Architectures for Open Access Hotspots

António Rafael C. Paiva, Tiago J. Martins Duarte

Abstract – **This article envisages the study of wireless access points in an open access configuration. In this configuration, the users of the service have access to the network without the need of authentication and without accounting their access.**

Therefore, we intend to consider the particularities of an access perspective of this kind. Various technological possibilities to the wireless access network are presented and analyzed. The problem of economical sustainability of this service is also addressed. Finally, we also present two possibilities of implementation of this configuration considering two different situations for usage.

Resumo – **Este artigo foca o estudo da utilização de pontos de acesso wireless numa configuração de acesso livre. Nesta configuração, os utilizadores do serviço têm acesso à rede sem necessidade de autenticação e sem taxação do seu uso.**

Pretendemos, portanto, considerar as particularidades de uma perspectiva de acesso desde género. As várias possibilidades tecnológicas para a rede de acesso wireless são apresentadas e analisadas. O problema da sustentabilidade económica deste serviço é também analisado. Finalmente, apresentamos ainda duas possibilidades de implementação desta configuração tendo em vista duas situações de utilização distintas.

Keywords – **Hotspot, IEEE 802.11, Wi-Fi, Bluetooth, open access, network architectures**

Palavras chave – **Ponto de acesso, IEEE 802.11, Wi-Fi, Bluetooth, acesso livre, arquitectura de redes**

I. INTRODUCTION

Since the introduction, in 1997, of the standard IEEE 802.11, that several devices dedicated to mobile computing started to appear. However, it was only after the release of the standards 802.11a and 802.11b (Wi-Fi), that these devices really found their way into the market, dedicated to provide wireless extensions to the existing ethernet LANs. Approximately one year later, a first version of the Bluetooth specification was announced by the Bluetooth Special Interest Group (SIG), formed by several industry heavyweights in an effort to enforce Bluetooth developing as a Wireless Personal Area Network (WPAN) standard. These two new types of technologies brought a breath of fresh air to mobile computing. Several Wireless Internet Service Providers (WISP) appeared dedicated to supply access points – *Hotspots* – through which users could access the Internet with the payment of a fee.

Although most hotspots are based on a *pay per use* basis, this article presents scenarios, and their support architectures, in which hotspots with an open, and therefore free, access can be used. Moreover, we will show why someone may want to provide a hotspot freely and how this hotspot can be economically sustainable. In fact, this model of hotspot can have several advantages over others, like the above referred based on pay for usage. Such properties will be more extensively analyzed in the later sections of this article.

Wireless data communication technologies are a recent subject in Portugal and have an increasing potential. People are becoming more in touch with this new way of accessing information. Wireless networks are extreme flexible systems of communications due to the combination of two important factors: connectivity and mobility of the user. There are other important factors that we must take into account, such as, velocity and easy installation, flexibility, accessibility, property cost reduction, among others. All of these factors create the concept: "Always connected: anytime, anywhere." The market projected growth for home networking shows one exponential evolution and the enterprise WLAN market projected revenue shows exactly the same evolution, so this is one great area to start a new business trade [1].

In the remainder of this article, we start by introducing the two types of wireless technologies considered in this article: those based on the standard IEEE 802.11, more specifically 802.11a and 802.11b, and Bluetooth. Then, we present the general business models associated to the hotspot and a survey which can give a first impression on the field to the usage of this technology. Finally, we propose and develop some analysis of the architectures used to implement the situations presented.

II. WIRELESS TECHNOLOGIES OVERVIEW

A. IEEE 802.11

The standard IEEE 802.11 is the base standard to wireless LANs. This standard is an extension of the existing standard IEEE 802.3 (ethernet) to wireless communications [2], introduced a MAC layer and considered three physical layers, for bit-rates of 1Mbps and 2Mbps: direct sequence spread spectrum (DS-SS), frequency hopping spread spectrum (FH-SS), and infrared (IrDA). However, these possibilities for the physical layer are not compatible, especially the DS-SS and FH-SS since they would use the same frequency band. To the channel access the standard specifies the carrier sense multiple access with collision avoidance (CSMA/CA) mechanism. A tutorial on the IEEE 802.11 standard is provided in [3].

