Frame Relay Congestion Control

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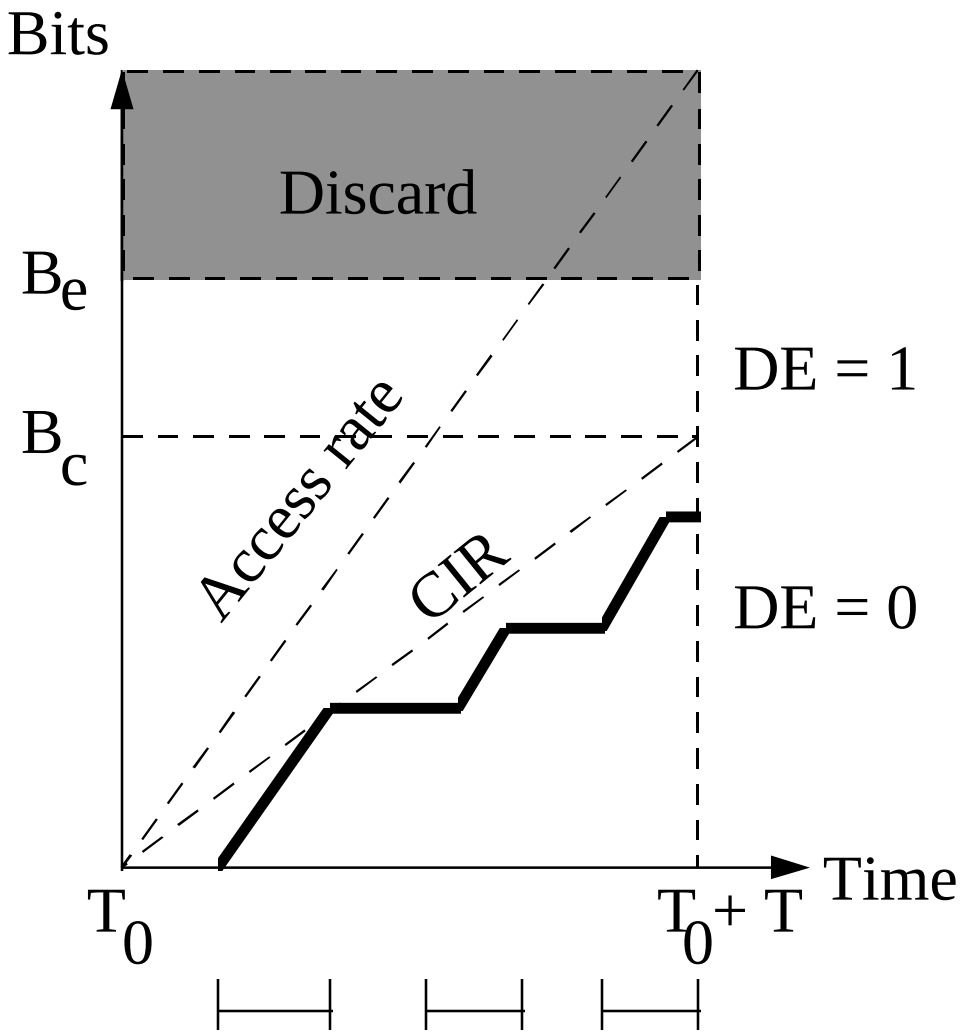
- Congestion avoidance vs recovery
- Discard control
- Explicit forward/backward congestion notification
- Implicit notification

