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A Comprehensive Study of Wireless Communication Technology for the Future Mobile Devices

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Abstract

With the widespread rapid development of computers and the wireless communication, the mobile computing has already become the field of computer communications in high-profile link. Mobile clients and Mobile Ad Hoc Network (MANET) are a collection of two or more devices or terminals with wireless communications and networking capability that communicate with each other without the aid of any centralized administrator also the wireless nodes that can dynamically form a network to exchange information without using any existing fixed network infrastructure. Mobile clients and MANET can be either heterogeneous or homogeneous depending on the types of mobile nodes being involved. In this paper we proposed an overview of wireless communication technology for mobile node and mobile ad hoc network, wireless transmission and the end Mobile communication through homogeneous and heterogeneous networks.

Keywords: Ad hoc, WiFi, WiMAX, 3G, MN, Vertical Handover, Horizontal Handoff.

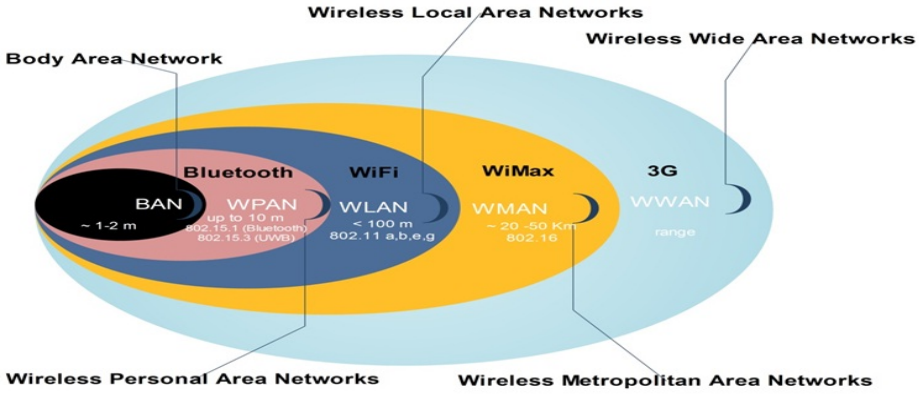
1. Introduction

The wireless mobile networks have traditionally been based on the cellular concept and relied on good infrastructure support, in which mobile devices communicate with access points like base stations connected to the fixed network infrastructure. To access the services seamlessly is required to have supportive network and infrastructure whereby the service can be accessed within local area network such as building premises as well as in wider area such as outdoor environments. Typical examples of this kind of wireless networks are classified it into three types according to the coverage area, wireless local area network can provide high-speed Internet access at limited places (i.e., Wi-Fi/ IEEE 802.11)

[17], whereas cellular networks can offer universal network access but with limited access rate, wireless metropolitan area networks (i.e., WiMAX/ IEEE 802.16), and wireless wide area network such as 3ed Generation [8].

The development of communication technology has the cable toward wireless broadband service, but wireless communications technology development in recent years, is more rapid to develop a variety of protocols used in different environment, so that the people can use these technology at anytime and anywhere. In Figure 1, we classified the communication technology and ad hoc network according of the coverage area, into several classes such as Bluetooth (WPAN, IEEE 802.15), Wi-Fi (WLAN, IEEE 802.11), WiMAX (WMAN, IEEE 802.16), 3rd Generation (WWAN), is not expected to govern at anytime and at anyplace can make many appropriate services, integration of various networks advantages in order to achieve more service quality and performance to make the people interesting to pursue the technology.

Figure 1: Classification of Wireless ad hoc Networks



2. Wireless Transmission

Wireless network is using a wireless LAN connection, using radio waves as the medium of transmission distance of about tens of meters to wireless access points allow users to join network; the first prototype of WLAN is published in 1997, followed by 802.11a and 802.11b which is published in 1999. 802.1b wireless network is commonly used because it can provide speed up to 11Mbps transfer rate meanwhile 802.11a and 802.11g is up to 54Mbps[1].

