Adoption of Open-Source Software in Mission-critical Applications

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## Agenda

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Alstom Grid’s Comprehensive Solutions/Products

**Solutions**
- Electrical substations, Turnkey solutions & Services
- Super Grid technologies
- Smart Grid technologies

**Products**
- Air Insulated Switchgears
- Gas Insulated Switchgears
- Power Transformers

**Power Electronics, Network Management Systems & Automation**
- Network Management Systems
- Substation Automation Solutions
- Power Electronics
Network Management Solutions (NMS)

**e-terra Operation IT**...When Information meets Energy

A suite of interoperable Solutions from demand side, generation fleet, energy storage, self healing distribution grid, active stability & control, network assets capabilities, up to energy market

- **e-terra platform**
  Transmission Network Management

- **e-terra distribution**
  Distribution Network Management

- **e-terra market**
  Energy Market

- **e-terra DRBiznet**
  Distributed Energy Resources Management and Demand Response

- **e-terra Phasorpoint**
  WAMS and Online Stability Solutions

- **e-terra pipeline**
  Oil & Gas Solutions

- **e-terra assetcare**
  Asset management and Condition monitoring

- **e-terra gridcom**
  Telecom for Utilities
Network Management Solutions
Extending e-terra Smart Grid features

- Heavy R&D investment

- Disruptive technologies
- Complementary solutions
- Channels to market

Strategic customers
- Universities
- National Labs

Partnerships

R&D & Pilot projects

Acquisitions
R&D Strategy

Research → Prototype → Commercialization

Smart Grid Initiatives

Pilot Research Projects

R&D Process

e-terra suite

Technology Refresh and Innovation

Commercialization

Partnership & Collaboration
Agenda

Background

Adoption of Open Source Software

Case Study 1: Business Workflow (e-terra market Market Control)

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Case Study 3: Load forecasting application (ALF)

Conclusions
Adoption of Open Source Software

- It is no more about yes or no but how to adopt OSS
- Software architecture and framework (e.g. JBoss)
- Applications (e.g. load forecast, openPDC)
- Development tools (e.g. Eclipse, GWT)
- NMS consists of many **mission-critical applications** to support control center operations.

Source: [http://integration.pervasive.com/Integration-Senarios/Application-Integration.aspx](http://integration.pervasive.com/Integration-Senarios/Application-Integration.aspx)
Adoption of Open Source Software (Cont’d)

- Licensing (MIT, BSD, GPL, LGPL, CPL, EPL etc.)
  - T&C for copying, redistribution and modification
  - Compliance is essential
  - Integration with proprietary software

- Lack of documentation – system installation and maintenance guide, user’s guide, design notes, testing procedures etc.

- Lack of technical support
  - Mission-critical 24x7 application

- Lack of functional, system, and reliability testing

- Flexibility and configurability

- Ease of maintenance

- Ease of extension and customization
Adoption of Open Source Software (Cont’d)

- Software security
  - Usually not a focus of open source communities
  - NERC CIP requirements
  - Corrective:
    - How to deal with security vulnerabilities?
    - What is the vulnerability response process?
    - What is the security patch process?
  - Preventive:
    - Secure coding standard
    - Security assurance as part of continuous integration process

https://www.securecoding.cert.org/confluence/display/seccode/CERT+Secure+Coding+Standards
https://www.owasp.org/index.php/Main_Page
http://cwe.mitre.org/top25/index.html
Adoption of Open Source Software (Cont’d)

- **Software quality**
  - Coding done by researchers often time with limited software development training

- **Different development tools and test environment**
  - Defect tracking
  - Source code control and management
  - Testing environment
  - Shared tools and environments among different parties

- **System design and integration**
  - Functional modules packaged as callable libraries (embeddable)
  - Adapt to existing/legacy system architecture
Adoption of Open Source Software (Cont’d)

• Team collaboration
  – Work cultural differences (with third-party companies, universities, and national laboratories)
  – Collaboration models

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Branch Management Coordination

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<th>Developer 1</th>
<th>Developer 2</th>
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<td>Merge in Vendor A supported Bug fixes</td>
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<td>Developer 1</td>
<td>Developer 2</td>
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<td>Open source release</td>
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<tr>
<td>Vendor A’s Integration Testing</td>
<td>Vendor A’s product release</td>
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<td>Vendor’s A Service Request Bug Fixes</td>
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Open Source Version N

Open Source Version N+1
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Process Management and EBPF

- Business processes are volatile; they will be different for every customer, and must be changed easily.

