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DEVELOPMENT TRENDS OF MODERN TELECOMMUNICATIONS

This paper is dedicated to Prof. Ilija Stojanović on the occasion of his 75^{th} birthday and the 50^{th} anniversary of his scientific work

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Abstract. The paper contains the survey and the comments of the present-day state and modern trends of the development of world's telecommunications. The development trends of public mobile telephony systems, terrestrial as well as of new satellite mobile systems, WLL systems, data networks and the access networks, multimedia, some aspects of Internet, etc., are involved. In the second part of this paper the data on the state of art and development trends of telecommunications in Serbia are discussed

1. Introduction

Some characteristics of the contemporary society, at the end of the 20th century are the following:

- the globalization of the world economy with high requirements regarding production and its flexibility;
- process control of manufacturing and infrastructure systems;
- mobility of the population;
- the development of global, personal telecommunication systems; the development of global computer network INTERNET and a series of local networks, INTRANET.

This concept of the development of the present-day society implies a high degree of the development of telecommunications. In the course of the previous 20 years both quantitative and qualitative changes in telecommunications have occurred, which had practically immeasurable effect on the

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contemporary society. From the present-day standpoint telecommunications represent,

- a basic need of the modern society;
- a measure of economic, social and cultural development o of the society;
- a unique limitless uniting phenomenon, irrespective of the curtural, social an political development.

In other words, it could be considered that the modern telecommunication are the infrastructure of the modern society.

In the framework of the this paper a concise survey of the development of contemporary telecommunications is given, with a special refernce to the development of telecommunications in our country. As it is a frequent case, when such a large area is at stake, the authors were faced with a dilemma what to select from the telecommunications field and in which way to present it for the purpose of this paper.

Hitherto, a conventional approach to the analysis of the development of telecommunications through the density of users in fixed public telephone systems, does not provide an adequate image of the development. However, if these data are completed with the data on,

- the density of the users in the mobile telephony systems, and
- the density of Internet users, we get an insight, in an indirect way, into the development of whole telecommunication structure, starting from the manufacturer, through the provider till the final users. It is interesting to emphasize that the adduced parameters very really reflect the economic power of the society, too. For example, according to the report ITU 96/97 World Telecom. Report,
- telecommunication industry is expected to participate with cc. US$ 1300 billion in 1998;
- telecommunication industry is more developed than the information industry;
- with respect to the invested money the order of importance is: banking system, health system, telecommunications...
- telecommunication companies are at the seventh place in the world by their income, etc.

The analysis of the development of telecommunications in the previous period points out very clearly to the concept of the development of modern telecommunications. The main issues are "**Personalization**" of telecommunications, "**Mobility**" of users and the phenomenon of the building of the "**Telecommunication network**". Parallel with such trends of the modern telecommunication advancement, the following are present, too;

- demonopolization, deregulation and liberalization at the telecommunication markets ;
- the emergence of new services;
- integration of particular functions and technologies in telecommunication traffic;
- privatization of telecommunication systems, i.e. services, in all developed countries of the world.

According to the ITU's and other specialized agencies analyses, the market of present- day telecommunications, including the infrastructure, equipment and services, is one of the most lucrative markets, with extremely high and fast turnover of the capital. This is a result of several trends that are globalizing the provision and consumption of telecommunications services. Fig.1 and Tab.1 show some basic quantitative indicators of this market, according [2].

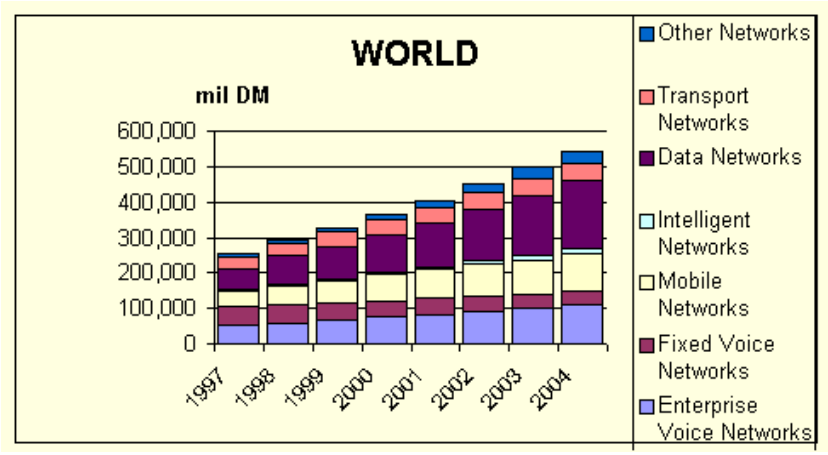

Figure 1. The value of the market of the present-day global telecommunications.

Having in view the variety of telecommunication systems and services, the classification of telecommunications is not simple. The following can be considered as general areas of the development of modern telecommunications:

- terrestrial and satellite personal telecommunication systems, with the respective services;
- satellite global telecommunication systems;
- basic trunked telecommunication systems;

Table 1. Quantitative indicators of the global market.

Market (mid DM)	1998	1999	2000	2001	2002	2003
Enterprise Voice Net.	**59.320**	**66.935**	**74.834**	**82.527**	**89.947**	**98.516**
PBX/KTS 7–200 L.U.	20.489	21.345	21.779	21.864	22.170	22.531
PBX/KTS > 200 L.U.	12.820	13.155	13.587	13.516	13.748	14.051
Applications	21.261	25.825	30.743	36.152	41.075	46.715
Prof. Sevice	4.750	6.610	8.725	10.995	12.954	15.218
Fixed Voice Networks	**50.991**	**46.530**	**46.446**	**45.464**	**43.872**	**40.754**
CO Switching	37.500	32.752	32.228	31.302	29.734	27.625
NB/WB Access	13.491	13.779	14.218	14.162	14.139	13.129
Mobile Network	**53.916**	**65.463**	**74.271**	**81.464**	**90.691**	**98.311**
Mobile Switching	19.555	23.585	26.349	28.643	31.633	34.019
Mobile Radio	33.296	40.159	44.865	48.771	53.861	57.925
Wireless Access	1.064	1.719	3.057	4.050	5.197	6.367
Intelligent Networks	**4.217**	**4.885**	**6.218**	**7.930**	**10.175**	**12.385**
Data Networks	**79.677**	**91.918**	**104.655**	**122.368**	**144.802**	**169.135**
Enterprise LAN/WAN	63.422	69.588	75.161	83.144	94.727	107.830
Carrier WAN	15.891	20.502	26.269	34.818	43.702	51.935
BB Access	364	1.828	3.226	4.406	6.373	9.371
Transport Networks	**35.847**	**39.121**	**42.526**	**44.840**	**46.516**	**47.422**
PDH/SDH/Sonet Net.	25.016	26.896	28.537	28.526	27.904	26.562
WDM Networks	4.294	5.634	7.426	9.767	12.108	14.424
Microwave Radio	6.538	6.591	6.564	6.547	6.503	6.436
Other Networks	**10.734**	**12.801**	**16.224**	**19.581**	**24.122**	**31.069**
TOTAL	**294.701**	**327.653**	**365.175**	**404.176**	**450.125**	**497.592**

- digital radio and TV broadcasting;
- wideband optical cable telecommunication systems, as the basic of the national, regional and global telecommunications.

The concept of the modern telecommunication development is based on,

- the use of wide frequency range;
- high density of traffic;
- high data rates;
- entire digitalization (processing and transfer);
- system transparency;
- interactivity;
- global mobility;

- permanent development of telecommunication systems,
- interconnection of various systems.

The development of telecommunications in our country, in the course of the last 10 years primarily depended on interior and exterior economic and political conditions. The lack of fresh investment money, a partial limitation of the access to modern technologies, the decrease or stagnation of all economic activities, obliterate and inadequate legal regulations, and so on, are not, certainly, a suitable environment for the growth of one so propulsive branch such as telecommunications are. However, though very slowly, the tremendous and intensive world processes of changes in telecommunications had a definite, but somewhat limited influence on telecommunications in our country, particularly on,

- digitalization of telephone systems;
- building of optical transfer systems;
- limited but clear development of infrastructure of home Internet and all other capacities and services for data transfer;
- intensive building of the GSM capacities of public mobile telephone systems;
- the development of the private segment of the radio and TV, etc.

This paper consists of five chapters. The second chapter provides the survey of the present state of art in the development of modern telecommunications. Particular attention being devoted to the public mobile telephony systems, having in view that the concept of their development affects essentially the growth of future telecommunication systems and services. The third chapter is devoted to the analysis of the present and future development trends of modern telecommunication in the course of the next several years. Particularly the possibilities of a future universal personal telecommunication system were analyzed. Within the framework of the fourth chapter a limited survey of the present-day state in telecommunications in our country is given. The final considerations are contained in the fifth chapter.

