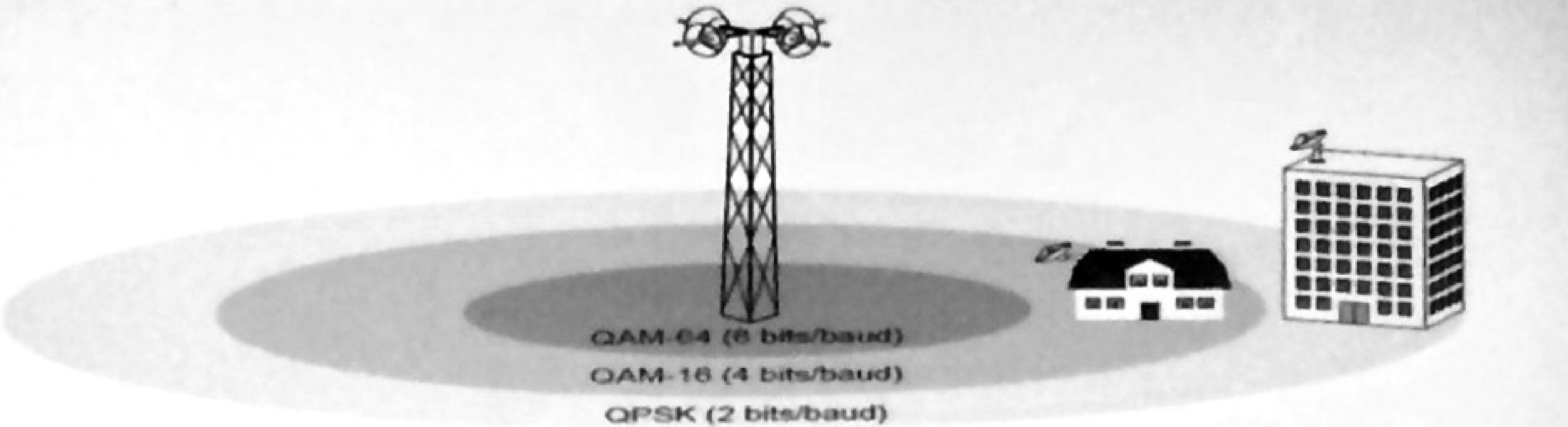
- Wireless network – 802.16 broadband wireless N/W (wireless MAN, WLL)
  - Need for a separate standard : 802.11 Vs 802.16
    - Static Vs Mobile
      - 802.16 provides wireless connection to buildings from static base stations
      - Much of 802.3 deals with mobility (both PCF & DCF)
    - Single Vs multiple stations in one location
      - 802.11 stations are usually a single entity – mostly, had held devices
      - Buildings can & do have multiple stations – handled by 802.16
    - Sophisticated high power Vs simple low power transceivers/ radio equipment
      - 802.11 mobile stations keep radio transceivers simple (half – duplex) because of cost/ size constraints, are highly power constrained (battery operated), have limited radio range
      - 802.16 transceivers & other radio equipment usually have non of these constraints; they are sophisticated state-of-the-art systems with full – duplex communication
    - Simple Vs elaborate security/ privacy mechanism
      - 802.11 is essentially for indoor use – an extended wireless 802.3 where perceived security threat level is appreciable lower as compared unrestricted outdoor urban environment
      - 802.16 wireless broadband 'MAN' needs elaborate security mechanism to ensure WEP

- Wireless network – 802.16 broadband wireless network
  - Need for a separate standard : 802.11 Vs 802.16 (cont.)
    - High Vs low bandwidth requirements
      - 802.16 must provide high bandwidth
        - All stations in most buildings(at varying distances from base station) may be streaming HD video, using real time interactive video, downloading big security sensitive files, etc.
        - Extremely unlikely that multiple 802.11 users will watch full length movies or download big sensitive files(financial transactions) on their hand held devices, all at the same time
      - High bandwidth channel possible only in available millimeter waves, i.e., 10 – 66 GHz range
        - Millimeter waves much more strongly absorbed by rain, snow, fog, etc., compared to longer wavelengths used in 802.11
        - 802.16 requires sophisticated error handling compared to 802.11
        - Millimeter waves can be focused in directional beams
        - 802.16 can use directional antennas to send focused radio beams to different city zones – NLOS transmission related complications minimised
        - 802.11 longer wavelength transmission is omnidirectional

