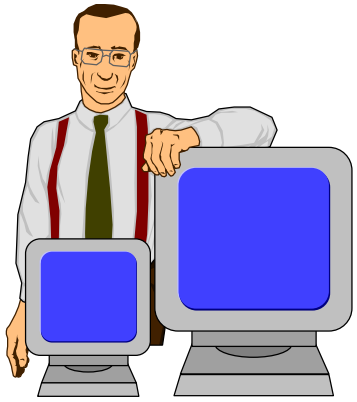
# ATM Traffic Management

**Dollar Day Sale**



One Megabit memory, One Megabyte disk, One Mbps link, One MIP processor, one dollar each.....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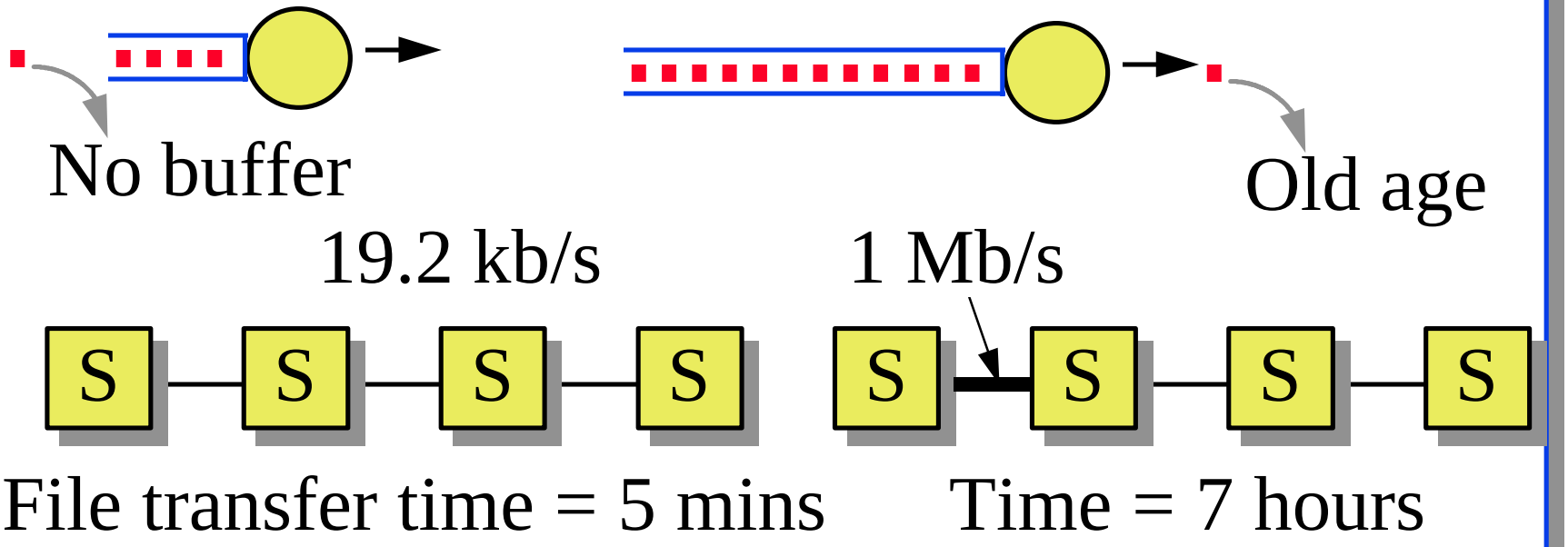
- Why worry about congestion?
- Congestion schemes for ATM
- Explicit Rate-based Control
- ABR Traffic Management

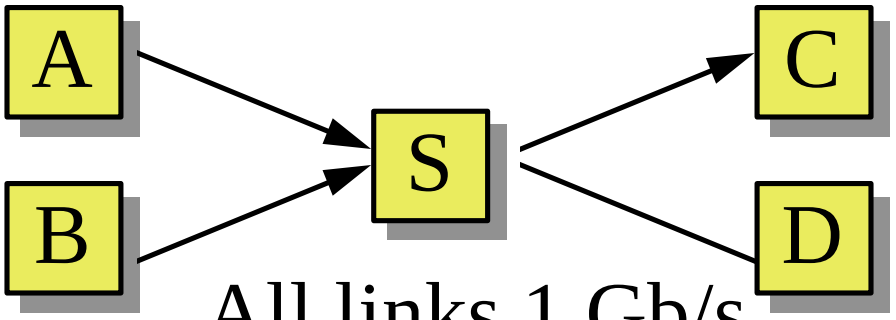
# Why Worry About Congestion?