Frame Relay Congestion Techniques

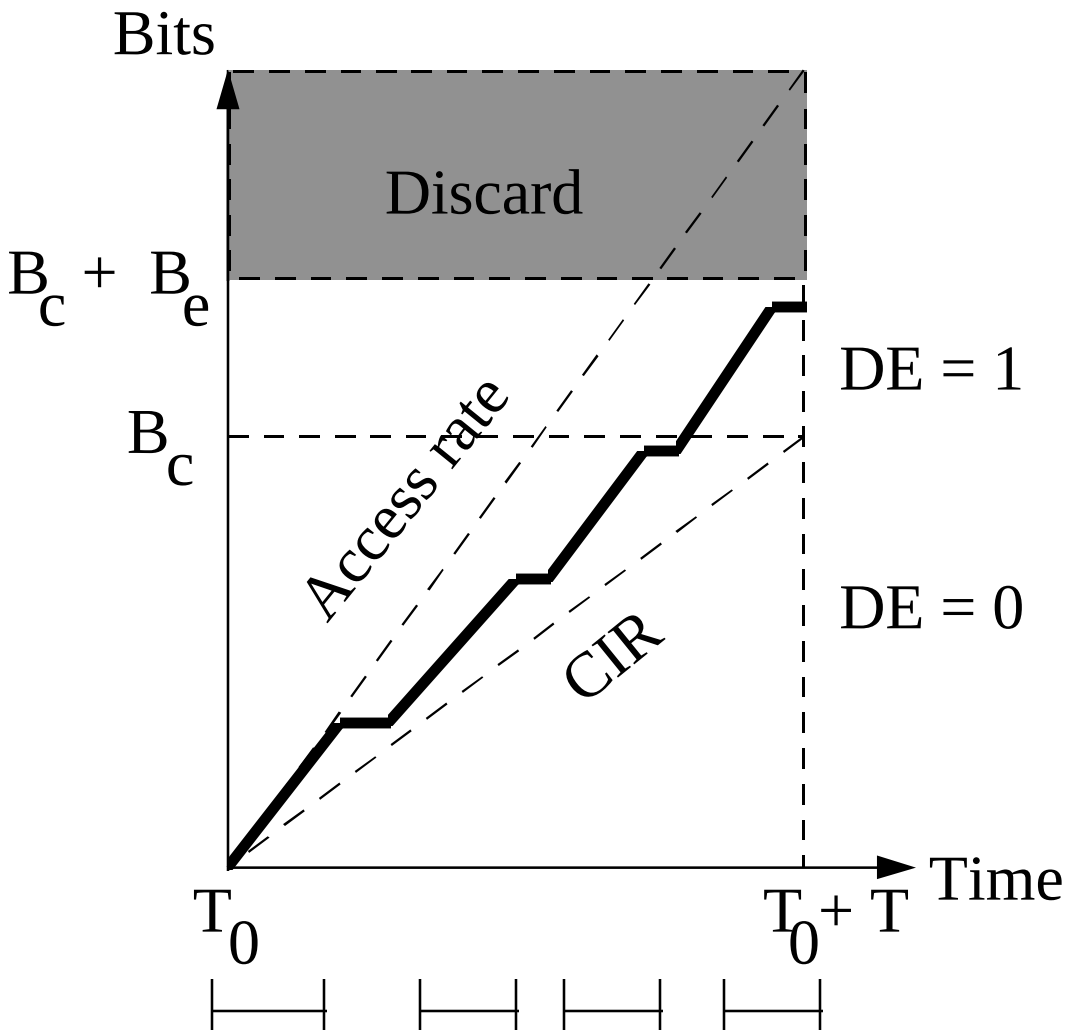
- Discard Control (DE Bit)
- Backward Explicit Congestion Notification
- Forward Explicit Congestion Notification
- Implicit congestion notification (sequence numbers in higher layer PDUs)

Discard Control

- Committed Information Rate (CIR)
- Committed Burst Size (Bc): Over measurement interval T
  T = Bc/CIR
- Excess Burst Size (Be)
- Between Bc and Be ⇒ Mark DE bit
- Over Be ⇒ Discard

