International Telecommunication Union

IP Over Satellite and Performance

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Outline

ITU-R SG 4B Status Report – Q.263/4

- Satellite IP Performance Objectives and Work Plan
- TCP Enhancements for Satellite
- Satellite TCP Test Results
- TCP & UDP Performance
- Conclusions

Satellite IP Performance for FSS

Question ITU-R 263/4

- Develop performance objectives for digital links in the FSS for transmission of IP packets
  - Availability and performance criteria
  - Impact of IP requirements
- Study the performance impact on satellite links due to
  - Network layer protocols e.g. RSVP, OSPF
  - Internet specific protocols e.g. DHCP, BGP
  - Transport layer protocols e.g. TCP, UDP
  - IP privacy and security protocols e.g. IPSec
- Reference satellite network architectures to support future applications
- Liaison activities with ITU-T, IETF, and ETSI

Satellite IP Preliminary Draft New Recommendation - Workplan

Develop a PDNR for satellite links to carry IP traffic for backbone, leased circuits, and access networks

- Identification of relevant protocols or QoS classes (for new applications)
- Assess the robustness of these protocols and study the impact on performance due to link delay
- For each of the protocols and classes, assess the link error, availability, and bandwidth performance
- Develop new protocols or QoS classes, if needed, by liaison with other appropriate standard organization

Schedule: Scheduled for end of 2001;
to reschedule during March 2003 meeting

Participation

- Australia
- Brazil
- Canada
- China (People's Republic of)
- European Broadcasting Union (EBU)
- European Telecommunications Satellite Organization (EUTELSAT)
- France
- Korea (Republic of)
- India (Republic of)
- Iran (Islamic Republic of)
- Israel (State of)
- International Telecommunications Satellite Organization (INTELSAT)
- International Telecommunication Union - Radiocommunication Bureau
- Japan
- Morocco (Kingdom of)
- Poland (Republic of)
- Russian Federation
- Spain
- Syrian Arab Republic
- United Kingdom of Great Britain and Northern Ireland
- United States of America

Global Broadband Satellite Networks – Partial List

Systems -->	Spaceway	Astrolink*	EuroSkyway	Teledesic
Data uplink	384 Kbps - 6 Mbps	384 Kbps- 2 Mbps	160 Kbps- 2 Mbps	16 Kbps- 2 Mbps
Data downlink	384 Kbps- 20 Mbps	384 Kbps-155 Mbps	128 Kbps- 640 Kbps	16 Kbps- 64 Mbps
Number of Satellites	8	9 (4, initially)	5	30
Satellite	GEO	GEO	GEO	MEO
Frequency Band	Ka	Ka	Ka	Ka
Onboard processing and switching	Yes	Yes	Yes	Yes
Operation Scheduled	2003	2003	2004	2004/5

** Program on hold*

All these systems are planned to support IP traffic.

Broadband Satellite Access Networks – Partial List

Systems ->	StarBand	WildBlue*	iPStar	Astra-BBI	Cyberstar
Data uplink	38-153 K	384K-6M	2M	2M	0.5-6 M
Data downlink	40M	384K-20M	10M	38M	Max. 27M
Coverage Area	US	Americas	Asia	Europe	Multi-regional
Frequency Band	Ku	Ka	Ku, Ka	Ku, Ka	Ku, Ka
Satellite	GEO	GEO	GEO	GEO	GEO
Operation scheduled	Nov 2000	Mid 2002	Late 2002	Late 2000	1999-2001

** Delayed*

These Internet access systems are planned to support IP traffic.

Satellite Link - Transport Protocols Impact

- **Latency**
  - Propagation delay is dominant part in broadband satellite links
  - Large variations of RTT may lead to false timeouts and transmissions
- **Link Impairments**
  - Multipath, interference, fading, rain attenuation
- **Bandwidth Asymmetry in up- and downlinks**
  - E.g. Direct broadcast satellite downlink vs. low bit rate (shared) uplink
- **Multiple Segment Loss**
  - Increased probability of multiple segment loss within a single window

Satellite TCP enhancements should consider the mitigation techniques.

