Understanding WiMAX

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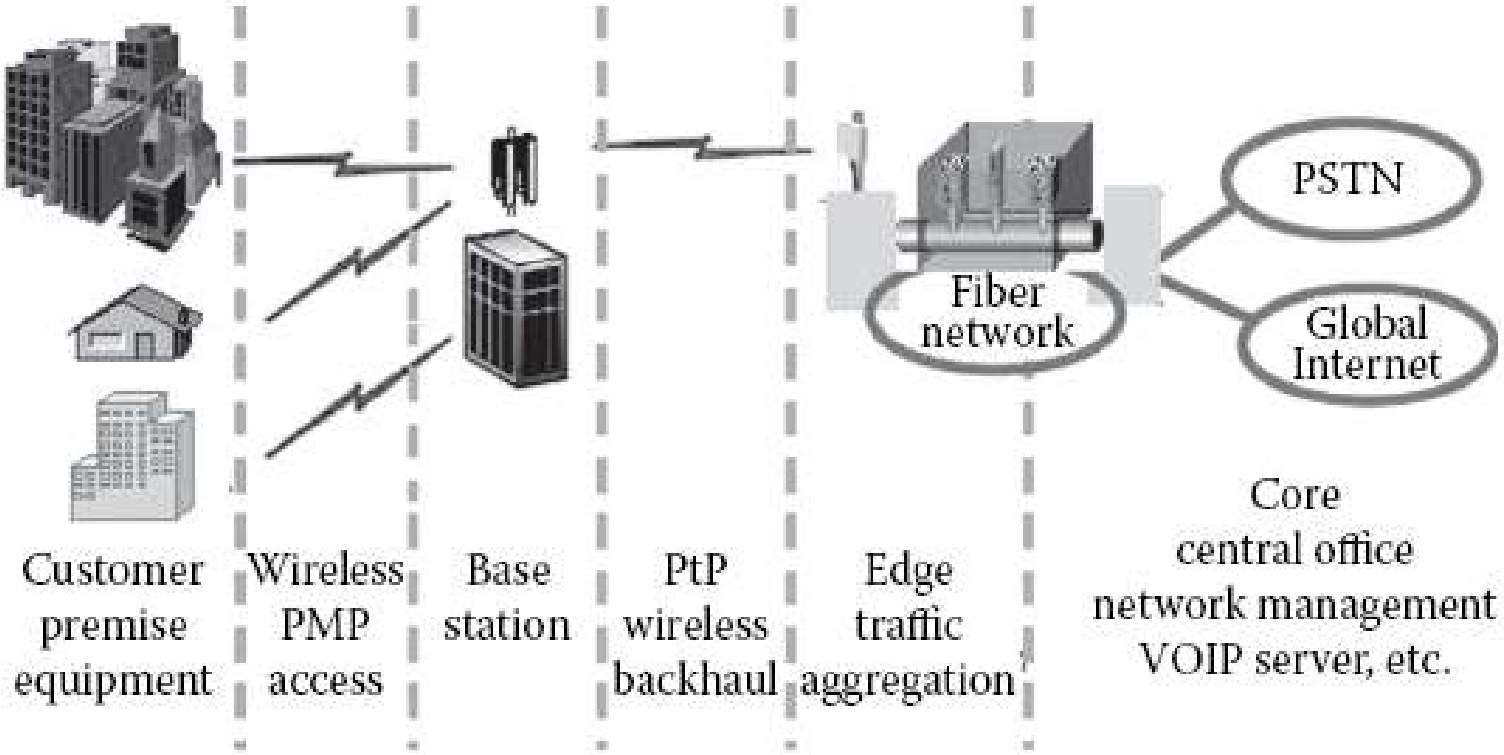
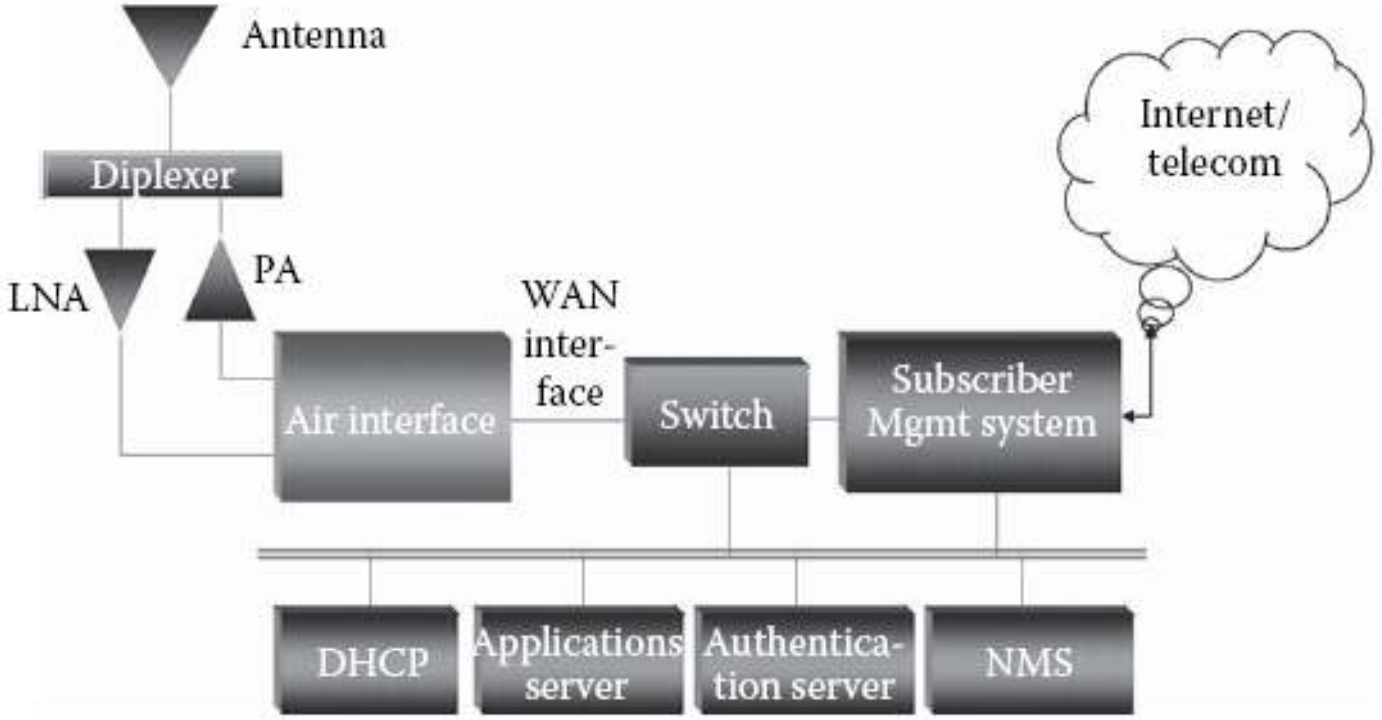
WiMAX Network

