Itron and Cisco Grid Intelligence

Distributed and Edge Intelligence in the Networked Grid

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INTRODUCTION

Grid modernization requires infrastructure investment focused on solving today's grid reliability problems with a view toward tomorrow's challenges and opportunities. Not only will the future bring dynamic exchanges of energy between distributed generators, electric vehicles, and home energy management systems, but additional connected devices will also mean more participation in energy transactions. Capturing the opportunity of distributed energy resources requires infrastructure which can not only communicate with those resources, but can also balance between local and global impacts of energy transfers.

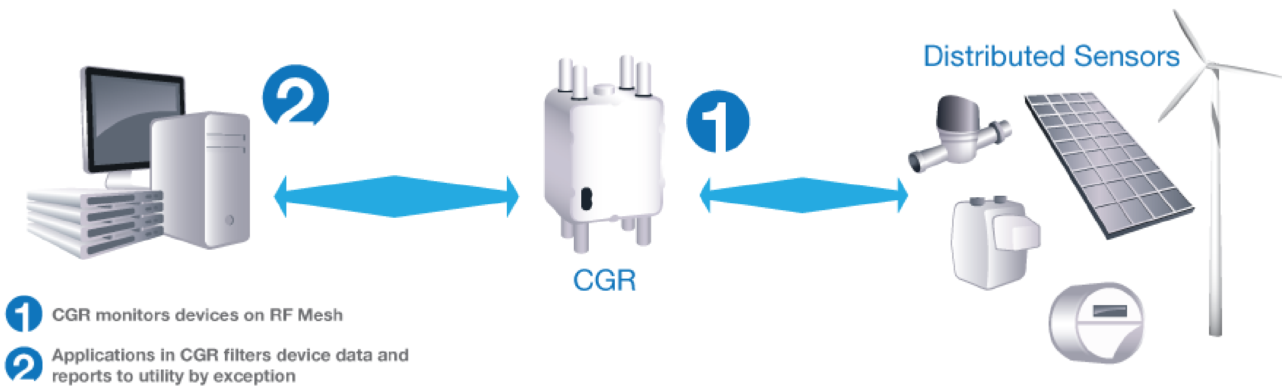
Enabling distributed energy transactions will require intelligent networking devices throughout a utility's service territory. Cisco has described such a distributed platform as Fog Computing, "a highly virtualized platform that provides compute, storage, and networking services between end devices and traditional Cloud Computing Data Centers, typically, but not exclusively located at the edge of network."[1] Itron and Cisco have combined our expertise in energy management and networking, respectively, to create a networked grid platform for enabling the energy exchange of the future.

This white paper describes how smart grid solutions from Itron and Cisco will support grid intelligence at multiple levels of the network hierarchy. We define grid intelligence as the capacity to store, process, and analyze energy data throughout the network hierarchy and grid topology. The notion of Fog Computing is discussed in the context of smart grid field area networks (FAN), meters and embedded sensors. We conclude by focusing specific attention on embedded sensors, and the Internet of Everything, which will extend the services of our modernized grid infrastructure.

DISTRIBUTED INTELLIGENCE

Enabling sensors and meters in the FAN with IPv6 communications creates unprecedented collaboration and connectivity for utilities. When distribution automation devices, transformer meters, street light sensors, solar inverters, EV smart chargers, and utility meters share the same network, applications that communicate with those devices must be prioritized and run efficiently over the network substrate. Cisco's Quality of Service (QoS) dynamically prioritizes applications on the network, allowing utilities to respond to changing conditions as the need arises. The network's QoS tuning is supplemented by the Cisco Network Management System, which maintains statistics about connected devices and their communication characteristics.

However, there is also a need to monitor device communications and availability within the network hierarchy itself, both to alleviate the data burden on upper layers and to leverage the power of a true distributed processing platform. Distributed intelligence in the Cisco network proactively monitors devices and network traffic while minimizing public carrier O&M costs. The Cisco Connected Grid Router (CGR) allows management applications to run in the CGR and monitor device connectivity and availability in the RF Mesh, and only notify the NMS by exception when problems occur. The report-by-exception capability is illustrated in the diagram below. This is an especially valuable option when more applications and devices join the network that are not part of the day-to-day critical business operations of a utility, but which may need to be called upon if conditions warrant.