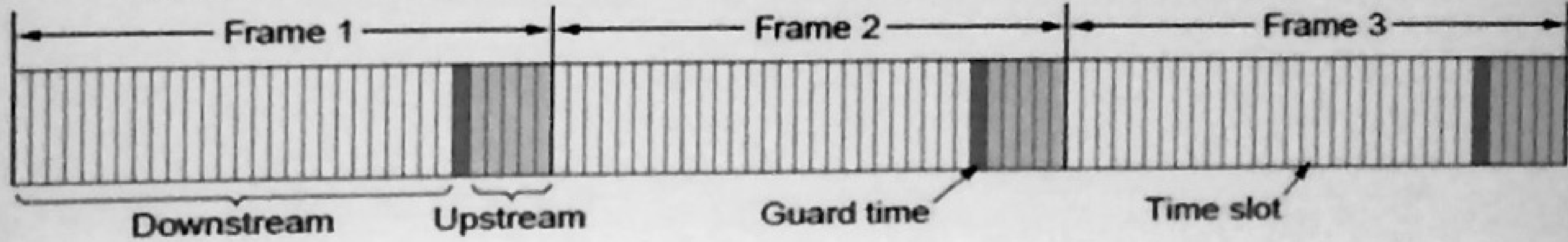
- Wireless network – 802.16 broadband wireless network
  - Need for a separate standard : 802.11 Vs 802.16 (cont.)



- High & multiple power levels Vs single, low power level transmission
  - 802.16 base station must communicate over full/ large part of city
  - Different power levels needed for city zones at different distances
  - Transmission/ reception at different power levels involves widely differing signal/ noise ratios
- Single Vs multiple modulation techniques
  - Varying S/ N ratio requires different modulation techniques
    - 802.16 uses three – QAM-64, QAM-16 & QPSK
  - Different modulation techniques result in different effective speeds : 25 MHz of spectrum gives 150, 100 & 50Mbps for QAM-64, QAM16 & QPSK respectively
  - 802.11 uses single power level & single modulation technique

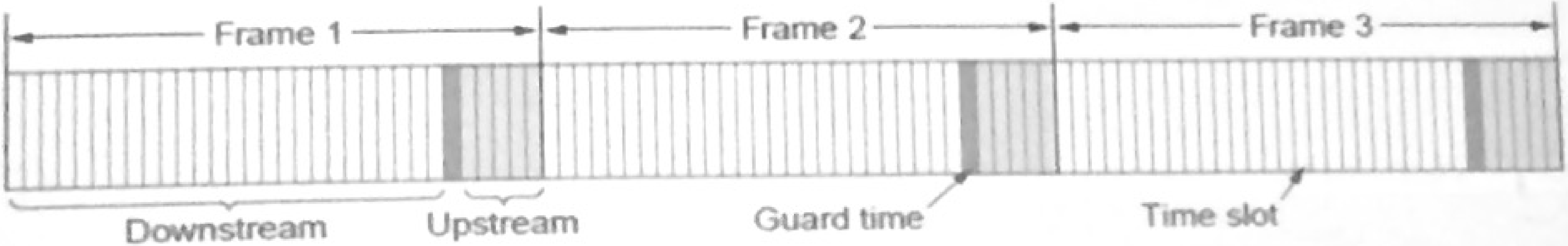
- Wireless network – 802.16 broadband wireless network
  - Need for a separate standard : 802.11 Vs 802.16 (cont.)
    - Quality of service (QoS), a very important parameter in 802.16; relatively less stringent in 802.11
      - 802.11 provides limited security support (half – duplex) for real time traffic (through PCF) for mobile stations, i.e., mobile Ethernet
      - 802.16 designed to provide wireless services to fixed/ static stations
        - Heavy duty multimedia (video on demand, interactive gamming, etc.,)
        - Secure high speed data transfer(secure transfer of large files, interactive sessions with sensitive data bases)
        - Both entertainment & business applications are full –duplex in nature
  - 802.11 & 802.16 have different design goals, try to optimise different parameters, hence standards are significantly different

