Distributed Waveform Analytics in the Wave Apps Platform

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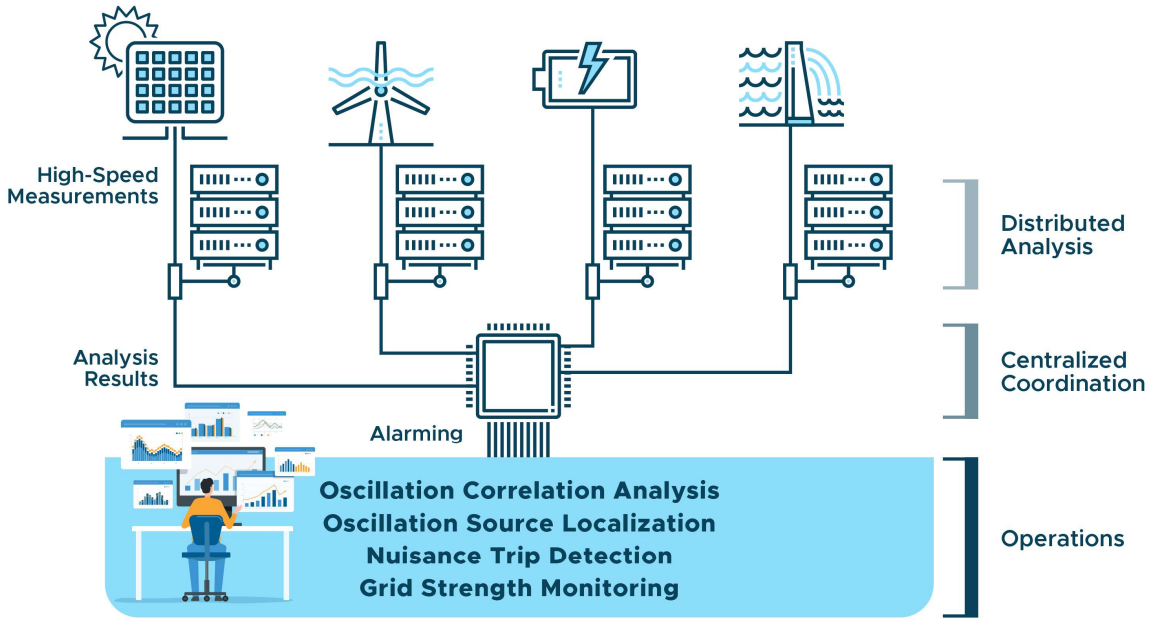
Concept

- Wave Apps is a distributed measurement-based platform that enables operators to monitor and mitigate inverter-based resource (IBR) performance issues
- POW measurements are analyzed within substations by distributed instances
- Analysis results are then streamed to the central platform for coordination, alarming, and visualization
- Streaming will be comparable to a PMU, so existing networks can be used
- Four high-value applications will be developed and demonstrated
- Extensible to allow additional applications



Team Roles

Platform Development

GRID PROTECTION ALLIANCE

Testbed Evaluation

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

Application Development

Pacific Northwest NATIONAL LABORATORY

+ PROJECT LEAD

GE VERNOVA

UTSA The University of Texas at San Antonio™

Field Demonstration

SRP®

Advisors

ISO new england

NEW YORK STATE | NY Power Authority

Timeline

2025
- Planning and early development of the platform and applications
- Hardware and demonstration site selection