TCP Enhancements

TCP	RFC	Late-ncy	Large BDP	Impairments & Disconn-ections	Asym-metry
Large IW	2414, 2581	X			
DACKs		X			
Byte Counting	2414	X			X
TCP NewReno	2582	X	X	X	
TCP SACK	2018, 2883	X	X	X	
TCP Vegas		X	X	X	
Window Scaling	1323	X	X		
T/TCP	1644	X			
PMTU Discovery	1191	X			
ECN	2481	X	X		
Header Compression	2507			X	

Satellite TCP Performance

RFC 2488	Enhancing TCP over Satellite Channels Using Standard Mechanisms	Jan 1999
RFC 2760	Ongoing TCP Research Related to Satellite	Feb 2000
RFC 3135	Performance Enhancing Proxies Intended to Mitigate Link Related Degradations	Jun 2001
RFC 3155	End-to-End Performance Implication of Links with Errors	Aug 2001
RFC 3150	End-to-End Performance Implication of Slow Links	Jul 2001
draft-ietf-pilc-asym-08.txt	TCP Performance Implications of Network Asymmetry	Oct 2002

These TCP enhancements have to be evaluated in developing PDNR on satellite IP.

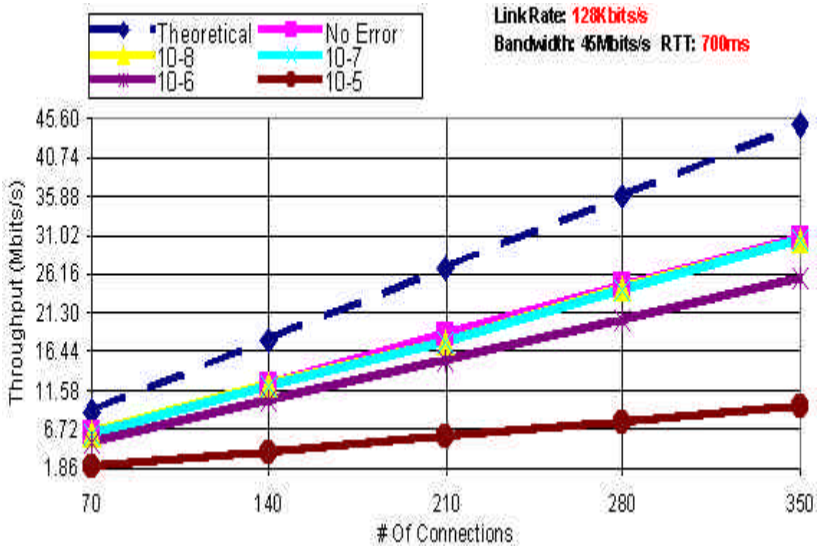
Satellite TCP Performance Example

- Study the impact of delay and BER on TCP/IP traffic over satellite
  - Test results with Mentat SkyX gateway
- Single TCP connection throughput for various link bandwidths
  - High speed LAN and Internet-2 applications
  - High speed transfers of large data files
- Multiple TCP
  - Satellite link simulator, protocol gateways on either side. WAN link of 200 ms, and satellite links of 700 ms.
- Multiple TCP connections with terrestrial packet loss
  - Satellite hop with 500 ms delay and no errors
  - Backbone link with delay of 200 ms and various loss rates

