Wireless Access to the Internet

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Abstract: The methods of wireless internet access have been presented. The digital cellular systems, wireless LANs and other solutions have been shortly described. The configurations of wireless internet access networks have been presented.

Key words: wireless transmission, internet access

1. INTRODUCTION

Internet became the main communication medium between computer based devices all around the world. Lots of information and services can be accessed from any computer connected to the Web. Progress in miniaturization of electronic parts has allowed developing portable and even handheld computers, small but with capabilities comparable to the desktop ones. These computers can be connected to the internet using standard wired links, but it is desirable to use wireless technique instead of the cable.

Main disadvantage of wireless connection is the speed of the transmission that is comparable to dial-up access using modem but is much lower then the leasing line connection. Wireless devices usually consume more power and need better processor to work. However benefits of wireless internet connection are unquestionable. Mobility, comfort of the use, uninterrupted access from work, home and even during travel cause using of portable Web connected devices very attractive.

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2. STANDARDS AND SYSTEMS OF WIRELESS NETWORKS

Nowadays, there are few ways to access the Internet using wireless transmission media. Probably the most popular method in Poland is an access using GSM cellular phones, including more advanced and cheaper to use GPRS protocol. In this case the transmission range is big, but the transmission speed is not very high. Therefore other methods are required. Possibly one of them would be an UMTS standard, but it seems it is a future solution.

Another ways to access the Internet without cables are wireless local area network (WLAN) standards. There are two main WLAN standards today: IEEE 802.11 and ETSI HiPeRLAN. Both of them have several versions, which offer different transmission speeds and which work in different radio bands.

There are also very short-range solutions, like IrDA and BlueTooth systems. Although it seems they can not be used as the only one wireless medium, they should not be omitted, because they have – or may have in the near future – some interesting applications.

2.1 GSM Standard

GSM (*Global System for Mobile Communications*) [1, 2] is an European standard of digital cellular telephony, defined by ETSI (*European Telecommunications Standards Institute*). Nowadays it is one of the most popular cellular telephony systems in the world. It allows not only voice, but also data transmission, therefore we can say it is some kind of network of global range.

GSM operates in few radio bands. The basic one, called GSM 900, occupies bands 890-915 MHz for uplink (from phone to base station) and 935-960 MHz for downlink (from base station to phone). In this band there are 124 frequency channels available. There is also GSM 1800 (formerly DCS 1800) band, which occupies frequencies 1805-1880 MHz for uplink and 1710-1785 MHz for downlink, which allows up to 374 frequency channels. These are the most popular band versions. There is, however, another band, called E-GSM, which has 174 channels in bands 880-915 MHz and 925-960 MHz and can be used instead of standard GSM 900 if the frequency bands are available. Yet another version is GSM 1900, which is used for instance in USA and Japan, where 900 and 1800 MHz bands are not available for GSM.

In general, the speed of data transmission equals to 9.6 kb/s. There is one exception – if both communicating terminals are placed within the range

of the same MSC (*Mobile Switching Centre*), the speed may grow up to 12 kb/s. The modification of protective coder allows transmitting at speeds up to 14.4 kb/s.

Because these speeds are very low, it is possible to assign two or more time slots to one user. This method, called HSCSD (*High Speed Circuit Switched Data*), allows transmitting at speeds up to 28.8 kb/s with standard phone and up to 76.8 or 115.2 kb/s when using modified mobile stations.

2.2 DECT Standard

DECT (*Digital Enhanced Cordless Telecommunications*) [1, 2] is an European standard of digital cordless telephony, defined by ETSI. It can be used, however, in many applications, for example as an extension of cellular network or as a wireless network access medium.

DECT works in the band 1880 – 1900 MHz. This band is divided into frequency channels of 1.728 MHz each, which are next divided into time slots. The transmitter power is limited to 250 mW, which ensures range of 200 m. The station may roam with speed up to 20 km/s.