Distributed Intelligence for Device Monitoring

[1] F. Bonomi, R. Milito, J. Zhu, S. Addepalli. Fog Computing and Its Role in the Internet of Things. Cisco Systems Inc white paper.

The advantages of distributed intelligence include:

- Scalability
- Latency minimization for real time functions
- Robustness and graceful degradation in the presence of component or subsystem failure
- Incremental implementation and expansion
- Flexibility to adapt to new functions and applications as the problem domain evolves

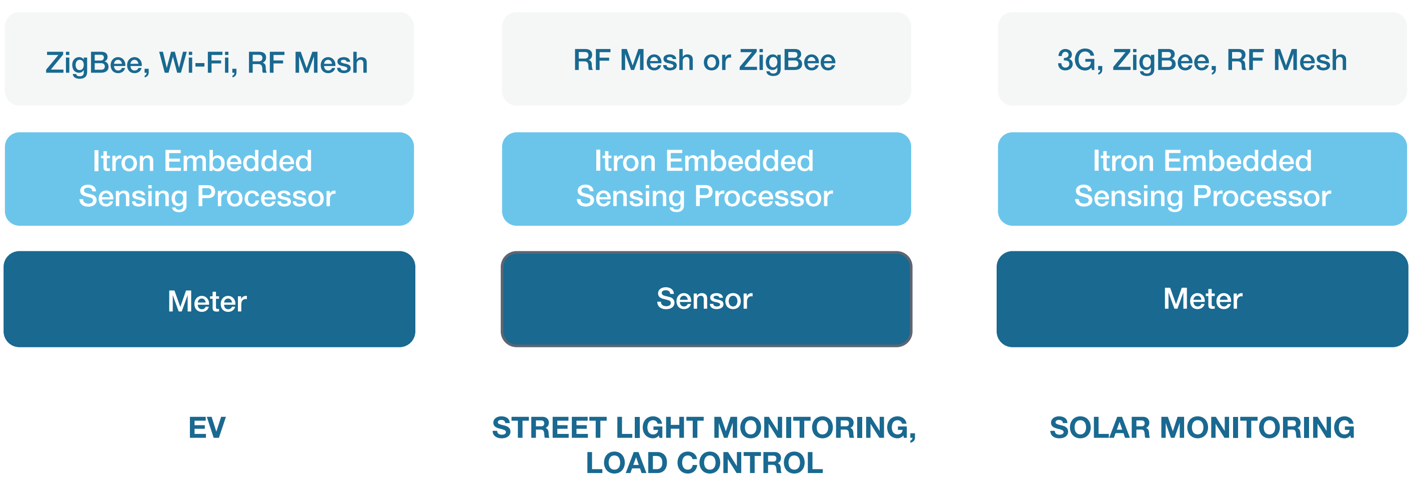
The Cisco GridBlocks Architecture enables distributed intelligence to reside in various communication tiers depending upon the specific use case requirements with centralized policy management. Some examples are the system control tier, the substation communication network, the Field Area Network that covers the NAN/WAN for the distribution grid, and the communication nodes at various endpoints. The Cisco GridBlocks Architecture provides a framework for how data is analyzed and shared efficiently across those communication tiers. The Cisco Connected Grid Intelligence platform enables applications to be embedded securely and reliably into the communication network.

In addition, Itron is incorporating ERT reading capability into the CGR, which will allow similar distributed diagnostics to track communications statistics to gas and water ERTs. Since ERTs do not utilize IPv6 communications, monitoring these assets requires a unique approach, but the same report-by-exception capability in the CGR can be leveraged to monitor ERT connectivity without over-burdening the public WAN backhaul. This flexibility allows sub-metering as a service, where smart grid infrastructure is leveraged to capture data and manage communications with overlapping utilities' gas and water endpoints.

EDGE INTELLIGENCE

Technology evolution continues to accelerate the market viability of distributed energy generation, energy storage and electric vehicles. With the adoption of these technologies come fundamental changes in the way energy is produced and consumed. Consumers and energy service providers must cooperate with utilities to ensure that the grid continues to function reliably in the presence of distributed, two-way energy transactions.

