Wireless
Local Area Networks

Wireless Local Area Networks

- The proliferation of laptop computers and other mobile devices (PDAs and cell phones) created an *obvious* application level demand for wireless local area networking.
- Companies jumped in, quickly developing *incompatible* wireless products in the 1990's.
- Industry decided to entrust standardization to IEEE committee that dealt with wired LANs
  - ***namely, the IEEE 802 committee!!***

IEEE 802 Standards Working Groups

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)
802.13	Unlucky number. Nobody wanted it
802.14 ↓	Cable modems (defunct: an industry consortium got there first)
802.15 *	Personal area networks (Bluetooth)
802.16 *	Broadband wireless
802.17	Resilient packet ring

Figure 1-38. The important ones are marked with *. The ones marked with ↓ are hibernating. The one marked with † gave up.

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Classification of Wireless Networks

- ***Base Station*** :: all communication through an ***Access Point* (AP)** {note hub topology}. Other nodes can be fixed or mobile.
- ***Infrastructure Wireless*** :: AP is connected to the wired Internet.
- ***Ad Hoc Wireless*** :: wireless nodes communicate directly with one another.
- ***MANETs* (Mobile Ad Hoc Networks) ::** ad hoc nodes are mobile.

Wireless LANs

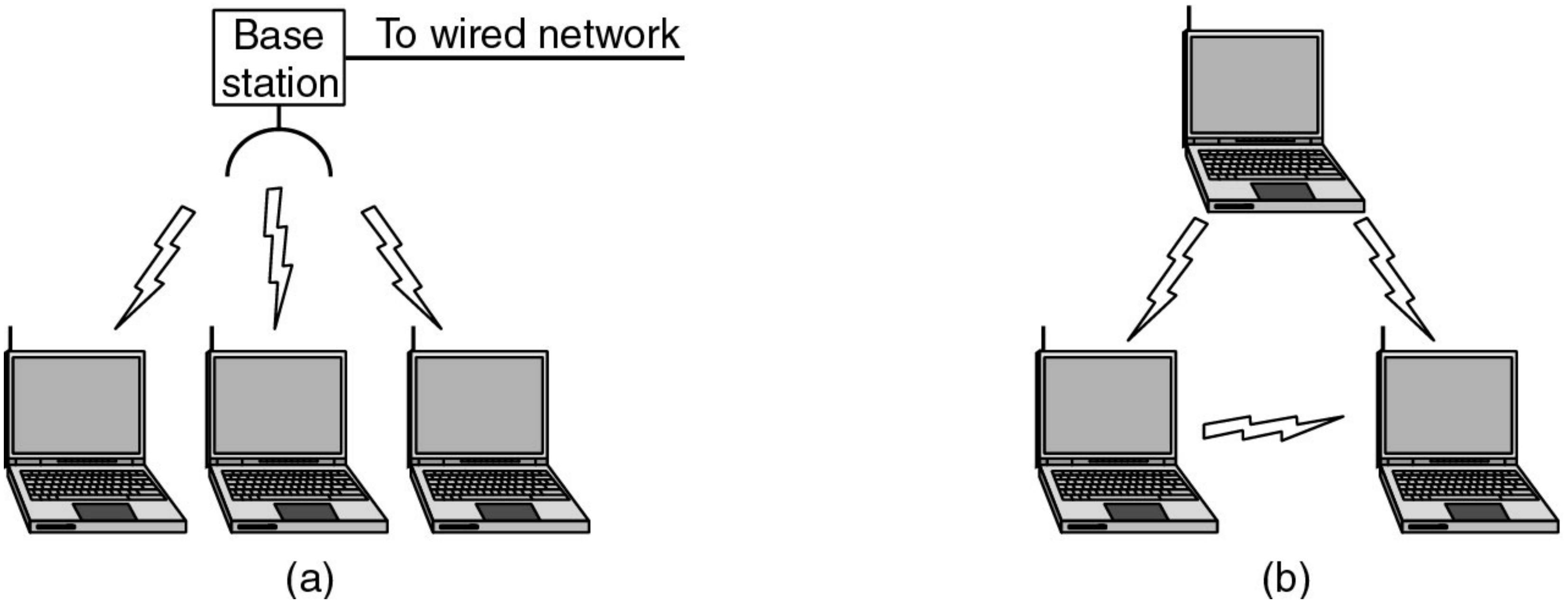

Figure 1-36.(a) Wireless networking with a base station. (b) Ad hoc networking.

