



CS120: Computer Networks

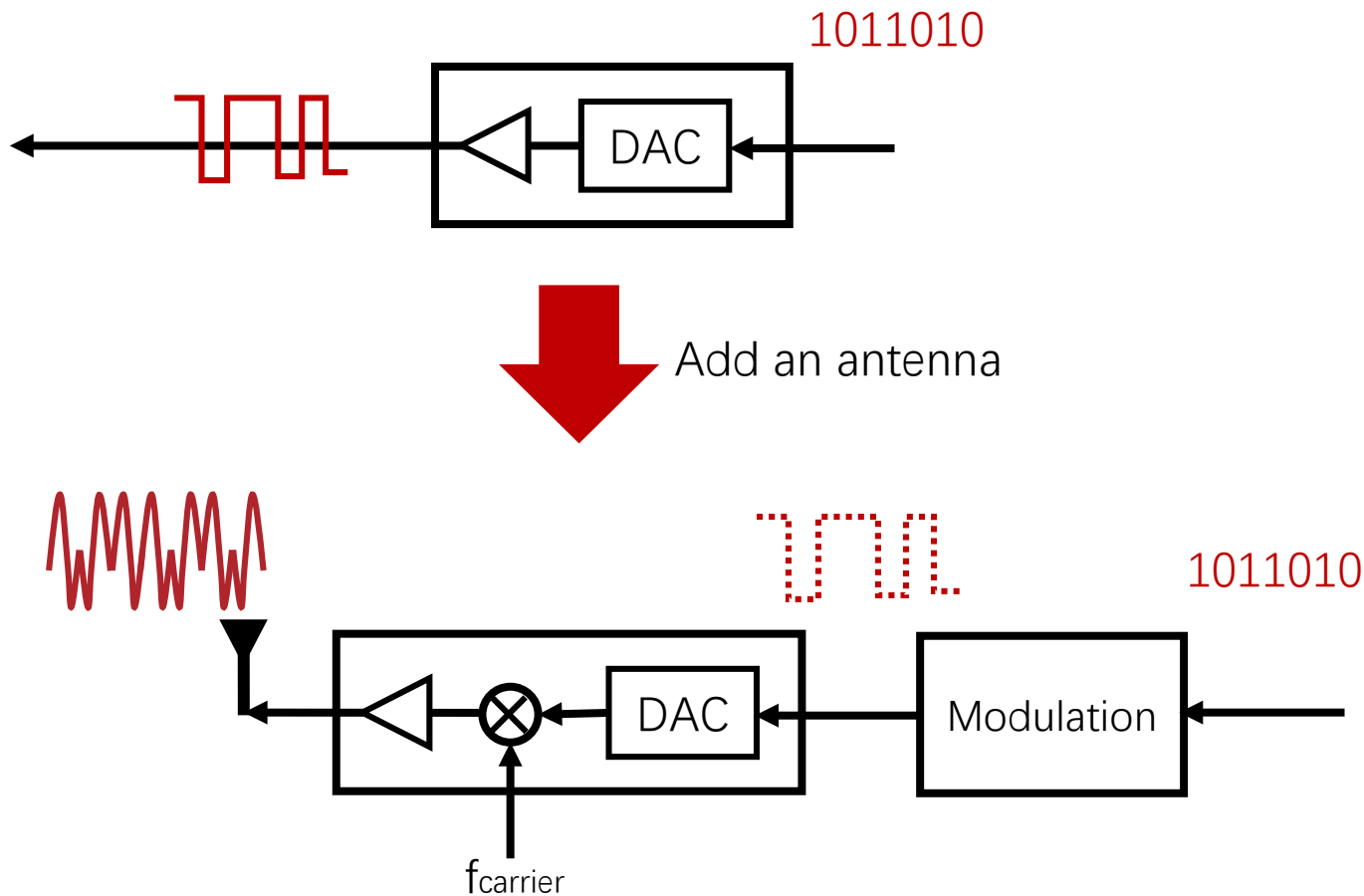
Lecture 7. Multiple Access 2

Zhice Yang

Outline

- Wireless MAC
 - Overview of Wireless Technologies
 - WLAN and WLAN MAC
 - CSMA/CD is not feasible
 - Hidden terminal and exposed terminal

Go to Wireless



• Two Requirements

- Antenna
 - Radiate out electromagnetic signal
- Carrier Wave
 - Choose suitable carrier wave to satisfy communication requirement (coverage, antenna size, spectrum sharing, etc.)
 - Radio: radio band
 - Audio: audio band

Radio Spectrum Allocation

- Radio spectrum is like a resource

3 – 300 kHz

$\lambda = 1000 - 10\text{km}$

300 – 3000 kHz

$\lambda = 10 - 1\text{km}$

3 – 30 MHz

$\lambda = 1000 - 100\text{m}$

30 – 300 MHz

$\lambda = 100 - 10\text{m}$

300 – 3000 MHz

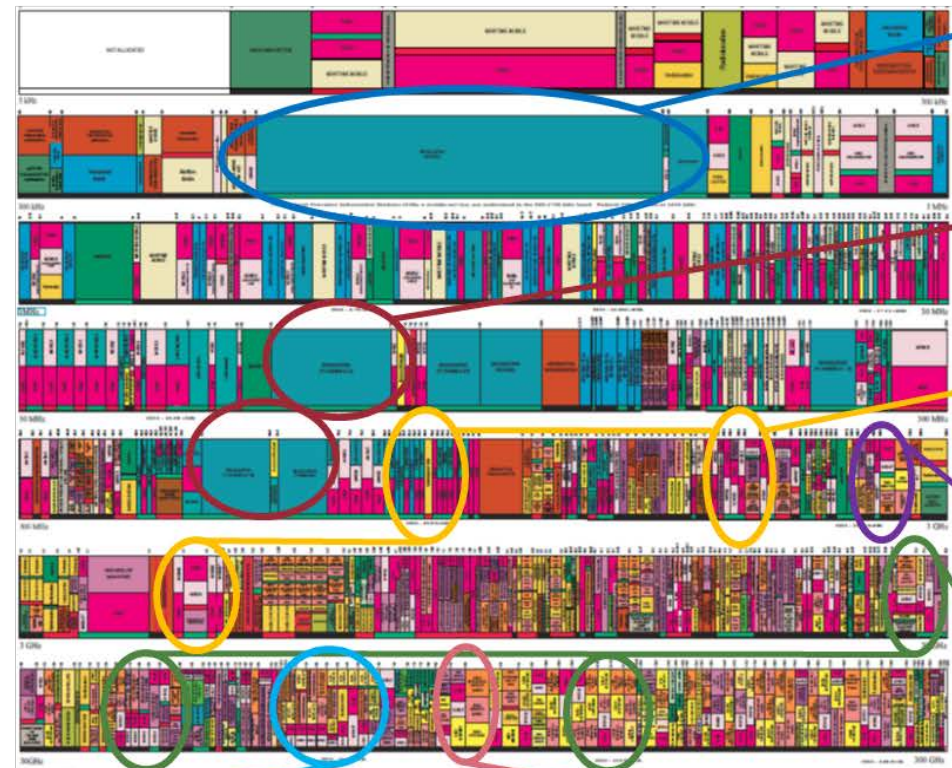
$\lambda = 10 - 1\text{m}$

3 – 30 GHz

$\lambda = 1\text{m} - 100\text{mm}$

30 – 300 GHz

$\lambda = 100\text{mm} - 10\text{mm}$



AM Radio

TV Broadcast*
(54-72, 600-700 MHz)

3G/4G
cellular
(0.9, 1.8, 1.9 GHz)

WiFi
(2.4 GHz)

mmWave
(28, 38, 80 GHz)

WiGig (802.11 ad)
(60 GHz)

