Wireless LAN – IEEE 802.11

Chapter 6

Chapter outline

1. What is a wireless LAN?
2. Ad Hoc and Infrastructure Modes
3. Wireless transmission
4. 802.11 MAC layer – CSMA/CA
5. Hidden Terminal problem
6. 802.11 – Reliability
7. 802.11 – RTS/CTS
8. 802.11 – MAC management
9. 802.11 – Frame format

What is a wireless LAN?

- **Wireless LAN (WLAN)** - provides all the features and benefits of traditional LAN technologies such as Ethernet and Token Ring, but without the limitations of wires or cables.

Wireless features

- Wireless signals are electromagnetic waves
- No physical medium is necessary
- The ability of radio waves to pass through walls and cover great distances makes wireless a versatile way to build a network.

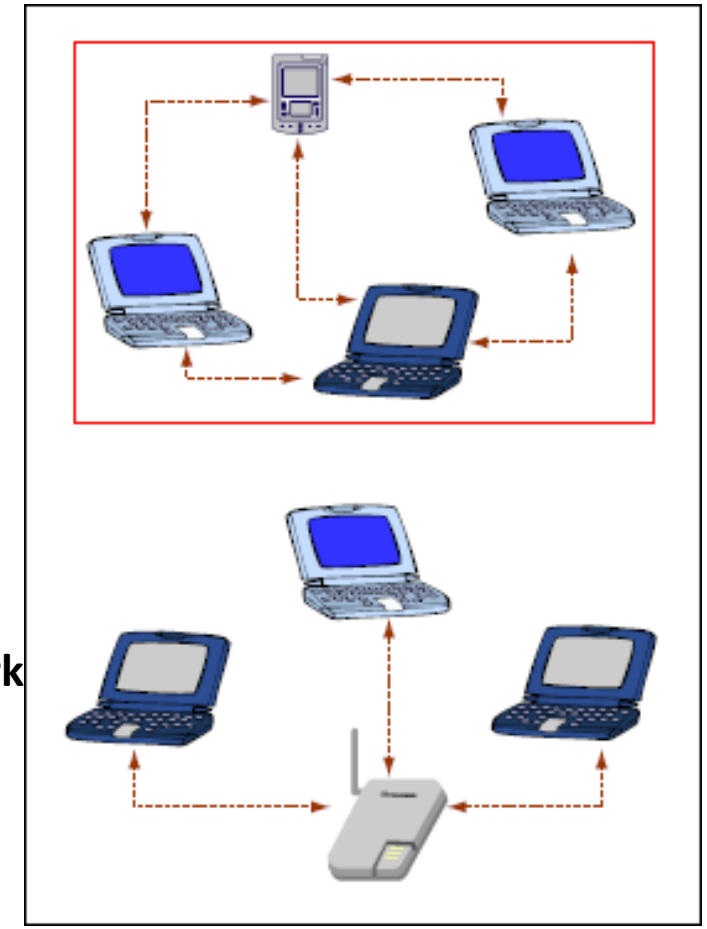
Ad Hoc and Infrastructure Modes

Ad Hoc mode (Independent WLAN**)**

- **The stations communicate with each other**
- **Not connected to a larger network**
- **Stations can move during communication**

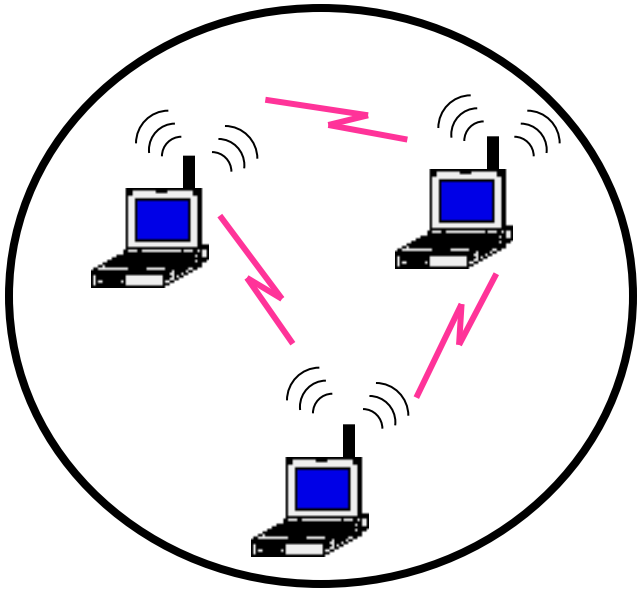
Infrastructure mode

- **An Access Point connects Stations to a wired network**
- **Overlapping Access Points connected to each other**
- **Allows Stations to roam between Access Points**

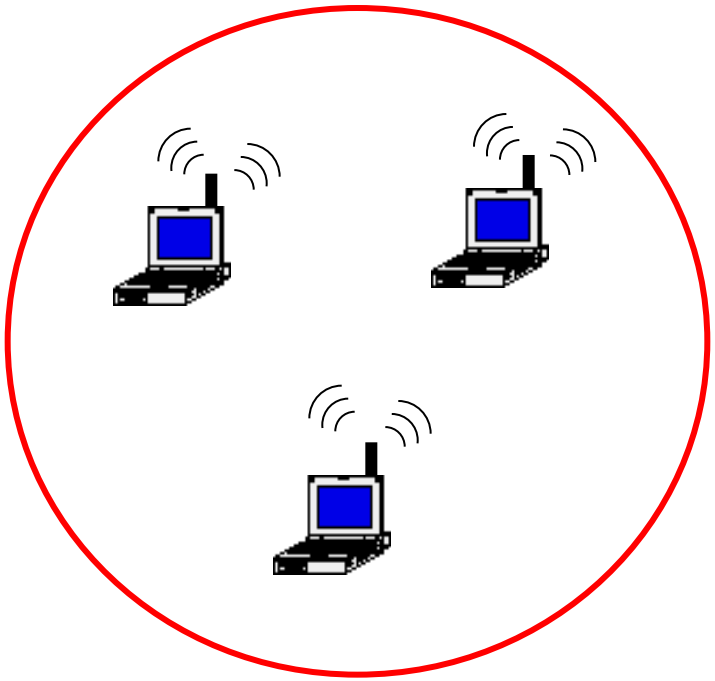


Ad Hoc mode (Independent WLAN)

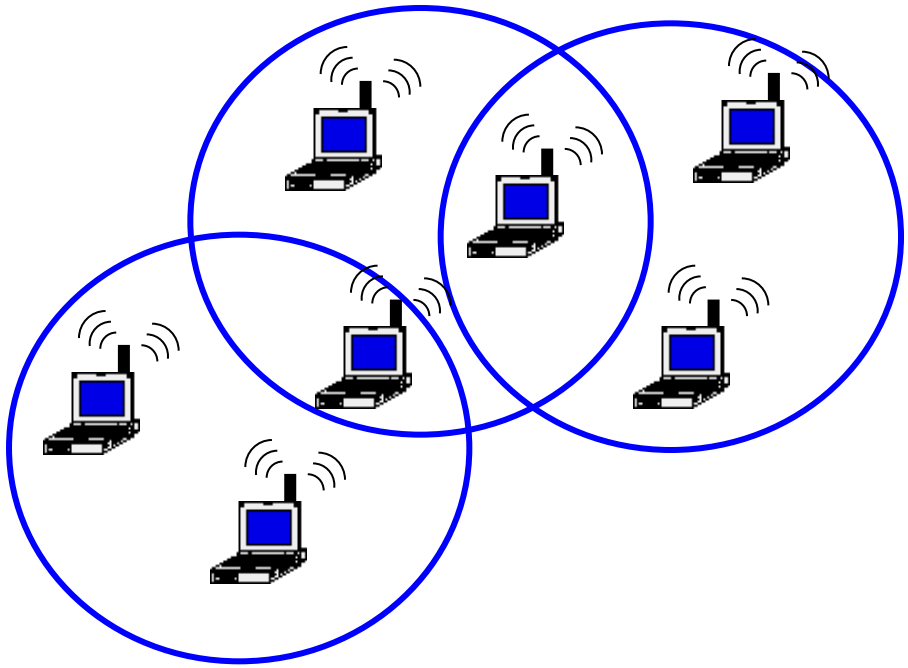
- Ad Hoc
- Simplest
- Rapid deployment
- Peer-to-peer
- No administration



