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THE DEVELOPMENT OF MOBILE TELEPHONY IN THE WORLD AND IN CROATIA

SUMMARY

The paper first describes the invention and introduction of mobile telephony in the world and in Croatia. Then the basic characteristics are compared as well as the possibilities of certain generations of the mobile radio telephone systems with emphasis on certain advantages. Finally, the prospects of further development of the mobile telephones are discussed, and the adequate conclusions made.

1. INTRODUCTION

Since the invention of telephone in 1876, until the 80s of the 20th century, wire telephones ruled the world of telecommunications, using metal wires to transmit audio signals. It had numerous advantages including the most important ones such as: quality connection regardless of weather conditions, great protection against tapping and a relatively low cost of the device. Wire telephony is even today the most widespread type of telecommunications. However, wire telephony has one great disadvantage: it cannot provide the user with a telephone line when under way. This is particularly inconvenient for business users, who travel all the time, and spend long working hours in various vehicles.

The discovery of radiotelephony (1915), enabled the possibility for cordless telephone connections, but the time was not ripe then for their wide application, since such mobile connections required modification of both terminal and commutation devices. Cordless telephony, i.e. telephony in which audio signal is not transmitted by current along wires but across radio waves, developed in two directions.

In one type of cordless telephony, planned for smaller ranges, with the so-called "tapeless telephones" only the wire connection was replaced according to the tape between the microtelephone (MT) combination and the rest of the telephone device by radio connection, which allowed the user to move away at least to a certain distance from the fixed device, carrying around only the MT combination.

In the other type of cordless telephony planned for greater ranges, the so-called "mobile", the wire connection between the telephone and the switchboard has been replaced by the radio connection, which allows the user to be completely mobile.

2. THE DEVELOPMENT OF MOBILE TELEPHONY IN THE WORLD

Mobile telephony appeared as early as 1955 when the Swedish company "L.M.Ericsson" designed the first radio-telephone, but it was publicly used only thirty years later. Until 1970 experiments were carried out with the frequency range of about 40 MHz, and from 1970 to 1980 about 150 MHz. The first mobile radio-telephone network on a minor territory started operating in 1979 in Japan, in the Tokyo region.

The mobile telephony systems are usually divided according to generations:

a) systems of the 1st generation
b) systems *of the 2nd generation*
c) systems of the 2+ generation
d) systems of the 2.5 generation

2.1. Systems of the first generation

The first generation of the mobile telephony system is characterised by analogue systems, intended only for audio communication, single-layer cellular structure, and relatively big user terminals, foreseen primarily to be installed and used in vehicles. There are three dominant standards of the first generation of these systems: NMT, AMPS and TACS.

a) NMT (Nordic Mobile Telephone) standard was developed by joint work of the operators from the four Scandinavian countries (Sweden, Holland, Norwegian and Finland) with active participation of the equipment manufacturer (Ericsson). NMT network was the first mobile radio telephone network covering a greater area, i.e. the area of several countries. NMT 450 standard plans 180 basic

radio channels of 25 kHz band and duplex gap of 10 MHz in the frequency range of 453.5-457.5 MHz i.e. 463-467.5 MHz band. Later the standard was expanded to the frequency band of 900 MHz (NMT 900). After the Scandinavian countries, the standard was soon accepted by the Western Europe, Asia- Pacific area, and the countries of the Persian Gulf and North Africa. A bit later, the standard was accepted also in the countries of the Central and Eastern Europe, which provided a significant incentive to its further development and improvement.

b) AMPS (Advanced Mobile Phone Service) standard was developed in North America for operation in the frequency of 800 MHz band. It was very soon accepted in the countries of South America, Asia, Oceania, and later in the countries of the former Soviet Union, thus becoming the widest spread analogue standard. AMPS standard foresees 666 radio channels of 30 kHz band and duplex gap of 45 MHz in the frequency range of 825 - 845 MHz i.e. 870 - 890 MHz.

c) TACS (Total Access Communication System) is a standard developed from AMPS standard but with the possibility of operating in the frequency range of 800 MHz and 900 MHz. The standard is dominant in the area of the United Kingdom, and accepted in China, Hong Kong, Singapore, Near East, and some European countries. The TACS standard version has been applied in Japan as well. TACS standard plans for 1006 radio channels, of 25 kHz band, and duplex gap of 45 MHz in the frequency range of 890 - 915 MHz, i.e. 935 - 960 MHz.

