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COMPARATIVE STUDY OF WLAN, WPAN, WIMAX TECHNOLOGIES

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ABSTRACT
Today wireless communication systems can be classified in two groups. The first group technology provides low data rate and mobility while the other one provides high data rate and bandwidth with small coverage. Cellular systems and Broadband Wireless Access technologies can be given as proper examples respectively. In this paper, WLAN, WPAN and WiMAX technologies are introduced and comparative study in terms of peak data rate, bandwidth, multiple access techniques, mobility, coverage, standardization, and market penetration are presented.

Keywords*:* WALN, WPAN, WiMAX, IEEE.

1. INTRODUCTION

Wireless broadband technologies promise to make all kinds of information available anywhere, anytime, at a low cost, to a large portion of the population. From the end user perspective the new technologies provide the necessary means to make life more convenient by creating differentiated and personalized services. In the last decade we were primarily used to accessing people via voice, but there are of course other forms of communication like gestures, facial expressions, images and even moving pictures. Today we increasingly need user devices wireless for mobility and flexibility with total coverage for small light and affordable terminals than ever. Evolving of circuit switched networks towards packet switched technology high data rates is acquired and this evolution has opened new opportunities. 2.5 and 3G networks provide high mobility for the packet domain users. On the other hand the development of the technology has opened a new era like WLAN, WPAN and WiMAX communication. Therefore the merging IP based services provide broadband data access in fixed, mobile and nomadic environments supporting voice, video and data traffic with high speed, high capacity and low cost per bit. In this paper WLAN, WPAN and WiMAX Technologies introduced and comparative analysis is done.

2. LITERATURE REVIEW

WLAN technologies were first available in late 1990, when vendors initiated introducing products that operated within the 900 MHz frequency band. These solutions, which used non-standard, proprietary designs, provided data transfer rates of approximately 1Mbps. It was considerably slower than the 10 Mbps speed provided by most wired LANs at that time. In 1992, sellers began selling WLAN products that used the 2.4GHz band. Even if these products provided higher data transfer rates than 900 MHz band products they were expensive provided comparatively low data rates, were prone to radio interference and were often designed to use proprietary radio frequency technologies. The Institute of Electrical and Electronic Engineers started the IEEE 802.11 project in 1990 with the objective to develop a MAC and PHY layer specification for wireless connectivity for fixed, portable and moving stations within an area.

3. IEEE 802.11 WLAN/WI-FI

Wireless LAN (WLAN, also known as Wi-Fi) is a set of low tier, terrestrial, network technologies for data communication. The WLAN standard operates on the 2.4 GHz and 5 GHz Industrial, Science and Medical (ISM) frequency bands. It is specified by the IEEE 802.11 standard and it comes in many different variations like IEEE 802.11a/b/g/n. The application of WLAN has been most visible in the consumer market where most portable computers support at least one of the variations. In the present study, we overview on different standard in table-1 and four WLAN standards were preferred for comparison that are IEEE 802.11a, IEEE 802.11b, IEEE 802.11g and IEEE 802.11n because these standards are very much popular among the users. It is noted that all

802.11 standards used Ethernet protocol and Carrier Sense Multiple Access / Collision Avoidance (CSMA/CA) for path sharing. [1][12][9]

Standards are a set of specifications that all manufacturers must follow in order for their products to be compatible. This is important to insure interoperability between devices in the market. Standards may provide some optional requirements that individual manufacturers may or may not implement in their products.