The Access Point (AP) not expensive and it is easy to build it, and there are many users use WiFi wireless network. Typically WiFi wireless used in the companies and business firms, schools, units and every individual has to use the Wifi to access internet. Hence this makes the Wifi wireless network so famous.

However, the wireless transmission of WiFi slandered only provide a small range, hence in order to solve the problem and to provide to the last mile wireless lines, 802.16 WiMAX (Worldwide Interoperability for Microwave Access) is proposed as an alternative to WiFi. This is because WiMAX can provide more than 70Mbps of transfer rate, and up to 70 miles of transmission range, in the Subsection 2.1 will explain briefly.

Because of the transmission range of WiMAX can be a large communication networks, WiMAX was proposed to replace the original 2G communication network, Compete with 3G. WiMAX cannot be mapped due to a faster mobile client, in terms of supporting communication networks have also proposed 802.16e [2] [16] standard. In this standard, although the low transmission rate and range, but it strengthened rapidly mobile client support, and still provides 30Mbps transfer rate. Also, due to low transmission rate, and insufficient to support audio and video data transmission has made the wireless phone 3G, UMTS and CDMA2000 to as the representative to provide more high-speed

transfer rate of communication technology, the transmission rate of about hundreds of kbps or more, and it to replace the 2G communication network.

2.1. Local Wireless Network (WiFi)

Wireless Fidelity, they referred to as WiFi is used to signify the line 802.11, 802.11a (with maximum bandwidth 54 Mb), 802.11b (with maximum bandwidth 11 Mb) and 802.11g (with maximum bandwidth 54 Mb) standards for these wireless communication equipment to produce the WMAN as we summarized it in Table 1. This term is by the WiFi alliance (an organization similar to WiMAX forum) they suggested that the organization is to allow the different companies to produce under the IEEE 802.11 standard Wireless Local Area Network (WLAN) communications equipment to have interoperability. The IEEE 802.11a, b, g and hotspot are designed for WLAN, and 802.16 is designed for WMAN [1][2][5] [14].

Table 1: IEEE 802.11 Standards

Standard	**802.11**	**802.11b**	**802.11a**	**802.11g**	**802.11n**	
Years	1997	1999	1999	2003	2009	
Bandwidth (GHz)	2.4~2.4835	2.4~2.4835	5.15~5.35 5.725~5.825	2.4~2.4835	20	40
Channel Bandwidth	83.5 MHz	83.5MHz	300MHz	83.5MHz	40MHz	
Coverage	100m	100m	50M	100m	In 10m	Out 250m
Modulation	DBPSK,DQPSK	DBPSK,DQPSK	M-PSK,MQAM	M-PSK, M-QAM	OFDM	
Max.bitrate (bps)	1M / 2M	1M / 2M /5.5M / 11M	6M to 54M	6M to 54M	54M-60M	
PHY Mod.	FHSS, DSSS	DSSS, CCK, PBCC	OFDM	OFDM, CCK	OFDM	

2.2. Wider area Internet access Ifrastructures (WiMAX)

With the rapid development of wireless networks, people have become accustomed to anytime, anywhere access to information through a wireless network, new applications constantly being developed, people use mobile devices for voice and video communication, while, can also send files and order such information. Therefore, the addition to be able to facilitate access in any location other than access the Internet, and mobile users for the bandwidth requirement of stability is gradually improving. Electrical and Electronics Engineers (Institute of Electrical and Electronic Engineers, IEEE) in 2001 to develop a new generation of 802.16 wireless network access technology. 802.16 dominated by Intel's WiMAX Worldwide Interoperability for Microwave Access Forum established to promote. Initially, WiMAX goal setting in the fixed broadband wireless network; in January 2003 to 2004, WiMAX to change the direction of portable broadband wireless network, set 802.16d [3]; in 2006 after the mobile broadband wireless network aim to develop 802.16e [4]. Such changes will also result in response to trends in the wireless network. In the WiMAX there are many working groups, one of the Forum Network Working Group aims to 802.16 as a basis for the upper network specification [5] in order to accelerate access to this line of technology commercialization efforts. The summarized of WiMAX (IEEE 802.16) standard shown in Table 2.

