ITRAINONLINE MMTK
WIRELESS STANDARDS HANDOUT

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1. About this document

These materials are part of the ItrainOnline Multimedia Training Kit (MMTK). The MMTK provides an integrated set of multimedia training materials and resources to support community media, community multimedia centres, telecentres, and other initiatives using information and communications technologies (ICTs) to empower communities and support development work.

1.1 Copyright information

1.2 Degree of Difficulty

The degree of difficulty of this unit is “Medium” with some additional “Advanced” parts.
All “Advanced” sections are marked with a red frame make the reader aware of a higher degree of difficulty of the content.

2. Introduction

This unit aims to give the reader a guide though the jungle of standards for wireless networks. We have all heard about IEEE 802.11 but what is really the technical difference between its “sub groups”? What in technical terms does it mean that standard X is 10 times faster than standard Y?

The unit discusses not only the commonly used IEEE 802.11 standards but also the new broadband standard IEEE 802.16 (WiMAX) . To provide a better understanding for the main differences between the standards, a technical comparison in terms of Range and Coverage, Scalability and Throughput and Quality of Service is presented.

3. What is a standard?

Before digging into the jungle of wireless standards, we would like to introduce the concept of “standard” first. What is a standard by definition and why are standards important?

In 1978 the US-NSPAC National Standards Policy Advisory Committee defined a “standard” as:

"*A prescribed set of rules, conditions, or requirements concerning definitions of terms; classification of components; specification of materials, performance, or operations; delineation of procedures; or measurement of quantity and quality in describing materials, products, systems, services, or practices*."

One aspect of standards that can be surprising is that technical standards are frequently established between competitors to the same shared market. How come that competitors are suddenly working together when they are fighting for the same market share?

One thing that we can be sure about, is that if standardization of hardware, software and systems were not beneficial for the vendors, no standardization would ever take place.

For vendors, having a product that complies with a specific standard implies interoperability between products of the same family. It also means the possibility to access a global market where clients that are familiar with a standard do not necessarily need to be familiar with the product itself. Standards are used by vendors to achieve a level of safety, quality, and consistency in their products towards the customer. For the customer, a product that follows a specific standard implies the possibility of interoperability with other products and not to be “locked” to a single vendor.

4. Open and Close Standards

For simplicity, we can divide standards as *open* or *close* (*proprietary).* An open standard is publicly available while the proprietary or close standard is not. Proprietary standards are only available, if available at all, under very restrictive contract terms from the organization that owns the copyright of the specification. An example of open standard is the HTML specification while Microsoft Office's document format falls under close.

An open standard increases the compatibility between hardware, software or systems since the standard is available for anyone to implement. In practical terms, that means that anyone with the right knowledge can build its own product which can work together with other products following the same open standard.

An open standard may not necessarily imply that there are no licenses or patent rights. While we can assume that all free standards are open, the opposite does not necessarily need to be true. Some open standards are free of charge while in others, patent holders may require a royalty fee for "using" the standard. Standards published by major international standardization bodies such as the ITU, ISO and IEEE are considered to be open but not always free of charge.

In summary, open standards are not only important for all players to create interoperable and affordable solutions but also to promote competition among vendors by setting up the clear rules of the game.

5. IEEE and its Working Groups

The Institute of Electrical and Electronics Engineers or IEEE (pronounced as eye-triple-e) is a international non-profit organization that is the leading developer of international standards particularly in the field of telecommunications, information technology and power generation. IEEE has a set of 900 active standards and another 400 standards under development.

Some of the well known IEEE standards are the IEEE 802 LAN/MAN group of standards that includes the Ethernet standard (IEEE 802.3) and the Wireless Networking standard (IEEE 802.11).

5.1 IEEE 802 LAN/MAN

IEEE 802 is a family of IEEE standards that refers to locale area (LAN) and metropolitan area networks (MAN). By the definition, the IEEE 802 standards are restricted to networks that transport **variable-sized packets** (by contrast to cell-based networks data is transmitted in short, uniformly sized units called cells).
All services and protocols specified in IEEE 802 relates to the two lowest layers of the OSI model, the Physical Layer and the Data Link Layer (see Advanced Wireless Networking Unit).

