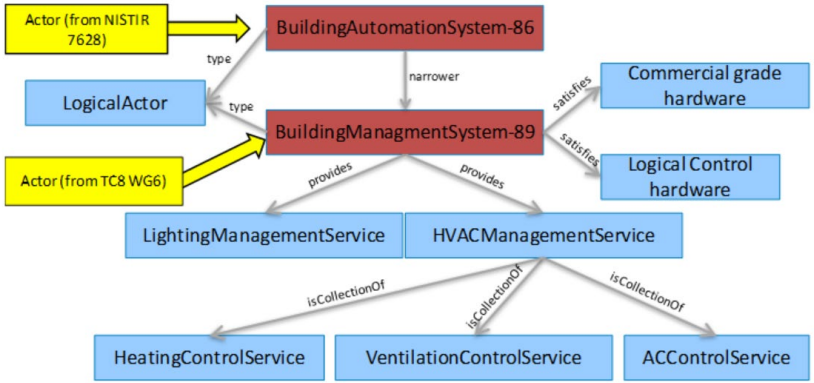

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Smart Grid Ontology Building Blocks: Aligning Business and IT/OT Architectural Elements

Tuesday, March 24, 2020

***Original recording of the webinar can be retrieved here: *https://sepapower.org/media-item/smart-grid-ontology-building-blocks-aligning-business-and-it-ot-architectural-elements/*

The Webinar Will Begin Soon

Navigation

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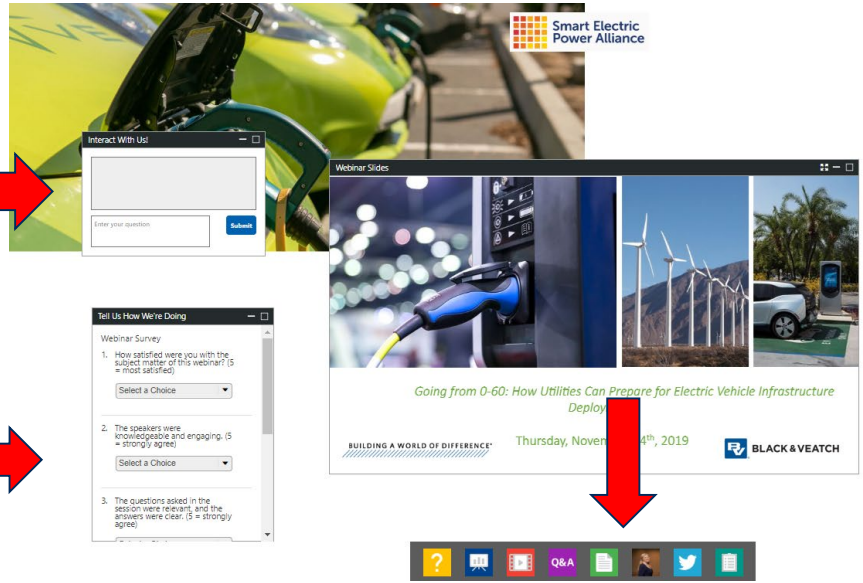

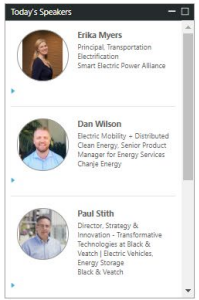

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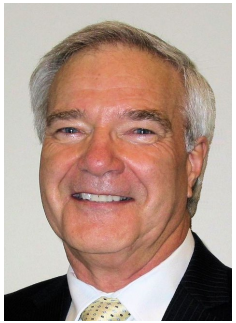
Today’s Speakers

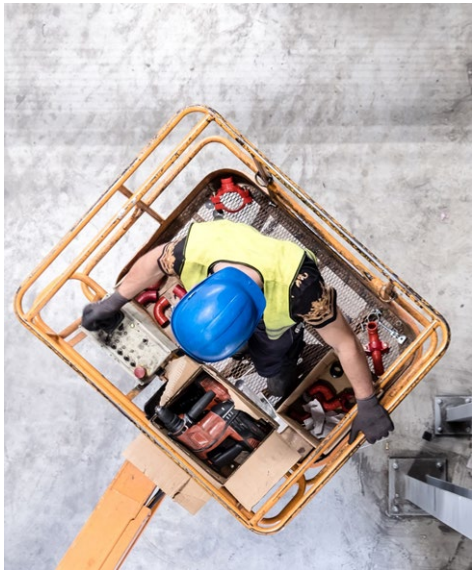


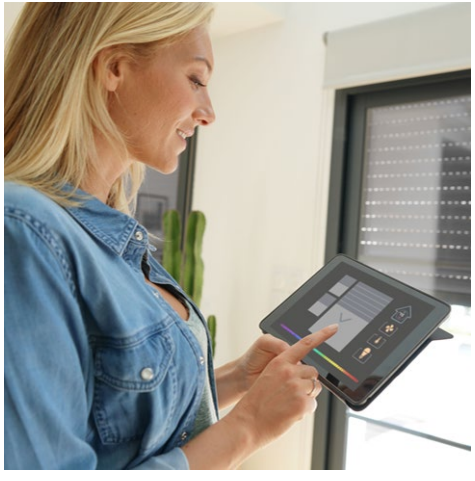
Ron Cunnigham
IT Enterprise Architect
rtcunningham@aep.com

AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY™

Steve Ray
Chief Executive Officer
steveraysteveray@gmail.com

QUDT





Who Are We?

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A carbon-free energy system by 2050

- A membership organization
- Founded in 1992
- Staff of ~50
- Research, Education, Collaboration & Standards
- Budget of ~$10M
- Unbiased
- Based in Washington, D.C.
- No Advocacy – 501c3

Pathways

Utility Business Models

Sustainable Utility business models to facilitate and support a carbon-free energy future.

Grid Integration

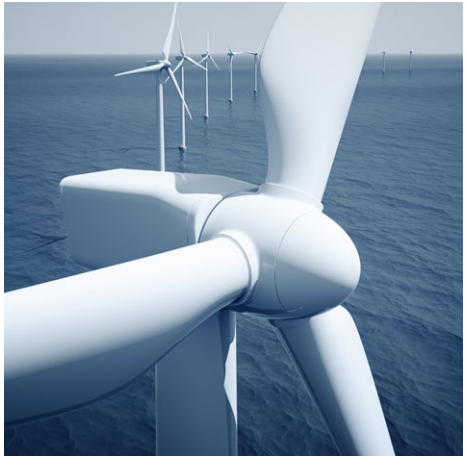
Seamless integration of clean energy yielding maintained or improved levels of affordability, safety, security, reliability, resiliency and customer satisfaction.

Regulatory Innovation

State regulatory processes to enable the timely and effective deployment of new technologies, partnerships and business models.

Transportation Electrification

The nation's fleet of light, medium and heavy-duty vehicles powered by carbon-free electricity.



Collaborative teams of member SMEs addressing important industry issues

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Working Groups

- Community Solar
- Customer Grid Edge
- Cybersecurity
- Electric Vehicles
- Energy Storage
- Energy IoT
- Grid Architecture
- Microgrids
- Solar Asset Management
- Testing and Certification
- Transactive Energy Coordination

Working Groups

Collaborative teams of member SMEs addressing important industry issues

> Grid Architecture Working Group (GAWG): Members with background and interest in grid, enterprise and other architectures associated with modernized electric power systems.

>> Electric Grid Ontology Task Force: Group interested in common set of architectural/ business elements and their relationships that can be interpreted and modeled consistently as it relates to the smart grid.

- Grid Architecture
- Microgrids
- Solar Asset Management
- Testing and Certification
- Transactive Energy Coordination

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Grid Ontology Background

The SEPA Electric Grid Ontology Project leverages earlier SGIP work and industry advances in smart grid and modernization architecture modeling efforts:

- NIST Framework and Roadmap for Smart Grid Interoperability Standards
- Ontology Intent
  - Smart grid architectural semantic modeling leveraging TOGAF, Zachman, SOA
  - Gathering and development of categorization guidance for architectural elements
  - Using advanced semantic modeling and ontology tooling and techniques
- GWAC Interoperability Layers

Work continues via the SEPA Grid Architecture Working Group and Electric Grid Ontology Task Force

What Started this Work?

...and Potential Solutions

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Original Challenge Pain Points

- **Relationships** between models are not understood – or worse interpreted incorrectly
- **Depth**: Many standards are still developing – many aspects of a model are incomplete or described more fully by another SDO, creating e.g. dups
- **Duplication**: Standards describe their environment using reference model(s). Different models quite often describe identical or similar concepts
- **Contradiction**: sometimes a model's concept describes elements that contradict how another model addresses it

An Approach – A Single Unified Model

Definition: unified model:

- Is ‘normalized’ (no duplicate modeling of the same semantic).
- Covers the entire problem scope of Smart Grid.

Challenges:

- Smart Grid large scope has to be partitioned somehow into domains so that different focus groups can operate in parallel
- Difficulty of coordinating normalized modeling goes up exponentially with the number of different domains
- Significant effort in separate domain models needed to achieve a global normalization. Stakeholder groups reluctance to change what they already have

Alternate Approach – Harmonize Semantic Models

Solution

Apply a common semantic method to document each standard's elements (formal ontology) – this defines an unambiguous definition of a standard's elements relationships to one another

Expected Results

- Identify identical element across the standards
- Infer relationships that are not explicitly defined amongst standards
- Identify conflicts between models
- Manages the complexity of emerging and evolving standards
    - Accelerates development and harmonizes change
    - Accelerates standards uptake and interoperability

Grid Ontology Terms

An Overview

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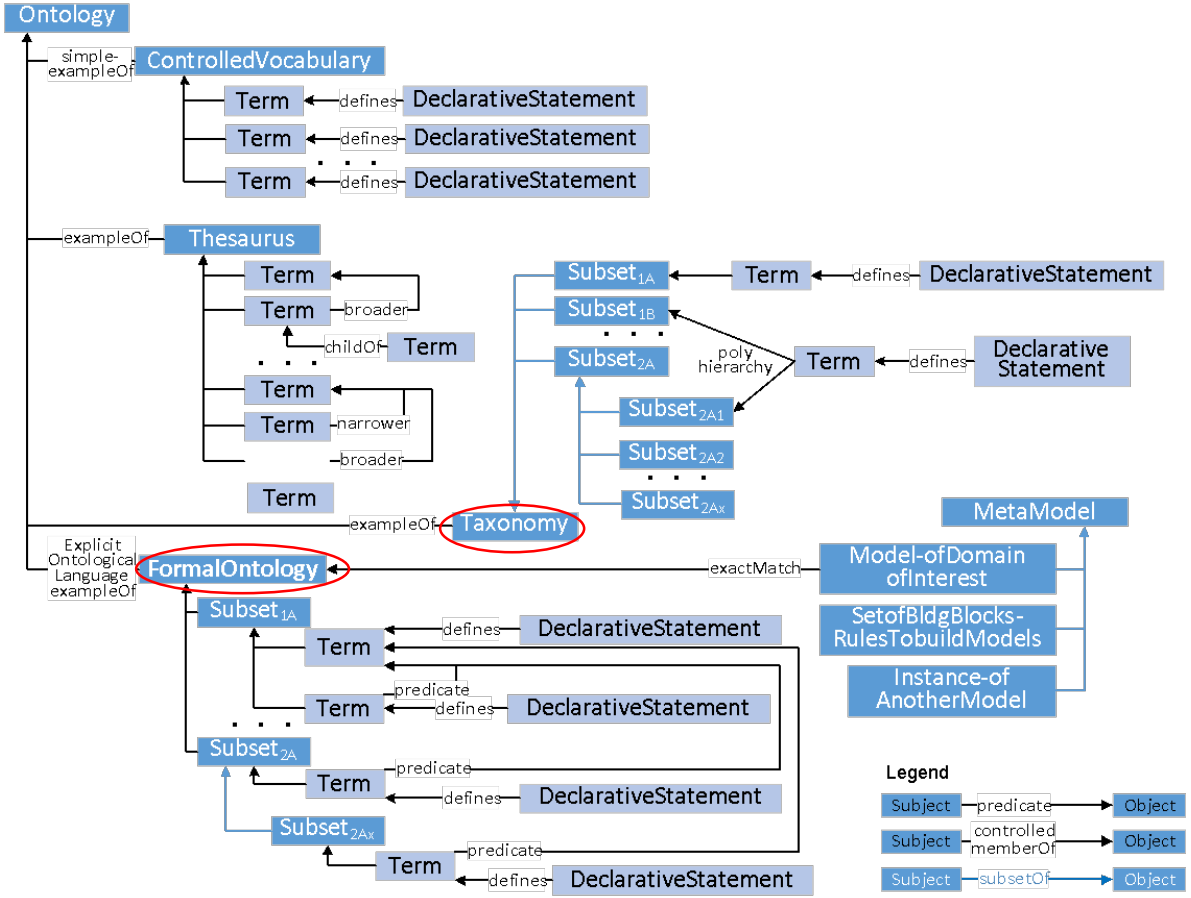
Definitions

