Smart Grid Architecture & Operations Best Practices

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But first, a word about an upcoming event
DGM: Sustainable Solutions: February 9-11, Santa Clara Convention Center

Sample of Panel Sessions on Energy, IT, Software, Transportation, Water, Urbanization

- Connecting a Continent: The Modernized Grid in the European Union
- Juicing the Grid: Alternative Energy Generation and Storage in India
- A Billion Future Commuters: Advanced Transportation Trends in China and Japan
- Razing the Roof: Bringing Solar to the Masses
- Powering a Continent: Financing Clean Tech Deployment in Africa.....and more!

Pre-Arranged 1:1 Meetings with U.S. Embassy Commercial Diplomats from Throughout Asia, Middle East, Africa, Western Hemisphere, and Europe

Networking Receptions and Exhibit Hall

Program Details and Registration:
www.export.gov/california/sustainablesolutions/index.asp

Questions? Contact: Shannon.Fraser@trade.gov
Vertically integrated silos

Single vendor for SCADA, communication, RTUs

Issues

- Custom software, special for each utility
- Legacy architecture from 1970s – 1980s
- Relied on long careers of power system engineers
The Legacy Utility

EMS

1200 Baud Lease Line

RTU

Status Input

Analog Input

CB

XDUCER
The Grid Today

- Relatively small number of large power plants
- Long transmission and distribution lines
- Intelligent devices in substations and on grid
The Grid Today

ENERGY FLOW

Generation → Transmission → Distribution → Consumption
The Paradigm Shift - Drivers

- Climate change – effect of storms on the grid
  - Largest impact is on Distribution
- Transmission congestion
- Environmental drivers
  - Desire to lower carbon footprint
  - Options through renewables
  - Improve efficiency of centralized generation
- Customer choice
  - Want to act as prosumers, not consumers, with choice of energy source
- Changing workforce
  - Different skillset in today’s college graduates. Shortage of people in Power Systems Engineering
Many small production sites
An interconnected mesh of generation, storage and consumption.
Smart meters, Smart inverters, EVs, mobile/stationary storage
2-way energy flow, 2-way communication
Devices that can both consume and produce energy
Many Distributed Energy Resources
More networked architecture in the Distribution system with smart switches and relays
Ability for portions to be voluntarily islanded (fractal)
Composed of autonomous interconnected Microgrids at the customer level (residential, commercial and industrial)
The Grid Tomorrow
The traditional approach will not work (Centralized architecture)

Distributed Intelligence is the only Viable Architecture

- Tremendous increase in the volume of data
- Yesterday’s systems were not designed to handle this amount of data
- Why the architecture must be distributed
  - Given the volume of data and the response time needed to control the dynamically changing grid, there is not enough time to transport the data to a central location, make a decision and return a control command.
  - Grid must be able to analyze data, make decisions, and take control action, even when the communication lines are down.
  - Increasing amounts of renewable energy is being integrated at the medium and low voltage levels
    - The substation must now be empowered to make decisions for local load balancing
- Security
  - By keeping the control broken down into individual, primarily isolated “nodes”, the strategic importance of each unit of distributed data is less to a hacker than a large central repository.
New Grid Architecture

- Layered
- Distributed computing and data storage
- Standardized data interfaces (vendor agnostic)
- Needs to provide interoperability at the business process level, not just the semantic interface standard and lower layers
  - Across a single protocol – different vendors implement data on the protocol in different ways
  - Across protocols – acquire data using one protocol, pass to another system using a second protocol
  - Across data models – acquire data using one data model (e.g. 61850) and serve data to higher level systems using another (e.g. CIM)
Grid Data Layers

DMS

Gateway/Data Concentrator

Intelligent Devices
RTU, PLC, Relay, Recloser, Switch, etc.

Sensors
Voltage, Current, Frequency, etc.
Elements of the New Grid

Many High Level Systems

OT

EMS  DMS  OMS  GMS

IT

Casual Users  Asset Mgmt  Maintenance  Non-op Users  Data Archive

Many Intelligent Devices

Intelligent Device  Intelligent Device  Intelligent Device  Intelligent Device  Intelligent Device  ...

Intelligent Device
Challenges Facing Utilities

- Data integration and scalability
  - The MxN problem
- Configuration, Administration, and Monitoring of many distributed systems
  - Take a centralized approach
The MxN Problem

How do you connect M systems to N devices

• Each high-level system must connect to each device
• Each system and each device must be configured to talk to each other
• The links are typically over a lower speed connection, so the same data travels multiple times over the slow bandwidth
• Requires M times N data paths
The MxN Solution

Solved by inserting a capability that allows movement of data seamlessly and efficiently between layers and across layers. M plus N data paths

RT|Smart Energy Suite

**DATA ACQUISITION**
- **RT|ICG** - Intelligent Communication Gateway

**SUBSTATION MANAGEMENT**
- **RT|ASP** - Advanced Substation Platform

**DISTRIBUTION AUTOMATION**
- **RT|ASR** - Auto-Sectionalizing and Restoration
- **RT|VVC** - VAR/Volt Control

**TRANSMISSION & DISTRIBUTION**
- **RT|TDS** - Transmission/Distribution SCADA

**ENTERPRISE DATA MANAGEMENT**
- **RT|EIS** - Enterprise Information System

**POWER GENERATION**
- **RT|RIG** - Remote Intelligent Gateway

**ENERGY STORAGE**
- **RT|SECS** - Stored Energy Control System

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**RT Modules**
- ICG
- ASP
- ICG
- TDS
- ASP
- ICG