2026
- Finalize and test platform and applications
- Begin hardware deployment

2027
- Field demonstration
- Laboratory evaluation

2028
- Report and wrap up

Hardware

Networking

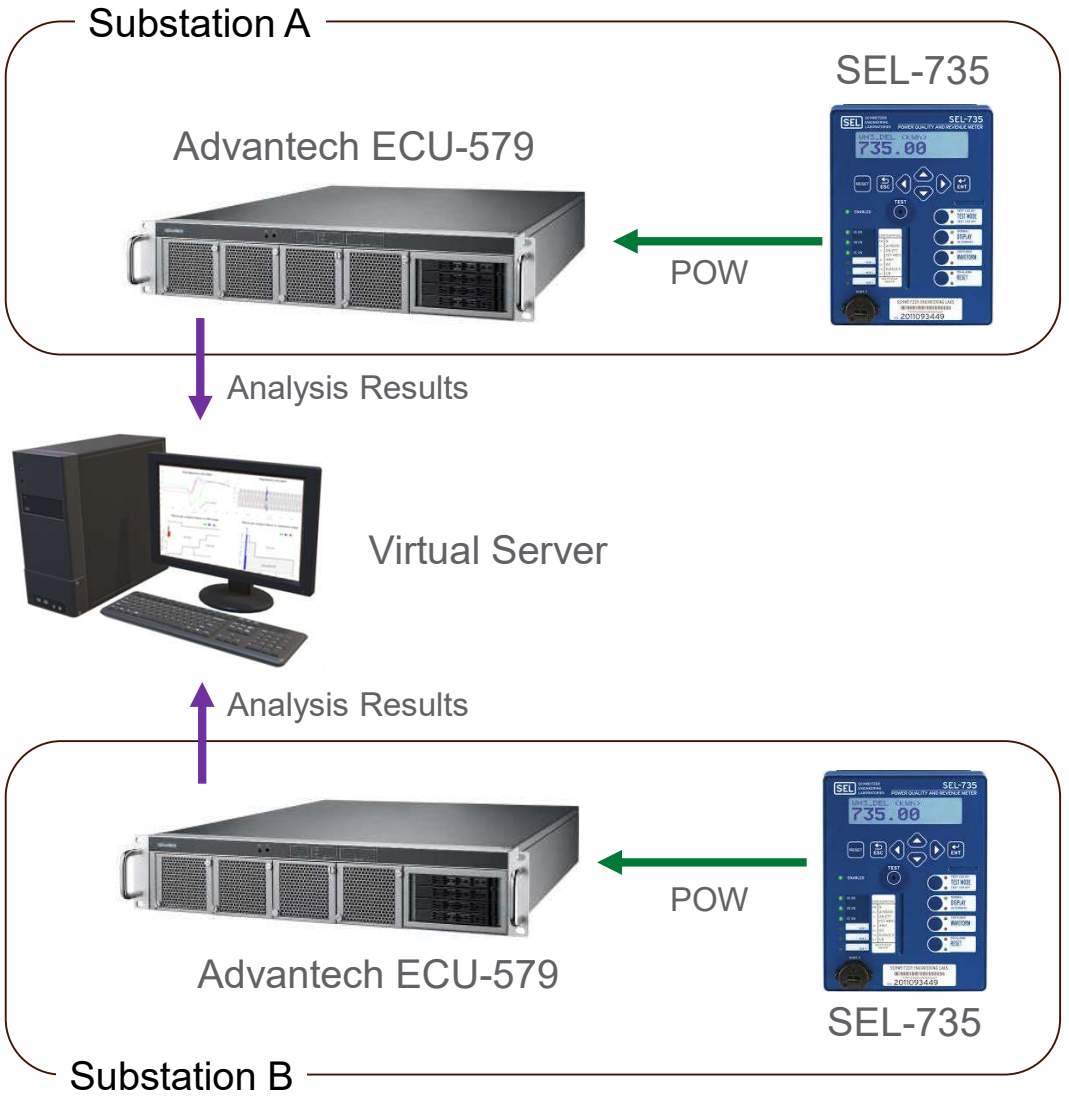
Platform

Applications

Hardware

Measurement Instrument

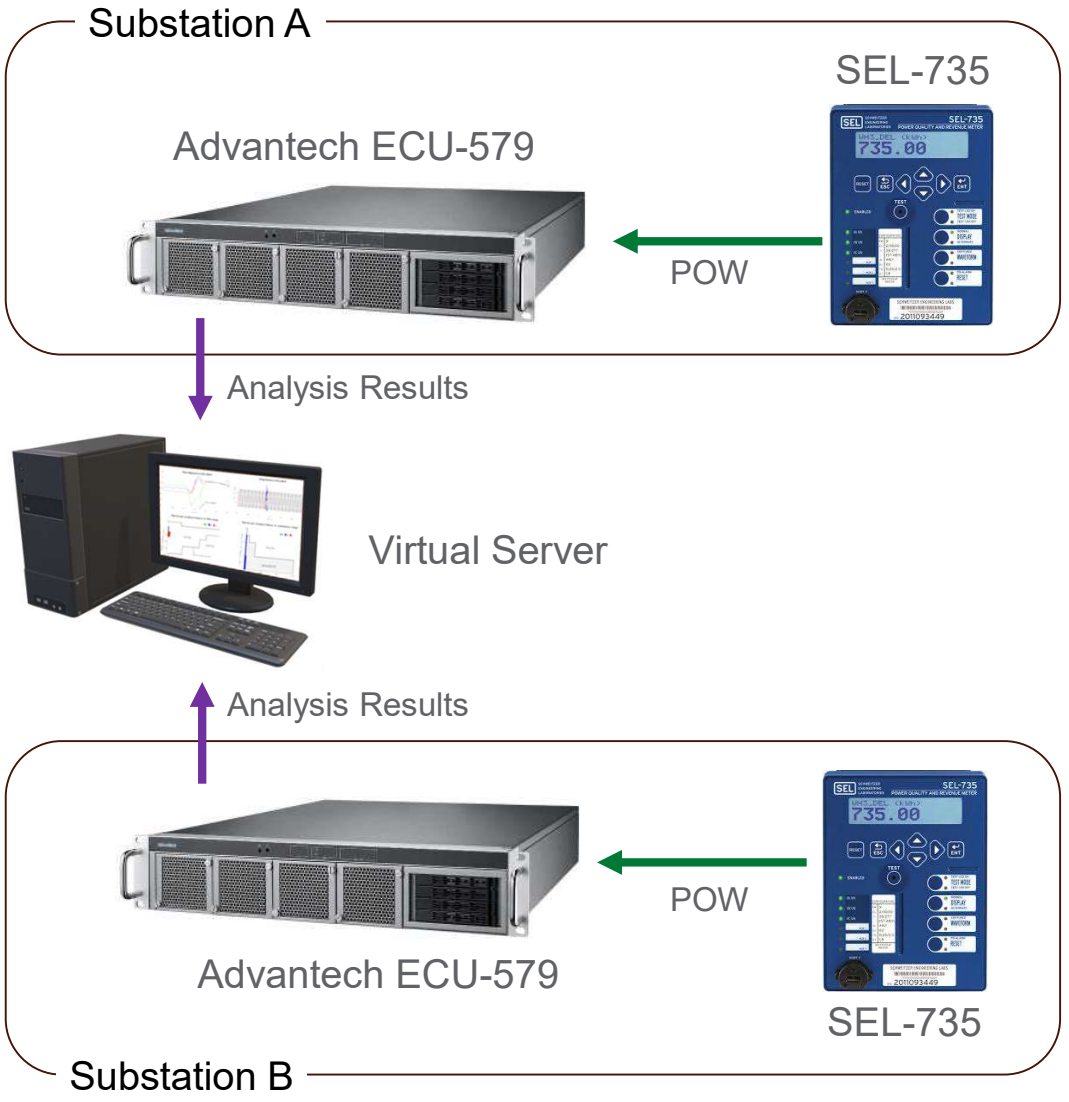
- SEL-735 power quality and revenue meter
- Capable of continuous waveform streaming at 3 ksps



