Networking technologies and applications

May 2, 2015

SWOT analysis

- SWOT
  - Strengths (technological)
  - Weaknesses (technological)
  - Opportunities (business)
  - Threats (business)

- When starting a company, introducing a new product or service on the market
  - Technological and business considerations

DSL SWOT analysis

- Strengths
  - Quite large speed over low distances (VDSL2)
  - Bandwidth is not shared among the uses
    - Individual guarantees can be provided
  - Secure
    - Each user has his own twisted pair
    - The other users do not see my traffic

DSL SWOT analysis

- Weaknesses
  - Quite low speed over large distances
  - Asymmetric speed (ADSL) is not always acceptable
    - Some applications ask for high uplink speeds (e.g., Skype)
  - No support for mobility
    - Technically possible to extend your DSL connection with a wireless link
    - Legal limitations to such extensions

DSL SWOT analysis

- Opportunities
  - Easy to deploy everywhere where there is a phone line
  - Preferred when a minimum bandwidth is always required
    - In a cable modem or WLAN access, congestion can occur if many users in parallel
  - In industrial areas there might be no CaTV network, but phone lines are there
    - Industrial subscribers might also pay more than normal home subscribers, they are an important target

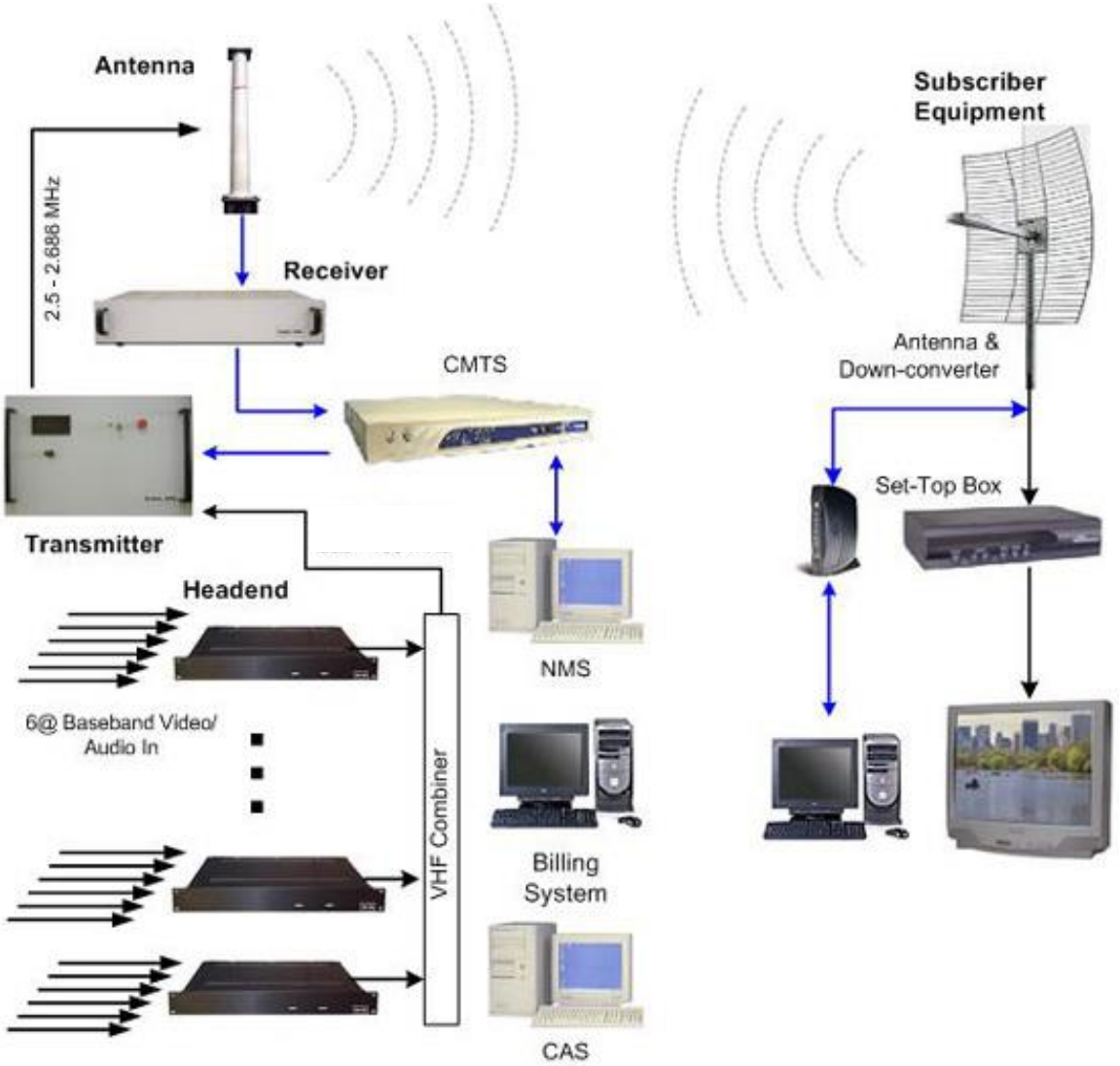
DSL SWOT analysis

- Threats
  - Where there is not yet a wired phone line (country side, developing countries) they might install FTTH from the beginning
  - FTTx (fiber to the home) ensures much higher speeds
    - Industrial subscribers probably will deploy FTTx
  - Wireless solutions (e.g., WLAN, WiMax, 3G) have a serious advantage as they allow mobility
  - In the country side, with sparsely distributed subscribers, it is costly to deploy, some wireless solutions (e.g., Wimax) would fit better

WLL

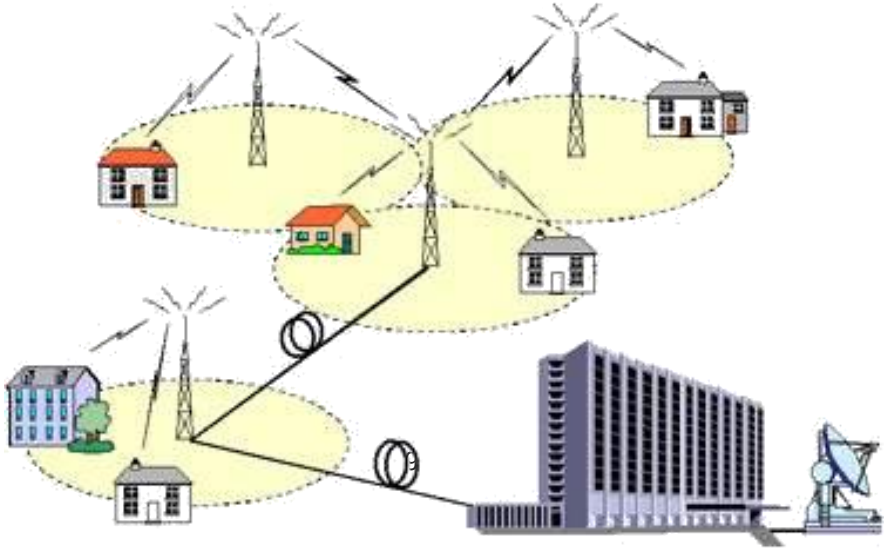
- Large competition on the broadband market
  - Many subscribers to reach
  - Very expensive to build an infrastructure
- Much simpler to build a wireless solution
  - Big antenna on the top of the hill, receiver antennas on the roofs
- Wireless Local Loop (WLL)
  - Fixed wireless solutions
    - Users are not mobile
- MMDS – Multi-channel Multipoint Distribution Service (wireless cable)
  - Microwave frequencies
    - 198 MHz wide frequency domain, between 2GHz and 3GHz
  - About 50 km range
    - Can pass through leaves and raindrops
  - Low bandwidth, many users share it (large range)

