td>
</tr>
<tr>
<td>Recurring costs</td>
<td>High</td>
</tr>
<tr>
<td>End user price</td>
<td>Stakeholder dependent</td>
</tr>
<tr>
<td>Financial feasibility</td>
<td>Participation of (semi-) public organisations required (government, schools, universities)</td>
</tr>
</tbody>
</table>

5.2 Realising roaming agreements with hotspot providers

Municipal wireless coverage could be approximated if subscribers could make use of all hotspots from different providers present in the municipality, if these hotspot operators together have a near municipal footprint. An organisation could arrange contracts with providers in which rules for exchanging AAA credentials, billing information, and possibly lower service prices are settled. Such an organisation is called a roaming provider\(^{20}\).

A roaming provider aggregates services of different hotspot providers

Customers of roaming providers will usually pay a fee, the roaming fee, in addition to the price of the service of the hotspot operator. The roaming provider collects billing information from all the affiliated hotspot operators and aggregates it in one bill. Usually, the roaming provider will provide a set of credentials for logging-in. These credentials can be used to login in to any of the affiliated operators' networks. For this, the roaming provider should have a billing and authentication system in place that interacts with the different billing and authentication systems of the affiliated operators.

An organisation that represents a community could act as a roaming provider

An organisation that represents a certain closed user group could act in a similar way as a roaming provider\(^ {21}\). The organisation could, for instance, negotiate for lower service prices for hotspot services, especially if the closed-user group is of any importance for the hotspot operator. The organisation could provide its closed user group with the credentials of each of the affiliated operators, but it could also put its own authentication system in place. Marketing and sales effort can be rather small because the organisation already represents a group of users, which are in close contact with the organisation.

\(^{20}\) Examples of roaming providers are iPass (http://www.ipass.com), WeRoam (http://www.weroam.com), PicoPoint (http://www.picopoint.com), Trustive (http://www.trustive.com)

\(^{21}\) eduroam is a roaming provider exclusively for the research and educational community
**Stratix**

**Service level and quality of the service is not uniform**
Because the different hotspot operators provide their services to the roaming provider, the service level and quality from the end-users' perspective is not uniform. Usually commercial hotspot operators provide a good service level and quality of service, but limited coverage. So the overall service level and quality of service will be comparable, within the footprint covered, to the city-wide roll-out of new infrastructure approach described in section 5.1.

The roaming provider has little influence on the desired wireless coverage because the affiliated providers follow their own strategy for hotspot roll-out.

**Aspects of the business case**
There are, however, some issues that are relevant if the roaming model is considered as an approach for creating a city-wide wireless network infrastructure:

- the roaming fee is in addition to the operator's price of the service. Even when negotiating a lower service price, the total price of the roaming approach for the end-user will be close to the operator’s price;

- roaming providers target international business travellers while hotspot operators target national business travellers, and people who need wireless connectivity occasionally;

- for an organisation that represents a community, it may not be worthwhile to contract services of commercial hotspot operators because community members could have different needs from those of the business traveller.

**Summary**

<table>
<thead>
<tr>
<th>Concluding roaming agreements with hotspot providers: advantages, disadvantages and remarks from the point of view of an organisation that represents a community acting as a roaming provider</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coverage</strong></td>
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<tr>
<td><strong>Quality of service</strong></td>
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<tr>
<td><strong>Recurring costs</strong></td>
</tr>
<tr>
<td><strong>End user price</strong></td>
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</table>

* except if the community consists of (international) business travellers

5.3 **Deploying outdoor wireless by community building**
A city-wide wireless hotspot network could be realised if every citizen with a fixed Internet connection connects a wireless access point to it. This would provide people on the street nearby with wireless Internet service. If everybody joined, this would create a city-wide wireless hotspot infrastructure.
Community members will share and strangers should pay
In general, only few people will share something with strangers without getting anything back for it, whereas friends or members in a community share without any problem. Community building is all about how to let people build and share a common good.

Communities are often initiated by a small number of persons, community initiators. Community initiators promote the community by applying guerrilla marketing\(^{22}\). Members of communities like to talk and describe their community, thus arousing the interest of their friends to make them join. The community grows therefore organically and at fairly unexpected places. Community initiators try to make the entrance barrier as low as possible to attract new members and try to keep the members together.

