II INTERNATIONAL CONFERENCE
TRANSPORT SYSTEMS TELEMATICS TST`02

ZESZYTY NAUKOWE
POLITECHNIKI ŚLĄSKIEJ 2002
TRANSPORT z.45, nr kol. 1570

telematics, transport, GSM, GPRS, UMTS

Stanisław KRAWIEC[1]

TRANSMISSION OF DATA IN THE CELLULAR TELEPHONY SYSTEM OF III AND IV GENERATION

Fast development of the information and telecom society in the world implied the creation of the data access services based on other than stationary work nodes. Mobility, being the engine of professional activities and the need of fast communication between people has made the telecom systems designers face the challenge of creating new applications and systems providing data transmission and information access services based on cellular telephony into a universal telecommunication system which, in addition to voice transmission and slow data transmission (GSM), will allow widening the scope of services to a broadband data transmission of a few Mbps, thanks to the latest digital technologies (CDMA). This, in consequence, will strengthen the lines between transportation and communication services.

TRANSMISJA DANYCH W SYSTEMACH TELEFONII KOMÓRKOWEJ III I IV GENERACJI

W artykule przedstawiono tendencje rozwoju transmisji danych w globalnych sieciach komórkowych drugiej, trzeciej i czwartej generacji.

Transmisja danych przez urządzenia mobilne z szybkością do 2 Mb/s koresponduje z mobilnością środków transportu. Sprawna mobilna transmisja danych, przy pomocy której tworzony jest stopniowo nowy ład telekomunikacyjny spowoduje kolejną zmianę w relacjach między usługami transportowo - spedycyjnymi a usługami telekomunikacyjnymi, zmieniając formy ich komplementarności i substytucyjności.

Powiązania mobilnych urządzeń sieci komórkowych, systemów satelitarnych, mobilnego dostępu do Internetu oraz systemów sterujących w jedną spójną całość tworzą nową techniczną infrastrukturę komunikacyjną, co stwarza możliwość generacji wielu nowych, ciekawych rozwiązań umożliwiających optymalizację globalnego, regionalnych i lokalnych Systemów Transportowych. Z punktu widzenia organizacyjnego zielone światło do nowych rozwiązań stanowi instytucja podpisu elektronicznego, wchodząca aktualnie do rzeczywistości gospodarczej.

Radio-communication with moving objects and data transmission are in operation for many years, but in the recent years the scale of their development has exceeded all expectations. Form systems being used by selected institutions, such as medical aid, police or army, they became objects of common use. Today a term of wireless personal communication is more and more widely used. The wireless communication area is now one of the quickest-developing branches of communication worldwide concentrated around large investment projects and promising high revenues.

[1] Faculty of Transport, Silesian University of Technology, Krasińskiego 13, 40-019 Katowice, Poland
krawiec@polsl.katowice.pl

Cellular GSM systems of second generation (2G) introduced in 1990, and now being used by most of the customers, are not designed for efficient sending of digital data, as GSM network platform is based on a classic concept of channel commutation, designed for connections of telephone type.

Basic station (BS) ensuring wireless communication with mobile terminals over the given cellular area uses several pairs of bi-directional radio channels within an assigned frequency band. Each unidirectional radio channel from a communication pair is divided into eight subsequent time slots located in the TDMA frame. Duration of one time slot is 577μs, and the entire TDMA frame lasts 4,615 ms.

In the traditional voice GSM connection, one slot repeated regularly within subsequent TDMA frame, and exactly every eight time sections, constitutes a radio voice channel (call channel or logic radio channel). An intention to put a call from a mobile phone results in reservation of a logical radio channel by the BS (this means allocating one of eight time slots within subsequent TDMA frames to the cellular terminal user). Within this time no other user of a traditional GSM network can occupy the same voice channel (time slot) of BS station until the moment when data or voice are sent directly to the destination point (end-to-end) and the connection is shut down on the entire route.