The 802.11 considers two type of networks: ad-hoc and structured. In the ad-hoc configuration the devices communicate in a peer-to-peer network. In the structured configuration the wireless network is controlled by an access point

(AP), also known as a base station, which can access the channel with greater privileges. In a hotspot, the structured configuration is used, with the AP acting as a bridge to the *wired* network. Also of most importance for the design of a hotspot network are the concepts presented in the original 802.11 standard, and also explained in [3], of Basic Service Set (BSS), Distribution System (DS) and Extended Service Set (ESS). A BSS is the area of radio coverage by an AP. A BSS is also referred to as a cell based on mobile communications nomenclature. The DS is the network which connects all the BSS. Finally, the ESS refers to the complete wireless network. These concepts apply to any of the standard IEEE 802.11 siblings.

B. Derivatives from IEEE 802.11

Being, at the time of writing, the standard with greater market integration, the 802.11b (Wi-Fi) extends one of the 802.11 physical layers. It specifies the operation in the unlicensed 2.4Ghz ISM frequency band using DS-SS, with support to bit-rates of 1, 2, 5.5 and 11Mbps [1], [4], [5]. Typically, the Wi-Fi devices have ranges in the order of 100 meters, with maximum output power of 20dBm. The standard also defines 11 frequency channels, depending on the 2.4GHz ISM regulations of each country, with 5MHz separation. Although this allows overlapping if all are used, since the transmission bandwidth is 20Mhz at -60dB of signal power, these channels are used to ease the process of radio network design. To protect the privacy of communications, the Wi-Fi uses the wired equivalent privacy (WEP) scheme, although with now known vulnerabilities. In hotspots, typically, the WEP is not used to ease the association to the wireless network, with the privacy being provided in upper layers.

The 802.11a is the very-high bandwidth version of the 802.11b, and operates in the 5GHz ISM band. It provides throughput up to 54Mbps but, because of its higher frequency, with lower range. The first implementations of this standard appeared after those of the 802.11b standard, being this a possible cause to its smaller use.

Currently, there are several IEEE working groups in many other extensions of the 802.11. For example, there is the IEEE 802.11g working group which should provide a physical layer with support of bit-rates up to 54Mbps, while working in the 2.4GHz ISM band. Some extensions to the 802.11 include [2] security improvements (802.11i), methods to provide quality of service (QoS) (802.11e), better interoperability between APs (802.11f), etc.

C. Bluetooth

Bluetooth is a low-cost, low-power, short-range wireless technology. It was designed as a replacement for cables and other short-range technologies like IrDA. Bluetooth [1], [4], [5] operates in personal area range which typically extends by tens of meters and, depending on transmitter power, up to 100m. It operates in the unlicensed 2.4GHz ISM band, with data transfer rates up to 721kbps. For the radio link it uses FH-SS, which hops 1600 times per second between 79 channels (depending on the country regulations) with 1Mhz intervals. Up to seven simultaneous connections can be established and maintained by each Bluetooth device. The channel access [1] is made through polling, where a master device controls the network access, and issues a poll to the slaves allowing them to transmit data. Bluetooth supports three security levels [1]. At the highest level, a 128-bit encryption and link key are used. However, the keys are calculated from a 4 digit PIN and are transmitted publicly, being possible to access information of others. Finally, Bluetooth specification includes both link layer and application layer definition. There are also the Bluetooth profiles which provide information to various usages.

