Ethernet

G54ACC

Lecture 8

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Contents

- Ethernet
- Efficiency
- Bridges to Switches
- Extensions

Contents

- Ethernet
  - Basic Aloha
  - Slotted Aloha
  - Unslotted Aloha
- Efficiency
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Ethernet Reminder

- 10Base5,2 are *broadcast networks*
- 10BaseT with hubs were the same, but just simpler “start” wiring
- CSMA-CD protocol used
  - Sense carrier
  - Start transmit if no carrier
  - Detect collision if more than one starts at once
  - Binary exponential back-off

Aloha – Basic Technique

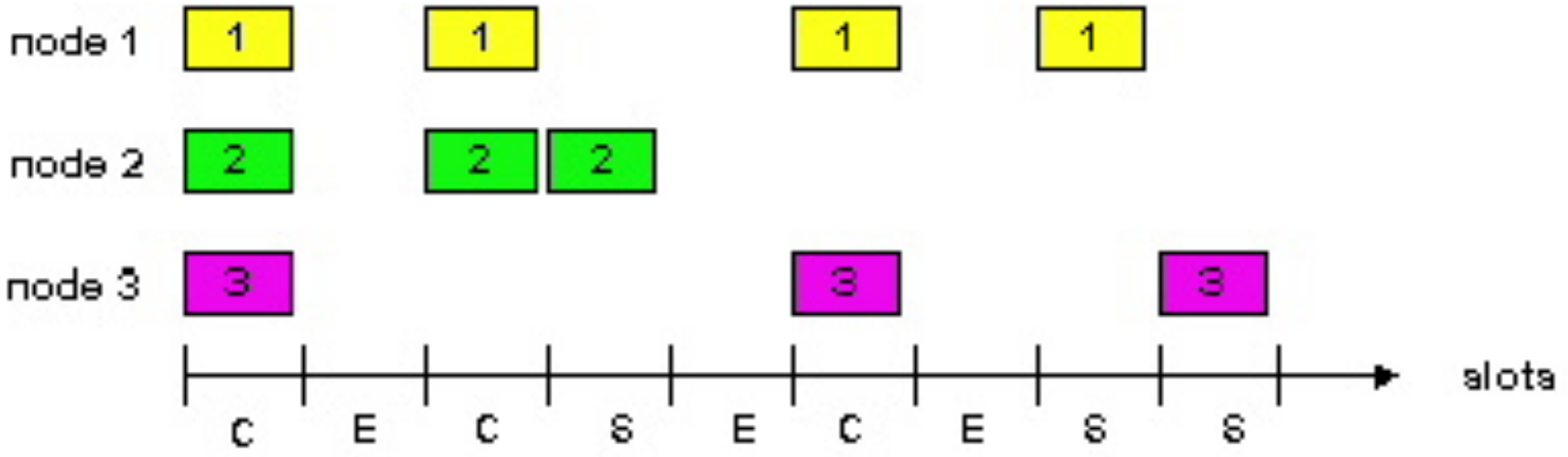
- First random MAC developed
  - For radio-based communication in Hawaii (1970)

Basic idea:

- When you're ready, transmit
- Receivers send ACK for data
- Detect collisions by timing out for ACK
- Recover from collision by trying after random delay
  - Too short → large number of collisions
  - Too long → underutilization