Because of the fact that in GSM data transmission is limited by the possibility of phone connection to the network only within the duration of dedicated time slot, standard transmission of data CSD (circuit switched data) – enables sending and receiving of data at a rate of 9600 bit/s. Data transmission through voice channel with full or half capacity, due to small transmission rates (for full capacity channel it is 9,6 kb/s) – constitutes a barrier for cellular phone users trying to send text messages using 2^{nd} generation mobile terminals.

An opportunity to increase the capacity of radio channels has appeared by, enabling transmission with switching of logic radio channels (for handling a call between two users, one (14,4 kb/s), two (28,8 kb/s) or more (up to eight) time slots may be allocated, identically in each repeated TDMA frame – thus obtaining increased rate of data transmission). Açcording to the GSM document Technical Specification - High Speed Circuit Switched Data it is possible to occupy up to four logic channels within one physical channels (up to 4 time slots) for high speed data transmission. Transmission rate in the case of one channel was increased up to 14,4 kb/s. With occupancy of 4 channels it is possible to make transmissions at a rate of up to 57,6 kb/s.

In the classic solutions of 2G telephony, the user who was making transmission of data had to dial a number, then the network allocated him one channel for the duration of the call. In the case of high speed data transmission based on HSCSD technique, the system reserves up to four radio channels, reaching finally rates that are four times higher that in the case of GSM technique, but the telecom system resources are still being used in a non-optimized way, because they are occupied also over these periods when information is not being sent (we occupy the connection from the beginning to the end of call).

Century break brings a new tendency to the cellular phone networks – development of data transmission in the cellular telephony. It is a modified system overlay of GSM 2^{nd} generation + so called GPRS (General Packed Radio Service), i.e. a basic service of packed data transmission through a radio channel. Information is divided into packages provided with an address. These packages are subsequently sent to the network. Radio channel is assigned on request and may be used by several users simultaneously. This deals with the issue of permanent allocation of radio channels for the entire duration of transmission through GSM

network, as this transmission occupies the radio media only for the time of real transmission of packages to the network.

The caller is assigned a transmission band when the data are being sent or received, This means that the system does not reserve a separate band for the entire connection. Each user may use several radio channels. Their number is defined in a dynamical way and depends of the possibilities of a particular model of phone.

Thus configured, the connection loses his channel switching transmission properties and becomes a typical transfer with package switching features, resulting in a flexible and dynamic control of radio transmission bandwidth according to the current simultaneous requirement from several network users. The GPRS standard assumes four different patterns of channel coding with respective capacities 9,05 kb/s, 14,4 kb/s, 15,6 kb/s and 21,4 kb/s. The maximum unidirectional transmission rates obtained in this way are different depending of the number of channels connected and usually are limited to the maximum capacity of 115,2 kb/s (typically 8 x 9,05 kb/s = 72,4 kb/s), and in particular situations, theoretically even to 171,2 kb/s (8 x 21,4 = 171,2).

In spite of the fact that the theoretical capacity of transmission in this technology reaches over 170 kb/s, in practical solutions seldom a rate of several tens of kb/s is exceeded – what is generally sufficient for mobile transfer of text messages, high capacity data files or slowly changing graphic pictures and simple contact with Internet.

The maximum data transmission rate measured with a Polish operator, depending of the type of cellular terminal coding, was respectively either 4 x 9,6 kb/s or 4 times 14,4 kb/s. In spite of the fact that the data transmission rate in the cellular phone network is far from system assumptions, the operators note a rapid growth of interest for GPRS platform services.

Communication in GPRS standard is a first stage of implementation of packed data transmission through GSM cellular phone networks, based on Internet protocol IP and supported by routing mechanisms. As a connection platform between the digital cellular systems of second (2g) and third (3G) generation in 1997 a concept of mobile network EDGE Enhanced Date Rates For Global Evolution recommended by the International Telecom Union (ITU-T), that is to be treated since then as a proposal of European standard. Technology of EDGE radio transmission being an improved version of GPRS, because of new coding patterns, provides for use of the same carrier frequencies, identical bandwidths and structure of time slots as in GSM (there is no counter-indication to use this technology in other cellular systems such as TDMA (IS-136)). An important novelty of EDGE system is modernization of radio interface.

