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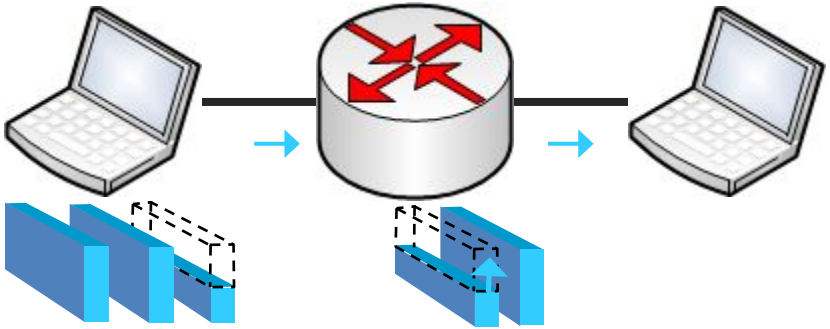
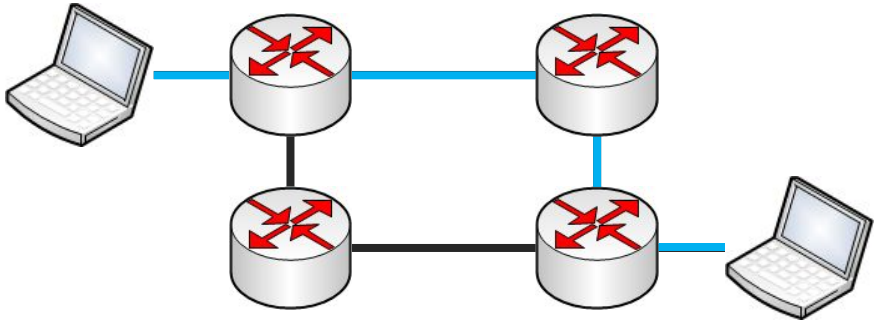
Forwarding methods

Packet switching

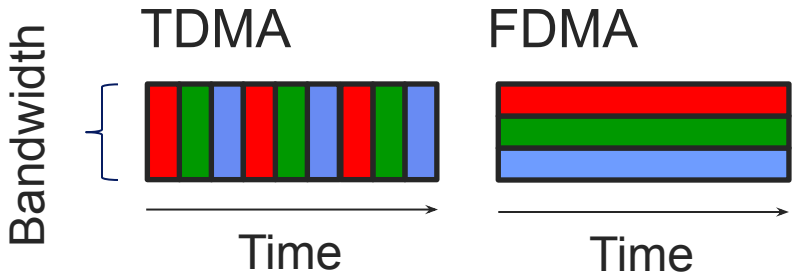


- *Store and forward*: entire packet must arrive at router before it can be transmitted on next link

Circuit switching



- End-to-end resources reserved for the duration of transmission



Packet vs. Circuit switching

Which gives better performance in terms of:

- End-to-end delay?
- Flow throughput?
- Network throughput?

