Tools for Real-Time Business Integration and Collaboration

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***Abstract*—Business integration platforms (aka middleware), enable companies to improve integration of information systems, integration with partners, automation of business processes and workflow, and real-time visibility into the operations. Middleware is an important component in building a flexible, scalable, fault tolerant, secure, standards-based, IT architecture. It reduces application development and maintenance costs, and it allows best-of-breed application deployment where systems can be expanded incrementally by plugging in new applications into a message bus. As such, it positions utilities to manage business structure and business process changes introduced by wholesale and retail deregulation. Over 100 utilities and two ISOs have already acquired middleware, and many have successfully applied it. Applications include back-office applications integration, trade floor applications integration, integration with energy exchanges, eProcurement, retail applications integration, and T&D mid-office integration. Reported experiences have been very positive. Applications of middleware to real-time control and distributed resources integration are yet to come.**

***Index Terms*—Computer applications, Distributed information systems, Information technology, Internet, Open systems, Power industry.**

I. Nomenclature

Enterprise Application Integration (EAI), Business-to-Business integration (B2Bi), Business Process Management (BPM).

II. Introduction

To maintain competitiveness, companies in all industries are moving quickly to capitalize on the Internet as a medium for business integration. Successful companies efficiently integrate people, processes, and partners to achieve total business integration and superior business performance. They integrate disparate computer systems in the entire enterprise, from front-office customer service to back-office financial systems, so that the systems can communicate together in real-time. They also integrate electronically with business partners to improve business-to-business transaction processing. They provide people with an integrated and real-time view of all the information they need to make better decisions faster. Most importantly, they automate business processes involving computer systems, people, and partners to streamline operation, integrate the supply chain, and enable real-time business collaboration. Such real-time, total business integration is best achieved by using a commercially available business integration (software) platform, often referred to as middleware.

Integration is typically the number one priority for Chief Information Officers who are responsible for creating a business-responsive information technology infrastructure. Use of commercial middleware software has become particularly popular now that many companies in multiple industries have reported favorable return on investment (ROI) in commercial middleware tools.

The need for real-time business integration and collaboration in the (electric) utility industry has been high and is intensifying. A typical utility company has dozens of major business systems, totaling several hundred individual applications, often poorly integrated with one another. Quite often a company is compelled to improve integration due to a major change driver such as deregulation or merger, which justifies investment in middleware to improve the information technology architecture. There is evidence that as many as 100 utilities world-wide have already undertaken EAI and B2Bi initiatives, with an increasing number reporting favorable experiences. In some segments of the utility industry, such as trading floor, use of commercial middleware has been pervasive. While the reported business integration initiatives are encouraging, the implementations are often relatively simple in scope, leaving much potential for future applications.

In this paper we first present a view of today's reality of integration in the utility industry where the bulk of integration is through point-to-point links and much of business-to-business communications are based on phone, fax, and mail. We then outline some of the key business drivers for improving business integration in the utility industry. Next we present a brief overview of the tools that can support business integration and collaboration; namely the business integration platforms. We discuss how these tools are used for enterprise application integration (EAI), business-to-business integration (B2Bi), and business process management (BPM). Finally we present the state-of-the-art in application of EAI, B2Bi, and BPM in the utility industry, other potential applications, and the benefits of middleware.

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III. UTILITY INTEGRATION--TODAY'S REALITY

A. Integration Within the Utility's Firewall

Major applications in the utility industry are depicted in Fig. 1, for six segments of the industry—Generation, Transmission Wires, Distribution, Trading/Scheduling, System Operation/ISO, and Retail. The significance of the shading used in Fig, 1 will be discussed in section VII.

Each major application in Fig. 1 may represent a tightly integrated package, or a number of individual applications that are somehow interfaced together, or not interfaced at all, requiring manual duplication of data from one application to another. In most cases applications are integrated as illustrated in Fig. 2, posing the following major business problems:

- Applications are tightly coupled using hard-to-maintain, fault-prone, point-to-point links, making system changes and maintenance costly. As an example, replacing the "Metering" system in Fig. 2 involves replacing the four links that ties this system with Maintenance, Planning, Settlement, and Scheduling.

