Welcome to the Active Grid

Today's Challenges Require a Solution Built for the IoT World

When it comes to how we manage the delivery and use of energy and water, or how we run our cities, there's a lot of opportunity for improvement. Each year in the U.S. alone, nearly $100 billion in energy and water are wasted, stolen or otherwise lost before reaching the end user. As migration toward urban centers accelerates, cities are under increasing pressure to manage resources more effectively and to utilize new technology to make the urban landscape more livable, sustainable and economically vibrant.

LET'S START WITH THE POWER GRID

According to the U.S. Energy Information Administration, 6 to 8 percent of the electricity generated at the power plant disappears due to "technical losses" from the lines and equipment that deliver power to the end user while another 1 to 3 percent is lost to electricity theft or other "non-technical" losses. In some countries, those numbers can reach as high as 30 or 40 percent. Our natural gas pipeline and distribution infrastructure presents similar challenges. According to a 2015 study led by Stanford University and supported by the U.S. Department of Energy, invisible gas leaks from aging or damaged pipelines cost consumers billions of dollars per year. In a time when climate change and persistent drought in some areas are pressuring water resources as never before, the typical water utility in the U.S. loses somewhere between 14 and 18 percent of the water — or more than 2 trillion gallons per year — it treats and pumps before it ever reaches the end user, according to the American Water Works Association. And that does not include a comparable volume of water lost at the customer premise.

In 2010, for the first time, more than half of the Earth's 7 billion people were living in urban areas. By 2025, that number will increase to 60 percent and will be as high as 80 percent in many Western, economically developed countries, according to a recent article in Forbes. This confluence of demographics, technology and resource management pressures is animating the smart cities movement. And there are many opportunities for cities, often working in partnership with utilities, to leverage new technology to drive significant improvements in energy efficiency, water conservation, transportation and traffic management, refuse collection and recycling diversion, public safety, city services and other areas.

Not Just Possible; Practical and Cost-effective

All of these needs and opportunities – making our energy and water infrastructure more efficient, more reliable and less wasteful, and making our cities more functional, livable and sustainable – are readily achievable if we apply the right technology to approach problems in new ways in the Internet of Things (IoT) age. At Itron, we call this the Active Grid. It's much more than smart metering and it's more than smart grid. It encompasses electricity, gas, water and smart cities, and an entirely new frontier of opportunity.

The Active Grid leverages significant recent advancements in Internet of Things (IoT) technology, including distributed intelligence; machine-to-machine communications; multi-application network architecture; cloud computing; data analytics; and a new generation of battery-powered edge devices and sensors to deliver an entirely new level of awareness into the state of the distribution network. All this means we can achieve resource management outcomes than were simply not possible just a few years ago.

Instead of just collecting and transporting rafts of data for analysis after the fact, the Active Grid analyzes data continuously at the edge of the network, dispatching insight rather than bytes. Intelligent devices communicate and collaborate directly with each other and make decisions in real time. The Active Grid is supported by a network that is both open and secure, resilient and interoperable. The network is capable of connecting everything from utility smart meters, distribution sensors and control devices to urban infrastructure such as streetlights, traffic sensors, EV charging stations, solar installations, safety sensors and air quality monitors to name a few. Most importantly, the Active Grid also connects people to their surroundings, providing a robust technology platform to make our communities more livable, sustainable and economically vibrant.

While utility-centered applications such as smart metering will often provide the initial impetus for network infrastructure investment, the benefit stream can be broadened significantly and at a manageable incremental cost with the right building blocks in place. The Active Grid brings four key technology building blocks that, applied together, redefine what is possible for smart distribution of water, electricity and gas, and smart city infrastructure.

One Network, Many Applications

First, the Active Grid requires a unified, scalable, multi-purpose IoT network infrastructure for smart utilities and cities. This means that once the network is deployed, it's very easy and cost effective to expand the value of the network investment over time by adding new capabilities. This standards-based IPv6 multi-application network separates the network infrastructure from the devices and applications that run on it. This means that new devices and applications can be added easily to the network, just like a new laptop or a printer would be added to an enterprise-class IT network. It also provides standardized, robust security, state-of-the-art network management and quality of service to optimize network operations and dynamically prioritize network traffic based on application and business requirements for an IoT world. All while utilizing a common and existing IT skill set to keep operations simple and support costs under control.

A Better Way to Communicate

The Active Grid demands both high-performance communications and reliable connectivity. That means a communications solution that combines multiple communication media – RF wireless, powerline carrier and Wi-Fi – on the same chipset and in the same edge devices. Edge devices are able to intelligently select the most appropriate path, data rates and communications mode (e.g. mesh, point-to-point, peer-to-peer, local broadcast) to assure the highest level of communication performance and reliability to support an entirely new portfolio of smart grid, smart distribution and smart city use cases. We call this Adaptive Communications Technology and it delivers assured connectivity at the highest possible speed.

