

G 364: Mobile and Wireless Networking

CLASS 2, Wed. Jan 7 2004

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M-W, 11:40am-1:20pm, 109 Rob

Wireless Issues

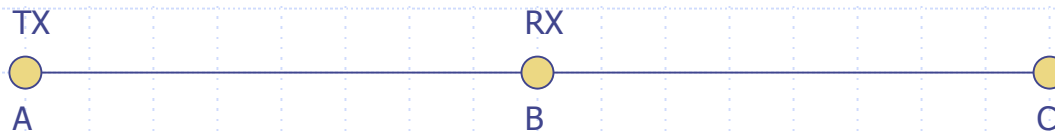
- ◆ Architecture, communication model and duplexing define the framework where wireless MAC (wMAC) protocols are defined
- ◆ wMAC protocol design must also take into accounts the unique characteristics of the wireless medium

Boundaries and Interference

- ◆ Due to physical layer problems
 - No definite boundaries for radio waves
 - → higher Bit Error Rate (BER)
 - Asymmetric channel qualities
- ◆ Concept of “**neighbors:**” nodes within each other transmission range. Only neighbors detect the carrier on the channel
- ◆ Attenuation of signal strength depends on node distance

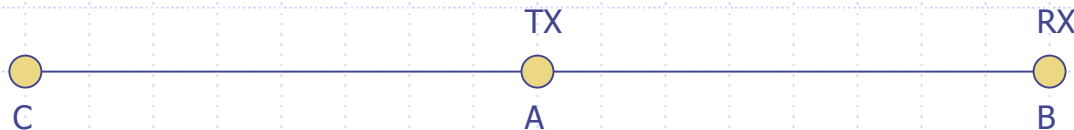
Hidden Terminal Problem

- ◆ A **hidden** node is a node in the range of the receiver and not in the range of the transmitter
- ◆ Node C is hidden to node A: Collisions limit the channel efficiency



Exposed Terminal Problem

- ◆ An **exposed** node is in the range of the transmitter and not in the range of the receiver
- ◆ Node C is exposed to node A: C can be denied access till A is done → bandwidth is under-utilized



Propagation Delay et Al.

- ◆ Time needed for the transmitted packet to reach the receiver
 - Affect carrier sensing-based protocols
 - Affect slot size → Additional overhead
- ◆ **Half duplexing**: A node can either be in TX or in RX mode at a time
 - Collision detection is more involved
 - Hardware switching time becomes significant

Fundamental MAC Protocols

◆ Universal, basic techniques

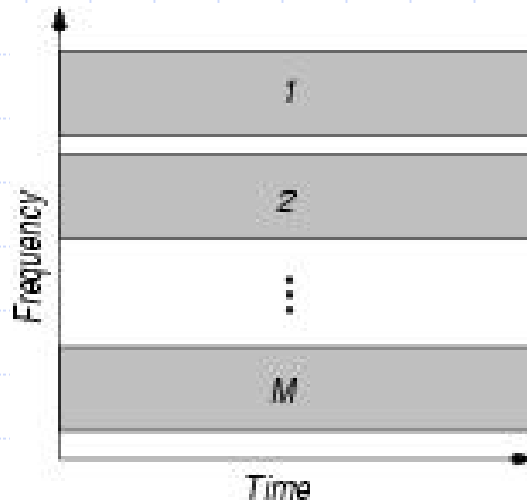
- Used by most wMAC protocols
- Derived from wired MAC protocols or specific for the wireless domain

◆ Common goal: Multiple Access (MA)

- FDMA
- TDMA
- CDMA
- Aloha protocols

Frequency Division MA (FDMA)

- ◆ The available bandwidth is divided into M sub-channels (separated by guard bands)



FDMA: Capacity

- ◆ C = capacity (bit per second) of the available bandwidth $\rightarrow C/M$ = capacity of each sub-channel
- ◆ Each TXing node is assigned one or more of the frequencies
- ◆ Each RXing node must listen in the proper frequency

FDMA, Pros and Cons

◆ Pros

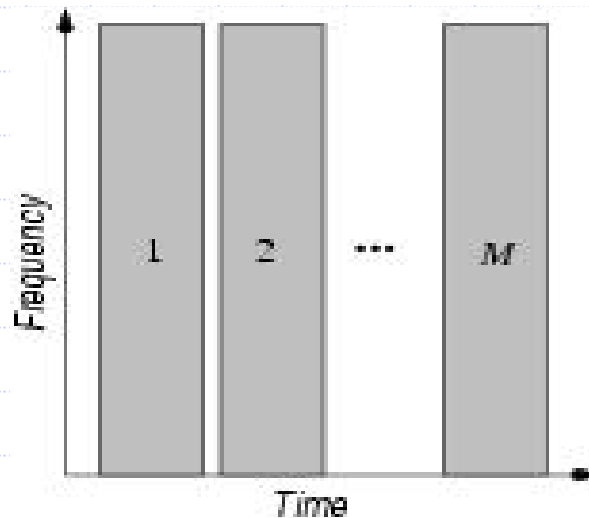
- Simultaneous packet TX can occur without collision
- Less overhead (no switching, no synch)