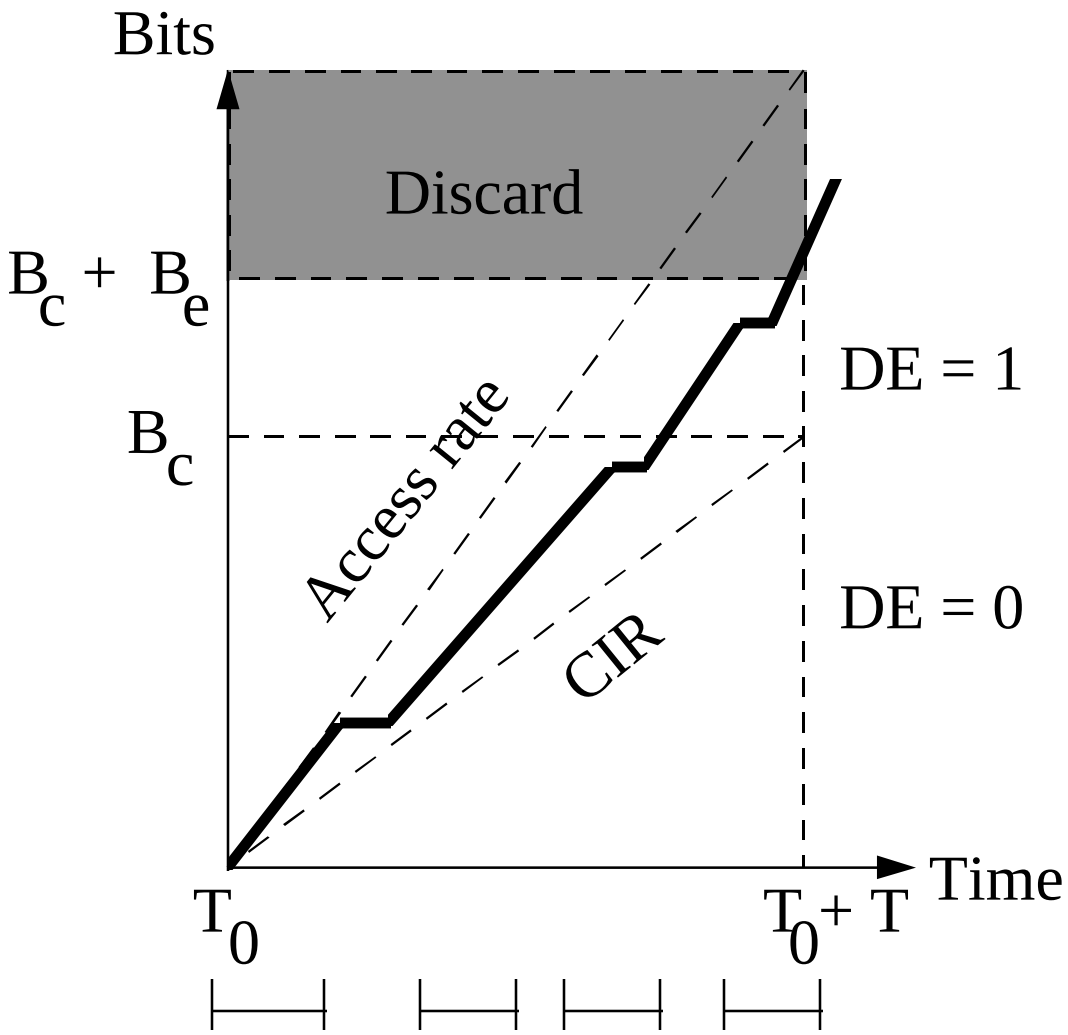


All frames with CIR



Frame 1 Frame 2 Frame 3 Frame 4

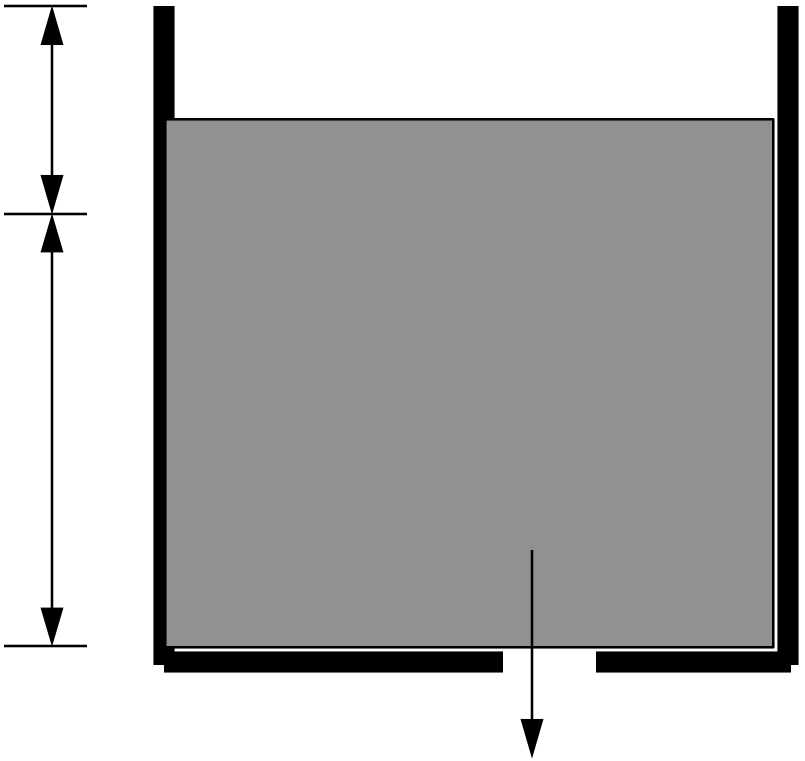
One Frame marked DE



Frame 1 Frame 2 Frame 3 Frame 4

One Frame marked DE; one frame discarded

Leaky Bucket Algorithm



B_e = Excess burst size

Limit C to $B_c + B_e$

Discard any incoming data while C is at its threshold

C = counter; increment with incoming data

Decrement C by MIN [C,B_c] every T Time units

CIR = B_c / T_c

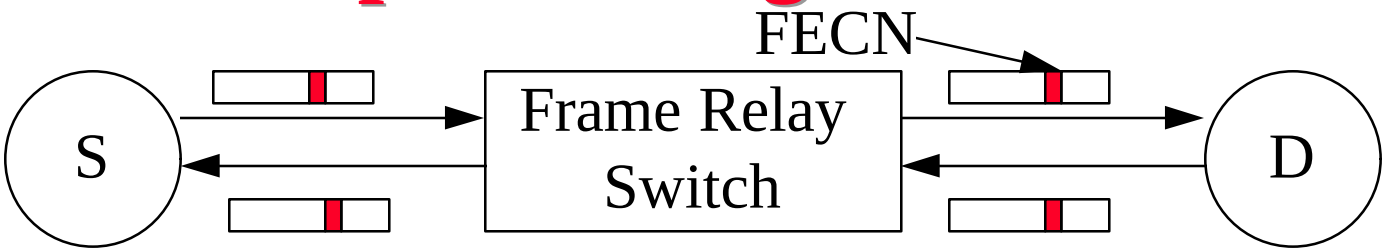
Performance Parameters

- Defined in I.233 Annex A and in T1.606 Section 4
- Used by commercial networks in customer contracts
- Throughput: Successful information bits/second.
- Transit Delay: first-bit in to last bit out. Over one or all networks.
- Residual error rate (RER): 1 - Frames with no error/total frames
- Delivered Errored frames: Frames with undetected errors
- Delivered duplicated frames
- Delivered out-of-sequence frames
- Lost frames: Not delivered within a specified time

Performance Parameters (Cont.)

- Misdelivered frames: Delivered to the wrong destination
- Switched virtual call establishment delay
- Switched virtual call clearing delay
- Premature disconnect
- Switched virtual call clearing failure

Forward Explicit Congestion Notification



- Source sets FECN = 0
- Networks set FECN if avg Q >1