Not a Meter; a Grid Sensor and Computing Platform

With a powerful distributed computing platform, the Active Grid transforms the smart meter from a consumption measurement device to an advanced grid sensor with metering being one of multiple applications. That means embedding the equivalent computing power of a smart phone or desktop computer in every device, enabling real-time analysis of high-resolution data (1-second or better) at the edge, while eliminating latency and loss of data resolution during transfer over the network. This distributed computing platform also provides the ability to run multiple “apps” on meters and other edge devices, thereby unleashing a growing ecosystem of developers to innovate on the platform.

Edge Device Collaboration

With its ability to support multiple application and communication protocols, this distributed computing platform also enables an increasingly diverse ecosystem of grid devices, sensors and assets – ranging from smart meters to IoT sensors to utilize peer-to-peer communications to share data and collaborate in real time to solve problems at the edge of the network as conditions change. That means a smart meter or grid sensor can talk directly to a distribution automation control device or to an inverter on a solar panel, or a remote valve control on a gas or water pipeline. This type of self-directed device interaction has always been central to the vision of a smart distribution network but never possible until now.

Why Does All This Matter?

Each of these attributes we’ve described represents a significant industry or technology advancement in and of itself. But what really sets the Active Grid apart from the current status quo is what happens when we start combining these capabilities to enable new use cases.

For example, by combining device-based computing power with tight integration to the electricity meter, smart meters can access and analyze very high-resolution data (1-second or better) in the edge device and analyze it there in real time, compared to current solutions that are processing only 1-minute, 5-minute or 15-minute data after collecting it and transporting it over the network. That’s a comparative eternity in grid operations time. With the Active Grid, utilities can now have SCADA-like insight that extends to every delivery point on the lower voltage network.

That same device-based processing power combined with advanced powerline carrier communications enables the Active Grid to maintain an accurate and continually updated connectivity model of smart meters and their connection to distribution assets such as transformers, phases and feeders. That’s an industry first and an absolute requirement for more advanced smart grid use cases involving real-time monitoring and control of loads, power flows, grid equipment and distributed energy resources.

Or by combining a unified multi-application network with Adaptive Communications Technology, edge devices are able to utilize peer-to-peer communications to “compare notes” by sharing data in real time with other devices at the edge of the network for local learning, pattern recognition and even inter-device command and control, all critical functionality for enabling smart distribution and smart cities applications. For instance, intelligent meters continuously calculating resistance on the lower-voltage network may detect a progression that indicates a degrading connection, or voltage fluctuations combined with momentary outages could indicate an equipment problem and likely outage. The Active Grid monitors for these conditions continually so timely action can be taken to correct them.

One of the key trends identified in the latest Itron Resourcefulness Index, an annual survey of utility executives, industry stakeholders and consumers to gauge progress in achieving more effective management of energy and water resources, was that utility executives are very concerned about creating business value from all the new data coming their way. The Active Grid fundamentally changes the approach to data management and analytics by applying intelligence to where the problem is best solved, whether that's in the utility back office, or increasingly, at the edge of the network. This approach utilizes distributed intelligence and analytic capability in edge devices to greatly reduce the volume of data that must transit the network, while also overcoming the latency challenges and requirements associated with many distribution operations use cases. With the Active Grid, it's less about big data and much more about the right data.

Let's look at the capabilities of the Active Grid in the context of a complete electricity distribution operations use case.

THE ACTIVE GRID IN ACTION

It's getting late in the afternoon on a hot day in mid-August. In a suburban neighborhood, newly installed rooftop solar panels are producing a prodigious amount of electricity. In fact, quite a bit more than the homes they serve require. At the same time, two shiny new electric vehicles are charging simultaneously under a single transformer. And people arriving home from work are turning up their air conditioning. All this means that transformer loading in the neighborhood is headed for the red line from greatly increased load and current flowing in both directions.

As the temperature rises, smart meters on the homes are analyzing 1-second data in real time to sense exactly what's going on. Guided by a continuously updated connectivity model and using an app downloaded over the network, the meters communicate with each other locally via peer-to-peer communications to calculate total load on the nearby transformers and compare it to the transformer's rated capacity, which the meters are aware of. These meters quickly discern when their transformer is approaching overload conditions and whether that's from the line side or from the solar assets on the customer side of the meter.

When this occurs, a distributed analytic running on the meters' open application platform determines the most appropriate course of action: whether to shut off controllable loads behind the transformer or to turn on/increase or shut off/decrease distributed generation output behind the transformer to reduce load on the transformer below rated capacity.

As a result, safe loads are maintained on each transformer by the smart meters working intelligently and collaboratively with other devices and assets – load control switches, smart thermostats, EV charging stations, storage controllers, smart inverters — at the edge of the network. The system is even smart enough — via apps running locally on edge devices — to create and administer a "local power pool" behind the transformer so that excess solar generation from the rooftop panels can be can be stored or purchased and used locally instead of going to waste in an effort to maintain grid stability or protect assets.