4. OVERVIEW ON IEEE802.11 WLAN STANDARD

Sr. No.	IEEE 802.11 Standard	Year of Release	Comments
01	IEEE 802.11a	1999	Speed 54 Mbits and 5 GHz band
02	IEEE 802.11b	1999	Enhancements to 802.11 to support 5.5 and 11 Mbits speed
03	IEEE 802.11c	2001	Bridge operation procedures; included in the IEEE 802.11D standard
04	IEEE 802.11d	2001	International (country-to-country) roaming extensions
05	IEEE 802.11e	2005	Enhancements: QoS, including packet bursting
06	IEEE 802.11F	2003	Inter-Access Point Protocol, Withdrawn February 2006
07	IEEE 802.11g	2003	54 Mbits, 2.4 GHz standard (backwards compatible with b)
08	IEEE 802.11h	2004	Spectrum Managed 802.11a (5 GHz) for European compatibility
9	IEEE 802.11i	2004	Enhanced security
10	IEEE 802.11j	2004	Extensions for Japan
11	IEEE 802.11k	2008	Radio resource measurement enhancements
12	IEEE 802.11n	2009	Higher throughput improvements using Multiple In Multiple Out
13	IEEE 802.11p	2010	WAVE-Wireless Access for the Vehicular Environment
15	IEEE 802.11r	2008	Fast BSS transition (FT) (
16	IEEE 802.11s	July 2011	Mesh Networking, Extended Service Set (ESS)
17	IEEE 802. 11t		Define recommended practice for evolution of 802.11wireless performance.
18	IEEE 802.11u	February 2011	Improvements related to Hot Spots and 3rd party authorization of clients, e.g. Cellular network offload
19	IEEE 802.11v	February 2011	Wireless network management
20	IEEE 802.11w	September 2009	Protected Management Frames
21	IEEE 802.11x	-	Extensible authentication network for enhancement of security
22	IEEE 802.11y	2008	3650–3700 MHz Operation in the U.S.
23	IEEE 802.11z	September 2010	Extensions to Direct Link Setup (DLS) (September 2010)
24	IEEE 802.11aa:	June 2012	Robust streaming of Audio Video Transport Streams
25	IEEE 802.11ad	December 2012	Very High Throughput 60 GHz

26	IEEE 802.11ae	March 2012	Prioritization of Management Frames
In process			
27	IEEE 802.11ac:	February 2014	Very High Throughput <6 GHz, potential improvements over 802.11n: better modulation scheme (expected ~10% throughput increase), wider channels (estimate in future time 80 to 160 MHz), multi user MIMO
28	IEEE 802.11af:	June 2014	TV Whitespace ()
29	IEEE 802.11ah:	January 2016	Sub 1 GHz sensor network, smart metering.
30	IEEE 802.11ai:	February 2015	Fast Initial Link Setup
31	IEEE 802.11mc:	March 2015	Maintenance of the standard
32	IEEE 802.11aj:	October 2016	China Millimeter Wave :
33	IEEE 802.11aq	May 2015	Pre-association Discovery
34	IEEE 802.11ak	-	General Link

Table-1: List of Concurrent and Future IEEE Standard of WLAN/ Wi-Fi.[2][6][7][9][10]

4.1 IEEE 802.11a

Ratification of 802.11a took place in 1999. The 802.11a standard uses the 5 GHz spectrum and has a maximum theoretical 54 Mbps data rate. Like in 802.11g, as signal strength weakens due to increased distance, attenuation (signal loss) through obstacles or high noise in the frequency band, the data rate automatically adjusts to lower rates (54/48/36/24/12/9/6 Mbps) to maintain the connection. The 5 GHz spectrum has higher attenuation (more signal loss) than lower frequencies, such as 2.4 GHz used in 802.11b/g standards. Penetrating walls provide poorer performance than with 2.4 GHz. Products with 802.11a are typically found in large corporate networks or with wireless Internet service providers in outdoor backbone networks [9] [12].

4.2 IEEE 802.11b

In 1995, the Federal Communications Commission had allocated several bands of wireless spectrum for use without a license. The FCC stipulated that the use of spread spectrum technology would be required in any devices. In 1990, the IEEE began exploring a standard. In 1997 the 802.11 standard was ratified and is now obsolete. Then in July 1999 the 802.11b standard was ratified. The 802.11 standard provides a maximum theoretical 11 Megabits per second (Mbps) data rate in the 2.4 GHz Industrial, Scientific and Medical (ISM) band [9][12].

4.3 IEEE 802.11g

In 2003, the IEEE ratified the 802.11g standard with a maximum theoretical data rate of 54 megabits per second (Mbps) in the 2.4 GHz ISM band. As signal strength weakens due to increased distance, attenuation (signal loss) through obstacles or high noise in the frequency band, the data rate automatically adjusts to lower rates (54/48/36/24/12/9/6 Mbps) to maintain the connection. When both 802.11b and 802.11g clients are connected to an 802.11g router, the 802.11g clients will have a lower data rate. Many routers provide the option of allowing mixed 802.11b/g clients or they may be set to either 802.11b or 802.11g clients only. To illustrate 54 Mbps, if you have DSL or cable modem service, the data rate offered typically falls from 768 Kbps (less than 1 Mbps) to 6 Mbps. Thus 802.11g offers an attractive data rate for the majority of users. The 802.11g standard is backwards compatible with the 802.11b standard. Today 802.11g is still the most commonly deployed standard [9][12].

