R&D Progress in Wireless Communications in China: A Review on Chinese High-tech R&D Programs for Wireless Technology

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Abstract

China has experienced fast growth in mobile communications. Now, China is the world largest mobile communication country with near to 500 million users. Widely applications of mobile communication are giving strong pull to the research and development on the broadband wireless communication technology to meet the fast growing demand for high speed access into the information infrastructure. This makes the R&D on wireless technology plays great role in the Chinese High-Tech program. This paper will review the key project – FuTURE (Future Technology for Universal Radio Environment) - development of the 863 program, which represents the Chinese efforts towards IMT-advance. Taking some works done in the Tsinghua National Laboratory for Information Science and Technology as examples, the paper will show what has been made in China on the broadband wireless technology, including efforts made in special, code and power domain.

I. INTRODUCTION

20 years ago, 4 well-known Chinese Scientists wrote to Mr. Deng Xiaoping, the leader of China, proposing to implement a national high-tech R&D program to meet the technological challenges raised by the worldwide scientific revolution. The proposal had been accepted and the Chinese high-tech R&D program-"863"program has started since March, 1986.

As important reform of the Chinese R&D system, the 863-program has 3 distinguished characteristics:

(1) Focusing on selected high-tech areas, in which IT is the first one;

(2) Opening to all researchers in all research institutes, universities, industry and military for application;

(3) Steering by experts group to select proper projects from thousands of applications and to determine the amount of money assigned to projects.

Now, the 863-program is the largest Chinese governmental program for R&D with Billions RMB budget in the 2006-2010 period.

Though IT has been selected as the 1st area of the 863-program, the telecommunication technology had not listed in it until 1992!

In 1987, in a south province near to Hong Kong, the public mobile telecom system, using TACS standard, had been implemented. By the end of that year, there were hundreds of subscribers using the handset cost 20 times higher than the China's GDP per capital of that year or 50 times higher than yearly income of ordinary workers. Nobody believes, only in few years, mobile communication has revolutionary changed the Chinese telecom system and the market.

Entering the 1990's, China realized that it must pay attention to the information revolution, especially to catch up of world's pace by taking the opportunity of "digitalization" of telecommunication technology, so that, "telecommunication", as a special area called "Tele-863", had been added into 863 program with emphasis on digital mobile communication and high speed optical communication.

Reviewing to the 15 years of "Tele-863" program, in term of mobile communication, it could be divided into two phases. In the first 10 years, the program could be considered as "3G"-oriented one, while in recent years which has become "B3G" (beyond 3G) - oriented. The latter is represented by the "FuTURE" project.

II. "FUTURE" PROJECT

Experienced the fast growth of mobile communication, there is strong pull to the wireless technology by the wide-band or high-speed applications. And, there are notable trends of the merging of the next generation of internet, the next generation of optic communication and the next generation of wireless communications. Therefore, in recent year, the IT sub-program has been focusing on (1) Next generation of networks, especially the IPv6 based next generation of internet; (2) optical technology for internet with multi-wavelength environment (O-TIME project) and (3) Future technology for universal radio environment (FuTURE-project). The last one - FuTURE - project is a wireless technique R&D project with about 30 million USD national budget, aiming to develop a B3G trial system with innovated techniques to meet the requirements the evolution from 3G to access to the IP-based new generation of core networks. It is to note that a distinguished feature of FuTURE project is international collaboration. The main topics of FuTURE (2003-2005) are:

(1) B3G test system and key techniques

(2) B3G RTT assessment platform

(3) B3G applications, standards and measurement

(4) Self-organized network based on WLAN & 3G

(5) New type of antenna and diversity techniques

(6) Ultra-Wide Band (UWB) transmission techniques

(7) Emerging wireless techniques

  (a) THz techniques

  (b) Cognitive radio techniques

  (c) Novel access architecture to public mobile network

  (d) EMC for multiple wireless systems with shared frequency spectrum

the FuTURE. The following are 3 examples of TNList's works starving for breakthrough the limitation of power and bandwidth to the high speed and high capacity wireless communications.

