### GridWise® Architecture Council

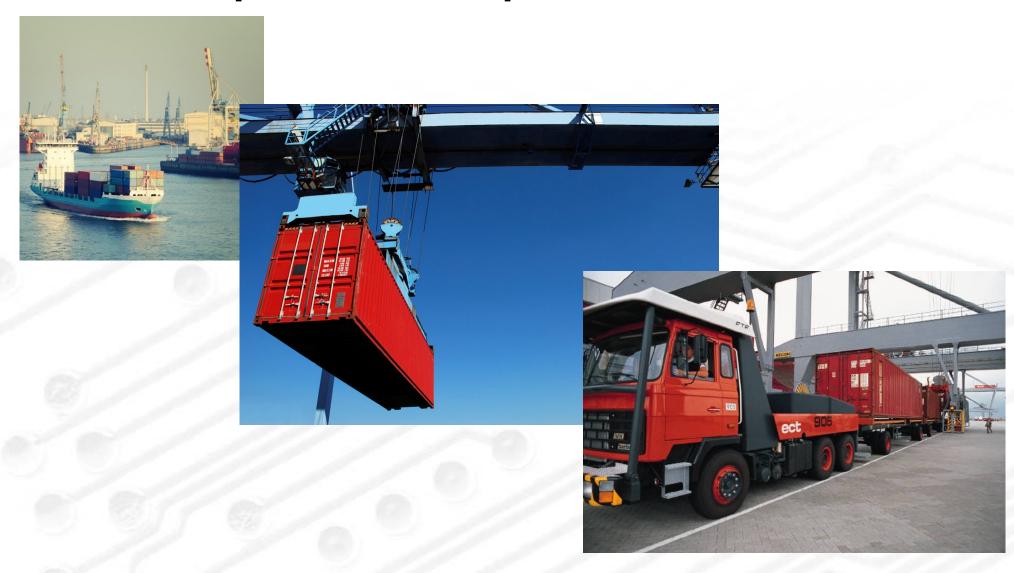
# Interoperability 101 Introduction and Overview

Ron Melton, Pacific Northwest National Laboratory Ron Ambrosio, IBM Watson Labs





# A Simple Example





## Reference Material

- Interoperability Context Setting Framework
- GridWise® Interoperability Constitution
- GWAC Interoperability Benefits Papers
  - Economic
  - Reliability
  - Environmental
- GWAC Smart Grid Interoperability Maturity Mode
- Available at: <u>www.gridwiseac.org/about/publications.aspx</u>



## GWAC Mission - Interoperability

Organization/Human **Business process** Interrelations Issues **Policies** Communities Technical/ (systems) Standards Interconnectivity Compliance Information **Semantics** Syntax Data **Business** domains

Interoperable Software - Expected Impact:

- Reduces integration cost
- Reduces cost to operate
- Reduces capital IT cost
- Reduces installation cost
- Reduces upgrade cost
- Better security management
- More choice in products
- More price points & features

All items provide compounding benefits



### Interoperability – Integration at Arm's Length

- Exchange of actionable information
  - between two or more systems
  - across organizational boundaries



- Shared meaning of the exchanged information
- Agreed expectation with consequences for the response to the information exchange
- Requisite quality of service in information exchange
  - reliability, fidelity, security

