

# On-chip Networks

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6.5900 Fall 2022

# Announcements

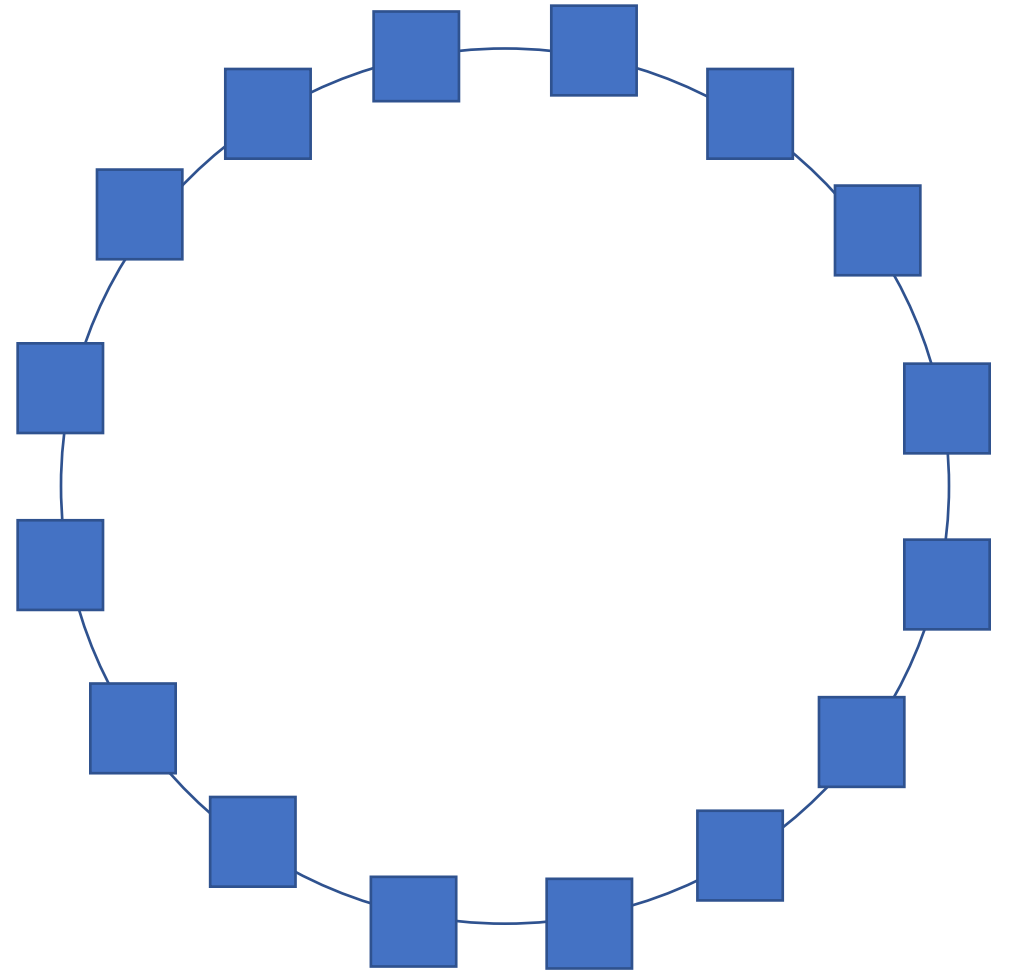
- Quiz 3 next Wednesday (Nov 9)
  - Review session on Tuesday, 7-9pm, Room 36-144
- Lab 3 due Nov 18

# Topology

- Describes how the nodes of the network are connected
- Decide based on use case:
  - Central nodes?
  - Optimizing for latency?
  - Traffic patterns?

