

Data and Computer Communications

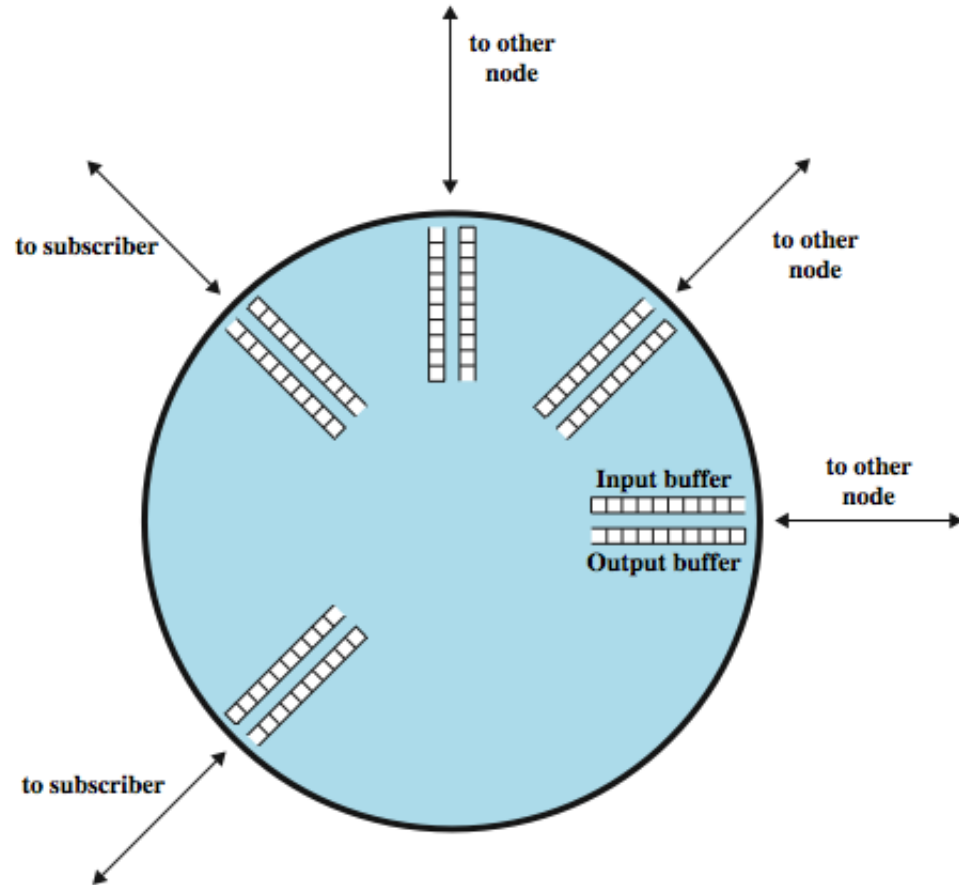
Chapter 13 – Congestion in Data Networks