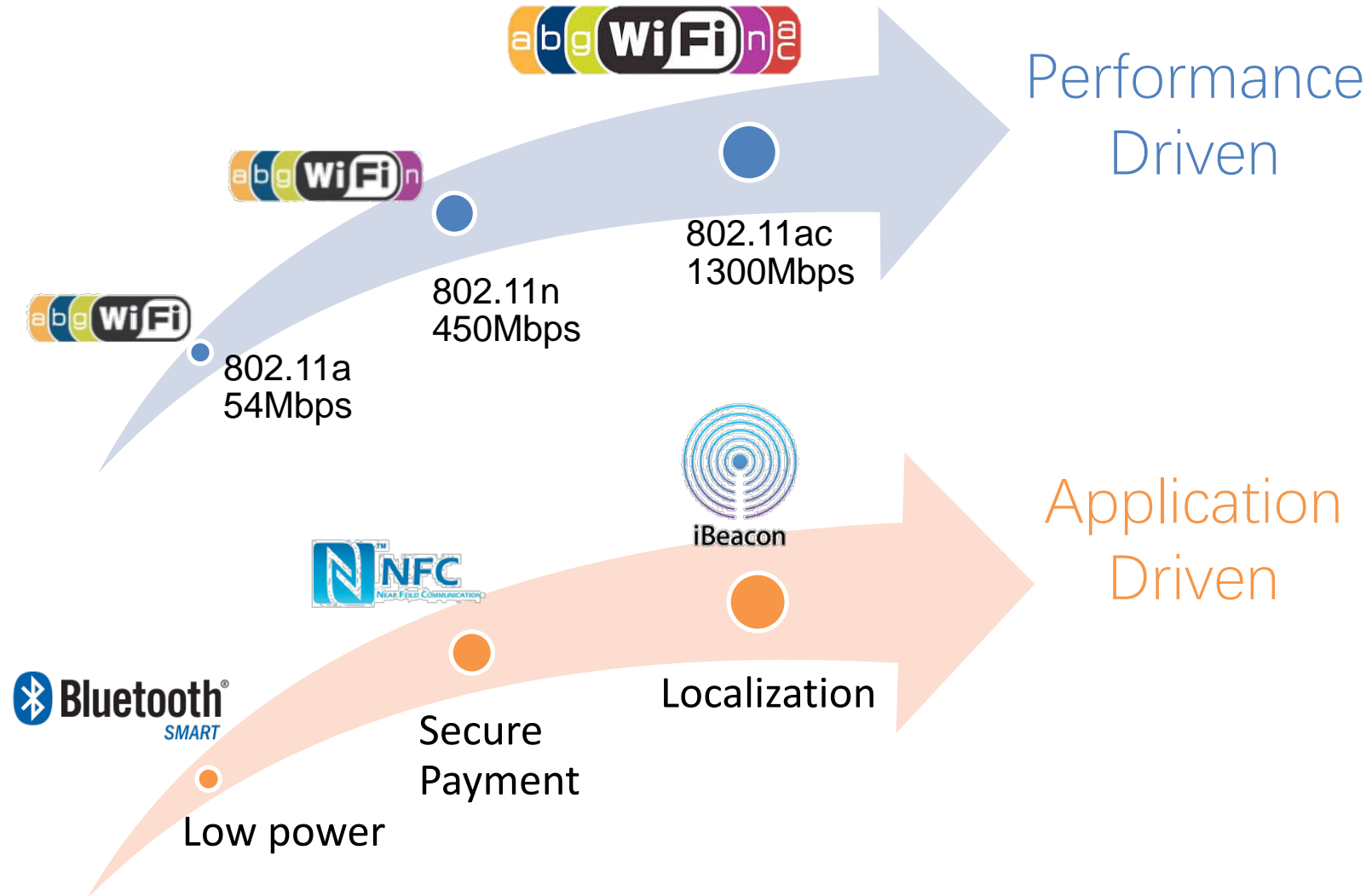
Vehicular Radar
(77 GHz)

Radio Spectrum Allocation

- Regulation: defines how to use the radio spectrum
 - Price: licensed and unlicensed
 - Frequency bandwidth
 - Power
 - etc.
- Regulatory Agency
 - China: CMIIT
 - U.S.: FCC



Wireless Technology Overview



Two Big Players: Wi-Fi and Cellular

Cellular and Wireless



Model A1865*

FDD-LTE (Bands 1, 2, 3, 4, 5, 7, 8, 12, 13, 17, 18, 19, 20, 25, 26, 28, 29, 30, 66)
TD-LTE (Bands 34, 38, 39, 40, 41)
TD-SCDMA 1900 (F), 2000 (A)
CDMA EV-DO Rev. A (800, 1900, 2100 MHz)
UMTS/HSPA+/DC-HSDPA (850, 900, 1700/2100, 1900, 2100 MHz)
GSM/EDGE (850, 900, 1800, 1900 MHz)

All models

802.11ac Wi-Fi with MIMO

Bluetooth 5.0 wireless technology

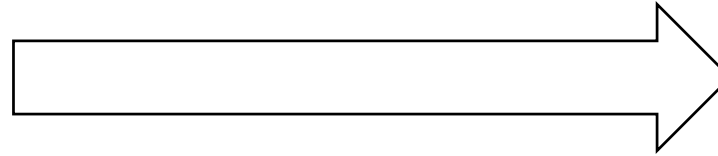
NFC with reader mode

Two Big Players: Wi-Fi and Cellular

Telephone



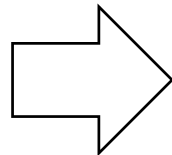
Cellular



Ethernet



WLAN (Wi-Fi)



Two Big Players: Wi-Fi and Cellular

Telephone



Microcell



Cellular



Ethernet



WLAN (Wi-Fi)

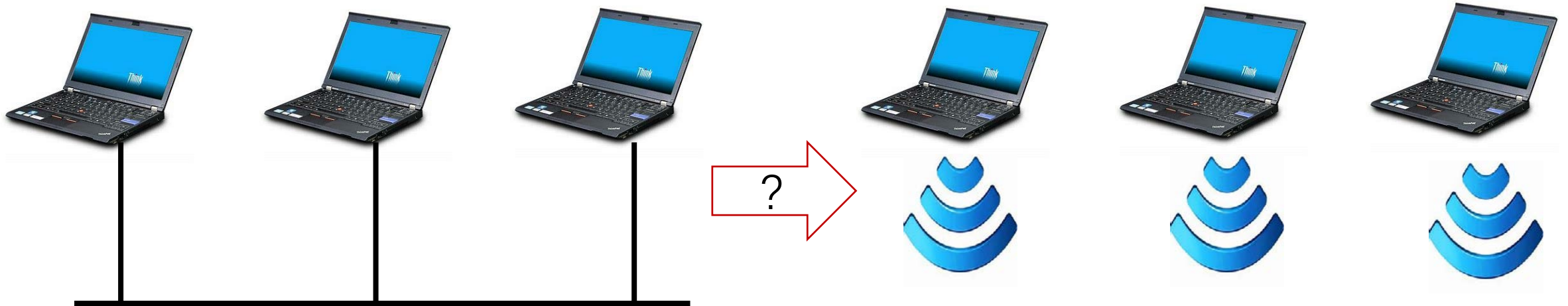


WiMAX



WLAN

- Wireless Local Area Network
 - The original goal is to design a “wireless” LAN



Reconsider CSMA/CD in Ethernet

- Assumptions:
 - Full Duplex: transceiver can send/receive concurrently
 - To detect collision while transmitting
 - Symmetry: signals are identical at all receivers
 - Collision is detected at transmitter => collision at receiver

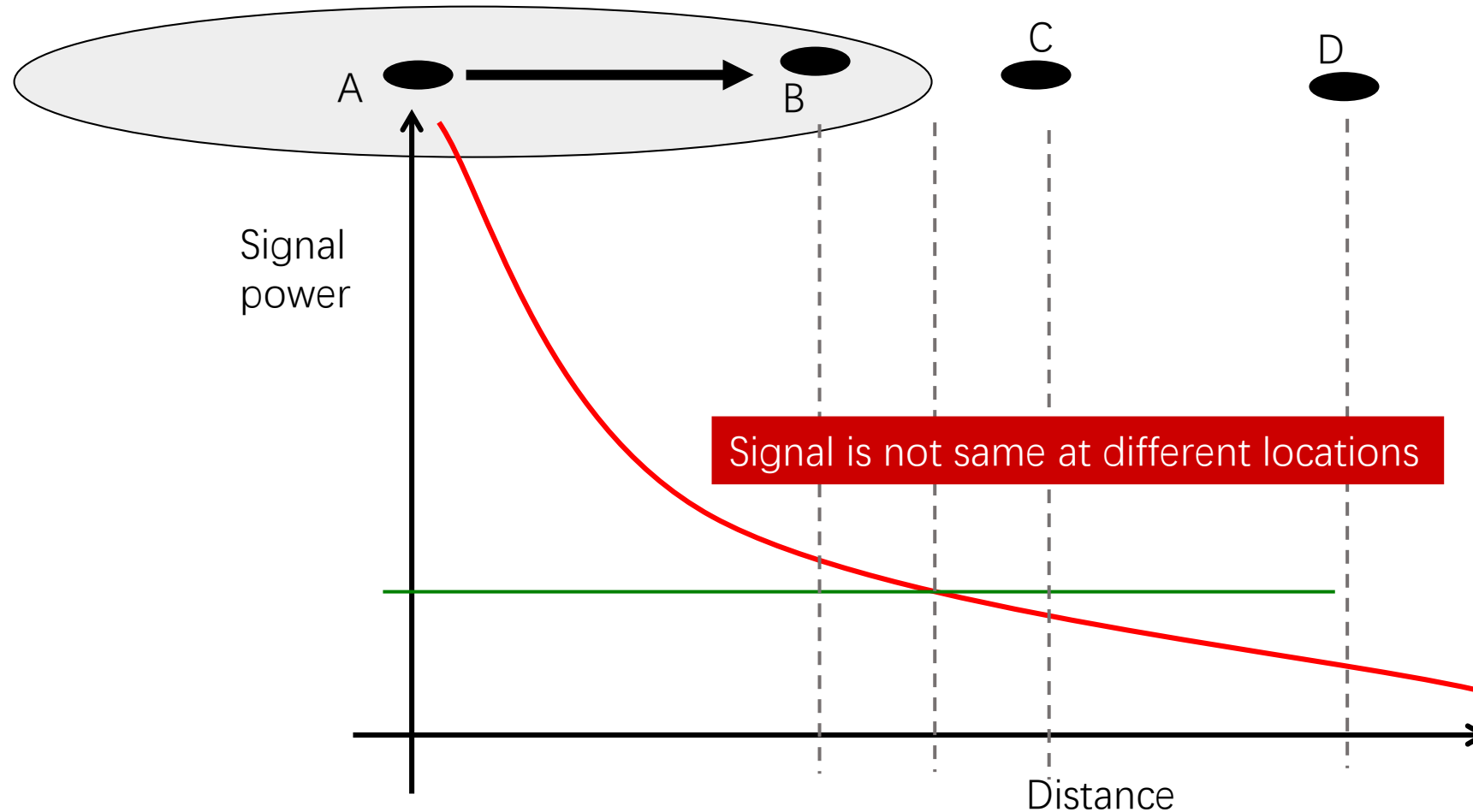
Ethernet transceiver can detect collision
when collision occurs at the receiver

