Cooperative Communication and Cognitive Radio (4)

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Editor's Desk:
Cooperative communication and cognitive radio have become hot topics in recent research of communication networks, attracting a widespread attention. Cooperative communication technique can enhance the transmission capacity of a communication system, while cognitive radio technique can improve the spectrum utilization ratio. As a result, the combination of the two techniques will have a significant impact on the future wireless mobile communication system. This lecture comes in four parts. This part analyzes the impacts of cooperative communication technology on modern wireless communication systems.

3.2 Impacts on Modern Wireless Communication Systems

As analyzed above, cooperative communication technology can improve a communication system's anti-fading capability, and CR technology can improve utilization of radio spectrums. Doubtless, the integration of the two technologies will have great impact on network architecture, terminals, service models and applications of future wireless mobile communication systems.

3.2.1 Impacts on Network Topology

(1) Constructing distributed communication systems in homogeneous network

As we know, the channel capacity of MIMO system increases linearly with the number of antennas, so multiple-antenna technology can significantly increase the capacity of a wireless communication system on the premise that all antennas are independent of each other, which means the distances among antennas have to be large enough and there are enough number of scatters around the antennas. Consequently, there is only few antennas can be configured in a single communication device, which results in the limited increasing capacity. Moreover, with the development of communication technologies, communication devices become more intelligent and smaller than before. This makes the implementation of multiple-antenna technology in a single device more difficult and complicate. Cooperative communication technology can construct a virtual MIMO environment without adding more antennas. Like real MIMO environment, this virtual one can obtain diversity gains, increase channel capacity and improve transmission performance, while its implementation is much simpler. Compared with MIMO systems, the systems with cooperative BSs can be considerably simplified and easier to implement, while the performance is better. Besides, cooperative BSs can be connected in a wired way without degrading their transmission performance. Therefore, cooperative communication technology offers a possible scheme for implementation of multiple-antenna technology. In such a scheme, the antennas are not installed at one point, but just shared by several nodes, hence the system is often called a distributed MIMO system in order to distinguish it from traditional centralized system. As a complement to the centralized system, the distributed one is one of hot topics in recent research.

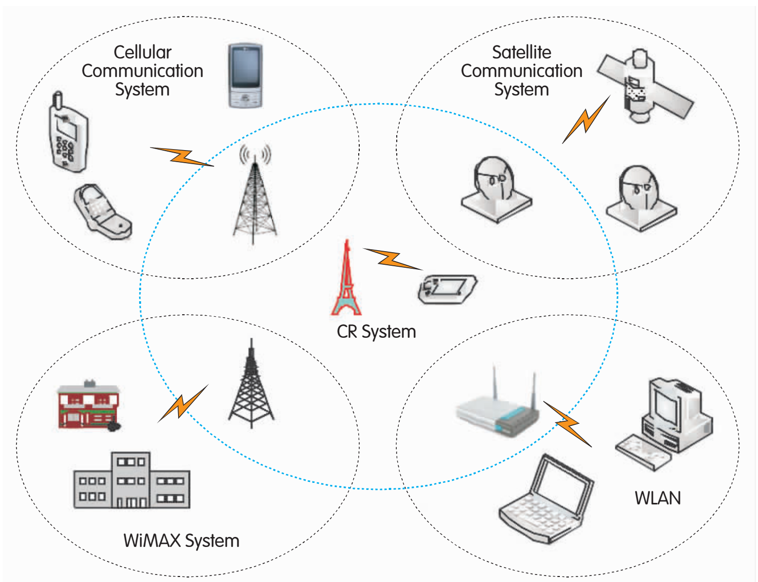
(2) Constructing environment-sensing ubiquitous communication network by means of heterogeneous network convergence

Base on environment sensing information, terminals can real-time adaptively adjust themselves to access the optimal network with the best services. This is called cooperative communication among heterogeneous networks. Obviously, a ubiquitous communication network can be constructed based on cooperative communication among heterogeneous networks, as shown in Figure 14. In such a network, terminals are required to be highly intelligent, which is the prerequisite for implementation, and be able to seamlessly switch and roam among different access networks; while cooperative communication technology and CR technology are key technologies. The environment-sensing ubiquitous communication network enables mobile users to access the optimal network and enjoy quality services at any time without adding new investment.

(3) Constructing symmetrical CR system based on free spectrum access

In fact, either the distributed system

This work was supported by the National Natural Science Foundation of China under Grant No. 60872049, the National High-Tech Research and Development Plan of China ("863" Program) under Grant No. 2007AA10Z235, and the Teaching and Research Finances for the Returned Overseas Chinese Scholars.



▲Figure 14. Environment-sensing ubiquitous communication network.

or the environment-sensing ubiquitous communication network may be just a transitional solution. People expect the next generation communication network to be an integrated platform that can offer various services. Many organizations have described future communication networks from different perspectives, for instance ITU, 3GPP and 3GPP2 from the perspective of telecom network and Internet Engineering Task Force (IETF) from the perspective of IP packet network. Despite difference in their descriptions, they all agree that future network should be based on IP technology and apply cooperative communication into different access networks so as to provide the users with both various circuit-switched and packet-switched services. At present, related research pays much attention to IP Multimedia Subsystem (IMS). IMS is based on soft switch technology and it can overcome the differences among different operators to achieve service convergence, thus offering various services to the users, including fixed services, mobile services, real-time circuit-switched services and non-real-time data services.