The 802.11 Protocol Stack

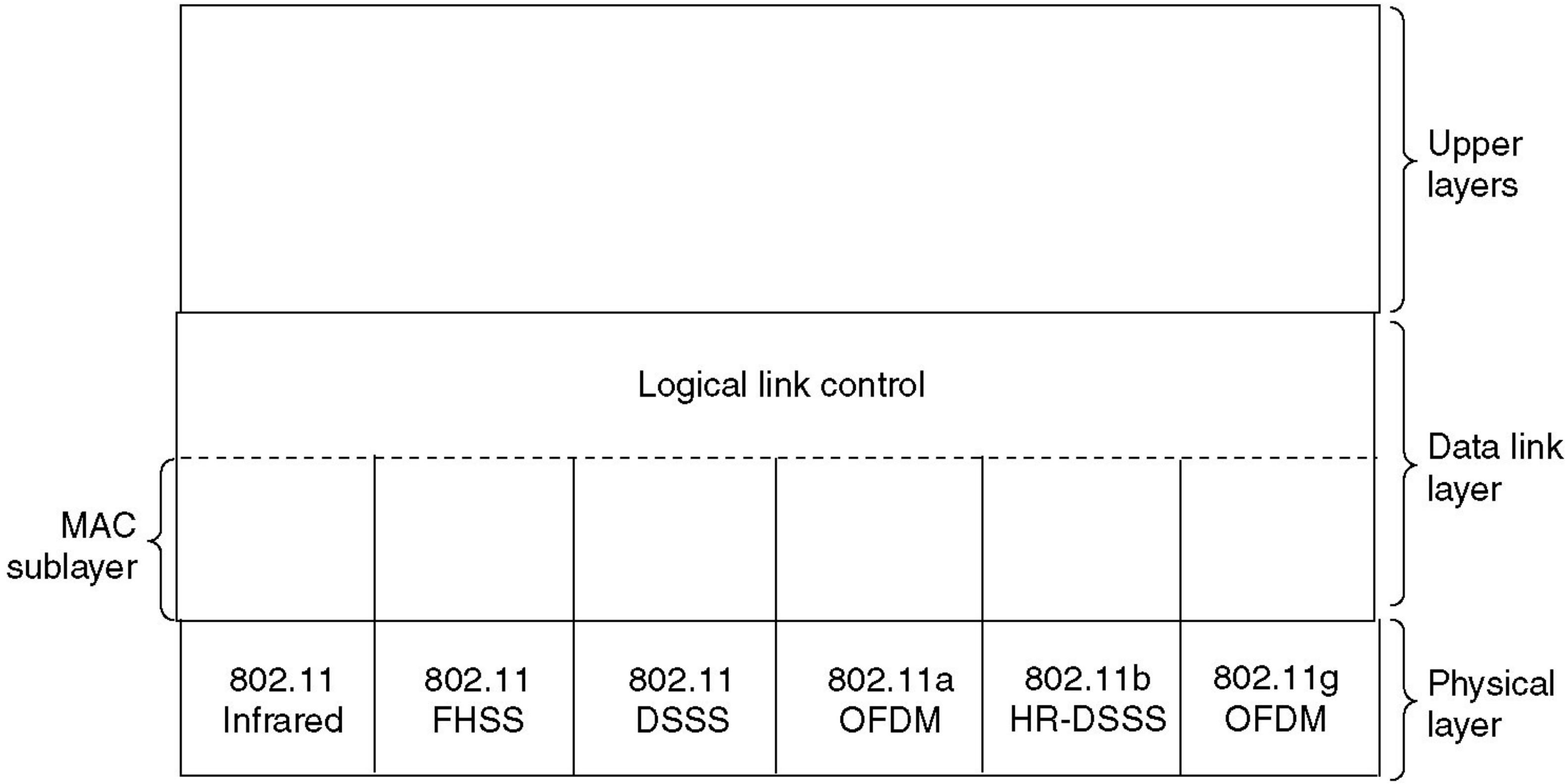

Figure 4-25. Part of the 802.11 protocol stack.

Note – ordinary 802.11 products are no longer being manufactured.

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Wireless Physical Layer

- Physical layer conforms to OSI (five options)
  - 1997: **802.11** infrared, FHSS, DSSS {FHSS and DSSS run in the 2.4GHz band}
  - 1999: **802.11a** OFDM and **802.11b** HR-DSSS
  - 2001: **802.11g** OFDM
- **802.11 *Infrared***
  - Two capacities: **1 Mbps or 2 Mbps**.
  - Range is 10 to 20 meters and cannot penetrate walls.
  - Does not work outdoors.
- **802.11 *FHSS* (*Frequence Hopping Spread Spectrum*)**
  - **The main issue is *multipath fading*.**
  - ***[P&D] The idea behind spread spectrum is to spread the signal over a wider frequency to minimize the interference from other devices.***
  - 79 non-overlapping channels, each 1 Mhz wide at low end of 2.4 GHz ISM band.
  - The same pseudo-random number generator used by all stations to start the hopping process.
  - Dwell time: min. time on channel before hopping (400msec).

Wireless Physical Layer

- **802.11 *DSSS* (*Direct Sequence Spread Spectrum*)**
  - ***The main idea is to represent each bit in the frame by multiple bits in the transmitted signal (i.e., it sends the XOR of that bit and n random bits).***
  - Spreads signal over entire spectrum using pseudo-random sequence (similar to CDMA see Tanenbaum sec. 2.6.2).
  - Each bit transmitted using an 11-bit chipping Barker sequence, PSK at 1Mbaud.
  - This yields a a capacity of 1 or 2 Mbps.