How about the Wireless Situation

- Assumptions of CSMA/CD
 - ~~X~~ Full Duplex: transceiver can send/receive concurrently
 - ~~X~~ Symmetry: signals are identical at all receivers

CSMA/CD are not Feasible in Wireless Situation

A cannot send and listen in parallel



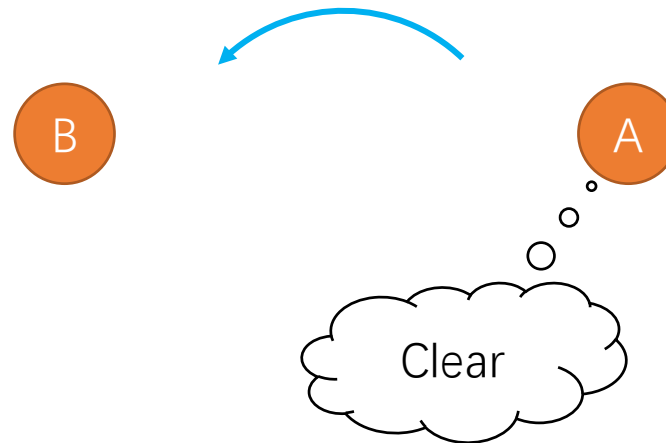
How about the Wireless Situation

- Assumptions of CSMA/CD
 - ✗ Full Duplex: transceiver can send/receive concurrently
 - ✗ Symmetry: signals are identical at all receivers

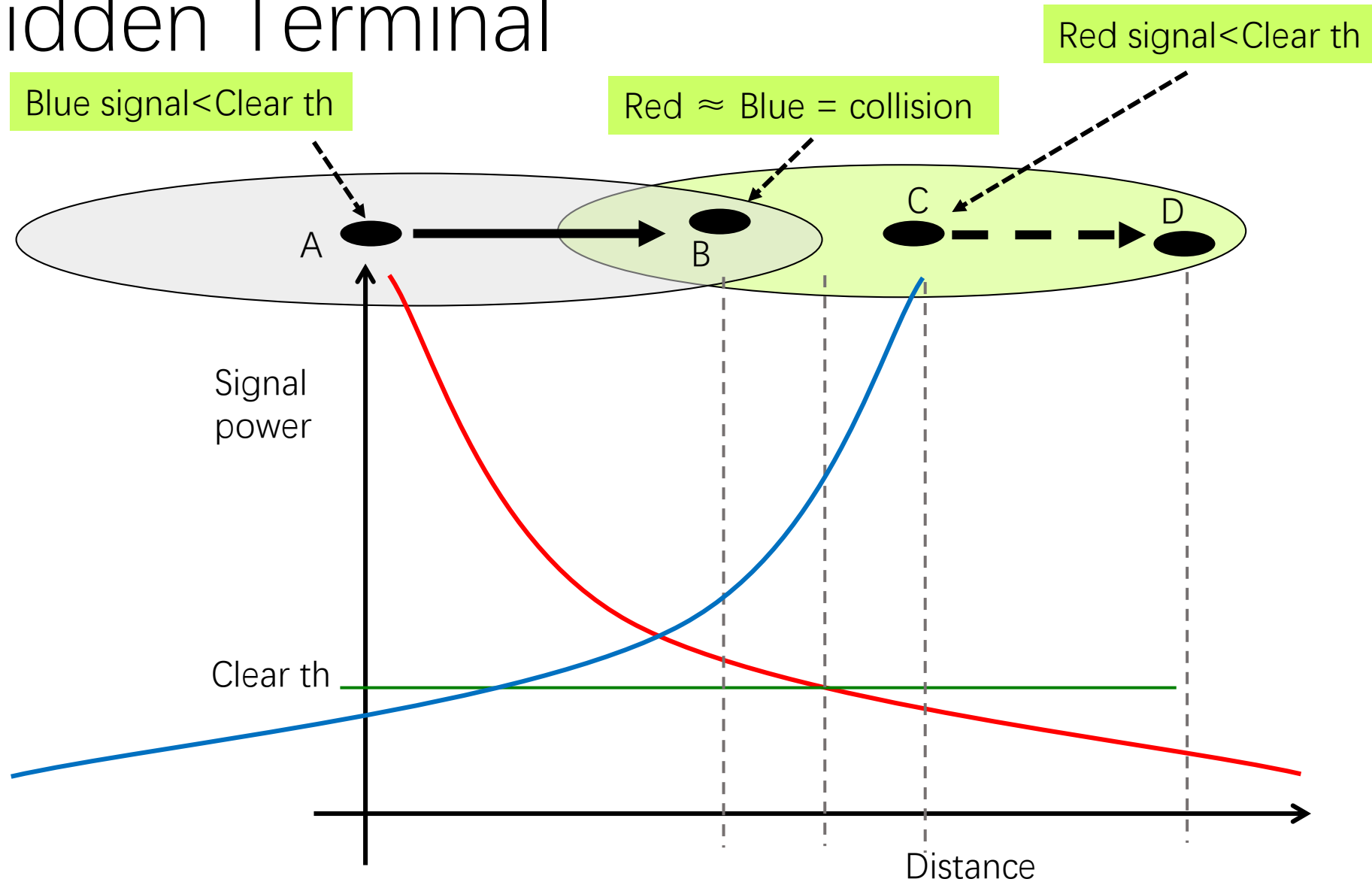
How about CSMA?

