Use of the CIM Standard for Managing Assets at the Long Island Power Authority

Dr. Predrag Vujovic, Member, IEEE, and Greg Robinson, Member, IEEE

Abstract— The Long Island Power Authority (LIPA) requires accurate and accessible data to optimally manage its assets as well as its service providers. From LIPA's perspective of an asset owner and manager, four key performance areas must be considered: technical performance (such as reliability of assets and system), financial performance (cost and revenue), customer satisfaction, and regulatory compliance. Data stemming from each of these areas is interrelated and needs to be understood in the context of the whole. Therefore LIPA prefers vendors and service providers to fit their systems into LIPA's enterprise based upon predefined and well-documented interfaces. To optimize cost and efficiency, these interfaces need to be based on useful industry standards. One such standard is the Common Information Model (CIM), which has been used on several projects in recent years. While these projects have achieved most of their project goals, there is still significant room for improvement regarding company-wide data flow objectives. Consequently, LIPA has recognized that Service Oriented Architecture (SOA) based on company-wide and standards-based data modeling is an essential component of longer term business solution. This paper describes the experience and motivation driving LIPA's data management strategy and the methodology now being employed to implement it, which has at its core a CIM-based Enterprise Semantic Model (ESM).

Index Terms— Asset Management, Business Semantics, Common Information Model (CIM), Data Quality, Data Warehouse, Enterprise Application Integration, Enterprise Semantic Model (ESM), LIPA, Risk Management, Standards, T&D.

I. Introduction

DATA availability and data quality is at the center of LIPA's effort to further enhance its asset management. With their history of more than ten years of smaller pilot projects, LIPA is currently undertaking company-wide effort to establish standard-based infrastructure for data integration and process automation (refer to Figure 1). The roadmap for this multi-year effort includes leveraging industry-wide progress in the area of data modeling and standardization, while taking into account in-house lessons learned from multiple smaller data consolidation and integration projects. Development and implementation of effective asset management is a key driver for data consolidation and integration at LIPA. Separated roles of asset owner and service provider are underscoring importance of data quality and data availability for effective performance and risk management.

II. Use of Standard-based Infrastructure for LIPA Assets Management

Soon after its establishment in 1998 LIPA's management for T&D Operations started focusing on improving performance of systems and its T&D assets. This inevitably brought the problem of data availability and data quality to the very top of the list of issues. Data consolidation and data integration were recognized as an area that requires specialized knowledge and management attention. However, individual projects ware primarily being driven by the end-users of specific data. Over time, the continuous process of improving performance and risk management has evolved into two parallel and highly interrelated projects: implementation of asset management and integration and consolidation of data required.

A. – Evolution of LIPA data needs for Asset Management

LIPA is state authority created by New York State in 1998 as the Long Island primary electric service provider. It is third largest public power utility in the nation in terms of customers served (more than 1.1 million). LIPA system, with peak load of over 6000 MW, consist of approximately 9000 miles overhead transmission lines, 5000 miles of underground cable, over 550000 poles, 900 distribution circuits, and 180 substations operating at 345, 138, 69 kV transmission, 33 and 23 kV sub-transmission, and 13,2 primary distribution voltages.

LIPA is operating as a non-profit entity managed by Board of Trusties and uses service agreements with service providers to accomplish asset operation and maintenance. In T&D business area, LIPA is sharing asset management with a subcontracted service provider. LIPA's primary role is strategy development, company and assets performance and risk management, including asset life cycle cost, capital budgeting, project prioritization, and guidance for maintenance and operation of key assets.

LIPA invested around $2.5B in T&D assets since being established and managed to improve reliability to be in the first quartile for overhead utilities, and at the top of the list of neighboring NE utilities.

By the late nineties, industry had already learned much about deregulation, cost cutting, and reliability problems. LIPA T&D management was faced with task of simultaneously improving technical and financial performance, customer satisfaction, and regulatory compliance.

It was clear that balance need to established between cost of asset maintenance and reliability. It was obvious that aging infrastructure can not simply be replaced and therefore that asset life cycle cost and asset performance need to be better managed and optimized. This was the time when concepts of Reliability Centered Maintenance (RCM) and Condition Based Maintenance (CBM) ware already adopted through EPRI collaboratives and other projects.