Table 2: IEEE 802.16 Standards

Standard	**802.16**	**802.16a**	**802.16-2004**	**802.16e**
	Last mile & Back haul			*Mobile Device*
Bandwidth (GHz)	10-66GHz	2~11GHz		2~6GHz
Max.bitrate (bps)	32~134Mbps	75Mbps		15Mbps
PHY Mod.	QPSK 16QAM 64QAM	QPSK, 16QAM, 64QAM (256 subcarrier OFDM)		QPSK, 16QAM, 64QAM (257 subcarrier OFDM)
Coverage	1~3 Mile	4~6 Mile (30Mile)		1~3Mile

2.3. 3rd Generation

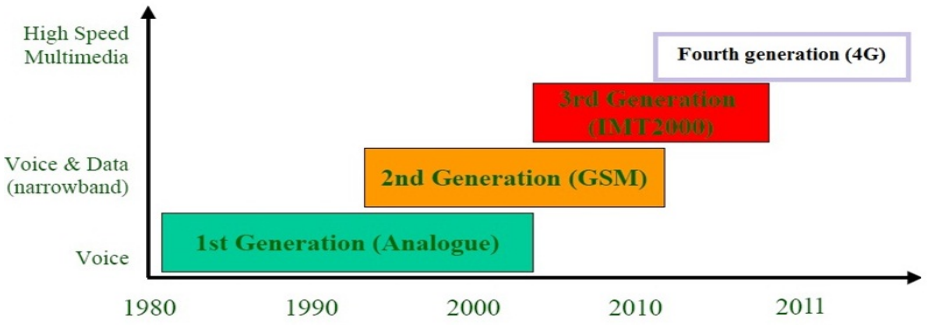
The First Generation (1G) began in the early 80's with commercial deployment of Advanced Mobile Phone Service (AMPS) cellular networks. The Second Generation (2G) emerged in the 90's when mobile operators deployed two competing digital voice standards. In north Aamerica, some operators adopted IS-95, and across the world, many operators adopted the Global System for Mobile communication (GSM) standard. The International Telecommunications Union (ITU) defined the third generation (3G) of mobile telephony standards IMT-2000 third generation mobile standard enables mobile users to harness the full power of the Internet through efficient high-speed radio transmission, optimized for multimedia communications. For example, GSM could deliver not only voice, but also circuit-switched data at speeds up to 14.4 Kbps. But to support mobile multimedia applications, 3G had to deliver packet-switched data with better spectral efficiency, at far greater speeds. The range and capabilities of data services that can be supported by digital mobile systems, service providers will have to upgrade their networks to one of the 3G technologies. These can support data rates up to 2 Megabits / second (indoors environments) and up to 384 kilobits / second (outdoors environments). 3rd Generation (3G) [1] [18] is "a technology for mobile service providers.

The Mobile services are provided by service providers that own and operate their own wireless networks and sell mobile services to end-users". In the Figure 2 (a) depicts the evolution towards 3G according to the year from 1980 to 2010 (b) shown the migration from the first generation to 3G and 4G. So far, the work is still continues to develop successor to the 3G and 2G families of standards, in the near future the 4G will be fully built. [10][21].

3rd generation (3G) is a technology for mobile service providers. The Mobile services are provided by service providers that own and operate their own wireless networks and sell mobile services to end-users. 3G mobile standard enables mobile users to harness the full power of the Internet through efficient high-speed radio transmission, optimized for multimedia applications and support higher bandwidth digital communication. The range and capabilities of data services that can be supported by digital mobile systems, service providers will have to upgrade their networks to one of the 3G technologies. These can support data rates up to 2 Megabits / second (indoors environments) and up to 384 kilobits / second (outdoors environments)[13].