2. Current State of the Art in the Development of Modern Telecommunications

2.1. The Process of Structural Reforms

The process of big structural changes in the telecommunication area has started at the beginning of the 80s. The process of deregulation, liberalization and privatization, which previously struck other industrial sectors, demanded the adjustment of telecommunications, as one of the infrastructural foundations of a modern society.

At that time, in a majority of countries of the world, the basic services in telecommunications, telephony, data transfer and telex, have represented the monopoly of national operators. However, by the European Union's decision of January 1998 on the cancellation of the monopoly in these fields, a fast process of liberalization has started in the telecommunication field, except in underdeveloped European countries, such as Portugal and Greece, who got a time-limited prolongation of the monopoly.

The first and the most important step in a general liberalization of telecommunications is undoubtedly the deregulation of legal relationships in this field. The State administration using legally regulated functions of the State, with the active participation of national operators, through the change of regulations, decreases the State's influence and limits the national operators' monopoly. In such a way, a path to liberalization is opened, which implies the presence and a free rivalry and more providers of telecommunication services and equipment at an entirely open market.

The liberalization in the open market conditions implies a large freedom, but simultaneously a major responsibility in the offer of new telecommunication services, as well as the improvement of the existing ones. It is users-oriented and its basic aim is to satisfy public interests through the increase of the operator's efficiency and innovations in the equipment and services offered. The first steps of the liberalization were made in the USA; afterwards this approach was accepted by the European Community's countries and Japan. The liberalization in telecommunications has yielded the best results in data network systems, on the market of terminal equipment, and particularly in the system of public mobile telephony. In the field of telecommunications there is the general tendency to perform simultaneously both the liberalization and the privatization.

2.2. Public Systems of Mobile Telephony

The basic characteristic of the present state of contemporary telecommunications is the accelerated application of the second generation of public systems of mobile telephony, of residential cordless telephone systems, cordless WAN/LAN networks, as well as intensive developments of the standards for the third generation of the mobile telephone systems. The main characteristics of the mentioned systems are quoted in Tab.2-4.

The present state of the number of users in mobile telephony as well as the predictions for several future years are presented in Fig.2. The development of the mobile telephony system in Europe is plotted in Fig.3, where it is easy to see the widespreadness of the GSM system.

The role of modern public mobile telecommunications is not exclusively

Table 2. Main characteristics of the 2nd generation of mobile telephone systems.

Charact.	**IS-54/-136** N. Amer. Dig. Cell.	**IS-95** N. Amer. Dig. Cell.	**GSM**	**DCS 1800**	**PDC** Person. Dig. Cellular.
Mobile Frequency Range MHz	Rx:869-894 Tx:824-849	Rx:869-894 Tx:824-849	Rx:925-960 Tx:880-915	Rx:1805-1880 Tx:710-1785	Rx:810-826 Tx:940-956 Rx:1429-1453 Tx:1477-1501
Mult. Access Method	TDMA/ FDM	CDMA/ FDM	TDMA/ FDM	TDMA/ FDM	TDMA/ FDM
Duplex	FDD	FDD	FDD	FDD	FDD
Number of Channels	832 (3us./ch.)	20 (798us./ch.)	124 (8us./ch.)	374 (8us./ch.)	1600 (3us./ch.)
Ch. Spacing	30kHz	1250kHz	200kHz	200kHz	25kHz
Modulation	4 DQPSK	QPSK/ OQPSK	GMSK	GMSK	4 DQPSK
Ch. Bit Rate	48.6 kb/s	1.2288 Mb/s	270.833 kb/s	270.833 kb/s	42 kb/s

Table 3. Standards for residential digital cordless telephones.

Standard	**CT1/CT1+** Cordless Telephone 1	**CT2/CT2+** Cordless Telephone 2	**DECT** Dig. European Cordless Teleph.	**PHS** Pers. Handy Phone System
Frequency Range (MHz)	CT1:914/960 CT1:885/932	CT2:864/868 CT2+:944/948		
Multiple Access Method	FDMA	TDMA/FDM	TDMA/FDM	TDMA/FDM
Duplex Method	FDD	TDD	TDD	TDD
Number of Radio Channels	CT1:40 CT1+:80	40	10 (12 users/ch.)	300 (4 users/ch.)
Channels Spacing	25kHz	100kHz	1.728MHz	300kHz
Modulation	FM	GFSK	GFSK	4 DQPSK
Channel Bit Rate	n/a	72 kb/s	1.152 Mb/s	384 kb/s

to realize the users' mobility, as it could be thought at the first instant. Those are the systems whose installation is relatively fast and simple, with less investments with respect to public systems of fixed telephony. The data contained in Fig.4 show that by means of mobile systems the development of

Table 4. Standards for WAN/LAN networks.

Standard	**CDPD** Cellular Dig. Packet Data (WAN)	**RAM-Mobitex** (WAN)	**Ardis-RD-LAP** (WAN)	**IEEE 802.11 Wireless LAN**
Freq. Range (MHz)	Rx:869-894 Tx:824-849	(North Amer.) Rx:935-941 Tx:896-902 Eur./As.403-470	Rx:851-869 Tx:806-824	(North America /Europe)2400-2483 (Japan) 2470-2499
Mult. Access Method	FDMA	TDMA/FDM	TDMA/FDM	CSMA
Duplex Meth.	FDD	FDD	FDD	TDD
No. of Radio Channels	832	480	720	FHSS:79 DSSS:7
Ch. Spacing	30kHz	12.5kHz	25kHz	FSHH:1MHz DSSS:11MHz
Modulation	GMSK	GMSK	FSK (2&4 Level)	FHSS: GFSK DSSS: DBPSK (1MB/s) DQSK (2MB/s)
Ch. Bit Rate	19.2kb/s	8kb/s	19.2kb/s	1 or 2MB/s

telephone systems in underdeveloped countries, on the one hand, and completing the development of the existing fixed telephone network, in developed countries, on the other hand, can be considerably accelerated.

2.3. The Existing Telecommunication Networks

The hitherto telecommunication networks were built purposefully, for pre-defined services. The existence of many specialized networks is unfavorably reflected on indirect users as well as on the providers, i.e. the networks owners. From the users' point of view, the services are more expensive and more complicated for application, because the users of every service employ the respective equipment and the manner of work. On the other hand, providers have to ensure many networks with different equipment, manners of work, maintenance, which requires major investments. Having in view the directions of the development of contemporary telecommunications, the dominant approach being the integration of telecommunication systems and services, the conclusion is reached that the concept of particular specialized telecommunication networks is a non-effective and non-economic solution.

In the period from 1990 to 1995 the wideband ISDN emerged through

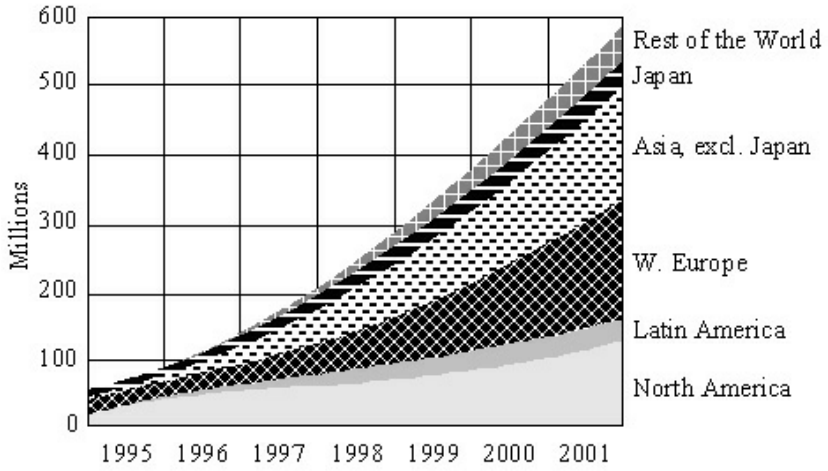

Figure 2. The growth of the number of users in mobile telephony systems and the predictions till the 2001st year.

