IBM’s Business analytics and optimization (BAO): The “intelligence” behind the utility industry’s Smart Meter and Smart Grid deployment
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It is a brave new world for most utilities embarking on the mission to transform from the current electro-mechanical meters to Smart Meters and aging networks into Smart Grids. A favorite statement of one utility executive beginning this endeavor is "if Thomas Edison was resurrected today and looked around at our current utility environment he would remark 'things pretty much look the same'". Well no more. With the advent of Smart Meter deployment and Smart Grid, the industry is taking a quantum leap forward in terms of technology.

Many utilities have chosen to initially deploy the smart meters without analytics. While this approach may seem to be successful from a deployment perspective, it will be costly in terms of operating this very complex environment. With the advent of millions of new devices in the field (e.g., meters, routers, intelligent grid sensors, etc.) comes several opportunities for optimizing the enterprise and utilizing the resulting mountain of data to build a smarter enterprise.

Based on an April 2009 survey of 225 business leaders worldwide, we found that enterprises are operating with bigger blind spots and that they are making important decisions without access to the right information. In an environment that has little resemblance to the past, old ways of decision making and management are breaking down. Today’s leaders sense an inflection point, an opportunity to re-visit their use of information, or analytics, and fundamentally alter the way in which they conduct business.

One utility executive accurately describes his company’s culture as "a broken pole environment". His company is very good at reacting to and mobilizing a work force to correct a problem after it is identified; however, his company is not very good at addressing why the issue occurred in the first place. The idea of being able to predict when or where a problem might occur and use captured events and data with correlated intelligence to prevent future occurrences from even taking place is unimaginable.

Utilities deploying Smart Meters who wish to get ahead of their problems and begin sensing and predicting events must begin to consider the following questions - how do I:

- Manage this Smart Grid environment?
- Keep track of versions (hardware and firmware) on all of these new devices?
- Implement an early warning system to prevent critical problems?
- Detect equipment failures and anomalies?
- Correlate all of this data to deliver actionable events?
- Detect and perform root cause analysis on Smart Grid devices?
- Use the data to make better business decisions about outages and diversion?
- Implement analytics to detect not only that a fault occurs in a system but where the fault is located, why the fault occurred, and to determine the business impacts?
- Use the data to make smarter decisions about executing service orders and prevent nonessential truck rolls?
- Know what processes and procedures to put in place to measure the results?
- Begin? Where do I begin?

The answers to these questions provide insights into the critical need for advanced analytics and optimized outcomes in the new smart utility enterprise. The utility of the future is no longer supporting isolated electro-mechanical devices; instead it is operating integrated, interconnected, intelligent devices. This is a major business paradigm shift from simply reading and managing electro-mechanical meters and analog networks. From an installation perspective not much of a shift occurs in terms of the physical installation of the meter, but in the registration and communications back to the legacy systems a major shift has and will continue to occur.

The new Smart Grid environment, rich with the promise of benefits, has numerous components along this solution chain that can and will fail. This is where preventive measures must be taken. For example:

- If a meter does not register with the legacy systems, why? Where did it fail? In which system did it fail?
- If a meter stops reading, why? Where did it fail?
- If a service order fails to execute, why? Where did it fail?
- Are assets meeting my lifespan and reliability projections?
- When do I replace or maintain assets in the field?
- When upgrades are required and new firmware and software versions must be pushed, if a device does not receive the push, why? Where did it fail?

Now suppose you have 2+ million of these new smart meters deployed and you are attempting to gather meter reads once a day. With a 99% success rate this would mean that the utility must ascertain why 20,000 meters missed reads every single day and tomorrow brings another 20,000 meters. This will quickly snowball into an unmanageable situation. Production outages, increased costs, customer dissatisfaction and unrealized Smart Grid benefits along with a large volume of manual ad hoc investigations to determine a root cause will require an army of resources to address these issues. Now add in line sensors, remote terminal units (RTUs), etc. and the situation is even more exacerbated. The data volumes guaranteed by Smart Meter and Smart Grid devices will potentially be many terabytes each month. In this scenario, data and analytics are often an afterthought when thinking about the beneficial use for core operational efforts surrounding the Smart Grid and Smart Meter deployment.