by William Stallings

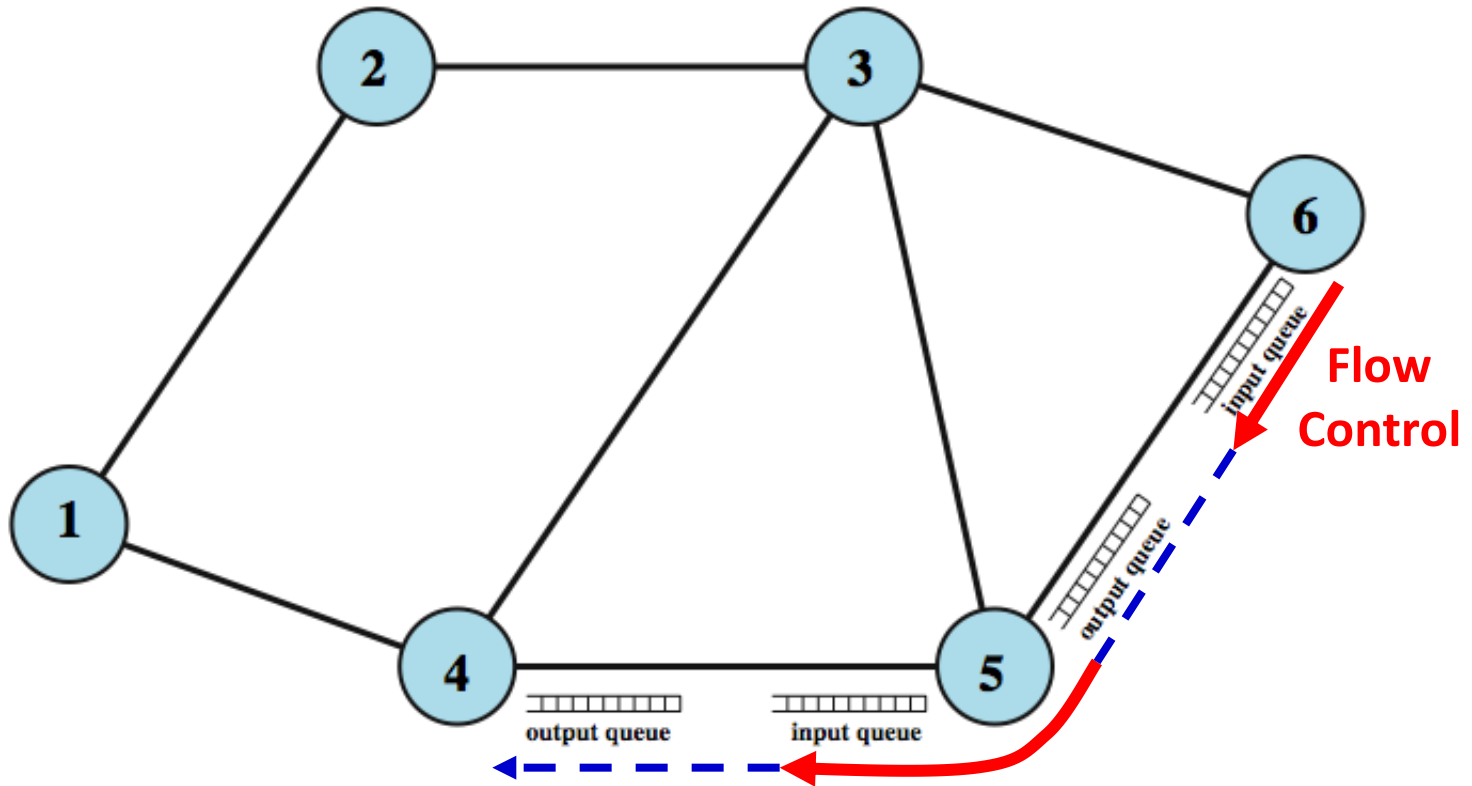
What Is Congestion?

- congestion occurs when the no of packets being transmitted through the network approaches the packet handling capacity of the network
- congestion control aims to keep no of packets below a level at which performance falls off dramatically
- a data network is a network of queues
- generally 80% utilization is critical
- finite queues mean data may be lost