Slotted Aloha

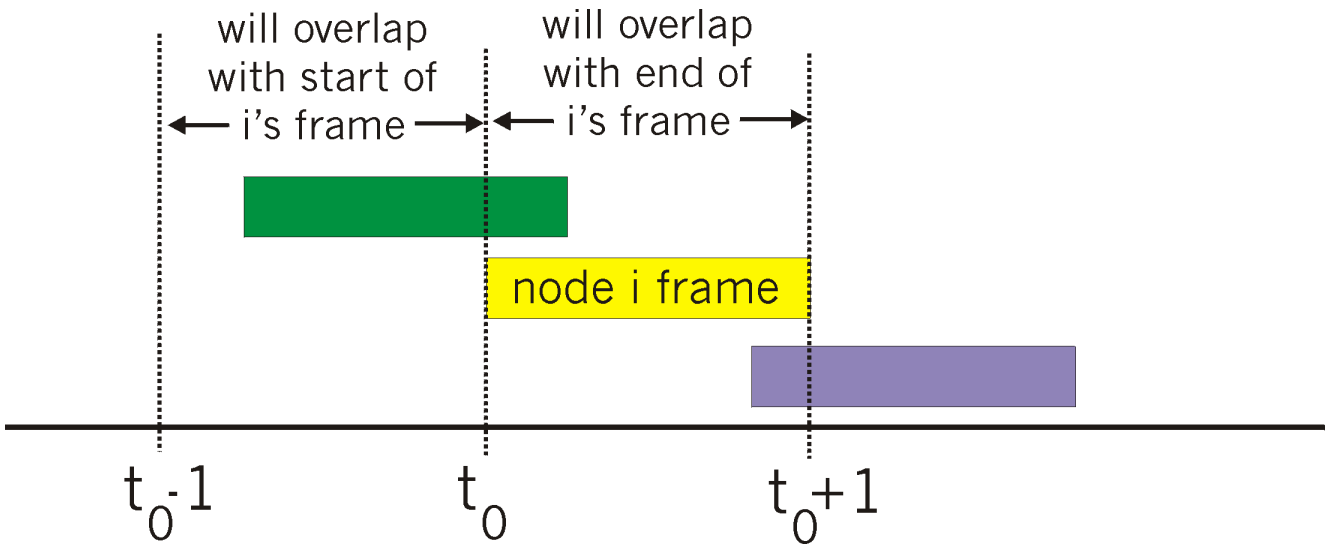
- Time is divided into equal size slots
  - Packet transmission time
- Node (with packet) transmits at beginning of next slot
- If collision, retransmit in future slots with probability *p*, until successful



Success (S), Collision (C), Empty (E) slots

Pure (Unslotted) Aloha

- Simpler, no synchronization
- Packet needs transmission?
  - Send without awaiting for beginning of slot
- Collision probability increases:
  - Packet sent at t_0 collide with others sent in $[t_0-1, t_0+1]$



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  - Slotted Aloha
  - Pure Aloha
  - CSMA/CD
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Slotted Aloha Efficiency

What is the maximum fraction of successful slots?

- Suppose *N* stations have packets to send
- Each transmits in slot with probability *p*
- Probability successful transmission S is:
  - By single node, $S = p(1-p)^{(N-1)}$
  - By any of *N* nodes
  - S = Probability(only one transmits)
    $= N\,p\,(1-p)^{(N-1)}$
- But, to be stable $p \leq 1/N$, so …
  - S = 1/e = 0.37 as $N \rightarrow \infty$

channel used *at best* for useful transmissions 37% of time!

Pure Aloha Efficiency

P(success by given node)

= P(transmits)

.P(no other node transmits in $[p_0\text{-}1, p_0]$)