Ontology - an explicit formal specification [language] of how to represent the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them[1]

Taxonomy – the formal structure of classes or types of objects within a domain. It organizes knowledge by using a controlled vocabulary to make it easier to find related information[2]

1) **Scott Neumann, Arnold DeVos, Steve Widergren, Jay Britton presentation DistribuTECH 2006 Use of the CIM Ontology**
2) **https://www.dataversity.net/what-is-taxonomy/**

Ontology Types and Related Terms



Smart Grid Ontology Focus:

- Taxonomy
- Formal Ontology

Terms - Architectural Abstraction Level and Element Categories

Architecture Abstraction Levels

- Conceptual, Logical, Physical, Implementation

Service Oriented Architecture (SOA) Elements

- Actors
- Services
- ServiceCompositions (~roles)
- ServiceContracts

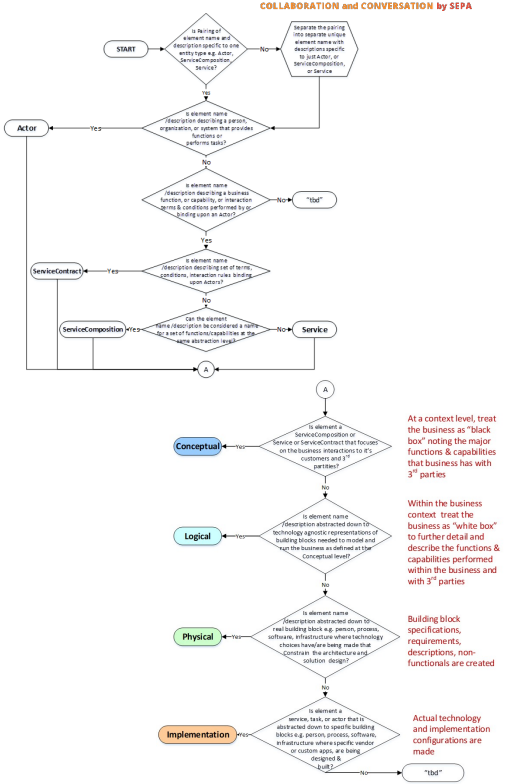
Element Abstractions:

- Conceptual:
  - Cooling Service
- Logical:
  - Temp. Mgmt. Service
  - Refrig. Cyclic-Vapor Compression Actor
- Physical:
  - Temp. Control Service
  - French Dr-Stainless Actor
- Implementation:
  - Temp.Pckg.build-AK3 Srvc.
  - Mnft. BigAppl, model 9910, s/n##### Actor

Element Categorization Guidance Decision Trees

Categorize the original elements by:

- **Element types** e.g.: Actors, Services, ServiceCompositions, and ServiceContracts
- **Architecture Levels**
  - **Conceptual** - business-to-business (B2B) relationships: B2C (consumer) and B2R (regulatory & policy). Services, ServiceCompositions, and ServiceContracts. A black-box view of the business.
  - **Logical** – White-box view of the business, showing the internal elements and their relationships. Actors, Services, ServiceCompositions, and ServiceContracts
  - **Physical** - the representation of a Specification, where the required features (functional and non-functional) are included.
  - **Implementation** – actual technology instantiations and implementation configuration decisions are made



Results To Date

- SGAC Architecture Development Working Party (ADWP), gathered set of Use Case elements from 18 organizations and performed initial categorization of elements to Conceptual, Logical, Physical architecture abstraction levels, resulting in:
  - **Grid Ontology OWL metamodel** (SOA focused), that shows the relationships of the elements across the Conceptual, Logical, Physical abstraction levels
  - **Grid Architectural Element Categorization Guidance**
- "**Neutral Concepts**" model via OWL introduced with simple use case example
- SEPA Electric Grid Ontology Task Force (EGOTF) continued work of SGIP ADWP and completed categorization of elements **Grid Architecture Taxonomy**

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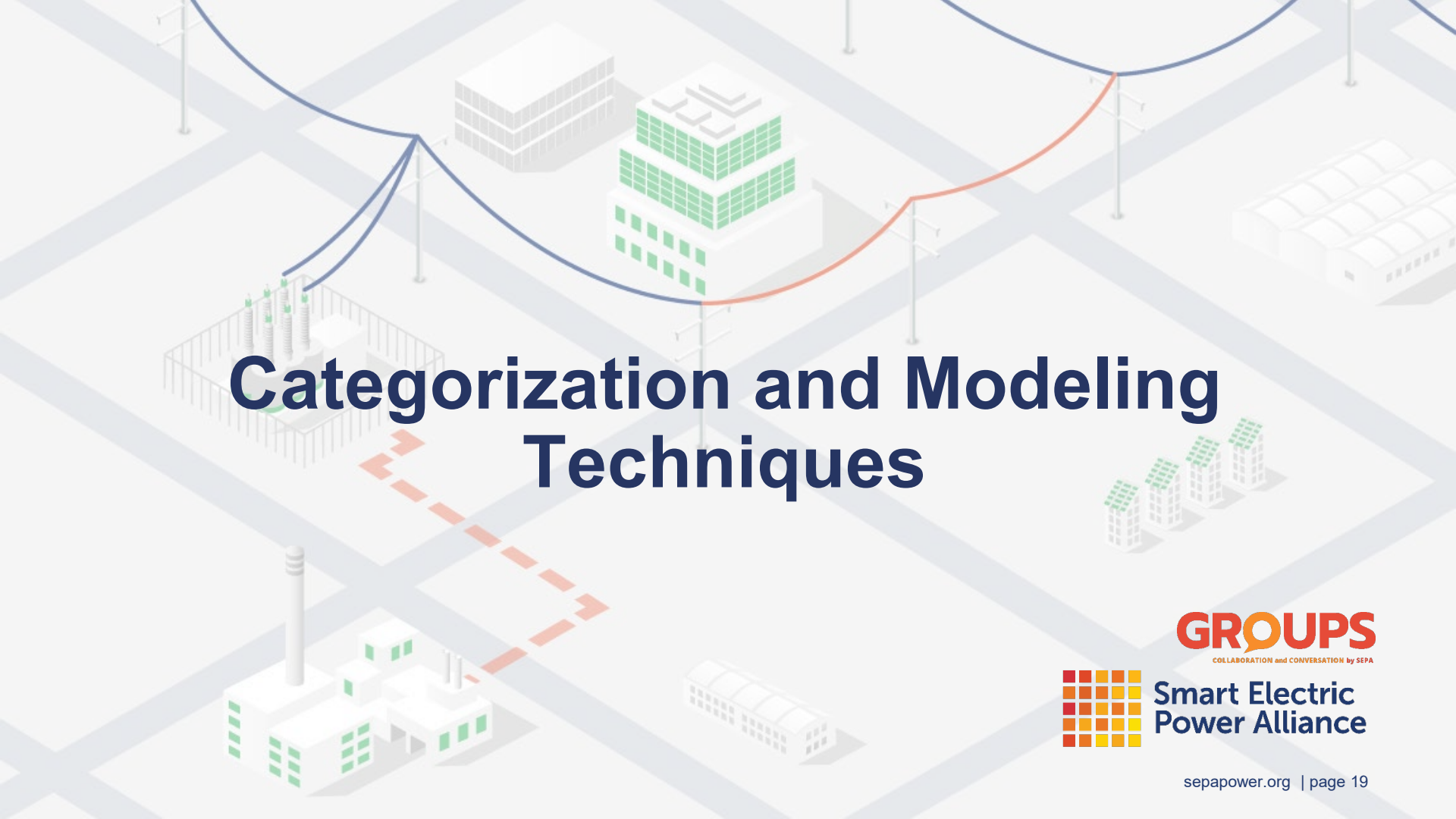
Grid Architecture Taxonomy contains:

- ~ 180 Actors
- ~ 230 Service-Compositions (~role)
- ~ 800 Services

Categorization and Modeling Techniques



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Shifting from UML to Semantic Modeling

UML and ArchiMate (UML based) models use **element objects and connector line specific styles to convey meaning** via: line types, end terminations, some annotation, and object outline form styles-icons.

Semantic Technology allows the meaning of and associations between concepts to be represented precisely and, used in a run-time environment. E.G. semantic **Web Ontology Language (OWL) is more expressive than UML**.

Semantic Technology represents information in a neutral form called **Triples that consist of a Subject, a Predicate and an Object**. Each of these can have properties that infer new information. Each has a unique identity (web addressable), enabling:

- Formal verification across diverse vocabularies
- merging of different datasets
- Inference and analysis of data and concepts

Meta Object Modeling Approach

Meta Classes - Used to categorize classes

- Actor
- Service
- Service Composition (Role)
- Service Contract

…with relations between them

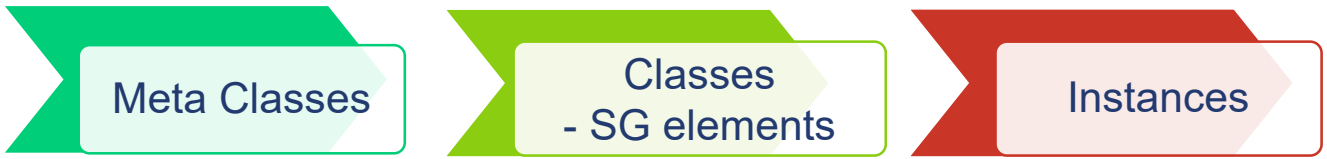
Classes - Used to represent terms e.g.

