COMP3721 Week Ten/Eleven Lab Synopsis

Inter-networking Devices

- In the most basic terms, data communication involves the movement of information across a channel
- The channel is often more complex than just a single piece of cable – often there are a series of devices together acting as the channel
- The devices that create the channel can be subdivided in accordance with the OSI layered model:
  - *Layer 1 devices (physical layer)* – physical layer counteract the distortion introduced by noise, delay, attenuation or other channel impairments. They interpret and re-generate electromagnetic signal in terms of its information content. Example device: *repeater*.
  - *Layer 2 devices (data-link layer)* – the link layer in the OSI model involves network devices that are able to directly communicate via the channel.

    An analogy would be a number of people within a room – any person can talk to one (unicast) or all other people (broadcast) directly. A protocol is needed to determine who may speak at a given time (media access – MAC sublayer).

    Link-layer inter-networking devices are those that maintain the ability to directly unicast or broadcast to other nodes (with varying efficiency). Example devices: *switch, bridge*
  - *Layer 3 devices (network layer)* – Continuing the analogy from above, the (link-layer) protocol that would work for 20 people in a room trying to intercommunicate would be unlikely to work for a million people in a room. Larger scale networks need different solutions to deal with the larger number of machines intercommunicating.

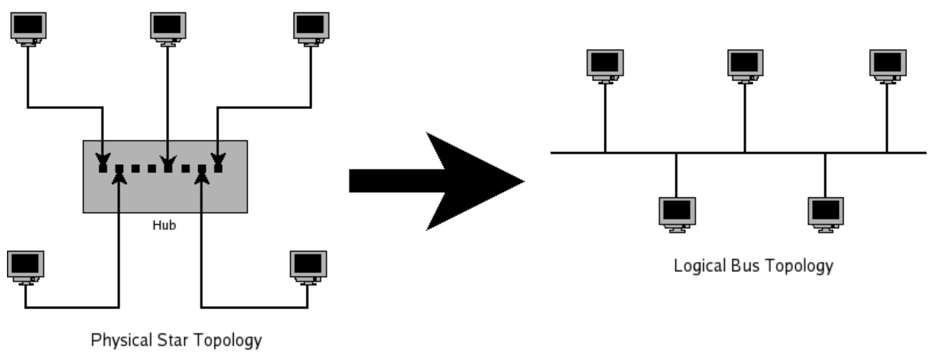
    Layer 3 devices are those that sit on multiple links, moving information from one link to another as needed. Another analogy may help. If a letter is destined for someone in the same room as yourself, you can deliver it yourself (directly, link level). If the recipient is in a different room, building or country you will instead rely on interoffice mail or the post office for delivery (indirect, network level).

    Note that you could share the letter with everyone in the room by placing on an overhead and ‘broadcasting’ it onto a projection screen (link-layer supports broadcasting). This is not easily accomplished when on a larger scale (network layer is a broadcast boundary).

Example device: *router*

Hubs

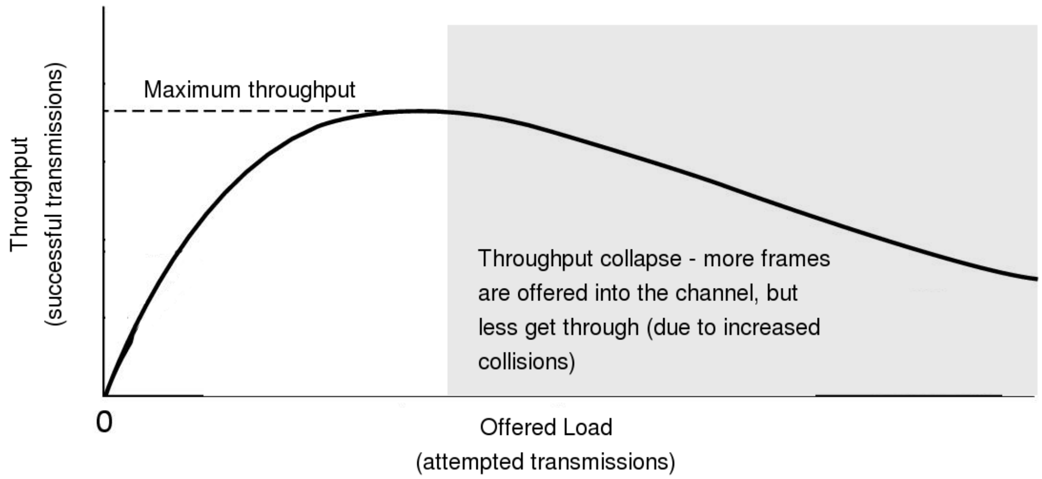
- Hubs are layer 1 devices – they simply duplicate the signal from all input ports out to all other ports.
- While a hub appears to be the centre of a star topology, it’s function logically transforms the physical topology to a logical bus.