Ad Hoc mode (Independent WLAN)



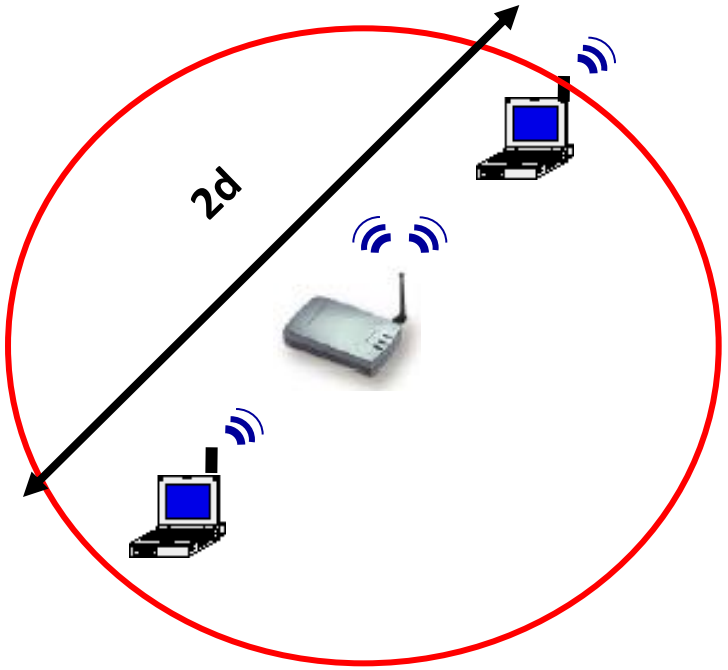
Single Cell



Multiple Cells

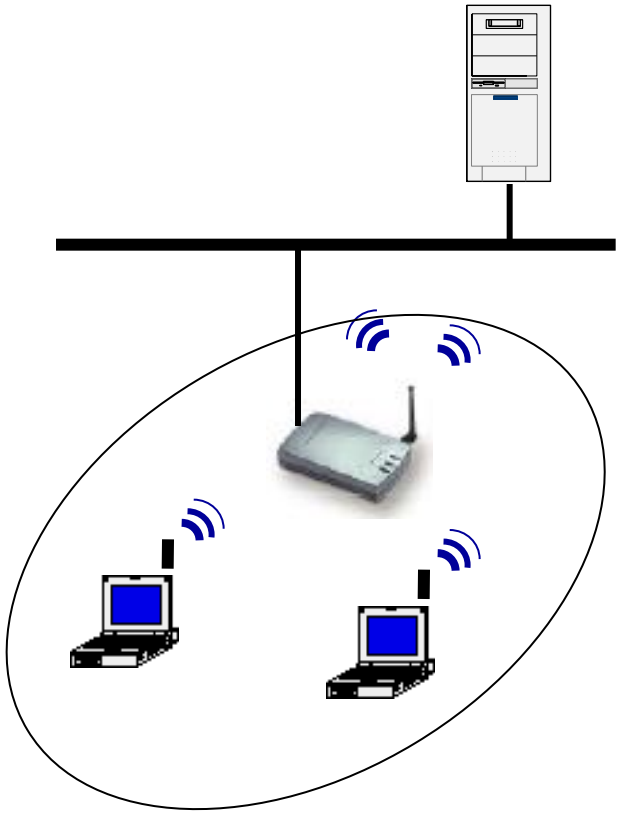
Ad Hoc mode (Independent WLAN)

- Can extended range by using an Access Point (acting as a repeater)



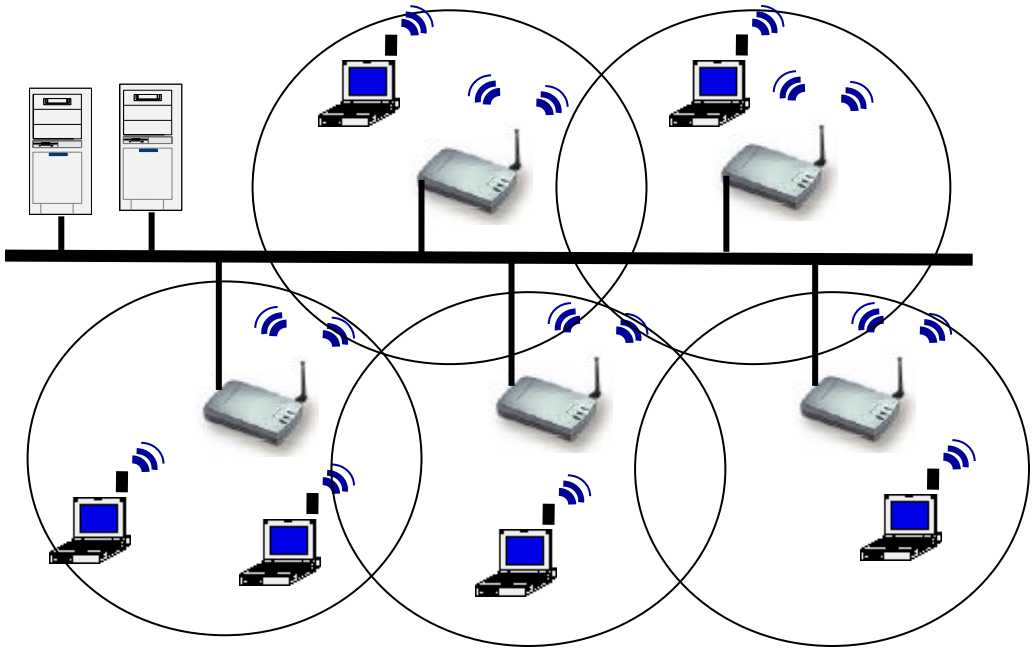
Infrastructure mode

- Need an Access Point
- Connect to the wired LAN
- Need Infrastructure
- Need administration