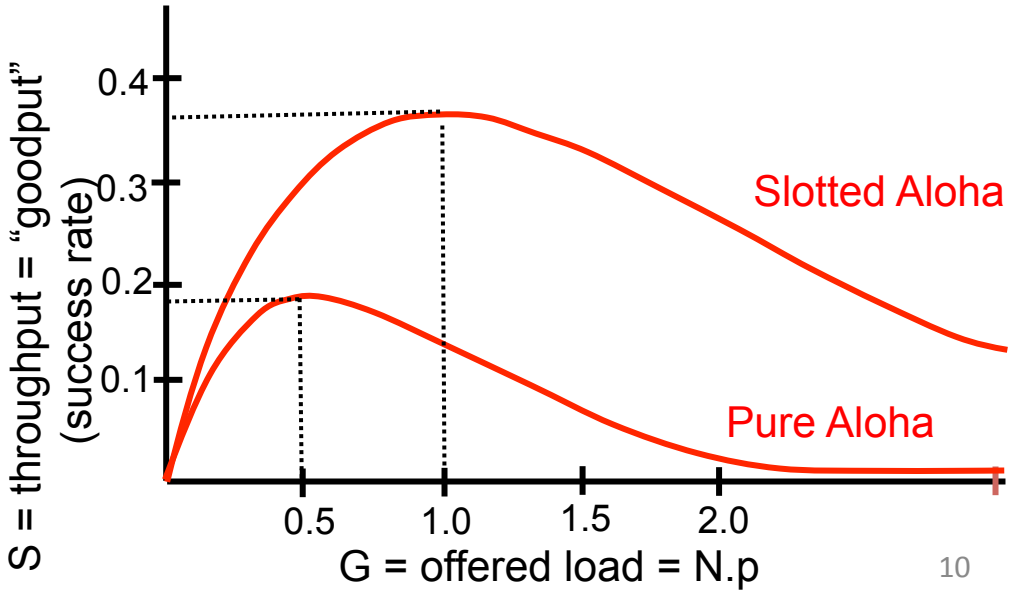
.P(no other node transmits in $[p_0, p_0+1]$)

= $p.(1\text{-}p)^{(N\text{-}1)}.(1\text{-}p)^{(N\text{-}1)}$

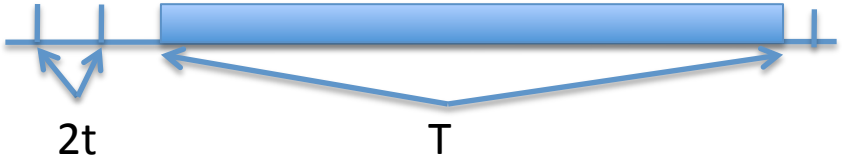
P(success by any of N nodes) = $N.p.(1\text{-}p)^{(N\text{-}1)}.(1\text{-}p)^{(N\text{-}1)} = 1/(2e) = 0.18$

Choosing optimum p as $N \rightarrow \infty$ gives $p = 1/2N$

protocol constrains effective channel throughput!



CSMA/CD



- View CSMA/CD as Aloha system with slot size 2*t*
  - But this reserves the channel for many slots
- 2*t* is the *collision window*
  - Time for packet to propagate across the network and someone else to just start sending as it arrives – when do I see the collision?
- The interval between successful packets

$$I = (e-1)2t + T + t$$

I = [Delay to acquire mini-slot]
+ [Data transmission delay] + [Wait for next mini-slot]

Efficiency

- Efficiency of CSMA/CD

$$E = T / I = T / (T + t(2e-1))$$

$$\approx 1/(1 + 4.4\gamma), \text{ where } \gamma = t/T$$

- Say 10Mbps network with 500m diameter
  - T = 1000 bits = 10^{-4}s
  - t = 1000m/[signal speed in copper] = $5x10^{-6}$s
  - E ≈ 82%
- What happens at 100Mbps, 1Gbps?