- Destination tells source to increase/decrease the rate (or window)
- Start with R = CIR (or W=1)
- If more than 50% bits set ⇒ decrease to 0.875 × R (or 0.875W)
- If less than 50% bits set ⇒ increase to 1.0625 × R (or min{W+1, Wmax})
- If idle for a long time, reset R = CIR (or W=1)

Backward Explicit Congestion Notification

- Set BECN bit in reverse traffic or send Consolidated Link-Layer Management (CLLM) message to the source
- On first BECN bit: Set R = CIR
- On further "S" BECNs: R=0.675 CIR, 0.5 CIR, 0.25 CIR
- On S/2 BECNs clear: Slowly increase R = 1.125 R
- If idle for long, R = CIR

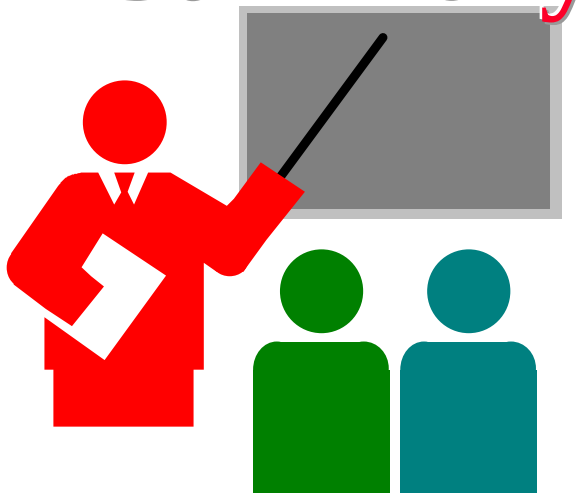
BECN (Cont.)

- For window based control:
  - S = One frame interval
  - Start with W=1
  - First BECN W = max(0.625W,1)
  - Next S BECNs W = max(0.625W,1)
  - S/2 clear BECNs $\Rightarrow$ W = max(W+1, Wmax)
- CLLM used if no reverse traffic
- CLLM = XID message on maintenance DLCI = 1007 (decimal)
- CLLM contains a list of congested DLCIs

Implicit Congestion Control

- Decrease window on frame loss
- Increase window slowly
- Decrease by 1, Decrease to Wmin, Decrease by a factor α
- Increase by 1 after N frames
- Increase by 1 after W frames

Summary

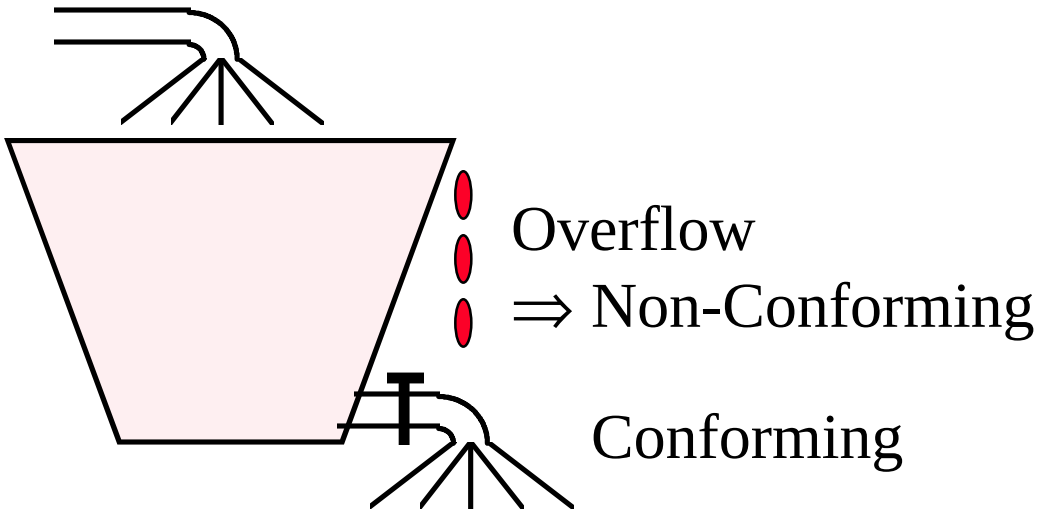


- Discard strategy: Leaky bucket
- Forward explicit congestion notification
- Backward Explicit congestion notification
- Implicit congestion control

