Cisco GridBlocks Architecture: A Reference for Utility Network Design

In today's rapidly transforming energy industry, utilities are focused on modernizing the electrical grid with an integrated communications infrastructure. However, interoperability concerns, legacy networks, disparate tools, and stringent security requirements all add complexity to the transforming grid.

To address these challenges, the Cisco GridBlocks™ Architecture provides a forward-looking view into how the electrical grid can be integrated with digital communications across the entire power delivery chain. The model is a starting point for creating utility-specific designs, and offers guidance on deployment of grid-specific applications. It also lays out a framework for designing and deploying comprehensive management and security solutions across the grid. This will help utilities to lower the total cost of ownership of their communication infrastructure, as well as create additional value by helping to enable new utility services.

Addressing the Challenges of Utility Architecture Design

Many of today's utilities still rely on complex environments formed of multiple application-specific, proprietary networks. Information is siloed between operational areas, substations, and regulatory authorities. This prevents utility operators from realizing the operational efficiency benefits, visibility, and functional integration of operational information across grid applications and data networks. The key to modernizing grid communications is to provide a common, multi-service network infrastructure for the entire utility organization. Such a network serves as the platform for current capabilities while enabling future expansion of the network to accommodate new applications and services.

A platform based on the Cisco® GridBlocks Architecture integrates utility networks into a single, highly secure and reliable communications infrastructure across the various levels of utility operations. By supporting multiple applications on a converged network, it also provides a framework for integrating new technologies and utility-specific applications. At the same time, its modular approach enables implementation of projects over time, allowing utilities to plan their investments and flexibly adapt to rapidly changing business circumstances. This extends the life of existing infrastructure investments as part of a grid modernization roadmap.

The Cisco GridBlocks Architecture Suite

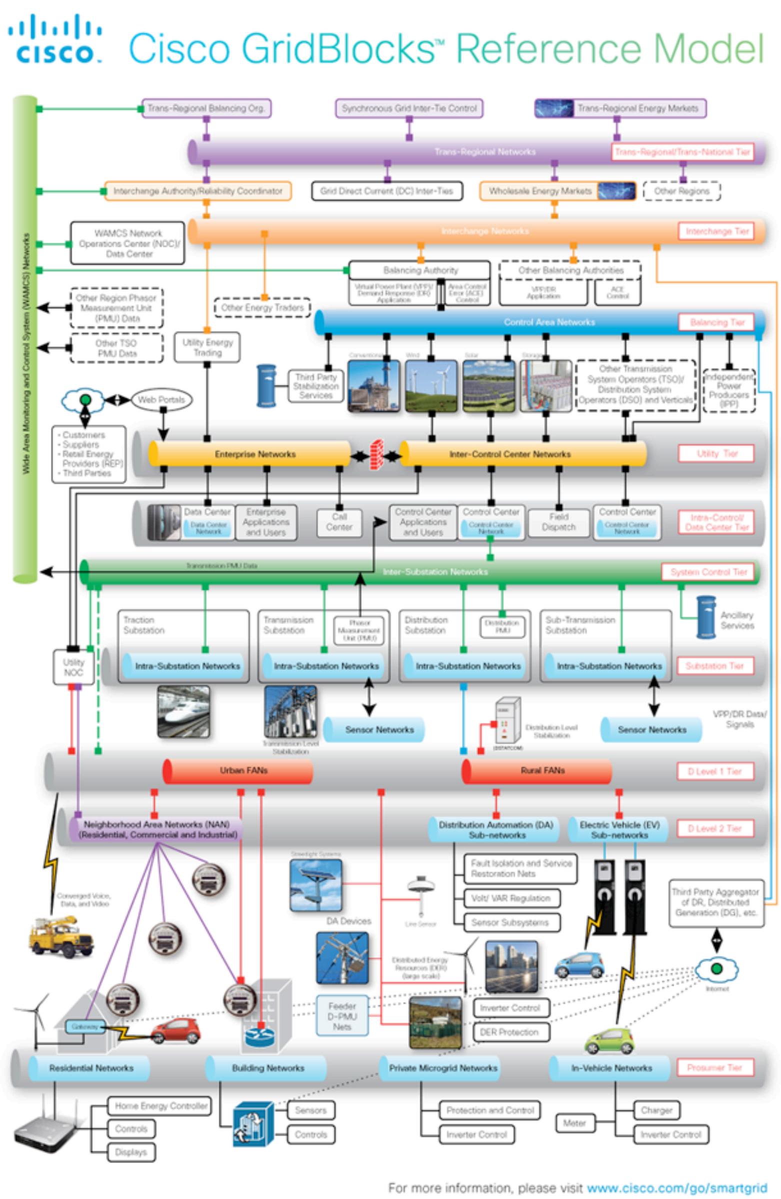
To support utility planners and operation teams, Cisco provides a complete suite of technical architecture offerings from the reference model to design and implementation guidance. This architectural approach is consistent with industry and standards organizations (e.g., NIST, EPRI), but provides a finer level of granularity to support design and implementation across multiple tiers of electric power operations. The Cisco GridBlocks Architecture suite comprises:

- GridBlocks reference model:
- GridBlocks reference architecture
- Solution architecture and designs
- Implementation designs
- Connected Grid services

The GridBlocks Reference Model

The Cisco GridBlocks reference model partitions the electrical power communications infrastructure into 11 logical tiers, which support networking the entire power delivery chain and define interaction across the tiers. This design provides a finer level of granularity than is available in other models to support unique tier requirements. It also supports tiers that represent networks owned and managed by different utility entities, while maintaining the necessary convergence and interoperability between them. This helps utilities understand the scope of upgrading a specific tier without impacting the others. Figure 1 displays the tiered approach of the reference model.

Figure 1. Cisco GridBlocks Reference Model



This tiers-based model facilitates segmentation of all capabilities and functional areas within a single, converged architecture. The tiers, from the bottom to the top of Figure 1, include:

Prosumer Tier—The prosumer tier (combining the concepts of energy producer and consumer) encompasses all third-party elements that impact the grid. This tier includes devices and systems that are not part of the utility infrastructure, but which interact with the utility. These may include networks managing distributed generation and storage, responsive loads in residences or commercial/industrial facilities, onboard electric vehicle networks, and so on.

Distribution—Networks at the distribution level—between primary distribution substations and end users—are broken into two levels:

- **Distribution Level 2 Tier**—The lower Level 2 tier is composed of purpose-built networks that operate at what is often viewed as the "last mile" or neighborhood area network (NAN) level. These networks may service metering, distribution automation, or public infrastructure for electric vehicle charging.
- **Distribution Level 1 Tier**—The upper Level 1 distribution tier supports multiple services that integrate the various Level 2 tier networks and provide backhaul connectivity directly back to control centers using the system control tier (see below) or directly to primary distribution substations to facilitate distributed intelligence. This tier also provides peer-to-peer connectivity for field area networks (FANs).

Substation Tier—This layer includes all internal substation networks. These can have wide-ranging requirements, from relatively uncomplicated secondary stations to complex primary substations that provide critical low latency functions such as teleprotection. Within the substation, networks may comprise from one to three buses (system, process, and multi-service). Primary distribution substation networks may also include distribution (field area network) aggregation points.

System Control Tier—This tier includes all of the wide area networks (WANs) that connect substations with each other and with control centers. Their high-end performance requirements can be stringent in terms of latency and burst response. In addition, these networks require flexible scalability and at times, due to geographic challenges, mixed physical media and multiple aggregation topologies as well. System control tier networks provide networking for SCADA, SIPS, event messaging, and remote asset monitoring telemetry traffic, as well as peer-to-peer connectivity for teleprotection and substation-level distributed intelligence.

Intra-Control Center/Intra-Data Center Tier—This tier encompasses networks inside utility data centers and control centers. Both are at the same logical tier level, but control centers have very different requirements for security and connection to real-time systems, compared to enterprise data centers that do not connect directly to grid systems. Both provide connectivity for systems inside the facility and connections to external networks in the system control and utility tiers.

Utility Tier—This tier encompasses enterprise or campus networks, as well as networks that link control centers to each other. Since utilities typically operate multiple control centers and campuses across a wide geographic area, this tier includes both metro and regional networks.

Balancing Tier—This tier includes networks that connect generation operators and independent power producers with balancing authorities, and balancing authorities with each other. In some cases, balancing authorities may also dispatch retail-level distributed energy resources or responsive load.

Interchange Tier—The networks at this tier connect regional reliability coordinators with transmission operators and power producers, and wholesale electricity markets with market operators, providers, retailers, and traders. In some cases, bulk markets are being opened up to small prosumers so that they have a retail-like aspect, impacting networking for the involved entities.