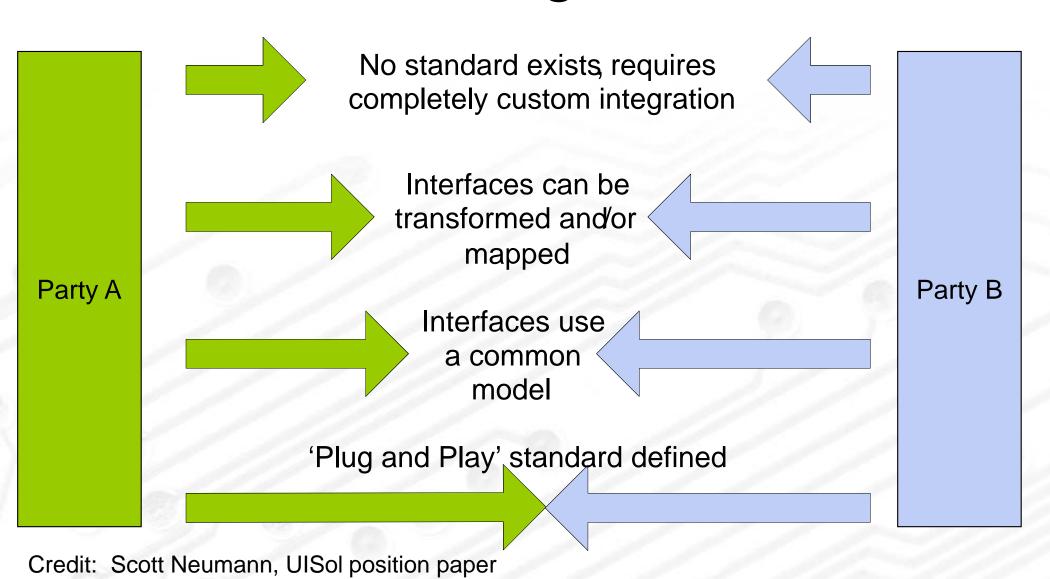


# Heterogeneity – Vive la Difference!

- Multiple versions and mixtures of technology
  - Including today's tech with tomorrow's innovations
- Multiple vendors with multiple products
- Multiple services needing integration
- Multiple organization structures
  - IOUs
  - Rural Co-ops
  - Munis



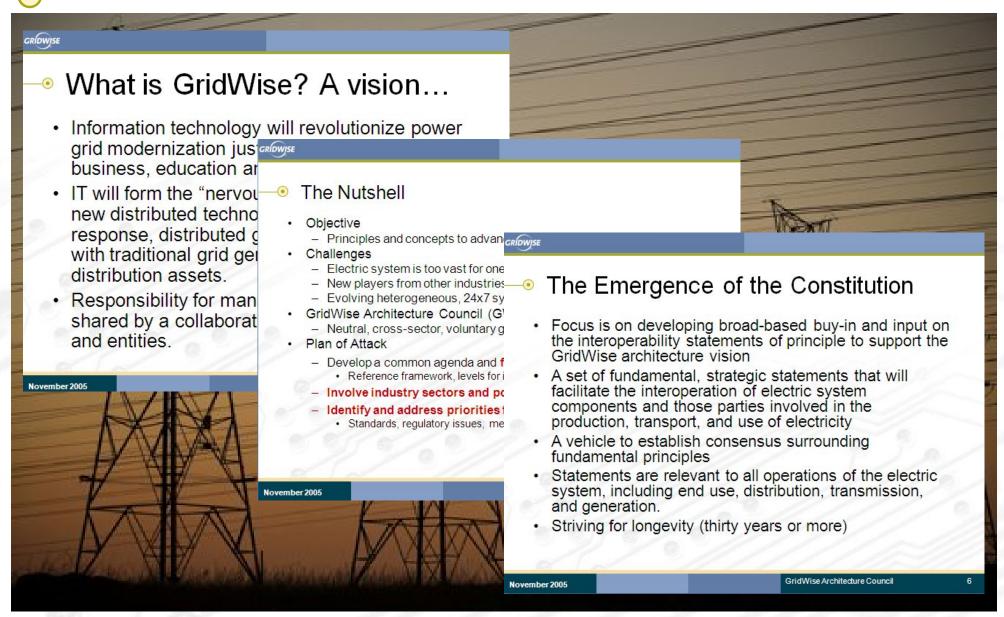
# Distance to Integrate



Grid-Interop 2011



### Where we started – The Constitution





### Constitution:

We the People as well and

relative, have disperte facultation, positions to common below, promos embeldy of decreics, and around to bination of filters and a decreation technology to members and comparingly decreases as neablish tale GridWise Countration for Interconnectings.

