Communication Networks:
Technology & Protocols

Stavros Tripakis (stavros@eecs)

Lecture 17

October 1

FDDI example:

- When node i receives the token:
  - THTi := TTRT - TRTi;
  - TRTi := 0;
  - Transmit synchronous traffic for Si time units.
  - If THTi > 0, then transmit asynchronous traffic until THTi reaches 0.

FDDI analysis

- Can prove that for each node i :

  $TRTi < 2\ TTRT.$

  This implies that the medium access timeis at most 2 TTRT.

  Note book error: assumption $2TTRT < \rho$ to be replaced by $TTRT > \rho$.

- Efficiency: close to 100%.

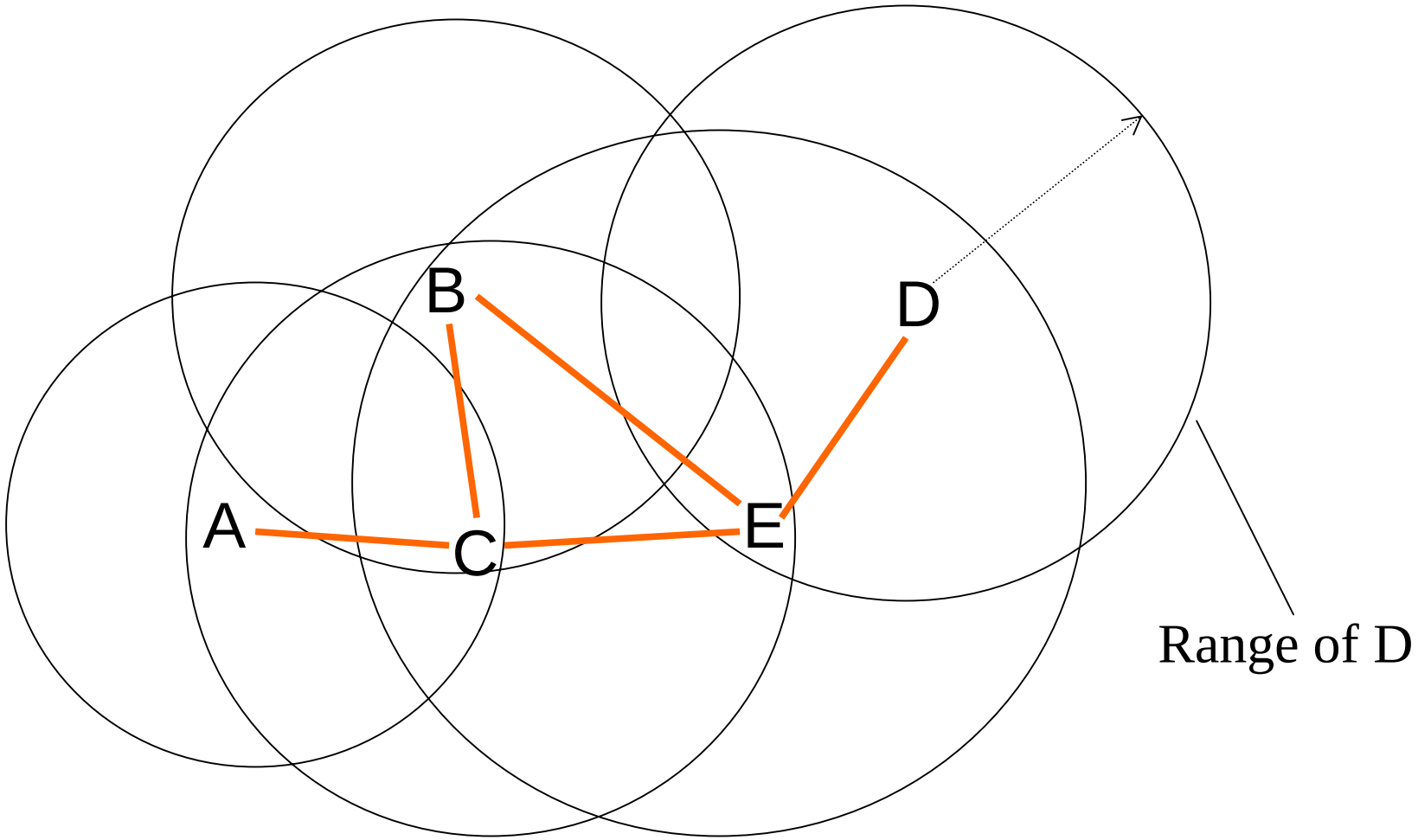
Wireless LANs

- Unique features of wireless networks.
- Emerging standards:
  - Europe: ETSI Hiperlan
