sttp

Streaming Telemetry Transport Protocol

STTP / IEEE 2664

Data backfilling and applicability for POW data.

GRID PROTECTION ALLIANCE

New Protocol Streaming Data – IEEE 2664

Advanced Synchrophasor Protocol Project

sttp

DOE FOA 1492
DE-OE0000859

ASP

Streaming Telemetry Transport Protocol

- 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
- Detailed metadata exchanged as part of protocol
- Includes lossless compression to reduce bandwidth utilization
- Security-first design with strong authentication and option for encryption

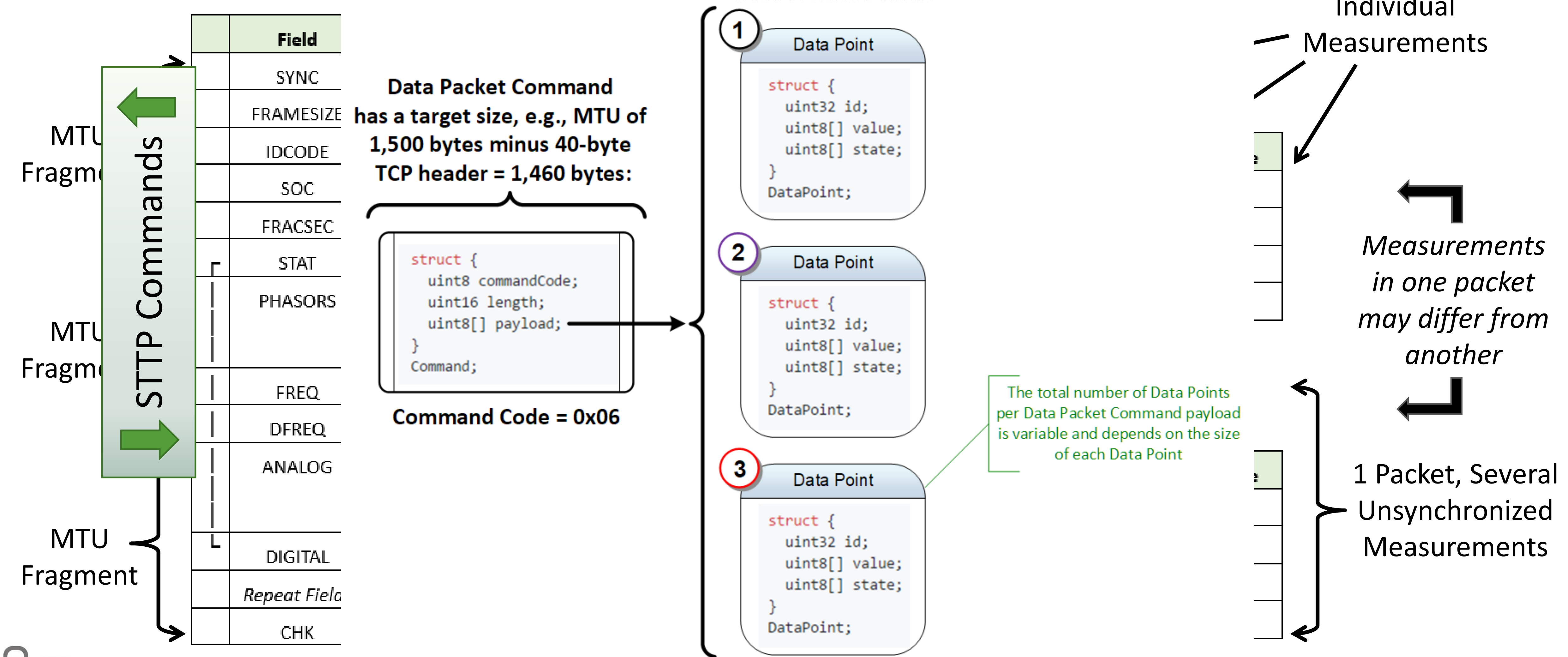
Background – The Problem Statement

- Protocol data formats are fixed
- Large data frames require a sizable number of network packets
  - Increasing opportunity for UDP loss
  - Increasing TCP latency
- Data frame will include “place keepers” for data that did not arrive within the lag-time
- Volume of data per frame has a fixed upper limit -- typically 64K
- Limited built-in security options, with most protocols offering none

