

CIGRE – Grid of the Future
Chicago, IL

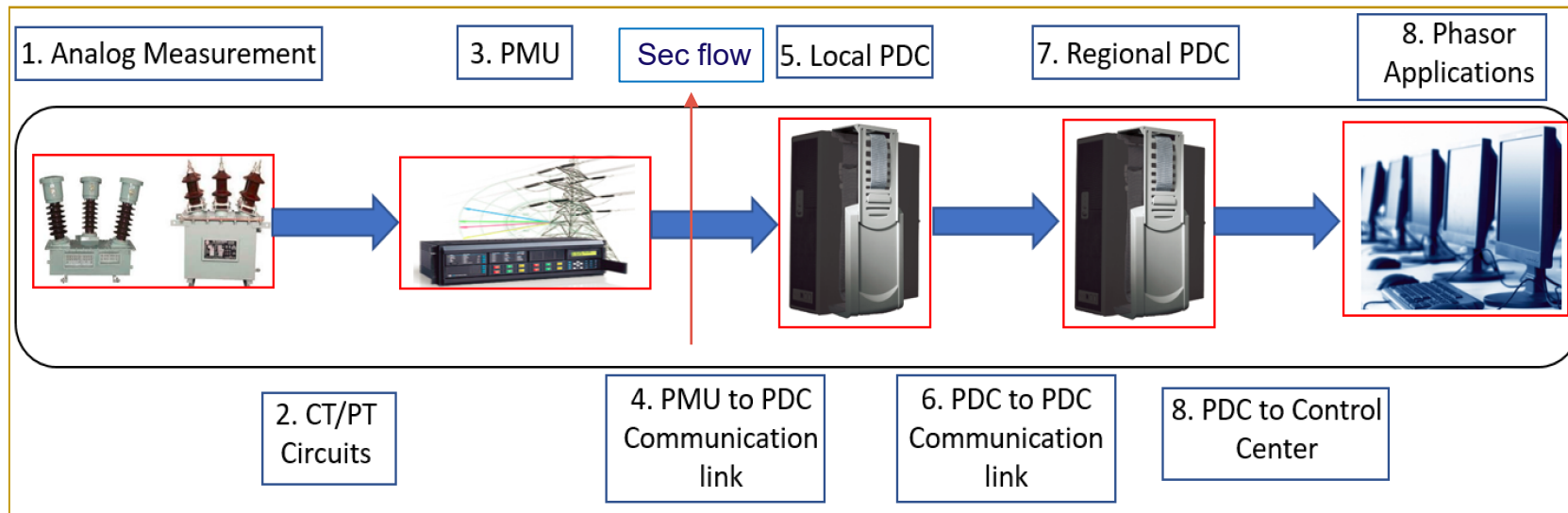
Cloud-Hosted Data Platform for Distribution Synchrophasor and Waveform Sensors to Drive Analytics and Applications