- The single logical cable means that all frames are seen by all nodes (connected to the hub)
  - the machines are then considered part of a single *broadcast domain*
- The single logical cable means that all machines are in competition for access to that cable. If two machines transmit simultaneously, the frames will collide
  - the machines are then considered part of a single *collision domain*
  - a media-access protocol, such as Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is required to resolve contention for access to the channel within a collision domain
- Scalability – the number of devices that can be interconnected is generally limited by the shared medium
  - the channel has finite bandwidth – static division of the

channel (TDM, FDM) means less bandwidth for each devices as the number of devices increases.

- In a contention-based design, collisions will increase as more devices are added. As more devices are added, more collisions are generated. In the case of too many devices, collisions will dominate traffic meaning less actual information is transmitted – this is called *throughput collapse*



- the point of throughput collapse depends on the particular media access protocol utilised
  - a typical office using Ethernet cannot support more than about 50 or 60 machines interconnected via hubs. The number can be much lower in the case of heavy network utilisation

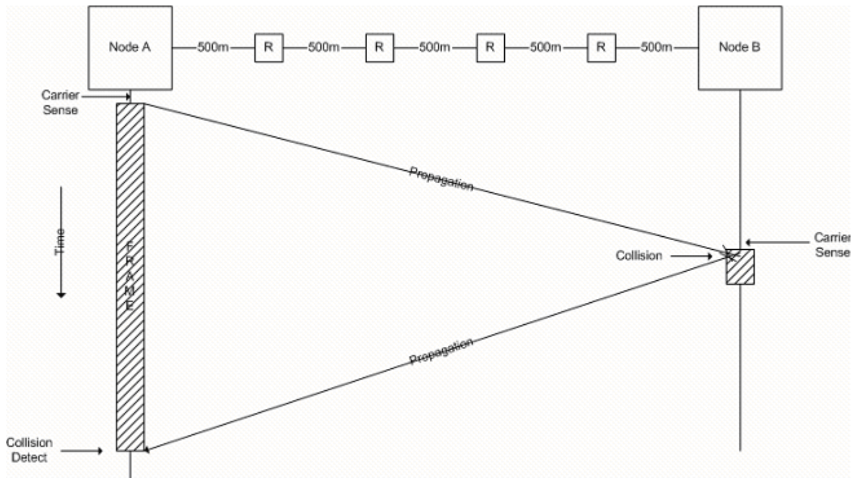
CSMA/CD

- Carrier-sense (CS) – listen to the channel before transmitting in order to avoid collisions. If the channel is in use when sensed, wait until it is clear before transmitting
- Multiple-access (MA) – resolves the issue who, among multiple users, may use the channel at a given time
- Collision detect (CD) – if a transmitter senses a collision while transmitting, frame transmission is terminated.

  Collisions can still occur due to propagation delay – a signal on the channel may not be sensed as it may not have propagated the entire length of the cable

  Non-collision (= successful frame delivery in CSMA/CD) can be guaranteed after 2x the total propagation delay

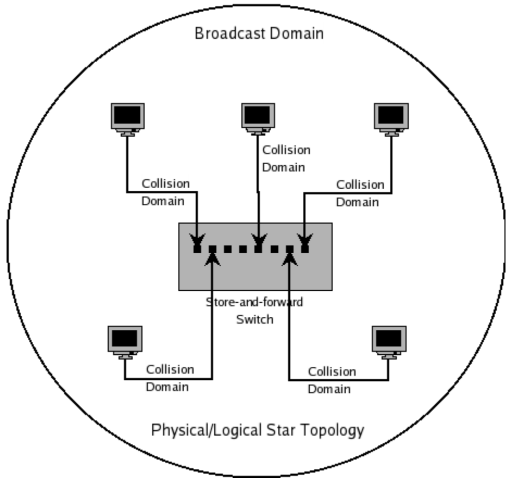
- In the diagram below, node A only detects the collision with node B after
  - 1) the first bits of the frame have propagated to node B at the far end of the cable and
  - 2) the ‘collision’ bits have propagated back to node A



- CSMA/CD considers a packet successfully transmitted if no collision is detected
  then the time to transmit a frame must be a minimum of 2x the propagation delay to ensure that collisions are detected (before assuming successful delivery)

Switches

- Overcome the issue of throughput collapse while maintaining the direct-communication semantic
  - separate collision domains
  - one broadcast domain
- True star topology – the switch receives and buffers inbound frames and retransmits them out the appropriate physical ports

