Putting Smart in the Right Place

How the distributed intelligence of OpenWay Riva™ is changing smart grid thinking

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WHITE PAPER

APPS NOW RULE

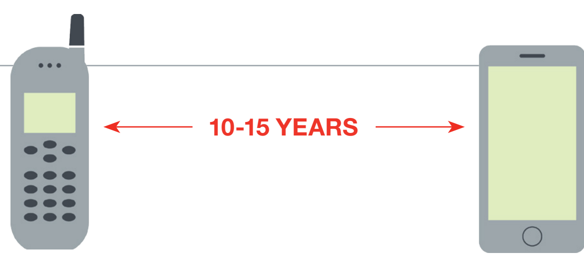
2014 was watershed year in terms of how people utilize “distributed intelligence” in their everyday lives.

For the first time, consumers were more likely to use “apps” on their mobile and tablet devices than mobile browsers or PCs to access the internet and get things done. In other words, apps running at the edge of the network, that utilize the intelligence and computing power of a lower-cost and unified mobile computing platform are dominating our increasingly connected world.

While this may not seem like much more than interesting technology and marketing statistics, there’s important insight to be gained from these trends as we plan and build the next iteration of the smart grid. Just as distributed applications and edge intelligence offer specific value to consumers – particularly in use cases involving interactivity of devices, multiple communications media, complex calculations and reporting, native functionality and robust data processing – these capabilities are even more important for the interconnected power grid of tomorrow. The move to leverage distributed intelligence to improve the reliability, efficiency and flexibility of the grid is well underway.

LOTS OF DATA, NOT YET SMART

In North America, for example, utilities have installed over 70 million smart meters over the last decade, representing more than 50 percent market saturation. These meters are generating some 1.5 billion data points per day — interval consumption data, monitoring data, event data – and sending all that data over their networks back to the utility every day. Thus far, this data has largely been used to improve billing and customer service in the “meter-to-cash” area of utility operations.



2000
Basic mobile phone, voicemail & text

2015
Smartphone: Applications – transact, navigate, communicate, share, device control, data access, new business streams

SMART GRID 1.0

- Lots of meters sending lots of data back
- Lots of smart meters creating lots of data

SMART GRID 2.0

- Beginning to utilize the data for distribution side benefits, value-added services, etc.
- Application of analytics in utility back office

SMART GRID 3.0

- Coordinated analysis and action to the edge of the network and endpoint
- Interoperation of diverse grid devices/assets

But utilities are also beginning to operate in a “meter-to-grid” mode by utilizing analytic applications — usually operating in the utility back office — to sift through the data to gain new insights to improve grid operations and energy delivery. Thus far, the ability to aggregate and disaggregate smart meter data is particularly suitable to analytic use cases such as load forecasting and asset management, where immediacy of awareness and action is not necessarily required.

However, there are limitations to the back-office only approach to analytics. The latency of the collected smart meter data, the inefficiency of bringing all the data back over the network for post hoc analysis and the inability to act on it in a timely manner currently limit the value of the data smart meters generate. This is particularly true for smart grid use cases that involve near real-time decision making about the flow of power, connecting and disconnecting things, and the coordinated interaction of assets and devices in response to rapidly changing grid conditions.

ENTER ITRON RIVA™

It is with these challenges clearly in focus that Itron developed its new OpenWay Riva distributed intelligence platform. Itron Riva is Itron's revolutionary sensing, computing and communications technology that is changing how we think about collecting and acting on important data in the field. OpenWay Riva integrates an edge computing platform, distributed applications and dynamic communications technologies into field devices to offer predictive analysis and localized control throughout the network, for smart grid, smart cities and the Internet of Things.

When integrated with Itron's OpenWay smart grid solutions, OpenWay Riva represents a game-changing technology platform that empowers the grid to make decisions and respond to changing conditions in real-time. By extending intelligence throughout the network, OpenWay Riva brings new approaches to solving today's critical challenges in grid operations.

A DIFFERENTIATED APPROACH TO SOLVING KEY GRID CHALLENGES

High-performance, adaptive communication and control networks	+	Distributed computing and high resolution data analytics at the edge	=	Real-time grid sensing and increased operational state awareness	▶	Adaptive grid operations based on predictive and diagnostic analysis

NOT JUST POSSIBLE, BUT PRACTICAL

While it would be technically feasible to deploy SCADA-like capabilities all the way to the edge of the distribution system to enable these real-time analyses, sensing and control capabilities, that would be cost prohibitive. But thanks to advancements in software-defined networks and communications, and the affordability of greatly increased computing power, it is now possible to deploy a much more robust smart grid technology platform on the lower-voltage network. The result is pervasive monitoring, communication, analysis and control capabilities all the way to the edge of the network, to the customer premise.

