Mobile and Wireless Technology

CT090-3-2-MWT Version VD01

WiMax and LTE

Topic & Structure of The Lesson

- 2G, 3G, 4G, 5G
- WiMAX and LTE
- Key Network Technologies
- Cellular Network Architecture
- Mobile WiMAX Versus Wi-Fi
- Mobile WiMAX Versus Cellular Mobile Networks

Learning Outcomes

At the end of this topic, You should be able to

- Be familiar with 2G, 3G, 4G and 5G technologies
- Compare WiMAX and LTE
- Know Key Network Technologies
- Know the importance of Network Architecture
- Compare Mobile WiMAX with Wi-Fi
- Compare Mobile WiMAX with Cellular Mobile Networks

Key Terms You Must Be Able To Use

If you have mastered this topic, you should be able to use the following terms correctly in your assignments and exams:

- WiMAX (Worldwide Interoperability for Microwave Access)
- Wi-Fi (Wireless Fidelity)
- LTE (Long Term Evolution)
- Bluetooth
- Zigbee
- Mobile WiMAX
- Cellular Network

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1G vs 2G vs 3G vs 4G vs 5G

Generation	Definition	Throughput/ Speed	Technology	Time period	Features
1G	Analog	14.4 Kbps (peak)	AMPS, NMT,TACS	1970 – 1980	During 1G Wireless phones are used for ***voice only***.
2G	Digital Narrow band circuit data	9.6/14.4 Kbps	TDMA,CDMA	1990 to 2000	2G capabilities are achieved by allowing ***multiple users on a single channel via multiplexing***. During 2G Cellular phones are used for ***data also along with voice***.
2.5G	Packet Data	171.2 Kbps(peak) 20-40 Kbps	GPRS	2001-2004	In 2.5G the ***internet*** becomes popular and data becomes more relevant.2.5G ***Multimedia services*** and streaming starts to show growth. ***Phones start supporting web browsing*** though limited and very few phones have that.

1G vs 2G vs 3G vs 4G vs 5G

3G	Digital Broadband Packet Data	3.1 Mbps (peak) 500-700 Kbps	CDMA 2000 (1xRTT, EV DO) UMTS, EDGE	2004-2005	3G has ***Multimedia services support*** along with streaming are more popular. In 3G,***Universal access*** and ***portability*** across different device types are made possible. (Telephones, PDA's, etc.)
3.5G	Packet Data	14.4 Mbps (peak) 1-3 Mbps	HSPA	2006 – 2010	3.5G supports ***higher throughput and speeds*** to support higher data needs of the consumers.
4G	Digital Broadband Packet All IP Very high throughput	100-300 Mbps (peak) 3-5 Mbps 100 Mbps (Wi-Fi)	Wi-Max LTE Wi-Fi		***Speeds*** for 4G are further increased to keep up with data access demand used by various services. ***High definition streaming*** is now supported in 4G. New phones with HD capabilities surface. It gets pretty cool. In 4G,***Portability*** is increased further. ***World-wide roaming*** is not a distant dream.

1G vs 2G vs 3G vs 4G vs 5G

5G	Not Yet	Probably gigabits	Not Yet	Soon (probably 2020) **Update**: Samsung conducts tests on 5G	***Currently there is no 5G technology deployed***. When this becomes available it will provide very high speeds to the consumers. It would also provide **efficient use of available bandwidth** as has been seen through development of each new technology.

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Wi-Max and LTE

Long Term Evolution (LTE) is a 4G wireless broadband technology developed by the Third Generation Partnership Project (3GPP), an industry trade group.

3GPP engineers named the technology "Long Term Evolution" because it represents the next step **4G** in a progression from **GSM** (Global System for Mobile Communication), a **2G** standard, to **UMTS** (Universal Mobile Telecommunications Service), the **3G** technologies based upon GSM.

