SCE-CISCO-IBM
Smart Grid Reference Architecture

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Background

- The Smart Grid Reference Architecture was produced by a team of sixteen IT and OT architects from Southern California Edison, Cisco Systems, and IBM.
- Its development spanned a period of nine months (July 2010 through March 2011) and involved a number of face-to-face team workshops and web-based meetings.

Project Goals

- Provide a proven, utility-centric template solution for a Smart Grid architecture.
- Provide a common vocabulary with which to discuss Smart Grid implementations, based upon adoption of open standards.
- Share this Smart Grid Reference Architecture with other utilities through industry user groups, Standards Developing Organizations, and other appropriate venues

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- Stats:
  - 188 Pages – Intro: 10, Content: 60, Appendices: 118
  - 49 Figures, 27 Tables
- Executive Summary and Introduction
  - Primary Target Audience: Smart Grid Architects
  - Recognizes migrations needed to reach goal
  - Pervasive Security is integral to approach
  - Data services and management emphasized
  - Common foundational services a central theme
  - Architectural challenges briefly laid out

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- Smart Grid Architecture Overview
  - Goals and Principles (14 examples)
  - 3 architecture transitions: siloed to layered services
- Foundational Services: Domains & X-Domain
  - Based upon NIST seven conceptual model domains
    - Customer, Market, Service Provider, Ops, Gen, T&D
  - Extended – optional Balance & Interchange domains

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- Reference Architecture Views – Approach
  - Seven Domains Detailed (next slide)
  - Each Adhered to Similar Content Outline
    - Logical Model
    - Structural Model
    - Typical Specifications
    - Standards and Technology Recommendations
  - Examples of content in extended slide stack

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- Domains (views) in SGRA
  - Application Services
  - Analytics Services
  - Data Services
  - Control Services
  - Security Services
  - Communications Services
  - Management

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- Appendices
  - A – System of Systems Design Patterns

    whitepaper by K. M. Chandy (CalTech), J. Gooding (SCE), J. McDonald (Saker Systems)
  - B – Services Classes Concepts
  - C – Smart Grid Conceptual Architecture Project

    from Smart Grid Interoperability Panel (SGIP) Architecture Committee (SGAC)
  - D – Roadmap & Maturity Model
  - E – Glossary
  - F – Bibliography

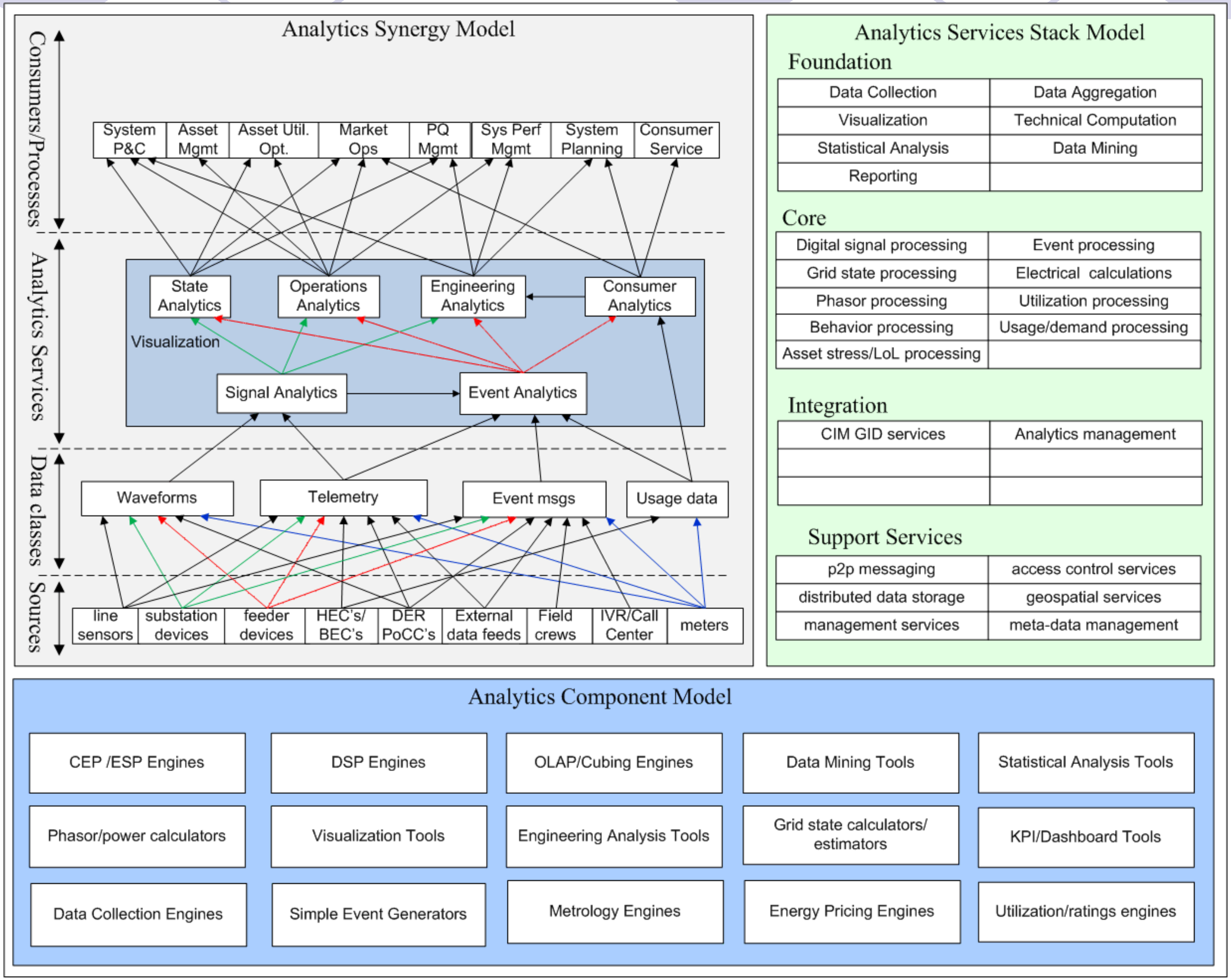
Your Turn!