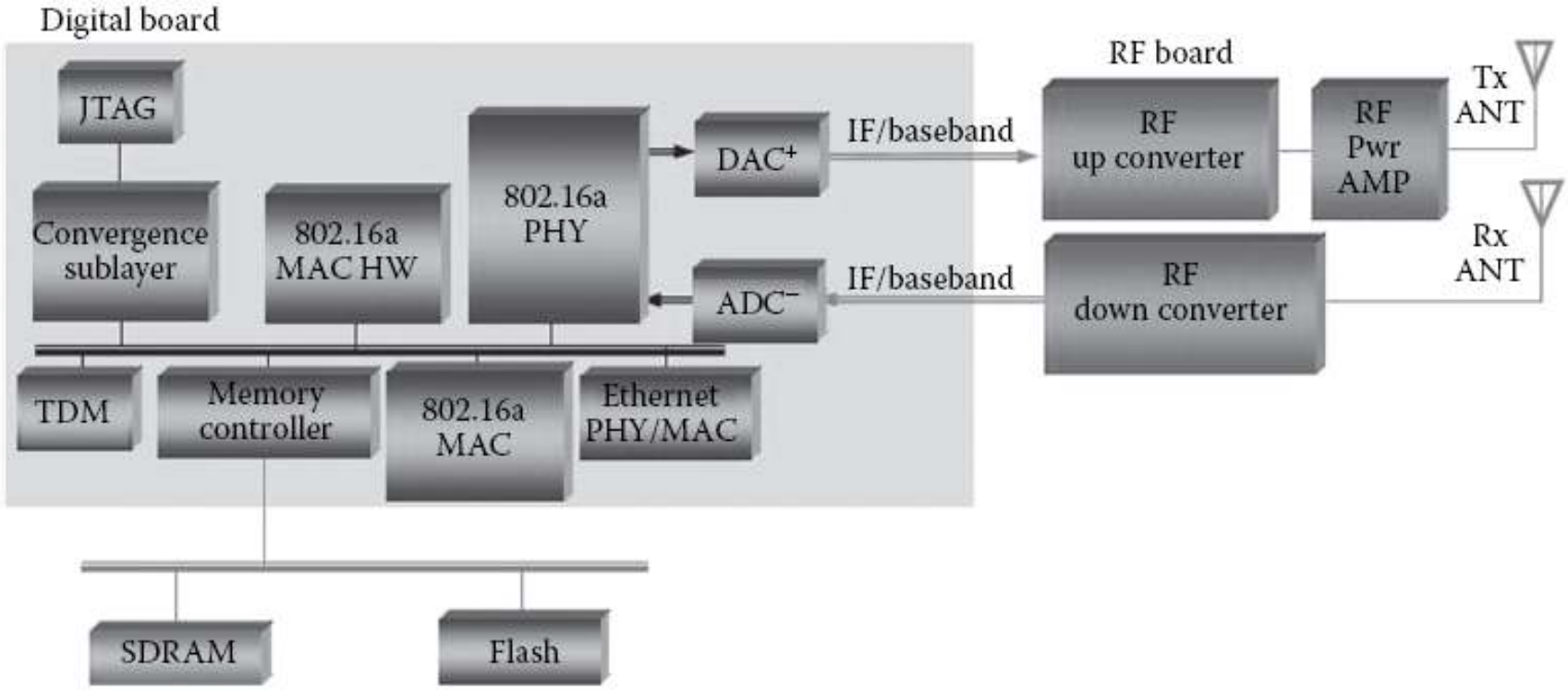


WiMAX Base Station



Support from a few to thousands of subscriber stations

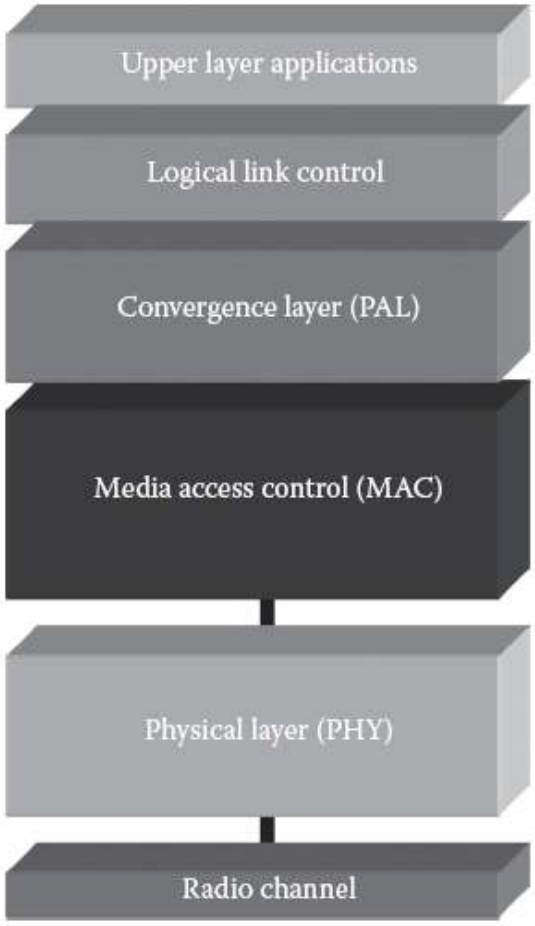
WiMax CPE


Digital board
JTAG
Convergence sublayer
802.16a MAC HW
802.16a PHY
DAC+
ADC−
IF/baseband
IF/baseband
RF board
RF up converter
RF Pwr AMP
Tx ANT
RF down converter
Rx ANT
TDM
Memory controller
802.16a MAC
Ethernet PHY/MAC
SDRAM
Flash

WiMax Standards

- IEEE 802.16 - 10 to 66 GHz, fix access, LOS, more bandwidth , up to 30 miles radius.
- IEEE 802.16a - 2 to 11 GHz, nomadic access, NLOS, up to 75 Mbps, more customer connection to single tower, limited radius between 4 to 6 miles.
- IEEE 802.16e – 2 to 66 GHz, add mobility/portability capability, smart antenna (MIMO), enhanced capability
- IEEE 802.16f – improve coverage using mesh networking
- IEEE 802.16g – add Capability to support mobility at higher layers and across backhaul.

