Introduction to WiMAX

WiMAX

- WiMAX- **W**orlwide **I**nteroperable for **M**icrowave **Ac**cess - IEEE 802.16 standard
- Based on Wireless MAN technology.
- A wireless technology optimized for the delivery of IP centric services over a wide area.
- A scalable wireless platform for constructing alternative and complementary broadband networks.
- A certification that denotes interoperability of equipment built to the IEEE 802.16 or compatible standard. The IEEE 802.16 Working Group develops standards that address two types of usage models:
  - fixed usage model (IEEE 802.16-2004)
  - A portable usage model (IEEE 802.16e)

Background of IEEE 802.16

- Formed in 1998 to develop an air-interface standard for wireless broadband.
- Initially developed to focus on Line of Sight (LoS) based point to multipoint system – 10GHz – 66 GHz.
- December 2001 – completed the original IEEE 802.16 standard.

Background of IEEE 802.16 (cont.)

- In 2004, an amendment was done - IEEE 802.16 - 2004
  - To include non LoS applications in 2GHz – 11 GHz
  - Using OFDM-based physical layer
  - Targeted fixed WiMAX applications – Fixed WiMAX
    - Fixed subscribers e.g. IEEE 802.11 hotspots, fixed subscriber stations.
- In 2005, another amendment was made – IEEE 802.16e – 2005.
  - Supports for users commuting at vehicular speed - mobile WiMAX

WiMax Speed & Range

- Speed - initially up to about 40 Mbps capacity per wireless channel for both fixed and portable applications
- Support voice and video as well as Internet data.
- Can be used alone or combine with existing wired network.
- Can also be used to connect WLAN hotspots to the Internet.
- Support mobile devices with speed about 15 Mbps capacity in a 3 km cell coverage area.
- Spectrum bands: 2.3GHz, 2.5GHz, 3.5GHz, and 5.8GHz.