- Q/A

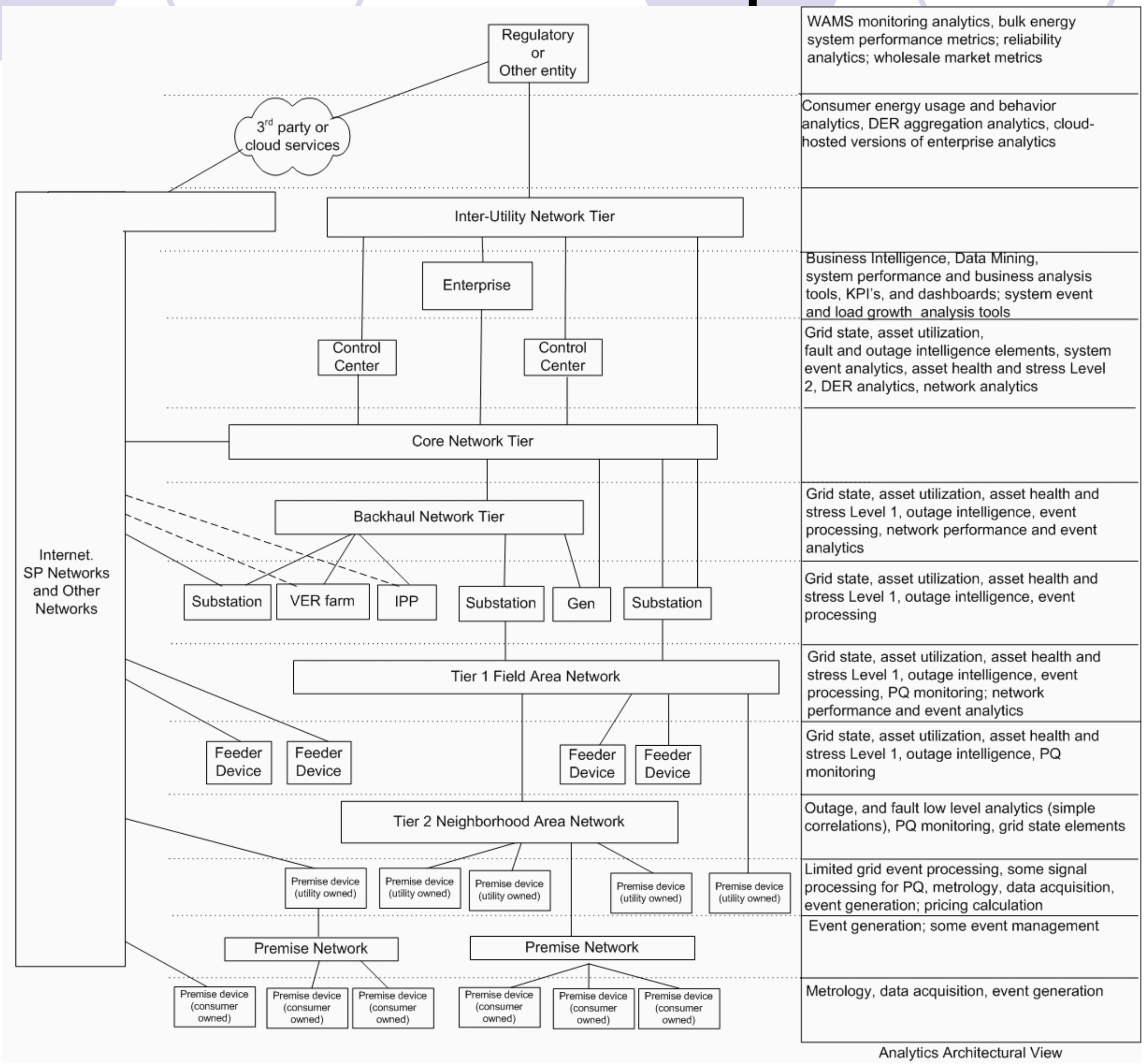

Thanks

Extra Slides

Logical Model Example



Structural Model Example



Typical Specifications Example

Table 4 - Typical Analytics Specifications

Specification	Justification
Analytics shall be dynamically re-distributable – a service to manage the re-distribution must be included in the analytics architecture.	Analytics change as the Smart Grid evolves and it is impractical to physically visit distributed analytics elements to make changes.
Analytics services shall be centrally and uniformly managed. The management mechanism should be integrated with the general network and grid device management services.	It is impractical to use a distributed architecture that requires field frequent visits to devices, in fact, Zero Touch deployment is necessary for Smart Grids at scale. Integration with the management services architecture for distributed architecture operations to be feasible.
Analytics services shall be deployable in a distributed fashion. Places on the grid for analytics deployment include: Data centers — Edge devices, including meters, gateways Control centers — Communications devices Substations — Cloud services (private and third party) Mobile devices — Distribution feeder power system devices	Wherever data is generated or information consumed is a location candidate for appropriate analytics. Communication network elements hosting additional software are also good candidates, since generally these elements are where data sources and consumers reside. Use of these to host analytics makes it possible to provide the benefits of distributed architecture while minimizing the number of devices to be managed and maintained. Zero-touch deployment is crucial.
Analytics shall be distributed according to a latency hierarchy. Some analytics will be implemented close to data sources and consumers, while others can be implemented at control centers or data centers. Analytics associated with protection and control should be distributed; analytics for asset health and stress accumulation can be centralized. Analytics for grid state should be distributed. Analytics for consumer behavior can be centralized.	The tradeoff between degree of distributed intelligence and communications requirements is one of the most significant decisions smart grid architects must make. This tradeoff must be made early in the design process and revisited periodically as the grid transformation proceeds.
