Service-to-Service Mapping of Differentiated Services to the ABR Service of ATM in Edge/Core Networks

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Organization

- Motivation
- Introduction
- Related Work
- Service to service mapping
- Scheduling algorithms to support DiffServ over ATM
- Implementation
- Performance Evaluation
- Conclusions
- Future Work

Motivation

IP community (IETF)

- Data Networking
- Connectionless approach
- IntServ and DiffServ to support QoS
- Moving towards a slightly connection oriented approach - Bandwidth Brokers

ATM community (ATMF)

- Voice and Video
- Connection oriented approach
- Various service classes inherent in the concept of ATM

Motivation (contd…)

Convergence and Interoperability between IP and ATM for QoS support is a topic of active research because of heterogeneity of Internet

How to support IP QoS when transporting IP DiffServ traffic over ATM?

Introduction

Quality of Service

- Average Delay
- Jitter
- Bandwidth
- Reliability

QoS Mechanisms

- Physical Layer Mechanisms
- Link Layer Mechanisms
- Network and Transport Layer mechanisms

Introduction (contd…)

Quality of Service in ATM

- Constant Bit Rate
- Real-time and non-real-time Variable Bit Rate
- Available Bit Rate
- Unspecified Bit Rate

Quality of Service in IP

- Integrated Services Model
- Differentiated Services Model

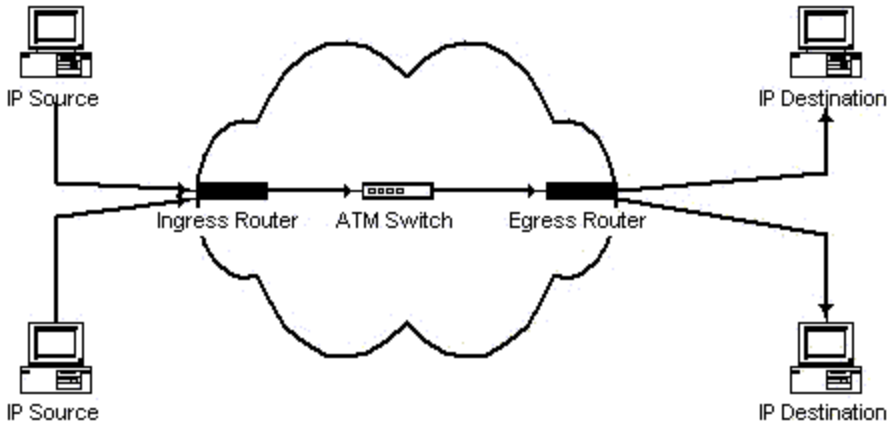
Introduction (contd…)

Per-Hop Behaviors (PHB) defined by the DiffServ WG of IETF

- Expedited Forwarding (EF)
- Assured Forwarding (AF)

Services defined by the DiffServ WG of IETF

- Premium Service
- Assured Service
- Olympic Service
  - relative service
  - no defined traffic or QoS parameters
  - packets of higher priority flow experience better performance than packets of low priority flows
- Best Effort Service



Simple Edge/Core Network

Related Work

Proposals for mapping of Differentiated Services to ATM

- Concept of a VC-bundle
  - Independent signaling problems
- PHB-to-Service Mapping
  - Incompatible entities
  - Parameter mapping issues
  - Limiting service definitions
- VC-to-VP Mapping
  - Requires enhancements to signaling

Service to Service Mapping

Mapping IP Services to ATM Services

- Compatibility and similarities between services of IP and services of ATM
- No restrictions on definitions of new services in IP

Examples

IP domain	PHB	ATM domain	Parameter
Premium service	EF	CBR	PCR
Allocated Capacity service	AF	ABR	MCR
Real-time service	AF	rt-VBR	PCR,SCR,MBS
Olympic service	AF	UBR	Different weights

Current proposal and its advantages for mapping Olympic Service

Features

- Service to service mapping
- Mapping happens at Ingress router of a core ATM network
- QoS support at Ingress router and appropriate choice of ATM VC provides QoS support throughout the network
- Achieved by providing queuing and scheduling support at Ingress router and experimenting with different VCs in the ATM core (ABR and VBR)

Advantages

- Service to service mapping
- Better guarantees when using ABR compared to UBR
  - Minimum bandwidth guarantees using MCR
  - No cell level dropping implies better service for Gold class
  - IP level scheduler is aware of ABR ACR resulting in lesser ATM level queuing
- Statistical multiplexing gains

Scheduling algorithms to support DiffServ over ATM

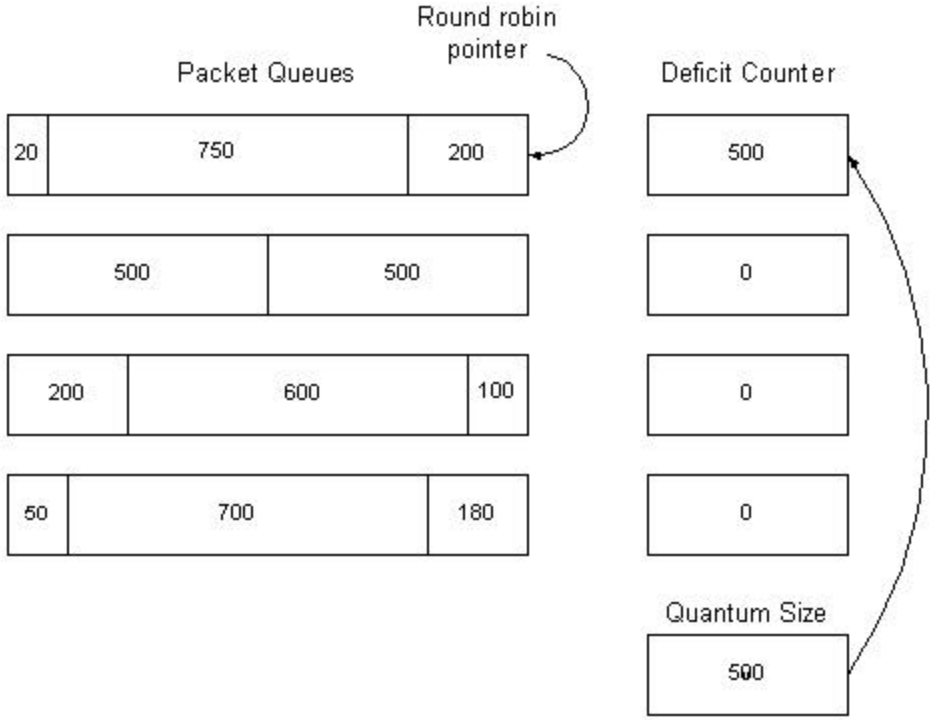
Scheduling Algorithms

- FIFO
  - Base of Best Effort
  - Supported by traditional routers
  - No Inherent Differentiation involved
- Priority Queues
  - Extension to FIFO
  - Provides FIFO support individually for each priority queue
  - Highest priority traffic receives minimum delay
  - Starvation for lower priority flows