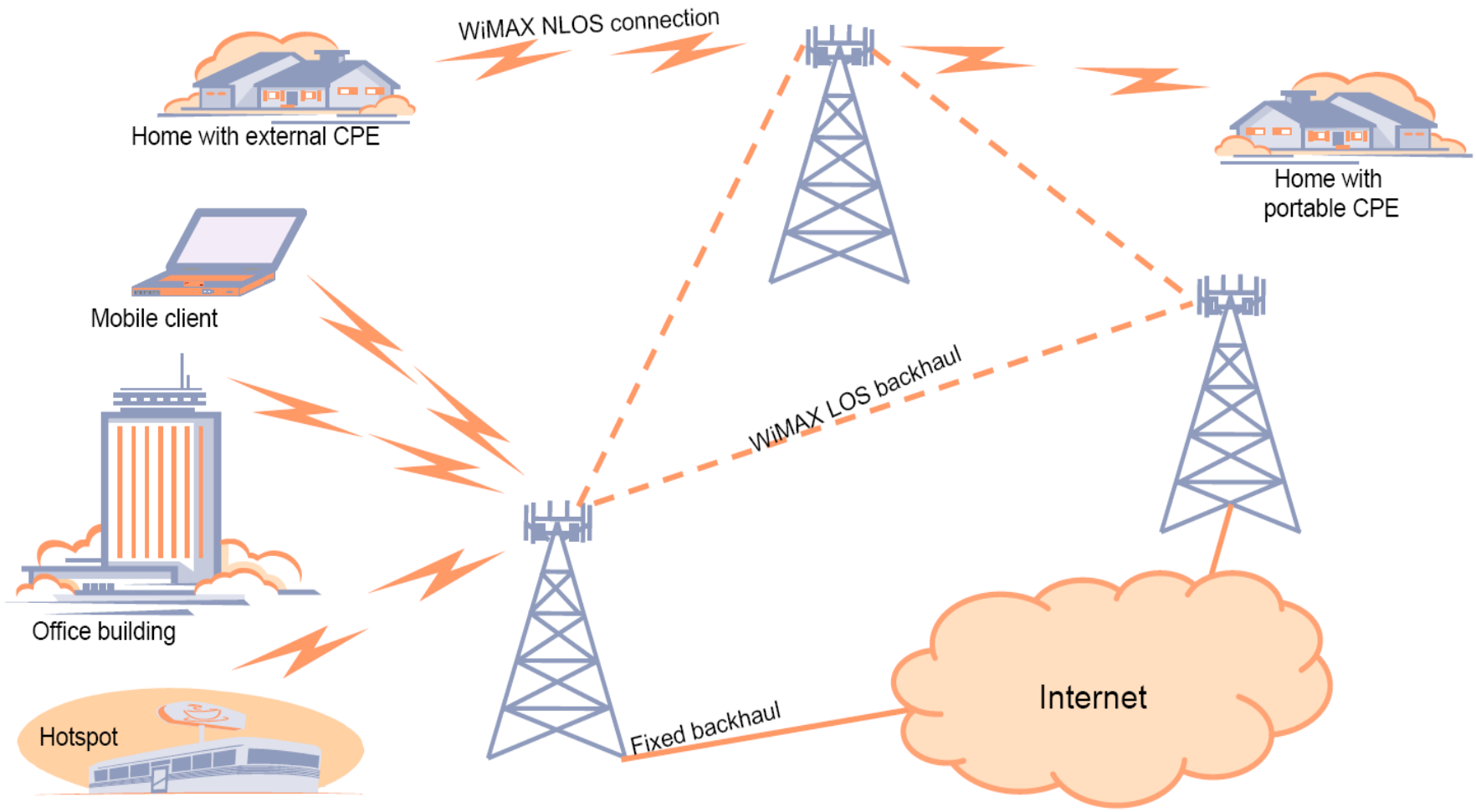
WiMax Standards

	802.16	802.16a	802.16-2004	802.16e-2005
Date Completed	December 2001	January 2003	June 2004	December 2005
Spectrum	10-66 GHz	< 11 GHz	< 11 GHz	< 6 GHz
Operation	LOS	Non-LOS	Non-LOS	Non-LOS and Mobile
Bit Rate	32-134 Mbps	Up to 75 Mbps	Up to 75 Mbps	Up to 15 Mbps
Cell Radius	1-3 miles	3-5 miles	3-5 miles	1-3 miles

How WiMax Works

- WiMax can provide 2 forms of wireless service:
  - **Non-LOS**: A small antenna on a computer connects to the tower. Uses lower frequency range (2 to 11 GHz).
  - **LOS**: A fixed antenna points straight at the WiMAX tower from a rooftop or pole. The LOS connection is stronger and more stable, so it is able to send a lot of data with fewer errors. Uses higher frequencies, with ranges reaching a possible 66 GHz.
- Through stronger LOS antennas, WiMAX transmitting stations would send data to WiMAX enabled computers or routers set up within 30 (3,600 square miles of coverage) mile radius.

WiMax is well suited to offer both fixed and mobile access



Advantages of WiMax

- WiMAX can satisfy a variety of access needs (compatibility). Potential applications include extending broadband capabilities to bring them closer to subscribers, filling gaps in cable, DSL and T1 services, WiFi, and cellular backhaul, providing last-100 meter access from fiber to the curb and giving service providers another cost-effective option for supporting broadband services.
- WiMAX can support very high bandwidth solutions where large spectrum deployments (i.e. >10 MHz) are desired using existing infrastructure keeping costs down while delivering the bandwidth needed to support a full range of high-value multimedia services.
- WiMAX can help service providers meet many of the challenges they face due to increasing customer demands without discarding their existing infrastructure investments because it has the ability to seamlessly interoperate across various network types.
- WiMAX can provide wide area coverage and quality of service capabilities for applications ranging from real-time delay-sensitive voice-over-IP (VoIP) to real-time streaming video and non-real-time downloads, ensuring that subscribers obtain the performance they expect for all types of communications.
- WiMAX, which is an IP-based wireless broadband technology, can be integrated into both wide-area third-generation (3G) mobile and wireless and wireline networks allowing it to become part of a seamless anytime, anywhere broadband access solution.