Smart grid analytics services architecture shall include analytics [illegible]	As the utility transforms its grid, forms and uses of [illegible]

Standards & Tech Recommendations Example

Table 5 - Recommended Analytics Standards

Standards	*Purpose/Relevance/Comments*
IEC 61850 GOOSE messaging	For use in low latency protection and control messaging, where analytics outputs are being used in applications such as adaptive protection and real time grid stabilization
IEC CIM GID Interface Services (GDA, HSDA, TSDA, GSE)	Four services associated with IEC CIM for data interchange in four classes: generic data, high speed data, time series, and events
IEC Common Information Model	Primary schema for data representation; should also be applied to analytics outputs, which in themselves are treated as data for purposes of transport, persistence, and interface to various consuming systems.
IEEE Computer Society FIPA (Foundation for Intelligent Physical Agents)	For analytics implementations using multi-agent systems

Table 6 - Recommended Analytics Technology

Analytics Technology	*Purpose/Relevance/Comments*
Data mining	Needed to analyze vast volumes of grid data to detect and extract underlying patterns and models
Digital signal processing	Needed to extract information from low level grid data such as waveforms and sensor telemetry
Event stream/complex event processing	Needed to filter, throttle, correlate, and extract situational understanding from multiple asynchronous event streams from up to millions of grid devices; management of event stream bursts.
OLAP/Cubing/Dashboards	These are visualization tools for data trending and status indication. Such tools should be connected via appropriate security services to data and analytics output feeds from the control center, as well as data residing in enterprise databases.
Phasor/power system calculation processing	Necessary to support a wide range of real time analytics involving grid state, device utilization, power flow and load control, and fault analysis
Statistical analyses	a variety of statistical analysis tools may be applied to problems such as demand and variable energy resources modeling, as well as customer behavior modeling.
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