Scheduling algorithms to support DiffServ over ATM (contd…)

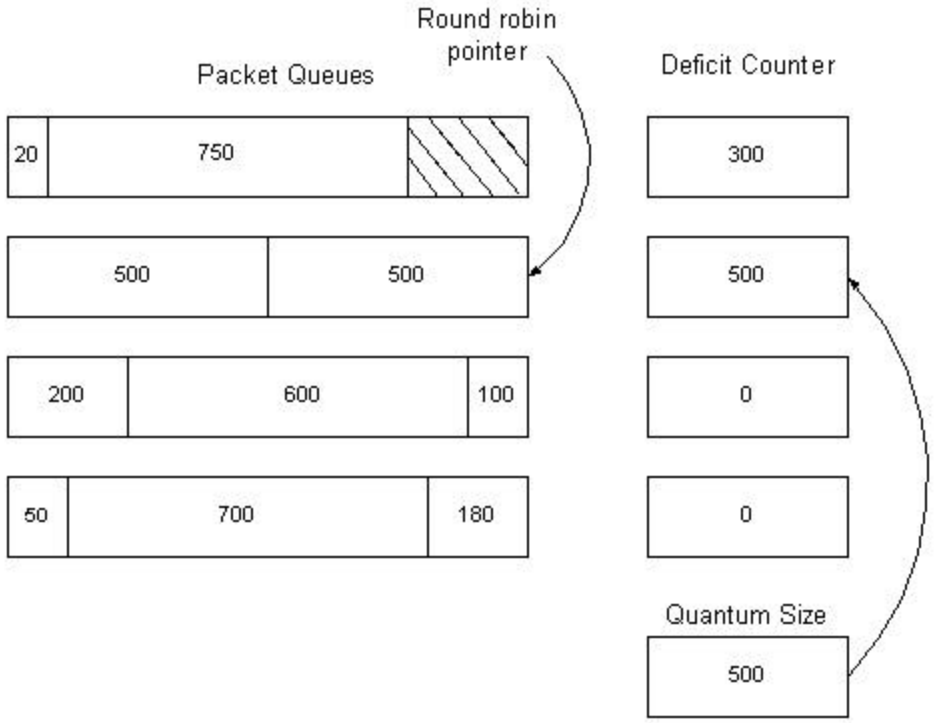
- Weighted Round Robin
  - Provides good approximation of GPS is identical sized packets
  - Fails to perform optimally if varying packet sizes like in IP
  - O(1) complexity
- Weighted Fair Queuing
  - Computes finish time of each queued packet based on bit-wise weighted GPS
  - No resource starving
  - Supports delay-bounded services
  - O(n) complexity
- Deficit Round Robin
  - Enhancement of WRR
  - Handles variable packet sizes
  - If unable to transmit packets because of large sizes, compensated in subsequent rounds

DRR Scheduling



Deficit Round Robin, at the start

DRR Scheduling (contd…)

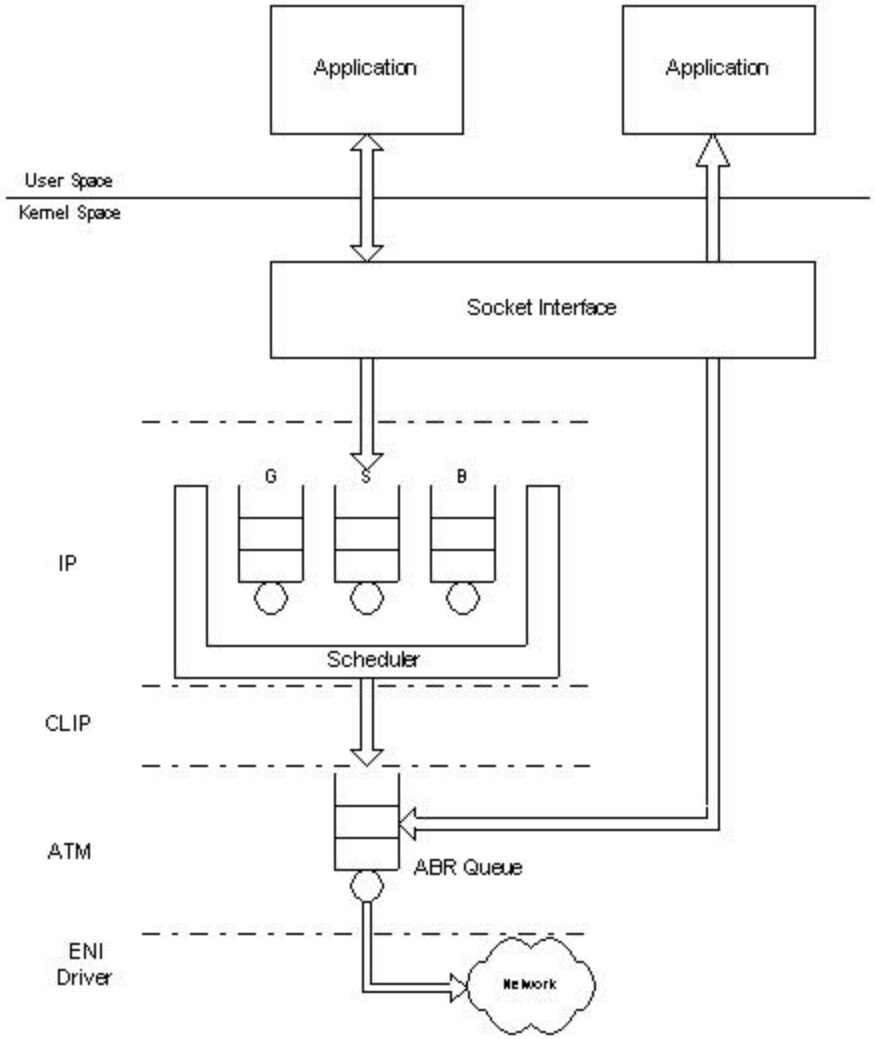


Deficit Round Robin, after sending out packet

Implementation

Features of Queuing Sub-layer

- Configurable number of queues setup by user
- Weights assigned to queues based on SLA
- Queuing done in IP layer
- IP datagrams classified based on TOS byte set by the source
- Queues serviced by an MDRR scheduler