Homework

- Read chapter 12 of Stallings' book

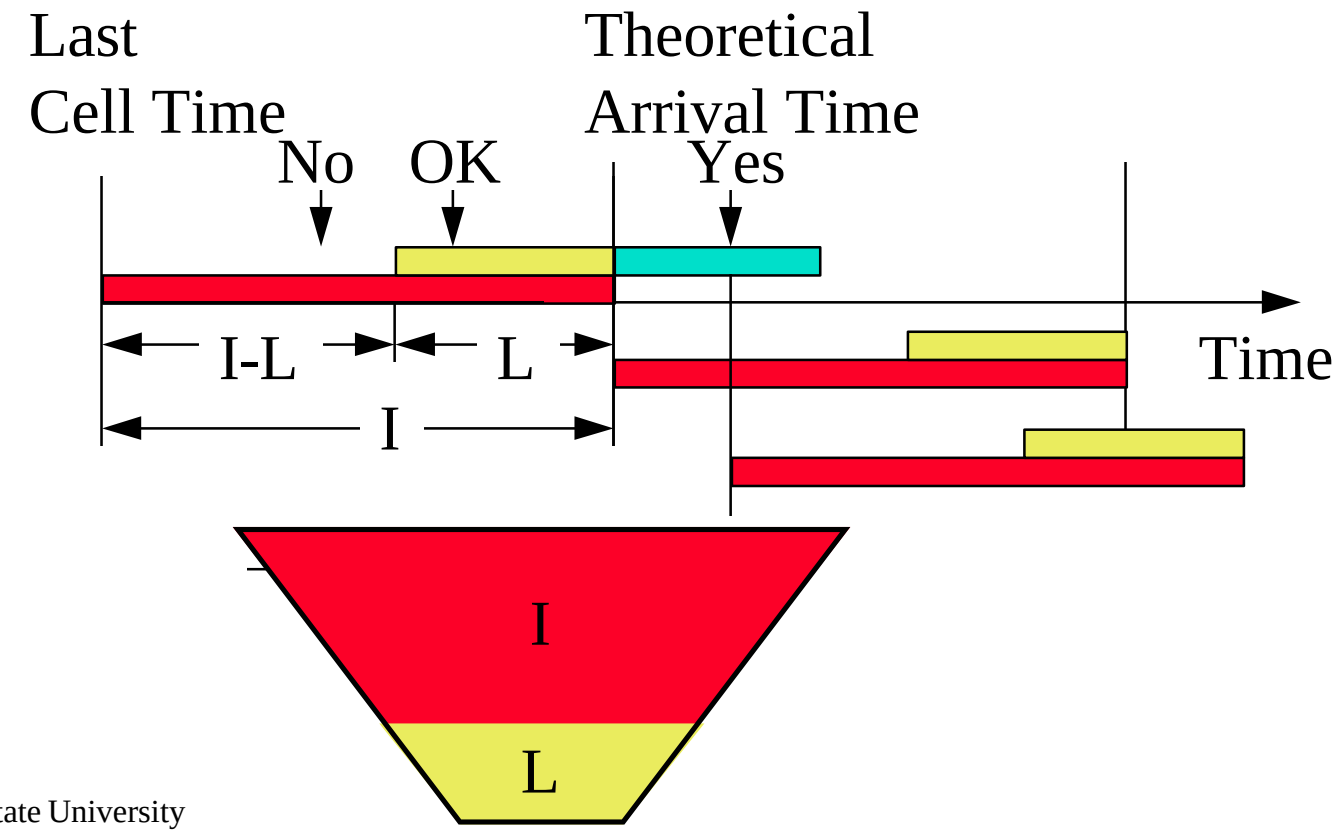
Leaky Bucket in ATM Networks



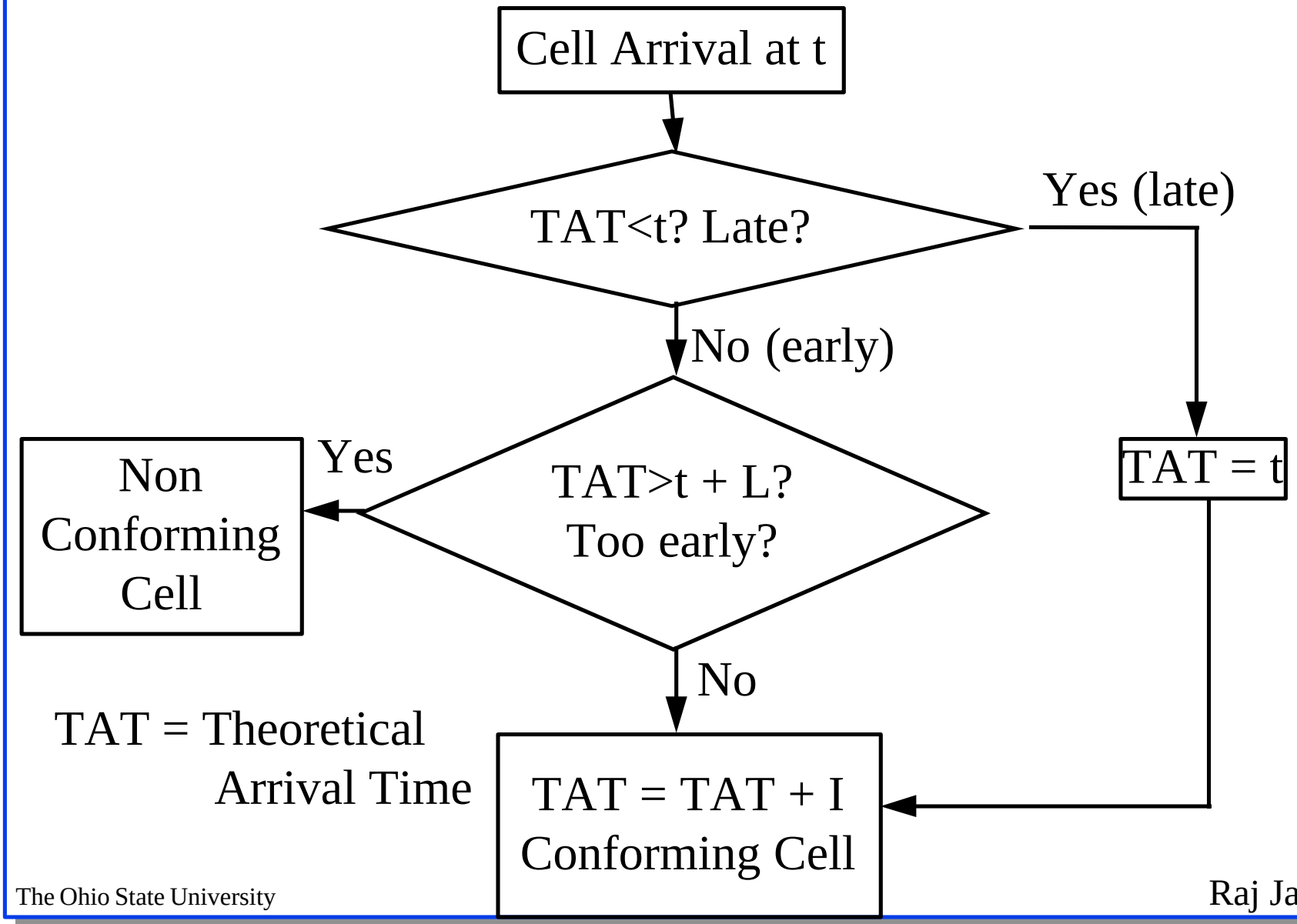
- Provides traffic shaping:
- Input bursty. Output rate controlled.
- Excess traffic can be discarded or admitted with CLP = 1

Generic Cell Rate Algorithm: GCRA(I, L)