How about the Wireless Situation

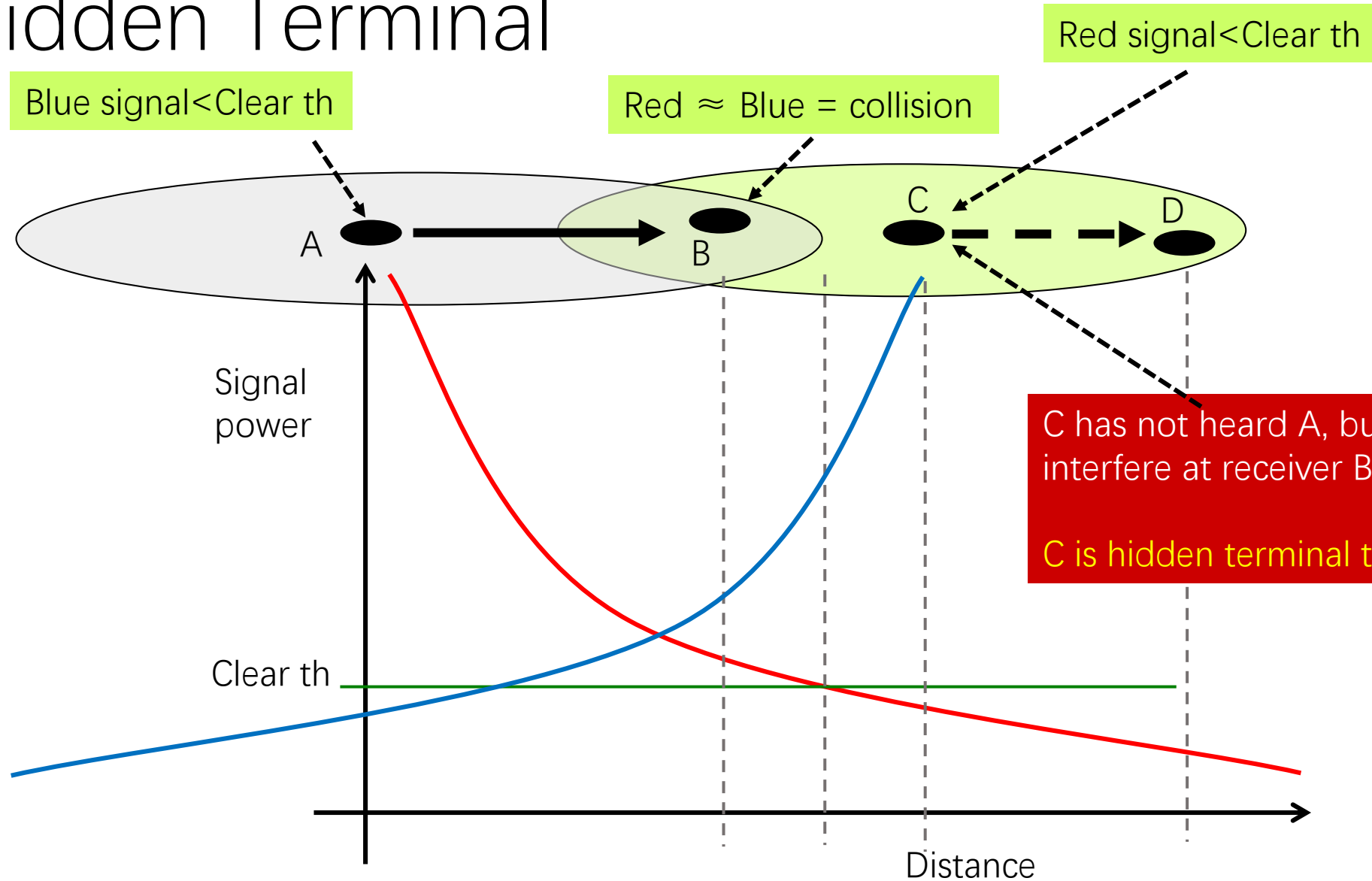
- CSMA in Wireless Situation
 - Not as good as wired situation
 - Hidden Terminal
 - Exposed Terminal



