Role of Cognitive Radio on 4G Communications A Review

Neeraj Kumar(15491), Ayush Singla(15462)

INFORMATION TECHNOLOGY

DRONACHARYA COLLEGE OF ENGINEERING

neeraj.136@gmail.com, shubhamsingla081@gmail.com

ABSTRACT

There is a rapid advancement in wireless communication technology providing the network services anywhere and anytime. 4G communication systems are being developed to solve the various problems the current communication systems (3G, 2.5G) are facing.4G will be an intelligent technology that will reduce the number of different technologies to a single global standard. Cognitive Radio (CR) is the key enabling technology for next generation networks. Cognitive Radio techniques provide the capability to use or share the spectrum in an opportunistic manner. With the use of CR, 4G wireless networks will support global roaming across multiple wireless and mobile networks. In this paper, the Role of CR in 4G Communications is reviewed. The recent research being done on Cognitive Radio and 4G technologies is identified. The main possibilities of implementing Cognitive Radios in 4G Communication Systems are surveyed. IEEE 802.22 networks are cognitive technology based networks which will enhance the performance of 4G Communication systems. IEEE 802.16h (WiMAX) provide extensions to support unlicensed coexistence. Keywords: Cognitive Radio (CR), WiMAX, 4th Generation (4G)

1.INTRODUCTION

In 4G, short for **fourth generation**, is the fourth generation of mobile telecommunications technology, succeeding 3G and preceding 5G. A 4G system, in addition to the usual voice and other services of 3G, provides mobile broadband Internet access, for example to laptops with wireless modems, to smartphones, and to other mobile devices. Potential and current applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

Two 4G candidate systems are commercially deployed: the Mobile WiMAX standard (first used in South Korea in 2007), and the first-release Long Term Evolution (LTE) standard (in Oslo, Norway and Stockholm, Sweden since 2009). It has however been debated if these first-release versions should be considered to be 4G or not, as discussed in thetechnical definition section below.

In the United States, Sprint (previously Clearwire) has deployed Mobile WiMAX networks since 2008, while MetroPCS became the first operator to offer LTE service in 2010. USB wireless modems were among the first devices able to access these networks, with WiMAX smartphones becoming available during 2010, and LTE smartphones arriving in 2011.3G and 4G equipment made for other continents are not always compatible, because of different frequency bands. Mobile WiMAX is not available for the European market as of April 2012.

2. COGNITIVE RADIO TECHNOLOGY

Recent studies and measurements have shown that, with the traditional spectrum access approach, the radio spectrum assigned to primary (licensed) users is vastly underutilized. Actual measurements conducted by the FCC's spectrum Policy Task Force which has determined that, in some

locations or at some times of a day, about 70 percent of the allocated spectrum may not be in use [5]. Measurements in [6] reveal that spectrum utilization is often heavy in unlicensed bands while low in TV bands or medium in some cellular bands. These observations on VOL. 3, NO. 2, February 2012 ISSN 2079-8407 Journal of Emerging Trends in Computing and Information Sciences ©2009-2012 CIS Journal. All rights reserved. http://www.cisjournal.org 273 actual spectrum usage have challenged approaches to the radio spectrum management and fueled interests in the opportunistic spectrum access problem. Opportunistic spectrum access has been enabled by cognitive radios. Unlike conventional radios, CRs have the capability to sense their surroundings and actively adapt their operation mode to maximize the quality of service for secondary users while minimizing interference to primary users. Hence, CRs must carry out spectrum sensing to identify white spaces or spectrum holes which are bands of frequencies assigned to primary users, but, at a particular time and specific geographic location, these bands are not being utilized by those users [7] as shown in Figure 2. Figure 2: Frequency Spectrum showing White Holes

The CR Technology will enable the users to:

• Determine which portions of the spectrum are available and detect the presence of licensed users when a user operates in a licensed band(spectrum sensing)

• Select the best available channel(spectrum management)

• Coordinates access to this channel with other users (spectrum sharing)

• Vacate the channel when licensed user is detected(spectrum mobility)

3.IMPORTANT RESEARCH ON COGNITIVE RADIO

Several entities including DARPA, the SDR Forum, IEEE and the FCC have done some important researches on cognitive radio**.**

3.1 DARPA Currently, DARPA is exploring many aspects of cognitive radio as a part of the XG (Next Generation) program and other ongoing programs. The most notable anticipated activity from DARPA is the launching of the Wireless Adaptive Node Network (WANN) project. It is hoping to achieve significant gains in throughput and network scalability through the incorporation of intelligence in the radios [9].