Substation Computer

Advantech ECU-579

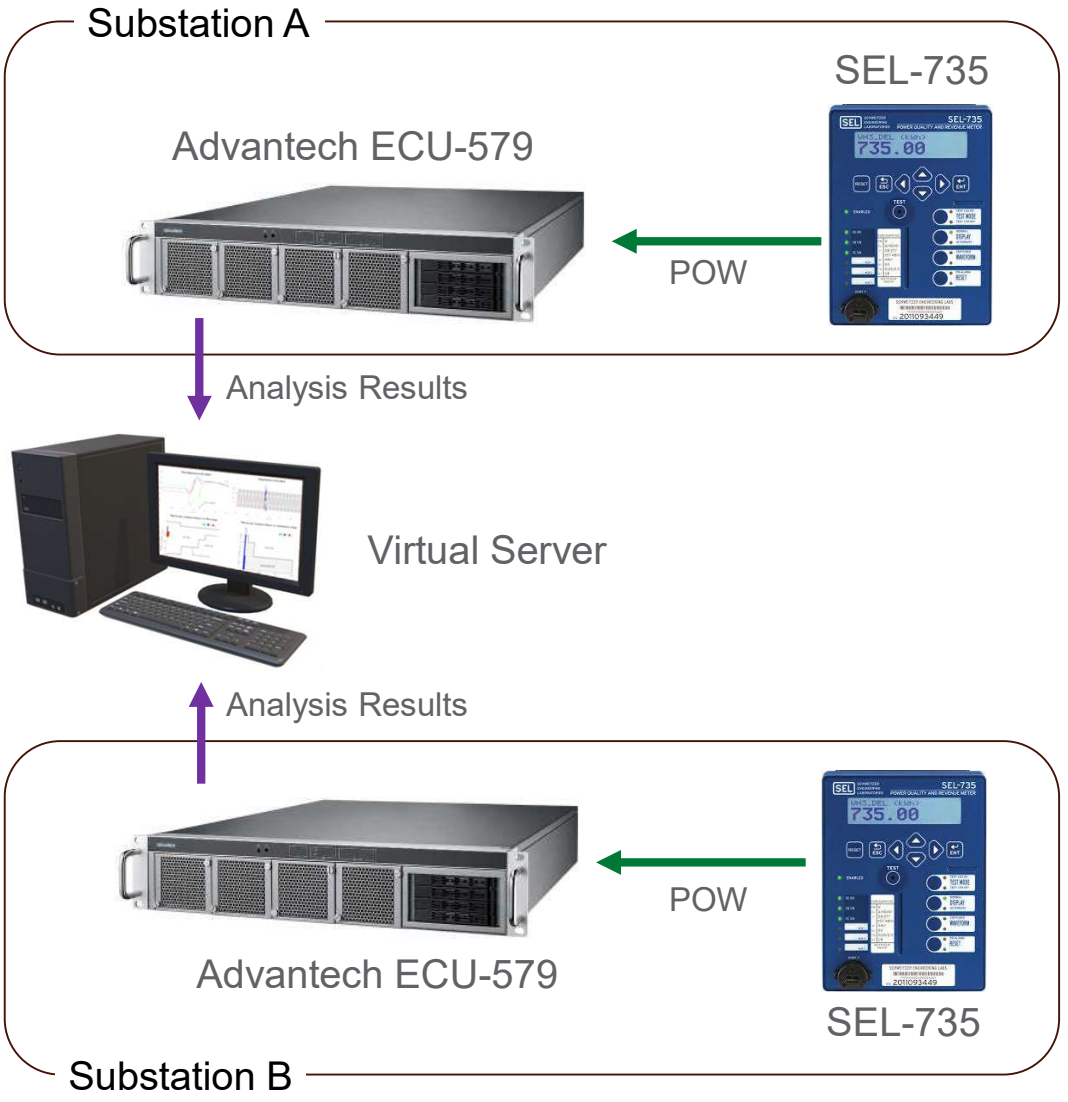
Operating System	Windows 11 Professional
Processor	Intel Xeon Gold 5218T
Processor Frequency (Base)	2.1 GHz
Processor Cores	16
Processor Threads	32
RAM	32 GB DDR4 3200 MHz
Storage	2 TB SSD
Network Ports	Four RJ-45 10/100/1000 ports
Required Rack Space	2U
Cooling	Active (Fan cooling)