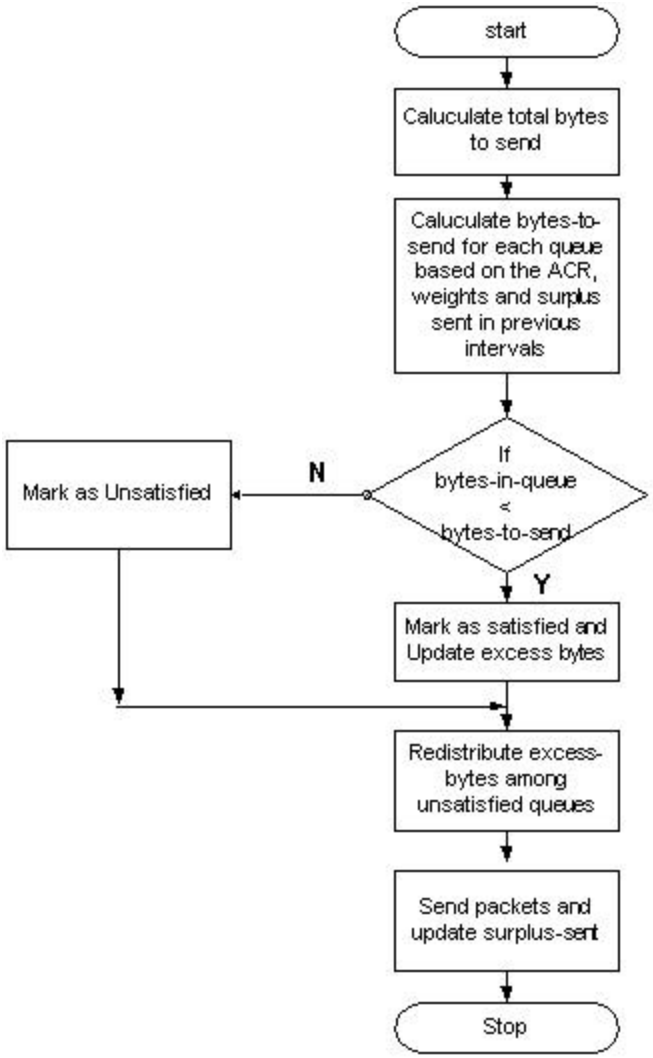


Architecture at the Ingress Router

Implementation (contd…)

Scheduling Support

- Variation of DRR scheduler, called MDRR
- Handles time-varying nature of ABR ACR
- Scheduler invoked periodically when ACR remains constant or decreases
- Scheduler invoked immediately if ACR increases and ABR queue drains
- Services queues based on ACR, weights and surplus sent in previous intervals
- Provides priority to Gold irrespective of weight associated with it
- Redistributes unused bandwidth among other queues if less bytes available in a queue



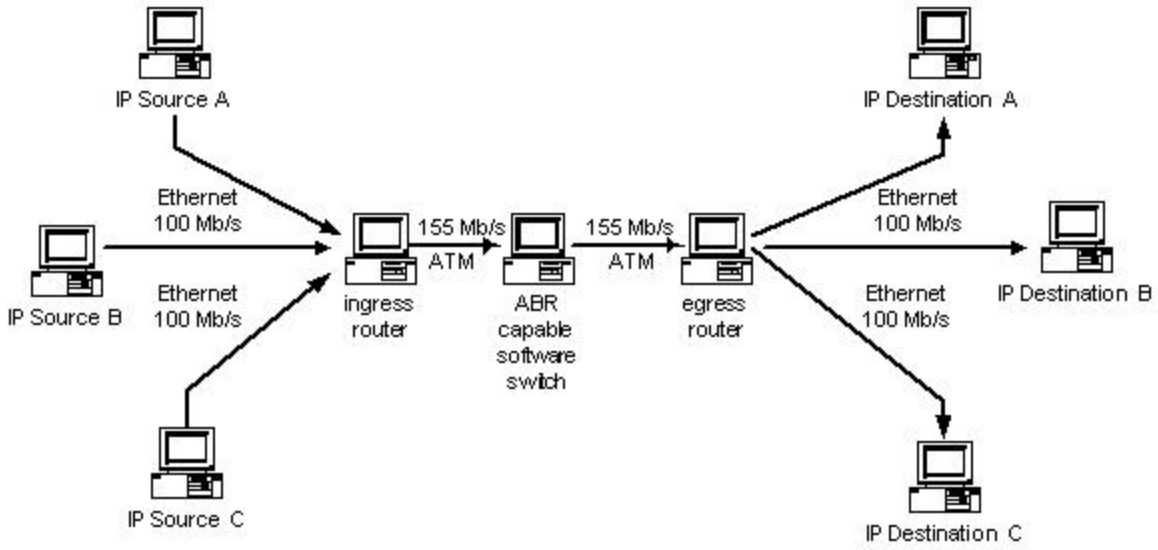
Flowchart of MDRR Scheduler

Performance Evaluation

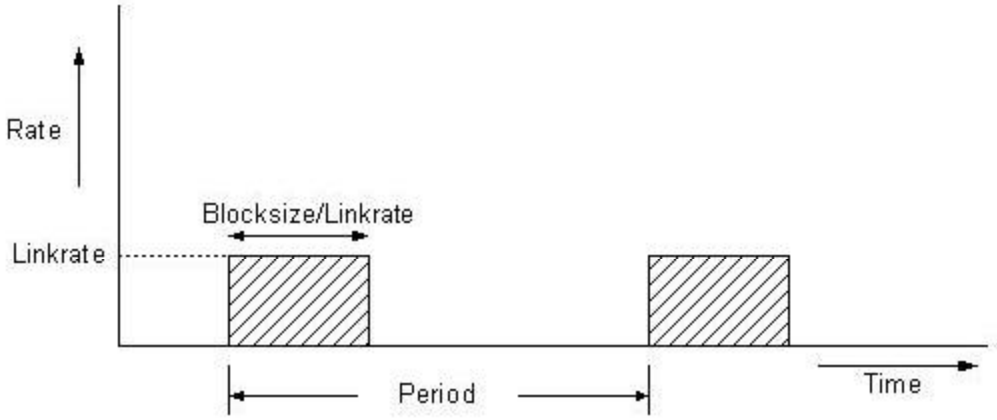
Overview of the tests

- Throughput measurements when mapping DiffServ to ABR, with and without VBR background traffic
- Effect of large packet size low priority flows on higher priority flows
- Throughput measurements when mapping DiffServ to VBR, with and without VBR background traffic
- Link utilization when mapping to both ABR and VBR
- Jitter measurements for mapping to both ABR and VBR