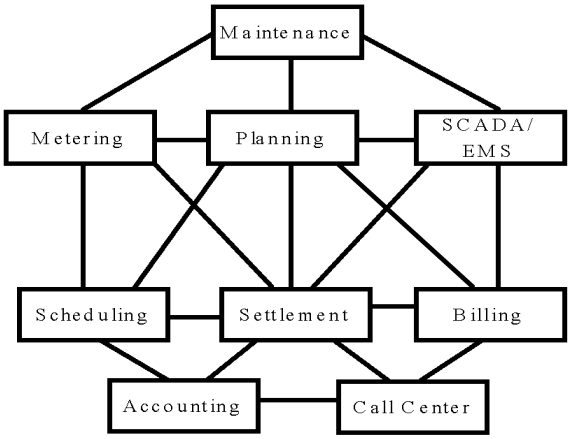

Fig. 2. Integrating applications via point-to-point links.

- Some applications do not efficiently communicate with others (e.g., There is no automated interface between Maintenance and Scheduling in Fig. 2), resulting in:
  - Manual processing of information
  - Erroneous information
  - Inconsistent information in various databases
  - Real-time events (e.g., outages, new orders) do not reflect in all systems immediately.
- It is difficult to have real-time access to information trapped in various systems to make timely decisions.
- Business processes such as outage management that involve multiple systems, cannot be automated.

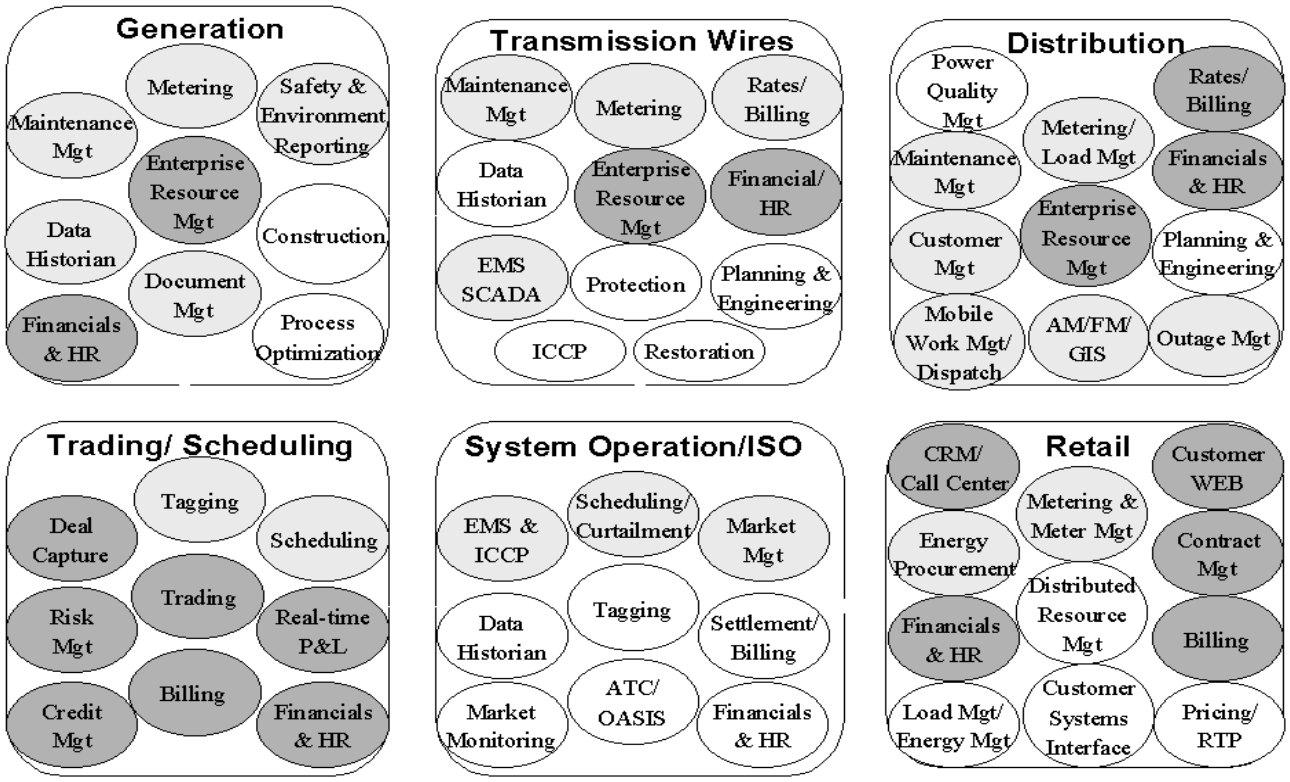

Fig. 1. Major application groups in six segments of the utility industry.

