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CS 598 WSI

Lecture 3

9/4/2024

Today's topics

- Medium access
- Hidden terminals
- ZigZag
- Rate adaptation and pitfalls

Medium access

With wireless communication, all devices share a broadcast medium

How do we mediate access to such a medium?

Aloha

Class of medium access protocols

Random access protocols

Any machine can attempt to send a message during a time slot, but machines must react when those packets are lost

They will attempt to resend lost packets during a later time slot

- With probability p they will attempt to resend a lost packet during the current time slot
- With probability $1-p$ they will wait for a future time slot
- Small p leads to underutilization
- Large p leads to overutilization and collisions

pros

- low overhead
- full rate: if you are the only one transmitting, you get 100% efficiency
- back off probability can reduce collisions

cons

- collisions can still happen
- low maximum efficiency (~37%)

Math behind low efficiency

- We have N devices
- Probability that no devices transmit in a time slot is $(1-p)^N$
- Probability that one device transmits is $p(1-p)^{N-1}$
- As N goes to infinity, p goes to $1 / N$

Aloha comes in an unslotted flavor

- Time slots assume synchronization
- Unslotted Aloha is asynchronous
- Unslotted Aloha has about half the efficiency (~18%)
- Unslotted Aloha has less overhead

TDMA vs FDMA

Time Division Multiple Access (TDMA)

- Each machine gets a time slot during which they can access the medium
- A machine cannot broadcast over the medium during time slots that are not theirs
- pros
    - no collisions
- cons
    - not full-rate
    - reallocation required for new users
    - coordination required

Frequency Division Medium Access (FDMA)

- Each machine is assigned a range of frequencies that they can use

Carrier Sense Medium Access (CSMA)

Listen-before-talk: machines listen to the medium to ensure that no other machine is using the medium before they begin using the medium to send messages

Machines sleep for a random duration before waking up and checking the medium

If the medium is unused, the machine begins sending its message

Hidden Terminals

Not all machines can hear each other

Machines that cannot hear each other can, at the same time, send messages to the same machine that can hear both of them, and this results in a collision

ZigZag

When we have multiple collisions of the same packets, can we use those collisions to decode the colliding packets?

It is unlikely that the packets collided in the same places in all collisions

There should be a “chunk” of one packet that is part of the collision in one collision but lies outside the collision in another collision

We can use the collision where the “chunk” lies outside of the collision to decode the “chunk”

Once we have the decoded “chunk,” we can subtract the “chunk” from the collision where the “chunk” is a part of the collision to recover a “chunk” of the other packet

We can use the newly acquired “chunk” to decode another “chunk” from the packet the first “chunk” came from

We repeat until the packets are decoded

How do we find the beginnings of packets in collisions, and how do we know if the collisions contain the same packets? The short answer is correlation

ZigZag can maintain decent throughput for users even when those users have significantly different SNRs

Rate Adaptation

Recap: Modulation

Modulation: bits are transformed into complex-valued symbols that are broadcasted

Demodulation: a broadcast of complex-valued symbols is received and transformed into bits

The number of bits that can be packed into a complex-valued symbol depends on the modulation scheme being used

Recap: SNR

Signal to Noise Ratio (SNR)

SNR = signal / noise

measured in decibels

measured logarithmically

- an increase of 10 dB is 10 times stronger
- an increase of 20 dB is 100 times stronger
- an increase of 30 db is 1000 times stronger
- and so on…

Higher SNR means less error

Shannon's equation: Capacity = Bandwidth * log(1 + SNR)

Rate Adaptation

With the same amount of noise, it becomes harder to demodulate using modulation schemes that have more bits packed into each complex-valued symbol

We want to have low bit error rates

We also want to send data quickly

Modulation schemes that have more bits packed into complex-valued symbols will increase bit error rates

Modulation schemes that have more bits packed into complex-valued symbols will send more data on successful transmissions, so they can increase the rate which we send data

We need to find the modulation scheme that allows us to send data quickly without having a high bit error rate

Digressions

Why does WiFi not use TDMA?

Networks would allocate their own time slots

Since WiFi is unlicensed, multiple networks can exist in the same physical space

The networks would not coordinate with one another

One machine would have a time slot on one network, and another machine would have the same time slot on another network

This would cause a collision if those machine operate in the same space

RTS/CTS

Request To Send (RTS)

Clear To Send (CTS)

A machine that wants to send a packet would send an RTS

The machine receiving the packet would broadcast a CTS, notify machines that can hear it that they should not broadcast

Reduces collisions

Increases overhead