The IEEE 802 family of standards is maintained by the IEEE 802 LAN/MAN Standards Committee (LMSC).
LMSC provides an individual Working Group for each one of the 22 areas that IEEE 802 includes. IEE802 11 (Wireless LAN) and IEEE 802.16 (Broadband Wireless Access) are two of those areas.

6. IEEE 802.11 Legacy (Wireless LAN)

IEEE 802.11 can, in simple words, be described as the standard for “wireless Ethernet”.

The original standard of IEEE 802.11 that was released in 1997 specifies Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) as the media access method, just like Ethernet does. All amendments to IEEE 802.11 are based on the same access method. However, CSMA/CA is a very inefficient access method since large amount of the bandwidth is sacrificed to ensure a reliable data transmission. This limitation is inherent to all CSMA/CA based technologies.

Furthermore, IEEE 802.11 specifies two basic data rates, 1 and 2 Mbps to be transmitted via Infrared (IR) or 2.4GHZ. Although there is no implementations based on IR, it still remains as a part of the original standard.

A handful of commercial products appeared on the market using the original specification of IEEE 802.11 but was soon to be replaced by the IEEE 802.11b products when the “b amendment” to the original standard was ratified in 1999.

6.1 Naming confusion

IEEE 802.11 is known by many names such as Wi-Fi, Wireless-Fidelity, WLAN, Wireless LAN and IEEE 802.11x. Let us try to sort out this confusion regarding the name before we move on to different amendments (versions) of the IEEE 802.11 standard.

- Wi-Fi is a “brand”, that is licensed by the Wi-Fi Alliance for products that meet the requirements for interoperability among products based on the IEEE 802.11 standard. In other words, a Wi-Fi network is a network meeting the standard IEEE 802.11. The name “Wi-Fi” is nowadays commonly used instead of “IEEE 802.11” in the same way as Ethernet is being used for “IEEE 802.3”.
  Despite what most Wi-Fi users believe, Wi-Fi is NOT an abbreviation of “Wireless Fidelity”. It was once used by the Wi-Fi Alliance when the marketing the certificate with the tag line, "The Standard for Wireless Fidelity," but later removed from their marketing[1].

- Wireless LAN or WLAN is commonly used as a name for any wireless local area network that uses radio waves as carrier. Wireless LAN is also the alternative name of the IEEE 802.11 standard used by IEEE.

- IEEE 802.11x is sometimes used to refer to the whole group of standards within IEEE 802.11 (b, a, g etc.). The same name is also used to refer to a group of evolving standards within the IEEE 802.11 family that are under development but that have not yet been formally approved or deployed. And, the name also is often mistaken with the IEEE 802.1x standards for port-based network access control. However, there is no standard or task group named "802.11x". To avoid confusion, we strongly suggest you to be careful when using the term IEEE 802.11x.

1 Want to read more about this, check: http://www.boingboing.net/2005/11/08/wifi_isnt_short_for_.html

7. IEEE 802.11 Technical Aspects

The 802.11 standard includes a set of amendments for wireless LAN. The amendments mainly differ in modulation techniques, frequency range and quality of service (QoS).

Like all standards of the IEEE 802, the IEEE 802.11 covers the first two layers of the OSI model (Open Systems Interconnection), that is to say the physical layer (L1) and data-link layer (L2). The section below will describe what each of those layers implies in terms of wireless standards.

7.1 Layer 1 (802.11 PHY)

The physical layer has as a role to transport correctly the signal corresponding to 0 and 1 of the data that the transmitter wishes to send to the receiver.

The physical later deals mainly with:

- Data encoding and modulation

7.1.1 Modulation Techniques

An important parameter that influences the data transfer of certain standard is the choice of modulation technique. The more efficient the data is encoded, the higher bit rate can be achieved. On the other hand, an efficient modulation technique also requires more sophisticated hardware to handle the modulation and de-modulation of the data.