One of the immediate problems in implementing these concepts at LIPA and across industry was the availability of data and cost-effective ways of integrating and using data. As an illustration of the typical situation and frustration facing utilities, one major utility identified 35 various places and internal systems that contained data needed for desired maintenance and asset management optimization. Options of integrating data by developing “point to point” interfaces between so many various data sources ware not even seriously considered. Instead, leading utilities, individually and/or through collaborative projects, ware taking two parallel approaches: standardization and use and/or development of new technologies. For example, EPRI and a group of leading utilities developed the concept of an “Integrated Monitoring and Diagnostic” approach to leverage and use data already available in protection relays and/or other IEDs (Intelligent Electronic Devices), CMMS (Computerized Maintenance Management Systems), SCADA and condition monitoring devices. At the same time and in parallel, several utilities and EPRI developed a tool for “one to many” points/systems data integration for RCM for T&D. The tool supported data mining across multiple systems and automated data analysis and reporting. It was misnamed “Maintenance Management Workstation (MMW), but its name illustrates the originally intended use and, at the time, industry drivers behind need for data integration and data analysis: optimization of maintenance cost and system and assets reliability.

LIPA took parallel paths: (1) adopting and further developing maintenance and asset management optimization concepts and (2) initiating consolidation and integration of data to support new concepts in optimizing cost and performance of assets. Within few years these projects evolved into two major multi year initiatives: Dynamic Asset and Risk Management (DARM), and Data Integration and Process Automation (DIPA). They will be further discussed from a perspective of data requirements and data integration perspective.

B. LIPA’s Concept of Dynamic Asset and Risk Management and Data Requirements

Many electric utilities do not have formal and separate organization and structure for asset management. Most utilities have traditional asset management processes organized by relatively autonomous organizations such as maintenance, operation, capital investment, design, engineering, customer management, substations, distributions, transmission, etc. Due to the fact that LIPA has so clearly distinguished asset ownership/management from service providers and because it must perform this management with a “lean” organization (most aspects of T&D operation are managed through one office), LIPA realized that it should think beyond RCM and maintenance optimization and expand focus on overall asset and performance management

Asset management, from LIPA’s perspective, includes impact on four key performance areas: technical performance (such as reliability of assets and system), financial performance (cost and revenue), customer satisfaction, and regulatory compliance. All four areas are interrelated and need to be considered simultaneously. This requires availability of all related data for all four performance areas. From the analysis perspective, historical performance is important. However, anticipated and probabilistic assessment of future performance and risk of achieving performance goals is of similar importance to LIPA.

In LIPA’s DARM concept, emphasis is on performance risk management in a dynamically (short and long term) changing environment and assumes continuous updates of data supporting “near real time” probabilistic performance risk assessment across assets and performance goals. The concept requires integration of operational and non-operation data, such as cost (labor and material), asset failures and condition data, operation and measurement data, planning and forecasting data, weather, customer, events data. This requires integration of tools to optimize risk mitigation. Future performance must be modeled, optimized, and what-if analysis performed of viable options and scenarios for short term planning and near-real-time operation. From the data availability and data integration perspective, this translates into a need to integrate data currently available from various and historically specialized company-wide systems such as CMMS, OMS, CIS, EMS, AMI, PSM, SCADA, IEDs, and ISO.

The concept of “dynamic” asset management underscores the need for effectively analyzing and supporting decision making processes by enabling “near-real time” analysis of risk and options related to operation - based on both current and forecasted operating conditions as well as historical and anticipated performance of assets and system. This assumes and LIPA is already working, for example, on integrating and expanding the use of tools across traditionally separated areas of planning and operation, transmission and distribution, integrating system modeling, short term and longer term analysis and optimization, and incorporating probabilistic and statistical analysis in determining “least risk” options and "most likely" scenarios for operation and longer term planning.

Requirements for data in this concept include availability of data for prioritization and criticality analysis based on asset, system, operation, and financial and customer data - all in forms/formats, quality and quantities required for credible statistical and probabilistic analysis in "near real time". As an illustration: AMI is considered as another very important and cost effective "data acquisition and communication" system that is used for T&D assets and system monitoring and operation.

In terms of current technology for data integration and process automation, LIPA is recognizing that SOA (Service Oriented Architecture) and company-wide data modeling are essential components of longer term solution.

C. LIPA's Business Model requirements for standard-based data and infrastructure

LIPA's business model of subcontracting service provider service(s) assumes clearly identified requirements regarding data management. These requirements are essential to other business models too, but shortcomings are more apparent in LIPA's case due to periodic changes of service agreements and/or service providers. Accordingly, LIPA insists on data ownership. However, LIPA does not require that it own the systems responsible for the data.