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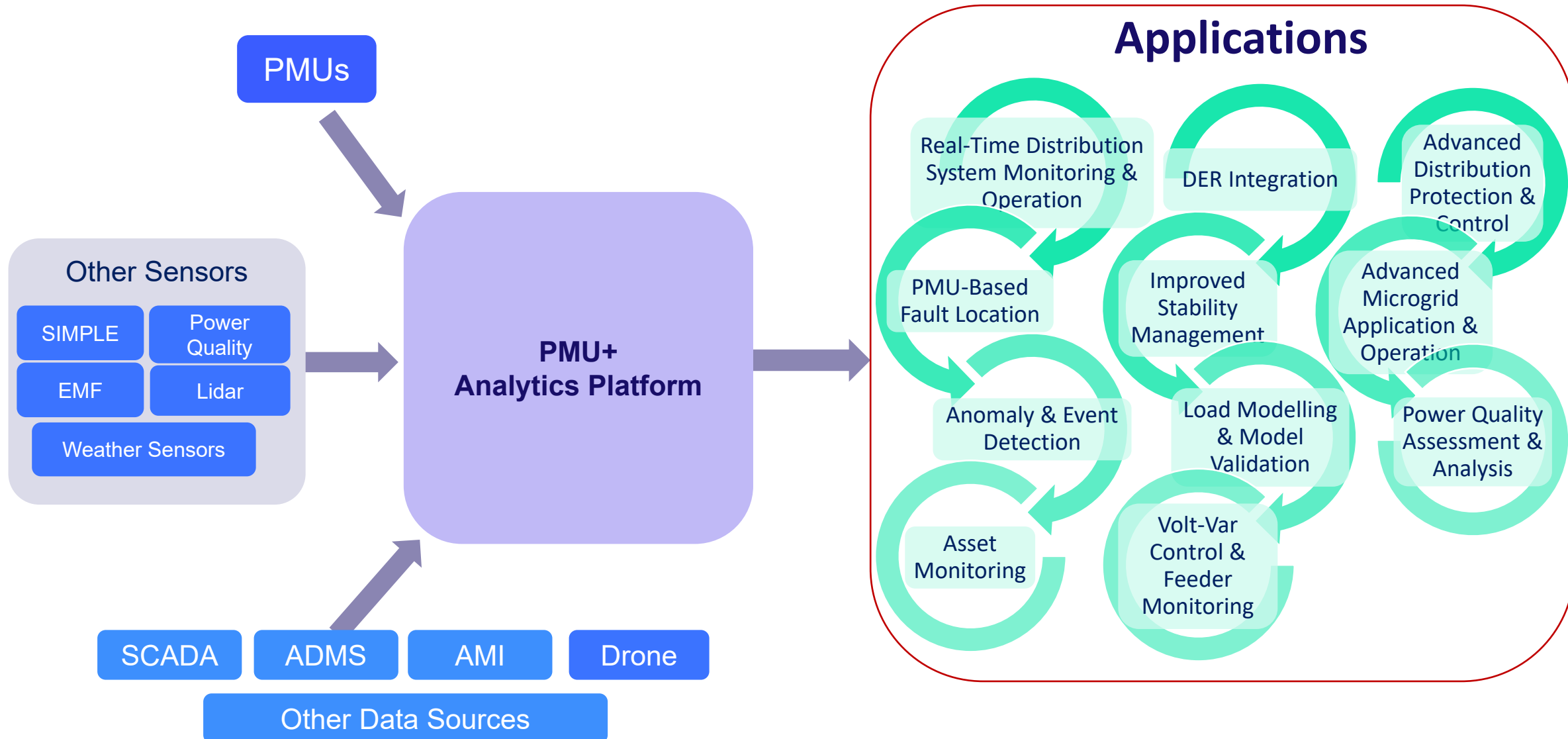
ComEd's PMUs and Application Roadmap

Background - What is PMU?

- PMUs: Phasor Measurement Units, a device to measure synchrophasors
- Measures at a reporting rate of 10, 15, 30, 60, 120 reports per seconds
- Measurement quantity:
 1. 3-Phase Voltage magnitude and angles (Voltage phasors)
 2. 3-Phase Current magnitude and angles (Current phasors)
 3. Frequency
 4. Rate of Change of Frequency
 5. Other optional analog and digital parameters
- PMUs in BCM area: 25 MicroPMUs and 2 Substation PMUs
- Total Distribution Substation PMUs across ComEd: 190 deployed/activated
- Currently, distribution PMU data is streamed to Super PDC (Regional PDC in figure), which is owned by transmission PMU team