The basic and common idea behind the different modulation techniques used in IEEE 802.11 is to use more bandwidth that is theoretically needed to send one "bit" to achieve resistance against interference. The way that the information is spread leads to different modulation techniques. The most common ones are presented below.

FHSS (Frequency Hopping Spread Spectrum)
FHSS is based on the concept of transmitting on one frequency for a certain time, then randomly jumping to another. i.e. the carrying frequency (carrier) changes during the times or that the transmitter periodically changes frequency according to a pre-established sequence. The transmitter synchronizes the receiver thanks to beacons which contain the sequence of jumps and the duration. In the IEEE 802.11 standard, the defined frequency band (ISM) that spans from 2,400 to 2,4835 GHz is divided into 79 channels of 1 MHz and the jump is made every 300 to 400 ms. Hops are made around a central frequency that corresponds to one of the 14 defined channels. This modulation is not common anymore in current products.

DSSS (Direct Sequence Spread Spectrum)
DSSS (Direct Sequence Spread Spectrum) implies that for each bit of data, a sequence of bits (sometimes called *pseudo-random noise,* noted *PN*) must be transmitted. Each bit that is 1 is replaced by a sequence of bits and each bit being 0 replaced by its complement. The 802.11 physical layer standard defines a sequence of 11 bits (*10110111000*) to represent a "1" and its complement (*01001000111*) to represent a "0". in DSSS, instead of splitting a data signal into pieces send in different frequencies, each data bit is encoded into a longer bit string, called a chip. This modulation technique has been common from 1999 to 2005.

OFDM (Orthogonal Frequency-Division Multiplexing)
ODFM, also sometimes called discrete multi-tone modulation (DMT) is a modulation technique based on the idea of frequency division multiplexing (FDM).

FDM, that is used both in radio and TV, is based on the concept that multiple signals are sent out at the same time but on different frequencies. In OFDM, a single transmitter transmits on many (dozens to thousands) different *orthogonal* frequencies. Orthogonal frequencies, are frequencies that are independent with respect to the relative phase relationship between the frequencies. OFDM involves the usage of advanced modulation techniques in each component which results in a signal with high resistance to interference.

An OFDM carrier signal is the sum of a number of orthogonal sub-carriers, with each sub-carrier being independently modulated commonly using some type of QAM or PSK. This is the most common modulation technique from 2005.

7.1.2 Frequency

802.11b and 802.11g use the 2.4 Ghz ISM (Industrial, Scientific, Medical) frequency band defined by the ITU. In specific, the "L" BAND ranging from 2 400 to 2 483,5 MHz is used.

The 802.11a standard is using the 5 Ghz band UNII (Unlicensed-National Information Infrastructure) covering 5.15-5.35 GHz and 5.725-5.825 Ghz.

The unlicensed 2.4 Ghz band has lately become very noise in urban areas due to the high penetration of WLAN and other devices that are communicating in the same frequency range, such as microwave ovens, cordless phones and Bluetooth devices. The 5 GHz band gives the advantage of less interference but faces other problems due to its nature. High frequency radio waves are more sensitive to absorption than low frequency waves. Waves in the range of 5 Ghz are specially sensitive to water and surrounding buildings or other objects due to the higher adsorption rate in this range. This means that a 802.11a network is more restricted when it comes to line of sight and more access points might be needed to cover the same area as a 802.11b-based network since 802.11a. for same amount of output power, provides smaller cells.

7.2 Layer 2 (802.11 MAC)

The data link layer of 802.11, is composed of two parts:

- Media access control (MAC)
- Logical Link Control (LLC)

The 802.11 LLC sublayer is identical to layer 802.2 allowing a compatibility with any other network 802, while the MAC sublayer is redefined by standard 802.11 (L2).

MAC characterizes the access to the media in a way common to the various 802.11 standards. It is equivalent to the standard 802.3 (CSMA/CD – Ethernet) for wired networks, with functionalities specific to radio transmissions (the error rate is higher than the copper media) which are normally entrusted to the higher protocols, like fragmentation, error control (CRC), the retransmissions of frames and the acknowledgment of delivery .