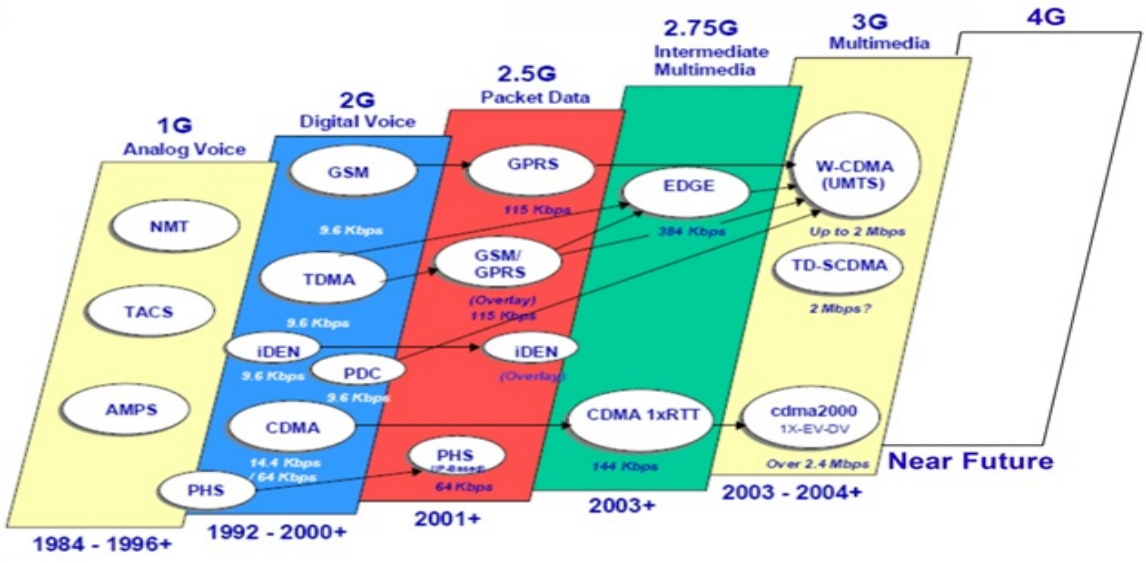
The 2ed generation was a total replacement of the 1st generation networks and mobile nodes and the 3ed generation was a total replacement of 2ed generation networks and mobile nodes. in this case, the 4G cannot be an incremental evolution of current 3G technologies, but rather the total change of the current 3G networks and mobile nodes. The international telecommunications regulatory and standardization bodies are working for commercial deployment of 4G networks roughly in the 2011 to 2015 time scale. However, there are certain objectives that are projected for 4G. These objectives include, that 4G will be a fully IP-based integrated system. 4G will be capable of providing between 100 Mbit/s and 1 Gbit/s speeds both indoors and outdoors, with premium quality, high security, and help the mobile devices move freely when connect the internet at any place and anytime[11] [12].

Figure 2: (a) Evolution towards 3G and 4G (b) migration to 3G and 4G.



(a)

Figure 2: (a) Evolution towards 3G and 4G (b) migration to 3G and 4G. - continued



(b)

3. Comparison between Wireless Communication Technologies

3.1. Comparison WiMAX Versus WiFi

In comparison with the WiFi, WiMAX improve the transmission speed and range, when construction the structure of the regional wireless network does not need a large amount of Access Point which can provide network connection to the entire region, but the wireless WiMAX frequency of the user can require to use a license, but in WiFi technology no such problem. Table 3 shows the comparison between WiMAX (IEEE 802.16) and WiFi (802.11b, a, g and n).