The common characteristics of the first generation standard include the frequency modulation (FM) of the audio signal, and FSK (Frequency Shift Keying) modulation of the control signals, whereas the difference is in the frequency operating range, number and bandwidth of the channels, duplex gap, and some other parameters.

2.2. Systems of the second generation

The need for increased capacities, i.e. more efficient utilisation of the frequency spectrum, along with other factors such as: the possibility to transmit data, need to protect the information, use of small handheld subscriber's devices, hierarchical cellular structure, global operating area, etc. have brought about the development of digital systems of the public mobile telephony system of the second generation. The development of the standard of the second generation of the public mobile telephone systems started in the mid-80s, and the first commercial system has operated since 1992. There are three leading standards of the second generation: D-AMPS and PDC and GSM.

a) D-AMPS

The approach to introducing the digital standard of the second generation in the United States of America differed from the European approach. Instead of introducing a completely new standard, the digital standard D-AMPS was developed based on the existing analogue AMPS standard and was planned to operate in the same frequency band. This approach allowed certain compatibility, i.e. a gradual transition from analogue systems to digital systems by upgrading and replacing the existing analogue infrastructure. D-AMPS was also developed to operate in the frequency band of 1900 MHz, and is represented in the same parts of the world as its analogue predecessor.

b) PDC

The Japanese digital standard for mobile systems of the second generation initially called JDC (Japan Digital Cellular), and currently called PDC (Personal Digital Cellular), was developed for operation in two frequency ranges: 800 MHz and 1500 MHz, and apart from Japan it counts on being present in the Asia - Pacific region.

c) GSM

The development of GSM (Global System for Mobile) standard started under the patronage of the Association of the European postal administrations - CEPT (Conference of European Telecommunication Operators) in 1987, when 18 countries signed a Memorandum of Understanding (MoU) in Copenhagen, with a clear intention of becoming a unique (unlike the standard of the first generation) completely digital standard for the whole Europe, which will allow international mobility of subscribers, huge capacity, and a wide range of telematic and data services of high quality and protection. The first GSM systems started operating in 1991. During 1993, all the major cities and airports in Europe were included, and in 1995 most of the main roads in the countries signatories of the MoU were included as well. Today, the development of the GSM standard is under the authority of the ETSI (European Telecommunications Standard Institute). The specification of the GSM standard is continuously developing, and improving by introducing numerous new possibilities and services. The systems operating today apply the GSM standard specification of the phase 1, which enables digital speech of the so-called full speed of 13 kb/s, i.e. 22.8 kb/s facsimile services of group 3, transmission of data at speeds of 9.6 kb/s, two-way transmission of SMS (Short Message Service) and some additional subscriber services. Additional services are being introduced such as identification of the calling party, conference connection, closed users' group, possibilities of forwarding information by means of all the basic switchboards of a certain area, and transmission of speech at the so-called

Table 1 - Comparison of the characteristics of the NMT 450 and GSM systems

Characteristic	NMT system	GSM system
frequency band	420-490 HMZ (all the countries do not have the same frequency band)	890-960 Mhz (this band is standard for all the signatories of MoU)
number of radio channels	180	992
bandwidth of one channel	25 (20) kHz	25 kHz
duplex gap	10 MHz	45 MHz
coverage range of the base station	15-40 km	2-18 km
max. power of the base station	50 W	25 W
power of the mobile station – max – medium – small	 15 W 1.5 W 0.15 W	 1.0 W 1.0 W 0.1 W
quality of the speech connection	good	better
roaming	fully automatically	fully automatically

half-speed of 6 kb/s i.e. 11.4 kb/s which insures that at every 8 intervals one frequency carrier supports two channels, thus doubling the system capacity.