B. *Integration Outside of the Utility Firewall*

Utilities need to communicate with many business partners including those depicted in Fig. 3. Today, many of these communications are by phone, fax, and mail. These manual processes are not only inefficient but also error prone. It is also impossible to automate B2B transactions such as procurement, invoicing, and bill payment if the company cannot communicate electronically with the business partners.

Some of the B2B financial transactions, such as commercial billing, are performed electronically over value-added networks (VAN) using X12 or EDIFACT Electronic Data Interchange (EDI) standards developed in forums such as the Utility Interest Group (www.UIG.org). Real-time measurement data is often communicated using IEC and/or IEEE standard protocols, such as the Inter-control center communication protocol ICCP [1]. Note that technologies such as VAN and ICCP are basically point-to-point communications, are inflexible, and are not particularly conducive to business process automation and collaboration among business partners (e.g., execution of a long-running muli-step business transaction including multiple partners, such as the process of electronic tag submission and approval).

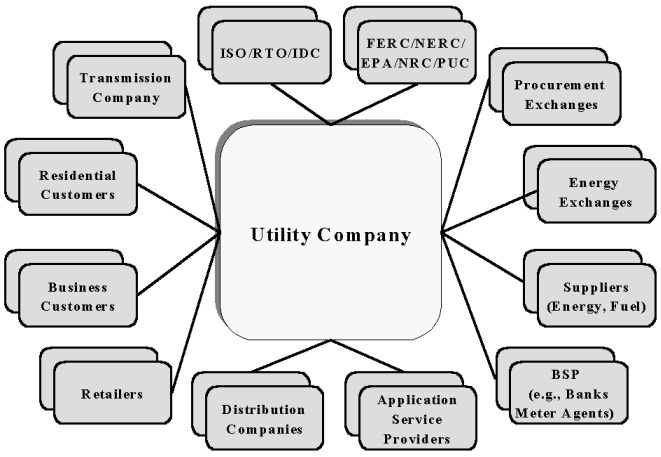

Fig. 3. Business-to-business communications.

Integration of internal applications, integration with business partners, and real-time visibility into operation must be improved because of a variety of change drivers such as those described in the next section.

IV. NEED FOR TOTAL BUSINESS INTEGRATION AT UTILITIES

Some of the key factors that are driving the need for improving integration and real-time visibility in the utility industry are:

A. *Cost Savings*

The most basic reason for improving integration is cost saving. According to reports from reputable information technology companies such as IBM, Gartner, and Forrester,

1. 70% of all code written today consists of interfaces, protocols and other procedures to establish linkages among various systems
2. 30% of entire IT budget is spent on building, maintaining, and supporting application integration
3. Use of a modern integration platform would reduce application implementation costs by one-third and the application maintenance costs by two-thirds

Several case studies in the utility industry seem to support such claims. As an example, Scottish Power reports a documented 400% ROI on middleware [2].

B. *Wholesale Power Market Deregulation*

Deregulation of wholesale power markets around the world gave birth to power trading and real-time risk management. This triggered the need to integrate the Trading/Scheduling applications in Fig 1. For many power traders who trade multiple products, such as power, gas, metals, financial derivatives, the scope of integration spans multiple trading and risk management systems supporting each product. Since traders need to know their overall position risk in real-time, the need for real-time communication among trade floor applications has been high.

C. *Retail Market Deregulation*

Retail deregulation, wherever present forces the utilities to address the major integration issues involved in customer switching. Utilities facing retail deregulation also need to improve business integration to be able to provide web-based customer self-service and offer new services such as real-time pricing in a competitive market.