- Wireless network – 802.16 : the details
  - Asymmetric traffic – downstream traffic, i.e., base station to subscriber station traffic is much higher than upstream traffic, particularly for interactive mult-imedia & business file transfer
  - 802.16 uses FDD or TDD (frequency/ time division duplexing) in physical layer; TDD is shown below



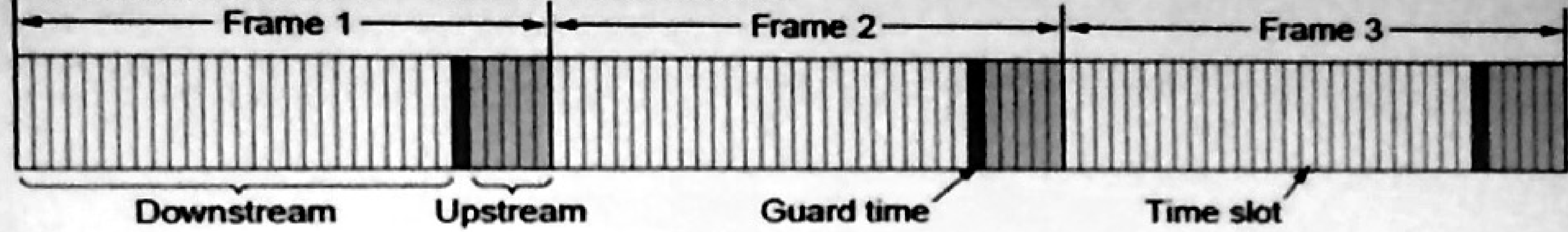
  - A frame consist of physical layer time slots in three sections
    - Downstream slots for transmissions from base station
    - A one slot wide 'guard time' to allow direction switching
    - Upstream slots for subscriber to base station communication
  - Position of guard time slot can be dynamically changed to allow for variable upstream & downstream traffic rates
  - Downstream traffic is completely under base station control
  - Upstream traffic is controlled by individual subscriber/ station
    - Depends on QoS needed by subscriber
    - Multiple subscribers may compete to acquire upstream slots

- Wireless network – 802.16 : the details (cont.)
  - Physical layer mapping of frame to time slot depends on frame size
    - Multiple short frames packed in a single block transmission; reduces no. of preambles & physical layer headers
    - Fragments large frames over several upstream/ downstream sections
  - Physical layer error rate is high (open wide area wireless broadband)
    - Error correcting Hamming code used in physical layer
    - Usual CRC used in higher layers (separate CRCs for header & payload)



  - MAC sub layer protocol
    - All services are connection oriented – unlike other 802.Q standards
      - Needed to ensure/ guarantee QoS to subscribers
    - Downstream/ upstream sections in a frame are called downstream/ upstream frame maps
    - Frame maps specify what is in which (physical layer) time slot & which slots are empty
    - Upstream frame map time slots are loaded with data/ info by subscriber stations

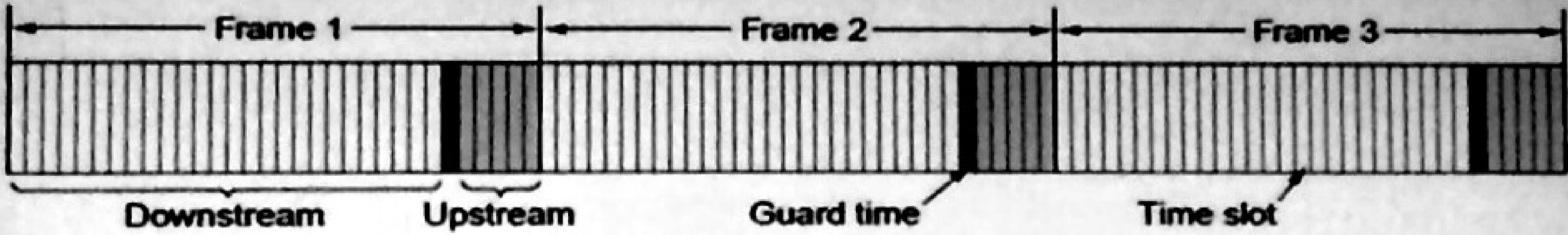
❑ Wireless network – 802.16 : the details