4.4 IEEE 802.11n

In January, 2004 the IEEE 802.11 task group initiated work. There have been numerous draft specifications, delays and lack of agreement among committee members. Yes, even in the process of standards development, politics are involved. The Proposed amendment has now been pushed back to early 2010. It should be noted it has been delayed many times already. Thus 802.11n is only in draft status. Therefore, it is possible that changes could be made to the specifications prior to final ratification. The goal of 802.11n is to significantly increase the

data throughput rate. While there are a number of technical changes, one important change is the addition of multiple-input multiple-output (MIMO) and spatial multiplexing. Multiple antennas are used in MIMO, which use multiple radios and thus more electrical power. 802.11n will operate on both 2.4 GHz (802.11b/b) and 5 GHz (802.11a) bands. This will require significant site planning when installing 802.11n devices. The 802.11n specifications provide both 20 MHz and 40 MHz channel options versus 20 MHz channels in 802.11a and 802.11b/g standards. By bonding two adjacent 20 MHz channels, 802.11n can provide double the data rate in utilization of 40 MHz channels. However, 40 MHz in the 2.4 GHz band will result in interference and is not recommended nor likely which inhibits data throughput in the 2.4 GHz band. It is recommended to use 20 MHz channels in the 2.4 GHz spectrum like 802.11b/g utilizes. For best results of 802.11n, the 5 GHz spectrum will be the best option. Deployment of 802.11n will take some planning effort in frequency and channel selection. Some 5 GHz channels must have dynamic frequency selection (DFS) technology implemented in order to utilize those particular channels [12][8][9].

Here, we compared IEEE **802.11 a/b/g/n** standard of WLAN/ Wi-Fi we use some basic characteristics like Operating frequency, Modulation technique, Data rate (Mbps), Slot time (µs), Preamble, Throughput, Speed, Indoor Range, Outdoor Range, Multiple Access, Channel Bandwidth, Half/ Full duplex, Number of spatial streams,
Mode of operation Ad-hoc, Infrastructure, VANET, FEC Rate, License/Unlicensed.

	IEEE 802.11a	IEEE 802.11b	IEEE 802.11g	IEEE 802.11n
Operating frequency	5 GHz UNII/ISM bands	2.4 GHz ISM band	2.4 GHz ISM band	2.4 - 5 GHz
Modulation technique	BPSK, QPSK, 16-, 64-QAM , OFDM	QPSK , DBPSK, DQPSK, CCK, DSSS	BPSK, QPSK, 16-, 64-QAM , OFDM	64-QAM, Alamouti, OFDM,CCK, DSSS
Data rate (Mbps)	6,9,12,18,24,36,48,54	1, 2, 5.5, 11	1, 2, 5.5, 11, 6,9,12,18,24,36,48,54	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2, 15, 30, 45, 60, 90, 120, 135, 150
Slot time (µs)	9	20	20,(9 optional)	Less than 9
Preamble	OFDM	Long / short (optional)	Long/ Short/ OFDM	HT PHY for 2.4 and 5 GHz
Throughput	23 Mbits	4.3 Mbits	19 Mbits	74 Mbits
Speed	54 Mbits	11 Mbits	54 Mbits	248 Mbits
Indoor Range	35 Mtrs	38 Mtrs	38 Mtrs	70 Mrs.
Outdoor Range	120 Mrs.	140 Mrs.	140 Mrs.	250 Mrs.
Multiple Access	CSMA/CA	CSMA/CA	CSMA/CA	CSMA/CA
Channel Bandwidth	20 MHz	20, 25 MHz	20 MHz	20 or 40 MHz
Half/ Full duplex	Half	Half	Half	Full duplex
Number of spatial streams	1	1	1	1,2,3or 4
Ad-hoc(mode of operation)	Yes	Yes	Yes	Yes
Infrastructure	Yes	Yes	Yes	Yes
VANET	Yes	Yes	Yes	Yes
FEC Rate	1/2,2/3,3/4	NA	1/2,2/3,3/4	3/4, 2/3 and 5/6
Licensed/Unlicensed	Unlicensed	Unlicensed	Unlicensed	Unlicensed

Table-2: Comparison overview of WLAN /Wi-Fi IEEE Standard 802.11 a/ b/ g /n [1][3][4][5][9][11]