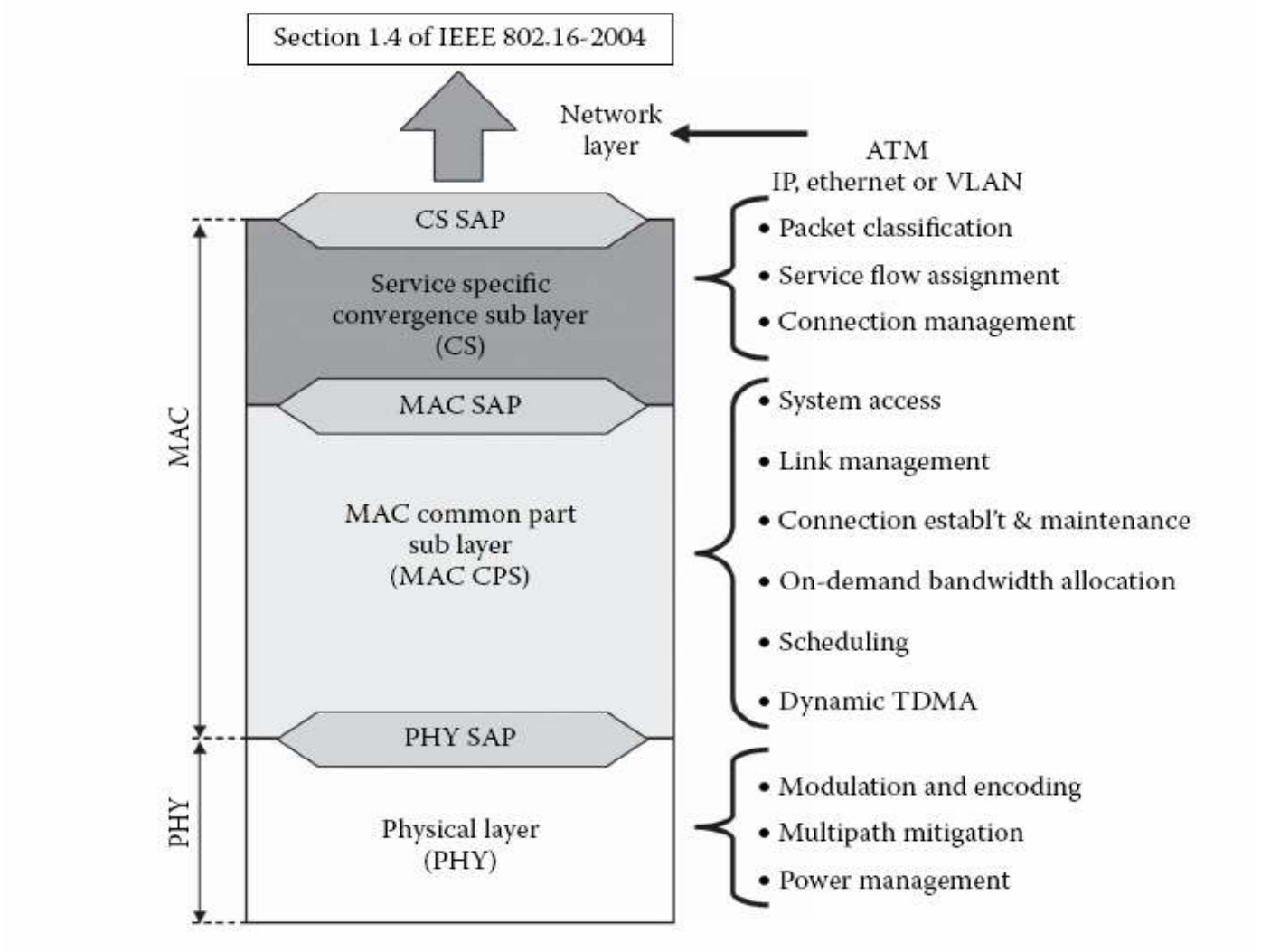
WiMax Protocol Stacks Reference Model



IEEE 802.11a Physical Layer Features

Features	*Benefits*
256-point FFT OFDM waveform	Built-in support for addressing multi-path in outdoor LOS and NLOS environments
Adaptive modulation and variable error correction encoding per RF burst	Ensures a robust RF link while maximizing the number of bits/ second for each subscriber unit
TDD and FDD duplexing support	Addresses varying worldwide regulations where one or both may be allowed
Flexible channel sizes (e.g., 3.5 MHz, 5 MHz, 10 MHz, etc.)	Provides the flexibility necessary to operate in many different frequency bands with varying channel requirements around the world
Designed to support smart antenna systems	Smart antennas are fast becoming more affordable, and as these costs come down their ability to suppress interference and increase system gain will become important to BWA deployments