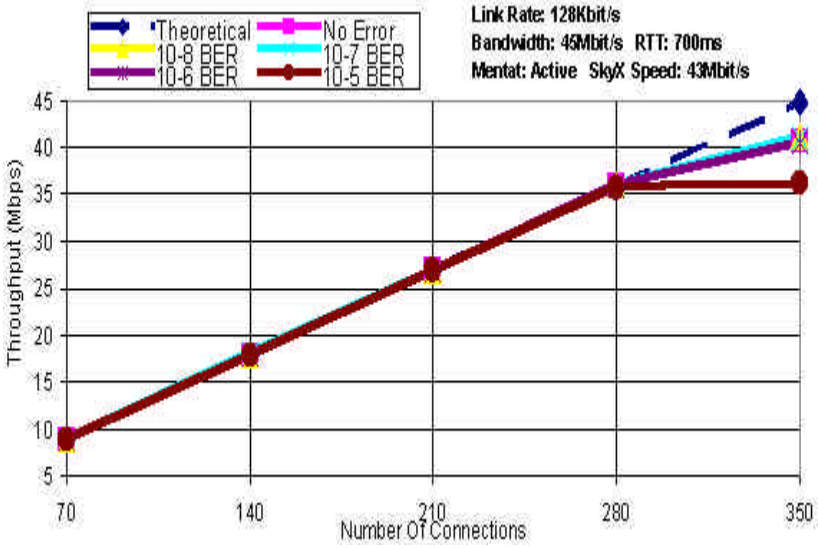
Reference: ITU-R 4B/28-E

Satellite TCP Performance Example Cont'd…

Multiple TCP Connections over Satellite Link



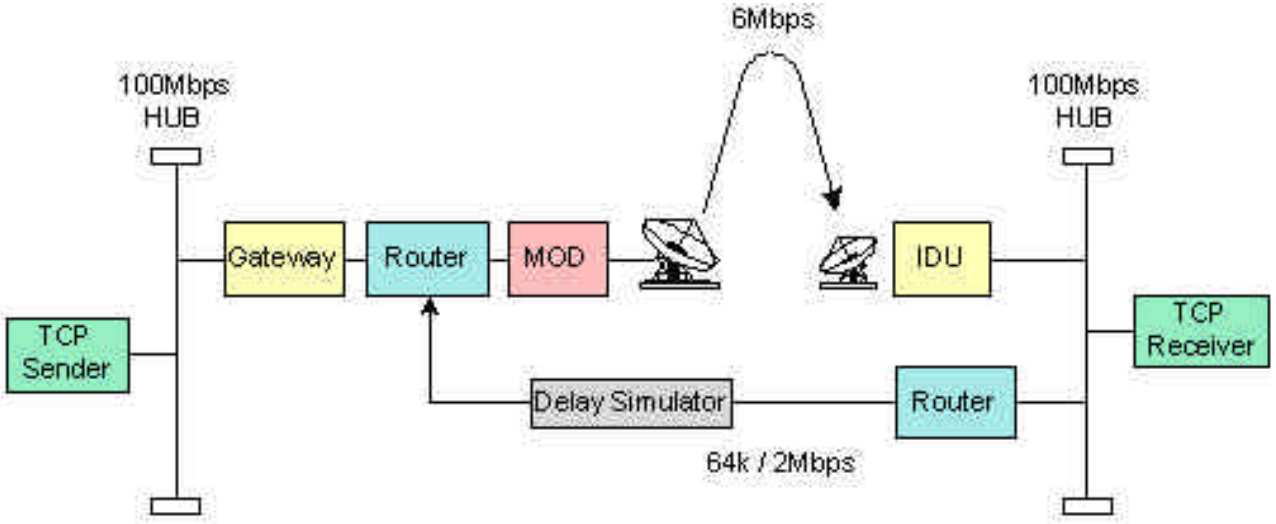
Without Enhancement



With Protocol Gateway Enhancement

- Protocol gateway (splitting) improve throughput for carriers with TCP/IP traffic on satellite links up to a delay of 700 ms
- TCP/IP throughput is not affected as long as link BER is better than 1×10^{-7}
- Study the impact of BERs < 10^{-7}
- Review recommendation ITU-R S.521-4 in view of satellite IP

Satellite TCP Splitting – Test Results

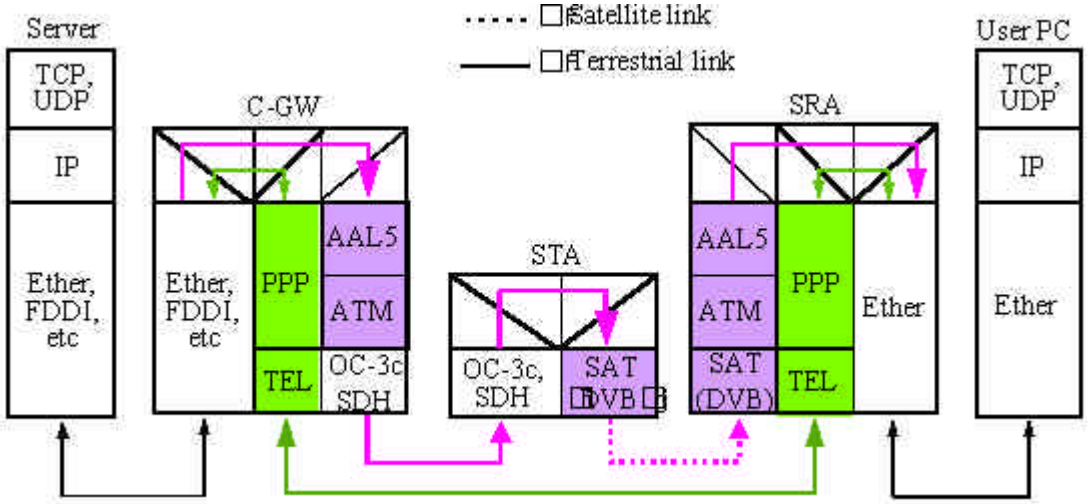


	Without Splitting (Mbps)	With Splitting (Mbps)
1 TCP 64 Kbps	0.090	3.18
1 TCP 2 Mbps	-	3.35
2 TCP 64 Kbps	0.090 / 0.090	1.93 / 1.95
2 TCP 2 Mbps	-	2.53 / 2.58