Queues at a Node

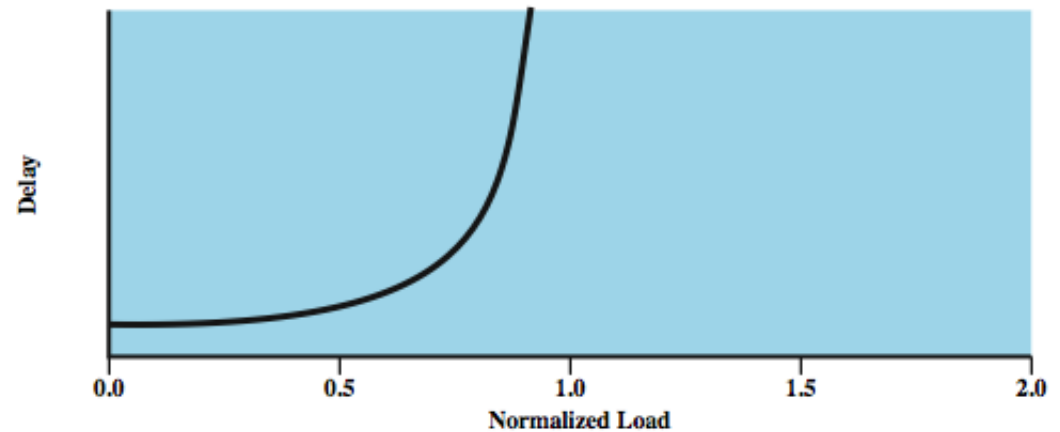
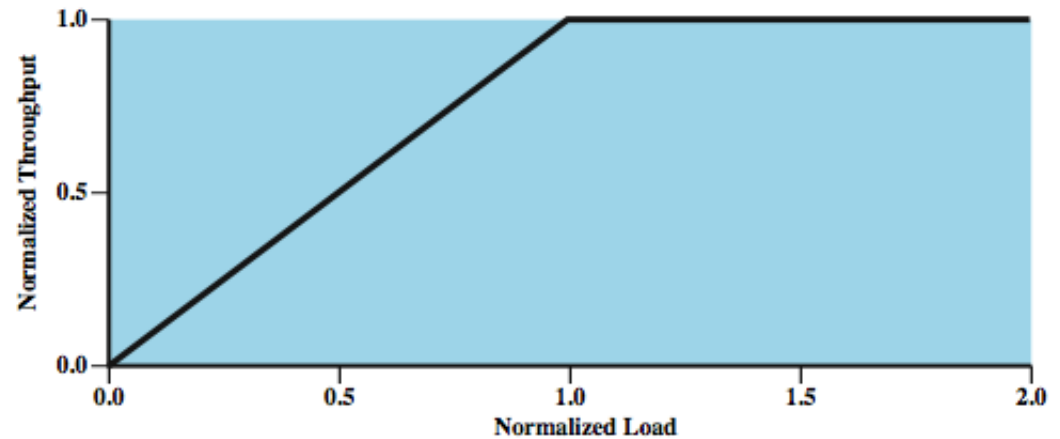