Wi-Max and LTE

LTE provides increased peak data rates, with the potential for 100 Mbps downstream and 30 Mbps upstream, reduced latency, scalable bandwidth capacity, and backwards compatibility with existing GSM and UMTS technology.

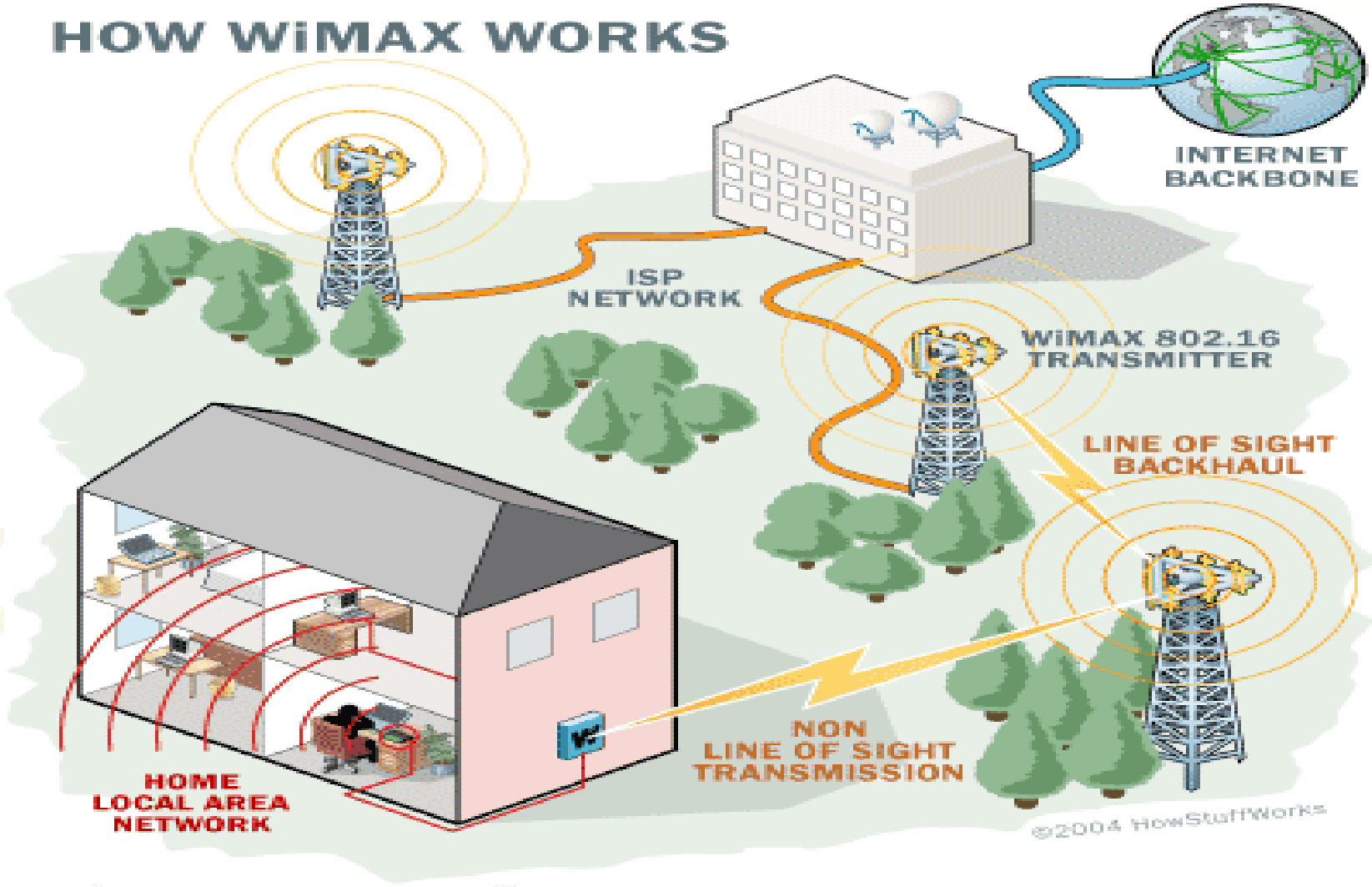
WiMAX is **Worldwide Interoperability for Microwave Access**. Based on Wireless MAN technology.

