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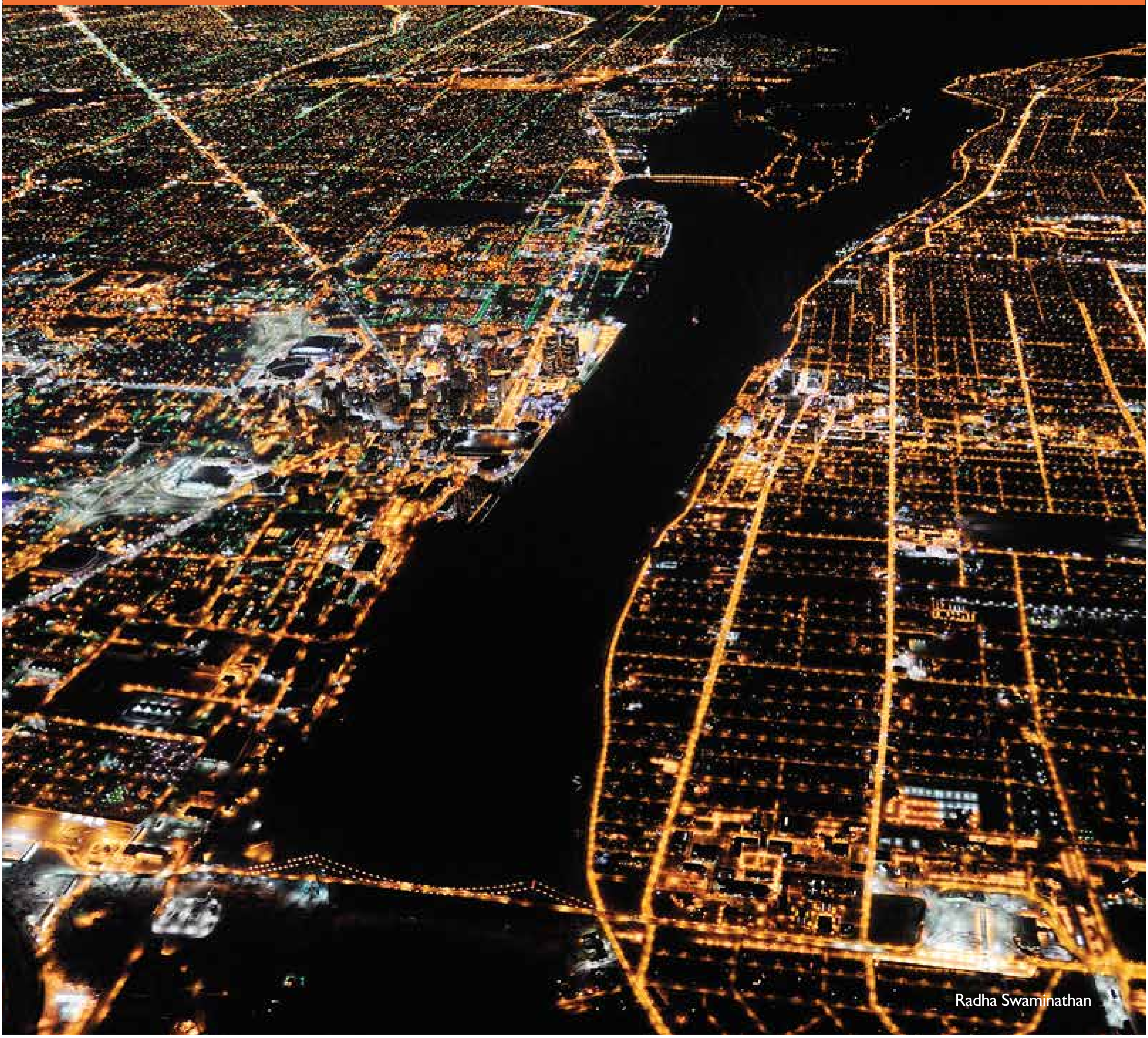
SMART GRID AND UTILITY TRANSFORMATION

A look at transitioning electric utilities into the 21st century.