This clearly introduces requirement of data mobility. Cost benefit analysis and investment decisions include consideration of cost and efficiency of data migrations. This highlights a need for low cost and efficient "switching" from one service provider to another and from one system/application to another - while preserving critical data and history and avoiding significant impact on system operation. The result is clear need for solutions enabling "near plug and play" for data, company-systems/applications/tools, and service providers.

The LIPA business model includes IT (Information Technology and IS (Information Services) in a category of subcontracted services and assumes options of switching IT/IS services providers. This is imposing additional requirements in developing and implementing solutions for data integration and process automation. They include requirements for fully documenting processes and solutions, limits use of proprietary solutions/tools/applications in favors of standard-based (or "de facto" standards), open architecture products and solutions, supported by commercial and competitive market of products and services.

The process of periodic competitive bidding ("RFP process") for selecting service providers requires well documented data requirements. LIPA's preferred option is for vendors and service providers to be responsible for integrating according to LIPA defined interfaces. This necessitates predefined and well documented company data models based on industry-wide standards in order to optimize cost and efficiency for both LIPA and its service providers.

D. Pilot Projects and Lessons Learned

The first company-wide solution for data integration was implemented in parallel with the first RCM projects and is still in use. It was an implementation of EPRI's MMW that provided "one to many" integrations for data sources. User friendly data mining and analysis along with automation and reporting is considered critical to ensure actual use and benefit of data integration. This project was focused on supporting maintenance and condition monitoring of assets. This was done by enabling simultaneous use of data from SCADA, CMMS, outage management, and other systems. Data integration was based on mapping data from various sources to MMW. Data is temporarily pulled from original data sources as needed for specific data mining/analysis in order to avoid duplication and need for data synchronization.

In early 2000's LIPA joined leading utilities in testing and implementing the CIM (Common Information Model) for applications in the Control Center. This project was initially focused on extracting system connectivity from EMS and measurements from SCADA to provide a system model in a CIM environment. The goal was to support simultaneous and near-real-time use of models for planning and operations. The first installation of Siemens' ODMS tool is now operational. One of practical applications is to continuously monitor accuracy of system modeling and simulations by comparing modeling with actual SCADA measurements. Another practical application is use of time-stamped historical system configurations and parameters for past events and what-if analysis.

The initial "CIM Control Center project" was focused on the transmission system. LIPA is currently expanding use of existing tools and the CIM to add connectivity of substations and the distribution system primary into a single model. This single T&D system model will be used for analysis and optimization of substations (reliability), distribution (load optimization, reliability), and transmission (load optimization, voltage stability, short and long term planning and operation studies). This effort is focused on enabling use of single and accurate system model for operation and planning, with the goal of having more accuracy in planning tools across both departments. Availability of the system model in CIM is opening new opportunities to work with vendors and developers specialized in specific systems (GIS) and/or aspects of system planning and operations. An example of one such new applications is "near real time" stability analysis and prioritization of contingencies for system operators.

In early 2000's, when CIM for T&D was not widely used and the message bus technology was relatively immature, LIPA initiated pilot project to evaluate feasibility of combining integration/message bus technology and the CIM for T&D operational and non-operational data. One of the goals was to test performance of larger data mining tasks required for maintenance and asset management. This required that large amounts of data from various systems be retrieved and transported using an integration bus. After several years of development and testing, it became clear that

that optimum solution is to use combination of customized integration buses: one to support “near-real-time” needs of control center environment and another to support asset performance and risk management in combination with data warehousing and ETL technology.

E. Roadmap and key requirements for future data integration

In 2007 LIPA initiated development of roadmap for data integration and future infrastructure. The goals included identification of lessons learned through internal pilot projects, evaluation of progress across electric utility industry in using standard-based data integration, and assessing SOA and technology development for data integration, archival, and process automation. Key findings and recommendations related to internal and industry-wide lessons learned are related to technology and also to organization and process related issues.

From the organization and process perspective it was obvious that one of the key elements for long term success is to establish strict data governance, policies, processes, organizational structure, data quality assurance, and clear decision paths and responsibilities in managing data.

On the technology side of the same issue, it was realized that company-wide (“top-down”) strategy for data modeling and naming need to be establish, and that processes, infrastructure, and tools need to be established that will ensure consistency and integrity of data modeling and naming so that that individual projects and integration efforts (“bottom up”) are consistent with and integrated into company-wide solution.