Central Computer

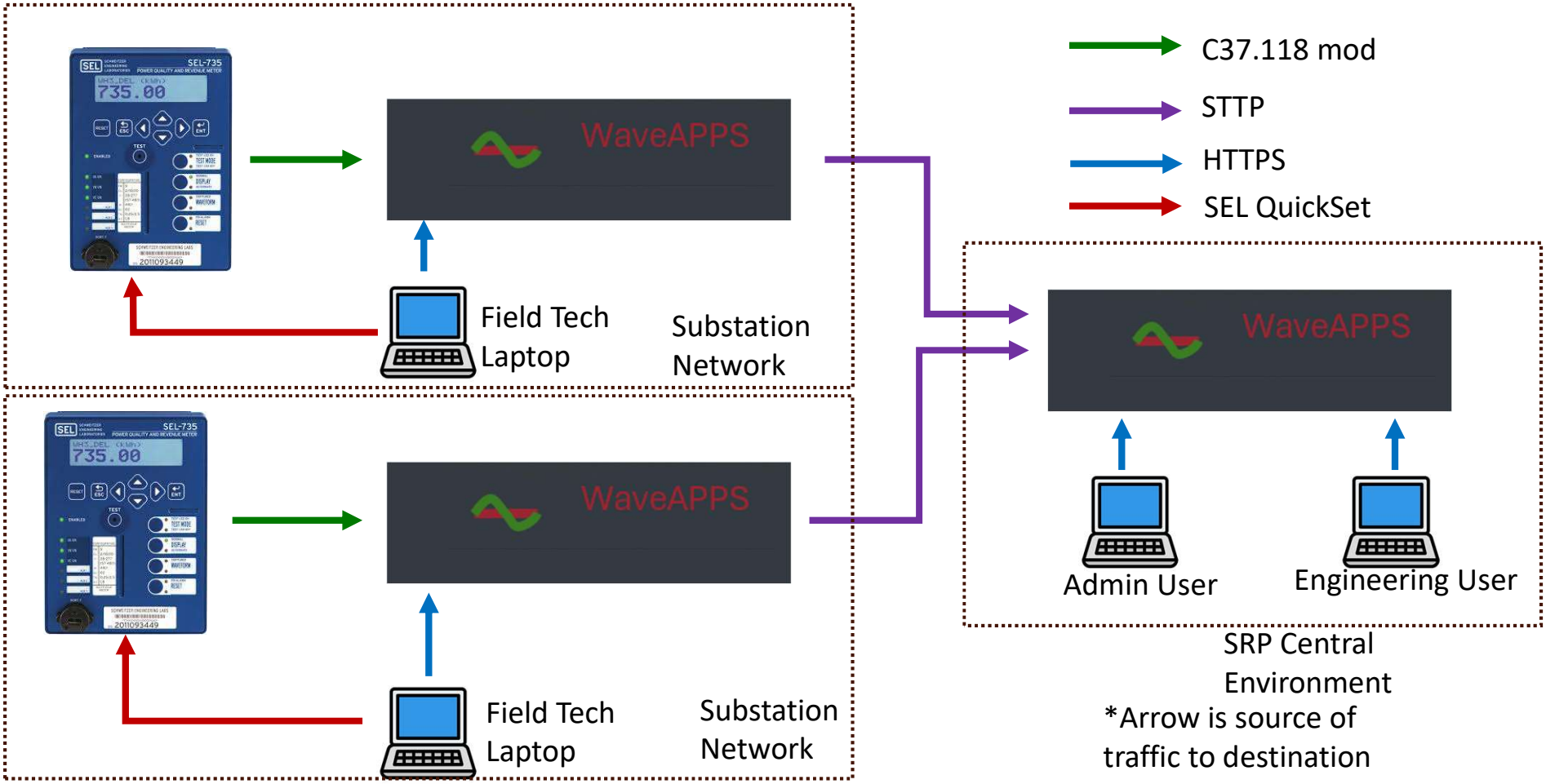
Virtual server hosted by SRP

Operating System	Windows 11 Professional
Processor Cores	16-24
RAM	32-64 GB
Storage	4 TB SSD
Virtual Network Interface Cards	Substation Computer
	Remote User Access



Networking

Networking Overview



Networking Instrument to Substation

- Sending Point on Wave Data
  - 3 Currents and Voltages
  - 3ksps resolution
  - Continuous data
- Use of IEEE C37.118*
  - Manufacturer modified version
  - Designed for specific device
  - Proven to work for PoW data

Networking Substation to Central

- Sending Analysis Results
  - Low resolution data
  - Large Variation in data volumes
  - Large packets
- Use of IEEE 2664
  - Proven to work for Synchrophasor data
  - Proven to work for PoW data
  - Supports Data Gap Recovery
  - Supports varying time resolution