Radha Swaminathan

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Abstract

The emerging market forces, impacting global utility landscape, will necessitate accelerated business transformations. However, the diversity of individual utility requirements will not allow for a one-size-fits all approach to transformation. Instead, utilities should pursue a competent and compatible value-driven approach that will deliver sustained results.

This paper presents a broad road-map and 'the big four' recommendations that can help realize sustained value with smart grid implementations. Additionally, it highlights key guidelines to realign, and transition, legacy architectural components and ease smart grid implementations.

Introduction

Transformative forces of disruptive economics and digital innovation will shape the 21st century utility, leading to consumerization of energy. Amidst several regulatory, environmental and capital market constraints, major electric utilities will lead transformation by employing differentiated processes, emerging technologies and data driven innovation. Aging infrastructure, aging workforce, constraining operating budgets, increasing security mandates and disruptive weather events will force utilities to employ innovative technology solutions and minimize operational risks.

Consumer driven self-sufficiency and cost effective renewable energy will challenge the legacy of building more conventional generation in order to meet growing demand. Efficiency is likely to emerge as a cost effective energy resource, seamlessly tying in with the consumer agenda of reduced bills and optimal usage. As in-home technologies mature, customers will gainfully adopt energy management solutions furthering segmentation and energy consumerization.

These emerging transformational epochs can be exploited in two distinct ways:

- Invest in a wholesale program to restructure operating models and operational processes.
- Or evolve incrementally by identifying and optimizing units of structure and process, few steps at a time.

The rate of technology churn and transient market structures lend easily to the adoption of an incremental approach and position utilities to sustain transformation over a period of time. Figure1 identifies a set of differentiated processes that can be leveraged by a utility to help define the transformation agenda.

Figure 1: Power up your portfolio: Differentiated business processes that can help build a transformation agenda.

CUSTOMER
- Customer centricity
- Multi-channel customer communications
- Energy management tools
- Customer outage
- Customer analytics

OPERATIONS
- Reliability improvements using smart grid data
- Conservation Voltage Reduction
- Micro grid management
- Crisis Management
- Smart Demand Side Management (DSM using customer profiles and smart grid data)
- Load forecast refinement using smart meter data
- Grid analytics and optimization
- Remote diagnostics and operations management
- Enterprise security management

EMERGING OPPORTUNITIES
- Home automation services
- Home energy management services
- Electric vehicle integration
- Differentiated rates and programs
- Revenue analytics

WORK
- Smart service work management using real-time data
- Advanced outage analysis and integration using smart grid data
- Smart work dispatch based on location services
- Risk based work prioritization

ASSET
- Utility scale renewable integration and hybridization
- Predictive, condition based asset maintenance using smart grid data
- Transmission planning to accommodate a range of future generation technologies
- Enterprise asset architecture and asset optimization
- Variable generation and unit committment

Four foundational pillars of transformation

High-performance imperatives to maximize value

It is important to prioritize and sequence the individual processes described in Figure 1 to sustain change with continued benefits. A utility can achieve game changing value and high resiliency by investing in the four foundational enablers: data driven innovation, customer centricity, enhanced cyber security and strategic crisis management.

1. Data innovation: Insights and foresights to enhance enterprise value

The analysis of real-time and historical grid data presents innovative insights to enhance enterprise value. However, there isn't a holistic set of processes, methods and tools available in the market place to implement data innovation. In the absence of a standardized architecture, the following guidelines should be adopted:

1.1 Pursue value based segmentation and prioritization of analytic opportunities

- **Revenue Analytics** identifies key prospects to minimize write-off, improve cash position and further the growth agenda. Examples include current diversion, uplift due to replacing slow moving meters and unidentified usage. For utilities that do not own generation facilities, Conservation Voltage Reduction may be choice in this category.
- **Customer Analytics** focuses on specific approaches and methods that deliver customer profiles, extract customer needs and highlight derived opportunities. Customer segmentation and High Bill analysis are primary examples of customer analytics.
- **Grid Analytics** encompasses methods to identify and exploit key processes that improve operational efficiency. Distribution outage optimization, asset optimization and improved load forecast are examples that fit this description.
- **Security Analytics** comprises methods that mine data to recognize abnormal behavior of devices and forewarn security breaches. An example would be to analyze smart grid network activity to predict emerging cyber threats.