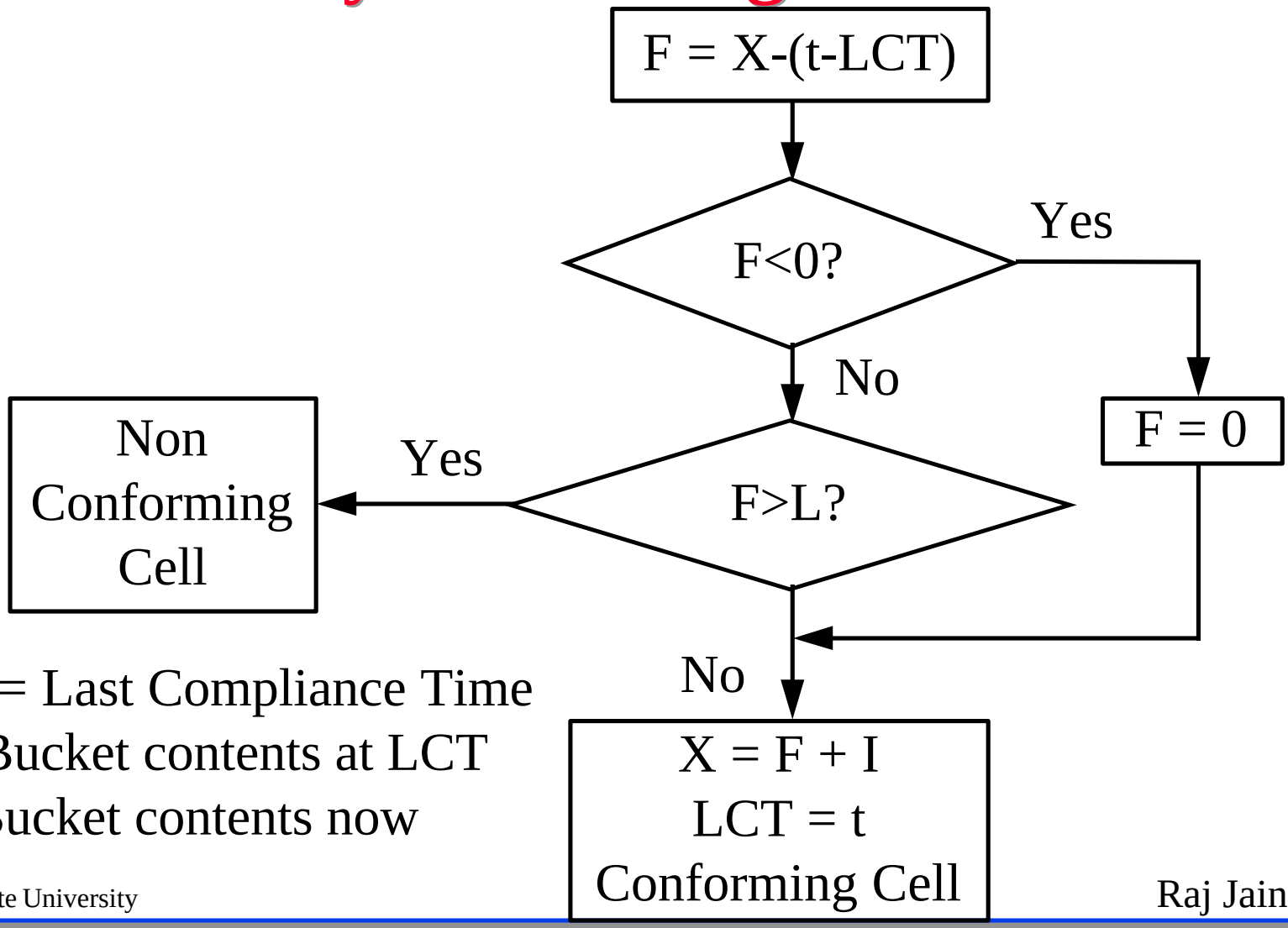
- I = Increment = Inter-cell Time = Cell size/PCR
- L = Limit ⇒ Leaky bucket of size I + L and rate 1



