Performance of National Scale IP/ATM Networks: Results from the AAI

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Introduction

- Goals
  - » Determine performance of a national scale high performance network under controlled stress
  - » Evaluate efficacy of congestion controls
  - » AAI traffic flow characterization
  - » Evaluate the performance of terrestrial/satellite ATM internetworks
- Contributions
  - » NetSpec: A WAN performance evaluation tool
  - » Measurement of the performance of ATM WAN under stress
  - » Measurement of the performance of terrestrial/satellite ATM internetworks under stress with different transport protocols
  - » Collection and archival of ~two years of AAI traffic flow data
  - » A new model and performance methodology for ATM queues

Outline

- Objectives
- Performance Metrics
- Measurement Tools
- Network Topologies
- Network Functionality
- Traffic Scenarios
- Results
- Lesson Learned

Objectives

- Performance of TCP(UDP)/IP over ATM
  - » Terrestrial component of the AAI under controlled stress
  - » Terrestrial/satellite network under controlled stress
- Evaluate open loop control mechanisms and emulated ideal ABR
- Study the terrestrial/satellite performance with different TCP implementations

Performance Metrics

- Throughput
- Delay Jitter
- Segment Loss

Tools--NetSpec: A Tool for WAN Performance Measurements

- Multiple host network loading of a national scale network
- Automated experiment execution
- Reproducible experiments
- NetSpec experiment description language
- All AAI experiments required upon NetSpec

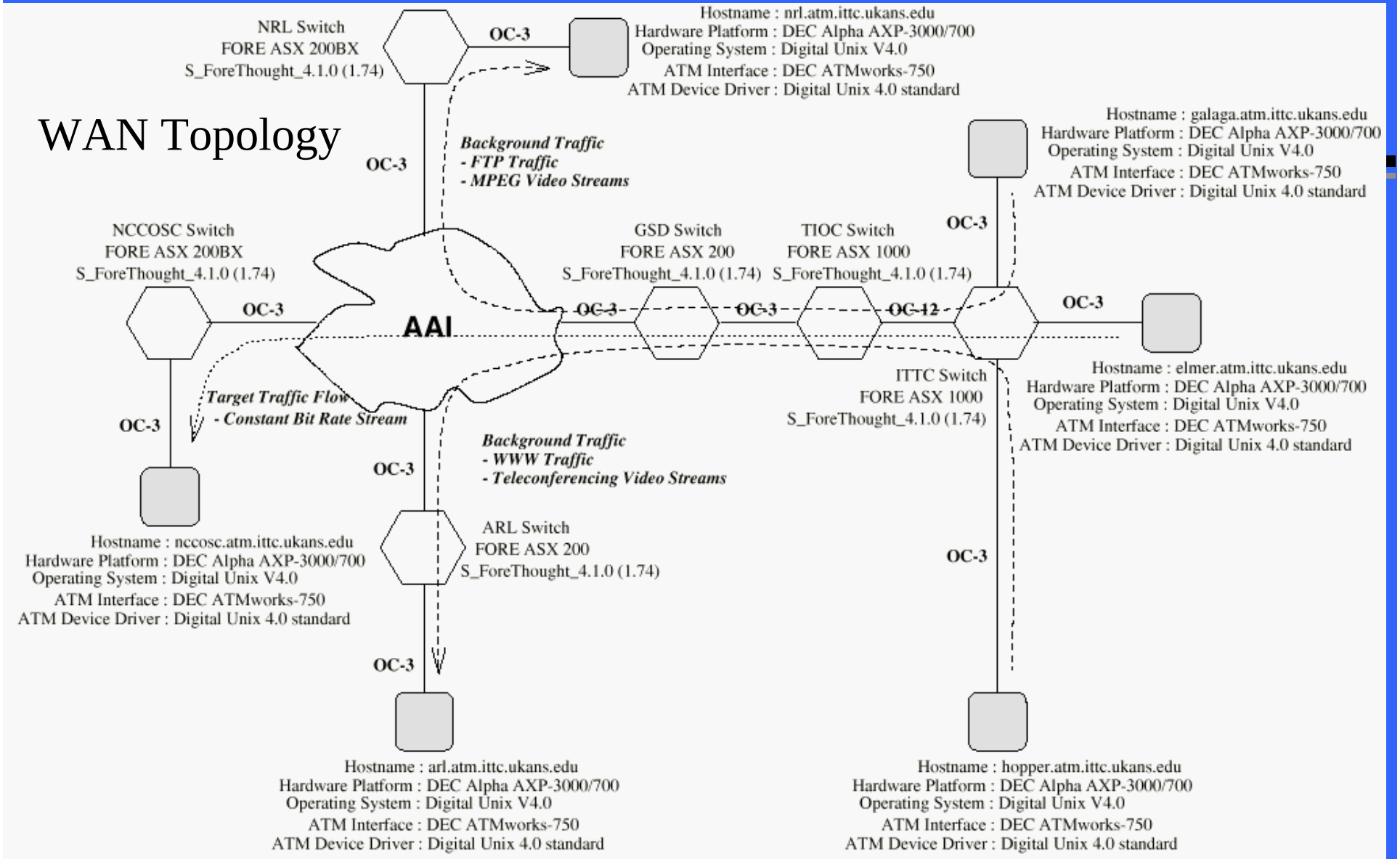
NetSpec: A Tool for WAN Performance Measurements

- Multiple Traffic Types
  - » Full speed (as fast as the source can transmit to the network)
  - » Constant Bit Rate, CBR (transmission of a periodic pattern of bursts)
  - » Random (transmission of a random pattern of bursts).
  - » Telnet
  - » FTP
  - » WWW
  - » Video
  - » Packet Audio

