GRID ARCHITECTURE

Grid Architecture: Wide-Angle View of the Grid

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10 May 2017

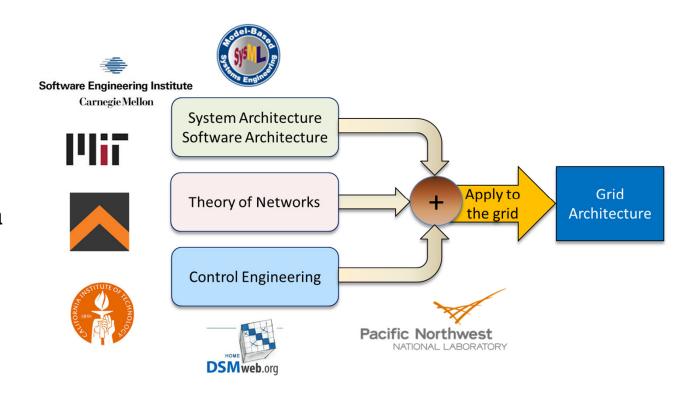


Grid Architecture Definition



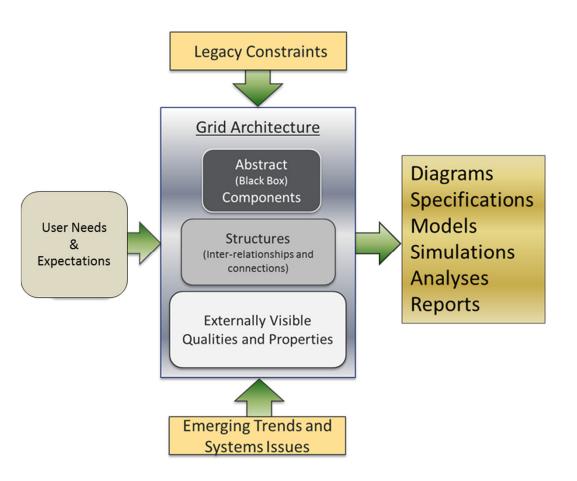
System Architecture

- An abstract depiction of a system, consisting of black box <u>components</u>, <u>structure</u>, and <u>externally visible</u> <u>properties</u>
- Purposes of architecture:
 - Support reasoning about a system's structure, behavior, and essential limits
 - Facilitate prediction of system qualities and properties
 - Manifest earliest design decisions/constraints
 - Enable (or inhibit) a system's possible capabilities
 - Identify gaps in theory or technology



Grid Architecture gives you an orderly, understandable, systematic view of a very complicated thing: the power grid.

Grid Architecture Has Multiple Purposes

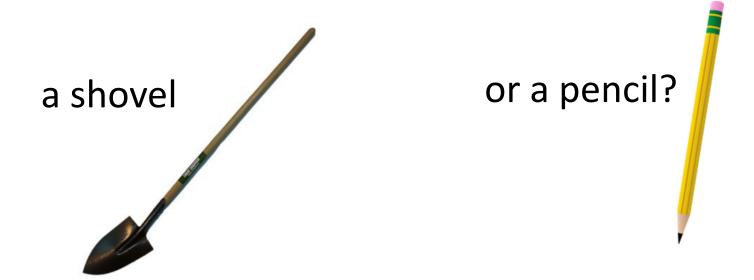


- Support early stage modernization processes
- Help manage complexity (and therefore risk)
- Assist communication among stakeholders
- Re-shape the grid
- Identify and remove barriers;
 re-define essential limits
- Identify/define interfaces and platforms

It helps you think about changes to the grid and their implications before a lot of money has to be spent.