D. *Unbundling of the vertically integrated supply chain*

In most deregulation scenarios around the world, transmission operation is unbundled and given to one or more independent system operators (ISO). Secure operation of power systems mandates real-time communications, business process integration, and collaboration among ISOs, the utilities, and the other market participants. Coordination of equipment maintenance outage is an example where collaboration among generation owners, control areas, and the ISOs is required.

E. *Mergers and Acquisitions*

Merged utilities typically end up with many duplicate systems (e.g., call centers) that need to be integrated seamlessly.

F. *Convergence with Other Industries*

Mergers of power utilities with other companies such as gas, water, home security, and telecommunication services companies creates the need to integrate some of the underlying applications to create a 360 degree view of the customer.

G. Higher Reliability for Digital Economy

Digital users require much higher quality of electricity. Some experts indicate that reliability will need to go from 99.9% (roughly 8 hours of power loss per year) to 99.9999999% (32 seconds of power loss per year) [3]. EPRI envisions that electric system of the future will need to leverage the newest communications and distributed computing technologies available to provide an interoperable and inter-workable foundation for advanced customer communications and a self-healing grid. The self-healing grid will integrate real-time information from embedded sensors with distributed intelligence and automated control to achieve a power system that can anticipate problems and quickly recover from disruptive events, including terrorist attacks on the electric infrastructure [4]. Achieving EPRI's vision would require an industry-wide business integration encompassing all elements of the utility industry intelligent equipments and applications.

H. Integrating Distributed Resources

Energy users need to be linked to markets, enabling real-time pricing, customer energy management and innovative energy services. This requires advanced revenue metering, power quality monitoring, and two-way, real-time, communications between utilities and customers [5].

V. The Business Integration challenge

Typically, companies first start looking at business integration when they have a simple integration problem to solve. For example, a company may want to look at data-oriented enterprise application integration (EAI) solutions to consolidate information from its internal systems into a full view of the customer in order to make customer relationship management (CRM) more effective.

Alternatively, it may want to implement a data-oriented business-to-business (B2B) solution that will send orders to a vendor. Then, as its business requirements become more complex and more sophisticated, it will need to extend and build on previous integration work to create a more comprehensive business integration solution.

It is, however, by no means easy to complete the transition to total business integration. Even the implementation of point solutions along the way can be labor-intensive and time-consuming. The process of integrating the company's internal information systems can require a great deal of effort if it involves a heterogeneous assortment of packaged and custom applications. The same applies to automating all the processes that coordinate interactions with customers, employees and business partners. Furthermore, business managers need to continuously analyze these processes in real time so that they can adapt them to support the changing needs of customers. Business processes also have to be tied to the company's information infrastructure. High levels of security and reliability must be observed when exchanging business information.

To meet these challenges, companies need a comprehensive business integration platform. Such a platform provides support for real-time business interactions over both internal and external networks. It makes it much easier to automate core business processes across multiple systems and to extend these processes to business partners where appropriate. Scalability is an important feature because the total solution is built up gradually, often from small beginnings.

VI. Elements of Business Integration Platform

A business integration platform usually involves several elements, as depicted in Fig. 4.

For most companies, business integration begins with EAI. EAI solutions consist of an internal middleware layer that connects business applications with one another across the local-area network or intranet, regardless of differences in data formats. It ensures that data can move between these applications easily. EAI is typically based on anonymous publish/subscribe messaging technology, where applications publish messages to a message bus and/or subscribe to certain messages on the message bus. The message bus can provide guaranteed delivery of the messages to the subscribing applications. A federated architecture often ensures flexibility, scalability, and fault tolerance. The adapters include advanced transformation capability, and the SDK to connect to various legacy systems. Off-the-shelf adapters for popular applications are available from vendors.