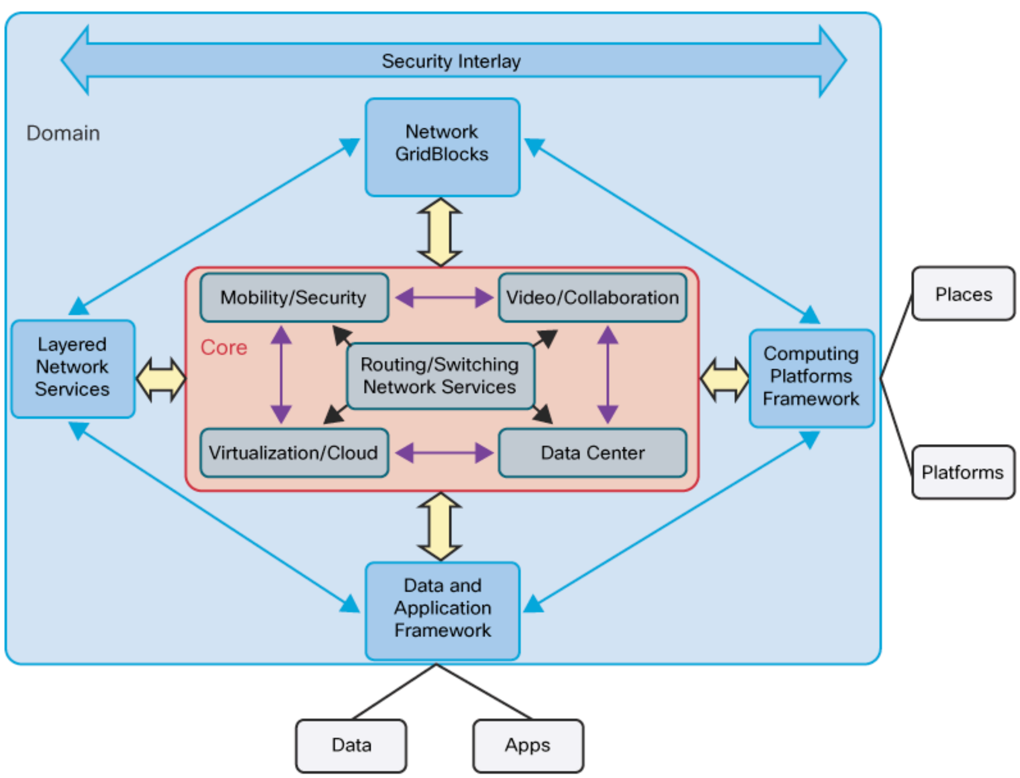
Trans-Regional or Trans-National Tier—This tier includes networks that connect synchronous grids for power interchange, as well as emerging national or even continental networks for grid monitoring, inter-tie power flow management, and renewable energy markets.

WAMCS Tier—This tier encompasses the networks of power management units (PMUs) known as Wide Area Measurement and Control Systems (WAMCS), Wide Area Measurement Systems (WAMS), or Wide Area Measurement, Protection, and Control System (WAMPACS). This tier must inherently connect to entities at other tier levels, but will typically do so through special network arrangements. In cases of wide area, low-latency networking, the owner of the network may not necessarily be one of the entities using it to share PMU data.

The Cisco GridBlocks Reference Architecture

The reference architecture consists of five sets of capabilities built into the network platform (see Figure 2). This fundamental structure supports deployment of a wide range of technologies and services that support grid automation solutions, information exchange, and management, including operational systems and extension of communications to reporting authorities.