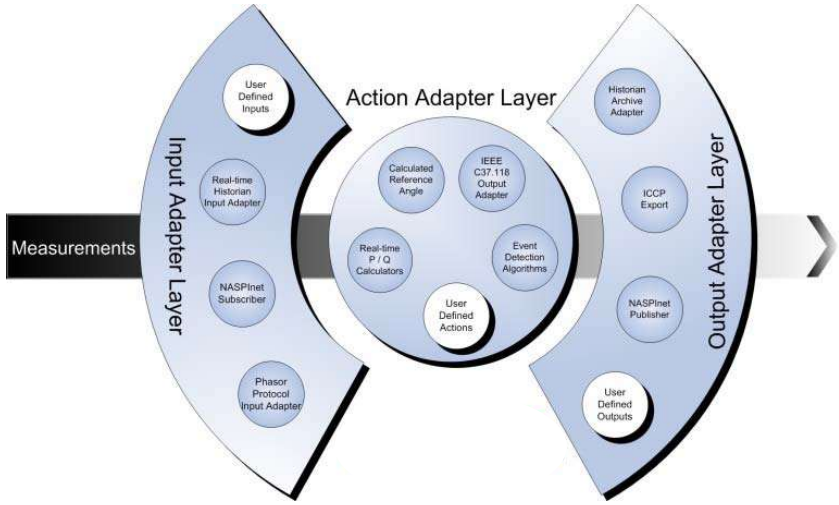
sttp IEEE 2664

Streaming Telemetry Transport Protocol

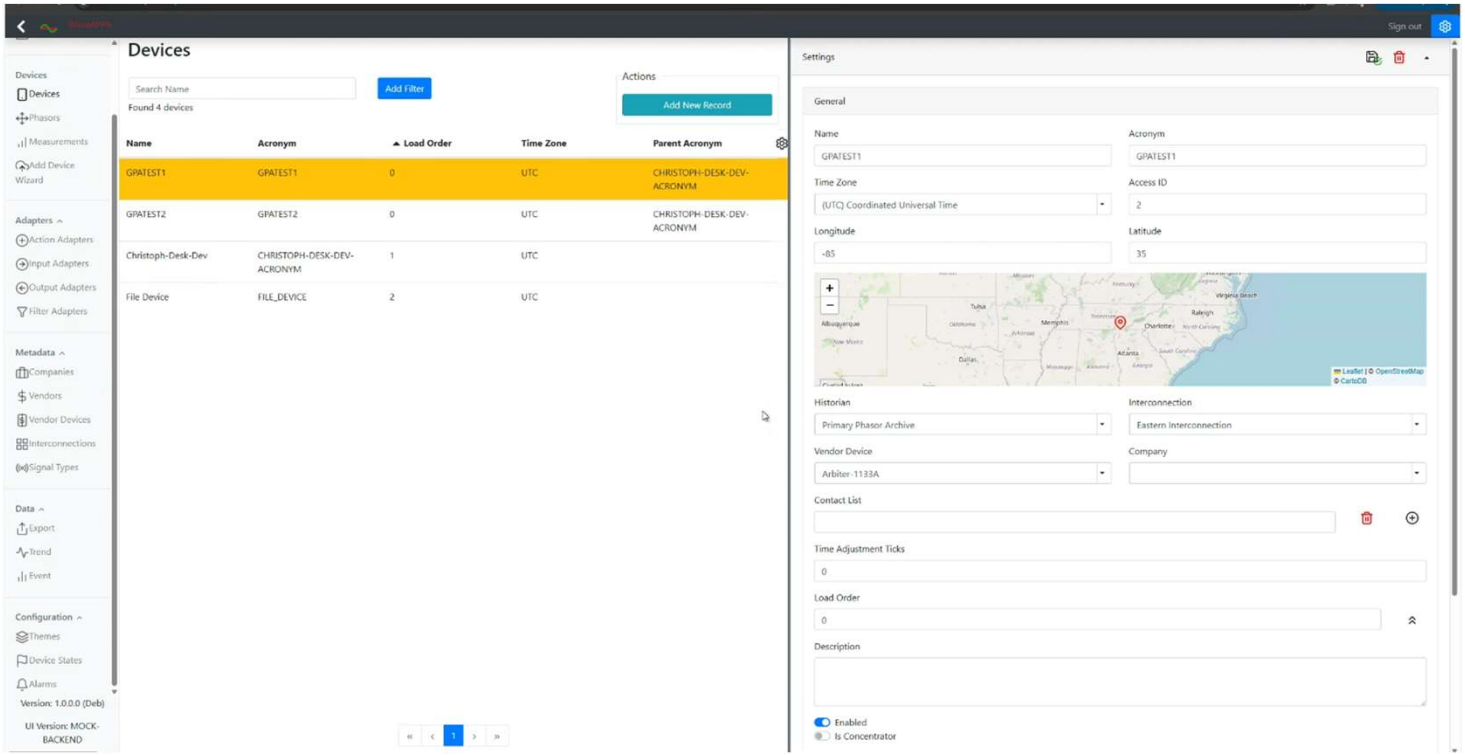
Platform

Platform Design

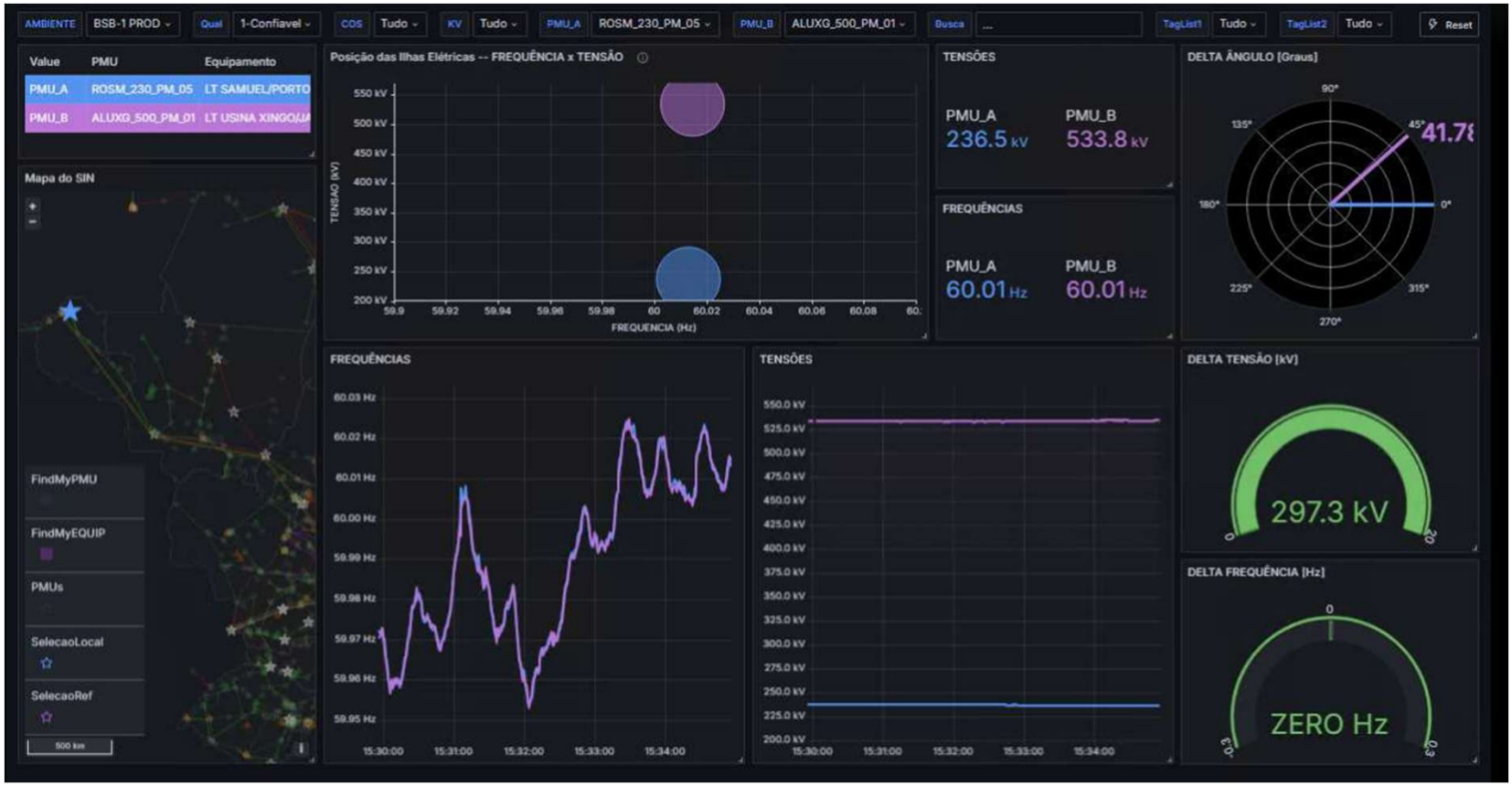
- Modular- adapter based
  - Deploy applications separately
  - Manage applications independently
