TCP over Satellite – Effects of Advertised Receive Buffer Size, Timer Granularity, and Bit Error Rates
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Dissemination of Project Results

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Outline

Related Research
- SCPS/TP ---- TCP ---- ATM Sat Scope

Simulation Environment
- Used Toolsets
- Simulation Workflow
- Simulation Model Verification

Network Model
- Parameter
- Verification

TCP Evaluation
- Characteristics of TCP
- Simulation Model
- Simulation Parameter

Simulation Results
- Effects of Timer Granularity and Receive Buffer Size
- Effects of Bit Error Rates
- Overall Performance
Related Research

SCPS-TP
- Highly specialized
- Performance Issues

TCP
- Large BDP
- Downward compatible vs. experimental improvements
- Constant vs. variable delay

ATM-Sat Scope
- Standard IP suite
- Variable delay
- BERs
Where we are

Related Research

Simulation Environment  - Used Toolsets
                        - Simulation Workflow
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Network Model          - Parameter
                        - Verification

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**Simulation Environment**

**Used Toolsets**

- **Satellite Toolkit STK**
  - Focus on satellite network aspects
  - Commercial standard tool

- **OPNET Modeler Radio**
  - Focus on communication networks aspects
  - Widely spread in commercial environments
  - opnet vs. ns
Simulation Environment
Simulation Workflow

STK

Satellite Path Description

AER Data
p2p-link w/ variable delay

Opnet

Definition of satellite network - Orbit altitude
- Orbit type

Parser Programs

*.c and *.h Files for pipeline stages

Definition of communication network aspects
- Bandwidth
- Bit Error Rates
- Internet Protocol Suite
Simulation Environment
Simulation Model Verification

Simulation Models for Research related Experiments

Simulation Models for System Verification
Where we are

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Network Model Parameter

Slant Range

Slant Range
- Analytical model
- Function of orbit altitude
- Visibility constrains

Analytical vs. Simulated Distance
- STK based simulation compared to theory
- Derivation less than 2%
Network Model Parameter
Delay

![Diagram of network model parameters and delay graphs](image_url)
Network Model Parameter
Bandwidth

ISL: 7 - 10 Gbit/s
Feder Up & Downlink: 32.768 Mbit/s
Service Downlink: 32.768 Mbit/s

Service Uplink (fixed): 2.048 Mbit/s
Service Uplink (portable): 384 kbit/s
Network Model
Verification Model

PTP-Duplex-Link:
- delay
- BW
- BER
Network Model Verification
Verification Measurements

Delay
- Expected values
- Consider queuing delay

Bit rate
- Upper Limit
Where we are

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TCP Evaluation
Characteristics of TCP

Retransmission Method
- ACK based
- Timeouts
- RTT Estimation

Throughput Limits
- Window Size
- Advertised Receive Buffer
TCP Evaluation
Simulation Model

Parameter Application
- File Size
- Put/Get Ratio
- Temporal behavior

Parameter Link
- Delay
- Bandwidth
- BER


## TCP Evaluation

### Simulation Parameter

**Given:**
- TCP Flavor
- Buffer Size
- BER

More than 140 experiments

<table>
<thead>
<tr>
<th>Lower Bound Of RTT in ms</th>
<th>None</th>
<th>100</th>
<th>200</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer Granularity G</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G=1 ms</td>
<td>2</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G=50 ms</td>
<td>3</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G=100 ms</td>
<td>4</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G=250 ms</td>
<td>5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G=500 ms</td>
<td>6</td>
<td>11</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Minimal G to avoid false retransmissions (varying)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Where we are

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Simulation Results
Effects of Buffer Size & Timer Granularity

Advertised Receive Buffer
- Larger than BDP
- Less than BDP
- Equal to MSS

Timer Granularity
- May cause false retransmissions

<table>
<thead>
<tr>
<th>Advertised Receive Buffer</th>
<th>64 kB</th>
<th>6.6 kB</th>
<th>3.3 kB</th>
<th>1.46 kB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;&gt; BDP</td>
<td>= BDP</td>
<td>1/2 BDP</td>
<td>MSS</td>
</tr>
<tr>
<td>Min. Timer Granularity (G)</td>
<td>1 ms</td>
<td>1 ms</td>
<td>4 ms</td>
<td>26 ms (250 ms)</td>
</tr>
</tbody>
</table>
Simulation Results
Effects of Bit Error Rates

BER = 2*10e-8
- Overlapping with BER = 0
- No needless retransmissions

BER = 2 * 10e-5
- No resemblance with variable propagation delay
- Prevention of false retransmissions
Simulation Results
TCP Performance

TCP flavor dominates

Influence of different timer granularities

Feasibility for real life environments
Conclusion & Outlook

TCP
- Sophisticated protocol
- Minor influence of hand-tuned implementations

SCPS-TP
- No better performance for today’s BER above FEC
- Acceptance by IETF for usage over Internet unsure

Simulation Environment
- Model exchange between industry and research vital
- Engineering approach necessary