  - US: IEEE 802.11
- Emerging products:
  - WaveLan (Lucent)
  - Metricom
  - Ricochet
  - Nokia
  - etc.

Characteristics of wireless networks

- Medium: 3D space.
- Signals: radio waves on specific frequencies.
  - Frequency is a precious resource.
- "Difficult" medium:
  - Interference, noise, shadowing, multipath effect.
  - Higher bit-error rates, lower capacity (1-2Mbps).
- Power limitations $\Rightarrow$ non-broadcast medium.
  - Carrier-sense not very helpful.
  - Collision-detection would require full-duplex radio channel $\Rightarrow$ too expensive.
- Mobility of hosts.

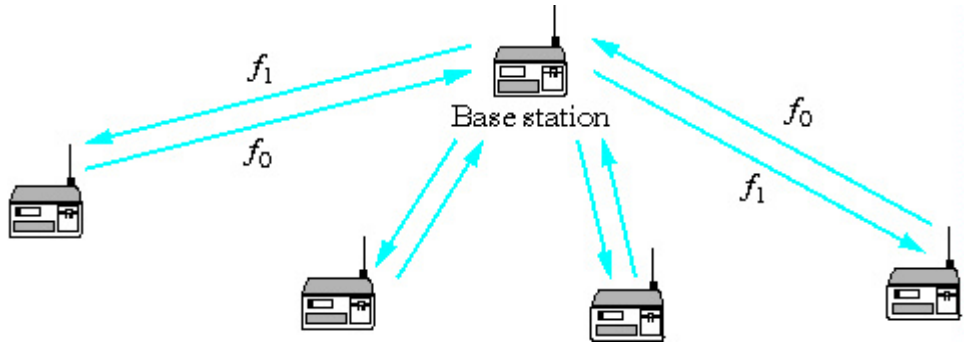
Simplified view of wireless network



Difficulties for carrier-sense and collision-detection.