- Smart Grid Elements
- Premise Management
- Communication Network

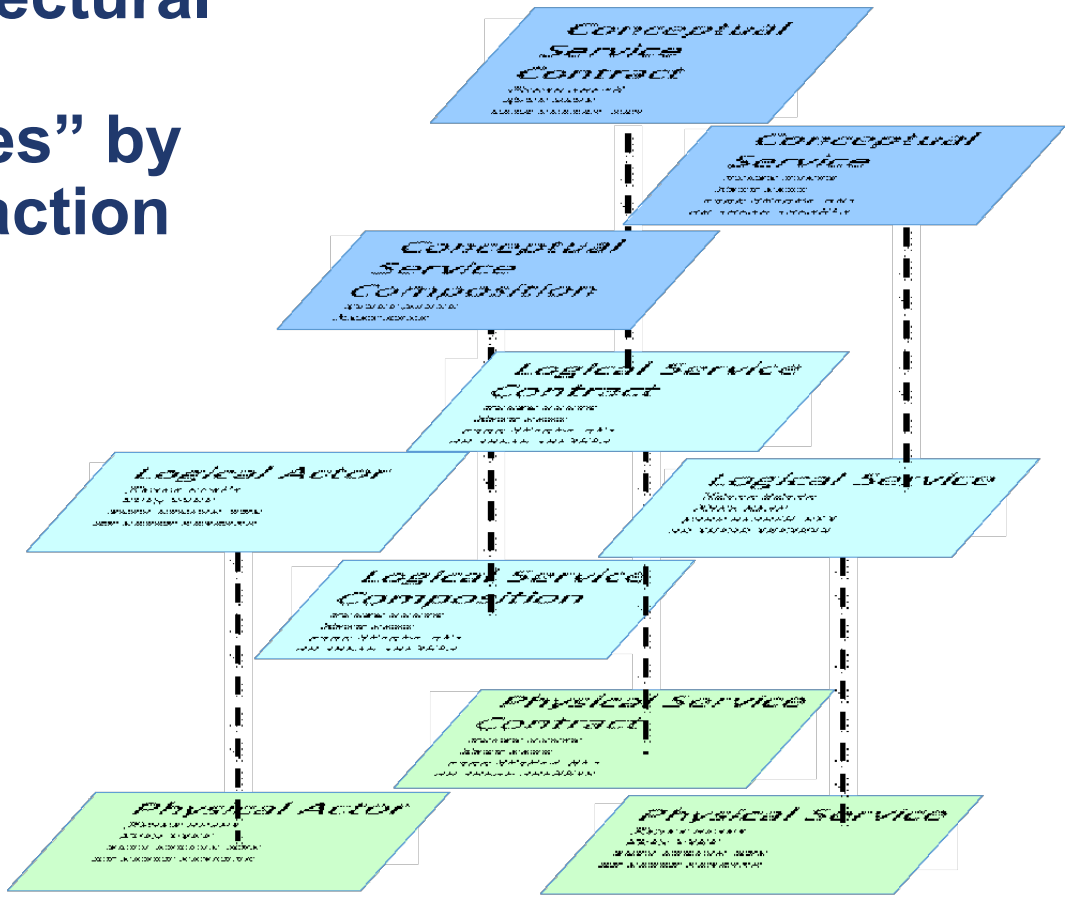
… categorized by the Meta Classes

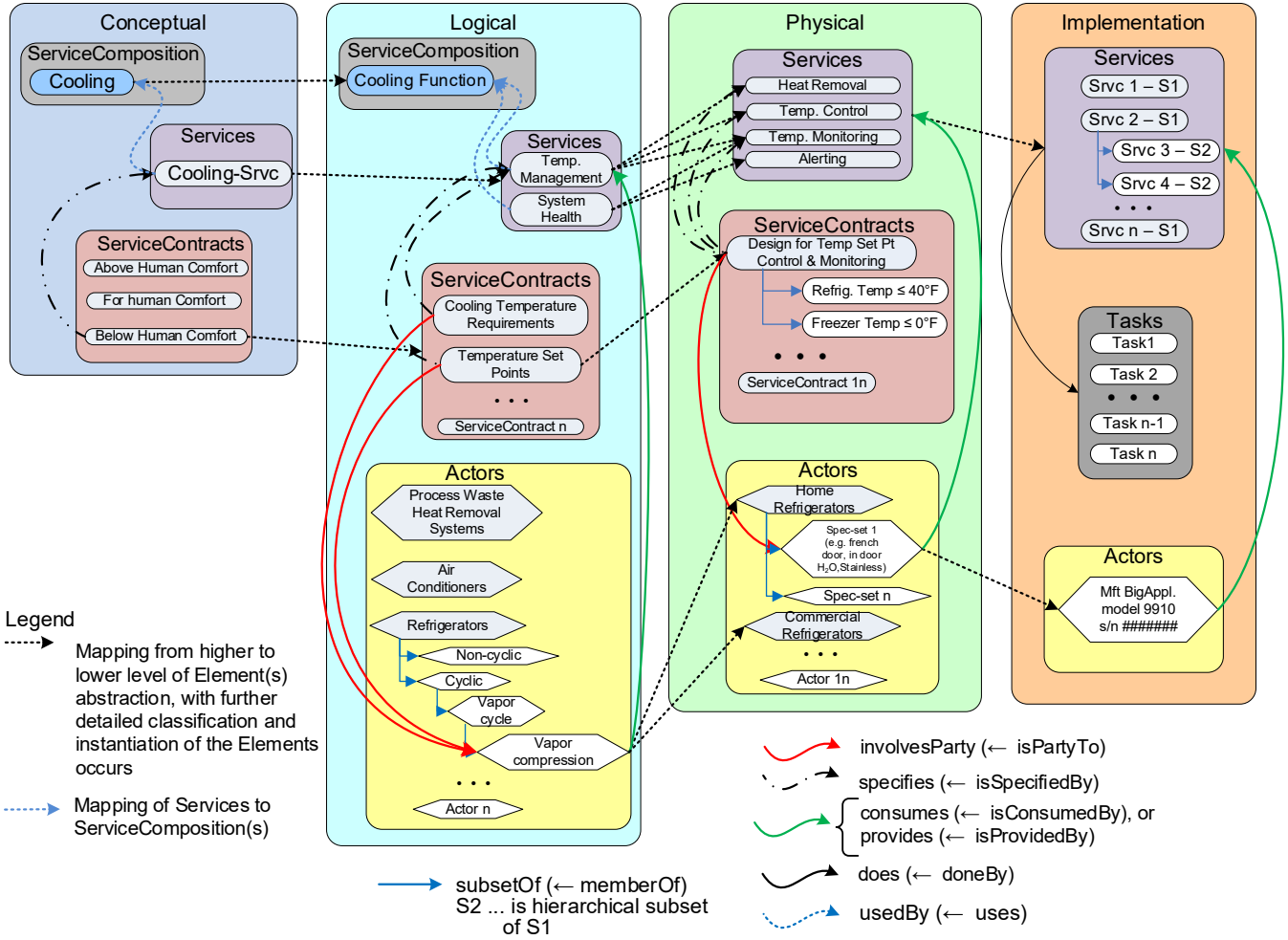
Instances - Used to inventory specific Systems and Services e.g.

- Meter #4127
- Web service implemented at http://fakesite.com/premise
- Network A at 129.6.24.159



Architectural "Meta Classes" by Abstraction Level

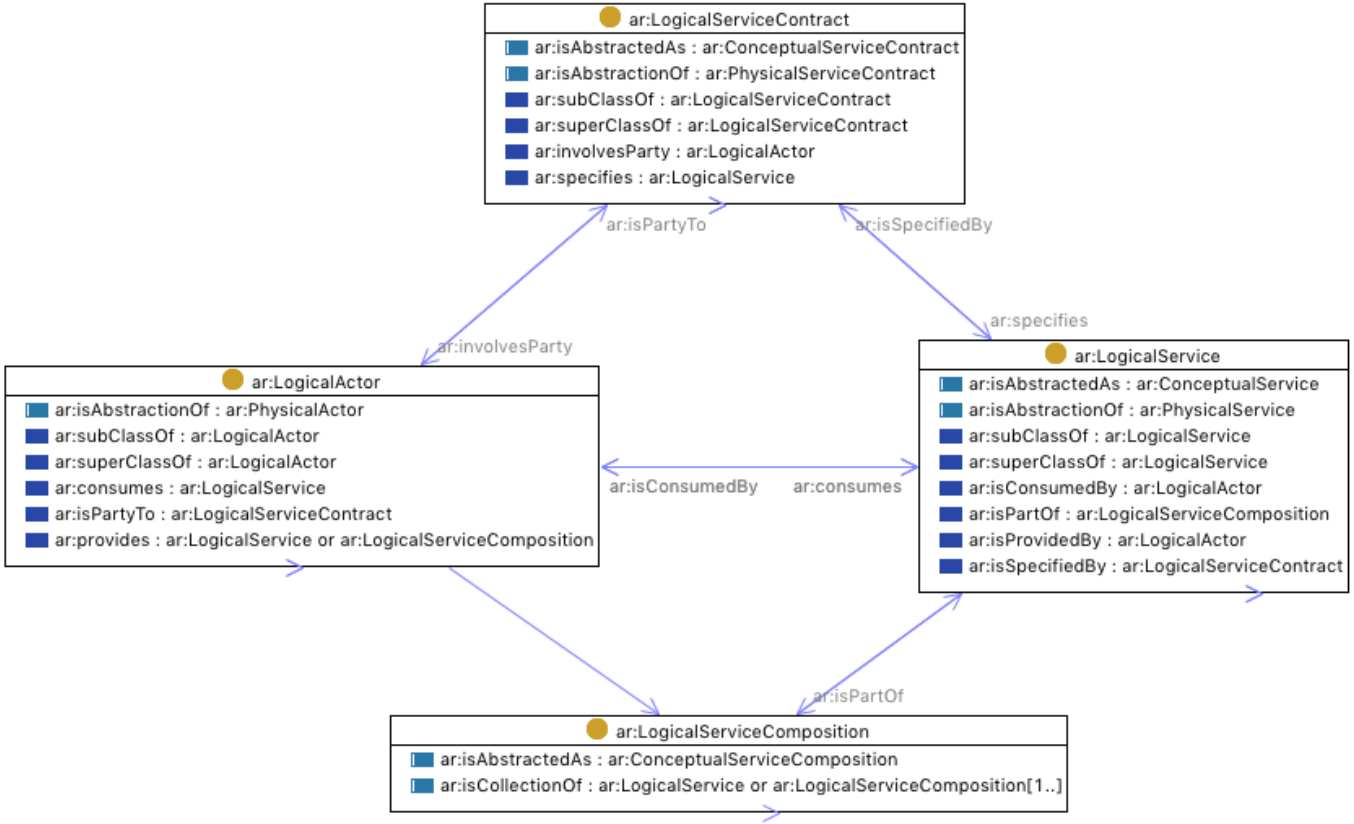




Ontology Graph
illustrative

Cooling Example

Smart Grid Ontology - Metadata Model extraction at Logical Abstraction Level



Taxonomy Illustrative from OWL Tool

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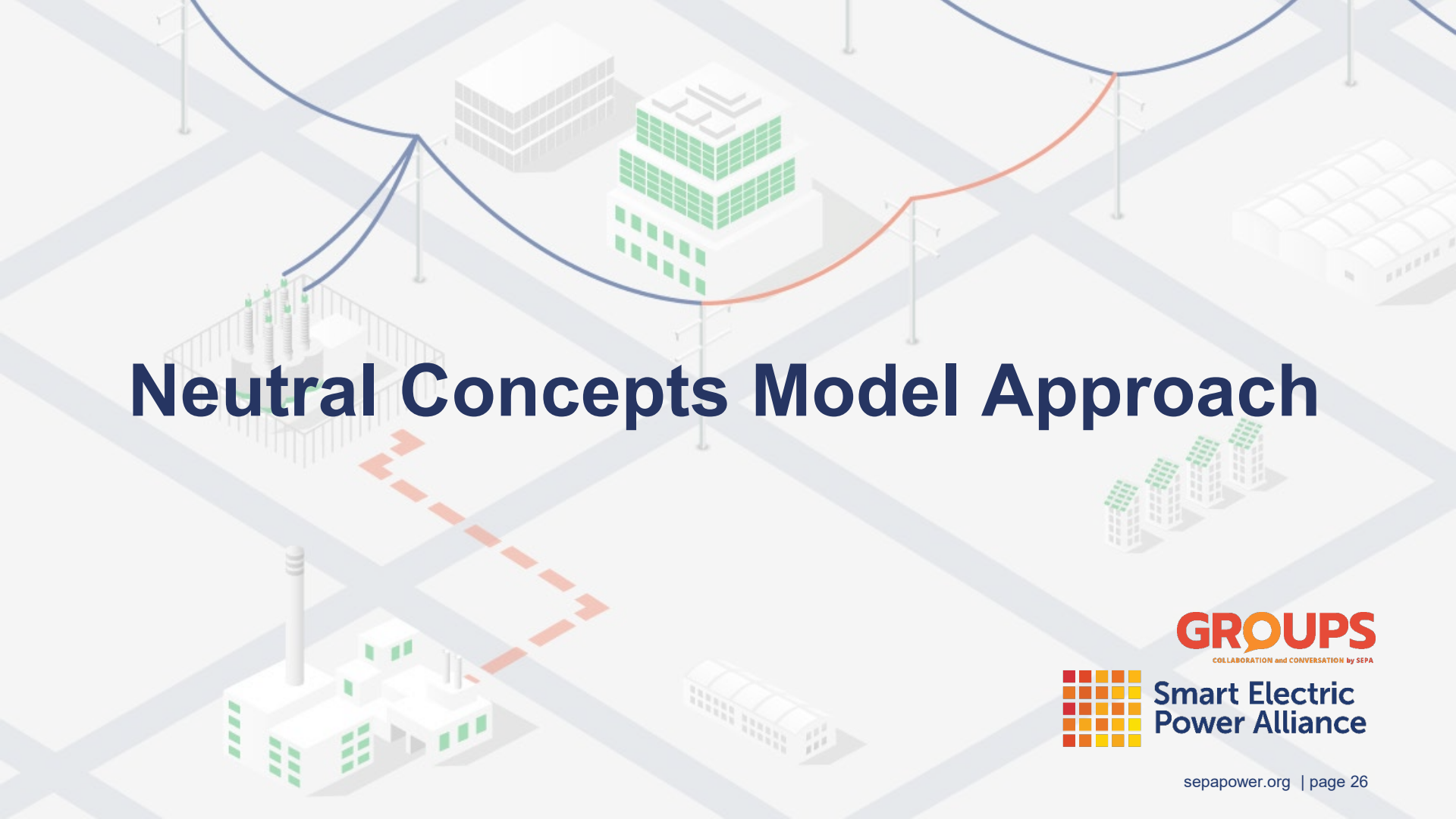
Entity Name	Description	Abstraction Level	Element Type	skos	NAESB	CSWG NISTIR 7628	CSWG Actors	IEEE P2030 Draft 3	EIS	EU Commission	EU WGSP Vers 0-5	SGAC Conceptual Arch
Aggregator	offers services to aggregate energy production from different sources (generators) and acts towards the grid as one entity, including local aggregation of demand (Demand Response management) and supply (generation management). In cases where the aggregator is not a supplier, it maintains a contract with the supplier.	Conceptual	ServiceComposition	TBD								
AMI Operations	General operator of the AMI system	Logical	Actor	TBD							X	
AMI Service	ServiceComposition responsible for the installation, operation, maintenance and de-installation of the system components. It may access, if properly identified and authorized, those components either directly, via local operation and maintenance interfaces, or from a system component from a higher hierarchical level (e.g. meters may be accessed for maintenance purposes via NNAPs or the HES).	Logical	ServiceComposition	TBD							X	

The Entity Name and Description were key to determining the abstraction level and element type. The submitting organization's identity was imported for traceability.