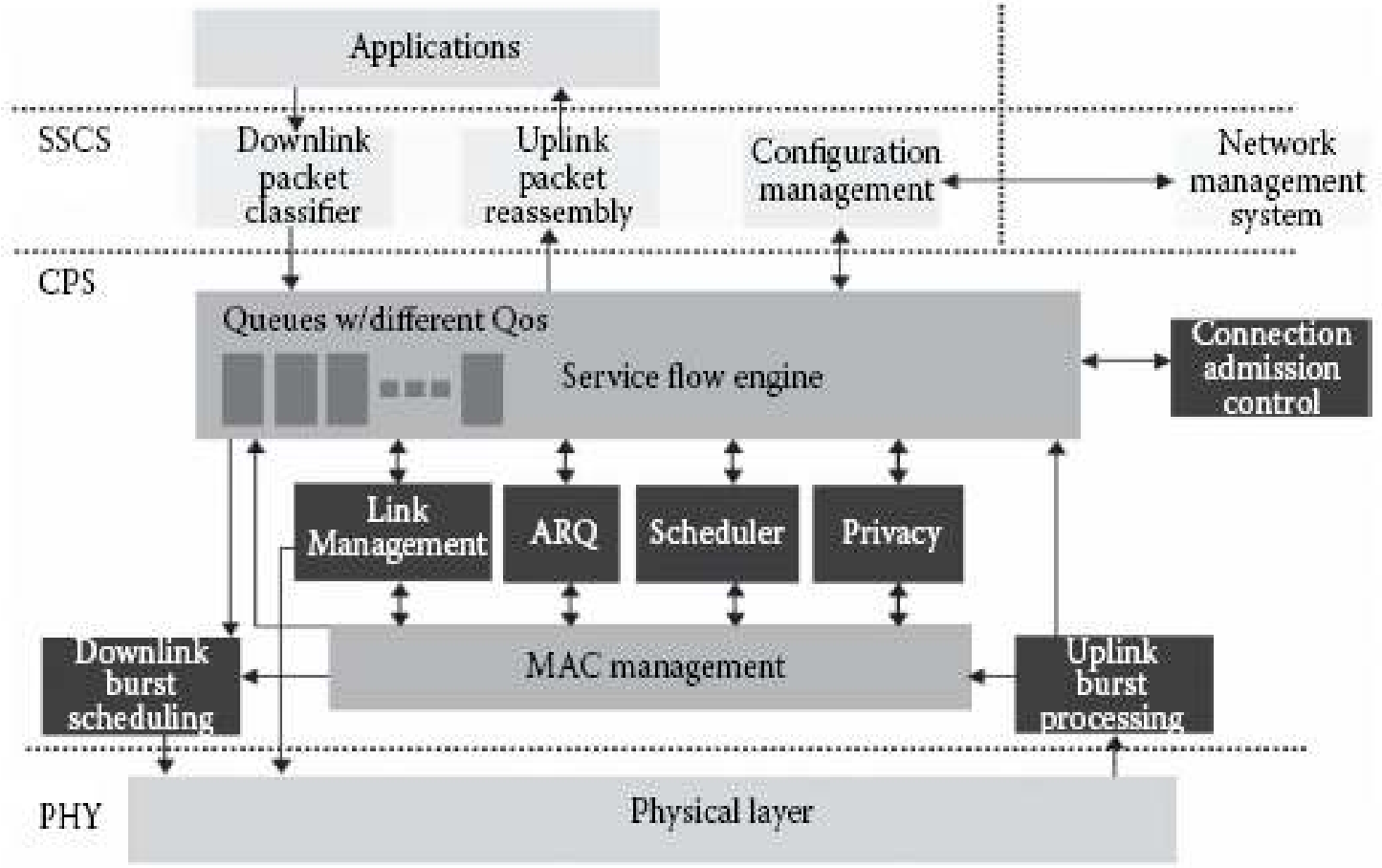
WiMAX PHY/MAC Layer



IEEE 802.16a MAC Layer Features

Features	*Benefits*
TDM/TDMA scheduled uplink/downlink frames	Efficient bandwidth usage
Scalable from one to hundreds of subscribers	Allows cost-effective deployments by supporting enough subscribers to deliver a robust business case
Connection oriented	Per-connection QoS; faster packet routing and forwarding
QoS support	Low latency for delay-sensitive services (TDM voice, VoIP); Optimal transport for VBR traffic (e.g., video);· data prioritization
Automatic repeat request (ARQ)	Improves end-to-end performance by hiding RF-layer-induced errors from upper-layer protocols
Support for adaptive modulation	Enables highest data rates allowed by channel conditions, improving system capacity
Security and encryption (Triple DES)	Protects user privacy
Automatic power control	Enables cellular deployments by minimizing self-interference

WiMAX MAC Layer



SSCS – Service Specific Convergence Sublayer

CPS – Common Part Sublayer

Power Control

- WiMAX network uses Power control algorithm to control both transmit and receive power
- Base Stations sends power control information to each CPE to regulate transmit power level so that the level receive at the base station is at a predetermined level