Q: Will the congestion problem be solved when:

- Memory becomes cheap (infinite memory)?
- Links become cheap (very high speed links)?
- Processors become cheap?

A: None of the above.






**Conclusions:**

- Congestion is a dynamic problem.
  Static solutions are not sufficient
- Bandwidth explosion
  ⇒ More unbalanced networks
- Buffer shortage is a symptom  not the cause.

# Economic Reasons

- Network is a shared resource
  Because it is expensive and needed occasionally
  (Like airplanes, emergency rooms)
- Most costs are fixed.
  Cost for fiber, switches, laying fiber and maintaining them does not depend upon usage
  $\Rightarrow$ Underutilization is expensive
- But overutilization leads to user dissatisfaction.
- Need a way to keep the network maximally utilized

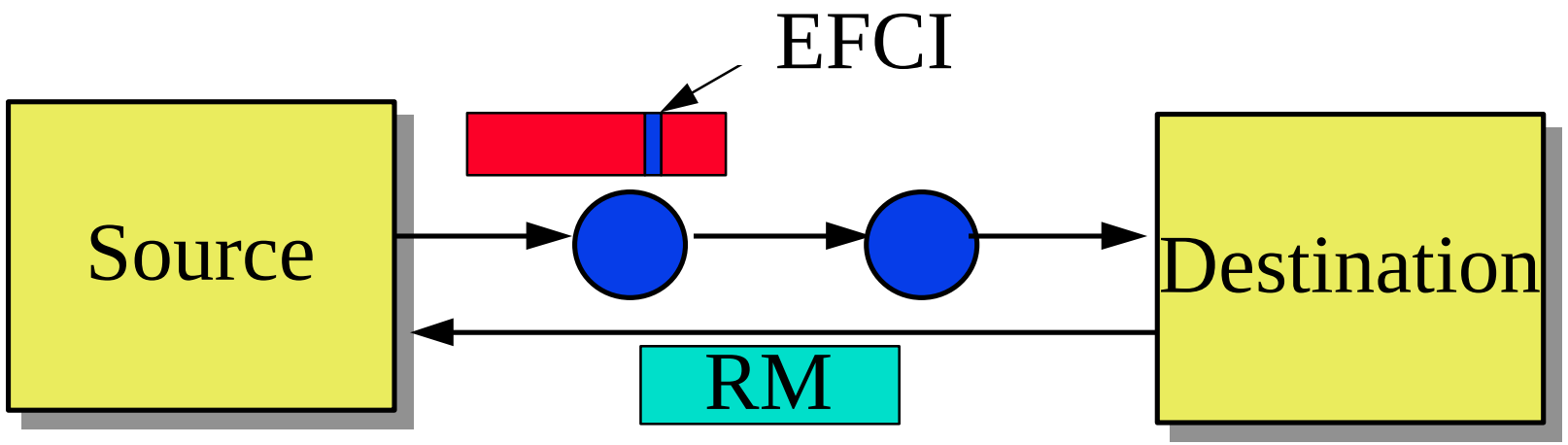
# Classes of Service

- CBR (Constant bit rate): User declares required rate. Throughput, delay and delay variation guaranteed.
- VBR (Variable bit rate): User declares average and max rate.
  - rt-VBR (Real-time variable bit rate): Conferencing. Max delay and delay variation guaranteed.
  - nrt-VBR (non-real time variable bit rate): Stored video. Mean delay guaranteed.
- ABR (Available bit rate): Follows feedback instructions. Network gives maximum throughput with minimum loss.
- UBR (Unspecified bit rate): User sends whenever it wants. No feedback mechanism. No guarantee. Cells may be dropped during congestion.
  -