Coverage grows with the number of members
An organisation that represents the community could provide software to share fixed Internet connections, routers, instructions and perhaps authentication methods to its community members\(^{23}\). A person becomes a community member if that person shares its fixed Internet connection in a wireless manner using the community software. At that point, the member’s place is called a community hotspot. In return, community members may access the Internet at any of the other community hotspots. Non-community members could access the Internet at a community hotspot, but may have to pay for it.

The service level and quality of the service is not guaranteed
The realised outdoor coverage of a community hotspot will be unpredictable because community members do not install their community ready access points at locations that are optimal for outdoor coverage. Secondly, the overall wireless coverage cannot be controlled and will contain blanks because the hotspots appear at random locations. Thirdly, public locations like shopping malls or train stations, which may be very relevant to users, will not be covered because it is not likely that community members can accommodate those places. Fourthly, the performance of community hotspots will vary from one hotspot to another because of varying speeds and quality of fixed Internet access links. The concept provides by nature an indoor service, because the access points' antennas are situated indoors. However with proper cooperation of the community members who place their access points near a window, some degree of outdoor coverage could be achieved.

Aspects of the business case
From the point of view of an organisation that represents the community, the following aspects are important for drafting the business case:

---
\(^{22}\) Guerrilla marketing consists in successfully promoting a product or concept with a very low marketing budget merely through verbal advertising and also publishing articles in newspapers and postings in blogs.

\(^{23}\) An example of a purely wireless community is FON (section 3.3)
The business case of purely wireless Internet communities, like FON, is about building a network of accessible Internet users whose personal details, geographical location and knowledge about their wireless usage are known. This might be of interest for companies that offer services to highly mobile clients over the Internet24.

Community member's contracts with Internet service providers may contain disclaimers about reselling Internet bandwidth or making Internet bandwidth available outside the family circle. There may also be legal issues in providing service to others (e.g. wiretapping rules);

The delivered service will be unpredictable. It helps to inform the community about the impact of good co-operation on the service;

In financial terms, the business case could be sound by asking a contribution from community members.

Summary

<table>
<thead>
<tr>
<th>Realising outdoor wireless by community building: advantages, disadvantages and remarks from the point of view of an organisation that represents a community offering a wireless service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coverage</strong></td>
</tr>
<tr>
<td><strong>Quality of service</strong></td>
</tr>
<tr>
<td><strong>Service level</strong></td>
</tr>
<tr>
<td><strong>Investments</strong></td>
</tr>
<tr>
<td><strong>Recurring costs</strong></td>
</tr>
<tr>
<td><strong>Legal</strong></td>
</tr>
<tr>
<td><strong>End user price</strong></td>
</tr>
</tbody>
</table>

24 e.g., Skype that might offer Wi-Fi handsets or mobile phones which are pre-configured with FON access software, or perhaps Google that could offer location-based information to community members.
### 5.4 Overview of approaches

<table>
<thead>
<tr>
<th></th>
<th>Full roll-out</th>
<th>Roaming</th>
<th>Community</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coverage</strong></td>
<td>Customised</td>
<td>Provider specific</td>
<td>Only at members’ locations</td>
</tr>
<tr>
<td><strong>Quality of service</strong></td>
<td>Customised</td>
<td>Predictable</td>
<td>Unpredictable</td>
</tr>
<tr>
<td><strong>Service level</strong></td>
<td>Customised</td>
<td>Market standard</td>
<td>Provider dependent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td><strong>Investments</strong></td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Recurring costs</strong></td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>End user price</strong></td>
<td>Stakeholder dependent</td>
<td>Comparable with provider's prices*</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Financial feasibility</strong></td>
<td>Participation of (semi-) public organisations required</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

* except if the community consists of (international) business travellers

### 5.5 Hybrid approach

A hybrid approach is a mix of the approaches stated in the previous sections: city-wide roll-out of new infrastructure, realising roaming agreements with hotspot providers, realising outdoor wireless by community building. There is no optimal mix; it all depends on the situation in which outdoor wireless access has to be realised. The next paragraphs give an example of a low-investment approach to municipal wireless coverage.