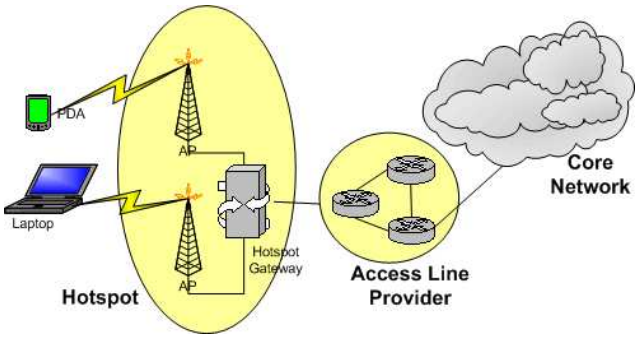

Figure 1 - The fundamental elements in the wireless Internet access

In terms of network structure, the Bluetooth basic network element is a *piconet*. A piconet is formed by a master, which controls the channel access, and the slaves. The piconets can be connected forming a *scatternet*.

Although Bluetooth was designed for completely different usages than 802.11a and 802.11b, it can also be used to provide WLAN, as it is specified in one of the Bluetooth profiles [6], [7]. This is done by using the TCP/IP protocol stack with a PPP connection over the RFCOMM Bluetooth layer, which basically emulates a serial port. This is much like using the Bluetooth as a wireless modem.

D. Wi-Fi and Bluetooth co-existence

Being these two standards widely used, and since both use the 2.4GHz ISM band, one concern arises with the use of Bluetooth and Wi-Fi in the same space [1], [4]. If both technologies are used, they will overlap, causing a performance reduction. With this concerns in mind, several groups are trying to solve the problem. In fact, Mobilian [8] and, Intersil and Silicon Wave [9]-[11] jointly, already presented approaches which allow the simultaneous use of both technologies, but products supporting both technologies are still not widely available.

III. BUSINESS MODELS

A. The intervenient elements

The figure 1 shows the possible intervenient parts in this kind of networks [12].

End User – This is the normal user. It is based on the type of use and in frequency.

Hotspot Operator (HO) – The equipment belongs to this entity and has to keep it in good working conditions. The owner of the space (area) and this entity should

not be confused, since in the general case they are not the same. There are some special cases where the HO is simultaneously the owner and the entity as we will see up ahead.

Access Line Provider (ALP) – The ALP provides the connection between the hotspot and the core network and, at a small scale, the connection between hotspots. The access elements to the core network belong to this provider.

Core Network – This is the core network. It is this network which connects the various ALP's, therefore, the hotspots in a wide scale, and to other services. Normally this function is performed by the Internet.

In addition to these elements, a Mobile Provider (MP) and a Service Provider (SP) can be used, however since these parts are mostly used in payed configurations to control what the user does, we decided not to include them.

B. Models

The numerous possibilities of business models depend on "what belongs to whom" and of the different roles of the intervenient parts. The hotspot is the major intervenient element. Therefore, the next models that we will see are based in to whom the hotspot belongs to.

The hotspot belongs to the owner of the surface – In this case, it is the owner of the surface that implements the wireless network, searching for other ways of incoming profits. One way of attracting costumers to a commercial zone could be the creation of this kind of infrastructure.

The hotspot belongs to the ALP – This means that the ALP is also the HO of the structure and he is the one that gives access to the final user. This is one way for the ALP to extend his network and reach the user demands. Doing this, the ALP assures that his clients won't run away to other wireless operators.

Both of these models can be used in an open access configuration. Although the usage of the first model in this configuration is obvious considering the explanation, the second is not. Of course, for the ALP to provide the service he will have to gain something. For example, the owner of the surface can pay to ALP in order for it to provide the service in his area without cost to user. The reasons for such behavior will be more developed in section IV-C.

C. Survey on wireless Internet access

This analysis is based on an empirical investigation which pretends to evaluate the market penetration possibility. It starts from gathering data of what people would demand if they could use wireless technology through the use of palmtops or mobile computers in their quest for information. One survey was made to evaluate the people's receptivity to wireless networks and what they would like to see in a wireless web portal. It took place in Centro Comercial Forum Aveiro, which is a large shopping mall in a average representative Portuguese town. The survey was made out of an universe of 40 people from different professional areas and equally distributed by gender.

