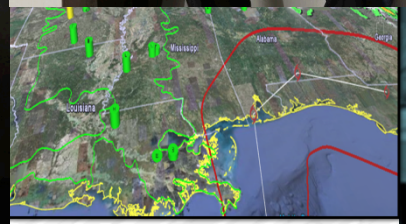
Entergy Phasor Project
Phasor Gateway Testing



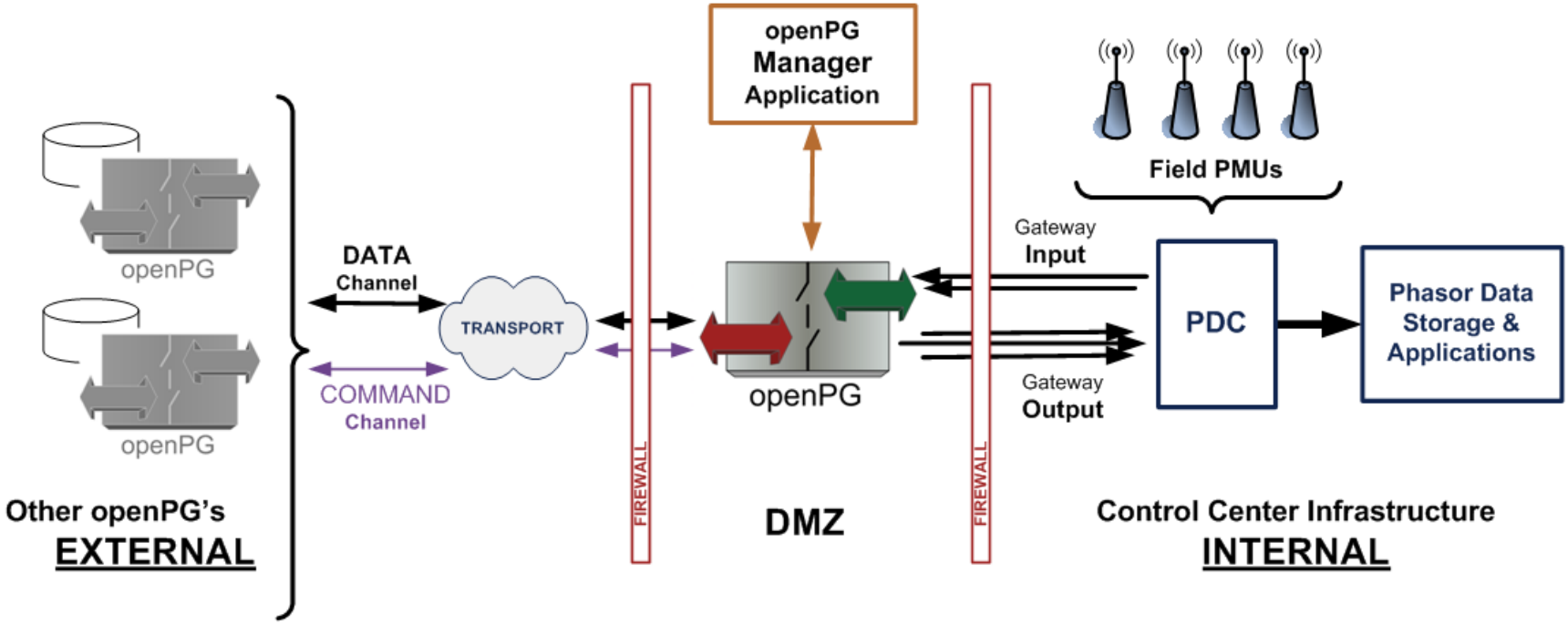
Tim Yardley, University of Illinois

A Phasor Gateway?

- Simply put…

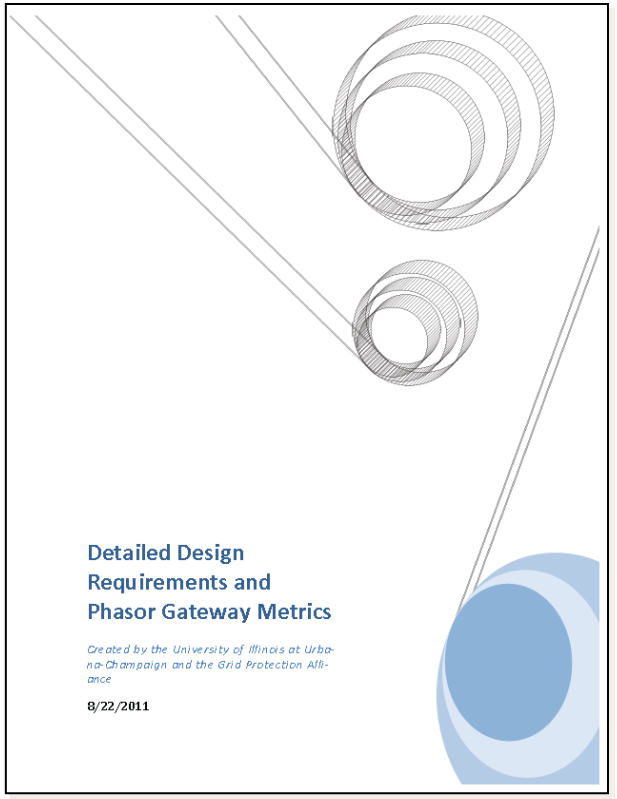
- Designed to be a front-end
- Meant to share real-time PMU information between utilities
- Designed for WAN communication
- Needs to be secure, selective, and flexible

