



Advanced Communication Networks

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Lecture - 8

WIRELESS METROPOLITAN AREA NETWORK (WMAN)

Wireless Metropolitan Area Network : WiMAX

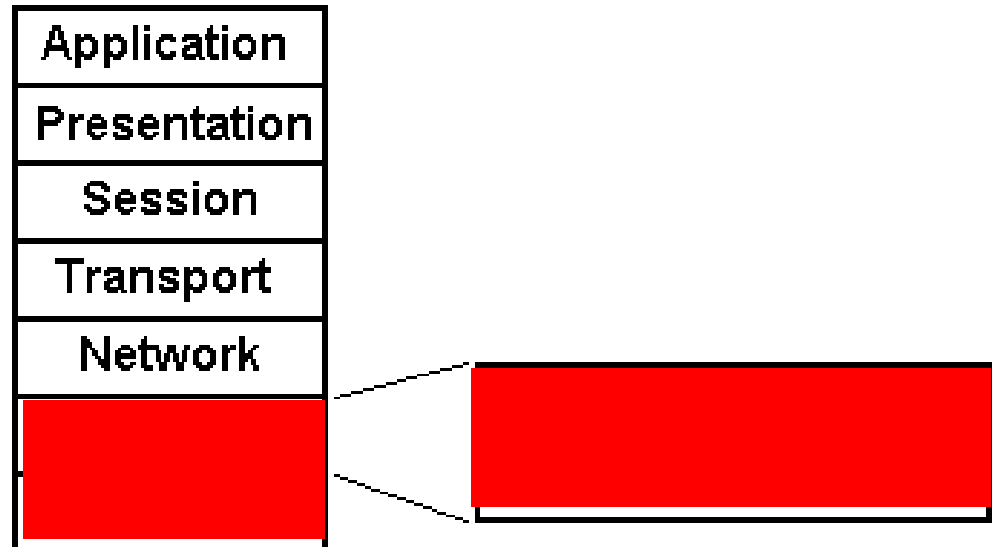
- **Worldwide Interoperability for Microwave Access**
 - Based on IEEE 802.16
- A last mile **broadband wireless access (BWA)** alternative to cable modem, wired broadband services.
- It is basically considered as Wireless Metropolitan Area Network (WMAN), but few times also referred to WWAN
- Service providers in Pakistan
 - Wateen
 - Wi-Tribe
 - Qubee



WiMAX 802.16

OSI Perspective

- Similar to WiFi, the 802.16 WiMAX standard is also specifies into two lower layers
 - Improvements in Air-interface, are also incorporated at MAC and LLC layers



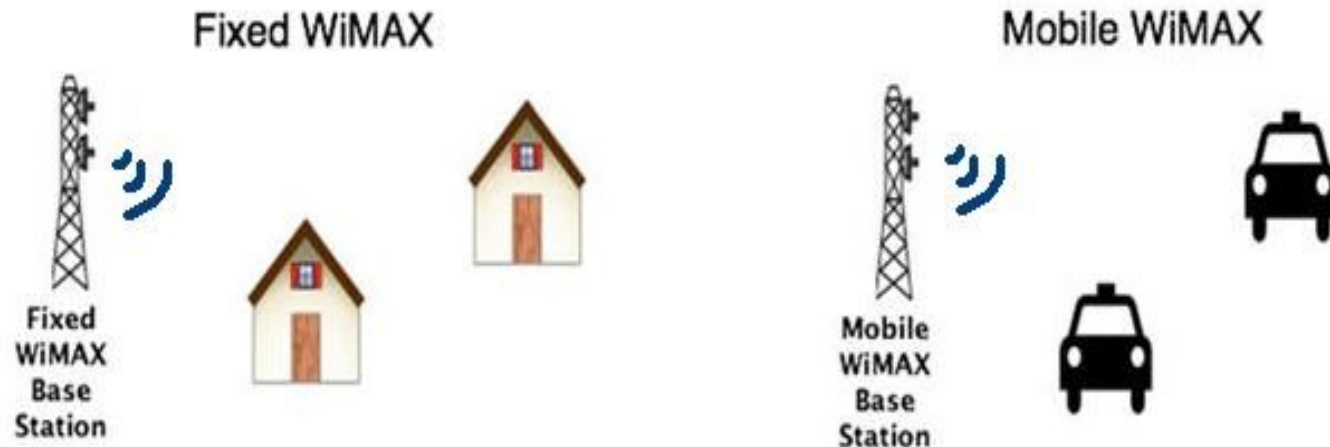
WiMAX 802.16

- The 802.16 standard specifies transmission range
 - 802.16a standard in 10 - 66 GHz range,
 - 802.16d allowed in 2 to 11 GHz
 - Lower frequencies: improved range and better coverage within buildings (no need for external antenna).