- Power control reduces the overall power consumption of the CPE and the potential interference with other colocated base station. *For LOS, CPE transmit power proportional to distance from base station and NLOS depends on clearance & obstruction*
- Power levels are dynamically adjusted on a per-subscriber basis, depending on the profile and distance from the base station. *For the base station transmitter, the actual transmitted power will depend on the subscriber distance, propagation characteristics, channel bandwidth, and modulation scheme (BPSK, QPSK, 16QAM, or 64QAM).*

Smart Antenna

- WiMAX uses smart antenna to increase signal spectral density (channel capacity) and SNR to reduce multi-path fading/interference.
- WiMAX supports several adaptive smart antenna types:

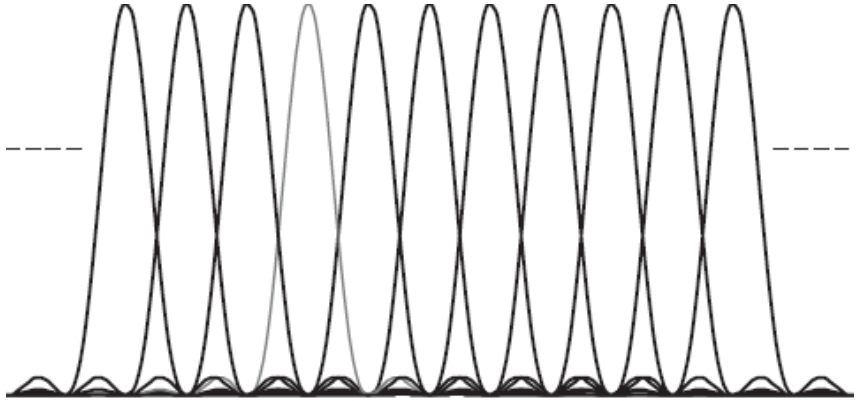
  1) Transmit/Receive spatial diversity antennas (MIMO): Multiple antennas transmitting & receiving the signal on Base Station and Subscriber stations. The antennas need to be placed at least half a wavelength apart. This minimum distance ensures that the antennas are incoherent to reduce multi-path fading

  2) Beam-steering antennas: These shape the antenna array pattern to produce high gains in the useful signal direction or notches that reject interference.

  3) Beam-forming antennas: These allow the area around a base station to be divided into sectors, allowing additional frequency reuse among sectors.