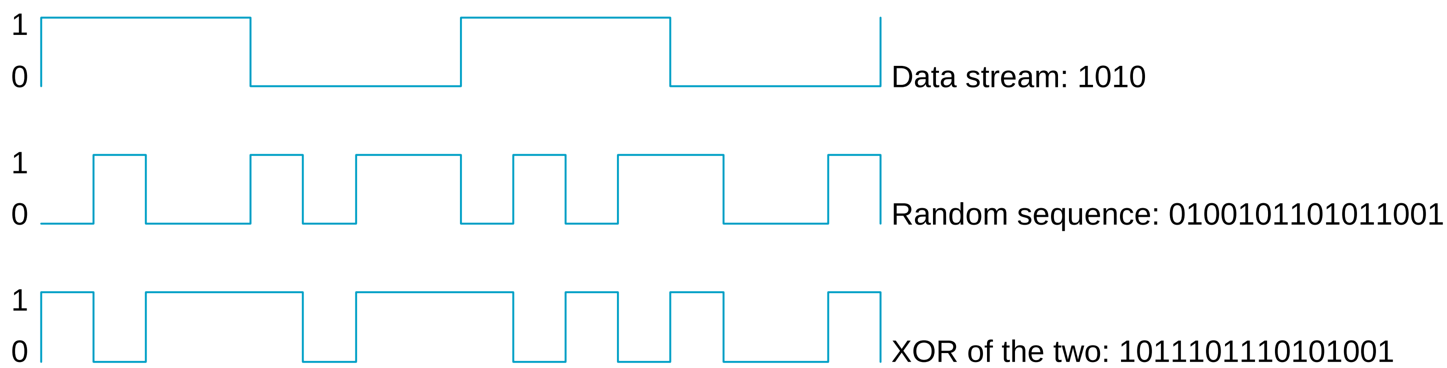

Figure 2.37 Example 4-bit chipping sequence

P&D slide

Wireless Physical Layer

- **802.11a *OFDM* (Orthogonal Frequency Divisional Multiplexing)**
  - Compatible with European HiperLan2.
  - 54 Mbps in wider 5.5 GHz band ➔ transmission range is limited.
  - Uses 52 FDM channels (48 for data; 4 for synchronization).
  - Encoding is complex (PSM up to 18 Mbps and QAM above this capacity).
  - E.g., at 54 Mbps 216 data bits encoded into into 288-bit symbols.
  - More difficulty penetrating walls.

Wireless Physical Layer

- **802.11b** ***HR-DSSS*** **(*High Rate Direct Sequence Spread Spectrum*)**
  - **11a and 11b** *shows a <u>split</u> in the standards committee.*
  - **11b** approved and hit the market before **11a.**
  - Up to 11 Mbps in 2.4 GHz band using 11 million chips/sec.
  - Note in this bandwidth all these protocols have to deal with interference from microwave ovens, cordless phones and garage door openers.
  - Range is 7 times greater than **11a.**
  - **11b and 11a are incompatible!!**

Wireless Physical Layer

- **802.11g *OFDM(Orthogonal Frequency Division Multiplexing)***
  - **An attempt to combine the best of both 802.11a and 802.11b.**
  - Supports bandwidths up to 54 Mbps.
  - Uses 2.4 GHz frequency for greater range.
  - Is backward compatible with 802.11b.

802.11 MAC Sublayer Protocol

- In 802.11 wireless LANs, “seizing the channel” does not exist as in 802.3 wired Ethernet.
- Two additional problems:
  - Hidden Terminal Problem
  - Exposed Station Problem
- To deal with these two problems 802.11 supports two modes of operation:
  - **DCF (Distributed Coordination Function)**
  - **PCF (Point Coordination Function).**
- **All implementations must support DCF, but PCF is optional.**