Wi-Max and LTE

WiMAX is one of the **hottest broadband wireless technologies** around today. Wi-MAX systems are expected to deliver broadband access services to residential and enterprise customers in an **economical way**.

WiMAX would **operate similar to Wi-Fi, but at higher speeds over greater distances** and for a **greater number of users**. WiMAX has the ability to provide service even in areas that are difficult for wired infrastructure to reach and the ability to overcome the physical limitations of traditional wired infrastructure.

Wi-Max and LTE



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Key Mobile & Wireless Technologies

Wi-Fi, the most popular wireless standard for networking computer systems, has the following basic characteristics:

- Multi-user configuration
- IEEE 802.11b data rate is 11Mbps
- IEEE 802.11g data rate is 54Mbps
- Frequency band is the 2.4Ghz band
- Range of 100-150 feet
- Equipment and Wi-Fi systems/access points are usually privately owned

Key Mobile & Wireless Technologies

WiMAX (IEEE 802.16) wireless technologies has a primary focus of enabling a wireless alternative for cable, DSL, and T1 communication channels for consumer last-mile access to the Internet, including high-speed data, Voice over IP (VoIP), Video on Demand (VoD), and backhaul for IEEE 802.11 LANs.

WiMAX addresses the "first-mile/last-mile" connection for longer distances and faster rates.

- Multi-user configuration
- Range of 5 to 30 miles (5 more likely)
- Data rates of (45-75 Mbps)

Key Mobile & Wireless Technologies

Cellphone data standards, **GPRS, is part of GSM effort** to create a common European mobile telephone standard for a pan-European mobile cellular radio system (and now worldwide).

The resulting mobile telephone standard allows cellphone users to "roam" across many cellphone systems and between most countries world-wide.

Key Mobile & Wireless Technologies

New generations of cellphone technologies, termed 2.5G, 3G, and 4G are deployed in certain countries or are still under development.

- Multi-user configuration
- GPRS commonly used for data, with 30-80 kbps typical.

Key Mobile & Wireless Technologies

Bluetooth is used in cellphones, Personal Digital Assistants (PDAs), and other mobile wireless devices, primarily for communicating with computers, Intelligent Electronic Devices (IEDs), headsets, hands-free systems, and other gadgets.

The characteristics of Bluetooth as follows:

- Point-to-point links
- Very short range of only 33 feet (approx 10m)
- Frequency band is the 2.4Ghz band.
- Relatively low data rate of 1.5Mbps
- Equipment and Bluetooth systems are privately owned

Key Mobile & Wireless Technologies

Zigbee, based on IEEE 802.15.4, defines low-rate, very low duty cycle, wireless personal area networks often termed "meshed networks" as opposed to point-to-point.

Zigbee builds upon this 802.15.4 standard to define application profiles that can be shared among different manufacturers to provide system-to-system interoperability.

This effort is still a work in progress, although of great interest to industries (such as the power industry) that have extensive sensor networks.

Key Mobile & Wireless Technologies

The characteristics of Zigbee as follows:

- Multi-user configuration
- Range between devices is 30-300 feet.
- High availability due to meshed network configuration
- Low data rate of <250 kbps
- Equipment and Zigbee systems are usually privately owned