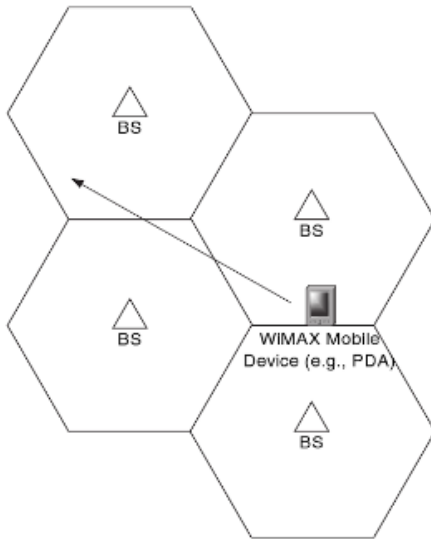
WiMAX 802.16 Architecture

- Fixed WiMAX is optimized for home/office networks
- Mobile WiMAX is optimized for mobiles

WIRELESS is not MOBILE



WIRELESS is not only MOBILE



IMT-Advanced Requirement:

- Stationary: 0 km/h;
- Pedestrian: 0 to 10 km/h;
- Vehicular: 10 to 120 km/h;
- High speed vehicular: 120 to 350 km/h

- Moving across
 - Nomadic
 - Portable / Mobile
- Session interruption while
 - out-of-zone
 - Into another WLAN
- WiMAX Mobility/Portability
 - Seamless transfer & HO
 - Portable : 10's Km/h
 - Mobile : 120-350 km/h

About IMT-Advanced

Framework for the development of IMT-Advanced and systems beyond IMT-Advanced

- It is evolved from evolution of IMT-2000 baseline systems, and it is focused for Integration and convergence of wireless systems and services that can be characterized by
 - connectivity (provision of an information pipe including intelligence in the network and the terminal),
 - content (information including push and pull services as well as peer-to-peer applications),
 - e-commerce (electronic transactions and financial services).
- IMT-A is focused towards communication schemes such as
 - machine-to-machine, machine-to-person, and person-to-machine.

WiMAX 802.16 Architecture

Fixed WiMAX

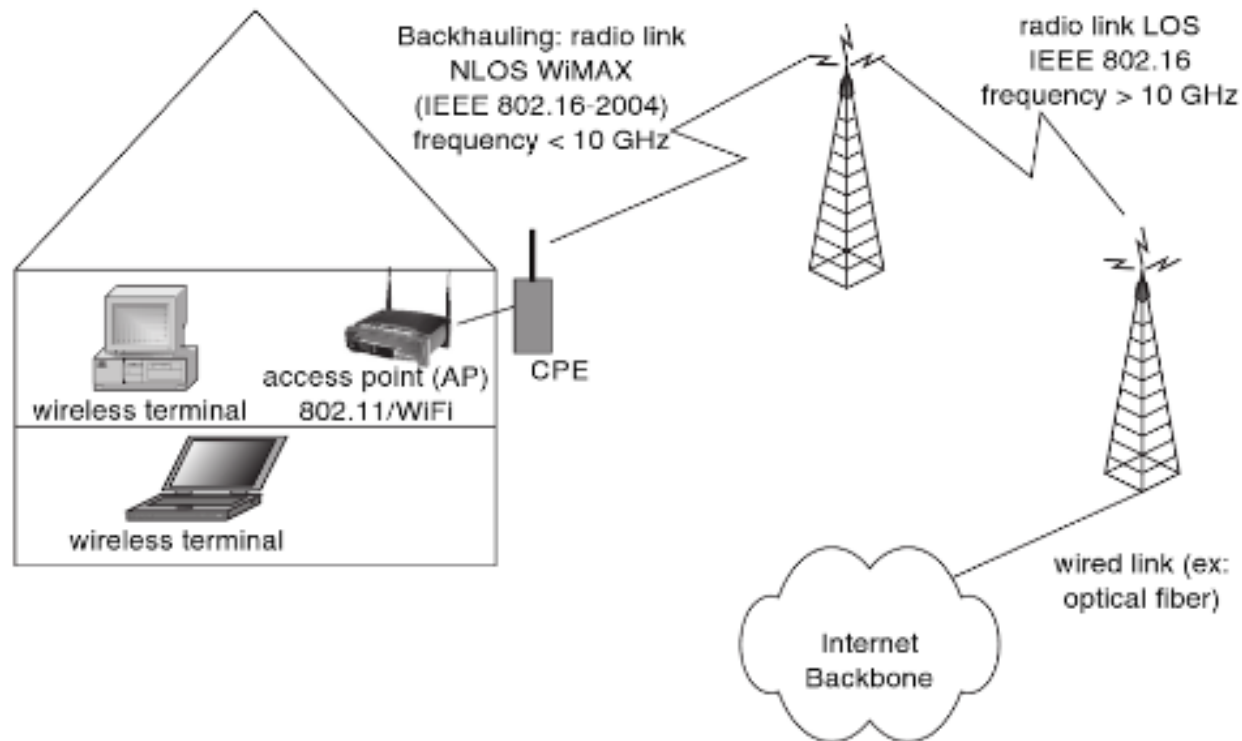
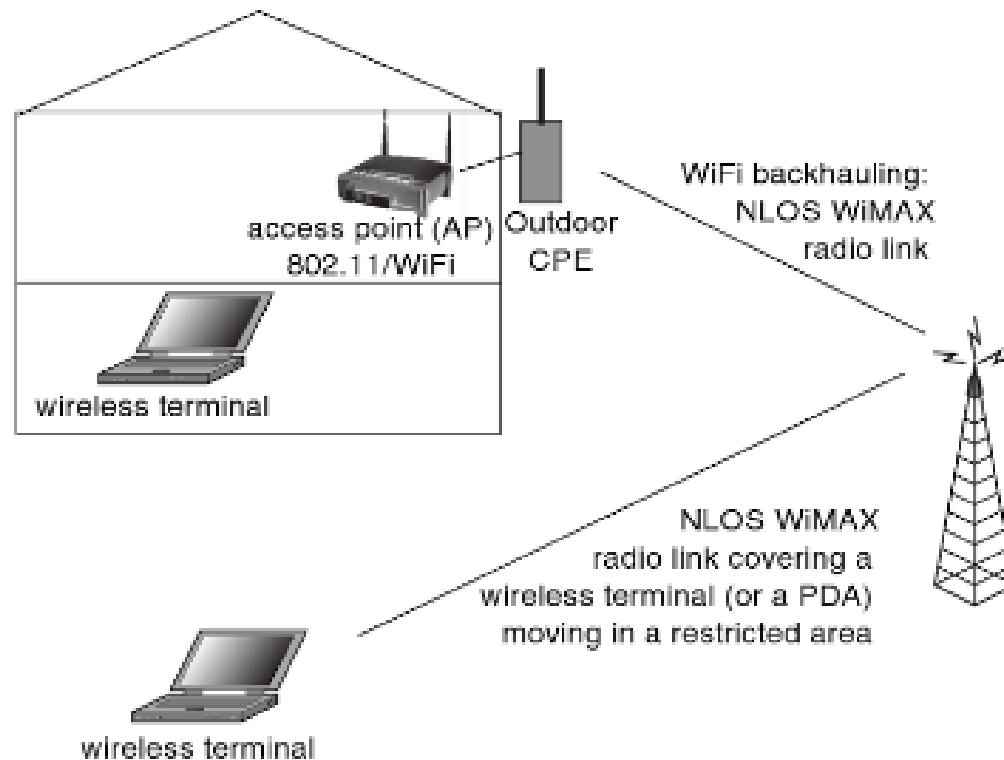


