UBR+ : Improving Performance of TCP over ATM-UBR Service

Rohit Goyal, Raj Jain, Shivkumar Kalyanaraman, and Sonia Fahmy

Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/

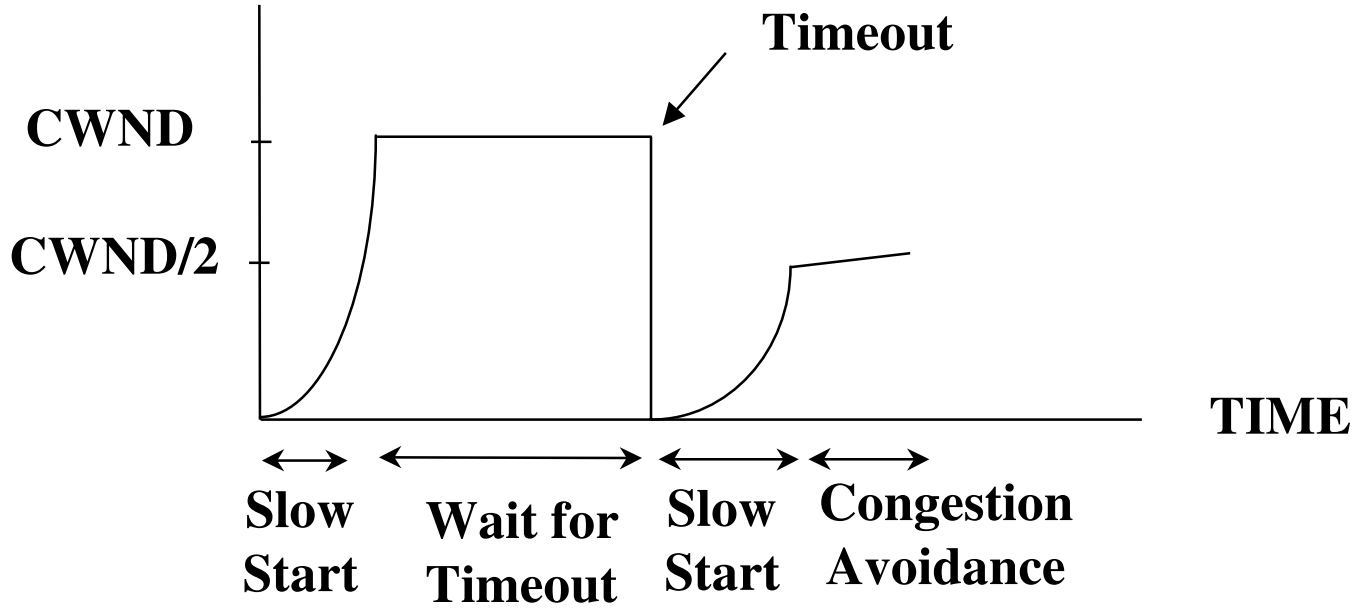
Overview

- TCP over ATM UBR: Introduction
- The Simulation Experiment
- TCP over UBR: Buffer Requirements
- UBR with Early Packet Discard
- Selective Drop and Fair Buffer Allocation

ATM Unspecified Bit Rate (UBR)