It was recognized, for example, that company-wide consistent asset identification and naming is one of keys for consistent data integration of technical, financial, customer, and data required for performance and risk management.

To avoid continuous discussion about completeness of CIM data standardization, the LIPA data standardization goal was formulated as implementation of “LIPA Information Model” that will leverage and use available industry data models at the optimum level for company’s long term goals. This includes further developing existing and available models by using accepted conventions, and forwarding LIPA extensions of models to standardization working groups for future updates.

Development of company-wide “top down” processes, tools, and data models that will take into account needs of T&D asset management, energy trading, and future AMI, is considered a critical first step. This will provide a common base and repeatable “patterns”, templates, and tools for integration of individual sets of data.

F. Applying Lessons Learned to Implement a “Top Down” Methodology

To accomplish LIPA’s objectives, a holistic information management methodology was sought that facilitates the resolution of semantics across numerous systems, industry standards, and various sources of its enterprise (including data from its service providers) to capture understanding of its business semantics. So while the methodology must allow for leveraging industry standards, it must also support resolving semantic ambiguities inherent in standards such as the CIM and other reference models – doing so relative to one another in the LIPA context.

LIPA selected MD3i - Model Driven Information, Integration, and Intelligence (by Xtensible Solutions) as the methodology for creating an Enterprise Semantic Model (ESM) and using it to design a semantically consistent data warehouse and integration solution across projects (depicted in Figure 2). It provides a repeatable process for incorporating numerous enterprise and industry references thereby allowing an enterprise like LIPA to define, control, and own the semantics for information required to operate their business. It is realized using the Unified Modeling Language (UML) and uses standard UML modeling constructs to capture semantic concepts and traceability across systems. Incorporated into this methodology are design principles borrowed from controlled vocabulary and ontology development. This disciplined approach to semantic modeling not only captures the current state of enterprise semantics, it lays a strong foundation for adopting future implementation technologies as they mature, particularly those technologies typically associated with the Semantic Web, i.e. Web Ontology Language (OWL) and Resource Definition Framework (RDF).

LIPA selected Enterprise Architect (by Sparx Systems) as it has become an industry de facto standard UML tool, which will use a set of Xtensible add-ins to provide additional functionalities required for effective ESM management. The ESM serves as the base model both for generating implementation artifacts such as data warehouse schemas and integration message schemas, and as the primary model of the LIPA controlled vocabulary. The resulting LIPA controlled vocabulary will serve as the data interface design specification in future RFPs for LIPA system acquisition and integration.

The methodology and supporting tools provides LIPA full ownership and responsibility of the resulting ESM to not only allow the ESM to evolve with LIPA’s enterprise requirements, but to also minimize the risk of vendor lock-in caused by adopting the semantics of proprietary data models. Vendor lock-in avoidance also applies to the methodology itself, meaning that the methodology should be implementable on various modeling tools by any modeling service provider that LIPA chooses.

The overarching philosophy of this methodology and LIPA’s use of it is that numerous information references in various forms should be used to arrive at a controlled vocabulary that is then used to model semantics relevant to the enterprise – the ESM. While the ESM is a design model, it is used to generate runtime artifacts, such as database and message schemas. A controlled vocabulary is easily understood as a glossary where every significant term used in definitions is also a defined term in the glossary. By basing an ESM on a controlled vocabulary, semantic ambiguities are driven out before being modeled, which results in greater semantic clarity and lower cost of information management.

Creating LIPA's controlled vocabulary is a collaborative process that requires participation from both business and IT staff, much of which will be from service providers. References being used to create the controlled vocabulary and model an ESM include business terms and definitions, relevant information standards, and LIPA's application-specific metadata and definitions. Subject Matter Experts (SME) are consulted during the semantic resolution process to ensure a consistent semantic layer built into the enterprise architecture to facilitate business processes, function, and service reuse across various implementation and integration projects.

The ESM is used to generate implementation models for different purposes, e.g. process integration messaging, data services canonical schema, database design models, etc. Implementation models typically vary in structure (canonical form), but they all represent the same business semantics as defined in the ESM. Other uses of the ESM include driving data quality and integrity assessments as part of bulk data transfers or data warehouse initiatives, impact analysis for system replacement, and publication of specific integration requirements to business partners and vendors.