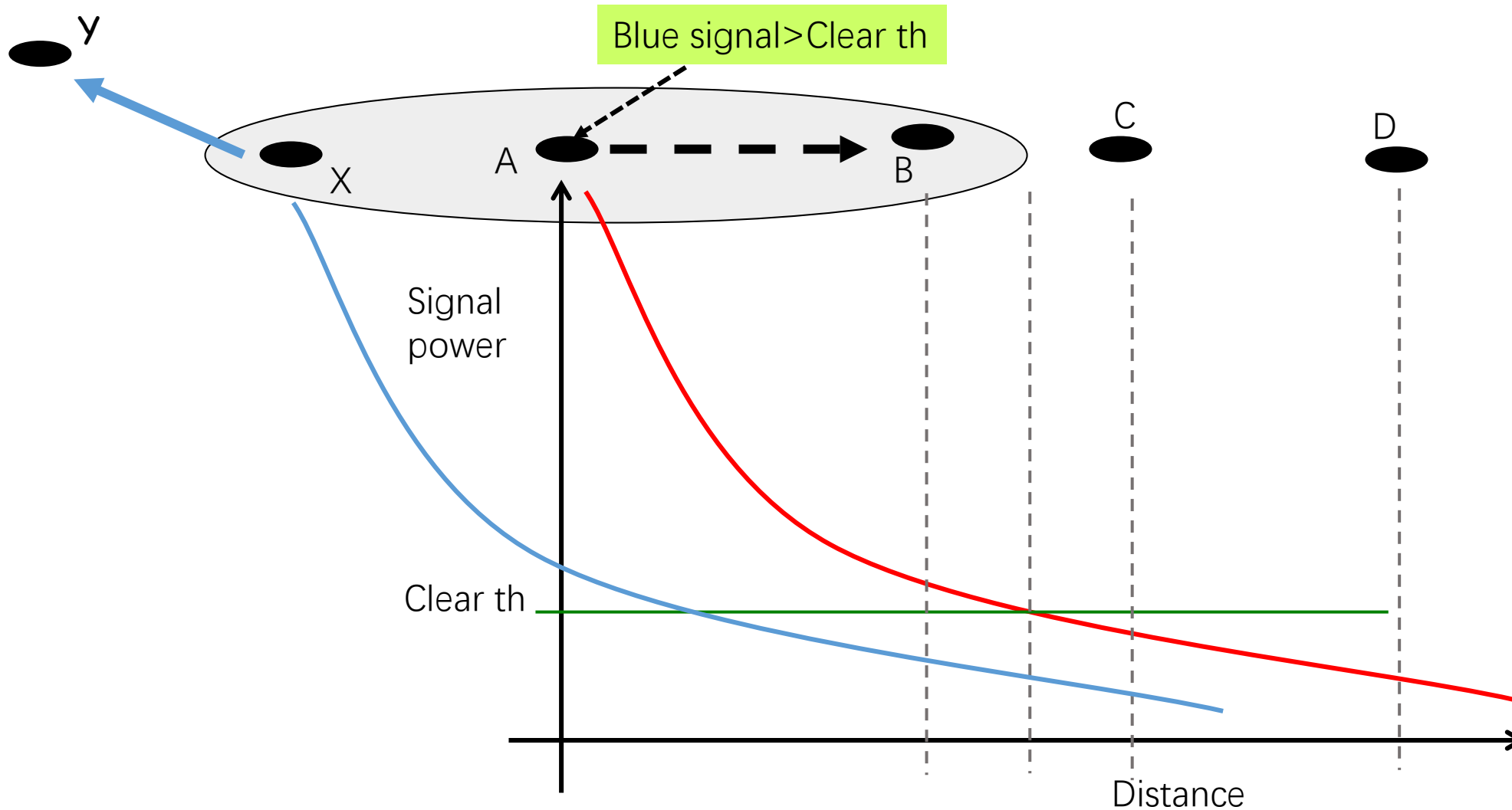
Hidden Terminal



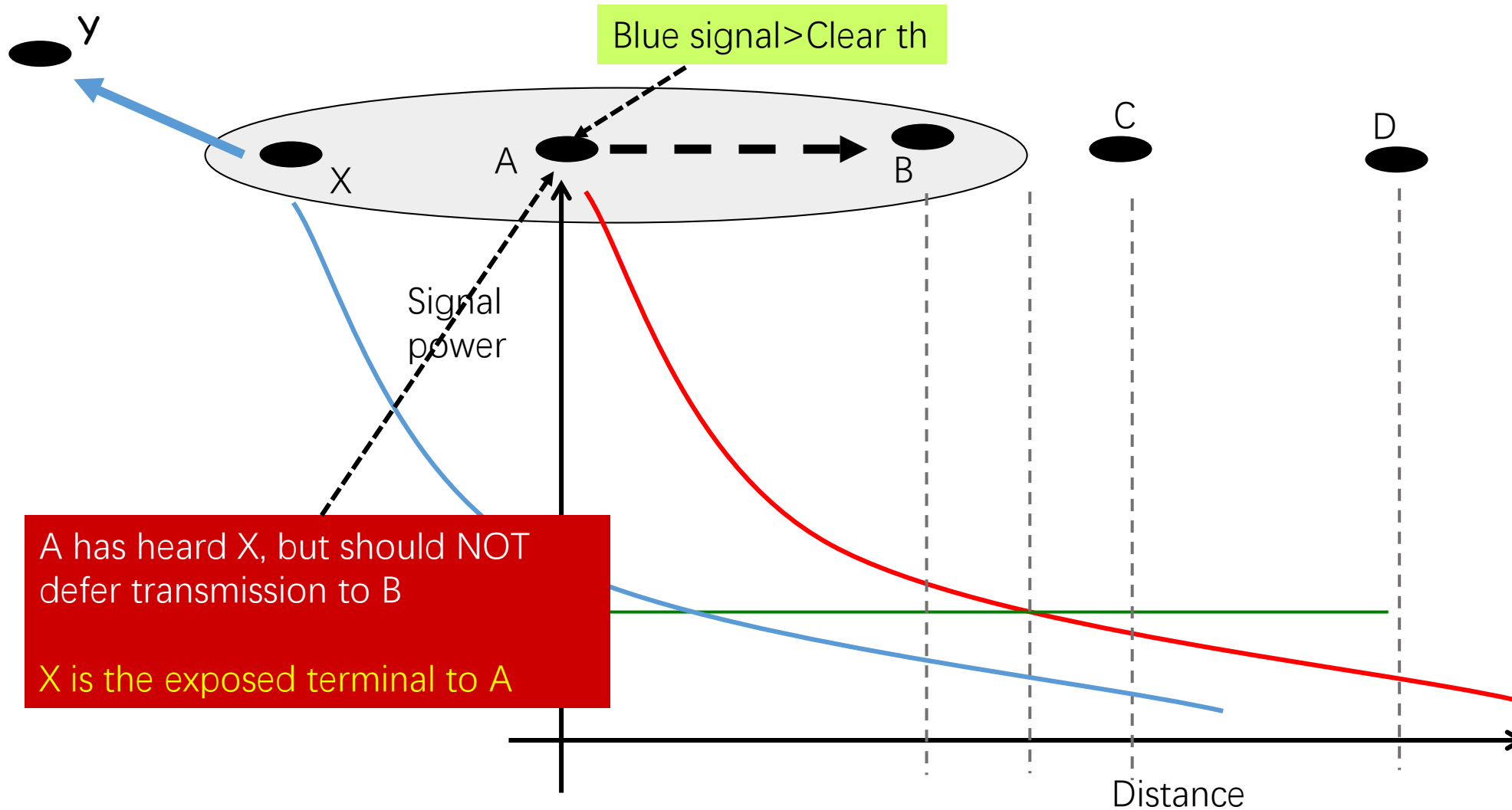
Hidden Terminal



Exposed Terminal



Exposed Terminal

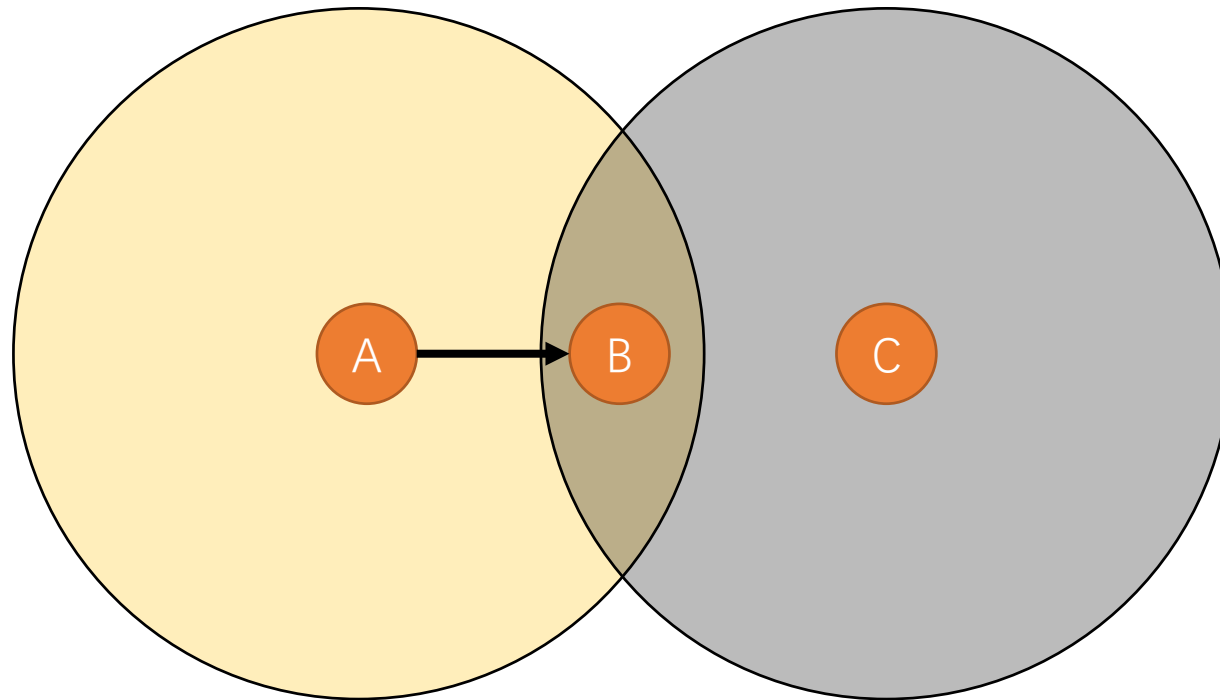


Wireless LAN MAC

- Consider CSMA in Wireless Situation
 - Not as good as wired situation
 - Hidden Terminal
 - Exposed Terminal
- CSMA/CA
 - CA stands for collision avoidance
 - CTS/RTS scheme

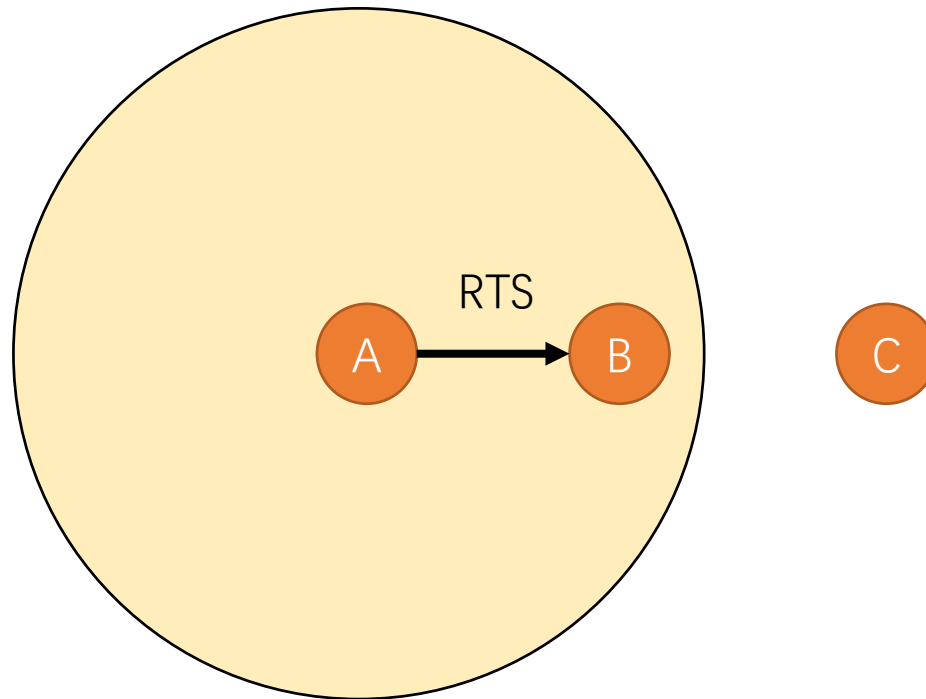
RTS/CTS

- A wants to transmit to B, but C may interfere B



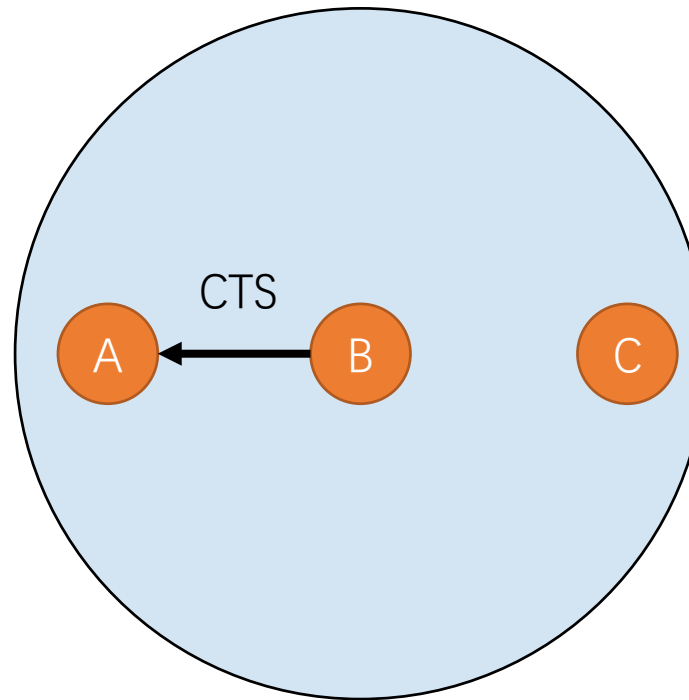
RTS/CTS

- A transmits a short packet to B and announces the expected transmission duration
 - Request to Send (RTS)