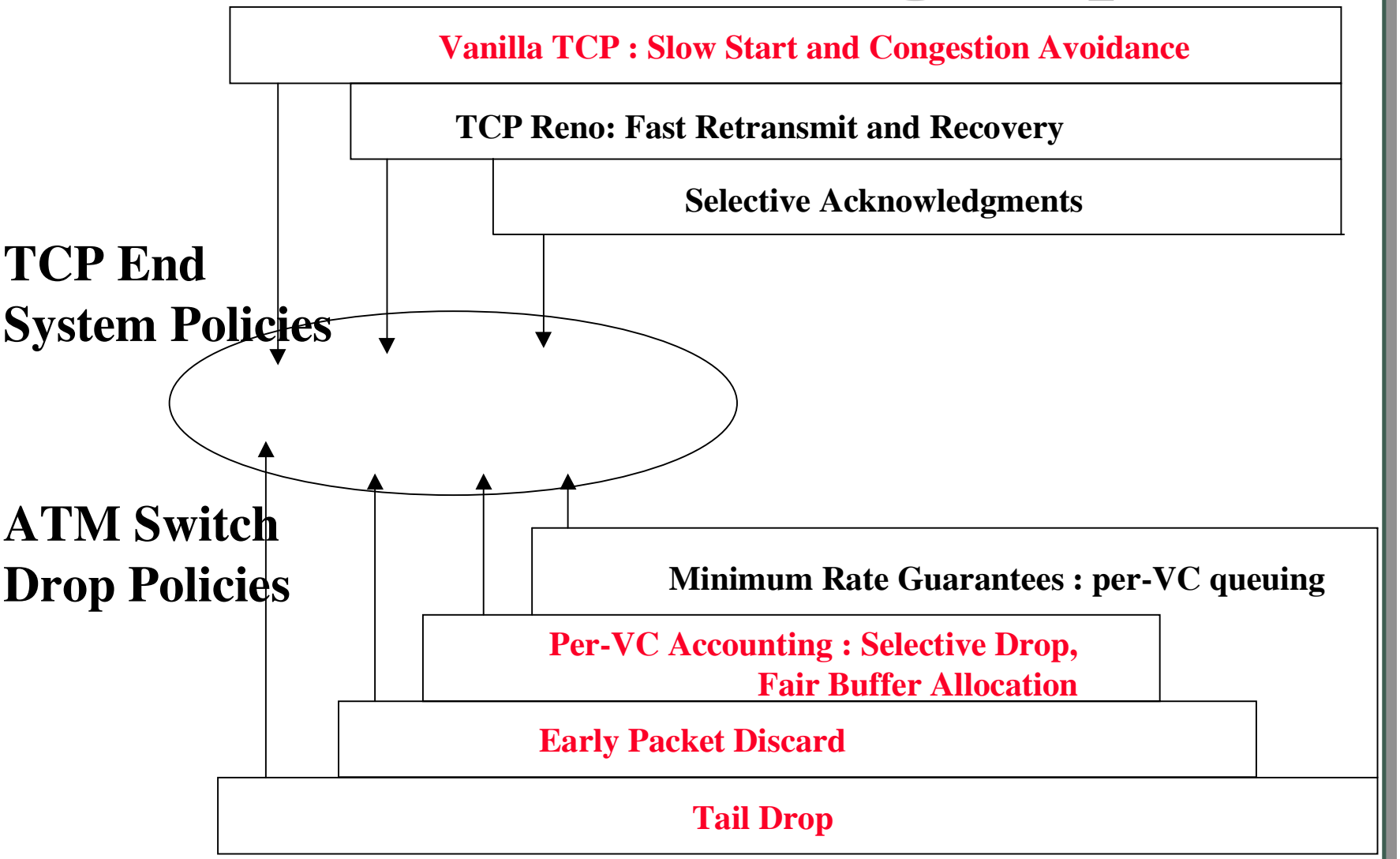
- UBR is the lowest priority ATM service category.
- The UBR service provides no Traffic Management functionality.
- When switch buffers become full, the switch drops cells.
- UBR is the cheapest ATM service because it offers no guarantees to the user.
- Switches may individually implement buffer management policies to improve performance.