Implementation of modulation and compression method assumed in EDGE technology enables transmission of data through GSM networks at a rate not less than 384 kb/s. Increase of capacity was possible due to the changes in the modulation method, increasing efficiency of information coding in the 8-slot radio channel above the value of 1,35 b/Hz/s, (271 kb/s in the band 200 kHz) hitherto used in the digital 2G networks.

The EDGE technology enables maximization of throughput of channels belonging to one time slot within the values from 8,4 to 59,2 kb/s. For this reason and by allocating eight slots to one connection the theoretical throughput of channel in EDGE technology for high quality radio connections may change from 67,2 kb/s to the maximum value of 473,6 kb/s.

Technologies GSM/EDGE (EGPRS) are treated as a platform to the cellular technologies of third generation (3G) known as UMTS. The Universal Mobile Telecommunication System UMTS is a part of general concept of third generation's mobile communication systems named IMT 2000 (International Mobile Telecommunication). IMT 2000 it's a basic component of global system of futuristic personal communication UPT

(Universal Personal Telecommunication), that assumes convergence (combination) of hitherto ground systems (cellular, paging, dispatching) and satellite systems in one consistent system that would enable access from anyplace and anytime to all radio and television telecommunication networks. Implementation of IMT-2000 will ensure an integrated wireless communication with moving objects expanded by data transmission with throughput to 2 Mb/s in the band of ca. 2 GHz. For IMT 2000 standard 2 basic frequencies have been allocated, valid worldwide:

- satellite 1980-2000 MHz – 2170-2200 MHz,
- ground (available in full after 2005) in the bands 2010-2025 MHz and 2160-2170 MHz.

IMT 2000 systems will operate in important regional variations (UMTS in Europe) because of various occupancy of radio bands in various countries)

In the UMTS system the frequency ranges are defined as follows:

- ground UMTS:
  - frequency 1900-1920 MHz (bandwidth 20 MHz)
  - frequency 1920-1980 MHz (bandwidth 60 MHz)
  - frequency 2010-2025 MHz (bandwidth 15 MHz)
  - frequency 2110-2170 MHz (bandwidth 60 MHz)
- frequency UMTS:
  - frequency 1980-2010 MHz (bandwidth 30 MHz)
  - frequency 2170-2200 MHz (bandwidth 30 MHz)

Certain sub ranges of UMTS radio bands have been grouped in pairs (paired, double or symmetric bands) with destination for duplex frequency distribution, whereas other ones – without pair (unpaired, odd bands) – will be used in transmission with duplex time division. For each national public operator UMTS Forum recommends one paired band 2 x 15 MHz and one unpaired band 5 MHz wide.

In accordance with the progress of standardization work IMT 2000, for European UMTS system a ground radio interface was determined, so-called UTRA standard (UMTS Terrestrial Radio Access), based on CDMA technology whereas for USA a radio interface was developed CDMA2000 constituting an expansion of hitherto standard IS-95 and radio interface UWCC-136, constituting an evolution of the existing standard called IS-136.

The technology, code multi-access CDMA – Code Division Multiple Access – means, similarly as in FDMA, division of the transmission channel into narrower frequency bands, but during the transmission, the user occupies subsequent frequency bands using a code known to both transmitter and receiver.

