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Performance of TCP over UBR+

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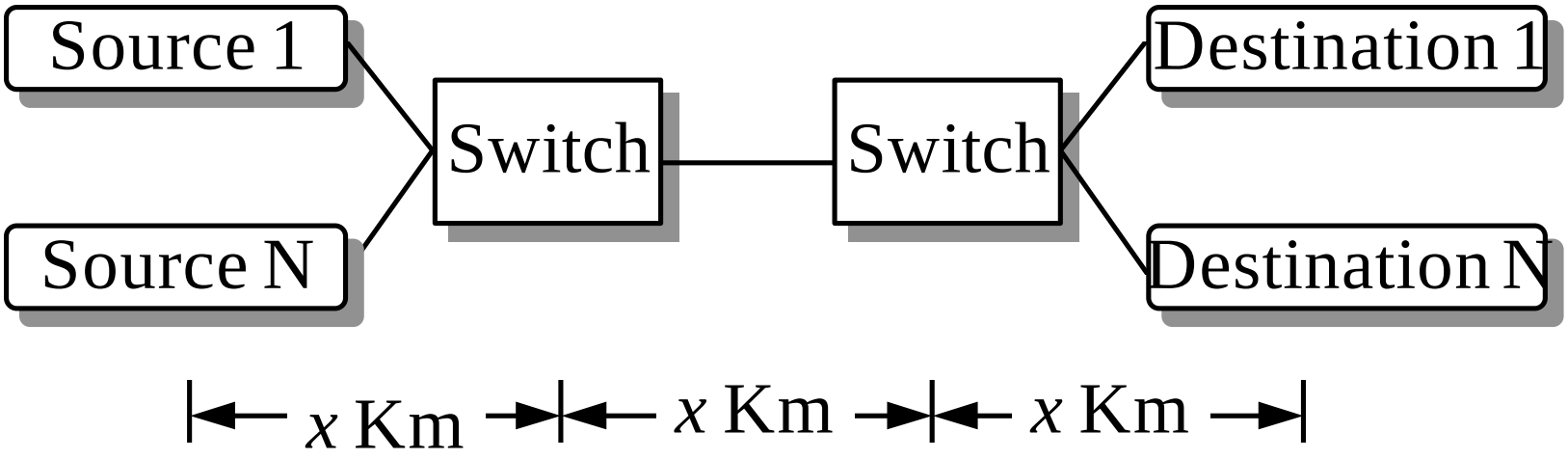
Overview

- Simulation Model
- UBR
- UBR+ EPD
- UBR + EPD + Selective Drop
- UBR + EPD + Fair Buffer Allocation

Simulation model



- N identical infinite TCP sources
- Link Delay: LAN: 5μs, WAN: 5 ms.
- Link Capacity = PCR = 155.52 Mbps
- Unidirectional traffic

TCP Parameters

- TCP maximum window size = 64 kBytes for LAN and 600,000 bytes for WANs
- No TCP delay ack timer
- Duration: 10 sec for LAN, 20 sec for WAN
- All processing delay, delay variation = 0
- TCP sources are not staggered nor randomized. All start and stop at the same times.
- TCP Fast Retransmit and Recovery disabled
- TCP MSS = 512 bytes
- TCP timer granularity = 100 ms

Performance Metrics

- Efficiency = Sum of throughputs/Max poss. throughput
  - Maximum Segment Size = 512 data
    = 512 data + 20 TCP + 20 IP + 8 LLC + 8 AAL5
    = 12 cells = 12×53 bytes = 636 bytes in ATM Layer
  - Maximum possible throughput = 512/636 = 80.5%
    = 125.2 Mbps on a 155.52 Mbps link
- Fairness = $\frac{(\Sigma x_i)^2}{n \Sigma x_i^2}$

  Where x_i = throughput of the ith TCP source

TCP over UBR: Zero Loss

N	Configuration	Efficiency	Fairness	Max. Queue (cells)
5	LAN	1	1	7591
15	LAN	1	1	22831
5	WAN	1	1	59211
15	WAN	1	1	196203

- For zero TCP loss:
  Switch buffers = Σ(TCP window sizes)