TCP Congestion Control

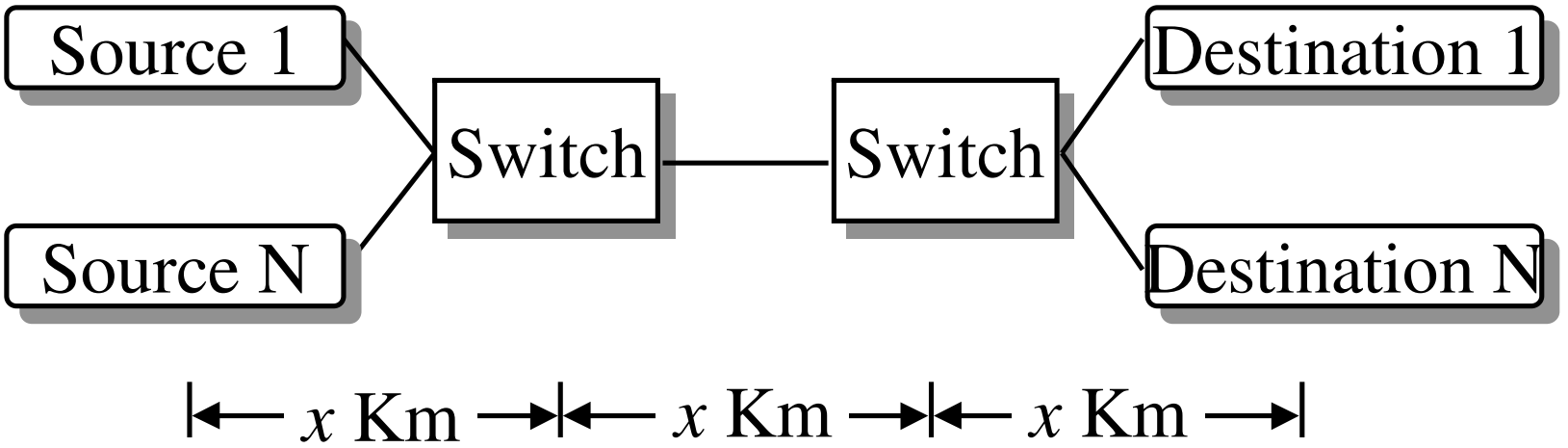


- TCP's congestion avoidance and control recovers from congestion and packet loss.
- ATM UBR can be a cost-effective technology for non-real time TCP applications.

TCP over UBR: Design Options



The Simulation Experiment



- N identical infinite TCP sources
- Link Delay: LAN: 5 µs, WAN: 5 ms.
- Link Capacity = PCR = 155.52 Mbps
- Single FIFO buffer for all UBR traffic in the switch
- Buffer size:LAN:1k,2k,3k. WAN:12k,24k,36k cells

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 unidirectional
- 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: Buffer Requirements for Zero Loss

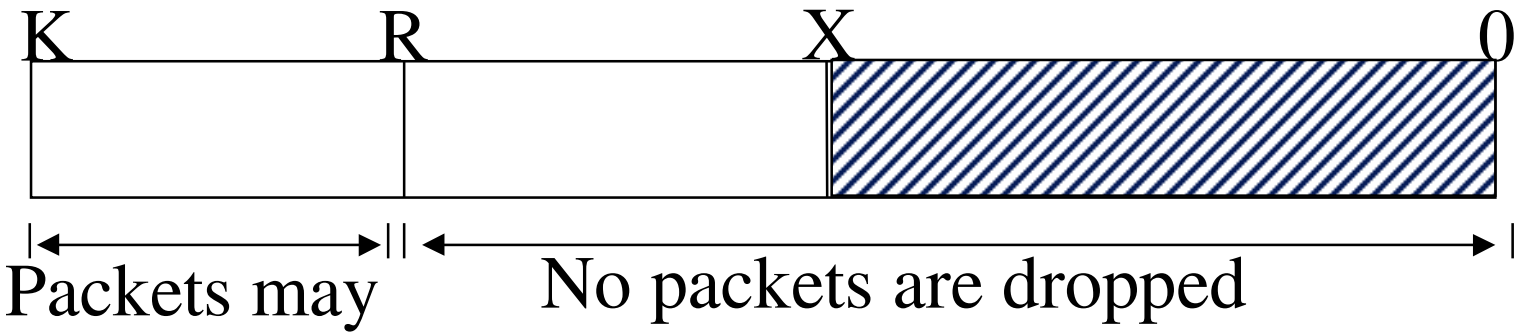
N	Configuration	Efficiency	Fairness	Max. Queue (cells)
5	LAN	1	1	7591
15	LAN	1	1	22831
5	WAN	1	1	59211
15	WAN	1	1	196203

- Total TCP window sizes in cells :
  - LAN: 6827 (N=5) and 20480 (N=15)
  - WAN: 62500 (N=5) and 187500 (N=15)
- For zero TCP loss:
  Switch buffers = Σ (TCP window sizes)

TCP over UBR: Limited Buffers

- Low efficiency
- Low fairness
- Efficiency and fairness improve with more buffering.
- TCP timer granularity (100ms - 500ms) is a key factor that reduces efficiency
- How can we do better with limited buffers?

UBR +: Early Packet Discard



- K = Buffer Size (cells).
- R = Drop Threshold.
- X = Buffer Occupancy.
- When (X > R) new incoming packets are dropped.
- Partially received packets are accepted if possible.
- EPD improves efficiency but not fairness

UBR+: Per-VC Accounting

- N_a = Number of active VCs in the buffer.
- 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:
  - Selective Drop: $(X > R)$ AND $(Y_i/(X/N_a) > Z)$
  - Fair Buffer Allocation: $(X > R)$ AND $(Y_i * N_a / X > Z*((K – R)/ (X – R))$
- SD and FBA improve efficiency and fairness