One of the hybrid approaches is characterised as realising an outdoor Internet service for the benefit of and with help from members of an existing community. The hybrid approach is a mixed solution, partially based on rolling out new infrastructure (section 5.1) and also on the community building approach (section 5.2).

Any organisation representing an existing user group such as SURFnet has already established a close relation between community members, and between the members and the organisation. The wireless service is just a desired add-on for the community. The community needs a wireless service in order to better share information in the area of interest on which the community owes its reason for existence.

Such an organisation could deploy the community building approach to provide an outdoor wireless access service to the community. However, this approach does not guarantee quality of service, nor does it provide coverage at public locations like train stations and shopping malls as

---

25 An example close to the hybrid model is Wireless Leiden ([http://www.wirelessleiden.nl](http://www.wirelessleiden.nl)). The Wireless Leiden community aims at providing a wireless infrastructure for enabling communication between community members. Internet is seen as a service provided to community members using the Wireless Leiden network. Other services such as authentication services could be enabled as well.

26 Unlike a wireless community such as FON, which is a community of members with a common interest in wireless access.
described in section 5.3. The hybrid approach addresses these opportunities to improve quality of service and coverage.

**Quality of service will be higher than in the community building approach**

If community members are interested in a wireless service, members are more likely to cooperate to improve the quality of service. Although the quality of the delivered Internet service in the vicinity of the community members' houses will stay unpredictable, community members are likely to follow instructions for placement of access points at optimal locations for realising outdoor coverage. Like in the community building approach, the organisation provides access points with pre-configured authentication software. The “roll-out” of the access points could be planned because the members' locations are known beforehand. The quality of the delivered Internet service at the roll-out locations can be customised.

In the community building approach, the coverage grows organically and at random places. If an existing community asks for wireless coverage, the organisation that represents the community knows the exact location of potential access points. The organisation can analyse the possible coverage and could decide to roll-out extra infrastructure on places where no members are housed.

**Realising coverage at public places like train stations or shopping malls**

The community could roll-out access points at public locations where no community members are housed. The number of such hotspot locations are limited as compared with full municipal roll-out of new infrastructure as described in section 5.1. Because the number of hotspot locations are limited, the costs for creating a community useful coverage are significantly reduced. As wireless services are exclusively provided to the community members, no typical operator nor ISP platforms (like billing, subscriber management, etc.) are required. And because only an Internet service is provided, no special technology is needed for the backhaul (standard DSL or cable Internet connections may be sufficient).

**Provisioning of an indoor authentication service as a bonus**

Because access points are placed inside the community members' houses, indoor coverage within those houses is automatically achieved, besides the targeted outdoor coverage. Indoor coverage can be provided without a need for separate authentication methods\(^ {27} \).

**Aspects of the business case**

From the point of view of an organisation that represents an existing community, the following aspects are important for drafting the business case:

\(^ {27} \) e.g. the international authentication method *eduroam* on campuses for the research and education community could be extended to the in-home situation creating a single sign on environment for the whole *eduroam* community.
the business case is about providing a cost-effective wireless Internet service to community members only. No participation is needed of other organisations (that are likely to demand network access for non-community members).

Community member's contracts with Internet service providers may contain disclaimers about reselling Internet bandwidth or making available Internet bandwidth outside the family circle;

In financial terms, the business case could made be sound by asking for a contribution from community members;

Summary

<table>
<thead>
<tr>
<th>Advantages, disadvantages and issues of the hybrid approach described above</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>Fairly predictable</td>
</tr>
<tr>
<td>Quality of service</td>
<td>Unpredictable</td>
</tr>
<tr>
<td>Service level</td>
<td>Fair</td>
</tr>
<tr>
<td>Investments</td>
<td>Fair</td>
</tr>
<tr>
<td>Recurring costs</td>
<td>Fair</td>
</tr>
<tr>
<td>Legal</td>
<td>Issue: sharing fixed internet connection</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Community only</td>
</tr>
<tr>
<td>Community benefits</td>
<td>A wireless Internet connection, if available also at public locations</td>
</tr>
</tbody>
</table>
6 Financial case for the city of Utrecht from a SURFnet perspective for creating a municipal wireless network

To understand the impact of creating a local city-wide wireless infrastructure, we decided to consider the specific situation of the city of Utrecht.