Interaction of Queues

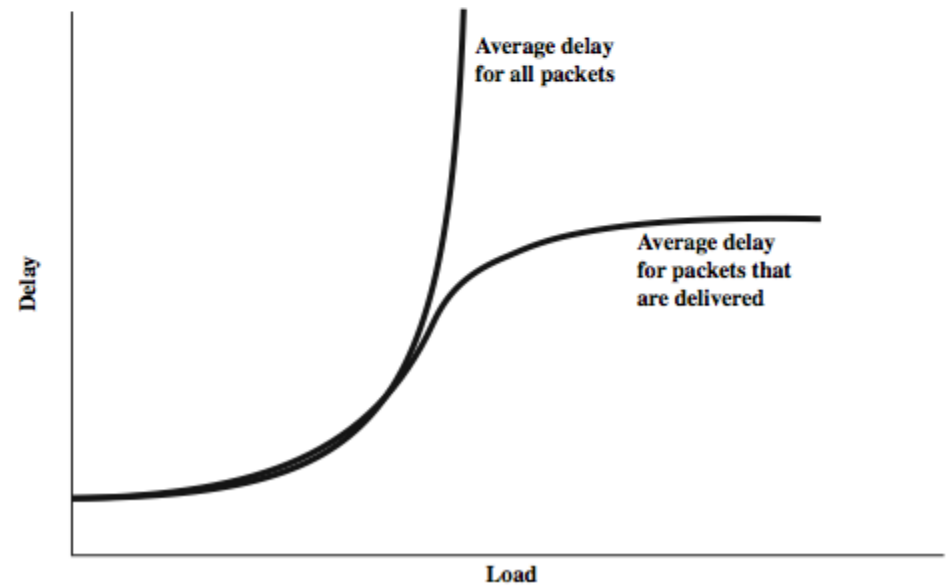
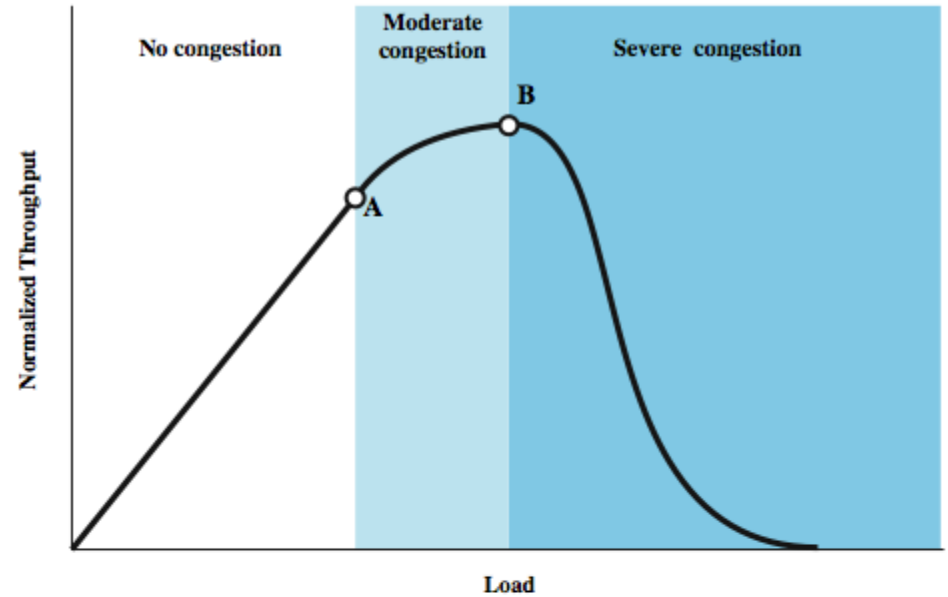


Ideal Network Utilization

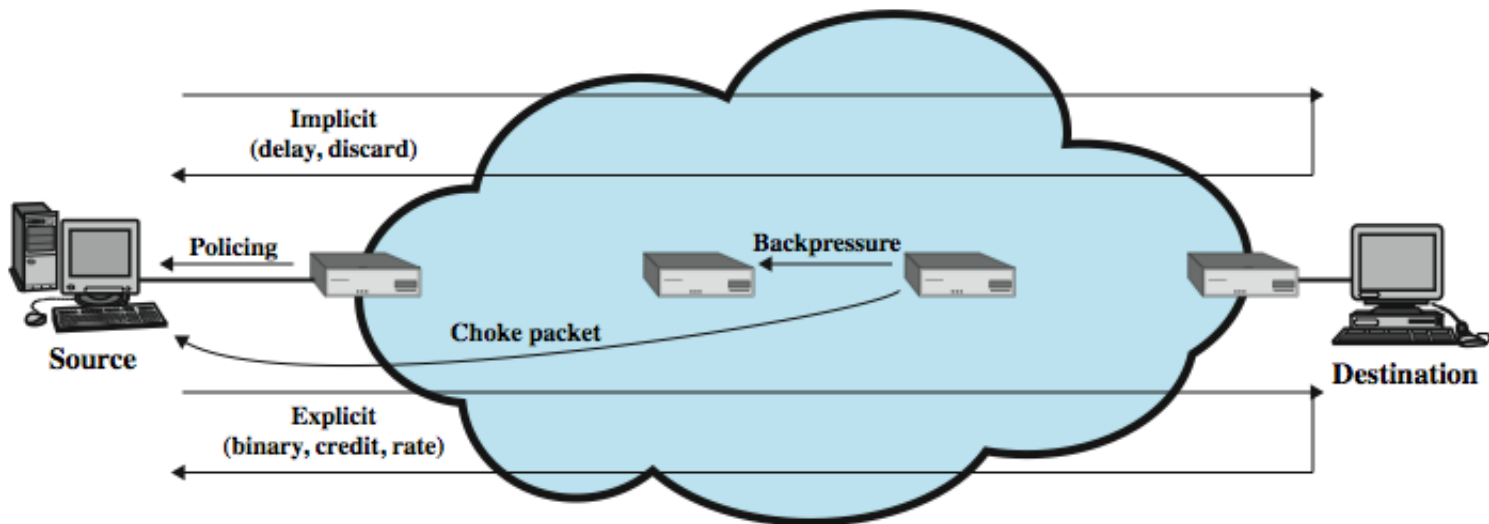
1. Infinite buffers
2. No signaling overhead



