RADIO AT THE OUTSET OF THE NEW MILLENNIUM

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Abstract - **After a short survey of the development of wireless communications in the past, the radio services which are expected to mark the outset of the new millennium, have been discussed. The dominant characteristic of these telecommunication services is the mobility of the terminals. This enabled their personalisation which is to become a main feature of coming telecommunications. Digital cellular, Satellite system for Personal communications, Personal acces system and the use of millimeter waves have been presented in some detail.**

I. INTRODUCTION

On June 3, 1898. Scotish scientist William Thomson (Lord Kelvin) visited Italian-born British entrepreneur Guillielmo Marconi at his wireless telegraph station in southern England. Lord Kelvin asked Marconi to send a message via his wireless telegraph; Lord Kelvin insisted on paying for this service which, in his own words, was destined to become the first commercial telegram, known as a Marconigrame. Later, wireless telegraphy and wireless telephony came to be known as radio.

How prophetic Lord Kelvin's words were! Since then, radio and the commercial use of electromagnetic waves have become an indispensable part of our everyday life:

- ☐ point - to - point communications;
- ☐ dissemination of messages by radio-broadcasting of audio and TV;
- ☐ microwave communications, and shortwave transmission;
- ☐ operation of different services such as emergency assistance, public security, fire, taxi and others;
- ☐ military application;
- ☐ radio-navigation and radar;
- ☐ dissemination of precise time;
- ☐ radio-localisation;
- ☐ modern diagnostics in medicine;
- ☐ our knowledge of the world, our own planet and other planets and stars etc.

There is a large number of those who entrusted the humanity with their discoveries, and their work. Before Marconi's work, in 1893. Nikola Tesla in New York City and along the Hudson River experimented with wireless radio transmission. In April 1898, in Central Park, he demonstrated the first remote-control boat model. In 1888, at the University of Karlsruhe, Heinrich Hertz concluded his famous experiments on radio and radar. A year earlier, English scientist Joseph John Thomson, a pupil of J.W. Strutt (Lord Rayleigh) discovered electron. In Russia, A.S. Popov 1896. sent the telegram containing the wording "Heinrich Hertz". In France, E. Branly developed a coherer receiver. Tesla claimed to have measured around the globe propagated signals at extremely low frequencis and correctly described earth-ionosphere waveguide frequencies; these facts were theoretically confirmed in 1952. by German scientist Schumann, what is now known as Tesla-Schumann resonance.

All of these colossal achievements were barely noticed among other events of that epochal year of 1898. The world paid much more attention to the English-Boer War, Spanish-American War when America conquered Cuba and Porto Rico, annexed Hawai and conquered Guana and Philippines, as well as the passing away of von Bismarc and others.

In our days, radio is a multibillion - dollar business.

Why is it so?

There is no doubt that the inherent human need to communicate is constantly present. This primeval desire has been and has remained motor which gave impetus to the people to search for the better, simpler, finer technical solutions, which more and more will satisfy the human needs. People have invented extraordinary communication systems, systems of guided waves, cables, metallic and optical. However, by using them man has remained tied down by the "wire" to a fixed location.

Radio has afforded something new: mobility. It has been developed under the syndrom: "wire quality, but the freedom from wire".

This freedom and this mobility which in their very nature carry portability is basically ensured by the successful development in two fields. They are: semiconductor physics with the emphasis on miniaturisation and the break-through of computer technology in the telecommunications.

Mobility has changed the phylosophy of telecommunications: the user terminal in the literally sense of the word is not any longer a box called phone, fax or PC, the user is a person who has his or her name, his or her

identity. Where is a person, there is the communication set.

This fact opens incredibly fast the door to a very rapid deployment of services, the consequence of which is quickly growing number of users.

These are the reasons that led us to bring this topic into consideration at this Conference.

