Lessons Learned at Scale with the World’s Largest STTP Deployment for Synchrophasors

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April 17, 2022
Spring 2022 NASPI Meeting
Streaming Telemetry Transport Protocol

Advanced Synchrophasor Protocol Project

STTP Initially DOE Funded

- US DOE Project
- Intrinsically reduces losses and latency compared to frame-based protocols
- Allows the safe co-mingling of phasor data with other operational data network traffic
- Includes lossless compression to reduce bandwidth utilization
- Security-first design with strong authentication and option for encryption

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STTP Measurement Structure

- **Unique ID**
  - Unique ID is a UUID (a.k.a, Guid):
    - 128-bit randomly generated integer that is statistically unique
    - This allows for dataset conflation without worrying about ID conflicts

- **Measurement structure values transported on the wire are compressed**

<table>
<thead>
<tr>
<th>Field</th>
<th>Byte Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL</td>
<td></td>
</tr>
<tr>
<td>SIGNAL</td>
<td></td>
</tr>
<tr>
<td>VA</td>
<td></td>
</tr>
<tr>
<td>TIME</td>
<td></td>
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</tbody>
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<td>SIGNAL INDEX</td>
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<tr>
<td>VALUE</td>
<td></td>
</tr>
<tr>
<td>TIMESTAMP</td>
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</tbody>
</table>

MTU

**Individual Measurements**

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Benefits: Lower Data Loss / Reduced Bandwidth

The Wire Protocol

STTP

Data Loss

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>UDP</td>
<td>0.14</td>
<td>0.31</td>
<td>0.12</td>
</tr>
<tr>
<td>TCP</td>
<td>0.22</td>
<td>0.04</td>
<td>0.02</td>
</tr>
</tbody>
</table>

IEEE C37.118 STTP

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STTP on track to become: IEEE 2664

- Draft is nearly complete!
  - Most remaining work is in appendices
- Standard planning to go to ballot in May
Major STTP Source Code Commits by Language

C#  
C++  
XML  
Go

Represents Structured Code Comments

Gateway Exchange Protocol

sttp
Streaming Telemetry Transport Protocol

2015  
2022

Source: https://www.openhub.net/
### STTP Reference Implementations

All implementations are open source and MIT licensed for easy, immediate industry implementation:

<table>
<thead>
<tr>
<th>Target Platform</th>
<th>Funding Source</th>
<th>Subscriber</th>
<th>Publisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>C++</td>
<td>DOE</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>C#/C++</td>
<td>DOE / GPA</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Go</td>
<td>Dominion</td>
<td>Yes</td>
<td>In Progress</td>
</tr>
<tr>
<td>Python</td>
<td>Dominion</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>C#</td>
<td>Dominion</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Rust</td>
<td>?</td>
<td>Planned</td>
<td>Planned</td>
</tr>
</tbody>
</table>

**STTP Now Industry Funded**

Thank you to Dominion!

https://github.com/sttp
The PredictiveGrid Platform

Data Sources
- T&D Electric Utility
- RC / ISO
- Solar Fleet
- Wind Farm
- EV Charging Fleet
- Research Partners
  - Sensor Fleets
  - Data Concentrators
  - Historians
  - Individual Sensors
  - Edge Devices

PredictiveGrid™
- BTrDB
  - High performance, extremely scalable time series database for real world sensor data at scale.
- DISTIL
  - High performance stream and signal processing for time series measurements.
- Geospatial Data Store
- Topology Store
- Metadata Store
- User Defined Functions
- Jupyter Hub
  - Secure, Scalable, and Reliable Infrastructure

Applications
- General Purpose
  - Data Explorer
  - Dashboards
  - Notebooks
- Alerting
- Admin
- Platform Mgmt
- BI Tool Integrations
  - Data Explorer
  - Dashboards
  - Notebooks
- Industry-Specific
  - Solar Integration
  - Model Validation
  - Small Signal Analysis
  - Wildfire Detection
  - GMD/GIC
  - Capital Optimization

Optional Managed Services
- Spark
  - Analytics
- TensorFlow
  - Deep Learning
- RAY
  - Compute

API and Access Control Layer
- GraphQL
- gRPC

Applications
- Solar Integration
- Model Validation
- Wildfire Detection
- GMD/GIC
- Capital Optimization
Vanity Platform Metrics

• 53 trillion points under management
• 200,000 streams or time series 24/7/365
• >1M points per second streaming
• Additional points processed in batch (mostly Comtrade files)
• Too many use cases
• Rolling out ~10 CPOW @ 10KHz
Drivers for Update

- Desire for Golang-native ingress
- Enhanced stability of stream
- Reduced resource utilization
  - Bandwidth
  - Memory
  - Compute
Single Stream Benchmarks

• 53% decrease in CPU utilization
• 7% memory reduction
• 10% increase in startup time, however STTP has notably more robust metadata processing
### At Scale Snapshot

<table>
<thead>
<tr>
<th></th>
<th>Points Per Second</th>
<th>Memory</th>
<th>CPU</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEP</td>
<td>425,000</td>
<td>1300MB</td>
<td>1.35 CPU</td>
<td>~900kB/s</td>
</tr>
<tr>
<td>STTP</td>
<td>575,000</td>
<td>220MB</td>
<td>1.5 CPU</td>
<td>~650kB/s</td>
</tr>
</tbody>
</table>
At Scale Benchmarks

• 87% reduction in memory
• 18% reduction in processing
• 47% reduction in bandwidth
Key Findings

• Simpler, smaller code base
  • Easier to maintain
  • Easier to find bugs
  • Easier to update and optimize

• Obvious resource savings

• Substantial “stability” increase
Operational Takeaways

• A data platform is only as good as the data that it can ingest
• Many problems only emerge at scale
• Resource consumption matters more at scale as well
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