3.2 SDR Forum Some activities:

• Technical committee on cognitive radio • Also groups on secondary spectrum access testing, meta-language for mobility work, and possibly security

• Various Projects are currently being worked on**.**

3.3 IEEE The IEEE P1900 Standards Committee was established in 2005 by the IEEE Communications Society (ComSoc) and EMC (Electromagnetic Compatibility Society). It was reorganized further as SCC 41(Standards Coordinating committee).IEEE SCC 41 will develop standards related to dynamic spectrum access networks, focusing on improved use of spectrum as of the year 2009. Currently, the 1900 working groups and their focuses: •

1900.1- Standardize definitions and terminology related to cognitive radio and next generation radio systems.

• **1900.2-** Interference and coexistence analysis. •**1900.3**- Conformance evaluation of SDR software modules.

• **1900.4-** Architectural Building Blocks Enabling Network Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks.

• **1900.5**- Managing Cognitive Radio for Dynamic Spectrum Access applications.

• **1900.6-** Spectrum sensing interfaces and data structures for dynamic spectrum access and advanced radio communications.[10]

3.4 FCC The FCC released its R&O for TV Whitespace on November 4, 2008 allowing unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used given they use CR / DSA capabilities. Recently, FCC defined provisions that allow unlicensed devices to operate in the licensed bands so long the unlicensed devices do not create interference for licensed services [11].

3.5 Other Institutions Several other institutions are also currently pursuing cognitive radio research including Virginia Tech, International Telecommunication Union (ITU), European Radio Spectrum Policy Group (ERSPG), U.K. Ofcom (consultation on DySPAN), Japan's Ministry of Internal Affairs and Communication (MIC)

4. 4G FEATURES 4G is the stage of broadband mobile communications that will supersede the 3G. While neither standards bodies nor carriers have concretely defined or agreed upon what exactly 4G will be, it is expected that end-to-end IP and high quality streaming video will be among 4Gs VOL. 3, NO. 2, February 2012 ISSN 2079-8407 Journal of Emerging Trends in Computing and Information Sciences ©2009-2012 CIS Journal. All rights reserved. http://www.cisjournal.org 274 distinguishing features.4G networks are likely to use combination of WiMAX and WiFi technologies[13]. Table 1:Series of mobile generation and their features [12] Techn ology 1G 2G 2.5G 3G 4G Design began 1970 1980 1985 1990 2000 Imple mentat ion 1984 1991 1999 2002 2012? Servic es Analo g voice Digital voice Higher capacit y, packeti zed data Higher capacity, broadban d data up to 2 mbps Comp letely IP based, speed up to hundr eds of mbs Standa rds NMT, AMP S, CDP D GSM, iDEN, D- MPS GPRS, EDGE etc WCDM A, CDMA2 000 Single Stand ard Data Bandw idth 1.9 kbps 1.4 kbps 384 kbps 2 Mbps 200 Mbps Multip lexing FDM A TDMA , CDM A TDMA , CDMA CDMA CDM A? Core Netwo rk PSTN , PSTN PSTN, PSTN, Packet networ k Packet network Intern et 5. ROLE OF COGNITIVE RADIO(CR) IN 4G When fully implemented, 4G is expected to enable pervasive computing, in which simultaneous connections to multiple high speed networks provide seamless handoffs throughout a geographical area. The network Operators may employ technologies such as cognitive radio and wireless mesh networks to ensure connectivity and efficiently distribute both traffic and spectrum [13]. Multiple standards of 3G make it difficult to roam and interoperate across various networks, whereas 4G provides global standard that provides global mobility. This is possible with the help of cognitive radio. As a support of Mobility Management the communication between different systems should be established through generic interfaces. Multimode terminals are the one aspect considered for 4G systems. 4G systems will prove to be far cheaper than 3G, since they can be built atop existing networks and won't require carriers to purchase costly extra spectrum. In addition to being a lot more cost efficient, so carriers can do more with less [12]. With 4G systems there will be a need to design a single user terminal that can operate in different wireless networks and overcome the design problems such as limitations in size of the device, its cost and power consumption. This problem can be solved using Software Defined Radio/Cognitive Radio approach i.e user terminal adapts itself to the wireless interfaces of the network. Another important role of Cognitive Radio in 4G communications is that the 4G devices are expected to be more visual and intuitive rather than today's text and menu based systems. They will be able to interact with the envoirnment around it and act accordingly.

