Annex A – THE PHY AND MAC LAYERS OF 802.16-2001

PHY CONSIDERATIONS

- Line of Sight (because of 10 – 66 GHz)
  - Negligible multi-path => Large channels Large
- Broadband Channels
  - Wide channels (20, 25, or 28 MHz)
  - High capacity – Downlink AND Uplink
- Multiple Access
  - TDM/TDMA
  - High rate burst modems
- Adaptive Burst Profiles on Uplink and Downlink (choose QPSK, 16 QAM, 64 QAM depending on link conditions)
- Multiple duplex schemes
  - Time-Division Duplex (TDD)
  - Frequency-Division Duplex (Frequency-Division Duplex (FDD) [including Burst FDD]
  - Support for Half-Duplex Terminals

ADAPTIVE BURST PROFILES

- Burst profile
  - Modulation and FEC
- Dynamically assigned according to link conditions
  - Burst by burst, per subscriber station
  - Trade-off capacity vs. robustness in real time
- Roughly doubled capacity for the same cell area
- Burst profile for downlink broadcast channel is well-known and robust
  - Other burst profiles can be configured “on the fly”
  - SS capabilities recognized at registration

MODULATION

- Single Carrier QAM, Gray coded
  - QPSK
  - 16QAM

    - Mandatory for Downlink, Optional for Uplink
  - 64QAM
    - Optional for both Downlink and Uplink

- Preambles based on 16-symbol CAZAC sequences

FEC

- Reed Solomon
  - RS GF(256), t =0 …16
- For most critical communications, RS is concatenated with a BCC
  - No interleaving, suitable for burst
  - BCC is a rate 2/3 block code based on a tail-bite termination of the $(7,5)_8$ Convolutional Code for every 16 data bits
  - Shortening allowed
- Turbo Product Codes (TPC) are optional

DUPLEX SCHEME SUPPORT

- On DL, SS addressed in TDM stream
- On UL, SS is allotted a variable length time slot for transmission
- Time-Division Duplex (TDD)
  - DL and UL time-share the same RF channel
  - Dynamic asymmetry
  - SS does not transmit/receive simultaneously (low cost)
- Frequency-Division Duplex (FDD)
  - Downlink and Uplink on separate RF channels
  - Static asymmetry
  - Half-duplex SSs supported
    - SS does not transmit/receive simultaneously (low cost)

BAUD RATES AND CHANNEL SIZE (10 – 66 GHZ)

- Flexible plan – allows equipment manufactures to choose according to spectrum requirements

Channel Width (MHz)	Symbol Rate (Msym/s)	QPSK	16-QAM	64-QAM
		Bit Rate (Mbit/s)	Bit Rate (Mbit/s)	Bit Rate (Mbit/s)
20	16	32	64	96
25	20	40	80	120
28	22.4	44.8	89.6	134.4

802.16 MAC: OVERVIEW

- Point-to-Multipoint
- Metropolitan Area Network
- Connection-oriented
- Supports difficult user environments
  - Very high bit rates, downlink and uplink
  - Hundreds of users per channel
  - Continuous and burst traffic
  - Very efficient use of spectrum
  - Likelihood of terminal being shared (Base Station may be heavily loaded)
- Protocol-Independent core
  - Convergence layers to ATM, IP, Ethernet, ...
- Balances between stability of contentionless and efficiency of contention-based
- Flexible QoS offerings
  - CBR, rt-VBR, nrt-VBR, BE, with granularity within classes
- Supports multiple 802.16 PHYs
  - Adaptive mod, TDD/FDD; single-carrier, OFDM/OFDMA, etc.
- Security

ATM CONVERGENCE SUBLAYER

- Support for:
  - VP (Virtual Path) switched connections
  - VC (Virtual Channel) switched connections
- Support for end-to-end signaling of dynamically created connections:
  - SVCs SVCs

    - Soft soft PVCs PVCs
- ATM header suppression
- Full QoS support

PACKET CONVERGENCE SUBLAYER

- Initial support for Ethernet, IPv4 and IPv6
- Payload header suppression
    - Generic plus IP-specific
- Full QoS support
- Possible future support for:
    - PPP
    - MPLS

MAC ADDRESSING

- SS has 48-bit IEEE MAC Address
- BS has 48-bit Base Station ID
    - Not a MAC address
    - 24-bit operator indicator
- 16-bit Connection ID (CID)
    - Used in MAC PDUs

DOWNLINK TRANSMISSIONS

- Two kinds of bursts: TDM and TDMA
- All bursts are identified by a DIUC
    - Downlink Interval Usage Code
- TDMA bursts have resync preamble
    - Allows for more flexible scheduling
- Each terminal listens to all bursts at its operational IUC, or at a more robust one, except when told to transmit
- Each burst may contain data for several terminals
- SS must recognize the PDUs with known CIDs
- DL-MAP message signals downlink usage

UPLINK TRANSMISSIONS

- Invited transmissions
- Transmissions in contention slots
  - Bandwidth requests
  - Contention resolved using truncated exponential backoff
- Transmissions in initial ranging slots
  - Ranging Requests (RNG-REQ)
  - Contention resolved using truncated exponential backoff
- Bursts defined by UIUCs
- Transmissions allocated by the UL-MAP message
- All transmissions have synchronization preamble
- Ideally, all data from a single SS is concatenated into a single PHY burst

CLASSES OF UPLINK SERVICE

Characteristic of the Service Flow

- Unsolicited Grant Services (UGS)
  - For constant bit-rate (CBR) or CBR-like service flows (SFs) such as T1/E1
- Real-time Polling Services (rtPS)
  - For rt-VBR-like SFs such as MPEG video
- Non-real-time Polling Services (nrtPS)
  - For nrt SFs with better than best effort service such as bandwidth-intensive file transfer
- Best Effort (BE)
  - For best-effort traffic