RTS/CTS

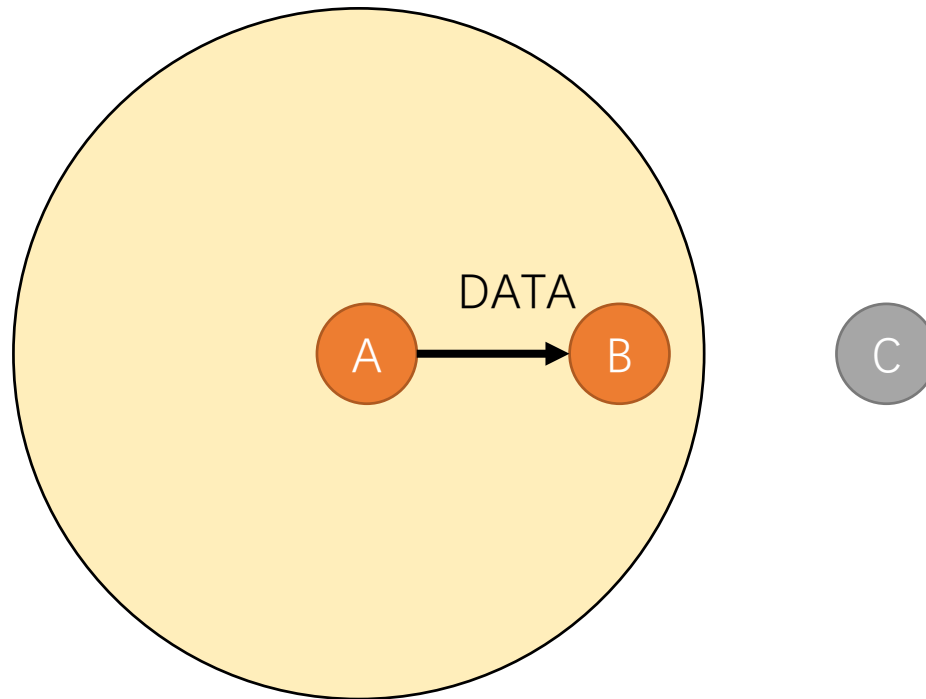
- B transmits a short packet to A and announces the expected transmission duration
 - Clear to Send (CTS)



C can hear CTS and knows that there will be a transmission soon

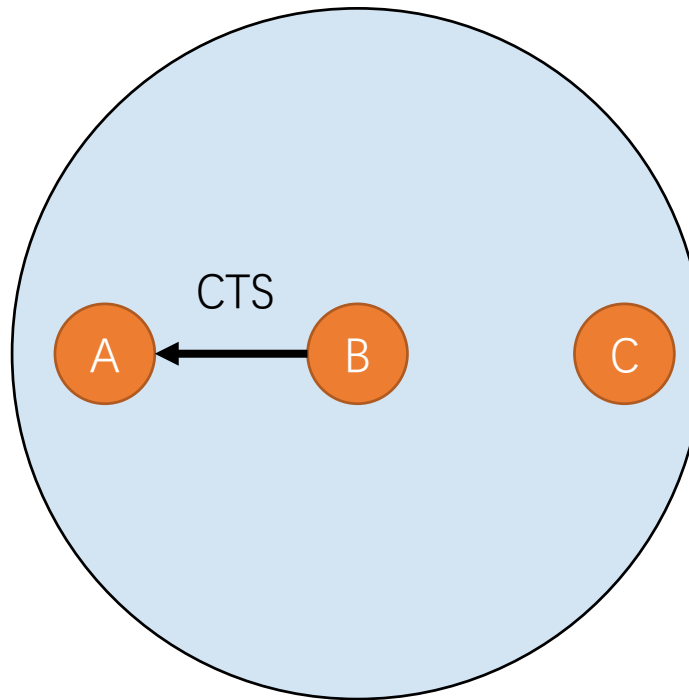
RTS/CTS

- C knows the expected transmission duration from CTS and defers
 - Avoids the hidden terminal problem



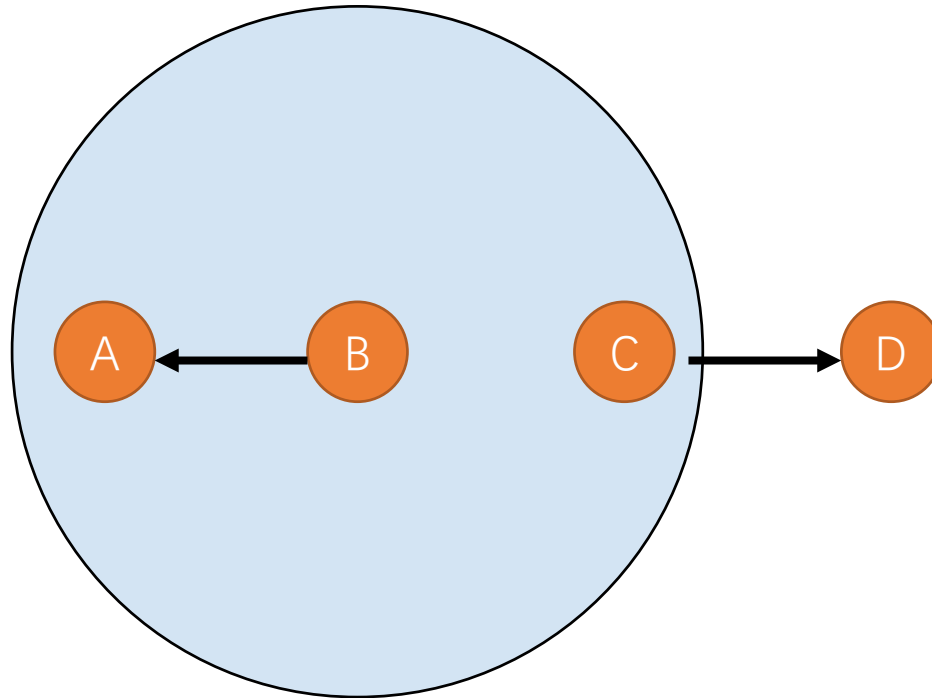
RTS/CTS

- However
 - If CTS is lost at C, C can still interfere B



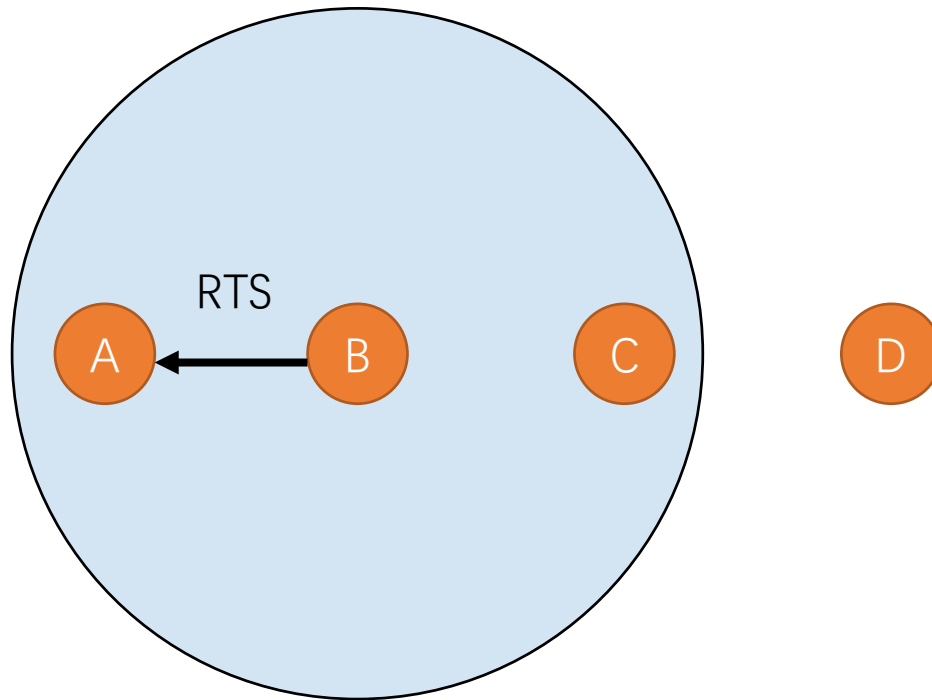
RTS/CTS

- C wants to transmit to D, but B may interfere C.