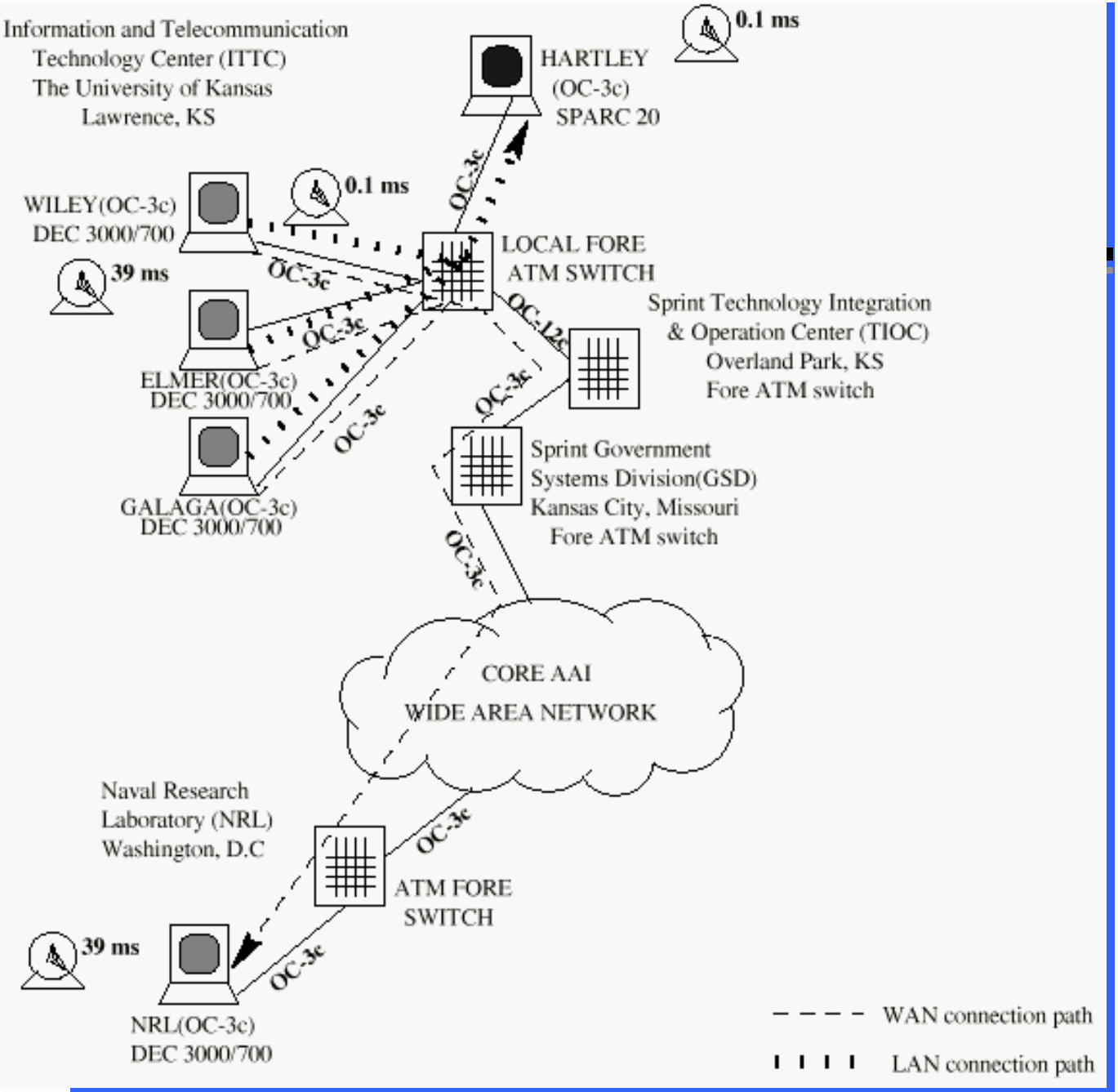
NetSpec Extensions: A Tool for WAN Performance Measurements

- SNMP
- Data steam kernal interface
- Call generation
- ATM Reference Traffic Source (ARTS)
- Corba performance object

WAN Topology



LAN and WAN Configuration with Congestion for the **LAN/WAN/Satellite** Study



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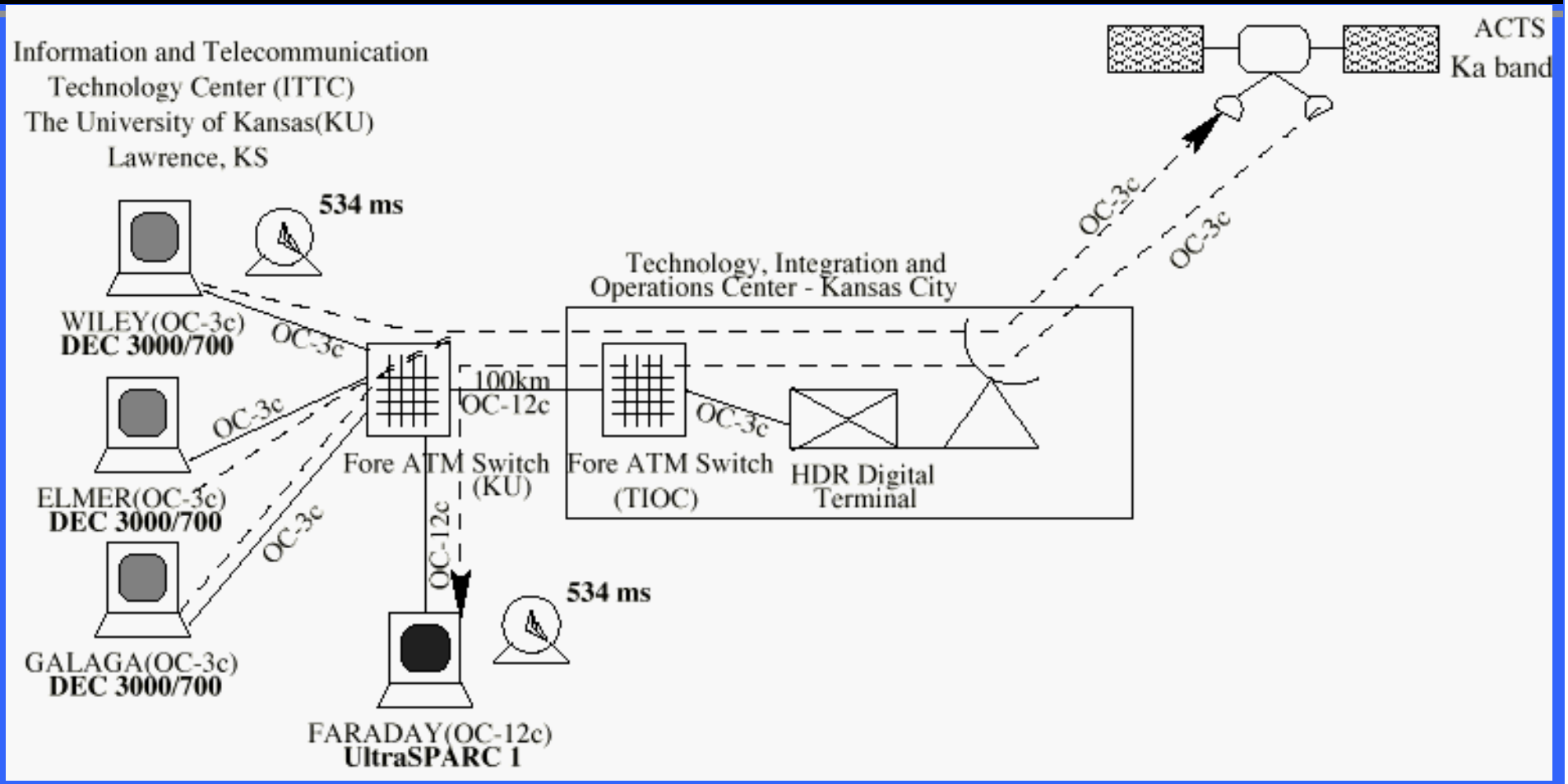
Terrestrial/Satellite ATM internetwork