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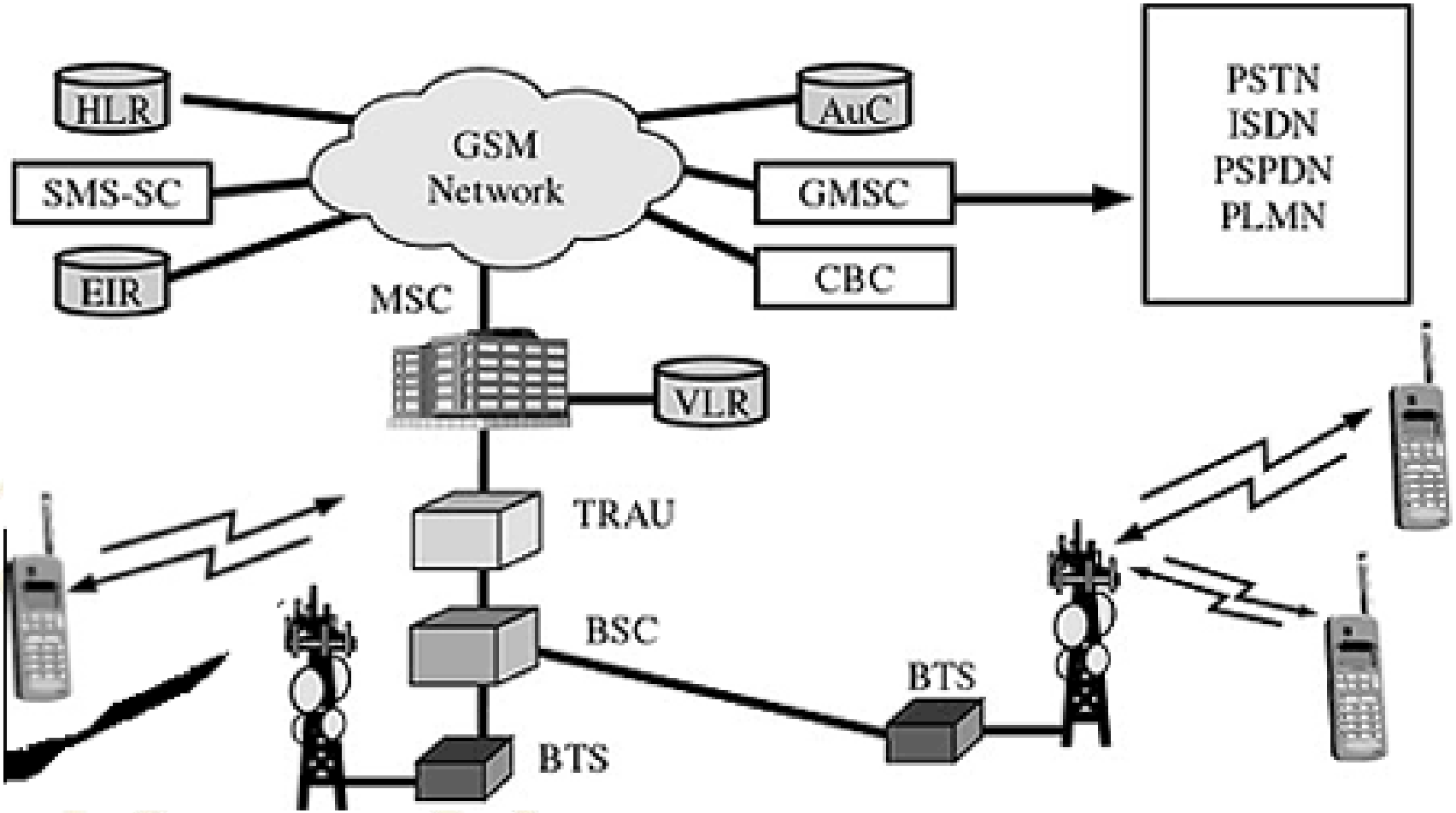
Cellular Network

Traditional base station infrastructure systems

Cellular network consists of three subsystems. They are:

- Base Station Subsystem – MS,BTS & BSC
- Network Switching Subsystem – VLR,HLR,EIR,AUC & MSC
- Operation Support Subsystem - OMC

Cellular Network



Cellular Network

Base Station Subsystem

Mobile Station - Hardware & SIM (Subscriber Identity Module)

BTS – Base Transceiver Station

The BTS is the Mobile Station's access point to the network. It is responsible for carrying out radio communications between the network and the MS.

