# Evolution of the Fourth Generation Mobile Networks: Trends and Tendencies

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## ABSTRACT

This paper will showcase, the simple way of evolution for mobile networks pointing to trends and tendencies. By 2008, the first signs of fourth generation mobile systems will appear. An account of the user's requirements as of present, and how these systems will look in the future shall be discussed. The goal of this paper is to confirm the necessity of the fourth generation systems and devices.

(Keywords: mobile networks, digital technology, data transmission, modulation, and frequency bands)

## INTRODUCTION

The introduction of the third generation mobile networks (Casal, et al 1999) has just been taking place (in Europe). This holds out possibilities for mobile communications that have never been seen before. Each mobile technology generation created something new, and the fourth generation will not be an exception. The broad question is what can the reasonable expectations be now, given that we have not even reached the boundaries of first generation capabilities across developing countries like Nigeria, and the second-generation networks worldwide. Additionally, the notion of 3G network has just become generally known and it remains unknown how these 3G technologies can be applied to much of the world's infrastructure. To answer the questions highlighted, we will need to examine the phases of improvement for mobile systems and their technology.

## GENERATION BASED COMPARISON OF AD HOC NETWORKS

The first generation of mobile networks were developed at the beginning of the eighties. They were based on direct analogue modulation and adapted cellular structure. Their main achievement was the realization of the cellular concept by reusing frequencies. Circuit switched communication was an idea prevalent throughout these technologies. The idea of mobility and the maintenance of nimbleness appeared in this period among users, but cooperation of independent systems was not accomplished. Additionally, the roaming function was also missing.

The second-generation mobile networks owe their success and progress to the intensive development of microelectronics and the digital technology. As the result of this development, the weight of the terminals (handset) considerably decreased (from about 1 kg to between 10-20 g). Due to their more user-friendly structure, the appearance of the SIM card and their services based on circuit switched digital communication, millions of user opted for this successful system and chose a GSM terminal (Shoewu, 2003).

In the frame of circuit switched network structure, besides the transmission of voice, the possibility of low- (9.6kbps, 144.4kbps) and high-speed (64kbps, HSCSD) data transmission arose. Intensive expansion of databank and data managing services required the further increase of speed and consequently due to this progress; the possibility of sending IP based packages (up to theoretical limit of 164kbps, GPRS) developed. Through this improvement, the notion of packet switched data transmission has become known in connection with mobile communication systems.

The roaming function had also been solved in the 2G technology with clients that can use the services of their providers even abroad. As a result, the PAN-European mobile network was created.

The most important element of this period is the idea that mobile communications could be used by.

Third generation mobile systems [Richardson, 2000] (e.g. UMTS) include the communication systems below:

- Cordless radio systems
- Cellular radio systems
- Satellite radio systems
- Paging
- Private mobile radio system

According to plans the UMTS (Universal Mobile Telecommunications System) was constructed to fulfill such requirements while the speed of the terminals can reach the value of 500 km/h. The frequency bands reserved for the first and second generation is found about at the border of 1 GHz. In order to increase the number of users and to enhance the average data speed (384 kbps) required by today's users, the set of the UMTS band will be about to 2 GHz and the bandwidth will be also extended.

The higher data transmission speed opens new prospects in mobile telecommunication. The technical obstacles have considerably been averted from the expansion and development of mobile implementation and for applications up to the present. To date, developers created general, one-kind applications on a limited platform that every body was forced, because here was no other possibility. However, from here forward, system engineers can supply their customers with a wave of new applications and the customers can decided if they need the offered services or they could choose something else. This process could be compared to the PC period of the 1990s for computers of medium size capacity (i386) when firm's developed huge quantities of software and the users only had to choose the most suitable of them.

In the field of mobile communication, the bottle-neck of the relatively constant but not unlimited bandwidth will give stimulation for application developers to produce more efficient applications. This trend will likely continue until at least 2010, when fourth generation mobile systems will be able to ensure extremely high bandwidth. According to the plan of Ericsson [Royer,1999] by 2011 the mobile connection will be equal to an internet access of 100 Mbps.

The third generation technology was also supposed to become a heroic-age; a period where groups of applications were approved by customers. This period fostered the demand of users to transmit and receive their data messages and information in a multimedia environment.

One of its most intensive stimuli and determining base is the Internet and its effect on mobile communication systems demands. Specific combinations of tests, graphs, animations, voice, and real time video broadcasts will be a usual part of everyday life. End users will have the intention to reach these facilities with mobile access equipment.

The packet switched data transmission method of the 3G technologies (which means more and more UMTS on this continent) is IP based [Casal, et al 1999]; consequently there will be difficulties in embedding internet-based applications in mobile environment. The 3G systems follow a philosophy of standardization through their construction [Abu El-Ata, 2000]. UMTS is one of the members of IMT 2000 family which will be installed in USA and Japan, too. These systems are not the same, but the modulation type, the allocated bandwidth, and the basics of these systems are similar to each other. Of course, the UMTS has not been able to cover all situations, nor have its wireless access networks (WLAN, Bluetooth, DECT). By the time of 4G, access to the Internet through wire or wireless will not be distinguishable; the user will recognize a uniform, world-wide communication system in everyday work.