TCP over UBR: Limited Buffers

Conf.	Srcs	Buffers	Eff.	Fairn.
LAN	5	1000	0.21	0.68
LAN	5	2000	0.32	0.90
LAN	5	3000	0.47	0.97
LAN	15	1000	0.22	0.31
LAN	15	2000	0.49	0.59
LAN	15	3000	0.47	0.80
WAN	5	12000	0.86	0.75
WAN	5	24000	0.90	0.83
WAN	5	36000	0.91	0.86
WAN	15	12000	0.96	0.67
WAN	15	24000	0.94	0.82
WAN	15	36000	0.92	0.77

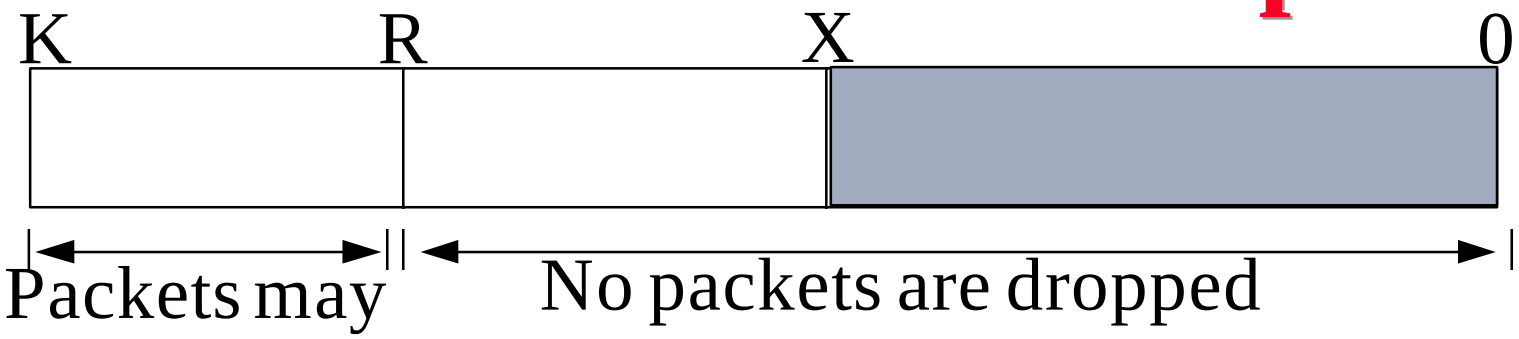
- Low efficiency and low fairness. Better with buffers.

UBR + EPD

			UBR		EPD	
Conf.	Srcs	Buffers	Eff.	Fairn.	Eff.	Fairn.
LAN	5	1000	0.21	0.68	0.49	0.57
LAN	5	2000	0.32	0.90	0.68	0.98
LAN	5	3000	0.47	0.97	0.72	0.84
LAN	15	1000	0.22	0.31	0.55	0.56
LAN	15	2000	0.49	0.59	0.81	0.87
LAN	15	3000	0.47	0.80	0.91	0.78
WAN	5	12000	0.86	0.75	0.90	0.94
WAN	5	24000	0.90	0.83	0.91	0.99
WAN	5	36000	0.91	0.86	0.81	1
WAN	15	12000	0.96	0.67	0.92	0.93
WAN	15	24000	0.94	0.82	0.91	0.92
WAN	15	36000	0.92	0.77	0.96	0.91

