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.

Categories of Wireless Networks

- ***Base Station*** :: all communication through an ***access point*** {note hub topology}. Other nodes can be fixed or mobile.
- ***Infrastructure Wireless*** :: base station network 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

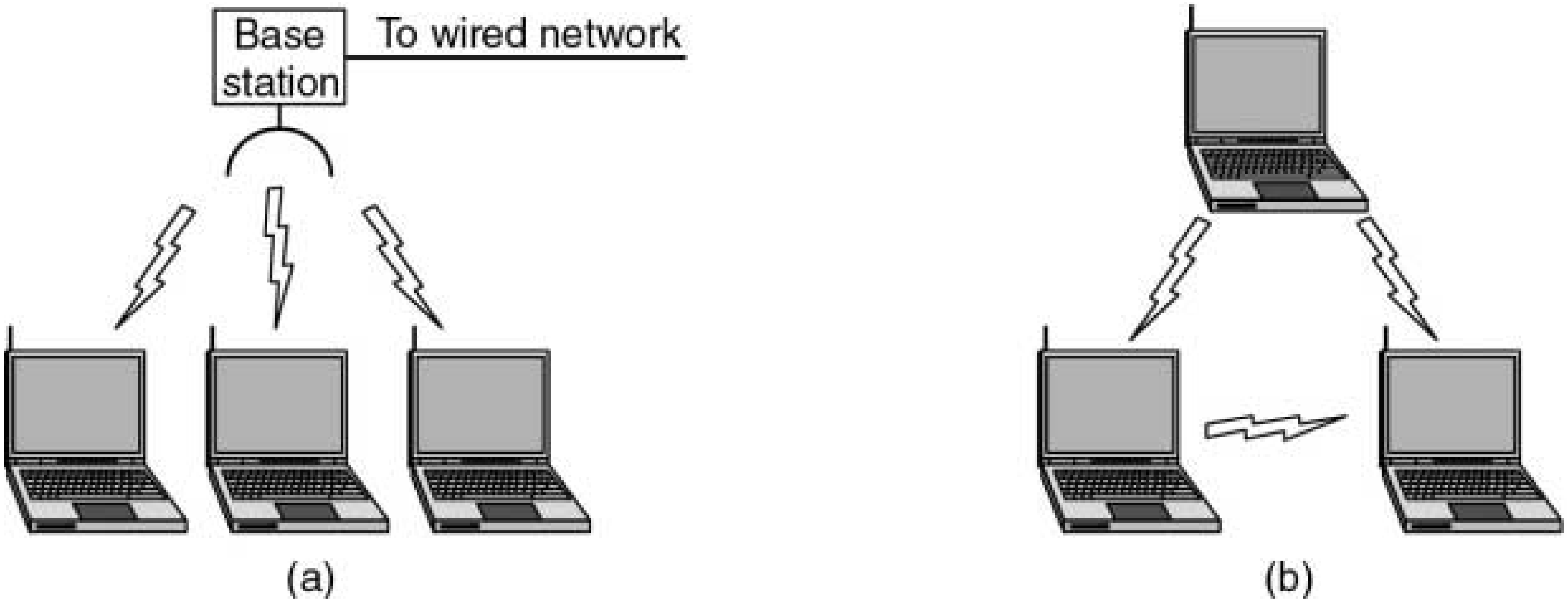


Figure 1-36.(a) Wireless networking with a base station. (b) Ad hoc networking.

