

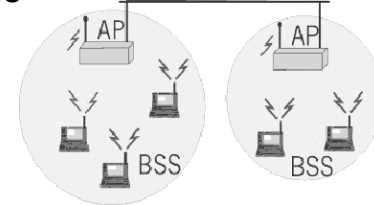
# Introduction to Wireless Networks

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## IEEE 802.11 Wireless LAN - 1

- Wireless LANs: untethered (often mobile) networking
- IEEE 802.11 standard:
  - MAC protocol
  - ~~unlicensed frequency spectrum~~: 900Mhz, 2.4Ghz



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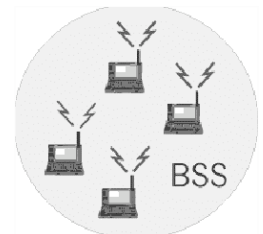
## IEEE 802.11 Wireless LAN - 2

- Basic Service Set (BSS) (a.k.a. “cell”) contains:
  - wireless hosts
  - access point (AP): base station
- BSS’s combined to form distribution system (DS)

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## IEEE 802.11 used for Ad Hoc Networks

- Ad hoc network: IEEE 802.11 stations can dynamically form network *without* AP
- Applications:
  - “laptop” meeting in conference room, car
  - interconnection of “personal” devices
  - battlefield
- IETF MANET (Mobile Ad hoc Networks) working group



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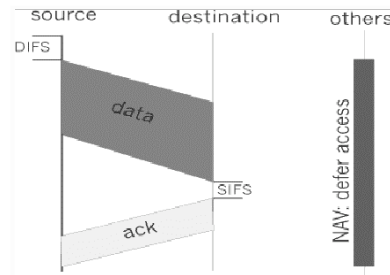
## IEEE 802.11 MAC Protocol: CSMA/CA

### 802.11 CSMA sender:

- if sense channel idle for DIFS sec.
- then transmit entire frame (no collision detection)
- if sense channel busy then binary backoff

### 802.11 CSMA receiver:

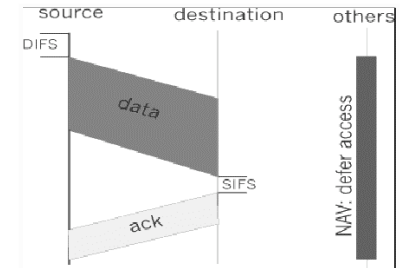
- if received OK
- return ACK after SIFS



## IEEE 802.11 MAC Protocol

### 802.11 CSMA Protocol: others

- NAV: Network Allocation Vector
- 802.11 frame has transmission time field
- others (hearing data) defer access for NAV time units

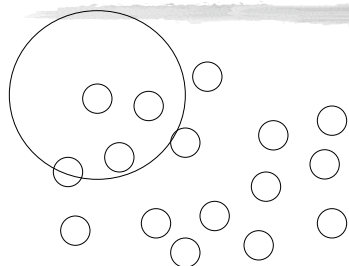


## Ad Hoc Networks

## What is an ad hoc network

- A collection of nodes that can communicate with each other without the use of existing infrastructure
- Each node is a sender, a receiver, and a relay
- There are no "special nodes" (in principal)
  - No specialized routers, no DNS servers
- Nodes can be static or mobile
- Can be thought of us: peer-to-peer communication

## Example: Ad hoc network



- Nodes have power range
- Communication happens between nodes within range

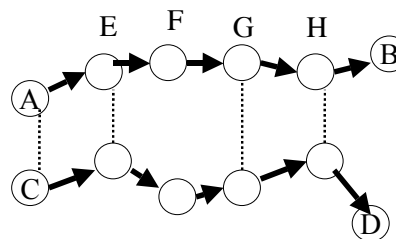
## What Is Different Here?

- Broadcasts of nodes can “overlap” -> collision
- How do we handle this?
- A MAC layer protocol could be the answer
- If one node broadcasts, neighbors keeps quite
- Thus, nearby nodes compete for air time
- This is called **contention**

## Contention in ad hoc networks

- A major difference with wireline networks
- Air-time is the critical resource
- Fact 1: connections that cross vertically interfere
- Fact 2: connections that do not share nodes interfere
- Fact 3: a single connection with itself interferes!

