MAC Design for light-based networks
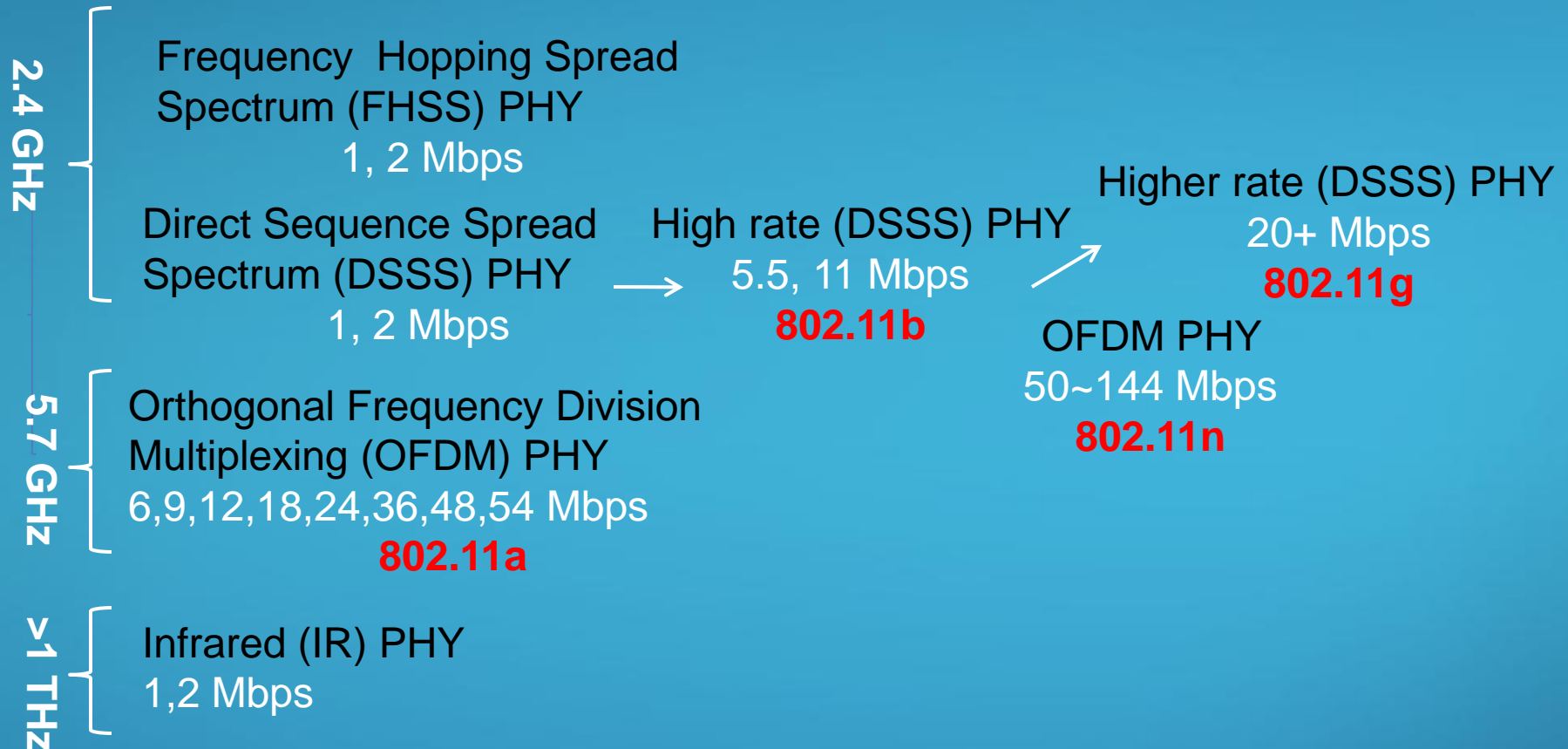
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802.11 PHY

Frequency Hopping Spread Spectrum (FHSS) PHY
1, 2 Mbps

Direct Sequence Spread Spectrum (DSSS) PHY
1, 2 Mbps

High rate (DSSS) PHY
5.5, 11 Mbps
802.11b

Higher rate (DSSS) PHY
20+ Mbps
802.11g

OFDM PHY
50~144 Mbps
802.11n

Orthogonal Frequency Division Multiplexing (OFDM) PHY
6,9,12,18,24,36,48,54 Mbps
802.11a