### Article B Business Principles

Contract Subject to the compliance environment in which they question required environ free to all entire the number in the number of eye to be taken to the contract the number of eye to be taken to the contract of the contract of their even of the contract of their even one. there are in a general markety or improvide. Enterprises our as-comparised lists of a real-markety segment, incomes, the just flow producer to consumer may provide require vertice of businesses each profiling their entropy ratio or led managing. Have into stanked process of numbing a basiness.

BOI dub on to regulatory annihilating requirements, interspeed they approaches should be so an the ordered investigation and the interaction at the boundary between transacting parties willow properting the privacy of the internal capacit of the r-bank co beinedge this adjacement.

BIC haterpersons, approaches must as port the ability to re-less. charges to real-costs are acted rules while preserving within opera-tion of the events oversity.

BOS has represented approaches must a know the common types of maching have transactive to energy as one along the party intercess produces a sub-construent appropriate to the level of energy pro-

Hit less provide, a quarter user made implementation men-tendent and in partie to the parties included in the researcher. BIG Interpretably appropriate must support well-min multipolitical dynamics are proportionally appropriate and the side are able to be contact.

### Article U Usability Principles

Contract Electricity carry care a work range of most, and energy carry agenture impactation, or well as energing degrees of will large on to put for my given storny product. The new frontier in accommission of compy system is the participation of new parties in overall system, operations leak-like and use, distribution to traversistian, and provinces.

100 incoperability approaches should address the administrapoid the people is support the mergener of readers for constructs to those the appropriate electricity sortice program that dealer.

1022 in the rest of a communications below however at moving medica, the performant communication governor that here pre-eater stakes operation of the owned observing system. 1000 not operating strategic, Arm the correspondent appropriate every that marks understood and adopted by all straded less in

### Article I -Information Technology Principles

Commer Advances in information technology on power electronic builrous and intelligent much are connectivity. July serious of the connectivity on behavior to the logs to or also greater beginn a production.

officiency, and reliability of service. This provides a visu mathophics for the application of informs for technicage and reduces the need for holiss the question adarrance to the copy approaches believe the control technicage is characterized by a high rate of hardendom with impacts to large scale. gotoms of colors that must expensely the deployment of two solutions as legacy approaches continue to operate in timber.

III Almody believe persons compy to their regation and advert to large one or product and activities also are necessaries, and many interaction.

302 Sins, po to a expendite ded stay to health applicate and anchose information containing over early relayer formation of both inches and the shorth contents operation and

KB to icomperibility friendsock shall address a seeings for the idea the docal enter with beyond approximation between a more consignate interestica, and shall appeal to moving all groups or adiction of access makes. 34 As histoponisky francoust and knowness information and day approximation foliar for the relationing an estatement of extremely and enterprising from the according to the extremely according to the extreme

(G) increased by stronger shall obtain the spectroscopic of squeeze allowers, the tagging, and above on increasing shall to their an appropriate to the service provided.

10 corrected by diverges shall alread develop to a top too, the tree and configure system components in they can job, modify log., pgm/s1 and creations first configure to stores.

807 Act despectable framework and abless information over-security and privary executes, believe their appropriate in the per co provided, and apport adaptation to him cake.

100 An appropriate transfer interests, a minerape willby for research

could address compare for electrical materials for may extend common of a pressured, responsive, ad whiting, colors from sections of 180 g or 1 time to therefore.

800 An interspeciality framework must be procified and action white \* Merch performance requirements.

 Is middle.
 He saffice. I me th known the range of basicars much. 100 As his repensibly energy men area modes: the continues of and evolverion through overall potentials of III standards on I technologic that will reside at the point in from our for GAA.