Neutral Concepts Model Approach



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What is the Neutral Concepts Model?

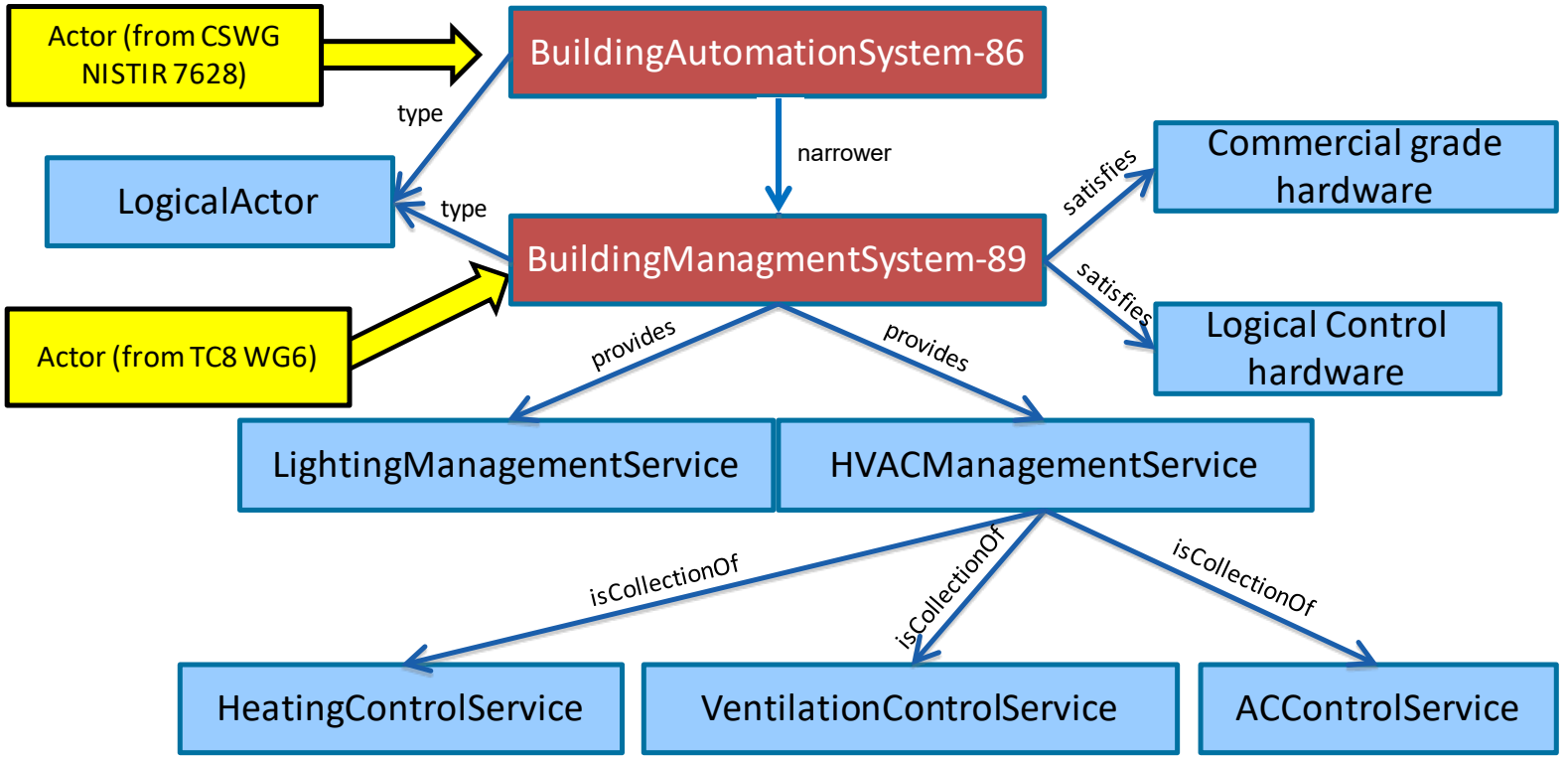
Definition – It is a semantic model, (an ontology), designed to capture each element's unambiguous definition and relationships with other elements in the context of the smart grid. It is called "Neutral" because it is intended to be independent of any specific standard in the smart grid, to be used as an "interlingua" – a bridge that relates terms across all the smart grid standards and communities.

The Neutral Concepts Model can be used :

- As a "Rosetta Stone" to show how other stakeholders' business scenarios or use-case elements relate (or not) with other stakeholder or business scenario / use-case model elements
- To identify missing concepts and aid in modeling them
- To compare two solutions/applications to see if they are interchangeable without loss of functionality

"BuildingAutomationSystem" use of Neutral Concepts model - example

…and we can infer that BuildingAutomationSystem-86 can do everything BuildingManagementSystem-89 can do because of the "narrower" relation.



There are Missing Concepts

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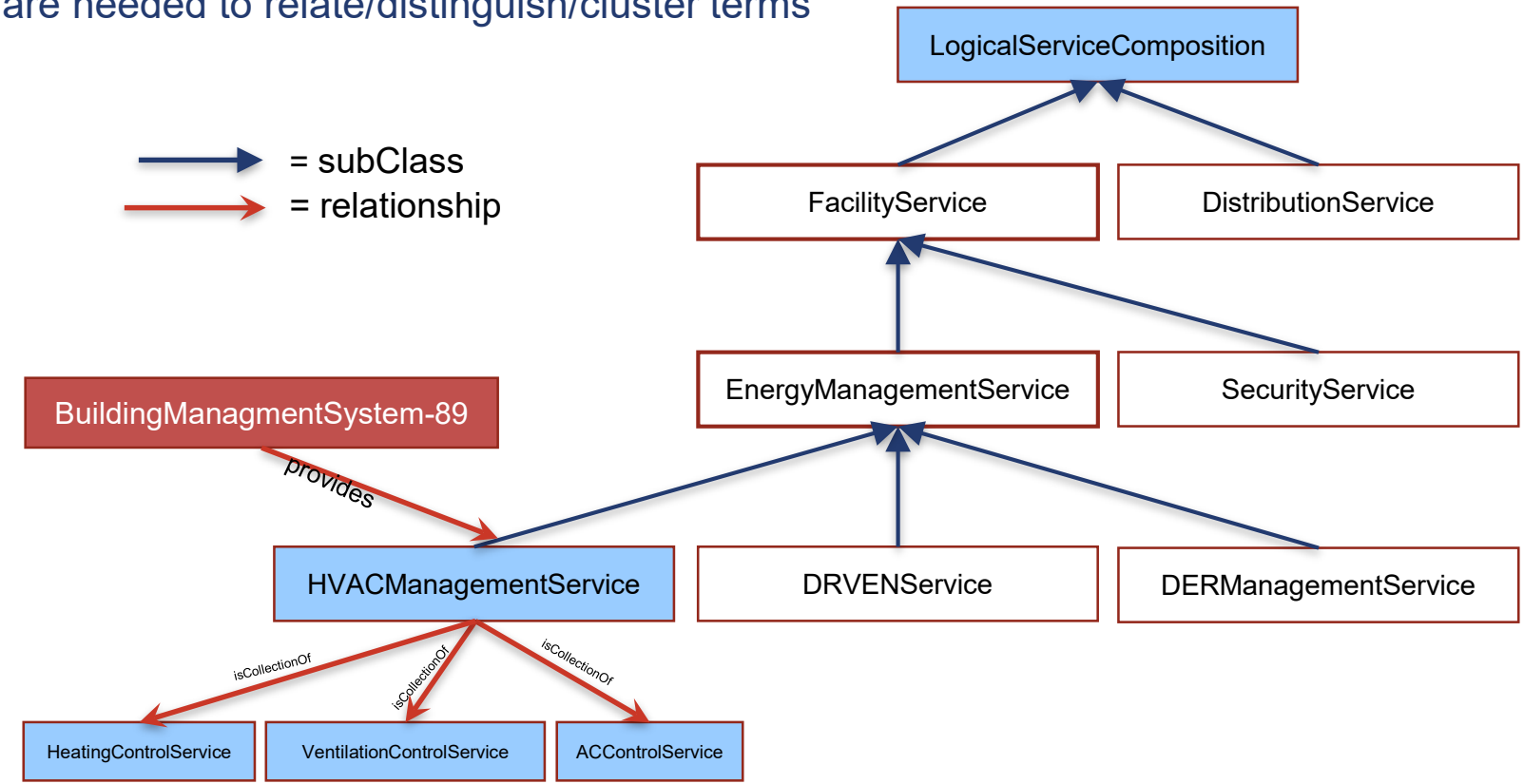
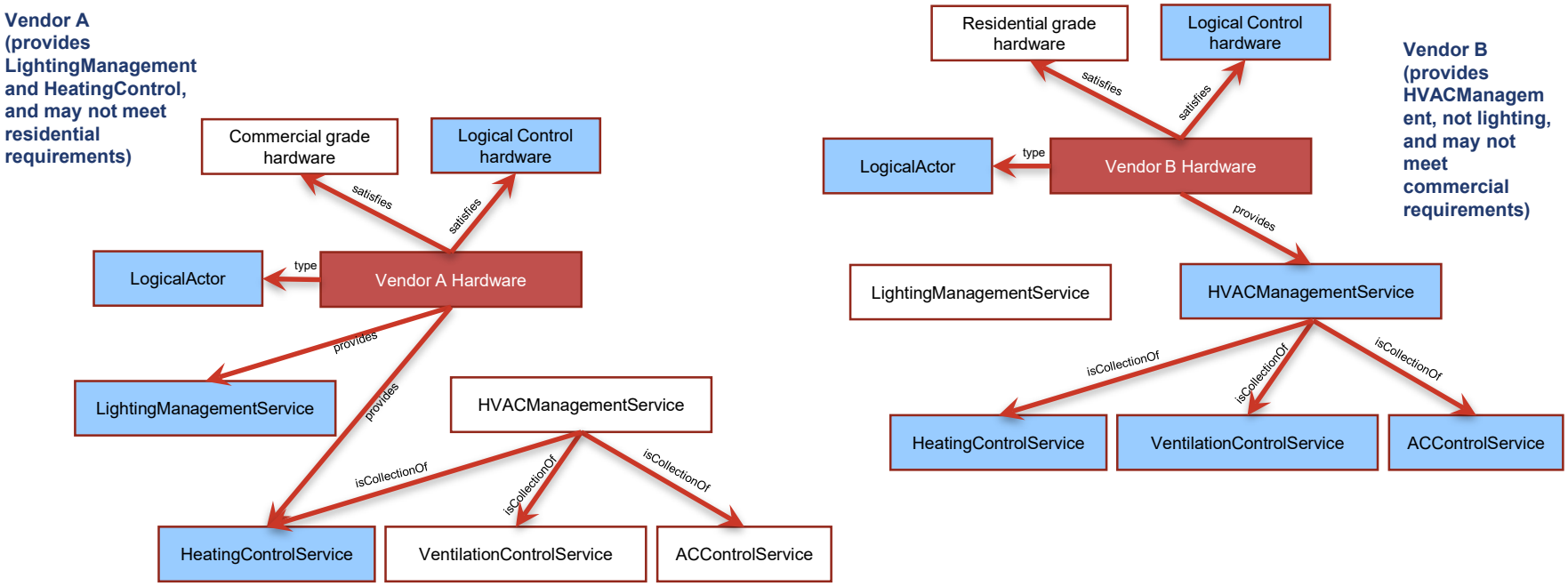
They are needed to relate/distinguish/cluster terms



