PG&E Synchrophasor Project

Communication and Data Quality of Issues

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Pacific Gas and Electric Company

PG&E's High-Level Synchrophasor Project Goals

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1. Evolutionary improvement to the grid monitoring and control process through introduction of time synchronized measurements into the Energy Management Systems (Enhanced EMS)
2. Use of synchrophasors for daily functions, to add to the tools already available for managing operations.
3. Take a sustainable path to train and familiarize all potential users of the system and deploy advanced applications as they become available.
4. To enable system users to enhance and shape the future of PG&E's system operation, monitoring, protection, and control.
5. Provide interfaces with Remedial Action Scheme (RAS) system and with third parties
6. To enable future value added function through demonstration of reliable performance of the function.

System Performance

- Function/Application-based requirements for availability and performance.
  - First establish requirements for the functions deployed or envisioned to be deployed in the future (as part of a sustainable roadmap)
  - Next function/application requirements are flowed-down to system functional requirements
  - The system is next designed to meet its functional requirements
- Summary of application to be deployed in the short-term
  - Situational Awareness, Visualization and Alarming for Electric Transmission Operators
  - Enhanced Energy Management Systems and State Estimation for current EMS users
  - Post-Disturbance Event Analysis for Planners and Engineers
  - Operator and Engineering Training, Enhanced Dispatch Training Simulator (DTS)
  - Cognitive Tasks and Human Performance Analysis
  - Provide interfaces with EMS and with third parties
  - Distributed State Estimation

Phasor application classes - A Perspective Based on Real-Time "Phasor Taxonomy“

	Small Signal Stability - Class A	State Estimator Enhancement - Class B	Post Event Analysis - Class C	Visualization - Class D
Low Latency	●	◒	⊙	◔
Reliability Availability	●	◔	◒	⊙
Accuracy	●	◔	●	⊙
Time Align	●	●	⊙	◔
Message Rate	●	◔	●	◔

⊙ Not very important
◔ Somewhat important
◒ Fairly important
● Critically important

Sample Application Requirements

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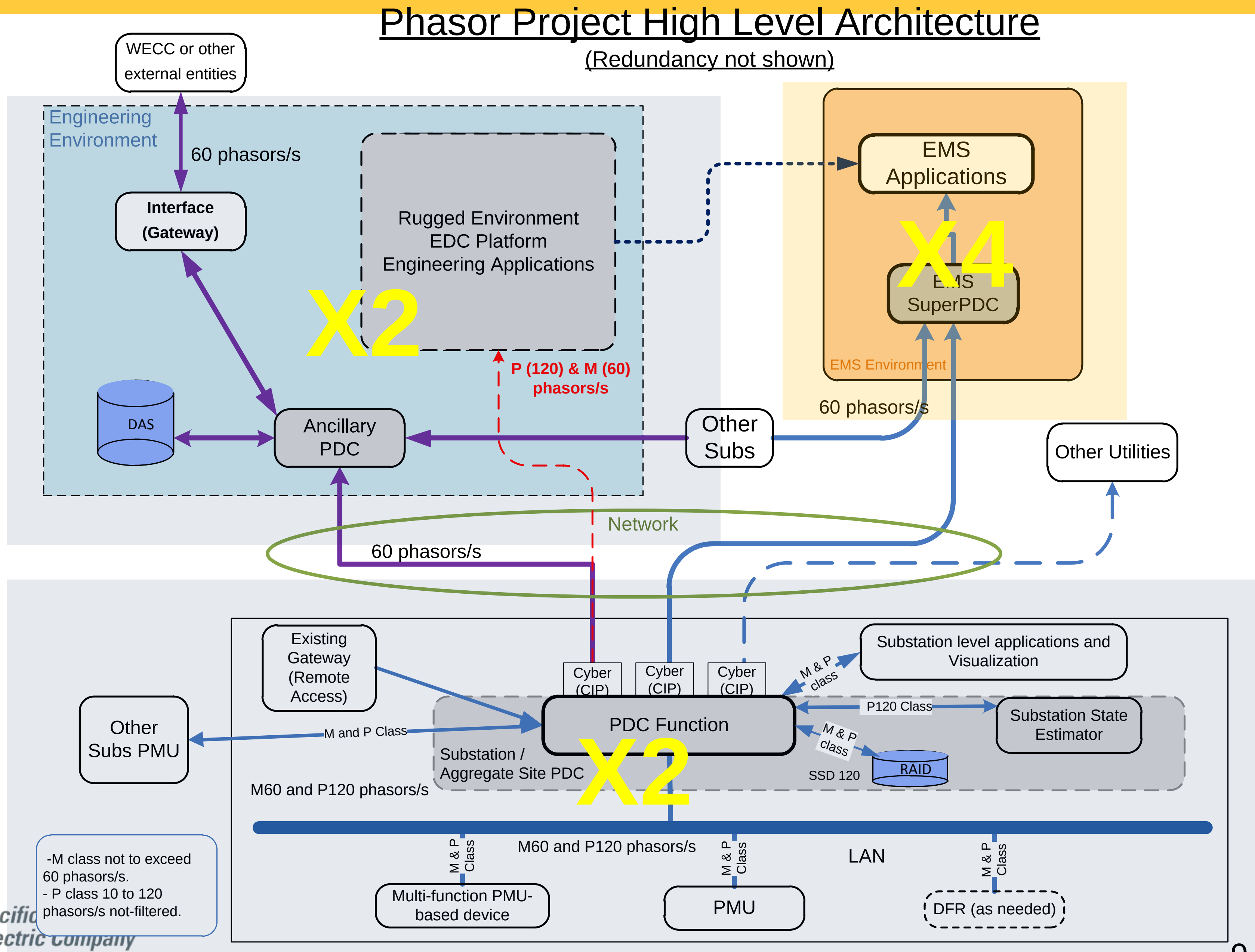
Application Group	Overall Latency	Availability	Data rate (frames/s)	Fail-over Time
Visualization (Voltage, Current, Mag/Phase, Frequency, df/dt)	2 s	99.9%	1	1 s
Alarming	0.5 s	99.9%	2-4	1 s
Oscillation Monitoring	60 s	99%	60-120	30-60 s
Post-Event Disturbance Analysis	N/A	99.9%	30	N/A
EMS / State Estimation	30 s	99.95%	1	1-30 s
Stability Analysis	300 s	99%	30-120	5-300 s
Closed-loop Control	0.15 s	99.995%	60-120	0.1 s