WiMAX vs. Wi-Fi

Feature	WiFi	WiMax
Standard	IEEE 802.11	IEEE 802.16
Coverage/Speed	few hundred feet with the speed of up to 54 Mbps	single WiMAX antenna is expected to have a range of up to 40 miles with the speed of 70 Mbps
Scalability	Support users scale from one to tens with one subscriber for each CPE device. Fixed channel sizes (20MHz).	support from one to hundreds of Consumer premises equipment (CPE), with unlimited subscribers behind each CPE. Flexible channel sizes from 1.5MHz to 20MHz.
Bit Rate	2.7 bps/Hz and can peak up to 54 Mbps in 20 MHz channel.	5 bps/Hz and can peak up to 100 Mbps in a 20 MHz channel.
Quality of Service	not guarantee any QoS	Support several level of QoS.

WiMAX Rollout

- WiMAX Forum anticipates rollout of its technology in 3 phases:
  - Phase 1: Fixed Location, Private Line Services, Hot Spot Backhaul.
  - Phase 2: Broadband Wireless Access/Wireless DSL
  - Phase 3: Mobile/Nomadic Users.

WiMax Spectrum

- WiMax Forum is focusing on 3 spectrum bands for global deployment:
- Unlicensed 5 GHz: Includes bands between 5.25 and 5.85 GHz. In the upper 5 GHz band (5.725 – 5.850 GHz) many countries allow higher power output (4 Watts) that makes it attractive for WiMax applications.
- Licensed 3.5 GHz: Bands between 3.4 and 3.6 GHz have been allocated in majority of countries.
- Licensed 2.5 GHz: The bands between 2.5 and 2.6 GHz have been allocated in the US, Mexico, Brazil and in some SEA countries.

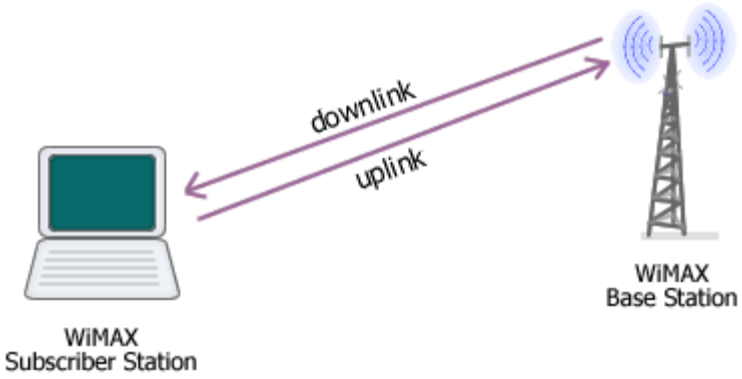
Benefits of Licensed and License-Exempt Solutions

Licensed Solution	License-Exempt Solution
Better QoS	Fast Rollout
Better NLOS reception at lower frequencies	Lower Costs
Higher barriers for entrance	More worldwide options