# Traffic Management Functions

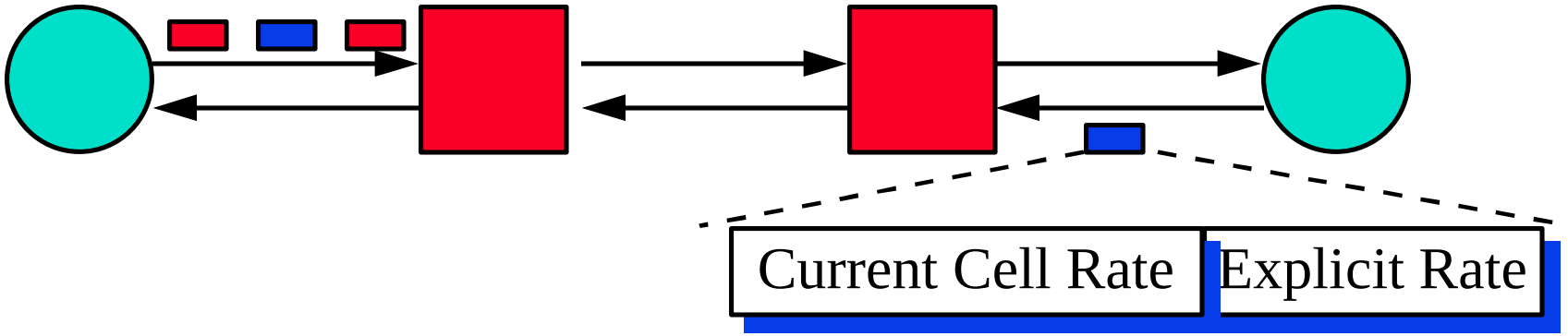
- Connection Admission Control (CAC):
  Can requested bandwidth and quality of service be supported?
- Traffic Shaping: Limit burst length. Space-out cells.
- Usage Parameter Control (UPC):
  Monitor and control traffic at the network entrance.
- Network Resource Management:
  Scheduling, Queueing, virtual path resource reservation
- Selective cell discard:
  Cell Loss Priority (CLP) = 1 cells may be dropped
  Cells of non-complient connections may be dropped
- Frame Discarding
- Feedback Controls: Network tells the source to increase or decrease its load.