BSC – Base Station Controller - The BSC controls multiple BTSs.

Network Switching Subsystem

It consists of five functional units. They are:

MSC - The **Mobile Switching center** is the heart of the GSM network. It handles call routing, call setup, and basic switching functions.

HLR – Home Location Register- The HLR is a large database that permanently stores data about subscribers. The HLR maintains subscriber-specific information such as the MSISDN, IMSI, current location of the MS, roaming restrictions, and subscriber supplemental features.

VLR - Visitor Location Register (**VLR**) The **VLR** contains a copy of most of the data stored at the HLR. It is, however, temporary data which exists for only as long as the subscriber is "active" in the particular area covered by the **VLR**.

AuC –Authentication Center - The **authentication center** (AuC) is a function to authenticate each SIM card that attempts to connect to the GSM core network (typically when the phone is powered on).

EIR – Equipment Identity Register - The EIR is a database that keeps tracks of handsets on the network using the IMEI.

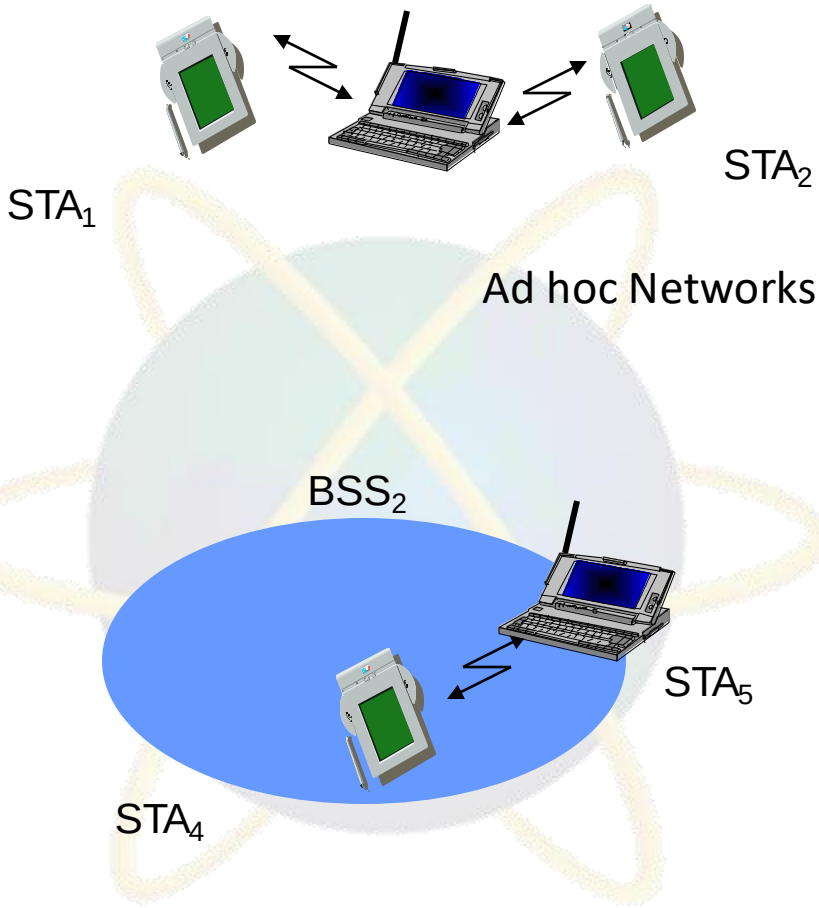
Cellular Network

Operation Support Subsystem - OMC – **Operation and Maintenance center** monitors and controls the system. It supports Maintenance activities of different operations.