PMU Analytics Platform and Application



Platform Requirements

High Level Platform Requirements

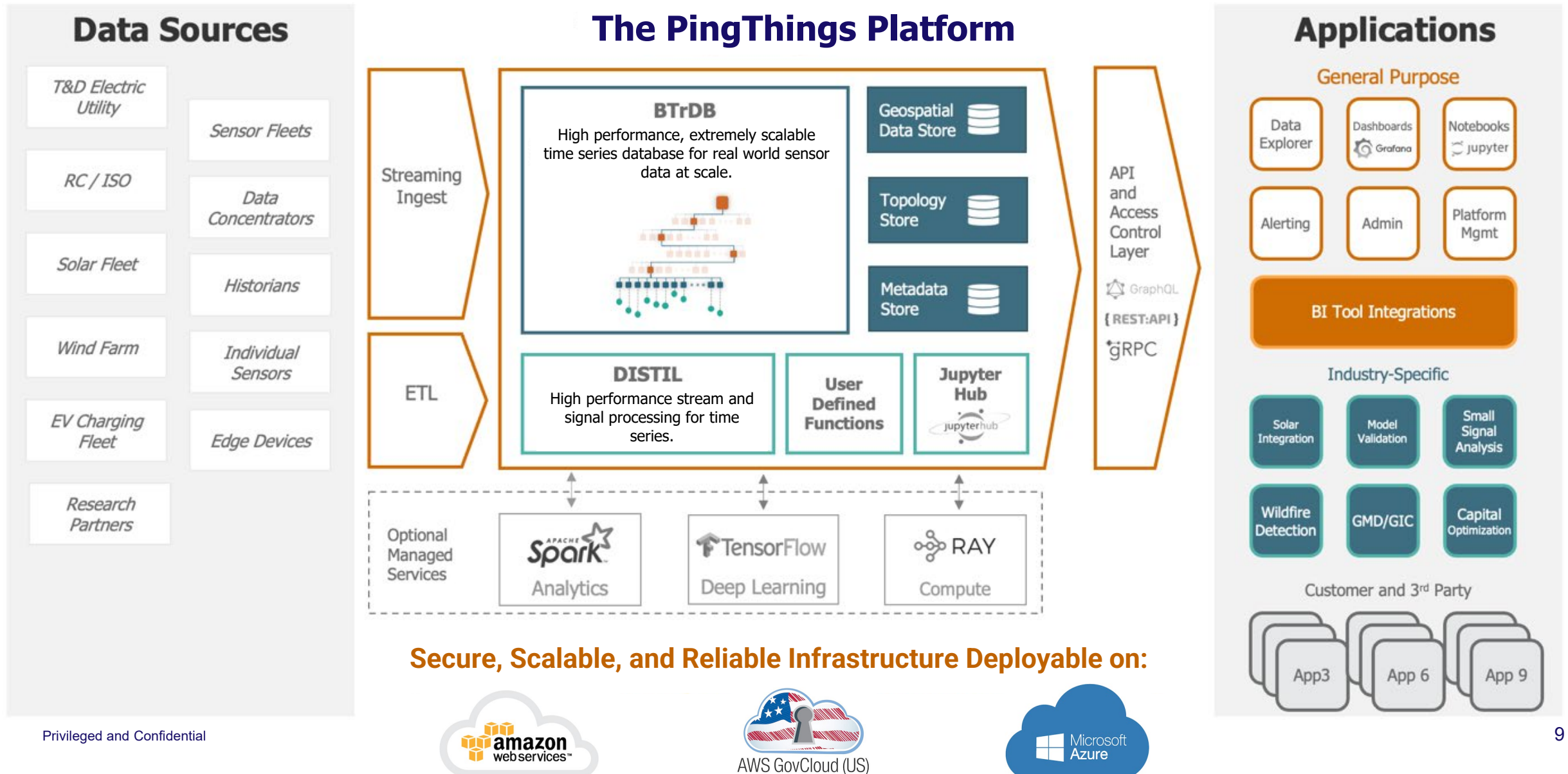
1. Data storage
2. Scalability
3. Performance
4. Data access latency
5. Programming language agnosticism
6. Application hosting

Understanding the Need for Speed

Read Speed (data points per sec)	Time to Read 1.89 Trillion Data Points
10,000	6.0 years
100,000	7.3 months
1,000,000	3.125 weeks
10,000,000	2.1875 days
100,000,000	5.25 hours
1,000,000,000	31.5 minutes