Code sequences (spread codes) enabling particular users' signals to be separated from their total within the receiver, allow using the entire available radio bandwidth simultaneously by all users. This enables flexible determination of a number of users that are active at the same time and falling to one cell (base station). This number is established by level of interference, not by number of time slots and available frequencies, as in the multi-access TDMA/FDMA system

Transfer technologies in the IMT-2000 system are defined as follows:

- IMT-DS. (CDMA Direct Spread) – i.e. CDMA technology with direct spread, known as wide-band W-DCMA and constituting a version of radio interface UTRA FDD (with frequency division) for paired bands,
- IMT-MC (CDMA Multi Carrier) – technology using multiple carriers realized in CDMA code technology,

- IMT-TC (Time Code) – technology with code spread CDMA supplemented by a duplex time division, thus being a version of UTRA TDD interface (with time division) in Europe,
- IMT-SC (Single Carrier) – variant with a single carried operating in TDMA technology and adapted for cooperation with American wireless standard UWC-136,
- IMT-FT (Frequency Time) – variant of mixed technologies TDMA/FDMA compatible with the European DECT system DECT (Digital Enhanced Cordless Telecommunications).

As a result of such 3G standardization it is possible to achieve an uniform access to the radio medium operating in three basic radio communication modes used today: frequency duplex FDD DS. (Direct Spectrum) and FDD MC (Multi Carrier) and differing from them, time duplex system, TDD.

In Europe, for a wide-band radio interface with direct spread of signals spectrum WCDMA two associated bands (2x60 MHz) will be available in frequency duplex mode FDD (Frequency Division Duplex), founded in the frequency ranges 1920-1980 MHz and 2110-2170 MHz. Two next radio bands in the frequency ranges 1900-1920 MHz and 2010-2025 MHz have been assigned to the same area in the TDD Time Division Duplex mode. Probably till 2010, the demand for subsequent radio bands for UMTS will grow several times – up to width 550 MHz for ground sector and up to 85 MHz for satellite segment.

The mode of frequency duplex FDD (used in 2G and GSM systems) will be used globally, while the time duplex mode TDD will be available only locally.

UTRA Standard, approved for Europe 3G (UMTS) radio interface in the ground sector is established by two transfer technologies:

- W-CDMA technology (Wide band – Code Division Multiple Access) with duplex frequency division FDD (Frequency Division Duplex) – adequate for wide band communication in suburban areas with low local traffic.
- TD-CDMA technology (Time Division CDMA) with duplex code spreading expanded by time package TDD (Time Division Duplex) – adequate for communication in densely inhabited areas with high local traffic.

For both W-CDMA and TD-CDMA technologies the system operation principles for paired connections (frequency duplex) and unpaired ones (time duplex) have been determined.

Operating mode with time duplex TDD uses the band in a more efficient way, as it is able to allocate spectrum ranges varying in quantity for "up" and "down" streams. It is then perfectly suitable for Internet and corporate networks users with high traffic asymmetry.

UNTS/UTRA Standard is based then on a wide-band spread of specter using a code sequence and operation in a double mode of duplex operation: in the area of frequency FDD and time TDD, depending of user's means. The solutions assumed the UNTS/UTRA standard give flexibility in the configuration of transmission channel, a possibility of parallel transmission with variable rate over several channels, use of efficient packed transmission, easy transfer to other systems with special consideration to GSM network.

Fig.1 shows five types of 3G communication system modes.

The basic parameters of assumed interface WCDMA/FDD important from the data transmission point of view might be characterized in the following way:

- frame TDMA contains 15 elementary frames,
- duration time of a TDMA frame is 10 ms,
- time of duration of elementary frame is 666μs,
- transmission of speech signals in the range 4,5-12,2 kb/s,

- local data transmission from 1 kb/s to 2,3 Mb/s, globally from 64 to 384 kb/s.

The differentiated set of transmission rates (from 1 kb/s to 144 kb/s globally and from 384 to 2 Mb/s locally), accompanied by quality offered by stationary networks and multi-degree cryptographic protection should be available in various propagation environments. The ground segment will include urban, municipal and mountain areas as well as interiors of buildings. The satellite segment will make available services on desert areas, seas and oceans and in mountains where ground telecommunication infrastructure is not available.

