MAC Design for light-based networks

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802.11 PHY

2.4 GHz
- Frequency Hopping Spread Spectrum (FHSS) PHY
  1, 2 Mbps
- Direct Sequence Spread Spectrum (DSSS) PHY
  1, 2 Mbps
- Orthogonal Frequency Division Multiplexing (OFDM) PHY
  6, 9, 12, 18, 24, 36, 48, 54 Mbps
  802.11a

5.7 GHz
- Higher rate (DSSS) PHY
  5.5, 11 Mbps
  802.11b

>1 THz
- Infrared (IR) PHY
  1, 2 Mbps
- OFDM PHY
  50~144 Mbps
  802.11n

802.11a

802.11b

802.11g

802.11n
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 $\rightarrow$ more spatial reuse
  – Better signal quality $\rightarrow$ 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.