## USERS' EXPECTATIONS FROM 4G MOBILE NETWORKS

What information infrastructure will be present in 2008 in developing countries? Presumably, the signs of the information society will appear. Masses of people will be schooled on an increasing scale so they will able to apply and to value new services, devices, and possibilities. Because of existing demand, the information market will increase to a significant size and communication will become a kind of citizen right. Globalization will show up strongly because everyday life will be simpler and cheaper. What will the ordinary person see around his world in terms of future data? Some potential scenarios

[Zeng, et al. 2000] were contrasted and common points are shown here after.

- New type input/output devices will arise for the sake of faster data exchange (glasses displaying 3D virtual world, collapsible screens, e-paper, voice and handwriting recognition)
- New type semiconductor industries will arise (by means of plastic based chip technology extremely cheap or throw-away electronic tools will be common; 4G terminals will be available for everyone).
- Access to the fourth generation mobile systems will be low-priced (advertisements could be displayed on the screen of 4G terminals as a means of user interaction)
- Amount of new users will reach a high level
- There will be heavy competition between applications and service-providers for users
- The quality of Internet access by wire or wireless will be equal or almost the same (quality of content-providing will be excellent using a mobile terminal)
- Multimedia will be required for trivial work and activities (multimedia mean a kind of extra information)
- Some economic, social, or state groups could maintain their own part-networks (virtual private networks will be used well at administration, personal data-managing – for example mobile ID – and voting for a president).
- It follows that the mobile networks should be stable and dependable, should be available 24 hours per day
- Conception of a global telecommunication system becomes real; for example a telephone or data call from a jungle to an advanced mega city should be trouble free (there are ground settled wired or radio-based backbone networks in well built-up areas and everywhere else there are satellite-based backbone telecommunication systems)
- Easy interconnection of different systems (e.g. GPS, Internet, other communication networks)
- These effects would meant that a person could be found easily anywhere in the world he stays.

## TECHNICAL CONDITIONS OF REALIZATION OF FOURTH GENERATION MOBILE NETWORKS

Anatomizing the 4G mobile systems by developing parameters; it will be a complete network if the set of features are realized as listed below:

- A majority of people can access voice-or data-based services that are provided by mobile networks (this requires efficient resource-management, for example usage of ad hoc extension in wireless systems)
- The mobile network is able to attach to the Internet fully because of basic integration concepts; in this way LP based technologies would be used through mobile network (e.g. VoIP)
- The problem of virtual private networks is worked out and their security and authentication technology are well improved
- The network is able to realign itself (it manages several type backbones and it uses the best one as a means of adaptation)
- The system is able to keep on Quality of Service (QoS) parameters
- The parameter of the availability of communication networks is close to 100%
- Applications that are required for a daily normal lifestyle will be run on mobile terminals without any restrictions (e.g. news reading with multimedia, sending orders, voice recording, pocket-secretary functions, etc.)
- A universal software/hardware interface could be standardized that should facilitate development of new services without any

problem (easy to develop for fourth generation mobile systems).

## CURRENT TRENDS FOR THE FOURTH GENERATION MOBILE NETWORKS

There are four technical trends (Hjelm, 2000) that are reckoned among pioneers in this moment, but they have well-grounded concepts. They are: 1) content provision and agents, 2) software radio, 3) managing ad hoc networks, and 4) virtual private networks.

In the future, the group of network supporters and the group of content-providers will be significantly different. At present, we differentiate between Internet supporters of information and entertainment providers (e.g. CNN on the Internet) as we will in the market of mobile communication.

The customer will pick and choose among the mobile applications and their providers for those that offer a high level of performance. The user chooses the best news reader program for his terminal and additionally he will determine his network supporter, too. So-called agent–technology (Shoewu, 2003) will help his decision.

Agent in this context, means a special, intelligent program which runs basically on the owner terminal. Its aim is to collect the user's habits in telecommunication and everyday functions and to offer gathered services based on that data. Often these programs create new agents that run independently from user's terminal and travel in different networks to complete the tasks of their parent agents. They contact network supporters and exchange information with application providers to collect information of specific interest to the user (Schweighofer, 1999). Finally, they compose a list of found and suitable services.

Advantages of this technology are: the agents could accomplish multiple tasks (data mining, self location, finding other agents and users, etc.) due to programmed intelligence; the agents usually do not run on user's equipment so they do not allocate its resources but they run on specified systems (for example internet); and the processed results could be displayed on the screen of mobile device easily. Through this way, the monitoring of networks could be easier to accomplish as well (Fan et al, 2000).

### Software Radio

Software radio [Butach, 1995] is a newer tendency to reduce the number of hardware components but keep the performance of functionality of the radio terminal high. Software radio is an emerging technology, thought to build flexible radio systems, multi-user-vice, multi-standard, reconfigurable, and be reprogrammable by software.
The flexibility of a SW radio system consists in its capability to operate in multi-service environments, without being constrained to a particular standard, but able to offer, in theory, services of any already standardized systems or future ones on any radio frequency band.