Figure 1.4 Broadband Wireless Access (BWA) applications with a fixed access. The two main applications of a fixed BWA are wireless last-mile for high data rate and (more specifically) WiFi backhauling

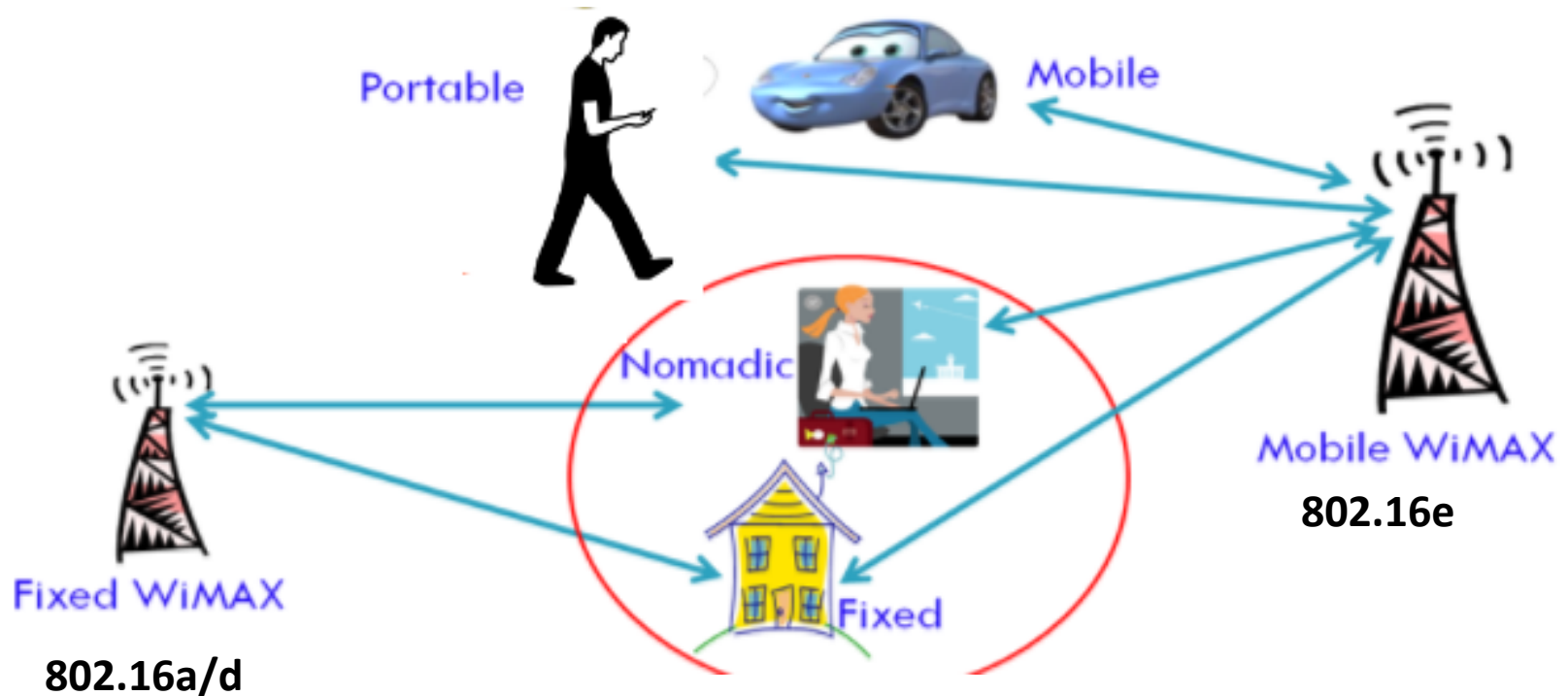
WiMAX 802.16 Architecture

Mobile WiMAX



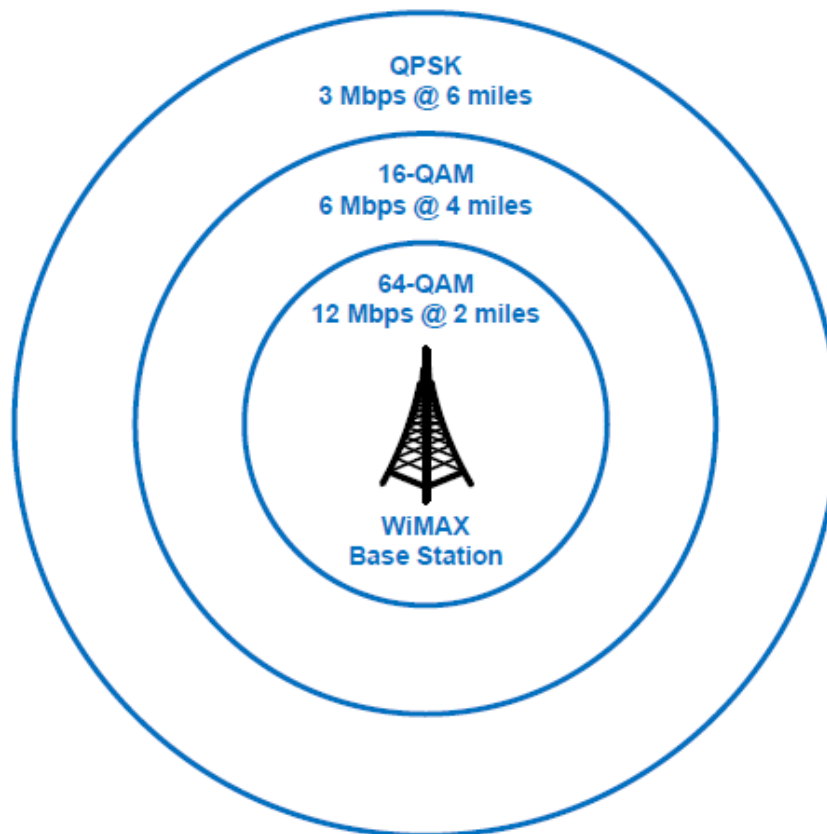
WiMAX 802.16 Architecture

Fixed and Mobile WiMAX



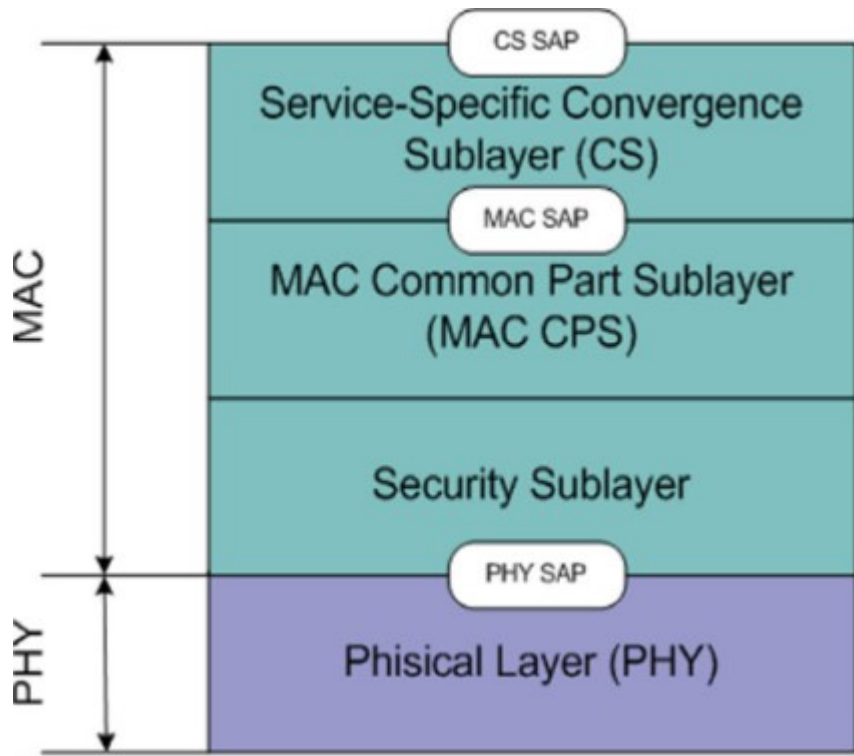
WiMAX 802.16 : PHY

- Data rate depends on user location (RSS)



How this can be achieved?

WiMAX 802.16 – MAC Layer



MAC CS :

Accept PDU

*Classifying and Mapping into CID/SFID
(Connection/Svc Flow Identifier)*

MAC CPS :

BW allocation

Connection Establishment

Connection maintenance

Security Sub layer:

Data Encryption : AES Advanced Encryption Standard
+ Cipher Block Chaining Message, CCM