Table 3: Comparison between WiMAX and WiFi standards

	WiMAX	**Wi-Fi**			
Standard	**IEEE 802.16**	**802.11b**	**802.11a/g**	**802.11n**	
Max. Bitrate	75M bps @BW=20MHz	11M bps	54M bps	54M bps-600	
Max.Distance	30-50km(LOS)/4-9km(NLOS)	100m(indoor)/ 300/(outdoor)	100m(indoor)/3 00m(outdoor)	10m(indoor)/25 0m(outdoor)	
Rradio frequency	2-66GHz	2.4GHz ISM	5GHz U-N11,2.4gHz ISM(g)	2.4/5 GHz	
Channel bandwidth	1.25-20MHz	22MHz	20MHz	20 MHz	40 MHz
PHY Mod.	OFDM/OFDMA	DSSS	OFDM	OFDM	
QoS	Yes	No	No	Yes	
Duplex	TDD or FDD with support of MAC	Done by MAC	Done by MAC	MIMO	
Mobility	Low	High	High	High	

3.2. Comparison WiMax Versus 3G

The comparison between WiMAX and 3G speed is not about the fastest transmission, it about support the mobility. And this is this is weaker point which WiMAX is lower than the 3G. Table 4 shows the comparison between WiMAX (802.16e) and 3G (CDMA-2000, WCDMA).

Table 4: Comparison between WiMAX and 3G standards

	WiMAX	**3G**	
Standard	**802.16e**	**CDMA-2000**	**WCDMA**
Max. bitrate	30M bps@BW=10MHz	11M bps	54M bps
Max.Distance	2-5km	2-5km	2-5km
Rradio frequency	2-6GHz	400,800,700 900,1800,2100MHz	900,1800,2100MHz
Channel bandwidth	1.25-20MHz	1.25MHz	5MHz
PHY Mod.	OFDM	CDMA	CDMA
Duplexing	TDD	FDD	FDD
Mobility	Low	High	High

4. Mobile Communication through Homogeneous and Heterogeneous Networks

With the rapid development of technology, the network connection has been developed from a wired to wireless network connection, the most common wireless network access technology used by the United States of Electrical and Electronic Engineers (The Institute of Electrical and Electronics Engineers, IEEE) [6], Formulated by the series of IEEE 802.11 standards, that is called Wi-Fi network. However, the WiFi network nature of transfer encoding, making Wi-Fi network, the maximum transmission distance is only between one or two hundred meters, so when the mobile clients in the wireless Access Point (AP) move between the wireless network access point and if the deployment does not cover the range of mobile clients, mobile clients will be out of the Wi-Fi services, which can cause the network connection interruption.

In recent years, Nokia, Ensemble Communication, Harries, Cross Span, OFDM and other global effort, driven by a number of telecommunications giant global microwave access communication technology (Worldwide Interoperability for Microwave Access, WiMAX). WiMAX is a new generation of broadband wireless network access technologies (Broadband Wireless Access System, BWA). This is the IEEE 802.16 [3] [7] series of broadband wireless standards, Using the wireless medium to reach the wired cable technology and digital subscriber loop (Digital Subscriber Line, DSL), access the same way, through those technology, the wireless network to enhance the transmission distance for the number ten km. In addition WiMAX and Wi-Fi can access within the same higher bandwidth load.

With the development of wireless network, people can use notebook, cell phone and PDA which has the support mobility, to make the mobile devices move freely from one network to another [19] [20]. In order to maintain the connection services, the mobile devices need to switch between different base station connections. When the mobile devices move from one network to another is known as a handoff (Handover). If the handover process occurs in the same nature means between the same networks, it is called horizontal handoff. Horizontal handoff between Access Points (AP) or base stations (BS) can communicate with each other to support the homogeneity of the mobile node handoff, such as in WiFi network environment, the mobile nodes (MN) move from Access Points to another as shown in Figure 3 and it is the same in WiMAX network environment, the MN move from BS to another. The handoff procedure is based on the IEEE working group in 2005 finalized the IEEE 802.16e [7] standards as shown in figure 4.