How to Build A House

What do you pick up first:

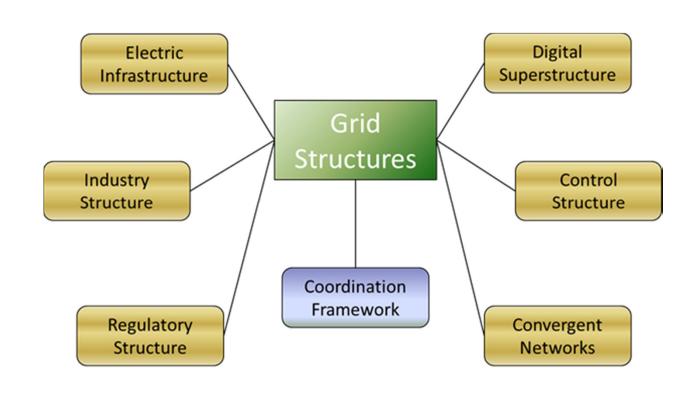




The same thing is true if you are modifying the house.

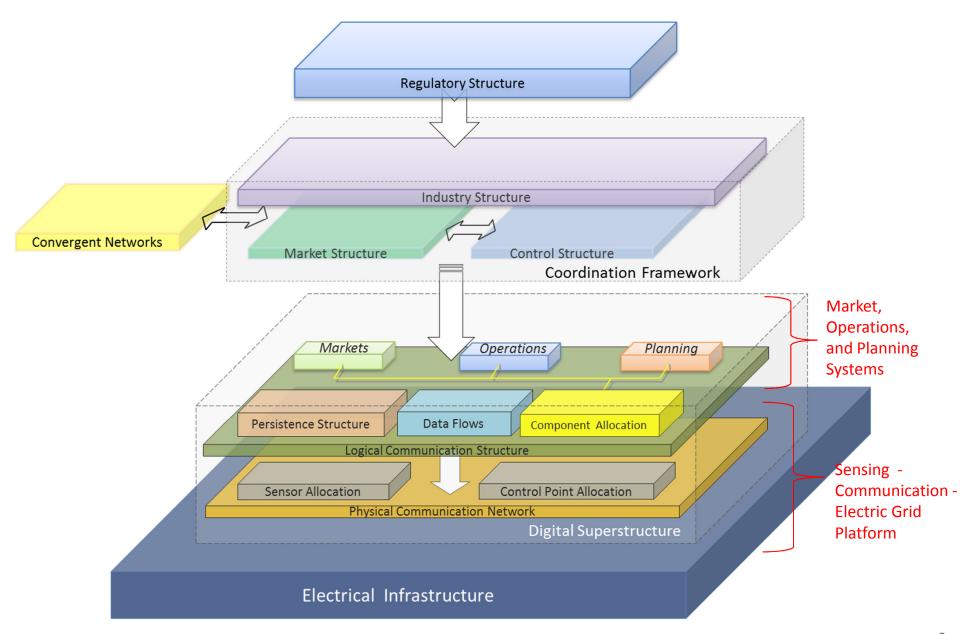
Structure and Structure Modification

- Grid Architecture treats the grid as a network of structures
- Grid structure is changing
- Some legacy structures need to be changed to relieve constraints

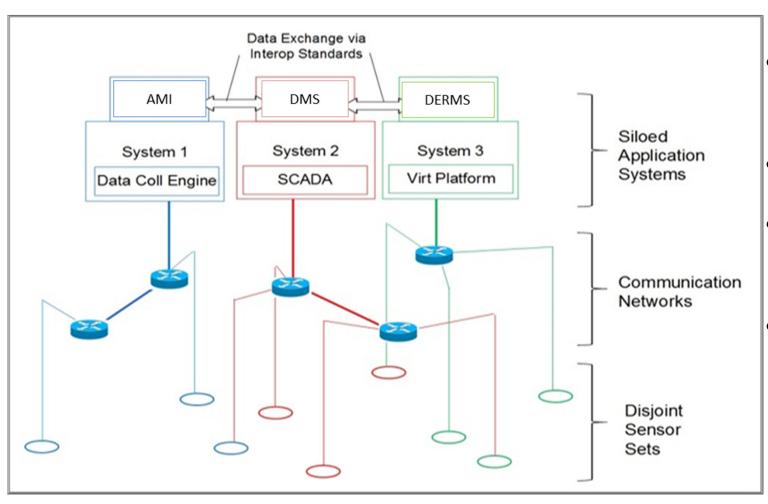


Getting structure right simplifies the downstream decisions.