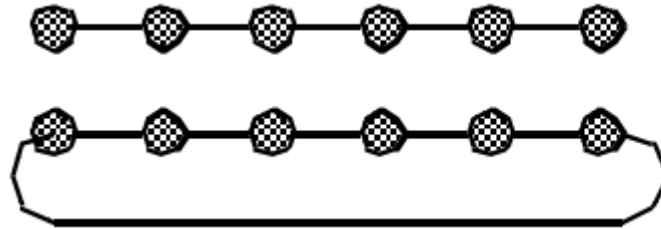
# Topological Properties

- Diameter
- Average Distance
- Bisection Bandwidth

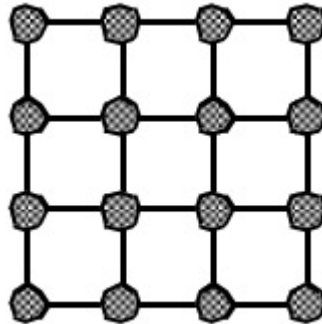


# Basic Topologies

- Linear Array
- Torus



- Mesh

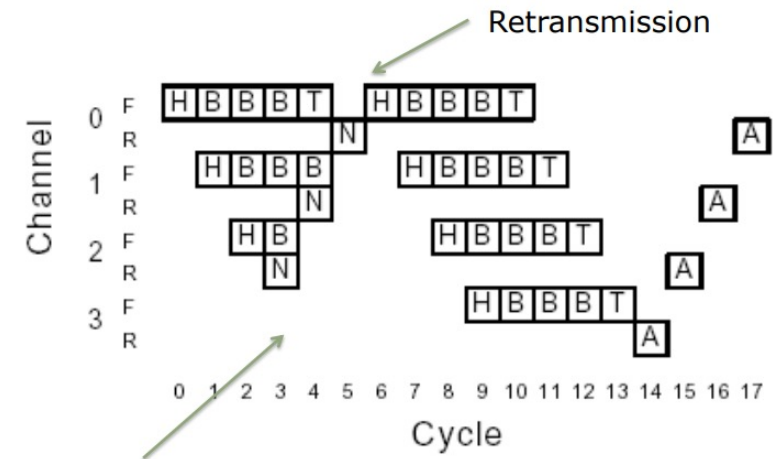
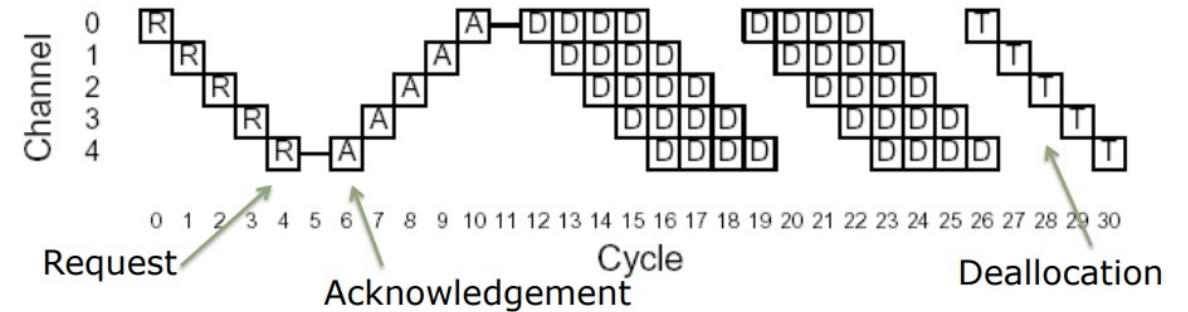


# Flow Control

- Packet: Basic unit of routing and sequencing
- Flit: Basic unit of bandwidth/storage allocation
- Why do we need flow control protocols?  
Contention!