Usually there is one slot occupied by uplink and one by downlink in the connection. This is, however, not mandatory: it is allowed to assign more channels to one connection, not excluding asymmetric mode. Thus, it allows data transmission with speeds from the range of 24 – 552 kb/s, which makes DECT an attractive alternative when creating a wireless local area network. Unfortunately, there are not many commercially available devices which support such an application.

2.3 GPRS Method

GPRS (*General Packet Radio Service*) [3] is the system of data transmission that uses data packet switching instead of circuit switched data transmission. It can work over standard mobile telecommunication networks as GSM or TDMA. Packet switching means that GPRS radio resources are used only when users are actually sending or receiving data, thus GPRS method allows to efficiently use the network bandwidth.

User data is transferred transparently between the mobile station and the external data networks with a method known as encapsulation and tunnelling. Data packets obtain GPRS specific protocol fields and are transmitted using one or more time slots that are reserved dynamically. Maximum number of time slots that can use one mobile device is 8. Theoretically GPRS offers maximum speed of transmission as much as 171 kb/s but actually available devices support one slot of 14,4 kb/s in uplink direction and four slots of summary 57,6 kb/s in downlink. Dynamic slot

reservation allows network to balance between data and voice transmission. Packet switching allows using time slot of the same number by many mobile users. Modified coding scheme could increase slot throughput from 14,4 kb/s up to over 21 kb/s but because of lack of error correction mechanism transmission requires stronger radio signal.

GPRS is dedicated to internet connections and uses the same protocols so it can be viewed as internet subnetwork with mobile hosts. It is possible to address any GPRS connected device with its own IP address.

2.4 UMTS

UMTS (*Universal Mobile Telecommunications System*) [2] is an European proposal of a system, which would integrate all the wireless and mobile systems segments (for example, paging systems, cellular systems, local area networks, trunking systems and so on). This proposal, initiated by ETSI, is also developed by ITU (*International Telecommunication Union*) as an IMT-2000 (*International Mobile Telecommunications*) standard.

The frequency bands for UMTS are reserved in the 2 GHz range. There are two bands: 1885-2025 MHz and 2110-2200 MHz. As in UMTS there are several transmission methods implemented, these bands are then divided into subbands:

- terrestrial UMTS with time division duplex and TDMA/CDMA access method (1900-1920 and 2010-2025 MHz),
- terrestrial UMTS with frequency division duplex and wideband CDMA access method (1920-1980 and 2110-2170 MHz),
- satellite UMTS with frequency division duplex (1980-2010 and 2170-2200 MHz).

There are several services available in UMTS standard, like telephony, remote control, data transmission, e-mail and so on. Transmission speed, acceptable time delay and error foot are defined individually for each service. The maximum transmission speed is 2 Mb/s, but only few services need such a high speed.

2.5 IEEE 802.11

IEEE 802.11 [4] is an American standard of wireless local area networks (WLAN). As based on commercially available devices, it is nowadays very popular. There are still more and more devices compatible with this standard and available on the market. Among others, there are network cards for different bus types (PCI, PCMCIA, previously also ISA), access points which allow wireless access to the wired network, and finally wireless bridges. This standard has been also accepted by ISO as 8802.11.

There are two network architectures defined by the standard:
- ad-hoc network, with no wired elements,
- infrastructure network, with access points which act as bridges between wired and wireless network segments.

The 802.11 standard is now available in three versions. The basic one, 802.11, defines three physical medium variants:
- direct sequence spread spectrum (DSSS),
- frequency hopping spread spectrum (FHSS),
- baseband infrared.

For all these physical layers there are two transmission speeds available: 1 Mb/s, which is mandatory, and 2 Mb/s, which is optional for data frames only. In addition, there is one medium access protocol defined for all three variants. This access protocol is based on carrier sensing (CSMA) with an optional RTS-CTS frame exchange.