MMDS


Antenna
2.5 - 2.686 MHz
Receiver
CMTS
Transmitter
Headend
6@ Baseband Video/
Audio In
VHF Combiner
NMS
Billing
System
CAS
Subscriber
Equipment
Antenna &
Down-converter
Set-Top Box

LMDS

- Local Multipoint Distribution Service
- 1.3 GHz wide frequency domain
  - In the US between 28-31 GHz, in Europe around 40 GHz
  - The largest continuous frequency range ever reserved for a technology
- LMDS tower, many directional antennas
  - Each antenna covering a specific sector
    - 2-5 km service range
  - Several towers needed to cover a town



LMDS

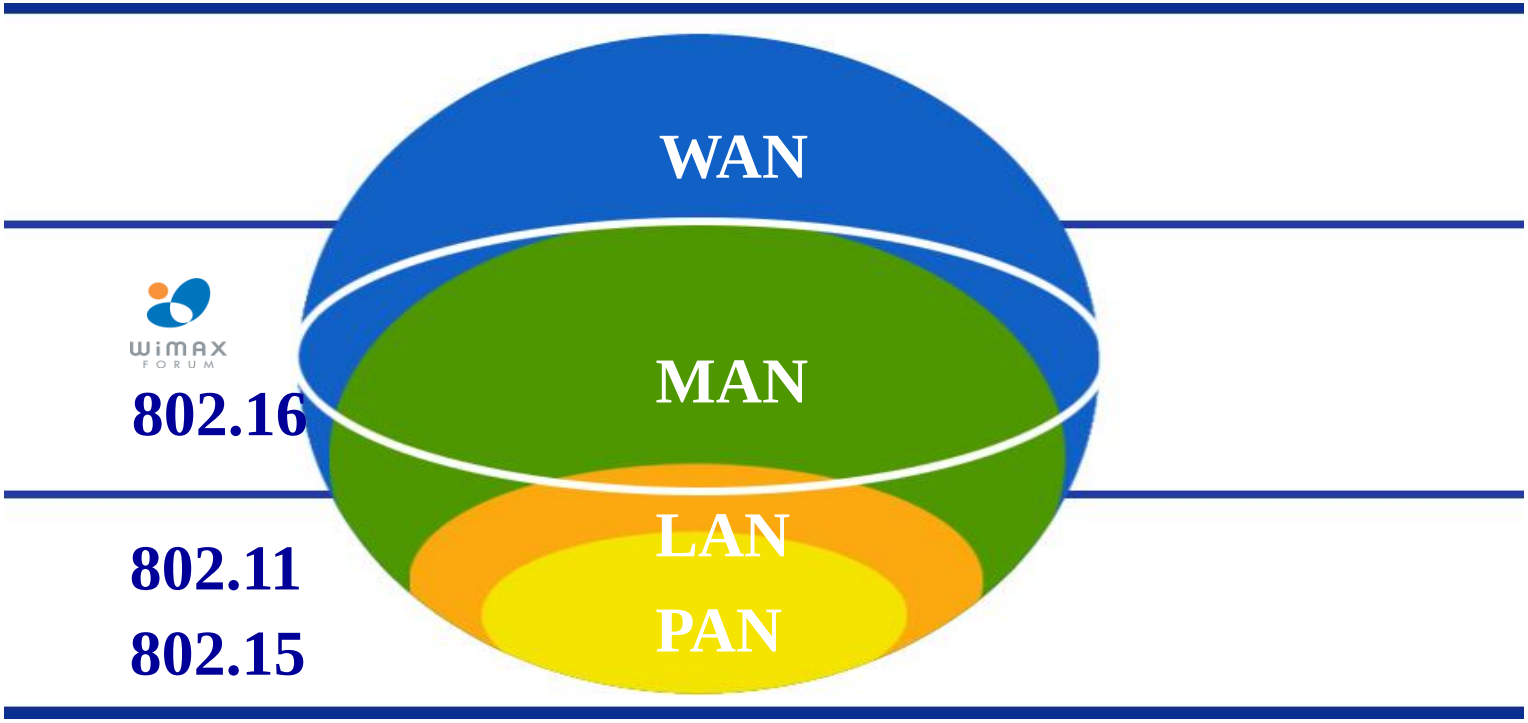
- Asymmetric bandwidth, similarly to ADSL
  - Larger downstream speeds
  - In each sector, 36 Gb/s downstream, 1 Gb/s upstream
    - shared between all the users
  - Maximum 9000 users in a sector
    - For a tower with 4 sector antennas, maximum 36.000 users in parallel
    - If at the peak time 33% of the subscribers are present, 1 tower can serve 100.000 subscribers
- Drawbacks
  - Needs direct line of sight between the antennas and the tower
  - Tree leaves and raindrops disturb the radio waves
    - Error correcting coding can reduce this
    - The tower has to be high enough
      - If free line of sight seems OK in December, this might not be true in July (because of the tree leaves)
- High prices and sparse deployment, because of the lack of standardization
  - In 1999 the IEEE starts working on the 802.16 standard family