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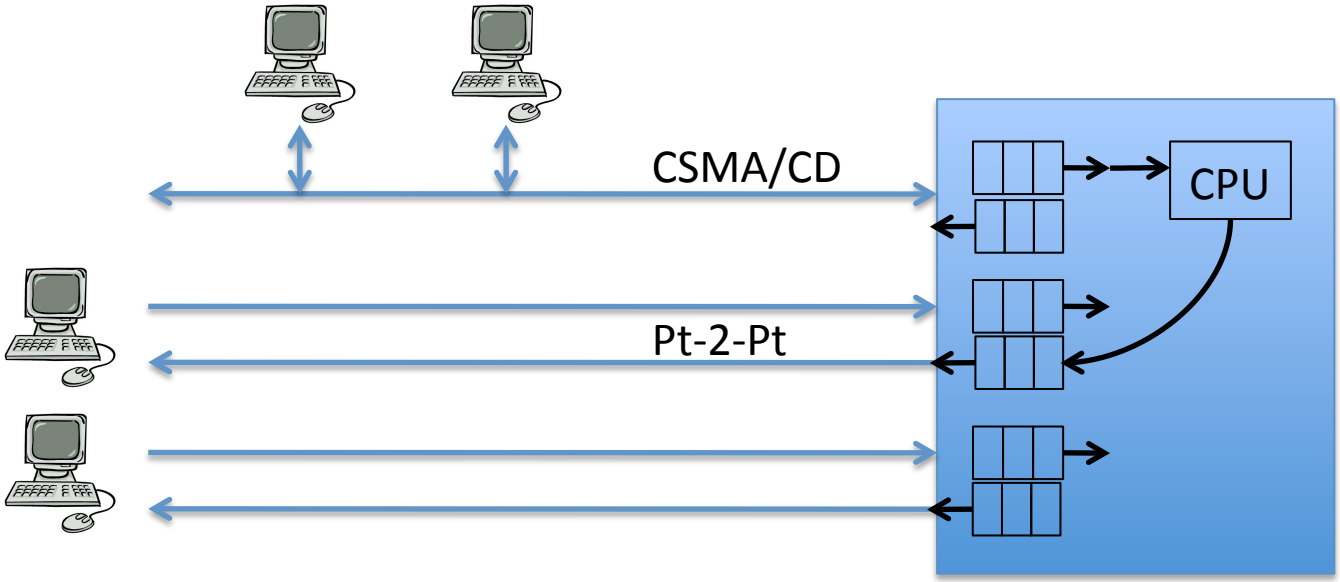
- Bridges to Switches
  - Buffering
  - Hubs *vs.* switches
  - Issues
- Extensions

Bridges to Switches

- CSMA/CD works well for certain packet sizes/ physical network size/speed trade-offs
  - 100Mb/s for normal network traffic profile started to stress CSMA/CD in larger LAN deployments
  - Needed to move away from pure CSMA/CD
- Started with “bridges”
  - Partition CSMA/CD into smaller segments
  - Bridges originally connected two CSMA/CD segments…
- …then to full blown switching