The 802.11 Protocol Stack

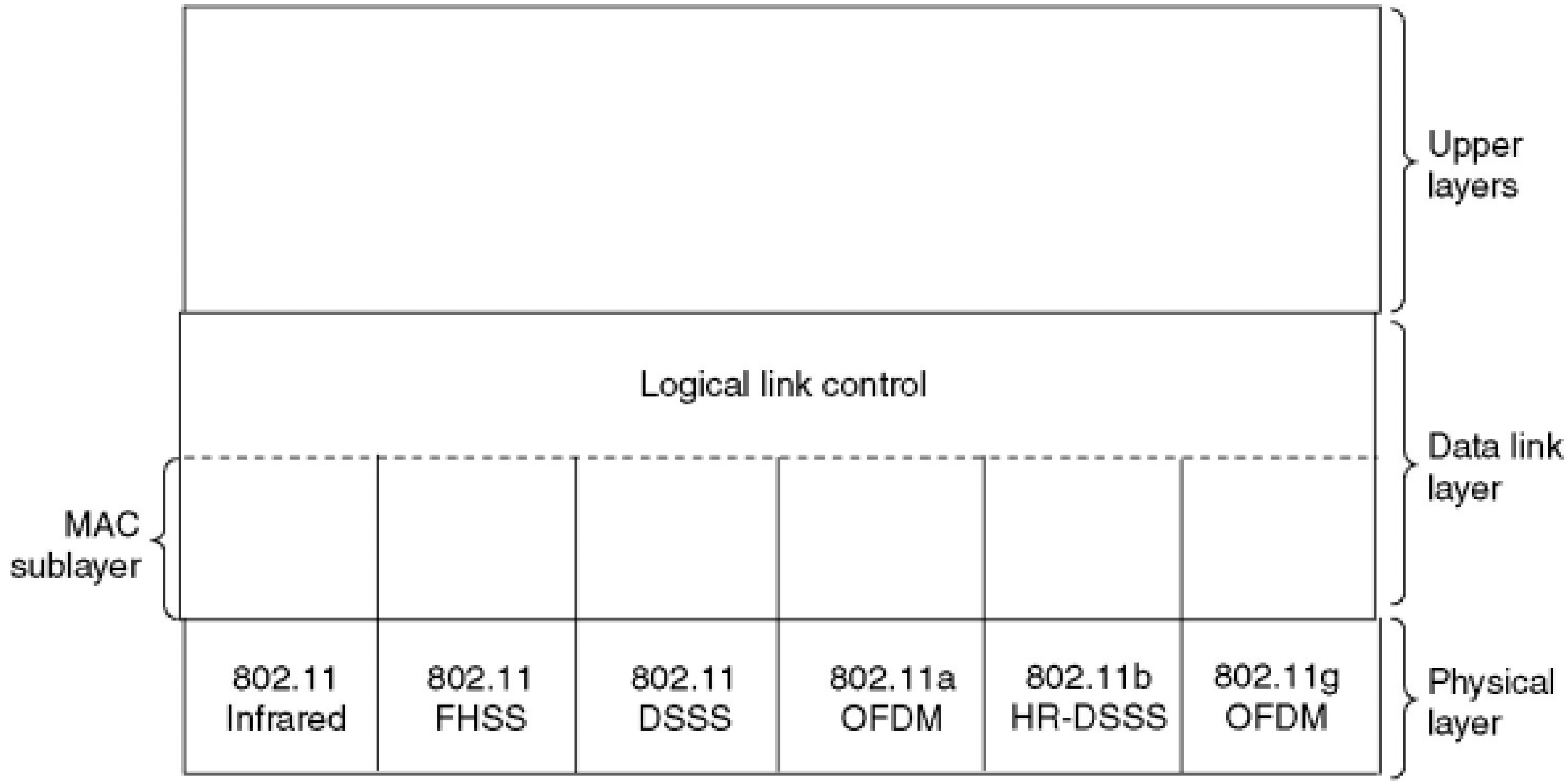


Figure 4-25. Part of the 802.11 protocol stack.

Wireless Physical Layer

- Physical layer conforms to OSI (five options)
  - 1997: **802.11** infrared, FHSS, DHSS
  - 1999: **802.11a** OFDM and **802.11b** HR-DSSS
  - 2001: **802.11g** OFDM
- **802.11 *Infrared***
  - Two capacities 1 Mbps or 2 Mbps.
  - Cannot penetrate walls.
- **802.11 *FHSS* (*Frequence Hopping Spread Spectrum*)**
  - 79 channels, each 1 Mhz wide at low end of 2.4 GHz ISM band.
  - Same pseudo-random number generator used by all stations.
  - Dwell time: min. time on channel before hopping (400msec).

Wireless Physical Layer

- **802.11 *DSSS* (*Direct Sequence Spread Spectrum*)**
  - Spreads signal over entire spectrum using pseudo-random sequence (similar to CDMA see Tanenbaum sec. 2.6.2).
  - Each bit transmitted as 11 chips (Barker seq.), PSK at 1Mbaud.
  - 1 or 2 Mbps.
- **802.11a *OFDM* (Orthogonal Frequency Divisional Multiplexing)**
  - Compatible with European HiperLan2.
  - 54Mbps 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 54Mbps 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 split 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*****)**
  - Supports 54 Mbps.
  - Uses 2.4 GHz frequency for greater range.