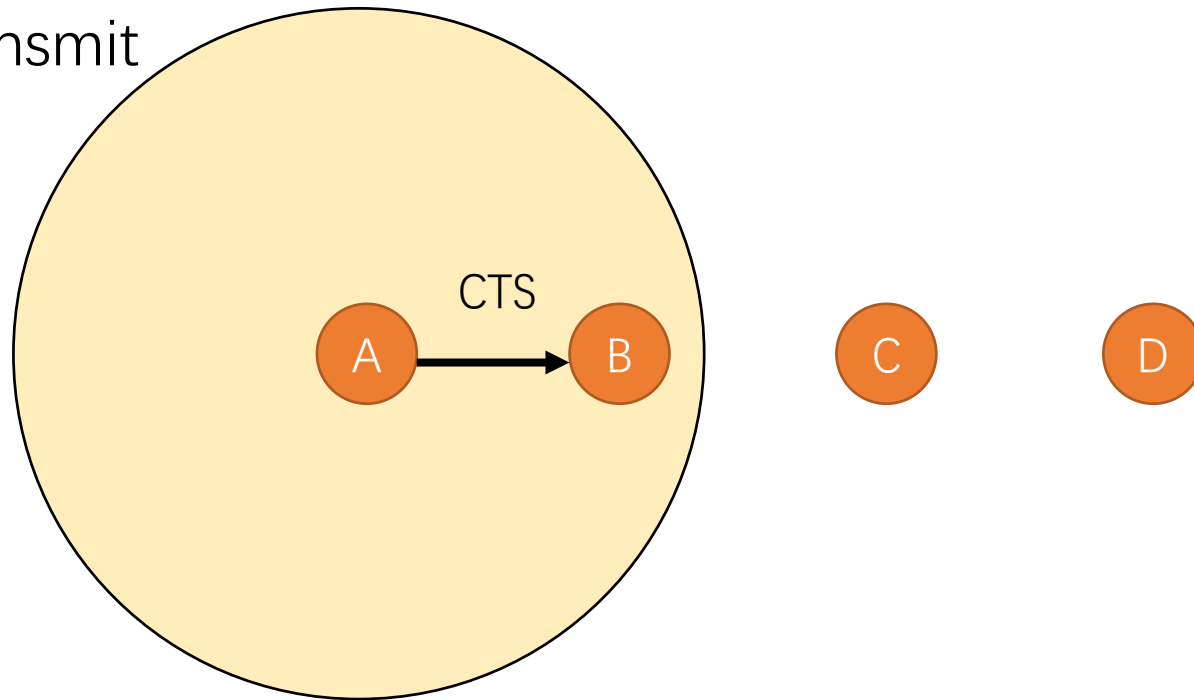
RTS/CTS

- B sends RTS. C waits CTS packet.
 - CTS packets must be replied within a short period of time



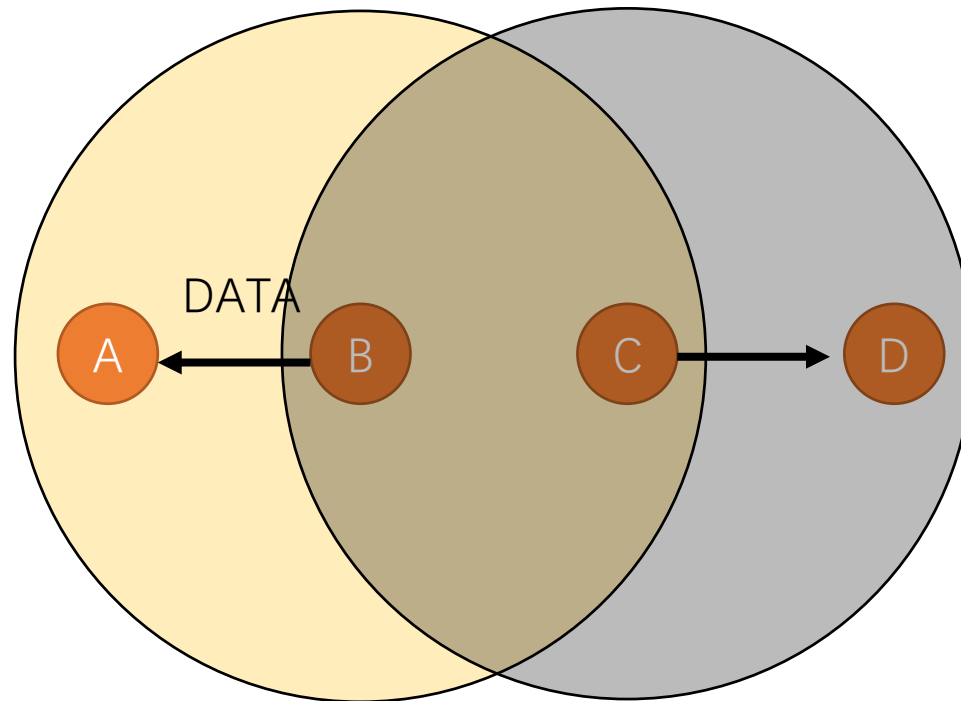
RTS/CTS

- C does not hear CTS packet.
 - C is not in the coverage of B's receiver (A)
 - B's receiver (A) is not in the coverage of C
 - C can transmit



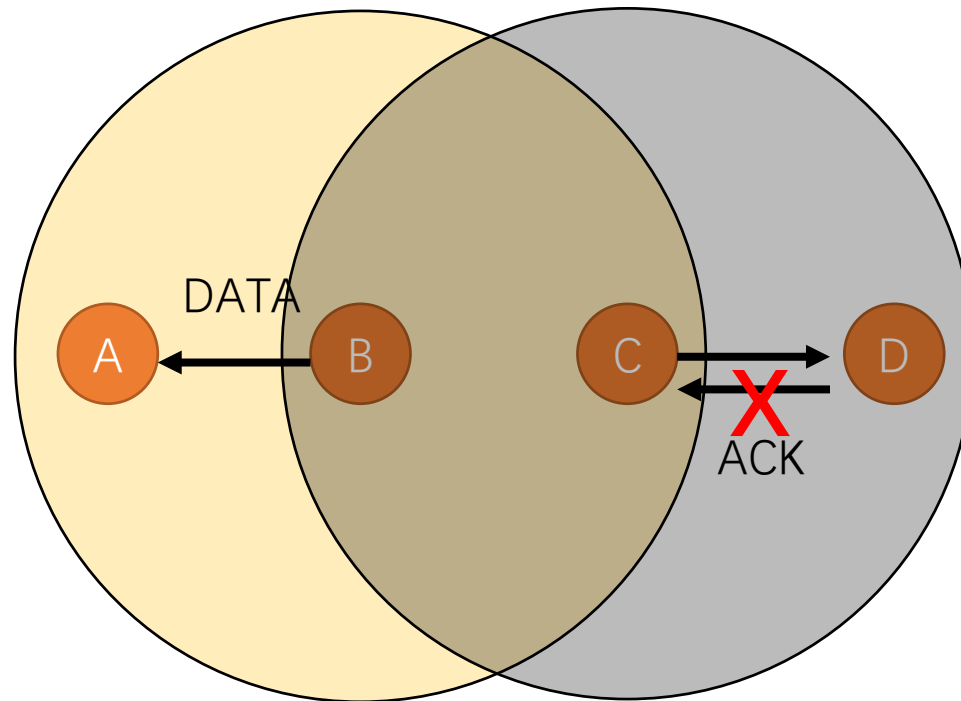
RTS/CTS

- C transmits to D
 - Avoids the exposed terminal problem



RTS/CTS

- However
 - ACK is interfered

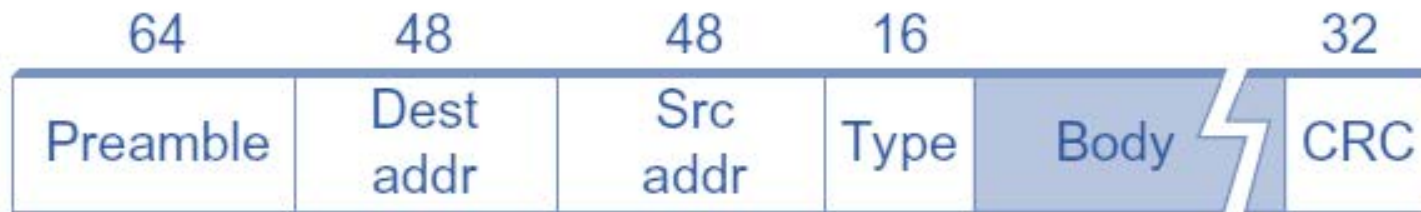


RTS/CTS

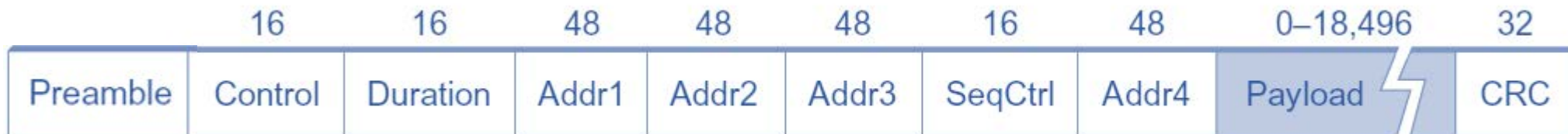
- RTS/CTS does not solve hidden terminal and exposed terminal completely
- Designing Wireless MAC is non-trivial

