

PROCESS AUTOMATION FOR DISTRIBUTION OPERATIONS MANAGEMENT

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INTRODUCTION

To prosper in a competitive market, distribution utilities are forced to better integrate their system activities and processes in order to reduce operating and maintenance costs as much as possible and to improve customer responsiveness. Utilities must develop architectural strategies that integrate the best available technologies with existing systems. Traditional departmental and corporate boundaries are becoming bottlenecks for more efficient operation. Most utilities have many islands of information spread throughout the organization. In most cases, these islands are not interactive or mutually accessible. The trend is to integrate these islands and thereby improve information flow throughout the organization. Several utilities have already started development of new strategic solutions by combining new and legacy applications with newer web technologies. Those applications require both Internet and intranet system communication with internal as well as with outside organizations. This paper addresses issues of Enterprise Application Integration (EAI) with a special emphasis on the Business Process Automation (BPA) of the distribution operations management. It promotes an automated solution for distribution operations management. The EAI/BPA technology [3] provides the infrastructure to facilitate integration of diverse systems and applications. The paper covers topics like integration architecture, middleware, business process modeling, design approaches, role of standards, etc. The distribution operations real estate along with the required infrastructure (architecture, business process model, middleware) is addressed as well as a couple of business functions targeted for automation. The list of business functions subject to the business process modeling include network update, feeder lockout, control commands (open/close) switching order creation and execution, trouble call related functions such as receive call, process call, update/cancel call, order completion, etc. In order to illustrate the proposed automated concept two of these functions are described here in greater detail.

DISTRIBUTION OPERATIONS MANAGEMENT REAL ESTATE

The automated Distribution Operations Management Environment, described in this paper, is designed to operate in a distributed computer environment that includes Voice Response Unit and service representative (VRU/REP), Coordinator, Customer

Information System (CIS), Outage Management System (OMS) / Distribution Management System (DMS), Geographical Information System (GIS), Resource Management (RM) and Supervisory Control And Data Acquisition (SCADA).

Components

VRU - Interactive Voice Response (VRU) units and the service representatives (REP) are entities responsible for receiving customer calls and providing adequate feedback.

CIS - CIS is designed to support all interactions with utility customers. It contains basically all customer-related information. The CIS database is synchronized with GIS database periodically.

GIS - The GIS system is used to manage the facilities and infrastructure for the utility. The OMS typically uses GIS data to build a model of electrical circuits. The network model is an abstracted circuit structure derived from the GIS data.

SCADA – The SCADA system is used to monitor and control the distribution and transmission networks. The operator can access and view the network real-time data and issue operating commands remotely. Whenever status of a SCADA controlled switching device is changed (open/close), that information is furnished to OMS/DMS via dedicated interface. Also whenever in the OMS/DMS environment a control command is issued against a telemetered switching device, that information is passed to SCADA for execution.

OMS/DMS – OMS/DMS provides a user-friendly environment designed to display and track all customer related outages and corresponding restoration process. OMS/DMS is modeled in such way that manages distribution network operation, interactions with customers, regulatory reporting as well as crew management.

RM - The RM is a software system that is used for dispatch operations and crew management.

Coordinator - The coordinator is an application that can be thought as the manager between VRU/REP, CIS, and OMS/DMS components.

In order to understand better the distribution operations management real estate, an architectural overview together with data flows are presented on the following diagram:

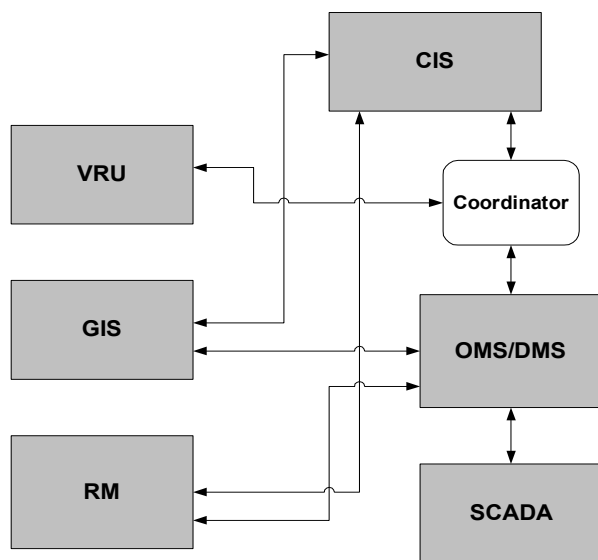


Figure 1. Logical Data Flows

ENTERPRISE APPLICATION INTEGRATION AND BUSINESS PROCESS AUTOMATION PERSPECTIVE

A number of operational functions require the exchange of information between different systems and applications within the utility enterprise. EAI and process automation are not only the art of passing information between disparate systems but also the art of processing the information. Business process automation is seen as the passing of information between participating systems and applying appropriate rules needed to achieve a given business objective. A typical automated system is designed considering three levels of technology:

- Process automation or workflow level. At this level, workflows paths are described using dedicated BPA modelling or appropriate drawing tools.
- Transformation, routing and rules processing level. At this level, a set of rules for moving information from one system to another is identified. The data are read from the source, restructured if needed, and routed to receiving systems at the required level of abstraction. The timing of these transactions is typically driven by a set of dedicated rules as well.
- Middleware level (e.g. messaging services). This level is responsible for moving data between various connected components.

Middleware

Middleware is software that facilitates communications between different computer systems and applications. It provides typically, generic interfaces through which applications invoke services, and it controls the transmission of the data exchange over the network. The most basic middleware services include:

- Message oriented middleware
- Object Frameworks (Distributed Objects)
- Advanced middleware products/tools
- Other (Transaction Processing Monitor, Remote Procedure Calls, home-grown middleware)

Typical advanced middleware products come with several functional layers including:

- Communication or transport layer
- Interface (adapter/connector) layer
- Metadata model
- Process control layer
- Process analysis layer

Integration Vision

Utilities are positioning themselves to create an environment where collaboration and integration take place seamlessly, enabling them to build an effective e-business solution that crosses corporate boundaries. The ultimate vision is to:

- Automate business processes
- Manage exchange of goods and services automatically
- Acquire business intelligence automatically across value chain partners and suppliers.

An Inside-Out Approach

Before utilities can implement e-business and customer relationship strategies, they must integrate their internal business practices. In order to implement this vision, the utility industry can anticipate a multi-phased transformation:

- EAI/BPA--At the very beginning, the utility develops technology that integrates and automates business processes within its company
- Business-to-Business Integration—Groups of competitors and suppliers create the infrastructure to link the utilities' systems with systems of other companies.
- Business Orchestration--This phase will allow utilities and other companies (partners and suppliers) to automate their mutual business processes and manage them in real-time.

EAI/BPA Design Approach

Each EAI/BPA solution is typically described in terms of:

- Functional description
- Integration architecture
- Metadata model
- Business Process Modeling (Workflows and data flows)
 - Generic functions
 - Process rules, if applicable
 - Use cases
 - Sequence Diagrams
 - Action, state and collaboration diagrams, if required
- Required Interfaces
 - Source and target data structures and required data transformation
 - New processes needed to tie existing processes and databases

Role of Unified Modeling Language (UML) - For EAI/BPA requirements and design specifications, a use of Unified Modeling Language (UML) is recommended. UML is a standard language used to visualize, specify, construct and document the complex software-intensive systems. UML-based tools offer a user-friendly environment for writing EAI/BPA blueprints. Use of UML for requirements and design consideration speeds-up the overall process of implementing EAI/BPA projects.

Integration Architecture

Several configurations have been used so far architecturally for EAI/BPA solutions. They are:

- Point-to-point
- Hub-and-spoke / Message Bus configuration
- Distributed integration architecture

When message brokers were originally conceived, they were based on hub-and-spoke configurations, where all translation, transformation and routing are performed at a central hub. Each hub or message broker typically has a rules-processing engine and metadata repository. The rules-processing engine provides the capability to create rules needed to control processing and distribution of messages. The metadata repository is nothing more than a data model that describes information to be exchanged.