Wireless Network

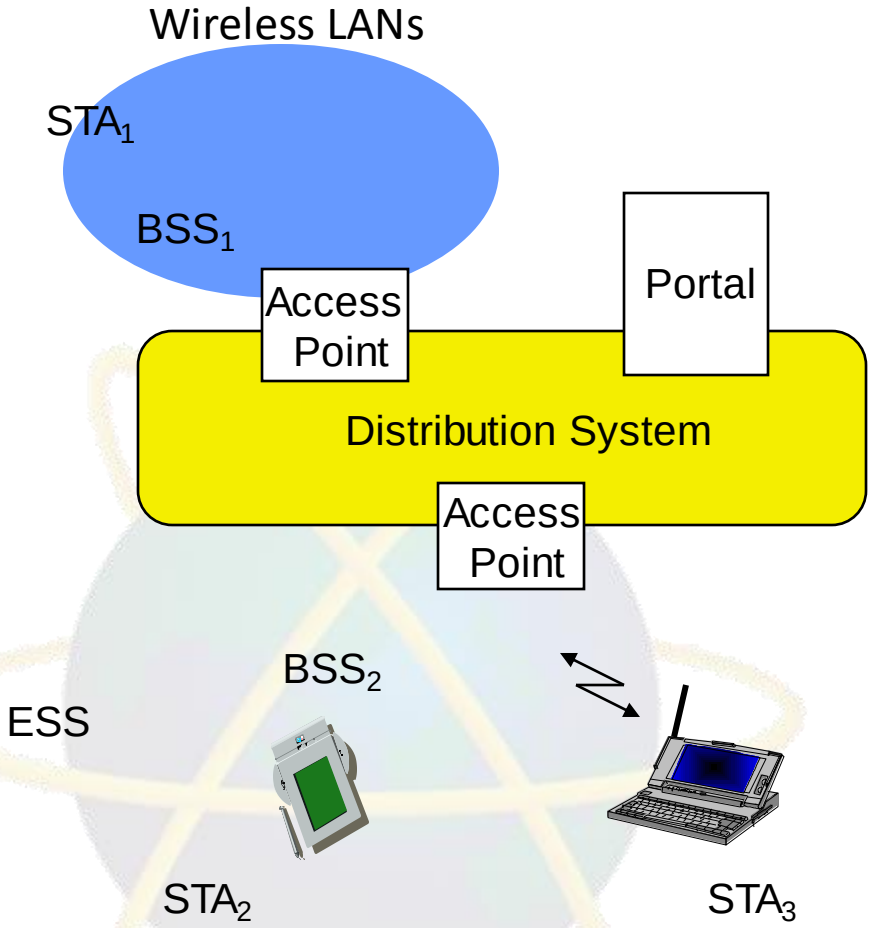
- Infrastructure as well as ad-hoc networks possible
- Very flexible within the reception area
- Low bandwidth compared to wired networks (1-10 Mbit/s)

Cellular & Wireless Network Architecture- Wireless Network Ad-hoc Network



- Direct communication within a limited range
  - Station (STA): terminal with access mechanisms to the wireless medium
  - Basic Service Set (BSS): group of stations using the same radio frequency

Mobile & Wireless Network Architecture- Wireless LAN- Infrastructure



- Station (STA)
  - terminal with access mechanisms to the wireless medium and radio contact to the access point
- Basic Service Set (BSS)
  - group of stations using the same radio frequency
- Access Point
  - station integrated into the wireless LAN and the distribution system
- Portal
  - bridge to other (wired) networks
- Distribution System
  - interconnection network to form one logical network (EES: Extended Service Set) based on several BSS

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Mobile WiMAX Versus Wi-Fi

WiMAX was designed to replace the last-mile wired-broadband access networks while Wi-Fi was created for providing services into LAN networks.

