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NATIONAL STRATEGIES FOR PUBLIC WLAN ROAMING

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HELSINKI UNIVERSITY OF TECHNOLOGY ABSTRACT OF THE MASTER'S THESIS

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The global public WLAN market is experiencing constant growth. At the same time the recession in the development of the Finnish mobile data market has generated discussion both in governmental level as well as in business life. This study focuses on exploring means to refresh the development of the Finnish public WLAN business as a part of a more extensive LEAD project.

Compared to GPRS and 3G networks, WLAN offers the operators a profitable way to provide wireless broadband network services. Therefore WLAN should be seen rather as supporting technology that enables the supply of versatile technology independent mobile data services.

In the first part of this thesis introduces the most common public WLAN business models and studies the importance of national roaming. The second part applies the gathered information considering the suitability of these models if used in the Finnish public WLAN environment. The objective is to identify the best model for the current situation.

The most suitable business model for the Finnish public WLAN market is based on a value chain consisting independent network and service providers. In this model service providers buy capacity from several network operators. The problem of national roaming often seems to be a situation called *backdoor competition*, because of which the service operators seldom are willing to sign national roaming agreements.

Keywords:	Public WLAN, national roaming, business model, value chain, wireless broadband

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Kansainvälinen julkinen WLAN-markkina kasvaa jatkuvasti. Samaan aikaan kotimaisen mobiilidatamarkkinan kehitys takkuilee, mikä on herättänyt huolestunutta keskustelua sekä valtionjohdossa, että yritysmaailmassa. Tässä diplomityössä keskitytään etsimään keinoja kansallisen julkisen WLAN-liiketoiminnan kehittämiseksi osana laajempaa LEAD-projektia.

GPRS- ja 3G-verkkoihin verrattuna WLAN-teknologia mahdollistaa operaattoreille edullisen vaihtoehdon tarjota langattoman laajakaistaverkon palveluita. WLAN olisikin syytä nähdä matkapuhelinverkkoja tukevana teknologiana, joka mahdollistaa monipuolisten mobiilidatapalvelujen tarjoamisen verkkoteknologiasta riippumatta.

Tämä diplomityö koostuu kahdesta kokonaisuudesta. Ensimmäisen osan tavoitteena on tunnistaa globaalilla tasolla yleisesti käytössä olevat julkisen WLAN-liiketoiminnan liiketoimintamallit ja tutkia verkkovierailun merkitystä erityisesti kansallisella tasolla. Toisessa osassa koottua teoriaa sovelletaan käytäntöön tutkimalla esiteltyjen liiketoimintamallien soveltuvuutta Suomen markkinaolosuhteisiin. Kansainvälisiltä markkinoilta kertyneiden tietojen avulla pyritään löytämään Suomen olosuhteisiin parhaiten sopiva ja markkinan kehittymistä edesauttava liiketoimintamalli.

Vertailumarkkinoiden perusteella Suomessakin toimivin liiketoimintamalli olisi itsenäisten verkko- ja palveluoperaattoreiden muodostama arvoketju, missä palveluoperaattorit hankkivat verkkokapasiteettia usealta verkko-operaattorilta. Kansallisten verkkovierailusopimusten ongelmana on ns. *backdoor competition*, minkä takia operaattorit eivät kovin halukkaasti tarjoa kansallista verkkovierailua.

Avainsanat:	Julkinen WLAN, kansallinen verkkovierailu, langaton laajakaista, liiketoimintamalli, arvoketju

Preface

This Master's Thesis is the last major obstacle between me and the Master of Science degree. Most of the work for the thesis was carried out in Networking laboratory during the years 2004 and 2005.

Completion of this kind of work is 70 percent battle of wills and 30 percent hard work, at least it often has felt like it. Therefore I wish to express my gratitude to those people who have supported me during these years and from whom I have received support and guidance throughout the Thesis project.

First, I am thankful to my supervisor, Professor Heikki Hämmäinen, for his guidance during the whole process. I also want to thank my instructor Sauli Kamppari for the numerous comments as well as the whole LEAD research group for the interesting discussions we had.

Furthermore, I want to thank Marita Vuorinen from TeliaSonera as well as Johan Friis from DNA Finland for all the time and valuable information they gave me. I also want to thank Markku Ranta from Nokia for the myriad of articles he sent me.

I want to give a big hand to all my friends and a big hug to my loved ones. Without you my disposition to workaholism would have been uncontrollable.

Finally, I would like to express my gratitude to my family for their infinite support and understanding during my studies.

Espoo, February 6th, 2006

Timo Ralli

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Key concepts

Commercial hotspot	A commercial hotspot is situated in public environment. However, the network access is based on authentication and the usage is subject to a charge.
Public WLAN environment	The public environment is an area, where the public presence is unrestricted, including outdoor areas, streets, transportations centers, retail stores, hotels, restaurants and public spaces and lobbies in major civil buildings.
Roaming	The possibility for an end-user of a WLAN device to use the commercial hotspots of an operator other than the one(s) he has bought the subscription from. Roaming implicitly indicates a relationship between a visited WISP, a home WISP and the end-user who is client of the latter.

Abbreviations

2G	2nd Generation (of mobile networks)
3G	3rd Generation (of mobile networks)
AAA	Administration, Authorization and Authentication
AAA-H	Home network AAA server
AAA-V	Visited network AAA server
ADSL	Asymmetric Digital Subscriber Line
AP	Access Point
ARPU	Average Revenue per User
BSSID	Basic Service Set Identifier
CAPEX	Capital Expenditures
CDMA2000	Code Division Multiple Access (3rd Generation cellular/radio technology)
DHCP	Dynamic Host Configuration Protocol
DSL	Digital Subscriber Line
DSSS	Direct Sequence Spectrum Modulation
EAP	Extensible Authentication Protocol
EAPOL	Extensible Authentication Protocol over Local Area Network
EAPOW	Extensible Authentication Protocol over Wireless Local Area Network
EDGE	Enhanced Data Rates for Global Evolution
ETSI	European Telecommunications Standards Institute
FHSS	Frequency Hopped Spread Spectrum
GPRS	General Packet Radio Service

GSM	Global System for Mobile Communications
HLR	Home Location Register
HSCSD	High Speed Circuit Switched Data
ID	Identification
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISP	Internet Service Provider
IEEE	Institute of Electrical & Electronics Engineers
LAN	Local Area Network
LLC	Logical Link Control
MAC	Medium Access Control
MVNO	Mobile Virtual Network Operator
NAI	Network Access Identifier
OFDM	Orthogonal Frequency Division Multiplexing
OPEX	Operational Expenditures
OSI	Open Systems Interconnected
PAN	Personal Area Network
PDA	Personal Digital Assistant
PDH	Plesiochronous Digital Hierarchy
QoS	Quality of Service
RADIUS	Remote Authentication Dial-In User Server/Service
RAND	128-bit random number
R&D	Research and Development
SIM	Subscriber Identity Module
SMS	Short Message Service

SSID	Service Set Identifier
UMTS	Universal Mobile Telecommunications System
VLAN	Virtual Local Area Network
VWISP	Virtual Wireless Internet Service Provider
WAN	Wide Area Network
WCDMA	Wideband Code Division Multiple Access
WEP	Wired Equivalent Privacy
WISP	Wireless Internet Service Provider
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access
WWW	World Wide Web
xDSL	x Digital Subscriber Line (of any type)

1 Introduction

1.1 Motivation for the study

This master's thesis is made in collaboration with the Networking Laboratory's LEAD (Optimal Rules for Leading Mobile Data Market) project. The justification for the project is to support the renewal of Finnish telecommunications cluster by improving the understanding on market dynamics in the mobile data business. The objectives are to identify and understand the key obstacles and potentials of co-operation and regulation for Finland to become a leading mobile data market. [LEA04]

The global public WLAN market has experienced exponential growth under the last five years providing operators a chance to execute very diverse business models. The public WLAN business is however relatively immature and understanding of the industry is in developing phase. The immature business situation hinders the exploitation of the existing public WLAN capacity and coverage increasing the overall profitability. This study aims to bring more clarity into this subject matter.

1.2 Background

The mushrooming of fixed broadband technologies and subscriber connections are shaping the usage of Internet services into a totally new form. In Finland the penetration of household broadband Internet accesses has grown from zero to twenty percent between the years 1999-2003. Also the amount of personal computers has increased in a linear fashion from 40 % to 60 % at the same time. This kind of development is shaping also the consumer habits and the fast access and services is becoming a trivial commodity.

The terminal equipment manufacturers and service providers have noticed this trend and also the wireless technologies have been developing rapidly. Such cellular network technologies as GPRS, EDGE and UMTS are developed to improve the network efficiency but also portfolio of wireless broadband technologies has developed significantly during the last years. Especially the IEEE standardization of Wireless Local Area Network (WLAN) has been a catalyst for terminal and service development.

The global public WLAN user base is currently several million and it is anticipated to grow up to 150 million in 2009. At the same time the amount of commercial hotspots is estimated to quadruple up to 185.000.

1.3 Research problem

As pointed out earlier, public WLAN services use unlicensed frequency band, which means that the monitoring of the operating companies is less strict than in other branches of telecom industry, where the law provides that the licensed companies must fill certain boundary conditions. The diverse basis of the companies manifests itself as numerous business models. The research problem is:

What are the most common business models used in global public WLAN markets?

This problem is discussed by studying the structural differences of the existing value systems. As the LEAD project concentrates on the Finnish telecom market, it is reasonable to further refine the research problem:

What is the current situation of the Finnish public WLAN market?

What actions are needed to accelerate the development of the domestic market?

By comparing the market situation in reference countries and in Finland it is possible to conceptualise the linkage between the business model and the operating environment in order to understand what kind of model should be used in certain environment. The one last insertion to the research problem relates to roaming. International roaming has been said to be one of the main reasons behind the success of GSM [Jen04]. Therefore the research problem is extended with the question:

What is the role and value of national roaming in public WLAN business?

1.4 Objectives of the study

The objectives of the study can be defined as follows:

1. Define the current situation and the most common business models used in the global and domestic public WLAN markets.

2. Based on the information gathered from the global markets, outline what should be done to accelerate the development of the domestic market.

By inspecting the global market and the cases, where roaming between service providers has been implemented, it is possible to conclude if national roaming should exist in Finland and would it be of commercial benefit.

1.5 Scope of the study

This thesis is made from an unbiased point of view. The technical and business aspects are approached with a view to finding the most practical and purposeful models to give the best added value to all interest groups. Technical issues, being outside the scope of this study, are presented in adequate level to give the reader the readiness to understand the further analysis. Geographically the scope of the study is limited to the national public WLAN industry.

From access technology point of view, the scope of the thesis is limited to unlicensed wireless broadband technologies based on IEEE Std 802.11. The main analysis is made considering the laptop segment but also the development of the handheld segment is kept in mind.

1.6 Research methods

The research methods include literature survey, open interviews and a case study. Public WLAN being relatively new and fast developing branch of business, acquiring relevant free material is hard. Magazines, academic studies and analysis are used as the main information source.

The business model analysis is based on Porter’s value system, which allows us to present the structural differences of the most common models. The Five Forces model is used as the suitability of these models is discussed. The gathered information is used to build up a case example that illustrates the current situation in Finland and discusses the possible actions to be made and their outcomes.

1.7 Structure of the study

The structure of the thesis is illustrated in figure 1.1.

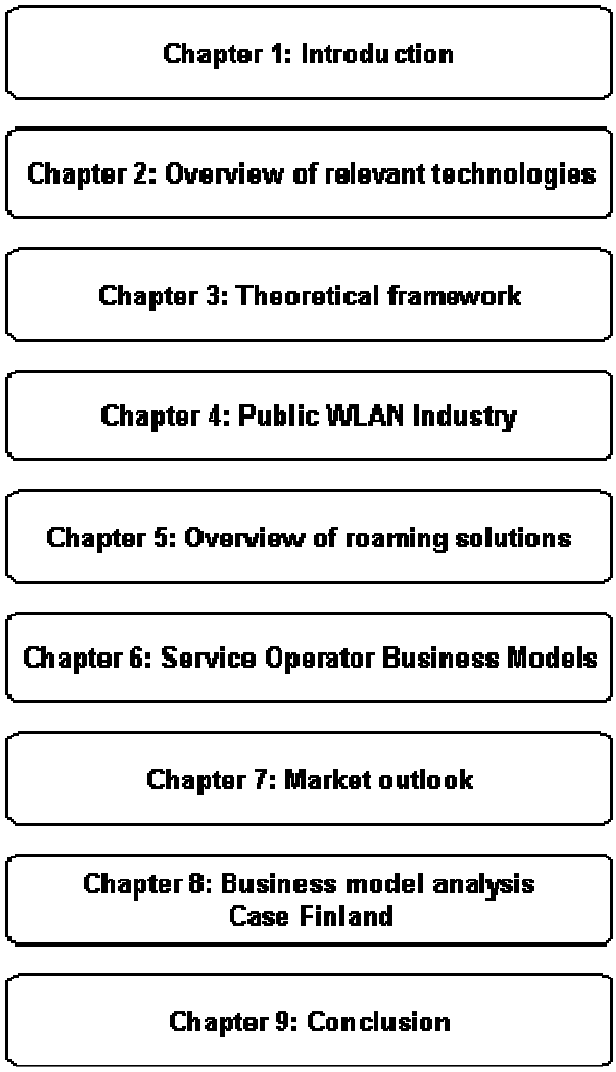


Figure 1.1: Structure of the thesis

The first chapter provides an overview of the topic, description of the research problem, objectives and scope.

The second chapter presents the overview of relevant authentication, network and radio technologies. As the technical aspects mostly are outside the scope of this study, the description is rather general.

The third chapter gives a brief description of the methods that are used in this study. The academic framework is constructed around Porter's theories and the technology adoption lifecycle model. Also the Internet business model is discussed in general.

The fourth chapter introduces the public WLAN industry. The value system, including all the players, as well as the overview of current roaming models is presented.

The fifth chapter demonstrates the business solutions used in public WLAN roaming. Because of the tight relations to the GSM and dial-up Internet worlds, both topic are introduced briefly.

The sixth chapter contains a more detailed description of the public WLAN industry. This chapter introduces the most common business model in use.

The seventh chapter presents both the global and domestic public WLAN markets. The previous chapters have presented the business in raw, while this chapter goes deeper to the environmental differences.

In the eight chapter includes detailed analysis of the Finnish public WLAN market. The suitability of the existing business models in prevailing environment is discussed and also the role of the service provider is analysed, both in laptop and handheld segments.

The ninth chapter contains the conclusions and summarises the study.

2 Overview of relevant technologies

2.1 Wireless networks

Wireless networks are commonly classified into Wide Area Networks (WAN), Local Area Networks (LAN) and Personal Area Networks (PAN). This division is based on the range of the radio transmitter and each class may include several standards and technologies.

2.1.1 WAN - Wide Area Network

Networks spanning over a country or even world wide are referred as Wide Area Networks, Internet being one of the most well-known fixed WANs and GSM/GPRS and 3G networks representing the wireless WANs. GSM (Global System for Mobile communication) is currently world's largest mobile communication system providing circuit-switched services. GPRS (General Packet Radio Service) was introduced as a standardised packet-switched data service extension of GSM architecture providing also higher maximum transfer rate. Packet-switched data service makes it possible to use mobile terminal in the same way than a computer attached to Internet, the network is loaded only when data is being transmitted, which also decreases the usage costs.

The third generation mobile networks, developed by ETSI in 1999, were designed to eventually provide transfer rates equal to fixed networks. This makes 3G an interesting alternative for WLAN networks. Despite the original objective of a finally global wireless network, two different technologies exist. In Europe WCDMA was chosen as the main technology, while CDMA2000 was spreading in the U.S. 85 percent of the world's 3G networks are based on WCDMA technology.

However, the implementation of the new technology has not followed the original plans. World's first operational 3G network for public service was rolled out in spring 2001 by NTT DoCoMo, but for example in Finland the first network was opened not until October 2004.

2.1.2 LAN - Local Area Network

The LAN segment has been very active during the last years, the biggest reason being the success of the IEEE 802.11 standard. Wireless local area networks are mainly used with a laptop or a PDA equipped with external or integrated network interface card. The technical issues as well as various use cases are discussed later on in this chapter.