Infrastructure mode

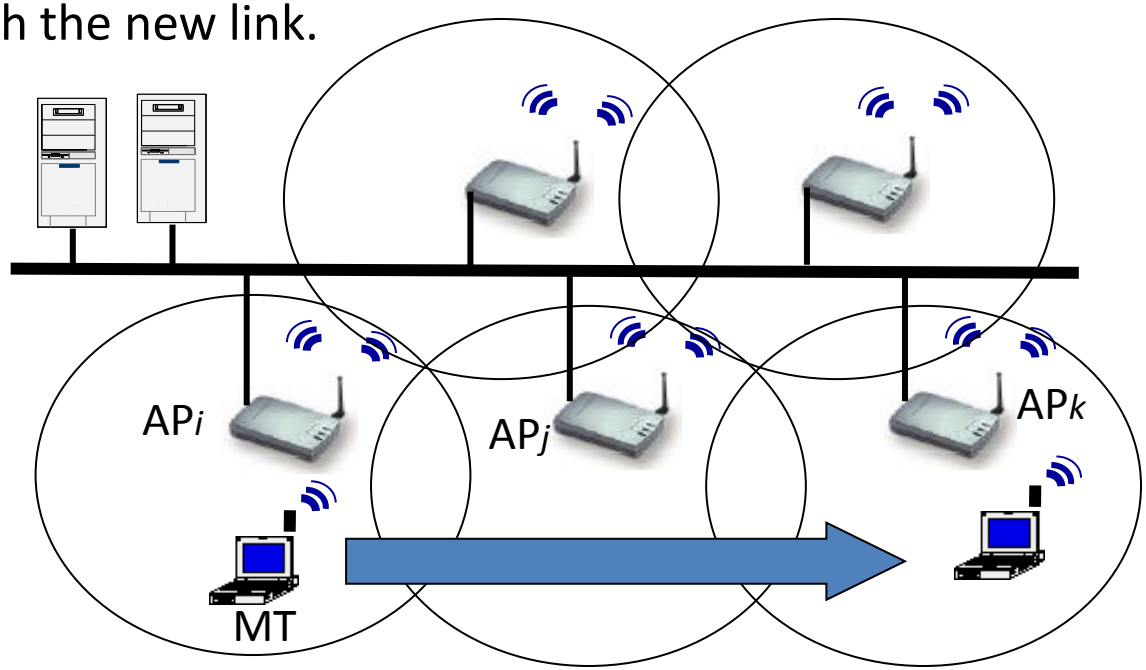
- Many overlapping cells are created,
- Each cell is managed by an AP,
- Interconnected by a distribution system,
- Cover a large area (support many users),



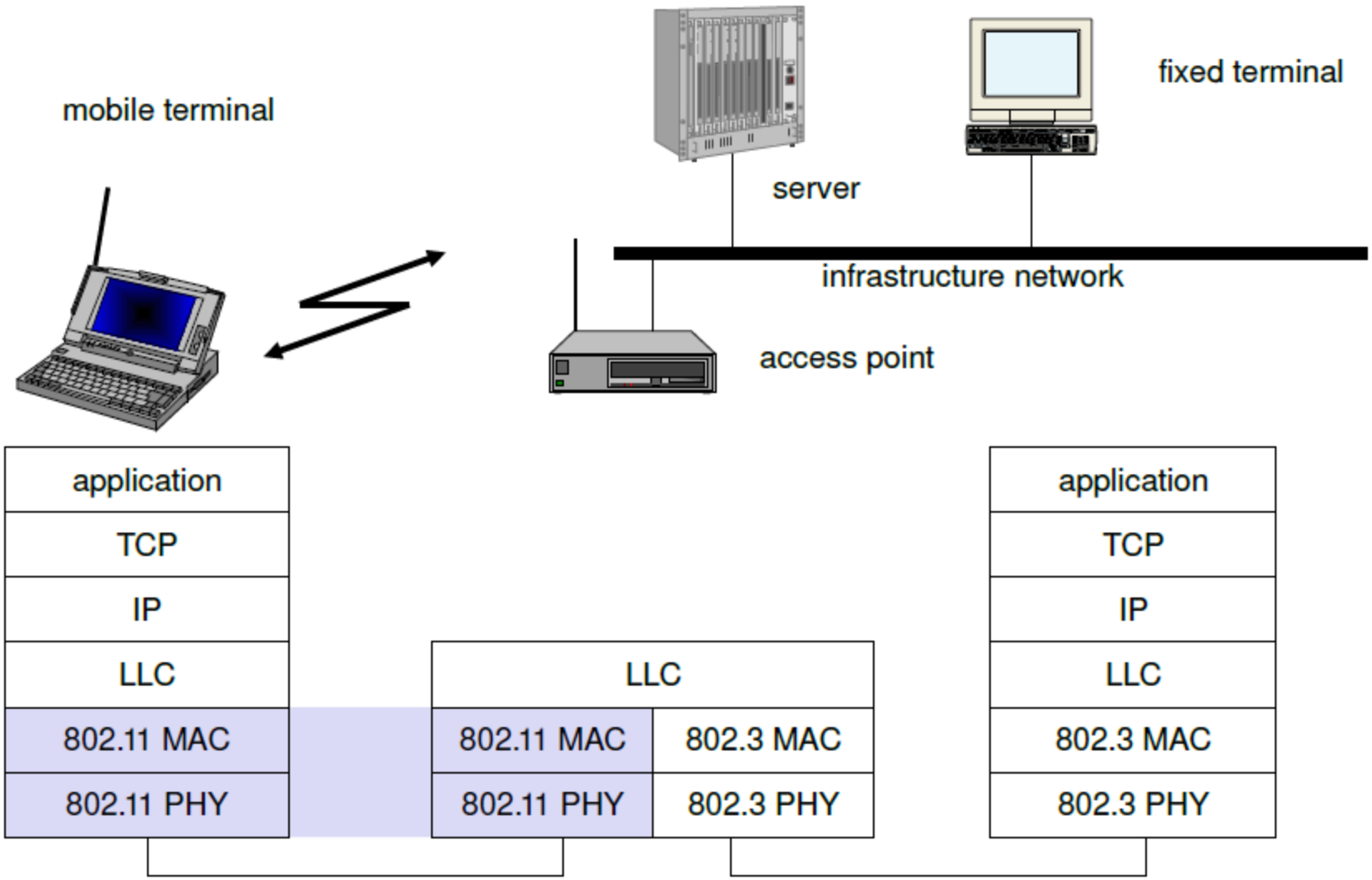
Infrastructure mode

Allowing mobility of wireless devices among cells

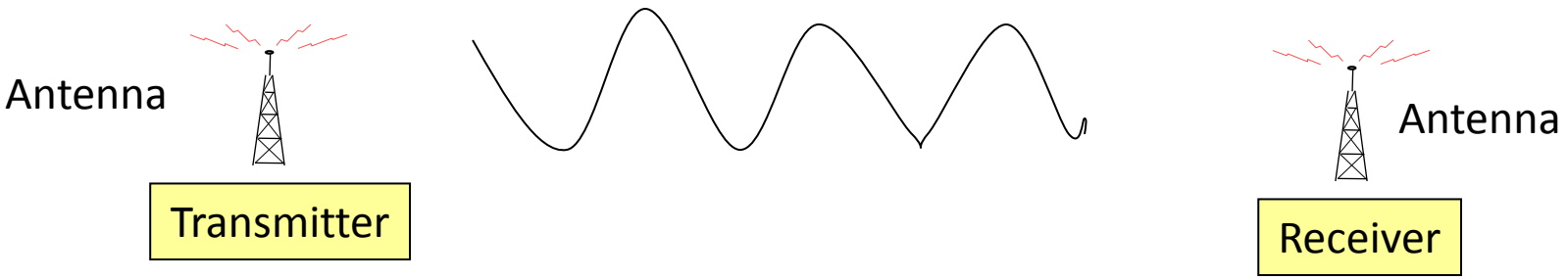
- An established connection over AP*i* is maintained when the MT becomes near the AP*j*
- Handover (Handoff)
  - Establish new link over APj,
  - Release the old link over APi,
  - Route packets through the new link.