Both DSSS and FHSS physical layers operate in an ISM band 2.4-2.4835 GHz, which is available worldwide (except some countries) for data transmission with no license required. There are, however, power limitations which may vary between countries, and there is an obligation to use spread spectrum techniques in the transmission devices. The transmission range is about 20-30 m within buildings and up to 300 m outside. The range can be extended by the usage of directional antennas.

The 802.11b [5] version defines two higher transmission speeds: 5.5 and 11 Mb/s. This standard operates in 2.4-2.4835 GHz as well, but the only physical medium is direct sequence spread spectrum. The MAC protocol remains the same.

The 802.11a version is quite different [6]. It operates in 5.15 – 5.35 and 5.725 – 5.825 GHz UNII (*Unlicensed National Information Infrastructure*) band with narrow band radio signal. The band is divided into three domains, which have different transmitter power limits (50 mW, 250 mW and 1 W). Unfortunately, availability of the domains may vary between different regions (for example, in Europe there is only the lower band available and in Japan only the higher one).

In each domain there are several independent frequency channels of 20 MHz, which are then divided into 52 subchannels each. Instead of spectrum spreading, in 802.11a the signal is transmitted on 48 carrier frequencies in parallel, while the remaining 4 frequencies are left for error correction. Depending on the modulation method used, the speeds can be equal to 6, 9, 12, 18, 27, 36 or 54 Mb/s.

Like in the IEEE 802.11, the MAC protocol in 802.11a is CSMA/CA.

Current works are concentrated over 802.11g standard, which should be backward compatible with both 802.11a and 802.11b versions. One of the

aspects addressed in this version is implementing transmission method used in 802.11a in the ISM 2.4 GHz band.

2.6 ETSI HiPeRLAN

HiPeRLAN (*High Performance Radio Local Area Network*) [4] is an European standard defined by ETSI. It ensures high transmission speed, allowing both asynchronous and time-bounded applications coexist on the same link. It also allows creating ad-hoc and infrastructure networks. Unlike IEEE 802.11, HiPeRLAN was not based on any commercially available device, thus its availability is nowadays still very poor, although the standard is now few years old.

For the needs of HiPeRLAN, there are two radio bands reserved in Europe: 5.15 – 5.30 GHz and 17.1 – 17.3 GHz. Both bands are divided into several frequency channels of 25 MHz each. There are two transmission speeds:

- LBR (*Low Bit Rate*), equal to 1.4706 Mb/s ± 15 b/s,
- HBR (*High Bit Rate*), equal to 23.5294 Mb/s ± 235 b/s.

The LBR speed is used to exchange control information, whereas HBR may be used to transfer larger pieces of data. The transmission range for LBR is up to 800 m, while for HBR it is only 50 m. The stations may roam with speed not exceeding 10 m/s. The transmitter power limit is 1 W in the 5 GHz band and 100 mW in 17 GHz band.

A very interesting part of the HiPeRLAN standard is medium access procedure, called EY-NPMA (*Elimination Yield – Non-preemptive Priority Multiple Access*). It uses carrier sense mechanisms as well as conflict elimination and solution procedures. It allows multiple priorities transmissions share one link, thus allowing for both time-bounded and asynchronous transmission. It is, however, relatively complicated when compared to other MAC protocols, and in authors' opinion it may be one of the reasons why HiPeRLAN is not as popular as IEEE 802.11 which offers lower transmission speeds, even in 802.11b version.

The HiPeRLAN/2 [7] standard is a new proposal, which can be viewed as an European alternative for the IEEE 802.11a standard. Both standards operate in 5 GHz band, and both offer transmission speed as high as 54 Mb/s. These standards are very similar on the physical layer. However, the main difference lies in the medium access control – HiPeRLAN/2 uses dynamic TDMA scheme instead of CSMA, which is used in IEEE 802.11. This is because 802.11 was designed to play a role of wireless Ethernet, while HiPeRLAN was designed to be rather a wireless ATM.

