Mobile Communications: 4G

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Abstract
4G of mobile communications describes the main research and development directives and technologies beyond the 3G of mobile communications. The name is interpreted slightly differently in various publications but signifies similar ideas.

Mobile communications have been one of the hottest areas of telecommunications, famous for fast development and growth. First steps of cellular telephony reach back to the year 1981 which is the year of introduction of Nordic mobile telephone (NMT), termed also the first generation (1G). In 2006 there are approximately 2.5 billion mobile phone users worldwide. 3G has been introduced to most of the developed countries around the world and has already reached the number of 100 million subscribers in 2006. It seems that the number of mobile devices connected to Internet will soon exceed the number of static desktop clients. Next generation has not been defined yet but various scenarios and ideas have been proposed. In this entry we summarize some most important published predictions of future mobile communications, and its main concepts and technology background. It seems that next generation is going to be "user-centric", which means that user needs and wishes will drive the research and development. Undoubtedly high data transfer rates, quality of service (QoS) and continuous coverage will be the most important features. We point out the key technologies which will form the basic platform for future mobile networks and list the most important forums and research groups in this area.

FROM 1G TO 4G

NMT network started in September 1981 in Saudi Arabia, consisted of 20 cells, operating at 450 MHz .[1] In Europe NMT started operating in 1982 in Sweden, Norway, Denmark and Finland. The first multi-national cellular system (NMT450) contained 600 cells and also offered roaming. Later on, nine different and incompatible cellular systems developed around Europe: Total access communications system (TACS) in Great Britain in 1985, C-Netz in Germany, Radiocom 2000 in France, Radio Telefono Mobile Integrato (RTMI) in Italy, etc. All systems worked well but would not work together which means that roaming was not possible.

First commercial cellular system in United States—advanced mobile phone service (AMPS) started operating in 1983 in Chicago. AMPS was bought and applied also in South Korea in 1984.

NMT is considered as the official first generation of mobile communications (1G). It was an analog system which outlined some basic "laws" of cellular mobile telephony:

- Cell structure of system (repetition of frequency);
- Total mobility of users and roaming between different NMT systems;
- Continuous connection despite changes of communication channel and environment.

NMT served specifically for voice communications while data transfer to and from mobile terminals was not considered at that stage. High prices of mobile phones and services limited the use of 1G mobile communications mostly to professional users only.

The incompatibility between different cellular systems forced Europe into the planning of new uniform system. In 1982 the research and development of 26 European Telecom companies resulted in GSM. New entirely digital

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cellular system operated in a new radio band (900 MHz) and without backward compatibility. Commercial GSM networks started operating in Europe in 1991.

In USA in 1989 Telecommunication Industry Association (TIA) developed standards for new digital system called interim standard-54 (IS-54) or digital-AMPS (D-AMPS) with compatibility with analog AMPS systems. North American cellular network formally adopted new digital standard in 1990. In 1993 first narrow-band code division multiple access (CDMA) system, called IS-95, was standardized as an alternative digital standard in USA.

GSM is considered as the representative of the 2G of mobile communications. Due to low costs of mobile equipment and services, 2G began some kind of a revolution in mobile communications. It spread worldwide in just a couple of years, with exponential growth of subscribers. Some main characteristics of 2G systems are:

- Digital technology which enabled encryption of data due to simple and effective signal processing;
- SIM card built into mobile equipment which enabled its mobility;
- SMS,
- Data or non-voice traffic;
- Efficient roaming system across the entire Europe.

GSM service started also in USA in 1995 using a different frequency band (1900 MHz) from that in the rest of the world.

Japan began operating its own digital standard called Personal Digital Cellular (PDC) in 1994. PDC was D-AMPS system modeled after IS-54. In 1995 a cordless system called personal handyphone system (PHS) was introduced, allowing the same phone to be used at home and also in the city. The alternative cordless system that became popular in Europe is called digital enhanced cordless telecommunications (DECT)

In 1995 first commercial CDMA/IS-95 system was started in Hong Kong, followed by American IS-95 in 1996.