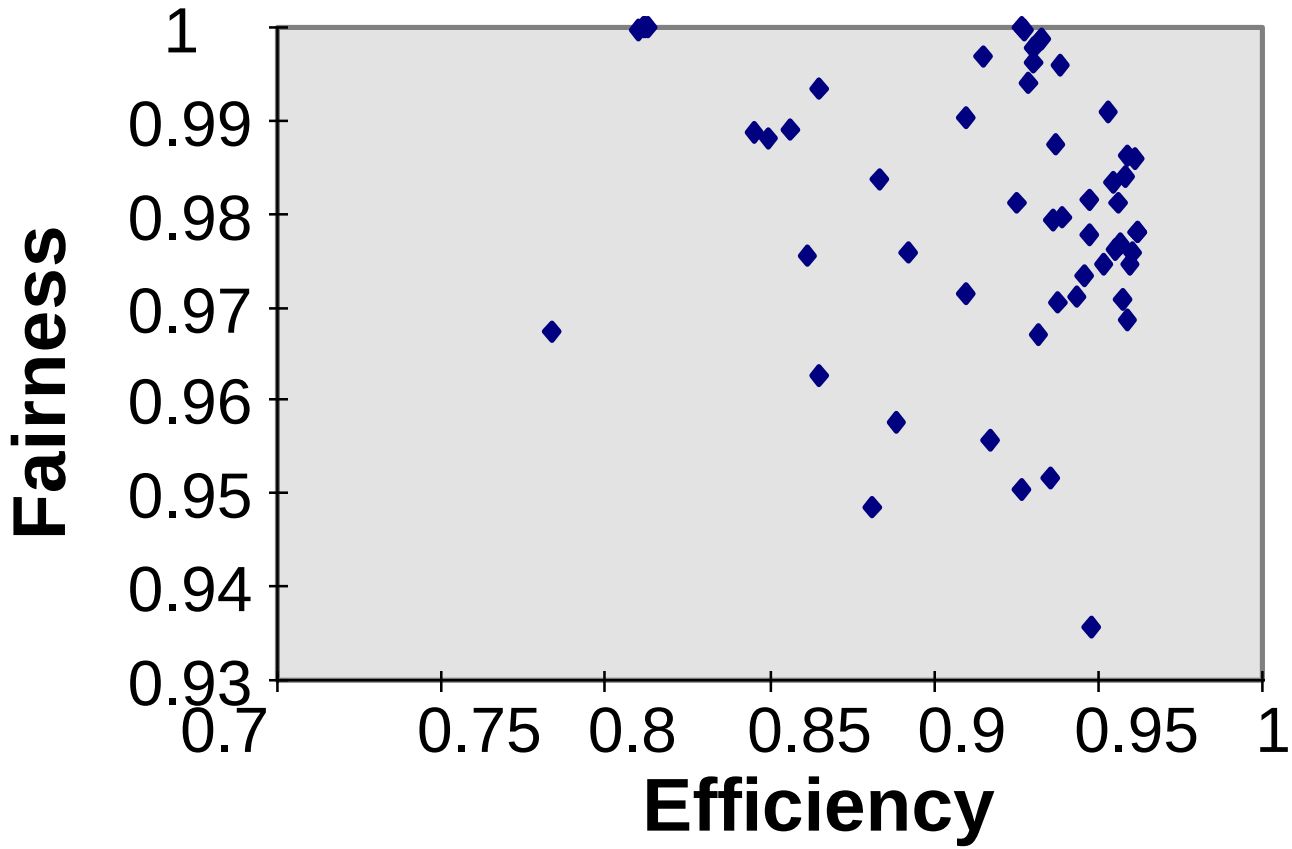
- EPD improves efficiency but not fairness

UBR+ : Selective Drop



- K = Buffer Size (cells), R = Minimum Threshold, X = Buffer Occupancy
- Fair Allocation = X / N_a
- Per-VC Accounting gives Yi = # of cells in buffer
- Buffer Load ratio of $VC_i = Y_i /(X/ N_a)$
- Drop complete packet of VC_i, if $X > R$ and $Y_i/(X/N_a) > Z$

SD: Effect of Parameters



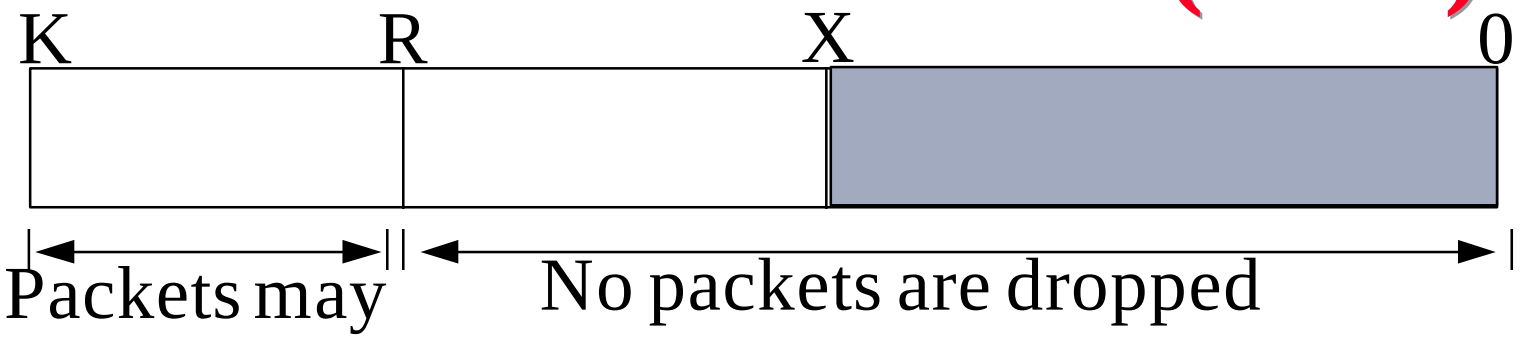
- Tradeoff between efficiency and fairness
- The scheme is sensitive to parameters
- Best value for Z = 0.8, R = 0.9*K