Reference model



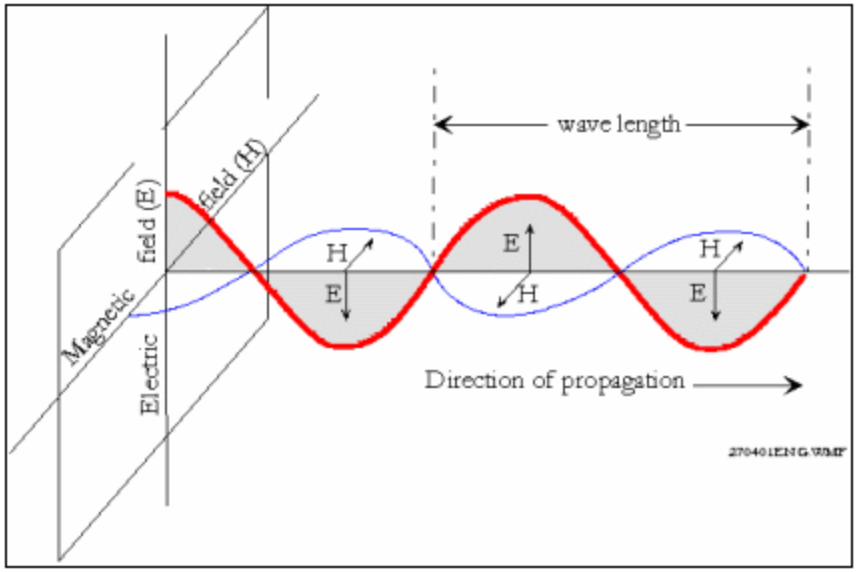
Wireless transmission



- Wireless communication systems consist of:
  - Transmitters
  - Antennas: radiates electromagnetic energy into air
  - Receivers
- RF devices communicate through the transmission and reception of electromagnetic waves
- In some cases, transmitters and receivers are on same device, called transceivers.

Electromagnetic Waves

Electromagnetic wave: alternates **electrical** (E) and **magnetic** (H) fields in a flow characterized by an oscillating waveform



E. Electrical field (vertical)

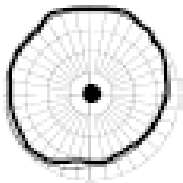
H. Magnetic field (horizontal)

The **wave of the electric field** and the **wave of the magnetic field** are propagated perpendicularly to the direction of propagation and to each other.

Antenna

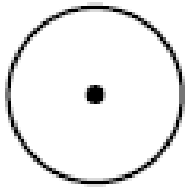
- Transmitter converts electrical energy to electromagnetic waves
- Receiver converts electromagnetic waves to electrical energy
- Same antenna is used for transmission and reception
- **Omni-Directional**: Power radiated in all directions
- **Directional**: Most power in the desired direction
- **Isotropic** antenna: Radiates in all directions equally
- Antenna Gain = Power at particular point/Power with Isotropic Expressed in dBi

$$Pr = P_t G_t G_r (\lambda/4\pi d)^2$$



Omni-directional

Directional



Isotropic

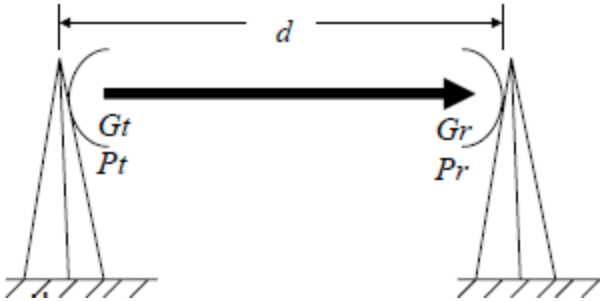
Transmission Characteristic

- Free-Space loss model

$$Pr/Pt = Gt\ Gr * [\lambda /(4\pi d)]^2$$

where:

Pt – transmitted power level
Pr – received power level
Gr – receive antenna gain
Gt – transmit antenna gain
λ – carrier frequency wavelength
d – distance between transmitter and receiver



- **Path loss** is defined as L = Pt/Pr – usually measured in dBs (i.e. $LdB = 10\log_{10}(L) = 10\log_{10}(Pt/Pr)$)

- If Gt and Gr are not given – assume Gt = Gr = 1.

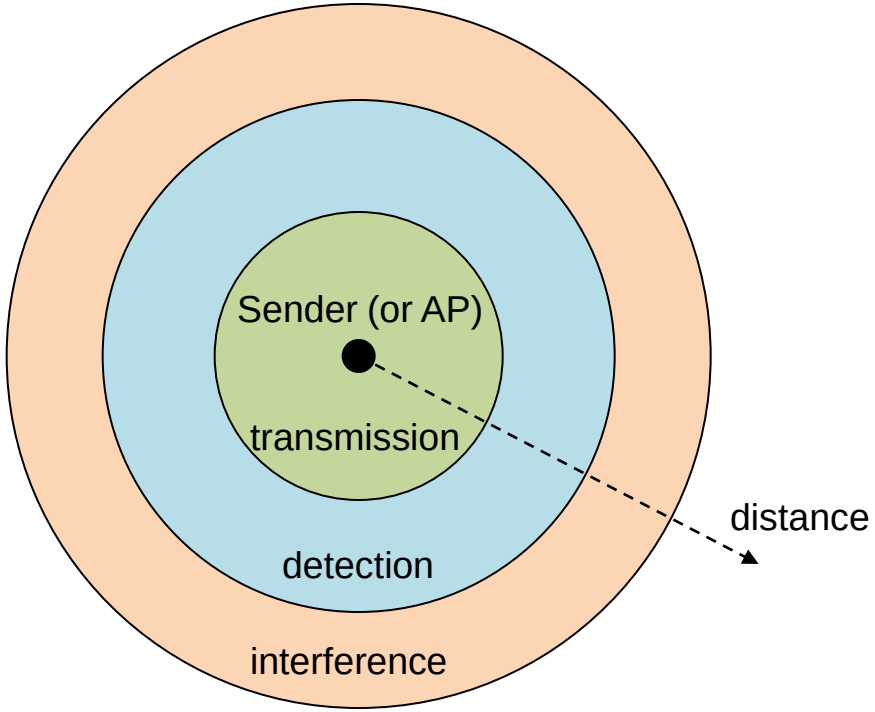
Defining Range and Coverage

- **Range** – The maximum distance at which the sender and receiver can mantain a connection

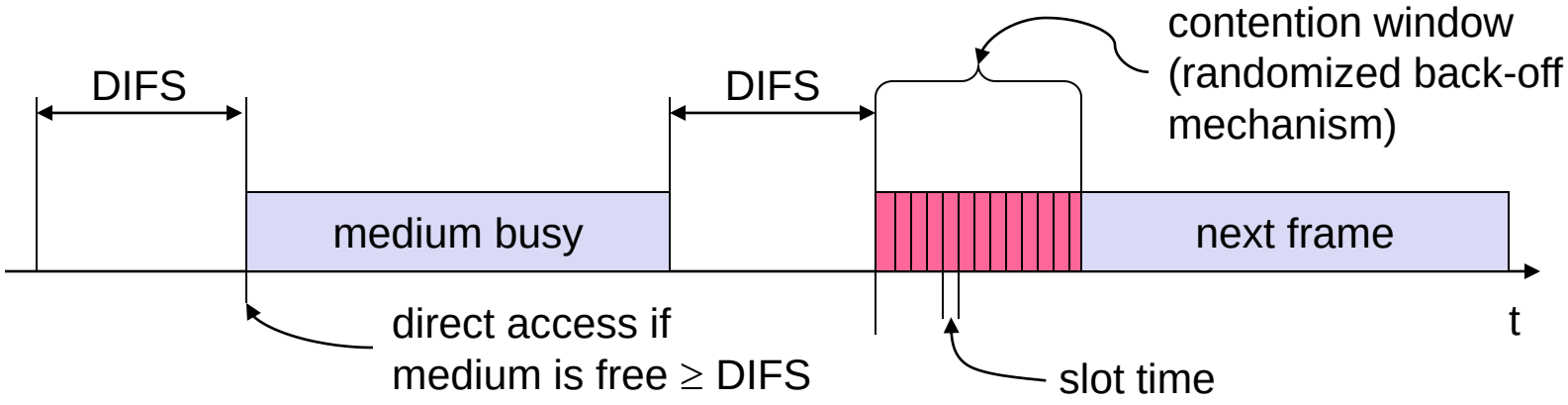
- **Coverage** – The total area that a wi-fi enabled device can be in and make a connection to an access point