Article R-Regulatory Principles
Control I sit on introduced make a limit and of release beautions
to little policy publishes. The raise no pro-translational and endorsel terinarional state, and federal agracies in accordance with finite productions. Statement attended on a suscept of with the obsets of masters are produced and anothered by those regulatory bedies whose vote into more a state electron actual environment the supersistant execution and behaves some a second epote.

BOT intersperability examples and leaves must be communicated in a

lens to be understood by registers and policy nature.

IEEE knows probably approaches moral propositions must allow registers the unity or more than business or constructed what contributed rates with the destruction of the allowant proposition over as fit also.

### Article G Governance Principles

County Commission is a long, colong from an it as in a second to the observe space, Though the Sameon of Translation is as in an in the long bod, the daily to correct space, and the it is a constitution of Translation is as in an in the long bod, the daily to correct space, and the it is a meabled and compared.

GRIT As interspendidly framework unit making the needs and views of the full maps of streets domain as integrated view of the ele-

RECORDER GIZ Cate none practice that if you are not once the more

ngs c'hanterperialty franceoù, ast dire a porcaen. GBI lle promas-c'han mentatur mat le inhoes les c'han surficials: can hards experiently and proverse the sectorial top

trails, of these prices on.

G04 With regard to recovered a structural mandards

 Million of the condition
 Million of the condition
 Million of the condition
 Million of the condition
 Million of the condition of the condit made de depart tour little activit particulties.

When have after recognised stanks by where a proposed to considering objectives and

W.S processed extracting collaboration, morphy, and anticolorism of standards where appropriate to constitution of produce.

Description of the Description of the Description of the Standards QIS There king from Succession of Principle and the change approaches that dorder from thou must be able to change through the change through the change through.

digit created by the Desillation to construct the col-or to a part these equalities to be of and any state for each or program and a figure to though with participant tops during and alternity



Interoperability Statements of Principle

"B04- (v2.0) Interoperability approaches must consider implementation costs/benefits and impacts to the parties involved in the transaction."





# The Framework: Context for Interoperability Dialog



# Interoperability Framework

- Organizing concepts
  - Taxonomy, definitions, levels, tenets
- Attempts to simplify the complex
  - Warning it's still complex
- Aids communication between community members
  - Careful semantics remain a stumbling block
- Provides perspective from selected viewpoints
- Reveals points where agreement simplifies integration
- Focus plight of integrator, not component developer

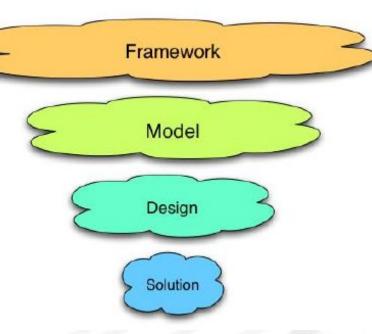


## What do we mean by "Framework"?

 Framework organizes concepts and provides context for discussion of detailed technical aspects of interoperability

 Model identifies a particular problem space and defines a technology independent analysis of requirements

- Design maps model requirements into a particular family of solutions
  - Uses standards and technical approaches
- Solution manifests a design into a particular developer software technology
  - Ensures adherence to designs, models, and frameworks.



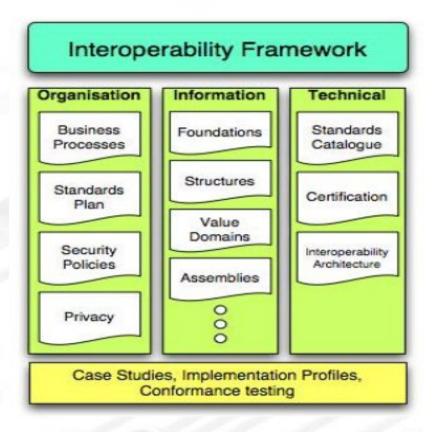
Borrowed from NEHTA: Australian National E-Health Transition Authority



