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Autor: Varone, Sacha / Meier, Cyrill

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Wireless Broadband Access Technologies

For over ten years wireless data transport for computing devices has been studied. The aim still is to use data communication devices without wires. There are quite a lot of broadband wireless technologies available today with different reach, bandwidth and power consumption. Categorised by their coverage and usage we can distinguish the "wireless device connections", the "wireless office networks" and the "mobile telecommunication networks". This article describes each category by related technologies and intended usage.

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SACHA VARONE AND CYRILL MEIER

The market for wireless broadband access shows a lot of new technologies and applications for the three categories depicted in figure 1. In the area of wireless devices connections, *Bluetooth* is establishing, for the office networks the *Wi-Fi* (Wireless Fidelity) enhances mobility, and for mobile telecommunication networks UMTS deployment is to come by 2002. This looks like there will be clear borders for each one of these areas in terms of reach and technology. But these borders are blurred by technologies like Wi-Fi, which in fact can be used to connect devices wirelessly, as well as to offer wireless office networks and to deploy public mobile data networks.

Current WLAN technologies allow cheap deployment of broadband wireless networks for mobile Internet or Intranet access. The next generation WLAN technologies will offer even more bandwidth (about 5 times) while keeping costs at a very low level. These technologies are and will be natural choices for any kind of mobile data communication.

In the USA WLAN is already available in a few hundred hotels, airports and cafés. Furthermore, there are growing community networks in Seattle, San Francisco, Boston, Portland or Oregon. In August this year the pioneer in the field of wireless data access *(Ricochet)* had to terminate its service. Ricochet's product was the first one offering wireless Internet access, but could no longer compete with the much cheaper WLAN services. In Switzerland, *Monzoon* networks made an agreement with Swissair to provide WLAN in their business lounges. Furthermore, they offer public WLAN access at the "Züriseepromenade".

Wireless Device Connections
Wireless device connections are short range (up to 10 m) and mainly used by devices like mobile phones, PDAs etc. The term WPAN (Wireless Personal Area Network) is used as a synonym. Currently, there are three main technologies offering broadband wireless device connections (fig. 2):

IrDA *(Infrared Data Association)*
IrDA's international membership is supported by hardware, systems, software, peripherals, component and communications manufacturers, cable and telephone companies, automobile and service providers. It is one of today's most often used technologies and allows, for example to use a mobile phone (with integrated modem) to access the Internet from a notebook. The weakness of IrDA is its limited usability, as it forces the user to place the mobile phone and notebook in a line of sight no further than 1 m away.
IrDA is a point-to-point ad-hoc data transmission standard based on infrared light. It is installed in about 150 million electronic devices like television remote controls, PCs, PDAs or mobile phones. The developed standard provides data rates from 9.6 kbit/s to 4 Mbit/s, while a standard for 16 Mbit/s is under development. The speed most often used is 115.2 kbit/s. With about 2 US-$ integration costs IrDA is a cost-effective technology.

Bluetooth
The Bluetooth SIG (Special Interest Group) has members from telecommunications, computing and network industries and was formed by Ericsson, IBM, Intel, Nokia and Toshiba. In a second step, Lucent, Microsoft, 3Com and Motorola joined the team. Today more than 2400 manufacturers are involved. Bluetooth is designed for short range and low power consumption voice or data transfer. It defines 79 channels (each one 1 MHz wide) in a licence-free spectrum (2.40-2.48 GHz) and hops between these channels (1600 times per second). Each channel offers 1 Mbit/s throughput and gets profiled into syn-