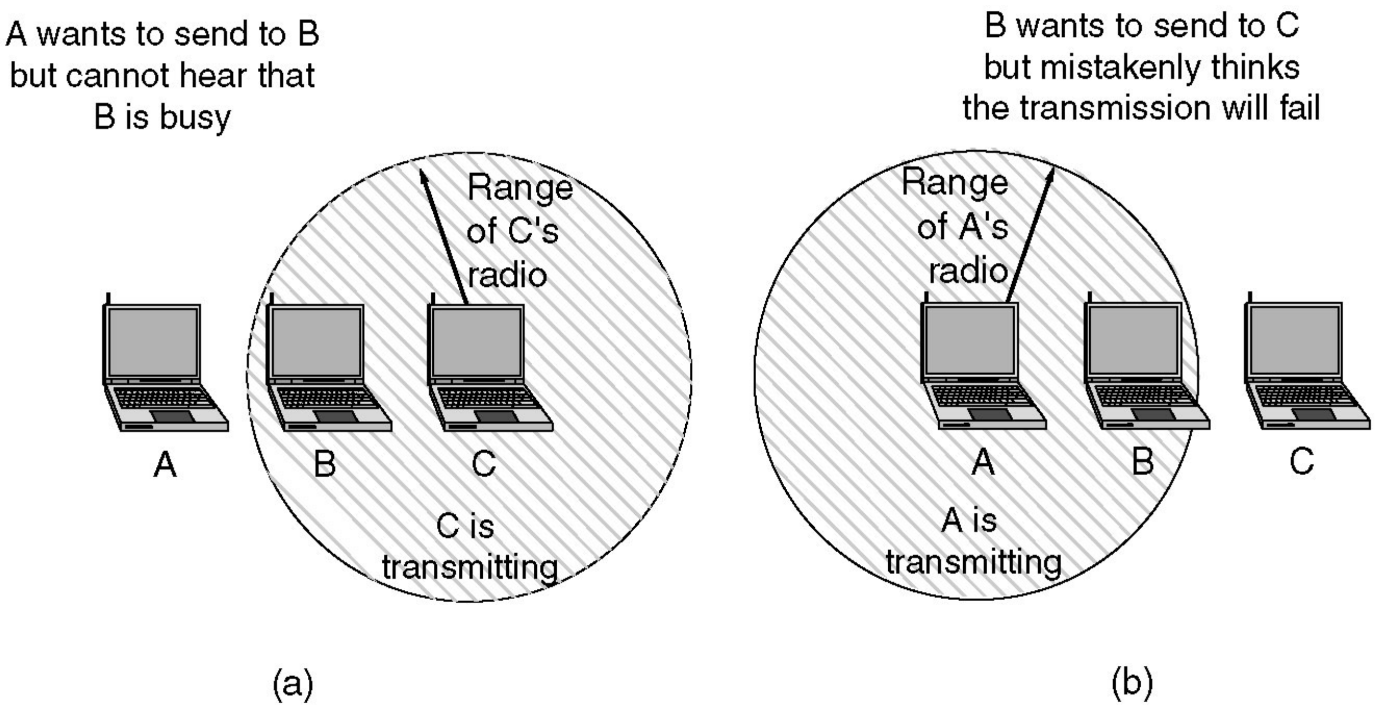

Figure 4-26.(a)The hidden terminal problem. (b) The exposed station problem.

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The Hidden Terminal Problem

- Wireless stations have transmission ranges and not all stations are within radio range of each other.
- 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.

Distribute Coordination Function (DCF)

- Uses *CSMA/CA* (*CSMA* with *C*ollision *A*voidance).
  - Uses one of two modes of operation:
    - ***virtual carrier sensing***
    - physical carrier sensing
- The two methods are supported:

1. ***MACAW*** **(Multiple Access with Collision Avoidance for Wireless) with virtual carrier sensing.**
2. **1-persistent physical carrier sensing.**

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 (Collision Avoidance).
  - Can a collision still occur?