- MAC sub layer protocol (cont.)
  - Downstream frame map completely controlled by base station, it decides what to put in a time slot & what slots to keep empty
  - Four classes of service provided by base station

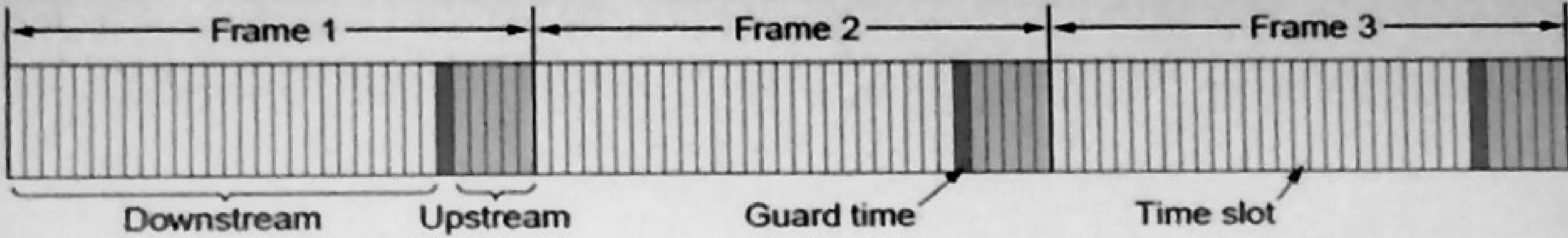
  1. Constant bit-rate service (e.g., uncompresed voice data)
     - Predetermined volume of data transmitted at predetermined intervals
     - Base station allocates certain time slots in every frame or every 'n' frame to requesting subscriber
     - Once allocated, these slots automatically become available to subscriber without need to ask for it over & over again
  2. Real time variable bit-rate service (e.g., compressed multimedia)
     - Base station polls subscribers at fixed time intervals
     - Subscribers specify bandwidth requirement for next interval
     - Base station allocates necessary number of upstream slots to individual subscribers for next interval
     - Base station conveys polling & slot allocation info through

❑ Wireless network – 802.16 : the details



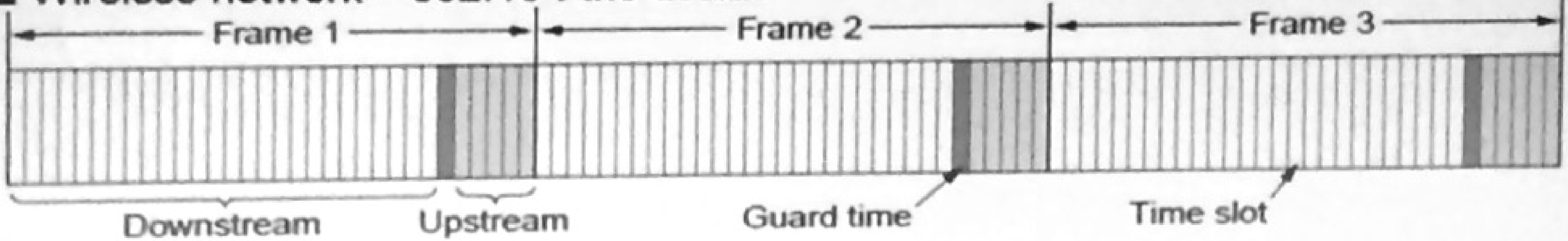
- MAC sub layer protocol (cont.)
  - ❖ Four classes of service provided by base station (cont.)
    3. Non real time variable bit-rate service (e.g., large file transfer)
       - o Base station polls subscriber frequently, but not at rigidly defined regular intervals
       - o Subscriber station specifies bandwidth requirement for next interval, as usual (value may be influenced by elapsed time since last poll)
       - o Base station allocates necessary slots in next upstream section; informs subscribers about allocated slots in appropriate downstream slots
       - o A 'constant bit-rate' subscriber is also allowed to set certain bit(s) in its upstream time slots to request a poll so that it can ask for additional bandwidth if needed