# Initial Binary Rate-based Scheme



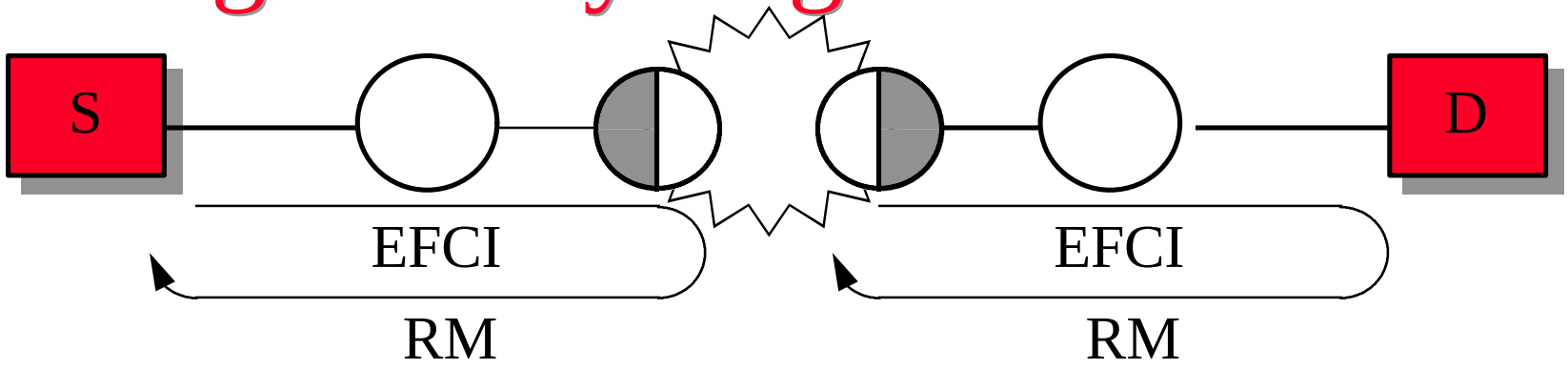

- *Based on DECbit scheme (1986). Implemented in many standards since 1986.*
- *Forward explicit congestion notification (FECN) in Frame relay*
- Explicit forward congestion indicator (EFCI) set to 0 at source. Congested switches set EFCI to 1
- Every *n*th cell, destination sends an resource management (RM) cell to the source indicating increase amount or decrease factor

# The Explicit Rate Scheme

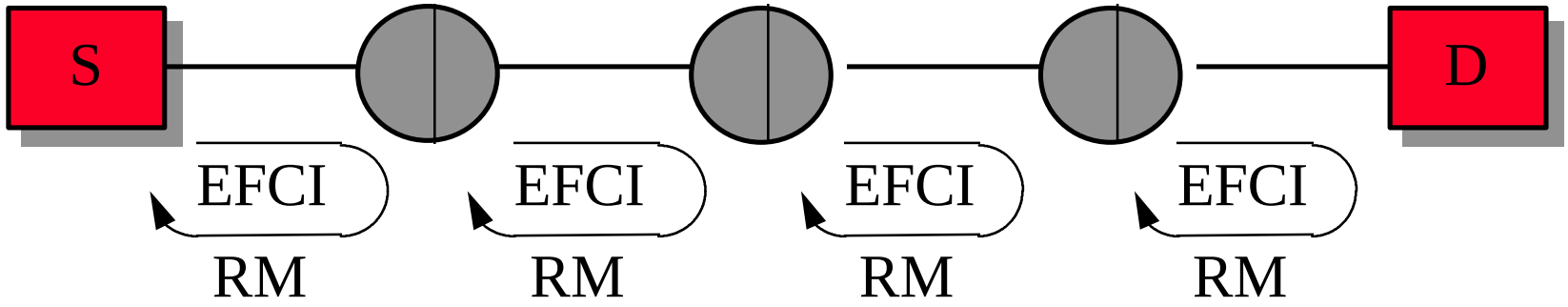



- Sources send one RM cell every n cells
- The RM cells contain "Explicit rate"
- Destination returns the RM cell to the source
- The switches adjust the rate down
- Source adjusts to the specified rate