The analytic outcomes can be prioritized using benefit estimates derived from sample data.

1.2 Integrate existing legacy reporting and data mining environments

Advanced analytics offers strategic frameworks to life-cycle manage conventional data reporting. However, utilities should evaluate the cost benefit before planning migration projects. Typical standardized reporting environments are institutional and entrenched in legacy architecture. In many cases, migration costs to newer architectures and change management costs may drive a negative ROI. Utilities should proceed with caution and lay out an end state architecture that can serve as a road-map for migration activities.

1.3 Develop a holistic architecture to enable enterprise analytics

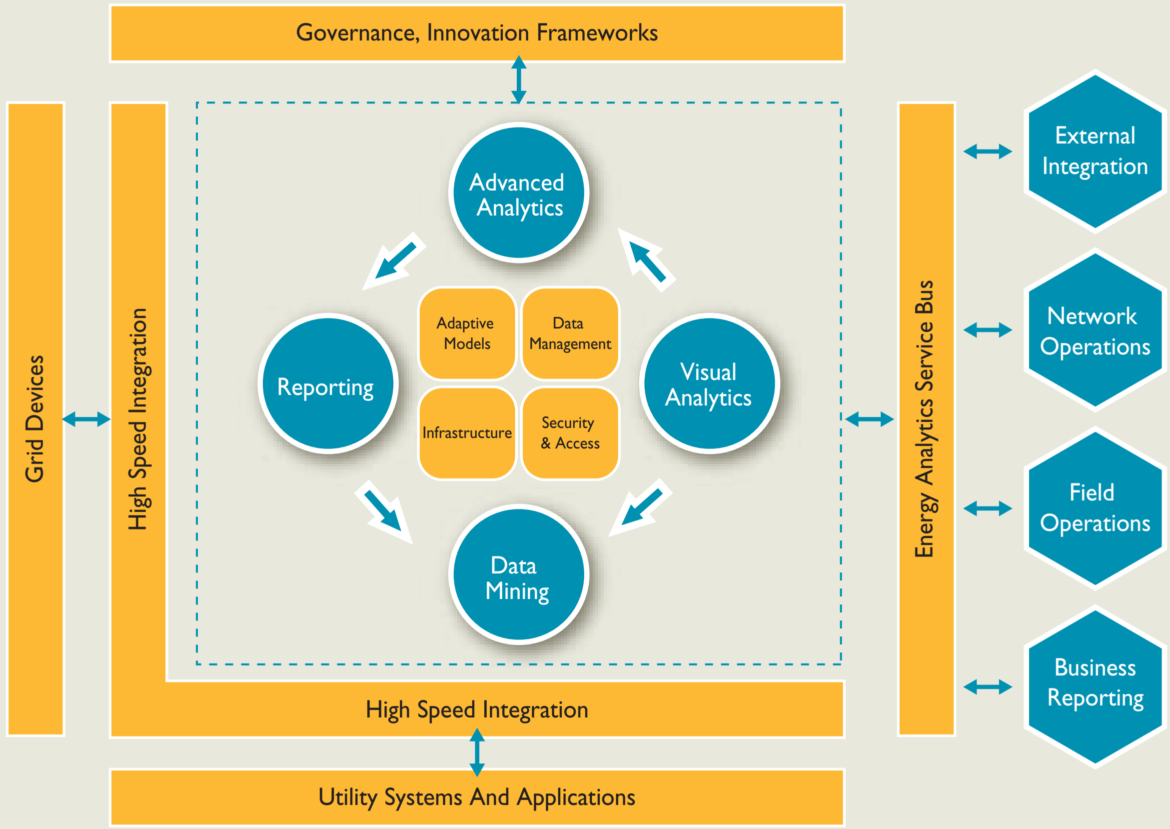
Utilities should invest in architectural models that can incrementally evolve and adapt to specific implementations. The architecture must take into consideration the following key aspects:

- Ability to harness emerging technologies and create data overlay solutions
- Agile methods for decentralized application development
- Data model agnostic data management tools
- Tools to capture and manipulate both real-time and historical data
- High performance computing environment
- High speed data movement technologies

1.4 Establish data governance

A strong enterprise governance to facilitate data innovation must be set up early in the transformation process. Governance committees should be adequately represented and owned by business units. Convergence on prioritization schemes and funding models will be a first step in aligning outcomes to benefit overall enterprise.
Figure 2 represents an enterprise analytics model that can be customized for specific implementations.

Figure 2. Enterprise Analytics Model



2. Customer centricity: Integrated customer information to improve brand value and market share

As digital society matures, consumers will expect more customized and content enriched information from utilities. Increasingly self-sufficient, they will digitally communicate and leverage social networks to shape brand value. As a result, consumers will compel enterprises to shift from infrastructure centric to customer centric communications that can effectively deliver personalized and actionable content. In order to effectively engage with customers, decentralized and silo'd internal customer data must be integrated, analyzed and organized for external delivery. The organized data can be used to build customer profiles and provide personalized energy information.

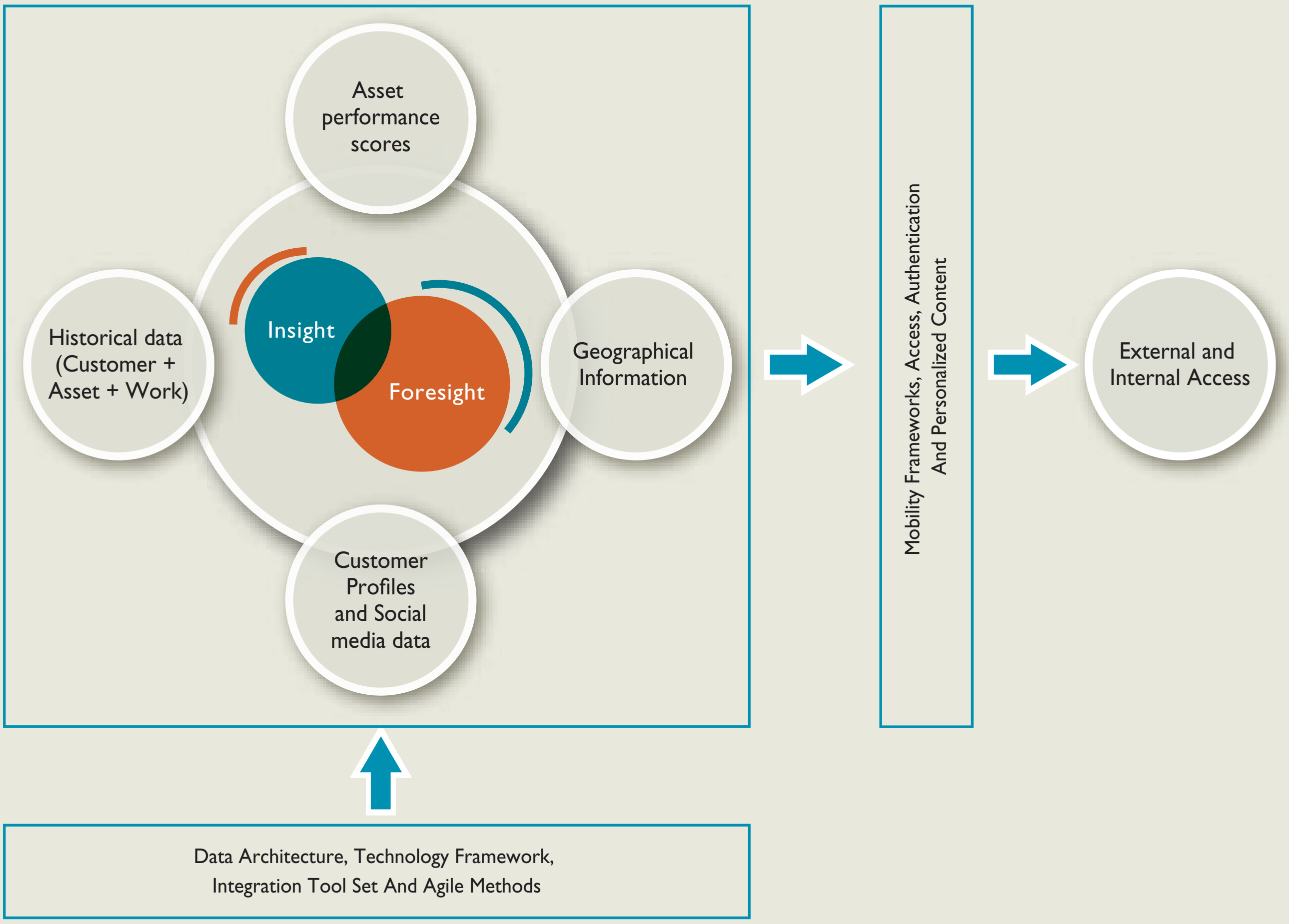
2.1 Provide customers with personalized energy information and conservation tips