The big evolution of the Internet in 1990s demanded the transfer of data also over mobile networks. Circuit switching which was used for voice communication turned out to be rather inappropriate and too slow for data transfer. Simple upgrade of the system called high-speed circuit switched data (HSCSD) offered speeds 43,2 Kbps, joining three GSM channels. Introduction of packet switching technologies to mobile networks leaded to development of new data transfer techniques such as GPRS and its successor enhanced data rates for global evolution (EDGE). These packet switching technologies only complemented existing GSM networks. GSM with GPRS and EDGE are often presented as a transitional stage between 2G and 3G of mobile communications or as 2.5G.

3G of mobile communications called UMTS had developed already in 1991. Standardization in Europe began in 1999 by 3G partnership project (3GPP)—established by ARIB, CCSA, ETSI, ATIS, TTA, and TTC. UMTS is a wideband CDMA (WCDMA) standard enabling data rates up to 2 Mbps.[2,3] It is a new and independent system based on circuit and packet switching techniques.

ITU-T[4] defined global 3G standard called IMT-2000 which covers CDMA2000 (USA, Canada, Korea, etc.) and WCDMA (Japan, Norway, Finland, etc). European UMTS system belongs to WCDMA group.

Introduction of 3G systems lacked new services and applications which would encourage users to change their equipment and adopt new technology. 3GPP attempted to introduce some advanced services, such as multimedia broadcast and multicast service (MBMS) and IP multimedia system (IMS). Mobile video communication was supposed to be a "killer application" but did not succeed due to the low video quality and the fact that video conversation requires complete concentration of the user and is therefore inappropriate for use in mobile environments (e.g., walking on the street or driving a car).

The successor of the 3G has not been formally defined but the main idea of the next generation can already be seen. There are many research groups worldwide concentrating on the question and suggesting the directions of the future development. In the following paragraphs we intend to summarize the concepts, key technologies and research groups to denote future of mobile communications.

MAIN CONCEPT OF NEW GENERATION—"USER CENTRIC" SYSTEM

There are two main concepts or visions on how the 4G should be introduced. Asian mobile operators, mostly in Japan and Korea, predict so-called linear 4G vision where new, more powerful mobile networks will replace old systems. They will be based on cellular structure with very high data rates (probably over 100 Mbps), supporting mobile multimedia with characteristics such as: anytime, anywhere, and to anyone, and customized personal services, etc. Europe predicts so-called concurrent 4G vision with seamless provisioning across different wireless systems, always providing optimum delivery through most appropriate network available (Fig .1).

Research and development of next generation should learn from the mistakes made in the introduction of 3G and focus on users' expectations and needs. Frattasi et al.[5] predicts 4G as "user-centric" system where different user scenarios should first be identified and research should concentrate on how to realize those scenarios and fulfill users' needs. In other words, development should move from user to technology. Understanding users means understanding how they are subjected to the changes of the society around them or more specifically how they change through interaction with new devices and equipment. They should be considered as socio-cultural beings with individual preferences, motivations, cultural environments,

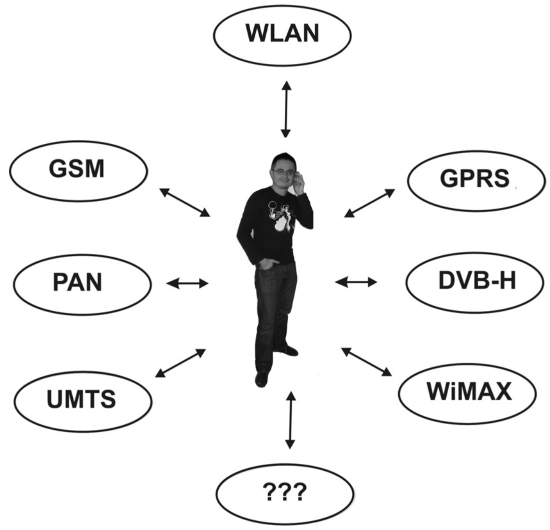

Fig. 1 Various available wireless networks will enable optimum delivery anywhere and at any time. User's terminal will connect to high-speed local area networks when being indoor and lower speed but better coverage cellular system when being mobile.

habits, etc. Their expectations and needs in everyday life situations should drive the design of new services and applications.