2.3. Systems of the 2+ generation

Parallel to introducing phase 2, the GSM specification phase 2+ is being developed and standardised. Phase 2+ includes new applications fields, new frequency operating area (1800 MHz and 1900 MHz), operation in several frequency bands (multiband), development of radio interfaces, and access by the users of other standards (e.g. DECT - Digital European Cordless Telecommunications) to GSM infrastructure, co-operation with other ground and satellite networks, introduction of IN (Intelligent Network) functions into the GSM network, adaptive assignment of resources to users at request (e.g. assigning of up to 8 intervals, i.e. speed of 64 kb/s to single users), integration of GSM systems and location GPS (Global Positioning System) services, and many other possibilities. Thus the development of the GSM standard has been gradually directed towards fulfilling the requirements of the third generation of the mobile communication systems. Thus, the basic GSM standard resulted in the DCS (Digital Communication System) 1800 standard for operation in PCN (Personal Communications Networks). The PCN concept tends to bring closer the mobile telecommunications not only to business people, but to every average man, thus significantly expanding the existing market. Therefore, GSM specification has been expanded and adapted for operation in the frequency range of 1800 MHz. The reduced propagation, along with a greater number of the assigned frequency carriers (324), and the limited power of mobile stations (1 W peak) enable the construction of high-capacity systems. The first DCS 1800 system started operating in the UK (1993), and today such systems operate also in Germany, France, Malaise, and Thailand. The EC (European Commission) recommendation is that every country member of the European Community should issue a concession for at least one PCN network.

2.4. Systems of the 2.5 generation

PCS (Personal Communications Services) concept has been defined in the United States of America and described as a "wide spectrum of radio communication services which overcome the limitations of the wire PSTN and enable users to communicate even when they are away from their home or office telephones" and as "communication network in which the same light mobile telephone will be used as a home, office or public network telephone for access to the user through a unique number anywhere, anytime". The concept has not been limited only to services of the mobile telephony, but includes various services of data transfer, storage and handling of messages, facsimile services, and other sophisticated applications. WARC (World Administrative Radio Conference) assigned in 1992 the frequency range of 1.8-2.3 GHz to mobile systems of personal communication and mobile satellite systems. Similarly, the American FCC (Federal Communications Commission) assigned the frequency range of 1.9 GHz to PCS networks in its

area. The PCS concept does not specify a special standard or access with which it would be implemented. As possible solutions the systems of various standards i.e. technologies can be considered: systems of CDMA (Code Division Multiple Access), wireless systems based on the DECT standard, and mobile cellular systems of TDMA access. Regarding the possibilities of coverage required by the PCS concept, and the existing experience in applying the selected technologies, the mobile cellular systems of TDMA access are considered the most logical choice for application in PCS networks. Mobile cellular systems which enable the PCS concept of personal communications are included in the 2.5 generation of the mobile cellular systems. The characteristic of this system is the application of the model of the hierarchical structure of cells - HCS (Hierarchical Cell Structure Concept), which organises cells of various sizes i.e. types into layers which do not mutually interfere. In this way, a certain area is not covered only by one cell but with several cells from various layers. Macro-cells cover greater areas and serve the fast mobile users, whereas the slower mobile users are served by micro-cells of a greater transport capacity, which cover areas of street sizes. Pico-cells of extremely high transportation capacity are intended to cover closed spaces, with a great density of users. The future will probably bring huge umbrella cells which will ensure global coverage, through satellite systems. The systems of TDMA access for application in PCS networks are specified by PCS 1900 and DCS 1900 standards. The PCS 1900 is based on the GSM world standard, and it was developed from the DCS 1800 standard with modification to the PCS frequency band and American signal protocols. PCS 1900 provides a high system capacity and specifies numerous applications and functional possibilities as well as services planned by the PCS concept. DCS 1900 was developed from D-AMPS 800 standard, and along with the introduction of new possibilities required by the PC concept it supports the operation in two frequency bands (dual bands): 800 MHz and 1900 MHz. In this way the standard is excellently integrated into the existing telecommunications environment of the future PCS networks allowing gradual transition towards the PCS concept.