Reference: ITU-R 4B/61-E

IP Network Performance

Protocol Stack



STA: Satellite circuit Transmission Adapter
SRA: Satellite circuit Receive Adapter

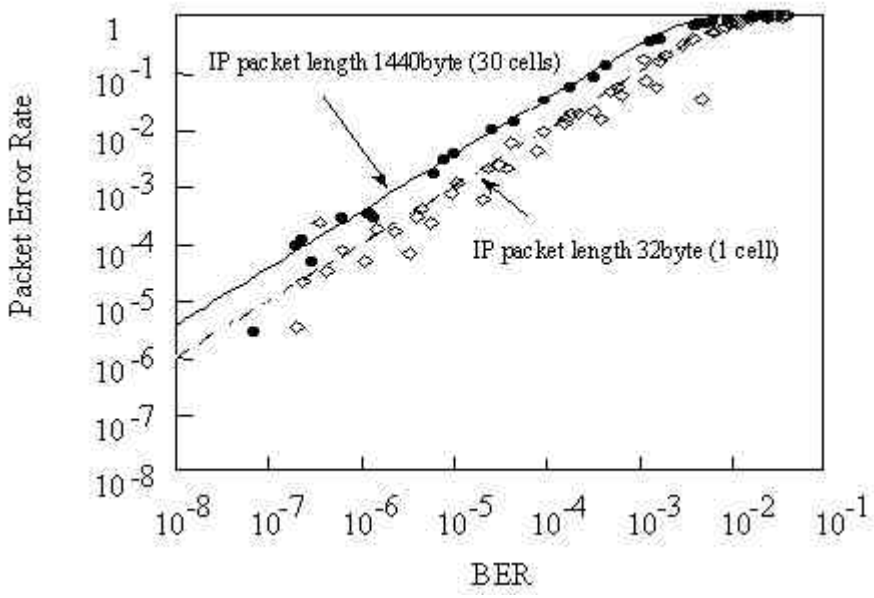
Physical layer errors result in

- Corrupted IP packets
- Lost IP packets
- Spurious IP packets when IP header is corrupted
- Packet delay, packet delay variation