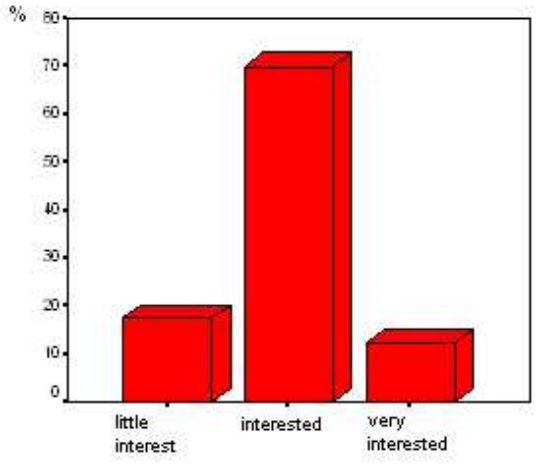

Figure 2 - Answer to the question "*Would you be interested in access Internet through wireless?*"

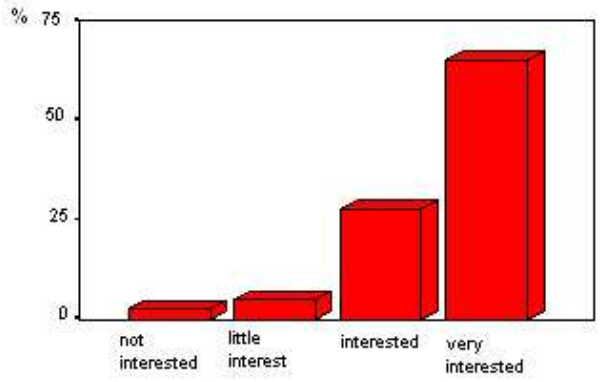

Figure 3 - Answer to the question "*What if it is free Internet access?*"

The first question was to know how interesting it would be if a person could access to services and the web while wondering around the shopping mall (figure 2).

In general, we see that almost everybody is interested in this sort of networks, specially if, along with this, people could get free access to Internet (figure 3).

What do people want in this kind of service? Most of the people wanted other services like online information, buying products and making reservations to other places. by the public in general. It was seen through this survey that the proposed open access configuration caught the possible users attention, which is a good indicator of growing possibilities.

IV. OPEN ACCESS ARCHITECTURES

The network architectures necessary to support the hotspots implementing the open access concept are quite simple. Moreover, since there is no need to authenticate the user and account it is usage, the hardware necessary to these operations is not needed, simplifying the architecture.

Basically, two different types of architectures were considered: with and without Internet access. These architectures are intended to completely different environments. The architecture with Internet access is intended for public areas

such as coffee shops, airports, shopping malls, etc. However, for those environments where Internet access is difficult to achieve, for example, in buses, trains or airplanes, the architecture without Internet access can be used.

A. With Internet access

Figure 4 presents the basic architecture to an open access hotspot with Internet access. The hotspot network has two sections: one with the APs, and other with the local servers. The APs provide the radio coverage of the hotspot area, while connected between them, to the network servers and to the Internet connection by the DS. The servers section is a demilitarized zone protected in both sides by firewalls, in order to protect from attacks either from the wireless network or from the Internet connection. The firewall from the wireless side also has the very important function of preventing that users in the wireless network can attack servers from the Internet.