### Figure 3:0 Treating a fundamental shift

<table>
<thead>
<tr>
<th>Traditional Approach</th>
<th>New Approach</th>
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</thead>
<tbody>
<tr>
<td>Sense and respond</td>
<td>Predict and act</td>
</tr>
<tr>
<td>Instinct and intuition</td>
<td>Real-time, fact-driven</td>
</tr>
<tr>
<td>Skilled analytics experts</td>
<td>Everyone</td>
</tr>
<tr>
<td>Back office decision support</td>
<td>Point of impact action support</td>
</tr>
<tr>
<td>Efficient</td>
<td>Optimized</td>
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Source: Business Analytics and Optimization for the Intelligent Enterprise, April 2009
For the intelligent enterprise, the new reality is this: personal experience and insight are no longer sufficient. New analytics capabilities are needed to make better decisions and responses.

**Advanced analytics and optimization with automation is the answer**

Business Analytics and Optimization (BAO) delivers value from every point throughout the enterprise. From the legacy systems in delivering “real-time” views of the supporting tool sets and components, to delivering services and information to customers, to better management of your work force and improved management and maintenance of smart equipment, to faster identification and resolution of issues in the Smart Grid environment.

**The key to realizing results lies in the ability to visualize the benefits of Smart Grid analytics delivered across the enterprise.**

The smart utility will have ready access to precise, relevant information, from all sources. Information will be analyzed, contextualized and shaped for right-now decision making – and right-timed action. Considering that today’s largely hierarchical enterprises are somewhat accustomed to equating information with control, they will need to get substantially better at sharing information with partners across the hall, down the street and in some cases around the globe. Imagine a fully integrated enterprise achieving the following benefits:

- Deliver the “trusted” data for improved decision making
- Improve asset investment results with targeted evaluation and enhanced maintenance projections
- Provide the intelligence behind support tools (dashboards) to bring needed information to employees and improve decisions with great accuracy and speed
- Provide process optimization to improve operational performance through integrated data from disparate sources
- Leverage large volumes of data to monitor and drive corporate performance management
- Reduce cost and complexity of regulatory reporting

Some of the benefits realized by these legacy system correlations include:

- The targeted identification of where a particular issue is located
- The identification of file translation issues between systems
- Faster identification of system processes stuck in a non-operational state
- Quicker identification of application issues leading to less down time
- Identification of meter provisioning issues
- Elimination of unnecessary truck rolls

Included in the monitoring and diagnostics for the network and infrastructure are routers, hubs, switches, firewalls, etc. The following are a few examples of the correlations defined around the network and infrastructure:

- Correlate router outages with meters not read
- Correlate hub outages with meters not read
- Correlate switch outages with meters not read

Some of the benefits realized by the network and infrastructure correlations include:

- The faster identification / resolution of router outages
- The impact of router outages on meter reads
- Faster identification / resolution of network outages
- Identification of network outage impacts on the communications network
- Elimination of unnecessary truck rolls
The communication network was identified early on as a focus area given the multitude of components required to sustain it. Monitoring and diagnostics for the communications network and infrastructure include but are not limited to take-out points (TOPs), head ends, wireless radios, microwave devices, etc. The following are a few examples of the communication network correlations implemented:

- Correlate take-out points (TOP) outages to determine impacts on meter reads and other communication outages
- Correlate cell relay outages with meters not read
- Correlate microwave radio outages with meters not read

Some of the benefits realized by the communications network correlations include:

- The faster identification of TOP outages
- A more in-depth understanding of communication outage impacts on meter reads
- The faster identification of cell relay outages
- The impact of TOP outages on meter reads
- Elimination of unnecessary truck rolls

Smart Meters provide vast amounts of data and events that are utilized for correlation purposes. The following are a few examples of the meter correlations implemented:

- Correlate meters not read with cell relay
- Correlate meter migrations between cell relays
- Correlate total number of meters by cell relay
- Identify meters not migrating away from cell relays which are not functioning
- Correlation of meters not read to power outage (PON) events
- Correlation of meters not read to diversion events
- Meter not read by read type (broadcast vs. point-to-point)

Some of the benefits realized by the meter correlations include:

- The faster identification of meter outages
- A better understanding of Smart Grid performance
- Early warning on the impact of updates (hardware vs. firmware)
- Elimination of unnecessary truck rolls

Utilities will realize greater value to business operations with analytics and optimization in the areas of:

**Asset Management:**
- Optimized asset investment process to deliver expected ROI
- Extended assets life thereby reducing overall O&M cost
- Reduced capital and O&M costs by moving away from time based management and leveraging condition based management of assets
- Improved outage management processes through increased system reliability

**Work Management:**
- Expedited critical information to improve efficiency for work force planning and materials/supplies
- Improved human capital performance through the optimization of work force data and automation of processes
- Increased dispatch accuracy and optimization of people and materials
- Increased productivity of the work force through availability of performance data and analysis