Reference: ITU-R 4B/62-E

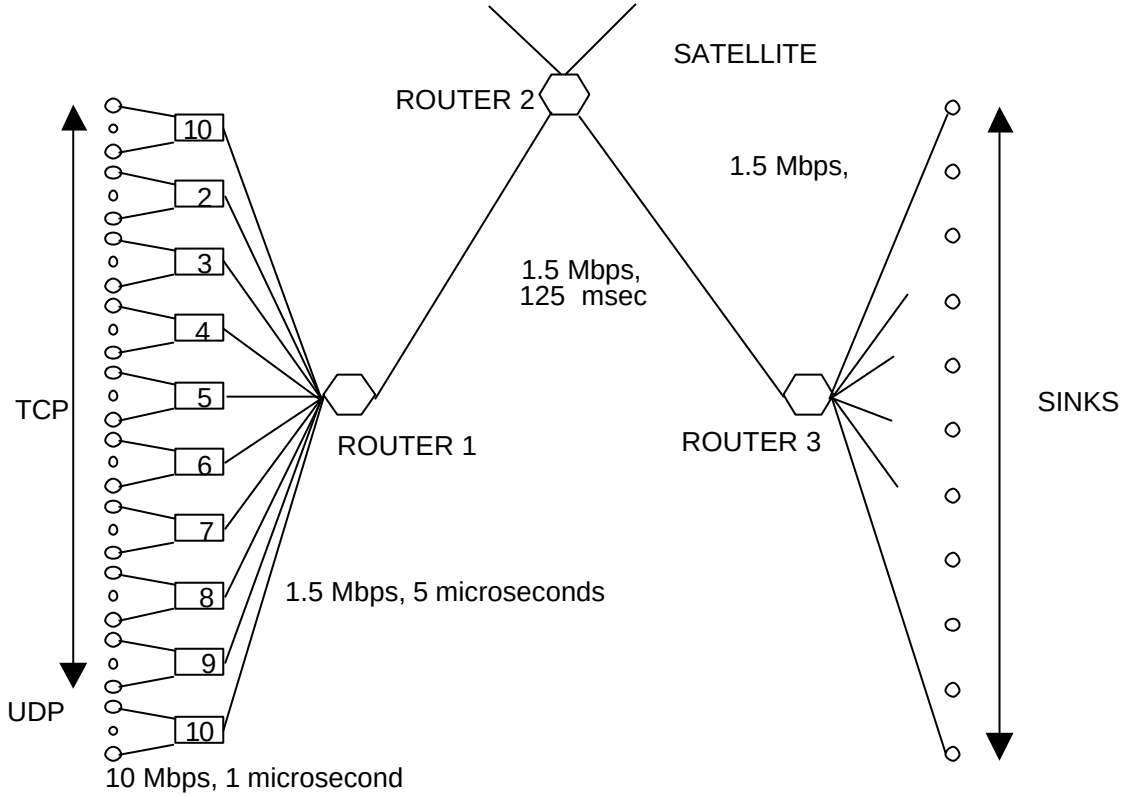
IP Network Performance Cont'd…

PER vs. BER



- Packet Error Ratio (PER) including Packet Loss Ratio Vs. BER between STA and the SRA
- Measured value of IPER of less than 10^{-4} if BER is less than 2×10^{-7}

TCP and UDP Performance - GEO Satellite IP Network

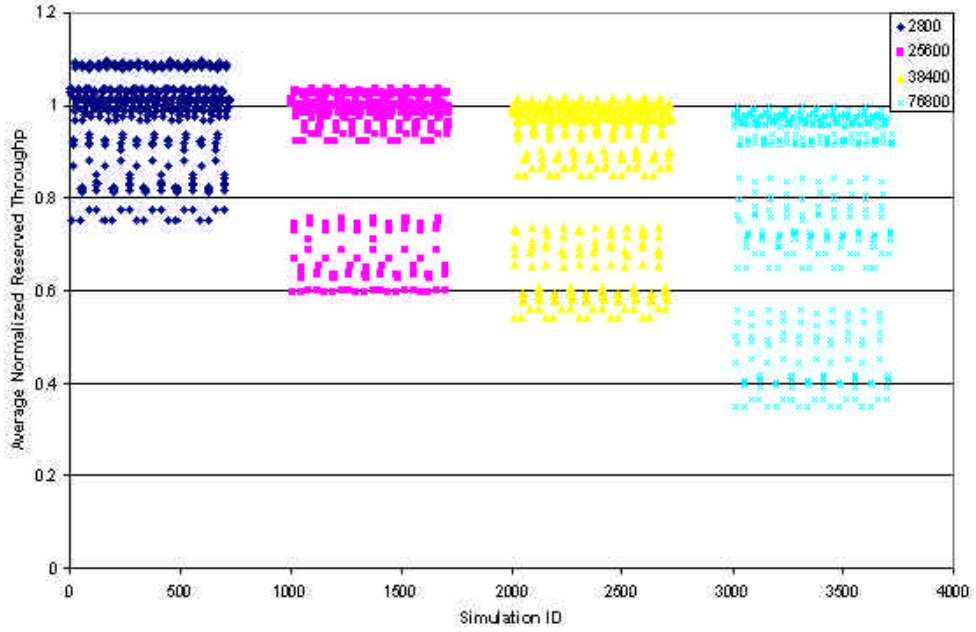


- Drop Policies at the routers – Random Early Detection (RED) and Drop Tail
- Satellite has onboard router

Reference: ITU-R 4B/67-E

TCP and UDP Performance - GEO Satellite IP Network (Cont'd)

Reserved Rate Utilization by TCP Customers in Three Drop Precedence with BER = 10^{-8}



- Three drop precedence levels are required for high reserved rate utilizations.
- Fair allocation of excess network bandwidth is achieved only through different treatment to TCP and UDP packets.
- Simulation results are similar for OBP/bent pipe, GEO/MEO due to DiffServ nature.

FSS Systems Performance
Over 15 GHz

- Preliminary Draft New Recommendation (PDNR): Performance Requirements for Fixed Satellite Service Systems Operating Over 15 GHz (S.Ka-P)

- Preliminary Draft New Recommendation (PDNR) :Availability Performance Requirements for Fixed Satellite Service Systems Operating in the Ka-Band (S.Ka-P-Av)

Contributions available; however need test and measurement results for completion.

Reference: ITU-R 4B/35-E

Conclusions

- Several planned systems use IP over satellite necessitating global standards development for performance objectives.
- PDNR for Question 263/4 provides Satellite link performance for IP transmission.
- Contributions on TCP and UDP performance, DVB-S, IPER-BER, simulations, experiments and test results demonstrate the initial performance objectives.
- Contributions for performance objectives for access networks and study of impact of other protocols on the link are required.
- Establish more liaison efforts with ITU-T, ETSI (BSM), IETF (PILC), and TIA.

Discuss the schedule for PDNR in March 2003 meeting.