Wireless LAN Protocols

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

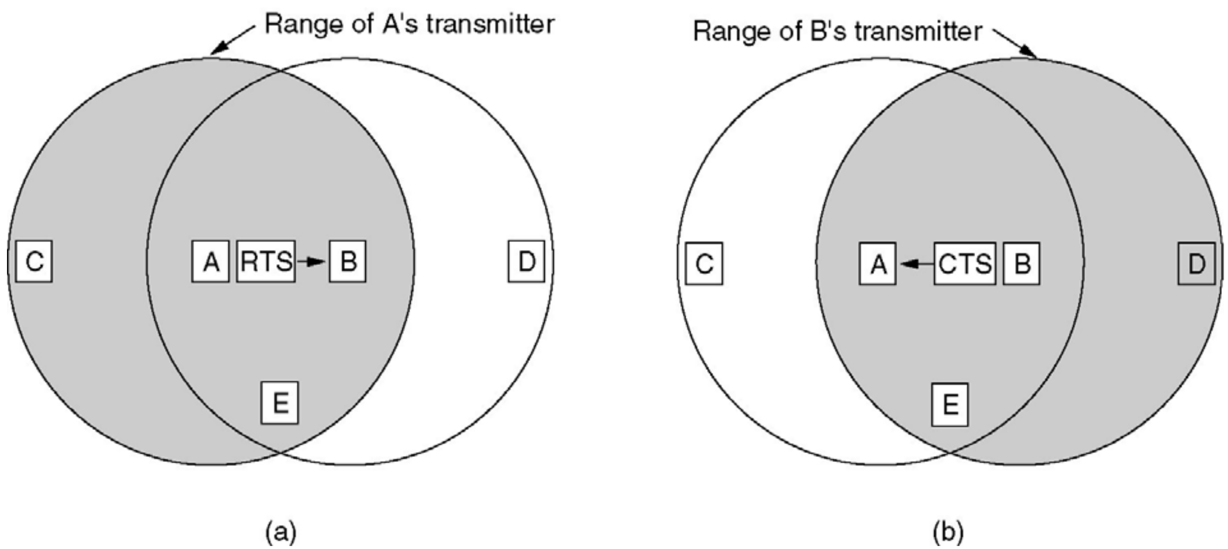

Figure 4-12. (a) A sending an RTS to B.
(b) B responding with a CTS to A.

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Virtual Channel Sensing in CSMA/CA

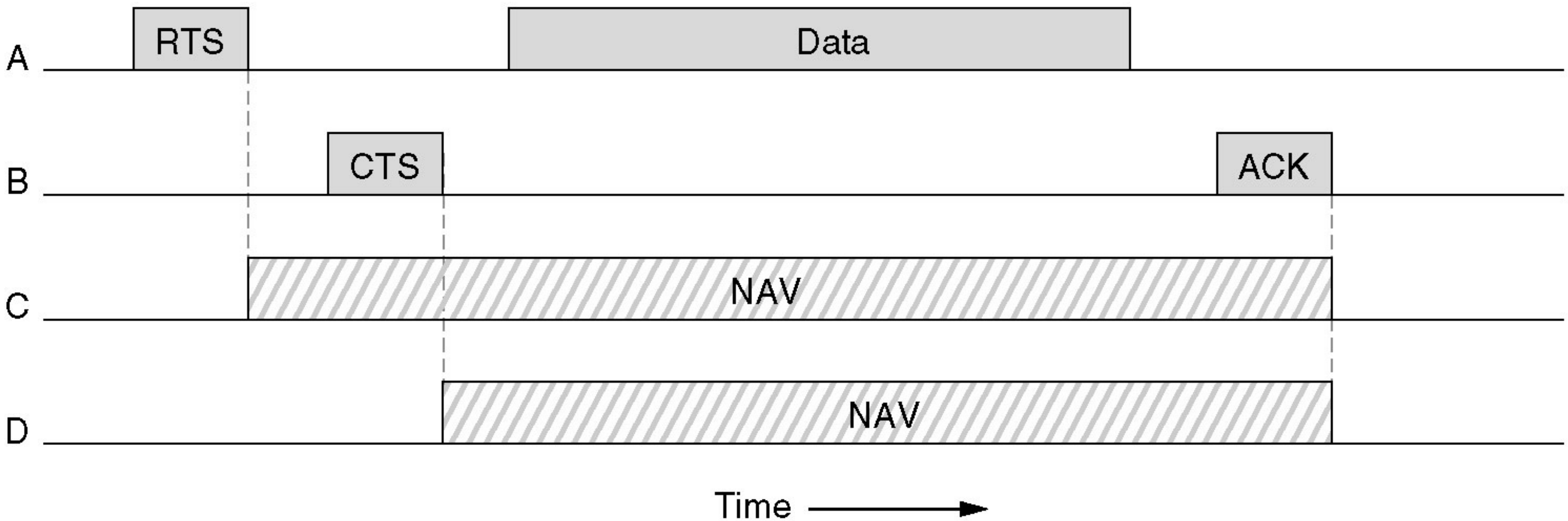

Figure 4-27. The use of virtual channel sensing using CSMA/CA.