A. Distributed wireless cellular system (DWCS) and MIMO

The Fig.1 shows the proposed new type of network architecture, in which a mobile user is not served by a certain base-station but by a number of "nodes" around it, where the Node-A is just an antenna only while Node-B has signal

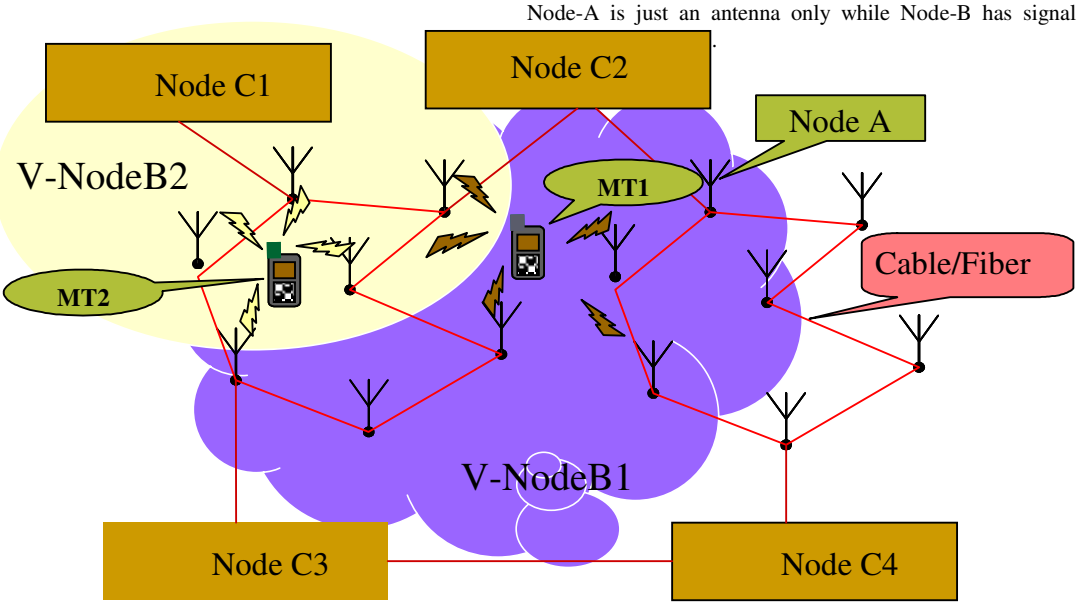


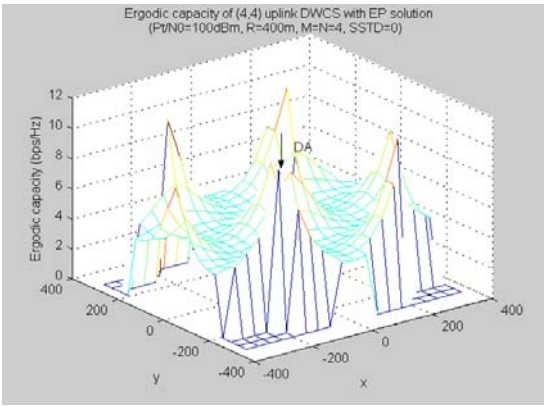
Fig. 1: The configuration of Distributed Wireless Cellular System (DWCS)

Thousands of researchers including students from many universities as well as research institutes and industrial companies are involved in the FuTURE project, and notable progress has been made by the years of afford. A field test system of B3G has been established integrating many new developed techniques, hundreds of technical papers have been published and more than 100 invention patents have been filed along with about 100 recommendations have been proposed to international standardization organization (3GPP, 3GPP2, etc.). Furthermore, a number of new techniques about MIMO, UWB, OFDM, etc., have been developed, which will play important roles in the next phase of FuTURE in the coming 5 years.

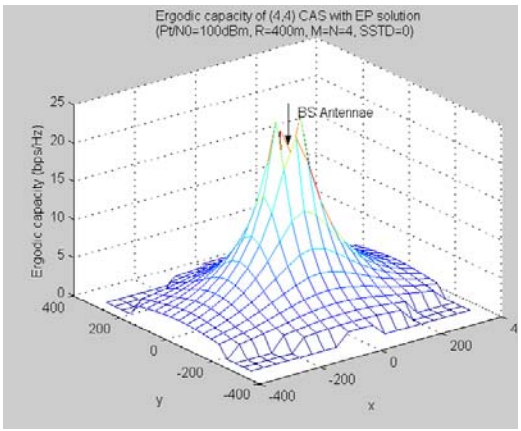
III. SOME EXAMPLES OF FUTURE PROJECT CARRIED BY TNLIST

TNList stands for Tsinghua National Laboratory for Information Science and Technology, which is one of the 6 Chinese National Laboratories. As an important member of the FuTURE project, TNList has carried out a number of topics of the project and made distinguished contribution to

A virtual Node-B (like a base-station) consists of Node As and Bs, serving a virtual cell. This kind of network is a user (mobile) centralized cellular system with user (mobile) centralized processing and coverage.