Example: Layering and Platform Definition

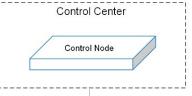


Practical Application: Distribution Network Structure



- Siloed, coupled apps
- Long latency
- Poor flexibility
- Expensive integration

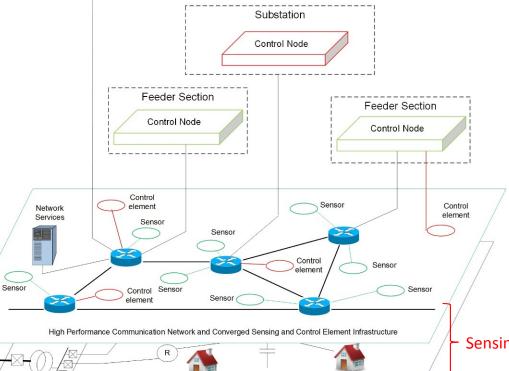
Sensing and Measurement/Grid Platform



Streaming data

Physical Infrastructure

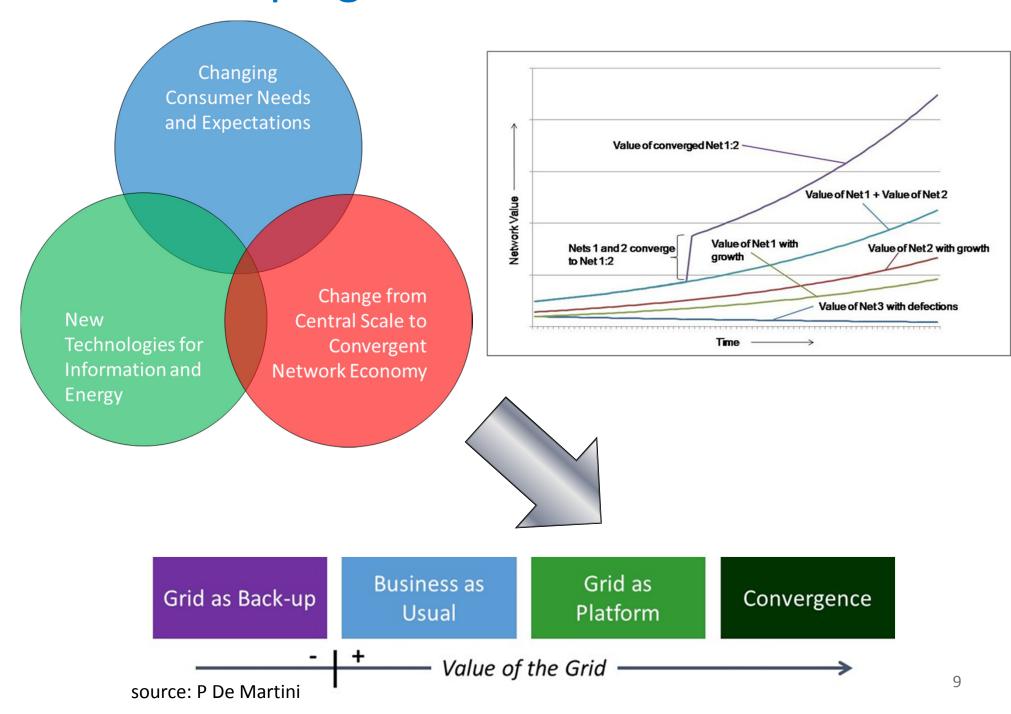
- Dynamic sensor binding
- Multiple use of sensor data