Itron's response to this challenge is Itron Embedded Sensing (IES)[2]. IES allows energy management assets, including EV charging stations, solar inverters, street light monitoring systems, and home energy management systems to be equipped with metering, local processing and simultaneous connection to multiple physical networks. IES leverages Itron's global portfolio of solid state measurement technologies where appropriate, but uses a sensing approach to monitor equipment cycling and control behavior in products where embedding a meter module is not feasible. The graphic below shows configuration options for communications and metering/sensing appropriate for various markets.



Itron Embedded Sensing Configuration in Different Markets

[2] S. Johnson. Itron Embedded Sensing White Paper. Itron, Inc.

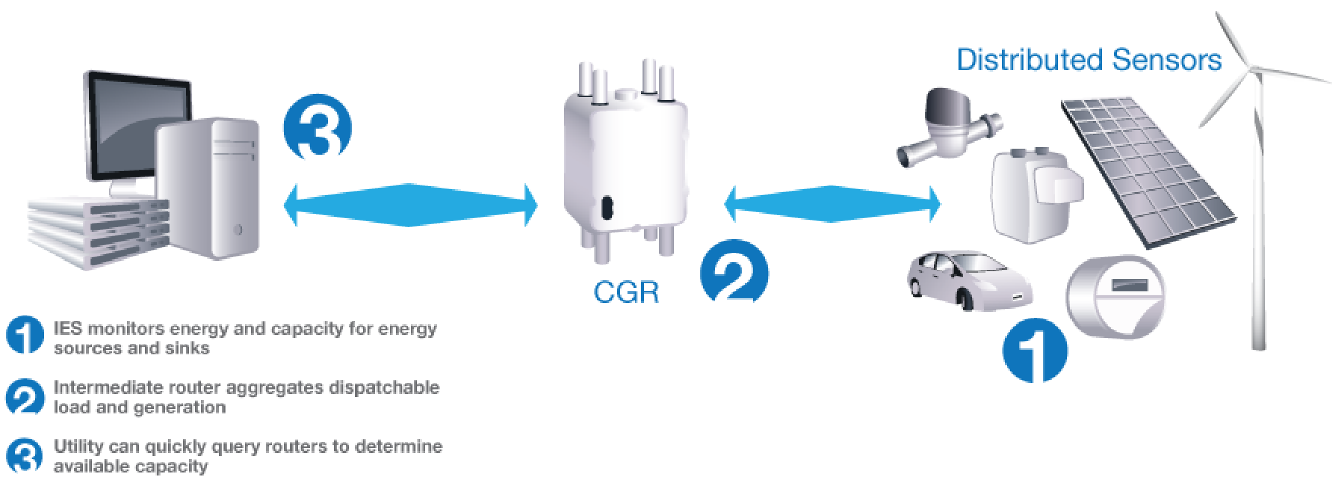
With IES, energy consumption and delivery can be monitored at any level in the grid hierarchy. By packaging this capability as an embeddable sensing platform, any third-party device can be transformed into a transactional grid asset. This is true regardless of who owns the asset; for example, municipal street lights can be connected to a utility FAN, a consumer's EV charging station can be connected either to the utility's meter or to the utility FAN, and solar inverters owned by a monitoring company, like Sunrun, can extend intelligence to a homeowner and the local utility.

Itron is integrating Cisco RF Mesh communications into the IES platform. This allows IES-enabled assets to participate directly in the FAN, utilizing the distributed intelligence capability described above for efficient monitoring of devices. Integrating FAN communications into the IES platform also means that distribution assets, including transformer meters and distribution automation devices, can also leverage IES, its local processing power and the distributed intelligence architecture described above.

The processing capability of IES includes a Linux OS running a protected code space, into which energy apps can be downloaded. Apps running on IES have full access to energy measurement and sensing interfaces, as well as wireless communications modules. This means that data processing and energy analytics can be pushed into the network hierarchy for coordinated grid control. Analytical "apps" such as Itron's baseline consumption calculations in Itron Enterprise Edition can be applied to local devices and micro grids, providing fast insight into energy consumption patterns and opportunities for better management of energy. Third parties can also contribute apps to the IES platform, enabling an open ecosystem of solutions to bring together utilities, consumers and energy service providers.

