Internet of Things
Impact on Critical Infrastructure Applications
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Tom Kindred, VP and CIO, SaskPower
Rick Geiger, Executive Director, Utilities & Smart Grid
September 2014
Internet of Things
Impact on Critical Infrastructure Applications

• How will IoE affect Utilities?

• How does IoE integrate with Smart Grid?

• What IoE strategy will be developed?

• IoE Driving IT / OT Convergence In Utilities

• What are Utility and Customer Benefits?
IoT Is Here Now—and Growing!

50 Billion
“Smart Objects”

Rapid Adoption Rate of Digital Infrastructure:

5X Faster Than Electricity and Telephony

The New Essential Infrastructure

Source: Cisco IBSG, 2011
Declining Cost of Computation, Storage, and Communications Over Time

Storage and Computation Falling Fastest:
- Sensors will evolve faster than bandwidth
- Distributed computing becomes more compelling over time

Sources:
- http://www.kurzweilai.net/sin-charts#prettyPhoto
Convergence Leading to IoT

Moore’s Law
Technology gets cheaper and more powerful

Metcalf’s Law
More connections create more value

Big Data Analytics
Lowers costs and creates new revenue/value

From
Sparse Data
History
Static

To
Big Data
Predictive
Near time
The Internet of Everything (IoE)

**People**
Connecting People in More Relevant, Valuable Ways

**Process**
Delivering the Right Information to the Right Person (or Machine) at the Right Time

**Data**
Leveraging Data into More Useful Information for Decision Making

**Things**
Physical Devices and Objects Connected to the Internet and Each Other for Intelligent Decision Making

Networked Connection of People, Process, Data, Things
Internet of Everything

How will IoE affect Utilities?

“The explosion of smart sensors and software-defined devices is driving unprecedented needs for robust processes for managing security, keys, device identity, configuration, provisioning, reliability and resilience.”
Utility Industry Megatrends

Changing customer expectations resulting from the digitization of services allowing anytime, anywhere personalized services

Rise of social networks the ability to quickly form communities of interest and communicate instantaneously with a billion people globally via text, video and/or voice

Pervasive connectivity and computing is unlocking a sea change in productivity gains for businesses, disrupting existing businesses and creating new opportunities for agile firms

Expansion of energy markets for distributed energy resources enabling greater adoption and increased transactions

Financial innovation that is enabling a wide range of customers to amortize initial capital costs of DER to align with benefit cash flows and make a stronger value proposition

Energy technology advancements for power system and distributed energy technologies are accelerating at exponential rates while also converging to enable breakthroughs on business models and system performance
Electric Grid Market Transition

- **Multiple Energy Sources**
- **Unpredictable Voltage Levels**
- **Human Intervention Too Slow**

**Centralized Analytics, Control, and Protection Applications**

- **Business Application No. 1**
- **Business Application No. 2**
- **Business Application No. 3**

- **Network No. 1**
- **Network No. 2**
- **Network No. 3**

- **Device No. 1**
- **Device No. 2**
- **Device No. 3**

**Distributed Analytics, Control, and Protection Applications**

- **Business Application No. 1**
- **Business Application No. 2**
- **Business Application No. 3**

- **Converged IP based Network**

- **Device No. 1**
- **Device No. 2**
- **Device No. 3**

**Government Regulation**

- **Central Operations**
- **Not Scalable**

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Global Policy Driving Decentralization

**USA**
- 43 States have NEM policies & 3.3 GWs of Solar PV installed thru 2012.
- Installed prices for PV systems fell 27% in 2012
- White House targets 122 GW of CHP

**Europe**
- Germany’s *Energiewende*: from nuclear to renewable and distributed energy. Volkswagen launched natural gas engine residential CHP unit. Solar PV reached retail parity in Germany, Spain and Italy

**China**
- Launched new policy to encourage distributed energy resources up to 6MW in size and allow surplus to be sold openly

**Japan**
- Ene.farm Sm. Comm. & Residential fuel cell program gaining market traction. Solar PV & battery storage subsidies driving adoption

**Brazil**

**Australia**
- Australian solar PV market currently at 2.5GW, will likely grow to 6GW-10GW by 2017
- Rooftop solar PV is reducing overall electricity demand by 3%
3 R’s for Utility Success in 21st Century
IoT enabling the Utility Platform from Enterprise to Customer/Producer

Relationships
with Customers, Community, Employees and Partners

Reliability
and Safety of Services for Consumers and Producers

Realization
of Operational Excellence
Internet of Everything

How does IoE integrate with Smart Grid?

“Ubiquitous connectivity, with embedded services for security, discovery, resilience, management and performance lowers cost barriers.”
Internet of Everything: Intelligent Energy

**Observable**
- Full determination of grid state—deep situational awareness

**Intelligent**
- Ability to gain situational intelligence to support operational decisions

**Automated**
- Rapidly adapt to changing conditions with minimal human involvement

**Transactive**
- Dynamically balancing diverse resources and distributed market participation
Connectivity: Everything -- Everywhere

Traditional Computing Model
(Terminal/Mainframe, Client-Server, Web)

- Data Center/Cloud
- Assumes Infinite, Bandwidth, 0 Delay
- Endpoint

IoT Computing Model

- Data Center/Cloud
- Assumes Limited Bandwidth, Variable Delay, and Intermittent Connectivity
- Distributed Computing
- Assumes Limited Bandwidth, Variable Delay, and Intermittent Connectivity
- Device

Speed of Light
Latency - Critical Responsiveness Required

Resiliency

Security

Data Grows Faster Than Bandwidth

Data Grows Faster Than Bandwidth

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Security
Pervasive Architecture-Based Secure IP Solutions

Defend
Defend Grid Operations

Extend
Secure Utility Connectivity

Prevent
Prevent Loss of Critical Assets

Comply
Achieve Regulatory Compliance

Threat Defense
Secure Mobility Workforce
Physical and Data Loss Prevention
Governance, Risk and Compliance

Securing the End-to-End Electric Power Supply Chain
Underlying Security Principles

Access Control
- User and device identity
- Authentication, authorization, and accounting

Data Confidentiality and Data Privacy
- Network segmentation
- Security connectivity and encryption (VPN)

Threat Detection and Mitigation
- Security zones and firewall
- Intrusion prevention

Device and Platform Integrity
- Device hardening
- Configuration assurance
Internet of Everything

What IoE strategy will be developed?

“Internet of Everything is not a single technology, product or project. It’s the continuing realization of connectivity, data, analytics and security.”
IoE Strategy

- Expanding Connectivity
  - Substation Automation & Security
  - Grid Sensors – PMUs, Volt/VAR, IED & Protection
  - Advanced Metering Infrastructure
- Multi-service Networks – going beyond point/multipoint
- Distributed Energy Resources
  - Advanced Distribution Management for multi-way power flows
  - Networking microgrids
- Identify common requirements, services, & security
This section introduces a model for understanding the value-add activities commonly performed by IoE solutions. The model is architecture and technology independent.

This model was developed by applying lean concepts (value, flow, pull, optimization) to the IoE value streams.
A Complete IoE Value Stream Model

Each activity adds value to the upstream’s output
A Complete IoE Value Stream Model

The Devices

Knowledge

Inform

Action

The Business

Your Customers

Forming Continuous value cycles

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Many Connected systems

An IoT Enabled Utility

<table>
<thead>
<tr>
<th>Act / Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decide</td>
</tr>
<tr>
<td>Analyze</td>
</tr>
</tbody>
</table>

Enterprise Systems

3rd parties

IoT based Solutions

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Using the IoT Value Stream Model

1. The business objective
2. Decisions and actions possible
3. Things to sense and signal
4. Detail IoT activities chained together
5. Other data needed?

Sense / Measure | Communicate | Receive / Collect | Manage | Analyze

Signal | Communicate | Command / Control (C2) | Act | Decide

Build, Operate and Maintain

Detail IoT activities chained together

Other data needed?
“One could argue that IT/OT convergence is not a high priority; we have been very successful without it for a very long time. Now the IT/OT debate is no longer a matter of if it happens, it’s a matter of when and to what extent.”
<table>
<thead>
<tr>
<th><strong>IT</strong></th>
<th><strong>OT</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PURPOSE</strong></td>
<td>Managing Asset Information, Automate Business Processes</td>
</tr>
<tr>
<td><strong>DESIGN</strong></td>
<td>Intelligent Design by Enterprise Architects</td>
</tr>
<tr>
<td><strong>ARCHITECTURE</strong></td>
<td>Transactional or Batch, Relational Database or Text</td>
</tr>
<tr>
<td><strong>INTERFACES</strong></td>
<td>Web Browser, Terminal and Keyboard</td>
</tr>
<tr>
<td><strong>OWNERSHIP</strong></td>
<td>CIO and Computer Grads</td>
</tr>
<tr>
<td><strong>CONNECTIVITY</strong></td>
<td>Corporate Network, IP Based</td>
</tr>
<tr>
<td><strong>SERVICE LEVEL &amp; AVAILABILITY</strong></td>
<td>99.5 to 99.9%, Scheduled Maintenance Outages, High Bandwidth</td>
</tr>
<tr>
<td><strong>EXAMPLES</strong></td>
<td>ERP, SCM, EAM, CRM, E-Mail, Billing</td>
</tr>
<tr>
<td></td>
<td>Running the Assets, Controlling Technology Processes</td>
</tr>
<tr>
<td></td>
<td>Evolutionary Design by Vendors/Engineers</td>
</tr>
<tr>
<td></td>
<td>Event-Driven, Real-Time, Embedded Software, Rule Engines</td>
</tr>
<tr>
<td></td>
<td>Sensors, Coded Displays, Terminal</td>
</tr>
<tr>
<td></td>
<td>Engineers, Technicians</td>
</tr>
<tr>
<td></td>
<td>Control Networks (Predominantly Analogue or Serial)</td>
</tr>
<tr>
<td></td>
<td>99.999 to 100%, 7/24, No Outages, Low Bandwidth, Low Latency</td>
</tr>
<tr>
<td></td>
<td>SCADA, PLCs, Modeling, Control Systems</td>
</tr>
</tbody>
</table>

Source: Adapted from Tech Channel MEA
OT/IT Convergence Drivers

- Competition
- Modernization of OT Systems
- New IT Affecting Operations
- OT/IT Capacity and Abilities
OT/IT Maturity Model

**Drivers:**
- Awareness
- Establish
- Core Infrastructure
- Control
- Building Foundation
- Level 1: Building Foundation
  - OT/IT networks and associated budgets
  - OT/IT cyber security
  - Increased operational reliability/resilience
  - Reduced cyber threats
  - Large OpEx savings
  - Risk: OT trust of IT
- Level 2: Standardizing Non-Critical Apps
  - "Intelligent Design" allows for greater integration
  - 7/24 on call
  - Corporate view of end to end data
  - Some OpEx savings
  - Risk: Often most controversial level
- Level 3: Leverage Critical Apps
  - 7/24 on site resources required
  - Real time analytics exposed to corporate systems
  - Advanced corporate functionality and capability
  - Risk: Need to ensure high availability of critical systems
- Level 4: Optimizing Critical Apps
  - Full OT/IT convergence
  - Intelligent devices and sensors are prolific (IoT)
  - Self healing
  - Self sustaining
  - Self service
  - Risk: Turning control over to machines - Speed of failure!
Maturity in a Power Utility

Level 1
- Desktop Productivity
- Telephony
- Business Intelligence
- ERP

Level 2
- Workforce Management
- GIS
- AMI
- Asset Management
- Outage Management System
- Distribution Management System
- Transmission SCADA System
- Generator Control Systems

Level 3
- Non-Critical OT
- Critical OT

Level 4
- Core IT Infrastructure
- Data Centre
- Network
- Intel
- Network Monitoring
- Mid-Range
- Access Control
- Storage

Level 5
- IT Devices
- Corporate LAN
- Access Controls
- Security Camera
- Material Sites
- Field Worker Support
- AVL Devices
- Gas Monitors
- Operational WANs

- OT Devices
- Customer Devices
- Smart Meters
- Home Energy Management
- Faulted Circuit Indicators
- Advanced Sensors
- Fault Location
- Remote Switching
- Phasor Measurement Units
- RTU/SCADA
- Protection Schemes
- Process Bus
- SCADA
- Protection Schemes
- Control Systems

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“Customers want reliability and control of the energy use and costs. Utilities must respond with operational efficiency, reliability and security; meeting Public Policy goals for renewability.”
Benefits of OT/IT Integration

- Single view of the truth
- Dynamic real-time optimization
- Cost reduction
- Increased employee engagement
- Increased customer satisfaction
- Robust and secure technology
Benefits of Distribution Automation

1. Improved reliability
2. Improved voltage control
3. Reduced man power
4. Accurate and useful planning
5. Better fault detection
6. Better management of system
7. Increased revenue
8. Improved capacity
9. Customer retention
10. Reduce interruption cost
11. Better quality of supply
Advanced Distribution Vision

Four over-arching business objectives:

- Optimize connection of Distributed Generators (DGs) into utilities rural distribution system
- Improve Distribution Reliability and Operations
- Optimize Outage Restoration Optimization
- Optimize Network Asset Planning
Early Findings from Canadian Utilities

**Distribution Automation and DMS can improve SAIDI by 1 hour**
- Transmission Feeders: could reduce customer interrupted hours (42 minute SAIDI improvement)
- Distribution Feeders: could reduce customer interrupted hours (expecting an additional 20 minutes)
- Fault location technology would reduce average time to locate faults by 30 minutes

**DMS provided additional benefits that were not in original business case**
- The number of cancelled outages can be reduced
- Reduction in site visits to address Power Quality Issues on the Distribution system
- Switch plans can be created and validated more efficiently

**IEC 61850 (P&C) beyond the fence should be pursued cautiously**
- Should not be pursued beyond the substation – continue to assess 61850 performance over next 5+ years

**Impact of Distributed Generation on grid less than anticipated**
- Focus for Distribution Automation will not have the same focus for Distributed Generation enablement - DG’s are having less of an impact than was originally anticipated
Early Findings from Canadian Utilities

Utilize third-party cellular instead of WiMAX for SCADA
- Third-party cellular is more cost effective if only using SCADA
- WiMAX is required for Protection and Control schemes
- WiMAX should be pursued if it can be leveraged by overall telecom strategy (AMI Collectors, Data, Leased Line Avoidance)

AMI for Operations has demonstrated significant benefits

Demand Response on water heaters and smart thermostats offer savings
- In addition to the value of peak savings and efficiency, external analysis shows more than $100/year in bill savings

Revenue Protection requires improved data to realize benefits

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Opportunities to Reduce Customer Bills

\[ \Sigma = \$130/\text{year for each customer} \]

Customer Benefit

- BRING YOUR OWN DEVICE THERMOSTAT
  - Reduce summer A/C consumption by 10%
  - \$22/\text{year}

Utility Benefit

- Meet Energy Efficiency Mandate
- Defer Investment by Managing Local Peak
- Meet Shareholder Mandate

- SMART WATER HEATER
  - Heats water off peak
  - \$75/\text{year}

- CONSERVATION VOLTAGE REDUCTION
  - Reduce usage by 1.6%
  - \$30/\text{year}

- ENERGY THEFT
  - Reduce energy theft by 1/3
  - \$7/\text{year}
# Early Findings from Canadian Utilities

<table>
<thead>
<tr>
<th>Technology</th>
<th>Recommendation</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMI for Operations</td>
<td>PROCEED IMMEDIATELY</td>
<td>Using meter infrastructure to support operations provide significant operations/ productivity benefits.</td>
</tr>
<tr>
<td>Distribution Automation</td>
<td>PROCEED IMMEDIATELY</td>
<td>Distribution Automation significantly improve reliability (&gt;1 hour reduction in SAIDI). This is the most cost-effective avenue for utilities to improve its reliability and get ops benefits.</td>
</tr>
<tr>
<td>Fault Location</td>
<td>PROCEED IMMEDIATELY</td>
<td>Fault location is able to successfully provide the location of the fault speeding restoration by an average of 30 minutes.</td>
</tr>
<tr>
<td>DMS / DMS Field Client</td>
<td>PROCEED CAUTIOUSLY</td>
<td>Distribution Automation requires a new control system and the DMS provides additional operational/ productivity benefits. Significant additional benefits could be realized by integrating OMS into an Advanced DMS Upgrade.</td>
</tr>
<tr>
<td>Conservation Voltage Reduction</td>
<td>CONTINUE WITH PILOTS</td>
<td>Significant bill savings and peak savings coupled with power quality benefits could be realized. Employed by many other utilities.</td>
</tr>
<tr>
<td>Demand Response</td>
<td>CONTINUE WITH PILOTS</td>
<td>Significant bills savings could be offered to customers and significant peak shaving as well as energy benefits could be realized.</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>DEFER UNTIL UTILITY STUDIES SHOW DIFFERENT</td>
<td>DGs are not currently causing significant issues that would justify the current cost of energy storage systems.</td>
</tr>
<tr>
<td>Energy Theft</td>
<td>DEFER UNTIL BETTER DATA</td>
<td>Current quality of distribution data makes identifying theft difficult. Will improve with DMS rollout and AMI base deployment</td>
</tr>
<tr>
<td>WiMAX</td>
<td>DEFER TO TELECOM STRATEGY</td>
<td>The advanced P&amp;C schemes that require WiMAX are not cost effective. Third-party cellular is more cost-effective for SCADA. WiMAX could be useful as part of overall telecom strategy.</td>
</tr>
<tr>
<td>IEC61850 PCT</td>
<td>DO NOT PROCEED PAST PILOT</td>
<td>The IEC61850 technology is still too new for the North American marketplace. Current engineering challenges would make it more expensive than current solution.</td>
</tr>
<tr>
<td>Advanced DG Protection Schemes</td>
<td>DO NOT PROCEED</td>
<td>The benefits associated with keeping DG connected in alternative configurations does not substantiate the costs. Continue to assess over next few years, re-assess if DG penetration expands again.</td>
</tr>
</tbody>
</table>
Thank you.
Thank you