IEEE 802.16

- Adopted in 2002
  - Wireless Metropolitan Area Network (Wireless MAN)

- WiMAX
  - Worldwide Interoperability for Microwave Access
  - A certificate that is given to a specific device if it complies with the 802.16 standard and is interoperable with other devices implementing the standard

Wireless Networking Standards



PAN: Private Area Network
LAN: Local Area Network
MAN: Metropolitan Area Network
WAN: Wide Area Network

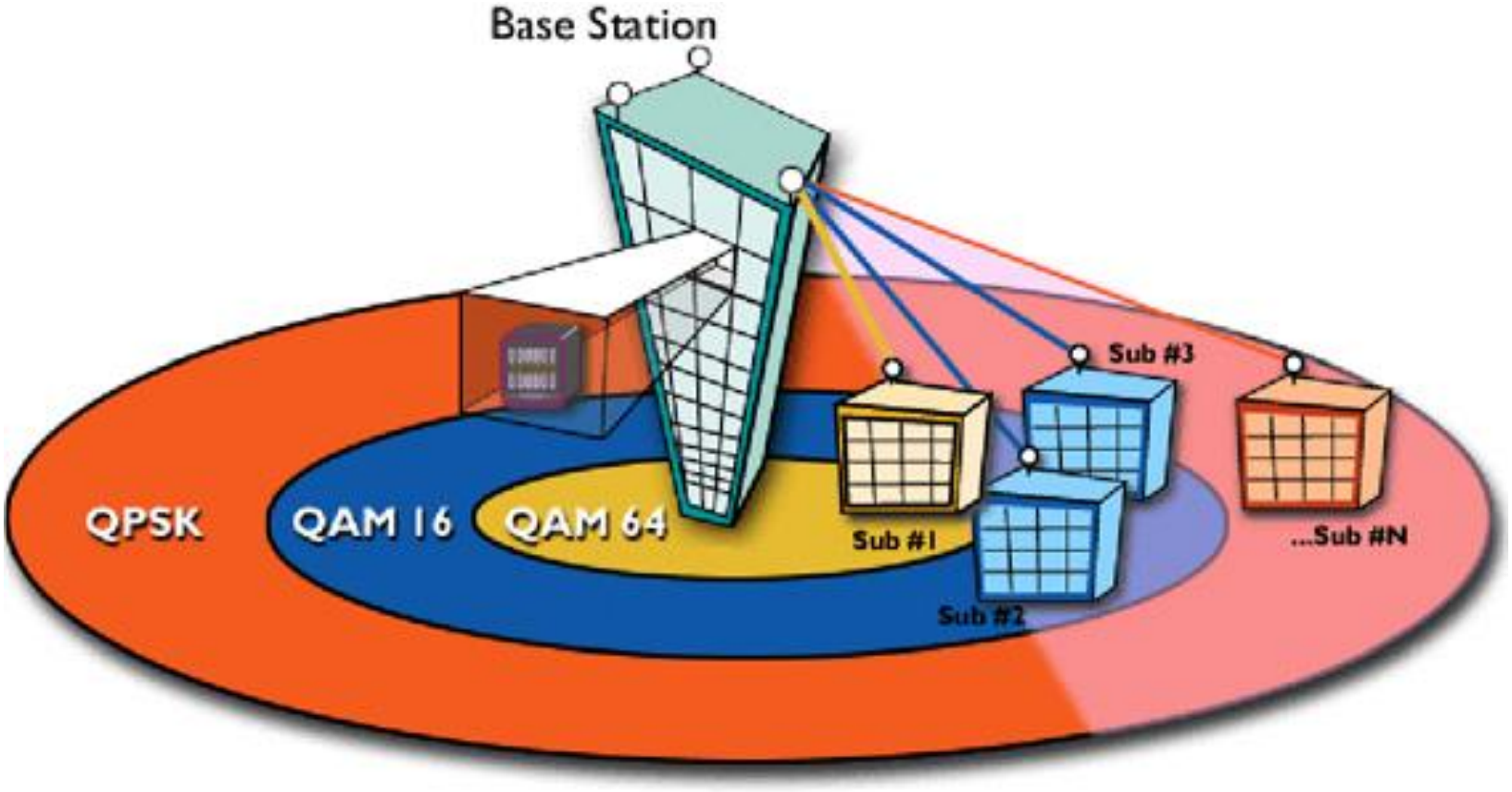
IEEE 802.16 versions

- 802.16c (2002) – WiMax in the 10-66 GHz domain
  - Maximum 134 Mbps, over a 2-5 km range
  - Line of Sight (LOS) operation mode
- 802.16a (2003) – WiMax in the 2-11 GHz domain
  - 70 Mbps speed, 50-70 km service range
    - Usually 10 Mbps, over 2 km range
  - Non Line of Sight (NLOS) operation mode
- 802.16d – integrates the16a and 16c versions
- 802.16-2004 – contains some small modifications compared to 16d
- 802.16e-2005 – support for mobile applications (Mobile WiMax)
  - Supports handover and power saving mechanisms