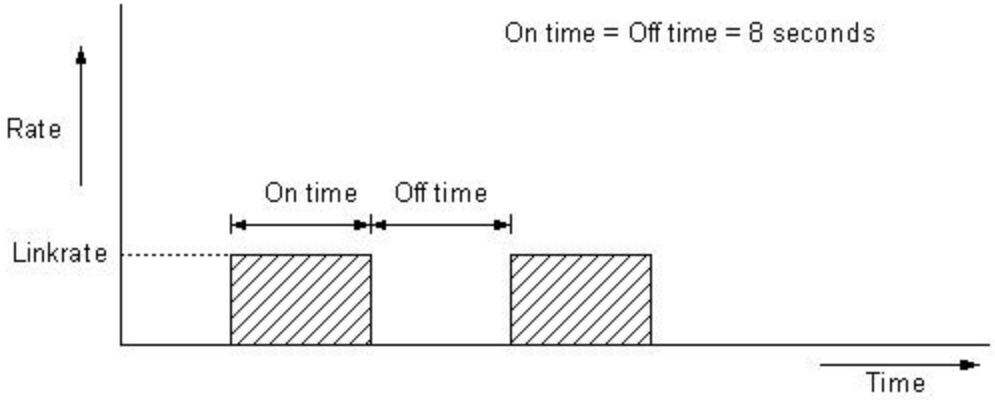
General Test Configuration



Traffic Patterns



Bursty TCP/IP source and Netspec parameters



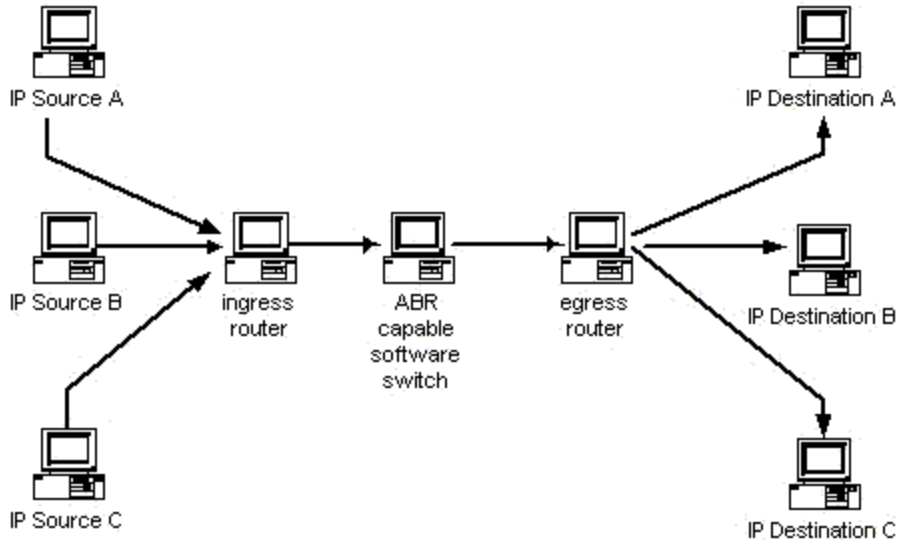
VBR background traffic trace

Traffic Parameters

	Bandwidth allocated for class	Scaled data generation rate for class
Gold (share – 80%)	112.0 Mb/s	116.0 Mb/s
Silver (share – 15%)	22.0 Mb/s	23.0 Mb/s
Bronze (share – 5%)	7.0 Mb/s	7.5 Mb/s