802.11 MAC Sublayer Protocol

- In 802.11 wireless LANs, “seizing 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)** and **PCF (Point Coordination Function).**
- **All implementations must support DCF, but PCF is optional.**

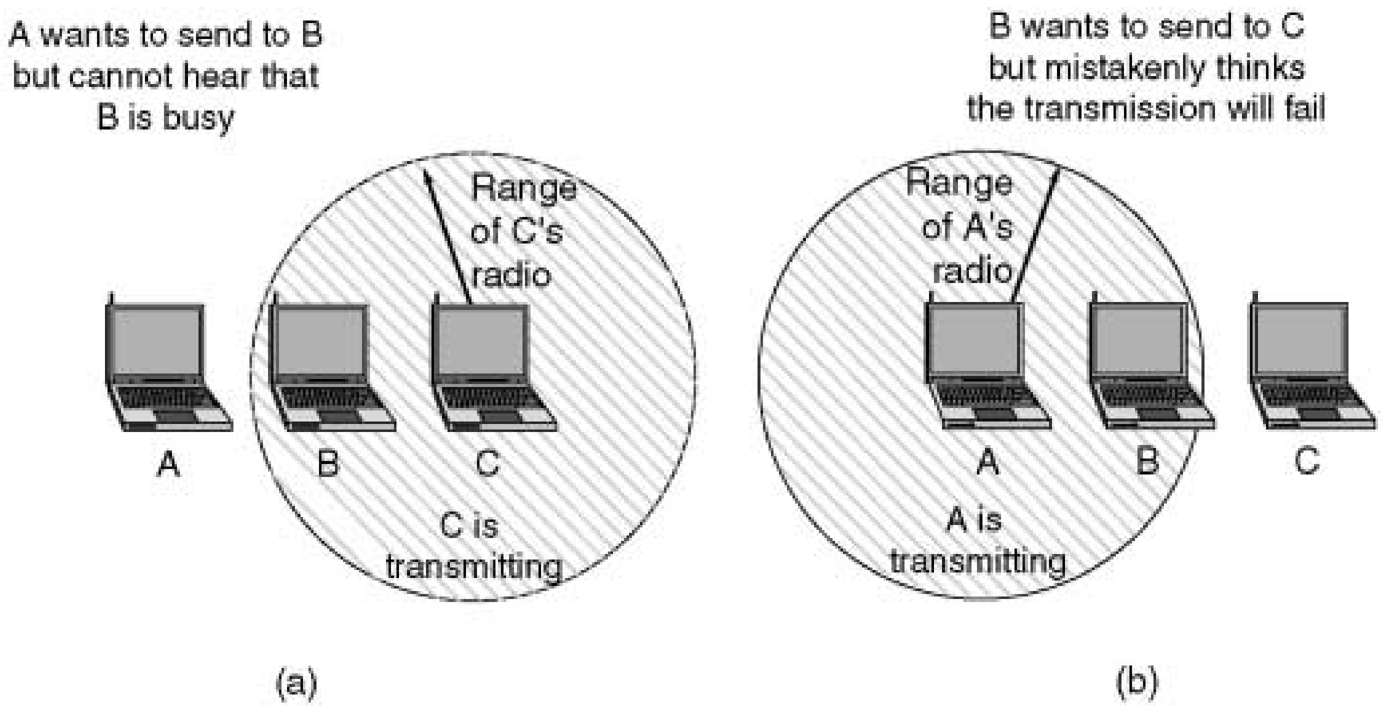


Figure 4-26.(a)The hidden station problem. (b) The exposed station problem.

