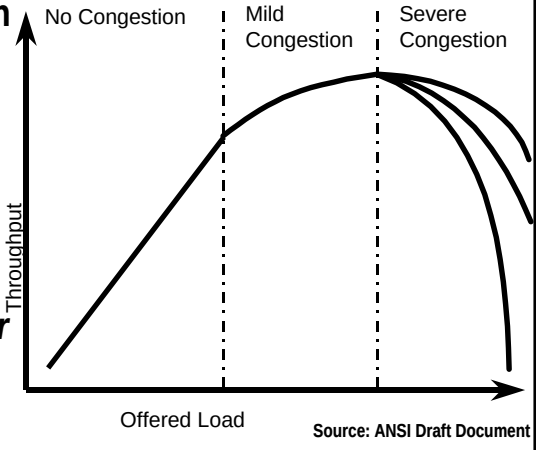
Congestion Management & Guaranteed Throughput

Section 5

Network Throughput

- **All packet networks can experience congestion when the desired throughput (offered load) approaches or exceeds the available bandwidth**
- **Networks that are *never* congested waste bandwidth**



Source: ANSI Draft Document

Congestion Management

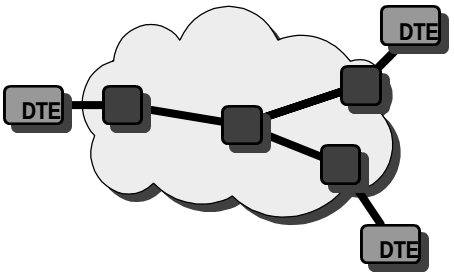
- Congestion Management Strategies

Congestion Management Methods

- Proper Planning
  - The 7 P's of Planning: "*Prior Proper Planning Precludes Pitifully Poor Performance.*"
  - Automated tools may help
  - Acccurate collection of data is a major challenge

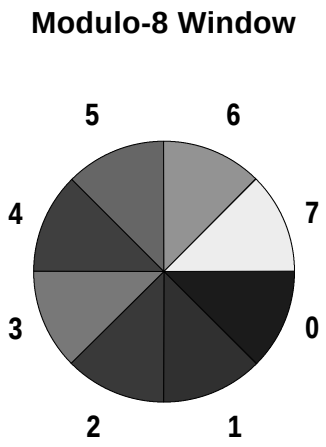
Congestion Management Methods

- ▼ Proper Planning
- ✓ Self-limiting protocols
  - ▾ Some protocols, notably later versions of TCP/IP, measure the network throughput and self-limit the amount of information submitted to the network.
  - ▾ They may control the window size to "window out" earlier



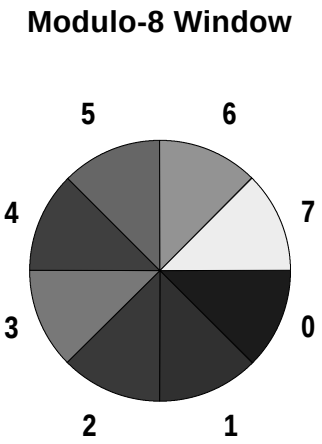
Protocols and Windows

- ▼ Almost all protocols have "windows" of frames that may be outstanding
- ▼ Essential for network throughput
- ▼ "Window out" once all outstanding frames are transmitted



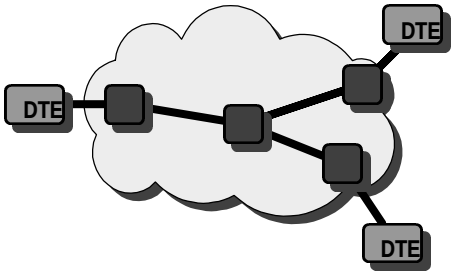
Protocols and Windows

- Almost all protocols historically use "Go-Back-N" rather than selective ARQ
- Large vs. Small Windows
  - Quality of facilities (% Error)
  - Memory in Devices
  - Delay factors
- Data = (Max Size) X (Win #)