Figure 3: Horizontal handoff (Homogeneous) between WiFi Access Points

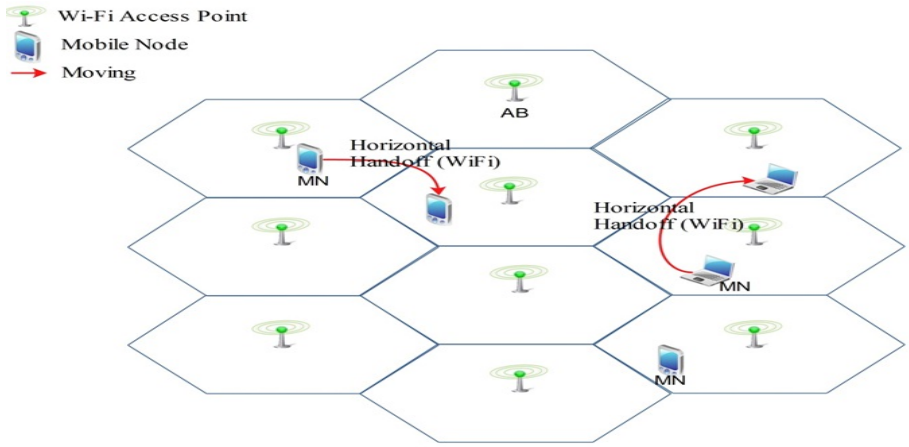
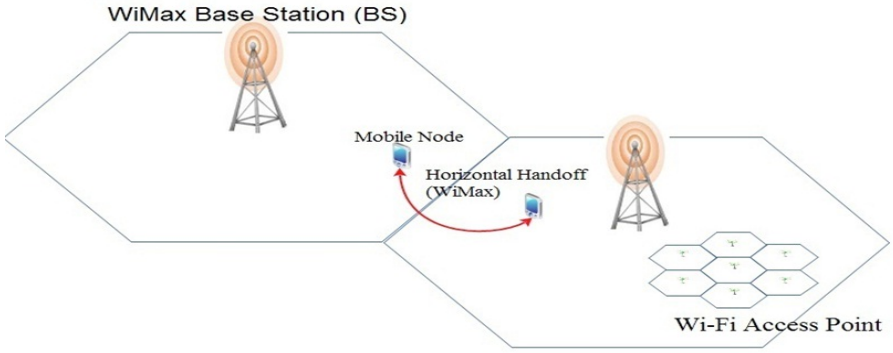
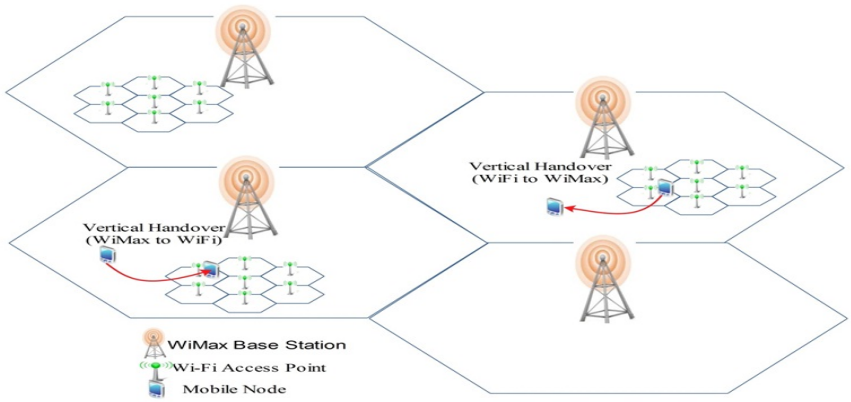


Figure 4: Horizontal handoff (Homogeneous) between WiMax Base Station (BS)