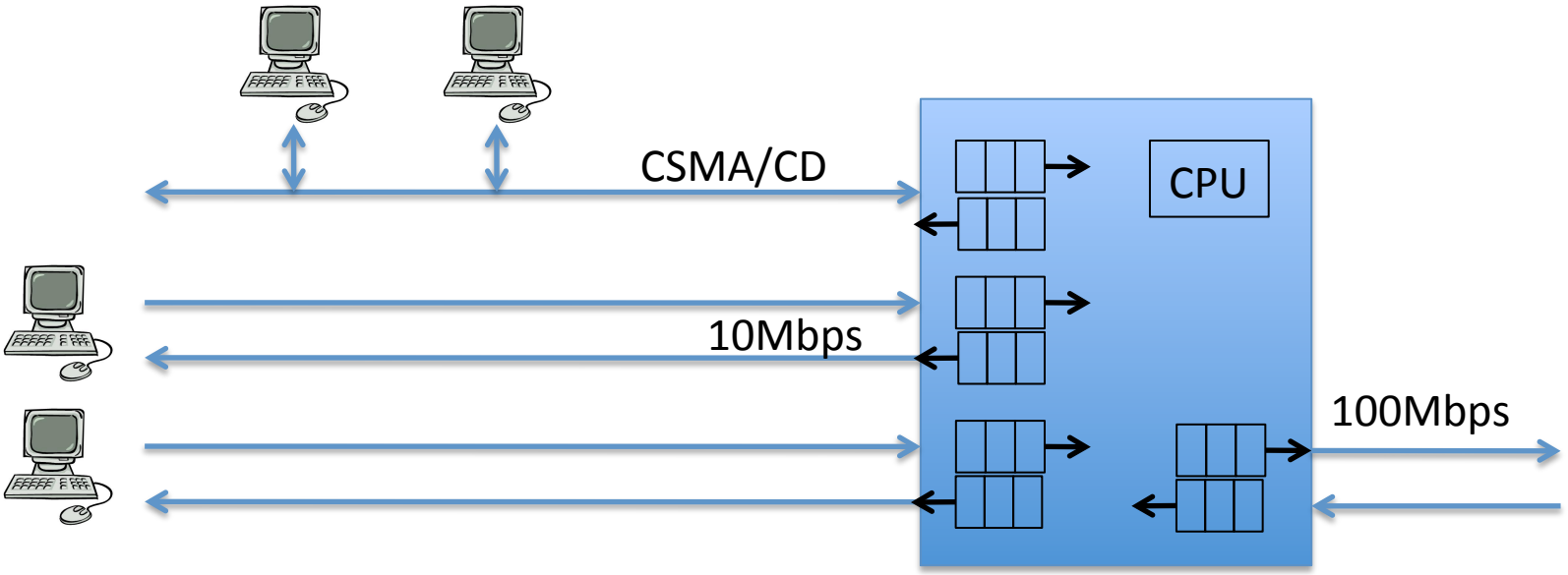
Buffering



- Attach CSMA/CD segment to switch, or
- Use point to point links from host to switch
- Buffer incoming packets in simple FIFO queues in switch
  - *Contention* resolved by scheduling packets to output queues
  - Simple queuing in software possible at low speeds

Decoupling Rates

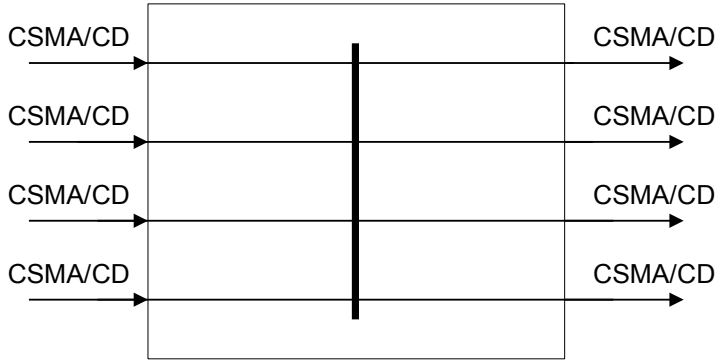
- Once we have introduced buffering we have decoupled the rates of transmission on the different switch ports
- Very common to see hosts attached at one speed and faster "uplinks" from switch to backbone network
- e.g.:



Ethernet Hubs *vs*. Ethernet Switches

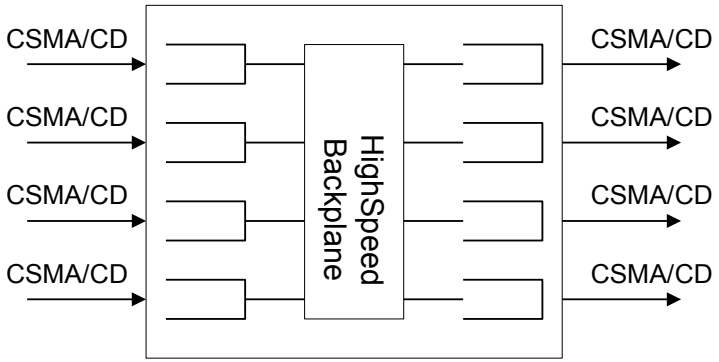
Ethernet Hub

- Does not perform buffering
- Collisions occur if two frames arrive at the same time



