The Medium Access Control Sublayer

- The channel allocation problem
- Multiple access protocols
- Ethernet
- Wireless LANs (WiFi)
- Data link layer switching
The MAC Sublayer

Responsible for deciding who sends next on a multi-access link.

This is an important part of the link layer, especially for LANs.

MAC is in here
The Channel Allocation Problem

- **Simple to state**: On a shared medium, who gets to talk now?
- **Two approaches**: static and dynamic.
- **Static allocation**
  - Divide up the bandwidth using FDM, TDM, CDMA, etc. If there are $n$ stations then each gets $1/n$ of the bandwidth.
  - Performs poorly for bursty traffic – allocation to a user will sometimes go unused.
- **Dynamic allocation**
  - Better to have some kind of dynamic allocation.
  - Queuing theory predicts the average wait time of a packet decreases by $n$ if we have a single queue rather than $n$ queues.
# Dynamic Allocation Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Implication</th>
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<tr>
<td>Independent traffic</td>
<td>Often not a good model, but permits analysis</td>
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<tr>
<td>Single channel</td>
<td>No external way to coordinate senders</td>
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<td>Observable collisions</td>
<td>Needed for reliability; mechanisms vary</td>
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<tr>
<td>Continuous or slotted time</td>
<td>Slotting may improve performance</td>
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<tr>
<td>Carrier sense</td>
<td>Can improve performance</td>
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Multiple Access Protocols

- ALOHA
- CSMA (Carrier Sense Multiple Access)
- Collision-free protocols
- Limited-contention protocols
- Wireless LAN protocols
ALOHA

In pure ALOHA, stations transmit frames whenever they have data; users retry after a random time for collisions — efficient and low-delay under low load.

User

A

B

C

D

E

Collision

Time

Collision
ALOHA Collisions

Collisions happen when other users transmit during a vulnerable period that is twice the frame time; synchronizing senders to slots can reduce collisions.
Slotted ALOHA

- Low load wastes slots
- Twice as efficient as pure ALOHA
- Efficiency up to $1/e$ (37%) for random traffic models
Carrier-Sense Multiple Access

- Improves on ALOHA by sensing the channel — station doesn’t send if it senses someone else
- If the channel is busy (ideas):
  - 1-persistent (greedy) sends as soon as idle.
  - Nonpersistent waits a random time, then tries again.
  - $p$-persistent sends with probability $p$ when idle.
CSMA Persistence

![Graph of CSMA Persistence]

- 0.01-persistent CSMA
- Nonpersistent CSMA
- 0.1-persistent CSMA
- 0.5-persistent CSMA
- Slotted ALOHA
- Pure ALOHA
- 1-persistent CSMA

S (throughput per packet time) vs G (attempts per packet time)
CSMA with Collision Detection

CSMA/CD improves on CSMA by detecting collisions and aborting. The reduced contention times improve performance.
Collision-Free Protocols

- Avoid collisions entirely.
- Senders must know when it is their turn to send.
- Basic bit-map protocol.
- Token ring protocol.
- Binary countdown protocol.
Basic Bit-Map Protocol

- Senders set a bit in the contention slot if they want to send.
- Senders send in turn.
Token Ring Protocol

There’s a token sent round the ring that defines the sending order. The station with the token may send a frame before passing it on. We don’t really need a ring, e.g., token bus.
Binary Countdown Protocol

- Stations send their address in contention slot (\( \log n \) bits instead of \( n \) bits for \( n \) stations).
- Medium logically ors the bits.
- Stations give up when they send a “0” but see a “1”.
- Station that sees its full address is next to send.