# Segment-by-Segment Control

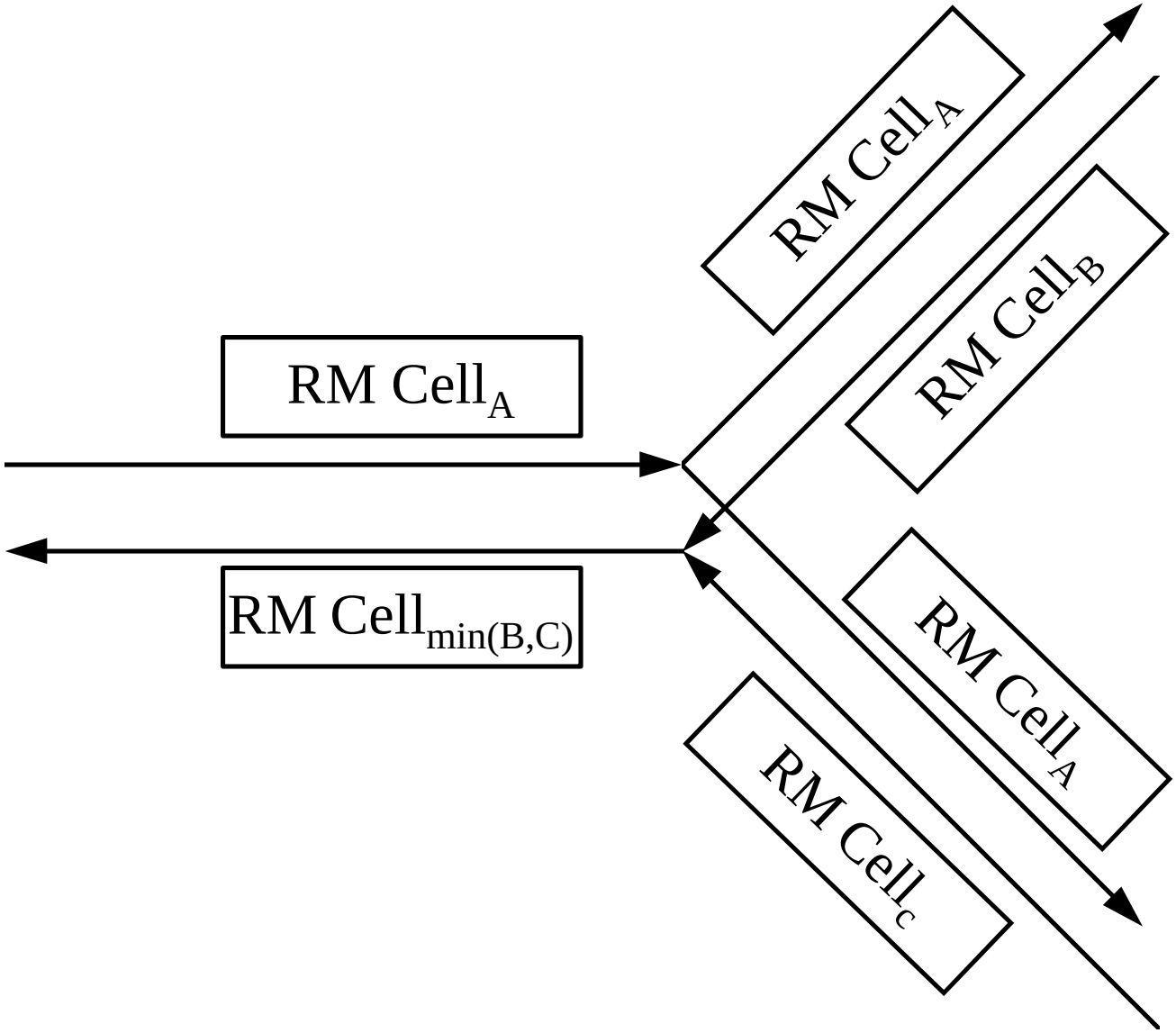



- Virtual source/virtual destinations follow all notification/control rules
- Can be hop-by-hop



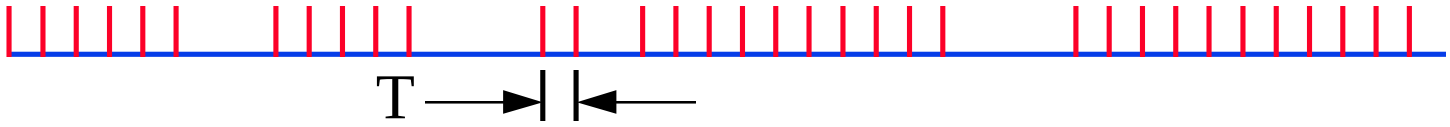

- Virtual dest/sources maintain per-VC queues.

# Multicast



# Traffic Contract Parameters

- Peak Cell Rate (PCR): 1/T




- Cell Transfer Delay (CTD): First bit in to last bit out
- Cell Delay Variation (CDV): $\simeq$ Max CTD - Min CTD
  - Peak-to-peak CDV
- Cell Delay Variation Tolerance (CDVT) $\tau$
  = GCRA parameter wrt PCR $\Rightarrow$ GCRA(T, $\tau$)

