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ERICA+: Extensions to the ERICA Switch Algorithm

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- ERICA under VBR
- Scheduling of multiple classes
- ERICA with full utilization
  - Features
  - New Algorithm
  - Simulation Results

Current Switch Algorithm: ERICA

- ERICA = Explicit Rate Indication for Congestion Avoidance
- Monitor:
  Overload = Input rate/Target Rate
  Fair Share= Available rate/# of active VCs
- This VC's Share = CCR/Overload
- ER = Max(Fair Share, This VC's Share)
  ER in Cell = Min(ER in Cell, ER)
- ER in Cell = Min{ER in Cell, Max(Available rate/# of active VCs , CCR/Overload) }
- Use BECN option when appropriate

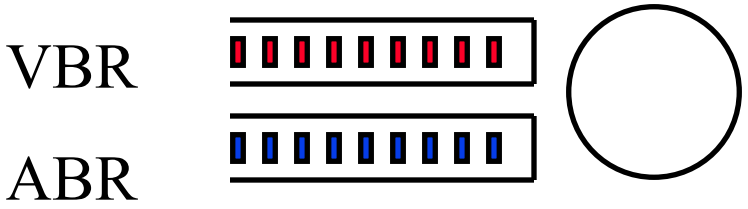
ERICA under VBR

- With VBR, the available bandwidth (AB) changes dynamically.
- Need:
  - An algorithm for setting explicit rates as changes
  - A scheduling algorithm for multiple classes

Innovation 1: Allocation

- Monitor VBR usage