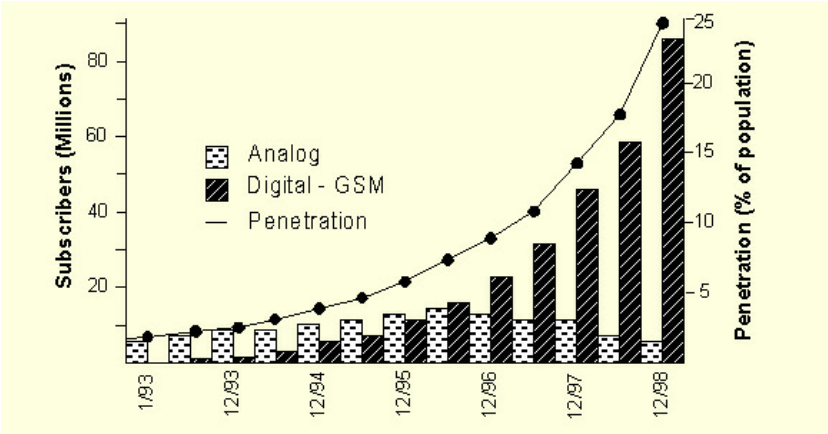

Figure 3. The growth of the number of users in public systems of mobile telephony in Europe.

ATM and the new data services such as SMDS. There is an omnipresent tendency to realize the user-system interaction. On the basis of the aforementioned it could be inferred that in future the technology for the user-directed transfer and services at the same point of the access to the networks is to

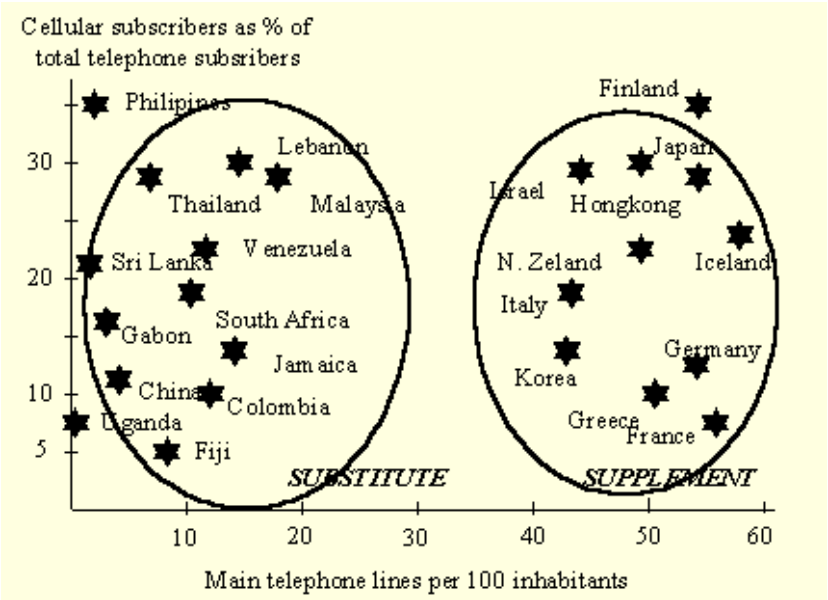

Figure 4. The role of mobile telephony in the development of the telecommunication infrastructure.

be simultaneously ensured. Since the precise requirements are difficult to be foreseen, flexible and economically justified superstructure of the existent infrastructure will be extremely important.

2.4. The Public Switched Telephone Network

Public switched telephone networks, PSTN, represent the majority of the present-day telecommunication networks. Their classification is simple; they are either analogous or digital. They consist of the transport systems, commutation and users' terminal devices.

The conduction of the telephone traffic is organized to the transit exchange plane at a hierarchical level; between the transit exchange points it is organized on a non-hierarchical principle, which means that the configuration of lower levels of the networks is starlike, and it is loop-like at the top plane of the national network. In accordance with the traffic flows the telephone network is divided to local, inter-city and international networks. The local networks can be centralized or decentralized depending on the number of telephone exchanges.

The basic function of the network is to ensure the transfer of voice and

other signals among different points in the respective plane or between the plane of the national network, involving the international traffic, too, in both directions. The public switched telephone networks primarily conceived to satisfy the requirements of a qualitative transfer of speech signals.

The access network, within a classical telecommunication network, is realized in the form of users' loops which connect the users with the telephone switchboard. In a classical telecommunication network the services of the hired lines, data services and switched services are using specialized equipment and networks, the flow being mainly limited to 1.5 $Mbit/s$ (T1) or 2 $Mbit/s$ (E1).

The physical structure of present day telephone networks in the majority of cases is realized by the cables with metal conductors, by connecting the points-to-points between the local exchange and the users. The couplings of the equipment for the switched services are specialized for every specific service as well as the respective control aspects. The basic drawbacks of the so realized networks are limitations of the range, limited reliability due to the point-to-point connection and due to non flexibility with respect to changes in services' profiles. Besides, due to the variety and non modularity of the equipment, the expenses of life circle as well as those of maintenance are high.

2.5. The Data Networks

Modern networks for data transfer involve thousands of terminals and computers, they are spatially almost unlimited and they are exceptionally flexible. The equipment connected to the network consists of computers, terminals and other devices for data transfer communication. The coupling with the network is done through the network nodes.

The data transfer networks are classified into commutation-based networks and distributive ones, depending on the architecture and technical solutions. The data networks are divided into:

- data networks based on commutation of circuits;
- data networks based on commutation of messages;
- data network on the basis of commutation of packages.

Through a comparative analysis of different types of data networks, which are nowadays in practice, the following conclusions can be inferred:

- systems for message commutation are not suitable for interactive work;
- for small traffic with frequent interruptions it is best to employ the circuit commutation;
- for a major traffic between two data terminals the most economic way

is to use the hired lines;

- the package commutation is the most suitable solution for data exchange;
- the package commutation by the method of virtual circuits is more suitable in the cases where there is a need for long-time data exchange.

The so-called distributing networks, which are today used, are radio, satellite or local networks for data transfer.

The present-day business information systems are mainly based on local computer networks, LAN, as well as on access to the networks in larger area, WAN.

The basic characteristics of the present-day LAN networks are relatively small area distribution at the level of macro cells of diameter of several km, with 2 $Mbit/s$ rate minimum, and the fact that in most cases they are the property of an organization. As their commutation access the LAN networks use multiple access channels. In such an approach, the basic problem is the allotment of channels' capacity in the case when a lot of computers send their data simultaneously.

The networks in a larger area cover a big territory with the respective flows. Usually the national administrations are the owners of external paths and nodes, while the users get the so-called host computers and appropriate LAN-s. It is important that in the manner of communication the WAN networks also ensure the connections from one point to another.

Among local LAN networks and the networks at a larger area of WAN type, the networks at city area emerge, MAN. These networks cover the territory of a town and according to the protocols they are using, they are close to the LAN networks.

The WAN networks are based on the existing public telephone network, while the LAN type networks are primarily based on its own wideband cables. Independent of the existing differences between LAN and WAN networks, they nowadays make a unique telecommunication infrastructure of information systems.

2.6. Integrated Services of Digital Networks

In the 80s, as a telecommunications network of the future, a universal narrowband digital network with integrated services, ISDN, was defined. According to definition, ITU-Rec.I.120, ISDN is a network developed from digital integrated network, enabling digital connections from one end to the other and supporting a large area of speech and non speech services. The users access to it by means of a limited number of standardized, multi-

purpose interfaces user- network. Technical preconditions making possible the realization of the so set goal are: digital transfer, SPC digital commutation, signalization through the mutual channel, universal protocols on the basis of the OSI reference model and standardization. In comparison with the digital telephone network wherein the analogue signals are transported to the user's equipment, the basic technical innovation of ISDN is digitalization of the user's line.

The user's access is conceived on the basis of the channels, marshaled into three groups:

- the B channel with 64 $kbit/s$ flow, which can transfer all types of information, and which is commuted by the circuit commutation technique;
- the D channel with 16 $kbit/s$ or 64 $kbit/s$ flow, commuted with the package commutation technique, used for CCS No7 signalization and other services;
- H channels having the radtes of $n \times 64$ $kbit/s$, with other characteristics same as for B channel.

Two configurations of the access ti ISDN are basic access and primary access:

- The basic access BRI consists of two B and one D channels. The total user's capacity of this configuration amounts to 144 $kbit/s$. Two B channels can be used independently one from the other;
- the primary access PRI uses 30 B channels and a D channel with 64 $kbit/s$ flow. The total capacity of the primary access is 2.048 $Mbit/s$.

The main users of ISDN, with rates which are multiples of 64 $kbit/s$, are residential users and small or middle sized business organizations. Those are the users who need modern telecommunication services, but are unable to organize them themselves and use the public ISDN basic access instead. On the other hand, due to wider use of computers and the introduction of specialized networks, such as LAN, MAN and WAN, it was necessary to start adjusting ISDN characteristics to these new requirements.