Now, flash forward, and imagine a fully integrated utility achieving the benefits of analytics delivered across all components of the Smart Grid, in real time. Analytics allows optimization and better operational focus on the Smart Grid to:

- Support integration of distributed energy resources (DER) to allow the utility to improve reliability and meet environmental demands
- Provide greater accuracy and timeliness of grid planning information
- Help system operators target grid problems faster and more cost effectively
- Monitor alerts / faults and assess outage scope
- Optimize potential actions and prioritize responses
- Automate actions once a decision is made

### Continuing to build the value of analytics

The process of developing on-going, effective analytics is not a once and done activity; rather the process is very much iterative and dynamic. Utilities will continue to realize ever increasing value as they progress down the path of advanced analytics.

Shown below are the key activities and flows that comprise analytics in the smart grid environment. Figure 4.0 shows the key activities and flows that comprise analytics in the smart grid environment.

In addition to being an iterative and dynamic development process, analytics will optimize interdependent business dimensions. By embracing advanced analytics, the intelligent utility will optimize:

- Intelligent profitable growth: Intelligent enterprises have more opportunities for growing customers, improving relationships, identifying new markets and developing new products and services.
- Cost take-out efficiency: Intelligent enterprises optimize the allocation and deployment of resources and capital to create more efficiency and manage costs in a way that aligns to their business and strategic objectives
- Proactive risk management: Intelligent enterprises are less vulnerable and more certain in outcomes as a result of their enhanced ability to predict and identify risk events, coupled with their ability to prepare and respond to them.

Each of these dimensions is a critical part of optimization – the impact of a decision or action along any one of them will have repercussions for the others.
For example, let’s examine intelligent profitable growth and the benefits of analytics delivered to customers. Figure 5.0 demonstrates how utilities utilizing Smart Grid and Smart Meter analytics are well positioned to better serve customers. Another example includes focusing on proactive risk management. How much revenue would be saved if, through a pattern of meter events, you could detect diversion in a matter of minutes or hours versus days or weeks? Consider a pattern of meter diversion events correlated to a specific drop in electrical usage on the premise and then being able to determine service was not performed on that customer’s location at that time. This is but one example of the many business analytics now available to the smart utility enterprise.

Tooling to deliver the analytics value

Business leaders, having identified significant information gaps, are poised for change. Enterprise leaders are getting ready to make fundamental changes in the way they work, which means moving decision making beyond “gut checks” to “fact checks.” What few enterprises understand, however, is the best way to go about analytics.

Based on our global research, extensive client project experience and discussions with business leaders, IBM has developed a framework to accelerate Smart Meter / Smart Grid initiatives based on open and industry standards, pre-built accelerators, and harvested best practices.

As with most endeavors, tooling is crucial in establishing a supportable and sustainable Smart Meter / Smart Grid analytics solution. Our suggested Smart Grid architecture is based on IBM’s Solution Architecture for Energy and Utilities (SAFE) depicted in the following view (see figure 6.0).

Having an enterprise view (see Figure 7.0) of the Smart Grid environment with drill down capabilities (see Figure 7.1) into a particular area of the Smart Grid is crucial in managing this complex environment.
The following Smart Meter analytics solution architecture is described from a bottom up approach starting with the event sources and event collection layers and ending with the presentation layer (see figure 8.0).

The Event Source layer depicted in the Smart Meter analytics solution architecture includes but is not limited to the following components: head ends, servers, network devices, communication devices, application processes, and web services.

The Event Detection layer is made of two distinct components:

A network management component that is utilized for:
- Discovery and Web-based User Interface showing network layers 1, 2 and 3 topology; interfaces and connectivity
- Correlation of events based upon the network connectivity and topology – Collector Agents
- Identification and isolation of root cause and symptom events
- Basic network performance collection, thresholds and graphs
- Tivoli® Common Reporting (TCR) Reports
- Defining, setting up and polling cycles

An IT management component that is utilized to collect events from applications, servers, processes, and other application related devices.

The Event Collection layer is made up of simple network monitoring protocol (SNMP) probes, event integration facility (EIF) probes and monitoring components.

The Event Enrichment, Normalization & Mapping layer provides:
- Deduplication (aggregation of events), correlation and automation of events
- Probe – lightweight software that collects events and forwards them to the ObjectServer
- Gateway – forwards ObjectServer data to applications or databases - Historical Database
- WebTop graphical user interface (GUI) – Browser-based event list or graphical representation of events
- Event Enrichment, advanced correlation and automation capabilities
- New Enrichment Database
- Information from other data sources and adds it to the event
- Maintenance mode
- Notification groups

The Business Management & Visualization layer is where technical events are utilized with business management tools to help business users visualize and assure the health and performance of critical business services with process automation. Business rules tools are utilized in this layer to provide a rules engine for users to configure and control business logic. Dashboards and Portals provide the visualization of the solution at the various layers.