- Because the software may coordinate multiple systems across many physical computers, debugging problems can be difficult. The software should mitigate this by providing detailed monitoring, auditing, and management capabilities.

- Originally, market management workflow was based on Oracle Advanced Queue.

- e-terra Business Process Framework (EBPF) is a set of utilities built on top of jBPM to integrate with our architecture
  - Implements common patterns shared across projects
  - Extends jBPM with a web service management API
  - Exposes visualization to APF applications
jBPM and Drools

- **jBPM (JBoss Business Process Management)**
  - Open source workflow and business process management engine written on the Java platform
  - Models workflows graphically, and persists them with an XML-based language (jPDL)
  - Stores process state in any modern RDBMS (Oracle, SQL Server, MySQL etc)

- **Drools**
  - Open source rule engine on the Java platform
  - Simplifies and externalizes business rule implementation in a declarative language

- Both projects are commercially backed by Red Hat.
e-terra market Market Control

- A replacement for Oracle AQ-based Workflow
- A Java application based on EBPF that orchestrates market studies
  - Uses more powerful programming languages, starting with Java.
  - Decouples database persistence and workflow logic.
  - Utilizes powerful tools: Spring, Drools, jBPM, JAX-WS etc.
- Leverage SOA to design with volatility in mind:
  - Everything is a service!
  - Component interfaces are technologically agnostic
  - Services are APIs
    - Provide clear boundaries
    - Integrate with your own IT
New Middle Tier Architecture
Comments on Deployment of Market Control

• Redhat JBoss Middleware
  – Leveraging IT
  – Large open source community
  – Visionary roadmap (mobile, cloud, integration)

• Redhat JBoss Community version vs. Enterprise version
  – Very different development process
  – Long-term stability, scalability, guarantee up time
  – Certified patches and updates (thousands of bug fixes)
  – SLA-based Support
  – Long term maintenance

• Licensing
  – LGPL

• High quality software
  – Very little reported issues
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ALSTOM’s Integrated Synchrophasor Solution

Phasor Point SynchroPhasor Applications

Phasor Data Concentrator (PDC)

Wide-Area Advanced Visualization

EMS
Improved State Estimation using PMUs

e-terravision

PMUs

PMUs

PMUs

1 per second

30-60 per second

PMU Measurement-based information (e.g. Oscillation Detection)
openPDC Background

- openPDC is a complete set of applications for processing streaming time-series data in real time.
- Originally (SuperPDC) developed by TVA in support of the DOE sponsored NASPI initiative.
- In service at TVA (as ‘superPDC’ for Eastern Interconnection) since 2004.
- Continually being enhanced & improved by Grid Protection Alliance (GPA), a non-profit company formed by the original openPDC developers, under contract to NERC.
- Delivered and supported by Alstom Grid since Feb 2010.
Modular Architecture (Adapter Layers)

- Extensible functionality through the notion of 'Input', 'Action', & 'Output' Adapters.

  - **Input Adapters**: process incoming data into a generic format.

  - **Action Adapters**: perform processing functions such as sorting the input data or performing calculations (e.g. MW and MVAR, Event Detection), then transmit the results.

  - **Output Adapters**: perform archiving functions.

Source: [http://openpdc.codeplex.com/wikipage?title=Overview&referringTitle=Documentation](http://openpdc.codeplex.com/wikipage?title=Overview&referringTitle=Documentation)
Supported Real-Time Input and Output Formats

**INPUT FORMATS**
- IEEE C37.118-2005 & Draft 6
- BPA PDC Stream
- SEL Fast Messaging
- IEEE 1344-1995
- Virginia Tech FNET
- Macodyne
- IEC 61850-90-5 (*Future*)

**OUTPUT FORMATS**
- IEEE C37.118-2005 (*optional auto-publish configuration frame*)
- BPA PDC Stream
- ALSTOM Inter-Site Data (ISD) protocol for integration with EMS applications
- Text based export
- OPC (*Future*)

**COMMUNICATION STANDARDS**
- TCP IPv4 & IPv6
- UDP Unicast / Multicast IPv4 & IPv6
- Serial (Input Only)
Comments on Deployment of openPDC

- **Alstom ISD (InterSite Protocol) Adapter**
  - Additional Alstom ISD module available for direct feed of PMU data into Alstom EMS.
  - Developed and delivered by Alstom under Alstom license.

- **Licensing**
  - EPL
  - Integration with Alstom’s ISD (interface with SCADA)

- **Documentation**
  - User’s documentations and Developer’s documentations available.
  - Alstom creates an additional set of testing and system installation and maintenance documentation for the integrated system.