The reasons for choosing Utrecht as potential roll-out city were as follows:
- The city had to be one with a mixed (alphas and betas) student population, to avoid a technology-based demand for wireless services
- there should be no initiatives yet, so a greenfield scenario could be applied
- previous participation in a project for investigating a city-wide wireless roll-out based on WiMax technology (2005)
- easy and central accessibility for interviews

6.1 The financial case

One of the models which can be applied for rolling out a wireless infrastructure in Utrecht is the so called full roll-out model. This type of roll-out is based on a municipal “blanket” containing wireless network coverage.

SURFnet’s objective has been defined as the creation of a city-wide wireless network, so all financial calculations are executed with the assumption of creating such a municipal network.

For business planning purposes in a business-oriented environment, the basics of a business case apply to three elements:

- Revenues (tangible and non tangible)
- Costs (upfront investments and expenses related to operations)
- Time (for purpose of (discounted) cash flow calculations and pay back period)

As revenues are unclear and unpredictable at this point in time, the approach consists in first defining the cost for a municipal wireless network for Utrecht. A basic cost model has been created hereto which consists of the elements set forth in section 4.6.

Costs

The calculations for determining the total costs of ownership are based upon desk research and interviews with suppliers and representatives of comparable initiatives. They give a total estimated cost of € 9.2 million for running a three year municipal wireless network. The high level build up of the cost is depicted in Figure 5.
Figure 5  €9.2 million of costs are built up for creating and operating a municipal wireless network in Utrecht over a 3-year period

Assumptions:
- The city of Utrecht has been defined as an area of 25 km² to be covered. This is the area east of the A2 motorway, north of the A12 motorway and west of the A27 motorway.
- 25 wireless mesh access points per km² will be required for outdoor coverage
- For every 12 mesh nodes, a wired connection is required (line rental – for both aggregation and internet uplink - under commercial conditions)
- Sites need to be acquired/contracted under commercial conditions (accounting for nearly a third (28%) of the total cost)

As almost one-third (28%) of the total cost goes to site acquisition and annual lease or rental, it is imperative to obtain the participation of local government in rolling out the infrastructure. Of course, this assumes that local government is able to facilitate the sites for mounting wireless antennas.

Appendix B gives a further drill down of the cost.

Options for improving the business case
1. A third of the cost is related to acquiring and rental of sites. If the cost of site acquisition and rental could be minimised through the participation of local government and local educational organisations (who own a significant portion of local real estate), this would result in a Total Cost of Ownership of less than €7 million (for 3 years).
2. The local government and the two major higher educational institutes (UvU and HU) have a total annual cost budget of €2.1 billion. If these 3 major local stakeholders could re-address, re-prioritise and free-up 0.05% of their budgets, this could cover half the projected annual cost. This of course requires that these organisations create their own justification (either tangible or non-tangible). The city of Taipei is an example of how this has been dealt with. But also a local government in the Netherlands could think of such participation as an opportunity to improve the communication with its community (and thus cut down on red tape and costs). It is worthwhile investigating how the “digital divide” in the city of Utrecht could be overcome by providing wireless access to low-income households. Although the Netherlands is one of the countries with the highest penetration of broadband access, there is still a digital divide.

3. Further improvement of the case is possible through keen procurement. All costs summed up are based on gross pricing. Without going into detail, it is expected that by utilising an established procurement process, the total cost could be reduced by an extra €1 million, leaving a total cost of less than €6 million for the 3-year period.

4. The remainder of the cost could be financed through private or other public participation. Options for recovering these costs consist in issuing an RFP to an ISP or other broadband access providers to manage the network and provide wireless services. A clearcut agreement with individual stakeholders (such as local government and educational institutes) needs to drawn up for participation in the venture (risk sharing versus risk avoidance, financing versus purchasing-consuming).