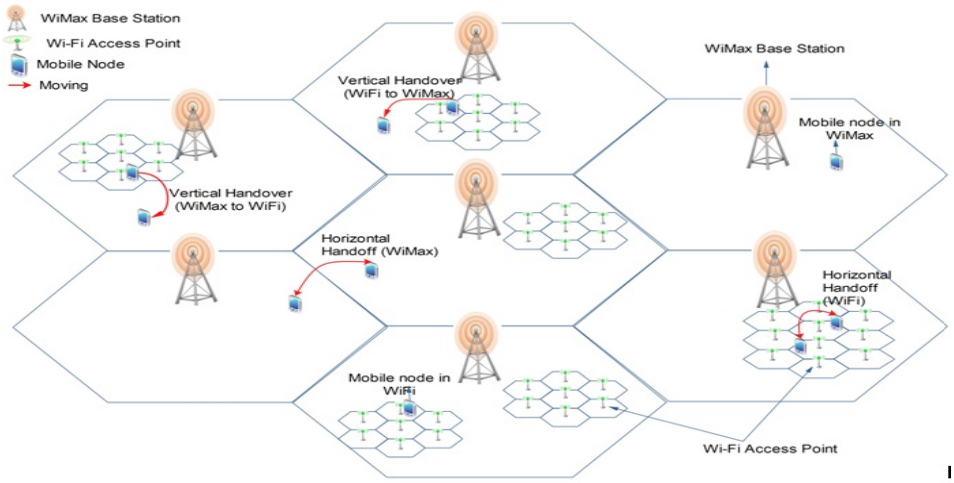
This standard is intended to support the mobile capabilities to mobile nodes, thereby allowing the mobile node move smoothly between networks in the 802.16 handover [9]. In contrast, if the handover occurs in heterogeneous network is known as Handoff between different networks is called vertical handoff, such as mobile node move from the Wi-Fi to WiMax or from WiMax to WiFi network as shown in figure 5. In the current co-existence of multiple network technology environments, the mobile node can own the network card device support in various network handoffs between access media. The authors in [15] [22] have proposed a new system architecture for VOD over heterogeneous network, which the mobile clients able to watch the video of their chose at anytime and anywhere.

Figure 5: Vertical Handover (Heterogeneous) from Wi-Fi to WiMax and WiMax to WiFi



In both process, the handoff will happen when the mobile nodes move between two different cell or access point within the same wireless communication system (homogenous networks) where one type of network is called horizontal handoff, on the other hand, handoff between different types of networks is also possible where mobile node move from one wireless communication system to another different wireless system (heterogeneous network). A handoff in heterogeneous environment is named vertical handoff. In Figure 6 shows the movements of the mobile nodes in both homogenous networks and heterogeneous networks. This scenario will help the mobile node roaming in a wireless networks, in order to make the mobile nodes move freely at anywhere and keep accessing the media.

Figure 6: Scenario of mobile nodes moving through homogeneous and heterogeneous network



4. Conclusions

In this paper provides an overview of the wireless communication technology for mobile node and mobile ad hoc network. Firstly, we begin this paper to introduce the main concept of the wireless transmission which classifies it into three types according to the coverage area, wireless local area network (WiFi), wider wireless Internet access infrastructures (Wimax) and 3rd eneration. Secondly, we explained the comparison between wireless communications technologies such as the comparison between (wifi and wiman) and (wimax and 3G). Finally, explained briefly about mobile communication through homogeneous and heterogeneous networks which the mobile devices or mobile ad hoc network can move freely between networks to another.

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References

[1] W. Lehr, and W.L. Mcknight, wireless internet access: 3g vs. Wifi? Telecommunication policy, Vol. 27, No.4, pp. 351-370, 2003.

[2] IEEE part 16: air interface for fixed and mobile broadband wireless access systems. Ieee 806.16e, ieee p802.16e/d12.

[3] Part-16 ieee standard for local and metropolitan area networks part 16: air interface for fixed broadband wireless access systems, ieee std 802.16-2004, 2004.