Difference: Synchronized Frames vs Atomic Packets

- IEEE C37.118 /

Data Packet Command payload is a set of Data Points:



Lower Bandwidth through Lossless Compression

The Wire Protocol

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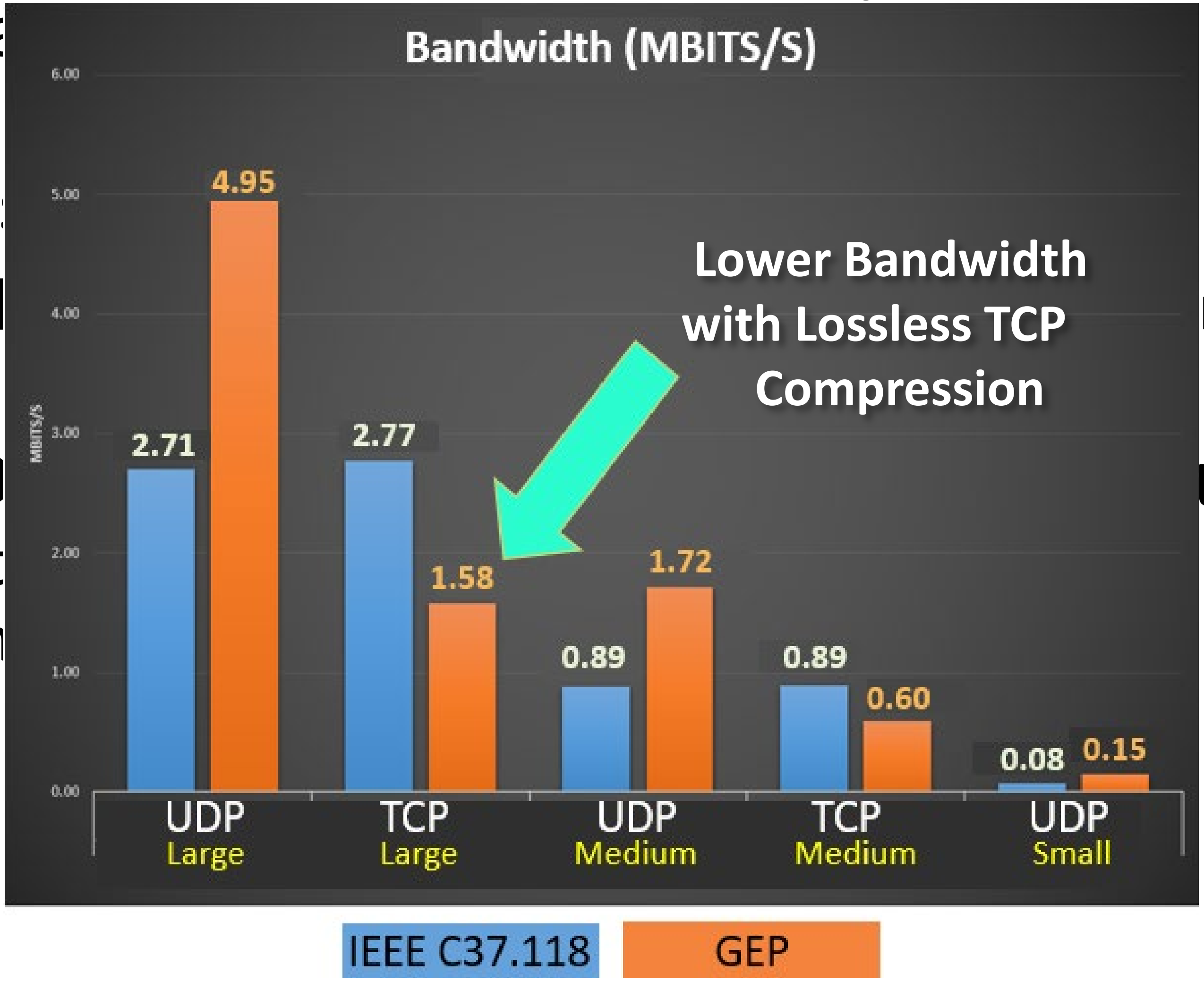