- Sustained Cell Rate (SCR): Average over a long period
- Burst Tolerance (BT) $\tau_s$ : GCRA parameter wrt SCR
  GCRA($1/T_s$, $\tau_s$)
  Maximum Burst Size (MBS) = $\lfloor 1+BT/(1/SCR-1/PCR) \rfloor$
  $BT \in [(MBS-1)(1/SCR-1/PCR), MBS(1/SCR-1/PCR)]$
- Cell Loss Ratio (CLR): Cells lost /Totals cells sent
- Minimum cell rate (MCR)
- Cell error ratio (CER)*
- Severely Errored Cell Block Ratio (SECBR)*
  (Block=Sequence of N cells. M or more lost, errored, or inserted cells in a block $\Rightarrow$ Serverely-Errored cell block)
- Cell Misinsertion Rate (CMR)*
  (Cell received with no corresponding transmitted cell)

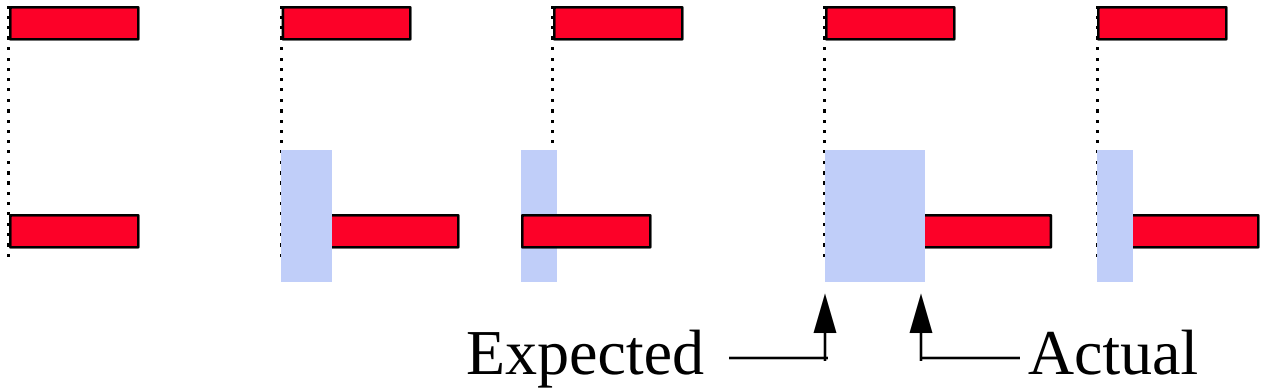
* Not negotiated

# Cell Delay Variation

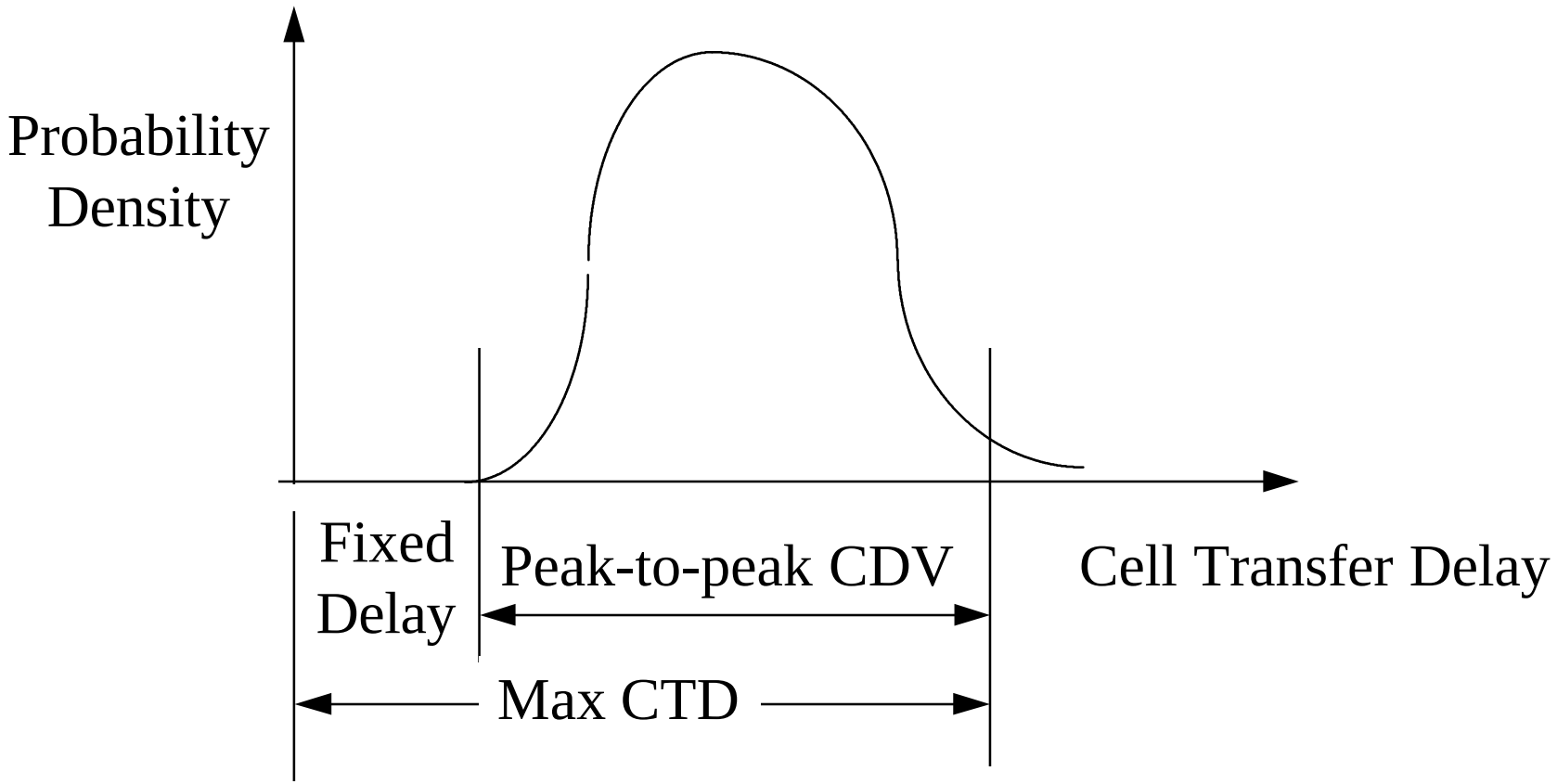
- Cell Transfer Delay (CTD): First bit out to last bit in
- Cell Delay Variation (CDV) = $CTD_{max}$ - $CTD_{min}$
  - Peak-to-peak CDV
  - Instantaneous CDV

# Instantaneous CDV

- I-CDV= Actual-Expected arrival time
- Expected = Emission + Nominal delay
- Cell Delay Variation Window (CDV-W)
  CDV-W = |I-CDV(Max)| + |I-CDV(Min)|
- Cells arriving outside window are considered lost
- Large CDV ⇒ Large buffers ⇒ Higher cost