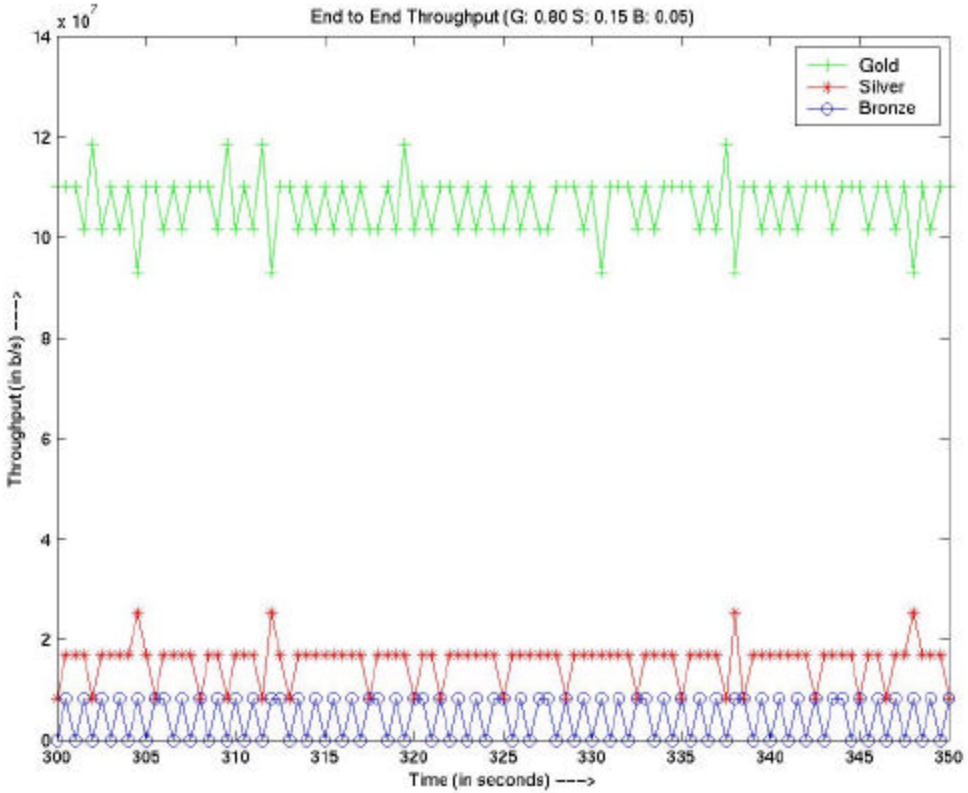
Rates used for different IP sources

Configuration 1



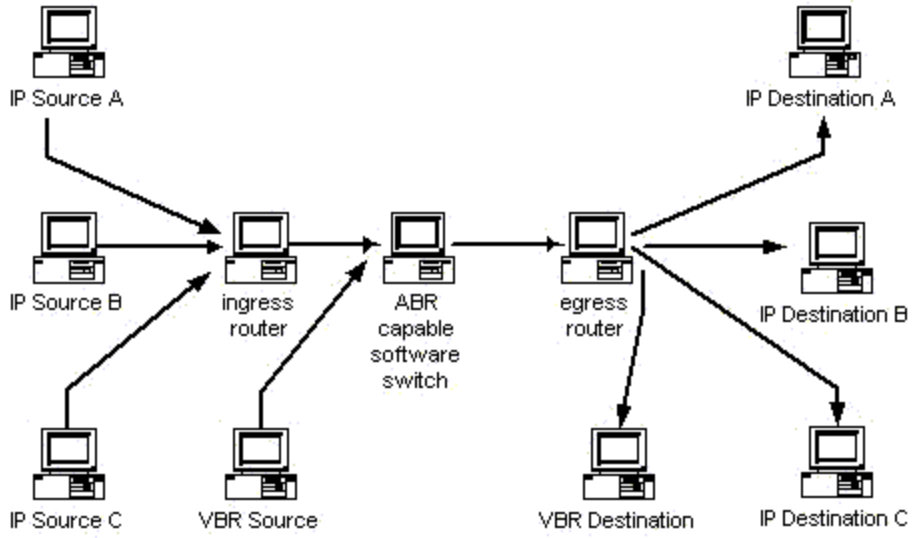
Motive: Throughput measurement when mapping DiffServ to ABR

Throughput when mapping DiffServ to ABR



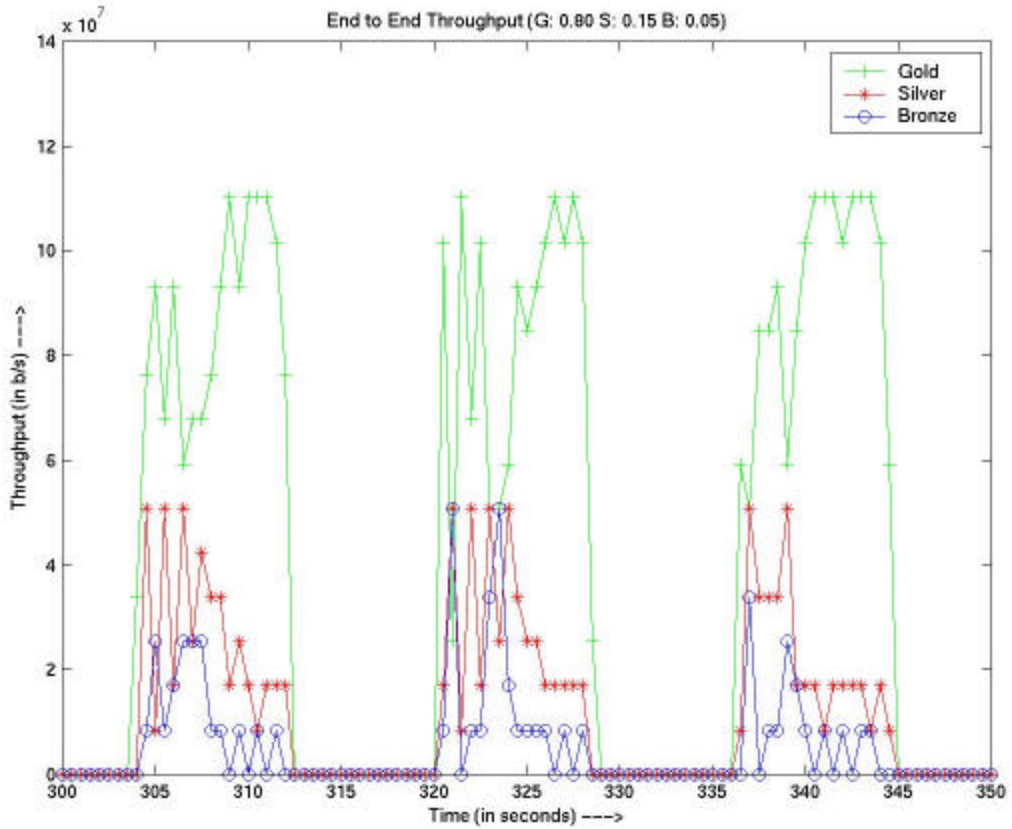
Share of Bandwidth - G: 0.80 S:0.15 B:0.05

Configuration 2



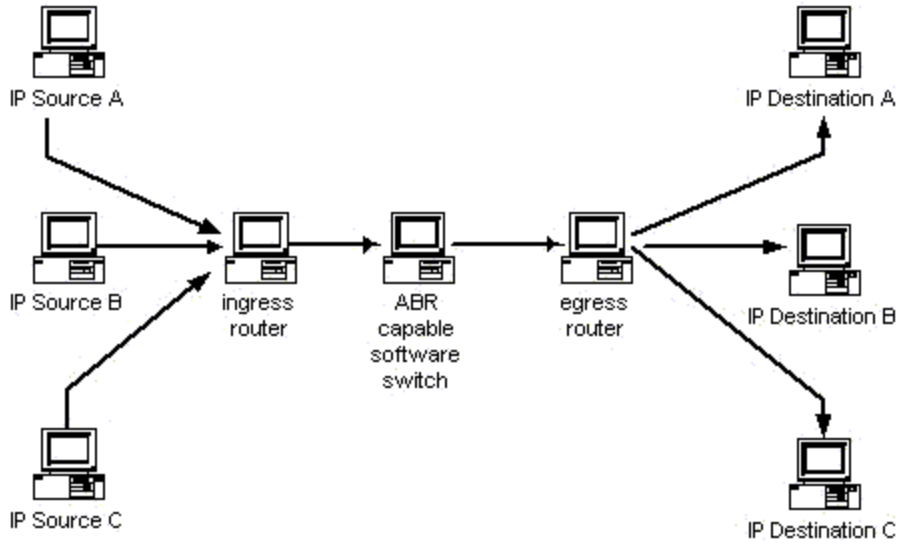
Motive: Throughput measurement when mapping DiffServ to ABR, in presence of VBR background traffic