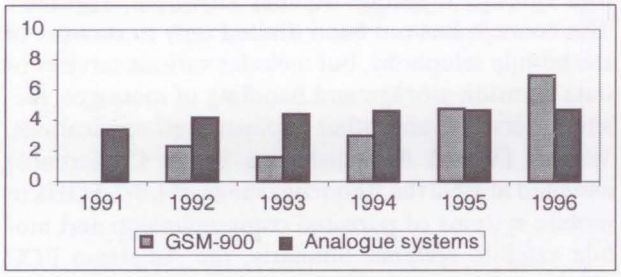

Figure 1 - the increasing number of mobile telephone lines in Europe, 1991-1996

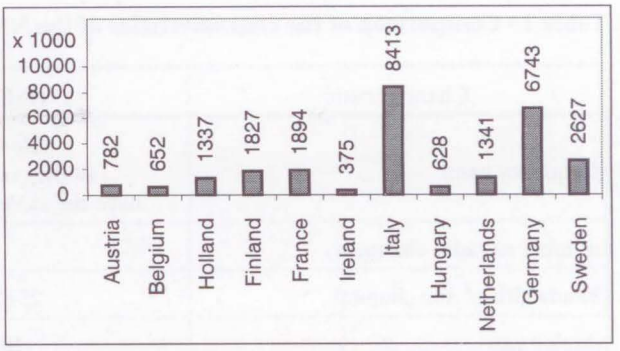

Figure 2 - the number of mobile telephone lines in certain European countries (August 1997)

Figure 2 presents the number of mobile telephones in certain European countries in August 1997.

3. THE DEVELOPMENT OF MOBILE TELEPHONY IN CROATIA

The idea of introducing mobile telephony in Croatia appeared just before the sport manifestation "Univerzijada 87". In 1985 the construction of a pilot mobile radio network was planned, for the requirements of "Univerzijada 87" according to the NMT protocol with a capacity of 800 lines. Due to financial problems and the problems with the frequency range of about 450 MHz already used by other users, the plan completely failed.

The public network of the analogue mobile telephony, MOBITEL started operating experimentally in October, 1990 and commercially in January 1991. It operates with NTM 450 standard with a somewhat lower frequency range:

- transmitting frequencies of the base-stations of 411, 675 to 415,850 MHz,
- transmitting frequencies of mobile stations of 421,675 to 425,850 MHz.

MOBITEL is primarily a national system of mobile communications which enables its users communication on the Croatian territory, and also on the territories of the two neighbouring countries - Slovenia and Bosnia and Herzegovina. The continuous growing of the number of MOBITEL network subscribers is the result of qualitative improvements, and good geographical coverage of the country. An important prerequisite for the increase in the number of subscribers to the MOBITEL network was the reduction of prices for subscribing to the network and of the mobile telephone devices, as well as the reduction in size and mass of these devices, thus contributing to greater mobility. The fact should also be remembered that the prices of making the calls in the MOBITEL network are nearing the prices of fixed telephone calls.

Due to the sudden growing need for the mobile telephony in Croatia, HPT (Croatian Postal and Tele-

Figure 3 - The map of MOBITEL network covering Croatia

communications) started in 1994 intensive preparations to introduce the modern GSM technology into the mobile telecommunication network of Croatia, and to be integrated into the Pan-European digital system of the mobile radio telephony. The public network of digital telephony, CRONET, started operating experimentally in August 1995 and commercially in March 1996. It operates according to the GSM standard in frequency range:

- transmitting frequency of the base stations from 935 - 960 MHz,
- transmitting frequency of the mobile stations from 890 - 915 MHz.

The advantage of GSM system is that it allows undisturbed communication not only within the country, but also from all the countries that have a network and agreement on mutual usage (roaming). Fast expansion of CRONET is the result of the increasingly good geographical coverage of the country, higher capacity, introduction of the additional users' possibilities, prices reduction, and market liberalisation of the GSM devices (benefits when individually importing the device).

The following Table 2, and Figure 5, present the increase in the number of mobile telephone lines in Croatia in the period between 1990 and 1997.