Most utilities currently provide customers with access to bills, payments and consumption information to granular levels of data availability. However, the information is mostly a collage of data and burdens the customers to understand, interpret and optimize outcomes. Utilities should in-turn look at smart ways to consolidate, summarize, interpret and provide customers with actionable messages that can help optimize energy usage. Specific methods should include bill estimation, alerts on customer set thresholds, alerts on usage variances, weekly summary emails with conservation and efficiency tips and energy analysis tools. In addition, utilities should look to develop and deploy smart mobile apps that can exploit real-time and historical information to provide personalized advice on energy savings.

2.2 Provide utility personnel with a consistent 360 view of a customer

Domain integrated data can be distilled to score in-depth customer perception, painting a unique inside-out view of a customer. Field crews and care center representatives should be empowered with tools that provide a real-time access to such integrated data. The views must integrate reliability, bills, payments, contact and complaint history, service-work history, claims and asset performance data. In addition, the scores will drive a level of segmentation that can be further used to target specific customer satisfaction initiatives. This implementation helps proactively address service improvements, empower field personnel to manage customer expectations, and act on direct customer comments.
Figure 3 represents a customer centricity model that can be customized for specific implementations.

Figure 3. Customer Centricity Model



3. Enhanced cyber security: Transition from vulnerable to valuable enterprises

Digital grid devices increase the probability of cyber exploitation, an ever-growing threat to destabilize utility operations. In order to stay ahead of cyber-attacks, utilities should look beyond existing security mechanisms and proactively shape solutions to fit individual requirements. The current utility security architecture should be augmented to meet the following requirements.

3.1 End-to-end integrated security architecture

Smart grid devices extend digital technology into core electric grid and horizontally integrate several utility functions necessitating end-to-end security architecture. Such architecture must address security requirements for the entire value chain from generators to refrigerators. Industry recognized models such as ES C2M2 can guide architectures and the DOE & Industry sponsored NISTR 7628, ASAP –SG can provide a set of requirement guidelines.

3.2 End point security solutions

Grid devices, being end points in the electric infrastructure, can be subjected to both physical and cyber exploitation leading to a hostile takeover of key services. For grid devices web scale confidentiality, integrity and access control solutions that are periodically tested and hardened must be considered. Device firmware changes must be thoroughly tested for security functions, before they are released to production. In spite of technological advances and best process controls, there will always be a minimal, residual risk of single device exploitation. Security implementations must ensure that a compromised device can be identified at the earliest and isolated from the grid so that the impact can be contained to a single device or entity.