User Scenarios

Frattasi et al.[5] identifies some typical scenarios based on the question: "What do people really need that they do not already have?"

Business related scenarios include users on their way to work, where they would, e.g., like to receive information on weather, public transport schedules, possible delays, walking distances, etc. According to their decisions and demands the system could suggest the best way to their working or meeting place. During waiting users could browse the Internet, read e-mails or their daily meeting schedules, talk to somebody, etc. Information should be automatically filtered according to user's preferences and interests and presented in the format which is most appropriate for the available terminal equipment (Fig. 2).

Scenarios related to shopping include so-called smart advertisements where users could receive pop-up messages based on their preferences and current locations. They should be in response to a specific request and not annoying and unwanted commercials.

Another interesting scenario could be a mobile tourist guide that would help users navigate around cities to different tourist attractions. Optimal routes could always be considered or alternative routes suggested in case of traffic jams or congestions. Tickets for busy museums or galleries could be purchased via their terminals so that waiting in queues could be avoided. Their terminals could also replace electronic guides inside museums, so that descriptions of different exhibition artifacts could be given based on users' location.

Key Features

Most important features of new systems should be user friendliness and personalization. A combination of these two should encourage people to adopt new services. User friendliness means as minimum and as simple interaction as possible between applications and users. This can be achieved with well defined user interfaces, possibly with natural interactions, such as speech interfaces, voice recognition, etc. Since each user likes to be treated as an individual subject with exclusive needs, high degree of personalization is required. Huge amounts of information should be filtered according to users' preferences and choices. All future services and applications should exploit the available network capacities in the optimal way.

Two other important features, background for user personalization, are "terminal heterogeneity" and "network heterogeneity." Terminal heterogeneity includes many different types of terminals, varying in size, weight, complexity, etc. On the other hand, network heterogeneity means coexistence of wireless networks [GPRS, UMTS, wireless LAN (WLAN), personal area network (PAN), etc.] that differ in coverage, data rates, QoS, etc. Data presentation should be tailored and filtered to a form, most appropriate for specific terminal and current network capabilities. As an example we can imagine a user driving a car and receiving a text message. As the user is incapable of reading text from the screen, mobile terminal could read aloud the message using voice synthesizer. Anther example could be a user with a small phone who wants to watch

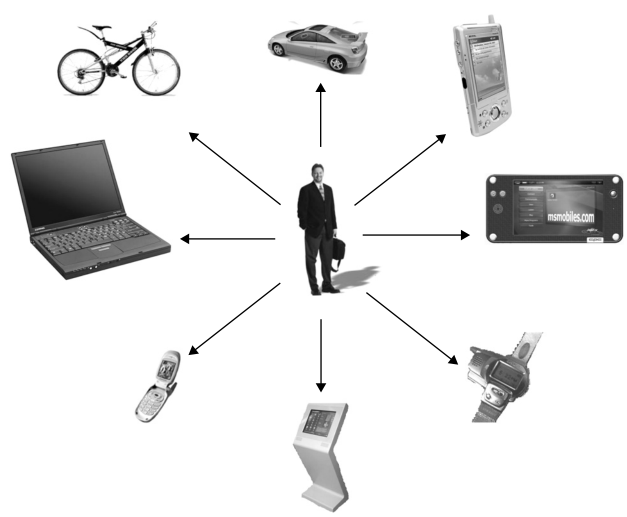

Fig. 2 Heterogeneous terminals will enable customized services in various situations. User interfaces and various applications should always be tailored for best performance on the specific terminal, with regard to the connection speed, screen and keyboard size, etc.

a football match. Instead of the small size display on the phone, larger external display could be used through some local wireless connection.