[4] Part-16 ieee standard for local and metropolitan area networks part 16: air interface for fixed and mobile broadband wireless access systems amendment 2: physical and medium access control layers for combined fixed and mobile operation in licensed bands and corrigendum 1, ieee std 802.16e-2005 and ieee std 802.16 2004 / cor 1-2005, 2006.

[5] Wimax forum network architecture (stage 2: architecture tenets, reference model and reference points)[part 2] release 1.1.0, july 11, 2007.

[6] IEEE 802 working group. [online] http://www.ieee802.org/ ieee 802 lan/man standards committee

[7] IEEE 802.16e std 802.16e-2005tm, ieee standard for local and metropolitan area networks, part 16: air interface for fixed and mobile broadband wireless access systems, feb 2006.

[8] I. Chlamtac, M. Conti and J. J.-N. Liu, Mobile ad hoc networking: imperatives and challenges, Ad Hoc Networks Vol.1, pp. 13 – 64, 3003.

[9] L. Wang, A. Chen and H. Chen "Network Selection with Joint Vertical and Horizontal Handoff in Heterogeneous WLAN and Mobile WiMax Systems" IEEE Vehicular Technology Conference, 2007.

[10] http://www.lightreading.com/document.asp?doc_id=183528&

[11] Subrat .S, "4G Mobile Communication System", division of computer engineering, school of engineering, Cochin University of Science & Technology, COCHIN-682022, 2008.

[12] Vidales. P. "Seamless mobility in 4G systems". Technical Report UCAM-CL-TR-656, University of Cambridge, Computer Laboratory, Cambridge, UK, 2005.

[13] ITU."What really is a Third Generation (3G)(3G) Mobile Technology" (PDF), 2009. http://www.itu.int/ITU-D/imt2000/DocumentsIMT2000/What_really_3G.http://www.itu.int/ITU-D/imt-2000/DocumentsIMT2000/What_really_3G.pdf. Retrieved 1 June 2009.

[14] Alven, D., Arjunanpillai, R., Farhang, R., Kansal, S., Khan, N., & Leufven, U. ''Hotspots—connect the dots for a wireless future: Final report for Ericsson Business Innovation and Telia Research'', 2001, available at http://www.dsv.su.se/Bmab/Alven.pdf.

[15] Saleh A. Alomari and Putra. S. "New System Architecture for Mobility to Provides VoD Services over Heterogeneous Mobile Ad Hoc Networks". 4TH International Symposium on Broadband Communications (ISBC2010) Melaka, Malaysia, Symposium, 2010.

[16] Dornan, A."The essential guide to wireless communication applications: From mobile systems to Wi-Fi (2nd 3ed.)". Upper Saddle River, NJ: Prentice-Hall PTR, 2002.

[17] Zawel, A. Enterprise need for public and private wireless LANs. Wireless/Mobile Enterprise Commerce, The Yankee Group, July 2002.

[18] Telecom A. M.''Public W-LANS Seen as essential to 3G services", Vol. 7, No. 132, 10, 2001.

[19] M. Sun and D. Blough, "Mobility prediction using future knowledge," in Proceedings of MSWiM, 2007.

[20] M. C. Gonzalez, C. A. Hidalgo, and A.-L. Barabasi, "Un-derstanding individual human mobility pattern," Nature, vol. 453, pp. 779–782, June 2008.

[21] Wang, Jiangzhou. Broadband Wireless Communications: 3G, 4G and Wireless LAN. Boston: Kluwer Academic Publishers, 2001.

[22] Saleh Ali K. Alomari and Putra. S. "A Video on Demand System Architecture for Heterogeneous Mobile Ad Hoc Networks for Different Devices. 2nd International Conference on Computer Engineering and Technology (ICCET 2010). Sichuan, China, IEEE and IACSIT. IEEE 2010, Vol. 7, pp. v7- 700 – v7-707, 2010.