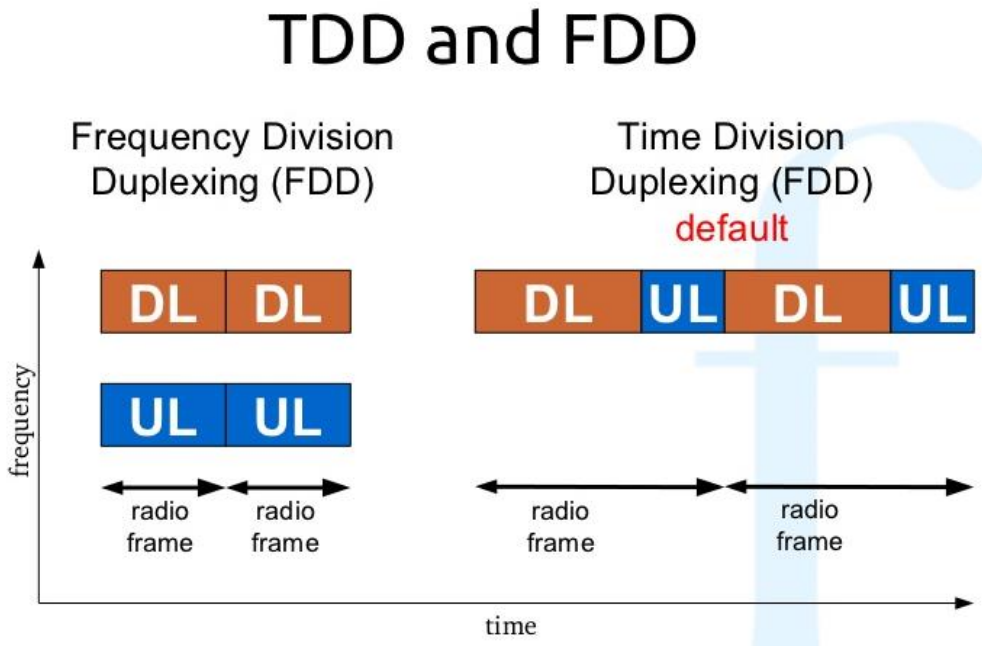
Licensed VS License-Exempt Bands

- Both solutions are based on IEEE 802.16-2004 standard, which uses OFDM in the physical (PHY) layer.
- OFDM provides benefits such as increased SNR of subscriber stations and improved resiliency to multi-path interference.
- For creating bi-directional channels for uplink and downlink, licensed solutions use FDD while license exempt solutions use TDD.

TDD vs FDD



UL: MS to BS
DL: BS to MS



FDD:
UL and DL use different frequency band
DL:
UL and DL use the same frequency band

Time Division Duplexing (TDD)

Description	A duplexing technique used in license-exempt solutions, which uses a single channel for uplink and downlink.
Advantages	Enhanced flexibility, easier to pair with smart antenna technologies, asymmetrical.
Disadvantages	Cannot transmit and receive at the same time.
Usage	"Bursty", asymmetrical data applications, environments with varying traffic patterns, where RF efficiency is more important than cost.

Frequency Division Duplexing (FDD)

Description	A duplexing technique used in licensed solutions that uses a pair of spectrum channels, one for the uplink and another for the downlink.
Advantages	Proven technology for voice, designed for symmetrical traffic, does not require guard time.
Disadvantages	Cannot be deployed where spectrum is unpaired, spectrum is usually licensed, higher cost associated with spectrum purchase.
Usage	Environments with predictable traffic patterns, where equipment costs are more important than RF efficiency.

Challenges to Overcome in WiMax Deployment

- **RF Interference:** Disrupts a transmission and decreases performance. Common forms are multi-path interference and attenuation. Overlapping interference generate random noise.
- **Infrastructure Placement:** The physical structure that houses or supports the base station must be RF friendly. A metal farm silo, for example, may distort signals, or a tree swaying in the wind may change signal strength. Obstacles such as trees and buildings frequently block signal paths. High RF activity in the area can cause interference.

Solving the challenges in WiMax Deployment

- Proper network design and infrastructure placement are critical for solving the challenges.

  - Subscriber Site Survey, Statistics Gathering, coordination of RF use with neighbouring providers.
  - Antennas (Type, Tilt Angles, Array Gain, Diversity Gain)
  - Proper design and deployment
  - Well deployed base station or cells with 24/7 access, RF friendly structure, and shielding from weather elements.

Orthogonal Frequency Division Multiplexing (OFDM)