ITU has defined B-ISDN, as a wideband digital network, which contains the channels and commutations capable to support the flows much bigger than the primary ones, 2 $Mbit/s$. The wideband B-ISDN is different from the narrowband ISDN in three key elements:

- the narrowband ISDN employs the existing telephone network, consisting of symmetric metal conductors, as an infrastructure, while B-ISDN uses the optical fibers cables and microwave radio systems;
- B-ISDN uses exclusively package commutation;
- B-ISDN uses virtual channel without previously defined flow.

The B-ISDN characteristic is to support transport of the wideband audio and video signals, but also the high data transfer, with non commuted and commuted connections on the principle of circuit and package commutations.

It is interesting to notice that ISDN systems are very developed in Europe, unlike the USA. The reason is the fact that hiring of lines in the States is much cheaper than in Europe, so the users do not need to have a developed ISDN.

During last years ADSL technology emerged as a main rival to ISDN technology; it makes possible the flow towards the user even till 6 Mb/s. It should be kept in mind that incompatible technologies are at stake, since ISDN is intended for a global transfer of speech and data, while ADSL is mainly intended for local networks.

2.7. Internet

The telecommunication and information world was drastically changed by the expansion of Internet, [18]. Its development started in early 70s, by linking American laboratories and larger academic centers into a common network known by the name ARPANET. At the end of 80s, Internet spread beyond the boundaries of the United States of America, and it grew into a real global network. The general architecture of modern INTERNET is shown in Fig.5

The proclamation of Internet as a global information infrastructure by the USA's government, as well as the emergence of the first real multimedia network service, **World Wide Web**, have conditioned the major break of networks in the commercial area. Almost all corporations linked themselves to Internet, primarily with universities with which they had cooperated on a permanent basis, and then with the specialized companies for the supply of Internet services - so-called Internet providers. In such a way Internet, from an academic network, grew into a network of donors and users of Internet services, based on the principles of market management. The use of Internet stopped being a luxury of big multinational companies and well-known universities and it became an imperative for each company, willing to be present and well known at the market. Simultaneously, a large population of residential users presently gets access to the global network.

On the other hand, the first successful experiments with the transfer of digitalized speech in the real time by means of Internet enabled the creation of an entire series of new, interesting services. The first services of such a type, making possible an interactive conversation between two or among several users through a *sound blaster device* (for example *IPhone*), probably

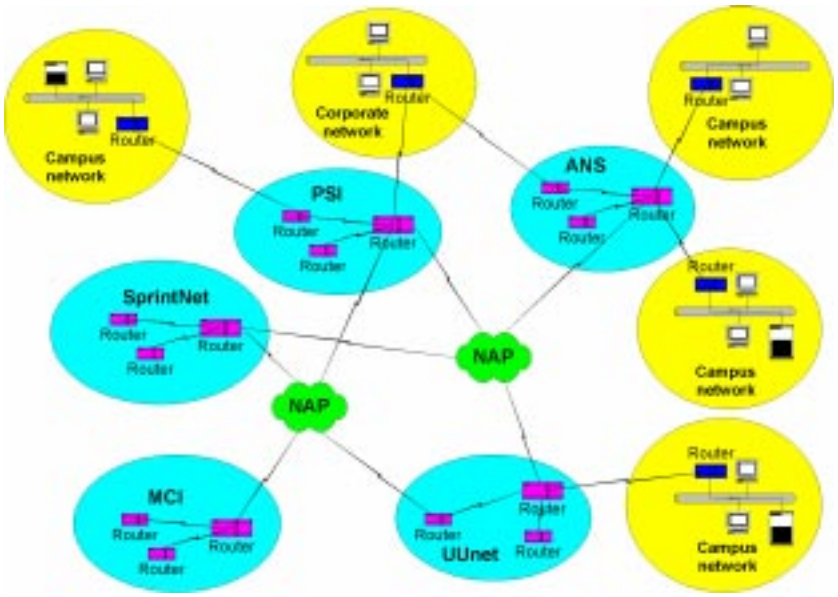

Figure 5. The Internet architecture today.

did not jeopardize seriously the interests of telecommunication operators. However, the appearance of specialized devices (*PSTN gateways*), capable to transfer the entire groups of telephone channels between classical digital telephone exchanges, forced many operators to change to a considerable extent their own business policy. That is why many telecommunication operators, who had earlier treated Internet just as a service for which they had to ensure a transport telecommunication network, have appeared at the Internet services market, on an equal footing with other providers. Like other providers, telecommunication operators started offering their own solutions for integrating classical telephony and data transfer.

Upon the successful carrying out of the first business transactions through Internet, it became clear that Internet nowadays is to be treated as a part of the global telecommunication infrastructure, not just as an ordinary service. This is also confirmed by the fact that in the present-day only few States do not have the access to Internet, for example Iraq, North Korea and some small Pacific countries. The omnipresence of Internet enables nowadays even small companies, with their representations in many States, to form their own corporate networks through Internet, in the form of the so-called virtual private networks. The low price of the network realization, which is reduced to hiring the links to the nearest local providers, is paid on

the other side by expensive solutions of cryptoprotection.

A particular problem for the implementation of electronic business activities in many States represents the lack of national or international legislative regulations, regarding the carrying out of transactions and communication by means of Internet. Unlike classical telecommunication networks, whose functioning, from the legal point if view, is regulated by corresponding inter-State agreements, as well as agreements with corresponding international organizations (United Nations, ITU, etc.), the most aspects of Internet functioning are regulated only by the agreements between the providers and their users. The solid coordination on an international level exists only in some technical aspects of the network functioning, indispensable to safeguard its integrity, performed by many international organizations (IANA, ICANN, ISOC, etc), mainly treated under the auspices of the USA government. On the other hand, aware of the Internet importance in electronic business transactions, the State bodies of many countries, as well as the institutions of international law, are preparing or are using the respective law regulations. Apart from that the governments of many countries investigate to a large extent the possibility to sign international agreements concerning various aspects of the global network functioning. It is difficult to foresee at this moment how these measures will affect the further development of Internet, as well as the prices of future Internet services on the market.

3. The Characteristic Development Directions of Modern Telekommunications

Modern telecommunications, as was stressed many times, represent one of the key fields of the development of contemporary society with exceptionally fast qualitative and quantitative changes. If we add there fast replacements of generations in equipment, systems, software and information technologies, it is clear that it is very difficult to predict precisely the development of modern telecommunications.

If the development of telecommunications in this century is analyzed, a constantly present premise could be noticed on the control of complexities of new telecommunication systems and services, which was grounded on the hierarchical principle. However, with the emergence of INTERNET, as an alternative to classic hierarchically organized telecommunication systems, it was noticed that the non hierarchical organization in many domains is superior, and that new telecommunication systems and services should be developed in that direction. Therein the global endeavors in the liberalization of telecommunication markets contribute essentially.

At this moment we can speak with certainty that researches are directed,

primarily, towards personalization, mobility and multimedia transparentness of telecommunications. In other words, "**communication wherever, in any conditions and independent of the type of the message**" is, in essence, a motto of the development of modern telecommunications, as is shown in Fig.6.

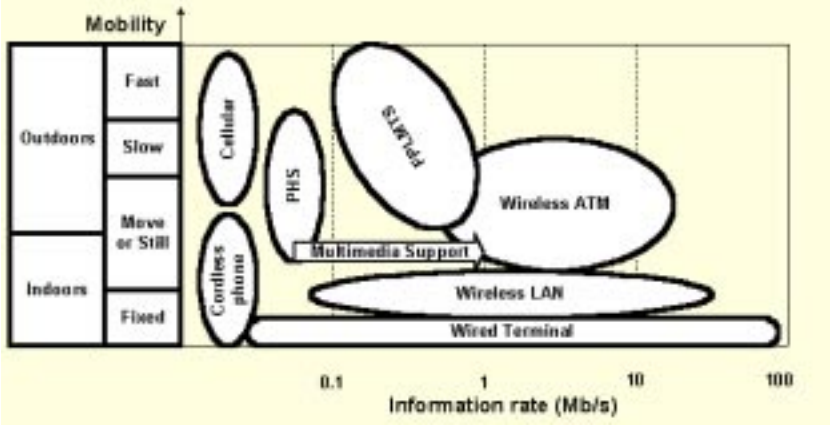

Figure 6. Mobility and information rates of future telecommunication systems.