- ABR capacity = Target Rate - VBR input rate
- Overload factor = ABR input rate/ABR capacity
- This VC's share = VC's CCR/overload factor
- Fair share = ABR capacity/Number of active ABR VCs
- ER = Max{Fair share, This VC's share}
- NOTE:
  - ABR capacity = Target Util. × Link Rate - VBR output rate
    and not
    ABR capacity = Target Util.×(Link Rate - VBR output rate)
    ⇒ Target utilization applies to total link load
  - VBR Output rate < Target utilization

Scheduling



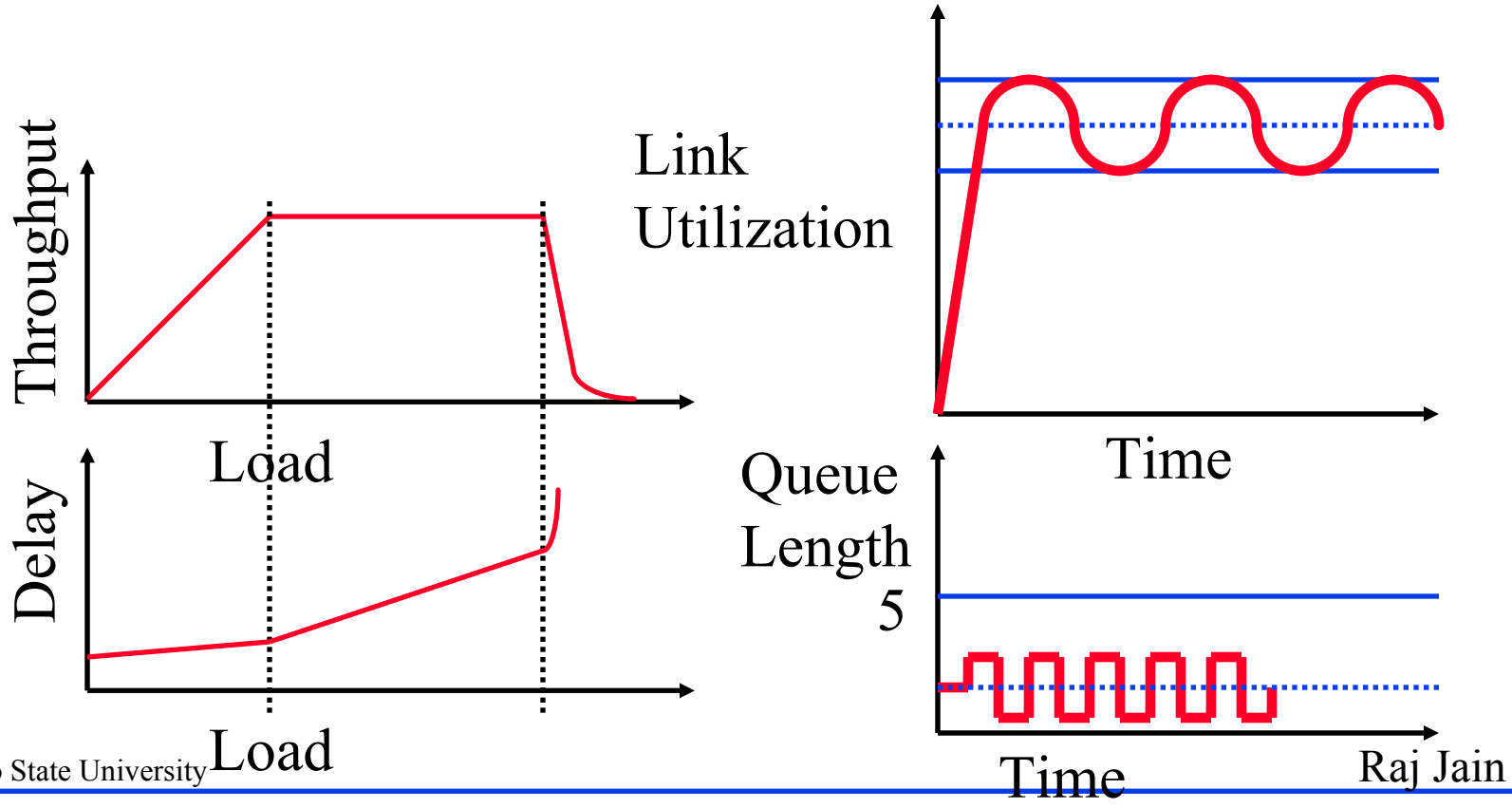
- Allows any desired allocation:
  V_{frac} = Fraction reserved for VBR
  A_{frac} = Fraction reserved for ABR
- Guarantees non-starvation.
  All classes can have a guaranteed minimum.
- No capacity is wasted.
  Capacity not used by one is used by the other class
- Scheduling decision is made per cell or per group of cells
- Keep scores for both (or n) classes
- The class with higher score is serviced next
- Complete pseudo-code in the contribution