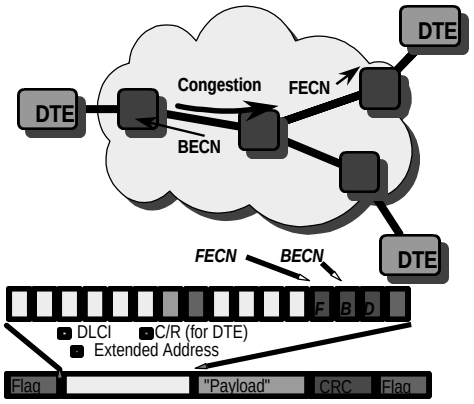
Congestion Management Methods

- Proper Planning
- Self-limiting protocols
- ✓ Explicit messages
  - Frame Relay has ability to send messages requesting less data (CLLM and "R-bit")
  - Equivalent of X-ON/X-OFF
  - Must be on DLCI by DLCI basis



Congestion Management Methods

- ▼ Proper Planning
- ▼ Self-limiting protocols
- ▼ Explicit messages
- ✓ Frame/Cell congestion indication bits
  - ▾ Frame Relay has FECN and BECN
  - ▾ Similar functions in some of the ATM AALs

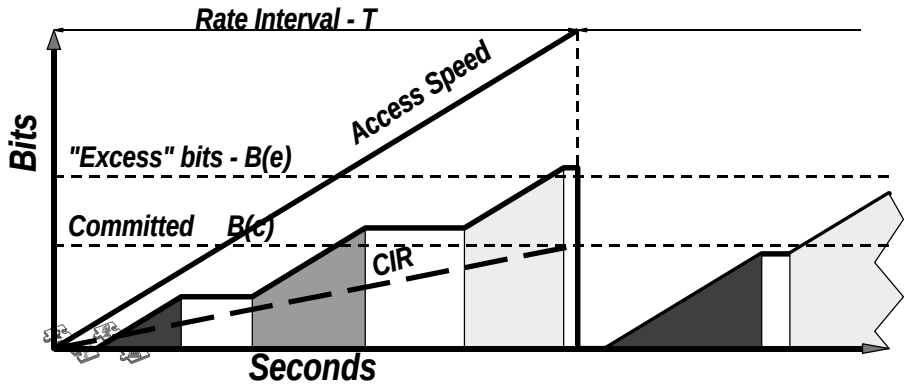


Congestion Management Methods

- ▼ Proper Planning
- ▼ Self-limiting protocols
- ▼ Explicit messages
- ▼ Frame/Cell congestion indication bits
- ✓ Discarding traffic
  - ▾ ATM has "CLP" bit
  - ▾ Frame Relay has "DE" bit
- ▼ Discard factors
  - ■ Congestion or exceeded permitted input rate?
  - ■ Method for recovery of data
  - ■ Fairness among users
- ▼ Compare with dedicated lines for throughput and reliability

Committed Throughput

- CIR is designed to guarantee a certain expectation of performance



CIR Issues

- Responsibility of (and opportunity for) the DTE to asign priorities
- What is a reasonable CIR rate interval?
- Intelligent discard of multiple segments of the same upper layer PDU
- Type of traffic to be discarded
- Network throughput vs. edge buffering
- "Edge" vs. internal network discard and monitoring

Congestion Management

- Congestion Management Strategies
- Available Bit Rate (ABR) / Class Y Services

ABR (Class Y) Services

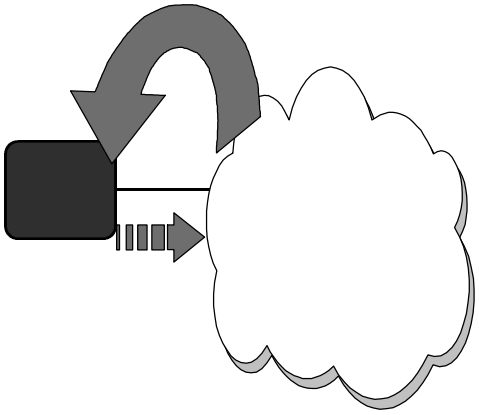
- Why ABR?
  - CBR reserves too much bandwidth
  - VBR has insufficient feedback mechanisms and specifications for ECN, etc.
  - ABR should provide very low cell loss
- What is ABR?
  - A service class with very low cell loss based on a strict feedback loop for admission to network
  - Must be supported at both the Network Node Interface and User-to Network Interface
  - Type of issue historically left to individual switch architectures

