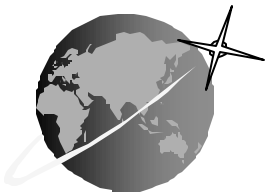

ATM and the Internet Over Satellite Networks

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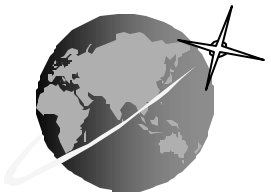

ATM and Internet Via Satellite

- **ATM Via Satellite: Key Challenges**
- **ATM Over (Point-to-point) Satellite Links**
- **Internet Over (Point-to-point) Satellite Links**
- **ATM/Internet Satellite Mesh Networks**
- **Conclusions**

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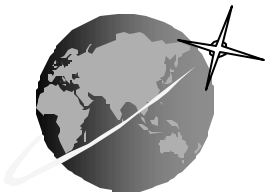
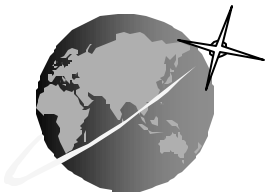
ATM Via Satellite: Key Challenges

- **Providing Fiber-like Quality (Cell Loss Ratio and Cell Error Ratio)**
  - ✦ Time-varying bit error rates and bit error distribution
- **Effect on Throughput Performance due to Geosynchronous Satellite Delay**
  - ✦ ATM Traffic Management, Congestion Control
  - ✦ End-to-end protocols, e.g., TCP
- **Efficient Bandwidth Use**
  - ✦ ATM and other ATM related protocols (such as ATM speech) are not bandwidth efficient
  - ✦ Satellite resources are relatively expensive
  - ✦ Dynamic Bandwidth-on-Demand Concepts
- **Meeting Cell Delay Variation QoS Requirements**
  - ✦ Satellite TDMA framing can result in unacceptable cell delay variation



Seamless Integration of Satellite and Terrestrial Networks

- Satellite link transparent to the end user
- Service provisioning in a cost-efficient manner



Steps for Achieving Seamless Integration

- Modify existing standards
- Develop new standards
- New Satcom interfaces
- New satellite networks

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Service Specific Connection Oriented Protocol (SSCOP)

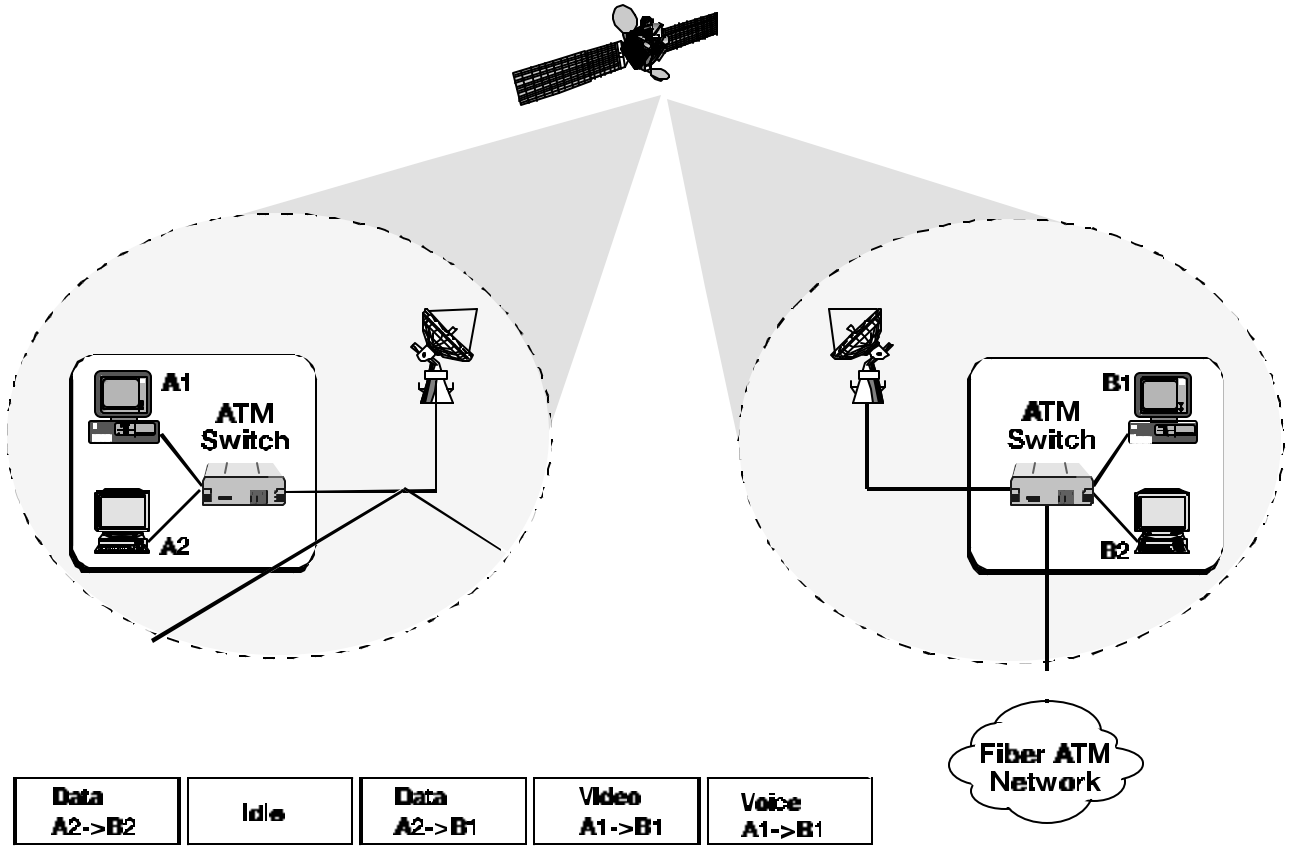
- SSCOP is the basic protocol for error recovery in ATM
- Very efficient over satellite links even at gigabits per second

Communications and Interoperability Section/TR 34.1

Major Accomplishments

- **Established a liaison with ATM Forum Wireless ATM Group for the joint development of satellite ATM network architectures, protocols, mobility standards**
- **Worked closely with Internet Engineering Task Force (IETF) for internet protocols to work well over satellite**
  - ✦ TCPSAT Group has been established
- **ATM traffic management (TM 4.0)**
  - ✦ Modifications to accommodate satellite delay were approved by ATM Forum
- **ATM speech**
  - ✦ Worked with ATM Forum to develop ATM speech standards to be bandwidth efficient
- **Common air interface for satellite systems**
  - ✦ Standardize common air interfaces for a range of satellite systems from satellite personal communications systems to broadband satellite systems