6.1. Universal Mobile Personal Telecommunications

Universal mobile personal telecommunication systems represent, at the present level of development, a superstructure of the existing public systems of mobile telephony. The basic properties of such systems are the following;

- open international standard;
- the unique user's personal number (identification);
- high capacity and flow of traffic,
- multimedia services;
- user-system interactivity;
- unified terrestrial and cosmic segment, mobile and fixed, with global roaming independent of the user's location, network or the terminal used;
- multimode, multiband terminals;
- privacy and secrecy of the communication;
- new expanded services:
  - *Information*: WWW, purchase on-line, on-line access to public media, intelligent search of locations;

- *Education*: virtual schools, on-line access to libraries, laboratories, knowledge bases;
- *Entertainment*: audio programs, video programs, news, clips and games on request, virtual travels...
- *Social services*: emergency squads, government agencies;
- *Business information*: virtual working posts, companies and business, access to specialized media, virtual purchase - universal SIM and credit card;
- *Communication*: all forms of personal communications, video phone, video conference, user's locating;
- *Traffic services*: traffic information, actual traffic situation, navigation and travel optimization;
- *Special services*: telemedicine, survey and security, on-line emergency squads, personal administration.

One of the most essential characteristics of UMTS is a global roaming, as given in Fig.7.

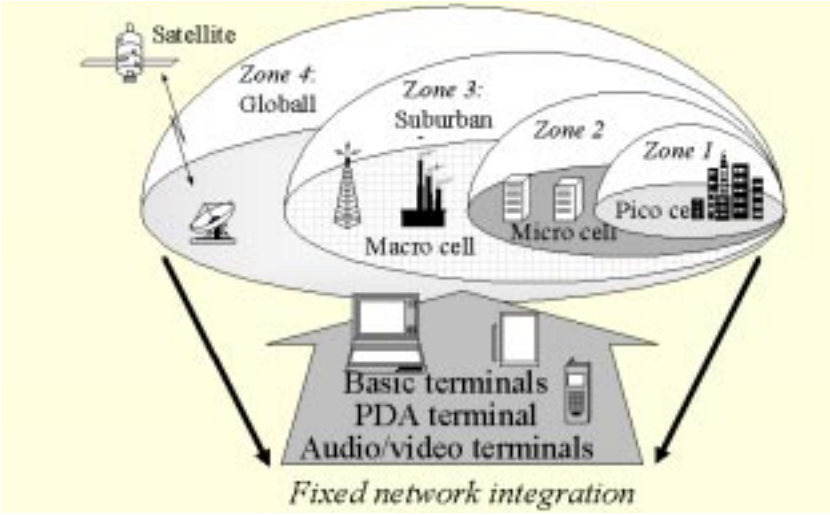

Figure 7. The zones covered by a universal mobile telecommunication system.

The prediction of the development of personal telecommunications is displayed in Fig.8. The basic conclusion is that they will be wideband systems with full user-system interaction and with a unique network service.

The basic problems encountered by the development of UMTS regard

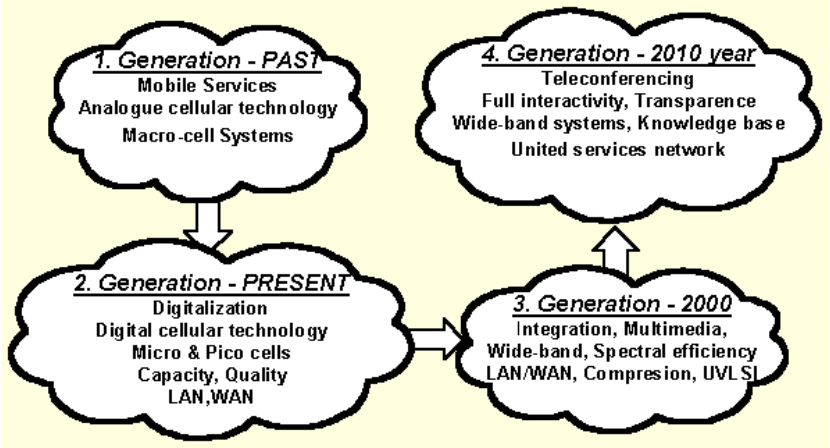

Figure 8. The chronology of development of personal telecommunication systems.

new frequency ranges, having in view the requests for high transfer rates, i.e. for multimedia services. The present research endeavors are directed to the development of the new radio-interface, based on the W-CDMA technology.

The requirements of new services could be divided into:

- *General requirements*: better transfer quality, new types of services, not present in the 2^{nd} generation systems;
- *Requirements for wideband multimedia services*: medicine data, travel maps, wireless packet business networks, interconnection of various networks;
- *The range on request*: very different services, from multimedia to paging, requesting the high adaptability of the radio system to instant demands of the widths of ranges, variable rate of transfer, and asymmetric transfers, as is the case with one direction downloads.
- *Successful implementation of data services on existing networks*: though UMTS will support voice services, its future depends on the use of mobile data within the mass market.
- *Per-packet billing systems in place*: billing and customer care are becoming ever more complex as a means to achieve competitive differentiation; UMTS will require complex interworking between many organizations, and the convergence of different industries will surely introduce new customer care and billing concepts.

UMTS is a significant opportunity for manufacturers, operators, and providers, both as a communications system in itself and also as part of the

greater Information Society. The vision of UMTS is as a customer-focused system, where customers include both network operators and end users. The challenge to the communications industry is to integrate the technologies needed for UMTS in a way which supports this goal and thereby transforms the vision into reality.

3.2. Satellite Systems of Mobile Telephony

The development of public mobile satellite systems at this moment still presents a big unknown, having in view definite conceptual and technical problems, as well as high financial investments. It should be emphasized that the reply of the market to these systems is still not quite clear. According to some analyses the LEO satellite markets will have the values of about US$ 6 billion in 2002.

On the basis of the analysis of technical and organizational characteristics of the designed satellite systems, it could be inferred that they are mainly directed towards multimedia services, LEO and MEO systems being the most prospective.

At this moment the sole operative system of public mobile satellite telephony is IRIDIUM, of a consortium headed by Motorola. This system uses 66 LEO satellites, distributed in 11 orbital planes. The covering zone spans the space from 80°N to 80°S of the geographical length. Data on the planned satellite systems of mobile telephony are quoted in Tab.5.

3.3. Wireless Local Loop - WLL

During the last few years there is a world spread very pronounced tendency to use the same type of realization similar to cell personal telecommunication networks, for expanding the already existent telecommunications installations. Such systems are known under the name WLL. Their basic advantages are the following:

- the building of WLL type radio telephone network requires much less time with respect to the time needed for the building of a classical fixed local network;
- further expansion of the network is very simple;
- exceptionally high investments in the building of infrastructure of classical telephone systems are avoided.

The existing WLL systems use both conventional techniques of a multiple access to the basic station, FDMA and TDMA.

By using technologies and experiences in the development of the third generation of personal communication networks - PCN, which use the spread

Table 5. Data on the planned satellite systems of mobile telephony.

System	Orbit	No. of Sat.	Life time	Services	Mod	Operab. (Forecast)
Orbcomm		28		D		Mid-1999
E-Sat		6		D		1999
FAISAT		26		D,Vm,P		1999
Koskon (Polyot)	B-LEO	32		V,D,F,P		1999
Globalstar	B-LEO	48	7.5y	V,D,F.P, GPS	CDMA	2000
I-CO	MEO	10	12y	V,D,F,P	TDMA	1999
Iridium	B-LEO	66	5y	V,D,F,P	FDMA+ TDMA	LIVE
GE Startsys		24		Dm		1999
GEMnet (CTA Sys)		38		D		1999
LEO One USA		48		D		1999
M-Star (Motorola)	Broadband LEO	72		broadband services		1999
ECCO (TELEBRAS)	B-LEO	46		V,D,F,P		2000
Ellipso (MCHI)	LEO/MEO	17		V,D,P,E		2002
Odyssey	B-LEO	12	15y	D,V,F,SMS	CDMA	1999
Teledesic	Broadband LEO	840	10y	broadband services	ATDMA+ CDMA	2002
Celsat (Hughes/Nortel)	GEO	3		V,D,F,P		2000
INMARSAT 3*	GEO	5	12y	V,D,F		LIVE

spectrum technique with a direct sequence and a code division multiple access, DSSS-CDMA, the third generation of the WLL systems is also developed based on this technology. The capacity of these systems is virtual, i.e. it is limited exclusively by acceptable interference, produced by the users themselves in the system. Comparing with WLL used by FDMA or TDMA, the network capacity can be increased even to 15 folds depending on the working conditions.

3.4. LAN

In the development of the local area networks, LAN, there is primarily the tendency to use fast Ethernet (100 Mb/s), i.e. ultra-fast Ethernets (1

Gb/s) networks. Other technologies, such as ATM, still has restricted use in this field.

The use of local cordless networks has become, in the course of later years, very attractive in business circles. Namely, the installation of information systems, with standard cable networking of many terminals, often represents a serious installation problems. By using the cordless systems which mainly use W-CDMA technology, this problem is relatively easily and quickly solved.