IEEE 802.11 MAC

- The Wireless LAN is standard by IEEE 802.11
 - “Wi-Fi” is a certification trademark of IEEE 802.11



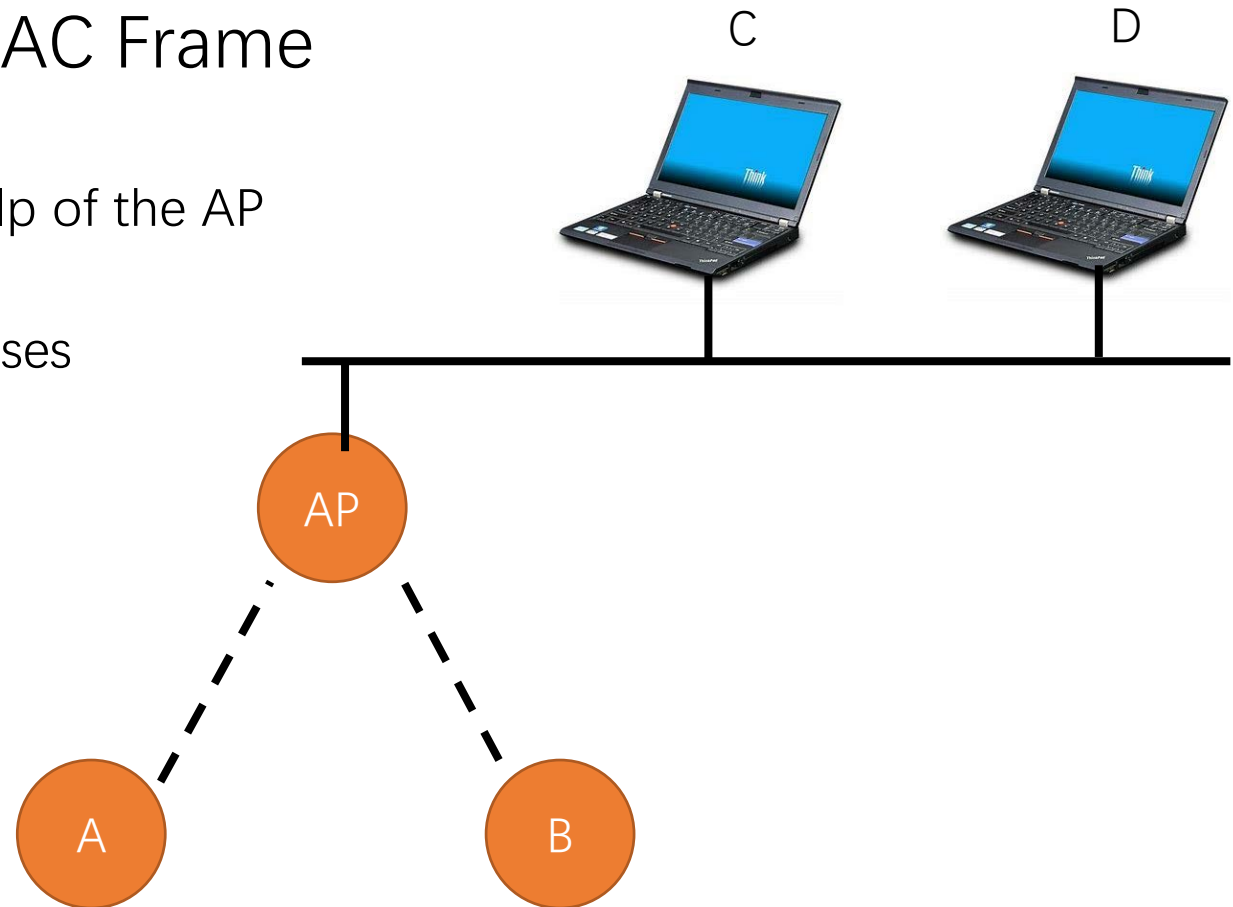
Ethernet



WLAN

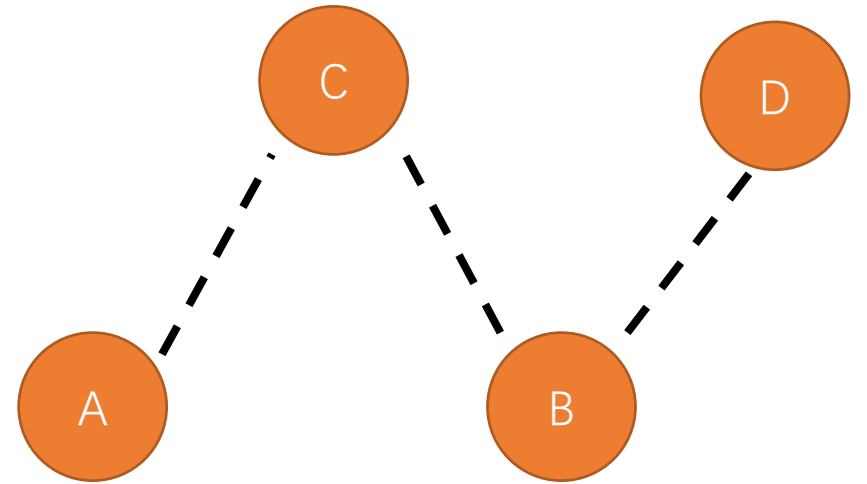
IEEE 802.11 MAC

- Four Address Fields in MAC Frame
 - AP mode
 - Communicate with the help of the AP
 - A -> AP: two addresses
 - A -> AP->B: three addresses



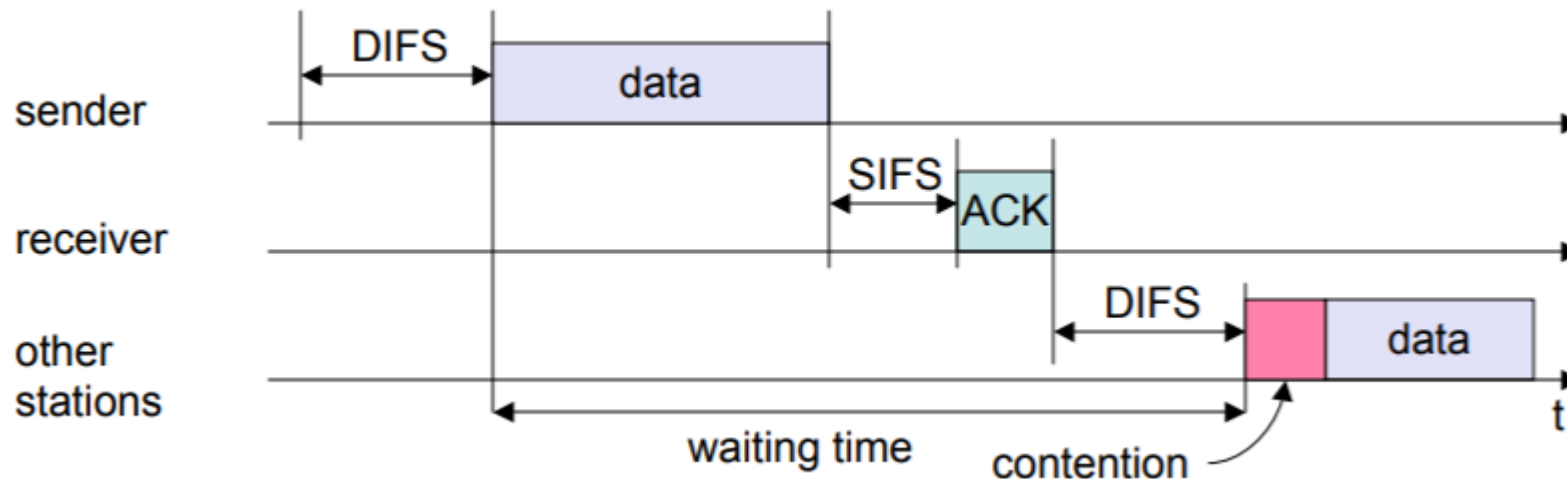
IEEE 802.11 MAC

- Four Address Fields in MAC Frame
 - AP mode
 - Communicate with the help of the AP
 - A -> AP: two addresses
 - A -> AP->B: three addresses
 - Ad-hoc mode
 - Directly communicate with each peer
 - A -> C -> B->D: four addresses



IEEE 802.11 MAC

- Sender has to wait for DIFS before sending data
- Receivers acknowledge at once (after waiting for SIFS) if the packet was received correctly (CRC)



IEEE 802.11 MAC

- With RTS/CTS