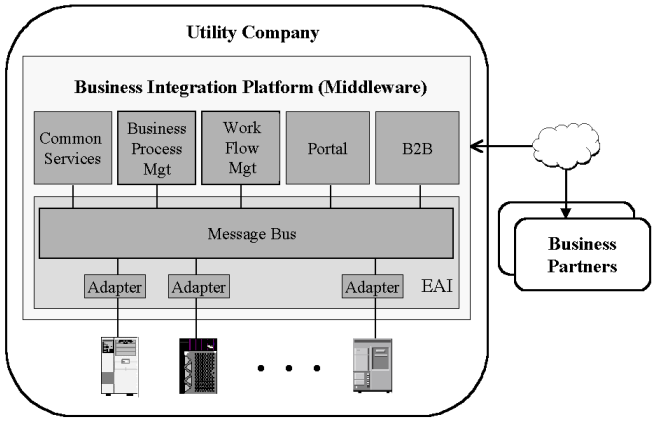

Fig. 4. Business integration platform.

EAI can be used to link core business applications in areas such as marketing, customer service, procurement, finance and human resources. It provides an effective way of aligning multiple enterprise resource planning (ERP) systems, whether these are independent applications or different versions of the same application. It is equally applicable to newer solutions such as risk management tools, portals, forecasting tools, geographic information systems (GIS), executive information systems or workforce dispatching tools. EAI is often used to achieve a "single view" of customers or business areas, and it

may be accompanied by the establishment of portals that provide a common user interface to heterogeneous systems.

B2B integration (B2Bi) extends the scope of EAI to encompass the reliable and secure exchange of data with external business partners and suppliers. The medium for this exchange is of course the Internet or, in the case of an electronic data interchange (EDI) solution, the value-added network (VAN). Most financial transactions are likely to use EDI or XML standards, and there may be a need to convert transactions from one of these formats into the other.

A variety of B2Bi applications are available for the utility industry. They support integration with a wide variety of entities, including procurement exchanges, energy exchanges and financial exchanges, as well as customers, suppliers and other partners. They can support data exchange with government agencies, industry groups, other companies and other industries. In some cases, they may be accompanied by the implementation of an electronic storefront for customer self-service, partner self-service or employee self-service.

Neither EAI solutions nor B2Bi solutions incorporate the ability to control and manage the flow of information and transactions from a central point. The underlying applications merely push and pull data as instructed; they have no understanding of the overall business process. Because of this inability, most business integration platforms require another important element, known as business process management (BPM).

BPM provides the intelligent business processing logic that is required to coordinate and monitor the exchange of information and transactions with business partners and internal business applications. Although it is possible for companies to create their own bespoke applications for BPM, this involves lengthy development periods and complex coding, and is usually very expensive. The alternative is to apply a BPM tool that can be used to graphically define and then control the flow of data among internal and external applications. Should the processes involved have to be adapted or fine-tuned, only the graphic model – and not the underlying data structures – will need to be changed. Effective BPM solutions enable very large volumes of business transactions to take place quickly, securely and at low cost.

For power companies, BPM can help to automate processes such as procurement, transmission reservation, scheduling, outage management, maintenance management, billing, settlement, environmental compliance, and project management. It can also automate whole groups of processes such as offer-to-order for bidding and scheduling of energy with an ISO, as depicted in Fig 5.

Most middleware packages provide a set of Common Services to support Meta Data, Naming, Transaction, Recovery, Security, Audit/Logging, and Partner Registration.

Taken together, EAI, B2Bi, and BPM enables business collaboration, facilitating real-time execution of complex business processes allowing business partners and

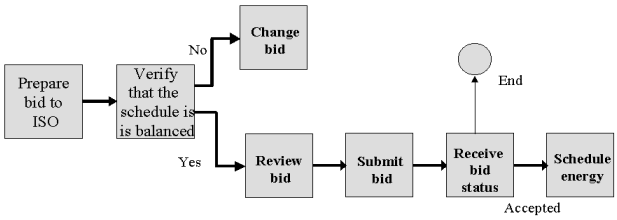

Fig. 5. Example of BPM.

applications to work collaboratively. Such integration enables greater control and visibility of a company's value chain, both within and across the extended enterprise. Prime examples of where EAI, B2Bi and BPM could be applied to enable collaboration are:

- Business collaboration among retailers and distribution wire companies to enable automatic processing of new connection requests and customer switching.
- Collaboration among entities involved in the Meter and Meter Data Management process depicted in Fig. 6, for meter installation and meter reads.
- Consolidated billings in a deregulated market as depicted in Fig. 7.