II. MOBILE TELECOMMUNICATIONS

The first generation of analogue cellular mobile systems appeared in early 1980's. The systems like Nordic Mobile Thelepony (NMT) and Advanced Mobile Telephone System (AMPS) using frequency modulation (FM) marked a turning point in telecommunications: the concept of a telephone at a fixed point was no longer valid.

The public interest to use mobiles was enormous: very soon in Europe the number of subscribers exceeded 10 millions. This gave the impetus for the search of better solution. As a result, the second generation of mobiles was born in the early 1990's. It was built in digital technology using Time Division Multiple Access (TDMA) known as (GSM) Global System for Mobile Communications. This system enabled a larger number of subscribers within a given frequency allocation, better voice quality and permitted a range of value-added services, such as data, fax, short message service etc.

Digital cellular has become a real success. Today, there are almost 100 million subscribers world wide. It is expected that this number will reach 500 milion in the year of 2001. Some forcasts forsee that the total number of mobiles will become equal to the total number of fixed phones in the year of 2010. and that this number will be about 1.4 billion. It means that in a period of 10 years, 1.3 billion of only mobile handsets should be produced. How huge is this busness!

It is interesting to note that low-tier digital cordless systems and the personal handyphone systems have not been as successful as digital cellular. The lesson from this fact is: people want to have coverage. When you are wireless don't be limited!

However, on the way toward one real unique worldwide digital system, differently grown systems in different countries presented the obstacle. Three of them are worthmentioning. They are GSM, TIA IS 136 and MPT in Europe, North America and Japan, respectively.

Therefore the ITU gave the initiative for the definition of a new standard for the third generation mobile system called IMT 2000. In 1992 World Radio Conference identified spectrum for IMT-2000 in the 2 GHz band and bandwidth of 230 MHz. However, this seems to be too small to satisfy the existing need. As a consequence, this problem is already put on the agenda of the ITU World Radiocommunication Conference in the year 2000.

The ITU formulated the chief requirements for such a system:

- voice quality comparable to that of the public switched telephone network (PSTN);
- a data transmission rate of 144 kb/s for users in motor vehicles moving fast over large areas;
- a data rate of 384 kb/s for pedestrians standing still or moving slowly;
- 2.048 Mb/s for operation in office use;
- support of both packet-switched and circuit switched data service;
- an adaptive radio interface for Internet communications;
- wireless e - mail, Web browsing, corporate local network, e-commerce, video-conferencing, IP telephony, video, text, graphic, in one world multimedia.

Ten different systems in the preliminary work have been offered for consideration. As a result of these studies, one of the most promissing approaches to the new, third generation system is to combine a Wideband CDMA (W-CDMA) air interface with the fixed network of the GSM. In January 1998. European Telecommunication Standard Institute (ETSI) decided to base the standard on a new wide-band WCDMA technology using 5 MHz wide-band radio-carriers. The same technology has been chosen by NTT DoCoMo and the Japanese standardization organization ARIB.

So, in conclusion, while no one can predict the future, it is certain that in less than one year, at the start of the new millennium, the way the world will communicate will be significantly different from the one of today. The rate of multimedia communications and the accessibility of mobile media are two such key changes.

The good reason for such conclusion is found in the convergence of the telecommunications, information technology and media industries.

III. SATELLITE SYSTEMS FOR PERSONAL COMMUNICATIONS

Along with the successful use of satellites for the fixed communication services and broadcasting, satellite systems for the mobile personal communications, as a special segment of mobile communications, have been developed. Such systems are originating with the appearance of Marisat in 1976 and creation of Inmarsat 1979.

These systems we are speaking about are of global character aiming at the radio coverage of those earth areas where the land mobile systems are not available.

Market studies performed by the proponents of these systems have identified four potential markets:

- international business travelers: travelers from the developed world traveling to less-developed counties;
- national roamers; travelers who need mobile communications in their own countries but who travel beyond the reach of terrestrial cellular systems;

- ☐ national rural fixed services: an extension of the national fixed services to regions where they are presently not available;
- ☐ government agencies: low enforcement, fire, public safety and other services.