7.2.1 Media Access Method

802.11b uses a protocol slightly modified compared to the CSMA/CD, called CSMA/CA (Collision Detection vs Collision Avoidance). CSMA/CA can avoid the collisions by using a basic polling method known as RTS/CTS in which the sender sends first a request to send (RTS) and the receiver (usually the AP) acknowledge the request by sending a clear to send (CTS) message when channel is ready to use.

During transmission between two pieces of equipment, the destination station checks the CRC of the frame and returns an ACK (acknowledgment of delivery) to the transmitter. If the transmitting station does not receive this ACK in time, it assumes that a collision occurred and the frame is retransmitted after receiving a new CTS.

The access to the media is controlled by the use of different type of interframe spaces (IFS), which corresponds to the intervals of time that an station needs to wait before sending data. High priority data as ACKs or RTS/CTS packets will wait a shorter (SIFS) time period that normal traffic.

While the CSMA/CA protocol permits to avoid collisions in a shared radio channel, mechanisms as RTS/CTS increases overhead (signaling frames that are necessary for the network but contain no user data) and can therefore never make the performance of 802.11b as good as CSMA/CD (collision detection) or TDMA-based technologies (think of Ethernet in a cable or synchronized E1/T1).

For further reading, see unit "Advanced Wireless Networking".

8. IEEE 802.11 Amendments

The most widely accepted amendments of the IEEE 802.11 family is currently b, a and g. All of them have reached the mass markets with cost efficient products. Other amendments in the family are [c-f], [h-j] and n which are enhancements and extensions or corrections to previous specifications in the family. We will take a closer look at b, a, g and n in this section.

8.1 IEEE 802.11b

IEEE 802.11b includes enhancements of the original 802.11 standard to support higher data rates (5.5 and 11 Mbit/s). IEEE 802.11b uses the same access method as defined the original standard IEEE 802.11.

IEEE 802.11b uses the DSSS modulation technique which is also defined in the original standard.

An IEEE 802.11b card can theoretically operate at 11 Mbit/s, but will, due to Adaptive Rate Selection scale, fall back to 5.5, then 2 and then 1 Mbit/s when packet loss takes place. The lower data rates are less sensitive to interference and attenuation since they are using a more redundant method to encode the data (i.e. the relation of signal and noise is better at lower data rates).

8.2 IEEE 802.11a

Just like IEEE 802.11b, this amendment uses the same core protocol as the original standard. IEEE 802.11a operates in the 5 GHz band and uses OFDM as modulation technique which gives it a maximum raw data rate of 54 Mbit/s. By using adaptive rate selection, the data rate is reduced to 48, 36, 24, 18, 12, 9 and, 6 Mbit/s if required.

802.11a has 12 non-overlapping channels whereas 8 of them are dedicated for indoor use and the remaining 4 are used for point to point links. 802.11a is NOT interoperable with 802.11b, except for equipment that specifically implements both standards (two radios).

As today, 802.11a has not reached the hype that 802.11b has. It has not been widely adopted due to the presence of 802.11b, poor initial product implementations and more restrictive regulations in the 5 Ghz band.

8.3 IEEE 802.11g

In June 2003, a third amendment to the 802.11 standard was ratified. It was given the name IEEE 802.11g. and just like 802.11b, it operates in the 2.4 GHz band,

802.11g uses the same modulation technique as 802.11a (OFDM) in high bit rates and can hence operate at a maximum raw data rate of 54 Mbit/s. To ensure interoperability with b products, at data rates of 5.5 and 11 Mbps it reverts back to CCK+DSSS (like 802.11b) and uses DBPSK/DQPSK+DSSS for data rates of 1 and 2 Mbit/s.

It is the 802.11g interoperability with 802.11b hardware that is one of the main reasons behind its major acceptance. However, it suffers the same problem at 802.11b regarding interference (crowded urban spots) since they operate in the same frequency band.