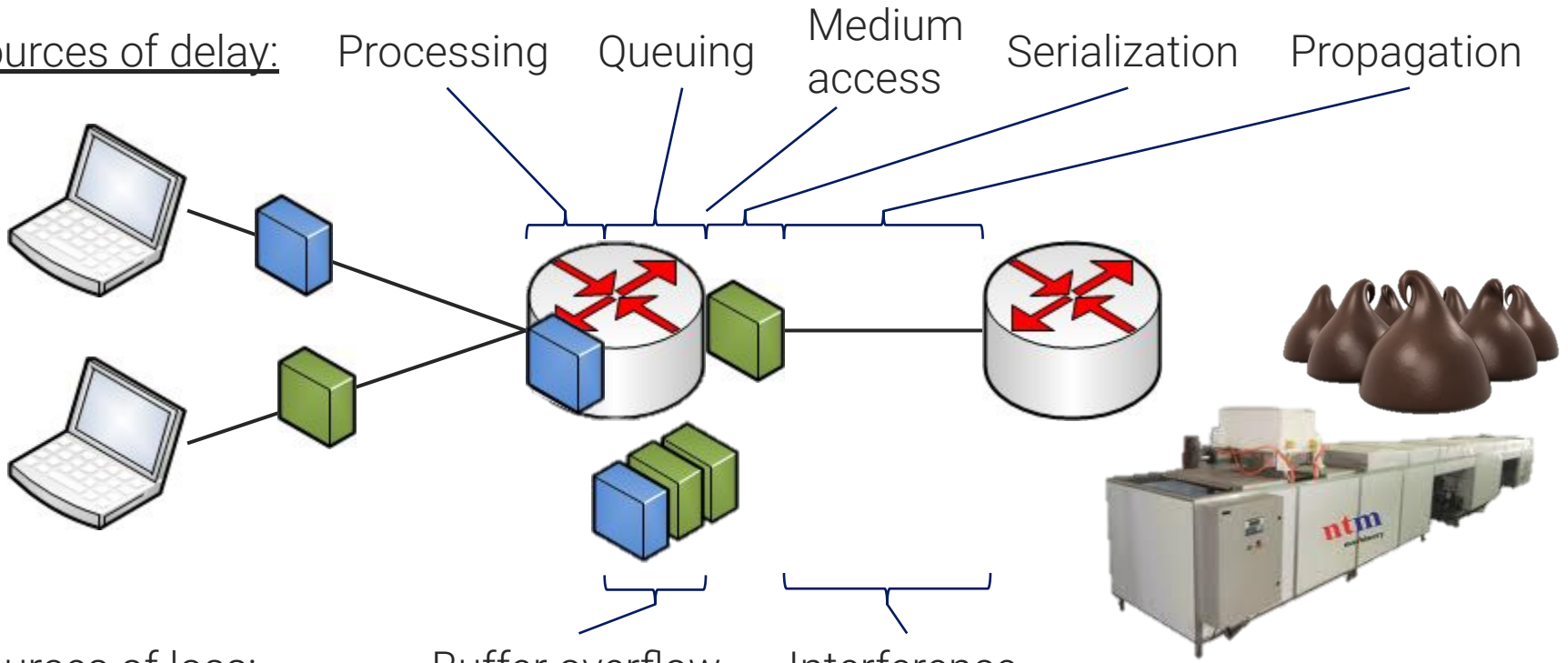
Packet switching

+ More efficient with bursty data
+ Simpler – no call setup
− Variable delay
− Need protocols for reliability and congestion control

Circuit switching

+ Lower end-to-end delay
− Wastes resources during quiet periods
− Need protocols for resource reservation

Network performance



Definitions of delay

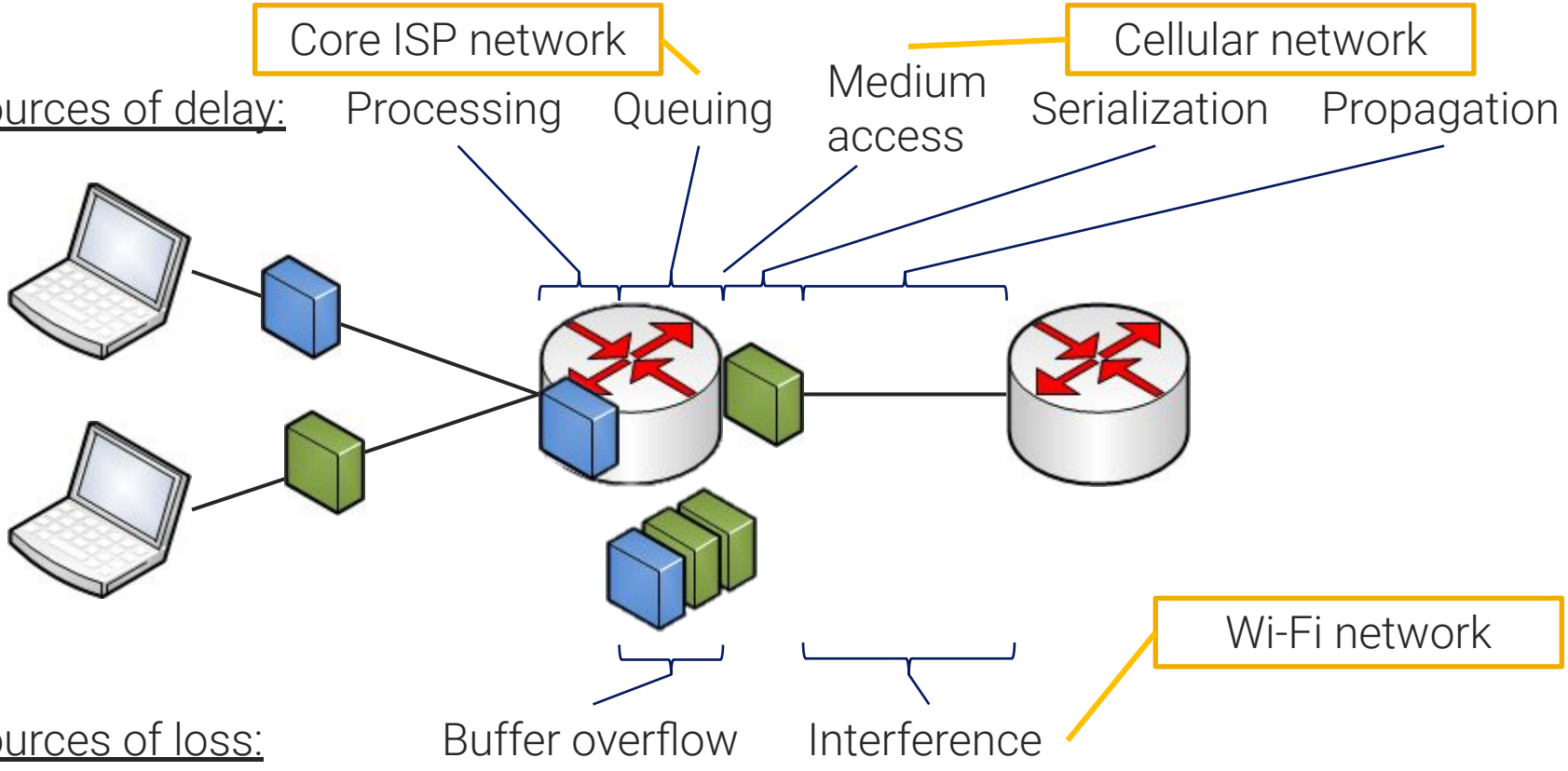
- Processing delay
  - The time it takes to read an incoming packet, determine on which link to transmit the packet, and to form packet headers.
  - *Analogy: The time to set up the chocolate chip making machine.*
- Queueing delay
  - The time it takes for the packet to get to the front of the queue.
  - *Analogy: The time to finish a run of white chocolate chips to start the regular chips.*
- Medium access delay
  - The time a packet has to wait at the front of the queue for the transmission medium to be free.
  - *Analogy: Wait for the conveyor to reach the correct speed.*
- Serialization delay
  - The time it takes to put all the packet's bits onto the transmission medium.
  - *Analogy: The time to drip down a batch of chocolate chips.*
- Propagation delay
  - The time it takes for the first bit of a packet to traverse a link
  - *Analogy: The time it takes for the first line of chocolate chips to cool before they are packed at the end of the conveyor.*