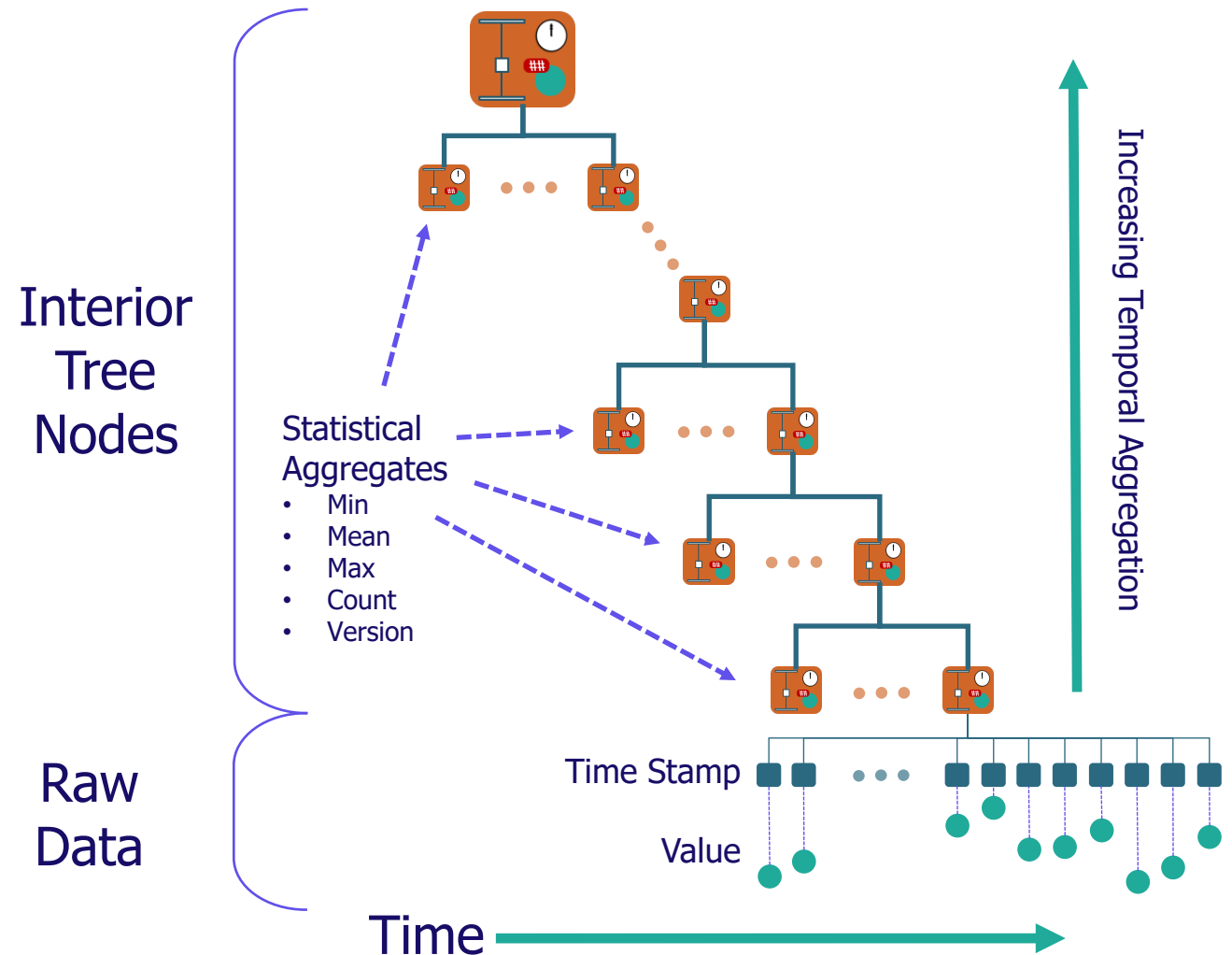
Platform Instantiation

A Scalable, Cloud-based Time Series Data Platform



A Scalable, High Performance Time Series Database

- Read and Write tens of millions of points/sec/node
- Scales easily to millions of sensors with petabyte data sets
- Interactive visualization with <250ms queries at any scale
- Natively supports:
 - Nanosecond time precision
 - Up to 1 billion samples/second/stream
 - Dynamic sampling rates & multiresolution time series
 - Out of order insertion without slowdown
 - Data versioning
 - Best-in-industry lossless compression



An abstract graphic consisting of several overlapping, wavy, organic shapes in shades of teal and light blue, positioned on the right side of the slide.