❑ Wireless network – 802.16 : the details



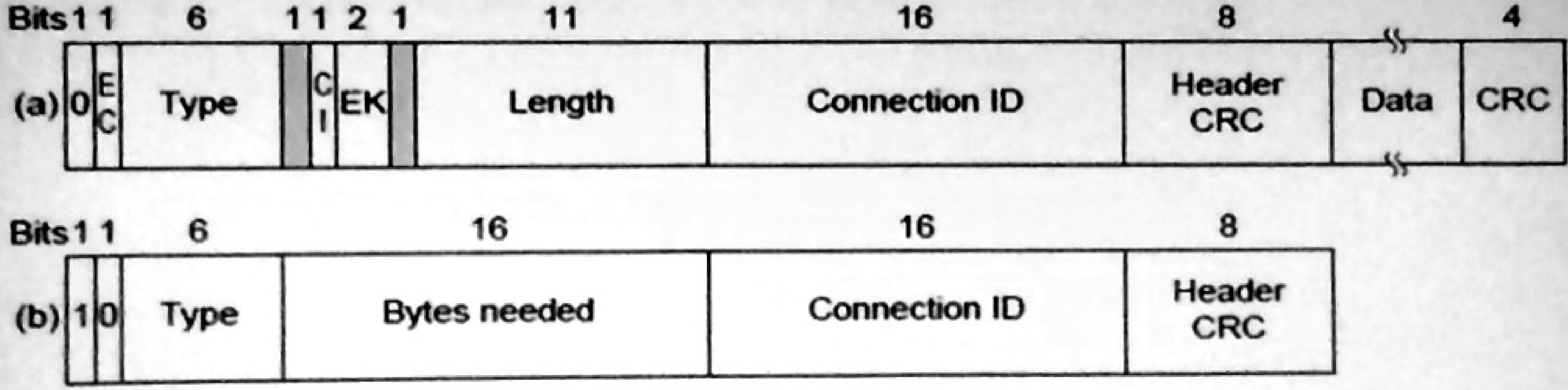
- ➢ MAC sub layer protocol
  - ❖ Four classes of service provided by base station (cont.)
    4. Best effort service (for general non-sensitive applications)
       - o No polling done by base station
       - o Subscribers contend for b/w, i.e., upstream slots with other best effort subscribers
       - o Request for b/w done in upstream slots marked for contention, contention slot nos. info conveyed by base station in some slot(s) of downstream frame map
       - o Successful subscribers allocated upstream slot(s) in next round as usual
       - o Collision between subscribers can occur; if so, subscriber station uses Binary Back-off before requesting again

❑ Wireless network – 802.16 : the details



- MAC sub layer protocol
  - For variable bit-rate subscriber stations not responding to k consecutive base station polls
    - Polling of subscriber stopped & it is put in a multicast group
    - When base station polls this group, any station in it may contend for services, usual contention rules apply
    - This avoids polling slot wastage on subscribers which no longer need high guaranteed bandwidth
  - 802.16 bandwidth allocation is of two types
    - Per connection – base station directly manages connection to each station/ computer
    - Per subscriber
      - If subscriber is just an individual station/ computer, treatment is similar to 'per connection'
      - For a building/ organisation with multiple stations, service provider must aggregate b/w requirements & request for this b/w
      - Allocated b/w is distributed between station as per norms mutually

❑ Wireless network – 802.16 : Frame format



- MAC frames of two types
  - Control frames
  - Data frames
- Frame contains
  - Generic header with own checksum
  - Optional payload (usually absent in control frame)
  - Optional payload checksum
    - Hamming code used to attempt error correction in physical layer
    - No retransmission for real time frames even under checksum errors
    - Retransmission may compromise guaranteed b/w and/or QoS
    - Error handling done at higher layers