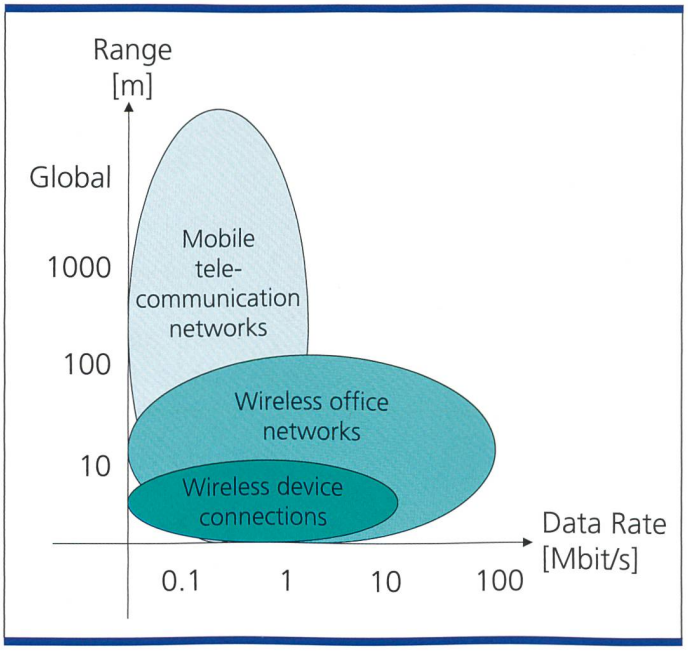

Fig. 1.
Wireless broadband access categories.

chronised data (430 kbit/s bi-directional), asynchronised data (720 kbit/s and 57 kbit/s) and synchronised vocal canals (64 bit/s bi-directional). Bluetooth transmits through solid non-metal objects and supports point-to-point or point-to-multipoint connections. The point-to-multipoint mode supports 2 to 8 Bluetooth devices. The nominal link range reaches from 10 cm to 10 m. The power consumption is as low as 50 mA if active or about 20-30 (A in standby mode. The evolution of Bluetooth generation 2 discussed today shall offer 10 Mbit/s throughput and extend the range up to 100 m.
Because of its targeted low implementation cost of 5 US-$ per unit (20 US-$ up to now) and the low power consumption, Bluetooth is a favourable technology for integration into mobile phones, PDAs etc. It is now entering the market and is forecasted to get big in 2002-3 [7].
Bluetooth is said to gradually replace cables and infrared as the primary means of wirelessly exchanging information between devices [12]. A study from Frost & *Sullivan* estimates the market to be 1.8 billion US-$ worth this year and rising up to 330 billion US-$ by 2006.

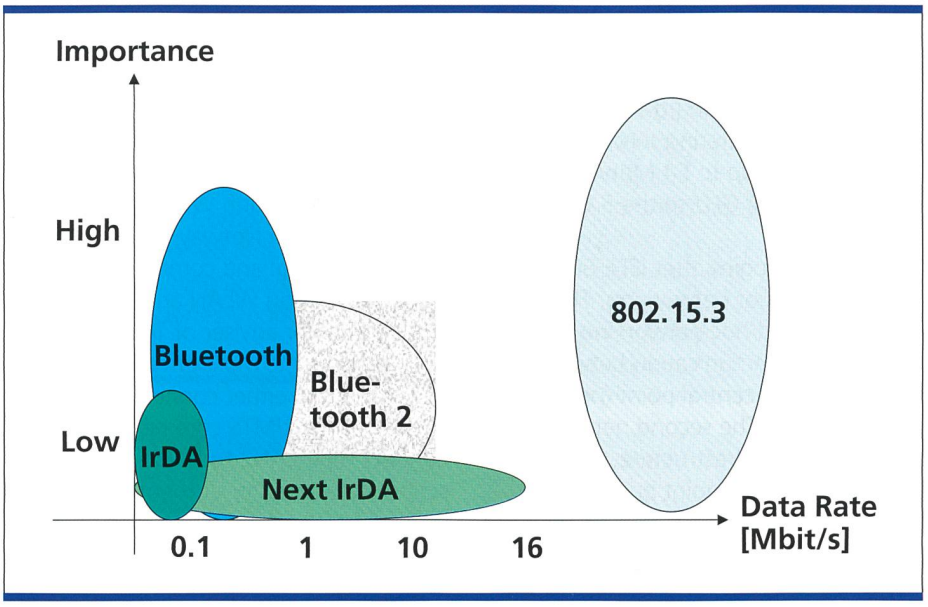

Fig. 2. Wireless devices connection technologies.