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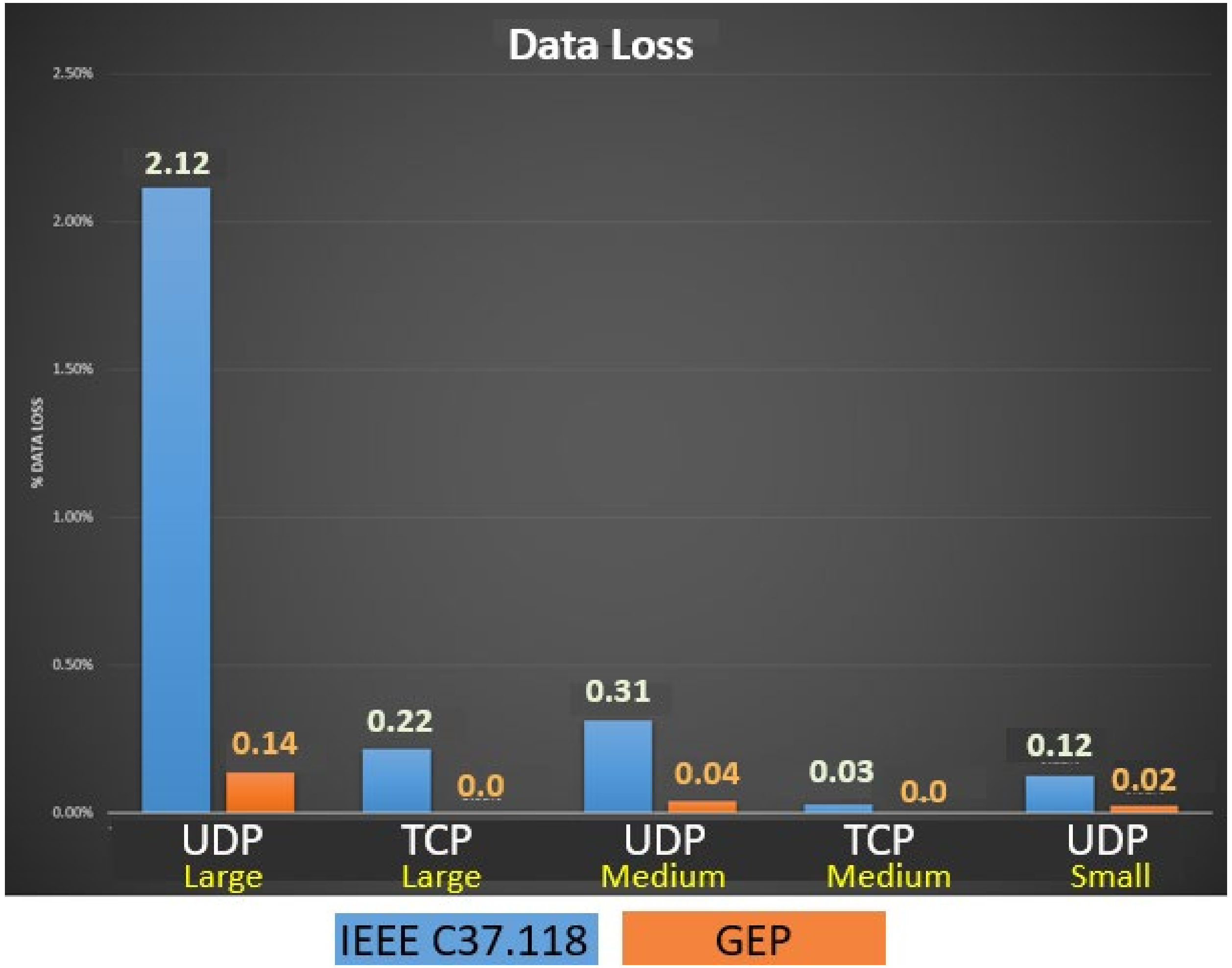
