MIS-Grid for Future Mobile Communications

MA Jian-guo¹,², XING Ling¹,², LI Zai-ming³

(1. School of Information and Control Engineering, Southwest University of Science & Technology Sichuan Mianyang 621002 China;
2. Dept. of Electronic Engineering and Information Science, University of Science and Technology of China Hefei 230027 China;
3. School of Communication and Information Engineering, UESTC Chengdu 610054 China)

Abstract The dilemma of modern mobile communications technology is analyzed. Aiming at some problems in the 3G systems, a new network architecture is proposed on the principle of mobile information sharing grid (MIS-Grid). The essence of MIS-Grid is to transfer the hot wide band information with cheap unidirectional broadcasting channels and the personalized services with relatively expensive interactive networks.

Key words beyond 3G; MIS-Grid; grid; mobile communications; information sharing

The ultimate target of mobile communications is to afford any service for anyone anywhere at anytime. The developments for this target have been receiving close attentions during the past decade. At present, many countries and communications unions all open their standards and productions in order to occupy the future communications market. Meanwhile, China has independently developed the 3rd generation mobile communications standard TD-SCDMA.

The demands of consumers have been increasing, especially for the access to Internet at any moment everywhere and for the high-speed mobile data service. According to the related research, more than half of voice consumers will connect Internet and make the data transmission by the end of 2004. This would inevitably result in many problems such as the lack of spectrum resource, the network congestion and so on.

1 The Characteristics and Dilemma of the 3G Technology

The target of the 3rd generation mobile communications is to establish a mobile integrative service digital network for the world, that is, to afford identical manifold voice and data services with fixed telecommunication network, and synthesize the mobile communication functions of cell, cordless telephone, page, diversity, mobile data, mobile satellites etc. So people can roam the world with pocket-sized personal terminations and realize their personal mobile communications. In the light of the demands of ITU, the ultimate target of the 3rd generation mobile communications is [1, 2]:

1) To provide various kinds of services with wide bandwidth and multi-rate.

2) To support all sorts of services, such as voice service, grouping data and wide band multi-medium service, and to provide the interface for Internet seamless cover and roam in the global in frequency bands from 1 885 MHz to 2 025 MHz and from 2 110 MHz to 2 200 MHz.

3) To possess the wide spectrum efficiency and the large of capacity.

4) To integrate multiple communications manners and technologies.

5) To offer characteristics such as QoS, good privacy protection, low power consumption and low cost.

The 3G system exhibits a fine blueprint for the personal mobile communications, but there are still many defects. Firstly, the system still keeps the independent core network, and utilizes fundamental facilities insufficiently. Secondly, it separates the
phonetic system form the data network, and does not adopt VoIP. Thirdly, it exerts the stand-alone telephone roaming system, and does not combine Mobile IP. Fourthly, the system uses many wireless interfaces. In fact, it is impossibly to roam with a terminal for the world. Fifthly, the contradiction rises between the limited spectrum resource and the increasing demands. Sixthly, the cost of spectrum is increasing constantly. The lastly, it demands to possess the independent intellectual property in every country.

As a result, there is none of united standard in the intercommunication. As shortcomings, the 3G system can not satisfy the final requisitions for mobile communications. So the 3G system is regulated to Beyond 3G which takes full advantage of existing networks and integrates the modern communications technologies to form intercommunication among the sorts of mobile networks\cite{3}.

2 The Networks Architecture Based on Information Sharing

2.1 The Theoretical Foundation of Information Sharing

It is important to study the relation or attributes of material, energy and information in scientific field for near decades. Some of research achievements have been formed into certain new subjects; some have brought huge economic benefits for the people and even have changed people’s lifestyle and the quality of life. Compared with material and energy, the knowledge of mankind for information is more superficial in spite of large accomplishments having been achieved in information technology.

According to the information theory of Shannon, we can derive the maximal rate of information transmission in the unit time\cite{4},

$$C = F \log_2 \left(1 + \frac{P_{s0}}{N_{s0}F}\right)$$  \hspace{1cm} (1)

where $F$ is the highest frequency, which can pass the channel. $P_{s0}$ is the signal power. $N_{s0}$ is the noise power density. At the same time we let that

$$P_{s0} = \frac{C_{s0}}{F} \text{ namely } \frac{C_s}{F} = \frac{P_{s0}}{E_{s0}}$$  \hspace{1cm} (2)

If we consider the Johnson noise only, then

$$N_s = KT$$  \hspace{1cm} (3)

$$\frac{C_s}{F} = \log_2 \left(1 + \frac{P_{s0}}{N_{s0}F}\right) = \ln \left(1 + \frac{P_{s0}}{KT}\right) \ln 2$$  \hspace{1cm} (4)

Because \(\lim_{x \to 0} \ln(1+x) = x\), and $F$ trends infinity, we can derive that

$$\frac{C_s}{F} = \frac{P_{s0}}{KT}$$  \hspace{1cm} (5)

According to Eq.(5), Sander derived the following formula in 1961.

$$E_b = 0.693KT$$  \hspace{1cm} (6)

where $K$ is Boltzmann constant and equals to $1.38 \times 10^{-23}$ J/k, $T$ is 300 k namely 27 °C in normal temperature.

$$E_b = 0.693 \times 1.38 \times 10^{-23} \times 300 = 2.87 \times 10^{-21}$$  \hspace{1cm} (7)

Eq.(7) is a theoretical limit value under the most ideal conditions, namely, the frequency bandwidth is limitless and the Johnson noise is only considered in the transmission channels. $E_b$ is a very small quantum and indicates that it needs extremely little energy to transmit or copy 1 bit information. Some literatures name Eq.(7) “energy limit formula of copying bit”.