Throughput when mapping DiffServ to ABR, in presence of VBR background traffic



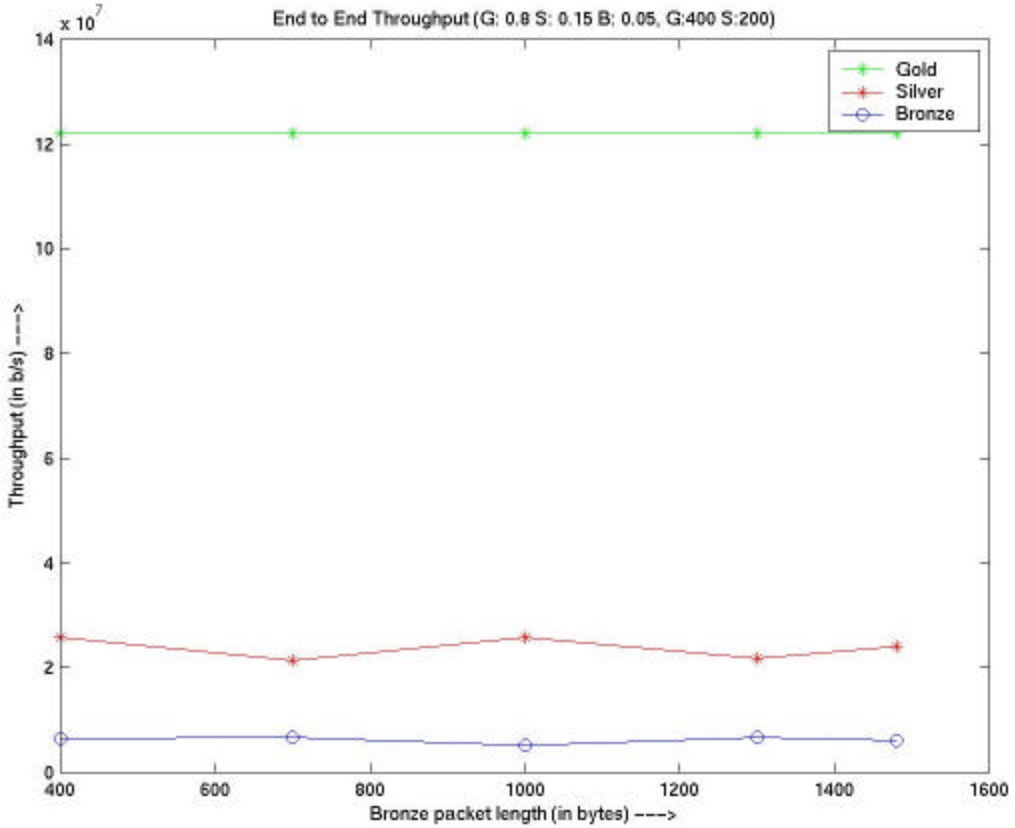
Share of Bandwidth - G: 0.80 S:0.15 B:0.05

Configuration 3



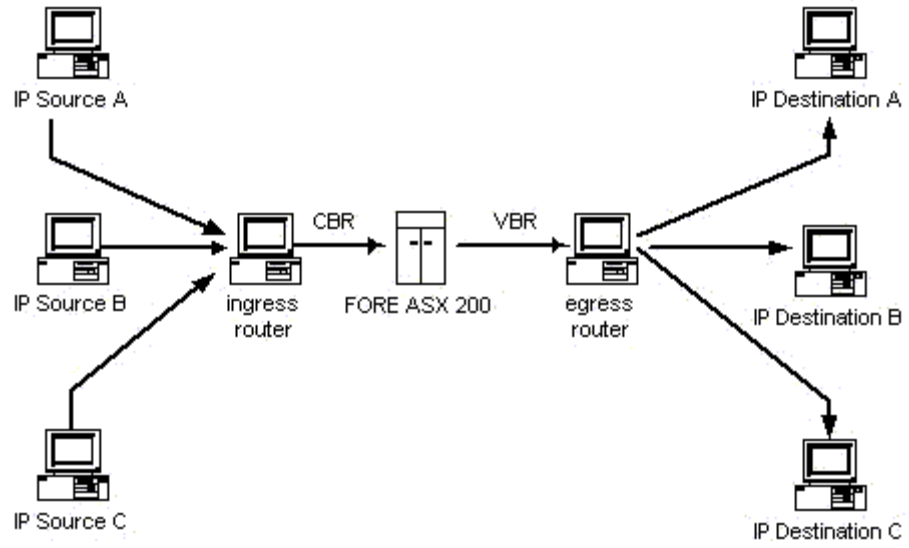
Motive: Effect of packet size of low priority flow on throughput of high priority flows

Effect of packet size of low priority flow on throughput of high priority flows



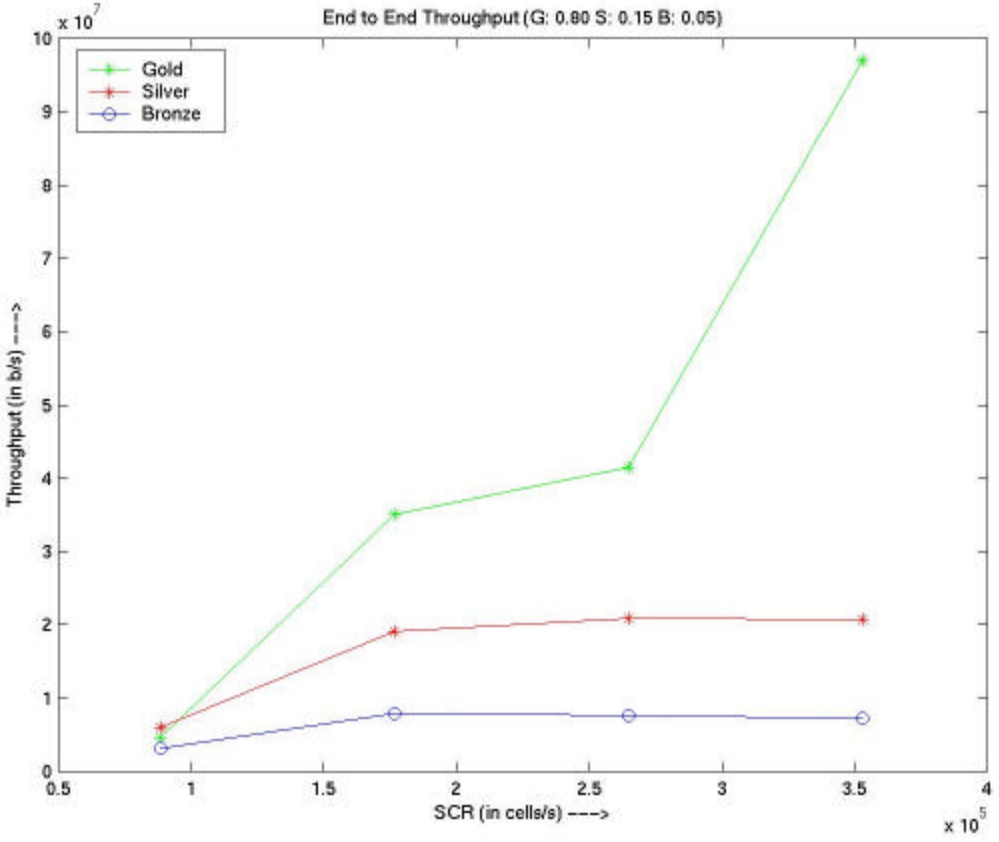
Share of Bandwidth - G: 0.80 S:0.15 B:0.05, Packet Sizes - G:400bytes S:200bytes