- Visualizations and user interfaces
  - Web based management interfaces
  - Grafana based visualization



Configuration GUI Concept



Event Review GUI Concept



Applications

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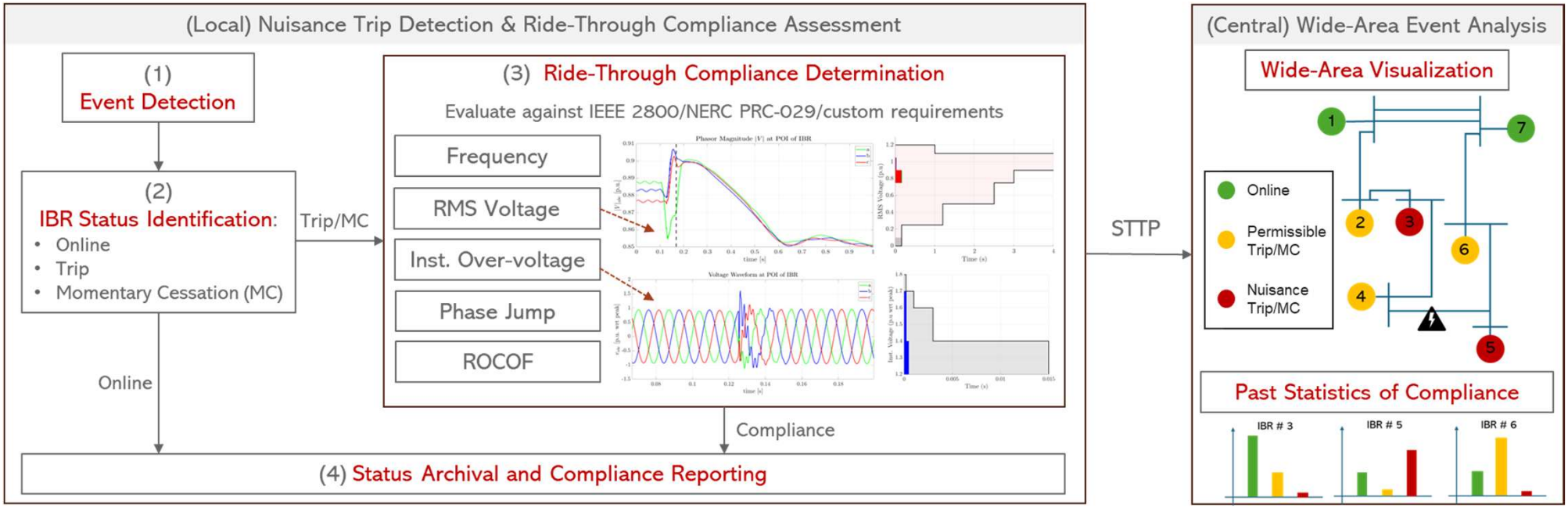
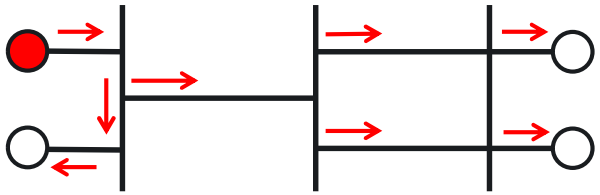
Nuisance Trip Detection