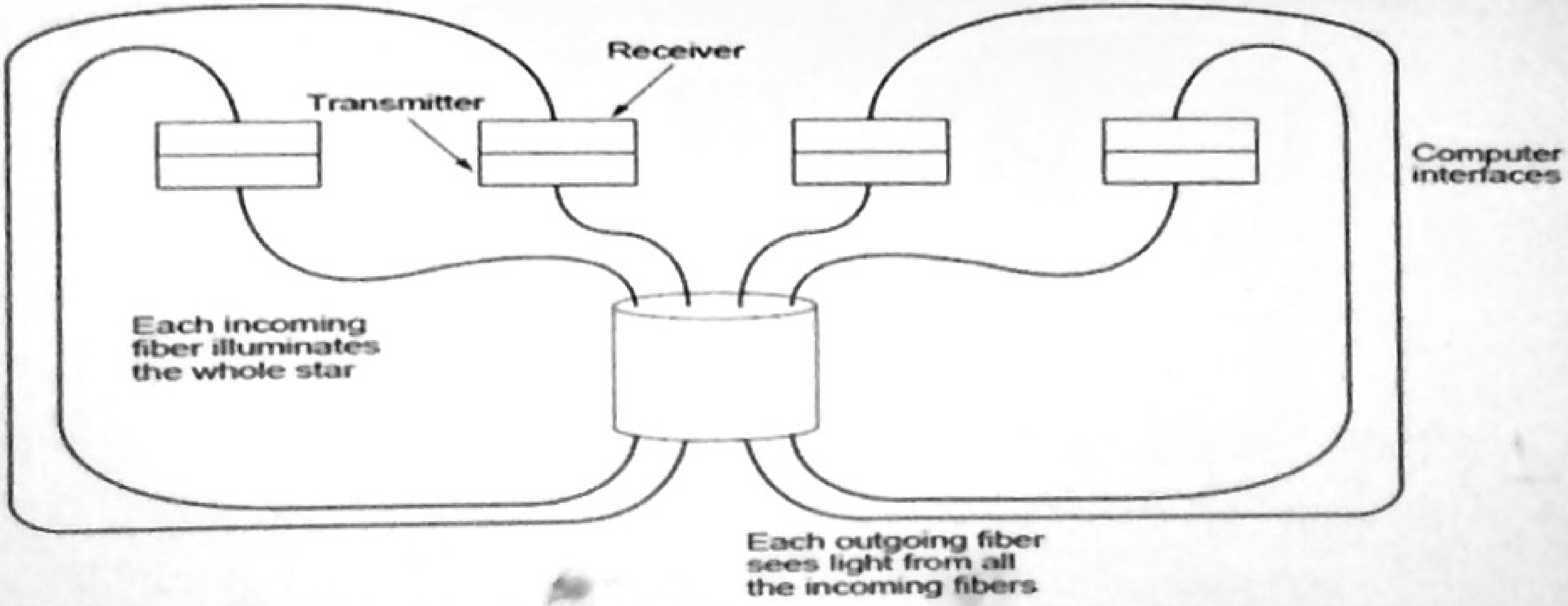
❑ Wireless network – 802.16 : Frame format (cont.)

Bits	1	1	6	1	1	2	1	11	16	8		4
(a)	0	EC	Type		CI	EK		Length	Connection ID	Header CRC	Data	CRC