(a)



(b)

Fig. 2(a) and Fig. 2(b): The effects of DWCS and MIMO on system capacity.

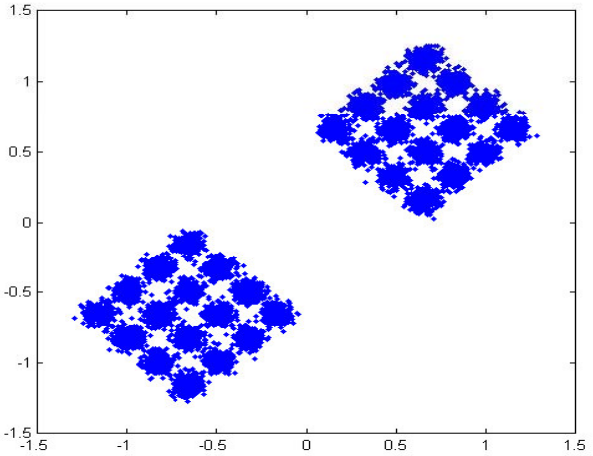


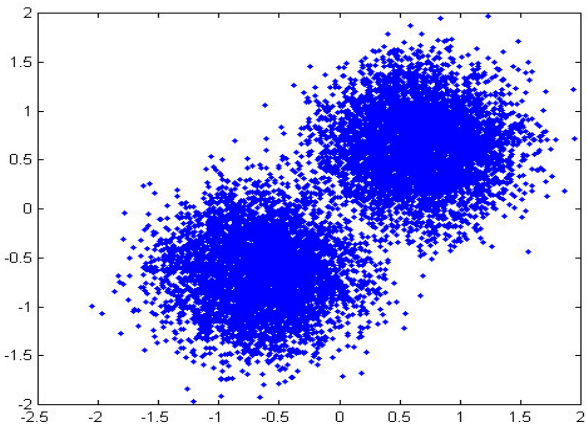
Fig. 3(a) and Fig. 3(b): Illustration of constellation overlapping

Comparing the performance of DWCS and MIMO as shown in Fig. 2(a) and Fig. 2(b), it is found that the MIMO increases the peak capacity while the DWCS increases the base-plat capacity. Therefore, the DWCS and MIMO could be combined and jointly optimized by balancing the elements between them to meet the different requirements of capacity.

B. Constellation Overlapping Technique

Besides the "special domain" technique of DWCS and MIMO, TNList has made effort in "power domain" to further increase the network capacity, called "constellation overlapping" technique.

In the wireless cell, different users are in different channel conditions according their positions. The traditional design of cellular network is to ensure the worst case performance. The adaptive modulation technique is to use TDM scheme to serve different user in different channel condition with different modulation scheme, e.g. user A and B are in different position with S/N of 25 and 10dB each, so that they could be served by 64QAM and BPSK scheme respectively to increase the overall transmission rate by exploring the potential of the channel.



Comparing to the conventional BPSK design with throughput efficiency of 1bit/s/Hz, the TDM adaptive modulation could increase the throughput efficiency to (1+6)/2=3.5 bit/s/Hz. However, instead of TDM based adaptive modulation, TNList proposed a constellation overlapping technique, which use overlapped 16QAM and BPSK to user A and B respectively, and could get a throughput efficiency of (1+4)=5bit/s/Hz.

Fig. 3(a) and Fig. 3(b) show the situation of constellation overlapping. It is apparent that the constellation overlapping technique (CO) could be a multiple definition technology in digital broadcasting systems and a power multiplexing technology in downlink transmissions.