2.1.3 PAN – Personal Area Network

Personal area network is usually related to the concept of wireless office. The range of PAN is couple of meters providing the ability to synchronise computers, transfer files and gain access to local peripherals like printers and various pocket terminals like cellular phones and PDAs. Currently the most well known PAN technology is Bluetooth.

2.2 IEEE 802.11 standard

The 802 LAN and MAN standards mainly specify the two lowest layers of the Open Systems Interconnection (OSI) reference model i.e. the physical and the data link layers. Figure 2.1 presents the relationship between these two models.

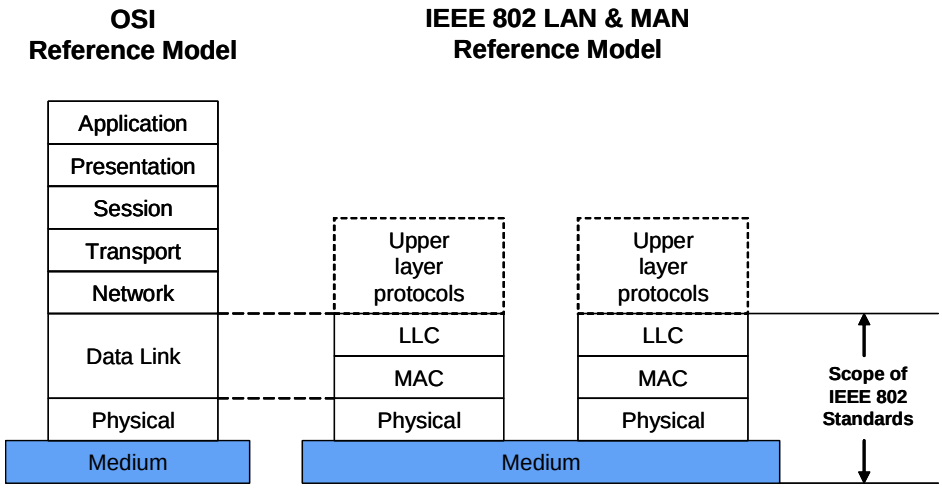


Figure 2.1: IEEE 802 LAN & MAN reference models (Adapted from IEEE Std 802-2001)

The IEEE 802 standard divides the OSI models Data Link layer into two sub layers. The Logical Link Control (LLC) sub layer is common for all the IEEE 802 standards but the Medium Access Control (MAC) layer is redefined in every substandard. IEEE 802.11 is a standard group currently including three separate physical layer specifications (802.11a/b/g) and service enhancements and extensions, or corrections to MAC layer (802.11c-f/h-j/n).

IEEE 802.11 *legacy* is the original protocol version released in 1997 and the only one including also the infrared transmission feature. From the subsequent revisions it has been dropped out because of more widespread specifications defined by Infrared Data Association IrDA. The original standard specifies a 2,4GHz operating frequency with data rates of 1Mbps and 2Mbps using two forms of spread spectrum modulation: frequency hopping (FHSS) and direct sequence (DSSS).

IEEE 802.11a & b standards were introduced in late 1999 802.11b being a data rate extension of the initial 802.11 DSSS. The updated version provides operation up to 11Mbps. 802.11a operates on 5GHz band giving a maximum bandwidth of 54Mbps

using orthogonal frequency division multiplexing (OFDM) modulation. In practice the average throughput is about 5,5Mbps and 25Mbps respectively. 802.11b has 3 or 4 non overlapping channels while 802.11a has 12. IEEE 802.11a started shipping not till 2001 because of the more controlled 5GHz band. In Europe the regulators considered the use of European HIPERLAN standard and the 802.11a was cleared for use in mid 2002.

802.11g was ratified in June 2003. It works in the 2,4GHz band but operates at 54Mbps. Like 802.11a the more realistic throughput of 802.11g is about 25Mbps. 802.11g is fully backwards compatible with 802.11b.

The latest standard version introduced in January 2004. 802.11n is supposed to provide a real throughput of 100Mbps the maximum speed being as high as 250Mbps. The ratification is expected to take place in the end of 2005. The following table 2.1 presents the current IEEE 802.11 protocol overview. [WIK04] [Gei01]

Table 2.1: IEEE 802.11 protocol overview (Wikipedia, referenced 06/2004)

Standard	Transfer Method	Frequency Band	Data Rates [Mbit/s]
802.11 legacy	FHSS, DSSS, IR	2.4 GHz, IR	1, 2
802.11b	DSSS, HR-DSSS	2.4 GHz	1, 2, 5.5, 11
802.11b+ non-standard	DSSS, HR-DSSS (PBCC)	2.4 GHz	1, 2, 5.5, 11, 22, 33, 44
802.11a	OFDM	5.2, 5.5 GHz	6, 9, 12, 18, 24, 36, 48, 54
802.11g	DSSS, HR-DSSS, OFDM	2.4 GHz	1, 2, 5.5, 11; 6, 9, 12, 18, 24, 36, 48, 54

2.3 Standards & certification

The role of IEEE working group is mostly guiding. It only sets specifications but does not test them. The charged certification program is controlled by a trade group called Wi-Fi Alliance. Virtually all companies selling 802.11 equipments are members. The Wi-Fi trademark guarantees interoperability and includes also the security standard Wi-Fi Protected Access (WPA). The current standards and task groups are presented in the following table 2.2. [WIK04]

Table 2.2: Current IEEE 802.11 standards & task groups

IEEE 802.11	The original 2 Mbit/s, 2.4 GHz standard
IEEE 802.11a	54 Mbit/s, 5 GHz standard (1999, shipping products in 2001)
IEEE 802.11b	Enhancements to 802.11 to support 5.5 and 11 Mbit/s (1999)
IEEE 802.11d	New countries
IEEE 802.11e	Enhancements: QoS, including packet bursting
IEEE 802.11f	Inter Access Point Protocol (IAPP)
IEEE 802.11g	54 Mbit/s, 2.4 GHz standard (backwards compatible with b) (2003)
IEEE 802.11h	5 GHz spectrum, Dynamic Channel/Frequency Selection (DCS/DFS) and Transmit Power Control (TPC) for European compatibility
IEEE 802.11i	Enhanced security
IEEE 802.11j	Extensions for Japan
IEEE 802.11n	Higher throughput improvements

2.4 Public WLAN network architecture

Public WLAN network, also known as a WLAN hotspot, is a wireless local area network based on IEEE standards. The basic architecture of a public WLAN network is presented in picture 2.2. Each hotspot consists of one or more wireless access points (AP), which are connected to fixed local area network (LAN, normally Ethernet). The LAN is connected to DSL/Frame Relay or PDH based access network with a bridge or router. The task of access network is to connect the hotspot with the service provider network.

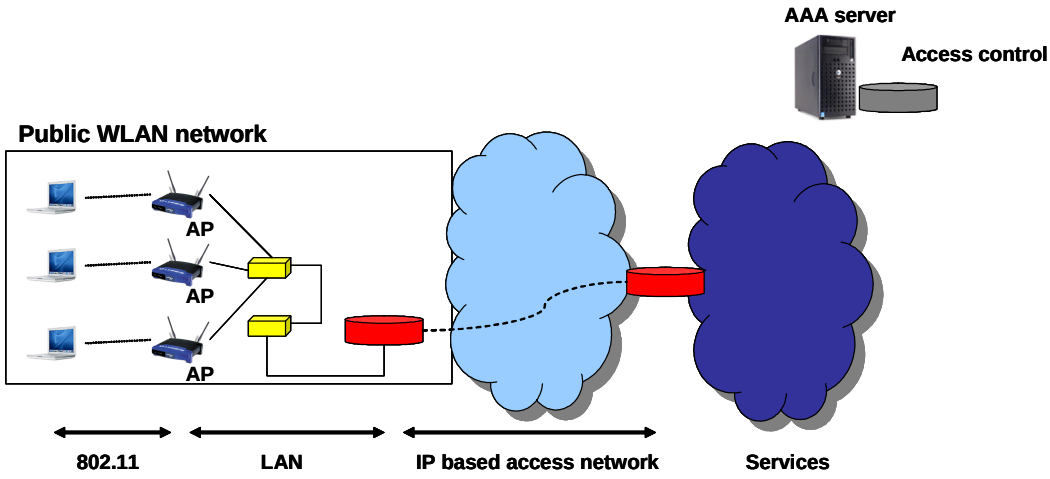


Figure 2.2: Public WLAN network architecture

In most cases some kind of user authentication is needed before the connection can be established. The access point advertises itself by sending a unique 32-bit identifier called Service Set Identifier (SSID) in a beacon frame. The terminal identifies the home network by using this SSID, access point-specific selection is based on signal strength. While the SSID identifies a wireless network, Basic Service Set Identifier (BSSID) can be used to identify each wireless device uniquely. BSSID is actually the MAC-address of each device and can be used by the terminal to select which access point to connect. A more precise picture presenting the access network is presented in figure 2.3.

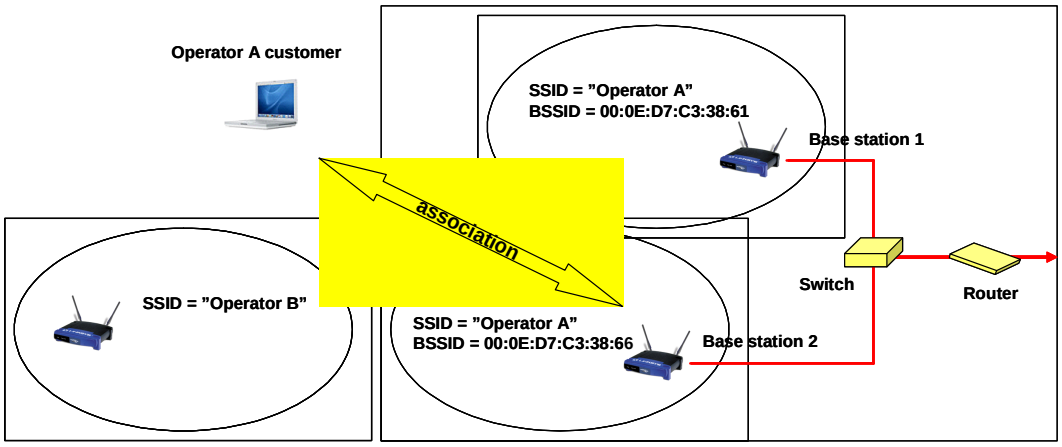


Figure 2.3: WLAN access network

2.5 Authentication methods

Authentication constitutes one of the basic elements of public WLAN services. As told in the previous subchapter, each access point must advertise its existence by sending the beacon frames identified by the customer terminal. This kind of architecture makes the network public. However, the actual access network is available only for customers authorised by the network. In most cases, this authorisation is based on some kind of service subscription. Authentication methods are used to control the existence of valid subscriptions. This can be made in several different ways.

2.5.1 WWW authentication

WWW authentication is principally based on *User ID* and *password* pair. Also combinations with SMS, GSM and credit card authentication systems are possible. User ID and password, as well as the network SSID are given to the customer when he or she purchases the subscription. When the SSID is set up and the connection between the terminal and the access point is established, a web page arises in the web browser asking the user to type in the user ID and password. This information is delivered to the AAA server attached in service provider's network and the validity is checked. An example of WWW authentication is presented in figure 2.4.

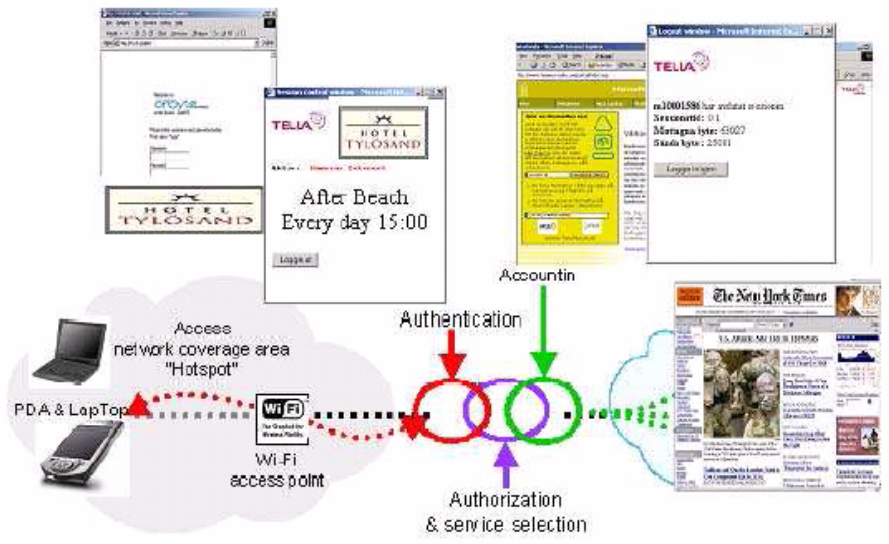


Figure 2.4: Implementation of a WWW based authentication

WWW based authentication is terminal independent and easy to use, but does not support the encryption of the air interface.

2.5.2 802.1X

802.1X authentication is based on the IEEE 802.1X standard offering an effective framework for authenticating and controlling user traffic to a protected network, as well as dynamically varying encryption keys. 802.1X defines a management protocol that stations use to request LAN port access. It uses the Extensible Authentication Protocol (EAP) originally defined for dial-up, but here sent over Ethernet LANs (EAPOL) or over wireless (EAPOW). The station must first physically connect to the communications medium. The station then sends an "EAP Start" message. This kicks off a flurry of management messages that ends with "EAP Success" or "EAP Failure". EAP is an envelope that can carry many different kinds of authentication -- challenge/response, one-time passwords, SecureID tokens, digital certificates, etc. What happens between "EAP Start" and "EAP Success" depends upon the type of authentication being used. Throughout most of the 802.1X exchange, the switch or access point ("the authenticator") is just a middleman, relaying EAP messages between the station ("the supplicant") and a RADIUS server ("the authentication server"). For example, the station is asked to supply its identity, which the authenticator relays inside a RADIUS Access-Request. Based on the station's identity, the RADIUS server issues a RADIUS Access-Challenge, the content of which the authenticator relays to the station. And so on, until the RADIUS server makes a decision to accept or reject the access request.

This 802.1X framework consolidates decision-making at the RADIUS server, so that ACLs no longer have to be individually configured into every switch or access point. It also allows stations to identify themselves with credentials other than MAC address. For example, the station's identity can be a Windows login, followed by a CHAP challenge/response to verify the station's password. Or the station's identity can be an X.500 Distinguished Name, bound to a digital certificate verified via public/private key cryptography. Supporting a wide variety of authentication schemes proves to be both an asset and challenge for 802.1X deployment.

In WLANs, an additional step follows EAP Success: an EAPOW Key exchange. This provides the access point and station with secret session keys to be used by Wired Equivalent Privacy (WEP) or Wi-Fi Protected Access (WPA) to encrypt traffic sent over the WLAN. The original 802.1X standard used a single EAPOW Key message for this purpose, but the new improved 802.1X (called 802.1aa) uses a four-way handshake to prevent man-in-the-middle attacks that might otherwise compromise these keys. After both ends of the wireless association -- the station and the access point -- have session keys, data sent over the air can be encrypted to prevent eavesdropping. In fact, this relationship between 802.1X and data encryption turns out to be just as important to WLAN security as controlling access and authenticating stations. Exchanging session keys with 802.1X is much more resistant to WEP key cracking than using static, manually-configured shared WEP keys. The desire to use dynamic, automatically generated per-session keys is a significant driver promoting 802.1X deployment, particularly in larger WLANs where managing static WEP keys is difficult anyway.

802.1X is considered as secure and easy to use enabling the use of automatic login. It also enables the use of multiple authentication methods as pointed out above. The problem with 802.1X is that not all operating systems will support it without a separated client program.

2.5.3 SIM authentication

SIM based WLAN authentication requires the use of a SIM reader attached to the computing device, so that the authentication software can use the SIM credentials.