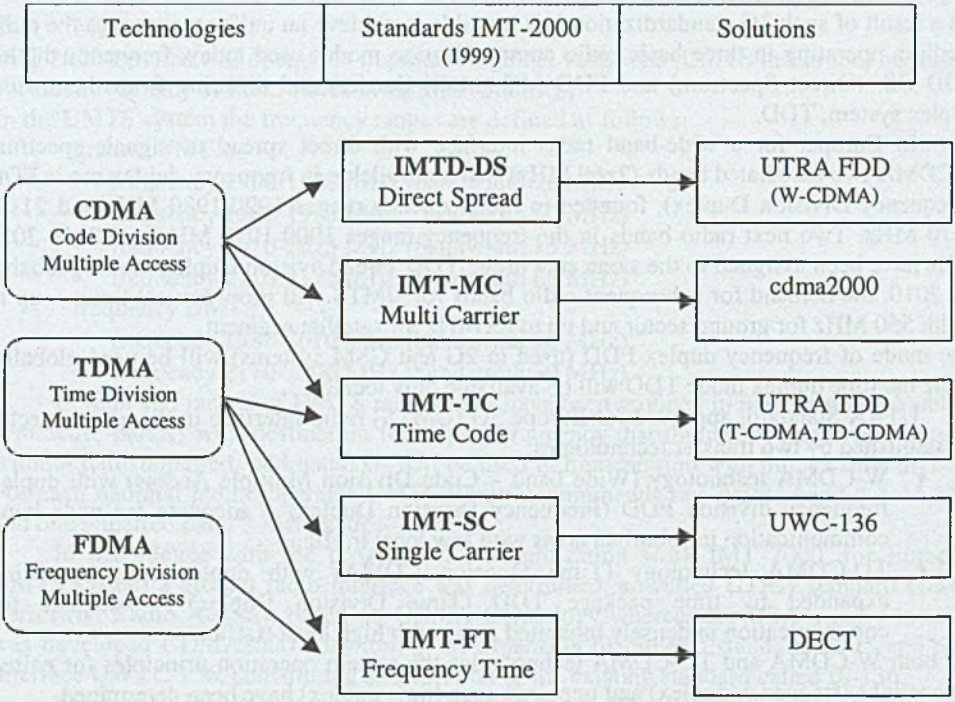

Fig.1. Modes of 3G system communications

The most important features of UMTS systems include:

- integration of services presently provided presently by separate radio-communication systems (cellular, dispatchers', paging and others),
- integration of various methods of radio coverage in one consistent mechanisms of global connection due to the use of infrastructure combining various ground and satellite segments,
- combining of services offered in narrow-band and wide-band systems available from mobile terminal,
- harmonization of transposition platforms (roaming) of communication between various systems and operators (communication with mobile users should take place in a correct way, independent of place of callers' location and time of providing the

service, and in various environments, and switching between separate systems (DECT, GSM, UMTS, satellite, others shall take place automatically),

- cooperation of terminals with various types of intelligent ground networks IN (Intelligent Network),
- hierarchical structure of cells with variable number of callers (Pico cells, micro-cells, macro cells and satellite sector),
- adaptation of mobile terminals for cooperation with various types of cellular phone networks (multimode terminals),
- wide offer of services from speech transmission to high speed data transmission (multimedia services),
- access to wide-band services from 144 kb/s to 2 Mb/s, while the highest transmission rates will be available only locally in urban areas and intensely operated main communication routes,
- selection of duplex transmission type (from two bands of unequal width assigned to UMTS results a need of application of both duplex transmission with time division (TDMA) and frequency division (CDMA) 0 art. of traffic may be asymmetrical in both directions),
- cooperation with permanent networks (in the UMTS system integration will take place with the wire wide-band networks (B-ISDN) and technology of intelligent networks will be used).

The scope of offered UMTS services will be depended on network operator and will be modified by the caller. The instances of basic UMTS services are shown in Table 1.