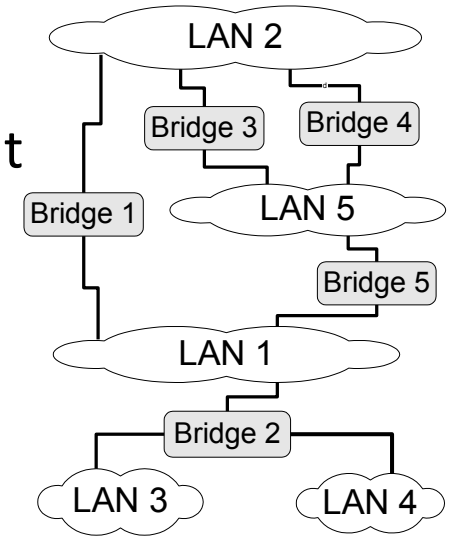
Ethernet Switch

- A packet switch for Ethernet frames
- Buffering of frames prevents collisions.
- Each port is isolated and builds its own collision domain



Issues

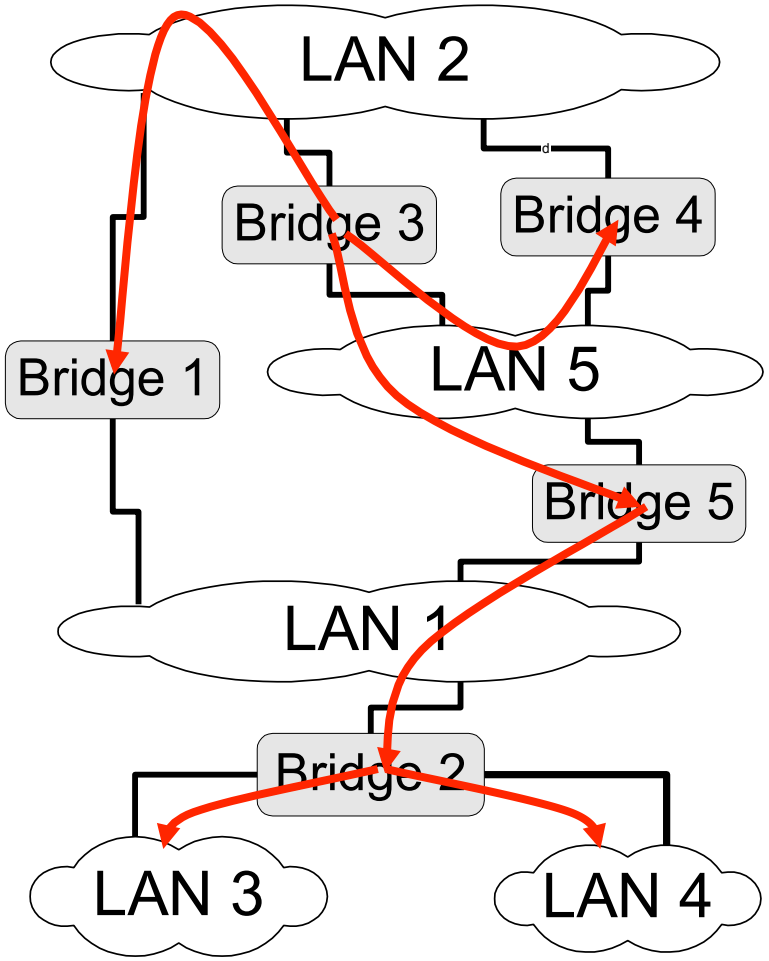
- Introducing switching introduces multipath
  - Fools will wire switches with loops by accident
  - Smart people wire with loops to increase redundancy
- So:
  - Where do we forward the packets?
  - How to support broadcast and multicast?