More importantly, this technology, for the first time, enables coordinated analysis and action across the solution and among diverse grid devices to solve key operational challenges that have not yet lent themselves to either practical or cost-effective solutions. The key to enabling these capabilities is deploying intelligence and analytic capability in the right place – whether that's in the edge device, in the mid-tier communication network, or the utility back office — to solve specific problems. To make this vision a reality, four key technology attributes are required:

1. Computing Power at the Edge: Thanks to Moore's Law, which holds that computing power doubles every 18 months while costs drop precipitously, it's now possible to embed the computing equivalent of a smart phone into smart meters and devices at price points competitive to current smart meter technology offerings. This enables advanced communications, high resolution data processing and analysis in the edge device – at several hundred times the data resolution compared with five-minute data. This allows us to solve key distribution operations and safety issues that could not be practically solved before. These developments also enable us to provide a unified software platform (running a Linux-based operating system) that takes smart metering and grid communications beyond the world of firmware running basic, pre-programmed functions to a robust platform for software applications.

2. New Communications Capabilities: Robust processing power in the endpoint combined with advancements in software-defined communications have also paved the way to solve critical connectivity and communication performance challenges that have long frustrated utilities deploying single-communications networks. OpenWay Riva's new Adaptive Communications Technology combines RF mesh, PLC and WiFi communications on the same chip set. This enables dynamic and continuous

selection of the optimal communications path and the most appropriate frequency modulation based on network operating conditions, data attributes and application requirements. In other words, high-performance communications without compromising connectivity. With adaptive communication capabilities, deployment of network infrastructure is easier, faster and less costly – a 30 percent reduction in required network infrastructure and a 50 percent reduction in network mitigation costs compared to current offerings in the marketplace. This new platform also provides peer-to-peer and local broadcast communications capabilities, so that edge devices can talk to each other individually, or to selected groups of devices simultaneously at a localized level to support new distributed analytics use cases.

3. Locational Awareness: Historically, the inability of smart meters to know exactly where they are on the distribution network has been the greatest obstacle to leveraging smart meter data and communication capability to support grid operations use cases. Now, for the first time, smart meters are intuitively and continuously aware of where they are in relation to other grid assets (feeders, circuits, phases, transformers, distributed generation, other meters, etc.). This awareness does not require a GIS component, nor is it dependent on the communication topology of the network. Rather it's enabled by continuous monitoring and algorithmic interpretation of electrical characteristics relative to various grid devices within the network. This continuous "self-awareness" and voltage awareness opens up an entirely new approach to smart grid use cases and applications that were simply beyond reach before.

4. Interoperability at Last: Robust processing power and memory also allow smart meters and grid sensors to simultaneously support multiple application protocols and "speak the languages" of not only smart metering, but distribution automation (DNP3 or IEC 61850), load control/demand response (OpenADR) or home area network (SEP 1.X and 2.0, Homeplug, etc.) to name a few. This communication "fluency" enables localized communication and coordinated action among diverse grid devices — that could never communicate or interact before — to respond to changing conditions at the edge of the network.

For instance, a group of smart meters, sensing increased load on a transformer from multiple electric vehicles charging under the same transformer, can now initiate coordinated and localized action, such as load control or demand response, to reduce the load. Similarly, smart meters can work directly with smart inverters on the other side of the transformer to monitor and stabilize voltage or manage feed-in from large numbers of nearby customer-owned solar assets to protect equipment during times of peak solar output.

This ability for smart meters, grid sensors and control devices and distributed generation assets to quickly sense changing conditions, analyze data immediately at the edge and take appropriate action to solve problems or respond to changing conditions in a highly automated fashion on a localized level has always been a core tenet of any smart grid vision. These technology advancements, represented in OpenWay Riva, now make that vision a reality.