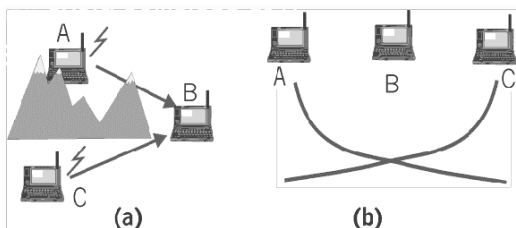
## Example of contention



- Yellow connection bothers pink connection
- Yellow bothers itself
- When A-E is active
  - E-F is silent
  - F-G is silent (is it?)

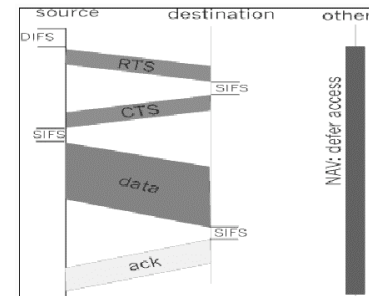
## The Hidden Terminal Effect

- hidden terminals: A, C cannot hear each other
  - obstacles, signal attenuation
  - collisions at B
- goal: avoid collisions at B
- CSMA/CA: CSMA with Collision Avoidance



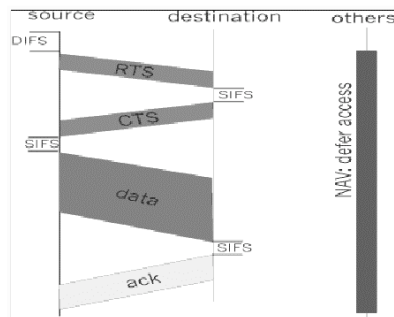
## Collision Avoidance: RTS-CTS exchange - 1

- CSMA/CA: explicit channel reservation
  - sender: send short RTS: request to send
  - receiver: reply with short CTS: clear to send
- CTS reserves channel for sender, notifying (possibly hidden) stations
- Avoid hidden station collisions

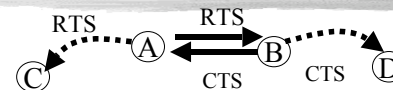


## Collision Avoidance: RTS-CTS exchange - 2

- RTS and CTS short:
  - collisions less likely, of shorter duration
  - end result similar to collision detection
- IEEE 802.11 allows:
  - CSMA
  - CSMA/CA: reservations
  - polling from AP

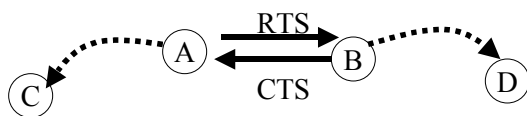


## The 802.11 MAC protocol



- Introduced to reduce collisions
- Sender sends Request To Send (RTS): ask permission
- Case A:** Receiver gives permission Clear To Send (CTS)
- Sender sends Data
- Receiver sends ACK, if received correctly
- Case B:** Receiver does not respond
  - Sender waits, times out, exponential back-off, and tries again

## Why is this necessary?



- ✱ A: RTS, and B replies with a CTS
- ✱ C hears RTS and avoids sending anything
  - C could have been near B (not shown here)
- ✱ D hears CTS so it does not send anything to B

## Some numbers for 802.11

- ✱ Typical radius of power-range: 250m
- ✱ Interference range: 500m
  - At 500m one can not hear, but they are bothered!
- ✱ RTS packet 40 bytes
- ✱ CTS and ACK 39 bytes
- ✱ MAC header is 47 bytes

## Typical Simulation Environment

- ✱ A 2-dimensional rectangle
- ✱ Fixed number of nodes
- ✱ Static: uniformly distributed
- ✱ Dynamic: way-point model
  - Pick location, move with speed  $v$ , pause
- ✱ Power range: fixed or variable
- ✱ Sender-receivers uniformly distributed

## Various Communication Paradigms

- ✱ Broadcasting:
  - one nodes reaches everybody
- ✱ Multicasting:
  - One node reaches some nodes
- ✱ Anycasting:
  - One node reaches a subset of some target nodes (one)
- ✱ Application Layer protocols and overlays
  - Applications like peer-to-peer