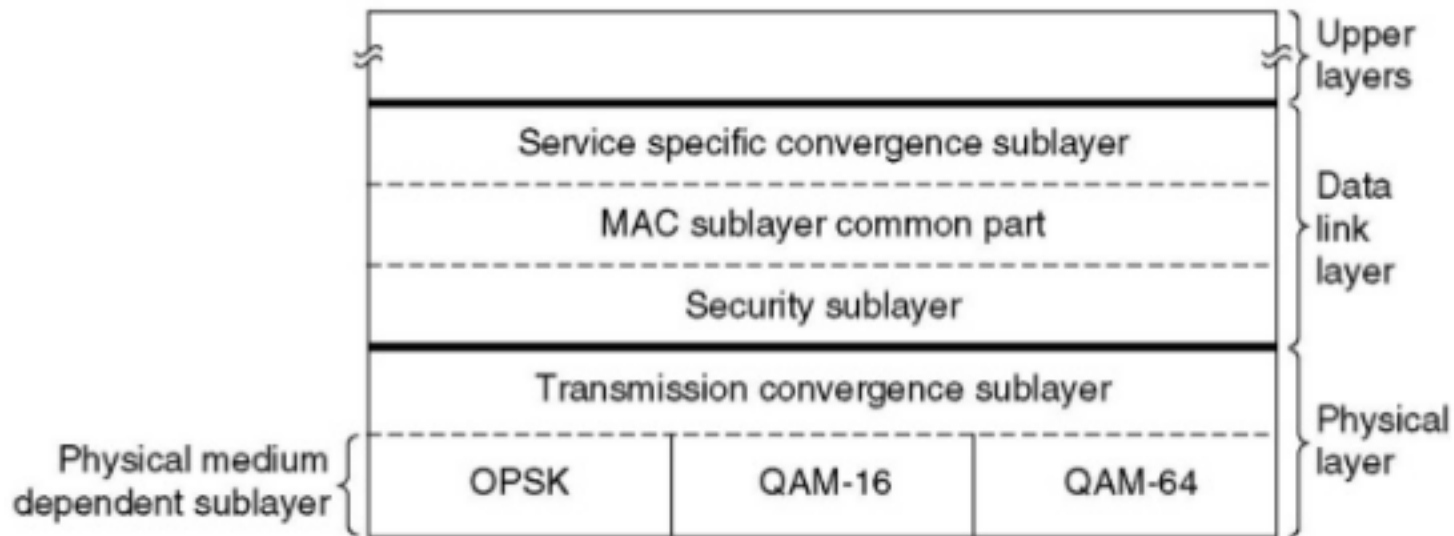
Key Exchange: Secure key exchange

Authentication : PKM (Privacy Key Management)

CS provides a mapping of external network data formats (e.g., IP layer packets, ATM cells) received through upper layers into MAC SDUs. This includes classifying external network SDUs and associating them with a proper Service Flow Identifier and Connection Identifier.

WiMAX 802.16 – PHY Layer

- Phy layer enhancements to obtain high throughputs



WiMAX : MAC Layer QoS options

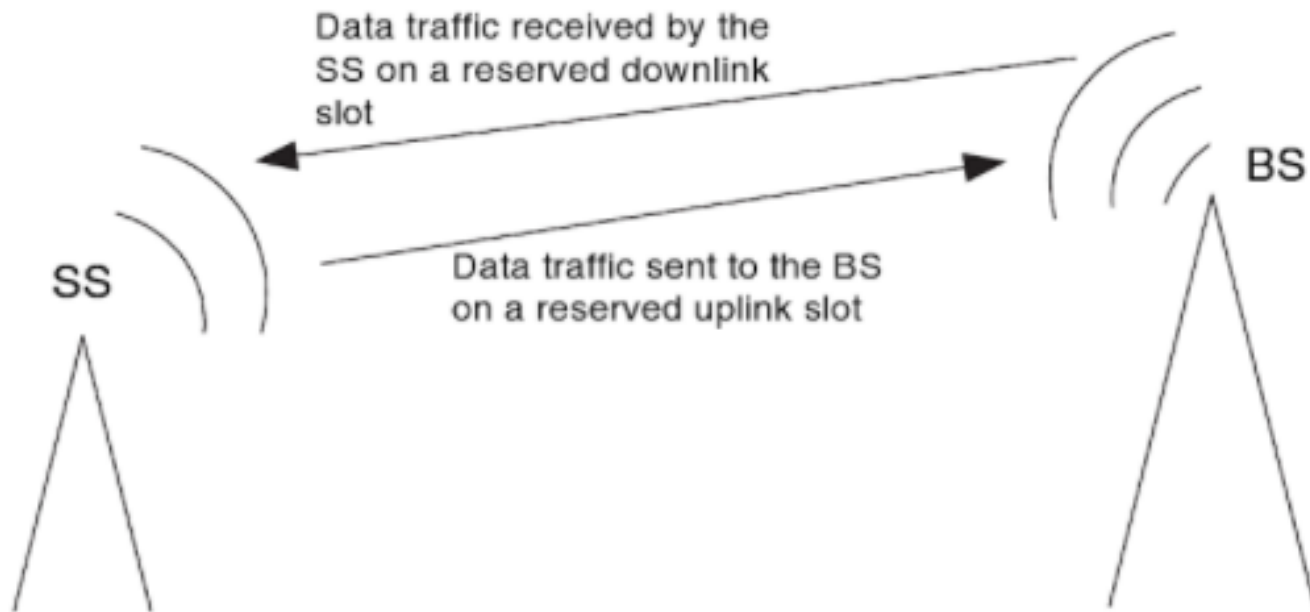
- Polling is the process by which the BS allocates bandwidth to the SSs for the purpose of making bandwidth requests.
 - The use of polling simplifies the access operation and guarantees that applications can receive service on a deterministic basis if it is required.
- Bandwidth allocation two main polling modes, unicast polling and contention-based polling
- **Unicast polling**
 - In the case of unicast polling, upon request by SS, it is allocated, sufficient bandwidth to respond with a Bandwidth (BW) request.

Which layer will do this?