Bits	1	1	6	16	16	8
(b)	1	0	Type	Bytes needed	Connection ID	Header CRC

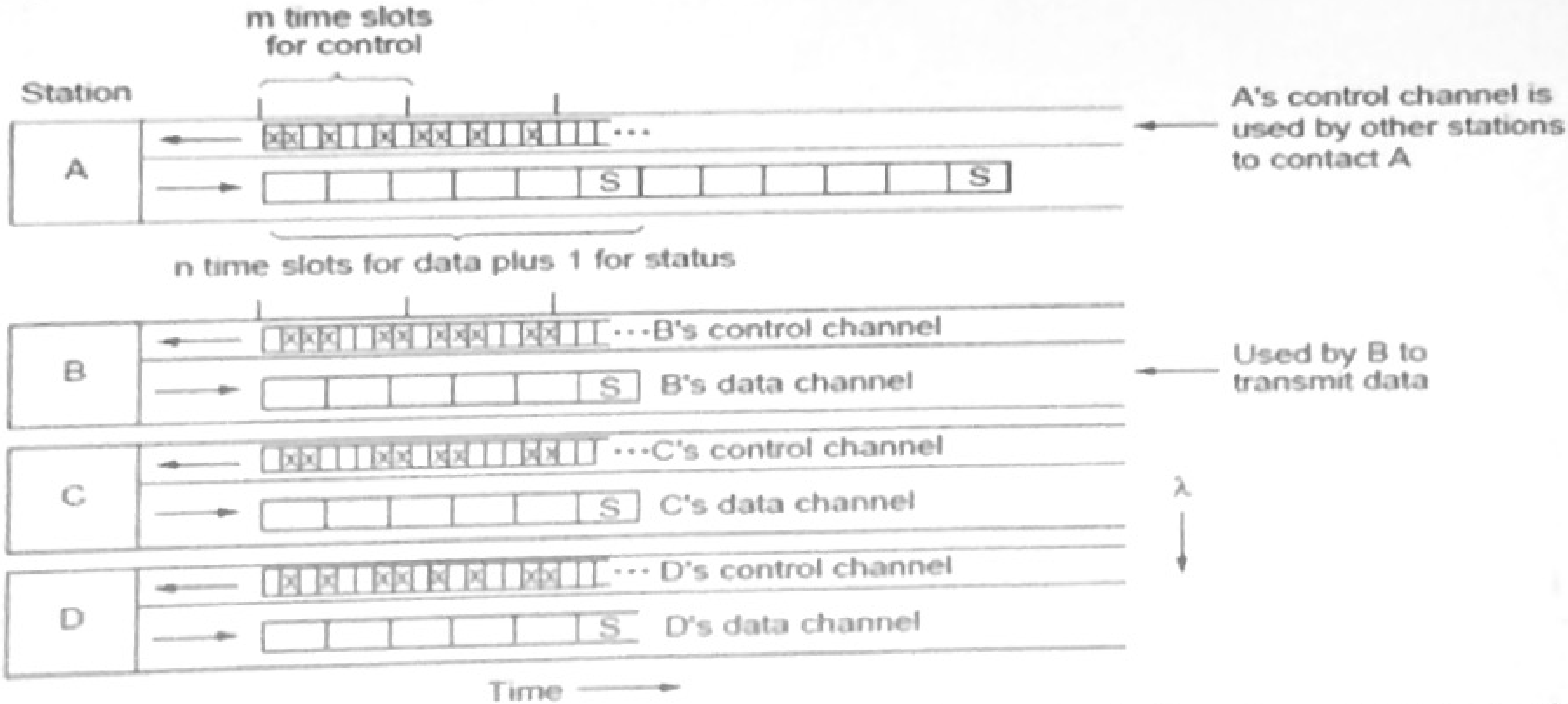
- Data frame – 1st bit is '0'
  - EC : frame encrypted or not; only payload is encrypted
  - Type : nature of frame, i.e., whether packaging/ fragmentation present
  - CI : indicates presence/ absence of final checksum
  - EK : specifies type of encryption, if present
  - Length : Specifies complete frame length (includes header)
  - Connection ID : Identifies connection for which frame is intended
  - Header CRC : Checksum for header only; computed using x^8+x^2+x+1
- Control frame – 1st bit is '1'
  - Type : same as in data frame
  - Bytes needed : required b/w needed to carry specified no. of bytes; b/w request frame has no payload or full-frame CRC
  - Connection ID & Header CRC : same as in data frame

- Optical network – WDMA (Wavelength Division Multiple Access)
  - Passive star coupler allows easy implementation of all –optical LAN & can handle hundreds of stations