The EAP-SIM protocol, resident on the client, specifies the Extensible Authentication Protocol (EAP) mechanism for authentication and session key distribution using GSM SIM. In EAP-SIM several RAND challenges are used for generating several 64-bit ciphering keys (Kc), which are combined to constitute a longer session key. EAP/SIM also enhances the basic GSM authentication mechanism by accompanying the RAND challenges with message authentication code in order to provide mutual authentication. The EAP-SIM client starts the authentication process by connecting to the AAA server. The AAA server issues a challenge over the 802.11b radio interface, which is then forwarded to the SIM reader by the EAP-SIM client. The EAP-SIM client communicates to the SIM through the SIM reader, the SIM calculates the response that contains the SRES and Kc, which is sent to the EAP-SIM client. The EAP- SIM client

then forwards the response to the AAA server, which then checks the response and provides access appropriately. In this scenario it is assumed that the AAA server has a secure connection to GSM backbone network components like HLR. [Ahm03]

2.5.4 MAC authentication

For devices that support this feature, MAC authentication provides a means of authenticating without the user login required by the web-based and 802.1X methods. On the device, you specify a MAC password, which will be used for all MAC addresses connected to that device. On the RADIUS server, instead of entering user names, you enter the MAC addresses, which are allowed to authenticate, and enter the appropriate MAC password for every MAC address. Then, when a MAC address attempts to access a port, the device sends the MAC address and the MAC authentication password to the RADIUS server for authentication. Automatic re-authentication is available with MAC authentication.

MAC authentication is an easy to use solution, but it requires the registration of the terminals to operator. MAC address is also prone to counterfeits.

2.5.5 MAC + 802.1X authentication

It is also possible to enable both 802.1X and MAC authentication on a device. When this feature is activated, it is possible for a device to receive a start or response 802.1X packet while a MAC authentication is in progress. If this happens, the device immediately terminates the MAC authentication, and the 802.1X authentication proceeds to completion. Regardless of the success of the 802.1X login attempt, no new MAC authentication logins may occur on the port until 1) the link is toggled, 2) the user executes an 802.1X logout or 3) the 802.1X session is terminated administratively.

2.6 Network partitioning

The technical constraints of the WLAN technology have until now hindered the network partitioning between several service providers. The new, more sophisticated network devices, however, enable several operators to provide services in the same physical network. This method is called network partitioning. Network partitioning enables the use of separated network and service provider business model instead of the traditional model, in which the service provider usually is also responsible for the network elements.

In order to provide real bit stream based services, a network operator should be able to divide the physical network between several service providers. Currently the partitioning can be done either by dividing the wireless access network between several service providers, by differentiating the traffic after the wireless access network or by using a virtual operator. A more specific introduction is given below. These service models are presented in a white paper provided by the Finnish Communications Regulatory Authority [Fic04].

2.6.1 Traffic partitioning in the wireless access network

The wireless network partitioning is conducted with several techniques.

- The wireless LAN can be partitioned by appointing a separate SSID to each service operator providing services in that network. The use of separated SSIDs makes it possible to implement several overlapping WLAN networks in one radio frequency.
- Base station can be partitioned by connecting the traffic of different service providers to separated Ethernet based Virtual Local Area Networks (VLAN). Service providers are identified by using separate SSIDs.
- The service providers can be separated to different VLANs inside the LAN.
- The traffic of each VLAN is bridged or routed to separate virtual channels through the IP based access network. A router is partitioned by using a virtual router, where one physical router consists of several logical routers. A virtual bridge has one group of bridges for each service operator.
- In bit stream model each service operator provides the service networks separately.

The bit stream network architecture is presented in figure 2.5.

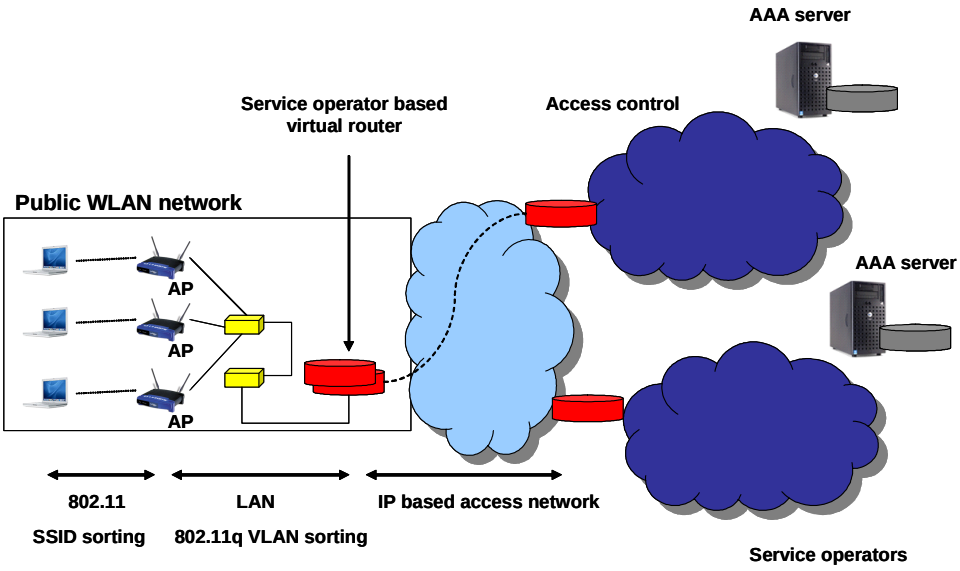


Figure 2.5: Network architecture for bit stream model

2.6.2 Traffic partitioning after the access network

It is discovered that not all WLAN access networks support the partitioning model presented in chapter 2.7.1. In these cases the traffic directed towards the service operator network must be partitioned on the edge of the access network (see figure 2.6).

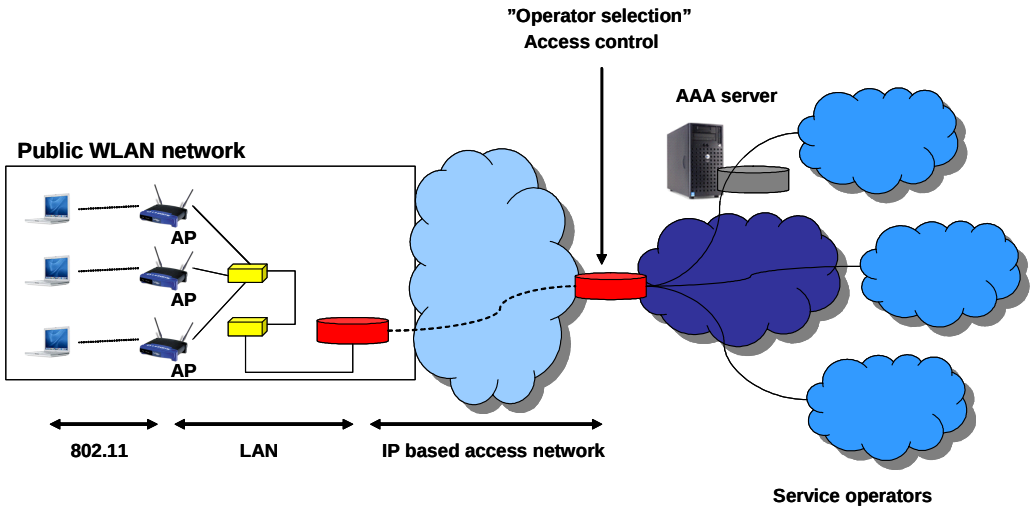


Figure 2.6: Traffic partitioning on the edge of the access network

If a web based authentication method is used, an IP address must be given to the user before the used service operator is known. After the user has logged in the network operators web page, the network operator must change the users network access in order to be able to route the returning traffic via the correct service provider. The network address can be changed either by using address resolution or by providing only temporary DHCP periods.

2.6.3 Virtual Operator Model

The virtual operator model is based on the WLAN roaming guidelines given by the GSM Association. This model defines the interfaces and practises between service operators, but does not commit on the implementation of the actual wireless access network despite the authentication. Both user ID/password as well as EAP/SIM based authentication methods are taken into account. Virtual operator model is discussed in more detail in chapter 2.8 Roaming implementation.

2.7 Roaming implementation

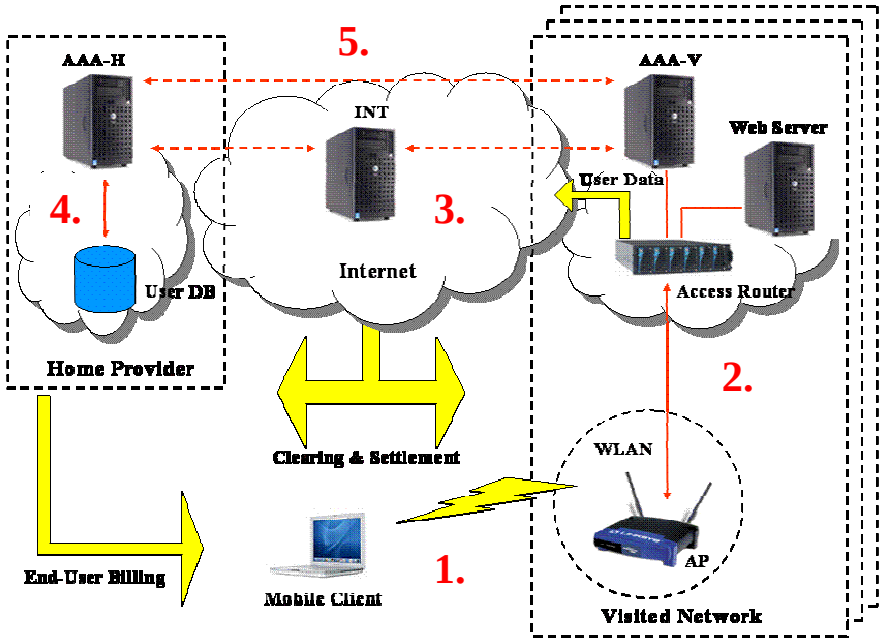
From the technical point of view the generic public WLAN roaming model is composed of three phases: authentication, authorization and accounting. The architecture represented in this paper is adapted from the Intel blueprint *Wireless LAN End to End Guidelines for Enterprises and Public Hotspot Service Providers* [Int03].

2.7.1 Generic hotspot roaming model

Figure 2.7 presents the generic hotspot roaming model proposed by Intel Corporation. As the mobile client tries to access the network (**1**), the access point (AP) identifies that this is not the home network of this user. The AP then sends a request to the access router (**2**). With this request the network tries to find out if a roaming agreement with the customer's home network exists or not. In case the agreement stands, the request is forwarded to authentication server of the customer's home network (**3**). The customer is authenticated and authorized to access to the network (**4**, **5**). A more precise presentation of network elements is given below:

- *The Mobile Client* – user equipment (a laptop computer, cell phone or PDA) that provides the access to the 802.11 network.
- *The 802.11 Access Point* – terminates the air interface to and from the mobile client.

Figure 2.7: Generic hotspot roaming model (adapted from [Int03])



- *The Access Controller* – verifies authorization and enforces access control for authenticated users, segregates traffic of non-authenticated (guest) users.
- *The Visited Network AAA Server (AAA-V)* – serves as an AAA proxy for inbound roaming customers.
- *The Home Provider AAA Server (AAA-H)* – RADIUS server, authenticates mobile client users. User credentials are disclosed only to the AAA-H. Billing &

settlement records are transmitted between the home service provider and the visited network's AAA server.

- *The Web Server* – optional component, used to serve several value-added service functions.
- *The Roaming Intermediary (INT)* – represents a wide variety of AAA and billing intermediaries providing translations of RADIUS billing records into other formats. INT function can be served by a Data Clearing House or a Roaming Broker.

2.8 Traffic routing in partitioned and Virtual Operator networks

The subscriber differentiation in partitioned network using WWW authentication is done in an access controller. If an 802.1X based authentication method is used, the differentiation is done in base stations based on the service operator information. Usually a menu including all existing service providers is presented in the authentication page or the correct network can be identified by using a Network Access Identifier (NAI)/realm combination, for example username@operator.fi. This routing model is presented in figure 2.8.

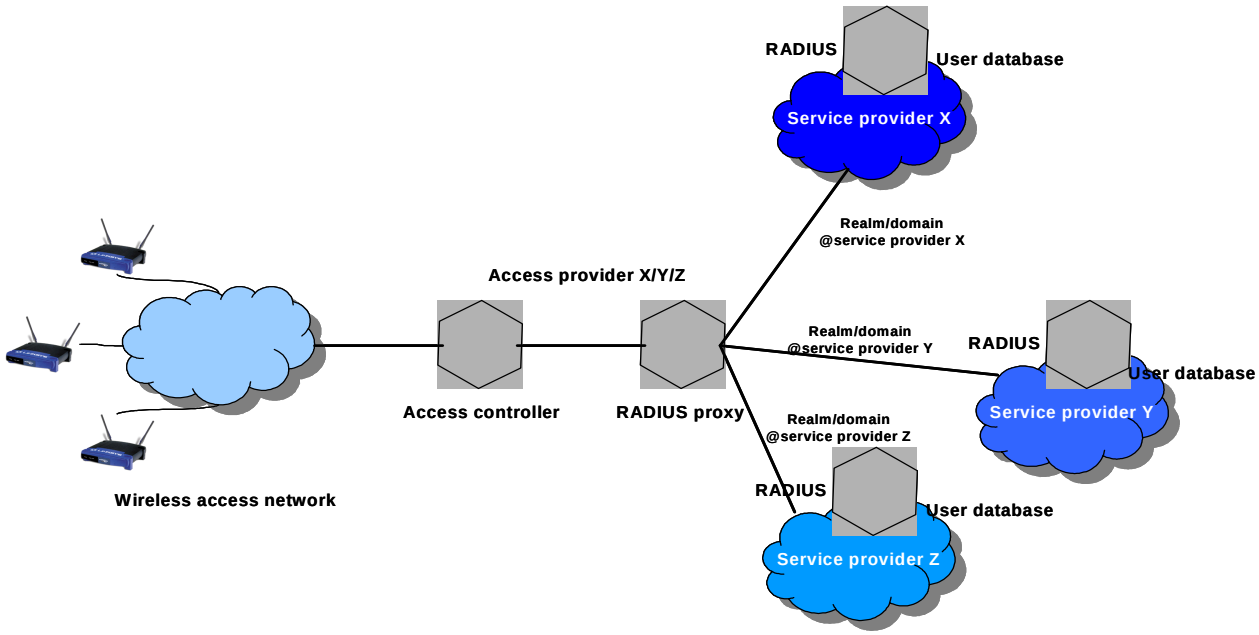


Figure 2.8: Service menu based service operator selection and user authentication

In the virtual operator model all subscriber traffic is routed through the visited network regardless of the user's actual home network. Access controller or base station then forwards the RADIUS authentication message to the RADIUS roaming proxy located in the service operators network. This proxy makes the decision whether the authentication message should be forwarded further or not.

If the subscriber is in the wireless home access network, the RADIUS proxy forwards the authentication check to be executed towards the service providers own customer database. If the user is a roaming user, the authentication message is forwarded either directly to the user's home network's RADIUS proxy server or alternatively to a

clearinghouse or roaming broker if a roaming intermediary is used. Forwarding is based on the realm information. In all cases the authentication message eventually ends up to the service provider's database. The network architecture used in virtual operator model is presented in picture 2.9.