Satellite

Configuration with Congestion



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Network Functionality

- No control
- User level traffic pacing of target flow
- ATM cell level of target flow
- ATM cell level of background flows
  Emulated ABR
- Edge/core network topology with edge early packet discard (EPD)
- TCP implementations
  - » TCP Reno
  - » TCP new Reno
  - » TCP Sack

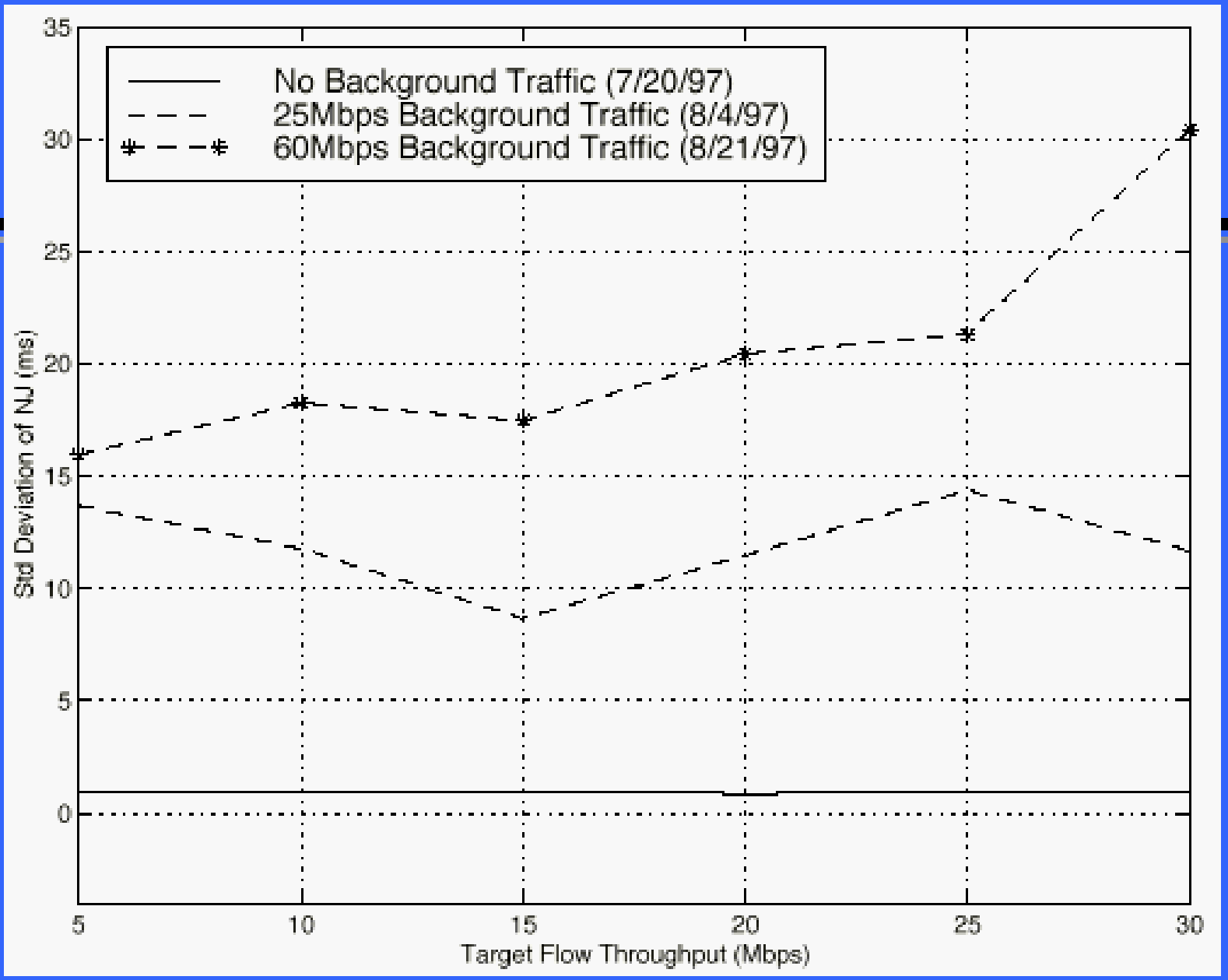
Target Flow	Blocksize (bytes)	Period (ms)	Rate (Mbps)
	9140	14	5.22
	18280	14	10.45
	27420	14	15.67
	36560	14	20.89
	45700	14	26.11
	54840	14	31.34
Background Traffic	Traffic Types	Mean Rate (Mbps)	Total (Mbps)
25Mbps	WWW	10	
	FTP	5	
	MPEG	5	
	Video Conference	5	25
60Mbps	WWW	30	
	FTP	10	
	MPEG	10	
	Video Conference	10	60

Traffic Scenarios: AAI Congestion Studies

Network Jitter for UDP Target Flows

AAI to ITTC

No Cell Pacing



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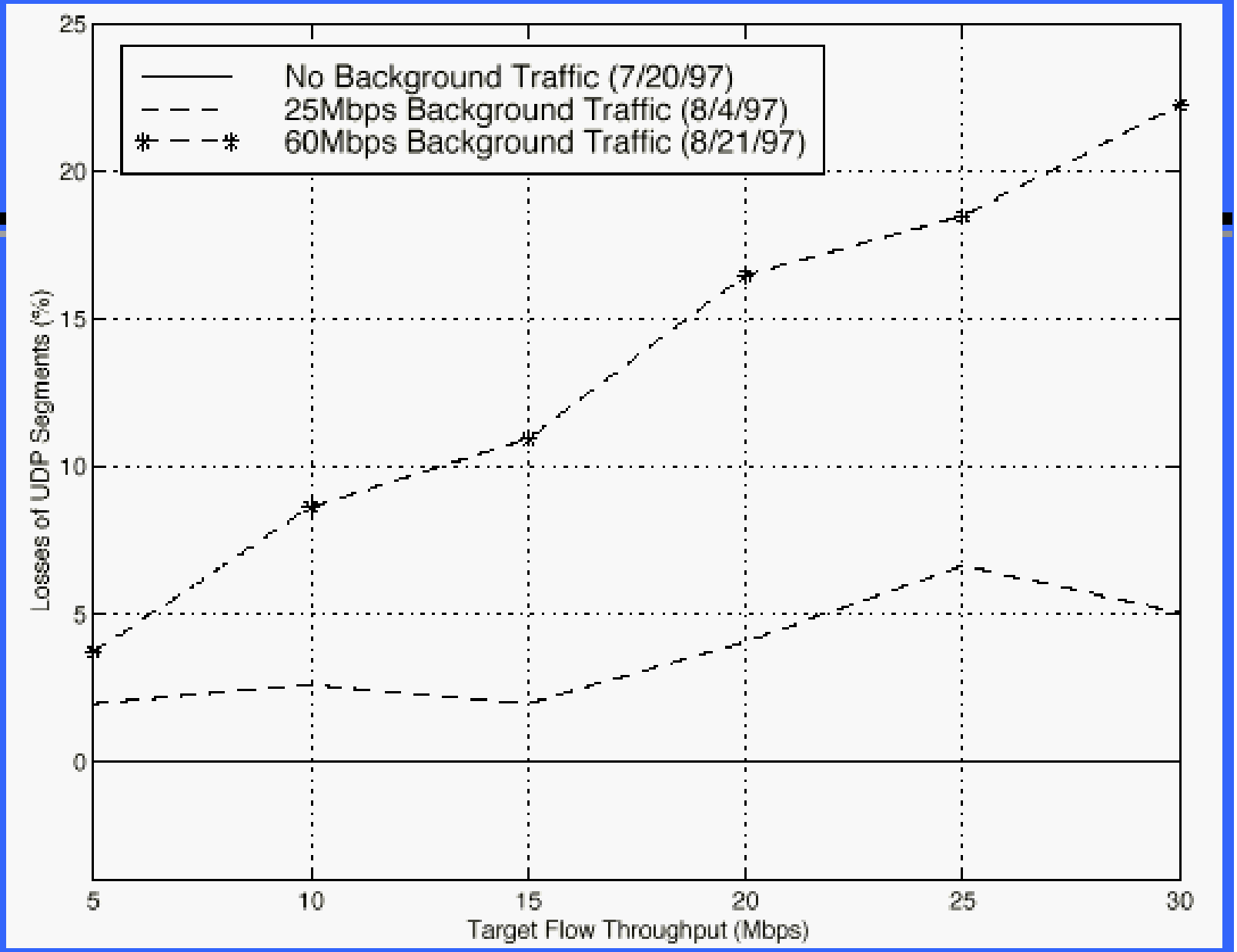
Segment loss for UDP Target Flows