The compatibility of a SW radio system with any defined radio mobile is guaranteed by its re-configurability, that is, by digital signal processing (DSP) engine reprogramability, which, in real time, implements radio interface and upper layer protocols. The users could take a trip round the world with a SW radio, and will be able to communicate anywhere even though the local radio parameters (modulation, bandwidth) could be different from the at home system.

Any changes in the functionality of the radio could be caused by reloading the software of radio across the air interface [Mitola 1995].

The software radio concept has several advantages. For manufacturers, there is the possibility to concentrate research and development efforts on a reduced hardware platform set, applicable to every cellular system and market. Mass production of this kind of terminal would allow lowered costs. Operators will be able to rapidly roll out new services tailored to the needs of each user. The advantages for users are the possibility to roam their communications to other cellular systems and take advantage of worldwide mobility. Moreover, users can configure their terminals according to their preferences.

### Forging Ahead of Ad Hoc Networks

We assume that the fourth generation mobile networks will mean global sized and uniform systems. In the case of significantly increasing users, efficient resource managing will be required because frequency bandwidth and data processing capabilities are limited. Situations could be evolved where users are close to the each other, but a distant base control processes

will be needed to keep their radio signals in conformity with current protocols.

A reasonable solution is that terminals should be able to transact their packet-based traffic while there is no need for administration of distance base control. In this way, a lot of resources are freed and they could be reallocated. Ad hoc networks was defined [Fuhua and Korba, 2000] as a set of uniform devices where the terminals have the self same hardware platform and there are no other assigned fix-settled equipment to control the systems. This type of network could provide better performance in particular cases.

Situations of ad hoc will be usual after 2008 in everyday life. By that time, the so-called intelligent household utensils will spread and they will be very popular. In our homes, the conventional tools and utensils will be "clever". For example, the refrigerator will able to sense the decrease of food and it will order them using the Internet; our coffee makers will make an offer about our breakfast; and our TVs will track our program-watching habits and try to propose the available best TV channels.

There are several situations where information-sources could be connected by ad hoc radio networks. If we bring home a new device, we will put it down and other household utensils will put it into operation. There is no need for a special center as our home-systems will be automated. Of course, there would be outdoor cases (disasters, extended network failures, etc.) where the fix settled infrastructures come to unusable states, but regular communications will be strong enough to cope with everyday occurrences. In this situation a fourth generation network with ad hoc extension could stand in the gap.

## VIRTUAL PRIVATE NETWORKS

We could determine as a rule that the near-future world-wide communication systems, that terminals are far cheaper. Let us follow a users' requirement that they want to establish a special private network. For example, a firm would like to deploy a mobile communication system to solve the communication problems between employees but there are difficulties because of the high price of unique systems and the complex administrative tasks that accompany them.

Instead, the solution would be easier if the firm could make a contract with a local or a global network supporter to divide its network reallocating resources. So the network supporter assigns a virtual private network to this firm where workers could access the network of their firm using a standard device. Of course, the fourth generation mobile networks require high security levels, so efficient security and authentication processes should have been worked up. Naturally, the stability of these systems is very important, too.

Also, larger social groups could have a kind of network in this scenario. We would have to analyze the fourth generation networks to assess whether they will have strong enough and efficient security processes to guarantee a level of data safety where general civic administration tasks would be done (e.g. prolongation of a driving license or execution of a general election). If executed in this way, the exercise of civic rights would be very cheap and the social decisions would be faster than currently available.

The primary disadvantage of this scenario is the dependence upon the technology. In a general failure of the communication network, unforeseeable economic and confidential crisis could arise. For these reasons alone, there will be some reserve forces that do want to rely on these types of mobile communication facilitated transactions (for example military). It is easy to see that kind of extension of fourth generation mobile networks will be developed only by a high level of user requirements and user confidence.

## FACILITIES FOR FIFTH GENERATION SYSTEMS

What kind of network will the fifth generation be? It is a difficult question. In the future, mankind will continue its exploration of outer space. It is possible that many space stations will circle the Earth as the International Space Station now does and there will be a lot of people to research new technologies, to do industrial work, or to take on cosmic sightseeing in these artificial satellites. These people will want to communicate regularly with Earth-based resources and the communication market will find a good answer for their requirements. The fifth generation mobile system will be very important in extra-planetary communications.

## CONCLUSIONS

The different directions of the development of mobile networks from the first phase to a future fifth generation was explored in this paper. The first generation created the mobile communication field but it had several shortcomings like roaming. The second one brought solutions to most of these problems; it also made it possible to build-up national and continental level networks.

The Internet related mobile communication networks would be accomplished by UMTS system in Europe. Their main characteristics are IP based communication and data transmission put into the multimedia environment. Although it is characterized by standards, which tend to be unified, beside them also are other wireless access networks.

Nowadays, there are trends and tendencies in the set requirements of technology and in society-at-large, that could not be accomplished by the third generation systems. The fourth generation will manage the global sized user population, and this could facilitate new human-machine interfaces. In everyday lifestyle, a mobile terminal will be indispensable. Naturally, fusion of Internet and mobile telecommunication starts in the third generation, but this process will accomplish this purpose in the fourth generation mobile networks.

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