2.7 IrDA

IrDA (*Infrared Data Association*) standard has been developed to define wireless data transfer using infrared light. Transmission is possible between up to eight devices on very short range not exceeding 3 meters. IrDA compliant components are small, cheap and consume little power so they are widely used in portable devices. Basic devices achieve speed of the transmission up to 115,2 kb/s. Contemporary available IrDA devices can transmit data at 4 Mb/s rate, but with new standard extension speed of the transmission can be exceeded to 16 Mb/s[8].

IrDA standard consists of layers similar to HDLC definitions. The lowest layer IrPHY defines physical parameters of infrared link and modulation and coding scheme used for different speed of transmission (Table 1).

Table 1. IrDA physical layer variant parameters

Layer	Transmission speed	Coding and modulation
Sir	9,600 – 115,200 kb/s	On off keying – OOK
Mir	0,512 Mb/s; 1,152 Mb/s	On off keying – OOK
Fir	4 Mb/s	Pulse position modulation - 4PPM
VFIr	16 Mb/s	Run length limited - RLL(1;13)|5

IrLAP layer, lying above IrPHY, standardizes protocol for accessing the medium, controlling the link parameters, connecting and disconnecting procedures with device discovery. Next layer called IrLMP describes protocol of link management with ability to maintain few logical channels in one IrLAP link. Next layers are optional. TinyTP defines transport protocol, IrLAN standardizes access to wired local networks, IrCOMM describes using infrared instead of wired serial or parallel computer ports. There are also extensions that establish the rules for voice and picture transmission, object exchanging and device controlling.

2.8 BlueTooth

BlueTooth [9] is some kind of *de facto* standard. The description was published by BlueTooth Special Interest Group (SIG) organisation and defines:

- radio link parameters,
- link controller functions,
- link management functions,
- software functions.

The radio link operates in the ISM band 2.4 – 2.4835 GHz and uses frequency hopping procedure of spectrum spreading. The band is divided into 1 MHz wide channels, allowing for transmission speed equal to 1 Mb/s. The transmitter power is limited to 100 mW, giving range of 10 m, which can be extended to 100 m.

In BlueTooth there are master and slave stations. Few slaves and one master form a *piconet*, while several piconets form a *scatternet*. Between master and slave two kinds of link can be established:

- SCO (*Synchronous Connection Oriented link*),
- ACL (*Asynchronous Connection-Less link*).

The SCO is a symmetric link between one master and one slave in one piconet. This link uses cyclic slot reservation, so it can be used for time-bounded transmission. The frames are never retransmitted. The transmission speed is equal to 64 kb/s.

The ACL is a multidrop link and it can be used for the transmission between master and all the slaves which belong to the same piconet. It uses time slots not used by SCO and can transmit both asynchronous and isochronous traffic. The frames can be retransmitted. The link offers speeds up to 2×432.6 kb/s in a symmetric mode and 721+57.6 kb/s in asymmetric mode. It is also possible to send data and voice together at speeds 2×64 kb/s (voice) and 2×57.6 kb/s (data).

There are several profiles, which describe the application of the BlueTooth system in different situations [10]. For example, there are Cordless Telephony, Intercom, Serial Port, Headset, Dial-up and LAN Access profiles.

Unlike IrDA, the BlueTooth system is going to be not only a *de facto* standard. It is a part of a new WPAN (*Wireless Personal Area Network*) standard, which is being defined by IEEE as 802.15 standard.

2.9 IEEE 802.15

At the point of interest of IEEE 802.15 standard [11] lay Wireless Personal Area Networks (WPAN). Networks of this type operate at very short range, typically not exceeding 10 meters in all directions. They are intended to provide data transfer between desktop or handheld devices such as cellular phones, palmtop computers, headphones and any device that can be carried and located near the owner's body. One part of this work called 802.15.1 is created with cooperation with the BlueTooth Special Interest Group to ensure compatibility with many devices that are already available on the market. In fact, the IEEE 802.15.1 standard is fully compatible with BlueTooth specification version 1.1.