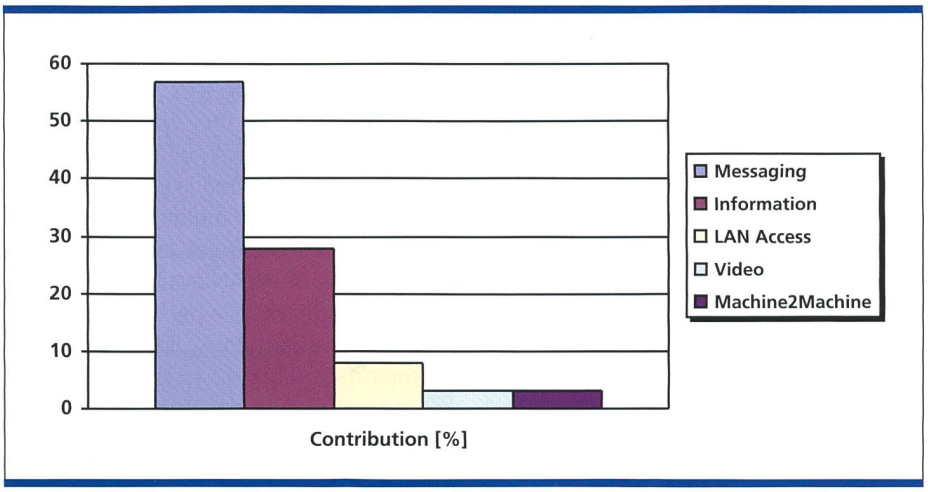

Fig. 3. Relative contribution to mobile services revenue.

IEEE 802.15
The IEEE runs a group called 802.15 with the goal to develop PAN consensus standards for short distance wireless networks. The following 4 task groups are defined:
- 802.15.1: WPAN (Bluetooth 1.0)
- 802.15.2: Coexistence Mechanisms in 2.4 GHz band
- 802.15.3: High rate WPAN
- 802.15.4: Low rate WPAN

The future IEEE standard for WPAN will support high data rates (22 Mbit/s to 66 Mbit/s) to facilitate the transfer of multimedia content among portable devices and operate in the licence-free 2.4 GHz band. The highest data rates will include redundant coding and therefore decrease the effective data rate. The first standards are expected to be completed in 2003 and the first devices to appear in 2005. The purpose is to replace Bluetooth, though the backward compatibility with existing Bluetooth devices is not yet defined.

Wireless Office Networks
The wireless office networks are characterised by their reach of about 100 m and throughput of about 10 Mbit/s. They are called WLANs (Wireless Local Area Networks) and have the goal to remove the data cables hindering the mobility of notebooks and PDAs. There are two strong competing norms: HomeRF and Wi-Fi, with advantages for Wi-Fi. Up to now WLAN technologies have used the license-free spectrum of 2.4 GHz, but will evolve into the 5 GHz band with the next generation. The advantage of free of charge unregulated frequency bands has the drawback of interference from other technologies like Bluetooth, microwaves, cordless phones etc.

HomeRF
The HomeRF Working Group has developed a specification called SWAP (Shared Wireless Access Protocol) for a broad range of consumer devices. It is an open specification allowing PCs, notebooks, cordless telephones etc. to communicate via voice and data. The initial standard offered 1.6 Mbit/s of throughput but is enhanced now by HomeRF 2.0 offering 10 Mbit/s and planned to offer 20 Mbit/s in the near future. Unlike other WLAN standards, the HomeRF protocol provides high quality voice capabilities. Nevertheless, the acceptance and importance of HomeRF on the consumer market is decreasing, mainly due to growth and bigger market acceptance of the Wi-Fi technology.

