Middleware for the Next Generation Power Grid

Jason Fuller, Mark Rice, Poorva Sharma, Adam Wynne
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Outline

- GridOPTICS Vision
- Middleware Overview
- Middleware Successes in Industry
- Value of open source and use in GridOPTICS
- GridOPTICS Middleware Projects
  - GridOPTICS Software System (GOSS)
  - Framework for Network Co-Simulation (FNCS)
  - Distributed Systems Architecture (DSA)
Open Source; Open Format; Open Forum

Enable interoperability and accelerate development of advanced technologies and tools for the future power grid.

GridOPTICS™ Architecture: links data to computation to visualization

GridOPTICS™

Data
- Data Processing
- Data Mgmt
- Research Datasets

Computation
- Numerical Lib
- Adv. Solvers
- Adv. Algorithms

Visualization
- Visual Analytics
- New Viz Concepts
- Human Factors

Power System Data Structure and Software Interface
GridOPTICS™ Vision

- Open Source; Open Format; Open Forum

Data
- Data Mgmt
- Data Ingestion
- Data Curation
- Metadata

Power System Data Structure and Software Interface

Power System Class Definition

Model
- Static Model
- Dynamic Model
- Topology Model
- Measurement Model
- Event Model

Simulation
- Functions
- Algorithms
- Solvers
- Matrix Ops

Computation

Visualization
- Visual Platform
- Visual Analytics
- Shared Perspective
- GUI

GridOPTICS = Grid Operation and Planning Technology Integrated Capabilities Suite
Middleware Overview

- Overview of Middleware
  - “Glue” between components in modern software systems
  - Frees developers from having to think about challenging communications programming

- Message Oriented Middleware (MOM)
  - Decouples system components
  - Allows components to operate asynchronously
  - Features for routing to component

- Service Oriented Architecture (SOA)
  - Components with well-defined interfaces
  - Offered over the web

- Enterprise Service Bus (ESB)
  - Communications backbone
  - Can connect different components over multiple communication protocols
Middleware in Industry

- Used in virtually every modern industry
- Accelerates development times, makes systems more manageable
- Can Support high performance workloads

Example - Financial Industry
- Big data problem
- Need to connect a wide variety of systems with each other: legacy systems, HPC systems, connectivity between organizations
- These systems are built around middleware (with specialized middleware products for the industry)
Open Source Software

- Open source successful in industry,
  - RedHat - Over $1B in yearly revenue
  - Apache foundation (~200 projects)
  - Hadoop – ecosystem of applications appeared “over night”

- Open source software in power industry
  - Grid Open Source Software Alliance
  - Grid Protection Alliance: Projects include OpenPDC, SIEGate, OpenHistorian

- Why open source GridOPTICS software?
  - Reference architecture
  - Open architecture
  - Modular middleware – can support any license type
FNCS - Next Generation Network Simulator

Objective

- Interface existing power grid and communication simulators
- Develop optimized HPC simulation platform

Approach

- Coordinate interaction of ns-3 with GridLAB-D and transmission simulators
- Modular framework links simulators via ZeroMQ
- Dynamically adjusts synchronization requirements among simulations
Distributed Systems Architecture Project

Cloud-based analysis

Organization Boundaries

Organization 1

Organization n
Expanded GOSS Architecture

- GridOPTICS Clients (client libs for mult. languages)
- Shared Perspectives
- Other client tool (Java-based)

Application Server (Tomcat)

Enterprise Service Bus (Spring Integration)

- Messaging Service (ActiveMQ)
- GridOPTICS Data Source Abstraction
- Service Adapter
- Service Wrapper
- Legacy Code
- Semantic Service Registry
- Metadata Library (MySQL-backed)

Data Sources
- PMU
- Topo
- NIS

External Services
- High Performance Computing
- REST/Soap Web Services

Wrapped Services

Integral Services and Systems
- Other client tool (Java-based)
Accomplishments / Impact of GOSS

- **Use cases**
  - Contingency Analysis – sharing between 2 SOA infrastructures
  - PMU Data Cleaning and Event Detection
  - NIS Load Forecasting Tool
  - Shared Perspective

- **API Support**
  - Platforms: Windows/Linux
  - Native client languages: Java, C#, R
  - Communication format: Java Object, XML, JSON, REST, SOAP

- **Databases**
  - Multiple MySQL servers (Grid topology, Contingencies, Events/Alerts)
  - GridMW (PMU measurements)

- **Line of Code / Development time/effort:**
  - Reduced significantly due to redundancy control