- Can we flood incoming packet onto all outgoing links?
  - Packets circulate forever unless ...?
  - Really need another solution – Spanning Tree

Spanning Tree Protocol (IEEE 802.1d)

- Prevents loops when forwarding frames between LANs
  - Standardized as the IEEE 802.1d protocol
- Organizes bridges and LANs as spanning tree in a dynamic environment
  - Bridges exchange messages to build the tree
  - Trees don't have loops
  - Frames forwarded only along the branches of the spanning tree
- Bridges that run the SPT are called *transparent bridges*



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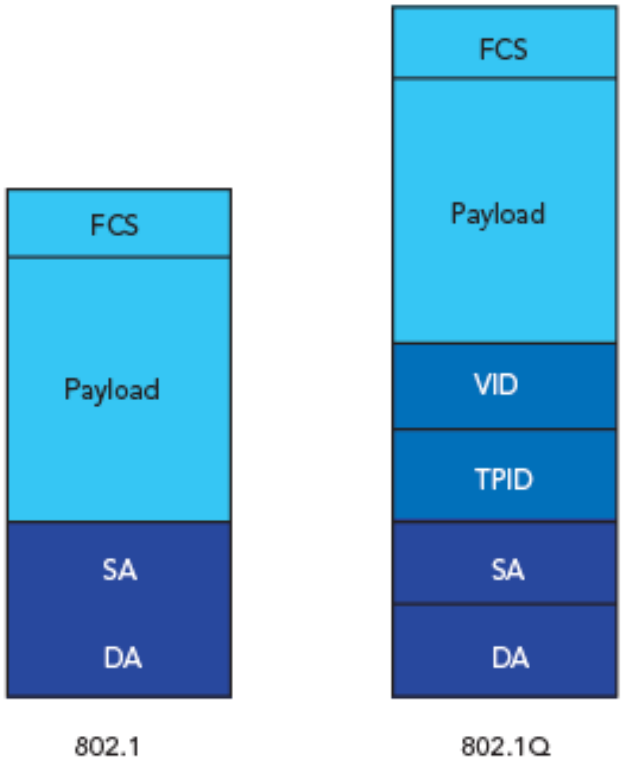
  - VLANs
  - Carrier-grade Ethernet