Automates detection and analysis of IBR tripping to prevent future multi-plant events



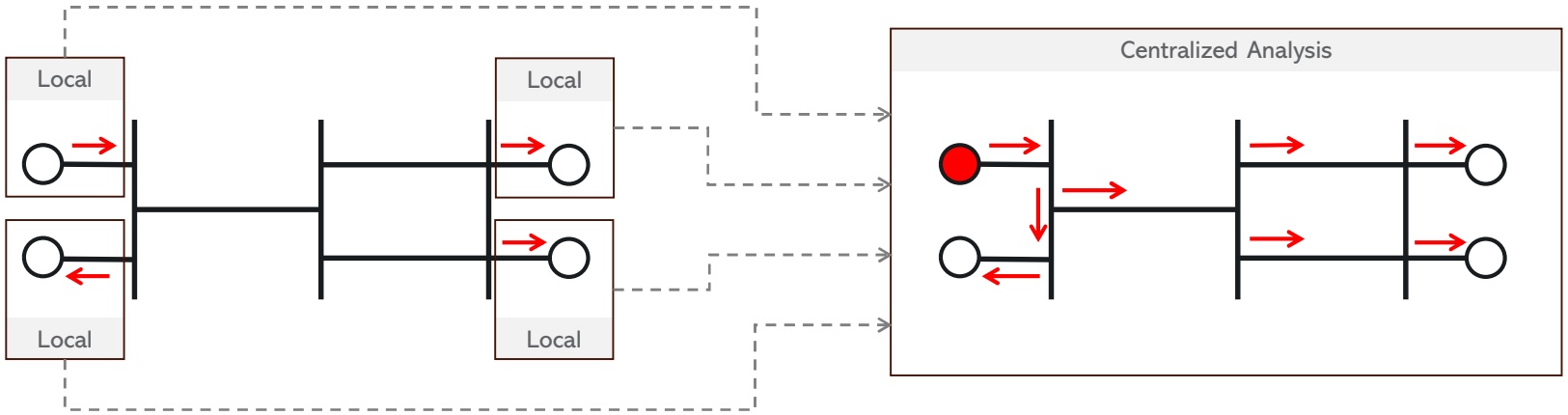
Oscillation Source Localization

- Dissipating Energy Flow (DEF)
  - Well-established PMU-based method
  - Traces the flow of oscillation energy back to the source