Several companies offer business integration platforms, and industry analysts regularly rank these platforms. Leading vendors include IBM, TIBCO, SeeBeyond, Vitria, and WebMethods. Systems integration companies offer assistance with product evaluation and selection.

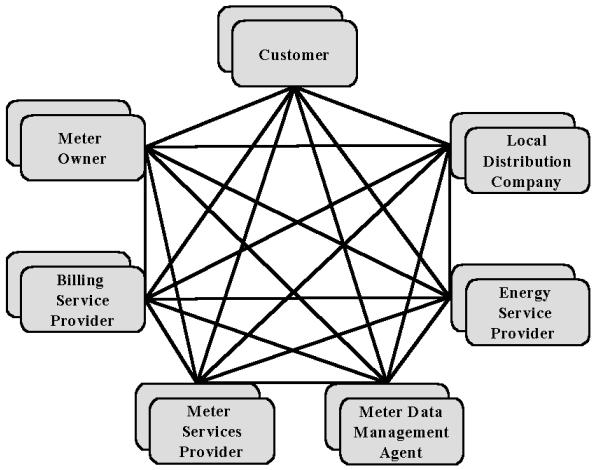

Fig. 6. Collaboration example: Meter & Meter Data Mgt.

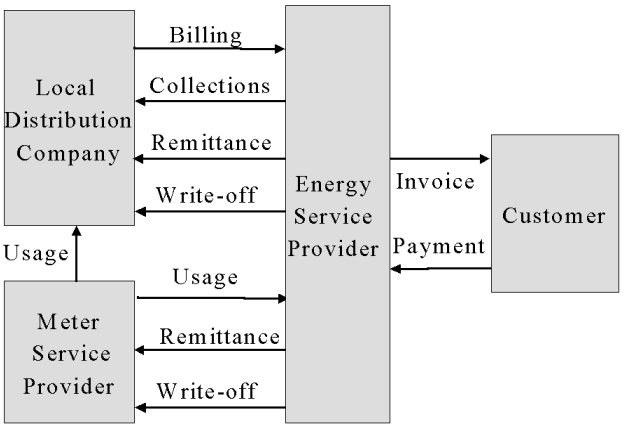

Fig. 7. Collaboration example: Consolidated billing.

VII. State-of-the-art in utility industry integration

Business integration platforms have been applied in different segments of the utility industry, driven by the key integration business driver for that segment summarized in Fig. 8. Note that the business drivers for integration are not the same in different segments.

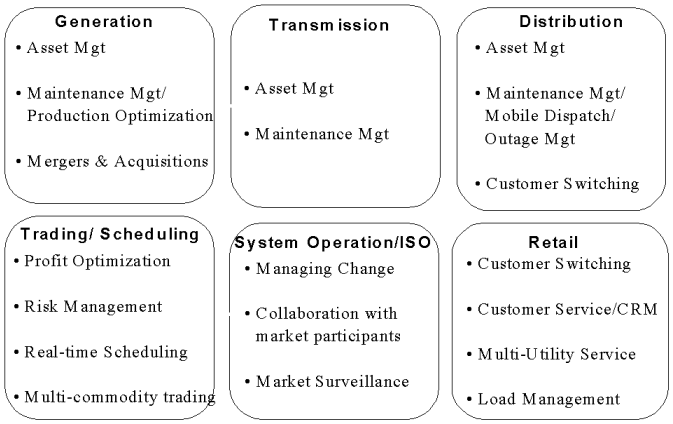

Fig. 8. Business drivers for integration in different segments of the utility industry.

Many trader/power marketers have applied business integration platforms to integrate systems for credit management, power trading, gas trading, and risk management, and to interact with energy exchanges. Indeed the use of commercial middleware packages on the energy trading floors has been pervasive, mirroring the extensive application of middleware in the financial industry and security trading.

Several generation companies have integrated real-time historians to bring real-time operations data from their plants to the trading floor so that the traders are aware of the available production and transmission/transportation capacities and incremental costs. They have also successfully implemented portal/executive dashboards to provide key performance indicators to their executives worldwide.

A number of transmission and distribution companies have also applied commercial middleware.