According to current research on commercial systems, radio spectrum resources are mainly allocated with fixed allocation policy and the situation will not change for quite a long time. CR technology is a useful complement to this fixed allocation policy and can improve spectral efficiency. but in existing CR systems, LUs take absolute priority over spectrum resources. Therefore, this is an asymmetric system. To simplified description, we call such systems asymmetric CR systems. According to information theory, the asymmetry is likely to result in system capacity loss, while the randomized, adaptive system may be with fully capacity. Technically, as CR theories and key technologies become mature, a symmetric CR system should be able to be developed. In such a system, there are no LUs, and all users select suitable idle spectrums for communications based on spectrum sensing rather than being assigned a fixed number of spectrums. The feasibility of symmetric CR system is still to be verified, but it is evidently a new trial on the basis of asymmetric CR system and may have great impact on future wireless communication systems.

3.2.2 Impacts on Communication Terminals

Both the ubiquitous communication system and symmetrical CR system impose higher requirements on terminals. Unlike existing single-mode terminals, CR terminals should be able to adaptively access various communication networks and perform seamless roaming with their own reconfiguration functionality. In the long term, future terminals are likely to be "universal". In other words, despite diversified access networks, there may be only one type or several types of intelligent, all-purpose terminals. With cooperative communication, SDR and CR technologies applied, such terminals will be more and more powerful and intelligent while their power consumptions and sizes will become smaller and smaller.

3.2.3 Impacts on Service Models and Applications

Apparently, both ubiquitous networks and symmetrical CR systems, which are based on cooperative communication and CR technologies, can deliver various and quality services to the users.

(1) Generating new service models

As future communication terminals become more intelligence, some new service models will be launched. It is well known that Point-to-Point (P2P) technology has been widely and successfully applied in wired networks, but there are many key technologies to be studied before it is applied in wireless networks. In fact, P2P can be basically regarded as a specific application of cooperative communication technology in wired Internet: The nodes in the network cooperate with each other to perform data transmission, thus shortening transmission delay immensely.

(2) Application in deep space communication

From the perspective of information theory, cooperative communication technology can create a virtual MIMO environment without adding antennas, which greatly increases channel capacity of a wireless communication system. This incremental capacity is the basis of improving the system's transmission performance in theory. In fact, cooperative communication technology comes from relaying technologies and is originally designed to enlarge transmission distance. So far, it has been applied in ultra-long distance deep space communications, where satellites, space stations and even moon are treated as relay nodes and an interplanetary Internet is constructed. This no doubt provides us a feasible approach to study the solar system as well as the immense cosmic space.

(3) Application in emergency communication and post-disaster network recovery

Nowadays, major emergent incidents frequently take place around the world. How to strengthen the national emergency management capability and develop a quick, scientific and effective emergency warning and response mechanism has become an important subject in every country. Wireless emergency communication network provides an approach to such a mechanism. When a disaster (e.g. earthquake, war and hurricane) happens, communication networks (both wired and wireless) may be fatally damaged and the boom in traffic in the disaster area may result in network congestion. Not only do voice traffics increase sharply, but also the traffics of data services such as video conferences, remote data access and onsite monitor bulge. However, existing emergency network cannot ensure smooth communications, which, in turn, prevents the emergency departments from quickly learning and judging the situations, thus causing their response to delay and the loss to increase. Therefore, how to set up a broadband wireless emergency communication system after a disaster has become an urgent issue. Our analysis shows that cooperative communication and CR technologies can quickly construct a broadband, self-organizing, cooperative emergency network in this case.

4 Conclusions

Although many valuable achievements have been made in the research of cooperative communication technology and CR technology, and cooperative communication technology has been accepted by some international standards, such as WiMAX, there are still many problems to be addressed before both technologies are applied in real communication environments. It is certain that the two technologies will be applied more widely and will have profound effect on future wireless communication systems with their theories and key technologies being mature and improved. (The end)

Biographies

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Luo Tao, PhD, is an associate professor at Beijing University of Posts and Telecommunications (BUPT). His research interests include cognitive radio, cooperative communications, MIMO, OFDM, and high-speed wireless network architecture. He has participated in several "863" Program of China and National Natural Science Foundation of China projects and has published more than 30 papers.

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Roundup

ZTE and TMN Launch Two Windows® Phone Based 3.5G Smart Phones

ZTE, TMN and Microsoft have jointly launched two new 3.5G smart phones in Portugal. The SilverBelt and BlueBelt II handsets feature the Windows® phone operating system which brings together the mobile phone, PC and Internet.

The customized ZTE Bluebelt smart phone has been sold in Portugal by TMN since May and has captured 30 percent of the Portuguese smart phone market. The new 3.5G smart phones have been customized by ZTE specifically for the Portuguese market and will be available from TMN throughout Portugal. TMN is Portugal's largest mobile operator with seven million subscribers from Portugal's population of 10.7 million.

The BlueBelt II handset delivers the complete Windows phone experience. It is an ultra-slim candy bar style smart phone with a 5 MP camera, and works with UMTS, GSM, Edge and GPRS networks. The handset has both touch screen and modified QWERTY keyboard data entry with dedicated keys especially customized for TMN users.The SilverBelt handset is also a customized candy bar ultra-slim 3.5G smart phone running Windows® phone, but also features a G-Sensor motion sensor supporting functions such as MP3 player start.stop and horizontal/vertical screen switch. The Silverbelt also has a large 3.2 inch touch screen with 5 Mp camera.

Both ZTE/TMN smart phones can provide high-speed data rates of up to 7.2 Mbit/s on HSDPA/HSUPA networks. They are fully featured phones providing multi-media functions, fast connectivity and up to 8 GB data storage capacity, giving a full phone and web experience combined with stylish design.

The handsets support WAP, Bluetooth, video and audio streaming, web browser and USB 2.0 connectivity supporting different multimedia formats including MP3, AAC+, MPEG4, H.263, H.264 and FM radio.

ZTE has invested heavily in the research and development of smart phones over the last five years and has focused on becoming the world leader in the development of customized mobile phones. (ZTE Corporation)