- Independent apps
- Low latency
- High functional flexibility
- Low cost integration
- Future-proofed investment

Sensing-Communication-Electric Grid Platform

Re-Shaping of the Grid is Inevitable



Defining the Modernized Grid

- Lots of definitions of "Smart Grid" in the previous decade
- Now, many definitions of the modernized grid
- "-ility" words used a lot

 DOE example from 2015:

Desirable Characteristics, 2030

Minimal-environmental footprint. Energy systems should be designed, constructed, operated and decommissioned in a manner that is low carbon, and with minimal impact to water quality and quantity; and minimize the land use footprint, impact on biological resources, and toxic emissions.

Affordability. Ensures system costs and needs are balanced with the ability of users to pay. (Note three potential balancing points: overall system costs, system needs/benefits, and system cost allocation). Also, estimating avoided costs can be more complex than for simple levelized costs - calculations require tools to simulate the operation of the power system with and without any project under consideration.

QER: Will provide four year planning horizon to enable these energy infrastructure characteristics in 2030.

Flexibility. Energy infrastructure that accommodates change in response to new and/or unexpected internal or external system drivers. Sub-characteristics of flexibility included:

- Extensibility. The ability to extend into new capabilities, beyond those required when the system first becomes operational.
- Interoperability. The ability to interact and connect with a wide variety of systems and sub-systems both in and outside of the energy sector.
- >Optionality. Provides infrastructures or features of infrastructures that would allow users to maximize value under future unforeseen circumstances.

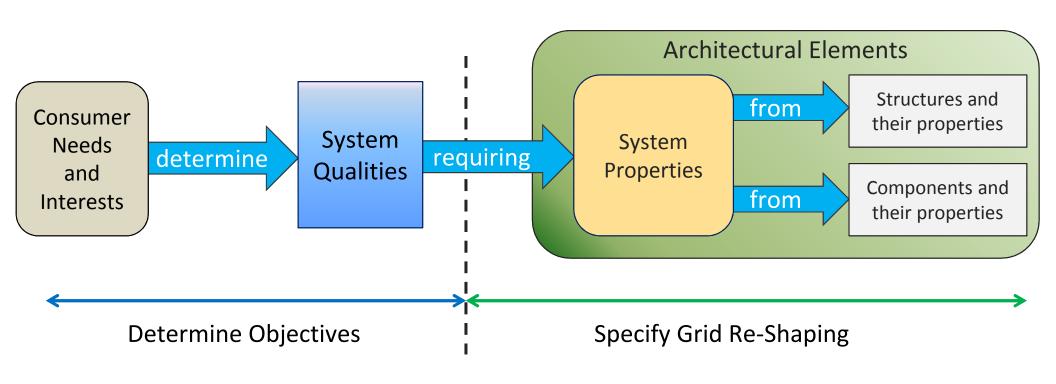
Robustness. A robust energy system will continue to perform its functions under diverse policies and market conditions, and has its operations only marginally affected by external or internal events. Sub

- characteristics of robustness include:
- Reliability. Sturdy and dependable, not prone to breakdowns from internal causes (e.g. due to component failures);
- > Resiliency. The ability to withstand small to moderate disturbances without loss of service, to maintain minimum service during severe disturbances, and to quickly return to normal service after a disturbance.

Scalability. Energy infrastructure should be able to be sized to meet a range of demand levels. Systems can be scalable by being replicable, modular, and/or enlargeable.

Safety. Energy systems should be designed, constructed, operated and decommissioned in a manner that reduces risks to life or health.

Defining the Architecture



First Logical Steps

- Start with objectives
 - understand the forces: emerging trends
 - qualities->properties->architecture->designs
- Understand legacy constraints
 - structural or component-based ?
- Get the structure(s) right
 - reduce/eliminate constraints
 - identify structures/platforms to futureproof investments
- Don't try to hang the windows first

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Thank You

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http://gridarchitecture.pnnl.gov/