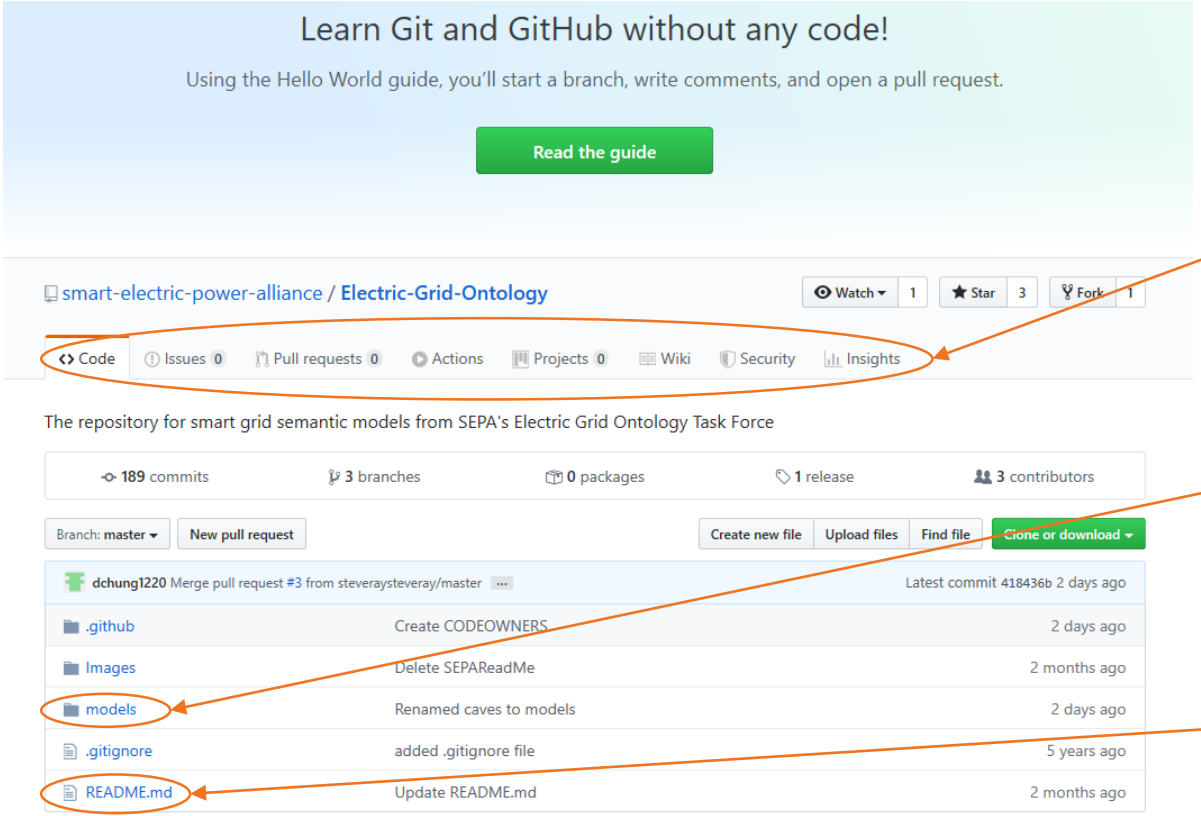
Implications

If we correctly categorize systems and services, we can begin to automatically identify where interoperability is possible, and where there will be problems.



Glimpse of the Grid Ontology Project: Landing Page

Grid Ontology GitHub Landing Page



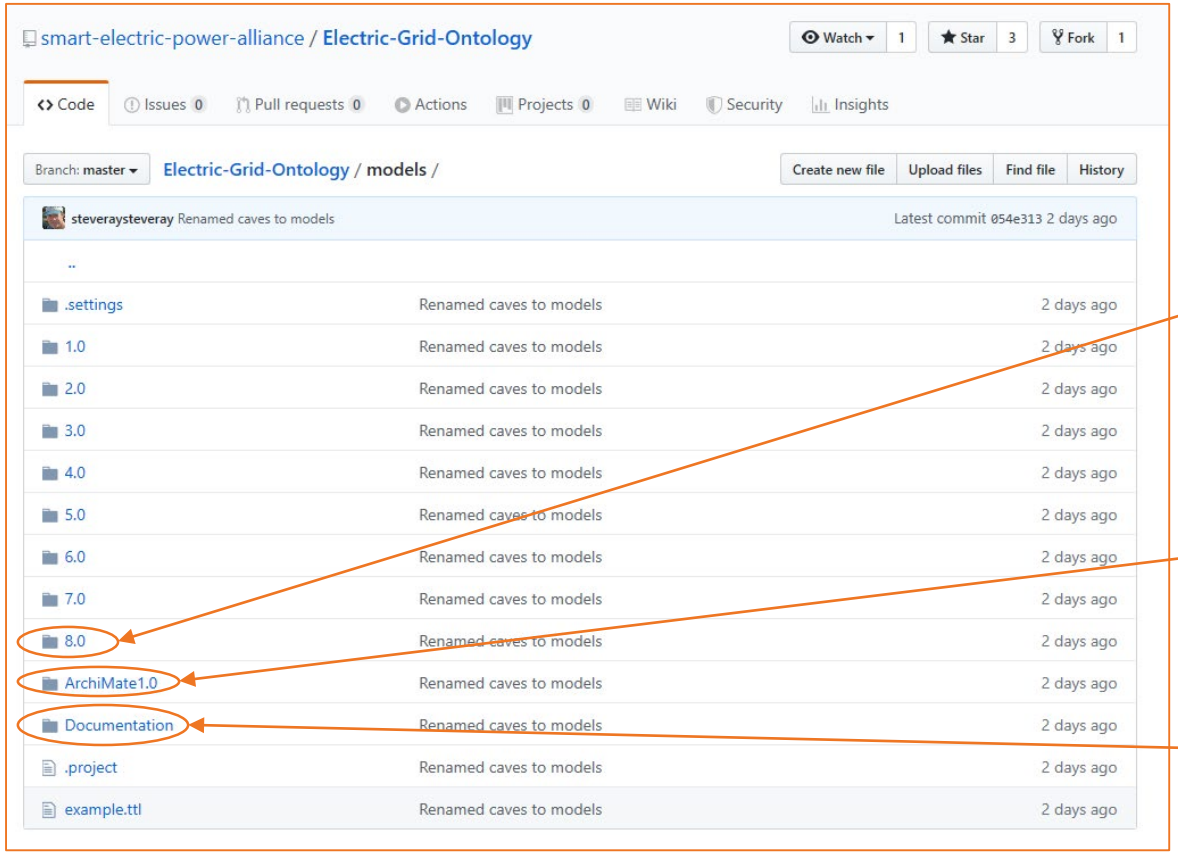
https://github.com/smart-electric-power-alliance/Electric-Grid-Ontology

GitHub drop down of tasks and information about this section of the GitHub universe

Entry point to the main set of Grid Taxonomy & Ontology Building Blocks. This is a work-in-progress area, and more content coming

"Rosetta Stone" prose that is the bottom portion of the landing page

“models” GitHub Page



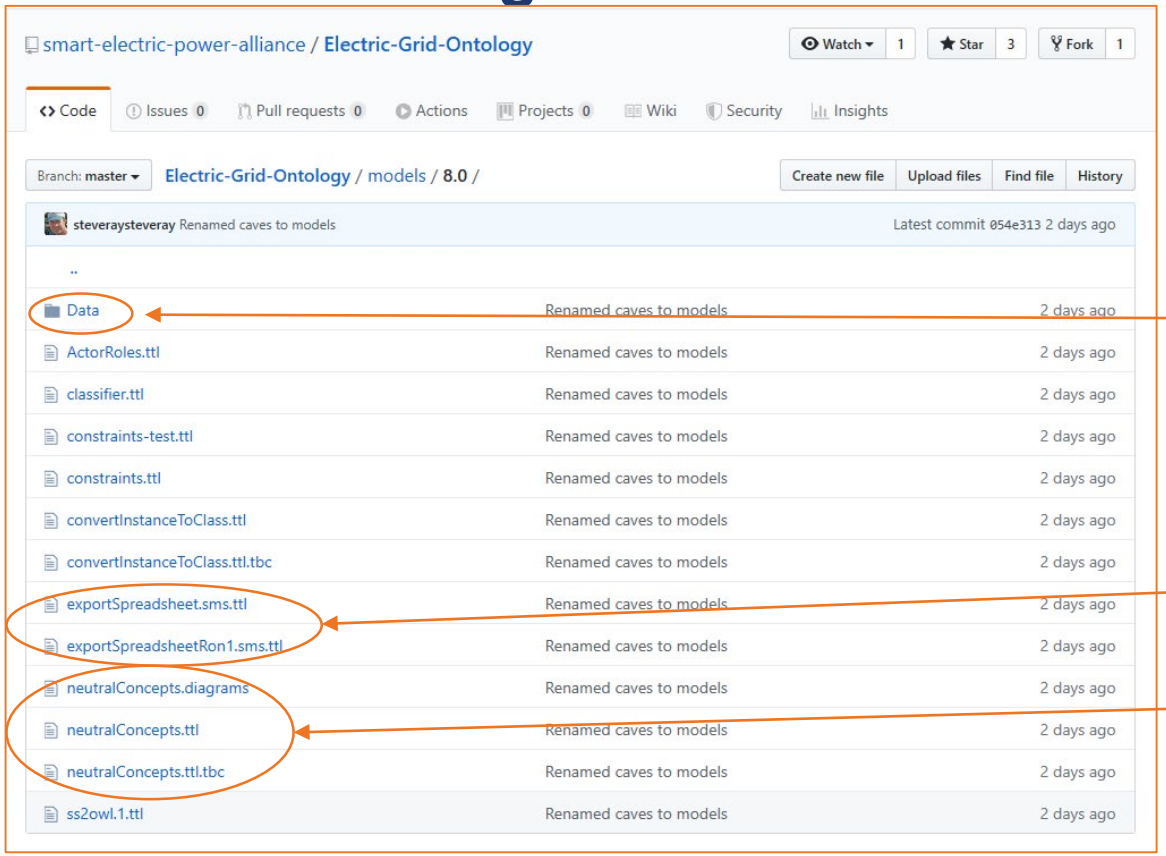
Current set of Grid Taxonomy, Grid OWL metamodel, Neutral Concepts example model, Scripts, queries

Collection of testing moving data and model aspects amongst table data, Archi, TopBraid Composer