Table 1

UMTS Servises

Service	Throughput (kb/s)	Required error rate	Acceptable delay (ms)
Telephony	8-32	10^{-4}	40
Data in acoustic band	2,4-64	10^{-6}	200
Sound hi-fi	940	10^{-5}	200
Video-telephony	64 – 384	10^{-7}	40-90
Short messages	1,2-9,6	10^{-6}	100
Electronic mail	1,2-64	10"6	100
Telefax (G4)	64	10^{-6}	100
Spread transmission or to a group of callers	1,2-3,6	10^{-6}	100
Public vocal announcements	8-32	10^{-4}	90
Digital data without predetermined restrictions	64-1920	10^{-6}	100
Access to databases	2,4 – 768	10^{-6}	>200
Teleshopping	2,4 – 768	10^{-7}	90
Electronic newspaper	2,4 – 2000	10^{-6}	200
Remote control	1,2-9,6	10^{-6}	100
Location and navigation	64	10^{-6}	100
Writing „at the distance"	32-64	10^{-6}	90

Offer of new services in UMTS is broad. Some from services planned for implementation in UMTS network will be realized not earlier than some years after implementation of the system. Variety of services will require application of various terminals. They will not be just phones, bout some of them will also fulfil role of today's personal computers. The more services it will perform, the more it will be complex and energy consuming. 3G terminals and phones will not be standardized, and then we may expect very large variety of videophone terminals, not only from the point of view of offered functions but also their ergonomy. As a target, the 3G services will be available through one (physical) common terminal operating in various network environments. Their future will be then related above all with development of digital cameras, synthesis and recognition of speech, pictures and with continuous miniaturization of PDA communicators, GPS positioners, laptops and Internet browsers.
The UMTS system was defined as an open standard for mobile systems with high-speed transmission. Mobile services in the third generation networks may be divided generally into two groups:

- Services related with data transfer,
- Services related with voice transmission.

Among services related with data transfer, two groups may be discerned:

- Related with Internet and Intranet access,
- Related directly with mobility of users.

Services related directly with mobility are based on direct possibility of location of a particular user and directing personal information to him (using for example MMS technology, the service providers will direct their offers to the particular users, located in addition within a certain area).

In relation with digital form of station communications (multi-access CDM) in the UMTS system, the transmission does not take place using time slots created by dividing the channel, as it is the situation in GMS and DCS. In UMTS system, the physical channel sends simultaneously up to 184 digital packages in the form of a CDMA code. Because of digital character of the transmission, the UMTS system bases its transmission upon power management. If the speed of transmission of packages being sent is slow, the station operates using full transmitting power parameters, but if the speed of transmission of packages being sent is high, the station reduces power in order to be able to conserve its data transmission ability and uses it to send a larger number of packages to the selected customer. In order to transmit large quantities of data we will cause reduction of real area coverage from the nearest basic station (our transmission will affect the station's range). Station's power management has a positive impact for data transmission, giving an increase of transmission up to 2 Mb/s, but it brings also significant restrictions of the transmission as related to the speed of the terminal (the higher is speed of the phone, the lower is rate of transmission).

It is estimated, that as a target, third generation GSM stations located in the transport vehicles should be able to perform a data transmission according to the following parameters:

- Speed up to 10 km/h will enable data transmission rate up to 2 Mb/s,
- Speed up to 150 km/h will enable data transmission rate up 384 kb/s (as a target: 512 kb/s),
- Speed up to 250 km/h will enable data transmission rate up to 144 kb/s.

Third generation networks enable access to Internet with quality and functionality close to the wire access. Quick connections and technologically advanced terminals ensure full access to WWW and sending files using FTP protocols.

Services related with voice transmission are related mainly with VoIP technology (voice over Internet protocol) based on package transmission. This method uses network in a more economical way as the network remains unoccupied when no words are said. Application of VoIP technology will enable realization of roaming calls (in GSM systems roaming means use of networks of operators abroad). In addition, a natural evolution of voice transmission will be video-phone calls and multimedia communication (first multimedia applications provided by cellular phone networks with rate 384 kb/s were presented by Ericsson company in 1999.).