# Framework Inspirations

**NEHTA Interop Framework** 

Layers of Coalition Interoperability



Political Objectives

Harmonized Strategy/Doctrines

Aligned Operations

Aligned Procedures

Knowledge/Awareness

Information Interoperability

Data/Object Model Interoperability

Protocol Interoperability

Physical Interoperability

Technical Interoperability

@2002 VMASC

A. Tolk, Beyond Technical Interoperability, 8th CCRTS, National Defense University, Jun 03



# System Integration Philosophy

- Agreement at the interface
  - Create an interaction contract
  - Terms and conditions, consequences for failure to perform...
- Boundary of authority
  - Respect privacy of internal aspects on either side of the interface (technology choice and processes)
- Decision making in very large networks
  - Decentralized/autonomous decision-making
  - Multi-agent v. hierarchical approach
  - Addresses scalability, evolutionary change, eases integration
- Role of standards in the framework
  - Encourages standards for improving interoperation
  - Agnostic to specific standards and technologies



## Interoperability Framework

**Organizational** 

8: Economic/Regulatory Policy

7: Business Objectives

6: Business Procedures

5: Business Context

4: Semantic Understanding

3: Syntactic Interoperability

2: Network Interoperability

1: Basic Connectivity

Political and Economic Objectives as Embodied in Policy and Regulation

Strategic and Tactical Objectives Shared between Businesses

Alignment between Operational Business Processes and Procedures

Awareness of the Business Knowledge Related to a Specific Interaction

Understanding of the Concepts Contained in the Message Data Structures

Understanding of Data Structure in Messages Exchanged between Systems

Mechanism to Exchange Messages between Multiple Systems across a Variety of Networks

Mechanism to Establish Physical and Logical Connections between Systems

**Informational** 

**Technical** 

Grid-Interop 2011



## Example: Demand Pricing Signal

- Economic/Regulatory Policy
  - PUC issues retail real-time price signal policy
- Business Objectives
  - Electricity retailer objectives align with building services providers to aggregate demand
  - Building owners choose service provider with package that best meets their needs
- Business Procedures
  - Hour ahead price sent by electricity retailer to building service providers, acknowledgement returned with forecast next hour demand
- Business Context
  - Tailored portion of CIM, e.g., model building and energy price information
- Semantic Understanding
  - IEC 61968/61970 Common Information Model (CIM) in W3C OWL
- Syntactic Interoperability
  - SOAP messaging, UDDI registry and discovery, XML
- Network Interoperability
  - TCP/IPsec
- Basic Connectivity
  - IEEE 802.11 wireless mesh network to building controller