Service Flow Identifier (SFID) at MAC

WiMAX : MAC Layer QoS options

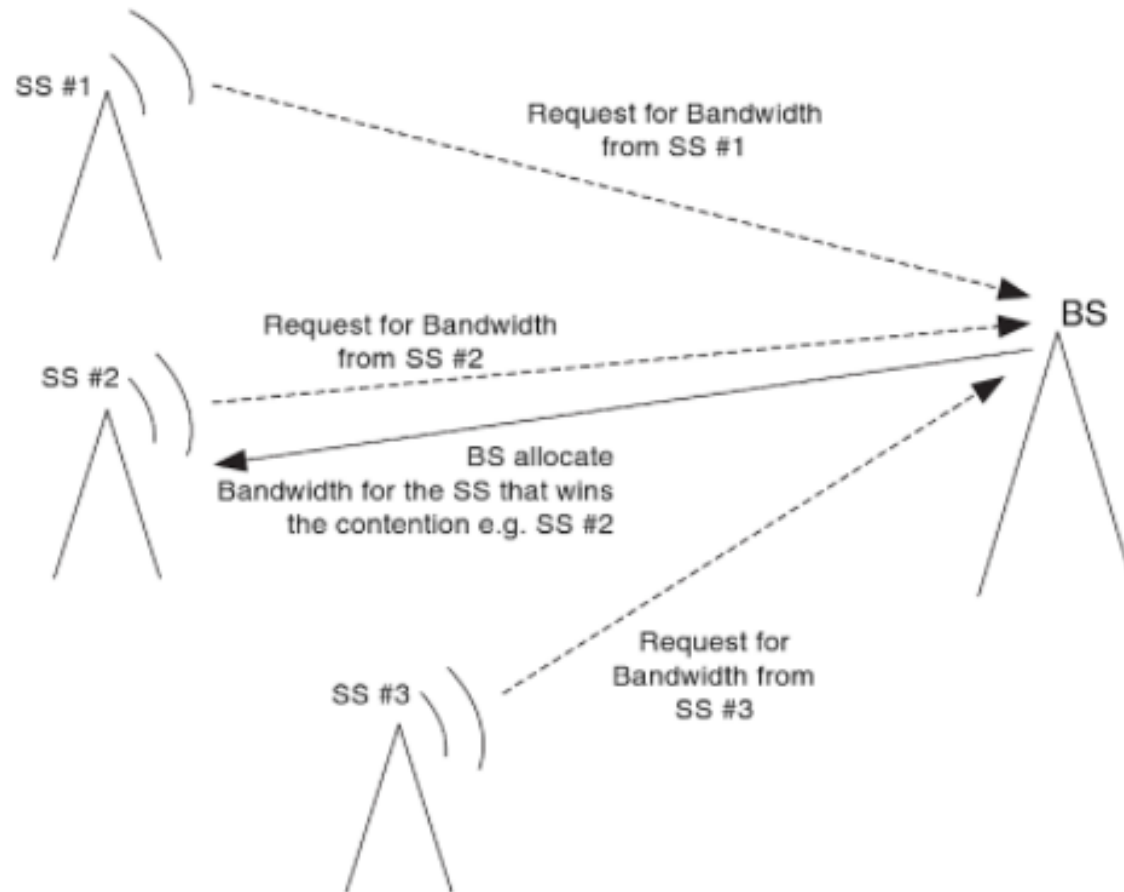
- Unicast polling



WiMAX : MAC Layer QoS options

- Contention-based Group (Multicast or Broadcast) Polling
 - The available bandwidth may not be sufficient to individually poll all inactive SSs. Contention-based grant-request mechanisms are allocated a small part of each uplink frame
 - If the BS receives the demand it evaluates the SS request in the context of its service-level, network state, scheduling algorithm and possibly allocates a slot in which the SS can transmit data.
 - Some SSs, such as those inactive for a long period of time and/or with low access priority, may then be polled in multicast groups. In some cases, a broadcast poll may also be made.
 - Thus, multicast polling saves the bandwidth with regard to the scheme where all SSs are polled individually. In the case where this polling is made to a group of SSs, the allocated bandwidth is specifically for the purpose of making bandwidth requests.

WiMAX : MAC Layer QoS options



What is the **service-level**?

WiMAX : MAC Layer QoS options

Quality/Classes of service

1. CBR => Unsolicited Grant Service (UGS)
2. Real-time VBR service => Real-Time Polling Service (rtPS)
3. Non-real-time VBR service => Non-Real-Time Polling Service (nrtPS)
4. Best-effort service (BE)

WiMAX : MAC Layer QoS options

- Unsolicited Grant Service (UGS)
 - UGS is primarily intended for Constant-Bit-Rate (CBR) services such as VoIP, which means that achieving low latency and low jitter is very important.
 - At the same time, low percentage of packet drops is possible.
 - UGS flows are configured to send fixedsize packets at recurring intervals with as little latency and jitter as possible.
 - Allows, BS to give automatic grants to a UGS flow (no access request, reserved slot), reduces latency
 - over-the-air latency in a WiMAX network is small (5-40 ms)
 - Relatively higher in IP backbone (100ms),

WiMAX : MAC Layer QoS options

- Real-Time Polling Services (rtPS):
 - Designed to support real-time services that generate variable size data packets on a periodic basis, such as MPEG video.
 - But it is sensitive to delay
 - It requires more overhead than UGS, but supports variable sizes for optimum data transport efficiency.
 - But overhead exists even when the flows are idle, and for as long as they are active.