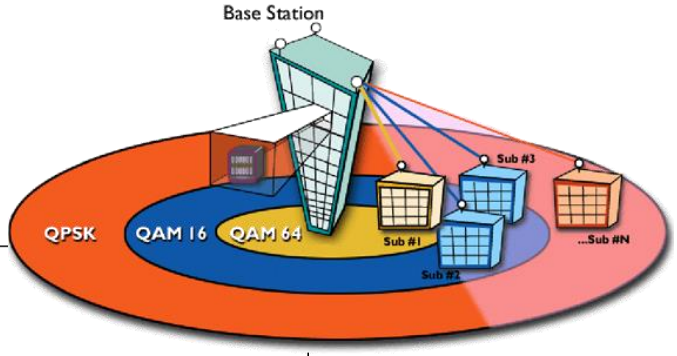
802.16 vs. 802.11

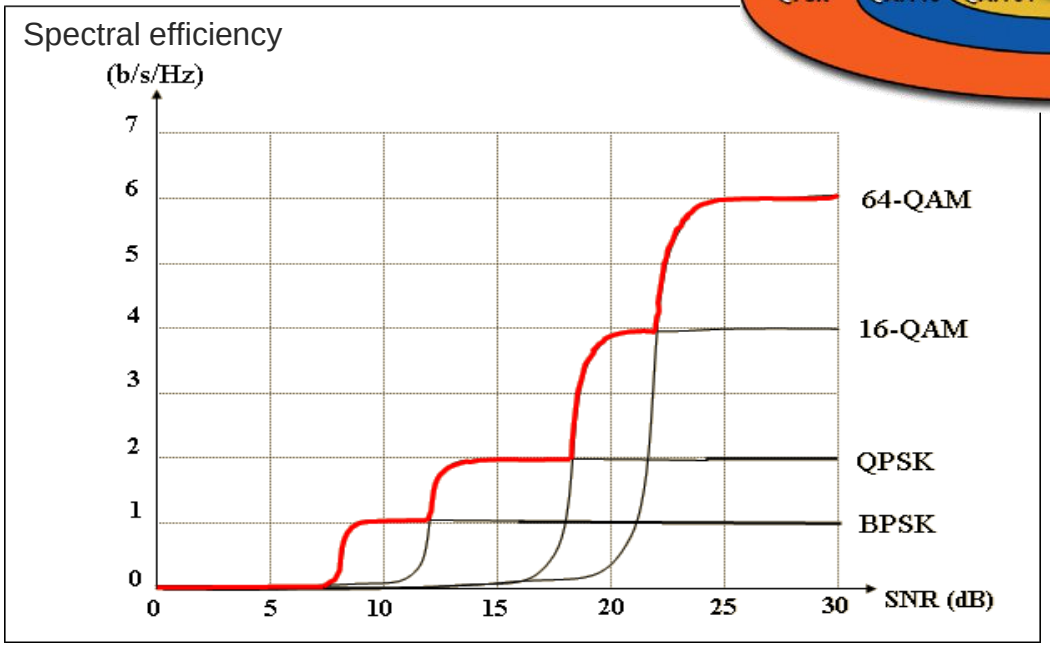
- Proposed to solve different problems
  - Both provide broadband wireless access
  - 802.16 provides services to „buildings”, no mobility
  - 802.11 developed especially for mobile environments
- The wireless communication over a large area provides important security & privacy concerns
- In an 802.16 cell much more users
  - Much larger bandwidth is needed than the ISM band can provide
- 802.16 covers entire cities or neighborhoods, over large distances
  - The base station’s signal strength shows large variations
    - Different modulation schemes, depending on the distance
    - Users close to the tower - QAM-64 (6 bit/baud)
    - Users not very far from the tower - QAM-16 (4 bit/baud)
    - Users far from the tower - QPSK (2 bit/baud)

802.16 physical layer



Modulation efficiency in function of the signal to noise ratio





Error correction coding in the physical layer

- In other solutions errors are detected and avoided only through the use of checksums
  - Wrongly transmitted frames are resent
- In a wireless networks, over a large service range, much more transmission errors are expected
  - Besides checksums in the upper layers, error correction in the physical layer
- The channel appears to be of a better quality than it really is

802.16 MAC layer

- In a GSM cell, similar frequency range for upstream and downstream traffic
  - Voice traffic is symmetric
- For broadband internet service, higher downstream required
  - In 802.16, flexible solution for duplexing