AAI to ITTC

No Cell Pacing



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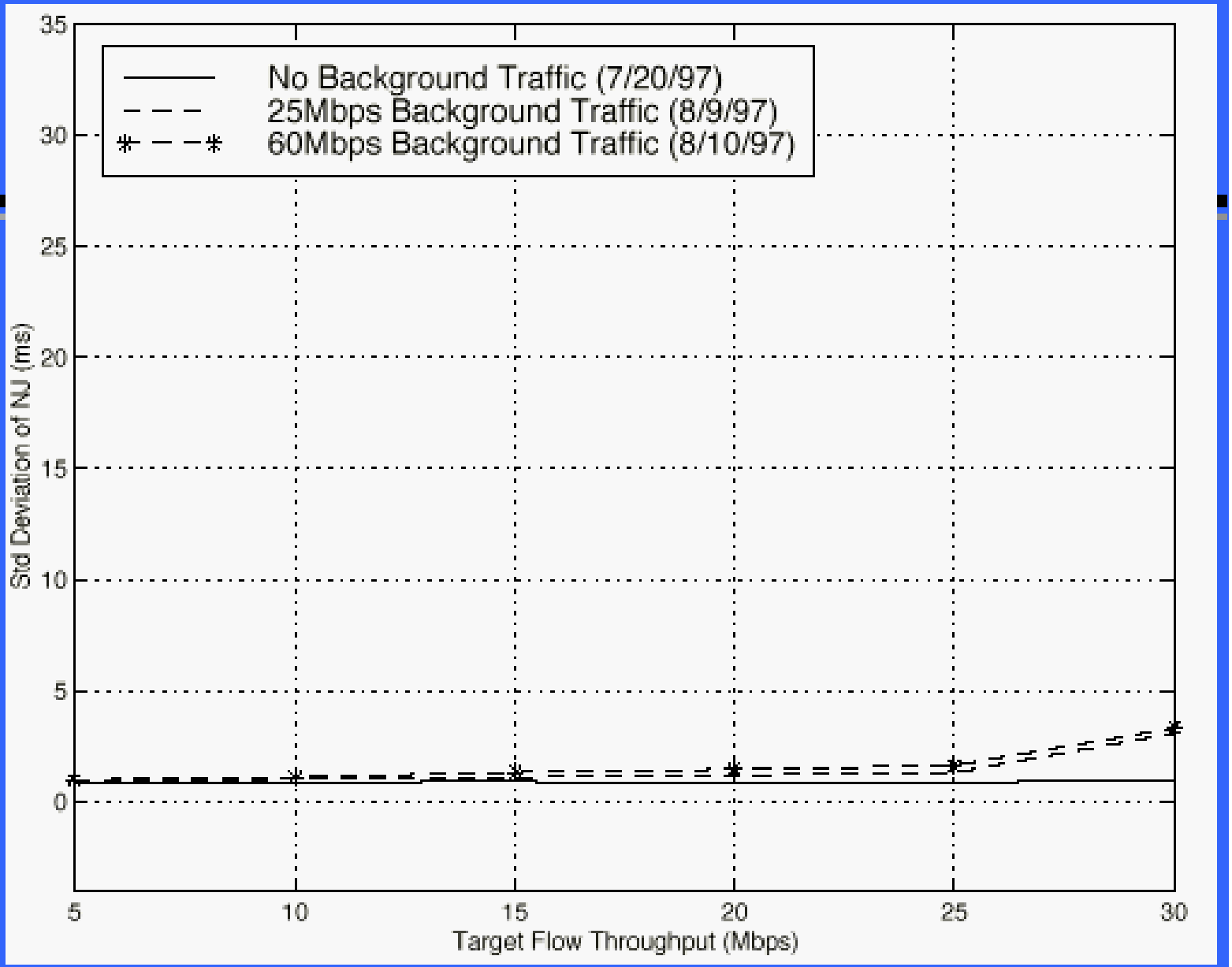
Emulated ABR