- C (in range of A) *receives the RTS and based on information in RTS creates a* ***virtual channel busy*** **NAV(Network Allocation Vector).**
- D (in range of B) *receives the CTS and creates a shorter* **NAV.**

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Virtual Channel Sensing in CSMA/CA

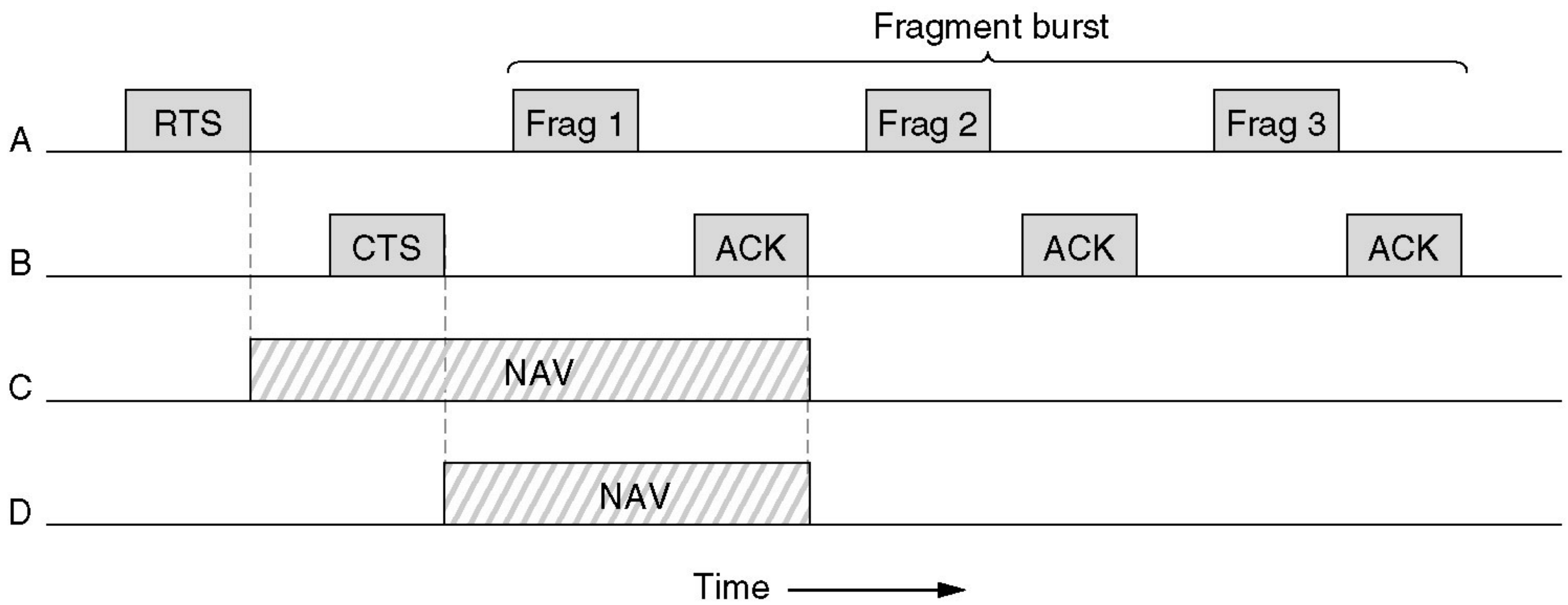
What is the advantage of RTS/CTS?

RTS is 20 bytes, and CTS is 14 bytes.

MPDU can be 2300 bytes.

- "virtual" implies source station sets the *duration field* in data frame or in RTS and CTS frames.
- Stations then adjust their NAV accordingly!

Figure 4-28.Fragmentation in 802.11



- High wireless error rates → long packets have less probability of being successfully transmitted.
- Solution: MAC layer fragmentation with stop-and-wait protocol on the fragments.

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1-Persistent Physical Carrier Sensing

- The station **senses** the channel when it wants to send.
- If idle, the station transmits.
  - *A station does not sense the channel while transmitting.*
- If the channel is busy, the station defers until idle and then transmits **(1-persistent)**.
- Upon collision, wait a *random time* using binary exponential backoff.