Looking now to the demilitarized zone where the servers are, we included a DHCP server to ease the configuration of the users device, making the process more attractive to them. Although not essential if the HTTP server is not used, a DNS was also included. Without the HTTP server the DNS server will act has a caching only server. On the other hand, if the HTTP server is used, the DNS server is necessary to provide its IP address, acting as a caching only server to the remaining names. The represented HTTP server can be used to provide local contents to the users, for example, store and promotion information in a shopping mall, either in a site format or as a portal with the information stored in a database as represented in the figure. Finally, a proxy is necessary since the number of users is unknown, but the use of a normal proxy has the disadvantage of having to configure manually the device, even with a configuration script. To overcome this problem, a transparent proxy is used instead, providing the functionality of a proxy, but without the need of any configuration by the users. In fact, most of them will not even know they are behind a proxy. Notice that in the presented configuration the servers are represented in different computers based on those which are more likely to be heavily loaded, but if the expected load of the servers is acceptable to a single computer, they can be concentrated. In such case, the firewalls are applied directly to the computer network interfaces.

For the servers the possibilities are enormous. For example, the HTTP server can be Apache or IIS; the contents database can be implemented in MySQL, PostgreSQL, or SQL Server; the DHCP can be the one from the Internet Software Consortium (ISC), and the DNS can be BIND, also available from ISC. Note that some more advanced (and expensive) access points already have integrated DHCP server. For the transparent proxy there are also numerous solutions like Squid, the built in Linux kernel routing capabilities, or Apache with a transparent proxy module. Non transparent proxies can also be used but then software is needed to emulate the transparent proxy. This software listens for requests and performs the requests to the proxy in the appropriate format, hiding the proxy from the users.

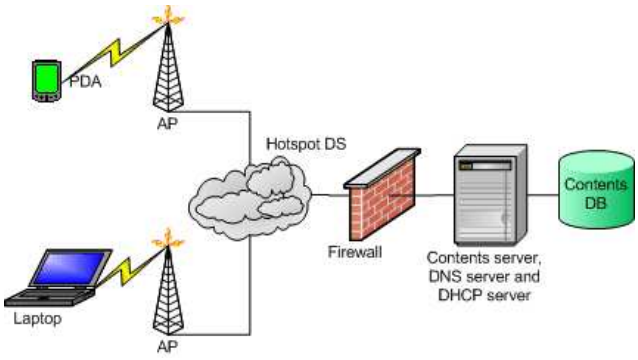

Figure 5 - Architecture to an open access hotspot *without* Internet access

B. Without Internet access

In the situations without Internet access everything necessary to support the Internet connection render useless. Basically, we have everything as in the previous case except for the transparent proxy and its firewall (figure 5). Of course, since in this case there is no way of accessing external information, the use of a local contents server became essential. Depending on the characteristics of the devices most likely to be used to access the server contents, and the nature of contents, the type of server must be chosen. For example, if palmtops and notebooks are going to be used, the server can provide multimedia content and a HTTP server can be used, on the other hand, if mobile phones are more likely to be used, then other server should be chosen. Although the figure represents all servers in the same computer, they can be on separate computers. However, the represented solution should be chosen since this configuration addresses more directly situations where low space is available and the solution is intended to be one of low cost. Like the previous architecture, a number of servers exist with similar functionalities, and any of them can be used as long as they perform the intended function.

This approach might seem useless or of very little interest at first glance, since this access is restrictive and the information is not updated immediately. Although this is true, there are some contents for which the information is accepted in spite of some time difference. Examples of such information sources are the newspapers. Multimedia contents like music or video can also remain without being updated for days or weeks. Note that this access is just like offline browsing where information is downloaded to the local server in order to allow users to access it even after the connection has been closed. The information in the server can be updated, for instance, every day. If we think of a vehicle, the database or site can update itself automatically when it reaches a hotspot with Internet connection.

C. Application scenarios

Several situations exist to which these architectures can be applied. To further show the possibilities of this hotspot concept, we now provide some “case studies” and analyze how the architectures can be used in such situations.