Network Jitter for UDP Target Flows

AAI to ITTC

With Cell Pacing



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Emulated ABR

Segment loss for UDP Target Flows

AAI to ITTC

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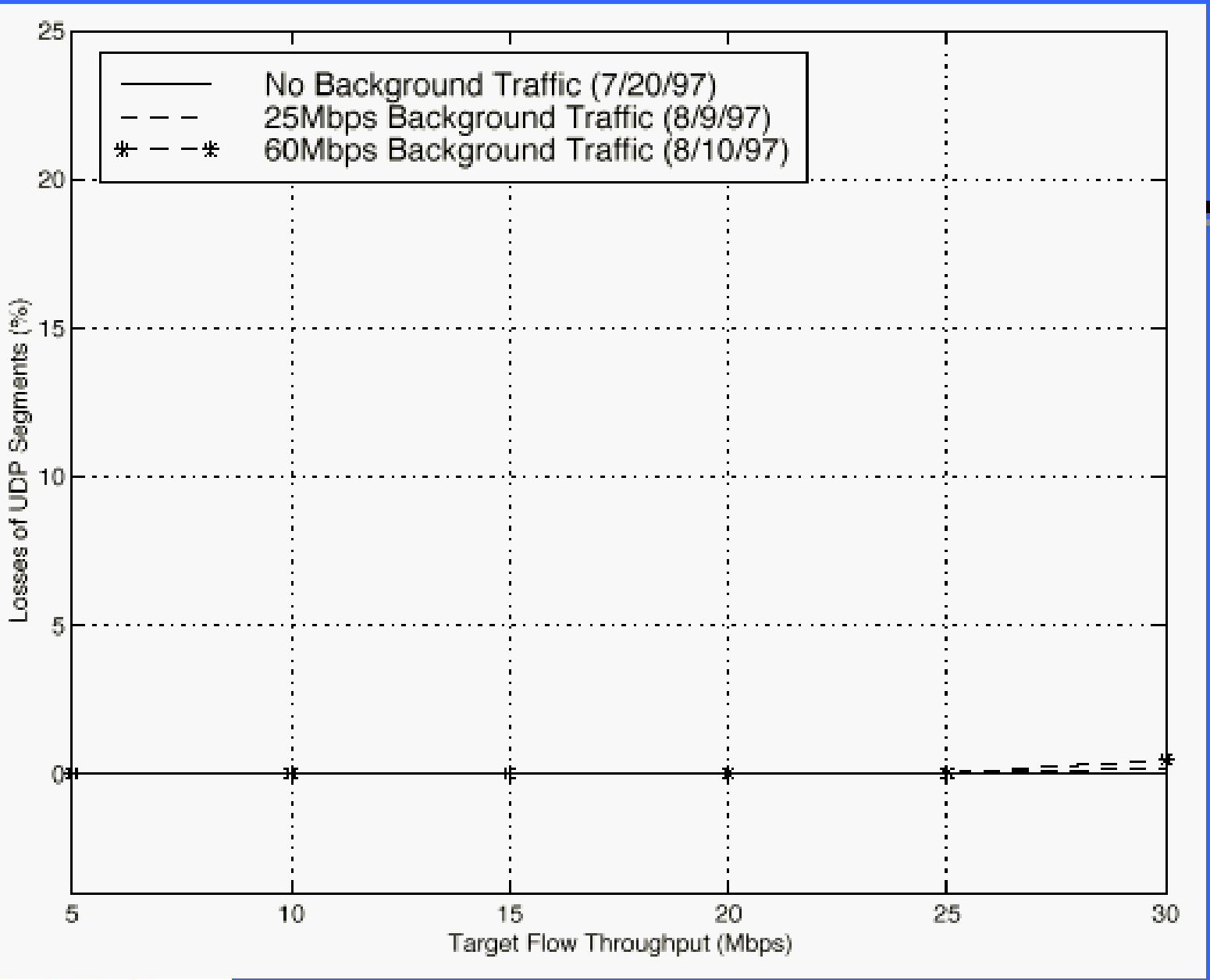
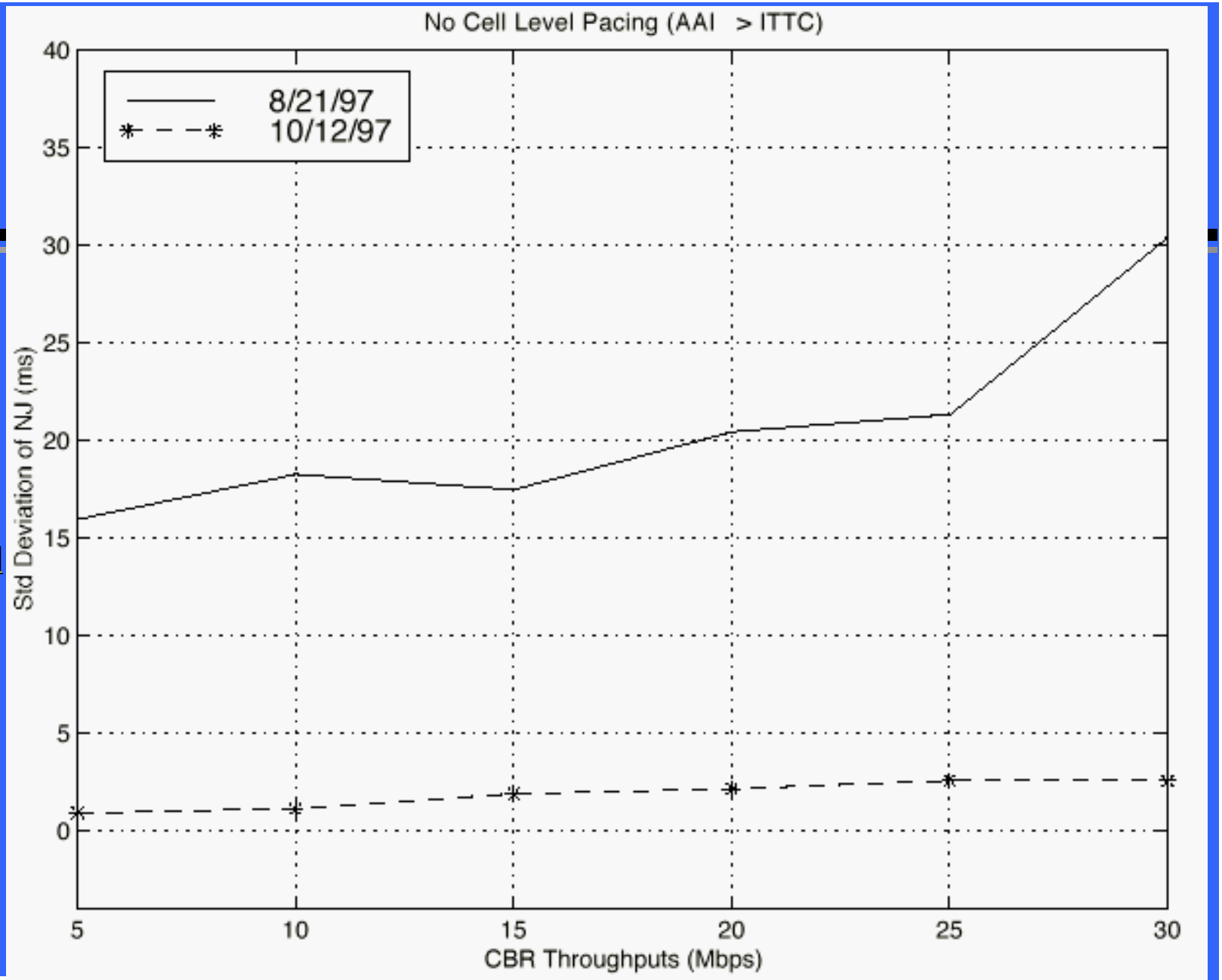


Impact of Transition to Edge/Core Network Architecture

- October 1997 the AAI 'cloud' network was upgraded to a edge/core network architecture
- Edge switches implemented Early Packet Discard (EPD)
- AAI VC's were changed from:
  VBR to UBR