8.4 IEEE 802.11n

The latest amendment of 802.11 is IEEE 802.11n[2] which "aims" to reach a maximum theoretical bit rate of 540 Mbit/s which would make it up to 40 times faster than 802.11b and 10 times faster than 802.11a or 802.11g. 802.11n is based on previous 802.11 amendments with the greatest difference of introducing MIMO, multiple-input multiple-output. MIMO implies that multiple transmitter and receivers are used to increase the data throughput and the transmitting range.

Several experts claims that MIMO is the future of the wireless LAN[3].

8.4.1 Spatial diversity

MIMO takes advantage of multipath propagation to increase the throughput (or to reduce bit error rate) instead of trying to eliminate the effects of the unavoidable multipath phenomena that other standards do. In simple words, MIMO takes advantage of what other standards sees as a hurdle: multipath.

When a radio signal is sent out though the air it is spread out as a beam. The receiver receives first the main line-of-sight signal and some time later echoes and fragments of the signal that has been reflected in buildings or in other obstacles. Normally, these echoes and fragments are seen as noise to the real signal but MIMO is able to use the information of this "non direct signals" to improve the main signal. This results in clearer signals (less noise) and longer signal ranges.

8.4.2 Spatial division multiplexing (SDM)

Another feature that MIMO includes is the use of many transmitters for the same data stream, so called Spatial Division Multiplexing (SDM). A set of independent data streams are sent out within a single channel of bandwidth. This increases the throughput as the number of data streams is increased. Since a MIMO antenna need a dedicated processing hardware, the cost of it is unavoidable higher than any standard WLAN antenna.

The IEEE 802.11n amendment is expected to be finalized in mid 2006.

8.5 Summary of 802.11 amendments

Below follows a short summary and comparison of the 4 most important IEEE 802.11 amendments.

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2 http://www.oreilly.com/catalog/802dot112/chapter/ch15.pdf

3 http://www.zdnetindia.com/insight/communication/stories/129508.html

Standard	Frequency	Modulation Technique	Max Data rate	Description
802.11a	5 GHz	ODFM	54 Mbps	8 non-overlapping channels. No QoS.
802.11b	2.4 Ghz	DSSS, CCK	11 Mbps	14 overlapping channels
802.11g	2.4 Ghz	OFDM, CCK, DSSS	54 Mbps	14 overlapping channels. Upward compatibility with the standard 802.11b
802.11n	2.4 Ghz/?	OFDM	360/540? Mbps	Builds upon previous 802.11 standards by adding MIMO that uses multiple transmitters and receiver antennas to allow increased data throughput through spatial multiplexing.

Table 1: Summary of IEEE 802.11b/a/g/n characteristics

9. WiMAX (IEEE 802.16) vs WiFi (IEEE 802.11)

During the last year, WiMAX has been marketed as the future broadband wireless standard. Many Wireless Internet Service Providers (WISPs) running solutions based on IEEE 802.11 are considering investing in WiMAX based solutions but they are not sure of what exactly WiMAX can offer them and to what price. Is WiMAX the latest "techno-hype" or does it open new opportunities for broadband wireless connectivity?

This section aims to serve as a reference for some of the technical differences between IEEE 802.11 and IEEE 802.16. It is assumed that the reader is already familiar with IEEE 802.11 based solutions and want to know what IEEE 802.16 can offer.

IEEE 802.16 has been designed specifically for point to multi-point outdoor environments which a single media access control (MAC) that can accommodate different physical layers (PHY) in the frequency range of 11-66 Ghz. IEEE approved the initial IEEE 802.16 standard for wireless MAN in the 11-66 GHz frequency range in December 2001. The 802.16a extension for sub-11 GHz was approved in January 2003. The 802.16-2004 standard was ratified by the IEEE in June 2004. The 802.16e standard is being reviewed by IEEE and is expected to be approved late 2005. Industry speculation suggests the standard will be officially named 802.16 2005. The purpose of 802.16e is to add data mobility to the current standard, which is designed mainly for fixed operation.

In simple words, although the radio modulation technique changes depending on the frequency of operation, the packet format, medium sharing or the error control techniques are independent of the frequency of operation. The "electronics" used in the IEEE 802.16 MAC (ISO layer 2 data link) are not dependent of the frequency of operation.