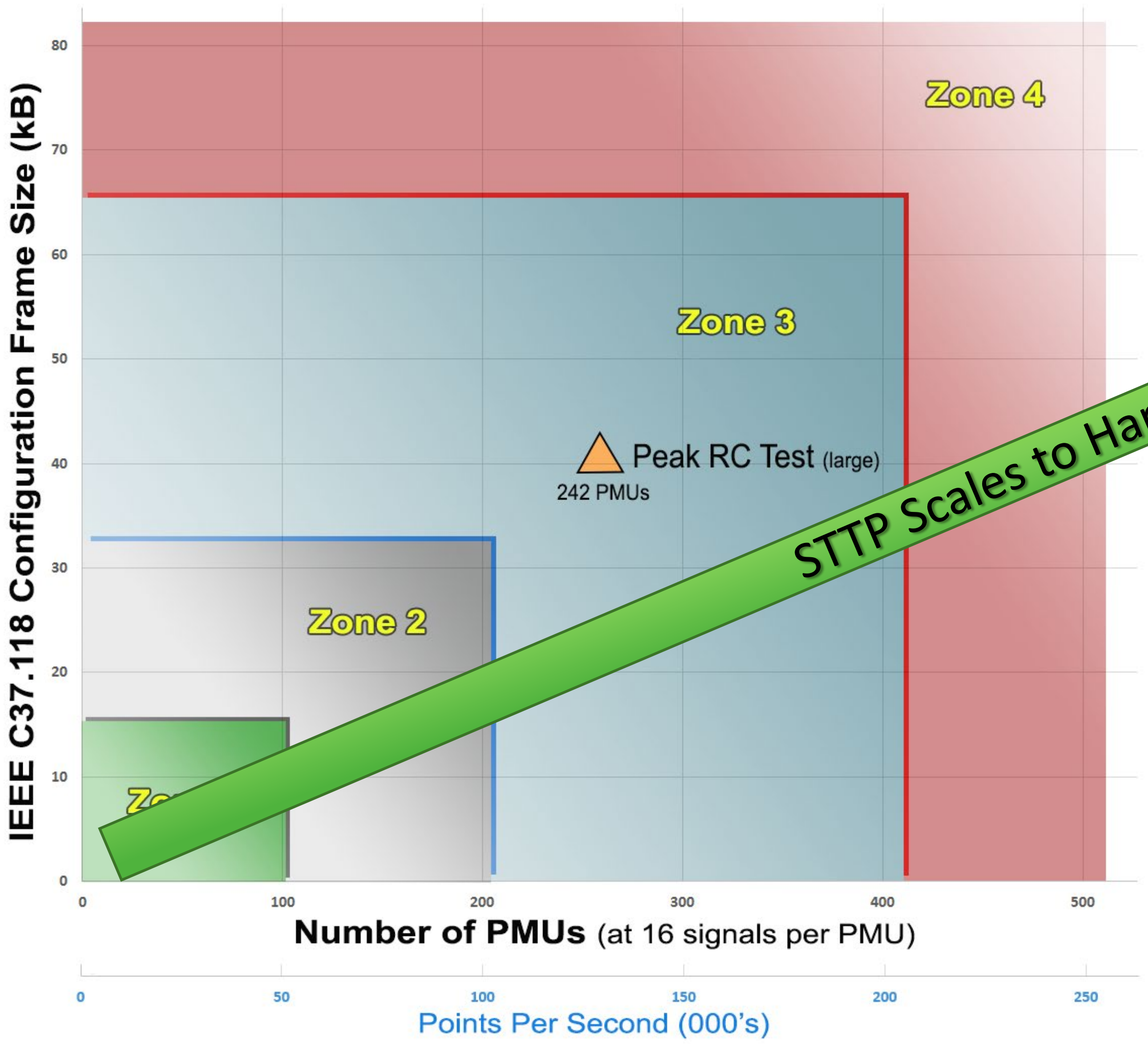
Via TCP Eliminates Data Loss with Lower Bandwidth