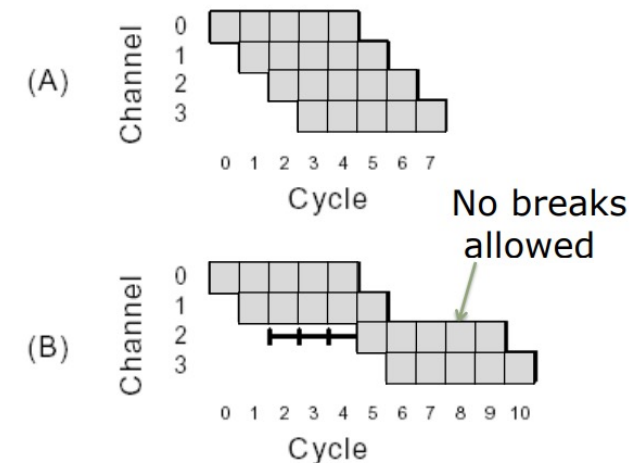
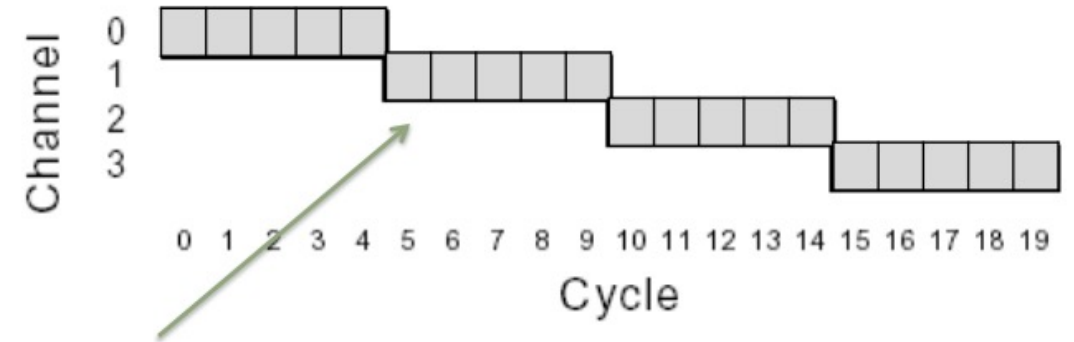
# Flow Control Protocols: Bufferless

- Circuit Switching
  - Reserve circuit, then send all data
- Dropping
  - If a packet arrives w/ no resources available, drop it!
- Misrouting
  - Route away from congestion



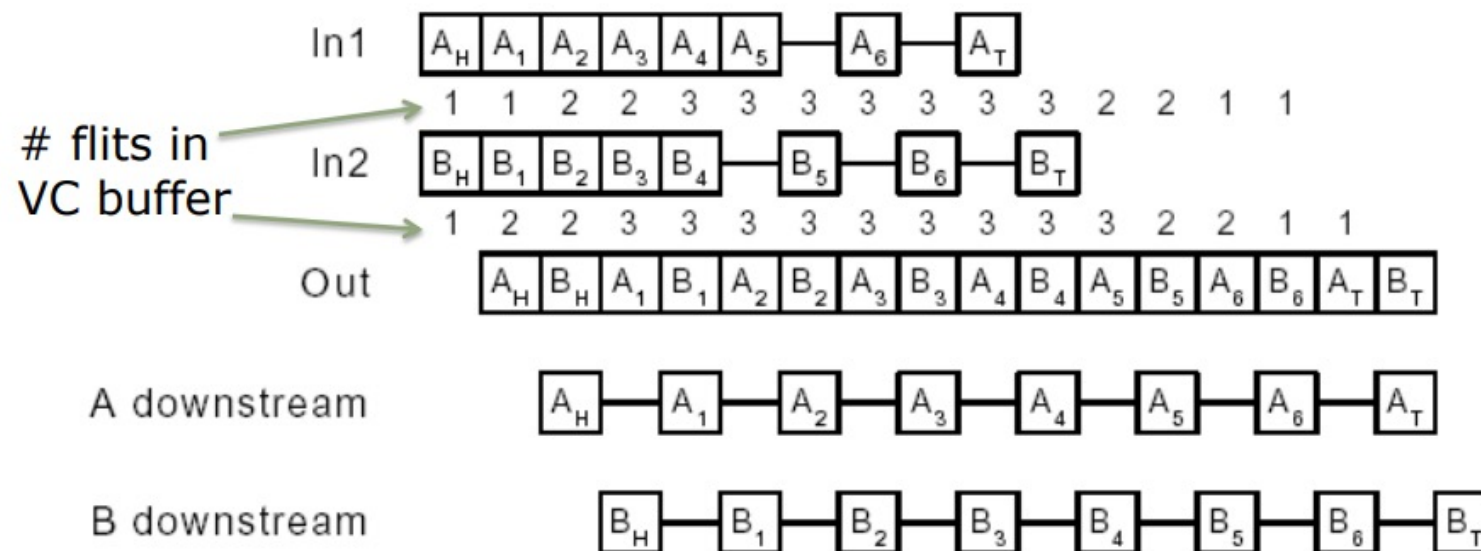
# Flow Control Protocols: Buffered

- Store-and-forward
  - Wait until entire packet arrives at intermediate node, then move on
- Virtual cut-through
  - Head of packet can keep advancing
  - If head is blocked, whole packet gets blocked at intermediate node
- Wormhole
  - When packet blocks, block all flits wherever they are
  - VC's allocated to packet so body can follow head