Effects of Congestion - No Control



Mechanisms for Congestion Control



Backpressure

- if node becomes congested it can slow down or halt flow of packets from other nodes
 - cf. backpressure in blocked fluid pipe
 - may mean that other nodes have to apply control on incoming packet rates
 - propagates back to source
- can restrict to high traffic logical connections
- used in connection-oriented nets that allow hop by hop congestion control (eg. X.25)
- not used in ATM nor frame relay
- only recently developed for IP

Choke Packet

- a control packet
 - generated at congested node
 - sent to source node
 - eg. ICMP source quench
 - from router or destination
 - source cuts back until no more source quench message
 - sent for every discarded packet, or anticipated
- is a rather crude mechanism

Implicit Congestion Signaling

- transmission delay increases with congestion
- hence a packet may be discarded
- source detects this implicit congestion indication
- useful on connectionless (datagram) networks
 - eg. IP based
 - (TCP includes congestion and flow control - see chapter 17)
- used in frame relay LAPF (control protocol)
 - End-to-end
 - Capable of detecting lost frames and adjusting the flow of data accordingly

Explicit Congestion Signaling

- network alerts end systems of increasing congestion
- end systems take steps to reduce offered load
- Backwards
 - congestion avoidance notification in opposite direction to packet required
- Forwards
 - congestion avoidance notification in same direction as packet required

Explicit Signaling Categories

- Binary
 - a bit set in a packet indicates congestion
- Credit based
 - indicates how many packets source may send
 - common for end to end flow control
- Rate based
 - supply explicit data rate limit
 - nodes along path may request rate reduction
 - eg. ATM

Traffic Management

- fairness
 - provide equal treatment of various flows
- quality of service
 - different treatment for different connections
- reservations
 - traffic contract between user and network
 - carry best-effort or discard excess traffic
 - E.g. ATM, RSVP
 - Traffic policing

Congestion Control in Packet Switched Networks

- send control packet to some or all source nodes
 - requires additional traffic during congestion
- rely on routing information
 - may react too quickly
- end to end probe packets
 - adds to overhead
- add congestion info to packets in transit
 - either backwards or forwards

Frame Relay Congestion Control

- minimize discards
- maintain agreed QoS
- minimize probability of one end user monopoly
- simple to implement
- create minimal additional traffic
- distribute resources fairly
- limit spread of congestion
- operate effectively regardless of traffic flow
- minimum impact on other systems
- minimize variance in QoS

FR Control Techniques

- difficult for frame-relay
 - Because of limited tools
- joint network & end-system responsibility
- techniques:
 - discard strategy
 - congestion avoidance
 - explicit signaling
 - congestion recovery
 - implicit signaling mechanism

FR Congestion Control

Table 13.1 Frame Relay Congestion Control Techniques

Technique	Type	Function	Key Elements
Discard control	Discard strategy	Provides guidance to network concerning which frames to discard	DE bit
Backward explicit Congestion Notification	Congestion avoidance	Provides guidance to end systems about congestion in network	BECN bit or CLLM message
Forward explicit Congestion Notification	Congestion avoidance	Provides guidance to end systems about congestion in network	FECN bit
Implicit congestion notification	Congestion recovery	End system infers congestion from frame loss	Sequence numbers in higher-layer PDU