System Architecture and Infrastructure

The main problem that was emphasized during migration from 2G to 3G was the incompatibility of infrastructure and consequent big investment costs. That is the problem that should be kept in mind when introducing future generations of mobile communications. As mentioned before, European vision of future communication is based on integration and merging of existing wireless systems, complemented by faster and more powerful technologies. According to Alcatel,[6] radio performance is to achieve a scalable of capacity up to 500 bps/Hz/km^2. Expected data rates are up to 100 Mbps in mobile situations and up to 1Gbps in pedestrian situations.

Open Wireless Architecture

According to Lu,[7,8] future infrastructure should be based on open wireless architecture (OWA) which would ensure that single terminal can seamlessly and automatically connect to any available network. In the offices, homes or different public places, when local high-speed access systems are available [WLAN, worldwide interoperability for microwave access (WiMAX), home radio frequency (homeRF), wireless ATM, etc.], terminal should automatically connect to one of those. When being mobile, terminals should switch to one the of available cellular systems (GPRS, EDGE, UMTS, etc.). The synergy of different networks can provide:

- Great increase of spectrum efficiency;
- Highest possible data rates for users;
- Best sharing of network resources;
- Best management of service quality and multimedia services.

Alcatel[6] suggests that at least two crucial technologies will be necessary to serve large number of users with high session data rates. First one is so-called parent coverage or "umbrella coverage" which is dedicated to large coverage and real-time or non-interruptible services and the second one is "pico-cell coverage" which will increase capacity and will be designed without any constraints on coverage continuity. Strong handover mechanism between parent and pico cells will be necessary, transparent to users and services. Parent system could also serve as a backup for service delivery if problems with pico-cell coverage appear.

Service-oriented Architecture

Lu and Hu[7] also point out that users will most likely dislike different names of various networks and technologies (UMTS, WLAN, WiMAX, etc.) and will not know the advantages of individual standards. Therefore he suggests service-oriented architecture (SOA) which converge various radio transmission technologies into an open system platform. Users mind only specific services and applications and do not care which wireless system is responsible for each of them. The cooperation between different operators will be crucial to set up the uniform billing policy and service quality.

Lu and Hu[7] also suggest low-powered ad hoc or "mesh" networks where, for upstream or downstream, subscriber terminals can cooperate and retransmit each other‘s signals. Special routing infrastructure and mechanisms should determine the "best path" for each transmission. Network system should calculate best path based on low power consumption. Therefore user terminals need not "shout" at a central base station but instead "whisper" to the nearest terminal which can route the transmission further to base station.

Open standards are essential to establish a unique but worldwide compatible communication system.

Research Challenges

Research and development focuses on three different aspects or three different areas:

- Mobile station,
- System,
- Services.

Mobile Stations

Owing to synergy of various networks future terminals should support many different technologies and should be completely reconfigurable. According to Hui and Yeung,[9] the key technology for such terminals is most probably software defined radio (SDR). The basic scheme of such radio is shown on Fig. 3.

Three most important components of the analog part are band-pass filter (BPF), low noise amplifier (LNA) and analog/digital converter (ADC). The basic idea of SDR is to have a reconfigurable digital part which can operate on many different frequencies and with various modulation techniques by just downloading and applying new software. The major problem of such system would be the antenna since it is impossible to cover such a big range of frequencies and modulations with just one antenna and LNA. Most probably many different analog parts would be necessary, which will lead to bigger physical size of terminal and also design complexity. The reduction of power consumption also will most probably be a great challenge for future research since energy consumption of DSPs is pretty high.