Asynchronous Transfer Mode (ATM) over Satellite



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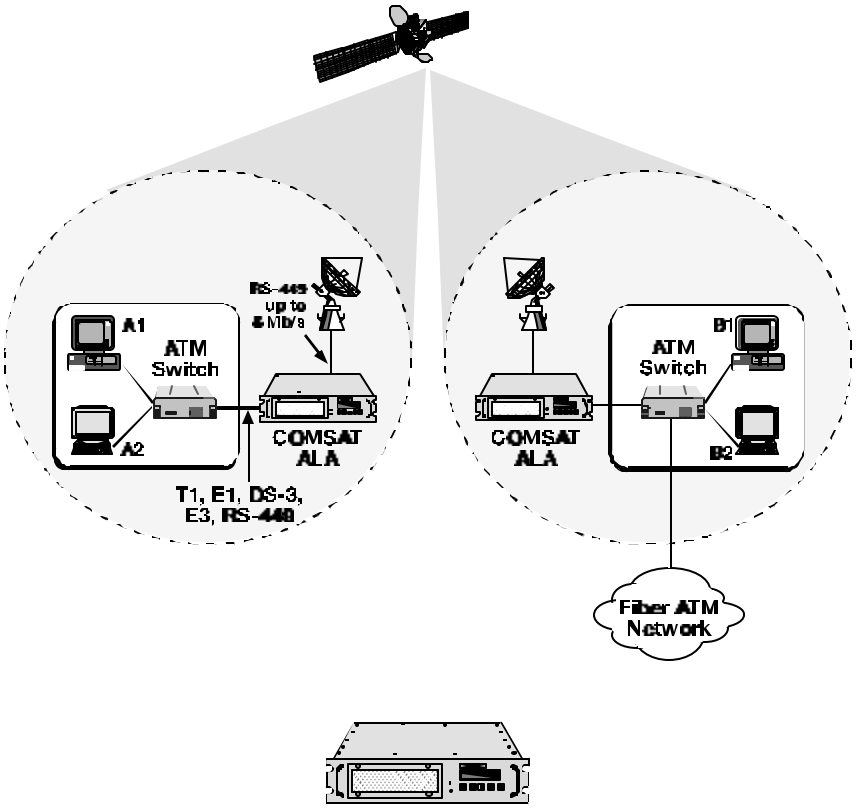
COMSAT ATM Link Accelerator - ALA



- **Provides fiber-like quality over satellite links for ATM traffic**
- **Improved BER (10-9 or better), very low cell loss ratio**
  - ✦ **Cell header and payload protected using powerful FEC codes**
  - ✦ **Adaptive FEC to maximize bandwidth utilization**
    - ■ **FEC overhead 0% to 8%, depending on link quality**
    - ■ **Idle cells stripped off**
  - ✦ **Interleaving to combat burst errors**
    - ■ **Can correct up to 72 octet burst errors**
- **Prioritized traffic management**
  - ✦ **High priority, low jitter for CBR and VBR traffic (e.g., video)**
  - ✦ **Low priority, large buffers for ABR traffic (e.g., LAN data)**
- **Lossless data compression for ABR traffic on selected VCs**
  - ✦ **Can double effective throughput**
- **Selectable T1, E1, DS-3, E3, RS-449 ATM interface**
- **Satellite interface up to 8 Mb/s**

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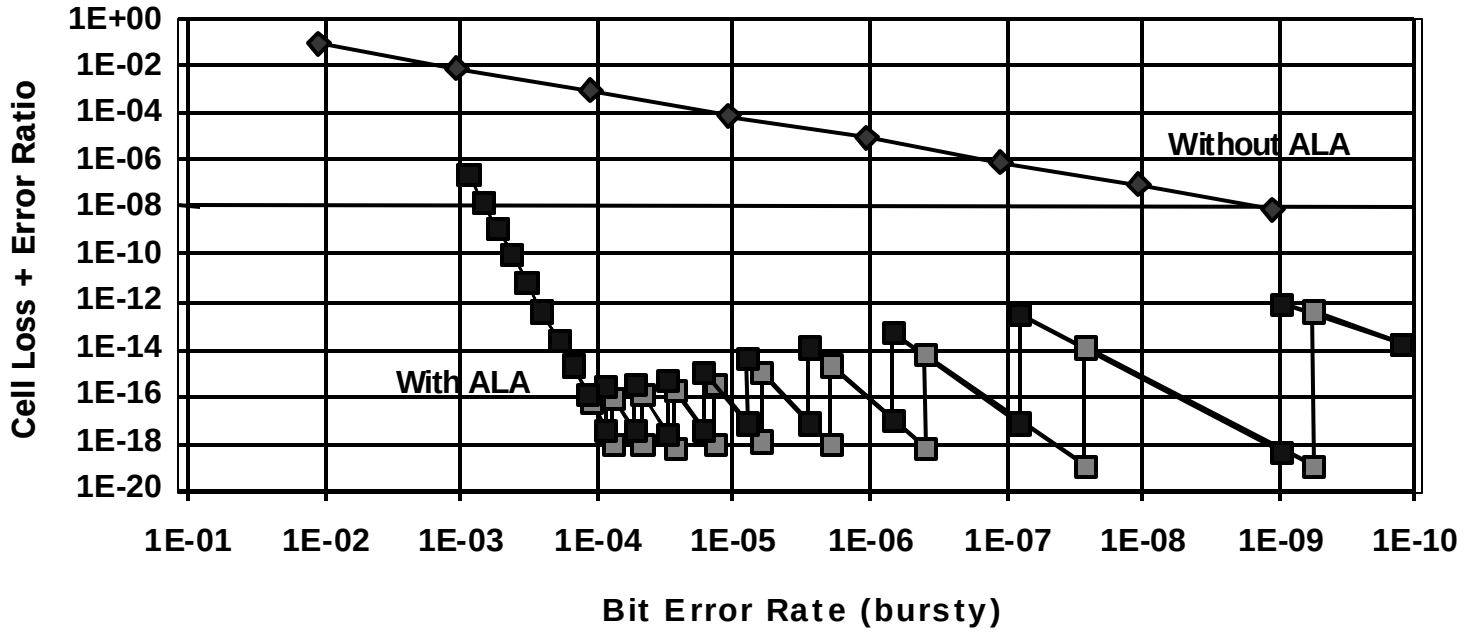
CLA-2000/ATM Performance v/s BER