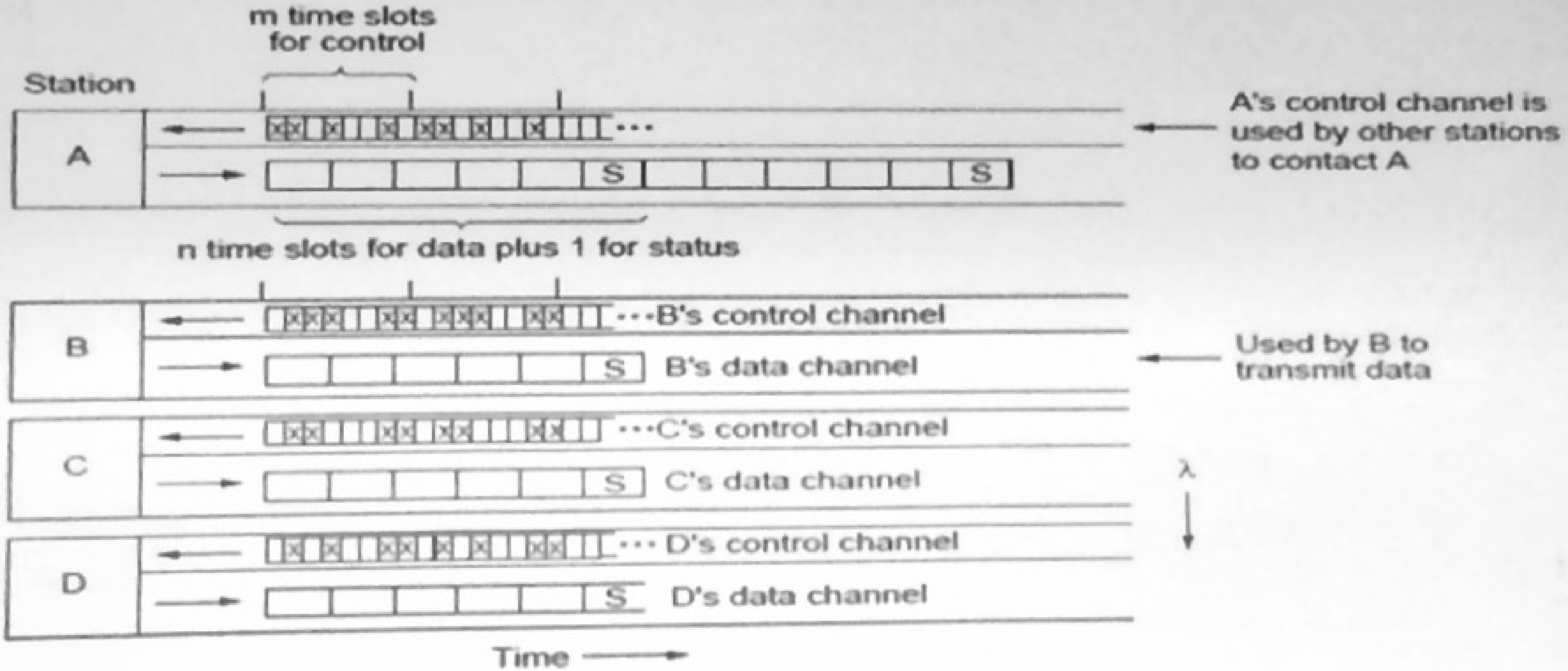
  - WDMA permits multiple simultaneous transmissions, each using different wavelengths
  - Uses FDM (visible & IR region) to divide available channel into subchannels
  - Uses TDM to dynamically allocate subchannels on need basis
  - Each station is assigned two channels
    - Narrow channel for control frames
    - Wide channel for data frames

❑ Optical network – WDMA (Wavelength Division Multiple Access)



- Each channel is divided in groups of time slots, start of each group marked
  - Control channel has m slots in a group
  - Data channel has n+1 slots in a group, n for data & 1 for status info.
  - Group of slots for both channels repeat continuously
- Channel slots (TDM part) synchronised is by global clock
- Three service classes supported
  1. Constant data rate connection oriented traffic
  2. Variable data rate connection oriented traffic
  3. Datagrams, e.g.., UDP (connectionless service)

❑ Optical network – WDMA (Wavelength Division Multiple Access)



- Each channel has two transmitters & two receivers
  - ❖ Narrow band fixed wavelength control receiver
  - ❖ Narrow band tunable control transmitter
  - ❖ Fixed wavelength data transmitter
  - ❖ Tunable data receiver
- Transmitter/ receiver tuning is done using electro-optical interferometers (Fabry – Perot)