3.5. Access Networks

The basic requests which are set even at present in the realization of the access networks, and which will be dominant in the course of several next years, are:

- a wide bandwidth;
- user specified network architecture;
- a fast realization of new services.

In other words it means that in the access network realization it is necessary to book in advance the space and technical capacities in the service zones and to enable the building of the network, in accordance with the users' requests, without big construction works. Such a concept of the access network realization is possible only by using optical cables, or wideband broadcasting networks, which implement the spread spectrum technique and CDMA.

The predictions of the share of various old and new technologies in the access networks are shown in Fig.9.

3.6. Digital Radio and TV Broadcasts

A large number of countries in Europe carry our technical preparations for the introduction of digital TV. For example, in Sweden and Finland the frequency bands for this new type of a telecommunication service are already determined. In other European countries, with developed cable TV, the introduction of digital TV is not anticipated in several next years. Having in view high material investments necessary for the realization of the digital TV system, in European countries of the former East block a fast introduction of the digital TV is not expected, either.

When the digital TV standard is concerned, all European countries have accepted the so- called DVB standard, based on MPEG-2 video compression.

The approach to the development and application of digital TV in the

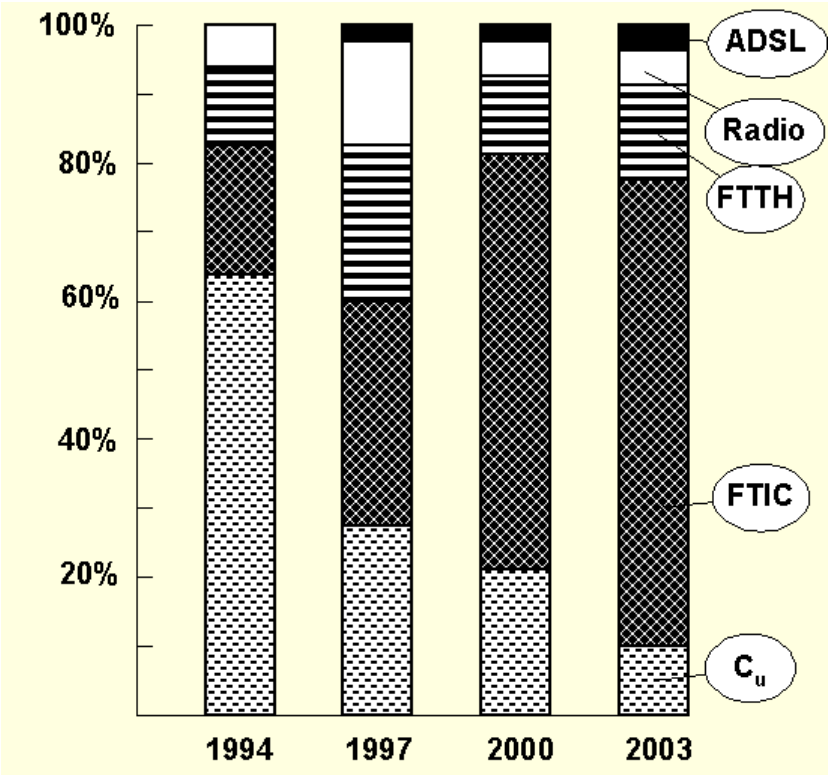

Figure 9. New technologies in the access network in the world.

USA differs from the European one, and it is based on the use of high–resolution computer monitors.

3.7. Satellite Telecommunication Networks for INTERNET

In 1998 the first public mobile telephone satellite system, IRIDIUM, started operating. In the course of this and next several years the launching of a large number of telecommunication satellites intended to multimedia services is anticipated. When the explosive growth of Internet is added to all this, it is natural to expect also the development of satellite systems with an optimized architecture for INTERNET. At present there are intensive discussions about the possible forming of an organization which would deal exclusively with the development of a world INTERNET satellite network, INTERNET SAC. At this moment it is not fully clear whether that organization would be entirely independent, or an alliance of many INTERNET

providers.

3.8. Digital Trunking Radio Systems

Private mobile radio networks, PMR, belong to a group of special purpose radio systems that are intended, primarily, for the services needing an alternative close telecommunication system.

There are about 6 million users of PMR systems in Europe. The majority of these systems are more or less mutually incompatible.

At the end of the 80s an initiative was launched at the European Community level to elaborate a unique PMR standard. As a result, the standard for terrestrial trunking radio system, TETRA, was adopted, similar to GSM. TETRA uses TDMA protocol, the basic services being the following:

- dispatch services;
- speech and data, with the possibility of channel combining;
- packet data optimized.

3.9. Multimedia

Multimedia services represent a new integrated area of telecommunications and information. It is a new area regarding presentation, storing, delivery, searching and processing of information with a simultaneous use of many services, such as text, audio, graphics and video. Within the framework of ITU Study group SG-XVIII, multimedia services are defined as wideband services containing inherently more than one type of information.

The basic characteristic of multimedia services is the existence of service attributes with multiple values, which makes them much different from traditional telecommunication services. Additionally, the bearer services and teleservices are standardized. The user will be enabled to have the access to service components separately. Some of the components are compulsory in the framework of the service, while the others are optional and can be either added or subtracted in the course of communication, Fig.10. The multimedia approach is nowadays very popular and aggressive in the development processes of almost all segments of telecommunications.

4. The Present State of Art in Serbia[1], Technology Capacities and Plans

The present telecommunication system in Serbia consist of many separate systems, such as:

[1]All data about telecommunication system in Serbia were colected before NATO agression

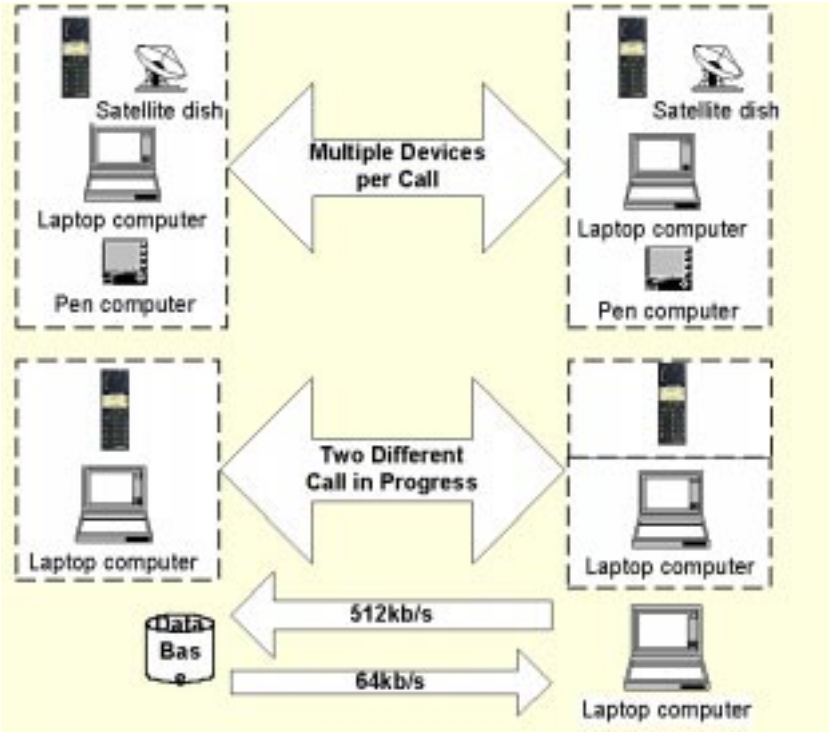

Figure 10. The example of multimedia communications.

- the network of the national operator "Telecom Serbia" a.d., with many characteristic logical parts, and with more or less unique physical realization ;
- radio and TV broadcasting systems, public and private;
- public mobile telephone systems, NMT and GSM, as well as paging;
- special purpose telecommunication systems - army, police, governmental services, , electric power system EPS, railway, oil economy, etc;
- "private" telecommunication systems of different economic and other subjects such as banks, industrial complexes, communal organization, taxis;
- Internet providers, etc.

It should be noted that though the legislature is not fully adjusted to a free market trends of telecommunications development, there is a growing participation of various subjects in national telecommunications which, according to the valid laws, are not intended for "owners" of telecommuni-

cation systems. Since the alterations of regulations are lagging, the real life conditions simply lead to the fact that new systems appear and are maintained simply by the force of their existence, market success and by their number. These systems are by rule used for the needs of the owners themselves, but there are also the growing tendencies to hire telecommunications capacities officially or unofficially to other business partners.