3.3 Smart meter security architecture

Smart meters communicate using varied networks and frequency bands. There is not a universal standard and every utility must take into consideration a set of prioritized security requirements for their operating domain. At a minimum, solutions must incorporate end-to-end confidentiality, data integrity and access control/authorization services. The solution must be able to segregate meter switch commands, consumer sensitive data transfers and network administration commands to implement a tiered security model. The decision to deploy distribution devices on the same metering network may drive additional requirements such as the ability to logically partition networks to ensure data separation. Utilities must define a holistic set of high-level requirements and ensure that the architecture and solutions meet the end state criteria.

3.4 In-home networks and security extensions

Market forces dictate the evolution of consumer in-home networks and utilities must partner with vendors to ensure that the solutions are secure and interoperable with grid infrastructure. It is imperative that meter, as an in-home gateway to a utility, is totally secure and the architecture is flexible enough to evolve with embedded security schemes in consumer devices. Security for emerging electric vehicles and roof-top solar (PV) must be considered early on as the retrofit could result in major changes to the previously deployed smart meters.

3.5 Extensions to information technology (IT) security

It is critical that utilities adopt open security architecture to accommodate dynamic changes in the IT environment. That said, it is not easy to extend conventional defense-in-depth models beyond the enterprise to field infrastructure. Thus models to detect intrusion and anomalous behavior in devices (and networks) along with models to predict cyber threats must be considered. In addition, integrated technologies should be utilized to strengthen security infrastructure. Examples include biometrics, embedded pattern recognition, high-speed security hardware, context aware authorization, and spatial-temporal aware intelligent identity management. Back office tiered data center implementations increase operational complexity and should be evolved along with the operational maturity of the enterprise. Existing security processes should be re-evaluated and extended to include smart grid elements.

4. Strategic crisis management: Transition from reactive to resilient enterprises

Recent trends in significant weather events, impacting electric infrastructure, is forcing utilities to look for a broader set of solutions, process models, communication schemes and scalable resource models to successfully manage such intense circumstances. The ability to handle all aspects of a crisis will bear a direct connect with stakeholder satisfaction and higher brand value. A crisis management execution model calls for detailed communication schemes, reasonable damage estimation models, dynamic work dispatch tools, predictive time to restore algorithms and asset classification schemes. A full scale solution must incorporate the following features:

4.1 Manage stakeholders

In a widespread damage scenario, utilities will have to manage a spectrum of stakeholders with different sets of expectations. While regulators focus on performance, municipalities, city officials and political groups expect effective communication on restoration schedule. The process and solution models should provide automated status updates to this group. Early in the process, utilities should seek to draw in stakeholders and prioritize restoration.

4.2 Manage communications

Timely and consistent communications of time to restore (TTR) is essential in engaging stakeholders during the entire restoration process. TTR messages must be geo-political centric and specific to commercial, critical and residential customer segments. Since the extent and pattern of damage, dynamic resource availability and restoration prioritization dictates TTR estimates; adaptive genetic algorithms should be considered over statistical predictive models.

4.3 Employ smart work planning, scheduling

The order of restoration will be dictated by the extent of damage and utilities should be prepared to dynamically prioritize and dispatch to meet societal needs. In many cases, the early focus may have to be on key infrastructure facilities such as gas stations and grocery stores to quickly restore normalcy. Also, utilities may have to balance normal operations in non-impacted areas, while focusing on intense restoration in affected areas.

Technology should be deployed so that real-time updates on restored facilities can be obtained and communicated. Considering the likely impact on day-to-day technology in a crisis situation, it is important to be prepared with alternate solutions for field enablement such as: special communication devices, vehicle area networks, integrated spatial overlays, multi-function tablets, localized and pre-loaded electric network maps, and easy-to-use work management forms. Crowd sourcing many aspects of damage estimation and restoration status will enable societal participation and reduce total costs.