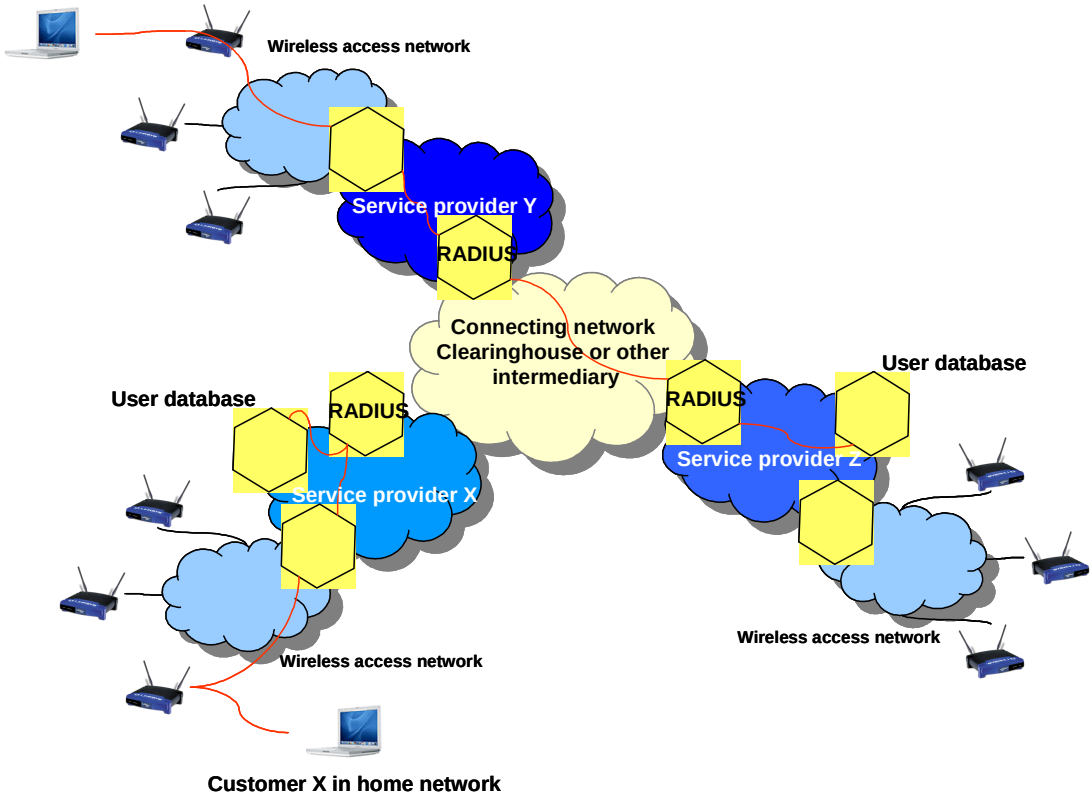


Figure 2.9: Network architecture of the virtual operator model.

3 Theoretical framework

This chapter introduces the theories and frameworks behind the analysis and is based on literature study including academic papers, management books and technical journals. Some basic theories are first discussed to give background information.

The objective of this paper is to study the Finnish public WLAN industry in order to find out the best ways to enhance the wireless broadband services. Economists teach that the secret of success is to satisfy the consumer needs. In practise this means that the buyers must be willing to pay the price from a product that exceeds its cost of production, as stated in Competitive Advantage by Michael Porter in 1985 [Por85]. The purchase decision is based on the buyer's image of how well the product price equals the value gained. Products providing the highest consumer value will also be the most profitable ones if the provider can capture the value instead of competing it away to others.

The market analysis is based on the value creation process. Value creation can be analysed with several tools, *value chain and value system* being two common frameworks. Consumers evaluate the products differently based on the maturity of the product. This evolution is illustrated with help of the *technology adoption life cycle* framework. Public WLAN industry is still in very early phase and is therefore changing quite rapidly, which makes the certain estimation of development difficult.

3.1 Value chain

3.1.1 Value chain &value system

The original value chain was created to illustrate the decomposed set of company's strategically relevant activities in order to understand the behaviour of costs and the existing and potential sources of differentiation [Por85]. A larger stream of activities is called a value system and it is formed of vertical linkages between different companies. Today the term value chain is often used in the same sense as Porter defined value system, to analyse activities taking place in a supply chain all the way to the end customer. In this study the value chain illustrates the different activities, that is, companies, which together constitute the service known as public hotspot.

Value chain corresponds to typically one industry. In Hitt *et al.* industry is described as a group of firms producing products that are close substitutes [Hit01]. The rivalry within an industry is commonly analysed using Porter's five forces of competition illustrated in picture 3.1. These forces determine the ultimate profit potential in the industry. In a broad sense the term competitor includes customers, suppliers, substitutes and potential new entrants as well.

3.1.2 The Five Forces of Competition

Historically the study of competitive environment concentrated on companies, which competed directly with the firm making the study. Subsequently the approach has changed and today competition is viewed as a grouping of alternative ways for customers to obtain the value they desire, rather than as a battle among direct competitors. In recent years the industry boundaries have become blurred and companies are producing goods and services also outside their traditional scope.

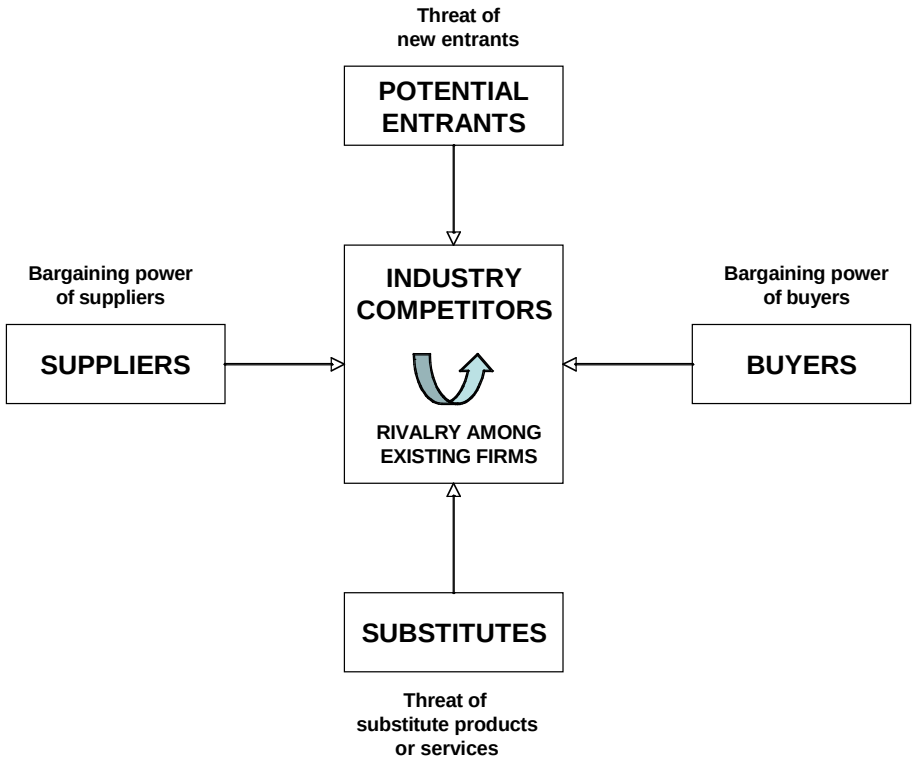


Figure 3.1: The five forces of competition [Por85]

The five forces model recognises that suppliers could become a firm's competitor by integrating forward, as could buyers by integrating backward. The rivalry within an industry is commonly analysed using a framework consisting five components: *threat of new entrants, bargaining power of suppliers, bargaining power of buyers* and *rivalry among existing firms*. [Por85]

3.2 Technology adoption lifecycle

Technology adoption lifecycle helps companies to classify potential customers based on their different characteristics and needs. Geoffrey Moore introduced the original model in 1998 for business-to-business marketing, but it has been widely used also in high technology consumer marketing. Technology adoption lifecycle divides potential customers into four categories (figure 3.2). The characteristics of these groups are discussed in more detail below.

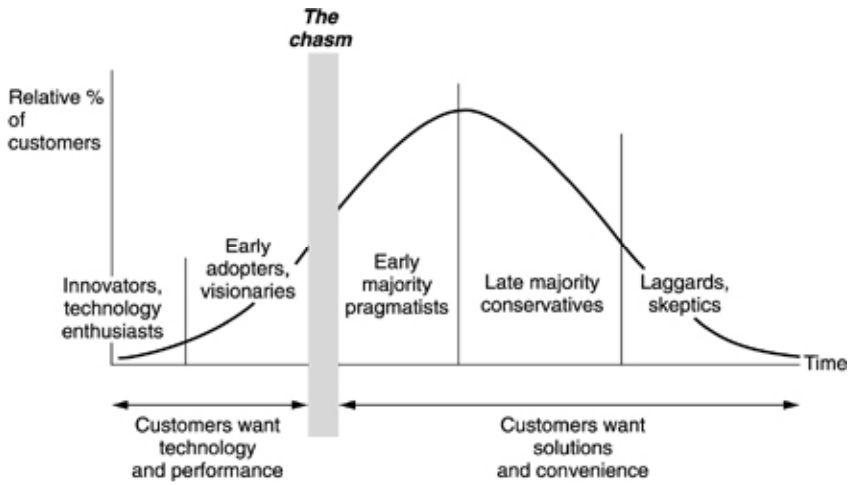


Figure 3.2: The technology adoption lifecycle (Adaptet from [Moo98])

- *Technology enthusiasts* like to explore new technology. They are the first ones to by a new technology but the buying power of this group is relatively small.
- *Visionaries* are interested in exploiting new technology for their own benefit and are after the competitive advantage over the older technology. Technology enthusiast and visionaries together are called the *early market*.
- *Pragmatists* and *conservatives* make up the *mainstream market*. The purchasing decision of pragmatists is based on strong evidence and references from trusted party. This group prefer to by from the market leader. Conservatives take new

innovations with a grain, are very price sensitive and invest in new technology only if it's absolute necessity.

- The last group is called *sceptics*. They typically criticise new technology and usually are not considered as potential customers.

A more precise consideration of these groups exposes an even more interesting characteristic. Transition along the curve from customer group to another is not continuous. The diverse values of early and mainstream market create a chasm (figure 3.2) that the companies are able to cross only by making considerable strategic changes. While visionaries appreciate the specific product offerings and technology itself, the pragmatists value the whole product and the entire value chain.

In public WLAN market the visionaries are willing to buy the service because it provides them a new and faster network access and pay less attention to the costs and availability. The consumers of mainstream market, however, require good service availability, ease of use and are price-conscious. [Moo98]

3.3 Internet business model

3.3.1 Determinants of business performance

As value chain and value system describe the elements or the intermediate phases generating the product or service, the technology adoption lifecycle model describes the willingness of the consumers to use it. *Business model is a method by which a firm builds and uses its resources to offer its customers better value than its competitors and to make money doing so,* which is how the concept of business model is defined in *Internet business models and strategies* by Afuah and Tucci [Afu03]. Business model details a firm's current and long-term strategy of making money and also enables a firm to have a sustainable *competitive advantage*. Business model can be described as a system that is made up of components, linkages between the components, and dynamics.

3.3.2 Components and linkages

A business model describes what is the value the firm is offering its customers, the target customers the value is offered to, the scope of products or services it offers to which segment of customers, the profit site it chooses, its sources of revenue, the price it puts on the value offered its customers, the activities needed in offering that value, the

capabilities these activities rest on, what the firm must do to sustain the advantages it has, and how well it can implement these elements of the business model. The quality of this system is not only a function of the type of components, but also a function of the relationships between these elements of the business model. A good business model always tries to take advantage of any opportunities in its environment while trying to dampen the effects of threats from it. A good management team also reacts on changes in the environment and changes the business model to fit the changed situation. Usually the best results are made if the changes are made before competitors.

3.3.3 Environment

Business models are not formulated or executed in a vacuum, but in a *competitive environment*. The operating environment includes also competitors, customers and suppliers with their own business models and which also are interested in making money or maximising the profits or benefits. Actions, which bring money to one player, may take it away from some others. On the other hand, some actions may be beneficial for many or all players. A company must, thus, also think about the consequences of its actions and if possible, make such decisions, which have the smallest effect on its business. It also has to figure out, how the possible and inevitable changes in its environment will effect on its performance by translating into higher or lower profitability.

3.4 Components of a business model

In their book Afuah and Tucci have explored those properties of the Internet that could transform the competitive landscape in many industries. They state that each firm exploiting the Internet should have an *Internet business model*, which describes how that company plans to make money in long term by using the Internet. Basically this business model answers to the question "*How can a firm take advantage of these properties to gain and maintain a competitive advantage?* "

A business model is composed of components describing the industry. Recognition of these components and linkages between them helps a firm to understand its industry and the key drivers of value in that industry. The components and their effect on the industry, defined in [Afu03], are presented in table 3.1.

Table 3.1: Elements of the Internet business model [Afu03].

Component of business model	Questions for all business models
Profit site	What is the relative (dis)advantage of a firm vis-à-vis its suppliers, customers, rivals, complementors, potential new entrants and substitutes?
Customer value	Is the firm offering its customers something distinctive or at a lower cost than its competitors?
Scope	To which customers (demographic/geographic) is the firm offering its value? What is the range of products/services offered that embody this value?
Pricing	How does the firm price the value?
Revenue source	Where does the money come from? Who pays for what value and when? What are the margins in each market and what drives them? What drives value in each source?
Connected activities	What set of activities does the firm have to perform to offer this value and when? How connected (in cross section & time) are these activities?
Implementation	What organisational structure, systems, people and environment does the firm need to carry out these activities? What is fit between them?
Capabilities	What are the firm's capabilities and capabilities gaps? Is there something distinctive about these capabilities that allows the firm to offer the value better than other firms and that makes them difficult to imitate? What are the sources of these capabilities?
Sustainability	What is it about the firm that makes it difficult for other firms to imitate it? How does the firm keep making money? How does the firm sustain its competitive advantage?
Cost structure	What drives costs in each component of the business model?

3.4.1 Profit site

Profit site is the location in the value system compared to its suppliers, customers, rivals, potential new entrants, complementors and substitutes and determines the competitive pressure against the firm constituted by these quarters. The site is said to be attractive if the pressure exerted by competitive forces is low and unattractive otherwise. This is a function of the type of operating industry and the type of strategy pursued by the firm.

The profit site impacts or is impacted by the type of value the firm offers, the customer segment it can pursue, the prices that it charges, its revenue sources, chosen activities, capabilities, the way the business model is implemented, the sustainability of the business model and its cost structure. In an unattractive site cultivating and executing a winning business model is more difficult.

Bargaining power of customers lets them to extract higher prices or better quality products from profit-site firms thereby influencing both the pricing strategies that firms can pursue and the type of customer value they can offer. Suppliers with bargaining power are able to force the firms to take lower-quality inputs or pay higher prices for the inputs that they buy from the suppliers. Lower-quality inputs may reduce the level of customer value and increase the costs of a firm.

3.4.2 Customer value

Customers buy a product only if it offers them something the competitors' products do not. Product differentiation is possible to carry out in several ways: product features, timing, location, service, product mix, linkage between functions, linkage with other firms and reputation to be the exact eight ways.

Being the first one providing a product or service gives a firm a chance to gain customers before others. A vast customer base makes the market entry more difficult to competitors, an important thing especially in smaller markets. By locating the service or production wisely also is an effective way to differentiate. The linkages are especially important in networking business. The networking externalities property suggest that the larger the coverage or the community is, the more valuable its membership, which distinguishes the community from others.

3.4.3 Scope

The customer value discusses about offering low cost and/or differentiated products. The scope is about the market segments or geographic areas to which the value should be offered as well as how many types of products that embody versions of this value should be sold. A firm's task of making decisions on scope is not limited to the choice of market segment. It must also decide how much of the needs of the segment it can profitably serve.

3.4.4 Pricing

An important part of profiting from the value that firms offer customers is to price it properly. A bad pricing can not only delay the product to become general, but also kill a product or stifle its prosperity. Knowledge-based products are heavy on know-how and have very high up-front costs relative to the variable cost of producing and offering each unit to customers.

Market share is critical to knowledge-based products. A firm's strategy early in the life of such products is to strive for high share. The achieved status is then possible to maintain, if the product has a very high ratio of fixed to variable costs and also exhibits lock-in, which means that the products have certain characteristics that lock in customers. This kind of lock in can be for example a different user interface between the existing and a new product.

3.4.5 Revenue source

A critical part of business model analysis is to figure out the sources of a firm's revenue and profits. Other companies receive their revenues from selling products and servicing them, with a larger share of their profits coming from the service.

3.4.6 Connected activities

Delivering the value to different customers means that a firm must perform activities that support the value. These kinds of activities are R&D, product design, wafer fabrication, testing, marketing and sales and field support. Offering of better value to the right customers requires the firm to choose which activities it performs and when. In choosing *which* activities to perform, the firm should consider if the activities

- are consistent with customer value and the scope of customers served
- reinforce each other

- take advantage of industry success drivers
- are consistent with any distinctive capabilities that the firm has or wants to build
- make the industry more attractive for the firm.

In choosing *when* to perform the activities, the firm should consider

- what are the characteristics of the industry at this stage of life cycle and what will they be down the line
- what are the existing competitors doing and what are potential ones likely to do
- are the activities consistent time wise.