Definitions of loss

- Buffer overflow
  - When the rate of arriving packets exceeds sending rate packets queue up. Eventually the number of queued packets exceeds queue size in router memory and newly arriving packets are dropped.
  - *Analogy: The box collecting chips at the end of the conveyor fills up and new chips are dropped on the floor. (No three seconds rule!)*

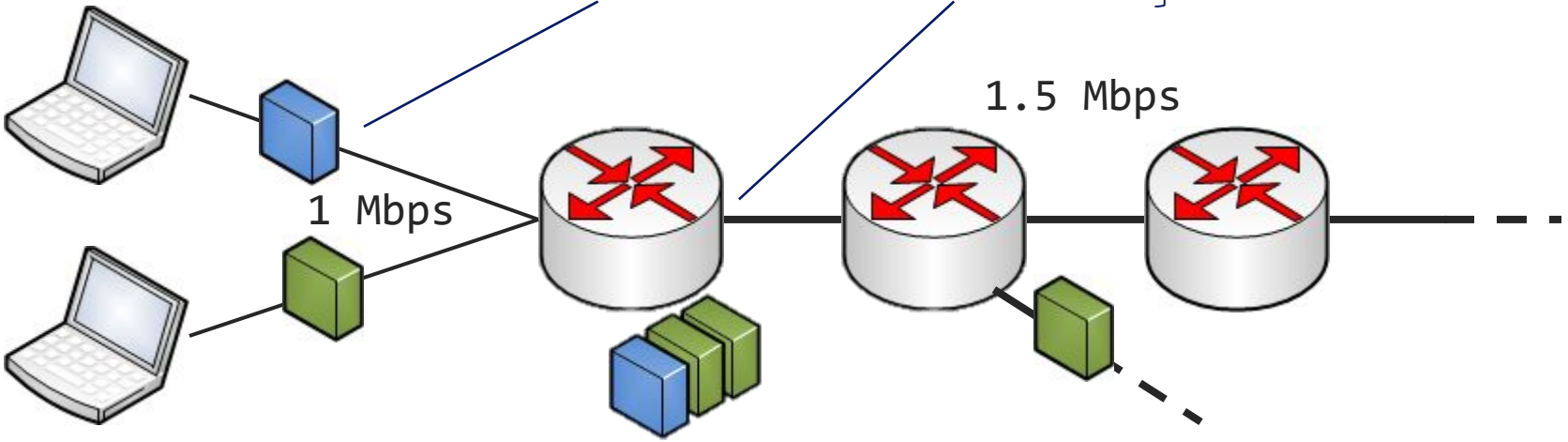
- Interference
  - When a transmitted packet collides with another packet on the transmission medium and neither one can be decoded.
  - *Analogy: Someone snags a chip of the conveyor belt.*