The 802.15 operates at 2.4 – 2.4835 GHz unlicensed band, the same as 802.11b, thus second part's scope is ensuring coexistence both wireless

networks and facilitating they cooperation. Third part of 802.15 standard focuses on physical layer allowing higher speed of the transmission. Symbol rate for 802.15.3 transmission equals to 11 Msymbols/s. According to data rates it uses different modulation techniques and coding schemes, as collected in Table 2.

Table 2. IEEE 802.15.3 physical layer parameters

Data rate	Modulation	Coding
11 Mb/s	BPSK	No coding
22 Mb/s	QPSK	No coding
33 Mb/s	16-QAM	8-state Trellis Code - TCM
44 Mb/s	32-QAM	8-state Trellis Code - TCM
55 Mb/s	64-QAM	8-state Trellis Code - TCM

The 802.15 standard is not fully completed yet, although compatibility with Bluetooth, and interoperation with popular 802.11b may lead to its success on the market.

3. NETWORK CONFIGURATION

Depending on hardware we use, various network configurations may use wireless transmission media. Although there are several systems and standards, their usage is limited only to certain places in the network. In addition, parameters of these systems will limit the transmission parameters, like range and speed.

3.1 Wireless access via the telephone line

Computer with modem that can work wirelessly according to DECT standard can access the internet through cordless base station. DECT base station is connected to the fixed telephony network and can be used by cordless phone and modem. If it is connected to the ISDN line, phone calls and internet access could be provided simultaneously. A very similar connection can be made using BlueTooth system instead of DECT standard. Using BlueTooth, user can sometimes achieve slightly higher transmission speeds at a cost of much shorter range. Maximum transmission speed for DECT is 552 kb/s, and for BlueTooth - 432 kb/s (or 721+57.6 kb/s in asymmetric mode). Maximum range is 250 m for DECT and 10 m for BlueTooth.

3.2 Wireless access via the local area network

Wireless internet connection can be made with 802.11b compliant devices. Computers that are equipped with radio wireless cards can communicate with the access point connected to the standard wired local network, as shown on Figure 1. There are also some computer models available with a built-in 802.11b communication module. It is also possible to use BlueTooth system in this application, but at limited speed and range. Obviously, one can also use HiPeRLAN standard compatible devices, however, there are not many products available in this category.

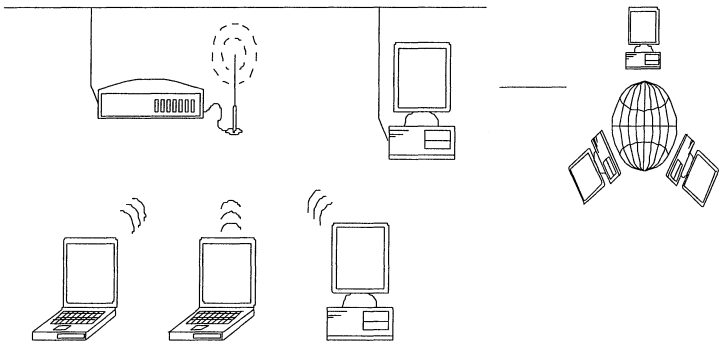

Figure 1. Wireless access via the local network

The maximum transmission speed for IEEE 802.11 compatible devices is 11 Mb/s, but it should be noticed, that the longer the transmission range, the lower the maximum speed is obtained. Typically, the range does not exceed 30-50 m, but in special cases (for example directional antennas) it can be extended up to few kilometres. When using BlueTooth, the range is limited to 10 m and speed to 1 Mb/s. HiPeRLAN-compatible devices should deliver speed of about 20 Mb/s at the range of 50 m.

3.3 Wireless access via the LAN using IrDA

One of upper IrDA layers called IrLAN [12] standardizes access to the local area networks. Using IrLAN the device can obtain internet access when is placed in the range of IrDA compatible access point device, as shown on Figure 2. Access point can be standalone device connected

directly to the wired LAN or internet connected desktop computer equipped with IrDA module.