3.4.7 Implementation

In the previous paragraphs we have described the decision process concerning what values to offer, whom to offer it, how to price it and what activities to perform. Implementation describes how these decisions actually are carried out and is dependent on the relationships between strategy, structure, systems, people and environment.

3.4.8 Capabilities

The performance of the activities underpinning the customer value is dependent on resources, competencies and competitive advantage. The resources can be divided into tangible, intangible and human. Tangible resources are both physical and financial, whereas intangible resources are the non-physical and non-financial assets that are usually not accounted for in financial statements. Human resources are the skills and knowledge that employees carry with them.

Competence describes the firm's ability to convert the resources into customer value and profits. Hamel and Prahalad argue that the competencies are core when they meet three criteria: *customer value, competitor differentiation* and *extendibility*. The customer value criteria require that a core competence must make unusually high contribution to the value that the customers perceive. A competence is competitor differentiating if it is uniquely held or, if widely held, the firm's level of competence is higher than that of its competitors [Afu03]. A competence is extendable if it is used in more than one product area. These core competencies allow the firm to have a competitive advantage because they allow the firm to offer its customers better value than competitors.

3.4.9 Sustainability

The achieved competitive advantage forces competing firms to answer back or maybe even leapfrog it. Sustainability means the firm's ability, depending on its capabilities, environment and technology in question, to maintain the competitive advantage. [Afu03] presents three generic strategies to do this: *block, run* and *team-up*.

The block strategy guides the firm to erect entry barriers around its product market space. Blocking works only as long as the company's capabilities are unique and inimitable or as long as barriers to entry last.

The run strategy admits that the entry barriers are often penetrable or eventually fail. Running means changing some subset of components or linkages of business models or reinventing the whole business model to offer customers better value.

If either of the preceding strategies is not assumed to work, and it seems that it is not possible to operate alone, the only possibility is to team-up with other companies. Co-operation allows a firm to share in resources that it does not posses and cannot or may not want to acquire.

3.4.10 Cost structure

Performing all these activities described above costs money. Cost structure expresses the relationship between its revenues and the underlying costs of generating those revenues. Irrespective of whether it pursues a low cost or differentiation strategy, a firm should keep its cost per revenue per unit customer value very low. In general, having a low cost structure entails paying careful attention to the cost of the other nine components of a business model and making sure that they are planned and executed efficiently.

4 Public WLAN Industry

4.1 The environment

The WLAN market environment consists of several different operating segments. The environment division and characteristics according to GSM Association are as follows:

- *The Public* environment is an area where the public presence is unrestricted, including outdoor areas, streets, transportation centres, retail stores, hotels, restaurants and public spaces and lobbies in major civil buildings.
- *The Corporate* environment includes offices and factories where the users are restricted to employees of the business. Restricted visitor access may also be accommodated. The services are primarily provided for internal users and access to other networks may be screened.

- *The Residential* environment includes individual homes and apartments where the users are restricted to the residents and their guests. The WLAN access point owner and user are most likely the same, but a multi-user solution is also possible. For example one access point may serve several users in a multi-tenant building.

In this paper the public environment is taken under a magnifying glass. The idea of the business is to provide wireless broadband access to customers also outside their homes and business premises. The concept is wide and several different types of services exist. The most common service types are commercial hotspots, broadband last-mile access networks, enterprise guest networks and free community networks.

4.1.1 Commercial hotspots

Commercial hotspots are access points situated in public places like airports, hotels, major civil buildings and so on. Either way, the requirement is that the presence is unrestricted. The billing is based either on monthly subscription or on a scratch card bought from an authorized reseller at the spot.

4.1.2 Broadband last-mile access

Broadband last-mile access networks are offered as a substitute for fixed DSL and cable modem access solutions. In Finland several energy companies are providing this citywide service outside the metropolitan area.

4.1.3 Enterprise guest networks

Several companies are providing wireless Internet access in their guest areas. The guest network is of course separated from the company intranet, but gives the visitors nevertheless a chance to read their e-mail or access their own company's intranet for example during a meeting.

4.1.4 Free networks

Free networks are hotspots provided by the site owner to its customers as a value-added service for free. Many venue owners are more interested in providing a hotspot as an amenity and convenience to their customers than in generating direct revenue.

4.2 The service

The idea of the public WLAN business is to provide wireless broadband access to customers also outside their homes and business premises. As described in previous section, the public environment is an area where the public presence is unrestricted, including outdoor areas, streets, transportation centres, retail stores, hotels, restaurants and public spaces and lobbies in major civil buildings. Subscriptions are sold by service operators and site owners.

Service operators provide public WLAN as a subscription service or as a value-adding service to other existing mobile data services. In these cases the end customer is billed monthly. The service portfolio includes usually also a possibility to buy fixed-term subscriptions either with credit card or SMS. In these cases public WLAN is part of the provider's core business.

Site owners provide public WLAN because it nurtures their actual core business by increasing the amount of customers or the time they spend in the location. In this scenario the subscription fees are included in the price of the primary service. The site owner can also sell fixed-term subscriptions, in which case public WLAN is used to increase the amount of total income.

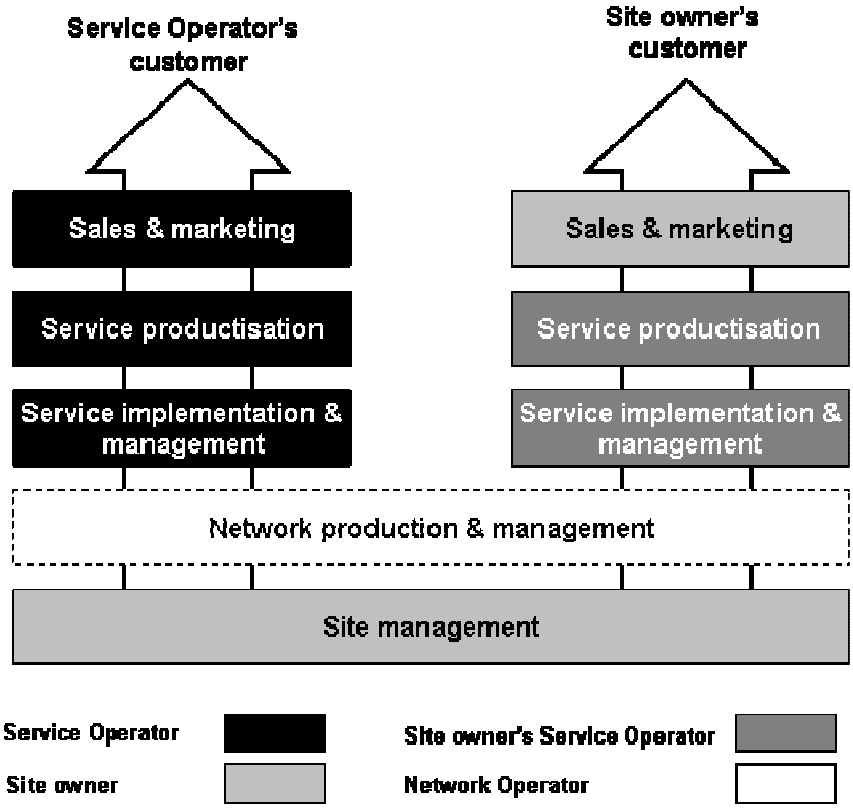


Figure 4.1: The public WLAN value chain

4.3 Value chain and players

Value chain of the public WLAN industry illustrates the relevant activities needed to compose the service as well as the vertical linkages between the companies providing these activities (figure 4.1). Public WLAN service consists of four activities (*Sales & marketing, Service productisation, Service implementation & management, Network production & management, Site management*), provided by three players (*service operator*, *network operator* and *site owner*).

4.4 Site owner

Site owner, hotspot location, and venue. Several terms meaning the party controlling the property or the premises the actual network is located. A site owner wanting to enter the market may choose from two different models. By integrating vertically forward [Hit01] the venue can operate the hotspots itself, but the more common way is by licensing the right to deploy the hotspots to a network operator. The revenue sharing is based on the infrastructure ownership. If the network operator is responsible for the deployment and maintenance, the site owner's revenue share is very small or none. The

percentage of course changes if the venue participates in the operating and maintenance costs.

4.5 Network provider

The network provider is responsible for the installing, operating and maintaining of the hotspot equipment (access points, access controllers, switches & cabling). Like the amount of hotspot locations, also the number of hotspot providers is continuously increasing making the industry severely competed. As the number of the hotspots owned by different entities easily rises very high, it is a quite difficult task for a single network provider to obtain significant market share. In the U.S. market analysis have shown that even significant capital investments on deployment will not provide more than 10 % of the total hotspot footprint [BOI04].

The market share maximisation not being the number one strategy, the success is mostly determined because of the cost leadership strategy. A cost leadership strategy is an integrated set of actions designed to produce or deliver goods or services at the lowest cost, relative to that of competitors, with features that are acceptable to customers [Hit01]. So minimising the operating costs and maximising the network utilisation is the way to success. Operating costs in most cases are fixed, so after these costs are covered all additional revenue is margin. The key factor affecting to the utilisation rate is the number of partners, that is, the number of roaming agreements.

4.6 Service provider

Service provider owns the customers and does the marketing, customer care and end-user billing. This layer includes wireless and wire line carriers, ISPs, cable companies, terminal manufacturers etc. Basically any entity seeking to offer public WLAN hotspot may become a service operator. As shown in the figure 4.1, the role of service operator suits for players throughout the value chain, which can be seen also in real life. However, practice has verified that the most successful players usually are the ones most focused and able to get economies of scale within a layer [BOI04]. The situation also resembles the one in the network operator market, a single player will find it really challenging to gain significant market share. Thus also service operators need roaming agreements to get the utilisation rate up.

4.6.1 Mobile carrier WISP

This is the largest WISP category. Mobile carrier WISPs, as the name implies, are mobile operators, that also offer wireless access to Internet. Two kinds of strategies can be identified. Some operators offer the wireless service extension only to their existing customers as a value-added service, while others offer it to anyone. This is one of the major issues shaping the industry and is thus considered in more detail in chapter 7.

Mobile carrier WISPs are currently targeting mainly on corporate customers with low price sensitivity. Preferred site locations are thus chosen based on the needs of this customer group, the most important locations being airports, hotels and conference centres. Players of this category include such companies as Sonera (HomeRun), DNA (dna WLAN), T-Mobile (T-Mobile HotSpot), O_2 (O_2 WLAN) and Vodafone (Vodafone WLAN). O_2, T-Mobile and Vodafone are also offering an integrated 3G/GPRS/PUBLIC WLAN data service in Europe. Table 4.1 presents the main advantages and disadvantages of this category.

Table 4.1: Advantages and disadvantages of Mobile carrier WISPs.

Advantages	Disadvantages
• Large existing customer base and good market penetration.	• Cannibalisation of operators other wireless services is a risk. May also lead into price competition between mobile and WLAN services.
• Existing billing system for mobile services, which makes it possible to bill both services in one bill.	• Degenerated QoS a risk to the brand name. May have an effect to the willingness to provide roaming.
• Experience in network design and maintenance.	• A large and hierarchical company may act ineffectively in rapidly changing WLAN markets.
• Ability to provide bundled services (mobile + WLAN).	• Lack of backbone capacity is possible; backbone leasing may generate additional costs.
• Economically steady, ability to invest in new services.	
• Existing brand facilitates to attract customers and lowers the market entry barriers.	

4.6.2 ISP WISP

Internet Service Provider (ISP) is a company that provides fixed Internet access via fibre, xDSL or cable to both companies and households. Wireless network access provides ISPs a chance to extend the reach of the network and also attract new customers. WLAN is currently provided both as service extension as well as a complementing service for a fixed line. In Finland this kind of service is mostly provided by the energy companies like Vantaan Energia (Vivanet), Porvoon Energia (PBEzone) and Haminan Energia (Haminetti).

ISPs provide Internet access as their core business, which gives them a competitive advantage over new players. Also the switching costs between fixed and wireless

service decrease if the same operator provides both services. A deeper analysis of this category is presented in table 4.2.

Table 4.2: Advantages and disadvantages of ISP WISPs.

Advantages	Disadvantages
• Good market penetration and large existing customer base.	• ISP business already a heavily competed industry. Therefore investing in new network infrastructure may be not be reasonable or even possible.
• Existing billing system for Internet services, which makes it possible to bill both services in one bill.	• Service mainly targeted to low-end users. Price level can therefore not differ much from the fixed network prices → low profit.
• Experience in network development and access to backbone and last mile cables enables cost effective supply of WLAN services.	• Identity problem → customers may consider a mobile carrier ISP as a more reliable provider of wireless services.
• Bundling of fixed and wireless services gives the operator a chance to differentiate and makes the potential customer base larger.	
• Easy to provide QoS.	

4.6.3 Greenfield operator

Greenfield operators are start-up companies that have identified the possibilities of the new wireless market and are providing public WLAN access as their core business. Normally the initial capital of these companies does not make it possible to build a large footprint and therefore hotspots are provided in a densely populated area. The relative amount of start-up WISPs is biggest in the North America, where companies like Wayport and STSN are in the top 5 of the local companies [PLA04b].

Table 4.3: Advantages and disadvantages of Greenfield operators.

Advantages	Disadvantages
• Small, agile companies that can quickly adapt to the evolving markets.	• Lack of experience (hype technologies may attract also incompetent players)
• This is the core business of these companies → market demand is easier to satisfy, because all resources are available.	• Billing problems (lack of billing systems).
• Enthusiastic and experienced people, business and technical knowledge from previous jobs.	• Capital constraints may slow down the rollout.
	• Internet connection needed → ISP dependent.
	• Brand not established → marketing needed to increase brand name and customer base.

4.6.4 Site related WISP

This category includes operators that provide wireless Internet access in their own premises or just in certain kinds of locations. Preferred locations include cafés and restaurants, libraries and other public places, shopping malls and so on. Hotspots might be for customers only or totally free to use. Usually all hotspots of this category are provided in order to increase the customer value of the site and because of that the access might apparently be free of charge to attract more customers.

The site can either purchase a "WLAN in a box" type of service from some other operator, in which case the site owner owns also the hardware or it can purchase the whole service from another operator. In the latter case the other operator takes care of the maintenance and billing services.

Table 4.4: Advantages and disadvantages of site related WISPs.

Advantages	Disadvantages
• Exclusive rights to the site or the type of location.	• Small footprint
• Expertise of a certain kind of location	• If roaming not established, a new subscription in every site is needed.
• Roaming with other similar sites makes it possible to enlarge footprint.	• Capital constraints may slow down the rollout.
• Cost efficiency → the site owner can use the same infrastructure for own purposes.	• Maintenance and billing not possible without outsourcing.
	• In free hotspots lack of AAA may lead to abuse of the network.

4.6.5 Virtual WISP

Virtual operators provide the services in networks leased from existing WISPs. Also other services are bought outside, which leads into a really cost effective business model. The success of the Finnish Mobile Virtual Network Operators (MVNO) has proved the potential behind this model and it has already adopted by the players of the public WLAN industry.

What makes virtual WISP business model really interesting is that almost in every case all parties are getting benefit out of it. Virtual WISP provides a network operator or WISP a chance to maximise the capacity utilisation by selling network resources. In this way the virtual WISP is able to make the market entry relatively fast, without huge hardware costs and with significantly lower risk. Also the customers benefit from this kind of business. They do not care who owns the network, what really matters is the price of the service.

Table 4.5: Advantages and disadvantages of virtual WISPs.

Advantages	Disadvantages
• No hardware costs.	• Revenue sharing.
• Low risk.	• Profitable deals hard to get.
• Short time to market.	
• Relatively larger footprint with less money.	

5 Overview of roaming solutions

Roaming technology enables a subscriber to use the network and services of another operator while outside the coverage of the home network. Roaming can be divided into four main types:

- *international roaming* means ability to use services of a foreign operator in another country,
- *inter-regional roaming* means ability to use services of a foreign operator in the same country where the operators have non-overlapping service areas,
- *national roaming* means ability to use services of a foreign operator in the same country where the service areas are the same or considerably overlapping,
- *inter-technology roaming* is roaming between different technologies, e.g. 2G to 3G or cellular to WLAN.