Collection of presentations, guidance, procedures

github /tree/master/models/

“8.0” GitHub Page



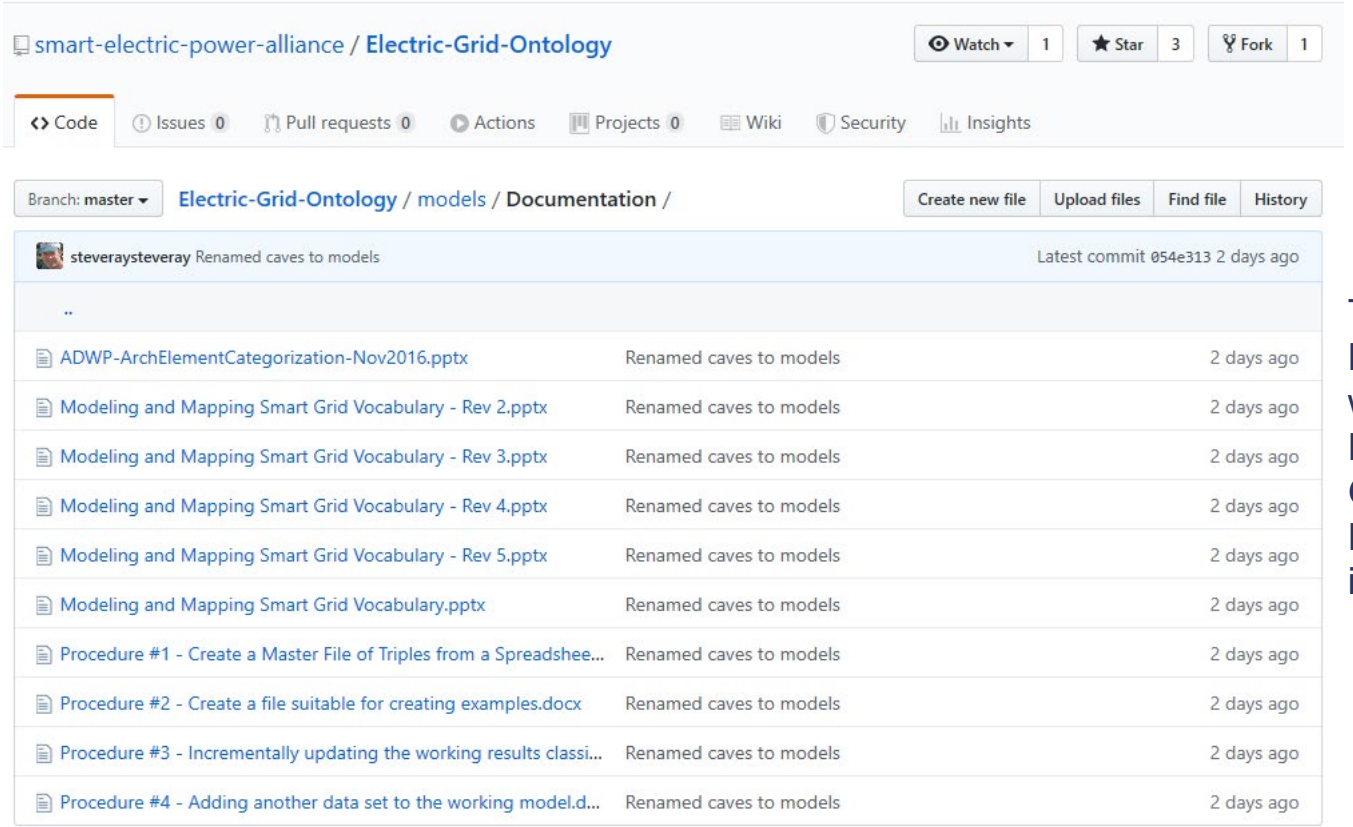
Input data and intermediate working models and code

Exporting model information back into tables

Neutral Concepts

github /tree/master/models/8.0/

“Documentation” GitHub Page



This collection of Presentations and documents will contain the bulk of the Element Categorization Guidance, the What’s and How-To information. A work-in-progress

github /tree/master/models/Documentation/

Grid Ontology Next Steps

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Grid Ontology Project Next Steps

- Setup routine TF meeting cadence with existing and new active collaborating members
- Determine what proof-of-concept project (from existing and new business scenarios/use cases submissions), to demonstrate effective use of the Grid Ontology building blocks to produce a useful for ontology for that business scenario
- Scope out the work plan and resources to work the POC project
- Execute the plan and communicate the results
- If sufficient interest and resources, extend the Grid Taxonomy with recent business scenarios/use cases
- Eventually determine if another POC project necessary for the SEPA EGOTF Incubator phase of this effort

Value Proposition: Tomorrow

S&P Global
Ratings

Industry Top Trends 2019

North America Regulated Utilities

November 8, 2018

Key assumptions

1. Conservation has reduced demand tied to economic growth

Historically, a strong correlation existed between economic growth and the demand for electricity. Since 2011, conservation has significantly curtailed sales growth, leading to a very weak correlation between utility sales and economic growth. Our base case incorporates flat to slightly negative sales growth over the next three years, reflecting new customer growth offset by conservation. To achieve growth, we expect that utilities will pursue mergers with other utilities as well as acquisitions of slightly higher-risk businesses outside of the direct utility industry.

To achieve growth, we expect that utilities will pursue mergers with other utilities as well as acquisitions of slightly higher risk businesses outside of the direct utility industry

Taking this information to the next level with pilot projects:

- **How do I merge divisional data systems ?**
- **How do I merge two utility's data systems?**
- **How do I enhance my interoperability ?**

Get Updates, Stay in Touch

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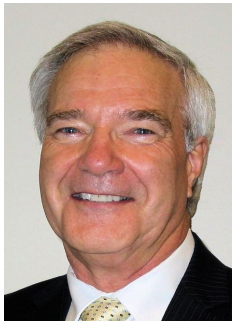
How to Participate…

1. **Join the SEPA Grid Architecture Working Group:**
   - Connect with the Electric Grid Ontology Task Force to pilot your Ontology with their help
   - Meet other utilities IT engineers / architects, Info analysts, system designers *https://groups.sepapower.org/home*
2. **Explore available resource**
   - GitHub: *https://github.com/smart-electric-power-alliance/Electric-Grid-Ontology*
   - General information: *https://sepapower.org/smart-grid-ontology/*

Be a part of SEPA !! Contact *membership@sepapower.org* for more information.

Questions



Ron Cunnigham
IT Enterprise Architect
rtcunningham@aep.com

Steve Ray
Chief Executive Officer
steveraysteveray@gmail.com

Thanks for Attending

Daisy Chung
Manager, Industry Solutions
Dchung@sepapower.org
202.559.2027

Aaron Smallwood
Vice President, Research
asmallwood@sepapower.org
202.871.7414

HEADQUARTERS

Smart Electric Power Alliance
1220 19th Street, NW, Suite 800
Washington, DC 20036-2405
202.857.0898

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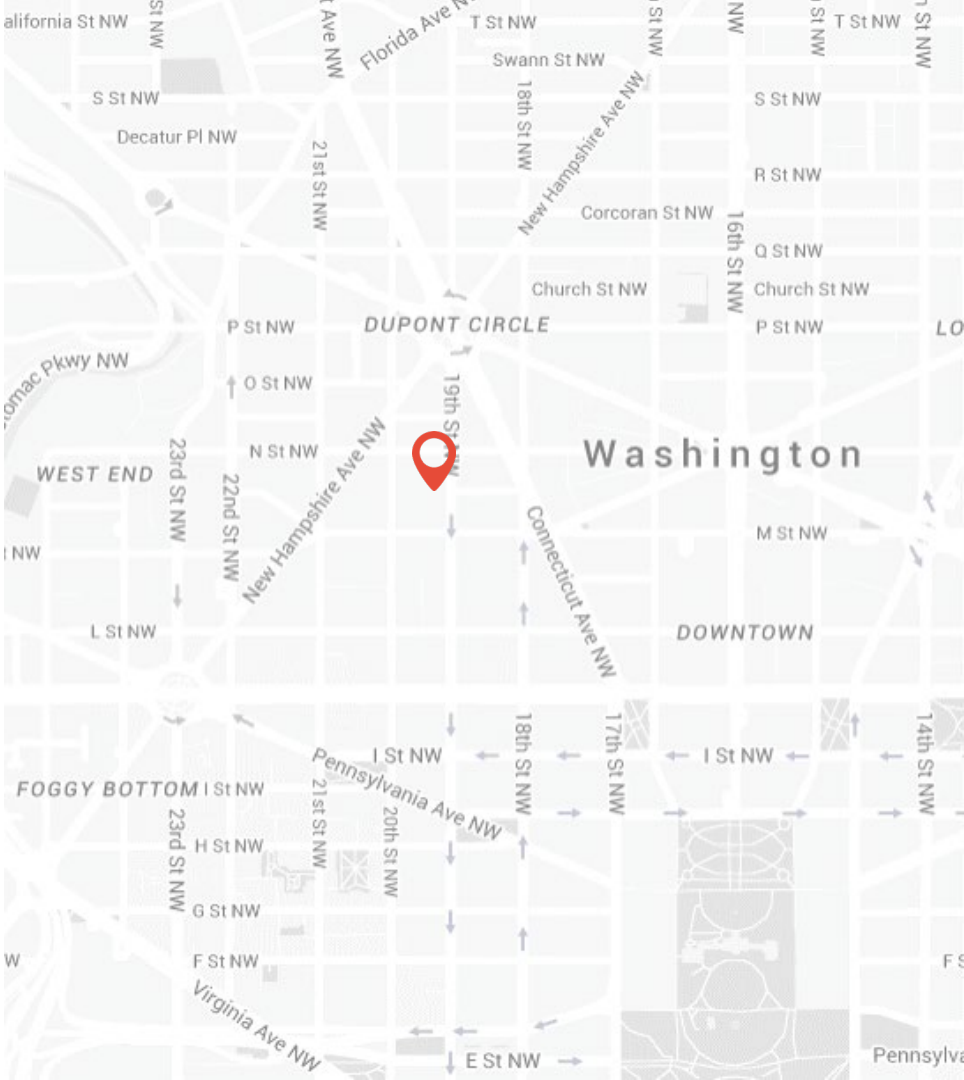

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Supporting Slides

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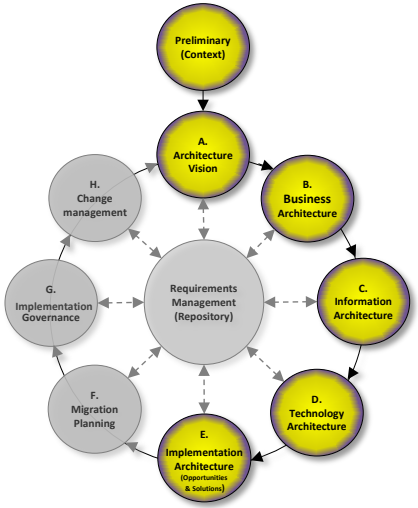
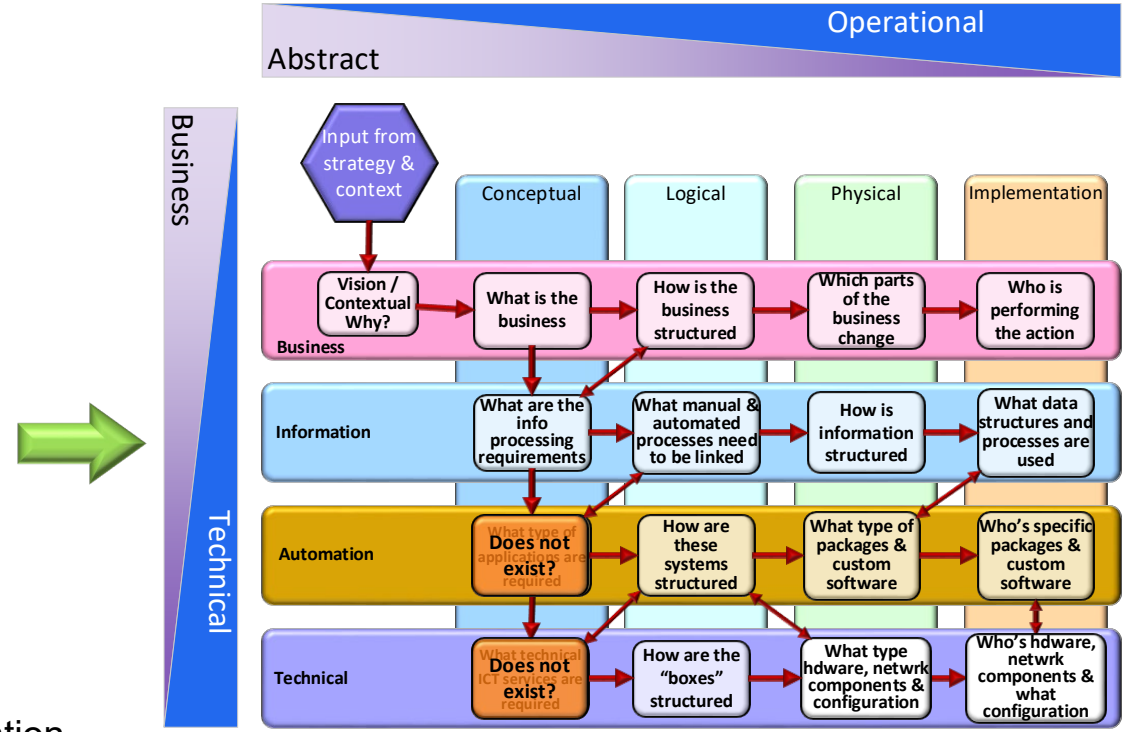
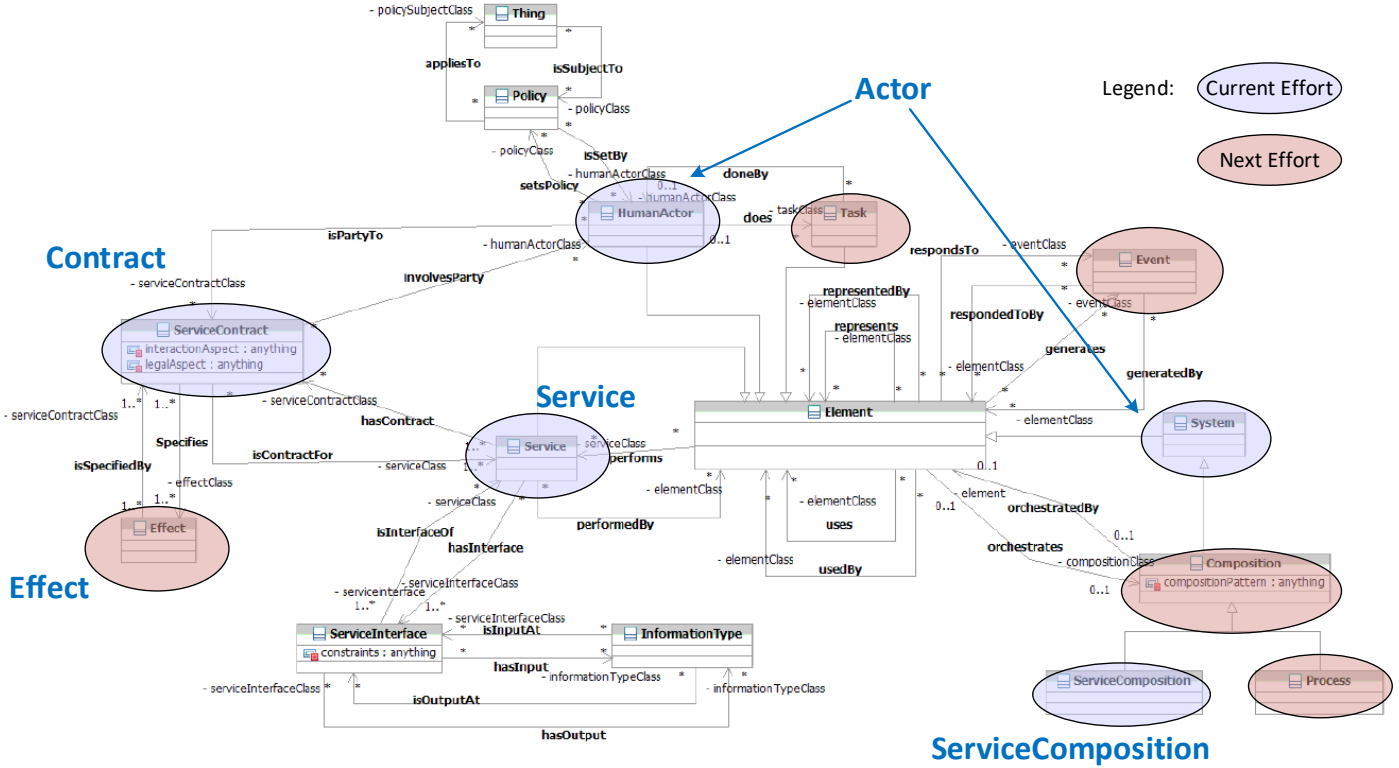
Conceptual, Logical, Physical, Implementation applied to Zachman Levels