Infrared (IR) PHY
1,2 Mbps

2.4 GHz

5.7 GHz

>1 THz

802.11 MAC

- Distributed and centralized MAC
  - Distributed Coordination Function (DCF)
    - multi-hop ad hoc mode
  - Point Coordination Function (PCF)
    - Access point (AP)/client mode
- DCF is a Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) protocol

CSMA/CA

- Carrier sensing (CSMA)
  - Sense channel busy → do not transmit
  - Sense channel idle → okay to transmit
  - Hidden terminal problem
    - Solution: RTS/CTS
- Collision Avoidance (CA)
  - Collision detection (CD) does not work over wireless media
  - exponential random backoff
 - Acknowledgement (two way handshake)

Directional Antennas

- Non-uniform antenna gain
  - Much higher/lower gains in particular directions
- Hardware realization
  - Antenna array
  - Beamforming
  - MIMO
- Opportunities
  - Less interference → more spatial reuse
  - Better signal quality → better network connectivity

Directional MAC Protocols

- Challenges
  - Range varies with beamwidth
  - Deafness problem
- Example solutions
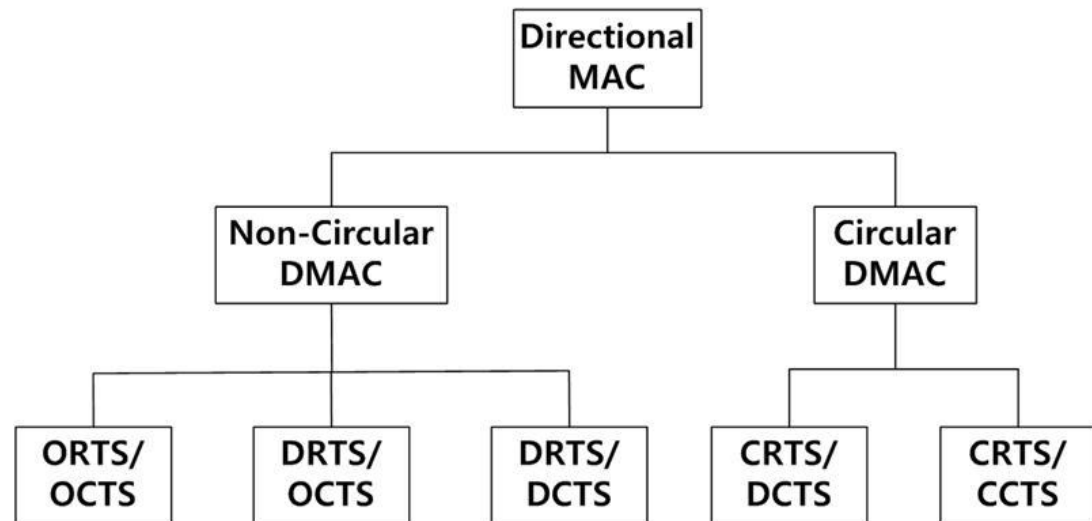
- CSMA/CA based
- DATA/ACK are transmitted directionally

Ultraviolet Wireless Communication

- PHY characteristics
  - Deep UV band is solar blind, good for outdoor
  - Directional transmission
  - Tunable pointing angle
    - Small pointing angle → full duplex, larger received energy, low propagation delay, small delay spread and higher data rates
    - Large pointing angle → beams are not easily blocked by obstacles in outdoor environments
  - NLOS links
    - Result from multiple choices of direction and pointing angle.

Opportunities and Challenges for UV-WOC MAC Layer

- Spatial reuse
  - A transmitter decides the (a) direction and (b) pointing angle to use for each new connection.
    - Based on his knowledge about the receiver and currently ongoing transmissions.
    - Aim to successfully establish a connection, meanwhile refine the interference caused to other communications.
    - Direction and pointing angle together provide two dimensional spatial reuse.

Opportunities and Challenges for UV-WOC MAC Layer (contd.)

- Opportunistic full duplex
  - If small pointing angle is used for transmission, operate in full-duplex mode.
  - If large pointing angle is used, operate in half-duplex mode.

- Multi-rate choice
  - Smaller pointing angle → less delay spread → higher rate

Challenges in light communications

- MAC design needs to be tightly inter-related to the PHY

- PHY characteristics such as delay spread, directionality etc. affect access strategies.

- Blockage, reflections and dispersion will also have an effect.