The existing "Telecom Serbia" network is functioning according to the organization set a few decades ago. This network had 2,175,600 telephone lines in 1998, which corresponds to the average of 21.7 lines per 100 inhabitants, and which lags much behind the OECD's average.

The density of telephone lines is uneven and it goes from over 44 in some developed areas to below 4 in hilly-mountainous regions, some parts of Kosovo, Pešter, etc. With an evident lack of other infrastructure systems, too, such a situation directly stimulates undesired migrations and makes more difficult the development of regional economy and tourism.

The telephone network of Serbia in 1998 had an international commutation center - Belgrade, consisting of two exchanges: (a) analogue of M-10C system, (b) digital of EXE-10 system and a temporary international exchange block carried out by GTD-5C system in Nš.

There are 6 transit zones in Serbia, 34 network groups with 172 primary exchanges located in 141 different regions, with 1451 local and end exchanges in total.

The equipment used in telecommunications in Serbia belongs, unfortunately, to a great extent, to previous telephone generations. If we know the present life of electronic devices, and especially of that in telecommunications, the general picture of a basic level of telecommunications in Serbia, with respect to its technological level and quality, seems very questionable.

New digital telecommunication network of Serbia, which has been for several years developing, is based on the following principles:

- the transition from strict hierarchical organization of the national network to the structure which will make possible a gradual transition to fully non hierarchical structure;
- integration of three characteristic parts (a) access networks, (b) commutation systems and (c) transport systems into a unique network, with the common possibility of $n \times 64\ kb/s$ rate from one user to the other;
- the introduction of new services, such as high data transfer, hiring of lines and renting of capacities, Internet, multimedia, video conferences, mobile telecommunications, Tele-medicine, Tele-education, providing in the same time the reserve capacities for new services, etc;

- building of unique transport network for the needs of all other users, particularly of big ones;
- the introduction of a new concept of control and the maintenance of the telecommunication network, TMN.

In the first phase of the building of the national digital telecommunication network, inclusive of the 2005^{th} year, there are two levels of commutation exchanges; national one with 6 exchanges and with an international exchange, and a regional level with 61 exchanges (including 7 tandem exchanges in Belgrade). The expected capacity of that new digital network is about 3,200,00 lines (including also 1,200,000 replaced analogue lines). With the existing cc. 800,000 analogue lines it would lead to almost doubling the number of lines per l00 inhabitants with respect to the state in 1998.

The "Telecom Serbia" transport network should, in the future period, be entirely planned with the use of SDH technology, compatibly replacing the existing PDH solutions. The strategy of introducing SDH equipment into Serbian telecommunication network is based on the principle "from top to bottom", i.e. the SDH equipment is first built-in into the national level of the network and then to regional and local planes.

In technological sense, in the period till the 2005^{th}, optical cables are exclusively planed at all levels of the transfer network (national, regional and local). Optical cables used in Serbian network are optimized also for the work in the 3^{rd} optical window according to the recommendation ITY-T G.652. The fibers with these characteristics enable the transfer of all hierarchical signals that are of interest for Serbian network, and simultaneously support the technique of wave multiplexing. The applied optical cable capacity is from 6 to 120 optical fibers. It is estimated that the entire length of high capacity optical cables will be in 2005 about 4,500km, and of those of low capacity about 6,000 km. Together with optical cables in access networks there will be at a disposal about 12,000 km optical cables of all types in total.

"Telecom Serbia" has at its disposal also the network of radio-relay highway links. It is expected in the forthcoming period that this existing system will be gradually substituted by radio-relay digital SDH systems, which can be fully incorporated into the SDH optical network either as redundant or as an alternative system of restricted capacity. In the same time the new generation of radio-links will be more and more used for other purposes, for example for transversal connections with other systems and for access networks.

Data transfer within the framework of the plans for the development of "Telecom Serbia" till the 2005th, has a special place, both on the highway as

well as on the access levels. Such an option is fully logical since in modern digital network practically all signals are transferred as data. Within the framework of this paper it is not possible to enter into details but it should be quoted that the data transfer is grounded on the following classes of access services:

- X.25, to 64 kb/s;
- Frame Relay, till $2Mb/s$;
- ISDN BRI, 2*B i.e. 2×64 kb/s;
- ISDN PRI, 30B+D i.e. 30×64 kb/s;
- ATM, without fixed limitations.

Fig.11 displays the future multi-purpose Telecom network.

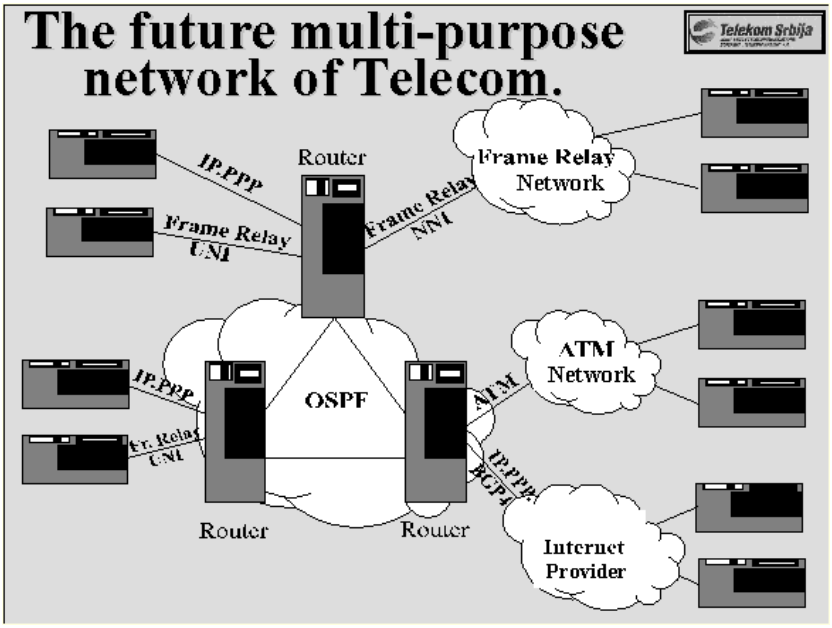

Figure 11. The future multi-purpose network of Telecom.

ATM network of Serbia, denoted in Fig.12, deserves a special attention. Asynchronous Transfer Mode - ATM is devoted to the needs of the transfer of digital users' signals, which due to their nature have to be transferred in a real time, together with the usual data transfer for which it is not indispensable. Regarding complexity, the volume of the flow and available services proposed for the integrated networks, the ATM technology seems to

be an optimal solution.

ATM is a transfer mode selected primarily for wideband digital network of integrated services, B-ISDN. ATM enables:

- support of all existing services, as well as those with still unknown characteristics which will emerge in the future;
- suitability for the so-called multimedia applications;
- the use of the network resources in the most efficient manner and in average cheaper than other services;
- minimization of the complexity of commutation;
- support of relatively modest as well as very voluminous rates;
- guarantee of requested performances (delay, error probability, rate,...) for the existing and expected applications.

In comparison with other transfer modes (X.25,Frame Relay, SMDS,...). ATM has considerable advantages.

With respect to physical milieus for the transfer, ATM uses special optical fibers, but it can also use the existing systems such as PDH and SDH.

The preparations for the realization of the Experimental ATM network in Serbia had started already in 1997. Within the framework of these preparations,

- a technical solution is proposed which would consist in the first stage of three ATM realizations, in Belgrade, Nis and Novi Sad, linked to the corresponding highway links;
- technical requests are prepared and potential suppliers of ATM equipment were contacted;
- it was proposed to realize the network on the principle "Try and then possibly buy", which was accepted by many deliverers;
- the design of the Experimental ATM network of Serbia is a high technology project which would enable "Telecom Serbia" to penetrate into a circle of operators who exploit such networks. The basic idea is to let this ATM network into a commercial work upon the completion of the experimental stage.

Fig.12 displays one of many possible variants of the experimental ATM network of Serbia, where, depending on needs, the flows along highway links could be easily changed, i.e. the experimental network can be extended or decreased.

Telecommunication systems of other owners or operators (except "Telecom Serbia") cannot be, due to the limited space, adequately covered.