Service request management anchors the Service Management & Notification layer and provides the service management, work flow and error processing functions for the Smart Grid solution.
Work products for analytics
Utilities embarking down the path of analytics around the Smart Grid and Smart Meter deployments fortunately do not need to start from scratch. Intellectual capital, reusable assets, and proven techniques have been established and continue to grow. The following are artifacts and assets available to support Smart Grid and Smart Meter Analytics:

- Analytics Solution Outline
- Analytics Project Plan
- Legacy System Analytics
- Communications Network Analytics
- Infrastructure Analytics
- Meter Analytics
- Customer Analytics
- Analytics Processes
- Smart Grid Analytics

Beginning the journey: Realizing the advantages of your Smart Grid and Smart Meter deployment
Utilities beginning or continuing their journey towards Smart Grid and Smart Meter deployment with analytics should be mindful of a few key considerations and challenges as they move forward:

A business analytics team spanning all of the utility enterprise organizations, including business and IT, should be created to establish Smart Meter / Smart Grid analytics. It is imperative to overcome thinking in silos. The creation of a business analytics team will begin this process of moving information out of each of the individual silos and streamline the flow of data and events for end-to-end diagnostics.

A topological architecture (see figure 9.0) and business process maps should be developed to identify all of the major components where failures might occur in the end-to-end Smart Meter / Smart Grid solution. You may or may not have all of these components in your architecture. The point here is to document the major components so you can then begin the process of identifying the failure points between the components that will provide a base for analytics. It is important not to attempt to start with too fine-grained components, start with the major components first and then build in complexity.

Figure 9.0: High-Level Component Groups for Diagnostics

A structure for processes and procedures around BAO should be established. A crucial step in the planning cycle is to spend sufficient time to design an overall solution with clear requirements and identified use cases. This is encompassing not only the monitoring solution to detect faults and generate events but also the method in which alarms are generated, communications are produced (dashboards, reports, email, etc.), outages are detected, outages are processed, and service management in general is established.

A data strategy should be developed. While the focus has been on analytics, data cannot be overlooked. A solid data integration and governance strategy is a key component in developing business analytics and optimization that meet business/technical requirements and support process models.

Conclusion
In Summary, achieving a true Smart Grid and Smart Meter environment is a major business paradigm shift facing utilities in this brave new world. While many companies will focus on fixing issues and viewing the environment in terms of delivery, there is great opportunity in pursuing business analytics within the solution from the very start. While utility commissions will be even more demanding on proof of customer benefits, cost benefits and efficiencies, business leaders, operational managers, and customers alike will demand faster, more granular information with targeted services turned around more quickly.

Operating this very complex Smart Grid / Smart Meter environment without consistent, accurate information will ultimately be costly without the analytics capabilities. Worse, those who forge analytics will be missing the potent upside potential. Utility leaders who are able to envision the comprehensive benefits of business analytics, optimization, and automation in total will be better equipped to take both the next great step forward in their smart meter / smart grid evolution, and be better positioned to reap the long-term benefits this brave new world offers.

About IBM
IBM’s commitment to energy and the environment began in 1971. Since then our specialized team of technologists and industry experts have continued to provide a comprehensive technology, and cost-effective methodologies to help utilities transform the utility value chain and realize business value. IBM Energy & Utilities (E&U) proven solution portfolio is based on our experience gained from solution implementations around the world and enabled by SAFE – an SOA-based E&U industry framework – which allows utilities to accelerate the development and delivery of new capabilities and offerings.

IBM has been a pioneer in the development of the vision for smart grid and recognized early the potential impact on our utility clients and their customers. IBM supports the adoption of smart grids around the world by driving standards, working with policy makers, helping define the future of the industry, and innovating on First of a Kind (FOAK) technology. We designated the smart grid as an IBM “Emerging Business Opportunity” area for growth. With this designation comes substantial investment—US$10 million between 2007 and 2010. This includes the continued expansion of our three Intelligent Utility Network (IUN) Solution Centers, the creation of key software assets to actually realize the solution architectures that many of our competitors are only talking about, and the development of a portfolio of key partners in order to be able to provide our clients with a comprehensive, fully integrated solution.

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