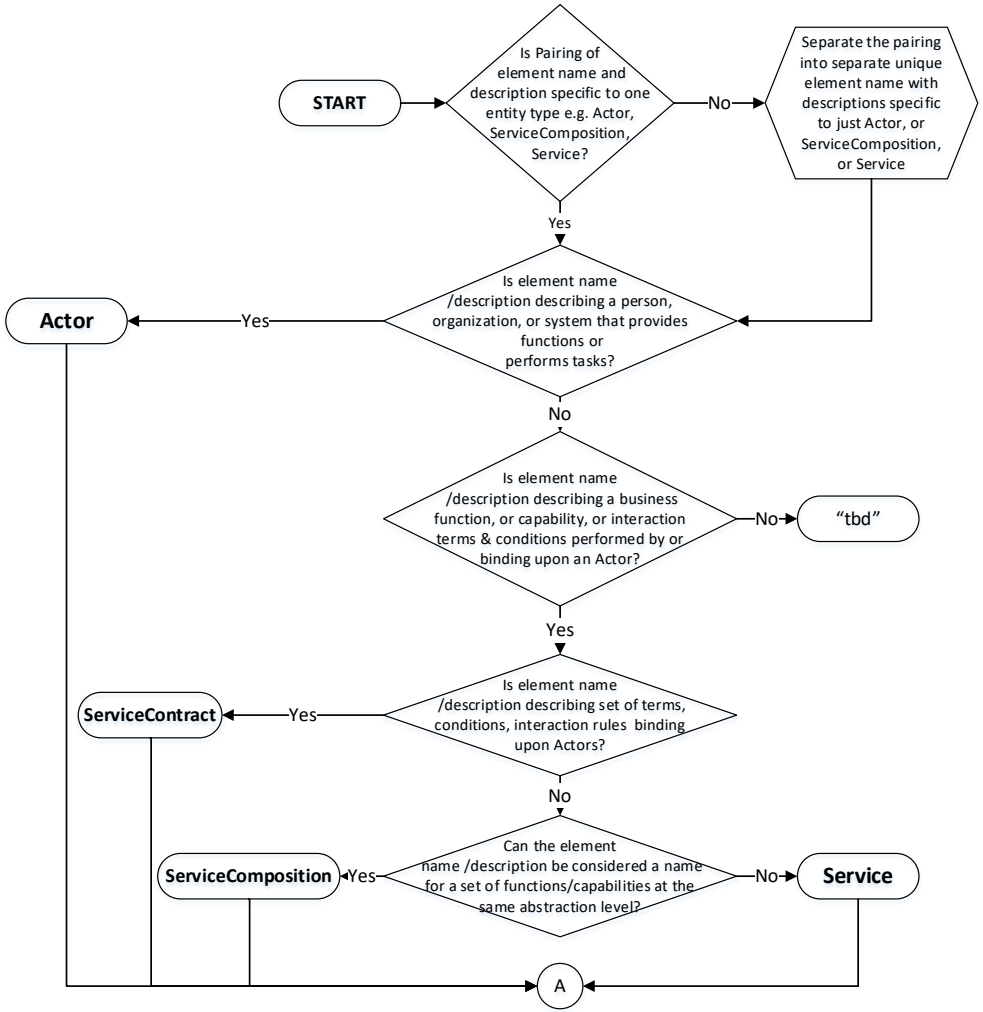




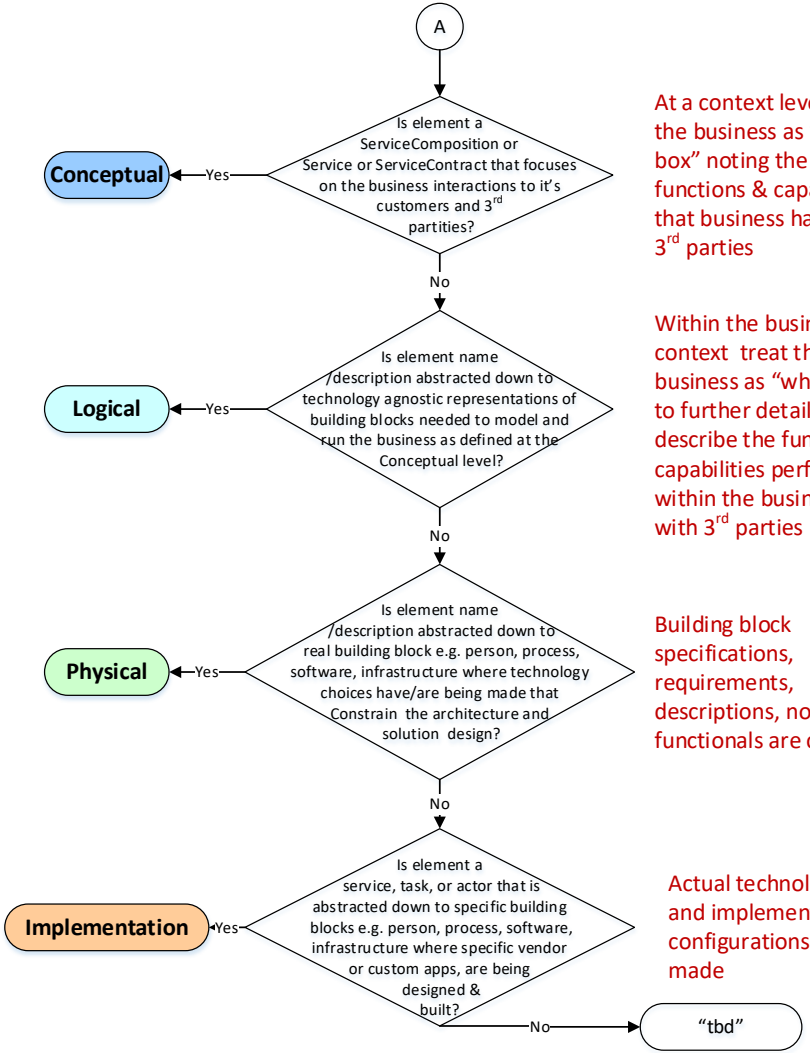
Note: TOGAF Phase C maps into Zachman Information and Automation

Full Open Group SOA Ontology Mappings to Grid Ontology Metamodel





Architectural Element Categorization Decision Tree



At a context level, treat the business as "black box" noting the major functions & capabilities that business has with 3rd parties

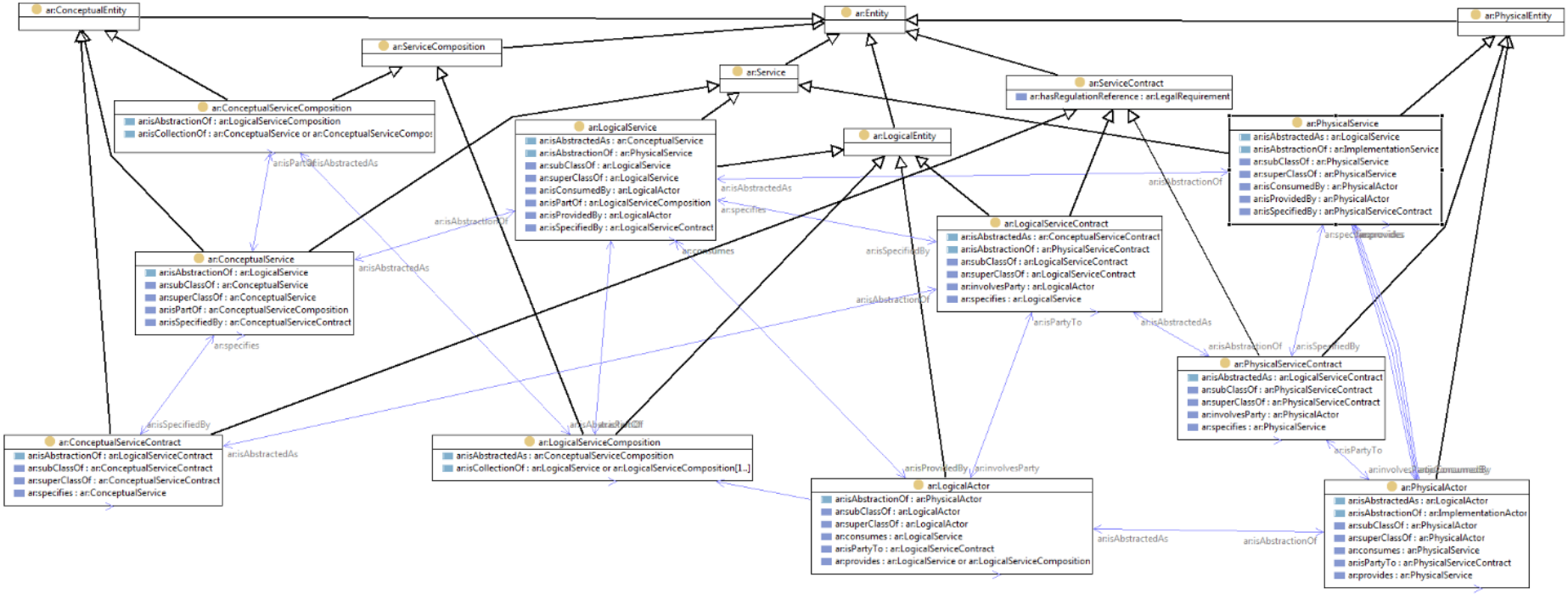
Within the business context treat the business as "white box" to further detail and describe the functions & capabilities performed within the business and with 3rd parties