OFDM- Orthogonal Frequency Division Multiplexing

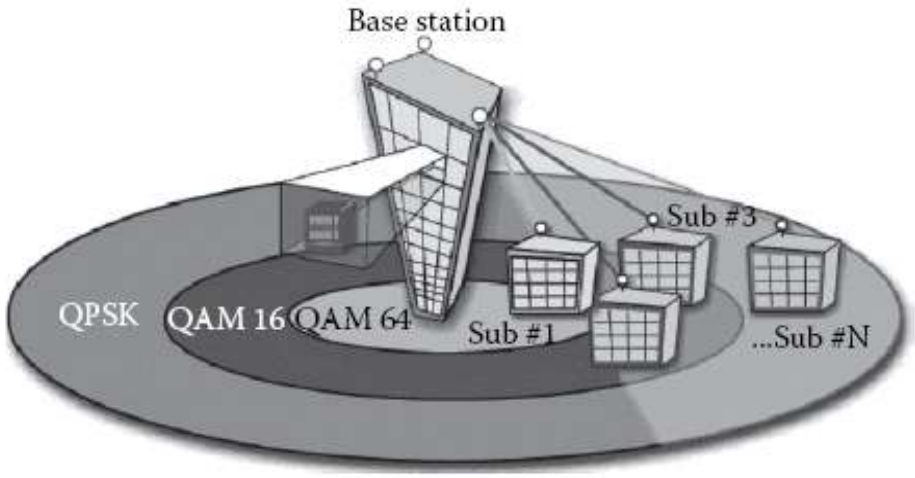
- OFDM - a multicarrier technique that allows broadband transmission in a mobile environment with fewer multi-path effects (interference and frequency-selective fading) than a single signal with broad bandwidth modulation.
- OFDM is similar to FDM but achieves more spectral efficiency by spacing the subcarriers much closer together by using frequencies that are orthogonal, allowing each subcarrier to overlap another without interference using no guard bands.
- OFDMA allows some subcarriers to be assigned to different users or subchannels with bandwidth range form 1.25 to 20 MHz.
- Inverse Discrete Fourier Transform (IDFT) for OFDM Modulation. Discrete Fourier transform (DFT) is used to demodulate an OFDM signal.
- OFDM's high spectral efficiency and resistance to multi-path make it an extremely suitable technology to meet the demands of wireless data traffic.



OFDM Subcarriers Spacing

Adaptive Modulation

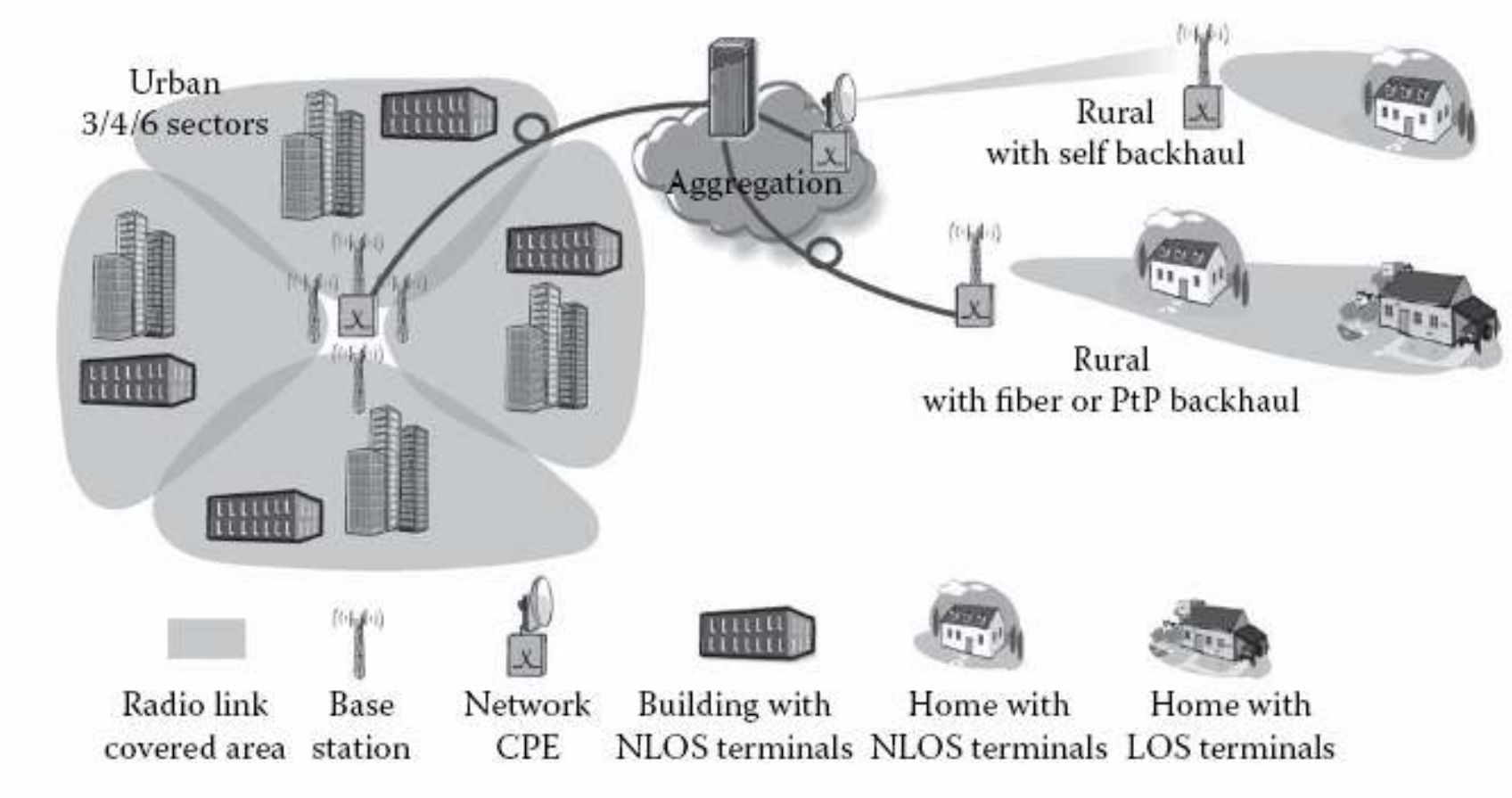
- 802.16 uses different modulation schemes: BPSK, QPSK,16QAM, 64QAM
- 802.16 supports adaptive modulation, which automatically increase effective range at the cost of decreasing throughput. Higher-order modulation (e.g., 64QAM provides high throughput at submaximum range, whereas lower-order modulation (e.g., 16QAM) provides lower throughput at higher range, from the same base station
- adaptive modulation allows a wireless system to choose the highest-order modulation, but better SNRs are needed to overcome any interference at a certain bit error ratio (BER). Adaptive modulation allows the system to overcome fading and other interferences by using lower order modulation.