The first system 3G worldwide was introduced by a Japan NTT DoCoMo cellular phone network operator. The system called FOMA (freedom of mobile access) was started on 1st October 2001. However, before the FOMA system has begun its commercial activity, it was being tested for 4 months by 4 thousands of users. The operator holes that in its first year of operation it will gain 140 thousands of customers, to end with 6 millions till the end of 2004. The NTT DoCoMo company has informed its investors that the first 2-3 years from 3G network it will not bring any profit. Presently FOMA system enables transmission of data with rate of 384 kb/s.

The American communication companies plan their own solutions based on narrow-banded CDMA technology. The best know are CDMA 1800 (IS 95C, CDMA 1900, PHS 1900/PHP, CDMA 2000).

In Europe, the concessions for UMTS have been distributed and implementation work is presently in progress. In Poland, 3 concessions have been distributed directly between the present cellular network operators and one will be subject to auction or tender procedure. The panned start of providing UNTS services is set for 1st January 2003, then moved to 2005.

The only 3G network in Europe is operating as a trial on British Island MAN
Evolution of data flow rate in GSM networks is presented on Fig.2.

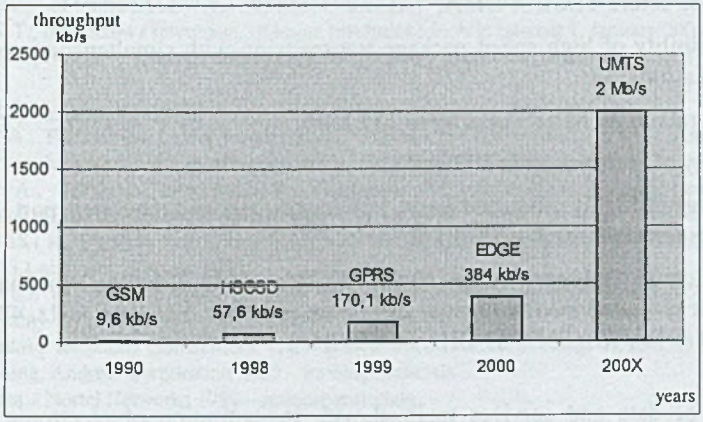

Fig.2. Evolution of data flow rate

3G systems are designed in particular with data transmission in mind. The UMTS system is being optimized not from the speed transmission point of view, but for global and differentiated multimedia transmissions.

Growth of data transmission speed in these networks, rating from 9,6kb/s to 2 Mb/s (UMTS) has not yet exhausted the evolution of cellular networks. Presently development works are in progress on four generation systems (4G).

For advanced communication systems expanding the standard of 3G telephony (IMT-2000) ITU provides application of two wide-band transmission standards:

- (WCDMA) standard, that should provide 8 Mb/s to the customer's direction as a target value,
- CDMA 2000 standard, that should provide transmission rate of 2,4 Mb/s in both directions of transfer simultaneously.

According to the forecasts of UMTS Forum in 2010 almost 60% of cellular network traffic will be generated by multimedia applications making available high quality sound and picture. This will result in demand for wireless service platform ensuring up to 155 Mb/s of throughput at the user's terminal (a possibility of several applications to be started up simultaneously is considered).

According to the preliminary assumptions, the 4G systems will include many radio media resources with high asymmetry and with throughput ranging from 384 kb/s in BAS (Basic Access) standards, through 1920 kb/s according to MED specification. (Medium Data) up to rate of 31872 kb/s in accordance with HID (High Data) proposal.