60 Mb/s
WWW
Video
ftp
Background
Traffic



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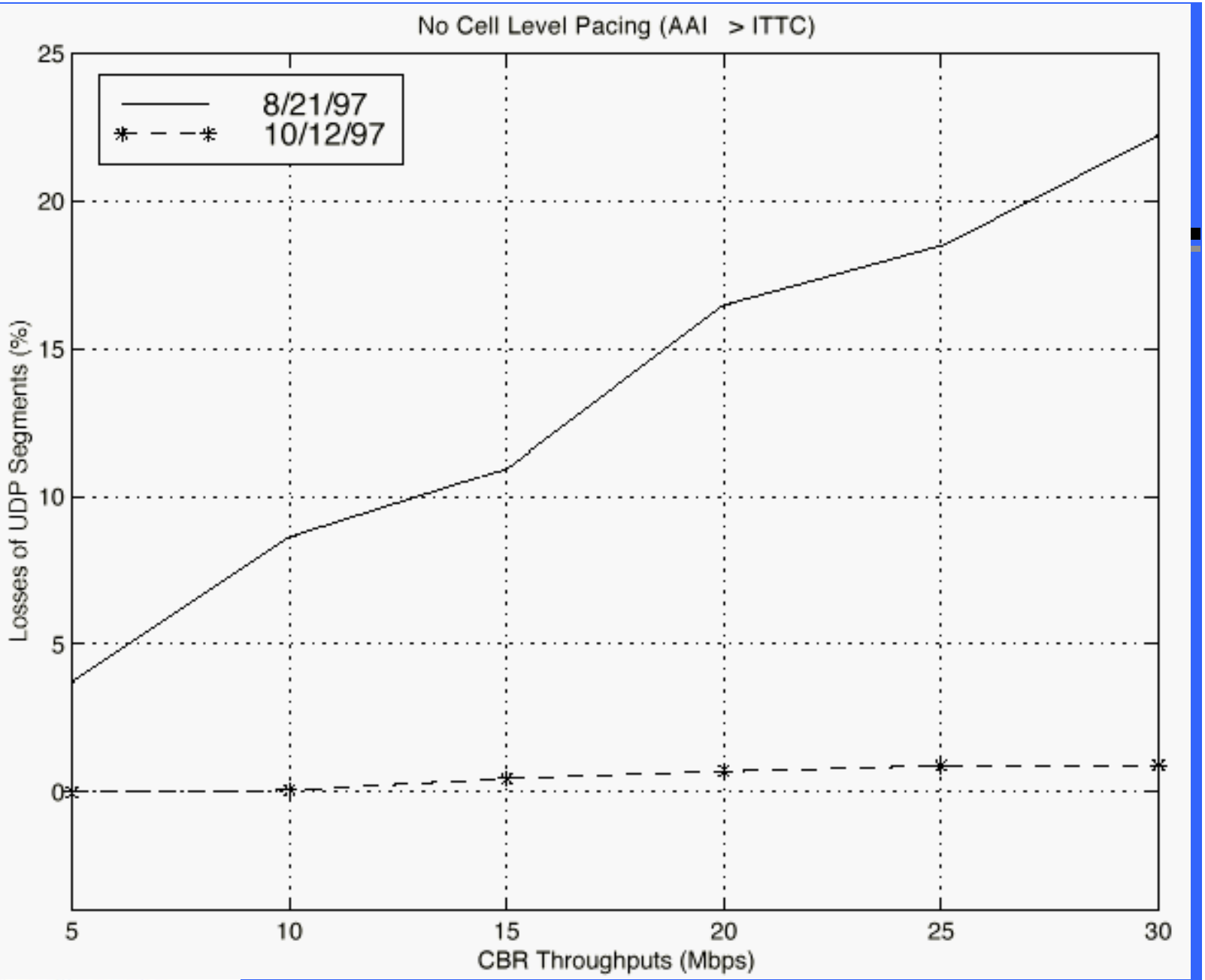
60 Mb/s
- WWW
- Video
- ftp

Background Traffic



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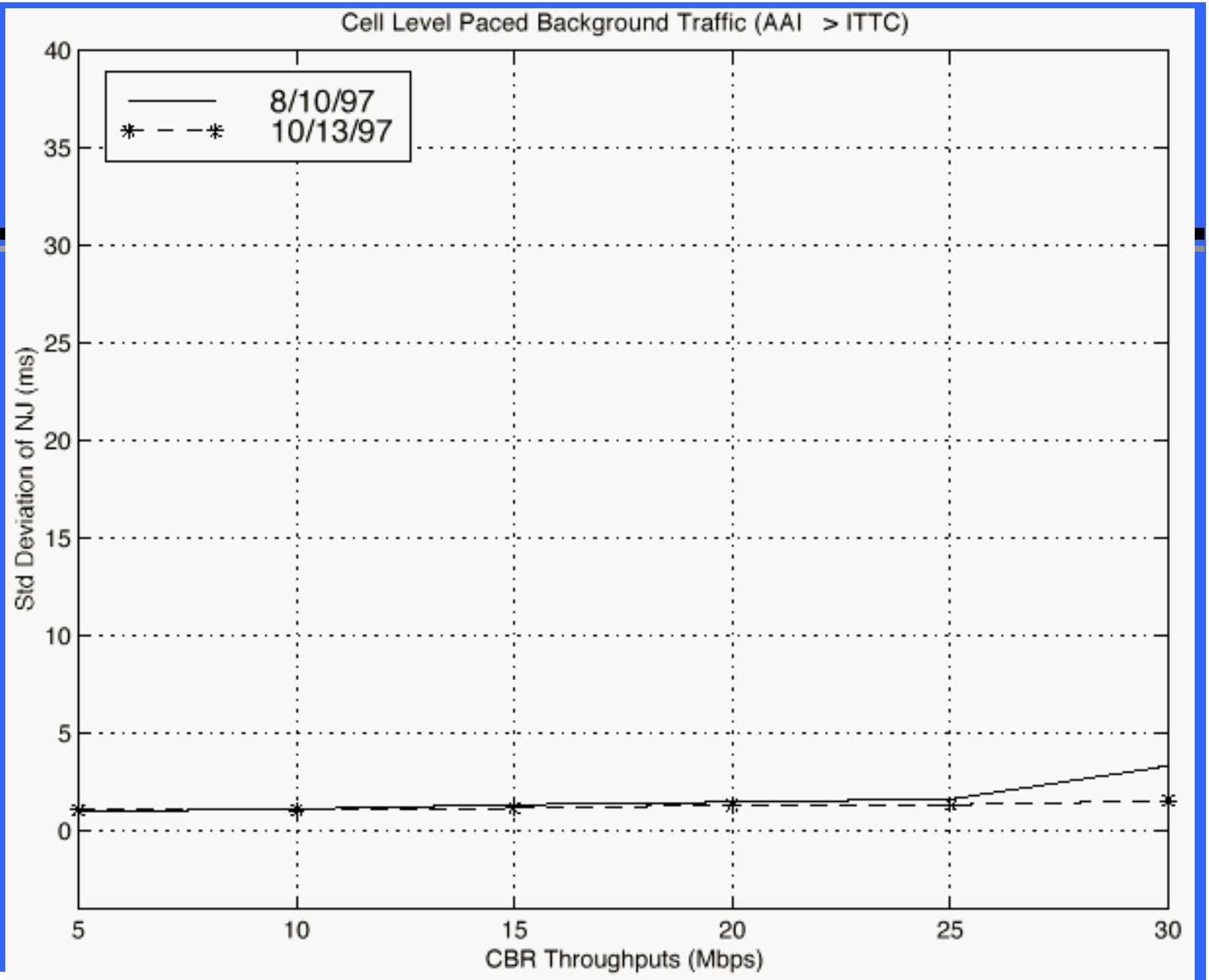