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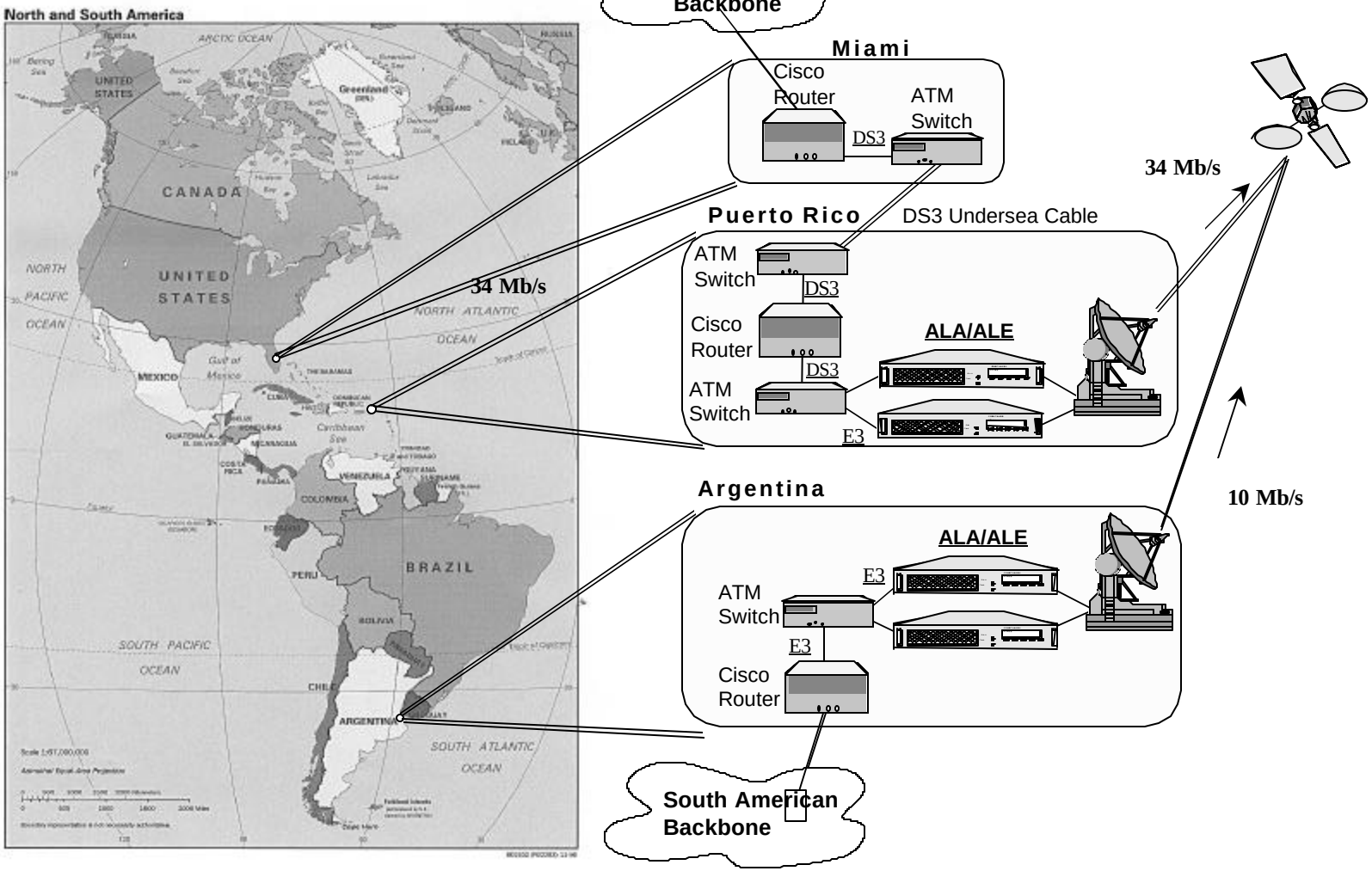
Example Operational Network



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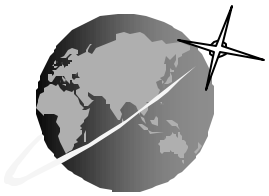
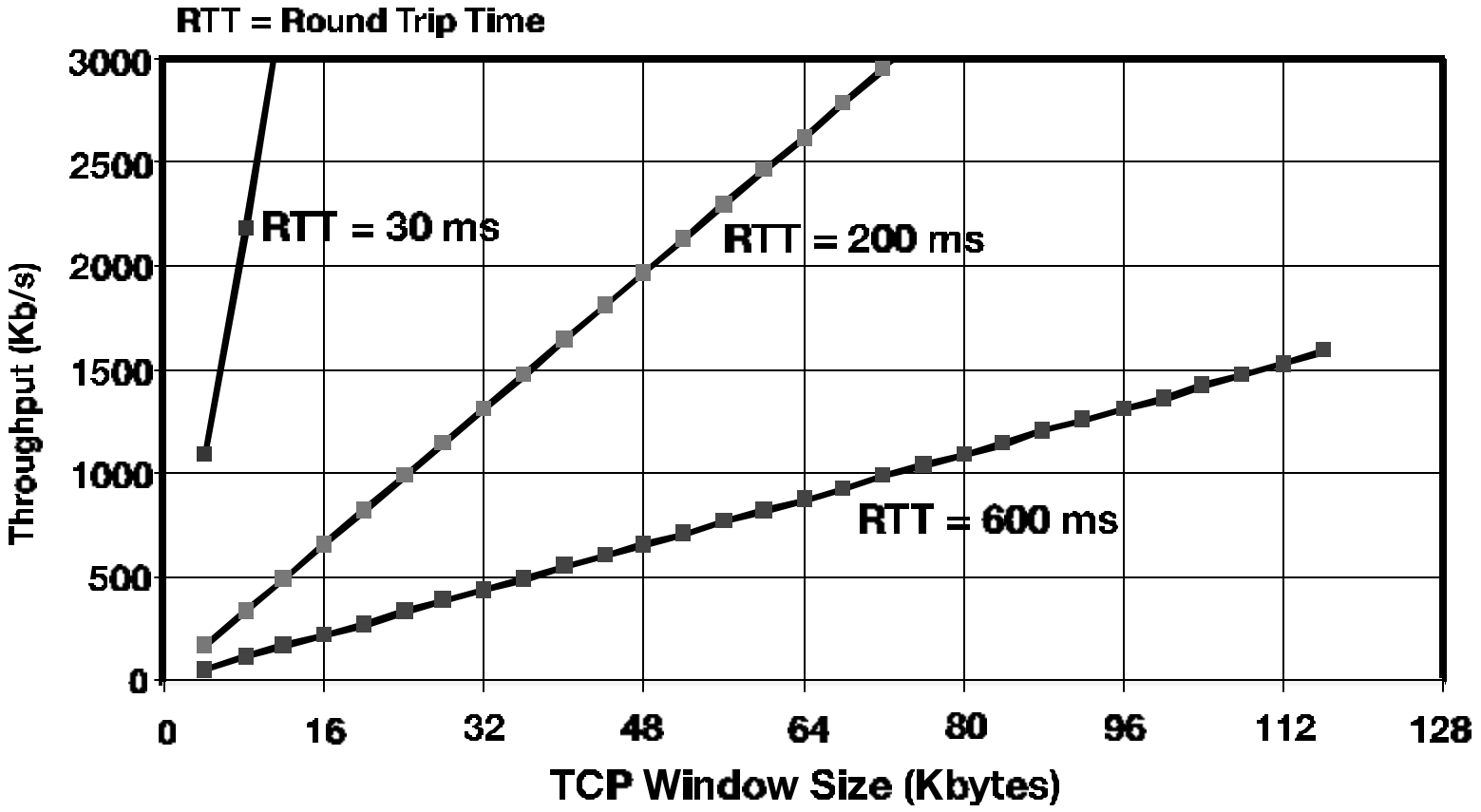