Configuration 4



Motive: Throughput measurement when mapping DiffServ to VBR using ASX 200BX

Throughput when mapping DiffServ to VBR using ASX 200BX



Share of Bandwidth –G:0.80 S: 0.15 B:0.05

Losses when mapping DiffServ to VBR using ASX 200BX

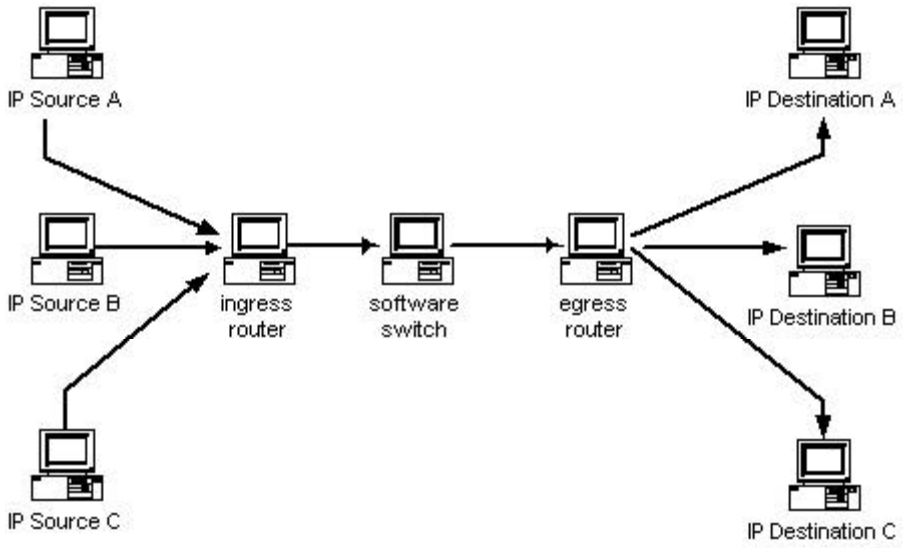
SCR	Cell loss
88250 cells/s	24 %
176500 cells/s	7 %
264750 cells/s	3 %
353000 cells/s	0 %

Cell Loss

SCR	Packet Loss		
	Gold	Silver	Bronze
88250 cells/s	35 %	36 %	27 %
176500 cells/s	20 %	18 %	18 %
264750 cells/s	19 %	15 %	13 %
353000 cells/s	0 %	0 %	0 %

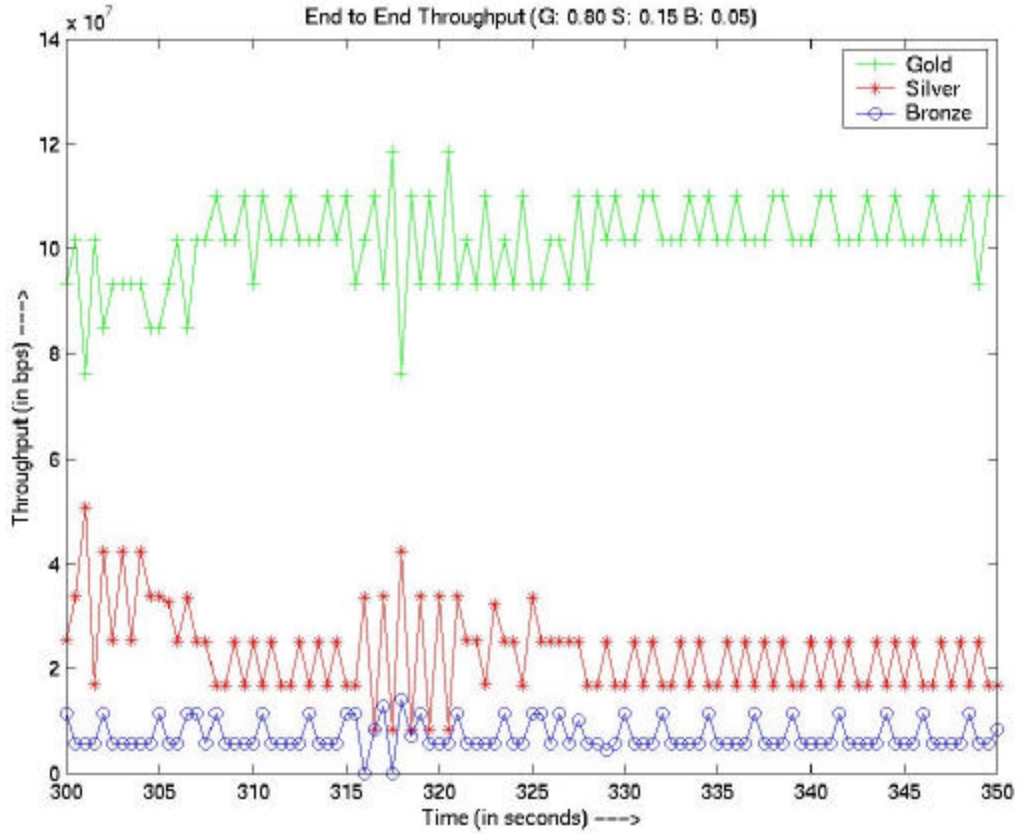
Packet Loss

Configuration 5



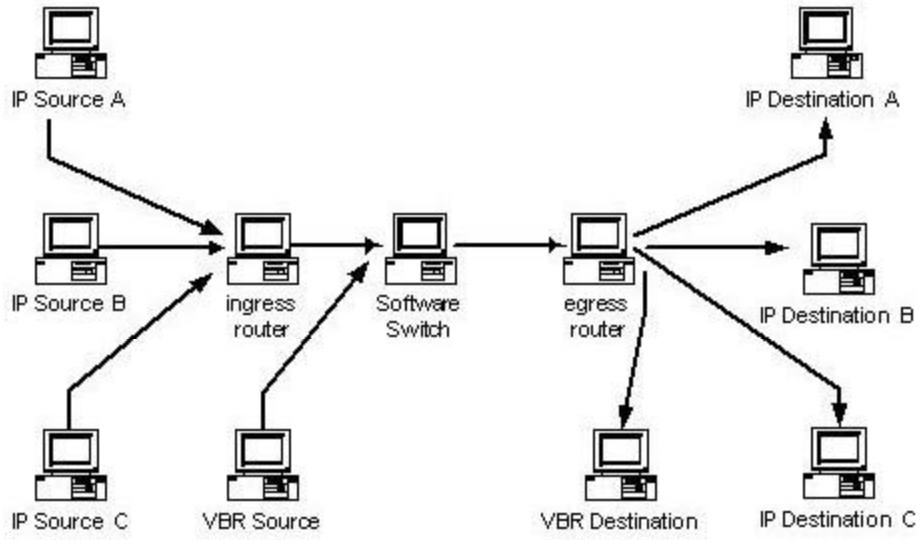
Motive: Throughput measurement when mapping DiffServ to VBR using software switch