In existing cellular systems (GSM and CDMA) base stations periodically broadcast signaling messages to

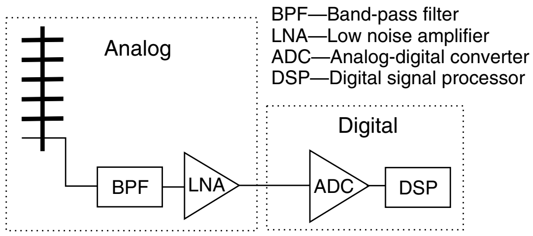

Fig. 3 Basic scheme of a software radio receiver: analog and digital part. The reconfigurable digital part can operate on many different frequencies and modulation techniques.

terminals in order to update information on the conditions in the system. In the system with various networks, technologies and protocols, such broadcasting will be impossible. Le and Angvami[4] propose single predefined broadcasting channel (global pilot and download channel—GPDCH) that informs terminals on available networks. In this case only one frequency and protocol is necessary to monitor conditions in all existing networks. If certain network is available, terminal can use GDPCH also to download appropriate software for its SDR. Each terminal downloads appropriate software only when necessary.

When technical multi-modal support on terminals is achieved some smart algorithms for selecting the most appropriate network also becomes necessary. Suitability of a specific wireless network depends on service requirements, such as required data rates and QoS. Prior to connection, terminal should receive some basic characteristics of each specific network in order to choose the most appropriate one.

System

An important background for providing constant wireless connection is terminal mobility. Mobile terminals should roam from network to network, changing communication protocols. Hui and Yeung[9] point out two main issues in terminal mobility: location management and handoff management. Location management means that system should track and locate different terminals which could connect to the network. Also some basic information on authentication, QoS capabilities, etc. should be tracked. Handoff management is responsible for maintaining active communication sessions when terminals roam. In 4G, besides so-called horizontal roaming (roaming between different cells of the same system) vertical roaming (roaming between two different wireless systems) also comes into consideration (Fig. 4). Since 4G networks are expected to support real-time multimedia services, the traffic will be highly time-sensitive. Quality handoff decision algorithms and policies should therefore be developed.

Another issue of 4G systems will be the integration of IP-based (WLAN, WiMAX, etc.) and non-IP-based networks (GSM, UMTS, etc.), especially for QoS in end-to-end services. Most existing QoS mechanisms are designed for one particular wireless system, e.g., UMTS bearer service in 3G systems (proposed by 3GPP), which enable certain QoS on all levels of system architecture. Such system-specific mechanisms are not appropriate for end-to-end services when other types of networks (non-UMTS) are also involved.

Due to heterogeneity of 4G systems security issues should also be reconsidered. Currently each individual wireless system has its own security scheme (e.g., highly secured voice communications in GSM or UMTS), but none could be applied to so many different networks with various technologies, devices, processing powers and security needs. New flexible and reconfigurable security mechanisms should be designed.

Services

Nowadays various operators offer various services to their subscribers and charge them according to their monthly traffic, call durations or simply with flat monthly rate charges. Hui and Yeung[9] predict that in 4G users may no longer subscribe to one specific operator but may subscribe to different services offered by different providers. In order to avoid customers handling different financial transactions and dealing with multiple providers, operators should design new business architectures and accounting processes. One billing scheme should replace and cover all the billing schemes involved (voice communication, multimedia, different QoS demands, etc.).

A "flat fee" billing scheme could be used just for an access, regardless of the network and current location of the user. On the other hand different levels of the QoS could be charged with different rates. Only in such a way, special needs for high speeds or high QoS demands would be charged extra.

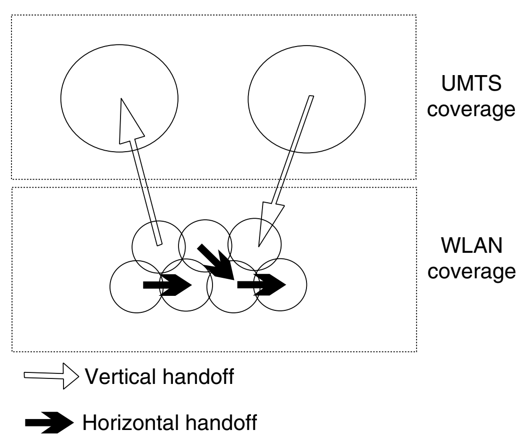

Fig. 4 The principle of a horizontal (between the cells in the network) and vertical (between various networks) handoff of a terminal.