Qualification Tests and Results

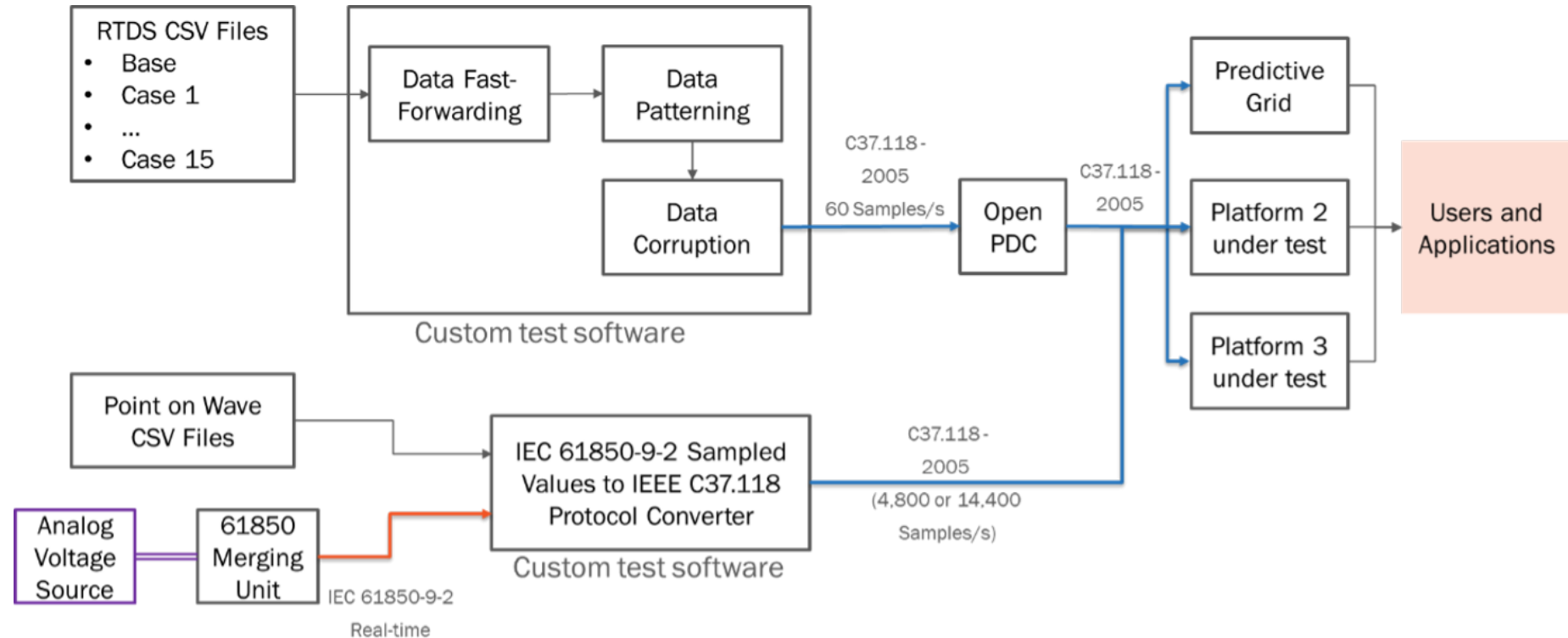
Test Suite Overview

- Realtime PMU Streaming
 - 46 PMUs x 6 phasors @ 60 fps (15 channels per PMU)
- Latency estimation
- Point on wave streaming
 - 1 MU x 6 channels @ 4,800 Samples/s (also tried 14,400 Samples/s)
- Historical Data Upload
 - 46 PMUs x 6 phasors @ 60 fps for 1 month
 - 1.7 TB of data
- Event Triggering (using APIs)
 - Under/over voltage based on 'patterning' of real-time stream
- Realtime data viewing
- Near real-time applications, e.g., PQ and harmonics monitoring (using APIs)

Objectives and Architecture for Real Time Testing

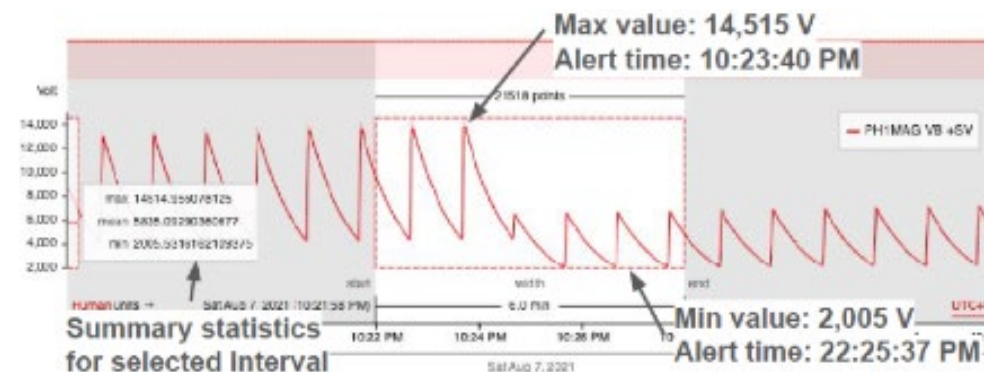
5 key objectives for the real-time streaming tests:

1. Evaluate the data flow performance
2. Observe latency
3. Observe data quality
4. Observe real-time access and visualization
5. Evaluate technical support for each platform



Test Results

- Initial setup was very easy and “just worked”
- All Streaming data tests from NuGrid facilities to PredictiveGrid in AWS East were successful
 - 46 PMUs x 15 channels @ 60Hz - No data drops were observed for a full test day of continuous streaming, including the C37.118 STAT words
 - Merging Unit (MU) with 3-phases (V & I) @ 4800 and 14,400Hz streamed successfully
- Round-trip latency, including network delays, was 280 milliseconds.
- A historical dataset, over 1.7 TB of time series data (46PMUs x 15 channels @ 60Hz), took 14 hours to ingest via a non-optimized import
- Successfully performed:
 - Real-time power quality calculations using platform’s Python APIs
 - Detected under/over voltage conditions based on input streams



Conclusion

- PMUs can enable real-time application for effective monitoring and control of the dynamic distribution system
- Sensors alone are useless
- Must be paired with an effective software platform
- Platform that can ingest, store, and access the data from hundreds or thousands of sensors and deliver it as inputs to applications in real-time
- With the evolving data system and cloud hosted data centres, a PMU platform hosted in the cloud enables data fusion-based applications
- The PredictiveGrid platform is under deployment at ComEd to stream PMU data from over 250 PMUs

Thank you

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