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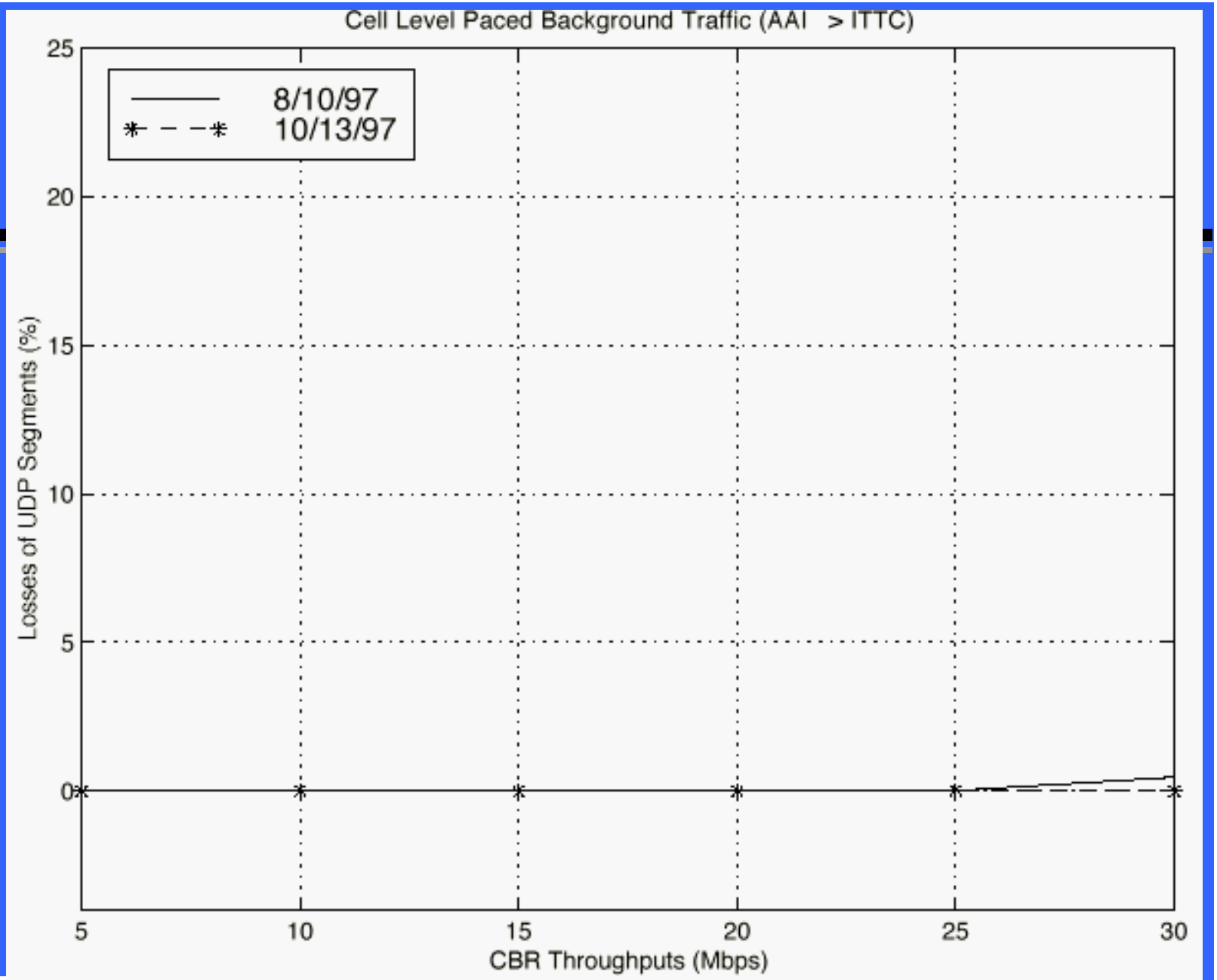
60 Mb/s
- WWW
- Video
- ftp

Background Traffic



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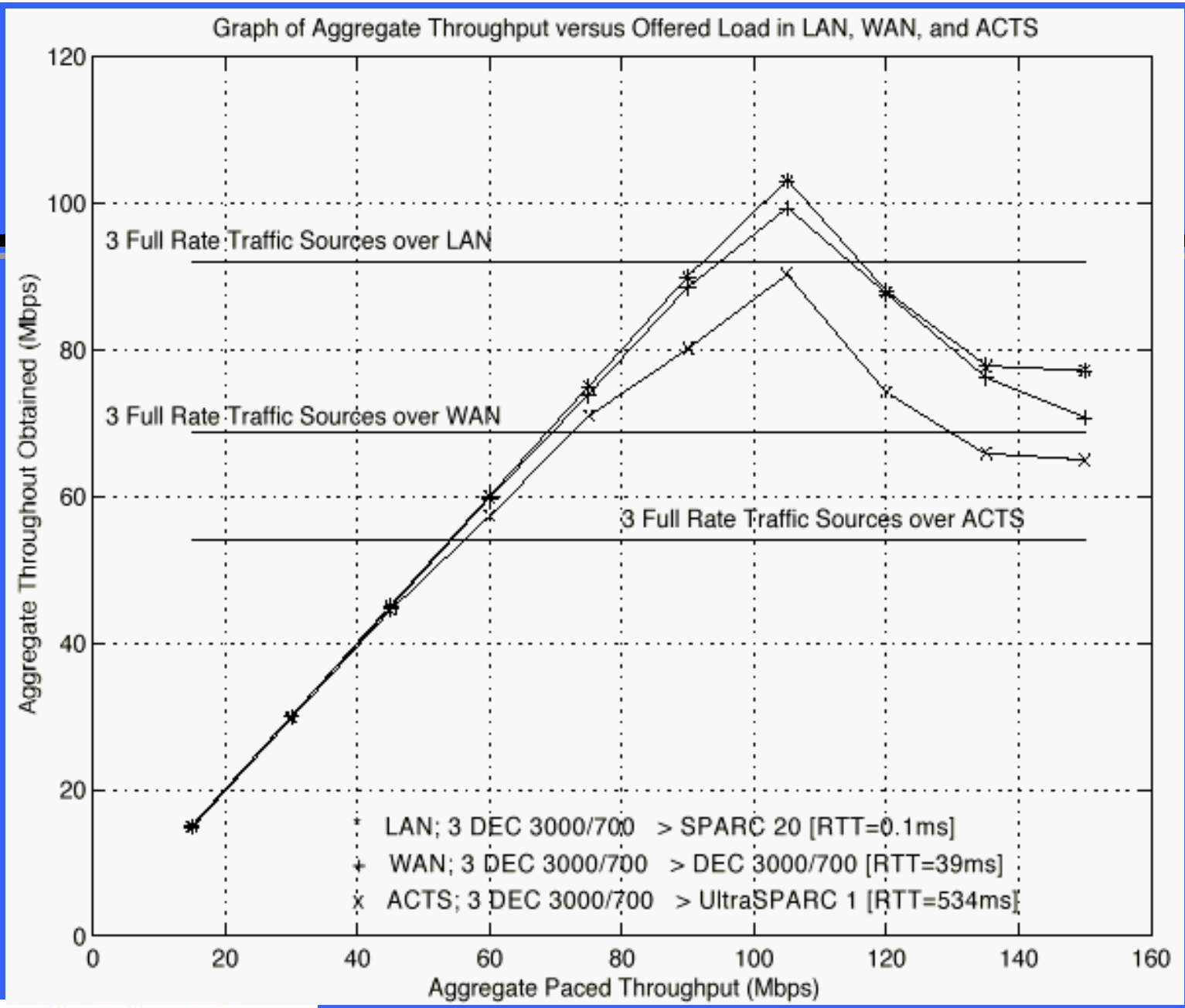
AAI WAN Measurements and Lessons Learned