Scheduling Variables

- A_{frac} = Minimum Fraction desired for ABR
  V_{frac} = Maximum Fraction desired for VBR
  (A_{frac} ABR cells are transmitted for every V_{frac} VBR cells)
- A_{credit} = Current credit for ABR traffic
  V_{credit} = Current credit for VBR traffic
  (In general, the traffic with higher credit is serviced next.)
- A_{queue} = Number cells in the ABR queue
  V_{queue} = Number cells in the VBR queue
- A_{count} = Number of ABR cells served
  V_{count} = Number of VBR cells served
- The complete pseudo-code is in the original contribution text.

Congestion Avoidance

- High throughput, Low delay
- Small queues
- Bounded oscillations ⇒ Good for Video traffic

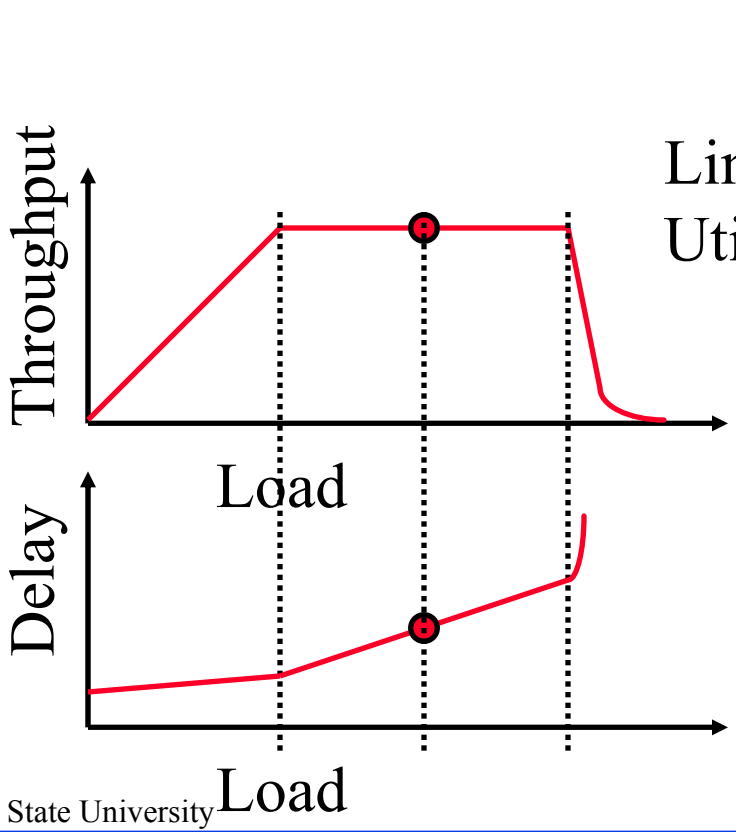


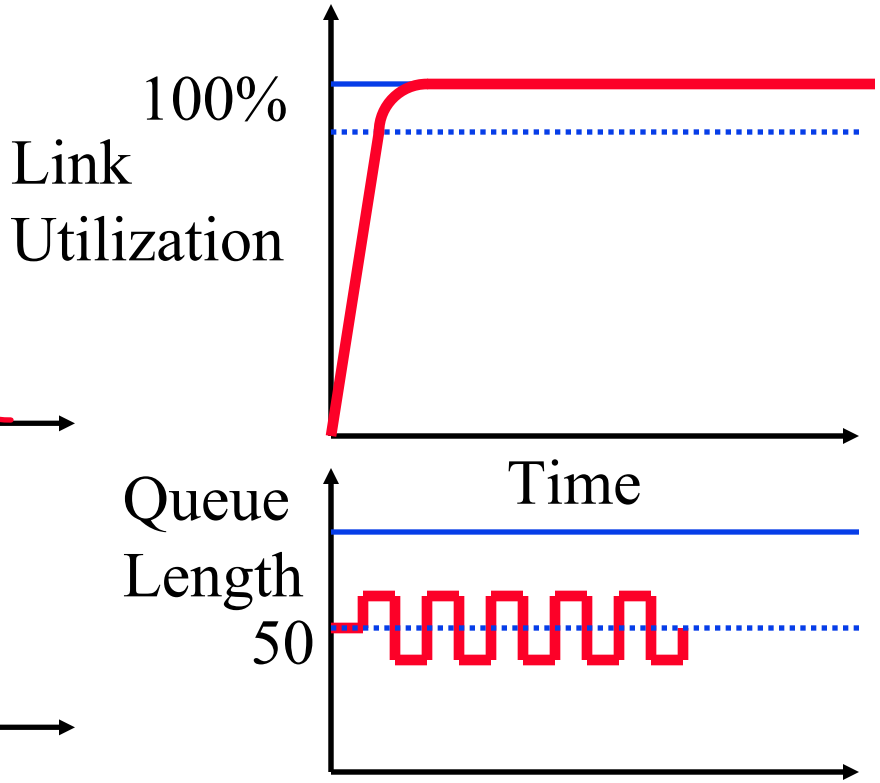
Issues with Current Congestion Avoidance Schemes

- Link utilization is 90% or below
  May not be acceptable for high-cost WAN links.
- Queue length is close to 1.
  Not good if bandwidth becomes available suddenly
  You can't use BECN to ask sources to increase
  Low rate sources may have long inter-RM cell times

Features of the New Scheme

- Allows operation at any point between the knee and the cliff
- The queue length can be set to any desired value.
- Allows utilization to be 100%





Features (Continued)

- Compatible with current ATM Forum TM agreements
- No changes to source operation required
- No changes to destination operation required
- No changes to RM cell format required
- Follows all switch requirements