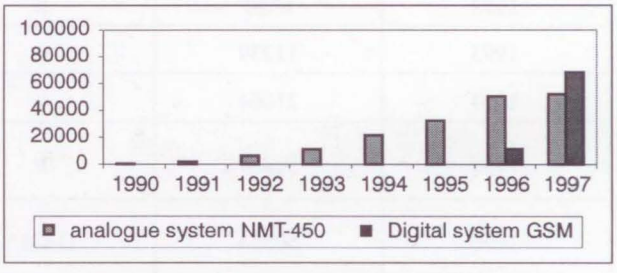

Figure 5 - the increase in the number of mobile telephone lines in Croatia

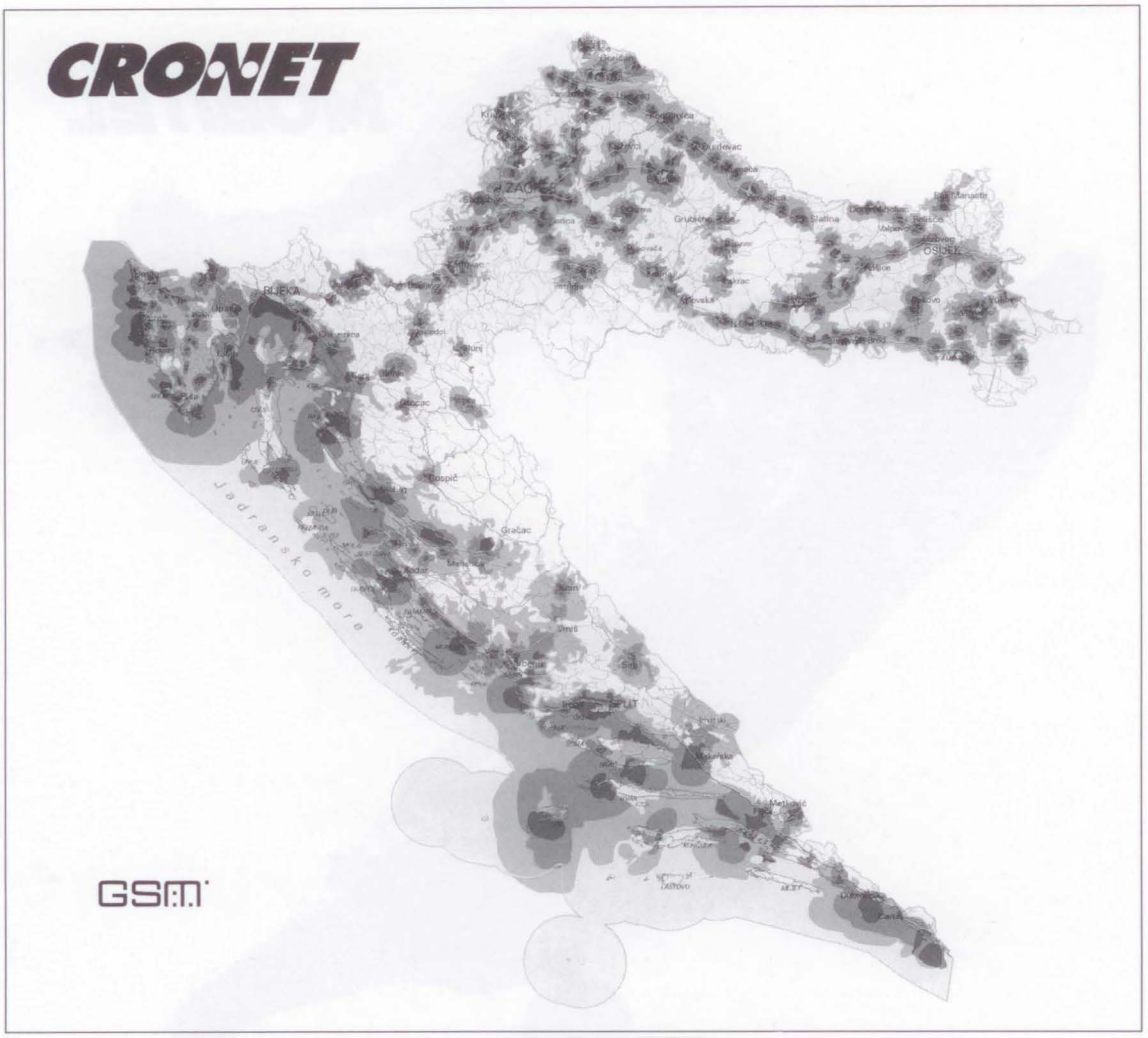

Figure 4 - the map of covering Croatia by the CRONET network

Table 2 - the increase in the number of mobile telephone lines in Croatia

year	Analogue system NMT-450	Digital system GSM	Total A + D	Remarks*
1990	500*	0	500	start of exp. operation - - October 1990
1991	2019*	0	2019	start of commercial operation - - January 1991
1992	6320	0	6320	
1993	11239	0	11239	
1994	21664	0	21664	
1995	32284	0*	32284	start of exp. operation - - August 1995
1996	50554	11421*	61975	start of commercial operation - - March 1996
1997	52155	68265	120420	