Additional financial resources could be attracted from innovation funds. Currently there is no city-wide wireless network in the Netherlands. Certainly, such an innovative network will create all sorts of new (business) initiatives, resulting in business models based upon revenues coming from local advertisements, and services such as educational gaming or remote health care. This is one of reasons for companies as Google and Skype participating in or even fully financing municipal wireless network roll-outs in the US. Such an infrastructure could also add value to Local Government in providing services to its residents (see the Taipei case, outlined in section 3.2).

6.2 Interpreting financials considering SURFnet’s role

SURFnet fulfils a strategic role within the community network of Dutch higher educational and research institutes. It is a task-oriented organisation which implements the policies and guidelines provided by its stakeholders. Stakeholders are organised in the Stichting SURF and most of them are the Dutch higher educational and research institutes.

It needs no further explanation to understand that a city-wide roll-out as calculated in the previous paragraph cannot be financed by the educational community of Utrecht. Nor will SURFnet be able to reach approval with its stakeholders to finance such a case on its own.
Participation however is an option for creating such a wireless infrastructure. In order to understand the options for participation, a model extracted from the value chain model is used for reference. This distilled model is presented in the diagram below.

**Figure 6  Typical roles in the value chain**

SURFnet has, for all its initiatives and innovations, approached the market from a demand aggregation point of interest (demand pull), either representing the Dutch educational and research community in full (resulting in SURFnet6, Gigaport) or facilitating parts of this community to create local solutions (GigaMAN). These roles apply mainly to the top link (innovation-concept-idea) of the chain and the two lowest links (customer/end-user) of the value chain.

For financing the cases in the past, the clients (higher education and research institutes) and typical stakeholders with an innovation interest (such as the Dutch Office for Economic Affairs) were involved.

The case for Utrecht (from a technical point of view) has been created in such a way that a municipal wireless network could arise where communities other than the higher educational institutes could benefit (such as local government, home care organisations or local businesses). It is set up as an open network. It is therefore key to generate interest and obtain financial commitment within the local communities (others than the educational one) when creating this network.
SURFnet can facilitate the process for Utrecht as a demand aggregator on behalf of the Utrecht educational institutes and as such take part in a Public/Private partnership, a similar approach to the one applied for the creation of the GigaMan networks. The educational community can, in this case, become an anchor customer on the network created. The Public Administration of Utrecht could be another anchor customer of the wireless network. However the Utrecht’s local government has not yet defined if and in what way it would want a municipal wireless network within its city.

In addition to the role of demand aggregator, SURFnet can take up the role for finding alternative sources of financing. It is most likely that funds will be available for creating an innovative environment.

### 6.3 Options for SURFnet

Although the maths in the previous paragraphs result in a financially feasible model, it is still very relevant to gain financial commitment. And this financial commitment must be based on the calculations that (business case) each individual anchor customer must make.

If the anchor customers, stakeholders, for the Utrecht case are not able or willing to fully participate, there are other options at hand for SURFnet to be part of the development of municipal wireless networks:

**Participate in the Groningen initiative**

Within today’s SURFnet community, the higher educational organisations in Groningen (Rijksuniversiteit Groningen and Hanze Hogeschool) are involved in creating a municipal wireless network. This project is in its business case/funding phase and there is a vision, drive and ambition amongst the initiators. SURFnet could participate in the project with the opportunity to:

- attract additional financial means;
- provide additional knowledge and tooling on several technological aspects;
- create a centre of expertise for other initiatives;
- speed up the process.

**Adhere to the Wireless Leiden "community initiative "**

This initiative in Leiden is built up and operated from local-private participants. Although the service is not comparable with a municipal roll-out, it provides a degree of Wi-Fi coverage. SURFnet’s charter in such a project could be to scale up the coverage for the purpose of its educational community. The expertise could be exploited to other educational communities in the Netherlands.
Downscale the ambition for creating a municipal wireless network in Utrecht