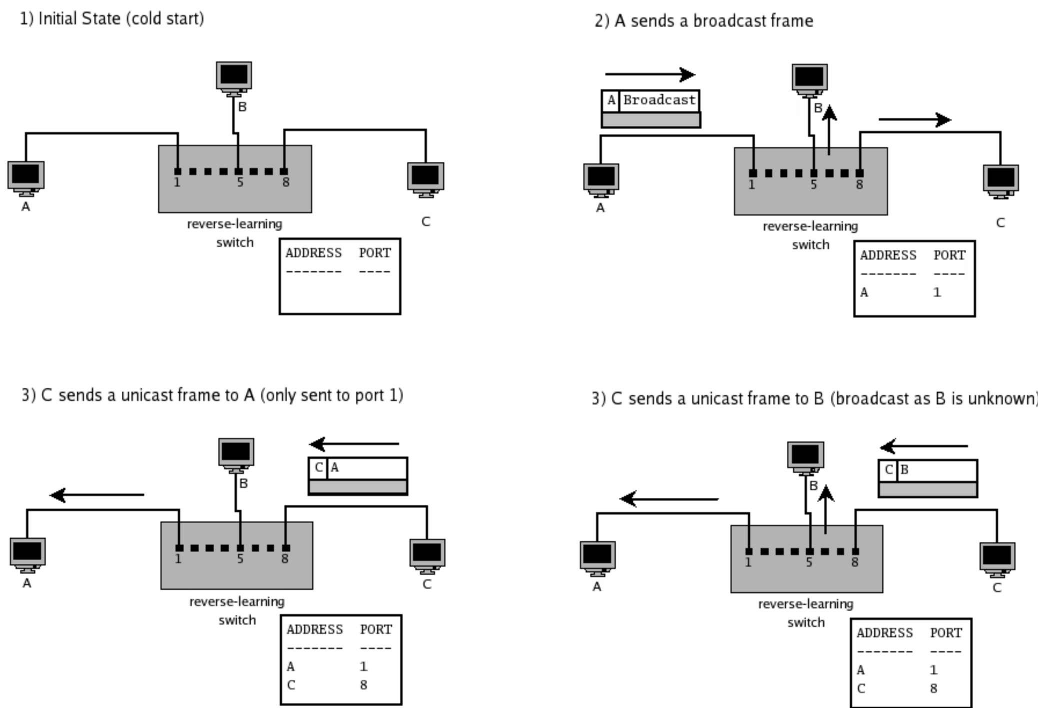


- Switches then reduce (and even remove) collisions but are necessarily much more complex than hubs
  - need memory to buffer inbound frames
  - need logic to determine the appropriate port to forward to
- collisions may still occur if hubs are connected to any of the physical ports

Data-Link Addressing

- each network node has a data-link address (i.e. MAC address in Ethernet)
- based on the destination data-link address, the switch may need to forward the frame out
  - a specific port – unicast frame – to a single recipient, or
  - all ports – broadcast frame – to all machines within the broadcast domain
- for unicast frames, the switch must somehow know the appropriate port to utilise for a given data-link address
- to accomplish this, a table is maintained that associated the ports with the data-link addresses
- table may be:
  - manually programmed (error-prone and labour-intensive)
  - automatically learned:
    - reverse learning switches look at inbound frames and associate the source data-link address with the physical port upon which the frame is received
    - outbound frames are then forwarded according to the table built from inbound frames

- unknown addresses are forwarded to all physical ports (broadcast)



Limitations

- where physical-layer scalability is limited due to collisions, link-layer scalability is limited due to broadcasting
  - each node added to the link will generate some broadcast traffic
  - broadcast traffic uses bandwidth within all of the separate collision domains
  - as more nodes are added, more of the overall network capacity (bandwidth) is utilised for broadcasting
  - when too many nodes are added, the link becomes overwhelmed by broadcast traffic and cannot deliver unicast frames (or even all of the broadcast traffic)
  - again, throughput collapse occurs, only this time
    - due to broadcasting, not collisions, and
    - at a significantly larger scale (1000s of nodes)
- switching table also become more complex/expensive as the number of nodes increases

Routers

- belong to multiple broadcast domains
- when a network node wishes to send a packet to a machine within its own broadcast domain, it simply sends it directly (through the hub and/or switch)
- however, when a network node wishes to send a packet outside of its broadcast domain, it instead sends the packet to a router (within the broadcast domain)
- the router then determines moves the packet forward (via a different link/broadcast domain) towards the ultimate destination
    - routing decisions are made based on network-layer addressing (next week)
- routers do **not** forward broadcast frames – this allows inter-networks (networks composed of multiple broadcast domains interconnected by routers) to scale to millions of nodes