TCP/IP Issues for Satellite Networks

- TCP window size
- Buffer requirements at end nodes and routers
- Slow start
- Effect of bit errors
- Retransmission strategy
- Congestion control strategy
- Queue management

Maximum Throughput for Single TCP Connection as a Function of Window Size



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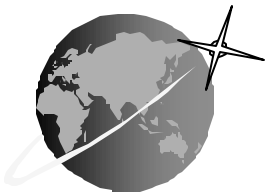

Current Work on TCP Enhancements

- **Random Early Discard (RED) scheme**
- **Selective Ack (SACK)**
- **Fast retransmit recovery enhancements**
- **Slow start enhancements**

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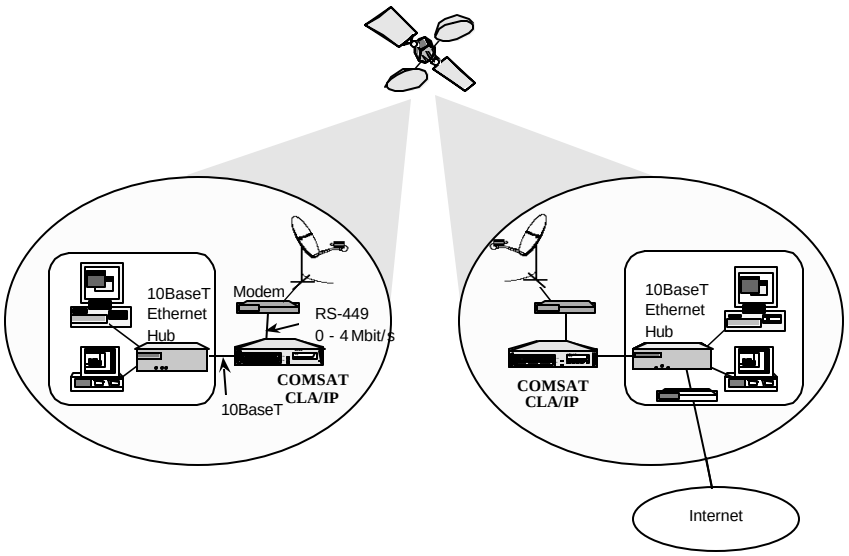
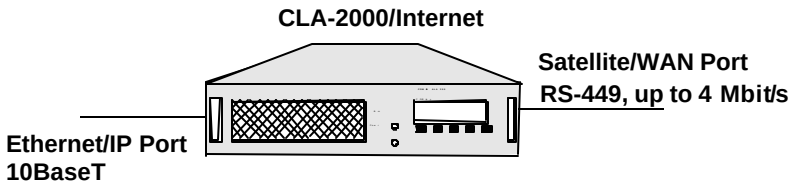
COMSAT Link Accelerator/ Internet - CLA-2000/Internet



- **IP Routing over satellite and wireless links**
- **Provides fiber-like quality over satellite links**
- **Improved BER (10-11 or better)**
  - **Packets protected using powerful Reed-Solomon coding**
  - **Interleaving to combat burst errors**
    - **Can correct 640 bit burst error**
- **Bandwidth Expansion**
  - **Adaptive Coding based on Measured Error rate**
  - **Reed-Solomon coding overhead 0% - 7%**
- **Lossless Data Compression Option**
  - **2:1 compression ratio typical**
  - **Up to T1 link rate**
- **RED Queue Management**
- **TCP Proxy (Spoofing)**
- **Satellite Interface, RS449, up to 4 Mbit/s symmetric**
- **Support for asymmetric rate links, low-speed links**



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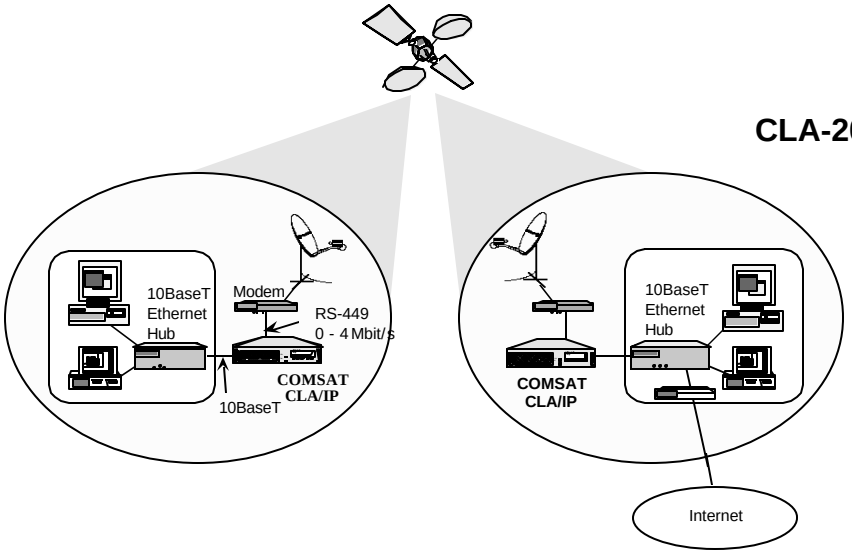
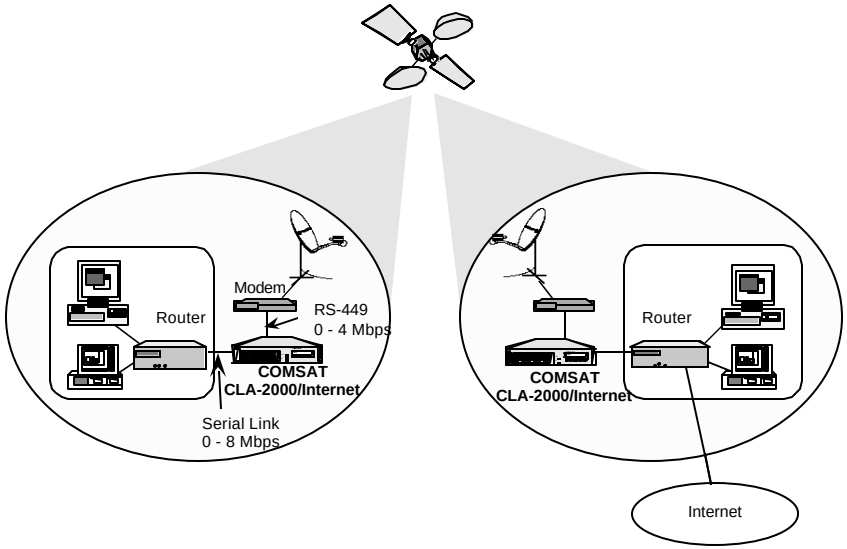
CLA-2000/Internet Usage