The Wire Protocol



STTP Scales Beyond Hard C37.118 Limits



STTP Scales to Hardware Limits

- 4 IEEE C37.118 V1 & V2 c... guration frame size max ... K). A second stream m... e created
- 3 I... sed data loss and latency. Purpose-built / allocated networks typically required
- 2 Data loss and latency issues begin to appear. Network tuning may be required
- 1 Issues, if any, are easy to resolve

STTP handles from 3 to 5 million points per second per connection on common hardware.

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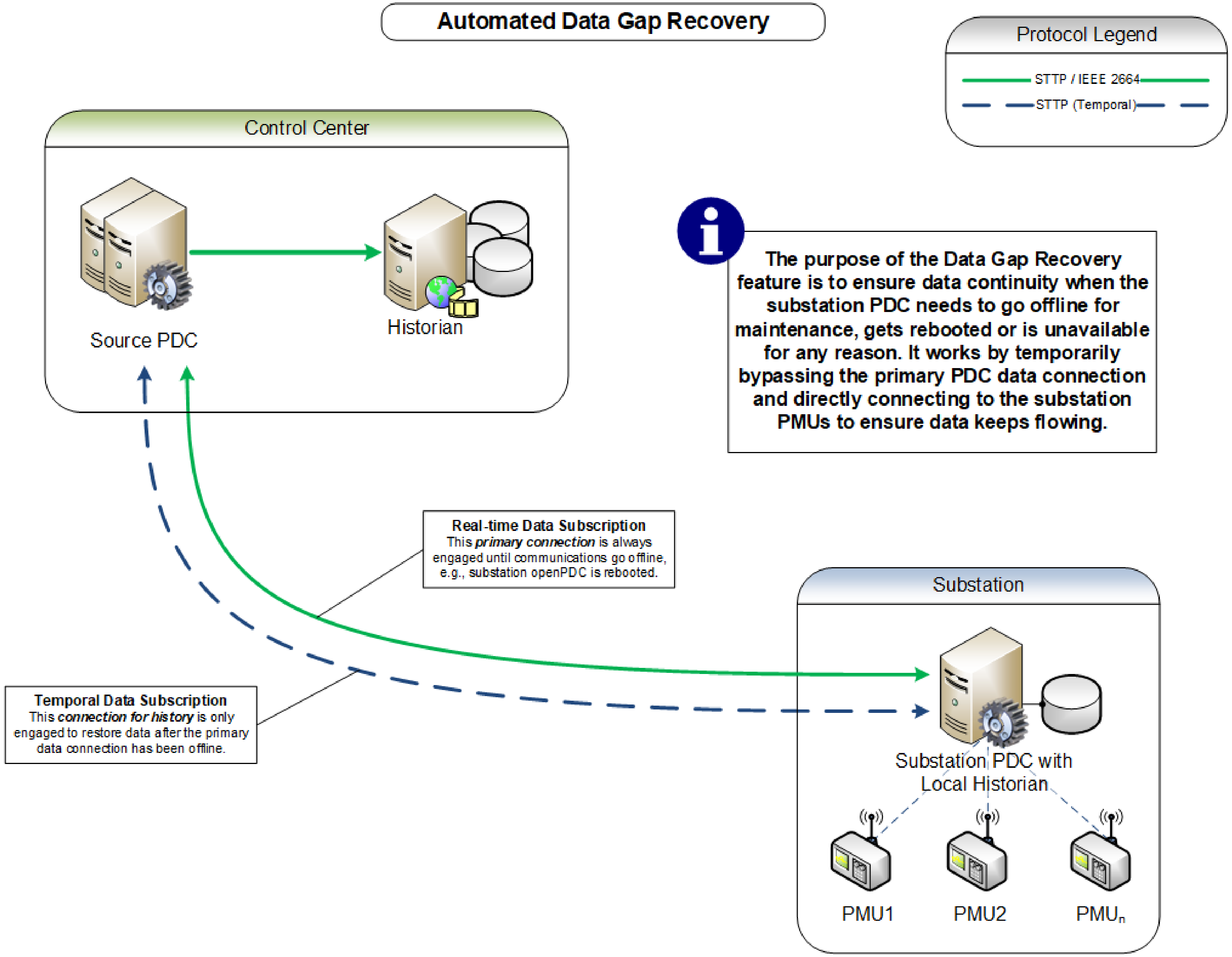
Backfilling Data after Communications Loss



Point on Wave Measurements

- Offers value – for utilities (equipment health / information consolidation) and consumers/regulators (robustness and higher reliability)
- Significant improvement over synchrophasors – captures transients, harmonics, and non-sinusoidal phenomenon
- The time is right -- No fundamentally new technology required to accommodate the communication and storage of large volumes of measured data. However, like phasors circa 2005 demonstrations are needed to refine both substation hardware and system software to reduce deployment cost and risk.
- Utilities would benefit from a coordinated industry effort – rather than differing monolithic solutions from vendors
- Interesting work needed to develop new analytic tools, models and model validation methods

What are CPOW measurements?