# Peak-to-Peak CDV



# Service Categories

| Attribute | CBR | rt-VBR | nrt-VBR | UBR | ABR |
|---|---|---|---|---|---|
| PCR, CDVT[4,5] | Specified | Specified | Specified | Specified[2] | Specified[3] |
| SCR,MBS, CDVT[4,5] | N/A | Specified | Specified | N/A | N/A |
| MCR[4] | N/A | N/A | N/A | N/A | Specified |
| Peak-to-peak CDV | Specified | Specified | Unspecified | Unspecified | Unspecified |
| Max CTD | Specified | Specified | Unspecified | Unspecified | Unspecified |
| CLR[4] | Specified | Specified | Specified | Unspecified | Specified[1] |
| Feedback | Unspecified | Unspecified | Unspecified | Unspecified | Specified[6] |

[1]Network specific

[2]Not subject to CAC/UPC

[3]PCR $\Rightarrow$ Max ACR

[4]Explicitly/implicitly specified for PVC/SVC

[5]Not signaled. Different values may apply at different interfaces along the path.

[6]Follow ABR rules

# Congestion: Summary

- Traffic Management is key to success of ATM
- Several different methods: CAC, Shaping, UPC, Scheduling, ...
- Service categories:CBR, VBR, ABR, UBR
- Binary feedback too slow for rate control. Especially for satellites.
- ER switches provide much better performance than EFCI.

# References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