One of the first situations we can think of is a shopping mall hotspot with Internet access. Like it was shown by

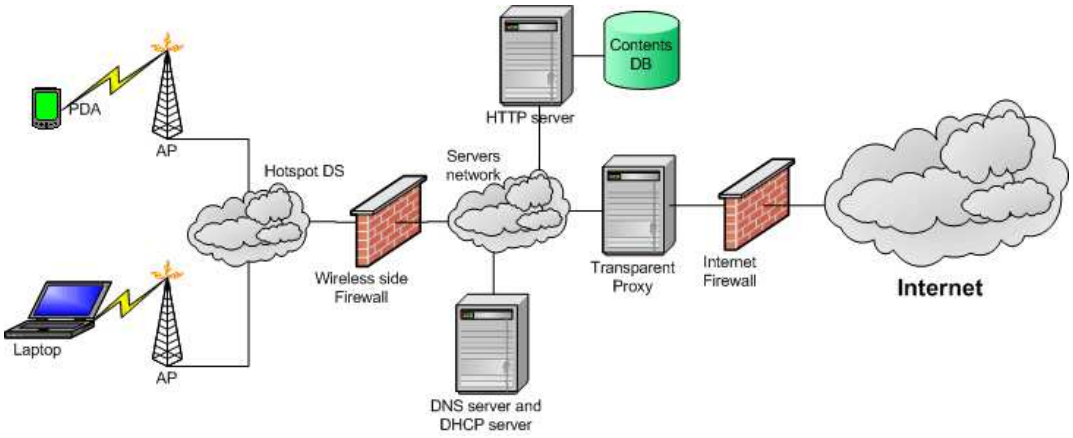

Figure 4 - Architecture to an open access hotspot *with* Internet access

the survey presented in section III-C, this scenario provides high growing usage perspectives. Therefore, a shopping mall providing an open access hotspot will attract more clients to it. The large number of clients will indirectly support the network installation and its maintenance. As was analyzed in the business models, this can be made either directly by the shopping mall or by paying the ALP in order for him to install and manage the hotspot. If the whole configuration of figure 4 is used, then the HTTP server can have a portal with useful information to the users such as: shopping mall maps, promotions, information about the stores, and more specifically, restaurants, cinemas, book shops, etc. An economical model more direct in terms of its return can be obtained by inserting publicity in the shopping mall site or portal, either from internal (related to the shopping mall) or external companies. With some effort, publicity can be inserted automatically in the fetched pages from the Internet by the proxy, ensuring that users get the publicity.

Other example can be a coffee shop with an hotspot, usually called a cyber-coffee. While retaining all the advantages, money can be saved since it is not necessary to buy the computers, or at least, not so many as usual. Certainly this also presents new possibilities to the regular coffee shops which can, painlessly, became a cyber-coffee. Many other possibilities can be found depending only on imagination and business possibilities.

There are also numerous situations where a hotspot without Internet access can be used. These are, most likely, moving environments like buses, trains, airplanes, in which the Internet connection is hard to achieve or more expensive. Furthermore, the use of wireless in some of these environments is being the subject of more extensive study by several entities [13], [14].

D. Implementation economical advantage

To end this section we would like to explain another of the great strengths of an open access configuration: the low budget deployment. Noticing the architectures depicted, we see that these are simple architectures as was indicated at the beginning of this section. This simplicity mostly happens because the equipment needed to support authentication and accounting (AAA) in the paid hotspots was suppressed, giving place to servers easily obtained and configured.

Allowing a rough comparison, we can say that, excluding the radio networks (i.e. the AP's) and to the configuration supporting Internet, the network can be made up and running by only the price of a single computer in a simple perspective. On the other hand, to the same conditions, a system based on a control gateway can cost above 5000 euros. Depending on the intended specifications the referred price can easily raise to 10000 euros. More specifically, we are referring to the Nomadix [15] and Vernier [16] gateways.

V. CONCLUSION

As you can see there are new ways to communicate and to get information, these new ways are more efficient and can be more pleasant, specially when you travel from one place to another one. The scenarios here presented intend to give you new perspectives to what can be done with wireless, it is just a first glance of what you can encounter in a near future. The architectures that were shown are simple but cost-efficient and intend to give some easy ways to implement services that the common passerby can use with tremendous benefits for everyone. The development of these services is a necessary mean to achieve a more demanding costumer need.