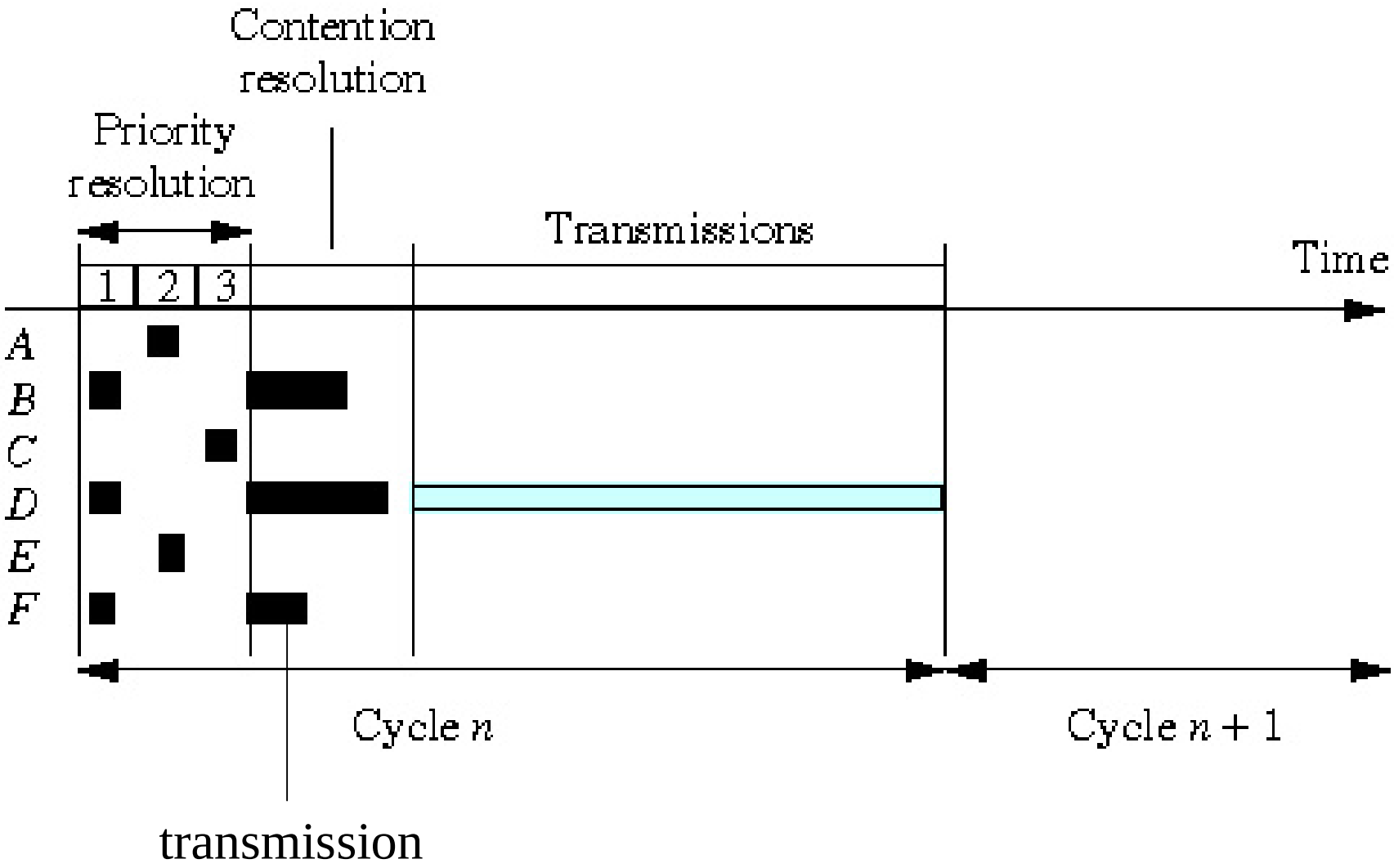
- *Hidden-terminal problem* : A cannot "hear" C transmitting. If A wants to transmit to B and hears nothing, it cannot assume that collision won't happen, so carrier-sense does not help. Collision-detection not possible at sender's side.
- *Exposed-terminal problem* : C can hear B transmitting but does not know who the receiver is. C can still transmit to D while B transmits (to A or some other node) without the two signals interfering at the receivers' sides.

ALOHA protocol



- Multiple access without carrier-sense or collision-detection (two terminals cannot hear each other).
- Two versions:
  - Pure ALOHA: a station can transmit at any time.
  - Slotted ALOHA: time divided into slots (each slot is enough for 1 packet), stations can transmit only at the beginning of a slot. Better performance, harder to implement (need to synchronize clocks).