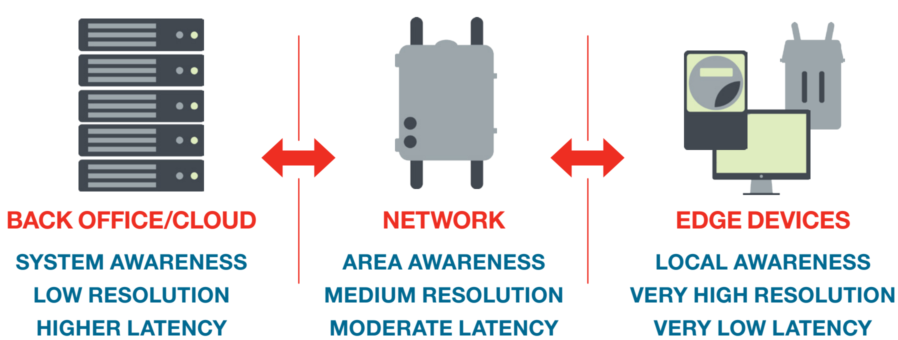
INTELLIGENCE WHERE IT BELONGS

This revolution in distributed intelligence capability does not mean that everything smart grid will be done at the edge, without human involvement or control. On the contrary, it's about putting or "distributing" intelligence in the right places based on the requirements and desired outcomes to optimize the use case. As we tailor the technology platform to the emerging smart grid use case requirements, we must ask ourselves three key questions:

1. **What is the breadth of knowledge and visibility required?** Is the use case highly localized and does it involve only a small number of devices or customers – such as transformer load management? Is it an outage management use case that requires network-level intelligence over a wider area? Or is it system-wide use case where large-scale demand response is needed to mitigate capacity constraints and operators can ask the system to intelligently "procure" a total load reduction of 100 MW by seeking an average .5Kw reduction from each metering point? In each of these scenarios OpenWay Riva enables the system to provide an optimized approach to solving the problem based on the breadth of data and awareness required for the use case.

2. **What is the required data resolution?** We used to think of hourly or 15-minute interval data from smart meters as "high resolution." No longer. By deploying robust data processing power and memory in edge devices, we increase – by orders of magnitude — the resolution of the data we can work with. Instead of 15-minute data or five-minute data (which had to be sent back to the utility via the network for analysis and action), edge devices can now process and analyze one-second data based on multiple kHz sampling. This opens up an entirely new frontier of use cases by enabling real-time data processing, analysis and filtering at the edge of the grid, and optimizes the utilization of network bandwidth and capacity by greatly reducing the amount raw data that must transit the communication network.

3. **What is the required response time?** How fast is fast enough? In an outage detection and response scenario, moderate latency is required; it doesn't need to be sub-second, but it can't be later in the day either. No more than a few minutes will do. For applications such as frequency load shedding or a safety issue such as a "conductor down" on the lower-voltage side of a transformer, an immediate, and preferably a more surgical response than tripping an entire circuit, is required. Whereas applications such as feeder phase balancing or load research, which are based on statistical averages over a longer periods of time, can be executed in the back office in the days and weeks that follow.



By answering these three key questions for each use case, we are able to place intelligence in the right place to optimize the solution for the specific problem we're addressing. This degree of flexibility and capability for smart grid operations has never been practical or affordable to deploy in the low voltage distribution network that is the true "point of service" to customers.

PUTTING THESE CAPABILITIES TO USE

As we've stated, the capabilities of Itron Riva technology open up many new possibilities in smart grid use cases by greatly extending the capabilities and business value a smart grid communications network can deliver. These benefits are made possible by enabling high-speed data processing and analysis at every level of the network, by making much more efficient use of network bandwidth and capacity, and by enabling a diverse ecosystem of grid devices and technologies to communicate with each other and interoperate on a localized level.

The result is optimized solutions to specific utility business problems and challenges that, until now, were neither practical nor affordable to solve. And while Itron is still in the early stages of working with our utility customers to define and validate the specifics of this new set of use cases for distributed intelligence, we already see tremendous potential value in several core applications that we're developing for commercial release this year and in 2016.

REAL-TIME DIVERSION DETECTION

Theft of electricity has a material financial impact on utilities and their customers throughout the world. While worldwide electricity theft is estimated to be in the range of 8 percent of revenues, in some regions, non-technical loss resulting from diversion represents 20 to 30 percent of revenue. That's a huge number, but it also represents a significant opportunity to improve financial performance of the utility. However, a new and better approach is needed.

Even with current generation smart metering technology, detecting energy theft can still be an inefficient and laborious exercise of analyzing historical data from disparate systems and drawing inferences about where diversion may be taking place. With OpenWay Riva technology, diversion detection is now based on real-time, continuous, and localized analysis of changes in electricity current flows and voltage levels in the distribution network rather than sifting through circumstantial data delivered after the fact. OpenWay Riva increases the accuracy of energy diversion and theft detection by as much as 300 percent over current smart metering systems.