CLA-2000/Internet as Router using Ethernet



CLA-2000/Internet as Transparent Frame Processor using Serial Port



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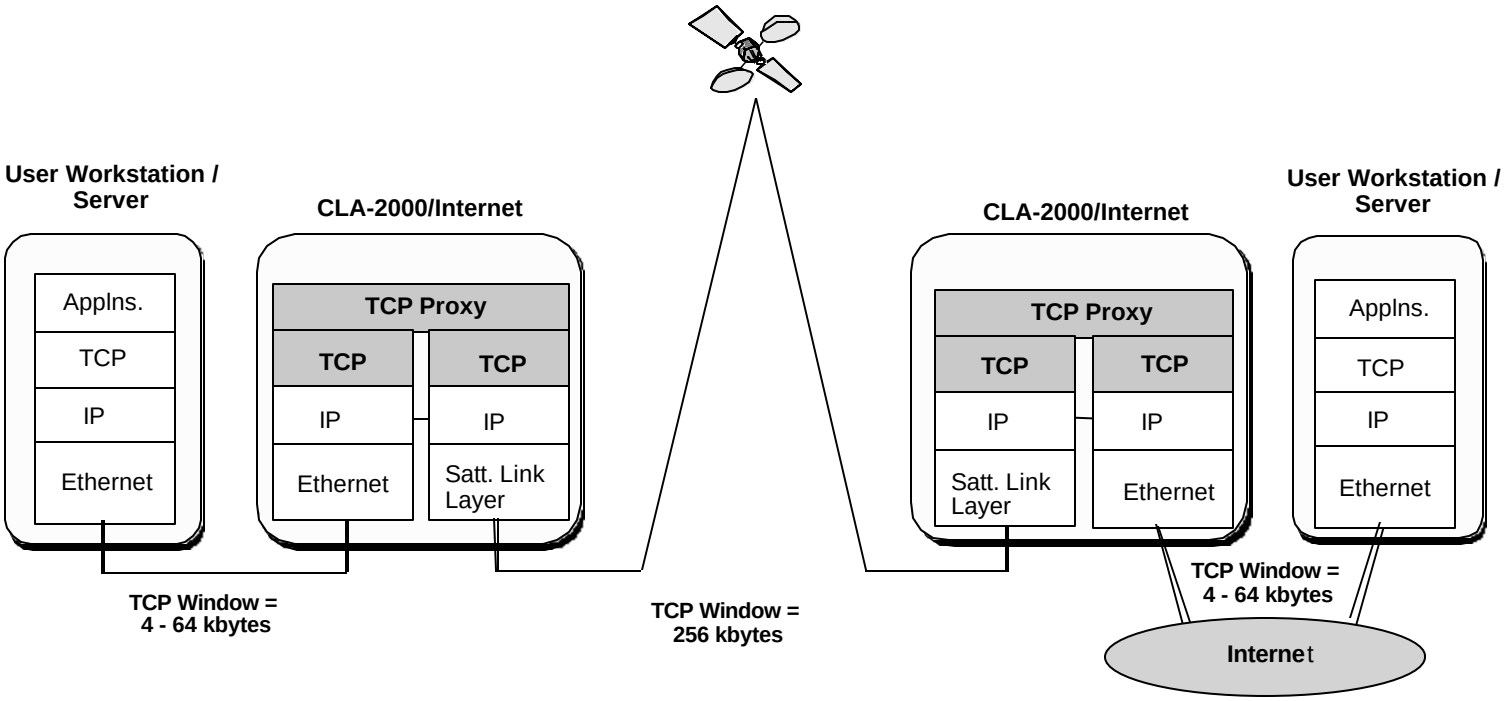
CLA/Internet TCP-Proxy Overview



Most PCs, workstations use TCP window size of 8 - 24 kbytes
Limits throughput per connection over geo satellites to 128 - 384 kbps
Max. TCP window size allowed = 64 kbytes (RFC 1323 enhancements allow larger sizes)

TCP Proxy enables full link rate throughput per connection
CLA-2000/IP uses TCP with large windows over satellite segment (RFC 1323)
Connection set-up/tear-down not spoofed

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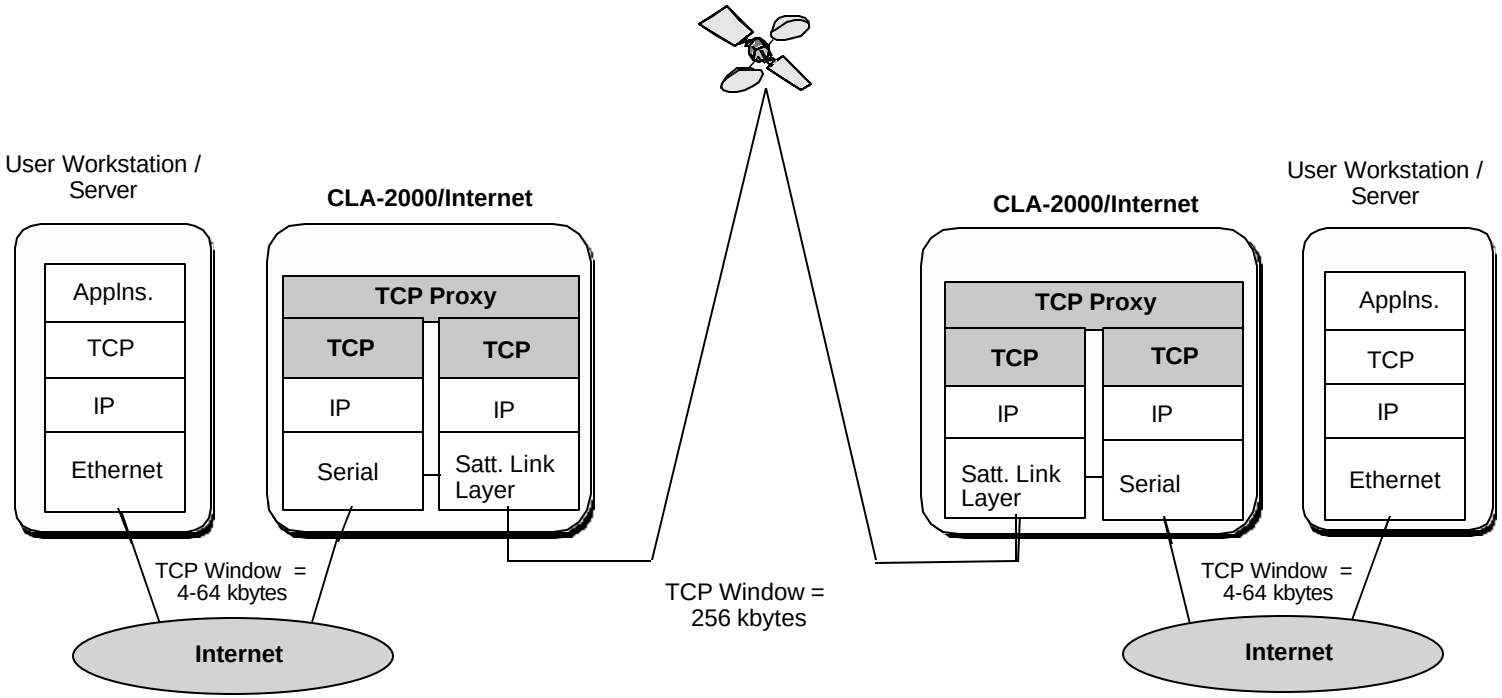
CLA/Internet TCP-Proxy Overview