- Poor network performance was observed without traffic flow control
- Performance can be highly asymmetric
- Emulated ABR was sufficient to overcome performance problems
- Change to edge/core with EPD was also sufficient to overcome performance problems

Terrestrial/Satellite ATM internetwork: Studies: Objectives

- Compare the performance of LAN, WAN, and Satellite TCP/IP over stressed ATM networks
- Determine how three TCP implementations, with different congestion control algorithms and different philosophies, perform over ATM over high data rate long distance networks, i.e. over high-bandwidth-delay-product networks.



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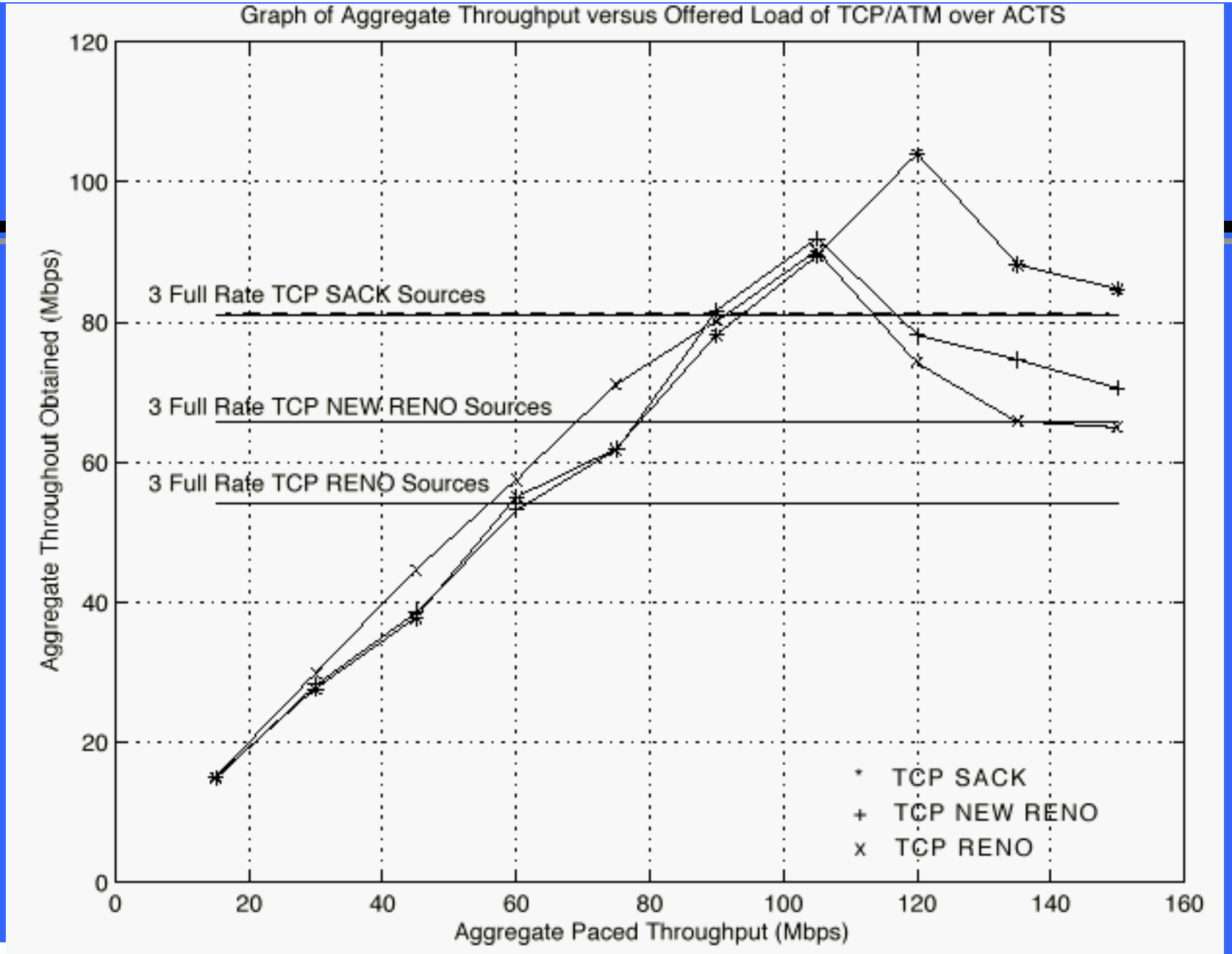
Graph of Aggregate Throughput versus Offered Load of TCP/ATM over ACTS
Aggregate Throughout Obtained (Mbps)
Aggregate Paced Throughput (Mbps)
3 Full Rate TCP SACK Sources
3 Full Rate TCP NEW RENO Sources
3 Full Rate TCP RENO Sources
TCP SACK
TCP NEW RENO
TCP RENO
0
20
40
60
80
100
120
140
160

Terrestrial/Satellite ATM internetwork: Lessons Learned

- Different enhancements on TCP can achieve high performance over GEO systems.
- Throughput results for TCP/IP hosts on ATM/SONET networks over LANs, WANs and satellite environments with very low BER and high speed channels (like ACTS) are similar
- In cases with high speed satellite links with high BER or when congestion is present, the throughput obtained by TCP Reno end systems will be degraded,
- Need to consider fairness between TCP implementations as well as throughput and channel utilization