◆ Cons: Increased TX time → Longer packet delay

- L-bits long packet takes $M * L / C$ seconds
- M times longer than if we had the whole bandwidth

Time Division MA (TDMA)

- ◆ The available bandwidth is divided into M equal time slots organized into a synchronous frame



TDMA: Capacity

- ◆ Each node is assigned one time slot for its exclusive use (either TX or RX)
- ◆ Transmission is non-continuous (buffer-and-burst)
- ◆ In that time slot it has the whole bandwidth
- ◆ L-bits long packet takes L / C seconds
- ◆ Long delays: Consecutive packets are separated $M-1$ slots (basic TDMA)

Code Division MA (CDMA), 1

- ◆ More than one TX in the same frequency at the same time
- ◆ No interferences
- ◆ Special coding technique: Orthogonal codes
- ◆ Information retrieved from combined signal

CDMA, 2

- ◆ Information bits are **spread** across a broadened channel
 - Less susceptible to **fading**
 - Require more sophisticated hardware
- ◆ Problem: How is the channel broadened?
 - **Spread spectrum** modulation techniques

Spread spectrum modulation techniques for CDMA, 1

◆ Direct Sequence Spread Spectrum (DSSS)

- Original message is multiplied by a pseudo-noise sequence
- Increase the amount of bandwidth occupied (**spreading factor**)
- SF is used at the receiving node to “raise” the signal from the interference

Spread spectrum modulation techniques for CDMA, 2

◆ Frequency Hopping Spread Spectrum (FHSS)

- The TX frequency is shifted according to a specific hopping sequence
- Aim is interference reduction: Short time in each frequency (**dwelling time**)
- Example: Bluetooth

MA Techniques in Communication Systems

- ◆ Advanced Mobile Phone System (AMPS) → FDMA/FDD
- ◆ Global System for Mobile (GSM) → TDMA/FDD
- ◆ US Digital Cellular (USDC) → TDMA/FDD
- ◆ Pacific Digital Cellular (PDC) → TDMA/FDD
- ◆ CT2 (Cordless Telephone) → FDMA/TDD
- ◆ Digital Euro. Cordless Telephone (DECT) → FDMA/TDD
- ◆ US Narrowband Spread Spect. (IS-95) → CDMA/FDD
- ◆ W-CDMA (3GPP) → CDMA/FDD and /TDD
- ◆ Cdma2000 (3GPP2) → CDMA/FDD and /TDD

Aloha Protocols

- ◆ (AlohaNet, Hawaii, Abramson)
- ◆ Brute force MA
 - Lack of channel access
- ◆ A node transmit a packet when it has it
- ◆ Packet delivery needs feedback mechanism (like ARQ=Automatic Repeat Request)
- ◆ If the packet gets lost, it is retransmitted
- ◆ Poor channel utilization

Slotted Aloha

- ◆ Packets are transmitted when needed, at the beginning of a slot
- ◆ Reduces the time a packet is vulnerable to collision
- ◆ Variant: p-persistent slotted aloha
 - Persistence parameter p , $0 < p < 1$
 - Probability of a node transmitting in a slot
 - Tradeoff between collisions and delay

Carrier Sense MA (CSMA)

- ◆ Carrier sensing to avoid collisions with ongoing transmissions
 - Busy channel → wait (keep testing)
 - Idle channel → transmit
- ◆ Many nodes can be waiting → collisions
- ◆ Collisions are reduced by using randomization:
 - Busy channel → compute a random time before testing again (random time increases exponentially)

p-Persistent CSMA

- ◆ Channel is slotted, BUT
- ◆ Nodes are NOT synchronized
- ◆ Slot length = max propagation delay
- ◆ Sensing occur at the beginning of each slot
 - Busy channel → wait a random number of slots
 - Idle channel → TX with probability p

MAC for Specific Architectures

◆ Centralized MAC Protocols

- Cellular telephony: Predominant form of wireless systems
- Wireless ATM: Broadband multimedia services

◆ Ad Hoc MAC Protocols

- Wireless MAC protocols specifically designed for ad hoc networks

Assignments

- ◆ Wireless MAC handout, to page x
- ◆ Updated information on the class web page:

www.ece.neu.edu/courses/eceg364/2004sp