Phasor Exchange Architecture



The Gateway Design

A phasor gateway requirements document was developed in 2011.



- Utility driven design
- Using COTS hardware
- CIP v5 ready
- Built with high availability and reliability
- Easy publish and subscribe point configuration
- Rapid extensibility to support new protocols
- Bridging multiple namespaces
- Ability to detect and alarm on communication or data issues

The Gateway Implementation

- Designed by GPA and UIUC, with extensive input from Entergy and feedback from other utilities
- Co-funded by NERC, DOE, and Entergy
- Derived from TVA/GPA OpenPDC code library
- Open-source and security reviewed
- Security features augmented, performance enhanced, and much more
- Initially released as OpenPG 1.0
- Inputs/Outputs/Exchanges
  - Everything OpenPDC speaks
  - NEW: Gateway Exchange Protocol (GEP)

The Gateway Security

- Conducted security review of the full code base
- Under review by industry security professionals
- Implemented CIP-informed controls and measures to be CIP v5 ready
  - Logging, Algorithm selection, Key storage, etc.
- Leveraging Microsoft SDL-based approach to software development and testing to ensure security model
  - Design, Attack/Threat models, fuzz testing, unit testing, code reviews, integration testing, functional testing, and security testing
- Standards based communication layer (TLS)
  - Alpha implementation
  - Leverages X.509 Identity Certificates and secure key storage

The Gateway Testing

- Functional Testing
  - Ensures everything works
  - Unit testing covers the code
  - Includes requirements driven by CIP
- Performance Testing
  - Baseline performance
  - Extensive stress testing
- Security Testing
  - Prior code review
  - SDL-based process forward
  - New TLS subsystem option
  - Reviewed with CIP in mind
  - Review underway by Industry Security Professionals

The Gateway Metrics

- Performance (target)
  - 1,000,000 points/second aggregate
  - Multiple streams, connections, and hosts
- Statistics
  - Connections, Points {transmitted, received, dropped, expected, out-of-order}
  - Uptime, errors, security events, alarms
- Logs
  - Security, Informational, Error, etc.
- Reports
- Centralized management and monitoring

Testing Methodology – Functional

- Intent: To test everything from basic installation through full system functionality
- Composed of approximately 75 aggregated human conducted tests
  - Designed to uncover discrepancies in implementation versus original drafted requirements
- Also includes Unit Testing
  - Currently over 450 complete unit tests covering the time series framework (the core of the system)
- Functional Acceptance Testing at Entergy

Testing Methodology - Performance

- Intent: To test boundary and normal performance conditions of the system
- Testing aims to investigate varying scenarios
  - Scaling up multiple PMU/PDCs reporting to a PG
  - Scaling up multiple PGs connecting to a central PG
  - Varying degrees of pass-thru of PMU measurement points to recipients
- Detailed log analysis and observations are made during performance testing to determine impact of tests and thresholds