Credit vs. Rate Algorithms

- Two fundamental methods
  - Rate vs. Credit debated heatedly in Fall '94
  - Both work
  - ATM Forum voted for a "rate based" algorithm

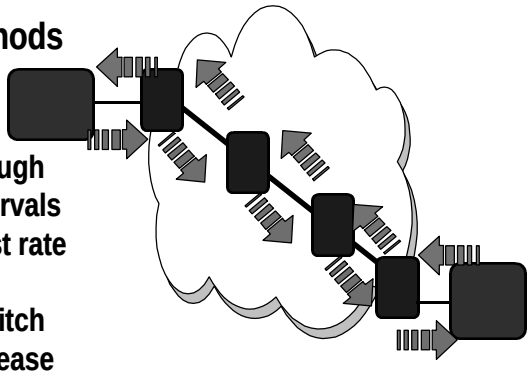
Credit vs. Rate Algorithms

- Two fundamental methods
- Credit Manager
  - Network issues "credits" for admission of information to network
  - Highly reliable
  - Somewhat more delay



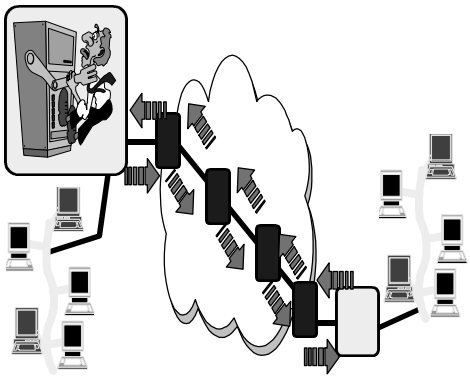
Credit vs. Rate Algorithms

- Two fundamental methods
- Credit Manager
- Rate Based
  - Control cells sent through network at regualr intervals
  - Outbound cells request rate
  - Return cells set rate (maximum) at each switch
  - Switches may not increase the rate



ABR Challenge

- ABR is becoming well defined at the ATM level
- LANs in general know little about flow control
  - Limited protocol level
  - No MAC layer control
- Router / Switch is caught in the middle



Congestion Management

- Congestion Management Strategies
- Available Bit Rate (ABR) / Class Y Services
- Network Delay

Network Delay

- Delay per node in transit
  - Short if cell switch
  - Neither frame nor cell tend to "pipeline" (cut-through) today, but it is possible with either

Network Delay

- ✓ Delay per node in transit
- ▼ Effects of network delay can be significant, especially as speed increases
  - T1 & T3 have typical delay of about 30 msec. round-trip
  - Specifications allow for up to 60 msec.
  - Actual measurements range from 10 to 90 msec.

Network Delay

- ✓ Delay per node in transit
- ✓ Effects of network delay can be significant, especially as speed increases
- ▼ Memory Effects: "Bits in the Pipe" must be buffered at some place in the network
  - "Bits in the Pipe" = Delay X Speed
  - At T1: 1.544 Mbps X 30 msec. = 45,000 bits = 5,600 bytes; OK for Modulo-8 protocols and medium-sized frames
  - At T3: 45 Mbps X 30 msec. = 1,350,000 bits = 160,000 bytes; Almost all protocols will "window out" for a single transmission

Protocol Issues

- All data must have some form of protocol, but it will usually be in the DTE or beyond
- The protocol ensures accurate delivery of the data
- Protocol factors affecting throughput include:
  - Modulo (number of outstanding frames)
  - Maximum frame size
  - Memory in protocol device
  - Selective vs. "Go back N" ARQ
- These protocol issues, especially selective ARQ, also affect net congestion.

DTE/LAN Issues

- The protocols in the DTE and the LANs are literally beyond the scope fo broadband packet, but they have a profound effect
- "Seamless" migration to a new technology is a myth
- Careful analysis of the DTE/LAN products and protocols is needed. For example:
  - Some LAN protocols have no windows
  - Many DTE products do not respond to congestion control
- Users can have a strong influence by demanding these features