The Active Grid scenario described above is made possible by deploying an IoT-enabled distributed intelligence platform where smart metering is viewed as an initial application rather than the fundamental purpose of the network. The ability of intelligent, connected devices to communicate, collaborate and take coordinated action in real time at the edge of the network to solve problems and create opportunities has always been central to any "smart grid" vision.

This is just one example of the Active Grid in action and these same capabilities can be applied to many other electricity use cases to deliver material improvements in energy theft detection; outage detection and analysis; more effective load control and demand response; and can even be used for early detection of unsafe grid conditions such as high-impedance connections.

NATURAL GAS, WATER, SMART CITIES …

The same technology innovations that are enabling an active electric grid also apply to battery-powered gas and water communication modules, enabling the realization of all the benefits of Adaptive Communications Technology and the IPv6 architecture. The result is a solution that assures both high performance communication and reliable connectivity in all types of service environments, including the hardest-to-reach areas.

By intelligently adjusting modulation schemes, transport speeds or finding alternative paths, the network adapts and continually self-optimizes to ensure that no node or device is left unconnected. The Active Grid combines multiple communication media in the same device with the intelligence to dynamically optimize both speed and connectivity.

The network can form either mesh or star configurations as the topography requires to provide a single, unified network for line-powered devices (e.g. smart electricity meters, distribution automation device) or battery-powered nodes, such as gas and water meters, and smart city and IoT sensors. In mesh configurations, battery-powered gas and water modules function as “leaves” on the network, sending their data to nearby powered devices, where they are routed to the head end, via RF and PLC communications. The primary benefit of operating as a “leaf” on the mesh is reduced network infrastructure; with gas and water endpoints able to utilize the existing electric infrastructure, minimzing the need to add additional network infrastructure, while also strengthening the overall mesh network. The “leaf” functionality also ensures the Itron battery-powered gas and water modules and sensors will deliver a 20-year battery life, under normal operating conditions, eliminating the need to revisit or replace the modules after installation for a very long time.

More importantly, these capabilities can also be applied to water and natural gas distribution systems to identify potential safety problems early and reduce losses. For gas and water applications, the peer-to-peer communications in combination with the distributed computing platform can be used to enable new pipeline safety, system integrity, pressure management, leak detection and loss reduction applications.

For instance, on the gas side, a network of sensors may detect the presence of methane, pipeline corrosion or pressure changes that could lead to unsafe conditions or the possibility of explosion or fire. Using distributed computing power, sensors can analyze data in real time at the edge of the network, and using peer-to-peer communications, they can communicate directly with a remotely controlled valve to immediately shut off gas flow to that area or customer premise without the data and command process having to transit the entire network.

For water utilities, connected pressure sensors deployed throughout the water distribution system monitor pressure in real time and are able to use the peer-to-peer communications to interact with neighboring sensors to identify pressure changes. If the changes exceed pre-determined thresholds, then the pressure sensors communicate with a pressure reducing valve to make adjustments and correct the pressure level. These capabilities enable water utilities to maintain consistent pressure levels to ensure good service and reduce stress on its infrastructure, ultimately increasing its useful life and decreasing distribution leaks leading to costly main breaks.

While these utility operations-centered use cases for increased energy efficiency, improved safety and more effective water conservation represent core initial applications for this technology, there are many other smart city opportunities for both utilities and municipalities to consider. For instance, a city or municipal government can utilize the installed network infrastructure to transform streetlight management. By combining LED lighting with network-based control technology, maintenance and energy costs for street lighting can be reduced by up to 80 percent, while improving public safety. That same streetlight device can also act as a "point of presence" and platform for other smart city sensors and applications. For instance, by adding sensing intelligence to trash receptacles can greatly increase the efficiency of waste management by reducing collection frequency and costs while also improving recycling diversion rates. The network can also be used to monitor and improve traffic flows and parking space management in the city. These are just some examples of what is now possible, but the key to unlocking all the potential future value is to invest in an IoT-ready technology platform and network infrastructure that was designed for many purposes; not one sole purpose as many AMI networks have been designed.

IT TAKES AN ECOSYSTEM

The smart grid and the IoT are bigger than any one company or any one technology. Itron recognizes this, and this recognition guides our approach to the Active Grid and also forms the foundation of Itron's strategic partnership with Cisco. The Active Grid is architected to provide an open application, interoperable environment that enables third-parties to embed the technology into their devices or to develop apps to run on the platform. To this end, Itron recently launched a developer's network to drive new innovation and grow a robust ecosystem of developers and applications for this platform.

A diverse ecosystem of intelligent devices and sensors, analyzing high-resolution data at the edge of the network, communicating and collaborating, making decisions and taking action in real time to transform our energy and water delivery systems, empower consumers and businesses, and make our cities livable and sustainable. This is the Active Grid, and it's what separates Itron's approach from other offerings on the market. Indeed, it is the broad potential of this new technology that enlivens our conversations with utilities, cities and technology providers when we get together and ask the simple question, "*What is now possible*?"

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