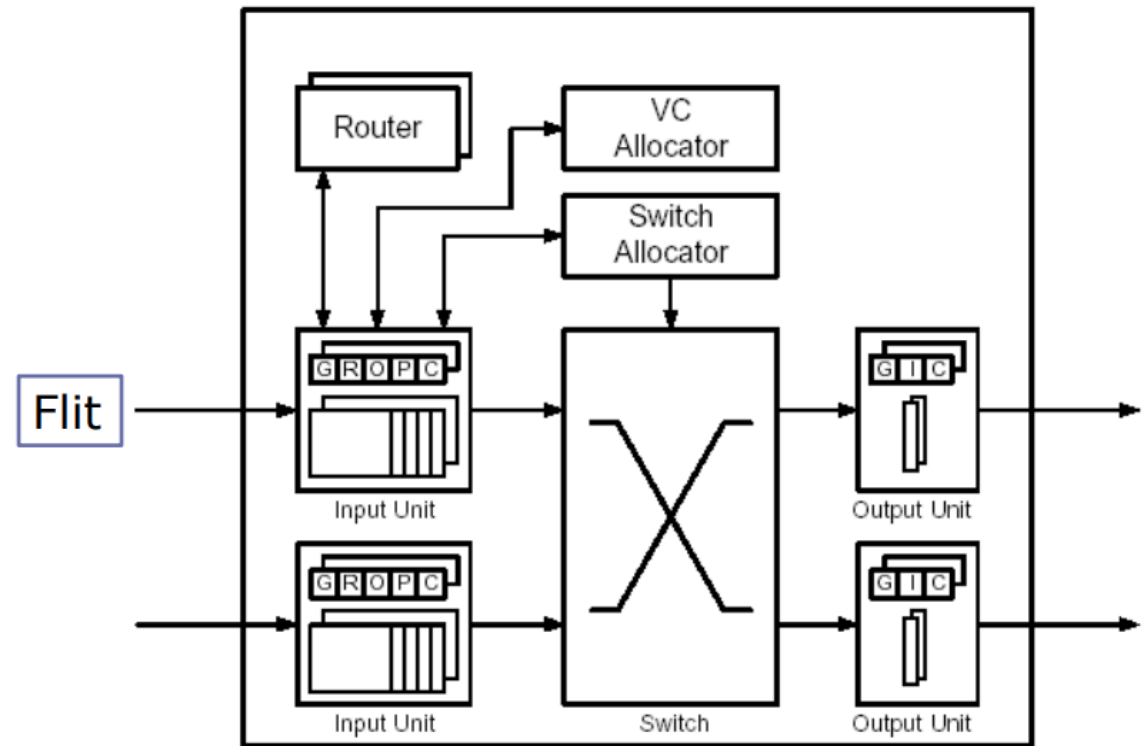
# Flow Control Protocols: Buffered

- Virtual Channel Flow Control
  - Hold on to channel when packet blocked
  - Essentially multiple queues in the buffer

