Effect of SCTP Multistreaming over SatelliteLinks

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12th International Conference on Computer Communications and Networks, Dallas, TX.

Introduction

- TCP is the main transport protocol in the Internet protocol suite
- Original TCP did not perform very well in satellite networks because of errors and long delay.
- Many schemes have been proposed to enhance TCP performance over satellite networks.
  - Window scale option
  - Byte counting
- IETF is developing the Stream Control Transmission Protocol (RFC 2960) for carrying PSTN signaling messages over IP.

Open question: Does SCTP offer any advantage in wireless and satellite networks?
Objectives

Determine suitability and advantages of SCTP’s multistreaming in
- Wireless and satellite networks
- Wireless handheld devices

Outline

- Introduction to SCTP
- Multistreaming
- Multihoming
- Simulation model of multistreaming over satellite links
- Results
Introduction to SCTP

Stream Control Transmission Protocol

- **SCTP (RFC 2960)** is being developed by IETF as a transport protocol for carrying PSTN signaling.
  - Reliable: retransmission of lost packets, ack of packets.
  - Non-duplicated service: uses sequence numbers.
  - In-order delivery: re-sequencing at the destination.
- **Transport layer protocol which operates on top of an unreliable connectionless network layer such as IP.**
  - Transparent to IPv4 or IPv6
- **Key features:**
  - Multistreaming – multiple streams per association
  - Multihoming – multiple IP addresses per host
SCTP in the protocol stack

Upper layer applications
- TCP, UDP, SCTP
- IP
- Link Layer
- Physical Layer

Multihoming
- Supports multiple IP addresses in an association.
- Requires multiple Network Interface Cards – already quite common in laptops !!
  - Can also be accomplished by one NIC using software radio

Node 1
  - Transport address 1
  - Subnet 1

Node 2
  - Transport address 3
  - Subnet 2
  - Subnet 1

Node 1
  - Transport address 2
  - Subnet 2
  - Subnet 1
SCTP Multistreaming over satellite

SCTP Multistreaming

- SCTP accomplishes multistreaming by creating independence between
  - data transmission (uses Transport Sequence Number)
  - data delivery (uses Stream Sequence Number)

![Multistreaming Diagram]

SCTP Packets

- Payload, SACK, etc.
SCTP Multistreaming over satellite

Chunk Type: Payload

```
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type = 0    | Reserved|U|B|E|    Length               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| TSN               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Stream Identifier S | Stream Sequence Number n |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Payload Protocol Identifier |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
/                User Data (seq n of Stream S) /
/                                                  /
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

SCTP Congestion Control

- SCTP congestion control assures that the traffic behaves in the network in the same way as TCP traffic.
- Enables a seamless introduction of SCTP services into existing IP networks.
- SCTP is rate adaptive similar to TCP.
  - Slow Start, Congestion Avoidance, Fast Retransmit
  - Fast Recovery is implemented, but in a slightly different way than TCP.
- Differences with TCP
  - Number of bytes acknowledged to increase cwnd.
  - SACK is mandatory
  - No explicit fast recovery phase
  - Unlimited number of Gap Ack Blocks in SACK
Simulation Setup

Assumptions

- *Ftp* traffic between source and destination.
- Packets are of fixed length of one MTU.
- Upper layer at destination is always ready to accept data.
- Association consists of a number of streams.
- Receiver buffer size = $B$

Link delay (L1+L2) = 260 msec
Results

Performance Metrics

- **Goodput**: Number of good packets received at the receiver.
- **Optimal receiver buffer size**
  - as a function of
  - Error probability \( (e) = \text{Prob. that a packet is lost in the network.} \)
- No packet loss means no blocking at the receiver.
- cwnd initially increases until it reaches $B$.
- Goodput is limited to $B/MTU$ packets every RTT; Goodput therefore increases linearly with $B$.

Since goodput is limited to $B/MTU$ packets every RTT; it increases linearly with $B$. 

$s = 4, e = 0, B = 15K$

$s = 4, e = 0$
Packet plot: Congestion Control limited

- Long delays in Retx of lost packets while waiting for DupAcks
- + drop in cwnd due to Retx results in poor goodput when receiver buffer is not a constraint.

\[ s = 4, e = 0.01, B = 35K \]

Goodput with errors

- Goodput is limited by the congestion control of SCTP.
- Goodput can only be increased by lowering the error rate
- Goodput initially increases as \( B \) increases when the goodput is constrained by \( B \) (\( a_{rwnd} \) frequently drops below 1 MTU)

\[ s = 4, e > 0 \]
- $B=15K$ results in the throughput being constrained by the receiver buffer size.
- $a_{\text{rwnd}}$ frequently drops below 1 MTU, and $cwnd$ is restricted to 15K.

$s = 4, e = 0.01, B = 15K$

- $B=35K$ makes the throughput constrained by the congestion control of SCTP.
- $a_{\text{rwnd}}$ never drops below 1 MTU.

$s = 4, e = 0.01, B = 35K$
One and four streams: Goodput vs. B

- For small $B$, multistreaming results in less HOL blocking
  - goodput of 4-streams is higher than 1-stream.
- For large $B$, the goodput is limited by the congestion control mechanism.

Multistreaming increases goodput for small receiver buffer sizes

Advantage of Multistreaming: High Throughput

- Small Buffer size of 15K shows the advantage of multistreaming with four streams.
- HOL blocking is eliminated as evidenced by the fact that $a_rwnd$ is not a limiting factor.
Optimal Buffer Size

- Optimal Receiver Buffer Size: The size beyond which the a_rwnd never falls below 1 MTU.

Multistreaming reduces receiver buffer requirements.

Conclusions
Conclusions

- Multistreaming increases goodput for small receiver buffer sizes when compared to a single stream (for example, TCP).
- Multistreaming reduces receiver buffer requirements.

Acknowledgements

- NASA Glenn Research Center

Further Information
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These slides are available at
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Thank you