WiMAX : MAC Layer QoS options

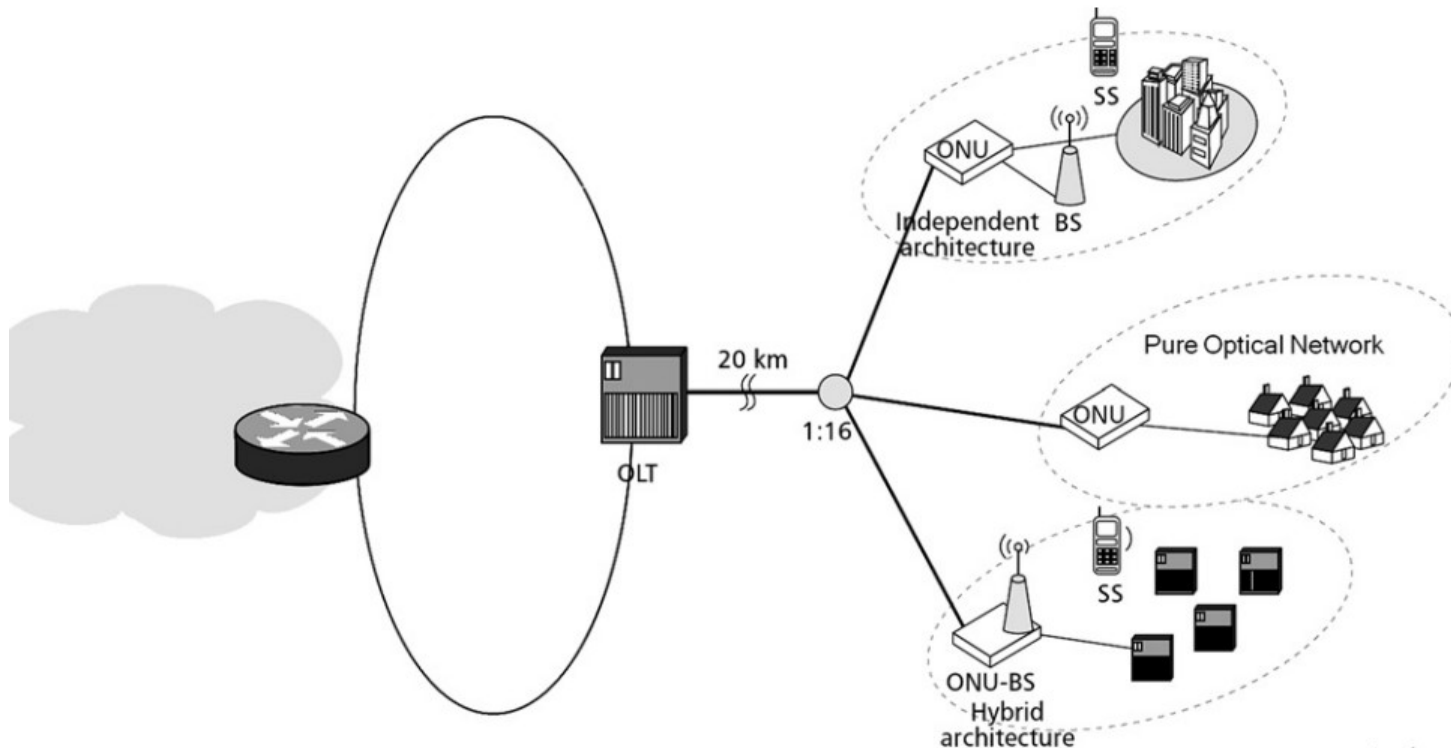
- Non-Real-Time Polling Service (nrtPS)
 - This service is intended to support non-real-time service flows that require variable size data packets and support delay tolerant services, such as FTP.
 - It provide services on a regular basis, which ensures that the service flow receives requests even during network congestion (get minimum data rate).

WiMAX : MAC Layer QoS options

- Best Effort (BE)
 - The BE service is intended to support data streams that don't require minimum guaranteed rate, and could be handled on best available basis. Unicast polling requests are not guaranteed in this
 - case, requiring contention requests to be used. BE packets may
 - therefore take a long time to transmit during network congestions.

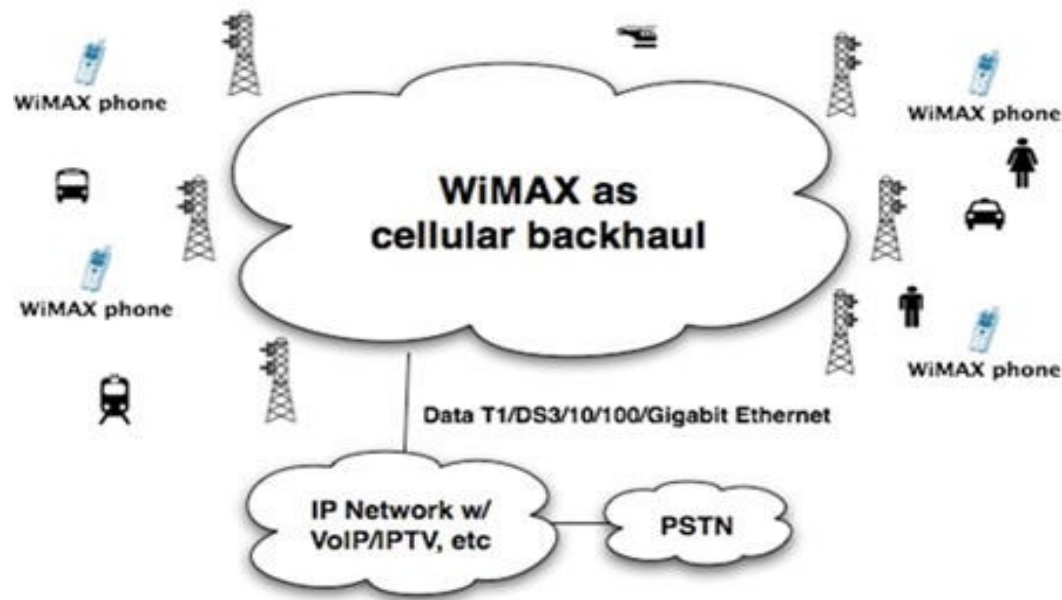
WiMAX

- Integrated with Optical Networks
 - For higher bit rates



Future WiMAX

- WiMAX as a mobile voice and data network is potentially exponentially more efficient (profitable) than the legacy cellular infrastructure