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

- 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 Collision Avoidance).
  - Uses both physical and ***virtual*** carrier sensing.
  - Two methods are supported:

1. **based on MACAW with virtual carrier sensing**
2. **1-persistent physical carrier sensing.**

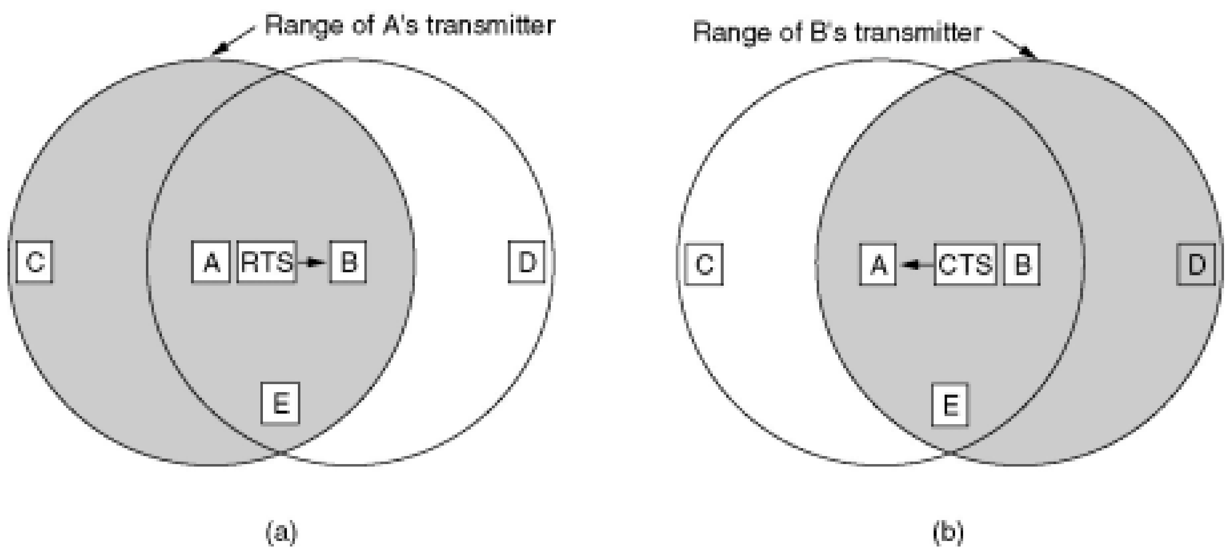
Wireless LAN Protocols

- MACA protocol solved hidden, exposed terminal:
  - Send Ready-to-Send (***RTS***) and Clear-to-Send (***CTS***) first
  - RTS, CTS helps determine who else is in range or busy (Collision avoidance).
  - Can a collision still occur?

Professor Agu's slide

Wireless LAN Protocols

- MACAW added ACKs and CSMA (no RTS at same time)



(a) A sending an RTS to B.(b) B responding with a CTS to A.