Wi-Fi *(Wireless Fidelity)*
Wi-Fi is a trademark promoted by the WECA (Wireless Ethernet Compatibility Alliance) to certify interoperability of IEEE 802.11 products and to promote Wi-Fi as the global WLAN standard across all market segments. The most current IEEE

WLAN standard available on the market is 802.11b offering 11 Mbit/s of throughput in a range of about 100 m. The next WLAN standard from IEEE is called 802.11a, offering throughput from 20 Mbit/s up to 54 Mbit/s and shifting from the 2,4 GHz to the 5 GHz frequency band.
WLAN technologies after IEEE 802.11 offer two modes of networking. The first one is called ad-hoc networking, allowing mutual communication between devices without a central point (peer to peer, see [13]). The second networking mode is called infrastructure, consisting of a central access point bridging the traffic from several devices connecting to this access point.
The IEEE WLAN standard includes an access control list for, and encryption of, the link layer. The access control list limits access to well-known MAC addresses. The encryption of the link is called Wired Equivalent Privacy (WEP) and should offer similar security as wired Ethernet connections. At the moment both of those security options are proven to be insecure for business applications, but still offer enough security for residential users.

Hiper*LAN*

The HiperLAN was defined by ETSI. It offers two different types and uses the 5 GHz frequency band. Type 1 offers 20 Mbit/s of throughput while type 2, also called HiperLAN2, enhances the throughput up to 54 Mbit/s. The HiperLAN2 and the IEEE 802.11a are competitors for the next generation WLAN standard. Nevertheless, ETSI has announced that it intends to work with the IEEE 802.11 Working Group for converged standards in the 5 GHz band. First products implementing HiperLAN2 are expected by end of 2002.

Mobile Telecommunication Networks

Mobile telecommunication networks like GSM have a coverage of several kilometres. Typically, they are link-oriented and offer per link about 10 kbit/s-20 kbit/s today (GPRS) and 0.1 Mbit/s-0.3 Mbit/s tomorrow (EDGE). UMTS, the third generation of mobile telephony, will deliver at most 2 Mbit/s. To recover network costs, carriers will probably need to charge high fees: Nokia for example envisions carriers to charge their customers 2 US-$ per multimedia message [6].
Compared to today's public WLANs the UMTS networks will offer lower throughput and comprise higher costs. Given this situation Wi-Fi can be seen as a complement [7] or as a concurrent to UMTS [8].
In Scandinavia Ericsson and Telenor explore the possibility of integrating UMTS with next-generation WLAN technology. A pilot project in Norway is designed to test the practical and commercial potential of combining WLAN and UMTS. Fin Trosby, a senior adviser of Telenor Mobile, analyses the most effective method of integration: either connect HiperLAN2 directly to the UMTS core network or connect HiperLAN2 to UMTS via the subscriber database, for authentication, authorisation and accounting, and via the Internet for user traffic [11].

Forecasting on the Market

Looking at today's offices we mostly see mobile phones, notebooks and PDAs of different flavour. Projecting this environment into the near future does not change or replace devices, but their meanings and how they will be used.
The mobile phone will fulfil the need for mobile communication like phoning, notifications and small multimedia messages. Notebooks will be even more mobile because of WLAN availability. The PDAs will offer mobile personal information management (PIM), linked wireless to the office network. All these devices will have a preferred wireless access technology, meaning that there are and will be other possibilities offering the same functionality. The mobile phone will use GSM, GPRS or UMTS (decreasing order of usage numbers). WLAN will be the default office network access for all new notebooks. PDAs will use Bluetooth or WLAN to synchronise their PIM data automatically or access data and services.
Looking at forecasted revenues for 2005, the mobile data services in Western Europe will generate 62 billion US-$ of annual revenues corresponding to 32% of total mobile service revenues. As shown in figure 3, the most significant contributors to revenue will be messaging (57%) and information services (28%). LAN access is expected to contribute less than 10% of the mobile data market. These numbers are based on the assumption that about 95% of all mobile phone customers will use some form of messaging and 68% will use information services. The Yankee Group thinks that customisable information will become a premium service and the focus must be on location-based content and transactional applications via mobile devices (e.g. mobile ticketing, secure payment). About 95% of all mobile phone users are assumed to use and pay for non-voice messaging services by 2005. The Yankee Group also believes that, despite earlier disappointments, WAP will play an important role in the mobile data marketplace [1].
In that sense, innovation in these markets is more about location than application, as pointed out by the Gartner Group [2]. For the Yankee Group, the ability to effectively bundle WLANs with existing products and services will be key to capture market share [5].