C. Interleaving Pattern Division Multiple Access Technique (IDMA)

Another "code domain" technique called "interleaving pattern division multiple access (IDMA)" has been proposed by TNList, as shown in Fig.4, the data from different users are processed by different interleaving scheme, and this outperforms the CDMA (Fig.5).

s considered that IDMA could be a good solution for same quency reuse among adjacent cells, or a multi-cell quency reuse technique.

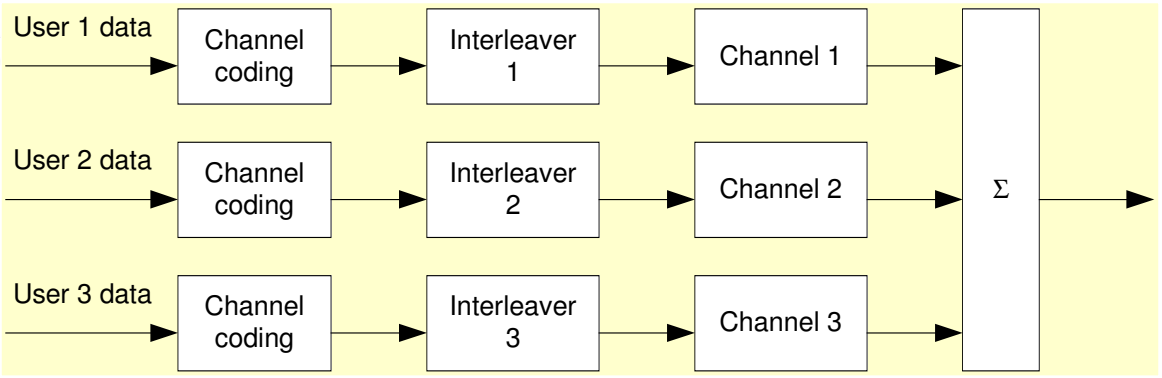


Fig. 4: The Interleaving Pattern Division Multiple Access Technique (IDMA)

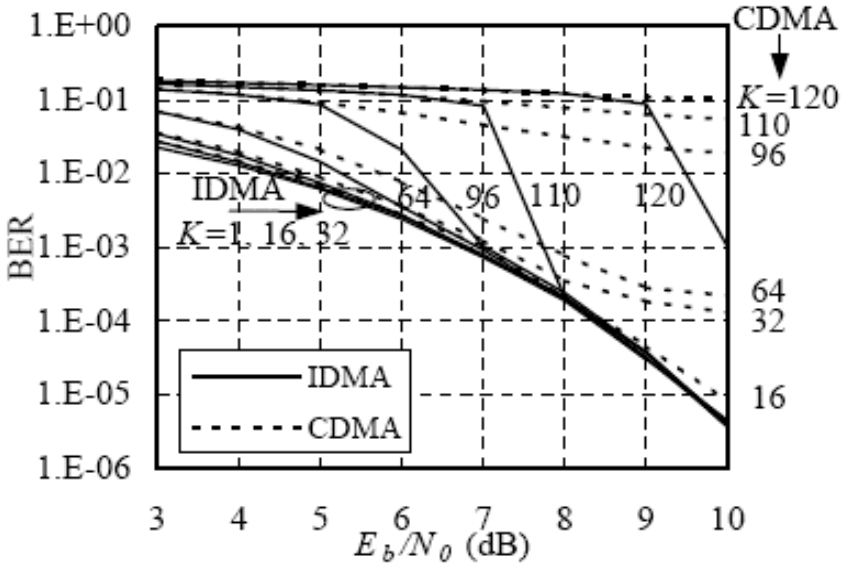


Fig.5 Performance comparison of IDMA and CDMA

IV. CONCLUSION

With the help of 863-program, China is now playing an ever-active role in world high tech development stage. FuTURE is the core project of Chinese wireless technique research and development, which is also a platform for international collaboration. Working closely with partners in China and in the world, TNList has been making great contributions to the FuTURE project with many innovative techniques in the network, transmission as well as physical layers. The further efforts of the FuTURE project (2006~2010) will focusing on IMT-advance relevant technology and low-cost high-speed short range wireless access system, including varies techniques of system architecture, networking structure and protocols, novel terminal and human-machine interfaces, open and reconfigurable hardware platform, pervasive radio communications, etc.