## Cross-Cutting Issues

### 5 Catting 155act

### Interoperability Categories Cross-cutting Issues

Organizational

**Informational** 

8: Economic/Regulatory Policy

7: Business Objectives

6: Business Procedures

5: Business Context

4: Semantic Understanding

3: Syntactic Interoperability

2: Network Interoperability

1: Basic Connectivity

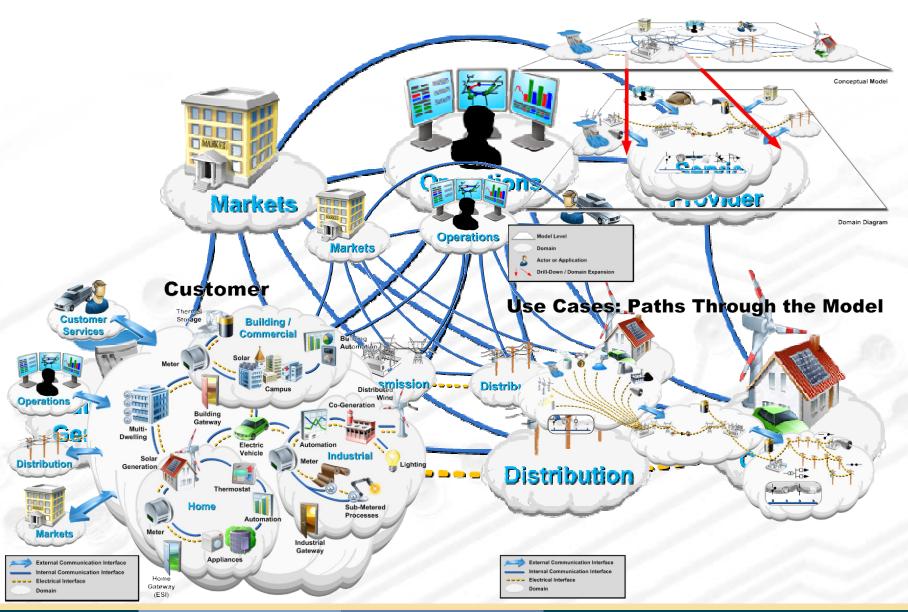
<b>^</b>	<b>1</b>	<b>↑</b>	<b>1</b>	<b>↑</b>	<b>1</b>	<b>1</b>	<b>↑</b>	<b>↑</b>	<b>1</b>
Shared Meaning of Content	Resource Identification	Time Synch & Sequencing	Security & Privacy	Logging & Auditing	Transaction & State Mgt	System Preservation	←Performance/Reliability/Scalability →	Discovery & Configuration	System Evolution
Sha	Re	Tim		PC	Ė		Perform	Disc	
<b>+</b>	<b>\</b>	<b>+</b>	<b>\</b>	<b>+</b>	<b>\</b>	Ψ	<b>→</b>	<b>4</b>	<b>V</b>

Technical



## Using the Conceptual Model

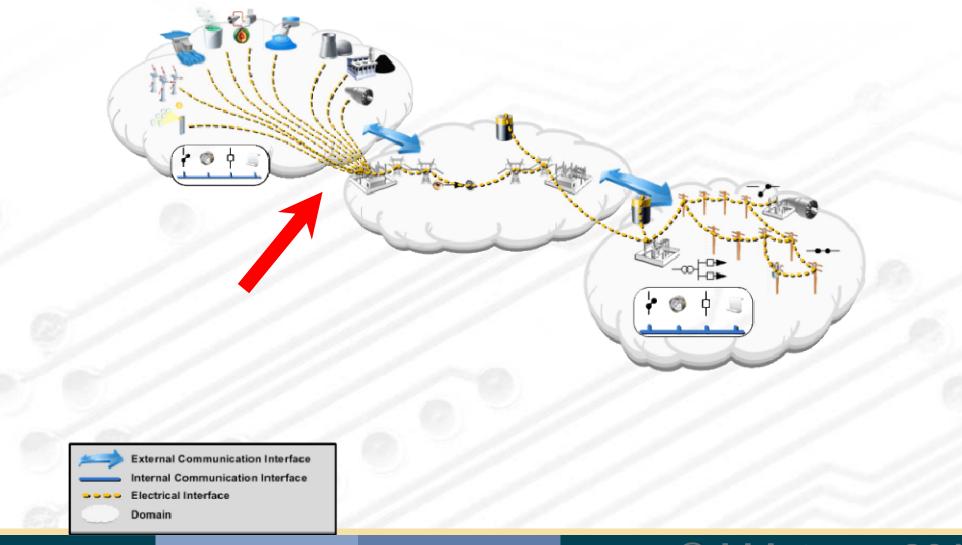
**Levels of the Conceptual Model** 





### **—**

# Inter- vs. Intra-System Interoperability Use Cases: Paths Through the Model





### The GWAC Stack and the Model

8: Economic/Regulatory Policy **Organizational** 7: Business Objectives (Pragmatics) 6: Business Procedures 5: Business Context Informational (Semantics) 4: Semantic Understanding 3: Syntactic Interoperability **Technical** 2: Network Interoperability (Syntax) 1: Basic Connectivity

Analyze interoperability at key inter-system points in the use case paths through the Conceptual Model ...

... using the GWAC
Stack top-down to
define lowest layer that
must be addressed