As mentioned above, fog computing is an approach that places networking, processing, and storage services at the network edge. In the context of the networked grid, "the edge" can mean many things, including buildings, homes, neighborhoods, smart cities, etc. This is a departure from the traditional notion of utility purpose-built networks that only connect utility-owned devices. Fog computing is also distinct from cloud computing, in which devices communicate with remote servers via the Internet. Fog computing extends cloud computing and utility networks by placing data storage and processing power in the field, such that round-trips to cloud servers or back office infrastructure is not necessary to enable data exchange and local decision making. This results in networks that provide autonomous services in near-real time.

Itron Embedded Sensing delivers fog computing to the networked grid, expanding the reach of utility infrastructure to enable intelligent energy management for multiple stakeholders. With IES, for example, day-burning streetlights can automatically shut themselves off without waiting to be detected by back office systems days after the problem begins. EV charging patterns and mobile vehicle demand can be monitored, and utilities can be alerted to changes that pose distribution constraints. Solar inverter operational characteristics can be monitored locally alongside generation capacity and local consumption, while critical alarms are brought to the utility's attention immediately. IES combines automatic detection of changing conditions with local coordination of resources to optimize energy management at multiple layers of the distribution system.



Edge Intelligence for Energy Monitoring

TRANSFORMING THE NETWORKED GRID INTO AN ENERGY EXCHANGE

We have explored how distributed intelligence provides fine-grained monitoring of networked devices, and how edge intelligence with Itron Embedded Sensing provides fine-grained monitoring of energy consumption and generation. The power of the networked grid is fully realized when these concepts are combined into an energy exchange infrastructure. The energy consumption and generation controlled by networked devices can be represented as layers of available capacity for energy management. These "energy management" layers are analogous to the layered architecture the Internet is based on (see diagram below). Just as each layer of the Internet builds on the layers beneath it, energy management begins with device communications, and culminates in an accurate picture of the energy available for dispatch into the distribution system.

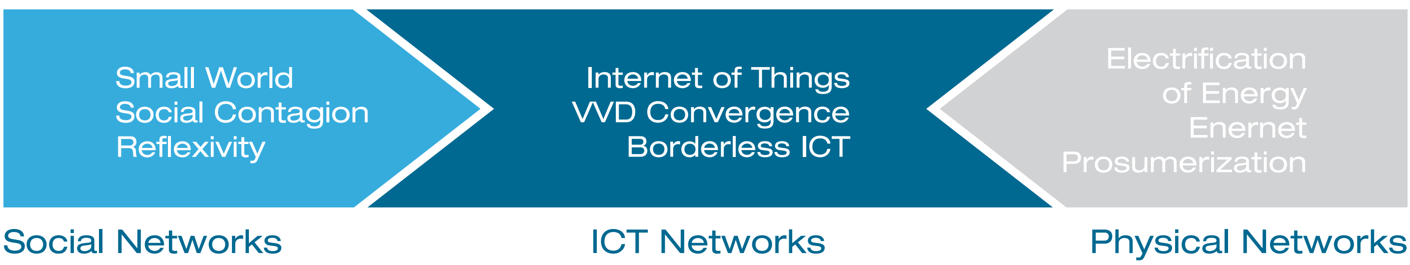
Cisco's CGR application environment works in concert with Itron Embedded Sensing apps to give network infrastructure an aggregated view not only of network traffic, but also of energy available to participate in transactions. Thus the CGR can monitor, for example, the total amount of electric vehicle demand, total solar generation capacity, and total load control capacity, on a near-real time basis, for all connected devices in the RF Mesh. This unique approach helps utilities go beyond operational benefits of modernized grid infrastructure, and meet the challenges of changing generation portfolios, consumers who store and produce energy ("prosumers"), and the disruptive technology trend of network convergence.