Southern California Edison has deployed a business integration platform as the foundation for an "information bus" that connects business-critical applications for outage management, power management, and distribution management. The new platform enables information from these disparate applications to be shared throughout the enterprise [6].

Florida Power and Light (FPL) is applying EAI to integrate a Distribution Management System (DMS), a new System Control Center (SCC), and a new Asset Management System (AMS) [7].

PacifiCorp's implementation of an Integration Bus aimed at integrating Customer Information System (CIS), Enterprise Resource Planning (ERP), Work Management, Geographic Information System (GIS), and Supervisory Control and Data Acquisition (SCADA) is reported in [8]. EPRI's Common Information Model (CIM) is used for common language for application information exchange and persistent storage [9].

Several retail energy service providers are integrating applications for customer care, contract management, and billing, and exchanging data with generation companies, distribution companies, and exchanges. A number of companies have successfully applied commercial middleware for managing the exchange of customer data with other companies in a deregulated market setting.

At least two Independent System Operators (ISOs) in US have applied commercial middleware to re architect their existing systems and enable future incremental upgrade and best-of-breed application acquisition.

Integration platforms are relatively complex software systems. Most successful business integration projects have involved assistance from experienced systems integrators with the upfront integration architecture, middleware installation and tuning, and program management. Attempts to integrate too many systems all at once without prior experience are often the root causes of the failed projects. Integration methodology and standards based on best practices also need to be developed and applied corporate wide with the support of a core architecture team set up to enable total business integration.

A series of standards to enable utilities to accomplish their objectives for EAI and integration B2Bi is being developed by various Working Groups of IEC TC57. These standards will be published as IEC 61968. The Common Information Model (CIM) has been developed by and continues to be extended by

Working Groups 13, in collaboration with the EPRI Control Center Application Program Interface (CCAPI) Project and the Open Applications Group (OAG). The CIM represents all the major objects in an electric utility enterprise. The model includes public classes and attributes for these classes, as well as the relationships between them [9].

Fig. 1 provides an aggregate view of the state-of-the-art in integration of application groups in the utility industry. The various applications are presented in three categories distinguished by the shading used, signifying the following:

- Applications that many utilities have successfully integrated using commercial middleware are shaded in dark gray (e.g., Financials/HR).
- Applications that leading utilities are just trying to integrate using commercial middleware are shaded in light gray (e.g., maintenance).
- Applications that have not been integrated using commercial middleware have no shading (e.g., distributed resource management).

Some observations regarding Fig. 1 are:

- Traders have embraced middleware
- Retailers are also rapidly adopting the technology
- Transmission companies and ISOs are beginning to adopt.
- Mid-office integration (e.g., maintenance, mobile dispatch) is lagging behind font-office (e.g., CIS) and back-office (e.g., Billing) integrations.
- Application of middleware in real-time control and telemetry is significantly behind business applications.

Despite the exciting applications of middleware in the utility industry, the electricity industry as a whole has been very conservative in its approach to business integration technology. Most of the applications in use are limited in scope and do not make full use of the capabilities of the technology on which they are based. In particular, business process management is grossly under utilized. A few leading utilities have begun taking advantages of BPM for the following applications:

- Straight through processing of trades from Trading System to Scheduling.
- Straight through processing of customer interactions from a new CRM system to an existing CIS/Billing.
- Straight through processing of customer trouble calls (Integration of Customer Information System-Outage Management System-Work Management System).

The next phase of implementations should take advantage of the vast potentials of BPM in business process automation and business collaboration to achieve far greater levels of automation than has been realized today.

Companies in other industry areas such as financial industry telecommunications, high-tech manufacturing, and health care, having been subjected to competitive pressures for much longer, are making far more sophisticated use of business integration platforms. For example, many leading telecom service providers have successfully deployed business integration platforms to significantly automate business processes for service provisioning, service assurance, and convergent billing of a multitude of telecommunication services. Analogous applications in the utility industry, such as automation of business processes for provisioning of multi-utility services, outage management, and convergent billing are still in mostly in pilot phases.

Potential applications of the business integration platform in the utility industry are summarized in the Appendix.