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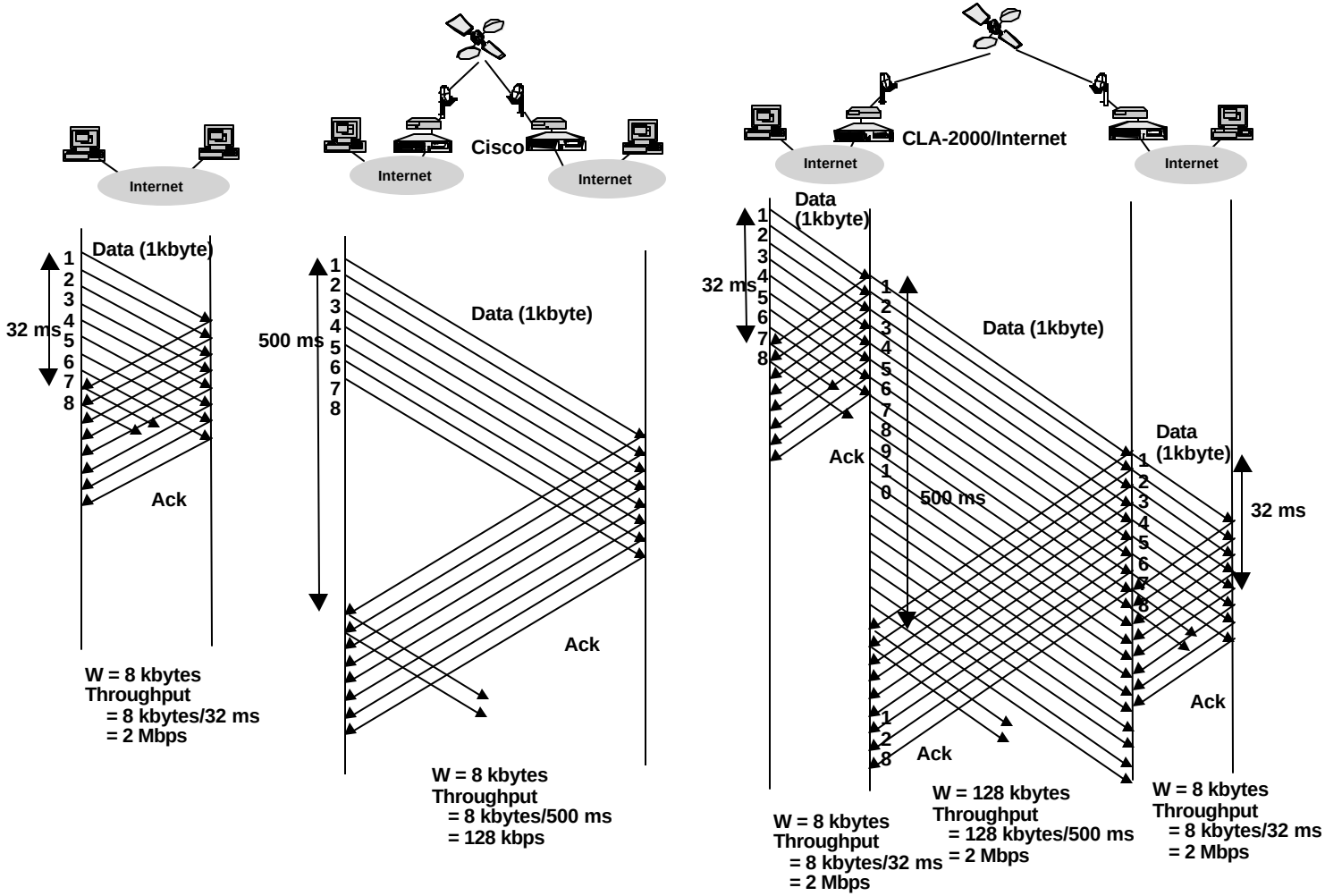
CLA/Internet TCP-Proxy Mechanism



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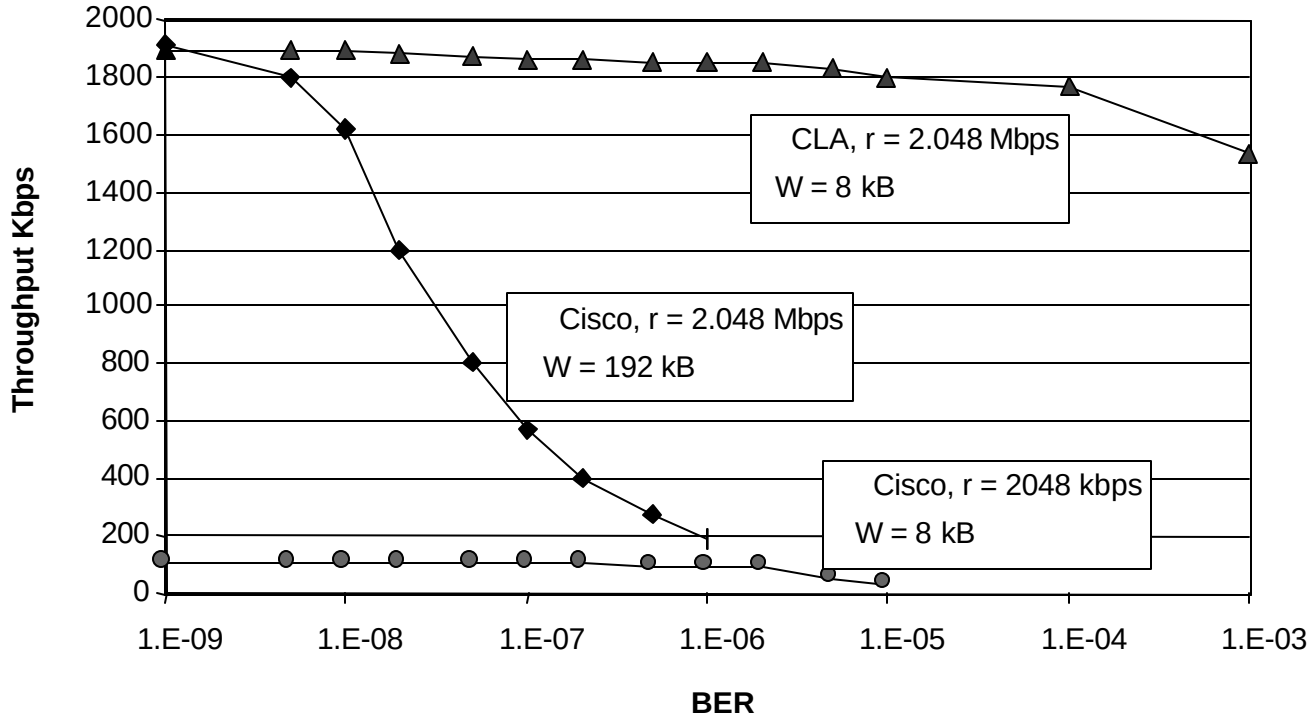
CLA/Internet Single TCP Connection Performance