4.5 Wireless Personal Area Network (WPAN)

Wireless Personal Area Network (WPAN) technologies have fueled the development as well as the wide proliferation of wireless personal devices (e.g. PDAs, Bluetooth headset, PSP, and etc). Yet, the popularity of these wireless devices has resulted in many forms of frequency spectrum clash amongst the different wireless technologies. To understand the performance of these wireless devices in different interference situations, it is increasingly important to study the coexistence issue amongst the existing wireless technologies. Various wireless technologies have been developed for WPAN purposes. A WPAN could serve to interconnect all the ordinary computing and communicating devices that many people have on their desk or carry with them today; or it could serve a more specialized purpose such as allowing the surgeon and other team members to communicate during an operation. The technology for WPANs is in its infancy and is undergoing rapid development. Proposed operating frequencies are around 2.4 GHz in digital modes. The objective is to facilitate seamless operation among home or business devices and systems. Wireless PAN is based on the standard IEEE 802.15. In this paper, we concentrate on the three most famous IEEE standard 802.15.1, 802.15.3, and 802.15.4 we overview on these standard pads compare on the basis of basic characteristic, application, limitation and their use.

4.6 IEEE 802.15 .1 is a working group of the Institute of Electrical and Electronics Engineers (IEEE) IEEE 802 standards committee which specifies Wireless Personal Area Network (WPAN) standards. It includes seven task groups. IEEE 802.15.1 [16] is a WPAN standard based on the Bluetooth v1. 1 Specification , which is a short-range radio technology operating in the unlicensed 2.4GHz ISM frequency band. The original goal of Bluetooth was to replace the numerous proprietary cables to provide a universal interface for devices to communicate with each other. However, it soon became to use Bluetooth technology to interconnect various Bluetooth devices to form so-called personal area networks , and facilitate more creative ways of exchanging data. Low cost and smaller footprint of Bluetooth chips consequently met with high demands [9][10][11][14].

4.7 IEEE 802.15.3 [17] is designed to facilitate High-Rate Wireless Personal Area Networks (HR-WPAN) for fixed, portable and moving devices within a personal operating space. The main purpose of IEEE 802.15.3 is to provide low cost, low complexity, low power consumption, and high data rate connectivity for wireless personal devices. Thus, it is designed to support at least 11Mbps data rate within at least 10 meters range2. The IEEE 802.15.3 standard is operated in 2.4GHz ISM frequency band. Unlike IEEE 802.15.1, which employs FHSS on PHY layer, IEEE 802.15.3 uses Direct Sequence Spread Spectrum (DSSS), and it does not allow changes of operating channels once a connection is initiated [9][10][11][14].

4.8 IEEE 802.15.4 [18] addresses the needs of Low-Rate Wireless Personal Area Networks (LR-WPAN). While other WLAN (e.g. IEEE 802.11.a/b/g) and WPAN (e.g. IEEE 802.15.1 and 802.15.3) technologies focus on providing high data throughput over wireless ad hoc networks, IEEE 802.15.4 is designed to facilitate those wireless networks, which are mostly static, large, and consuming small bandwidth and power. Therefore, the IEEE 802.15.4 technology is anticipated to enable various applications in the fields of home networking, automotive networks, industrial networks, interactive toys and remote metering [9][10][11][14].

Here we compared different standard of WPAN on the basis of the basic characteristic like Topic, Operational Spectrum, Physical Layer Detail, Channel Access, Maximum Data Rate, Modulation Technique, Coverage, Approximate Range, Power Level Issues, Interference, Price, Security, rcv Bandwidth, Number of Channels, Applications, Mode of operation (Ad hoc, Infrastructure, VANET), License/Unlicensed, QoS needs.