As a secondary but associated subject, this article begins with a introduction of the most used radio based wireless technologies for networks of relatively short-range. This overview can be used as a first tutorial providing some general knowledge about this subject.

In this article we presented and analyzed, from several perspectives, the open access hotspot concept. We showed the various advantages in adopting such a configuration for an hotspot, ranging from economical to technical. Moreover, we have shown that this technology has a tremendous growing potential.

REFERENCES

[1] Andus Chan, Gabriel Wiebe, Robert Schoffner, and William Chow, "Bluetooth evaluation project", Tech. Rep., BlueSuit Research, August 2001.

[2] James D. Gilsinn, "Synopsis on wireless ethernet (IEEE 802.11)", October 2001.

[3] Pablo Brenner, "A technical tutorial on the IEEE 802.11 protocol", Tech. Rep., BreezeCom Wireless Communications, June 1996.

[4] 3Com, "Bluetooth and Wi-Fi", July 2001, Positioning Paper.

[5] Eurescom, "Bluetooth and WLAN".
URL: *http://www.eurescom.de/˜pub-deliverables/P1100-series/P1118/D3/BLTandWLAN.html*

[6] Eurescom, "Bluetooth Access Points and Profile Specifications: Descriptions and recommendations".
URL: *http://www.eurescom.de/˜pub-deliverables/P1100-series/P1118/D3/bluetooth_profiles.htm*

[7] PaloWireless, "LAN Access Profile", Bluetooth Resource Center.
URL: *http://www.palowireless.com/infotooth/tutorial/k9_lap.asp*

[8] Jim Lansford, Ron Nevo, and Brett Monello, "Wi-Fi (802.11b) and Bluetooth simultaneous operation: Characterizing the problem", Tech. Rep., Mobilian Corp., 2000.

[9] Intersil, "Intersil and Silicon Wave unveil world's first dual-mode 802.11b and Bluetooth mini-PCI card reference design", May 2002, Press release.
URL: *http://www.intersil.com/pr/shell/0,1091,724,00.html*

[10] Intersil, "Microsoft demonstrates Blue802 technology from Intersil and Silicon Wave during WinHEC 2002", April 2002, Press release.
URL: *http://www.intersil.com/pr/shell/0,1091,713,00.html*

[11] Intersil, "Gigabyte licenses Blue802 technology from Silicon Wave and Intersil for dual-mode Bluetooth and Wi-Fi wireless solutions", June 2002, Press release.
URL: *http://www.intersil.com/pr/shell/0,1091,767,00.html*

[12] Thor-Gunnar Eskedal, Rima Venturin, Irena Grgic, Ragnar Andreassen, J. Charles Francis, and Christian Fischer, "Open access network concept, a B3G case study", in *Proceedings of the 12th IST summit on Mobile and Wireless Communications*, Atílio Gameiro, Ed. June 2003, pp. 618–622, Instituto de Telecomunicações.

[13] A. Rogoyski, O. Franzrahe, S. Tudge, and M. De Sanctis, "The market for wireless in-cabin aeronautical communications", in *Proceedings of the 12th IST summit on Mobile and Wireless Communications*, Atílio Gameiro, Ed. June 2003, pp. 623–627, Instituto de Telecomunicações.

[14] G. Bianchi, N. Blefari-Melazzi, E. Grazioni, S. Salsano, and V. Sangregorio, "Internet access on fast trains: 802.11-based on-board wireless distribution network alternatives", in *Proceedings of the 12th IST summit on Mobile and Wireless Communications*, Atílio Gameiro, Ed. June 2003, pp. 155–159, Instituto de Telecomunicações.

[15] Nomadix, "Nomadix Service Engine", January 2004, Datasheet.
URL: *http://www.nomadix.com/products/*

[16] Vernier Networks, "The Vernier Networks system", January 2004.
URL: *http://www.verniernetworks.com/products.html*