Single Connection, Large Data Transfer (20 - 40 min)
Sun Solaris 2.6
One-way Delay=250 ms

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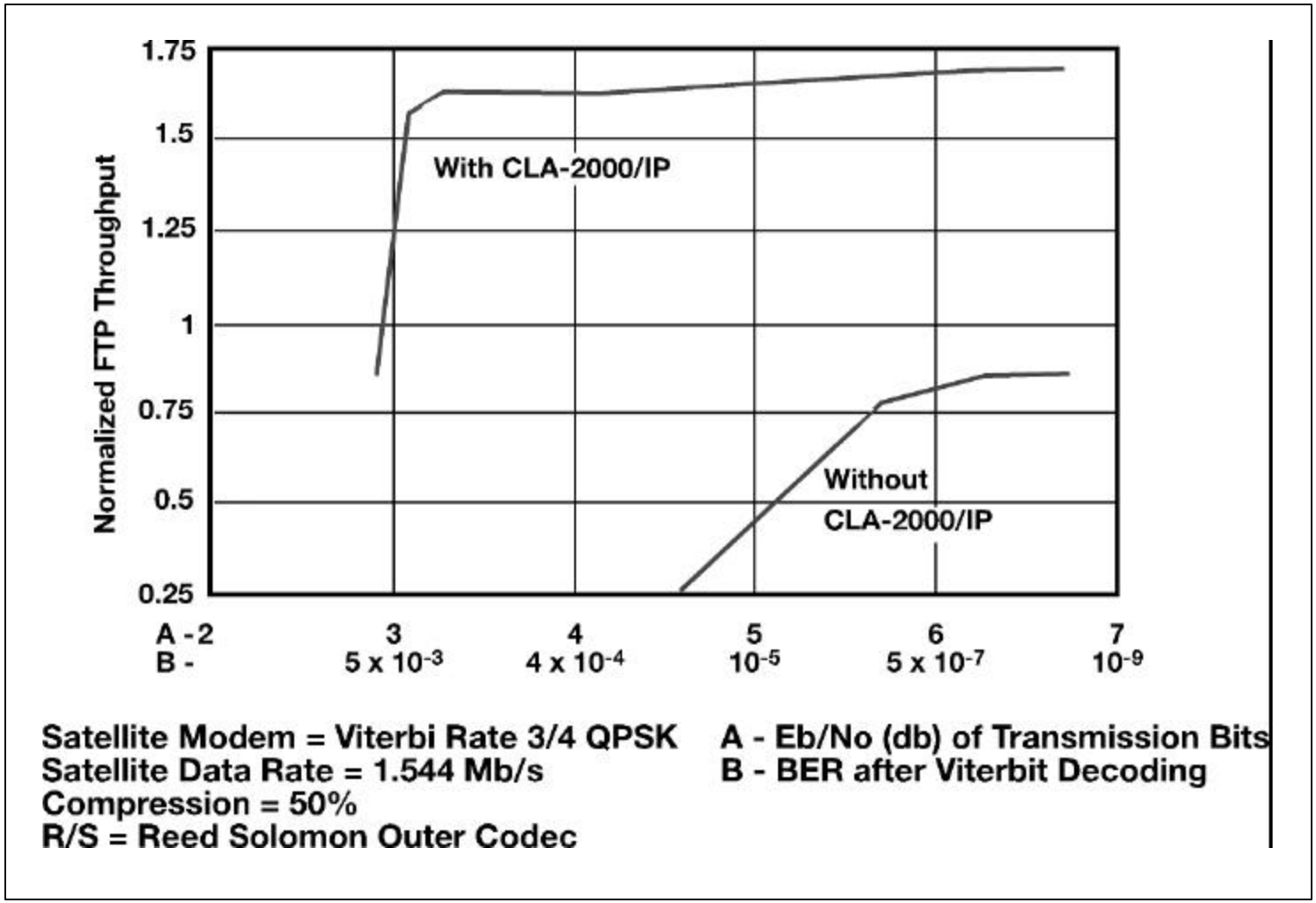
CLA-2000/IP Performance



Satellite Modem = Viterbi Rate 3/4 QPSK
Satellite Data Rate = 1.544 Mb/s
Compression = 50%
R/S = Reed Solomon Outer Codec

A - Eb/No (db) of Transmission Bits
B - BER after Viterbit Decoding

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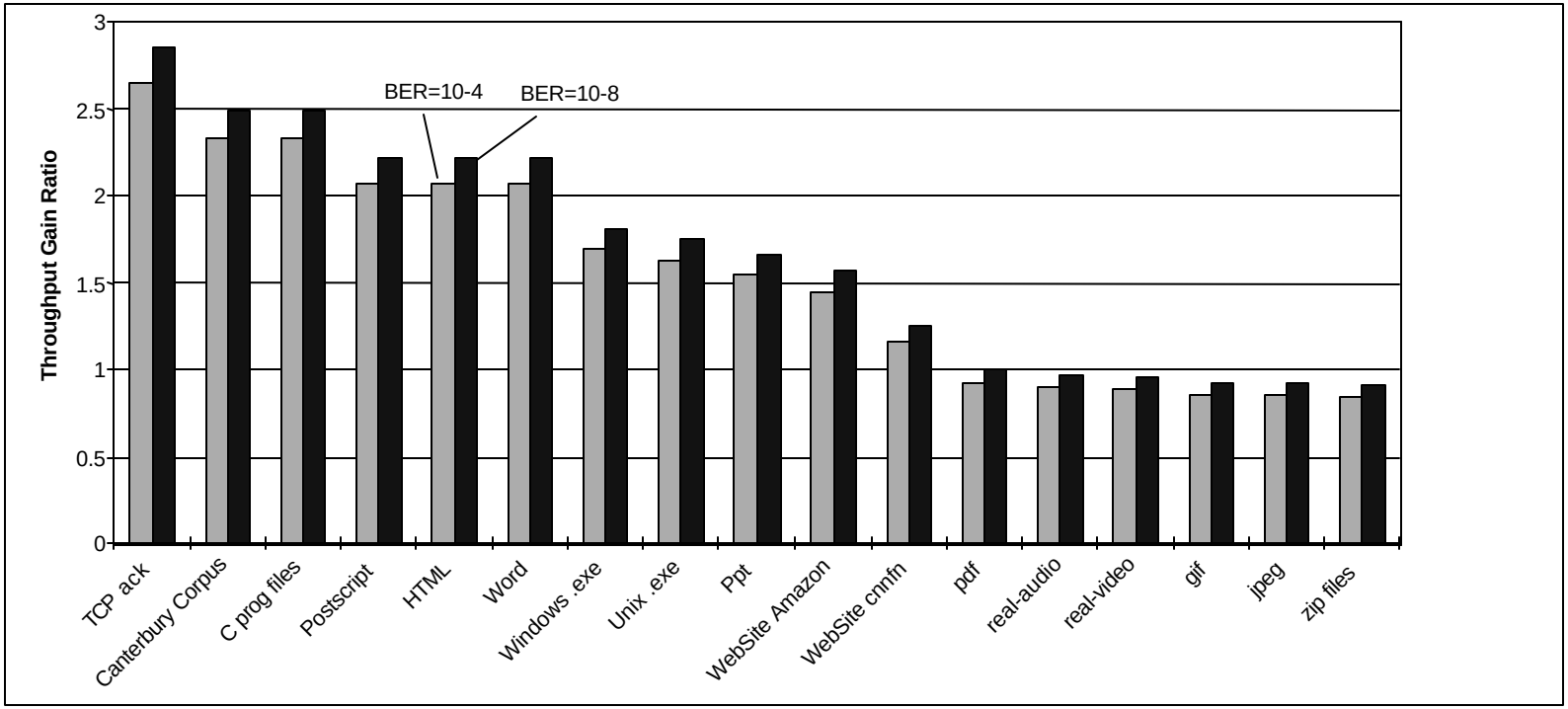
CLA/Internet Compression Measurements