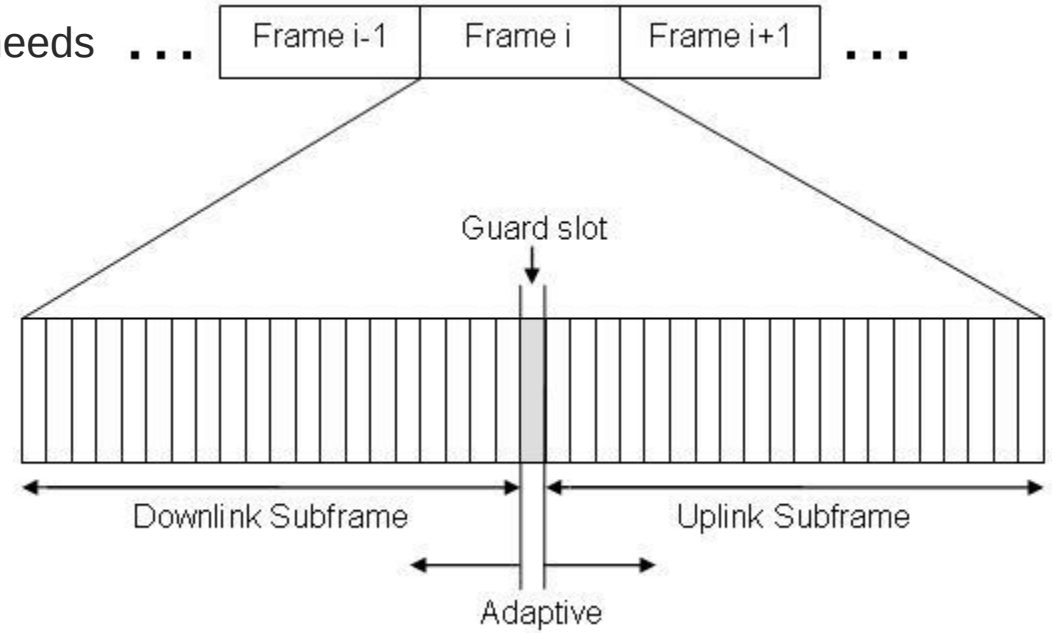
- FDD – Frequency Division Duplexing
  - Separate frequency band for upstream and downstream traffic
    - Two similar bands
  - A guard band between them
- TDD – Time Division Duplexing
  - Good solution for asymmetric traffic, with varying bandwidth needs

802.16 MAC layer

- Handling multiple users that share the channel
  - Downstream direction – TDM (Time Division Multiplex)
    - The base station serves the connections one after the other
  - Upstream direction – TDMA (Time Division Multiple Access)
    - Contention among the users

Time Division Duplexing

- The base station periodically sends its frames
  - Each frame contains time slots
    - First the slots reserved for downstream traffic
      - The base station assigns the traffic to the different slots
    - Then a guard slot
      - The stations change from listening mode to transmission mode
    - Then the time slots assigned for upstream traffic
  - The number of slots assigned for downstream/upstream can be changed dynamically
    - Based on the bandwidth needs



802.16 MAC layer

- A MAC frame is assigned an integer number of slots
  - Frames divided in sub-frames
  - The first 2 slots provide a map for the upstream and downstream traffic
    - What kind of traffic is assigned to the slots, which are the empty slots?
  - The downstream map contains some system parameters as well
    - Information necessary for newly connecting stations
- The downstream channel is handled by the base station
- Contention for the upstream channel
  - The channel access is closely related to the Quality of Service (QoS)
  - Four Service Classes defined in the standard