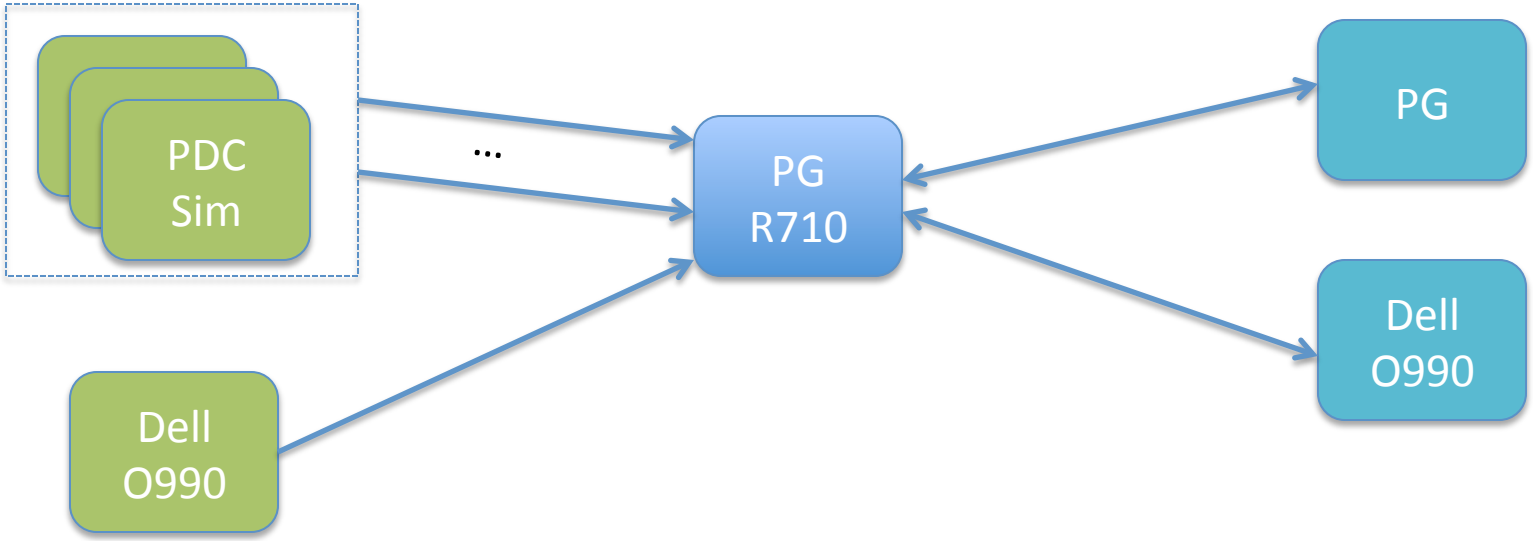
Testing Methodology - Security

- Intent: To uncover security issues in the code base and work towards mitigation
- Non-Entergy: Conducted a manual human audit of the code and provided results back confidentially directly to GPA
- Non-Entergy: Leveraged automated tools and human review to do a more in-depth analysis over several months and provided results confidentially to GPA
- Entergy: Security Professionals will continue to leverage Microsoft SDL practices and tools throughout the project

Testing Tools

- Computational Environment
  - Dell R710 – 2x6c HT (24 proc), 24GB (or more) RAM – 1 primary
  - Dell Optiplex 990 – 4 primary clients
  - Gigabit ethernet for all machines
  - Note, we can and do leverage other resources as needed from our environment
    - Multiple Dell R710's
    - VMWare virtualization
    - External imaging for rapid reinstallation
    - Automated configuration and testing
- Traffic Generation
  - PDC Traffic Simulation
    - Allows for simulation of PDC aggregated PMU traffic at scale
  - PMU Connection Tester
  - Physical PMUs
  - RTDS GTNET
    - Simulated power-model tied PMUs

Testing Setup



- Gigabit Ethernet
- Support Infrastructure not shown


openPG Manager
Home
Publication
Subscription
Inputs
Outputs
Monitoring
Adapters
Manage
Display Settings
Save Display Settings
Refresh Interval: 2 sec Last Refresh: 12:11:39.326
PDC-SIM-E1-001 Edit
PMU001-001 Edit
PMU001-001-DF NaN
PMU001-001-FQ NaN Hz
PMU001-001-SF NaN
PMU001-002 Edit
PMU001-002-DF NaN
PMU001-002-FQ NaN Hz
PMU001-002-SF NaN
PMU001-003 Edit
PMU001-003-DF NaN
PMU001-003-FQ NaN Hz
PMU001-003-SF NaN
PMU001-004 Edit
PMU001-004-DF NaN
PMU001-004-FQ NaN Hz
PMU001-004-SF NaN
PMU001-005 Edit
PMU001-005-DF NaN
PMU001-005-FQ NaN Hz
PMU001-001-FQ
PMU001-002-FQ
PMU001-003-FQ
PMU001-004-FQ
Frequency
60.04
60.02
60
59.98
59.96
17:11:22.000
17:11:23.233
Historical Playback
Start Time *-10m
Stop Time *
Process Interval
33
ms
Start Playback
Return to Real-time
ID
Signal Reference
Time Tag
Value
Unit
PMU001-001:1
PMU001-001-FQ
17:11:23.233
NaN
Hz
PMU001-002:7
PMU001-002-FQ
17:11:23.233
NaN
Hz
PMU001-003:1
PMU001-003-FQ
17:11:23.233
NaN
Hz
Run-time Statistics: PDC-SIM-E1-001
Refresh Interval: 2 sec
ID
Statistic
Value
TimeTag
STAT:158
Last Report Time
11:22.533
17:11:35.467
STAT:1030
Last Report Time
11:22.533
17:11:35.467
STAT:300
Last Report Time
11:22.533
17:11:35.467
Views
CPU
100%
0%
60 Seconds
Disk
1 MB/sec
0
Network
10 Mbps
0
Memory
100 Hard Faults/sec
0
ViewSonic

Results

- To be published Spring 2013

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Questions?

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