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Linkway 2000

- Multiservice Platform for Bandwidth-on-Demand Multimedia applications
- Multicarrier, Multirate, TDMA Mesh Network
- ATM, IP, Frame Relay, ISDN, SS7 Interfaces
- Internet Routing (RIP, OSPF, BGP)
- Automatic Adaptive Bandwidth Assignment
- Various Terminal Sizes in a Single Interoperable Network
- Highly Integrated Board Including Modem in the Indoor Unit

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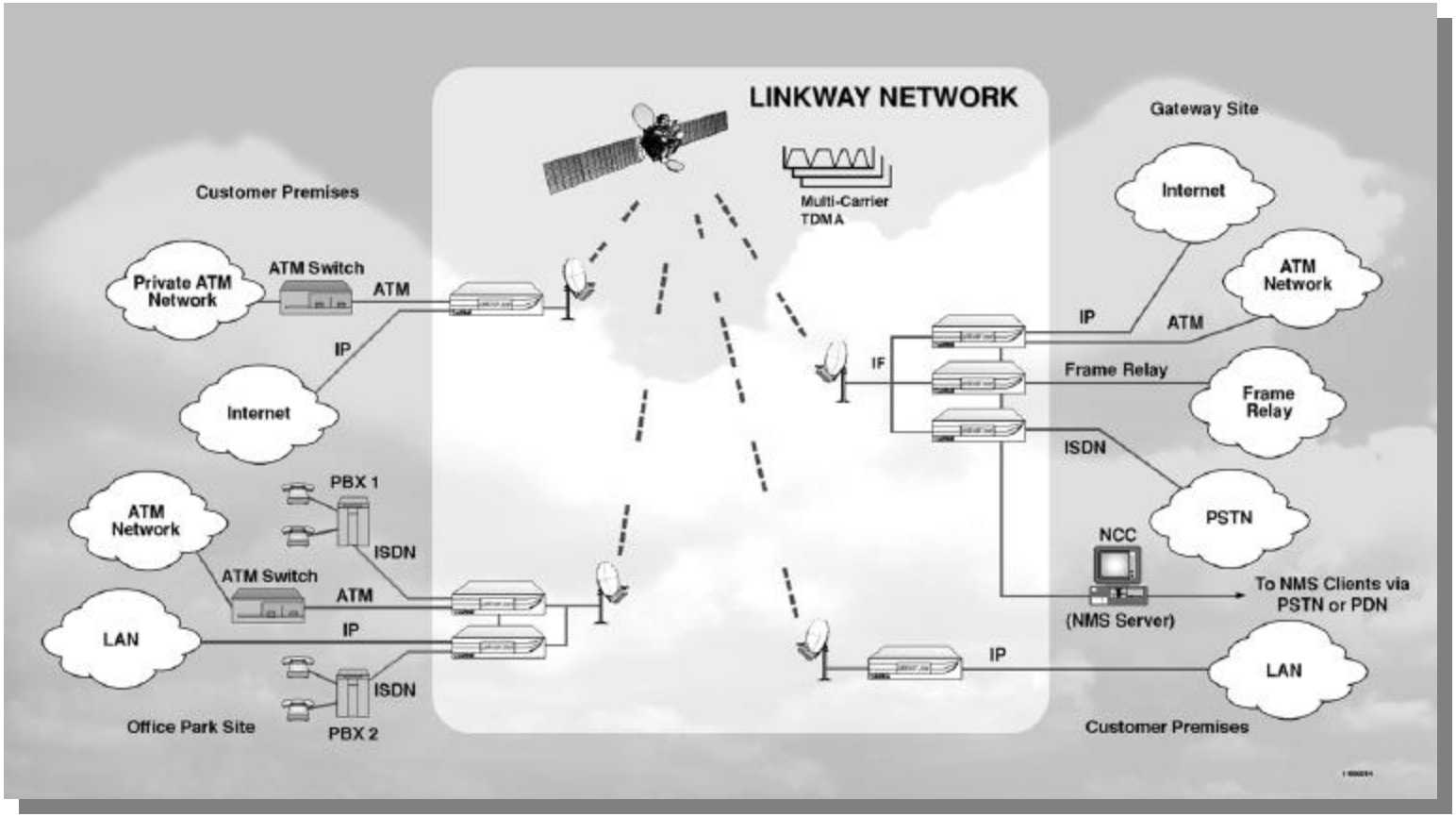
LINKWAY Overview



On Demand High Speed Access for

- Virtual Private Networks
- Multinational Corporate Networks
- Multimedia & Video Teleconferencing
- Internet Service Providers

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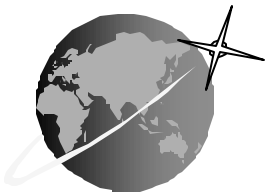
Bandwidth Management

- Fixed Bandwidth Allocation
- Dynamic Bandwidth Allocation

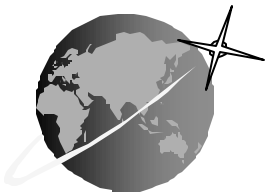
Dynamic Bandwidth Allocation Algorithm

- Adaptive to Traffic Changes
- Fair Assignment



Internet Routing Protocols

- Routing Information Protocol (RIP)
- Open Shortest Path First (OSPF)
- Border Gateway Protocol (BGP)



Conclusions

New generation of satellite link and networking products from COMSAT:

- **Provides high quality ATM and Internet Services over satellite links**
- **Provides efficient use of satellite bandwidth**
- **Meets customer demands**

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