VIII. Benefits

With business integration platforms, utilities have the opportunity to automate their processes to a degree that was not possible in the past. These platforms support the seamless integration of computer systems and business processes throughout the electricity value chain, enabling eBusiness and collaboration among business partners. Some of the specific benefits to utilities are:

- Increased ability to implement planned changes in the existing systems, integrate the needed new systems, in the time frame needed, and react to the changing deregulation.
- Protecting the investment in legacy systems and prolonging their lives
- Increased operation efficiency and workforce productivity through
  - --Automation of business processes and work flow (e.g., energy bid preparation, settlement, billing, payment processing, maintenance, procurement, inventory management).
  - --Reduction in manual data entry and errors
  - --Higher accuracy and consistent information
  - --Timely access to information
  - --Real-time visibility into events (e.g., outages)
  - --Customer self-service via customer portal
  - --Employee self-service via employee portal
- Visibility into operation and real-time Key Performance Indicators via operation/executive portal.
- Increased customer satisfaction by meeting customers' demand for information.
- Potential for increased revenues through better access to power market data in real-time, and quickly reacting to changes.
- Lower IT interface development cost, interface maintenance costs, and application monitoring costs.
- Increased information security, and the ability to implement sophisticated communications and physical security.
- Increased ability to "plug-and-play" "best-of-breed" applications.
- Increased flexibility to outsource specific applications or business functions.
- A scalable, fault-tolerant, high performance, flexible IT architecture responsive to business changes.

IX. Conclusions

There are compelling business drivers for real-time, total business integration in all industries including utility industry. Modern business integration platforms (i.e., "middleware) provide efficient tools to achieve such integration. Leading companies in the utility industry have applied commercial middleware in different segments of the utility industry for a variety of business reasons. Several utilities have reported very favorable experiences and have documented ROI. These experiences and the experiences from other industries all suggest that commercial middleware packages are very likely to become part of the information technology infrastructure at most utilities in not too distant of a future. While the reported success stories are encouraging, all in all the technology is under utilized in the utility industry. Potential application of middleware software to improve business performance and business collaboration in the utility industry is an exciting area for exploration. Two important areas of future research and development are 1) application of middleware in real-time control of power systems, and 2) integration of distributed resources.

X. Appendix

Modern commercial middleware packages have many applications in the utility industry including:

1. Making existing IT infrastructure more robust:
    a. Making data/file transfers transactional
    b. Making applications more fault tolerant
    c. Better exception management
    d. Better failure recovery
    e. Easier systems maintenance
    f. Easier change management
    g. Better security
2. Better integration of various applications in Fig. 1
3. Integration of new applications needed, such as: risk management, GIS, or data warehouse
4. Integration with business partners depicted in Fig. 3
5. Implementation of an electronic storefront for customers, partners, and employees
6. Automation/management of specific business processes such as procurement, transmission reservation and scheduling/balancing, outage management, maintenance management, customer relationship management, settlement and billing, document management, compliance with environmental regulation, construction project management, inventory management, invoicing, expense reporting
7. Streamlining workflow (e.g., Review and approval of requests to take equipment in and out of service, Trading transaction approvals, Purchase orders).
8. Providing visibility into the enterprise: (e.g., new connection requests, Inventory, forecast, equipment outages, real-time data, number of customers out of service, key performance indicators).
9. Providing "single view" of critical entities such as customer and assets.
10. Managing the outsourcing of a specific application or function (e.g., Billing, Maintenance, or Accounting).
11. Alignment of multiple systems
    a. Same application from different vendors (e.g., SAP, JDEdward, Oracle)
    b. Different versions of the same application
12. Information integration:
    a. Integrating financial data with engineering data
    b. Presenting key information to the executives
    c. Logging and archival of events
13. Portal implementation to present users with a common user interface to heterogeneous systems (e.g., ERP and SCADA)
14. Supply chain management:
    a. Visibility into upstream
    b. Visibility into downstream
    c. Collaboration among streams for supply chain optimization
    d. Flow through power or gas marketing (nomination) and scheduling
    e. Integrated demand planning
15. Bringing new services to market (e.g., RTP)
16. Managing mergers and acquisitions:

XI. References

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