Innovation 2

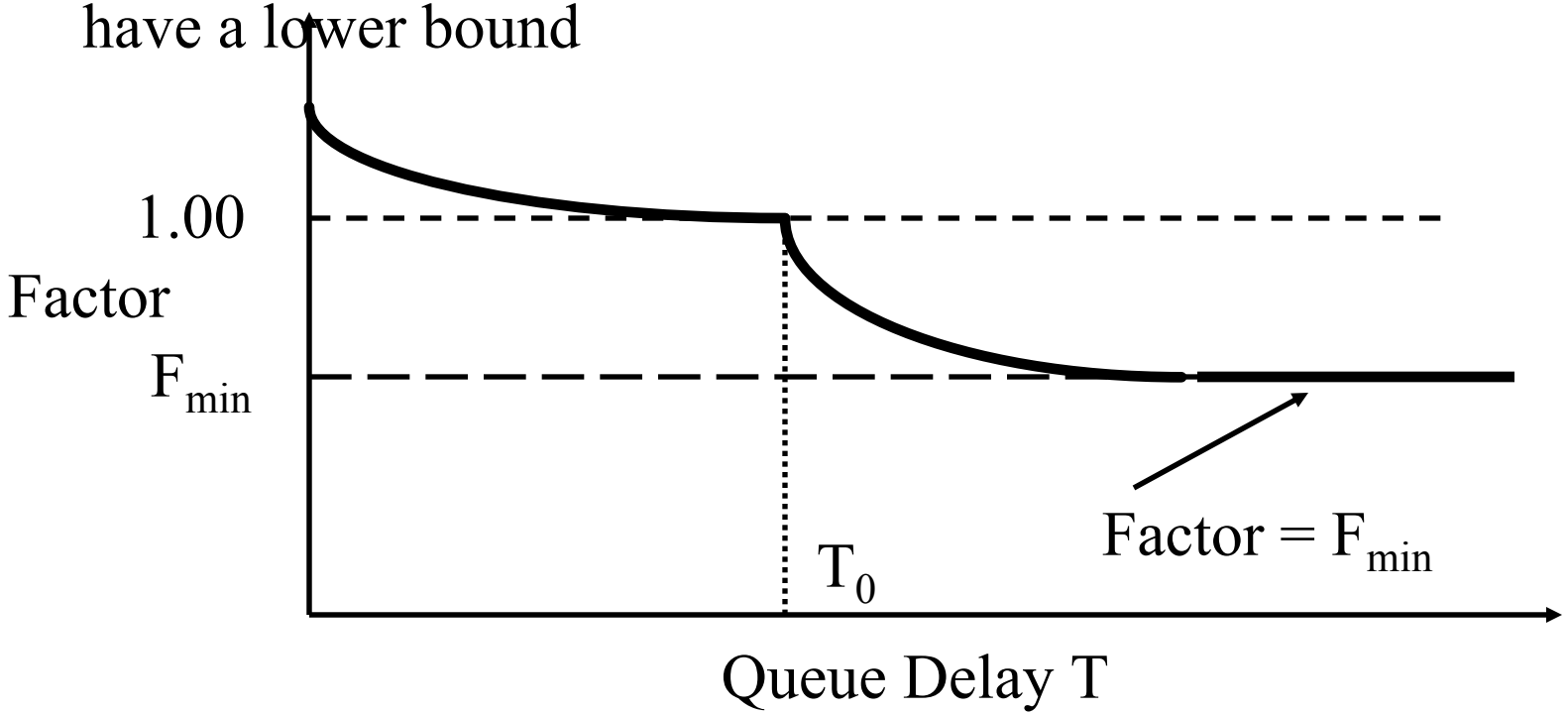
- Target utilization is dynamically changed.
- During steady state: Target utilization = 100%
- During overload the target may be low, e.g., 80%
- During underload the target may be high, e.g., 110%
- Available Bandwidth = fn(Unused bandwidth, Queue length, queue length goal)
- Unused bandwidth = Link Rate - VBR output rate
- Rest is similar to ERICA

Innovation 3

- Since available bandwidth (AB) varies dynamically, a queue of 30 may be too big when AB is 1 Mbps but too little when AB is 100 Mbps.
- Use queue delay instead of queue length
  Queue Delay = Queue length /Available bandwidth