Building block specifications, requirements, descriptions, non-functionals are created

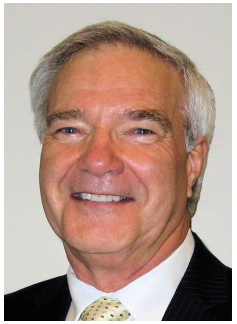
Actual technology and implementation configurations are made

Architectural Abstraction Level Categorization Decision Tree

Grid Ontology OWL metamodel



Today's Speakers



Ron Cunnigham
IT Enterprise Architect
rtcunningham@aep.com

Steve Ray
Chief Executive Officer
steveraysteveray@gmail.com

BUILDING A WORLD OF DI

AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY

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BLACK & VEATCH

Thanks for Attending

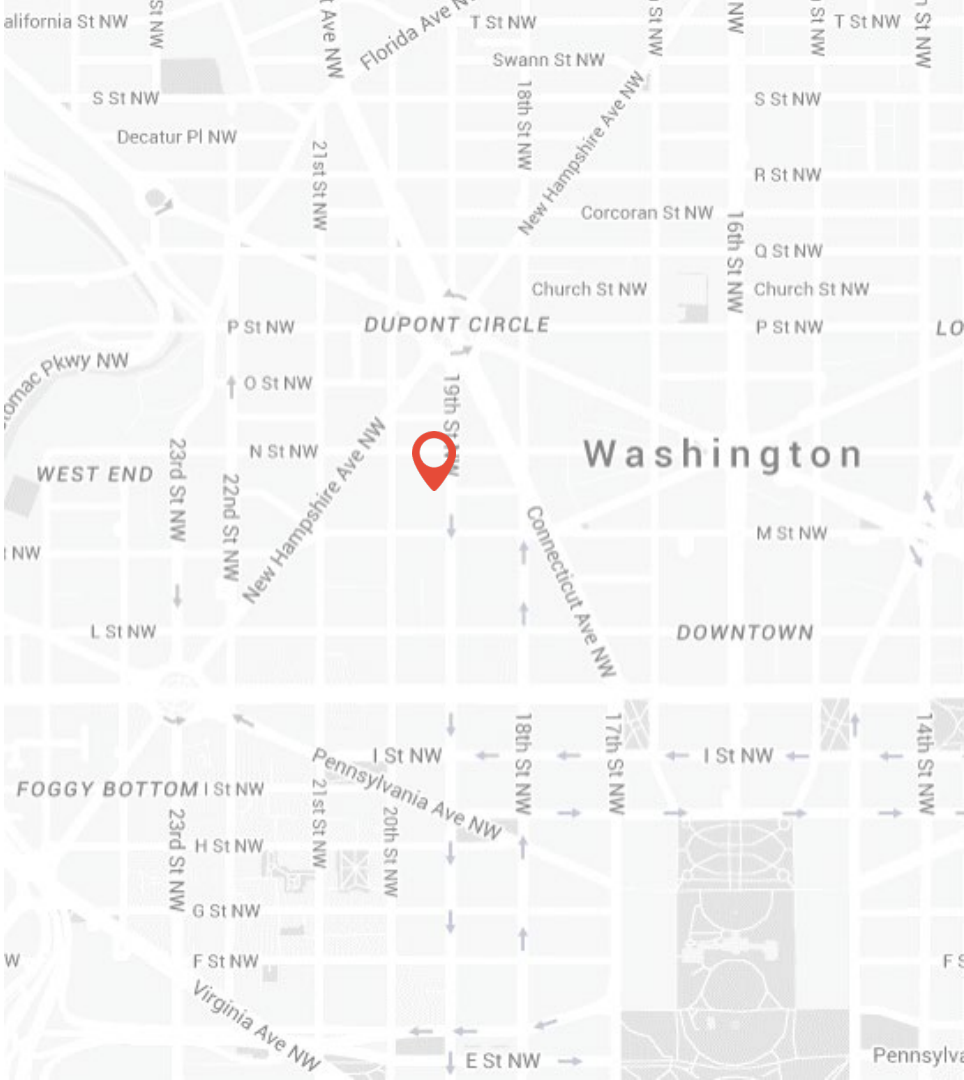
Daisy Chung
Manager, Industry Solutions
Dchung@sepapower.org
202.559.2027

Aaron Smallwood
Vice President, Research
asmallwood@sepapower.org
202.871.7414

HEADQUARTERS

Smart Electric Power Alliance
1220 19th Street, NW, Suite 800
Washington, DC 20036-2405
202.857.0898

GROUPS
COLLABORATION and CONVERSATION by SEPA



SEPA Electric Grid Ontology Task Force
Grid Ontology Project Webinar - Q&A
(Original recording of the webinar can be retrieved here: *https://sepapower.org/media-item/smart-grid-ontology-building-blocks-aligning-business-and-it-ot-architectural-elements/*)

1. How will this ontology be harmonized by other standard taxonomies for buildings such as Project Haystack?

   Ans: The perception of the Haystack Project is the focus on IoT and standardizing semantic data models and web services across the vendors in that ecosystem. The Grid Ontology architectural element categorization building blocks might be a reference material for the Haystack Project. As the team draws on all relevant standards, the goal of this work is to harmonize the terminologies, but not trying to build a universal smart grid model. Any harmonizing of the SEPA Taxonomy and Ontologies via the Neutral Concepts with Haystack, is dependent upon a business scenario, and/or use case that is in common between the groups be brought to the SEPA Grid Ontology Project as a candidate proof of concept (POC), and the Haystack Project delivering their standardized semantic model to harmonize with.

2. Is there a vision reference architecture you recommend?

   Ans: Vision reference architecture (or alternate models) at best would be classed and described as "Conceptual Models." They get the general concept of interactions across that domain of interest stakeholders, but do not go deeper into describing much more than that. Reference Architectures are classed as logical or physical reference architectures that expose more of the details behind what the conceptual models illustrate, e.g. taking those black box entity representations, opening the box and exposing major components and their relationships in that box as white box representations.

   As such, this might be a controversial topic that some have strong opinions about. Possibilities for suggested conceptual models and reference architectures include the International Electrotechnical Commission's Common Information Model, the Organization for the Advancement of Structured Information Standards' family of standards, The Open Group Architecture Framework, National Institute of Standards and Technology's Framework and Roadmap for Smart Grid Interoperability Standards, and others.

3. Smart Grid programs crosscut business capabilities and technology capabilities. What methods are available to weigh the impact of a single Smart Grid program element across both business and technology domains?

   Ans: This would be a great question to raise with other members of the Electric Grid

Ontology Task Force. If you are not yet a member, please consider joining to raise the question, participate in the discussion, and collaborate in determining the set of options. One approach starts out in the ArchiMate v3 UML space and builds from there.

Note: The Task Force is open to all SEPA members. For questions on how to join as a SEPA member, contact WorkingGroups@sepapower.org.

4. What is the biggest hurdle American Electric Power (AEP) experiences when deploying a new process or technology?

   Ans: *The Task Force Chair Ron Cunningham offers his personal opinion here, not to be taken or represented as official responses of his employer American Electric Power*: Stating "hurdles" or "pain-points" when deploying new process or technology goes back to the ability of the enterprise to assess, address and remediate the business capability(s) gaps to sustainably use the proposed new process or technology.

   Baseline information - business capability includes people, process, tools, technology, and culture that spans the entire lifecycle of that process or technology. The pain-points for one group, organization, or enterprise compared to another will be different based on where they are at the beginning of the lifecycle, and their ability to identify the business capability gaps that must be addressed for successful deployment and sustainability of that new process or technology.

5. Is your group's effort similar to traditional Logical Data Modelling?

   Ans: Not really, check out the 2011 TopQuadrant blog that addressed the question: "Ontologies and Data Models – are they the same?" (https://www.topquadrant.com/ontologies-and-data-models-are-they-the-same/)

   Keys points from that and other sources:

   i. Traditional Data modeling instances (per ANSI in 1975 era) included Conceptual, Logical, Physical schemas that describe clear progression of definitional differences across them.
   ii. Traditional data models need to consider data normalization and considering the types of queries expected to help guide how to structure the data tables and data relationships to improve query response times and adding new data elements.
   iii. Semantic Web standards of which RDF (triples) and OWL are part of, make it possible to implement Conceptual Models directly. In reality all three types of models can be considered ontologies but with different focus and intent.

iv. RDF data is schema-less with no constraints that require a dependence on tables or hierarchies in RDF.
v. OWL and the other modern-day semantic modeling techniques, allows focusing on those triples and not how they are stored, allowing for easily adding in new relationships of elements (including the business rules) that can be queried in ways not originally thought of with relative ease.

6. How do you plan to get a critical mass of users to make shifting to this ontology worth the effort for folks who have already documented their system in another standard?

   Ans: The goal of the Electric Grid Ontology Task Force is to harmonize the terminologies via vetted techniques to do so but not try to build a universal model. While there is no guarantee that new users will incorporate this project into their work, we are leveraging the effort of the Task Force and SEPA to lead as an industry convening body through their Working Group Program. We are bringing awareness to the potential solution that can address the business problems and pain points experienced by the utility industry. At the beginning of 2020, our message reaches over 1,000 organizations with about three-quarters of those being electric utilities. *For more information on SEPA's membership, check out:* https://sepapower.org/membership/

7. How much of this work aligns with Common Information Model (CIM) modeling or other modeling standards?

Ans: This work is intended to be aligned with as many smart grid standards as possible. So far, just the terms from a subset of smart grid standards have been categorized; therefore, there has not been much chance to be misaligned yet. The current SEPA Grid Taxonomy contains 100+ elements from IEC 61968 IRM and IECTC57 WG19 DER artifacts.

This effort adds to the prior body of work on helping remove ambiguity in definitions of the architectural abstraction levels and in earlier service-oriented architecture (SOA) metamodel terms and relationships. The effort adds to the general topic of taxonomies and formal ontologies via element categorization and use guidance.

Aside from the other architectural modeling and taxonomy or ontology research mentioned in prior presentations in contained in the SEPA GitHub Documents folder, no specific alignment of the techniques being presented has been performed with the wide variety of other modeling standards that exist in the industry. There are numerous scholarly and practical articles published and presented that can address portions of the model standards alignment question.

Generally speaking, also as noted in the webinar Q&A, the CIM and semantic modeling community 10+ years ago had started efforts to transform CIM's Unified Modeling Language (UML) model and the supporting prose into formal ontology via Web Ontology Language (OWL), with the CIM prose content transformed into OWL. In the last several years, there is increased interest and work by some utilities to:

- improve on those earlier CIM UML transforms to OWL
- use CIM with local utility extensions for that utilities canonical model for data/information modeling and usage.

8. Is CIM a more physical model?

   Ans: Baseline information - IEC CIM is a common information model intended to enable system integration and information exchange that employs a canonical data model. It includes three separate standards suites:
   - 61968 Message Payloads for Distribution System Integration,
   - 60970 Power System Network Model Exchange,
   - 62325 Deregulated Energy Market Comm.

IEC 61850 Communication networks and systems for power utility automation, is a competing IEC set suite of standard to IEC CIM focused on substation automation and other device level applications. It is really a physical data model whose structure and intent very different from IEC CIM. Efforts to harmonize IEC CIM applicable standards with IEC 61850 has been going on for years with issues still left to be resolved.

A review of IEC CIM Objects, including the Classes and how it is modeled in UML, indicates both logical and physical aspects as viewed across the three IEC CIM standards series. The IEC 61970 series of standards are a physical abstraction level view of the physical transmission network assets, including the substation, intended for control and planning services. When instantiations of those real-world assets are loaded into a data-store/database of the CIM IEC 61970 assets for active use, it results in an implementation abstraction level model.

9. How do you juggle between grid market participation/capacity markets and energy arbitrage in wholesale markets while the revenue streams are dynamic, changing on a half hourly basis? Or, is it possible to balance these revenue streams via an AI/ energy trading software?

   Ans: The question appears to be more appropriate for the SEPA Transactive Energy Working Group (*workinggroups@sepapower.org*) or other Transactive Energy discussion groups, e.g. GridWise Architecture Council. Generally, after the business scenario and/or

use cases are developed by the [utility business strategy] SMEs, then that would be a candidate for applying the Grid Ontology Building Blocks.