Downscale the ambition of a municipal wireless network within Utrecht by applying a hybrid model (section 5.4). Although the hybrid approach will not result in a complete municipal wireless network, it will result in a community network. This would be a hotspot infrastructure, which, to achieve a city-wide signal, would roughly require some 60,000 wireless antennas in the city of Utrecht and full co-operation of almost every individual household in Utrecht. With these kind of numbers it is obvious that city-wide coverage will never be achieved. We need to further examine the sort of coverage appropriate for the educational population in the specific Utrecht area, if a hybrid approach is chosen. Costs will still be involved for creating an infrastructure in places where wireless signals are required but where no community members live (like the “Hoog Catharijne” shopping centre, and other parts of the city centre). The costs involved in such a closed user group network, cannot be completely recovered from an open model (assuming aggregation and backhaul connectivity is provided through the SURFnet network).

Try to interest another city in municipal wireless access

SURFnet's role could be to establish demand aggregation on behalf of the educational community with different other communities and stakeholders. SURFnet could try to find or interest a city in municipal wireless access since participation of local government is essential. To interest a city in such networks, its innovation rational should be further explored.
**Appendix A  Cost elements of municipal wireless access**

The calculations for determining the total costs of ownership shown below are based upon desk research and interviews with suppliers and representatives of comparable initiatives.

<table>
<thead>
<tr>
<th>Access Layer</th>
<th>Units</th>
<th>Category</th>
<th>Per item</th>
<th>One-off</th>
<th>Recurring/PA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio/AP planning</td>
<td>20</td>
<td>days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Hardware</td>
<td>62</td>
<td>mesh AP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td>2</td>
<td>days/AP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration</td>
<td>0.05</td>
<td>days/AP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>20%</td>
<td>percentage/AP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site Acquisition/Configuration</td>
<td>573</td>
<td>sites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Full MuWi</strong></td>
<td></td>
<td></td>
<td>€ 2,485,750</td>
<td>€ 823,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aggregation Layer</th>
<th>Units</th>
<th>Category</th>
<th>Per item</th>
<th>One-off</th>
<th>Recurring/PA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Hardware</td>
<td>62</td>
<td>Routers/Wireless Gateways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td>1</td>
<td>days/AP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration</td>
<td>0.5</td>
<td>days/AP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>20%</td>
<td>percentage/Routers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site Acquisition/Configuration</td>
<td>62</td>
<td>sites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line rental -&gt; internet gateway</td>
<td>50</td>
<td>50 Mbps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UpLink</strong></td>
<td></td>
<td></td>
<td>€ 390,520</td>
<td>€ 780,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Design/Implement  | 200   | days                         | € 54,000  | € 58,000  |               |             |

<table>
<thead>
<tr>
<th>Management services (platform, systems, software and staff)</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subs-Contr Management</td>
<td></td>
</tr>
<tr>
<td>AAA</td>
<td></td>
</tr>
<tr>
<td>Billing</td>
<td></td>
</tr>
<tr>
<td>Roaming</td>
<td></td>
</tr>
<tr>
<td>Helpdesk</td>
<td></td>
</tr>
<tr>
<td><strong>Network</strong></td>
<td></td>
</tr>
<tr>
<td>NOC</td>
<td></td>
</tr>
<tr>
<td>NMS-FCAPS</td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
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<tr>
<td>€ 3,981,700</td>
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</tr>
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**ISP Organisation**

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<thead>
<tr>
<th>Sales-Marketing</th>
<th>HR</th>
<th>Finance</th>
<th>IT support</th>
<th>Management</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>tbd</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>tbd</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B  Breakdown of costs for Utrecht City

The calculations for determining the total costs of ownership shown below are based upon desk research and interviews with suppliers and representatives of comparable initiatives and result in a total estimated cost of € 9.2 million for running a three year municipal wireless network.
Appendix C  List of persons interviewed

Sander van Aalst, InterNLnet

Gerard Verwoolde, Hogeschool van Utrecht

Rene Ritzen, Universiteit Utrecht

Thomas Krüse, Gemeente Utrecht

Robert Janz, Rijksuniversiteit Groningen

Erwin Bleumink, SURFnet

Jan Karel Kleijn, FON

Olivier van Arkel, KPN Hotspots

Erik van Overijk en Paco Liebrand, T-Mobile

Fred Schäffers, Mobilander