Today, there are several such systems, some of them being launched, some in the implementation phase, some in developing status. Three of them are worth mentioning. They are: IRIDIUM, Globalstar and ICO. Their main technical characteristics are given in Tables 1 and 2.

Table 1

Parameter	IRIDIUM	GLOBALSTAR	ICO
COMPANY	MOTOROLA	Loral/Qualcom	ICO-Global
N° of active Satellites	66	48	10
Orbit Planes	6 circular polar (86.5^0)	6 circular inclined (52^0)	2 circular inclined (45^0)
Orbit Altitude (km)	780	1,414	10,355
Satellite per Orbit Plane	11	8	5
Beams per Satellite	48	16	163
Reported Cost ($ bil)	4.7	2.5	4.6

As it is seen IRIDIUM is low earth-orbiting (LEO) system. It is composed of the largest number of satellites. Users employ small handsets operating in frequency division multiplexed/time division multiple access (FDM/TDMA) mode to access the satellite. It has onboard processing in order to demodulate each arriving TDMA burst, determinate how and where to route it and then retransmit it to the desired destination. This can be to the ground if a gateway earth station is in view, or, failing that, to one of the four nearest satellites: the one ahead or behind in the same orbital plane, or the nearest in either orbital plane to the east or west. Link between satellites is realized by cross links at 23 GHz.

The use of cross links greatly complicate the design of the system, but the required number of ground stations is small. Otherwise, each satellite is capable of handling about 1100 simultaneous calls, and has sufficient fuel for an 8-year life.

Unlike IRIDIUM, which offers a true global service, Globalstar calls for launching the space segment and franchise its use to partners in different countries. The satellite orbits are circular with the inclination of 52^0. As a consequence two or more satellites are always visible between 25^0 and 50^0 latitude. Mission life is 7.5 years.

Table 2.

Parameter	IRIDIUM	GLOBALSTAR	ICO
Mobile user Link			
Frequency Up/Down (GHz)	1.62135-1.6265	1.6100-1.62135/ 2.4835-2.49485	1.980-2.010/ 2.170-2.200
Bandwidth (MHz)	5.15	11.35	30
Spot Beams per Sat.	48	16	163
Voice Bit Rate (kb/s)	4.8	1.9	4.8
Feeder Link			
Frequency Up/Down (GHz)	30/20	5.1/6.9	5.2/6.9
Gateway Antenne G/T (db/K)	24.5	28.5	26.6
User Terminal			
Multiple-Access	TDMA-FDMA	CDMA-FDMA	TDMA-FDMA
Carrier Bandwidth (kHz)	TDD - 31,5	1250	25.2
Carrier Bit Rate (kb/s)	50	2.4	36
Modulation	DQPSK	PN/QPSK	QPSK
RF power(W)	0.45	0.5	0.625
G/T (dB/K)	-23	-22	-23.8
Nominal Link Margin (dB)	16.5	11	10

The Globalstar does not employ satellite cross links. Therefore, a subscriber can access to the system only when a satellite in view can also be seen by gateway earth station. This means that service areas are within about 1600 km of each gateway station. In order to realise a true global service, it would be necessary to construct more than 200 earth stations.

ICO sysem has only two circular orbits with the altitude of 10355 km and the inclination of 45^0. Therefore, it has only 5 satellites in each orbit. In this way the coverage at high latitudes are reduced. In order to increase the link margins ICO satellite employs 163 narrow spot beam to cover desired area. Routing the signals in the correct beam is very complex and therefore filter design in ICO system is extremely difficult.

Concluding this debate about satellite systems for personal communications it is interesting to make some comments in the light of recently occurred event. Namely, two months ago, August 13, IRIDIUM filed for Chapiter 11 bankruptcy protection of USA law defaulting on $ 5 billions in loans.