Internet Protocol Layers	Energy Control Layers
Application Layer (HTTP, FTP, etc)	**Available Energy** (dispatchable negawatts)
Transport Layer (TCP)	**Control Constraints** (customer settings, other programs, etc)
Network Layer (IP)	**Device Capacity** (demand, available load drop, etc)
Link Layer (Ethernet, Wi-Fi, 802.15.4, etc)	**Communication Device** (EV chargers, HVAC, hot water heaters, pool pump)

Network Convergence

As utilities invest in grid infrastructure to better manage distribution assets, consumers and energy service providers are also leveraging communications technology to create awareness of energy management opportunities, including adoption of electric vehicles, solar generation, home energy management, and eventually energy storage. These technologies present new grid management challenges to utilities, but network convergence provides a way to transform those challenges into opportunities.

The graphic below depicts the convergence of social networks, information and communications technology (ICT) and physical networks that will shape our energy future[3]. According to Beckstrom's Law[4], the value of a network is proportional to the number of users connected to the network and the average number of transactions those users conduct over the network. Cisco's Gridonomics concept articulates the need to enable collaborative networking to fully realize the value-generating potential of the networked grid. Doing this will require extending networking and intelligence both vertically and horizontally. Cisco's focus on delivering the Internet of Everything, combined with Itron Embedded Sensing, captures this important horizontal dimension, allowing utility investment in networking infrastructure to continue to accrue value over time.



Network Convergence

[3] Gridonomics White Paper, Cisco Systems, Inc.
[4] Beckstrom's Law, http://www.beckstrom.com/images/law.pdf

Consider, for example, electric vehicle infrastructure. Whether utilities own charging stations or not, ideally the networked grid would deliver understanding of the location of stations, the charging capacity of each, and the current load on the system at any point in time. Insight and control can be delivered vertically in this case through Itron and Cisco's smart grid infrastructure. In addition, smart devices that route consumer and fleet vehicles, such as smart traffic lights, social media apps and vehicle telematics will influence the location and charging patterns of electric vehicles. Itron Embedded Sensing in EV charging stations connects to local and utility networks, providing a bridge between the horizontal and vertical dimensions. By providing energy insight and control interfaces through multiple communications networks simultaneously, utilities gain greater understanding of the impact of consumer behavior on mobile electric loads.

Dr. Jeffrey Taft, Distinguished Engineer at Cisco, has noted that large-scale distributed control systems require "decomposition of large complex control problems down into a series of smaller sub-problems, with the sub-problems being integrated via the hierarchy to solve the entire original control problem"[5]. This definition applies especially to the networked grid, given the inherently hierarchical nature of electric distribution systems, and the impact of energy flows within lower layers on upper layers of that hierarchy. As more energy generation and control devices connect to the networked grid, it becomes infeasible for a single head-end or cloud service to optimize energy flows in near-real time. Thus local analytics and hierarchical decomposition become essential enablers of an efficient grid infrastructure.

Energy delivery and grid balancing are quickly evolving to become a complex series of two-way transactions between utilities, prosumers, and energy service providers. These transactions will occur at all levels of the distribution hierarchy, and require a combination of distributed intelligence and edge intelligence that will accommodate the vast number of connected devices and the complex energy transactions initiated by those devices. Itron and Cisco are delivering distributed intelligence and edge intelligence in our networked grid platform to support the coming energy exchange.

CONCLUSION

Itron and Cisco are building an open, standards-based networking infrastructure to modernize the grid. We believe that the networked grid must have the flexibility to process data at multiple levels of the network hierarchy, and must extend connectivity and intelligence to many stakeholders. Our combined global expertise in networking, communications technology and energy management come together to build a platform capable of delivering on this vision. Distributed intelligence and edge intelligence are essential elements of a networked grid that will continue to evolve to meet the changing needs of the electric grid both now and in the years to come.

[5] J. Taft and P. De Martini. Ultra Large-Scale Power System Control Architecture. Cisco Systems, Inc. White Paper.

Itron

Itron is a global technology company. We build solutions that help utilities measure, manage and analyze energy and water. Our broad product portfolio includes electricity, gas, water and thermal energy measurement and control technology; communications systems; software; and professional services. With thousands of employees supporting nearly 8,000 utilities in more than 100 countries, Itron empowers utilities to responsibly and efficiently manage energy and water resources.

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