G. Conclusion

It its role of asset owner and asset manager, LIPA requires quality data to manage its assets and service providers. For effective performance and risk management, data must be available and used consistently across disparate manual and automated business functions. Applying lessons learned from pilot projects, LIPA is implementing an enterprise information management strategy that will enable it to effectively leverage its data for these purposes. With each increment of implementation, terms will have consistent meaning and use across LIPA's systems. This will greatly improve the quality of all forms of analysis and reporting - thereby facilitating improved asset performance while optimally mitigating risks. After many years of learning lesson, LIPA is now equipped to take charge of its data and is doing so.

References:

[1] Presentations and committee drafts from IEC TC57 Working Groups 13 and 14 (refer to http://www.iec.ch and http://cimug.ucaiug.org), 2008.

III. Acknowledgment

The content of this paper is based on work and concepts from the staff and numerous parties supporting LIPA through recent years during the course of numerous projects. The authors gratefully acknowledge the contributions of Michael Hervey LIPA VP of Operations for his long term vision and support of standard-based data integration and architecture, Stipe Fustar of PowerGrid360 for overall architecture, Scott Neumann of UISOL for the 2007 Roadmap, and Joe Zhou and Dan Martin of Xtensible Solutions for the "top down" methodology now being implemented at LIPA.

IV. Biographies

Dr. Predrag Vujovic, Director of T&D Planning of the Long Island Power Authority (LIPA), has been involved in data integration and data consolidation projects in various roles, including high voltage equipment and monitoring systems development, R&D management for manufacturing industry and EPRI, and project management and consulting for electric power industry. While with EPRI he managed development and implementation of T&D Reliability Centered Maintenance, new concepts of Integrated Equipment Monitoring and Diagnostics, new concepts of T&D Integrated Asset and Risk Management, and initiated and managed development of tools for company-wide data integration, data analysis and data mining, and process automation required to support performance-based maintenance and asset management. While with EPRI and in consulting he worked with LIPA in implementing latest technologies for maintenance and asset management and company-wide data integration, including pilot projects using CIM and Integration Bus. He joined LIPA in 2007 and continuous to work on LIPA's data integration roadmap and implementation of standard-based concepts and infrastructure for company-wide data integration.

Greg Robinson is a co-founder and President/CEO of Xtensible Solutions, which provides enterprise information management and integration solution and services to energy and utility industry. He helps utilities plan and implement semantically coherent application integration infrastructures. Robinson is convener of IEC TC57 Working Group 14, which is extending the industry standard Common Information Model (CIM) for enterprise-wide messaging. He is also the co-chair for the AMI Enterprise Task Force of the Open Smart Grid User Group. This volunteer work has enabled him to help utilities leverage and drive these industry standards to their benefit while simultaneously aiding the standards development process. He has a BSEE from Georgia Tech and a MBA from the Florida Institute of Technology.