IEEE Standard	802.15.1	802.15.3	802.15.4
Topic	Bluetooth	High rate WPAN	Low rate WPAN
Operational Spectrum	2.4 GHz ISM band	2.402-2.480 GHz ISM band	2.4 GHz and 868/915Mhz
Physical Layer Detail	FHSS 1600 hops per second	Uncoded QPSK, Trellis Coded QPSK or 16/32/64-QAM scheme	DSSS with BPSK or MSK (O-QPSK)
Channel Access	Master-Slave Polling, Time Division Duplex(TDD)	CSMA-CA and Guaranteed Time Slot(GTS) in a Super frame Structure	CSMA-CA and Guaranteed Time Slot(GTS) in a Super frame Structure
Maximum Data Rate	Up to 1 Mbps(0.72) / 3Mbps	11-55 Mbps/ 110Mbits	868 MHz -20,915 MHz- 40 MHz, 2.4 GHz-250 Kbps, 40

			kbps
Modulation Technique	8DPSK, DQPSK, _/4-DQPSK, GFSK, AFH	QPSK, DQPSK, 16/32/64QAM	BPSK, OQPSK, ASK, DSSS, PSSS
Coverage	<10 m	<10m	<20m
Approximate Range	100m	10m	75m
Power Level Issues	1mA-60mA	<80mA	Very low current drain(20- 50 µA)
Interference	Present	Present	Present
Price	Low(<$10)	Medium	Very low
Security	Less Secure. User the SAFER + encryption at baseband layer. Relies on higher layer security	Very high level of security including, piracy, encryption and digital service certificate	Security features in development
rcv Bandwidth	1MHz	15MHz	2MHz
Number of Channels	79	5	16
Applications	WPAN	HR-WPAN	LR-WPAN
Ad hoc	Yes	Yes	Yes
Infrastructure	No	No	No
VANET	Yes	Yes	Yes
License/Unlicensed	Unlicensed	Unlicensed	Unlicensed
QoS needs	QoS suitable for voice application	Very high QoS	Relaxed needs for data rate and QoS

Table -3: comparison of IEEE standard of WPAN [3][5][13][12] [9][10][11][14].

4.9 Worldwide Interoperability for Microwave Access (WiMAX)

WiMAX (Worldwide Interoperability for Microwave Access) is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations. The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". IEEE 802.16 stands for WiMAX (Worldwide Interoperability for Microwave Access) is a trademark for a family of telecommunications protocols that provide fixed and mobile Internet access. The 2005 WiMAX revision provided bit rates up to 40 Mbit/s with the 2011 update up to 1 Gbit/s for fixed stations. It supports the frequency bands in the range between 2 GHz and 11 GHz, specifies a metropolitan area networking protocol that will enable a wireless alternative for cable, DSL and T1 level services for last mile broadband access, as well as providing backhaul for 801.11 hotspots.

WiMAX allows for infrastructure growth in underserved markets and is today considered the most cost-effective means of delivering secure and reliable bandwidth capable of supporting business critical, realtime applications to the enterprise, institutions and municipalities. It has proven itself on the global stage as a very effective last mile solution. In the United States though, licensed spectrum availability and equipment limitations have held up early WiMAX adoption. In fact, while there are currently 1.2+ million WiMAX subscribers worldwide, only about 11,000 of those are from the United States. Future growth in this market will be driven by wireless ISPs like Clear wire who intends to cover 120-million covered POPs in 80 markets with WiMAX by the end of 2010. Growth will also be driven by the availability of the 3.65-GHz spectrum that the FCC opened up this past year. In this paper, we compared some IEEE Standard 802.16a, 802.16d, 802.16e, 802.16m on the basis of basic characteristic, Application, Limitation and their used.[2][19]

Standard	**Description**	**Status**
802.16-2001	Fixed Broadband Wireless Access (10–66 GHz)	Superseded
802.16.2-2001	Recommended practice for coexistence	Superseded
802.16c-2002	System profiles for 10–66 GHz	Superseded
802.16a-2003	Physical layer and MAC definitions for 2–11 GHz	Superseded
P802.16b	License-exempt frequencies (Project withdrawn)	Withdrawn