A basis for global fourth generation (4G) communications will be modernized 3G systems (IMT-2000). Their development concept assumes the following target parameters:

- Cooperation with wireless WLAN networks enabling reaching in 2010 transmission rate of 100 Mb/s,
- Frame structure TDMA/FDMA,
- A possibility of high speed package transmission with simultaneous voice and data transmission,
- Useful rate in ATM networks up to 155 Mb/s,
- Mobility of terminal up to 100 km/h,
- Coverage of highly urbanized areas, business centers and main transport lines with 4G services (antenna reach up to 1 km),
- Operation in frequency range 40-60 GHz (for MBS (Mobile Broadband System)) systems so-called medium ranges have been provided 39,5-40,5 GHz, 42,5-43,5 GHz as well as low ranges 60-63 GHz, 65-66 GHz).

Transmission of data and services realized with it, institution of electronic signature, a possibility of cost-efficient realization of such services like remote control, location, navigation and a possibility to separate virtual specialized networks will establish a new mobile infrastructure (universal communication system) in the near future. This will naturally affect form of structure and properties of Transport System in global, regional and local scale, in uni- and multi-branch transportation systems. A close, natural relationship between transport and telecommunication, featuring both complementary and substitutable transport

and communication services will establish a new structure of communication behaviors, a new model of human mobility and will irreversibly change the course of transport processes and services.

SUMMARY

The article presents the tendencies of development of data transmission in second, third and fourth generation global telecom networks.

Data transmission in mobile devices with the throughput of up to 2Mbps corresponds with the mobility of the means of transport. Efficient mobile data transmission gradually shaping the new telecom order will cause another change in relations between the transportation and dispatching services and the telecom services, as to their complementing and substitutive features.

The bundling of the mobile devices of cellular networks, satellite systems, mobile Internet and control systems into one coherent entity cause a new technological communications infrastructure. This in turn allows creation of several interesting solutions permitting the optimization of the global, regional and local transportation systems.

From the organization point of view, it is the electronic signature institution, currently becoming the part of economic reality that has lit the green light for the new developments.

BIBLIOGRAPHY

[1] BARTCZAK K., Technologie telematyczne, a globalizacja usług transportowych (Telematic technologies and globalization of transport services) „Spedycja i transport" No 8/2001 p. 8-12
[2] ŚWIDEREK T., Internetowa rewolucja, (Internet revolution) Mobile Internet 1, January 2001, p. 5-7
[3] ŚWIDEREK T., I-mode – droga do sukcesu, (I-mode – a way to success) Mobile Internet 2, February 2001, p. 9-11
[4] FLETCHER C., www.msolution.pl
[5] URBANEK A., Technologie i sieci komórkowe w Vademecum teleinformatyka II, (Cellular technologies and networks in the Vademecum of tele-information specialist II) IDG Warsaw 2002
[6] URBANEK A., Telefonia komórkowa w Vademecum teleinformatyka, (Cellular telephony in the Vademecum of tele-information specialist II) IDG Warsaw 1999
[7] WESOŁOWSKI K., Systemy radiokomunikacji ruchomej, (Mobile communication systems) Wydawnictwa Komunikacji i Łączności, Warsaw 1999
[8] HOŁUBOWICZ W., PÓŁCIENNIK P., GSM cyfrowy system telefonii komórkowej, (Digital system of cellular telephony GSM) Wydawnictwo Witold Hołubowicz, Poznań 1997
[9] System of cellular telephony GSM/DCS – Training at Warsaw Institute of Radio-electronics 1998
[10] System Planning, Andrew Corporation 2000 – training materials
[11] Mobile Phones – Nortel Networks 1999 – training materials
[12] Freq Hopping – Nokia Networks 2001 CPRB 5763 – training materials
[13] Advanced System Technique – Ericsson Radio System 2000 AB_LZU 108 857 – training materials
[14] GPRS System Course – Nokia Networks 2000 CTXX 4594 – training materials
[15] KRAWIEC S., Transmisja danych w telefonii komórkowej II generacji – tendencja rozwoju. (Transmission of data in the cellular telephony of II generation) II Scientific conference: Telematics and safety of road traffic, Katowice Szczyrk, October 2002.

Reviewer: Prof. Zbigniew Ginalski