Signal propagation ranges

- Transmission range
  - communication possible
  - low error rate
- Detection range
  - detection of the signal possible
  - no communication possible
- Interference range
  - signal may not be detected
  - signal adds to the background noise

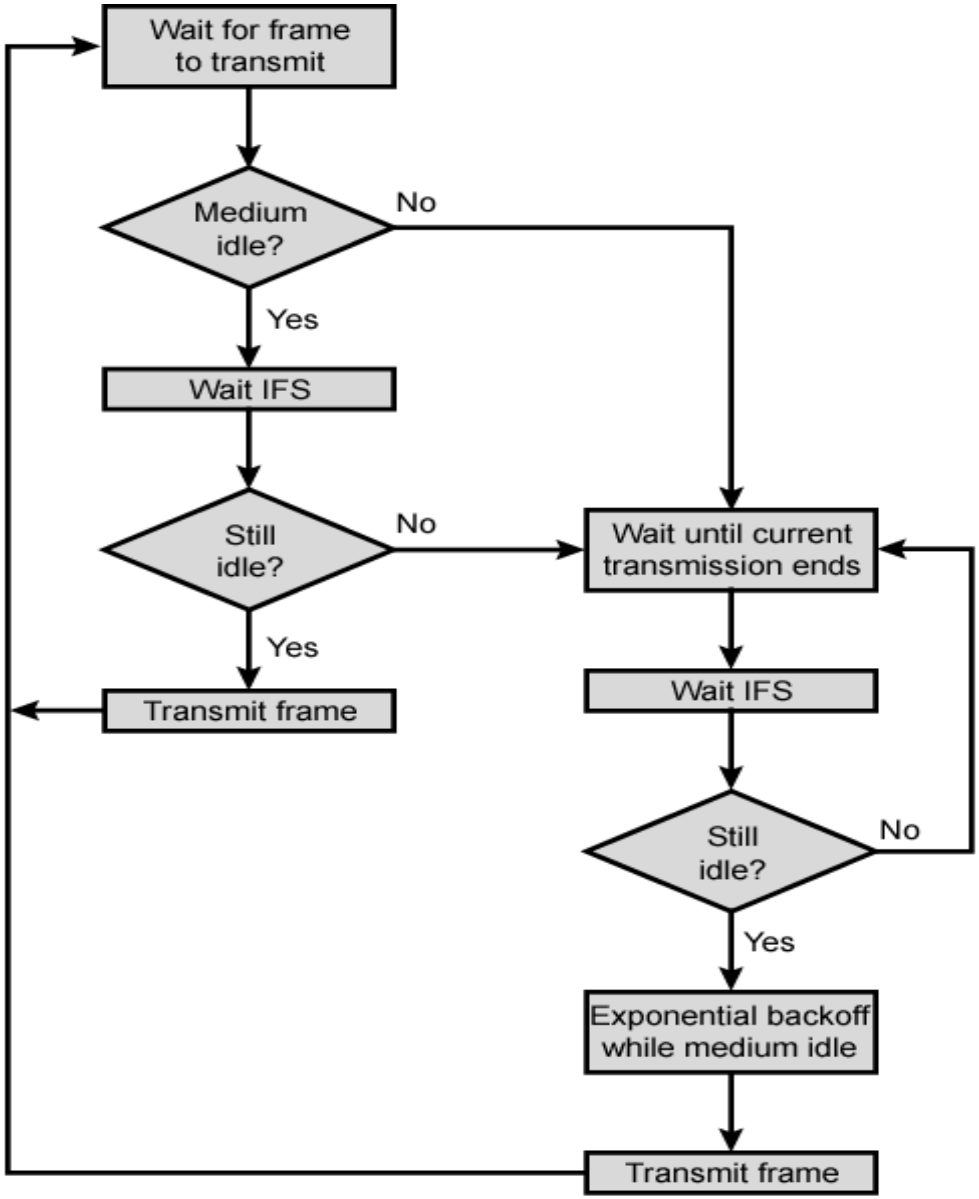


802.11 MAC layer – CSMA/CA



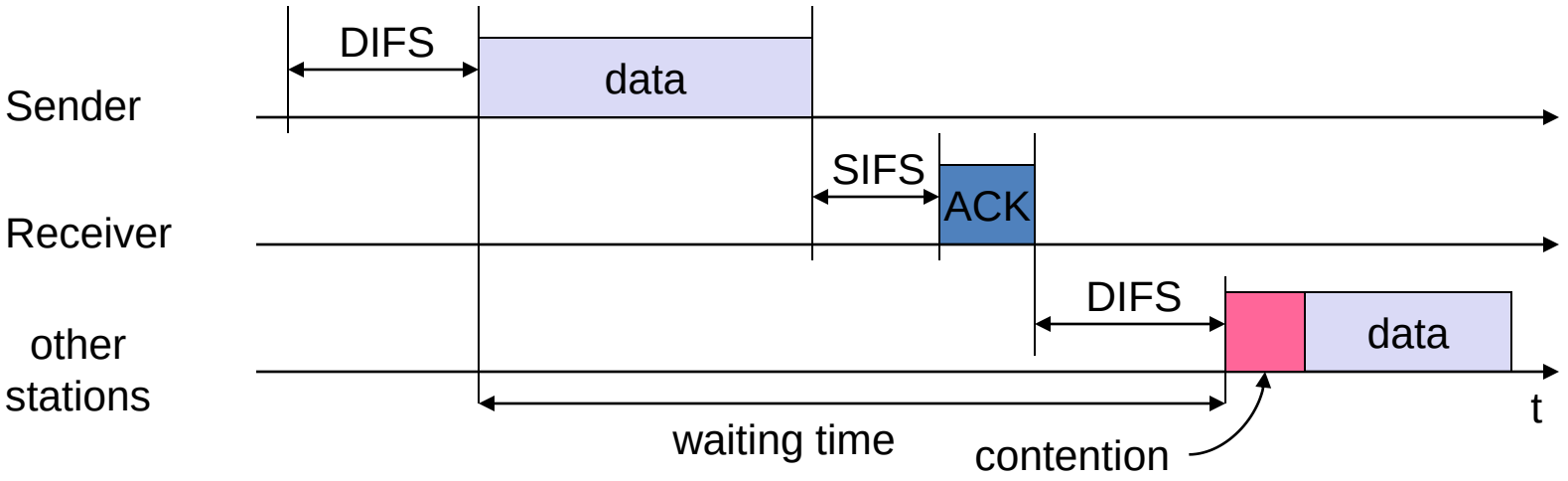
- station which has data to send starts sensing the medium (Carrier Sense based on CCA, Clear Channel Assessment)
- if the medium is free for the duration of an Inter-Frame Space (IFS), the station can start sending (IFS depends on service type)
- if the medium is busy, the station has to wait for a free IFS plus an additional random back-off time (multiple of slot-time)
- if another station occupies the medium during the back-off time of the station, the back-off timer stops (fairness)

802.11 - CSMA/CA



802.11 DCF – basic access

- If medium is free for DIFS time, station sends data
- receivers acknowledge at once (after waiting for SIFS) if the packet was received correctly (CRC)
- automatic retransmission of data packets in case of transmission errors