Besides terminal mobility personal mobility also should be available in 4G systems. User should be able to communicate in different environments and with many different types of terminals. A personalized operating environment should enable the adaptation of service presentation to different sizes and capabilities of terminals and networks. Users should somehow be tracked when moving between different networks and system architectures, and his or her profile should be updated with regard to current terminal capabilities.

KEY 4G TECHNOLOGIES

In the next paragraph we list some technologies that are expected to be a starting point for enabling services described before. All these technologies are being researched and many working prototypes have already been proposed.

Adaptive Modulation and Coding

The basic principle of adaptive modulation and coding (AMC) is in the adaptation of the modulation and coding format (transport format) according to instantaneous variations of the channel conditions.[7] In such way system can take advantage of excellent channel conditions or on the other hand become slower but robust in extremely bad channel conditions. The receiver is responsible for providing feedback on current channel conditions. For example,[7] terminals close to base station in the cell are assigned higher order modulation with higher code rates [64 quadrature amplitude modulation (QAM) with R = 3/4 turbo codes]. Terminals located far from the base station are assigned lower order modulation with lower code rates [quadrature phase shift keying (QPSK) with R = 1/2 turbo codes]. Due to the constant variations in the quality of the communication channel, terminal should constantly update information on channel properties and optimize system parameters, such as: modulation, coding, signal bandwidth, signal power, etc.

SDR

We already described the basic scheme of SDR (see Fig. 3).[6] The analog part consists of an antenna, BPF and a LNA. First part of the digital part, which is a link with the analog part, is the ADC which digitize analog signal from the receiver. All the necessary processing is then performed with the low-cost base-band DSP, which is reprogrammable in order to support many algorithms.

Today high processing power should enable the development of multi-band, multi-standard base stations and terminals. Terminals are expected to adapt the air interface to the available wireless technology. On the other hand, operators could reconfigure the network dynamically with SDR when necessary.

SDR also becomes a key technology for providing multi-standard and multi-frequency-band equipment with low development costs and effort through simultaneous multi-channel processing.

Multiple Access Techniques—Orthogonal Frequency Division Multiplex

The basic idea of orthogonal frequency division multiplex (OFDM) is the optimal adaptation to the changing conditions in a mobile channel. The principle is the division of the broad-band signal into narrow-band orthogonal subcarriers (tones) which makes it more robust to multi-path effects and distortions.[6] In order for the subcarriers to be orthogonal, a cyclic prefix is added which has length greater than the expected delay spread. Also a guard interval is inserted between each OFDM symbol.[7,10] With OFDM time, frequency, space and code domain can be exploited in order to optimize radio channel usage. For implementation of OFDM, FFTs at the transmitter and receiver are used (Fig. 5).

Multiple Access Techniques—Multiple-input Multiple-output

"Multiple" refers to the number of antennas, since signal transmitted by x antennas is received by y antennas[6,7] and is therefore an example of space division multiple access. The system that uses multiple-input multiple-output (MIMO) principle benefits in range, quality of received signal, reliability, spectral efficiency and consequentially also data rate. MIMO channel is usually non-LOS (line of sight) and suffers impairments such as time-selective and frequency-selective fading. Multiple antennas at both ends provide diversity in this fading environment. The communication is more efficient when many multiple-path signals are received. Frequency band for MIMO systems is 2–5 GHz where propagation characteristics are favorable and the cost of RF equipment is not high.