**N Devices**
- Intelligent Device
- Intelligent Device
- Intelligent Device
- Intelligent Device
- Intelligent Device
- Intelligent Device

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**Centralized configuration**
- Rapid data transfer
- Protocol translation
- Interoperability

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RT|SES Real-Time Smart Energy Suite

RT|EIS - Enterprise Information System
Centralized Interface, Configuration, Administration

RT|TDS - Transmission/Distribution SCADA

RT|ASP - Substations

RT|ICG – Intelligent Communication Gateway

WAN - Mesh Network, WiFi, BPL, CAISO ECN, etc.

RT|ASR
Recloser

RT|VVC
SCADA Switch

RT|SECS
Cap Control

RT|SECS
Energy Storage

RT|RIG
Generation

EMS
DMS
OMS
Data Archive
Casual Users
Asset Mgmt.
Maint- enance
GMS

Relays
Meters
IEDs

Real-Time Data

Feeder Devices

Substations

Control Centers

Enterprise

1/21/2015

GMS

Casual
Asset Mgmt.
Maintenance

DMS

RT|SECS

RT|RIG
Summary of Best Practices

- Use a modular solution with multiple distributed intelligence instances
- Acquire and Merge data at source of data
- Sequence data for WAN link
- Enable localized decision making
- Use a solution with multi-vendor interoperability for legacy devices today and new devices tomorrow
- Technology agnostic, vendor agnostic, protocol agnostic
Case Studies

RT|SES in operation
Problem

- Acquire over 8 million data points from 130+ substations and 7000 field devices
- Transport the data, present it to users at 35+ control centers and pass the data to EMS, DMS, OMS, corporate historian and other high-level systems

Solution – The RT|EIS Enterprise Information System

- A distributed intelligence system with over 200 interconnected systems
- Data and controls passed over network and communication circuits
- SCADA control interface at control centers
- Protocol translation and data interoperability
RT|Smart Energy Suite at a Western U.S. Utility

**RT|EIS** - Enterprise Information System
Centralized Interface, Configuration, Administration (20+ Servers)

**RT|TDS** - Transmission/Distribution SCADA (35+)

**RT|ASP** - Substations (130+)

**RT|ICG** - Communication Gateway/Concentrator (6)

Mesh Network, WiFi, BPL, CAISO ECN

- **EMS**
- **DMS**
- **OMS**
- Data Archive
- Casual Users
Benefits reported by Utility project manager

- Standardization of Controls
- Alarming
- Device templating
- Consolidated model
- Improved intersite communications
- Improved workload management
- Integration with EMS and DMS
- Standardization of IED and SCADA modeling
- Improved reporting and data mining
Problem
- Frequent outages on many Distribution feeders due to storms, tree limbs
- Outages lasting hours or even days

Solution – RT|ASR Auto Sectionalizing and Restoration
- 6 substations, 16 feeders, 80+ switches and reclosers
- GUI in all substations
- Interfaced to EMS system
RT|ASR at an Eastern U.S. Utility
Benefits reported by Utility Executive

Performance Improvements

- Number of Feeders protected by the ASR Scheme: 16
- Total Events: 48
- Number of Times that the Scheme Operated: 14
- Total Customers on the Four Feeders: 14,363

Reliability Indices for the Four Protected Feeders

<table>
<thead>
<tr>
<th></th>
<th>Without ASR Scheme</th>
<th>With ASR Scheme</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAIFI</td>
<td>3.07</td>
<td>2.45</td>
<td>20%</td>
</tr>
<tr>
<td>SAIDI</td>
<td>390.31</td>
<td>303.82</td>
<td>22%</td>
</tr>
</tbody>
</table>

NOTE: Percentage improvement is calculated on feeder lockouts only (events that ASR can act upon)
Industry Specific Applications
Control system for Grid-scale energy storage
Provides multiple simultaneous control modes via Virtual Power Plants
Provides ancillary services, e.g. frequency regulation, voltage regulation, peak shaving, renewable smoothing
How do you actually do all the things that your battery can do?

- Peak Shaving
- Energy Arbitrage
- Frequency Regulation
- Islanding
- Voltage Support
- Renewable Smoothing
- VAR Support

DISTRIBUTED ENERGY RESOURCE

VPP1  VPP2  VPP3
Sample Use Case – Storage Integration at Scale
RT|RIG Remote Intelligent Gateway

- Generation grid interconnection gateway
- Acquires interconnection data
- Provides control for large or small generation sites
- Provides data for utility, IPP, ISO
The world’s largest solar thermal plant, Ivanpah Solar Electric Generating System, went online earlier this year and is connected to the grid by a DC Systems RIG.

RT|RIG acquires and transmits secure, real-time data and commands between the plant and the California Independent System Operator (CAISO), providing real-time production data for use in grid management and enabling Ivanpah to participate in the California market.

“Never in my life have I had the situation where a vendor sent me a product, I plugged it in and it just worked.” – Lead Engineer, Bechtel
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