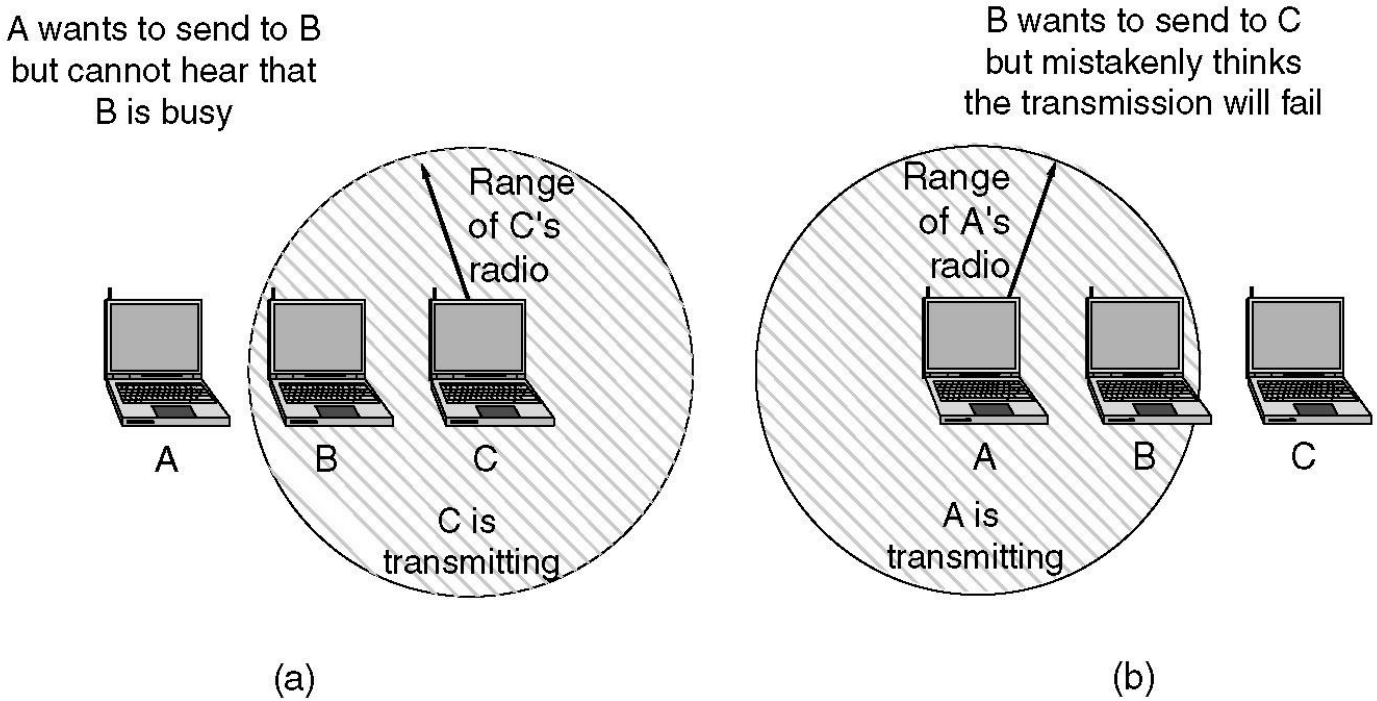


Figure 4-26.(a)The hidden terminal problem. (b) The exposed station problem.

Tanenbaum slide

The Hidden Terminal Problem

- Wireless stations have transmission ranges and not all stations are within radio range of each other.
- The trouble is, CSMA is not really a good way to think about wireless because what matters for reception is interference at the receiver, not at the sender.
- Simple CSMA will not work!
- C transmits to B.
- If A "*senses*" the channel, it will not hear C's transmission and falsely conclude that A can begin a transmission to B.

The Exposed Station Problem

- This is the inverse problem.
- B wants to send to C and listens to the channel.
- When B hears A's transmission, B falsely assumes that it cannot send to C.

Wireless LAN Protocols

[Tan pp.269-270]

- ***MACA*** protocol solved hidden and exposed terminal problems:
  - Sender broadcasts a Request-to-Send (***RTS***) and the intended receiver sends a Clear-to-Send (***CTS***).
  - Upon receipt of a ***CTS,*** the sender begins transmission of the frame.
  - RTS, CTS helps determine who else is in range or busy (***C***ollision ***A***voidance).

Wireless LAN Protocols

- *MACAW* added ACKs, Carrier Sense, and BEB done per stream and **not** per station.

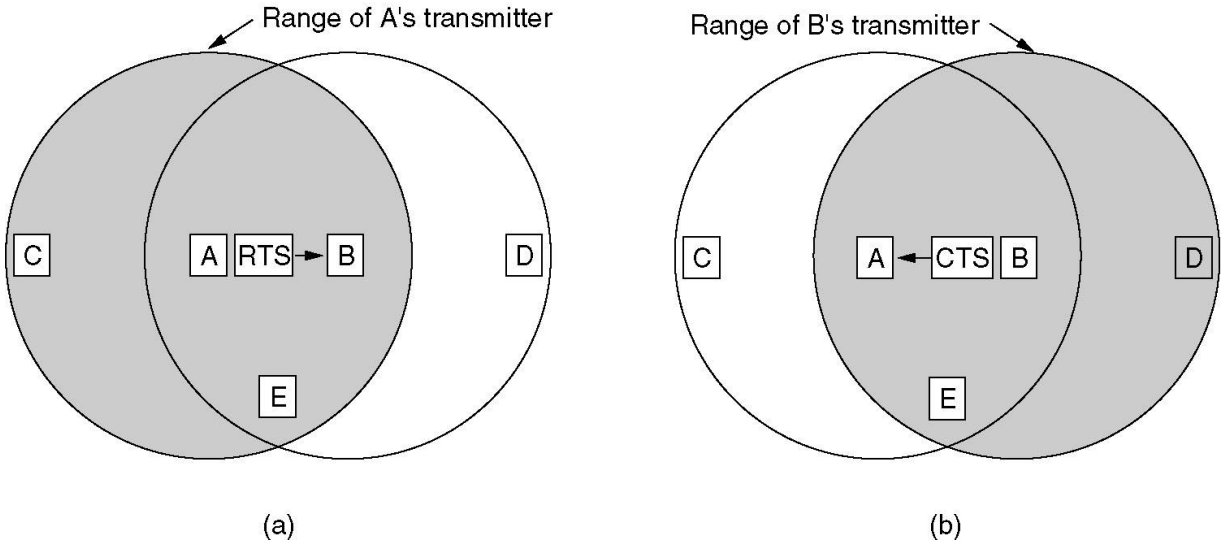


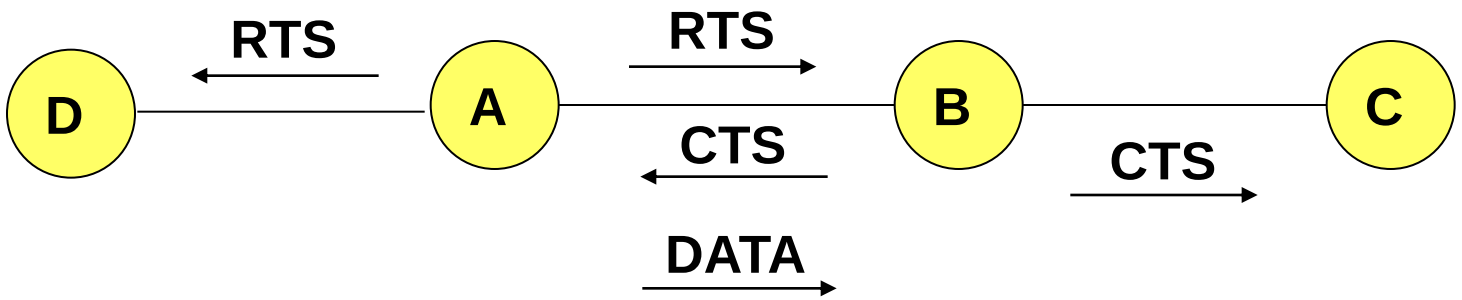
Figure 4-12. (a) A sending an RTS to B.

(b) B responding with a CTS to A.