Roaming is an established feature of both cellular and mobile telephony services and also, although to a lesser extent, of dial-up based Internet access. Most of the commercial and technical solutions of public WLAN roaming services have their background either in the world of telephony or dial-up Internet. The fist part of chapter 5 therefore illustrates the business aspects of GSM and dial-up roaming. The latter part then investigates the issues in public WLAN roaming and outlines possible solutions. Although inter-technology roaming is a somewhat related issue, it is still separate and not dealt further in this paper. The scope of this paper is to discuss the business aspects of national roaming. Therefore the technical solutions are not considered any deeper. However, the most basic technical issues of public WLAN roaming are introduced in chapter 2.

5.1 GSM roaming

Being one of the most successful and explosive developments in telecom industry ever, GSM networks are considered as a reference model in this paper. Global subscribers are estimated to exceed 1.5 billion in 2004 and reach 2.3 billion in 2010. Mobile network operator revenues alone totalled $ 426 billion in 2003. GSM is assumed to account circa 65 % of this total [Jen04]. One of the key success factors is supposed to be international roaming.

5.1.1 User experience

The GSM handset constantly detects the available networks. If the home network is not available, a permitted network is chosen either automatically or manually. A permitted network is the one the user's home operator has a roaming agreement with. After choosing the network, the user can use his phone pretty much like the local subscribers. However, the user experience is not totally transparent. Some services, for example SMS, are usually available as they would in the home network but there are also services like voice mail that are available but require a different access method and identification. The level of service transparency varies depending on the roaming agreement between the home and visited network operators.

5.1.2 Pricing and clearing models

The costs of calls made from the visited networks appear on the user's invoice. The financial aspects are regulated in roaming agreements between the operators involved. A more detailed description of different roaming agreements is given in paragraph 5.4. The clearing and financial settlements are handled by *clearinghouses* in accordance with the applicable bilateral agreement. The clearinghouse, however, only processes the Call Detail Records (CDR) generated by the visited network and forwards the CDRs to the home operator, which then bills the customer. [Bri03]

Each operator applies a tariff agreed in advance, which is called the inter-operator tariff (IOT). The IOT is valid for a set period of time and is equal for all its roaming partners. The bilateral agreement between the home and visited operator regulates the discount the home operator is entitled to relative to the IOT. This is somewhat parallel to the list price arrangement where all resellers see the same end user price list from a vendor but have a different discount depending for example on the volume sold. The IOT is often

roughly equal to the normal per minute price for local subscribers to the operator's network. The end user is normally charged the IOT plus a fixed mark-up. If the IOT of a visited operator changes, also the roaming user will be charged more. [Alm02]

5.2 Dial-up roaming

5.2.1 User experience

Dial-up Internet service refers to the capability of connecting to the Internet through a dial-up modem connection. The connection is established by dialling the access number of the subscribers ISP. The service is available also from abroad by making an international telephony call. This is however expensive and often both the connection time as well as the transmission quality are worse than those experienced during a local telephony call. A roaming agreement between the operators allows the end user to establish the Internet connection through a local ISP without subscription with that operator. The technical solutions needed are not considered in this paper.

5.2.2 Pricing and clearing models

In case of the GSM roaming the home and visited network operators usually have a direct relationship through a bilateral roaming agreement. ISPs do not typically deal directly with each other but have a direct relationship with a *roaming aggregator* instead. The aggregator negotiates a wholesale rate with each of the ISPs within its footprint and can then resell this capacity to ISPs and corporations with roaming users. With this kind of arrangement an ISP can offer roaming services to its customers but does not need to have bilateral agreements with other ISPs. The agreement defines both a seller relationship, where the ISP sells access capacity to the aggregator as well as a buyer relationship, where the ISP buys access minutes for the benefit of its own roaming users. The aggregator then pays the visited ISP for the minutes used and invoice the home ISP for the same usage. The aggregator's margin comes from the difference between the selling and buying prices of the access capacity used. This leaves out the need for end-to-end clearing and settlement, as the relationship is between the ISP and the aggregator. [Alm02], [WER04]

ISPs can also sign roaming agreements with other ISPs through a central entity, allowing each ISP to set its tariffs individually. This kind of *multilateral* approach was proposed by Excilan, a Luxembourg-based company providing payment system for hotspot users [EXL04]. Excilan was declared bankruptcy in April 2005 [WIF05]. The

essential difference between the bilateral and multilateral agreement types is freedom of price setting and service delivery.

5.3 Public WLAN roaming

The public WLAN roaming business model differs from the GSM/PSTN model due to its client-server nature. However, the similarities with the models of fixed access services are more adequate. Public WLAN roaming is a wholesale business, adding value for the end users by offering a wider geographical availability of the service. The fairly small coverage area of the WLAN access points makes large public WLAN networks quite expensive to build and operate. The unlicensed frequency bands limit the number of operators in one site and on top of that the amount of number of operators is quite high due to the sufficiently low market entry barriers. Basically this means that there is only one hotspot operator per site and latecomers will find it really difficult to find suitable premises.

5.3.1 User experience

The previous subchapters introduced the financial and technical challenges of both GSM and dial-up roaming services. In both cases the service is often associated with some disruptions and alterations to the service compared to the service the user experiences in the home network. Also in the case of public WLAN roaming, the transparency of the service is aspired and it is highly desirable that the user experience does not deviate too much between the networks. Therefore Wi-Fi Alliance, a non-profit industry trade association with more than 200 member companies devoted to promoting the growth of WLAN, published a technical recommendation for inter-WISP roaming [Ant03].

In addition to the technical issues, it is also important that the commercial service characteristics are preserved even when roaming. For example, an operator is offering two types of products, the premium one providing high speed and low latency and the second one only best-effort service with lower price. If the difference between these products is compromised in roaming situation, there will be less incentive for users to choose the premium product.

5.3.2 Pricing and clearing models

As already mentioned, public WLAN business has many similarities with both GSM and dial-up Internet businesses. Both worlds provide valuable models when designing public WLAN roaming. However, some of the features considering the public WLAN user experience are unique and some business models call for extensions to existing roaming models.

Business models for roaming and clearing in the dial-up space are founded on the need to keep transaction costs low for the ISPs involved. On the contrary, in the GSM world the roaming and clearing arrangements reflect the traditional independence and strength of the mobile operators and their need to control every aspect of the service. In the WISP world the operators are likely to put more emphasis on roaming than ISPs but would nonetheless be inclined to keep transaction costs low. The aggregating broker model established for dial-up Internet access has many features that should be attractive to WISPs. They will have somewhat different requirements from dial-up ISPs, however, and some of these may cause concern in relation to established aggregating broker practice. One of the most important features of public WLAN business is the number of service providers. Because of this fragmentation roaming will be a much higher priority for wireless than dial-up ISPs especially in international business.

The aggregating model offers a large, assembled footprint that will likely exceed what any individual WISP will be able to obtain in the short term through bilateral agreements. By using a broker the WISP is thus able to achieve this footprint with less work, which decreases also the administrative and legal costs for roaming arrangements significantly. However, as roaming is likely to be a priority with most WISPs, it is therefore likely that a desire to make special deals with priority partners may appear. The variety among service providers also increases the desire to regulate for the preservation of the user experience. If the other party is unable to provide similar level of service than experienced in the home network, a WISP may want to block its users from using that network or end up making a unidirectional agreement with that operator, which allows only inbound roaming.

However, this paper considers the issue from the national roaming point of view. Therefore the most important downside is the desire to avoid backdoor competition.

WISPs that invest heavily in infrastructure in a particular region or country probably are very sensitive to opening up their network to competitors targeting the same geographical user group [Alm02]. The worst-case scenario would be if a small WISP would make an agreement with an aggregator that enables its customers to use the network of some large WISP. The small WISP could then end up capturing market share by selling roaming access to the incumbent's network at a price that is lower than what the incumbent's native users pay. For similar reasons, mobile operators competing in the same geographical area do not generally have roaming agreements between them.

6 Service operator business models

6.1 Developing line of business

The public WLAN value system is undergoing a structural change as the markets mature. The amount of business models is settling down but several different value systems still exist due the large number of different service providers. Despite the variety of existing business models, only few of them are widely adopted. New business models have been developed as the technical evolution and maturation of the markets have changed the customer demand and needs as well as the capability to provide the service. Also the service providers' strategic way of thinking has changed in process of time.

If a top-down approach is used, the identified business models can be thought to represent two different types of business-level strategies with different service incentives. In this paper these groups are called *public WLAN as value-adding service* and *public WLAN as core business*. In the early market –phase, when the competition is still relatively small and the amount of competing service providers low, the competitive advantage is achieved by maximising the coverage. As the market matures and the competition becomes more severe, maintaining the same market share becomes economically impossible or at least is not profitable and the competitive advantage must be found from somewhere else. The competitive advantage depends on how the customer evaluates the service, which changes as the market matures.

6.2 Identified operator roles and business models

As described in chapter 3, business model details a firm's current and long-term strategy of making money and is made up of components, linkages between the components, and dynamics. The components presented in chapter 4 build up the public WLAN value system that consists of two parallel value chains (picture 4.1). Depending on the strategy of the service operator, these components are divided between the players. The casting depends on the role chosen by the service operator. This thesis introduces the four most essential operator roles.

6.2.1 Integrated WISP

The *Integrated WISP* –model is dominant in small and immature markets. The value system includes only two segments, the venue owner and the service provider, which also operates and provides the network services. Each service provider controls the whole value chain operating both the network as well as providing the actual service. This model is usually suitable for cellular and fixed operators, which have the financial and technical capability to design and maintain the networks, have an existing customer base and also have existing billing systems. The commonly used venue/operator agreement type is either exclusive or non-exclusive right contract. The venue usually acts as a reseller and receives at least some part of the cash flow received from the sold vouchers.

The service is available only to the service provider's own customers either through a subscription or a prepaid voucher. National roaming between competing service providers is not available. The cellular operators using the Integrated WISP –model usually consider public WLAN as an added value service that can be used to differentiate the service portfolio. The target group varies slightly with the location but usually the service is focused on business users. Because the service availability is dependent on the venue contracts, the challenges of maintaining the value of the service increase as the market matures and the number of competing operators gets higher.

This model provides operators the already mentioned possibility to differentiate their services, implement load balancing into their networks by sharing subscriber traffic from cellular networks to WLAN networks when possible and increase the income with relatively small capital investments. For the customers this model provides simply access to the Internet. As the geographical size of the market as well as the number of competing service provider increases, the customer value decreases as the lack of roaming agreements decreases the networking effect and thus the value of the network.

Competition for the valuable locations is fierce. In densely populated markets the amount of potential customers and valuable venues is relatively high attracting also many service providers. As already pointed out in chapter 4.4, the number of the hotspots owned by different entities easily rises very high, which makes it a quite difficult task for a single network provider to obtain significant market share. Market

analysis have shown that in the U.S. markets even significant capital investments on deployment will not provide more than 10 % of the total hotspot footprint [BOI04]. In smaller markets and especially in markets with smaller population density, the amount of profitable locations is considerably smaller and the early entrants are able to achieve a monopoly status.

The Integrated WISP –model is suitable for small and growing markets, where the competition from the market share is in moderate level and where the firms are able to improve revenues simply because of the expanding market. Usually the number of service providers is low and the market is created by large operators. For example both DNA Finland and TeliaSonera currently use this business model.

6.2.2 Integrated WISP with roaming

This business model is a sophisticated version from the previous model, providing also national roaming. It is still mainly used by cellular and fixed network operators and is usually adopted as the market matures and the competition becomes harder forcing the operators to change their service incentives.

It is, however, reasonable to underline that this model still primarily supports the owner of the network. Competing service providers are divided into different tiers very hierarchically. Bilateral agreements are made only with service providers belonging to a suitable tear that guarantees a sufficient quality of service in both directions. Unidirectional agreements can be made also with inferior operators by letting their subscribers to roam in the network of the higher tier operator. This can also be called as wholesaling of the network in order to increase the profitability of the network.

Integrated WISP with roaming –model is currently the most used business model in global public WLAN markets. Bilateral agreements, having their history in cellular network roaming, are mostly used in markets, where the service providers are cellular or fixed operators. This is the case for example in Europe. But then in North America the situation is different. Cellular network services are just growing and mobile data solutions have traditionally been based on some other network technology. The favour of both Blackberry e-mail and public WLAN are a good example from this.

6.2.3 Neutral Host

Because of this cultural difference, the public WLAN business in North America has developed differently. The value system is more fragmented as the network and service providers usually are separated as public WLAN is provided as core business. These Greenfield operators usually do not have the same capabilities than the larger cellular and fixed operators, which open a window for roaming enablers. This means also that multilateral roaming agreements are used. Neutral Host –model is the most sophisticated business model that currently exists. The retail and wholesale functions are separated as mentioned above, which allows the operators to focus their resources either to customers or to the networks.

The network operator, also called as the neutral host operator in this model, is responsible for negotiating security and reliability standards, as well as for negotiating the agreements with venue owners. It also builds the service provider agnostic hotspots and offers wholesale access to several virtual WISPs.

The service provider, also known as virtual WISP, provides the service to end users, possibly bundling it with other services. The virtual operator can be a mobile operator, fixed line operator, cable company, venue owner or a pure VWISP. The main difference with the integrated model is that the service provider does not need to have a wireless network of its own. It just brings the customers to the network for example with the help of its strong brand and existing customer base.

The role of the enabler is to bring the network and service providers together by providing authentication, billing and clearing services to service providers. Through an enabler one service provider has access to multiple networks with only one agreement, which also allows the service provider to specify the wanted service level as well as the companies to work with.

The fragmented value system enables investment sharing but requires also revenue sharing. This business model makes it possible to provide public WLAN services without own network and billing capabilities, opening the market also to smaller operators. However, this business model does not allow the service operators to compete with different network coverage. Also the size of the market must be adequate

to make the multioperator environment possible in general. Therefore the use of the Neutral Host –model has become more common only in North America and United Kingdom. One should also remember that this business model is only a national solution, international roaming agreements still has to be made separately.

6.2.4 Venue owner as service provider / Open hotspot

The last business model differs totally from the previous models because of its different service strategy. As the three previous business models strive for a maximal profitability of the public WLAN service, the Open hotspot –model uses the WLAN hotspot to increase the profitability of the core business of the venue owner, which usually is something totally different.

This kind of approach is typical for example of cafes, hotels and restaurants, which invite customers also with supplementary services. In these cases the customership usually enables free usage. Also public quarters like cities and municipalities might want to provide free wireless access to inhabitants in public buildings and places. In North America both Starbuck's Coffee and McDonald's provide public WLAN in their premises. The actual service is outsourced but the venue owner manages the usage of the network. This kind of examples can be found also in Finland. Scandic hotel chain provides free wireless Internet connection to all its customers. The service is provided by DNA Finland. PanOulu is an open WLAN network provided by the city of Oulu. It is available in public buildings as well as in pedestrian streets. The usage is free of charge.