IEEE 802.16 does not only aim to satisfy the wireless ISP and industry requirements in almost all possible scenarios but also to become the de facto broadband outdoor wireless standard. Having that said, it does not necessary mean that other technologies should automatically be considered obsolete. In many cases the discussion is about spectrum efficiency, regulatory aspects, access to technology or investment costs. In this document we have deliberately decided to focus on the main technical differences, as we believe that is a good starting point for the majority of the readers.

So, what is the answer to the question "WiFi or WiMAX?": It depends on. It depends on what you need today and what you expect to need tomorrow.

9.1 Range and Coverage

IEEE 802.11 is a wireless LAN (indoor) protocol that was designed to operate in small cells (up to 100 meters) and that in the design phase never was considered as a point-to-multipoint outdoor solution. IEEE 802.11 MAC suffers from the hidden-node problem and is known for bad performance in long distance links with many stations.

The access method in IEEE 802.11 (CSMA/CA) assumes that all nodes that are communicating with the access point can hear each other to avoid collisions. Collisions in IEEE 802.11 can be avoided if all nodes can effectively sense if the channel is occupied or not. Unfortunately, this requirement can not always be satisfied when implementing IEEE 802.11 based network in an outdoor environment. When more than ten <someone might say twenty> stations are associated to the same access point and the rate of collisions increases, the consequent backoffs and retransmissions introduce a significant waste of airtime resources. IEEE 802.11 performs bad when many users are associated to an access point in an outdoor environment. In order to solve some of this problems, proprietary solutions based on the principle of “polling the clients” or bandwidth reservations in the IP layer has been implemented. By introducing “polling” in IEEE 802.11, the access point decides in which moment a station is granted to talk to the access point. The hidden node problem is nothing new and as soon as IEEE 802.11 was standardized there were already modifications of the IEEE 802.11 MAC to solve the problem (e.g. Karlnet TurboCell, WORP etc.). Many other proprietary solutions became available but interoperability between vendors was not guaranteed. In the recent standard IEEE 802.11e the MAC was enhanced to include “polling” and make implementations interoperable.
On the contrary, IEEE 802.16 was born to be a wireless metropolitan outdoor solution and was designed as an outdoor solution from the beginning. IEEE 802.16 is designed to operate in a typical cell size of 7 to 10 km and can handle distances up to 50 km. The hidden node problem was solved from the very early design phase by including DAMA-TDMA for the uplink where the base station allocates slots to each station. IEEE 802.16 DAMA-TDMA uses the same principle as a satellite network where the stations (clients) can not hear each other.

To be able to operate better in non light-of-sight environments (NLOS), IEEE 802.16 included a more complex modulation based on 256-points of Fast Fourier Transform)(FFT) of OFDM instead of the 64-points in IEEE 802.11a/g. By including 256 points instead of 64, IEEE 802.16 is equipped with a better non-line of sight capability. IEEE 802.16 can tolerate 10 times more multi-path delay spread than 802.11. IEEE 802.16 can make better use of the available channel resources in an outdoor environment as the base station schedules the subscribers using dynamic scheduling algorithms. The number of subscribers does not effect the number of collisions and retransmissions of packets.

As mentioned before IEEE 802.11 coverage is limited by the hidden node problem. IEEE 802.11 performs well in a indoor environment or in point-to-point solutions but is not optimal for an outdoor point-to-multipoint solution.

The possibility in IEEE 802.16 to dedicate a certain bandwidth to a subscriber by means of TDMA, without worrying about hidden nodes, allows the introduction of smart antennas. A smart antenna combines multiple antenna elements with a signal-processing capability and can optimize its beam pattern automatically. IEEE 802.16 will allow advanced antenna techniques and hence better cell planing.

IEEE 802.16 has also included support for mesh networking. In mesh networking each subscriber access point is also part of the routing infrastructure. IEEE 802.16 makes a smarter “adaptive” modulation than IEEE 802.11 and enables optimization of each subscriber’s data rate by allowing the base station to set modulation schemes on a link-by-link basis. A subscriber station close to the base station can use high data rate modulation as 64QAM, while the weaker signal from a more remote subscriber might only permit the use of 16QAM or QPSK. The adaptive modulation included in the IEEE 802.16 MAC also allows to have different modulation method for downlink and uplink bursts.