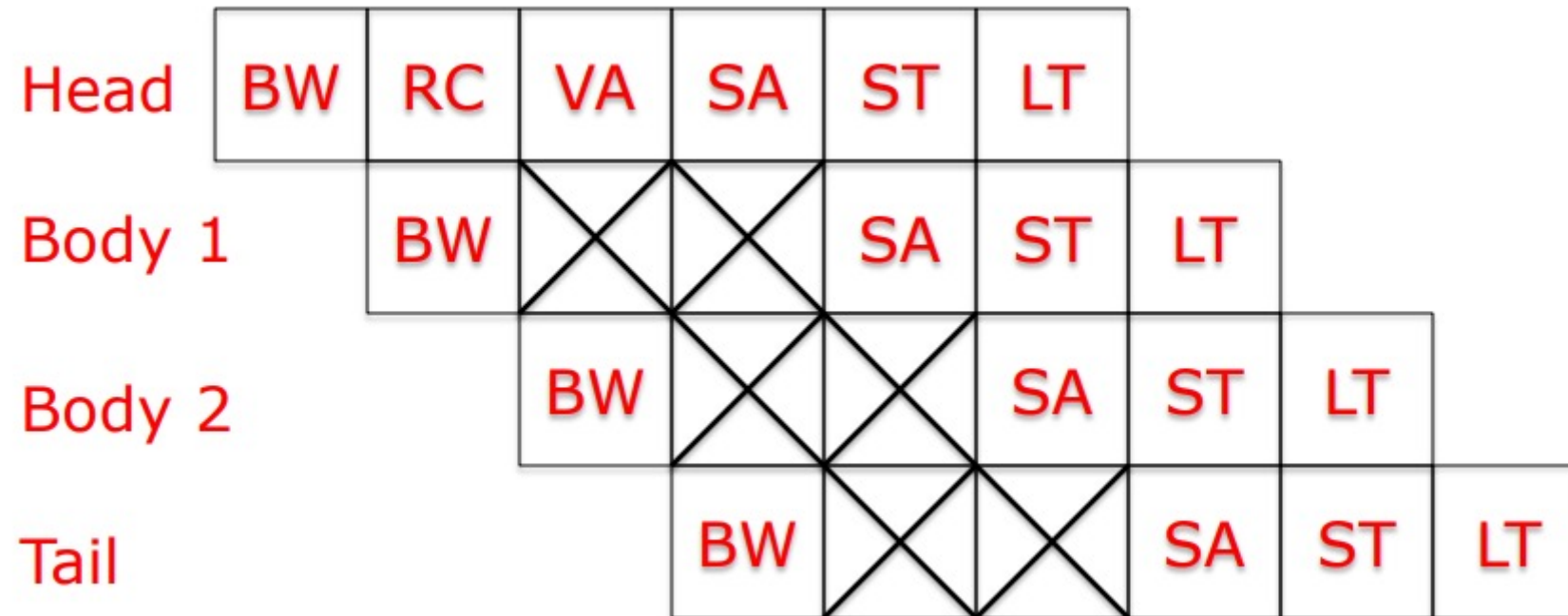


# Routers

- System of buffers, switches, crossbars, buses, etc to control data movement
- Flits go through certain stages to traverse a router



# Basic Router Pipeline



# Router Pipeline

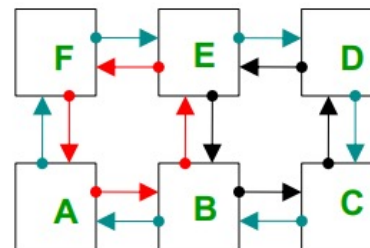
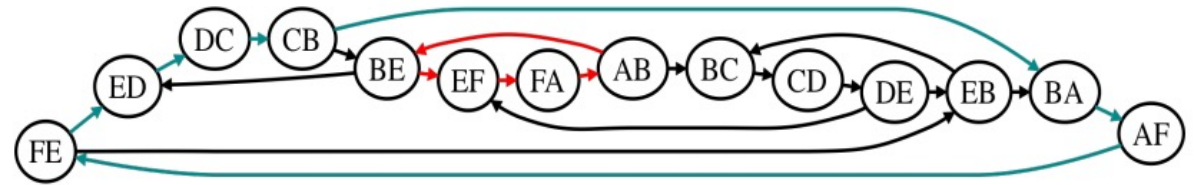
- Optimizations?
  - Perform RC for next router at the current router
  - Simplify RC
  - Speculatively perform VA and SA in parallel

# Routing algorithm Properties

- Deterministic/Oblivious
- Adaptive
- Minimal
- Deadlock-free

# Routing - Deadlock

- Traffic pattern where no packets can move forward
- Occurs when multiple flows own different resources that the others require in order to progress
- Channel Dependency Graph



Flow routed through links AB, BE, EF  
Flow routed through links EF, FA, AB  
Deadlock!

# Tackling Deadlock

- Restrict turns
- Enforce ordering for resource allocation
- Add more resources
- Restrict VC Allocation