UBR + EPD + SD

			UBR		EPD		SD	
Conf.	Srcs	Buffers	Eff.	Fairn.	Eff.	Fairn.	Eff.	Fairn.
LAN	5	1000	0.21	0.68	0.49	0.57	0.75	0.99
LAN	5	2000	0.32	0.90	0.68	0.98	0.85	0.96
LAN	5	3000	0.47	0.97	0.72	0.84	0.90	0.99
LAN	15	1000	0.22	0.31	0.55	0.56	0.76	0.76
LAN	15	2000	0.49	0.59	0.81	0.87	0.82	0.98
LAN	15	3000	0.47	0.80	0.91	0.78	0.94	0.94
WAN	5	12000	0.86	0.75	0.90	0.94	0.90	0.95
WAN	5	24000	0.90	0.83	0.91	0.99	0.92	0.99
WAN	5	36000	0.91	0.86	0.81	1	0.81	1
WAN	15	12000	0.96	0.67	0.92	0.93	0.94	0.91
WAN	15	24000	0.94	0.82	0.91	0.92	0.94	0.97
WAN	15	36000	0.92	0.77	0.96	0.91	0.96	0.89

- SD improves fairness and efficiency.

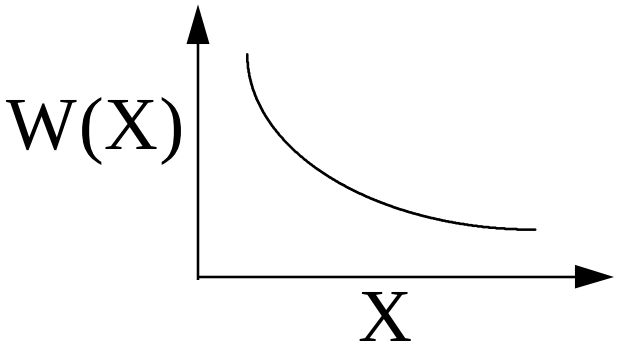
Fair Buffer Allocation (FBA)