Simulation Results

			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

Summary

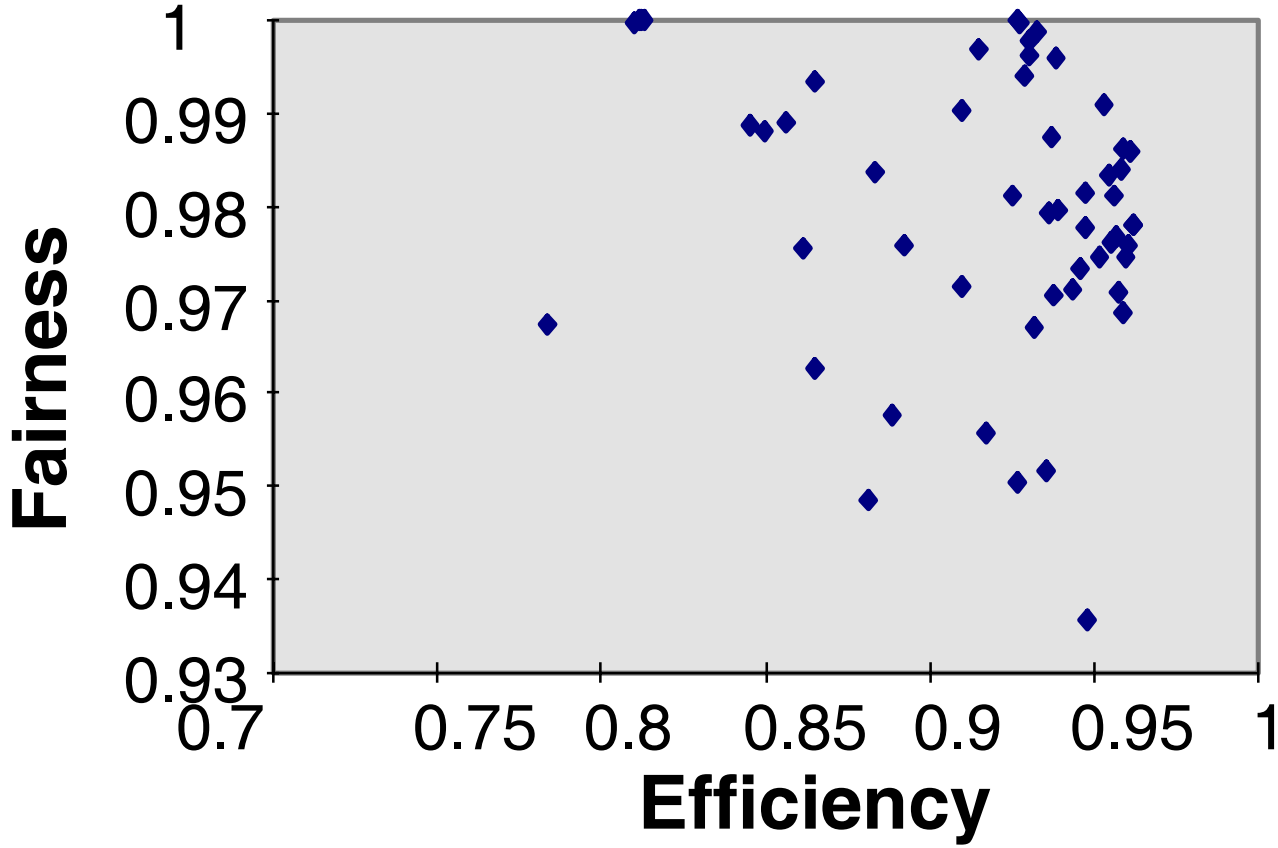
- Low efficiency and fairness for TCP over UBR
- Need switch buffers = Σ(TCP maximum window sizes) for zero TCP loss
- EPD improves efficiency but not fairness
- Per-VC accounting (selective drop and fair buffer allocation) improves fairness and efficiency
- TCP performance over UBR can be improved by network drop policies and end system policies.

If you liked this, you may want to check these out!!