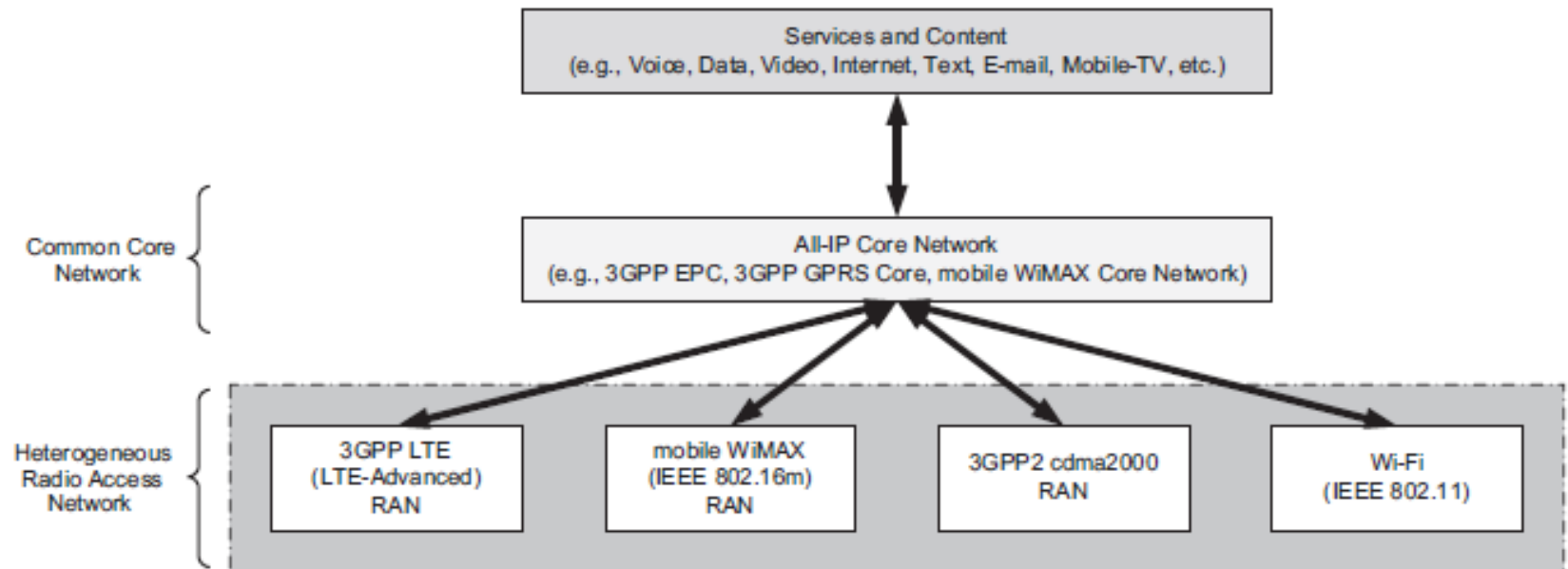
South Korea
developed first
commercial
mobile WiMAX in
2006

2009 first launch
of WiMAX
enabled phone



WiMAX

- Convergence of Mobile Broadband Wireless Access Technologies
 - The inter-technology interworking functions, handover between heterogeneous technologies, as well as use of unified core network functions such as user authentication, authorization, and accounting for various radio access technologies.



Variants of WiMAX

	802.16	802.16a/Rev d	802.16e
Completed	December 2001	802.16a: Jan 2003 802.16Revd: June 2004	Est. Mid-2005
Spectrum	10 - 66 GHz	2 - 11 GHz	2 - 6 GHz
Application	Backhaul	Wireless DSL & Backhaul	Mobile Internet
Channel Conditions	Line of Sight Only	Non Line of Sight	Non Line of Sight
Bit Rate	32 – 134 Mbps at 28MHz channelization	Up to 75 Mbps at 20MHz channelization	Up to 15 Mbps at 5MHz channelization
Modulation	QPSK, 16QAM and 64QAM	OFDM 256 sub-carriers QPSK, 16QAM, 64QAM	Scalable OFDMA
Mobility	Fixed	Fixed	Pedestrian Mobility – Regional Roaming
Channel Bandwidths	20, 25 and 28 MHz	Selectable channel bandwidths between 1.5 and 20 MHz	Same as 802.16a with UL sub-channels to conserve power
Typical Cell Radius	1-3 miles	4 to 6 miles; Max range 30 miles based on tower height, antenna gain and power transmit	1-3 miles

WiMAX vs WiFi

	WiFi 802.11g	WiMAX 802.16-2004*	WiMAX 802.16e
Approximate maximum reach	100 meters	8kms	5kms
Approximate maximum throughput	54 Mbps	75 Mbps (20 MHz band)	30Mbps (10 MHz band)
Typical Frequency bands	2.4 GHz	2-11 GHz	2-6 GHz
Application	Wireless LAN	Fixed Wireless Broadband (eg-DSL alternative)	Portable Wireless Broadband