It's a basic fact of the physics of electricity that when current is drawn through a conductor, voltage drops in a measureable way on the network. Through their ability to communicate directly with other meters at different levels of the network, and to know exactly where they are on the distribution system, OpenWay Riva-equipped meters monitor voltage levels on the network continuously, ubiquitously and precisely. They use that information to identify when current is drawn on the secondary of a transformer that did not go through a meter (i.e. theft) – and without requiring dedicated metering at the distribution transformer.

This process of monitoring and deductive communication happens continuously and intelligently throughout the network. This represents a sea change in the ability for utilities to quickly identify, stop and deter electricity theft and an opportunity to put a big dent in a problem that costs utilities, shareholders and consumers tens of billions of dollars per year worldwide.

REAL-TIME DETECTION OF HIGH-IMPEDANCE CONNECTIONS AND DOWNED CONDUCTORS

High impedance connections (HIC) on the low-voltage distribution system represent a safety risk, while also causing customer voltage problems and utility energy losses. A high impedance connection is simply a poor electrical connection that can be created when splicing, tapping or connecting wires, when foliage touches a line, or when a cable or connection fails.

When current is drawn through the high impedance connection, heating occurs and there is a voltage drop across the connection. As heating continues, the connection is further degraded, and this causes the HIC to worsen over time. Symptoms start as voltage problems and can deteriorate to power outages and/or fires. Unfortunately, until now there has been no practical way to identify and resolve these issues until they lead to severe voltage problems or failure/fire.

The distributed intelligence of OpenWay Riva changes the game in HIC detection and provides a practical and cost-effective solution for utilities to identify these losses, voltage anomalies and potential safety issues before they become a safety hazard or a costly liability. OpenWay Riva enables meters to continuously monitor impedance at each meter and notify the utility of the presence and location of high impedance connections.

In the event of a sudden change in impedance, as caused by failing connections or cables, the Riva solution immediately sends a priority message over the network to the utility informing them of the event, the relevant data and the location of the suspected fault so that field services resources can be dispatched quickly and precisely to correct the problem.

OUTAGE DETECTION AND ANALYSIS

While current-generation smart metering technology has added a valuable data stream to the outage management equation, it is not a panacea for improving outage detection, analysis and restoration efforts. Like energy theft detection, the current state of outage detection and analysis via the smart metering network is still an inferential exercise based on how many affected meters can successfully transmit "last gasp" outage messages over the network, how many of those reach the utility, and the filtering and analysis continues from there. This process is still hampered by lack of an accurate and continually updated connectivity model that associates meters and distribution system assets.

OpenWay Riva delivers a better approach to reduce outage analysis time by up to 50 percent compared to current AMI systems. By combining locational awareness on the grid with peer-to-peer communications at the edge of the network, OpenWay Riva systematically and continuously evaluates the status of nearby meters and devices to quickly model and localize outage events and report reliable and actionable information back to the utility in near real time.

When an outage event takes place, regardless of the scale or location, the system automatically initiates a "heuristic" analysis among Riva-equipped meters and devices on the network. The meters that still have power quickly go into a progressive outage analysis mode via peer-to-peer communications with other devices, in effect asking their "buddies," "do you have power?" By initially analyzing the data at the edge of the network, many of the difficulties current smart metering networks encounter in outage detection – including large-scale volumes of unfiltered outage data congesting the network – are eliminated.

Instead, the utility receives accurate and actionable information, including scale and location of the outage, affected meters, affected transformers, etc. – in a compressed timeframe. The outage is detected (usually before first customer calls), modeled so that the extent and probable cause of the outage is rapidly understood and the appropriate resources can be dispatched efficiently to exactly where they needed to begin restoration efforts.

This distributed approach to outage analysis is effective for both large-scale and small-scale outages, including "nested" and individual outages. This represents a dramatic improvement in outage detection and analysis through a combination of intelligence in the endpoint and network to ensure that outage detection data from smart meters adds business value, not just more data to sift through.

TRANSFORMER LOAD MANAGEMENT

Overloading of distribution transformers is an increasingly common problem caused by growing loads and the emergence of distributed generation on the customer side, which can overload transformers in the reverse direction. Itron distributed analytics on the Riva platform allow the load on individual distribution transformers to be analyzed continuously and managed locally in real time.

As we've mentioned, OpenWay Riva-equipped meters with distributed analytics determine which meters are on the same transformer and are able to detect changes and maintain correct relationships as restoration and maintenance work and the addition of new meters occurs over time. The Riva-equipped meters can also be interfaced with loads and generation resources within the homes for access and control.