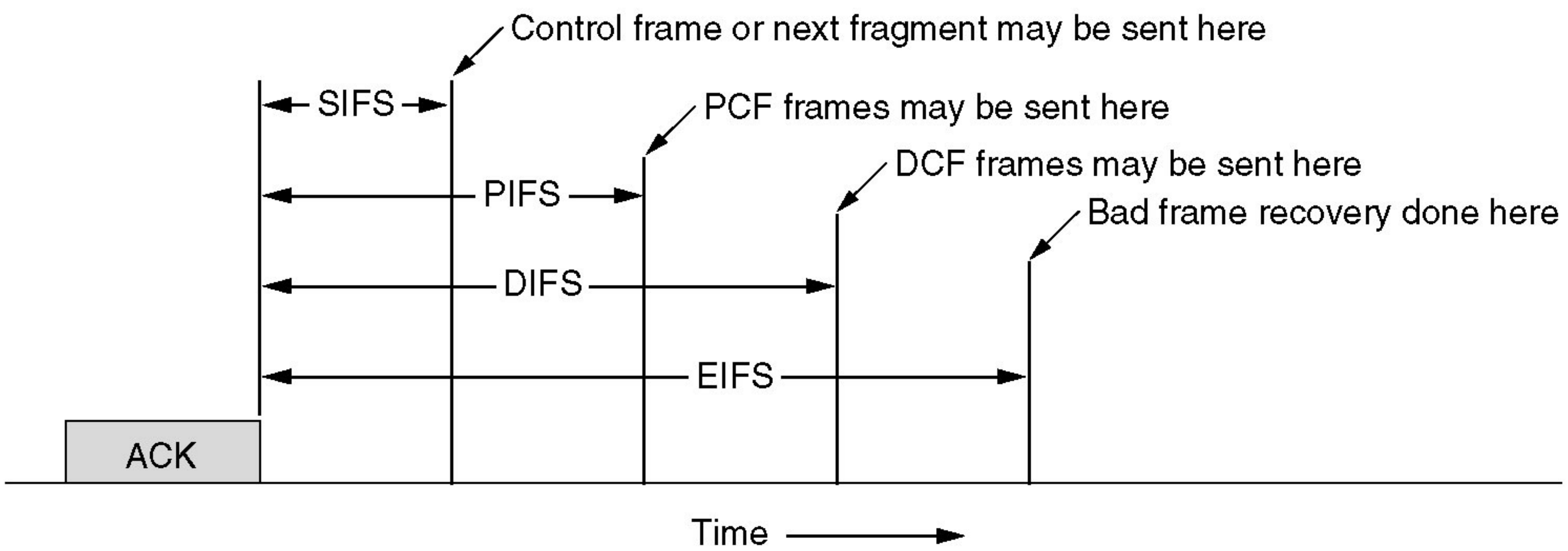
Point Coordinated Function (PCF)

- PCF uses a base station to poll other stations to see if they have frames to send.
- No collisions occur.
- Base station sends ***beacon frame*** periodically.
- Base station can tell another station to ***sleep*** to save on batteries and base stations holds frames for sleeping station.

DCF and PCF Co-Existence

- Distributed and centralized control can co-exist using InterFrame Spacing.
- SIFS (Short IFS) :: is the time waited between packets in an ongoing dialog (RTS,CTS,data, ACK, next frame)
- PIFS (PCF IFS) :: when no SIFS response, base station can issue beacon or poll.
- DIFS (DCF IFS) :: when no PIFS, any station can attempt to acquire the channel.
- EIFS (Extended IFS) :: lowest priority interval used to report bad or unknown frame.

Figure 4-29. Interframe Spacing in 802.11.



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Wireless Card Implementation Details

- 802.11b and 802.11g use ***dynamic capacity adaptation*** based on ?? (internal to wireless card at the AP)
  - e.g. for 802.11b choices are: 11, 5.5, 2 and 1 Mbps
- RTS/CTS may be turned off by default.
- All APs (or base stations) will periodically send a beacon frame (10 to 100 times a second).
- AP downstream/upstream traffic performance is asymmetric.
- Wireless communication quality between two nodes can be asymmetric due to multipath fading.