Throughput when mapping DiffServ to VBR using software switch



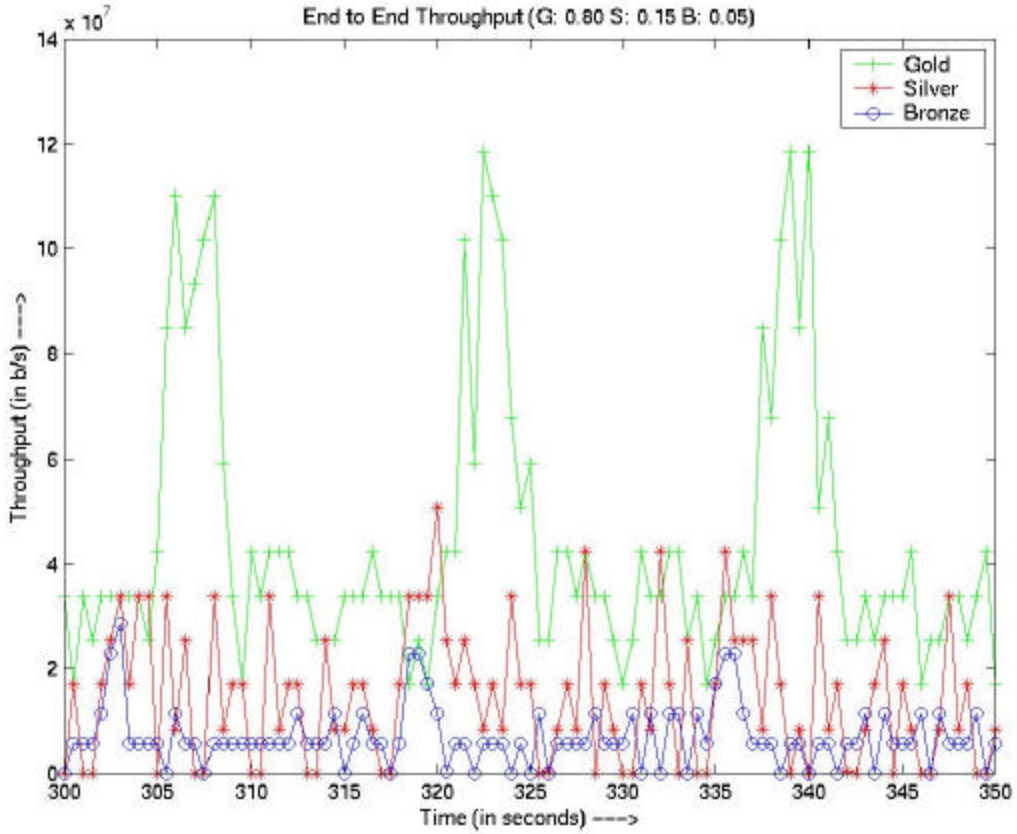
Share of Bandwidth – G:0.80 S: 0.15 B:0.05, SCR 353000 cells/s

Configuration 6



Motive: Throughput measurement when mapping DiffServ to VBR using software switch, in the presence of VBR background traffic

Throughput when mapping DiffServ to VBR using software switch, in the presence of VBR background traffic



Share of Bandwidth - G: 0.80 S:0.15 B:0.05, SCR:176500 cells/s

Comparision between mapping DiffServ to ABR and VBR

Link Utilization			
DiffServ mapping to ABR	DiffServ mapping to ABR with VBR background	DiffServ mapping to VBR using software switch	DiffServ mapping to VBR with VBR background using software switch
0.99	0.96	0.94	0.94

Link Utilization

	Standard Deviation of Network Jitter			
Gold's share of bandwidth	DiffServ mapping to ABR	DiffServ mapping to ABR with VBR background	DiffServ mapping to VBR	DiffServ mapping to VBR with VBR background
0.80	47.9 msec	637.0 msec	26.9 msec	169.3 msec
0.50	87.4 msec	734.8 msec	27.2 msec	221.6 msec
0.33	108.7 msec	1046.2 msec	26.9 msec	264.5 msec

Standard Deviation of Network Jitter for Gold

	Standard Deviation of Network Jitter			
Silver's share of bandwidth	DiffServ mapping to ABR	DiffServ mapping to ABR with VBR background	DiffServ mapping to VBR	DiffServ mapping to VBR with VBR background
0.33	106.6 msec	842.0 msec	38.4 msec	498.0 msec
0.30	118.0 msec	1041.5 msec	72.6 msec	445.8 msec
0.15	243.1 msec	1388.1 msec	75.2 msec	530.4 msec

Standard Deviation of Network Jitter for Silver

	Standard Deviation of Network Jitter			
Bronze's share of bandwidth	DiffServ mapping to ABR	DiffServ mapping to ABR with VBR background	DiffServ mapping to VBR	DiffServ mapping to VBR with VBR background
0.33	103.4 msec	881.4 msec	40.6 msec	281.5 msec
0.20	162.6 msec	993.8 msec	53.4 msec	980.3 msec
0.05	213.1 msec	1500.2 msec	337.3 msec	1903.2 msec

Standard Deviation of Network Jitter for Bronze

Conclusions

• End-to-end throughput of the different IP flows based on the weights assigned to the queues into which they are drained

• Existence of large IP datagrams in the low priority IP flow does not adversely affect the end-to-end throughput of higher priority flows

• Standard deviation of jitter is more when mapping DiffServ to ABR in the presence of VBR background traffic

Future Work

- Experiment with other schedulers
- Experiment with other VBR background traffic traces
- Higher MCR values must be tried when mapping DiffServ to ABR
- Interaction between TCP and UDP, mapping them to the same queue and to different queues