ENSC 835 project (2002)
TCP performance over satellite links

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Road map

- Introduction to satellite communications
- Simulation implementation
  - Window size
  - Maximum segment size
  - Initial windows size
  - Selective acknowledgement algorithm
    - TCP burst
- Conclusion
- References
Introduction to satellite communications

- Satellite communication is a type of the wireless communications technologies. It utilizes satellites to retransmit the wireless signal, and to connect with the multiple earth station.
Introduction to satellite communications

Geosynchronous Equatorial Orbit

(From *geo* = earth + *synchronous* = moving at the same rate.)
Window size

- Commercial satellite companies (e.g., Loral, Hughes, Lockheed Martin) have announced plans to build large satellite systems to provide broadband data service.

- Our simulation may help improve TCP performance over long delay and error prone channels.
Project objective

- Implement an combination of four approaches to enhance the performance over satellite links coupling with the long delay and high Bit Error Rate characteristics.
  - Effect of window size RFC1323
  - Effect of Initial windows size RFC2581
  - Effect of Maximum segment size RFC2488
  - Comparison of different TCP algorithms RFC 2018
- Extend the authors’ knowledge of TCP burst problem related to on board switch in GEO satellites.
  - TCP burst
Window size

- Large delay\times bandwidth product
  \[ W = B \times RTT \]

This product defines the amount of data a protocol should have “in flight”.
Window size

- The original TCP standard limits the advised window size by only assigning 16bits of header space for its value. (RFC793). Hence the advised window size can be no more than 64Kbytes.

\[
\text{throughput} = \frac{CWND}{\text{round trip time}}
\]

\[
= \frac{64 \text{ kbyte}}{585 \text{ ms}} \approx 112,000 \text{ bytes/sec} \approx 900 \text{ kbps}
\]
Why do we choose this project?

- Simulation scenario

- Parameters:
  - choose various window size: 16, 32, 64, and 128.
  - T1 link: 1.544Mbps.
  - Set the receiver and sender buffer size greater than the delay bandwidth product, so that we can examine how window size affect on TCP throughput: 120.
  - Application: FTP
Window size (Result 1)

Brief Analysis: Larger window size can help improve the throughput.
Window size (Result 2)

Brief Analysis

- Multiple long lived connections with small window size can still fully utilize the channel.
- Three 40kbytes window connections can almost fully utilize the T1 channel.
Window size - Discussion

- Advantages:
  - It is ideal for the connections that transmit big files such as FTP application

- Disadvantages:
  - Large window size can lead to more rapid use of the TCP sequence space.
  - Large window size will also increase the multiple packets loss possibility.
What about short lived connection?

- Slow start is a safety guard against transmitting an inappropriate amount of data into the network.

- However, Slow start is particularly inefficient for short lived connection (Telnet) in large bandwidth-delay product network.
Initial congestion window size

- By increasing the initial CWND, more packets are sent during the first RTT.
- Trigger more ACKs
- Allowing congestion window to open more rapidly
- Allowing congestion window to open more rapidly
Maximum Segment Size

Maximum segment size (MSS):

\[ \text{MSS} = \text{MTU} - \text{TCP header} - \text{IP header} \]

- MTU (or the maximum packet size):
  Maximum Transmission Unit
Initial CWND and MSS

- Simulation scenario

- Parameters:
  - Set the initial window size: 1, 2, and 4.
  - Set packet size: 576, 1152, and 1728.
  - Set the advised window size: 128.
  - Application: telnet
  - Other parameters are default.
**Brief Analysis:**

Using larger initial window size can help reduce the slow start period, so allows sender send more packets at the same period of time.
Brief Analysis:
Choosing suitable maximum segment size can improve TCP throughput.
Initial CWND and MSS-Discussion

- Advantages:
  - It is ideal for the short lived connections such as Telnet application.

- Disadvantages:
  - Make traffic burst
  - Increase unnecessary drops
Comparison of different TCP algorithms

- New Challenge for TCP performance: Large window size Vs limited buffer size
- Usually, in a high delay-bandwidth product link, TCP’s maximum window size is much larger than the buffer size of the router.
Comparison of different TCP algorithms

- Simulation scenario

- Parameters:
  - Add lose model, use different bit error rate: 10e-7, 10e-6, 10e-5, 10e-4, and 10e-3.
  - Compare TCP Sack with other TCP algorithms such as Reno and Vegas.
Brief Analysis:
TCP Sack performs better than Reno. However, when bit error rate is from $5 \times 10^{-7} \sim 10^{-3}$, Vegas is better than both Sack and Reno.
On board GEO satellite

Bent pipe GEO satellite  On board switch GEO satellite

Star network (switch at hub)  Mesh network (switch at satellite)
New Challenge for TCP performance: Large window size Vs limited buffer size

Usually, in a high delay-bandwidth product link, TCP’s maximum window size is much larger than the buffer size of the router.
TCP Burst

- **Simulation scenario:**

  - 3.1Mbps
  - 1.544Mbps
  - 3.1Mbps

- **Parameters:**
  - Set various buffer size: 30, 34, 40, and 50.
  - Set the window size: 128.
  - **T1** link: 1.544Mbps.
  - Other parameters are default.
**TCP Burst**

**Brief Analysis:**
The exponential growth of the router queue during initial period represents the macro burst of TCP during slow start, and the lower level of queuing occupancy in later period is due to smaller burst of TCP.
Brief Analysis:
The buffer size impacts on TCP performance severely. If the buffer size is approximately smaller than 1/2 of the window size when using basic ack (accordingly, 1/3 when using delayed ack), the throughput will reduce rapidly.
## Conclusion

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<tr>
<th>Experiment</th>
<th>Outcome</th>
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<tbody>
<tr>
<td>Window size</td>
<td>Larger window size can improve the performance</td>
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<tr>
<td>Initial window</td>
<td>Using a larger initial window can improve the throughput, especially for short transfers</td>
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<tr>
<td>Maximum segment size</td>
<td>Larger maximum segment size will improve the throughput, however, it may cause link congestion or router overload</td>
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<tr>
<td>Comparison of three TCP algorithms</td>
<td>TCP Sack is better than Reno under the error prone channel. However, Vegas performs even better than Sack if the bit error rate is large</td>
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<tr>
<td>TCP Burst</td>
<td>Burst has a severe influence on TCP performance</td>
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</table>
Conclusion

- For FTP application in satcom, implement SACK with larger window size can greatly improve the TCP throughput.

- For Telnet application in satcom, it is ideal to implement SACK with larger initial window and MSS


[5] A Simulation Study of Paced TCP, Joanna Kulik, Robert Coulter, Dennis Rockwell, and Craig Partridge, September 1999


[9] [RFC 1122] Transport Layer TCP