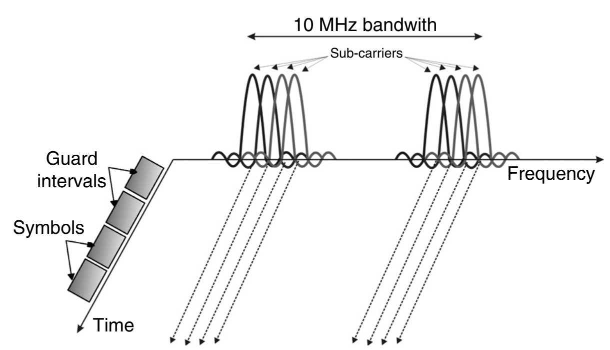

Fig. 5 Basic principle of OFDM. The communication signal is adapted optimally to the changing channel conditions through division of the broad-band signal into narrow-band orthogonal subcarriers.

MIMO system is meant to co-exist with OFDM. When using OFDM and MIMO simultaneously, channel response becomes a matrix. With proper coding and interleaving across frequencies, multi-path can be used as an advantage of OFDM system. Frequency selectivity improves the rank distribution of OFDM—MIMO response matrix which leads to increased capacity of the system.

High-speed Downlink Packet Access

High-speed downlink packet access (HSDPA) is a new standard in mobile communication that promises extremely high data rates (12 categories: 0.9Mbps to 14 Mbps).[11,12] It expands the existing WCDMA standard and provides much more capacity with the same network design. No modification to core network or traffic classes is required. HSDPA systems have already been applied by many mobile operators worldwide and could therefore be considered as a part of 3G systems.

The centre of HSDPA technology is a new common high-speed downlink shared channel (HS-DSCH) shared by several users and also the use of AMC and fast re-transmission techniques. Inside HS-DSCH channel there are 15 parallel channels which may be assigned to one or split among several HSDPA users. The channel is transmitted through, at a constant power. The modulation, the coding and the number of codes keep changing to adapt to the current conditions of the radio channel. That means the best of radio spectrum is always used and “bursty” traffic can be handled. Like in all cellular systems, final user’s experience will depend on the number of HSDPA users in the cell. Anyway, at least three to five times greater throughput can be expected compared to the systems without HSDPA.

Ultra Wide Band Radio for Wireless PAN

Ultra wide band (UWB) technology is prefect for short-range communications such as local area networks. The main principle of UWB is a wireless transmission of low-power digital signals in very wide frequency band. The signals are short impulses of different shapes transmitted with the antennas. Due to wide frequency bands of short impulses, the spectrum of radio signal is primarily influenced by the frequency characteristic of the antenna. Pulse-position modulation (PPM) is mostly used with UWB which requires very accurate synchronization between a transmitter and a receiver. The synchronization also suppresses the interruptions caused by the multiple-path signal travels.

Due to wide-frequency and low-amplitude signals UWB could be used in the same frequency band with other communication devices. In USA there is a specific frequency band assigned for UWB communication (3.1–10.6 GHz), but not in Europe or Japan. There is also a regulation about the maximum transmission power of UWB devices.

Mobile Internet Protocol v6

It is expected that future mobile communication infrastructure will be entirely based on IPv6 protocol, which contains practically unlimited address space and therefore enables the connection of unlimited number of devices with their own IP addresses in the network.[13] Besides larger address space, effective QoS mechanisms also are supported within IPv6. An important segment of IPv6 is also so-called mobile IPv6 (MIPv6), standardized by IETF. MIPv6 supports unlimited mobility between various access networks. That means users’ devices can roam freely and move from network to network without affecting active sessions and applications. Each mobile terminal has so-called own home agent, located in its home network. Home agent is a computer or server which is always aware of user’s current location and sub-network. It receives all traffic addressed to this mobile terminal and forwards it to the current terminal’s location. For other devices, that mobile terminal is addressed with a permanent static IP address and appears to be located at the same spot.

Important 4G Working Groups and Forums

ITU-R. Main player in the field of telecommunication ITU-R predicts new generation of mobile communications as constant and continuous development of wireless technologies and synergy of:[13]

- Existing, upgraded, and new cellular systems;
- Different nomadic wireless systems; and
- Wireless access islands (WLAN, WiMax, etc.).

