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
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
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
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
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
CLV-2000/ATM Performance v/s BER

With ALA

Without ALA

Bit Error Rate (bursty)
Example Operational Network

North and South America

- **Miami**
  - UUNet Backbone
  - Cisco Router
  - ATM Switch
  - DS3
  - E3
  - 34 Mb/s

- **Puerto Rico**
  - DS3 Undersea Cable
  - ATM Switch
  - DS3
  - E3
  - 34 Mb/s

- **Argentina**
  - ALA/ALE
  - Cisco Router
  - ATM Switch
  - DS3
  - E3
  - 10 Mb/s

- **South American Backbone**
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

![Graph showing maximum throughput as a function of window size for different round-trip times (RTT = 30 ms, RTT = 200 ms, RTT = 600 ms).]
Current Work on TCP Enhancements

- Random Early Discard (RED) scheme
- Selective Ack (SACK)
- Fast retransmit recovery enhancements
- Slow start enhancements
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
CLA-2000/Internet Usage

CLA-2000/Internet as Router using Ethernet

CLA-2000/Internet as Transparent Frame Processor using Serial Port
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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TCP Proxy enables full link rate throughput per connection
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CLIA/Internet TCP-Proxy Mechanism

W = 8 kbytes
Throughput
= 8 kbytes/32 ms
= 2 Mbps

W = 8 kbytes
Throughput
= 8 kbytes/500 ms
= 128 kbps

W = 128 kbytes
Throughput
= 128 kbytes/500 ms
= 128 kbps

W = 8 kbytes
Throughput
= 8 kbytes/32 ms
= 2 Mbps

W = 8 kbytes
Throughput
= 8 kbytes/500 ms
= 2 Mbps

= 2 Mbps
CLA/Internet Single TCP Connection Performance

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

Throughput Kbps vs BER

- **CLA, r = 2.048 Mbps**
  - W = 8 kB

- **Cisco, r = 2.048 Mbps**
  - W = 192 kB

- **Cisco, r = 2048 kbps**
  - W = 8 kB
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
CLA/Internet Compression Measurements

Throughput Gain Ratio

- BER=10^-4
- BER=10^-8

Files:
- TCP ack
- Canterbury Corpus
- C prog files
- Postscript
- HTML
- Word
- Windows .exe
- Unix .exe
- Ppt
- Website Amazon
- Website cinth
- pdf
- real-audio
- real-video
- gif
- jpeg
- zip files
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
LINKWAY Overview

On Demand High Speed Access for
- Virtual Private Networks
- Multinational Corporate Networks
- Multimedia & Video Teleconferencing
- Internet Service Providers
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