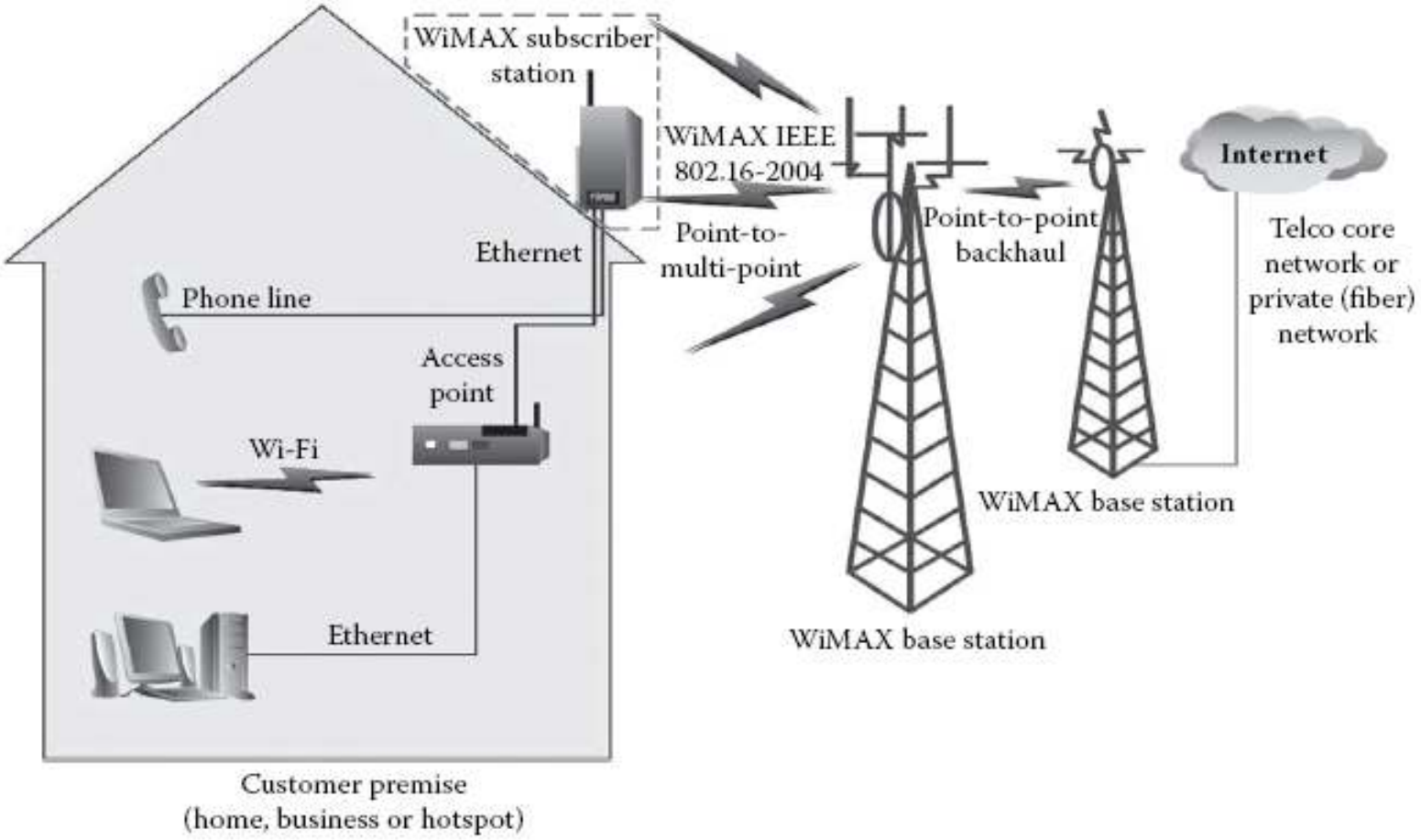
TDD Vs FDD

	TDD	*FDD*
Description	A duplexing technique used in license-exempt solutions and which uses a single channel for both the uplink and downlink	A duplexing technique utilized in licensed solutions that uses a pair of spectrum channels, one for the uplink and another for the downlink
Advantages	Enhanced flexibility because a paired spectrum is not required; Easier to pair with smart antenna technologies; Asymmetrical	Proven technology for voice; designed for symmetrical traffic; does not require guard time