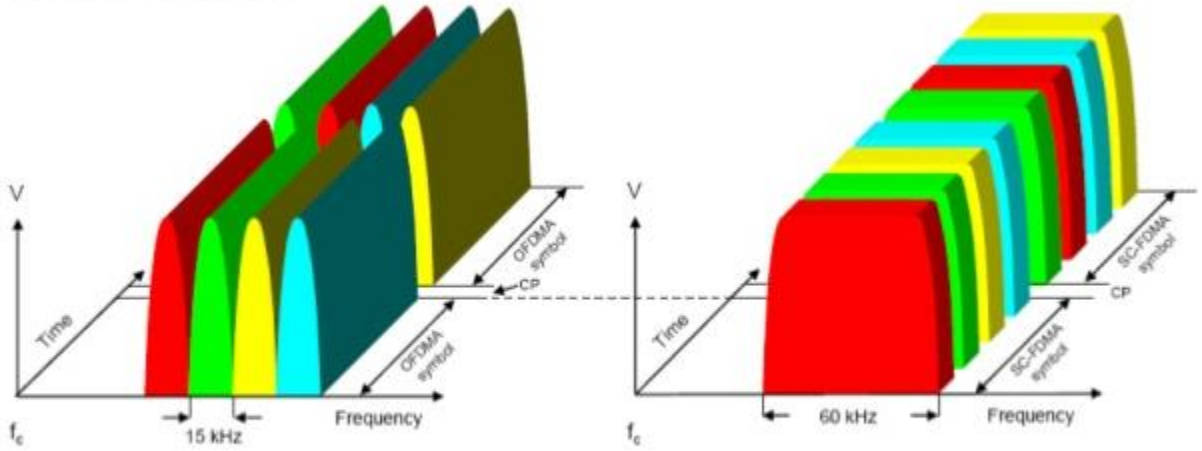
- All profiles currently defined by the WiMax Forum specify the 256-carrier OFDM air interface.
- Allows digital signal to be transmitted simultaneously on multiple RF carrier waves. Adaptable to NLOS schemes.
- Resistant to multi-path effects.
- Spectrally efficient technique to transmit wireless digital data.
- Able to deliver higher bandwidth efficiency.
- Disadvantage: OFDM signal exhibits a very high Peak to Average Power Ratio (PAPR).

OFDM vs SC-FDMA

Comparing OFDM and SC-FDMA*

- QPSK example using N=4 subcarriers
- How OFDM and SC-FDMA would be used to transmit a sequence of 8 QPSK symbols

The following graphs show how this sequence of QPSK symbols is represented in frequency and time



OFDMA
Data symbols occupy 15 kHz for one OFDMA symbol period

SC-FDMA
Data symbols occupy N*15 kHz for 1/N SC-FDMA symbol periods

WiMax Mobility Issues

- Device availability
  - Market introduction may be delayed
  - High initial costs will limit adoption growth
- Limited available spectrum
  - Bands < 3 GHz is better suited for mobile access
  - Licenses for fixed WiMAX may not allow service provider to offer mobile services
- Current demand for WiMax is mostly for fixed services.
- Demand for wireless data is growing, but still it is limited
  - Operators may see need for a data-only technology when demand is higher
  - Require dditional spectrum allocations for wireless mobile data service
- WiMax is not going to supplant other wireless technologies
  - It will not replace Wi-Fi in the LAN
  - Cellular technologies may still be needed for voice and data in the WAN
- Competing technologies have a time-to-market advantage
  - Many mobile operators have invested heavily in 3G systems

ITU Definitions

- **Fixed wireless access (FWA)**
  - Wireless access application in which the location of the end-user termination and the network access point to be connected to the end-user are fixed.
- **Mobile wireless access (MWA)**
  - Wireless access application in which the location of the end-user termination is mobile.
- **Nomadic wireless access (NWA)**
  - Wireless access application in which the location of the end-user termination may be in different places but it must be stationary while in use.

Fixed and Nomadic Mapping

Based on ITU-R Definitions

	Fixed	Nomadic
Use	▪ Service limited to installed area ▪ No roaming between service areas or operators	Location of end user terminal may change but stationary when in use
Device	Standalone outdoor subscriber station	▪ Indoor modems ▪ Laptops

WiMax vs LTE

	LTE	WiMAX
Uplink	SC-FDMA	OFDMA
Downlink	OFDMA	OFDMA
User Mobility	60 to 120 kmph	Up to 350 kmph
Coverage	Up to 50 km	Up to 100 km
Latency	Link layer: about 20 ms Handoff: about 35 to 50 ms	Link layer: < 5 ms Handoff: < 50 ms
Previous technology/ Standard	GSM, GPRS, UMTS, EDGE, WCDMA, HSPA, CDMA-one, CDMA2000, EV-DO, EV-DV and the synchronous SC-CDMA	IEEE802.11, 802.11b/Wi-Fi, 802.11a, 802.11g, 802.11n, 802.11ac