Enhancement of the TCP Module in the OMNeT++/INET Framework

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Thomas Dreibholz's SCTP Page
http://tdrwww.iem.uni-due.de/dreibholz/sctp/
Motivation and Goal

- **Transmission Control Protocol (TCP)**
  - The most important Transport Protocol in the Internet
  - Many variants and various optimizations
  - => INET/OMNeT++ to examine its performance

- **Missing TCP Features in OMNeT++/INET**
  - Finite receiver buffer
    - Allowing “Zero Window” (i.e. “send no more data yet”)
    - Requires “Window Probing”
  - TCP options handling
  - Maximum Segment Size (MSS) negotiation
  - **Selective Acknowledgement (SACK)**

- **Goal:**
  - Enhancement of the TCP model in OMNeT++/INET ...
  - ... to perform **state-of-the-art TCP** performance evaluations
Selective Acknowledgements (RFC 2018)

- **Idea:**
  - Lost segments are retransmitted, of course ...
  - ... but already received segments are not transmitted again
  - => Tell sender what has already been received (by SACK option fields)

- **Simulation example:**
  - 10 Mbit/s path
  - Variation of the bit error rate

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SACK support is important for accurate TCP performance evaluation!
Interoperability with Real Systems using the External Interface

- **ExtInterface**: connecting simulations to real network components

- Improved TCP module supports connections over ExtInterfaces
  - Support for TCP options, including SACKs
Using the TCPDump Module for Exporting a Packet Trace

- Improved TCPDump module to export TCP option fields ...

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000000</td>
<td>192.168.0.111</td>
<td>172.0.1.111</td>
<td>TCP</td>
<td>45315 &gt; 10021 [SYN] Seq=0 Win=5808 Len=0 MSS=1452 TSV=3226577 TSO=0</td>
</tr>
<tr>
<td>2</td>
<td>0.007217</td>
<td>172.0.1.111</td>
<td>192.168.0.111</td>
<td>TCP</td>
<td>10021 &gt; 45315 [SYN ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1452</td>
</tr>
<tr>
<td>3</td>
<td>0.007263</td>
<td>192.168.0.111</td>
<td>172.0.1.111</td>
<td>TCP</td>
<td>45315 &gt; 10021 [ACK] Seq=1 Ack=1 Win=5808 Len=0</td>
</tr>
</tbody>
</table>

- Flags: 0x12 (SYN, ACK)
- Window size: 65535
- Checksum: 0xc838 [correct]

- Options: (0 bytes)
  - Maximum segment size: 1452 bytes
  - NOP
  - NOP
  - SACK permitted

- ... including SACK handling ...

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<thead>
<tr>
<th>No.</th>
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<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>0.245918</td>
<td>172.0.1.111</td>
<td>192.168.0.111</td>
<td>TCP</td>
<td>10021 &gt; 45315 [ACK] Seq=1 Ack=182977 Win=65535 Len=0</td>
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<td>0.247596</td>
<td>172.0.1.111</td>
<td>192.168.0.111</td>
<td>TCP</td>
<td>10021 &gt; 45315 [ACK] Seq=1 Ack=185881 Win=65535 Len=0</td>
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<tr>
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<td>172.0.1.111</td>
<td>192.168.0.111</td>
<td>TCP [TCP Dups ACK 100#1] 10021 &gt; 45315 [ACK] Seq=1 Ack=185881 Win=65535 Len=0</td>
<td></td>
</tr>
</tbody>
</table>

- Flags: 0x10 (ACK)
- Window size: 65535
- Checksum: 0x973b [correct]

- Options: (12 bytes)
  - NOP
  - NOP
  - SACK: 187333-188785

- ... for analysis with external tools (e.g. Wireshark)
Conclusion and Outlook

■ Conclusion
– TCP model in OMNeT++/INET has lacked some important features
– Features have been added and contributed to GitHub tree of INET ...
– ... allowing for TCP evaluations with state-of-the-art model
– Interoperability with real TCP implementations

■ Future Work
– Adding further options:
  • Window Scaling (already done)
  • Timestamp (in progress)
  • ...
– Performance evaluations
Thank You for Your Attention!
Any Questions?

Visit Our Project Homepage:
http://tdrwww.iem.uni-due.de/dreibholz/sctp

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