Conclusions

The development of WPAN and integration into mobile devices (mobile phone, PDA , notebook, etc) does not seem very lucrative for telcos. It is true, telcos cannot profit directly from the generated local traffic, but the growth of mobile interconnected data devices will exhibit customer needs which should be fulfilled by telcos. One idea of such a need is a simple address book service that could be used from any mobile device a customer has in hands' reach.
Although the WLAN market has just started, it already gets crowded. This results in products focusing on specific customer needs, for example wireless home network, public WLAN operators, small or enterprise offices [2]. Furthermore, the market shows the Wi-Fi technology getting dominant by growing fastest into any customer segment (business and residential). The upcoming issues to be solved in the WLAN area are management and security [3, 4, 5], as well as quality of service (QoS) and roaming [9, 10].
Offering services for mobile Internet based on WLAN in public areas profits from the license-free frequency band, as well as cheap consumer products forming a de-facto standard. The drawbacks of public WLAN services are interference with any other technology using the same frequencies, as well as the strong first mover advantage, as no alternative frequency bands can be used if a hot spot already is covered by a competitor.
The evolution of the mobile telecommunication networks is set and leads to UMTS. It is designed for mobile voice and data communication. Mobile voice will most probably stay on these kind of

networks, but the current evolution in WLAN technologies and their public deployment shows a better and cheaper way for mobile data services. Most probably mobile telecommunication networks will not be able to aggregate the targeted data traffic, mainly because this traffic will be collected by public WLANs and linked WLAN roaming services. [3]

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Sacha Varone *holds an Engineer's degree in mathematics and received a doctoral degree in applied mathematics from the EPFL (Ecole Polytechnique Fédérale de Lausanne) in 2000. He then joined Swisscom Corporate Technology where he is involved in technology trends, data mining activities, text classification and business models.*

Cyrill Meier *worked as a Software Engineer since 1986, having previously studied electrical engineering for 3 years at the ETH, taking a dipl. Ing. HTL degree at ISB in 1994. He was then an assistant at ISB and worked for Ascom Tech before joining Swisscom. His technical experience ranges from Basic, Pascal, Modula, C, SmallTalk, C++, Objects, Components, and RDBs to xDSL, NT, IP, IPmc, Live-TV streaming over IP, PC & Server, and Games. Cyrill Meier is currently working as a Senior Engineer at Swisscom AG, Corporate Technology, in the field of Multimedia Services.*

Résumé

Depuis plus d'une dizaine d'années, la transmission de données sans fil est étudiée. Plusieurs technologies de transmission haut débit sans fil sont aujourd'hui disponibles. Elles diffèrent par leur capacité de couverture, leur consommation d'énergie ou leur taux de transmission des données. Dans la catégorie de couverture d'une dizaine de mètres, Bluetooth s'établit comme la technologie de choix pour des appareils comme des assistants personnels ou des téléphones portables, grâce à sa faible consommation d'énergie. Wi-Fi, soutenus par de grands groupes industriels, s'impose en tant que solution pour les réseaux sans fil à l'intérieur des bureaux ou chez soi. Les réseaux de communication pour les téléphones mobiles utiliseront prochainement les technologies du GPRS ou de l'UMTS.

Pointers

www.irda.org
www.bluetooth.com
www.homerf.org
www.wi-fi.org
www.etsi.org/technicalactiv/hiperlan2.htm
www.umts-forum.org
www.monzoon.ch
www.ricochet.com
www.uwifi.com

Abbreviations

EDGE	Enhanced Data rates for GSM and TDMA/136 Evolution
GPRS	General Packet Radio Service
HomeRF	Home Radio Frequency
IrDA	Infrared Data Association
ISP	Internet Service Provider
PDA	Personal Digital Assistant
UMTS	Universal Mobile Telecommunications System
UWB	Ultra Wide Band
WAN	Wide Area Network
WECA	Wireless Ethernet Compatibility Alliance
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network