Typical key applications scenarios of cognitive radio: • CR technologies are useful for the internal optimization of the networks, which are essential in solving the every-serious spectrum resource scarcity problem while the current 3G telecommunications networks are evolving to the all IP-based 4G telecommunications networks aiming at providing seamless, ubiquitous, end-toend, and quality-guaranteed services inside a specific operator and carrier[14]

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CR technologies lend themselves to the application in heterogeneous communications networks [15] encompassing different service providers and radio standards like WiMAX, BWA (World-wide Interoperability for Microwave Access Broadband Wireless Access), e.g. 802.16e/h, 3G/B3G/4G 3GPP mobile operators (e.g., UMTS/HSDPA/LTE/DVB-H).

• **CR technology** can become a key enabler for true heterogeneous communication environment where data-aided mitigation techniques, such as physical or logical layer cognitive pilot channel (CPC) will be implemented for optimal sharing of the spectrum and coexistence with least interference among various radio access nodes. These ideas gain in importance especially with respect to the vision of Future Internet or Internet of Things, where a multitude of different devices are expected to communicate seamlessly and rearrange their network configuration in an autonomous fashion in order to route/exchange the information in most efficient way. The cognitive and reconfigurable radio paradigms with CPC and cognitive routing schemes are expected to contribute greatly to the realization of this vision, as forecasted by the Future Internet Assembly and reflected in the 7th Framework Program (2007-2013) of the European Community for research, technological development and demonstration activities**.**

5.IEEE 802.16 e In 2005

The IEEE announced the approval of IEEE 802.16e (Mobile WirelessMAN) that will facilitate the global development of mobile broadband wireless access (BWA) systems. The standard specifies a system for combined fixed and mobile BWA supporting subscriber stations moving at vehicular speeds in licensed bands under 6 GHz [17].

5.2 IEEE 802.16 h Main features of IEEE 802.16h: • Improved Coexistence Mechanisms for LicenseExempt Operation • Basically, a cognitive radio standard • Incorporates many of the hot topics in cognitive radio ¬ Token based negotiation ¬ Interference avoidance ¬ Network collaboration ¬ RRM databases VOL. 3, NO. 2, February 2012 ISSN 2079-8407 Journal of Emerging Trends in Computing and Information Sciences ©2009-2012 CIS Journal. All rights reserved. http://www.cisjournal.org 276 • Coexistence with non 802.16h systems Regular quiet times for other systems

5.3 IEEE 802.16 m IEEE is now working on a new wireless standard called 802.16 m and it is said to deliver 1Gbps transfer rates. The standard also has a high mobility mode which allows for 100 Mbps rates. It is under the process of standardization. The new standard will use MIMO technology [17]. The new standard will be compatible with future 4G networks. The goal for the long-term evolution of WiMAX is to achieve 100 Mbit/s mobile and 1 Gbit/s fixednomadic bandwidth as set by ITU for 4G NGMN (Next Generation Mobile Network).

6. CONCLUSION

Current Communication systems are reaching a point where traditional network management and maintenance technologies will no longer able to cope with increasing system complexity. In this paper we surveyed the cognitive radio capabilities. The various research activities being done by various groups on cognitive radio have been reviewed. Furthermore, the role of cognitive radio on 4G communication systems has been emphasized in this paper. The various application scenarios and the standards incorporating them have been reviewed. Internet is a driving force for higher data rates and high speed access for mobile wireless users. 4G systems will give value added services but still they will offer a lot many challenges till they get fully implemented. 4G systems will depend upon the various issues of spectrum management, cost reduction, global roaming facility and mobility between various systems and that these are prime candidates for the implementation by Cognitive Radios. The growth of 4G technology will be enhanced with the development of the open standards.

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