P802.16d	Maintenance and System profiles for 2–11 GHz (Project merged into 802.16-2004)	Merged
802.16-2004	Air Interface for Fixed Broadband Wireless Access System (rollup of 802.16-2001, 802.16a, 802.16c and P802.16d)	Superseded
P802.16.2a	Coexistence with 2–11 GHz and 23.5–43.5 GHz (Project merged into 802.16.2-2004)	Merged
802.16.2-2004	Recommended practice for coexistence (Maintenance and rollup of 802.16.2-2001 and P802.16.2a)	Current
802.16f-2005	Management Information Base (MIB) for 802.16-2004	Superseded
802.16-2004/Cor 1-2005	Corrections for fixed operations (co-published with 802.16e-2005)	Superseded
802.16e-2005	Mobile Broadband Wireless Access System	Superseded
802.16k-2007	Bridging of 802.16 (an amendment to IEEE 802.1D)	Current
802.16g-2007	Management Plane Procedures and Services	Superseded
P802.16i	Mobile Management Information Base (Project merged into 802.16-2009)	Merged
802.16-2009	Air Interface for Fixed and Mobile Broadband Wireless Access System (rollup of 802.16-2004, 802.16-2004/Cor 1, 802.16e, 802.16f, 802.16g and P802.16i)	Current
802.16j-2009	Multihop relay	Current
802.16h-2010	Improved Coexistence Mechanisms for License-Exempt Operation	Current
802.16m-2011	Advanced Air Interface with data rates of 100 Mbit/s mobile and 1 Gbit/s fixed. Also known as Mobile WiMAX Release 2 or Wireless MAN-Advanced. Aiming at fulfilling the ITU-R IMT-Advanced requirements on 4G systems.	Current
P802.16n	Higher Reliability Networks	In Progress
P802.16p	Enhancements to Support Machine-to-Machine Applications	In Progress

Table-4: Different IEEE Standard under 802.16 Standard [19].

Here our comparison of WiMAX Standard on basis of Spectrum Bandwidth, Propagation, Throughput, Modulation, Usage/ Mobility, Range, Mode of Network (Ad-hoc, Infrastructure, VANET), License/Unlicensed

	WiMAX 802.16 a	**Fixed WiMAX 802.16d**	**Mobile WiMAX 802.16e**	**MobileWiMAX2.0 802.16m**
Spectrum Bandwidth	10-66 GHz	2-11GHz	2-6GHz	Sub 6 GHz
Propagation	LOS	NLOS	NLOS	NLOS
Throughput	up to 134 Mbps	up to 75 Mbps	up to15 /30 Mbps	Over 300Mbps
Channelization	28 MHz	20 MHz	5 MHz/10 MHz	100 MHz
Modulation	QPSK, 16QAM	256 subcarriers OFDM-BPSK,QPSK,16 QAM,64QAM	OFDMA,QPSK,16QAM,64QAM, 256QAM (optional)	64QAM
Usage/ Mobility	WMAN Fixed	WMAN Fixed	WMAN Portable	WMAN Portable
Range	Typical 4-	Typical 4-6 miles	Typical 1-3 miles	Typical 1-3

	6 miles			miles
Ad-hoc	Yes	Yes	Yes	Yes
Infrastructure	Yes	Yes	Yes	Yes
VANET	Yes	Yes	Yes	Yes
Licensed/Unlicensed	Unlicensed	Unlicensed	2.3, 2.5, 3.5, 3.7, and 5.8 GHz- Licensed	Unlicensed

Table-5: Comparison of Different WiMAX Standard 802.16a/ d/ e/ m [2][3][5][9][10][11][20].

Finally in this paper, we compared the Different technology WLAN/**Wi-Fi, WPAN, WiMax on the basis of** IEEE Standard, Operating Frequency, Bandwidth, Data rate, Multiple Access, Coverage, Range, Mode of Network, Target Market.

	WLAN/Wi-Fi	**WPAN**	**WiMax Fixed/Mobile**
IEEE Standard	802.11	802.15	802.16
Operating Frequency	2.4- 5 GHz	2.4GHz	10-66 GHz
Bandwidth	20MHz	15 MHZ	5-6 GHz
Data rate	1-150 Mbps	40 kbps- 110 Mbps	15,30,75,134,over300Mbps
Multiple Access	CSMA/CA	CSMA-CA	OFDM/OFDMA
Coverage	Small	Small	Low
Range	250 m	10- 75 m	1-6 mile
Mode of Network	Ad-hoc, Infrastructure and VANET	Ad-hoc and VANET	Ad-hoc, Infrastructure and VANET
Target Market	Home/ Enterprise	Home/ Enterprise	Home/ Enterprise

Table-6: Comparison of WLAN, WPAN, WiMAX [1][3][4][5][9] [10][11][12][13][14][20].

5. CONCLUSION:

This paper has presented a description of most prominent developing wireless access networks. Detailed technical comparative analysis between WLAN, WPAN, WiMAX wireless networks that provide an alternative solution to the problem of information access in remote inaccessible areas where wired networks are not cost effective has been looked into. This work has proved that the WiMAX standard goal is not to replace Wi-Fi in its applications, but rather to supplement it in order to form a wireless network web.

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