Once meters determine that they are on the same transformer, they communicate with each other locally and calculate the total load on the transformer in either direction. At the same, a back office component of the analytic application interfaces with utility asset management and GIS systems to identify the transformer and its rated capacity, and delivers that information to each meter it serves.

Based on the total load and the capacity of the transformer, the meters can identify locally when the transformer is approaching overload conditions, whether from the line side or customer side. When this occurs, a distributed analytic running on the meters determines whether to shut off controlled loads behind the transformer, turn on or increase local distributed generation behind the transformer, turn on loads behind the transformer, or decrease or shut off distributed generation behind the transformer, depending upon which direction power is flowing through the transformer, to automatically reduce demand below allowed levels. Calculations can be based on simple thresholds or allowed overload vs. time curves. In this way, safe loads are automatically and continually maintained on each transformer simply by the smart meters working together locally.

This represents a key area of opportunity for utilities to leverage the investment in distributed intelligence and AMI to significantly improve reliability, while optimizing capital and operational expenditures associated with transformer procurement and maintenance. Best of all, these results can be achieved with little to low incremental investment beyond the smart metering infrastructure.

INTELLIGENT DEMAND RESPONSE

Demand response programs and load control programs, especially those targeted at large numbers of residential customers, leave a lot to chance. Currently, utilities send out event pricing and/or control signals to large numbers of customers or devices. Results can be inconsistent and unpredictable, and the lack of a timely feedback loop limits these programs from being utilized as a "dispatchable" generation or capacity resource. By applying distributed intelligence, OpenWay Riva provides a more effective and precise approach to achieving demand response outcomes.

With Itron's intelligent demand response analytic, the total demand reduction requirement is recalculated as an average reduction-per-meter, based on the number of customers participating in the event. In addition, meters assigned to a demand response program are allocated to smaller local groups of meters based on customer profiles, load characteristics, etc.

When the demand response event is called, a broadcast request is delivered from the utility back office to meters in the field. The request is for each group to achieve the required average reduction per meter. From that point, meters within each group communicate and collaborate locally, just as described for Smart Transformer Demand Management, to control loads and generation locally to ensure that the overall required reduction is achieved on average.

The significance of "on average" is that within a given group, some meters may provide more reduction and some may provide less, as long as the average is met. This allows the required program reductions to occur even though some meters may not have any load to reduce at that time, because other meters within the group will automatically create larger reductions to compensate.

During the event, one "spokesman" meter from each group of meters will regularly notify the utility of the results, without the communications and high-volume data processing that would be required to attempt to communicate individually with each meter to evaluate performance.

By distributing the problem across intelligent groups of nodes, OpenWay Riva provides a practical method for achieving highly reliable demand response reductions and evaluating the performance of a demand response event during the event.

Whether the purpose is managing generation and capacity constraints, avoiding expensive spot market purchases or reducing distribution system congestion and asset overloading, OpenWay Riva distributed intelligence drives greater confidence and effectiveness into demand response planning and execution.

IT TAKES AN ECOSYSTEM …

Itron recognizes that the modern grid is bigger than any one technology or company. It's a collection of technologies, interacting and sharing information to achieve outcomes. We also recognize that it's vitally important to give our utility customers choices and flexibility in their selection of meters, grid sensors and distribution automation devices. That's why Itron architected the Riva technology platform utilizing open standards (including a Linux- based software platform) in a highly flexible form factor so that it can be embedded easily in third-party meters and other grid devices.

Itron is already beginning projects in Latin America and in Europe where we are embedding Riva technology in third-party meters. As we look forward, OpenWay Riva will also become a part of the Cisco Developer's network, a vibrant and growing ecosystem of more than 60 smart grid technology providers. Itron and Cisco are fully committed to porting and publishing open standard APIs that allow third parties to write new applications for the platform.

CONCLUSION

In the late 1970s, Bill Gates ignited a technology revolution at Microsoft with a bold vision that there should be a PC in every home and on every desk. A recent cover story in The Economist estimated that by 2020, 80 percent of adults in the world will have a "supercomputer" in their pocket. Now in 2015, with OpenWay Riva technology, we are able to put the computing equivalent of a PC or smart phone in every meter and grid device to enable a new and broader value stream that extends far beyond the cost delta to do so.

There is absolutely no doubt that the convergence of information technology and operational technology in the global utility industry will continue and accelerate. The convergence of smart grid with the emerging smart cities and Internet of Things markets are accelerating this trend. Nevertheless, thresholds of innovation are reached that warrant a shift in thinking about how to approach and solve problems. For tomorrow's grid, that time is now.

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