The transmission range is extremely short – it should not exceed 1m. The transmission speed depends on which physical layer is used so the transmission speed can be lower than 115.2 kb/s or even as high as 16 Mb/s.

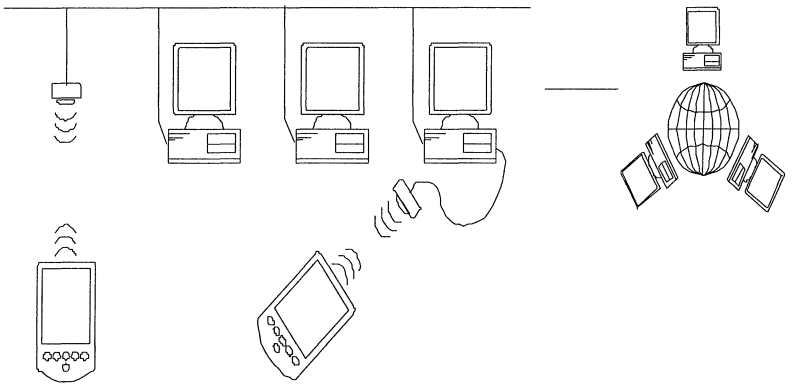

Figure 2. Wireless access via the LAN using IrDA

3.4 Wireless access via the cellular network

Another IrDA layer, IrCOMM [13], which is serial or parallel port emulation, can be used as a wire replacement to connect the computer to the mobile telephone that acts as a modem. Mobile phone is locally connected via infrared IrDA to the computer and on the other side via radio link to the web resources. The same technique can work with BlueTooth instead of IrDA. This configuration is shown on Figure 3.

The transmission speed is limited by the capabilities of the GSM standard, because the speeds between the computer and cellular phone are typically much higher. The distance between computer and phone is limited to 1-10 m, but users would rather see the global range of the GSM network.

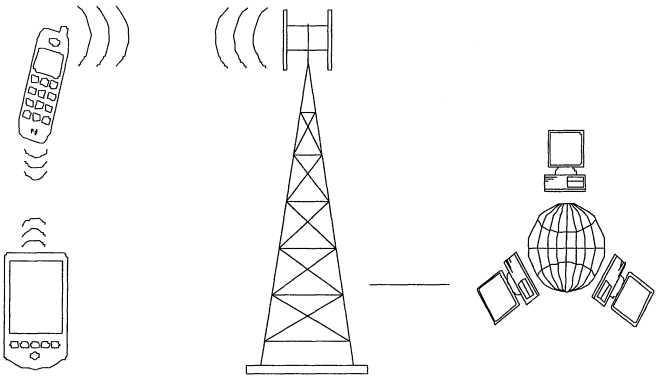

Figure 3. Wireless access via the cellular network

4. SUMMARY

It is not easy to predict the future directions of the wireless network development. There are, however, two ways, which in our opinion will be the most interesting for the users:

- global (world-wide) access via the cellular networks,
- local (short-range) access via the local area networks.

The global access via the cellular networks is nowadays getting very popular due to the expansion of cellular telephony and WAP technologies. Its usage is however limited because of relatively low transmission speed.

The access via the LANs will never be so popular, because of relatively short range of access points. But there are some places, where this way of wireless internet access will be a good solution, for example airports, hotels, restaurants and so on.

Between these two solutions there are few alternatives. The first of them is UMTS, which should ensure high transmission speed (up to 2 Mb/s) at the wide area range. But it is not free of some problems – the network operators behave as if they were afraid of investing in this system. And it should be noticed that the wide area range will not be reached at once – probably only the city centres will be covered in the beginning.

Another alternative is wireless broadband access network. There is some research in this area, but both American and European solutions seem very far from being completed.

Thus, for the next few years, we should not expect any revolution in the methods of wireless access to the internet.

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