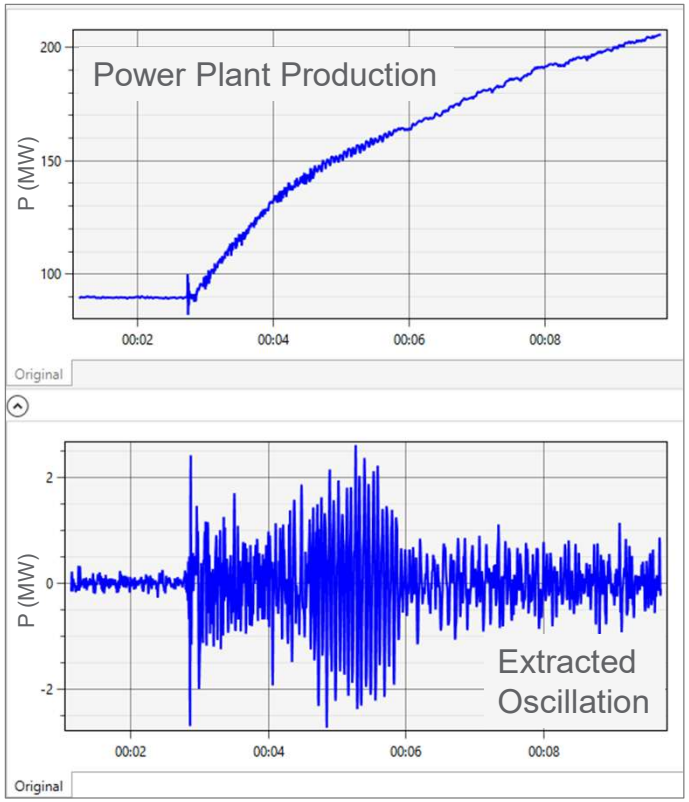


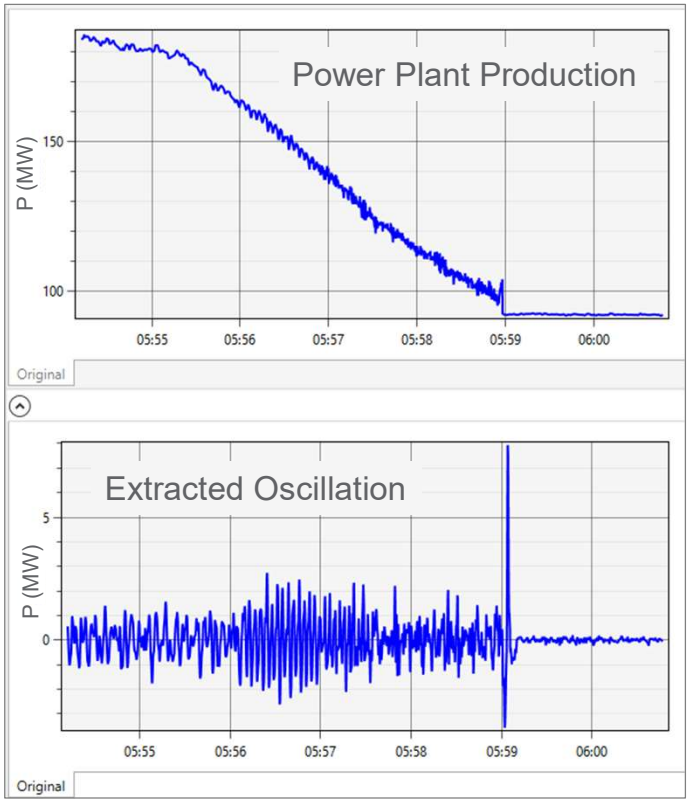
Oscillation Source Localization

- Dissipating Energy Flow (DEF)
  - Well-established PMU-based method
  - Traces the flow of oscillation energy back to the source
- A POW-based version is being developed to address oscillations too high in frequency for conventional DEF



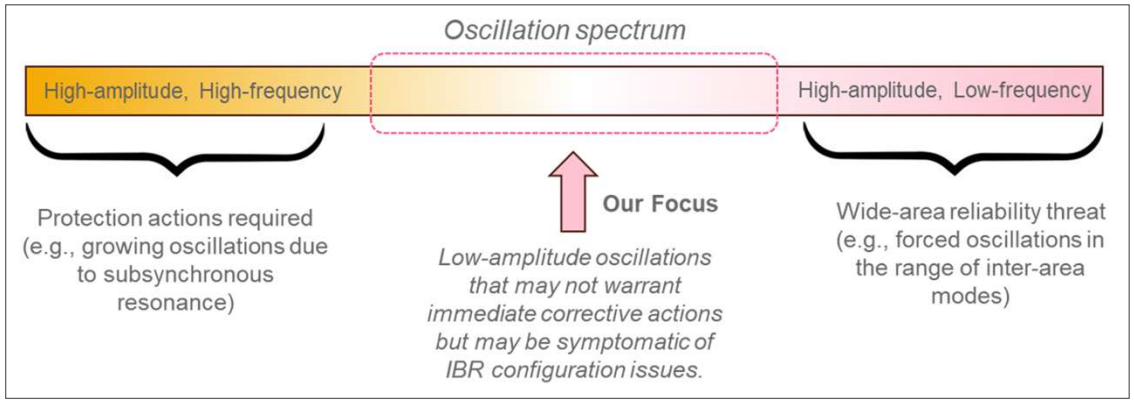
Oscillation Correlation Analysis

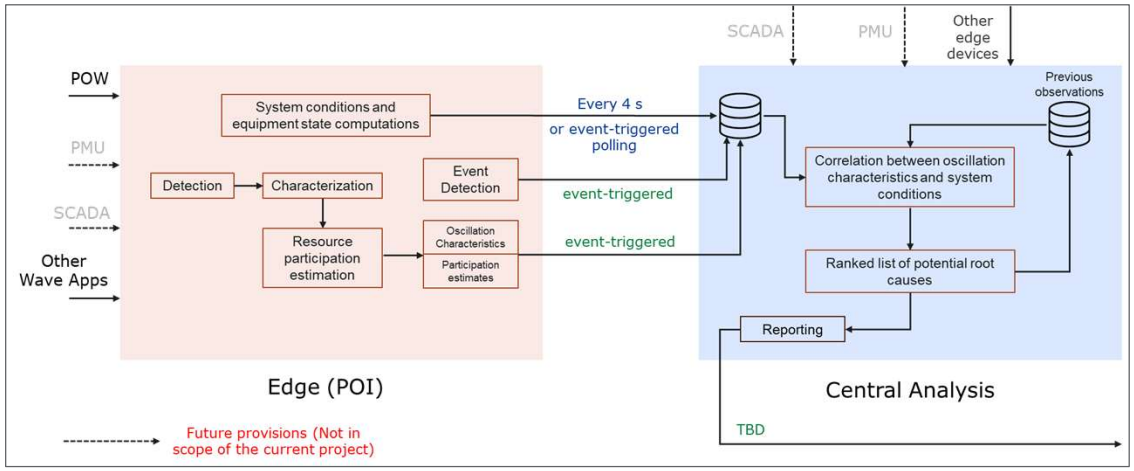




Oscillation Correlation Analysis

- Identifies root causes of IBR-induced oscillations
- Detects oscillations with the distributed instances
- Correlates the oscillation's appearance with grid conditions at the central instance





Summary and Next Steps

- The Wave Apps platform will address a gap in utilities' ability to monitor IBRs
- A distributed architecture enables POW-based analytics while limiting communication requirements
- The initial set of four applications will be extensible to meet emerging needs
- Looking forward:
  - Platform finalized
  - Algorithms translated to applications
  - Field demonstration at Salt River Project

Thank you