Likely sources of delay



Network performance

Loss of throughput: Low capacity link Congested link } *Bottleneck* links



Metrics of delivery rate:

- Capacity – bandwidth, serialization rate, thickness of the pipe
- Available bandwidth – unutilized bandwidth
- Achievable throughput – share of capacity achieved by a flow
- Goodput – rate of delivered application payload data

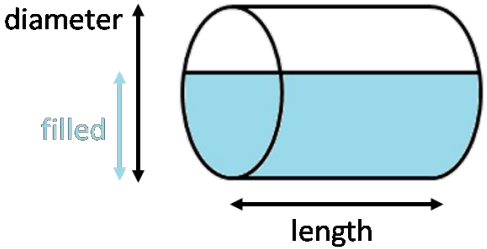


Illustration of queuing delay

B: link bandwidth (bps)

L: packet length (bits)

A: average packet arrival rate

LA/B ~ 0:

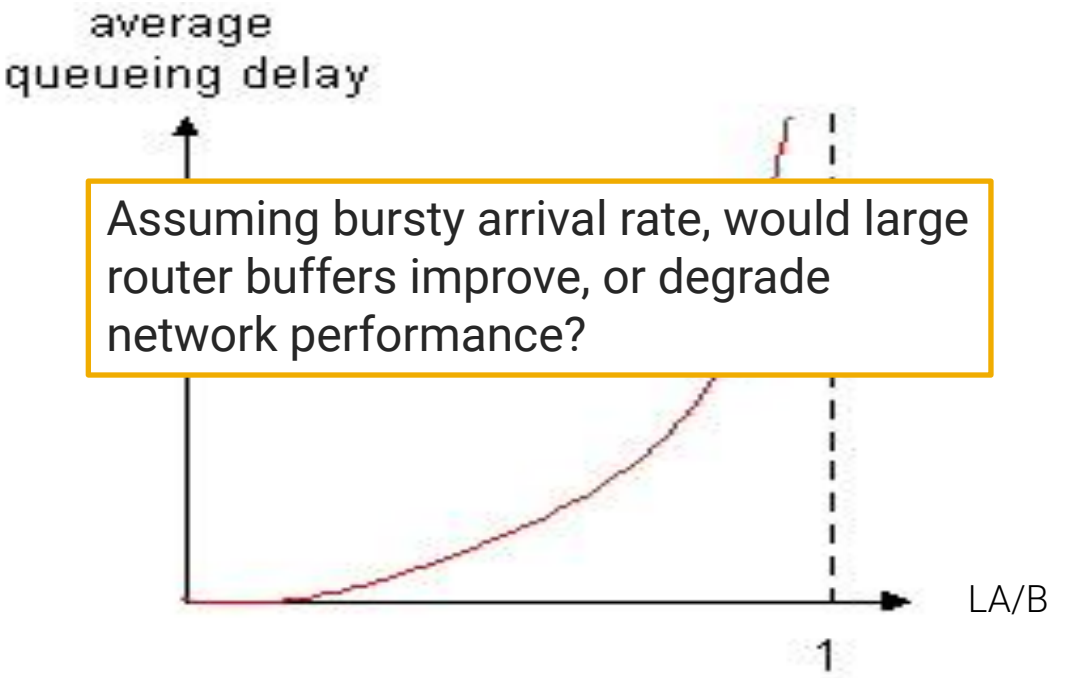
- Small queuing delay

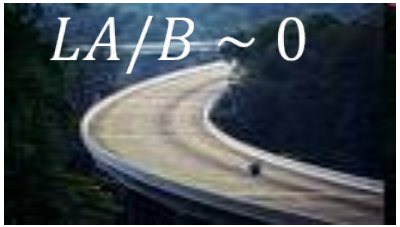
LA/B → 1:

- Large queuing delay

LA/B > 1:

- More "work" arriving than can be serviced
- Queuing delay infinite!



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