Tanenbaum slide

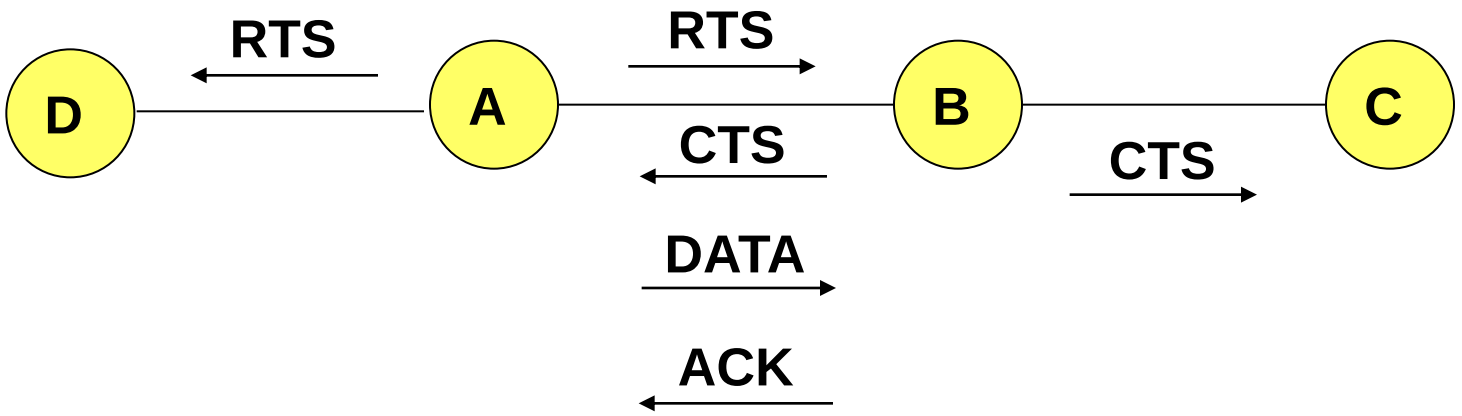
Solution to Hidden Terminals

- A first sends a *Request-to-Send (RTS)* to B
- On receiving RTS, B responds *Clear-to-Send (CTS)*
- Hidden node C overhears CTS and keeps quiet
  - Transfer duration is included in both RTS and CTS
- Exposed node overhears a RTS but not the CTS
- D's transmission cannot interfere at B, As long as it does not interfere with the CTS, it is free to transmit while the data frame is being sent.



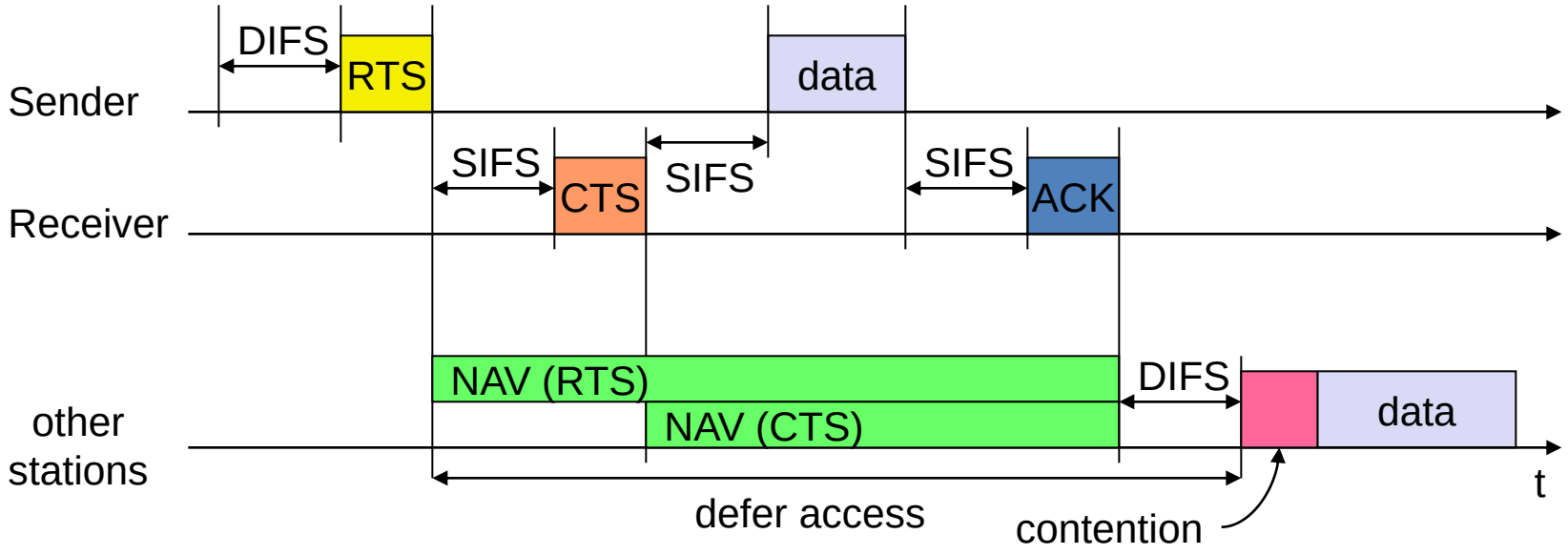
802.11 - Reliability

- Use acknowledgements
  - When B receives DATA from A, B sends an ACK
  - If A fails to receive an ACK, A retransmits the DATA
  - Both C and D remain quiet until ACK (to prevent collision of ACK)
  - Expected duration of transmission+ACK is included in RTS/CTS packets

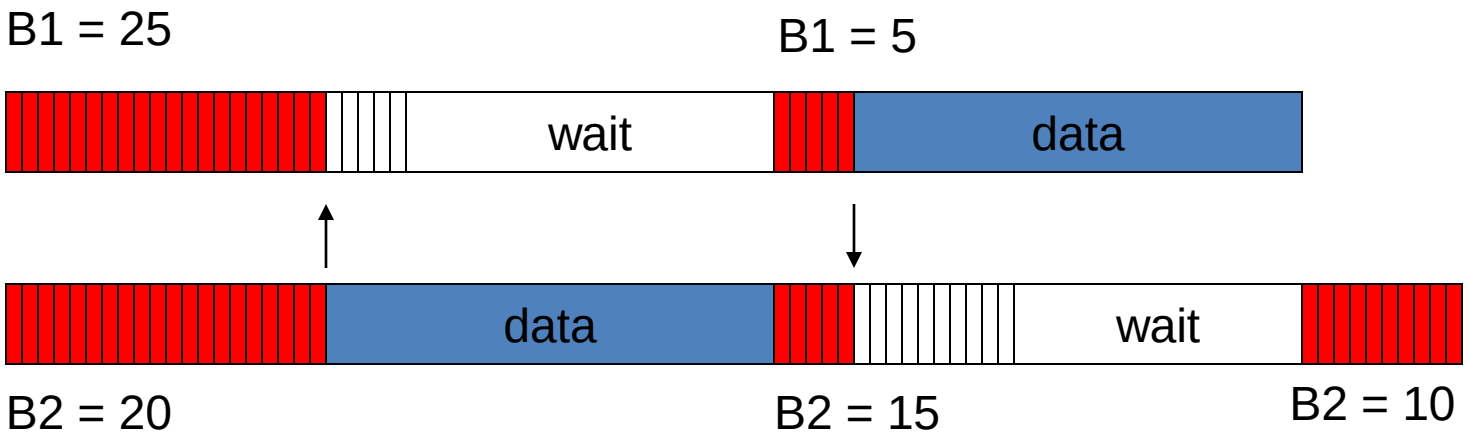


802.11 –RTS/CTS

- If medium is free for DIFS, station can send RTS with reservation parameter (reservation determines amount of time the data packet needs the medium)
- acknowledgement via CTS after SIFS by receiver (if ready to receive)
- sender can now send data at once, acknowledgement via ACK
- other stations store medium reservations distributed via RTS and CTS