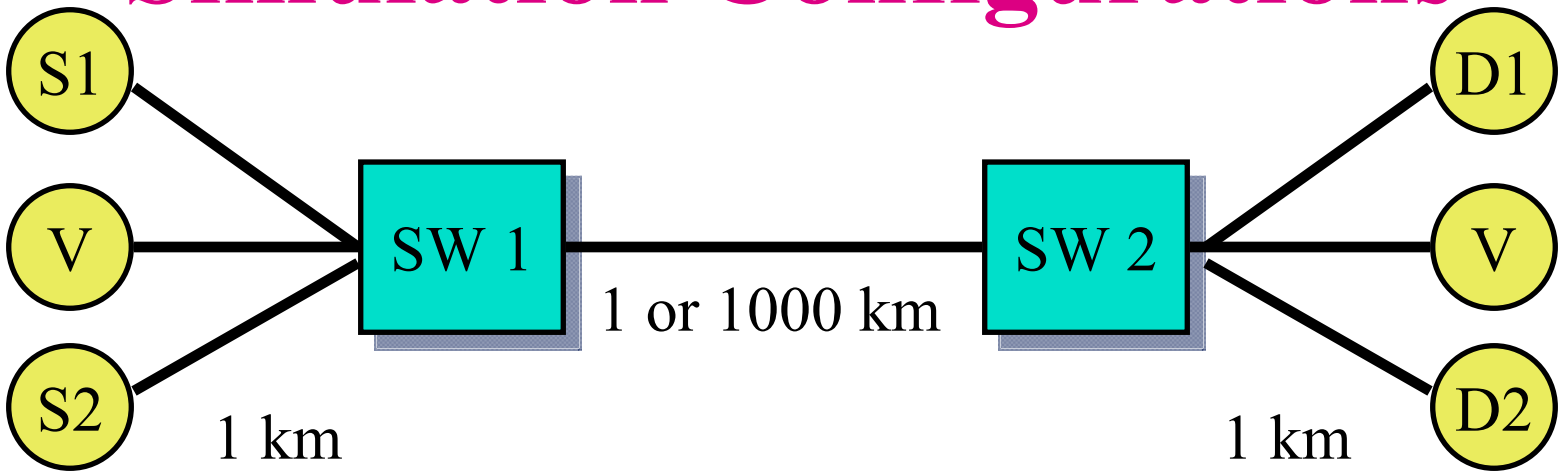
Innovation 4

- The function should be monotonically non-increasing and have a lower bound



Available Bandwidth = Unused Bandwidth ´ Factor

Simulation Configurations



- All links 155.52 Mbps
- One or Two ABR sources
- With/without VBR background traffic
- LAN or WAN
- The VBR source turns on/off
  - Every 4 ms (LAN) starts at t = 2 ms
  - Every 20 ms (WAN) starts at t = 12 ms

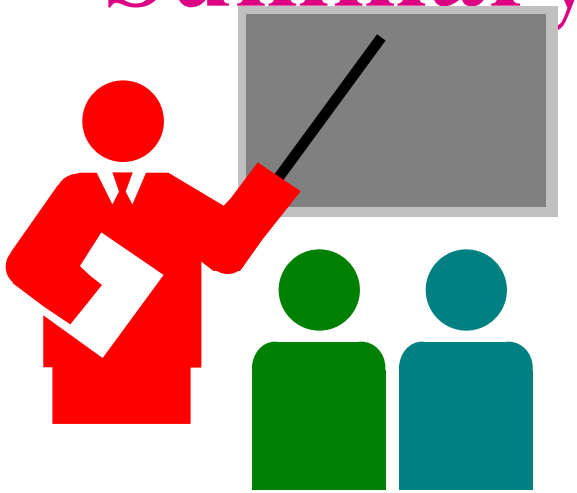
Simulation Parameters

- Source: Standard group #7
  Nrm = 32
  AIRF = 1 ⇒ AIR = PCR/Nrm ⇒ ACR is not limited by AIR
  RDF = 512 cells
  {TDFF, PNI} = {1/8, 0} ⇒ Rule 5 on
  CIF = 512 (LAN), 8192(WAN)
  ⇒ High ICR ⇒ Rule 5 not triggered
  RTT = 10 times the actual propagation delay
  ⇒ High XRM ⇒ Rule 6 not triggered
  XDF = 1/2
- Traffic: Unidirectional
- Switch:
  Averaging interval = min{30 cells, 200 μs}

Simulation Results

- ERICA+ provides 100% utilization
- No overflow or underflow of queues
- ERICA+ converges fast
- Queue length stays at the desired value

Summary



- ERICA with VBR and a general scheduling algorithm
- ERICA+ provides 100% utilization
- Allows operation at any point between the knee and the cliff.
- 100% throughput with any desired queue length possible.
- Provides quick response to transients
- High starts possible in LAN environments