ETSI Hiperlan standard

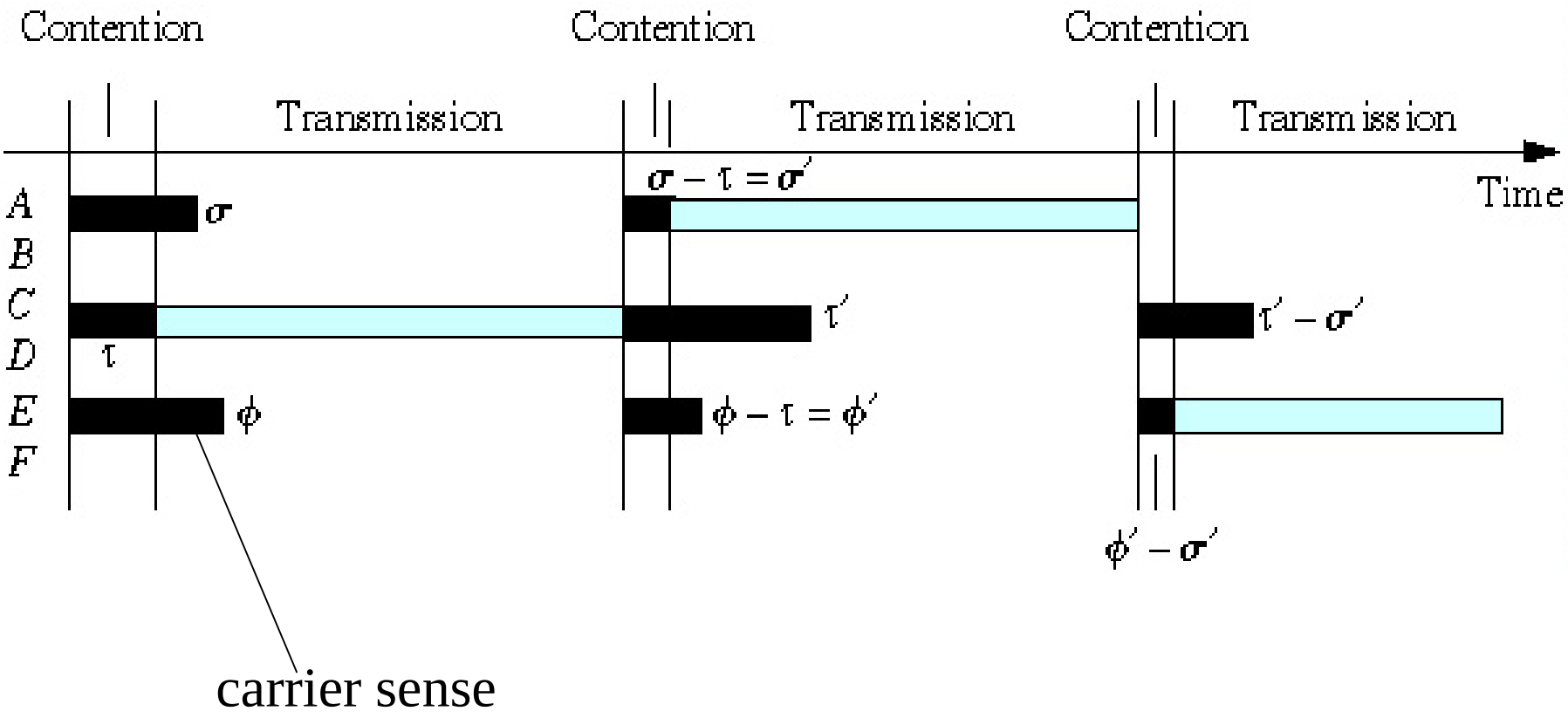


IEEE 802.11 standard

- Physical and MAC specifications.
- "Open" standard, leaves many possibilities for implementation $\Rightarrow$ not clear whether different 802.11-compliant devices can inter-operate.
- Physical:
  - Unlicensed bands, e.g., in US: 900MHz, 2.4GHz, 5.7GHz.
  - Various restrictions on use.
  - Direct-sequence or Frequency-hopping spread-spectrum.
- MAC: different modes of operation:
  - Centralized: a base station gives access to the nodes one-by-one.
  - Distributed: CSMA/CA.

IEEE 802.11 MAC (cont'd)

- Carrier-sense:



IEEE 802.11 MAC (cont'd)

- Collision-avoidance (stemmed from MACA protocol):
  - Sender transmits special Request-to-send (RTS) packet: the packet contains the length of data to be sent, L.
  - Receiver replies with Clear-to-send (CTS) packet: this packet also contains the length of data (same as before).
  - Every node hearing the RTS remains quiet for CTS+L.
  - Every node hearing the CTS remains quiet for L.
  - If sender does not receive CTS, it knows the receiver is busy and does not transmit data.
  - CTS/RTS packets may still collide, but they are small, so the probability of collisions is reduced.

IEEE 802.11 MAC: example

- Example: