Smart Grid
Interoperability Maturity Model (IMM)

ConnectivityWeek, 11 June 2009
Santa Clara, CA

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Objectives...

• Develop Interoperability Maturity Model (IMM)
  – Descriptive model
    • Explaining levels and properties
  – Prescriptive model
    • Mandating methods and requirements
  – Measure of Interoperability
    • Support self and third party assessments

• Minimize invention – mostly synthesis based on prior art
  – CMMI, GWAC Framework, ASD/NII Open Architecture Assessment Model, LCIM, NEHTA, etc.
GWAC IMM “Requirements”

• It would be desirable to use GWAC IMM to characterize Interoperability maturity from both the product and the process point of view

• Like all maturity models, it should be both descriptive and prescriptive

• Shall be applied to audit, assess, and explain current state, as well as reason a roadmap of activities, investments and best practices that lead to a desired future state – increased level of Interoperability
GWAC IMM “Requirements”

• Guide, appraise and improve toward a known goal through distinct levels of capabilities and associated results
  – Each level identifies characteristics and tasks, and expected results
  – Any level can be or define an end goal
  – If one wants to advance levels, each level lays the foundation for the next
CMMI Model

• The CMMI model identifies five levels of process maturity for an organization:
  – **Initial** (chaotic, ad hoc, heroic) the starting point for use of a new process.
  – **Repeatable** (project management, process discipline) the process is used repeatedly.
  – **Defined** (institutionalized) the process is defined/confirmed as a standard business process.
  – **Managed** (quantified) process management and measurement takes place.
  – **Optimizing** (process improvement) process management includes deliberate process optimization/improvement.

• Within each of these maturity levels are Key Process Areas (KPAs) which characterize that level
Interoperability

• Interoperability (a.k.a. “Openness”) - is the degree to which the stakeholder systems permits transparent access and integration among multi-vendor equipment and applications
  – An open/interoperable environment permits vendor-independent solutions, improves competition, and allows independence and flexibility.

• The IEEE defines interoperability as:
  – “... the ability of two or more systems or components to exchange information and to use the information that has been exchanged.”
Factors that Engender Interoperability

• Syntactic Interoperability
  – If two or more systems are capable of communicating and exchanging data, they are exhibiting syntactic interoperability. Specified data formats, communication protocols and the like are fundamental. In general, XML or SQL standards provide syntactic interoperability.
  – Syntactical interoperability is required for any attempts of further interoperability.

• Semantic Interoperability
  – Beyond the ability of two or more computer systems to exchange information, semantic interoperability is the ability to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of both systems.
  – To achieve semantic interoperability, both sides must defer to a common information exchange reference model. The content of the information exchange requests are unambiguously defined: what is sent is the same as what is understood.
Factors that Engender Interoperability

• Politico-Economic
  – Interoperability maybe linked to a value proposition for every stakeholder engaged
  – Interoperability may be linked to Business Strategy, Tactics, Business Process and further constrained by Economic/Regulatory Policy

• Competitive-Openness
  – Competitive factors frequently lead to competitor’s products to be not interoperable due to causes such as patents, feature differentiation, standards and technology royalty payments, trade secrets, and market failure e.g. monopolistic behavior
IT Factors Engender Interoperability

- Information Technology-related factors
  - System Capacity, Transactional Latency
  - Security and Privacy
  - Discovery, Resource Identification and Configurations
  - Logging and Auditing
  - Reliability and Scalability
  - Transactional integrity and State Management
  - System preservation and COOP
  - Time- Synchronization and Sequencing
  - System Evolution and Configuration Management
  - ...

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Process Related

• “IT Factors” and “Cross-cutting Issues” are typically captured in the ICD
  – With SOA, “Thin ICD” evolved into Service Specs
• ICD’s and governance process become a factor in Interoperability assessment
• Conformance Testing and Certification
Interoperability Context-Setting Framework

**Interop Categories**

- **Organizational**
  - 9: Economic/Regulatory Policy
  - 8: Business Strategy
  - 7: Business Tactics
  - 6: Business Procedures

- **Informational**
  - 5: Business Context
  - 4: Semantic Understanding

- **Technical**
  - 3: Syntactic Interoperability
  - 2: Network Interoperability
  - 1: Basic Connectivity

**Cross-cutting Issues**

- **Shared Meaning of Content**
- **Resource Identification**
- **Time Synchronization & Sequencing**
- **Security & Privacy**
- **Logging & Auditing**
- **Transaction & State Management**
- **System Preservation**
- **Performance/Reliability/Scalability**
- **Discovery & Configuration**
- **System Evolution**
Descriptive Model

• Determine what you would expect to see at each stage along the journey (additive)
  – “At Level 1, we would expect to see....”
  – ...
  – “At Level 5, we would expect to see...”

• Develop observable indicators of progress and Key Performance Indicators (KPIs) – measurable outcomes that should come with maturity
IMM Driving Issues

- Physical, Syntactic and Semantic factors are additive. IT and Organizational factors may be substantially independent, though
- GIMM levels as well as the “Cross-Cutting Issues” i.e. the interface behavioral maturity is likely to be subjective and based on ICD maturity and system objective and not a “yes/no”
  - Align with NESI (Navy Net-Centric Enterprise Solutions for Interoperability) 54 criteria over 9 evaluation categories?
    - ASD/NII Checklist Guidance Net Centric Implementation Framework v2.0 30 April 2007
- GIMM maturity score may not be indicative of the “true” interoperability maturity until several relatively mature applications make use of the interface
- Conformance testing and Certification is a critical factor
Interoperability Maturity Model

- Going down this path suggests a framework with graded levels ranging from rudimentary ICD information collection and basic control through increasingly sophisticated levels of interface management and integration, finally resulting in a mature state of interface governance linked to economic effect
  - Level 0: No Interoperability
  - Level 1: Technical (Physical)
  - Level 2: Informational (Syntactic and Semantic)
  - Level 3: Behavioral (Behavioral and Cross-Cutting Issues)
  - Level 4: Pro-Active governance, conformance and certification
  - Level 5: Business/Organizationally Linked
Assessment Model

- Maturity Level 5 – Complete compliance
- Maturity Level 4 – Adequate compliance
- Maturity Level 3 – Some compliance
- Maturity Level 2 – Minimal standards compliance
- Maturity Level 1 – Proprietary, limited documentation
- Maturity Level 0 – No evaluation or unavailable data
Hypothetical Assessment Score

- Evaluation results in a score

Assessment Score = 15 (Level 3)
# Maturity Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Assessment Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 5</td>
<td>Score 21 – 25</td>
</tr>
<tr>
<td>Level 4</td>
<td>Score 16 - 20</td>
</tr>
<tr>
<td>Level 3</td>
<td>Score 11 - 15</td>
</tr>
<tr>
<td>Level 2</td>
<td>Score 6 - 10</td>
</tr>
<tr>
<td>Level 1</td>
<td>Score 1 - 5</td>
</tr>
<tr>
<td>Level 0</td>
<td>No Assessment</td>
</tr>
</tbody>
</table>
## Descriptive Model

<table>
<thead>
<tr>
<th>Level</th>
<th>Interoperability at this Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Organizational</td>
<td>Interoperating systems at this level are completely aware of each other's business processes,</td>
</tr>
<tr>
<td></td>
<td>economic and regulatory context, constraints, and assumptions</td>
</tr>
<tr>
<td>Governed</td>
<td>Interoperating systems are able to evolve information production and consumption based on</td>
</tr>
<tr>
<td></td>
<td>understood changes to meaning and context through an articulated, mature, and resourced</td>
</tr>
<tr>
<td></td>
<td>governance process</td>
</tr>
<tr>
<td>Behavioral</td>
<td>Interoperating systems will be aware of the context (system states and processes) and meaning</td>
</tr>
<tr>
<td></td>
<td>of information being exchanged. Interoperating systems relevant behavioral requirements</td>
</tr>
<tr>
<td></td>
<td>Configuration Managed</td>
</tr>
<tr>
<td>Informational</td>
<td>Interoperating systems are exchanging a set of terms that they can semantically parse. (Semantic)</td>
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<tr>
<td></td>
<td>Have an agreed, standards codified, protocol to exchange the right forms of data in the right</td>
</tr>
<tr>
<td></td>
<td>order, but the meaning of data elements is not established. (Syntactic)</td>
</tr>
<tr>
<td>Physical</td>
<td>Have technical connection and can exchange data between systems</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
## Maturity Linked to Outcome

<table>
<thead>
<tr>
<th>Level Name</th>
<th>Premise, Information Defined</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Organizational</td>
<td>Articulated business assumptions and constraints</td>
<td>Grounded in Economic Effect, Business Concerns, Regulatory Policy</td>
</tr>
<tr>
<td>Governed</td>
<td>Articulated, mature, and resourced governance process</td>
<td>Interface evolution process is governed</td>
</tr>
<tr>
<td>Behavioral</td>
<td>Interoperating systems will be aware of the behavioral context (states and processes.)</td>
<td>Effects of information exchange are managed</td>
</tr>
<tr>
<td></td>
<td>Interoperating parties behavioral requirements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Configuration Managed</td>
<td></td>
</tr>
<tr>
<td>Informational</td>
<td>Common Information Reference Model (Semantic Meaning of Data)</td>
<td>Format, content, and context of information is exchanged</td>
</tr>
<tr>
<td></td>
<td>Common Data Structures (Syntactic)</td>
<td></td>
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<tr>
<td></td>
<td>Codified in a Standard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(preferably Open – royalty free)</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>Bits and Bytes over Common Communication Protocol</td>
<td>Symbols of information are exchanged</td>
</tr>
<tr>
<td>No Interoperability</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
## Prescriptive Model

<table>
<thead>
<tr>
<th>Level</th>
<th>Interoperability at this Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business/Organizational</td>
<td>A means of capturing and sharing business processes and economic models, assumptions, and regulatory constraints</td>
</tr>
<tr>
<td>Governed</td>
<td>Must have an articulated, mature, and resourced system evolution governance process</td>
</tr>
<tr>
<td>Behavioral</td>
<td>The means of producing and consuming the definitions of meaning and behavioral context (requirements) are required. Configuration Management process of relevant behavioral requirements</td>
</tr>
<tr>
<td>Informational</td>
<td>A method for sharing meaning of terms and methods for anticipating context are required.</td>
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<tr>
<td></td>
<td>Agreement between all systems on a set of terms (CIM) that grammatically satisfies the syntactic level solution requirements is required. (Semantic)</td>
</tr>
<tr>
<td></td>
<td>An agreed-to (standardized) protocol that all can be supported by the technical level solution is required. (Syntactic)</td>
</tr>
<tr>
<td>Physical</td>
<td>Have physical connection that supports exchange of data between systems</td>
</tr>
<tr>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
References:

2. GWAC Interoperability Framework
4. SOA-ness – OASIS reference model v1.0 7 Feb 2006