- **Technical support**
  - GPA’s technical staff is available during office hours
Comments on Deployment of openPDC (Cont’d)

- Good modular design. Pretty flexible in terms of configurability and extensibility.
- Reasonably good software quality
- Alstom assures software security using HP Fortify as part of its continuous integration process.
- Team collaboration
  - Alstom’s support team works closely with technical staff of GPA’s to address customers’ issues.
Comments on Deployment of openPDC (Cont’d)

• Installation and Configuration Services
  – Onsite or phone support for installation and device configuration is available.
  – Alstom openPDC documentation (User’s guide, System Installation and Maintenance Guide, Release Notes etc.)
  – Delivery from Alstom tested version

• openPDC Support Services
  – Alstom offers software support for openPDC
  – Testing of new releases
  – Tracking and fixing issues (Collaborate with GPA)

• Issue tracking and source management
  – Use CodePlex on GPA side and TFS/DevTrack on Alstom side
  – Issue tracking is open to public on the GPA side and close to public but open to customers on the Alstom side.
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UConn’s Load Forecast Engine Background

- Alstom has a broad vision of creating a next generation load forecasting solutions to support its sub-product lines including EMS, MMS, and DMS.
  - More accurate forecast (Expected load)
  - Forecast with confidence intervals (Modeling of uncertainty)
  - Load forecasts for multiple hierarchical levels
  - Ability to account for demand response, distributed generation etc.

Wavelet Decomposition
- High Freqs.
- Low Freq.

Aggregation Entity Types:
- National
- Island
- Zone
- GXP
- LD (Load)

Load (LD) Entity Types:
- conforming (C)
- non-conforming (N)
- embedded generation (EG)
UConn’s Load Forecast Engine Background (Cont’d)

- A wavelet-based neural network short-term load forecast engine (STLF) written in Java.

- STLF was originally developed by University of Connecticut (UConn) sponsored by ISO New England.
  - In service at ISO New England since 2010.
  - Continually being enhanced & improved by UConn and sponsored by Alstom.
  - Collaboration between UConn and Alstom on load forecasting research for distribution systems.
Software Architecture

- Alstom’s J2EE Application – Spring Framework
- Designed to support multiple forecast engines working together.
- Web service API supports an array of client applications that include .NET based rich client using MS WCF, Excel using Open Data Protocol or simply a web browser rendering HTML.
- Import and export from/to a variety of sources and targets.
Comments on Deployment of STLF

- Alstom has been working with UConn to commercialize the STLF solution as an Alstom’s product.

- Original UConn’s STLF Engine Licensing
  - MIT (Integration with Alstom’s software infrastructure)

- Documentation
  - Limited design documentation.
  - Alstom needs to create user’s guide, system installation and maintenance documentation for the integrated LF system.

- STLF Deliveries and Support Services
  - Hardening and testing of new open source releases
  - Tracking and fixing open source issues (Collaborate with UConn)
  - Tested and deliveries out of Alstom’s commercialized solution.
  - Alstom offers professional software support for STLF.
Comments on Deployment of STLF (Cont’d)

• Technical support
  – Professors and students are available to provide limited but very useful support for Alstom staff.

• Good software design and software quality from a university standard but a few things are hardcoded and need to be fixed.

• Enhancement is made to support day-light saving changes and Oracle database access.

• Defect Tracking and Source Management System
  – For source code management, UConn uses GitHub and Alstom uses TFS. Code was duplicated on both repositories.
  – Alstom uses DevTrack for product defect and software improvement tracking but UConn has no access. Issue tracking for open source release of STLF is via emails and phone calls with UConn.
Comments on Deployment of STLF (Cont’d)

- Integration with Alstom’s ESI (Energy Schedule Integrator)

- Alstom assures software security using HP Fortify as part of its continuous integration process.

- Team collaboration
  - Alstom’s support team works closely with students and professors (CS and EE) at UConn to address product and customers’ issues.
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*Note: *The text marked with *italics* represents software names or titles.*
Conclusions

• Having vendors sharing their software development guidelines with third-party development team(s) early on in some cases could help to minimize software rework down the road.

• Roles and responsibilities among different parties need to be clear in terms of addressing customer needs.

• Contributors, especially from universities and national labs, that have strong software engineering background will benefit development activities.

• IT infrastructure to support external distributed team(s) for software development will improve development efficiency.

• Early vendor’s involvement in research or pilot projects might enable a smoother transition from technology to market.

• BSD or MIT license is preferable from a vendor’s perspective.

• Patience and respect among distributed teams of different background.

• Open source could be a “win-win” game for everyone.
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