4. THE FUTURE DEVELOPMENT OF THE MOBILE TELEPHONY

Mobile telephony is a part of the telecommunication market which is growing most rapidly. Mobile telephones made up 4% of the world market of telecommunication services already in 1990, and they are growing daily. This increase is conditioned by intensive investments into the development of new technological solutions of the mobile telephone networks. This resulted in the development of the mobile telephone systems of the third generation. This generation is not going to be in commercial use in this century, but it is being intensively defined and standardised. FPLMTS (Future Public Land Mobile Telephone Systems) under the patronage of ITU and UMTS (Universal Mobile Telecommunications Services) was established within ETSI. These organisations work in co-ordination on defining and developing the third generation of mobile communication systems. Their vision is to take and improve the best characteristics of the fixed and mobile communication systems and combine them in a unique world mobile communication system which will be able to provide any required communication service. The systems of the third generation will work in multimedia surroundings, significantly different from the today's telecommunication environment, and they will be managed by various factors (telecommunication, computer, software, TV and video industry, etc.) with an important stress on the variety of applications and services. Unlike today's environment in which the service suppliers are the elements of the network infrastructure, the emphasis will probably be on the introduction of services into user terminals, whereas the network will be primarily used to transmit programme mediators between them. A significant difference between the systems of the second and those of the third generation is that systems of the third generation have to be of wide band, supporting various services of transmitting data up to the speed of 2 Mbit/s. This objective will be reached gradually, and the first step is supporting the 64 kbit/s ISDN of the basic access. The third generation of the mobile communication systems will provide high quality speed of the same quality as in the fixed network, allow application of video phones, plan for the use of ground and satellite network elements in order to achieve global coverage, multiple mode terminals, hierarchical cellular structure with multi-layers, and multi-operational environment.

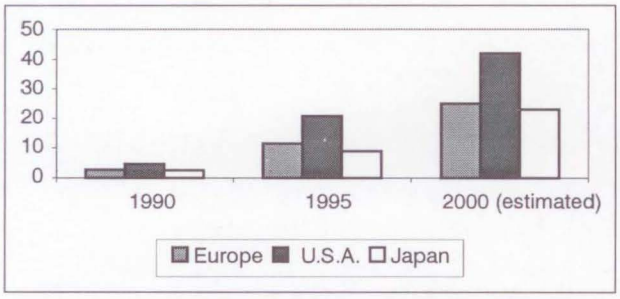

Figure 6 - the increase of the portion of telephone line numbers in relation to the main lines in certain regions in the world

5. CONCLUSION

The future of mobile telephony is in the expansion of the users' services, further minimisation of telephone devices, and constant increase in the coverage area. The currently smallest device weighs only 45.4 grams and is integrated into a watch. The European Commission has announced in the publication *Eurofocus* a suggestion to the European Parliament, and to the Board of Ministers of the European Union, about the introduction of the system UMST (Universal Mobile Telecommunications System) by the year 2002. A French telecommunications consultancy IDATE claims that mobile telephones will form 21% of the market by the year 2000, and 63% of the fixed ones.

SAŽETAK

RAZVOJ MOBILNE TELEFONIJE U SVIJETU I HRVATSKOJ

U radu se prvo opisuje otkriće i uvođenje mobilne telefonije u svijetu i Hrvatskoj. Zatim se uspoređuju osnovne karakteristike i mogućnost pojedinih generacija sustava mobilne radio telefonije te ističu pojedine prednosti. Na kraju se ukazuje na perspektivu daljnjeg razvoja mobilne telefonije i u tom smislu donose odgovarajući zaključci.

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