GCRA(I, L): Virtual Scheduling Algorithm



GCRA(I, L): Leaky Bucket Algorithm

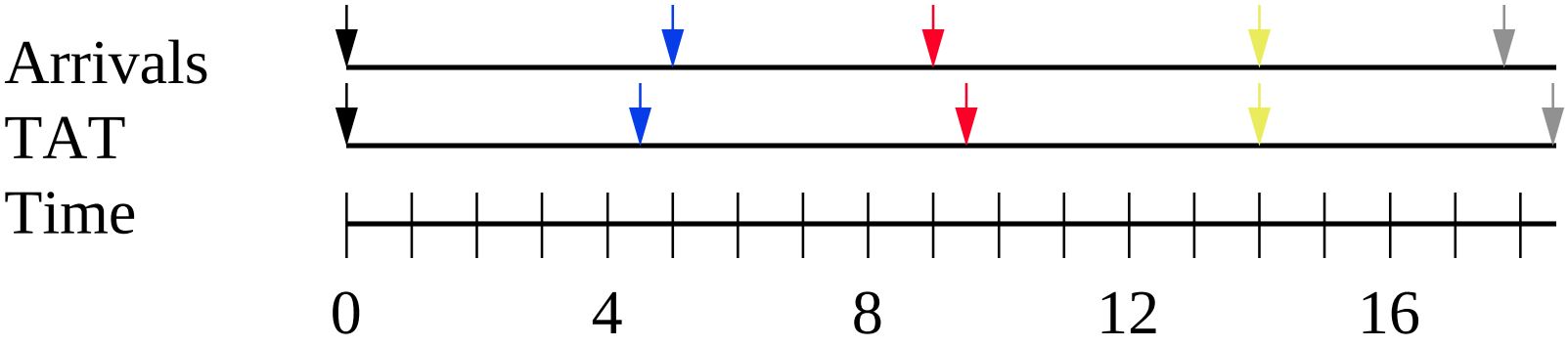


LCT = Last Compliance Time
X = Bucket contents at LCT
F = Bucket contents now

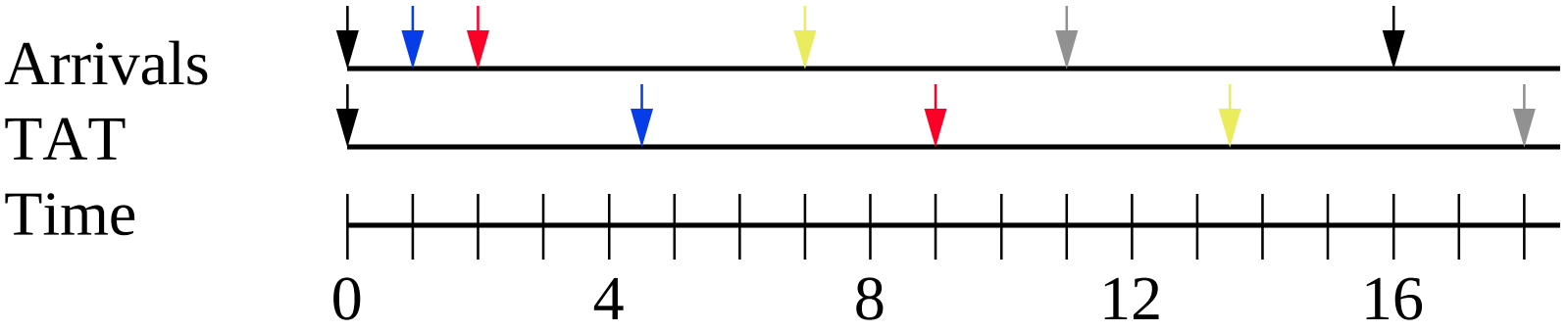
GCRA Examples

δ = cell time = 2.73 μs at 155 Mbps

- GCRA(4.5 δ, 0.5 δ):



- GCRA(4.5 δ, 7 δ):

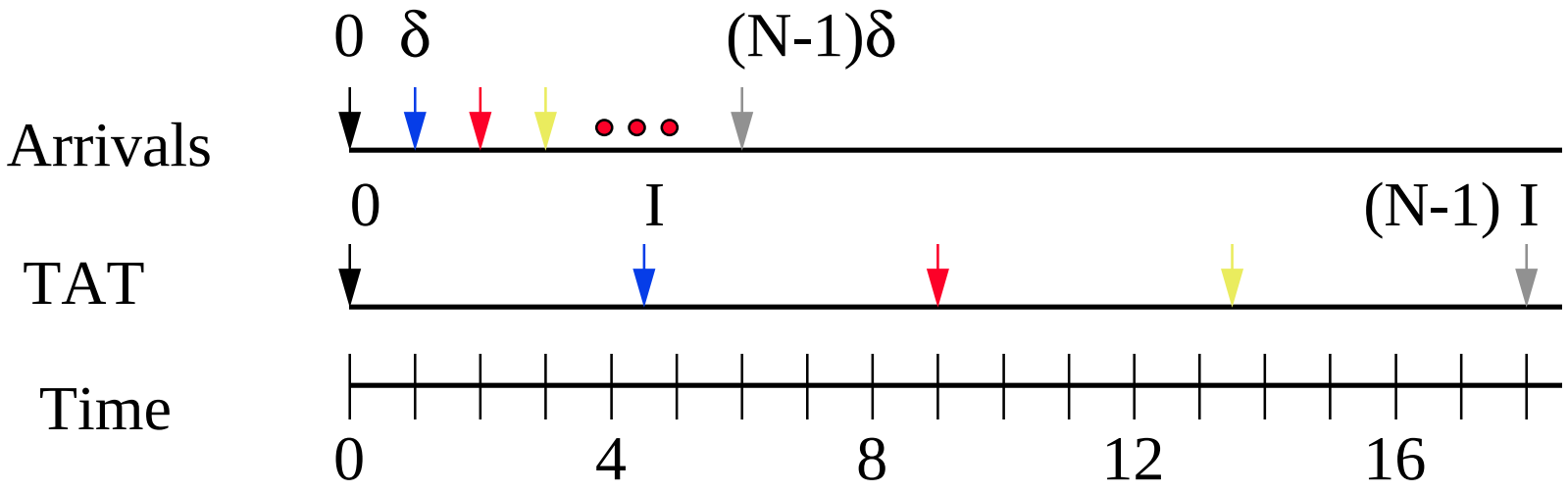


Maximum Burst Size (MBS)

δ = cell time at PCR, I = cell time at SCR, L=Limit

N = Maximum burst size

GCRA(I , L):



$$(N-1)\,I - (N-1)\delta < L$$

$$MBS = N = Int[1 + L/(I-\delta)]$$

$$L = (MBS-1)(I-\delta)$$