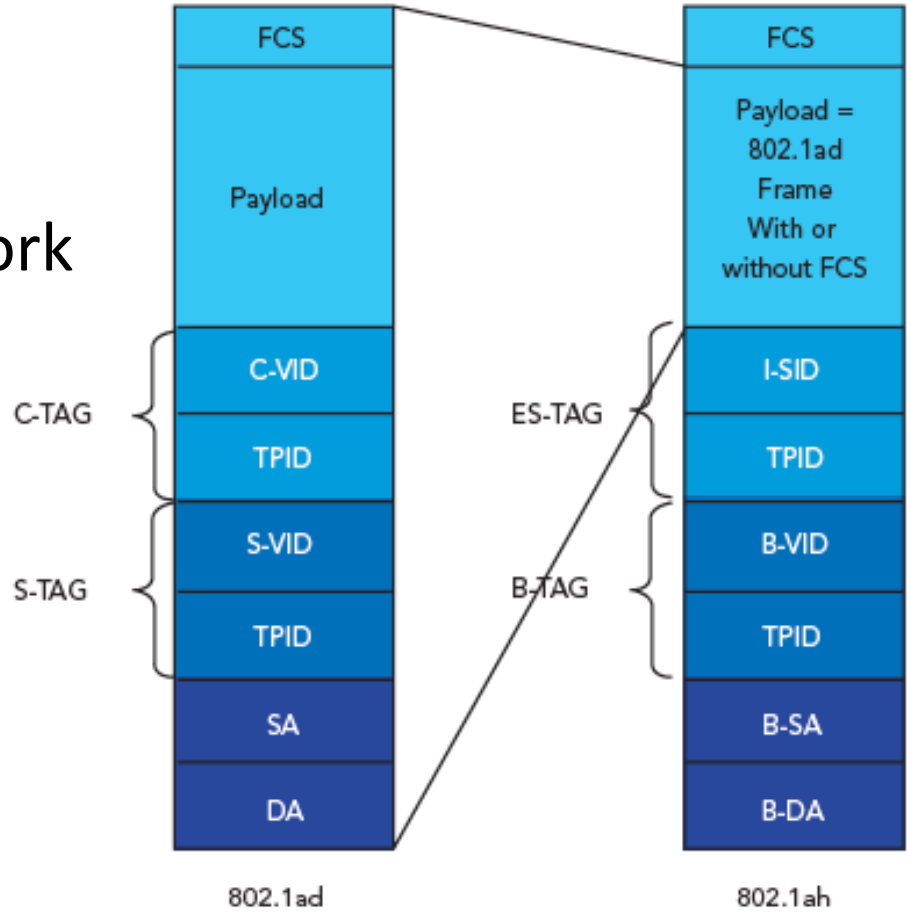
802.1Q VLAN

- VLAN – support multiple virtual LANs on one infrastructure
- Add VLAN tag that allows up to 64K virtual networks
- Label each spanning tree and forwarding table with VLAN tag
- Works on all 802 networks including 802.11
  - e.g., UoN wireless from one set of base stations…



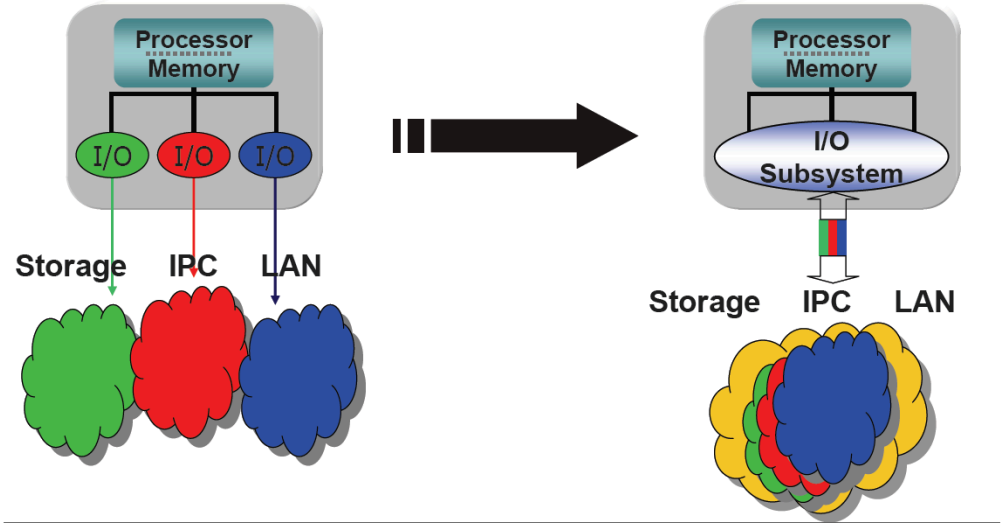
Carrier Grade Ethernet

- Ethernet service for customers using VLANs
- Desire to use Ethernet switching in the core network
- First try VLAN in VLAN
  - 802.1ad
  - But find customers already using VLAN in VLAN ...
- So do full 802.1ad encapsulation in another 802.1ad frame – 802.1ah



Data Centre Ethernet

- Desire to replace 3 networks with one:
  - Storage (e.g. Fibre-channel)
  - Inter-Process Communications (e.g. Myrinet)
  - LAN (e.g. Ethernet)
- Isolation between traffic types?
  - Ethernet with QoS
  - 802.1p



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  - Hubs *vs.* switches
  - Issues
  - Spanning Tree Protocol
- Extensions
  - VLANs
  - Carrier grade Ethernet

Quiz

1. What is a *broadcast* network?
2. What are the differences between pure Aloha, slotted Aloha, and CSMA/CD? What is the impact of those differences?
3. What is the primary problem with scaling a broadcast network? What are two ways to solve it, and what are the trade-offs?
4. What are the trade-offs between Ethernet hubs and switches?
5. Ethernet switches introduce a potential problem not seen with hubs – what is it and how is it solved?