7 Market outlook

7.1 Global public WLAN market

7.1.1 Market size

The public WLAN market has experienced continuous growth since the idea of a public hotspot was presented for the first time and this trend seems to continue also in the near future. Mobile operators are marketing handsets supporting both cellular and PUBLIC WLAN access partly because they are constantly seeking new ways of increasing average revenue per user (ARPU), and of paying off their investments in 3G licenses and network deployments. The delayed supply of the 3G services might also force the consumers to turn to WISPs for their wireless needs. The number of worldwide hotspots is estimated to jump from 34 700 in 2003 to close to 185 000 in 2009. Similarly, the amount of hotspot users is expected to grow from several million in 2003 to 150 million in 2009 (figure 7.1). The convergence of mobile networks and WLAN is argued with the fact that the cost to deliver a kilobyte through WLAN should be considerably less than through cellular network. [Pla04c], [ARC04]

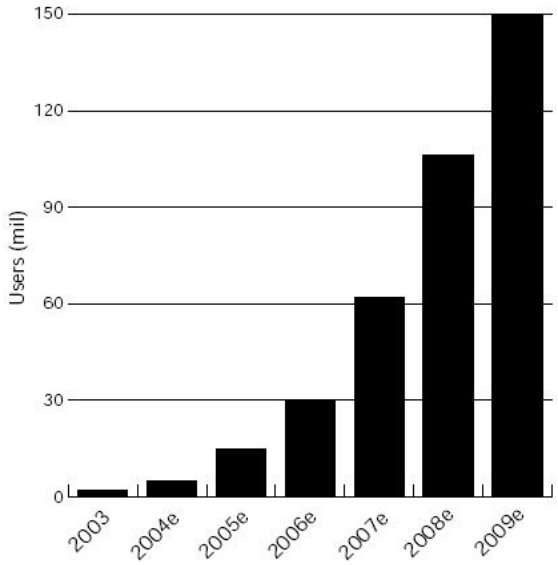


Figure 7.1: Public WLAN users worldwide (Adopted from ARC Group)

7.1.2 Competition

This direction of the market development has not been left unnoticed by the companies operating in the telecom industry. United States, being the originator of the WLAN technology, has a well-developed public WLAN market, with several competing service providers. In 2003, a clear phase difference could be detected while comparing the U.S. and European markets. FirstPartner, a UK based consulting company, explained this to partly stem from the cultural differences between Europe and the U.S. In Europe the higher mobile penetration and the availability of mobile operator Internet access solutions (GPRS, EDGE, 3G) led to slower adoption of public WLAN usage, whereas in the U.S. public WLAN was the first real experience of the wireless Internet for most of the people. Also the greater fixed broadband penetration in the U.S. had made the consumers familiar with fast access and thus created the demand also for high-speed wireless broadband solutions. In 2003 FirstPartner estimated the European public WLAN market to be around 12-18 months behind the U.S. [Fir03]. However, year 2004 changed the market situation rather dramatically. More than 70% of the hotspots deployed worldwide in 2Q04 were in Western Europe, which currently has 40% of the worldwide total leaving Asia-Pacific and North America with 39% and 21% market shares [Pla04b].

As can be seen from the table 7.1, mobile and fixed operators dominate the business. Based on the total number of operators and hotspots, the smallest markets are located in the Nordic countries. The number of hotspots grows relatively linearly with the population. The population in the other Western European countries is roughly ten times bigger than in Finland, Norway and Sweden as is also the amount of hotspots. Also the density of the population has a major effect on the business. The technical characteristics bound the effective range of a single hotspot leaving the footprint relatively small. The population density of the Nordic countries is much lower than the population density in the other countries presented in table 7.1, which partly explains the slower take-off of the public WLAN services, as the amount of potential customers inside the footprint is lower. Also the vogue of cellular networks has been relatively high in Scandinavia throughout the whole era of different mobile technologies, which has strengthened the position of cellular based mobile data services.

However, the table shows quite clearly that the increase of service providers inside one market area decreases the share of a single operator. According to the study made by Planet Wireless also the leading companies have signed national roaming agreements with smaller competitors. National roaming is most common between the U.S. based companies, but also European companies are signing national agreements. A more significant factor seems to be the scope of the service. Many of the current operators, even the large ones, have partnered with some nation wide hotel or coffee chain and are less willing to roam with competitors.

Table 7.1: Leading network operators in Europe & U.S [Pla04b].

Country	Population	Population density /km^2	Hotspots total	Operators total	Market leader	Type	Share of hotspots
Denmark	5 413 000	125,6	1179	6	TDC	Fixed & mobile	72%
France	60 424 000	110,5	5490	6	Orange France	Mobile	82%
Germany	82 425 000	230,9	7490	9	T-Mobile/ T-Com	Mobile	67%
Norway	4 575 000	14,1	673	3	Telenor	Fixed & mobile	74%
Sweden	8 986 000	20,4	542	3	TeliaSonera	Fixed & mobile	87%
UK	60 271 000	248,5	11180	9	The Cloud	Start-up	61%
U.S.	293 028 000	30,8	18419	17	T-Mobile USA	Mobile	30%
Finland	5 215 000	15,4	350	2	TeliaSonera	Fixed & Mobile	71%

7.1.3 Subscriptions and pricing

The subscription portfolio of the public WLAN operators is relatively similar throughout the world. The two main subscription types are post-paid subscriber connection and pre-paid voucher with limited lifetime. Despite the similar subscription types, the usage of the service is priced very dissimilarly in Europe, North America and Asia. According to the results of a survey made by Planet Wireless in August 2004, the average cost of a one-day pre-paid session in the North America was US$6.95, while in Western Europe the price was more than three times that at US$23.20, with the most expensive European operators charging more than US$35 a day. The average subscription costs in Europe were almost three times that in America and almost four times the Asian average. The numbers are presented in table 7.2.

Table 7.2: Hotspot operator tariffs end-2Q04. [Pla04a]

	Prepay/PAYG tariffs US$			Subscriptions US$	
	Hour	**Day**	**Month**	**Month**	**Year**
Western Europe average	8,96	23,20	122,86	79,07	382,60
North America average	4,67	6,95	24,19	26,35	182,89
Asia-Pacific average	4,91	6,90	N/A	19,83	103,24
Overall average	6,18	12,35	73,53	41,75	222,91

The vast array of tariff structures offered by operators easily confuses the customer. Even local rivals adopt varying pricing arrangements in an attempt to differentiate themselves from the competition or align public WLAN services with their existing business. Options range from the above-mentioned pre-paid scratch cards to complex monthly subscriptions with data limits, additional usage charges and minimum-term contracts. In general, mobile operators are more likely to collect per-megabyte charges, as they do for some cellular services, while fixed operators favour per-minute or per-month charging schemes.

Among the 94 companies interviewed in this survey, the single most popular form of charge was unlimited-access 24-hour pre-paid or pay-as-you-go option, with almost 77% of European operators offering this to customers. However, in Asia just 25% of the operators provided the daily tariff but have a very varying assortment of charging structures with various limitations instead. European operators are trying to serve the international business travellers looking for a simple and transparent paying method. In the long run it can be expected that unlimited-access packages will become more standard as the service gets more popular. In general, the bigger operators with widest footprints charge the most, and the smaller companies have to lower their prices in order to provide an incentive to customers. The continuing spread of roaming agreements and the aggressive hotspot rollouts of the smaller players will eventually make this gap to begin to narrow. [Pla04a]

7.2 Penetration of telecom services in Finland

The total population in Finland in the end of 2003 was 5 219 732 of which 67 % were between the age of 15 and 64 (Tilastokeskus). Despite the resent newspaper articles, the penetration of various telecom services has been fairly high in Finland. According to a report made by Taloustutkimus Oy, a Finnish market research company, 59 % people belonging to the age group of 15-79 were using Internet (September 2004). The amount of DSL-based broadband connections in January 2005 was 778 600. The development of these markets is introduced in figures 7.2 and 7.3, respectively. The reason of the small hiccup in figure 7.2 is that the scale of the age group was extended from 15-74 to 15-79.

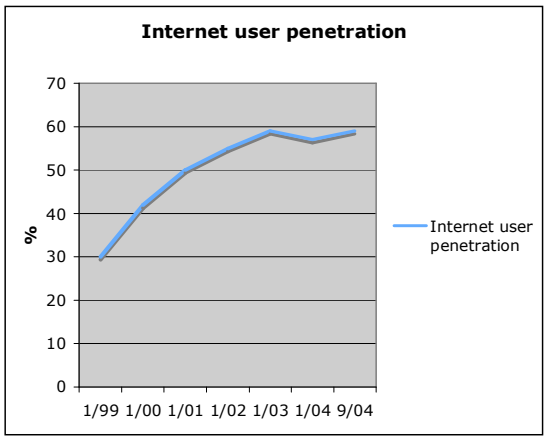


Figure 7.2: The Internet user penetration 1999-2004.

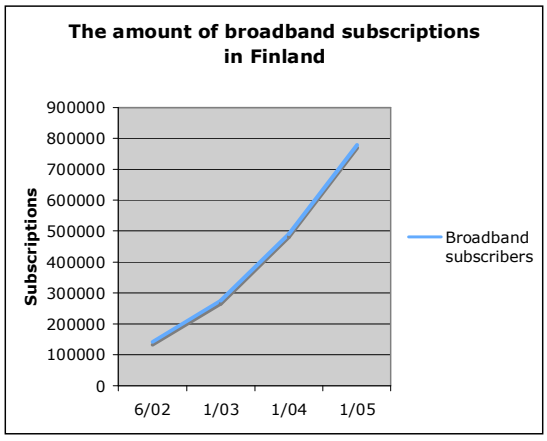


Figure 7.3: The amount of broadband subscriptions 2002-2005.

Market-Visio Oy, another Finnish market research company, published in 2003 a research considering the usage of wireless company networks in Finland. According to that study, 54 % of the 85 interviewed companies considered WLAN as a suitable technology for a wireless office 25,3 % of these companies with 50 or more employees were using a wireless network [Mar03]. 11 % the users of these wireless company networks also used some other WLAN networks.

The amount of mobile subscriptions is very high in Finland, as can be seen from picture 7.4, and the growth rate has been relatively stable over the past years. In 2003 the cellular penetration was 91% and it is anticipated to be 96% in 2005. The figures for years 2004 and 2005 are forecasts, the actual situation is still being correct. The most common data service among consumers is still SMS, but as figure 7.5 shows, among business users, the mobile phone provides an access to the Internet.

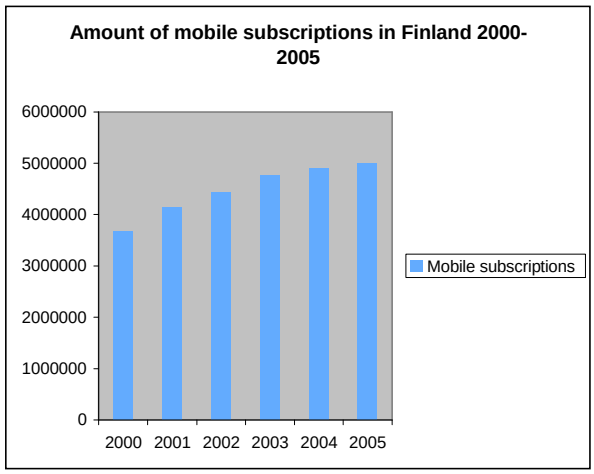


Figure 7.4: Amount of mobile subscriptions 2000-2005 (Ficora).

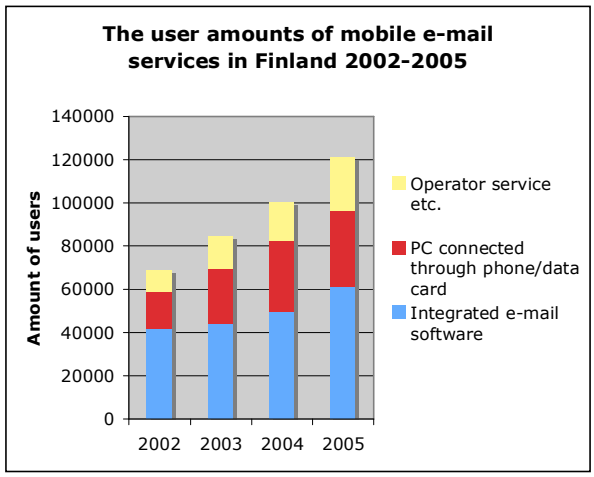


Figure 7.5: The usage of mobile e-mail services in Finland 2002-2005 (Ficora).

Figure 7.6 presents the value development of the Finnish wireless data service markets. The share of GSM data and HSCSD has clearly decreased since the GPRS services become available. However, the usage of the higher throughput services (EDGE, UMTS & public WLAN) is still immature and in very low level.

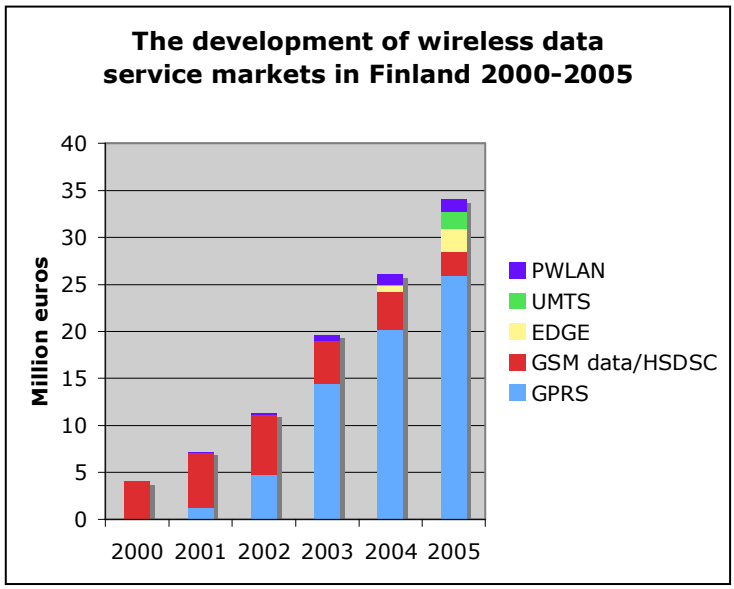


Figure 7.6: The value of wireless data services in Finland.

7.3 Public WLAN in Finland

Currently six companies are providing public WLAN in Finland. However, only DNA Finland and TeliaSonera are acting in the actual hotspot business the other four companies providing more like wireless broadband access and free wireless access in city centres. The players are introduces in more detail below.

7.3.1 DNA Finland

DNA Finland is currently one of the two companies providing public WLAN in Finland. The business is based on the Telia HomeRun service launched already in 1999. Telia's hotspots were passed to DNA in 2003 as Finnet Group bought Telia's businesses in Finland. The business model was based on integrated value chain and both the network as well as the service were provided and managed in-house. In summer 2005 DNA decided to re-evaluate the market situation and update the business model. As a result, DNA chose to abandon the old model and outsource the management and implementation of the network layer.

Currently the *dna WLAN* footprint consists roughly of 300 hotspots making it the largest public WLAN network in Finland. The size of the footprint has more than doubled during the year 2005. The most valuable sites include such nationwide chains as Hesburger, Scandic Hotels and Wayne's Coffee.

DNA Finland has implemented some international roaming agreements but is currently not providing national roaming. *dna WLAN* is provided as a stand—alone service. The portfolio includes three subscription types and two prepaid vouchers.

7.3.2 TeliaSonera Finland

TeliaSonera's *Sonera HomeRun* competes in the same market with DNA Finland with the total of 237 hotspots (7/2005). TeliaSonera is still using the integrated business model with focus on retail.

The Sonera HomeRun service can be connected as a supplementary service to Sonera's mobile phone subscriptions or to a separate data subscription. The service can also be utilised with the fixed-term vouchers of 24 hours, which are sold in the HomeRun

service areas. Sonera has service agreement for example with Sokos Hotels and an exclusive agreement with the Civil Aviation Administration considering the airports.

7.3.3 Mastonet

Mastonet is a free wireless open-air network provided by the City of Lahti. The service is currently in implementation phase and should be launched before the end of year 2005. Progression of the project can be monitored in the web pages of the City of Lahti (www.lahti.fi).

7.3.4 PanOulu

PanOulu is a free open-air WLAN network provided by the City of Oulu, University of Oulu, Oulu Polytechnic and Oulun Puhelin Plc, the local telephone company. Each of these four players has their own physical networks that are linked together and roaming between the networks is allowed. In June 2005 the network was opened to all users for free.

7.3.5 Sparknet

SparkNet is wireless network that is primarily provided for students and employees of educational institutes in Turku region. SparkNet provides also the technology for companies to establish a wireless network of their own. Inside the hotspot the usage is free but a roaming fee is charged if the network is accessed from another hotspot. In July 2005 the coverage was 553 access points.

Access to the network is provided in a form of subscription and 24-hour voucher. Company customers are invoiced with a time-based pricing. Both a credit card and SMS can be used as the payment method.

7.3.6 Zonet Finland

Zonet is an open consortium established in 2004 by several Finnish energy companies providing wireless broadband access in their own region. These networks are federated with roaming agreements. Zonet is primarily providing households with wireless last mile access but public hotspot-like business models are becoming more general. For example Mäntsälän Sähkö is building a wireless open-air network that covers the city centre.

The service is available as a subscription but also as fixed-term vouchers. The challenge of Zonet is the blur and varying coverage area of the hotspots as well as the divergence between the services of each individual service provider.