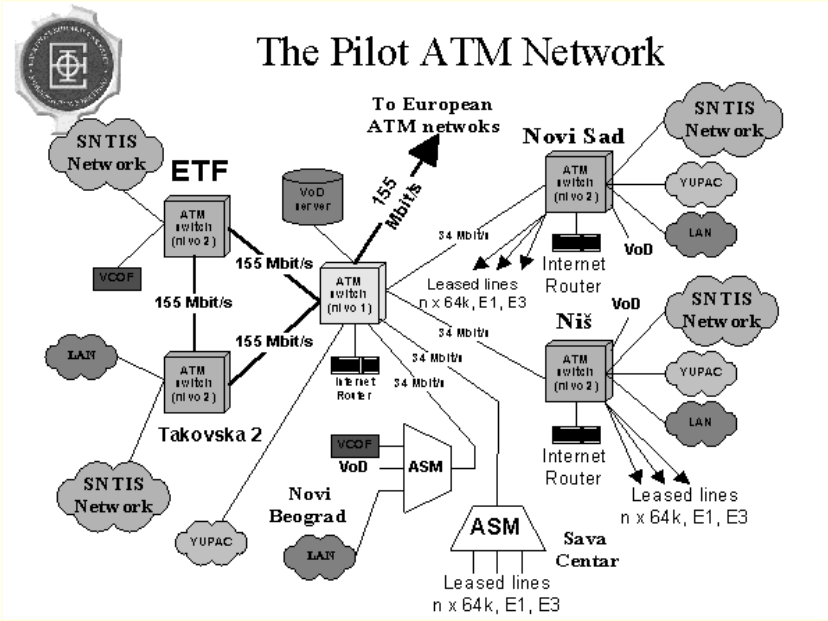

Figure 12. One of the variants of the planned experimental ATM network in Serbia.

However, some of their particular or common characteristics can be mentioned at least in general;

- Radio Television of Serbia, as a State radio broadcast system for the broadcasting of the picture and the sound (popularly called "TV and radio"), is formed as a separate technical system, in general independent of "Telecom Serbia" and other telecommunication systems, with its own transport systems, its transmitters and its services. The plans of further strategic development of the RTS are known neither to a larger professional public, nor to the authors of the present paper;
- there are several other broadcasting systems such as, for instance, "BK Telekom", or "Politika", which have their own development plans with tendencies and intentions to cover a larger part of Serbia and with the trends of application of all technical innovations existing in this field;
- public mobile systems, paging and GSM, appeared in Serbia with quite a delay with respect to developed European countries. However, their hitherto and present developments have similar characteristics to those of other countries in the world - relatively fast realization, quick additional area expansion, a considerable growth of the number of users

and solid profits. GSM 900 system of both present operators in Serbia, "Mobtel" and "Telecom Serbia", will cover, in one or two years, effectively at least 70 % of the territory of Serbia, which practically means that the GSM service will be at the disposal for over 90 % of the population.

- there are many plans for the introduction of different WLL systems and for the transition into the 1.8GHz area with GSM 1800, DECT or CDMA public mobile systems. Unfortunately, for the time being everything is mainly in the framework of plans;
- the access to Internet as a public service appeared in Yugoslavia only three years ago. Prior to that a very limited "exit into the world" was possessed practically only by academics , through the SNTI network. The present state on the market is characterized by the presence of a large number of small provides and a small number of providers and/or operators who really have their own or hired links towards foreign Internet operators. In any case, the capacities towards the world are insufficient, the internal links being limited by a slow realization of digital accesses to "Telecom Serbia" and by high prices of the link renting. The appearance of PTT "Serbia" as an Internet provider intending to cover the entire territory of Serbia by a sufficient number of Internet access points with enough capacities, promises to improve the state in this region;
- practically all big systems, like State (government, ministries, common services, police, army, etc), banks, traffic enterprises, public enterprises (electric power system EPS, oil and petrol production system NIS,..), communal organizations, etc., have in a larger or smaller degree their own internal telecommunication systems, or they are planning to introduce such systems, extend them or modernize them. Such systems are (a) systems for the support of the business decision-making and control, (b) information systems, (c) computer network for data transmission, (d) radio systems for covering larger territories, etc. A majority of these systems are at the highway level supported by "Telecom Serbia", but there are also the exceptions from this rule. In any case, hitherto all these systems were built independently, with a low degree of telecommunication exploitation and with relatively small capacities at the highway level. In l998 appeared somewhat more real tendencies and plans for providing of suitable services in this field. Apart from using their own systems for their needs, they offer or plan to offer, as a kind of providers, their free capacities to other professional organizations. Though such an approach is very suitable from the point of view of economy and

organization, it should be noted that the present legislative regulations do not follow these ideas.

At the end of this part on trends at the Serbian telecommunication scene, it can be stated with quite a risk, two things: (a) there is no taken, agreed upon or adopted strategy of the development of telecommunications in Serbia and (b) practically everyone needing telecommunications, irrespective whether he is operator, provider or user, carries out the development independently, depending only on his possibilities, plans, and abilities, a mutual cooperation and co-ordination being very seldom.

5. Conclusion

There are many different and even sometimes contradictory trends of the development in the present-day world of telecommunications. However, the positive world phenomenon is the present tumultuous development of mobile systems of all possible kinds, with a clear tendency that the future universal personal telecommunication systems will be developed primarily on the mobile base.

The second clear trend of development are the WLL networks, which on one side lean on the switched networks, and on the other present a part of the world trend "**everything is wireless**". However, it must be noted that there is a tendency of mutual overlapping of WLL and other public mobile systems.

The transport systems represent the spine of every telecommunication system. Practically all intercontinental, continental, national, regional and urban highway links are based nowadays on optical cables. Such a trend will be certainly continued, particularly having in view a growing application of multimedia interactive services. In the highest level satellite communications had lost to some degree their primacy, but they are therefore faced with an open field of satellite mobile telecommunications and other end-user satellite services.

Internet is certainly a phenomenon by itself. It is not solely a telecommunication phenomenon, services and connections are not only at stake, we cannot speak only about information, business, cultural or any other particular aspect, but it is sure that Internet has and will have the effect on every mentioned factor. On the other hand the development of Internet and Intranet cannot practically be separated from the development of any "ordinary" network, of LAN, MAN or WAN type. The already existing influence of Internet as an "alternative" world telecommunication system on the total development of telecommunications will be, certainly, in the coming period, even more prominent.

As it was said at the beginning of this paper, the modern telecommunication presents one of basic needs of the human society at the threshold of the third millennium. The development of this field on the world scale was in a few recent decades so fast and so diverse that it is even difficult to make an adequate classification and survey. Whatever yesterday seemed as a boundary which in theoretical and technological sense cannot be overcome, tomorrow is already normal and reachable, and the day after is overcome. The authors did not attempt to involve in this paper everything which is modern in the present-day world telecommunications. It is practically impossible. Authors concentrated to short surveys of some important and prospective trends of development. It should be said that reliable prognoses are relatively short-termed, only a few years in advance, which is a normal consequence of short generation circles of equipment, of fast turnover of investments, very quick rises or falls of the buying power of particular world users' markets, etc. However, one thing is certain - for the time being the signs of the slow down of the development are not observed in the telecommunication world.

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Appendix

Acronyms

ADSL	Asymmetrical Digital Subscriber Loop
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband ISDN
CCS	Common Channel Signaling
CDMA	Code Division Multiple Access
DECT	Digital European Cordless Telephone
DQPSK	Differential Quarternary Phase Shift Keying
DVB	Digital Video Broadcasting
DSSS	Direct sequence Spread Spectrum
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FHSS	Frequency Hopping Spread Spectrum
FPLMTS	Future Public Land Mobile Telecommunications Service
FSK	Frequency Shift Keying
FTTC	Fibre to the Curb
FTTH	Fibre to the Home
GMSK	Gaussian Minimum Shift Keying
GSM	Global System for Mobile
IANA	Internet Assigned Number Authority
ICANN	Internet Corporation for Assigned Names and Numbers
InSAC	Internet Satellite Access Commission
ISDN	Integrated Services Digital Network
ISOC	Internet Society
ITU	International Telecommunications Union
LAN	Local Area Network
LEO	Low Earth Orbit
MAN	Metropolitan Area Network
MEO	Medium Earth Orbit
MPEG	Moving Picture Experts Group
NMT	Nordic Mobile Telecommunications
OSI	Open System Interconnection
OQPSK	Offset Quaternary Phase Shift Keying
PCN	Personal Communication Networks
PDA	Personal Digital Assistant

PDH	Pleciochronous Digital Hierarchy
PMR	Private Mobile Radio
PSTN	Public Switched Telephone Network
QPSK	Quaternary Phase Shift Keying
SCPC	Single Channel per Carrier
SDH	Sinhronous Digital Hierarchy
SMDS	Switched Multimegabit Data Service
TETRA	Terestrial European Trunking Radio System
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TMN	Telecommunication Management Network
UMTS	Universal Mobile Telecommunications Systems
WAN	Wide Area Network
WATM	Wireless ATM
WCDMA	Wideband CDMA
WLL	Wireless Local Loop