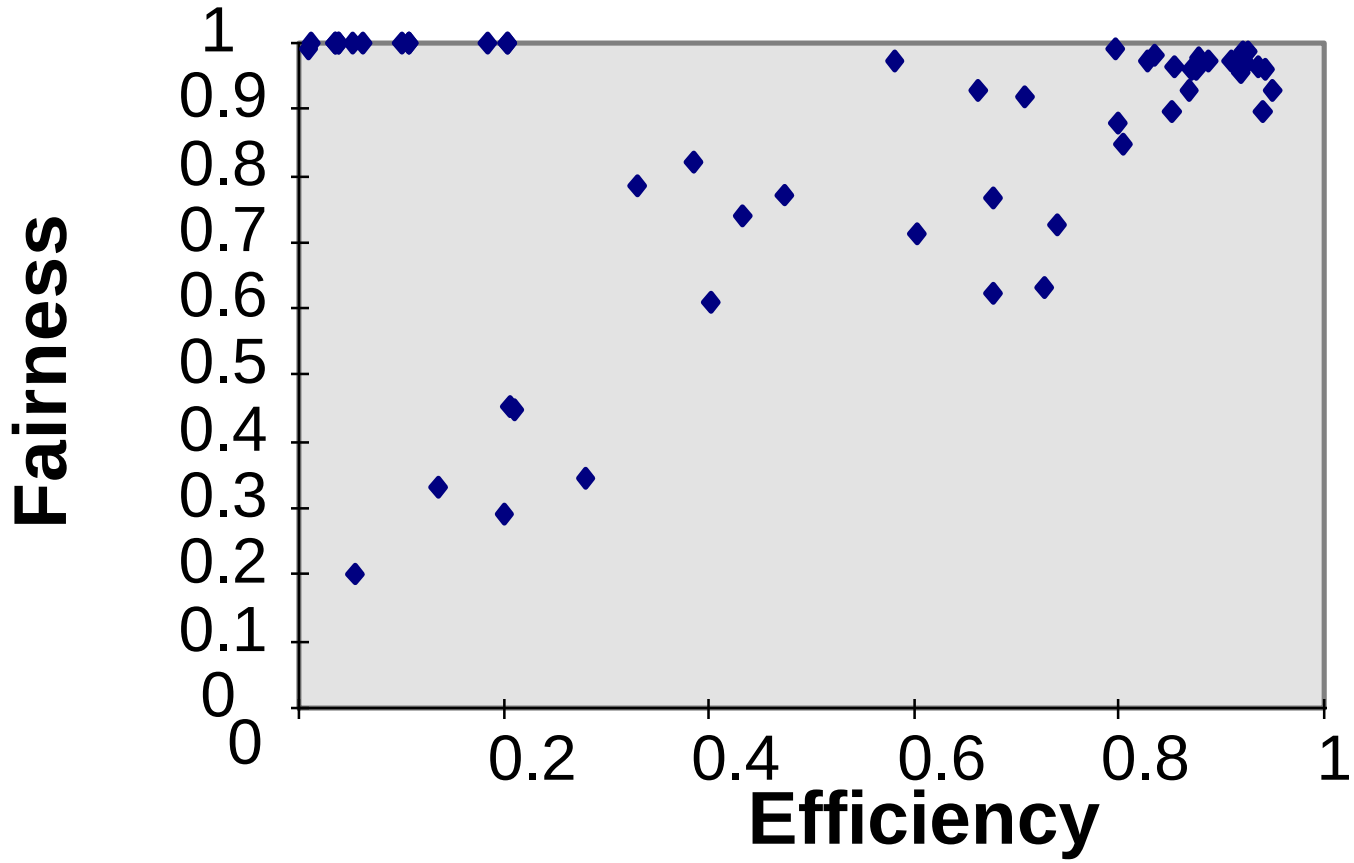
- Drop complete packet of VC_i if

  $(X > R)$ AND $(Y_i * N_a / X > W(X)$

  $W(X) = Z*((K - R)/ (X - R))$



FBA: Effect of Parameters



- Tradeoff between efficiency and fairness
- The scheme is sensitive to parameters
- Best value of Z = 0.8, R = 0.5*K

UBR + EPD + FBA

			UBR		EPD		SD		FBA	
Conf.	Srcs	Buffers	Eff.	Fairn.	Eff.	Fairn.	Eff.	Fairn.	Eff.	Fairn.
LAN	5	1000	0.21	0.68	0.49	0.57	0.75	0.99	0.88	0.98
LAN	5	2000	0.32	0.90	0.68	0.98	0.85	0.96	0.84	0.98
LAN	5	3000	0.47	0.97	0.72	0.84	0.90	0.99	0.92	0.97
LAN	15	1000	0.22	0.31	0.55	0.56	0.76	0.76	0.91	0.97
LAN	15	2000	0.49	0.59	0.81	0.87	0.82	0.98	0.85	0.96
LAN	15	3000	0.47	0.80	0.91	0.78	0.94	0.94	0.95	0.93
WAN	5	12000	0.86	0.75	0.90	0.94	0.90	0.95	0.95	0.94
WAN	5	24000	0.90	0.83	0.91	0.99	0.92	0.99	0.92	1
WAN	5	36000	0.91	0.86	0.81	1	0.81	1	0.81	1
WAN	15	12000	0.96	0.67	0.92	0.93	0.94	0.91	0.95	0.97
WAN	15	24000	0.94	0.82	0.91	0.92	0.94	0.97	0.96	0.98
WAN	15	36000	0.92	0.77	0.96	0.91	0.96	0.89	0.95	0.97

- FBA improves both efficiency and fairness

UBR+ : Summary

- Low efficiency and fairness for TCP over UBR
- Need switch buffers =Σ(TCP maximum window sizes) for zero TCP loss
- EPD improves efficiency but not fairness
- Selective drop improves fairness
- Fair Buffer Allocation improves both efficiency and fairness, but is sensitive to parameters
- TCP synchronization affects performance