Professor Agu's slide

Virtual Channel Sensing in CSMA/CA

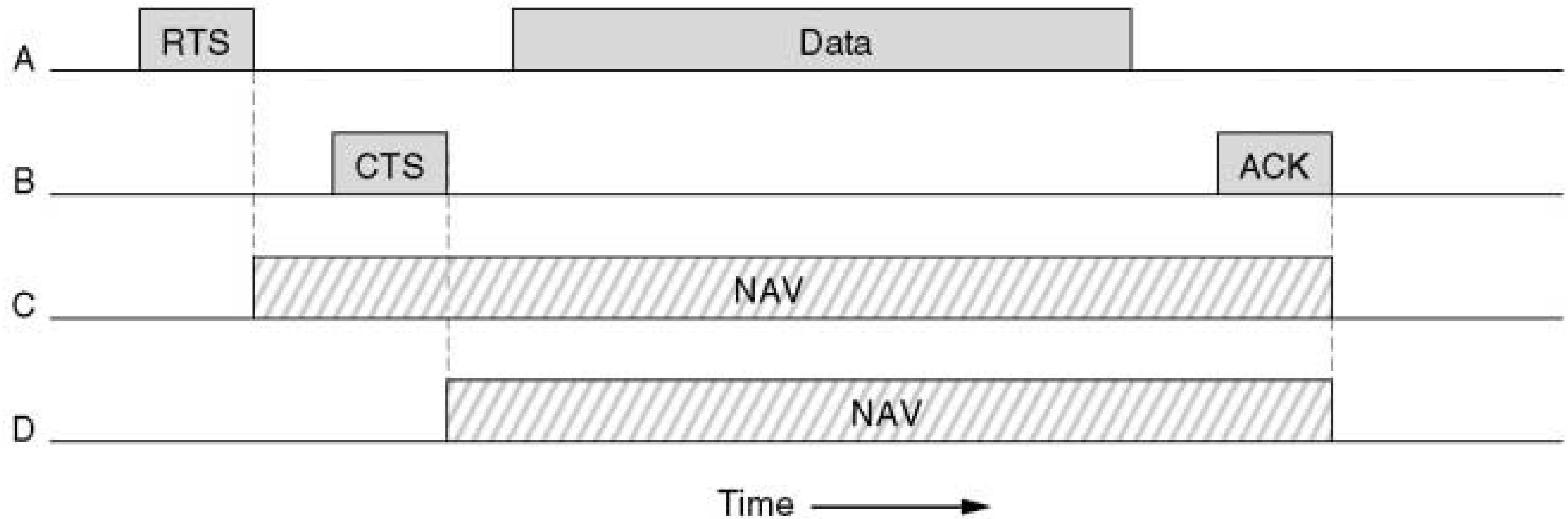
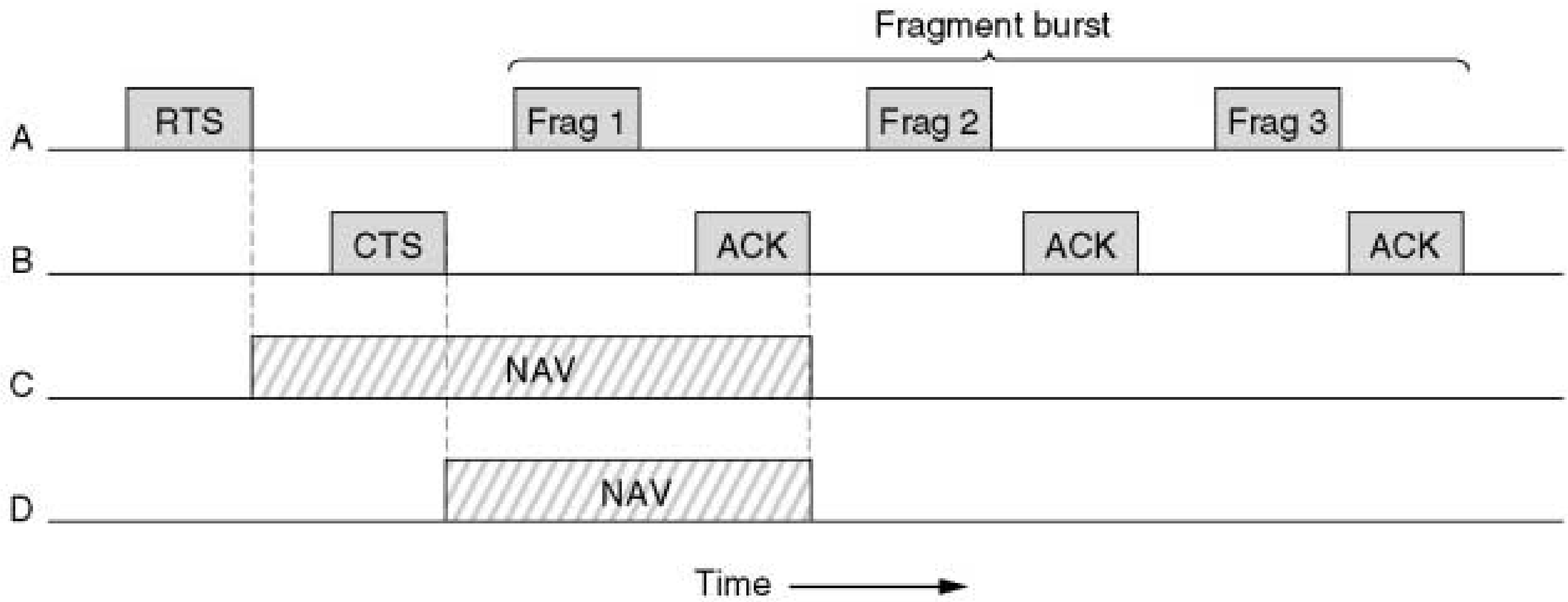


Figure 4-27. The use of virtual channel sensing using CSMA/CA.

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

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.

1-Persistent Physical Carrier Sensing

- Station *senses* the channel when it wants to send.
- If idle, station transmits.
  - *Station does not sense channel while transmitting.*
- If the channel is busy, station defers until idle and then transmits.
- 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.