ITU-R does not have a specific definition and vision of 4G, and it consists of two working groups. The first group concentrates on research and development of new high-speed data rates, and the second group concentrates more on design of open system architecture.

4G Mobile Forum

4G mobile operates since January 2004, under supervision of IEEE. The main vision of this forum is to become an international technical body which will control research and development of future broadband wireless communications and convergence of different wireless systems and mobile networks. The final goal is to offer users powerful broadband wireless access to various applications and services and assure high security and QoS. Future standards should concentrate mostly on application and media access control (MAC) layers of open systems interconnection (OSI) model.

Wireless World Research Forum

WWRF is probably the strongest European research forum for the field of 4G as it consists of all the largest mobile equipment developers and mobile operators in Europe[14] (Nokia, Alcatel, Ericsson, Siemens, etc.). It cooperates closely with other research groups and has a very clear vision of 4G. The forum is organized into six working groups:

- WG1—users perspective and service concepts;
- WG2—service architecture;
- WG3—cooperative and ad hoc networks;
- WG4—new radio interfaces, relay-based systems and smart antennas;
- WG5—short-range radio communication systems; and
- WG6—re-configurability.

In 2002, WWRF published its first *Book of Visions*, which describes their main working directions and planned activities of individual working groups. New version of *Book of Vision* was published in 2006.

Mobile IT Forum

Mobile IT forum (mITF) was established in 2001 in order to realize future mobile communication systems and commercial services, focusing on research and development activities, standardization, and coordination with related bodies, etc.[15] Forum consists primarily of all important mobile communication companies in Japan. It publishes different technical survey reports on a regular basis.

Integration in a Next Generation Network

The term next generation network (NGN) describes the general idea for future computer network architectures and technologies. NGN would serve for various types of traffic: data, voice, media, etc. All the information is transmitted via packets which are marked according to their type and therefore handled differently with regard to QoS, security issues, etc.

An important issue of future communication infrastructure is also the realization of convergence between fixed and mobile networks which is the basic idea behind IMS. The basic architecture of IMS systems is so-called horizontal architecture, comprising of three separated functional layers: transport layer, control layer and application layer. All functionalities of individual layers are available to various applications and services. The modularity of such infrastructure enables simple and flexible updates and upgrades of the system.

The goal is the development of a common packet-based communication framework which could be the backbone for all existing and future technologies, mobile and fixed. Majority of IMS standards have their origin in mobile domain, but they have been complemented with ETSI Telecoms & Internet converged Services & Protocols for Advanced Networks (TISPAN) NGN concepts for fixed domain.

Media–Mobile Comm

SUMMARY

Mobile communications have been influencing human lives for almost three decades. The capability of communicating with other people regardless of distance was a big revolution which led to the big popularity of different mobile communications systems. The development from 1G in 1981 to the present has established some important features of mobile systems which will definitely be an important part of future architectures as well: cellular structure with user and terminal roaming, inter-compatibility of different systems, digital technologies with high processing powers, high QoS, etc.

In the past, technology drove the development of new systems and tried to attract users to change their equipment and start using new services. Future systems should concentrate more on user's expectations and needs. The possible scenarios and interesting services should first be identified and the technology development should be guided by those ideas. Next generations of mobile communication will therefore be "user-centric," and their main characteristics are expected to be: constant coverage with multifunctional terminals which could connect to various mobile networks, filtered and customized content for each individual user, new and more natural user interfaces, and adjustment of the services to different mobile devices in different situations.

Currently some new technologies are being developed and tested which are expected to enable the above-mentioned scenarios. SDR enables multimode devices operating with various systems on different frequencies simultaneously. OFDM and MIMO are just two new more powerful and more efficient multiple access techniques which will enable faster data rates and better QoS. Some protocols or standards are being researched which will enable the convergence of mobile and fixed networks. Users will no longer be limited to either of them and could use same equipment and same services anywhere and anytime.

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