The reason is simple: the number of subscribers so far, is too small. Now, the question arises: Is it really necessary to develop such a true global system which will be used only for "VIP roamers"? The Globalstar has distanced itself from the true global solution. And its pricing carries the clear message, $1.25 for a minute, what is one third of the IRIDIUM fee. The result of one analysis says that the $ 3.8 billion system needs 200.000 subscribers to break even on operating basis.

Although at the first glance, this event might seem discouraging, the general view is that taking into account some after modification of the concept and corresponding pricing, systems will adapt to their social environment.

IV. PERSONAL ACCESS COMMUNICATIONS SYSTEM

The problem of the access of users to the core of communications system to use all offered services has always been a complex problem which required important financial means.

The copper pair that connects a telephone subscriber to the telephone network has proven to be a highly effective and cost-competitive means of linking the customer to the feature-rich telephone switch. In many developing countries as well as in densely populated area it is very difficult and costly to build rapidly such networks.

The Personal Access Communications Systems (PACS) developed by Bellcore, present a wireless alternative to wired local loop for both mobile and fixed wireless local loop (WLL) services.

PACS supports wireline quality voice and wide range of data services at low price and complexity. There exists a high synergy between the PACS architectures designed to offer WLL wireless and mobile services. Therefore, a WLL service has a small marginal cost when added to a mobile service or the mobile service has a small marginal cost when added to a WLL service.

It is to expect that the problem of how to deploy the telecommunications in developing countries as well as in dense populated areas such as urban and suburban, will be solved by PACS.

V. MILLIMETAR WAVES (MMW) FOR SHORT RANGE COMMUNICATIONS

The Radio-frequency spectrum is a limited natural resurce which is considered today to be the most precious resource in the industrial world. Technically available spectrum has become extremely congested. Therefore, in the last decade, several efforts have been dedicated to the investigation of the higher part of the spectrum, the milimeter waves applications.

Why Millimeter Waves?

The main advantege of the use of MMW's can be summarized as follows:

- the high attenuation in conjunction with oxygen and rain absorption (in the 60-64-GHz band) which leads to a high spatial filtering effect with consequent frequent channel reuse;
- small size of antennas and radio-frequency circuits;
- large spectrum availability.

On the other hand, large value of attenuation becomes a fundamental drawback when long-distance communication links are to be managed. Hence, significant applications of the MMW can be found in the field of short-range communication systems, i.e. when the distances range from a few meters up to one kilometer.

Among different applications the following ones are envisaged:

- intelligent transport systems;
- wireless local-area networks for multimedia applications; (WLAN)
- local multipoint distribution systems for interactive video services.

Intelligent transport systems use information, transport and communication technologies in vehicles and road-side aiming at improving safety and efficiency of traffic flow indifferent areas such as urban environments and highways. Information such as weather forecast, parking availability, traffic conditions, vehicle positions, speed, acceleration, presence of fog, ice on the ground, accidents and many others support drivers in today's congested traffics.

Increasing attention to the wireless local-area network is expected in the next few years due to the demand of wide-band multi-media services. The benefit that WLAN can offer to the end user consists of mobility and installation flexibility with respect to fixed LAN. It is to be emphasised that MMW LAN's are particularly interesting for in-door application due to short distances and to the fact that the link can exist even in nonline-of-sight conditions due to the multipath propagation.

The use of MMW has recently been investigated for distribution of broad-band services to fixed users, such as in urban and suburban environment. Especially, interactive video service and video on demand are the services expected to be very successful using this MMW distribution.

VI. CONCLUSION

It is difficult to predict the future. Never theless, it is certain that very soon, at the start of the new millennium, the way the world will communicate will be significantly different from nowadays. Wireless terminal with its

mobility is a platform for a whole range of communication services involving voice, data, video and images.

At the same time, use of Internet services has risen in a similar way as mobile telecommunications. As these two communications developments converge, take as an example Internet long distance telephony, they will create the next major trend: mobile multimedia services. I do hope I will see them.

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