Figure 2. Cisco GridBlocks Reference Architecture



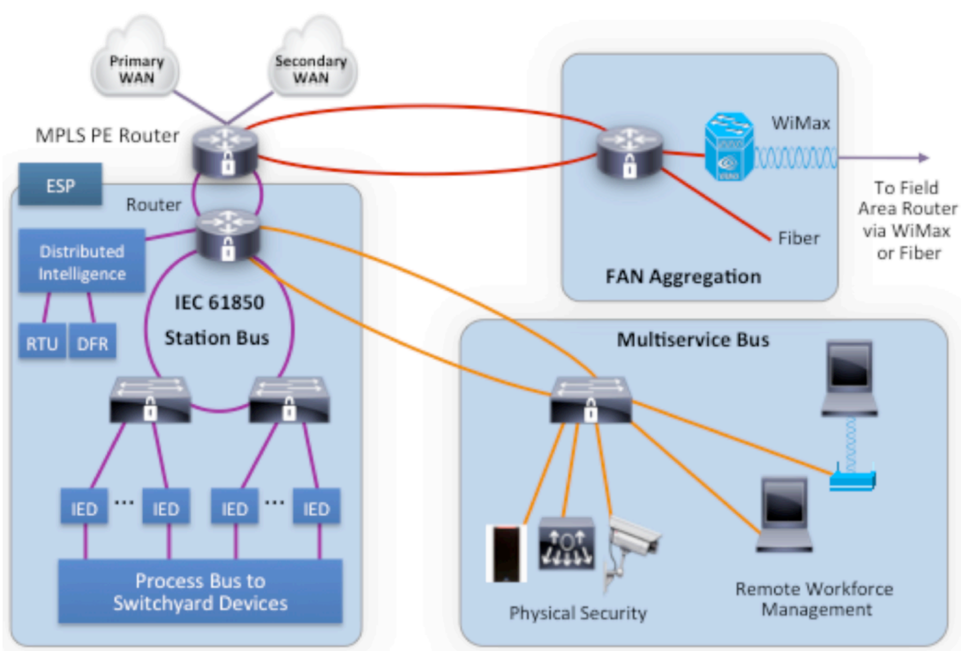
The five sets of capabilities include:

- **Network GridBlocks**—Uses the reference model and provides more detailed views of the specific architectures within each of the 11 utility tiers, as well as the interconnections between them. Examples include, the System Control GridBlock, Primary Substation GridBlock, or Field Area Network GridBlock.
- **Layered Network Services**—Offers a series of network layers that include both traditional network services and specific utility functions such as distributed intelligence, core functions, and discrete applications.
- **Computing Platforms Framework**—Provides a platform to unify grid-level elements and control and data centers using the network. The computing platform supports centralized, distributed, and hybrid intelligence models that can be extended beyond utility assets to field and external devices.
- **Data and Application Framework**—Enabled by connectivity, services, and computing capabilities, utilities run the business based on applications and their data. The GridBlocks model provides flexible, open standards-based applications support that encompasses requirements from traditional and mobile workforces, administration of large data sets, and regulatory audits to mergers, expansions, and new technology rollouts.
- **Security Interlay**—Provides pervasive security throughout the architecture, which includes multiple layers of access control, data confidentiality and privacy, threat detection and mitigation, and device and platform integrity.

Solution Architecture and Designs

Solution architectures are specialized versions of the reference architecture for a specific set of utility use cases or deployment scenarios, for example, a Substation GridBlock that has been customized for a primary substation automation deployment (see Figure 3). These solution designs provide a plan for building the solution and may include specifications, diagrams, bill of materials (BOM), etc. They also identify ecosystem vendor elements needed.

Figure 3. Primary Substation GridBlock with Ring Network



Implementation Designs

Implementation designs are detailed design plans that provide the implementation and configuration information needed to build and deploy the solution. Validated designs incorporate a set of products and technologies that have been tested as a complete system and are fully documented to support faster, more reliable, and predictive customer deployments, such as the substation network design implementation guide.

Connected Grid Services

Cisco Services has architected some of the world's largest industrial networks, offering architecture services to help utilities every step of the way from concept to completion. Cisco teams also provide a thorough analysis of use cases for current and future environments, and customize each service to specific needs for generation, transmission, and distribution. Built on extensive experience, they help utilities create a roadmap for highly secure, scalable, multi-service communications architecture. Specific services offered include:

- Network Architecture Discovery Service
- Network Architecture Assessment Service
- Network Architecture Planning and Design Service
- Cisco Network Optimization Service

Business Benefits

The Cisco GridBlocks Architecture offers significant benefits as a starting point for communications and smart grid initiatives to the utility:

- Provides a flexible, modular approach that supports incremental utility transformation
- Helps enable integrated system integration and security, increasing access to required information in and outside of the organization
- Offers an open standards-based vision of power delivery chain connectivity based on IPv6 convergence
- Lowers the total cost of ownership and creates value through new services and functional integration
- Provides a framework for developing custom grid modernization roadmaps for utilities well into the future

Cisco in the Utility Industry

Cisco provides one of the industry's most comprehensive portfolios of communications infrastructure solutions, spanning production, distribution and consumption of energy based on an end-to-end open standards network. By delivering multiple applications over a single, intelligent, and highly secure platform, electric utilities benefit from lower total cost of ownership as well as creating value from new services and functional integration well into the future. To learn more about the Cisco GridBlocks Architecture, please visit http://www.cisco.com/go/smartgrid

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