- Rohit Goyal, et.al.,"Selective Acknowledgements and UBR+ Drop Policies to Improve TCP/UBR Performance over Terrestrial and Satellite Networks," ATM Forum/97-0423, April 1997, http://www.cis.ohio-state.edu/~jain/atmf/a97-0423.htm (submitted to IC3N'97)
- Rohit Goyal, et.al, "Guaranteed Rate for Improving TCP Performance on UBR+ over Terrestrial and Satellite Networks," ATM Forum/97-0424, April 1997, http://www.cis.ohio-state.edu/~jain/atmf/a97-0424.htm(submitted to ICNP97)
- Rohit Goyal, et.al,"Further Results on UBR+:Effect of Fast Retransmit and Recovery," ATM Forum/96-1761, December 1996,http://www.cis.ohio-state.edu/~jain/atmf/a96-1761.htm
- Shivkumar Kalyanaraman, et.al, "Performance of TCP over ABR with self-similar VBR video background traffic over terrestrial and satellite ATM networks," ATM Forum/97-0177r2, April 1997,http://www.cis.ohio-state.edu/~jain/atmf/a97-0177r2.htm

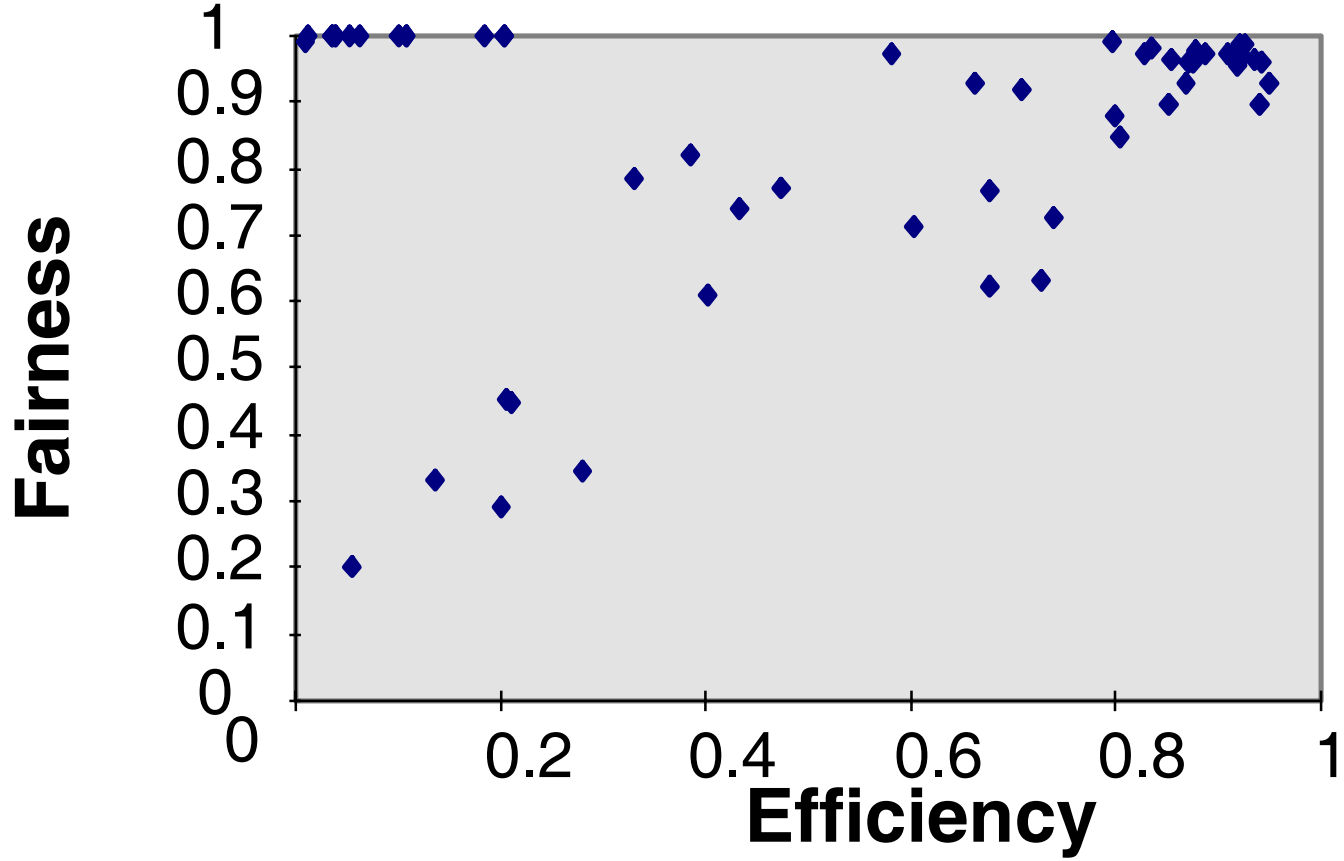
Thank You

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

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