Key System Architecture Drivers

- Application Requirements (present and future)
  - Availability (number and length of interruptions)
  - Latency
  - Data rates
- Cost vs. value
  - Geography
  - Available infrastructure
  - Cost versus value of redundancy
  - Redundancy at various levels (measurement device, data path, applications, …)
- System maintainability issues
  - Down time
  - Time to repair
  - Established processes
- Cyber security requirements
- Corporate processes and history
  - Including regulatory requirements

Synchrophasor System Architecture - Simplified



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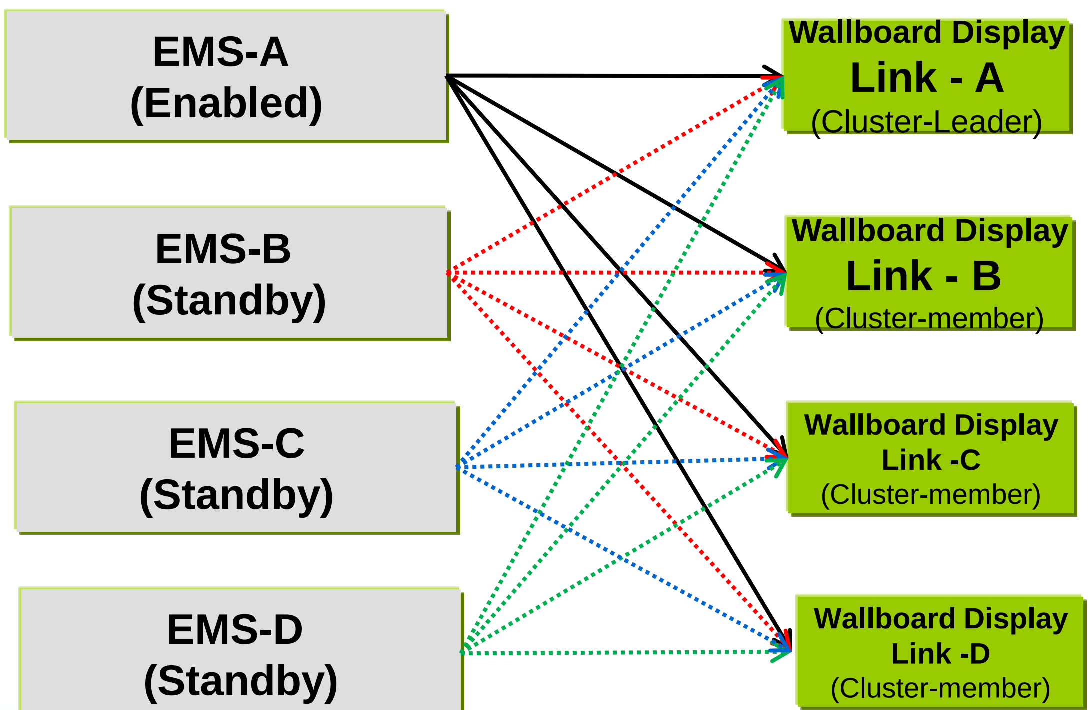
Multi-host EMS & Wall Display Connection

Downtime based on percentage

total sec/yr	31557600			
availability	outage sec/yr	outage min/yr	outage sec/day	outage min/day
100.00%	315.576	5.2596	0.8645918	0.01441
99.95%	15778.8	262.98	43.229589	0.720493



- Data flow is one direction – From EMS to Primate.

- A and B servers at TOC
- C and D servers at VGCC.

- Firewalls are setup TOC SFGO and VGCC subnet.

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System Architecture Summary – Operational Support

- Disaster Recovery Architecture – similar to RAS
- Multi-host architecture for EMS related applications
  - Two locations, two systems per location
- 24/7 monitoring
- Redundant data archival system
- Redundant (different locations) non-EMS applications
- Independent data routing
- Using established PG&E maintenance and operation processes for real-time systems
- Cyber security designed into the system