Eq.(7) stands for the certain relationship between the information transmission and energy. It can be illustrated as shown in Fig.1. Based on the “energy limit formula of copying bit”, suppose there are 5 billion persons in the world, every person needs 1 GByte information every day, then the general energy consumed during the information transmission in channels is

$$\left(5 \times 10^9\right) \times \left(2.87 \times 10^{-21}\right) \times \left(8 \times 10^9\right) = 0.115$$  \hspace{1cm} (8)
Eq.(8) shows that the energy needed is very small and is only about that of a bulb of 1 W consumed within 115 ms. From Eq.(8) we find that information can be shared. This testifies the prodigious difference between the information sharing and the substance sharing: The essence of substance sharing is the distribution or partition from the matrix, but the information sharing is the copying or reproducing for the matrix in fact.

Eq.(8) proves the possibility of information sharing in theory, differing from substance partition. However, for the number of information copies there is no upper limit, so there is no upper limit to the number of people for acquiring information. Modern technology has afforded the approach for copying bit in airspace via electromagnetism radiation from dots to sides. Broadband service demands for hot information are provided by broadcasting, which is constructed based on the sharing “information sunlight” for dealing the hot contents and bypassing the question of the users number limit.

2.2 The Networks Architecture Based on Information Sharing

At present the basic task of mobile communications is voice service, but the future service is the digital medium, which has prodigious information flow and needs quite wide bandwidth. Because a great deal of information can be shared in digital medium and data service, we may utilize the way of information sharing to resolve the transmission of digital medium and to achieve some objects, such as economizing the bandwidth, reducing the communication cost and improving crowded channels\(^{[6-7]}\). The new-style framework of information sharing is consisted of two dissimilar but complementary channels.

As shown in Fig.2, the interactive channels satisfy personal demands for users, especially the narrowband voice signals, but the unidirectional channels suffice commonness needs, especially the bandwidth signals such as VOD, STV digital video etc. In fact, interactive channels and unidirectional ones may be integrated by multi-networks.

2.3 The Effect and Value of Information Sharing in Future Communications

In the future, mobile communications can afford not only voice service, but also miscellaneous multimedia service, such as data, image, video etc, which are both wide-band and personal service. However, the development of multimedia communications faces the problem: “too many vehicles but narrow roads” in information highway. How to exploit a wider road from the current lane? It is necessary for us to renovate our conception with information sharing, to make all of the communications methods change information channel into information field, which is a kind of omnipresent physical environment. This is a revolutionary reform.

Two kinds of channels are separated according to the characteristics of information resources in the complementary framework. The one is interactive channel for communicating information from dots to dots, which realizes the cordial information service. The other is unidirectional for exchanging information from dots to sides in order to chiefly broadcast hot information, which realizes the economy and pragmatism. As the advantage of the architecture-complement, the congestion of channels and the waste of spectrum resource will be resolved, and communications cost will be cut down also. At the same time the personal demands can also be satisfied and the active service of information be provided to users.

3 MIS-Grid Based on Information Sharing Theory

We design a network framework for Beyond 3G on the principle of the mobile information sharing grid (MIS-Grid). The MIS-Grid represents information environment of Ubiquitous Computing and Pervasive
Computing[8–12]. It can affords different information for user requirements to realize that every ICP & ISP can provide information by themselves, and everyone can get knowledge on demand at last. The Fig. 3 shows the conception of mobile information sharing grid.

Mobile agent manages the information in the unidirectional broadcasting channels such as DAB, DVB-T, DMB-T etc and in the interactive channels such as GSM, CDMA, WLAN etc, which founds the principle of pervasive computing. Thus it can render every user different grade service in the best way and the most economy. In the meanwhile MIS-Grid can also contain all sorts of existing communications networks in optimum.

This framework, which is on the form of grid and on basis of theory in information sharing, is no longer simple connection and simplex utilization for the resources. It resolves the users requirements by interconnection and cooperation and generates new additional information such as data service, to satisfy the users new requirements. The framework brings the following features:

1) The framework entirely integrates all kinds of services. Personal communications, information system and broadcasting are interfused in the seamless network according to users’ requirements. And users can conveniently and safely gain more comprehensive services in the personal way.

2) It allows person to use diverse terminal equipments. Users may utilize all sorts of inexpensive portable mobile equipments to come into the networks.

3) The information will be classified in the complementary model. The hot information is broadcasted in the unidirectional channels to satisfy the common requirements economically, and the personal information is transmitted in the interactive way from dots to dots. By this way, we can resolve not only the congestion of channels, but also save the expensive spectrum resource.

4) It can realize active services of information. The terminal mobile agent can filter the abundant information to render personal service by the user’s setting.

The framework has the ability of self-adaptation and self-organizing. It makes use of spectrum resource efficiently and satisfies requirements of personal service for the future mobile communications. Therefore, the ultimate object of future mobile communications is achieved: to afford any service to anybody anywhere, in anytime.

4 Conclusions

The network architecture MIS-Grid of future mobile communications is introduced in this paper. The MIS-Grid makes use of existing communications networks and integrates all of modern communications technologies, and can enable the spectrum resource and operating costs of mobile communications to become more economical. Actually, the essence of MIS-Grid is to convert the hot wide band information to cheap unidirectional broadcasting channels, and to convert the personalized services to relatively expensive interactive networks. Therefore, it significantly saves the spectrum resource and reduces the cost of managements. It will be more flexible to personal services, especially in the future mobile communications.

References

(Continued on page 36)