Disadvantages	Cannot transmit and receive at the same time	Cannot be deployed where spectrum is unpaired; spectrum usually licensed; higher cost associated with spectrum purchase
Usage	Bursty, asymmetrical data applications; Environments with varying traffic patterns; In which RF efficiency is more important than cost	Environments with predictable traffic patterns; Where equipment costs are more important than RF efficiency

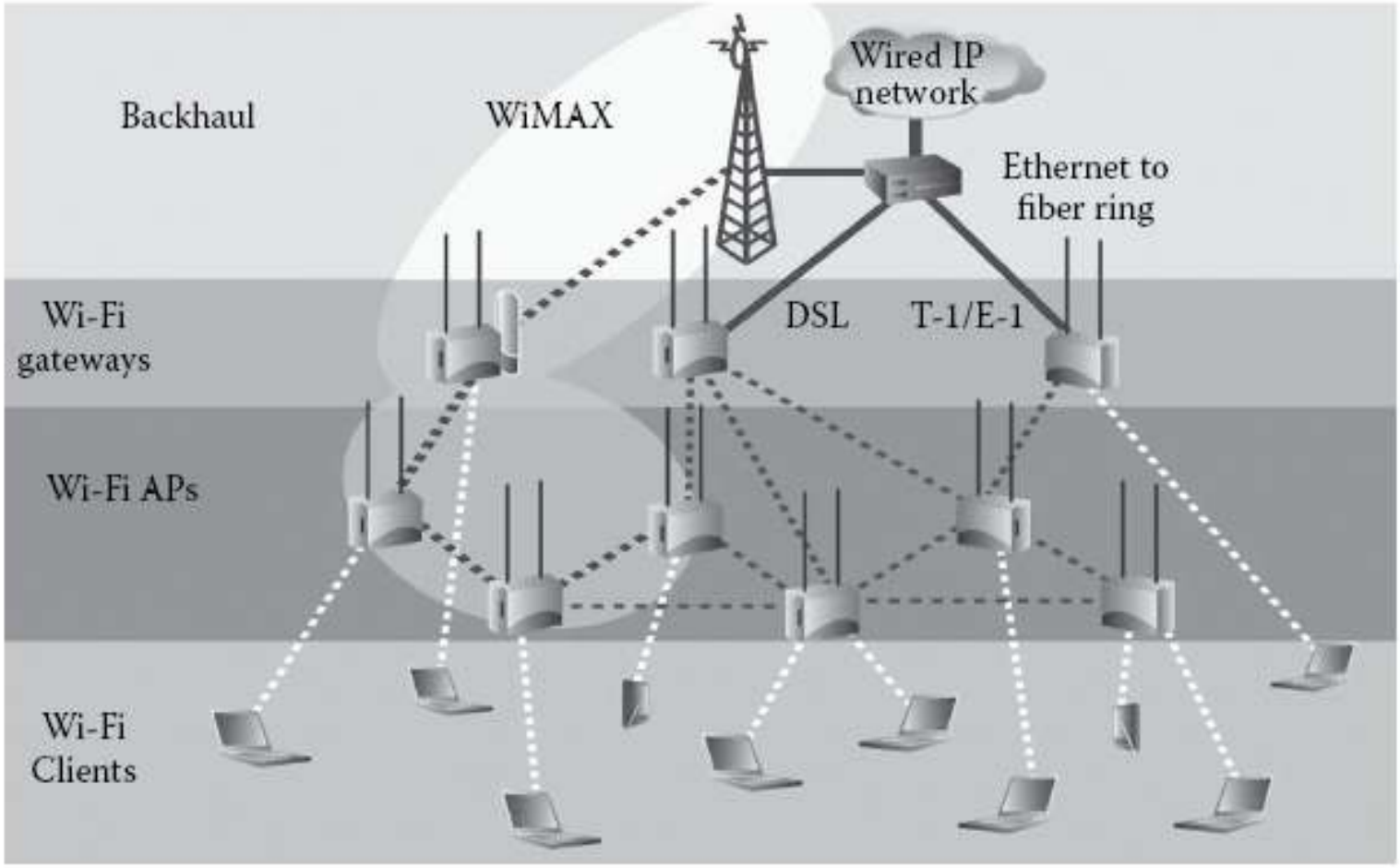
WiMAX in Rural and Urban Areas



WiMAX Network Topology



Mesh Networks



Mesh Network As Backhaul