- Captures high-speed grid behaviors for the system as a whole
  - For base-line phenomenon – e.g., inverters and power electronics (No triggering logic – everything is recorded)
  - For disturbances and fast-transients
- Each phase voltage and current is measured and saved
- Sampling must be at a rate that supports waveform analytics
  - Minimum of about 2 kHz (32 samples per cycle)
  - 7.68 kHz (128 samples per cycle) is a common rate for DFRs that represents a good candidate as a standard CPOW sampling rate
  - Devices commercially available to sample at up about 64 kHz (1024 samples per cycle)
- Measurements are GPS-time synchronized

CPOW Benefits – An enabling technology

- Enables new analytics, control and protection to improve grid resilience
- Improves modeling, esp. unmodeled high-speed equipment operations
- A complete functional replacement for the data collection layer for BES monitoring and situational awareness obtained from synchrophasor data*
- A complete functional replacement for the data layer for synchrophasors and digital fault recorders to meet compliance requirements for disturbance monitoring (PRC-002)
- Enables functional replacement of or "spare-tire" for SCADA data acquisition layer (but not control)
- Long-term – better interoperability, performance and security of commercial grid monitoring tools

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* CPOW does not replace the need for synchrophasor data (a good analytic technique to identify phenomenon like oscillations) – rather, it replaces the source of the measurements. Phasors are computed from the POW data.

CPOW Challenges

- Substation Communications -- At about 5Mbps (uncompressed) for a typical substation – requires about the same bandwidth from a substation as a single, continuous HD video camera. STTP is good candidate for the protocol to transport this data efficiently and securely.
- Control Center Data Aggregation – For a medium to large transmission company (e.g., 400 substations), combined full-resolution data flow will require large, highly-performant storage and analytic systems.
  - Data volume = 1.6 TB/Substation/Month = 7,600+ TB per year for 400 substations
    - *While storage costs will continue to fall – today, central storage alone would be close to a $1M investment for one year's data. Obviously, can't afford to store it all for very long.*

To be successful – Must address the data volume challenge.

STTP can Help!

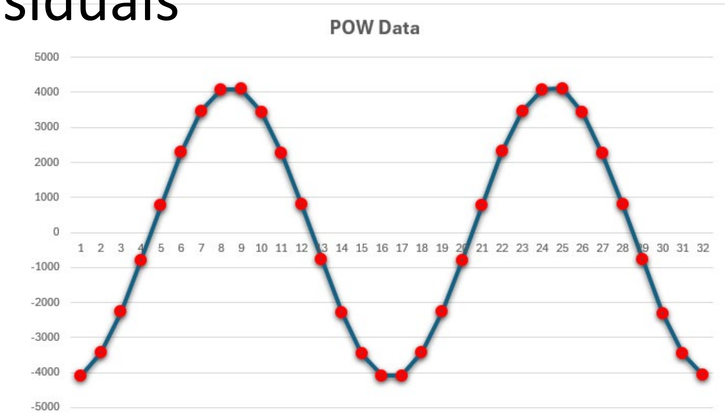
STTP Compression Algorithm: TSCC

- IEEE 2664 Standard (STTP) includes a compression algorithm:
  - Time Series Special Compression (TSCC)
- Tuned for Synchrophasor Data and Streaming Data
- Algorithm uses multiple algorithms for different time-series elements, with special focus on “Value”:
  - ID
  - Time
  - Value (differential / 7-bit encoding / last result cache / zero handling)
  - Quality

TSSC Testing with Point of Wave

- Compression is very good for streaming phasor data
  - Low latency, low CPU impact, and fast
- Compression of high-resolution wave form data greater than 2kHz also compresses well
- For wave form data that is *less than* 2kHz, new compression is needed:
  - STTP supports custom compression algorithms
  - Optional "Harmonic Differential Compression" can get compression ratio down to ~25% for sinusoidal inputs using curve matching residuals

At 960Hz, for every 16 measurements, you move through 360 degrees →



Harmonic Differential Compression

- For the current implementation, some default parameters (all configurable):
  - Harmonic count: 8
  - Supplemental compression algorithm: LZMA
  - Buffer size: 64K
  - Window size: 2 cycles
  - Frequency estimation: Fixed (options for zero crossing / FFT)
  - Target compression ratio: 26%
- Optimizations:
  - Caching of calculated omegas – reduces calls to trig functions
  - 3/7/13-bit encoding

STTP High Precision Time Options

- Custom timestamps sizes controlled by configuration:
  - Timestamp Size
    - Total bytes, 0, 2, 4, or 8
  - Timestamp Resolution
    - SI unit, e.g., milli, micro, nano or pico
  - Timestamp Precision
    - Time increment, common values are 1, 10 or 100)