9.2 Scalability and throughput

While IEEE 802.11 has a fixed channel bandwidth of 20 Mhz, IEEE 802.16 has the flexibility of allocating different bandwidth in each radio channel, from very narrow channels of 1.5 Mhz to a maximum of 20 Mhz. The possibility of setting different channel bandwidth enables frequency reuse and better cell planning. While the number of non-overlapping channels in IEEE 802.11b is 3 and 5 in IEEE 802.11a, the number of non-overlapping channels in IEEE 802.16 is limited by the total available spectrum.

When it comes to data rates, IEEE 802.11 can provide a peak data rate of 2.4 bps/Hz. In the 20 Mhz channel that implies a maximum of 54 Mbps. IEEE 802.16 allows a theoretical maximum of 70 Mbps in a 20 Mhz channel. The level of actual throughput will depend on Light-of-sight, distance, air quality, interference and other factors (real values of 50 Mbps are expected).

9.3 Quality of Service

IEEE 802.11 includes quality of service in the new standard IEEE 802.11e (products of a profile of the 11e standard known as Wireless Multimedia of WMM are already in the market). Unfortunately IEEE 802.11e will only support a limited prioritization on a single connection between the IEEE 802.11 access point and the station. In WMM, QoS is achieved by including shorter Interframe Space (IFS) for multimedia traffic.

IEEE 802.16 has implemented QoS in a “per-flow” basis, where multiple connections between a subscriber station and a base station can have different QoS attributes.
QoS in IEEE 802.16 is achieved by means of “polling”. The base station polls the subscribers stations for bandwidth requests and schedules the traffic according to their responses.

Four types of scheduling services are supported in IEEE 802.16 depending on the type of traffic.

1. Unsolicited Grant Service (UGS), designed to support constant- bit-rate applications, such as T1 or E1 emulation and voice over IP (VOIP) without silence suppression.
2. Real-Time Polling Service (rtPS), for applications that generate periodic variable-size packets, like MPEG and VOIP with silence suppression.
3. Non-Real-Time Polling Service (nrtPS), which supports applications like FTP that generate variable-size packets on a regular basis.
4. Best Effort (BE) Service, for low-priority applications like Web surfing or e-mail.

10. Conclusions

From this unit about wireless standards we can conclude that a standard is important for both vendors and customers. Standards ensures interoperability between products and trustworthiness towards the clients. Additionally its promotes competition between vendors and drives the development forward.

We have learnt that IEEE is the main standardization body for ICTs and stands behind well known standards as IEEE 802.11 (Wireless LAN), IEEE 802.3 (Ethernet) and IEEE 802.16 (WiMAX).

This unit mainly focus on IEEE 802.11 which is the family of standards for “wireless Ethernet”. We presented how the different IEEE 802.11 amendments (b/a/g etc.) differ in modulation techniques, frequency range and media access methods and concluded how that is reflected on the performance.

By presenting a comparison between WiFi and WiMAX performance we could clearly see the benefits of the new broadband wireless standards in terms of coverage, scalability, Throughput and Quality of Service. However, we should not forget the heavy investments that WiMAX includes and that we must always bear in mind the purpose of a network when planning for it. While WiMAX is suitable for a municipality network, WiFi is still working fine for a small scale network.

The five main issues to remember for this unit can be summarized as follows:

1. A standard ensures interoperability among products within the same standard
2. IEEE is the main standardization body when it comes to information technology and communication systems
3. IEEE 802.11 (Wireless LAN) is a family of standards for “wireless Ethernet”
4. The difference between IEEE 802.11 amendments (b/a/g etc.) lies in modulation techniques, frequency range and enhancements to the original media access method.
5. WiMAX (802.16) is designed to be an outdoor large cell broadband standard while WiFi (802.11) was intended to be an indoor solution built on small cells.