Example - backoff



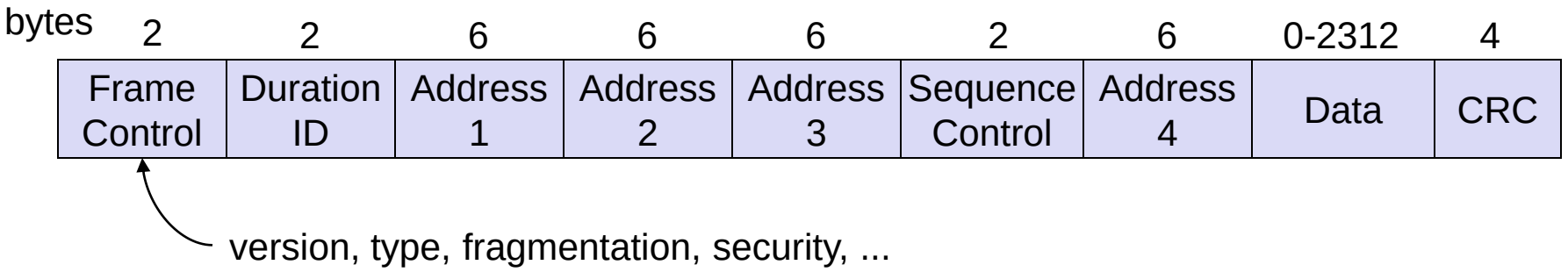
B1 and B2 are backoff intervals at nodes 1 and 2

802.11 - MAC management

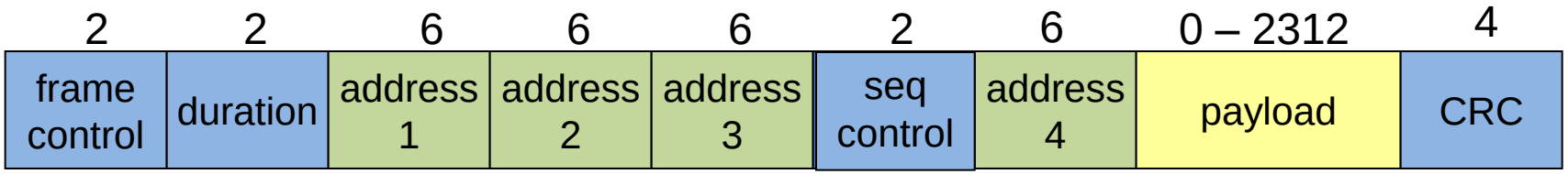
- Synchronization
  - try to find a LAN, try to stay within a LAN
  - timer etc.
- Power management
  - sleep-mode without missing a message
  - periodic sleep, frame buffering, traffic measurements
- Association/Reassociation
  - The association service is used by mobile stations to connect themselves to APs.
  - Reassociation lets a station change its preferred AP.
  - integration into a LAN
  - roaming, i.e. change networks by changing access points
  - scanning, i.e. active search for a network
- MIB - Management Information Base
  - managing, read, write

802.11 - Frame format

- Types
  - control frames, management frames, data frames
- Sequence numbers
  - important against duplicated frames due to lost ACKs
- Addresses
  - receiver, transmitter (physical), BSS identifier, sender (logical)
- Miscellaneous
  - sending time, checksum, frame control, data



802.11 frame: addressing



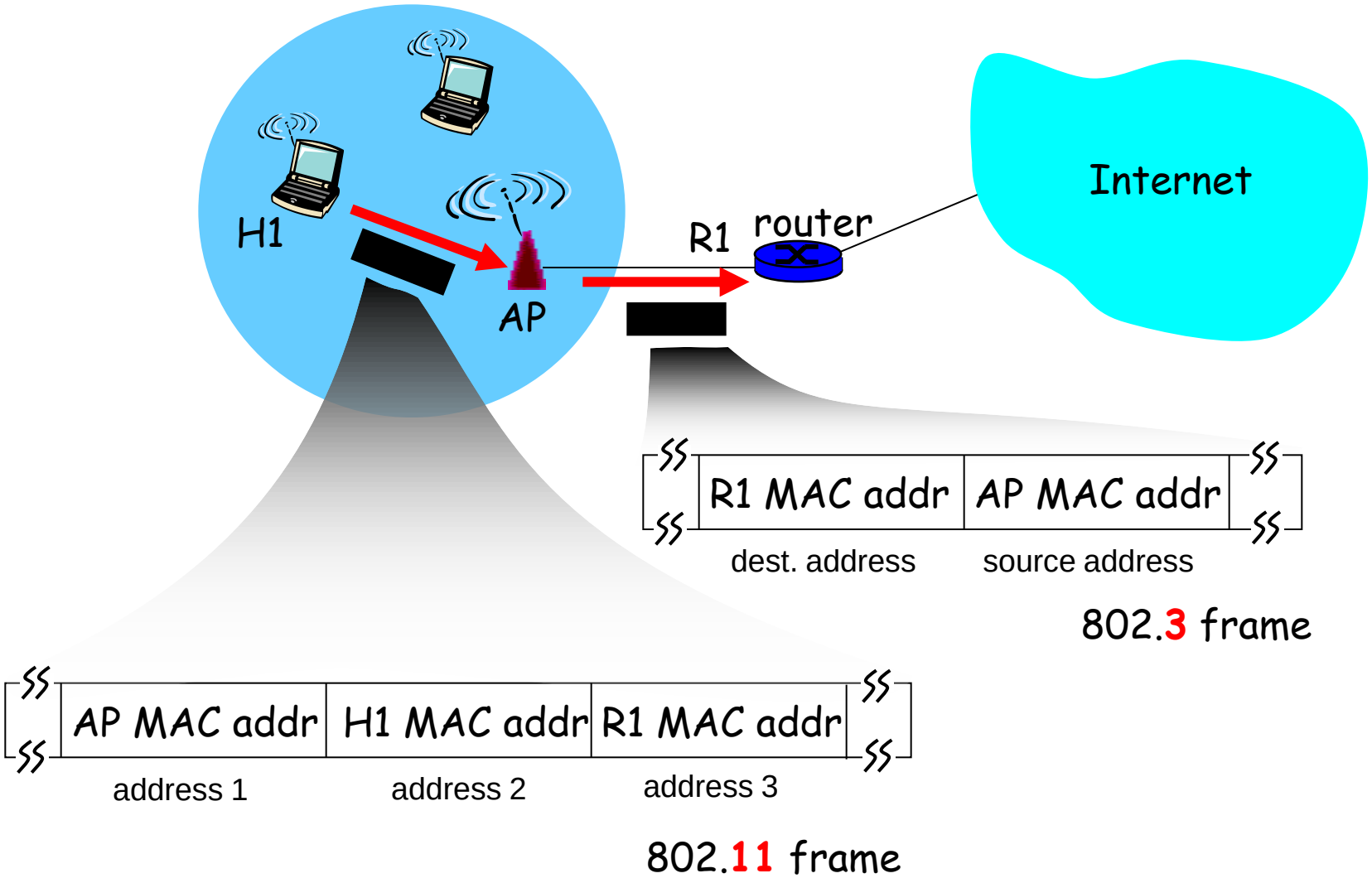
Address 1: MAC address of wireless host or AP to receive this frame

Address 2: MAC address of wireless host or AP transmitting this frame

Address 3: MAC address of router interface to which AP is attached

Address 3: used only in ad hoc mode

802.11 frame: addressing



802.11 frame: more