    - Constant Bit Rate (CBR)
    - Real Time Variable Bit Rate (rt-VBR)
    - Non-Real Time Variable Bit rate (nrt-VBR)
    - Best Effort (BE)

802.16 MAC layer

- CBR
  - Uncompressed voice transmission, without silence suppression
  - Unsolicited Grant Services (UGS)
  - Well defined amount of traffic to be handled at well defined time intervals
    - Time slots reserved for each such connection
    - No individual polling is needed
- rt-VBR
  - E.g., compressed multimedia traffic (MPEG video)
  - Real-time Polling Services (rtPS)
    - The required bandwidth is continuously changing
    - The base station periodically asks the stations about their bandwidth needs

802.16 MAC layer

- nrt-VBR
  - Transferring large amounts of data without real time requirements
  - Non-real-time Polling Services
  - The BS does a polling often, but not at strictly defined time intervals
    - If a station does not answer during k successive polling steps, the BS will not ask him anymore separately
      - Puts it in a multicast group
      - The group is also asked during the polling
      - Anyone can answer from the group, contention for the slots
    - Stations with low traffic demand do not waste the valuable time slots
- Best Effort
  - For all the remaining traffic
  - No polling, contention for the channel
    - In the upstream map, some slots reserved for contention
      - In these slots stations can ask for bandwidth
    - If their request is accepted, they will be informed about the assigned slots in the next frame
    - If the request is not satisfied, they might repeat the request
  - Collisions avoided like in Ethernet