7.3.7 Potential competitors

As the demand of public WLAN increases, the business is likely to attract also new players to the market. Currently Elisa, Saunalahti, TDC Song and Tele2 are not providing public WLAN. Elisa is a potential competitor as it already provides mobile data services in cellular networks. It was the first operator to provide 3G in Finland and launched mobile data service called Vodafone Mobile Connect in the beginning of the year 2005 [ELI04]. Vodafone Mobile Connect is a multi-access data card enabling access to GPRS and 3G networks with a laptop PC. Currently the Elisa 3G network covers over 30 localities [ELI05b]. Elisa has also shown increasing interest towards WLAN technology as Lounet Oy, one of Elisa's local telecom operator's, announced that it had started collaboration with OpenSpark and SparkNet [ELI05a].

As the value chain disintegrates, the window is open also for network operators to enter the game. A Danish network operator has recently opened a branch office in Finland and is reaching for a slice from the local market. Netpoint's core business is to provide both wireless and wired public Internet in large European hotels. Currently Netpoint has about 120 hotspots in over 20 countries including 6 Radisson SAS hotels in Finland. American based Wayport acquired Netpoint in spring 2005.

7.3.8 Market maturity

The comparison of hotspot and user amounts as well as the number of service providers makes it reasonable to argue that the Finnish public WLAN market is still relatively immature and small in size. In the terms of the technology adoption lifecycle model, Finland can be called as the *early market*. The largest customer group consists of business users, who appreciate the efficiency and performance WLAN provides and are willing to pay for it. This is an important thing, because there is a difference in mindset regarding what aspects are important for business and consumer users. An illustration of the different demands is presented in table 7.4.

Table 7.4: The different demands of corporate and consumer users. (Adapted from [ANA01])

Relative importance	Corporate users	Consumer users
Most important	Wide availability	Cost
	Reliability (QoS)	Wide availability
	Security	Seamless connection
	VPN access	Reliability (QoS)
	Seamless connection	Security
	Single billing relationship	Single billing relationship
	Data transfer speed	Data transfer speed
Least important	Cost	

The Finnish public WLAN industry is still in a growing phase. DNA Finland estimates the total amount of possible valuable hotspot locations to be around 2000, which quite clearly confirms this statement. Detailed information from the usage level of the DNA's and TeliaSonera's networks was not available. However, some indication could be found from the PanOulu network usage. The size of the possible user group is estimated to be around 100000. Currently the amount of regular monthly users is however only around 1500.

7.4 Specific features of the Finnish WLAN market

The examination of the Finnish market enforces to pick up few things that have a special importance as the suitability of the business models is later studied. Above all, the status of the cellular operators is really strong in Finland, as could be detected above. This makes the brake through of mobile data services based on some other technology much harder. At least partly because of this, the public WLAN penetration is behind the leading markets. However, the situation is the same with the penetration of the 3G networks in Finland, which opens a window for public WLAN providers.

If the size of the national public WLAN market is compared to other networks based on WLAN technology, it is relatively easy to notice that the usage of WLAN is more common in home and office networks, which also seem to be the more potential markets for growth in the future.

As mentioned in chapter 7.2.1, the amount of broadband subscriptions in January 2005 was around 780.000. If we suppose that 20% of those subscribers have a WLAN access point at home, the amount of wireless home networks is around 160.000. In 2003, the amount of labour was roughly 2 million. Again we can assume that 50% of them work in offices. From these million people, 11% have access to WLAN [Mar04]. If one access point serves 10 people, the amount of company WLAN access points is about 2500-3000.

8 Business model analysis – Case Finland

Chapter 6 presented the widely existing business models used in public WLAN industry. The current situation in both global and domestic markets was presented in chapter 7. Chapter 8 analyses the suitability of these models from the Finnish public WLAN industry point of view by exploiting the information presented in previous chapters. Both the prevailing laptop segment as well as the forthcoming pocket terminal segment is discussed separately.

I also have made a hypothesis considering the role of the service provider in the value system. Currently it seems that the whole industry in Finland is service provider-led, thus the service provider controls the value system. Apart from the suitability analysis, this chapter also presents some estimates considering the future role of the service provider and discusses how the service provider could maintain its current role by adopting a different business model. This analysis is based on the Porter's five forces – model, which can be used to describe the rivalry within an industry.

The suitability analysis is based on three variable groups. *Customer group* composes of business users and consumers. *Service type* describes the service incentive of the service provider, which can be either value-adding service or stand-alone core business. *Venue type* presents the type of a typical location the hotspots usually are located in. In this study these locations are divided into large and small venues, the previous group including locations like airports and hotels, while the latter group mainly composes of coffee shops and restaurants. By choosing one subtype from each group, a model can be formalised to illustrate the current market situation. Each business model is then dissected against this frame. The suitability is rated by using a tripartite scale: poor suitability (-), neutral effect (o) or good suitability (+).

8.1 Laptop segment

8.1.1 Suitability analysis

As described in chapter 7, the largest public WLAN user group in Finland is business users. The service strategy of both DNA and TeliaSonera is to provide public WLAN as value-adding service to their mobile subscribers. Also fixed-term vouchers are available for occasional users. DNA and TeliaSonera have slightly different venue partner profiles, but in general both operators favour large venues as hotspot locations.

Table 7.4 illustrated the most important characteristics that customers expect the public WLAN service to perform. For business users the two most important factors are wide availability and reliability. Thus the network coverage must be sufficient covering all places used by business users. Also the service provider must be able to guarantee a certain quality of service.

Thus, the best business model has the closest correspondence with the demands of business users, is suitable for a cellular operator providing a value-adding service and also is able to fulfil the needs of the users of a large hotspot. The customer profile of an airport or a hotel is very chequered including subscribers from several service providers.

	Integrated WISP, no roaming	Integrated WISP with roaming	Neutral Host	Venue owner as service provider
Customer group				
business users	-	+	+	o
consumers				
Service type				
value-adding service	+	o	-	-
stand-alone core business				
Venue type				
large (airport, hotel)	-	+	+	o
small (coffee shop, restaurant)				

Figure 8.1: Business model suitability analysis summary - laptop segment

These factors are bundled up and presented in figure 8.1. The best coverage and quality of service can be achieved by using either the Integrated WISP with roaming or the Neutral Host –model. Without national roaming the coverage and thus availability does not meet the required level. Both Finnish service providers are cellular operators and they have the required capabilities to manage all the areas of the value system, which supports the choice of the Integrated WISP –business model. As both operators see public WLAN as value-adding service and a way to differentiate, the lack of national roaming is justifiable. However, even if roaming is added to the Integrated WISP –model, the operator still is able to make the bilateral roaming agreement only with suitable operators leaving there the possibility to use a differentiation strategy. As the service is usually provided in locations, where the customer structure includes subscribers from several service providers, the existence of national roaming would be extremely important.

The summary is presented in figure 8.1 and as can be seen, the most suitable business model would be the Integrated WISP with roaming –model, the Neutral Host –model holding the second place. From a theoretical point of view, the currently used business model that does not include national roaming favours only the service provider.

8.1.2 Role of the service provider

The Finnish public WLAN value system is currently service provider-led. As the previous chapter pointed out, the current business level strategy adopted by the service providers brings only little benefit to other parties in the value system. Porter's five forces model can be used to describe the interrelationships between the players inside one value system. Analysing the rivalry within an industry, threat of substitutes, barriers to entry and the bargaining power of buyers and suppliers gives us a conception of the real status of the service provider and helps us to estimate what is the possibility of the other players to force the service provider to change its service strategy.

Because only two operators are providing commercial public WLAN service in Finland, the market can be assumed to be relatively stable [Hen76]. Also the estimation of a representative of DNA Finland considering the amount of valuable hotspot locations in Finland supports this postulate. The amount of interesting and profitable locations is estimated to be around 2000. As the current amount of hotspots is 550, one can consider

the Finnish market as a growing market, where firms are able to improve revenues simply because of the expanding market. This explains partly the operator's unwillingness to change their current service strategy by implementing national roaming. One of the strongest reasons for not implementing national roaming is the thesis considering the backdoor competition presented by Gunnar Almgren (chapter 5.3.2).

As with most consumer products, the bargaining power of buyers is relatively small. Also in the public WLAN market, the buyers are fragmented, which decreases the influence of a single customer. Also the buyer switching costs are relatively high as long as the main customer group is business users. Companies usually get their telecom services from one operator, which binds also the WLAN users to this particular company.

The supplier, in this case the venue owner, is in more powerful position. They have the possibility to change the service provider or integrate forward if the existing agreement does not fulfil the requirements. From the operator point of view the switch of supplier would generate significant costs, as the network infrastructure needs to be rebuilt. Some examples from venue owners changing the operator have already been seen, also in Finland, which proves the real existence of this risk scenario. In North America the fast-food restaurant chain McDonald's launched a WLAN pilot provided by Cometa Networks in 2004 but eventually ended up to make a contract with a competing company called Wayport. As an outcome, Cometa Networks was bankrupted in the same year [Por04]. In Finland, the hotel chain Scandic cancelled the service agreement with Sonera and became a service provider itself. The network is provided by DNA Finland.

8.2 Handheld segment

8.2.1 Technology scenarios

The range of mobile phones with integrated WLAN is going to increase in during the next couple of years bringing this feature also accessible to average consumers. Despite the current success in the U.S., the usage of public WLAN is still bounded by the terminal as from the user point of view a laptop computer or PDA device are not carried along as naturally as a mobile phone, which for the most people includes to the same category with home keys and wallet.

The handheld technology and services are, however, developing rapidly and currently two promising standards are on their way to the market. Unlicensed Mobile Access (UMA) and Voice over WLAN are services that raise the value of public WLAN networks to a whole new level among the consumers. UMA technology enables the usage of GSM network's services through WLAN and Bluetooth connections. Voice over WLAN makes it possible to provide Voice over IP (VoIP) subscriptions by using a handheld device including a SIP client. The main idea of this technology is to move the traditional voice services from circuit switched network to IP networks. From the operator point of view these technologies provide a way to broaden the service portfolio, which has a straight decreasing influence on churn and a positive influence on cash flow. By presenting new services the operators are also able to attract new customers.

8.3 Business scenarios

The increasing business has an effect also on the business models. The development of the Finnish public WLAN market has been enormous during the end-half of the year 2005. The amount of network providers has increased as more and more local operators are providing wireless networks. This can be considered as the first step towards a fragmented value chain, which then opens the window for virtual WISPs. This decreases the need for national roaming, as the service operators are able to acquire network capacity from several providers.

The availability of the service reaches almost the same priority level in among both corporate and consumer users the importance of the usage costs being emphasised in the consumer segment (table 7.4). The slow growth of the consumer mobile data market

gives a reason to assume that success of this sector is dependent on practical and tempting services the pure access not being enough. The top 3 list of demands includes also seamless connection, which in practise means minimal terminal configuration and similar user interface in every hotspot. Handset terminals allow SIM-based authentication making the experience of WLAN use more like a cellular subscription.

9 Conclusions and Summary

The unlicensed and unlimited usage of the frequency band used by the IEEE 802.11 devices has opened the public WLAN market for diverse companies providing both network and services. The market has experienced exponential growth under the last five years, the amount of different business models and value chains being almost as manifold as the number of existing companies. The current trend, however, indicates that the amount of business models is gradually settling down as the market matures.

The research problem of this study was to identify the most common business models used in the global commercial public WLAN markets, to describe the current situation of the Finnish commercial public WLAN market and to consider the actions needed to accelerate the development of the domestic market. The main target of the thesis was to study the influence of national roaming agreements to the market. International roaming has been considered to be one of the main reasons behind the success of GSM market and is also a very important part of international public WLAN business. If national roaming would turn out to be as important, there would be a heavy argument against the current situation of the Finnish public WLAN market.

9.1 Results and recommendations

Despite the diversity of the players operating in the public WLAN markets, the value system has attained a relatively stable and homogenous form (figure 4.1). The most common model is composed of venue owner and operator providing both the network and access services and thus controlling all parts of the value chain. This kind of value system is especially popular among large cellular operators, which have the capability to control the entity. This integrated model can be used in small and developing markets as such without national roaming, in which case it also provides the operator a way to differentiate its service. The increased demand can be responded by implementing national roaming, which increases the value of the network and makes the service more valuable and tempting. Bilateral roaming agreements provide the operator still the chance to keep on using the service differentiation strategy by choosing the roaming partners.

As the markets mature, the separation of retail and wholesale markets becomes more evident. The Neutral Host model describes this kind of fragmented value system, where independent network operators negotiate the agreements with venue owners, build service provider agnostic hotspots and offer wholesale access to several virtual WISPs. Neutral Host model is still relatively rare business model but the popularity of this model increases continuously with the number of pure WLAN network operators. The Neutral Host model is in many ways the most tempting business model of these four presented models

The examination of the different market areas (North America, Europe and Scandinavia) reveals the phase differences between these markets. If the situation is reviewed by using the lifecycle model, the North American market can be considered to represent the early majority phase, the European market being between the early adopters and early majority phases. The service took of much later in Europe but the European market is currently growing faster and already is the largest area if measured in the number of hotspots. This has been explained to be a consequence of the slow take off of the 3G networks, which continuously load the economy of the cellular operators and force them to come up with substitutive services. The larger customer volume in North America and Europe decreases the market entry barriers and lower price level compared to Scandinavia attracts the customers to use the services. The amount of service providers contribute to the competition level. Thus the operators in less competed Scandinavian markets have a different status than the players in more mature markets, where the degree of competition is higher. Currently it seems that in less competed markets the service provider still can dominate the value system and choose whether to provide national roaming or not, whereas in more mature markets the roaming and co-operation are obligatory prerequisites for the success of the business.

In Finland public WLAN services are currently provided by two cellular operators, DNA and TeliaSonera as well as a handful of energy companies and open access urban area networks. Basically the networks provided by energy companies are more like a substitute for fixed line broadband networks and thus predefined outside the scope of this study. Both DNA and TeliaSonera use the Integrated WISP business model without national roaming. Based on the analysis represented in chapter 8, the current immature market situation does not provide adequate power to other interest groups to undermine the status of the service providers. Although the implementation of national roaming

would be academically and theoretically arguable, in this situation the authority in practice remains in the hands of the operators. However, as the market matures and the amount of handset terminals increases, public WLAN becomes more and more a consumer service, which increases the bargaining power of the interest groups and may break the status quo. In that kind of situation, however, it is more presumable that the market will develop towards the Neutral Host model with several independent network operators, which sell the capacity to several service providers. The facts presented in [Alm02] (chapter 5.3.2) support this supposition. In his paper Mr. Almgren points out that if competitors are targeting the same geographical user group, national roaming may create a situation called *backdoor competition*.

Both DNA (former Telia HomeRun) and TeliaSonera entered the Finnish public WLAN business in a very early stage. The market demand in Finland has increased relatively slowly, which along with the 3G network investments has delayed the growth of the business. Their current public WLAN footprint covers most of the large business hotels but coverage of potential consumer hotspots is still relatively poor. Companies like Sparknet and Zonet Finland as well as the cities of Lahti and Oulu have already experience from the building of communal networks that both DNA and TeliaSonera could exploit. Also the local telephone companies could act as wireless network operators. This would provide them a new direction to expand the business and decrease the CAPEX and OPEX of the current service providers, which would encourage them to more actively develop the public WLAN service.

9.2 Assessment of results

This thesis differs from the traditional engineering studies, which usually are based on hard facts and where the findings can be justified with factors. Public WLAN industry is still developing at a cracking phase complicating the seeking of relevant data. Some of the sources of information have undoubtedly become obsolete during this process. Also many “facts” are based on estimates made by analysts and experts, which decreases their academic value. As well the financial constraints decline the access to the most current and valuable sources. However, these kinds of analysis are always based on opinions rather than hard facts, the competence of the writer being the weakest link of the chain.

Regardless of the self-criticism, this thesis describes the current situation in the fast changing market. Besides the business knowledge, this thesis has taught the importance of proper pre-study and systematic work. Many things would probably be represented more clearly but the final outcome would pretty much be the same, if done again with better knowledge.

9.3 Future research

As has been pointed out many times during this study, the public WLAN industry is still in a rapidly developing phase. The evolution of network production and business models is stable but the rapidly developing service technologies like UMA and VoWLAN are going to set new challenges to the networks as well as to the authentication mechanisms. The Quality of Service is going to be a major issue in public WLAN networks in two years time and will require deeper understanding and research.

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