WiMAX technology to support peak Down Link data rates up to 63 Mbps per sector and peak Up Link data rates up to 28 Mbps per sector in a 10 MHz channel. Whereas, Wi-Fi data rates summary as follows:

Protocol	Frequency	Signal	Maximum data rate
Legacy 802.11	2.4 GHz	FHSS or DSSS	2 Mbps
802.11a	5 GHz	OFDM	54 Mbps
802.11b	2.4 GHz	HR-DSSS	11 Mbps
802.11g	2.4 GHz	OFDM	54 Mbps
802.11n	2.4 or 5 GHz	OFDM	600 Mbps (theoretical)
802.11ac	5 GHz	256-QAM	1.3 Gbps

Mobile WiMAX Versus Wi-Fi

At the PHY layer, WiMAX channel sizes ranges from 1.75 MHz to 20 MHz while Wi-Fi based products require at least 20 MHz for each channel.

Wi-Fi uses the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) which is not an efficient protocol. The MAC layer in WiMAX has been designed to scale from one to up 100s users within one RF channel.

In WiMAX, the base station assigns a QoS class to each connection. In 802.11, QoS was not considered in the early stage of its implementation.

Mobile WiMAX Versus Wi-Fi

WiMAX supports many transport technologies, such as ATM, IPv4, and IPv6 which are not supported by Wi-Fi.

WiMAX has the ability to support longer range transmission. While 802.11 was designed for low power consumption which limit the coverage to hundreds of meters.

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WiMAX Versus LTE

Comparison in terms of	WiMax	LTE
Standard	Is a technology standardized by IEEE	Is a technology standardized by 3GPP
Spectrum	Higher licensed and unlicensed bands	Lower licensed bands
Mode of Operation	TDD is the main mode	FDD is the main mode
Coverage	Targeted dedicated coverage	Targeted wide coverage

Mobile WiMAX Versus Cellular

Comparative advantages	3/3.5G cellular	Mobile WiMAX	Remarks
Flexible bandwidth allocations		✓	Advantage of using multiple (both time and frequency) Duplexing modes in WiMAX
Performance in multi-path environment		✓	OFDMA performs better in suppressing ISI (Inter Symbol Interference) in WiMAX
Lower attenuation (Wider coverage)	✓		3/3.5G Cellular operates in lower frequency bands usually less than 2 GHz
Standardized		✓	IEEE 802.16e standard for mobile WiMAX
Voice capabilities	✓		Features such as multiple voice coding schemes, user selectable Enhanced Variable Rate CODEC (EVRC) are integrated in 3/3.5G
Data capabilities		✓	OFDMA Superior technology used in WiMAX for data
Mobility capabilities	✓		Better seamless hands-off and seamless roaming in 3/3.5G Cellular
Frequency reuse	✓		CDMA frequency reuse ratio is 1 while OFDMA is 1 to 3
Resistance to frequency selective fading		✓	Errors in sub-carriers can be corrected in OFDMA in WiMAX
Lower Bit Error Rate (BER)		✓	OFDMA symbols are longer in duration than CDMA symbols
Higher throughput		✓	Better use of AMC (Adaptive Modulation and Coding) techniques (Ergen *et al.*, 2003)
Higher number of users supported		✓	Fewer number of codes available in CDMA technology
Lower equipment cost		✓	No need for RACK Receivers and direct implementation of algorithms in frequency domain in WiMAX
Use of advanced radio techniques		✓	Better Use of MIMO and smart antenna technologies for WiMAX

Quick Review Question

- What is WiMax? How it works?
- Briefly explain cellular network.
- Compare WiMax with WiFi.

Summary of Main Teaching Points

In this chapter, we discussed the following:

- WiMAX
- LTE
- Wireless Network Technologies
- Cellular & Wireless Network Architecture
- Mobile WiMAX Versus Wi-Fi
- Mobile WiMAX Versus Cellular

Question and Answer Session

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Q & A

What we will cover next

IoT and Wireless Sensor Networks
Internet of Things – Applications
- Smart Cities
- Manufacturing
- Home Automation
- VANETS
- Body Area Networks

IEEE 802.5.14
Zigbee