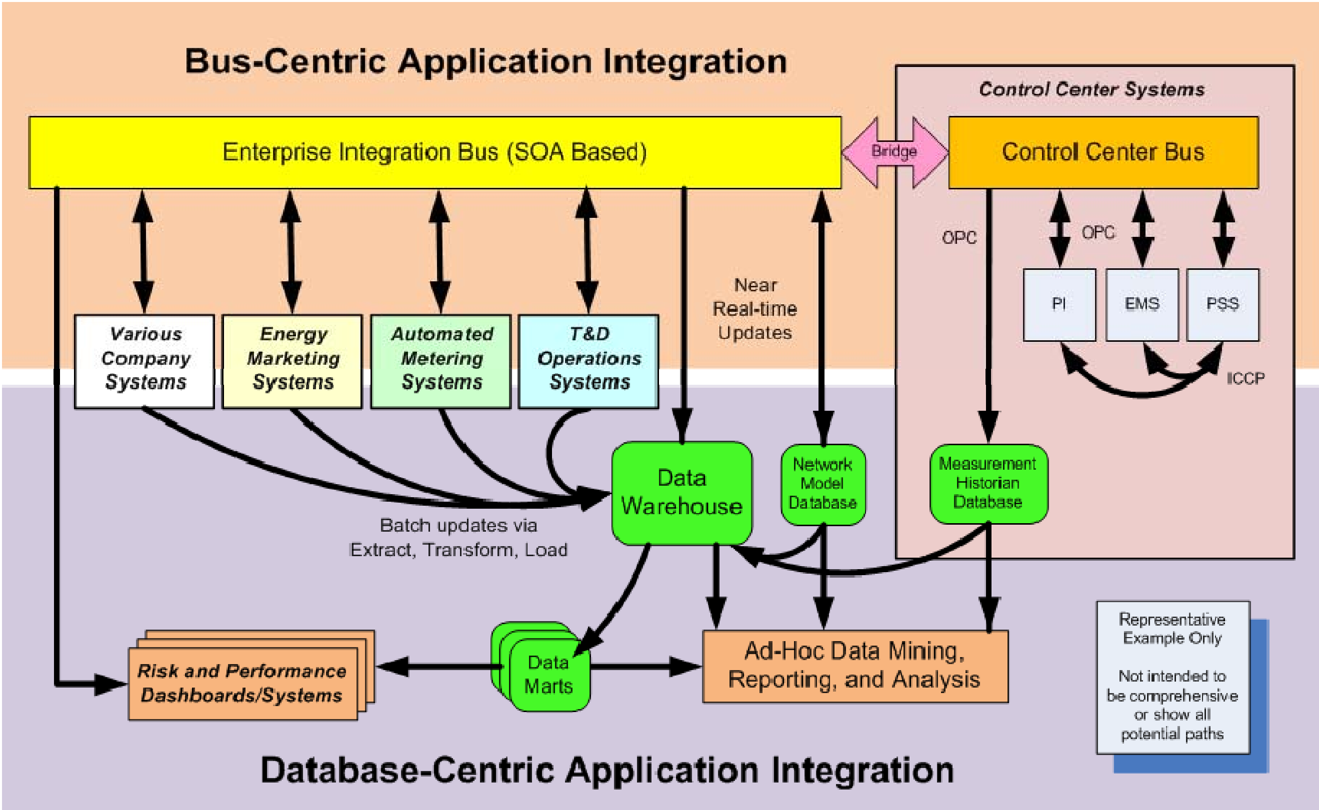

Figure 1: Data integration infrastructure

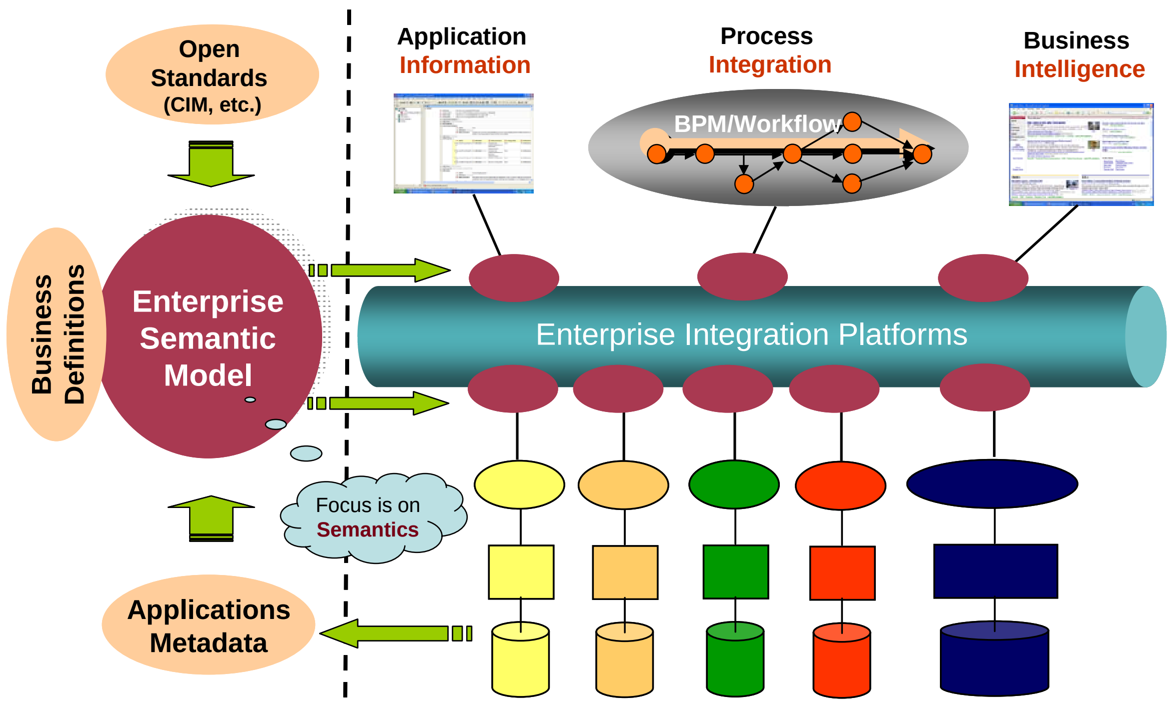

Figure 2: Using an ESM to drive Data Integration