Figure 4. Strategic Crisis Management Model

Setting the architectural framework

Key considerations to position your business for the future

Successful transformations should incorporate a strategy to include new technologies and solutions, while preserving legacy architectures. The following guidelines can be effectively applied to incrementally evolve legacy architectures to meet transformational goals.

1. Evolve component architecture and service. Emerging smart devices will directly embed process elements, compelling major business functions to be an aggregation of distributed components. For example, initial data validations can be performed right within a smart meter, distributing the pre billing validation process across the infrastructure. Therefore, smart device deployments must be complemented with modular software components at the back office to help integrate the process steps.

In order to build, integrate and realize component architecture, service frameworks must be considered. The existing legacy applications should be wrapped and exposed as common services that can be integrated with newer components. These frameworks provide the glue to extend the life of legacy applications and minimize life-cycle investments.

2. Manage decentralized technology and application development. The set of digital devices implemented in the operating domain (Generation, Transmission and Distribution) offer a unique opportunity for the corresponding business units to develop, control and manage specific application components. This scenario can lead to an unmanaged proliferation of redundant components, which over a period of time can increase IT debt and complexity. Utilities must implement common app stores, standardized application frameworks and industrialized agile development methods to ease transition and minimize long-term life-cycle impacts. Investment in change management will be essential to drive adoption and adherence during the transition period.

3. Govern technology and partnerships. The purchase and implementation of technology will be decentralized as operating devices continue to integrate digital components. In order to maximize the value of investments, utilities should implement enterprise governance that can help drive standardization and optimal utilization of such investments. Governance committees involving business owners and enterprise architects should prioritize technology investments and minimize vendor footprint.

Managing cost vs. complexity. While service frameworks can be leveraged to implement component architecture, utilities should drive for optimal number of components to minimize complexity. Adopting agile methods will minimize the cost of individual component delivery, but a large number of components will increase life-cycle debts over a three to five year timeframe. Alternatively, a utility can decide to enhance user interaction through a set of apps managed by an enterprise app store. This will provide a cost and complexity shield and minimize changes to enterprise applications.

Conclusion

This paper identifies a set of emerging processes that a utility can pursue as part of their transformative journey, fueled by digital technologies. To offset the initial phase, utilities should master the new approaches in data driven innovation and customer centricity to enhance enterprise value. In addition, cyber hardening and crisis management should be matured to achieve enterprise resiliency and business excellence. These four fundamental pillars will help utilities leverage more out of the utility grid and minimize business disruption. The architecture principles discussed will help utilities mitigate technology obsolescence and gain long-term value. Utilities should recognize the fundamental shift in society and the business environment, and capitalize on emerging technology solutions to improve their market position and minimize operational risks.

About the Author

Radha Swaminathan currently serves as Vice President and CTO for Energy, Natural Resources and Utilities (ENU) business unit of Wipro Technologies. The ENU business unit is among the fastest growing strategic business units and focuses on providing solutions and integration services to Oil & Gas and Utility clients. As CTO, Radha is responsible for future industry blueprints, customer co-innovation, technology innovation, solution development and strategic alliances.

Wipro's Energy, Natural Resources & Utilities Business

Wipro's Energy, Natural resource and Utilities (ENU) Strategic Business Unit (SBU) has over the last decade established itself as a trusted partner to clients across the globe to address their business challenges using its deep industry domain competency and technology expertise. It has over 6600 dedicated consultants serving businesses in the oil & gas, metals, mining, agriculture products, water, natural gas and electricity industries. Having a strong relationship with over 40 customers spread across Americas, Europe, India, Middle East, Southeast Asia, Australia and New Zealand, the ENU SBU has been continuously investing in building competencies to help them do business better. Recently, Wipro has acquired SAIC's Global Oil and Gas business unit, reinforcing its focus on this industry.

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