Hub-and-spoke or message bus configuration simplifies the design, implementation and management of EAI/BPA solution. However, since all messages go through the bus, it is also point of failure. If the hub is not operational, exchange of information between systems and applications are not possible.

“Distributed” and “federated” architectures are two terms that are often used interchangeably. However, there are some differences. A federated architecture is basically a multi-hub architecture where each hub typically has localized rules and metadata as well as global rules and metadata. Changes to global rules and metadata are automatically propagated to other hubs. Central management of multiple hubs simplifies tasks of managing and changing the system. Federation provides two conveniences: components can be accessed from anywhere in the system and transparent scalability (components can be added incrementally as needed and without shutting other components down).

A possible architecture for the proposed approach is presented in Figure 2.

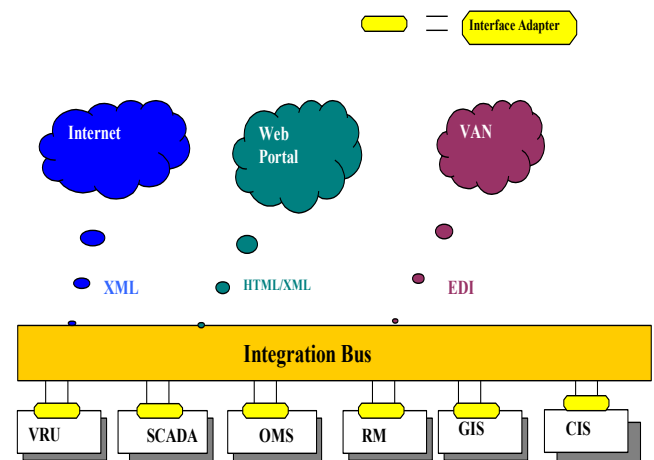


Figure 2. Integration Architecture using Integration Bus

The Message Bus is conceptually the backbone of EAI/BPA architecture. The Message Bus could also be distributed, such that it can be a virtual or logical entity rather than a physical entity.

Role of Standards

A number of industries have started development of standards needed for communication between disparate systems and applications. The standard bodies are taking a strong role in describing the most commonly supported interfaces. The most important standardization effort in the utility domain include the following:

- EPRI Control Center Application Programming Interface (CCAPI) project and its core Common Information Model (CIM).
- International Electro-technical Commission (IEC) Technical Committee (TC) 57
 - Working Group 13 on EMS APIs
 - Working Group 14 on DMS APIs
- EPRI Utility Communication Architecture (UCA) project.

- Utility Industry Group (UIG)
- Energy Trading Standards Group (ETSG)

IEC TC57 WG14 orchestrates one of the efforts for distribution operations management. Standardized interfaces will simplify the implementation of EAI and process automation.

BUSINESS PROCESS MODELING

Business Process Modeling is a critical step in implementing EAI and/or BPA. Therefore, it is necessary to define the business process model as collection of all business processes targeted for automation.

For a selected business unit, each business process is modeled as a series of discrete events called process steps. A process step is the basic building block of the business process and represents a single unit of work. Each business step is described using defined actions such as Publish, Get, Put, etc. This task typically includes capturing, assessing and elaborating all (current and new) business processes aimed for automation. The task includes the following:

- Detailed description of business processes
- Use case spreadsheets and diagrams: Business processes are described in terms of process step, and process steps are described in terms of real actions
- Required interfaces and data transformation spreadsheets

Each business process (scenario) represents a specific workflow in the integrated system and it is best described using use cases and sequence diagrams.

A use-case is a tabular and/or graphical description of how the business process is realized in terms of atomic functions. The complete sequence of the messages between components in one scenario in a time sequence is specified in a sequence diagram. A scenario is one flow through the use case. The message itself can carry data in either direction as parameters or result of the invocation. UML-based design may include use cases as well as activity, collaboration, sequence and other diagrams.

Use-cases and sequence diagrams are just elements of UML, which are used almost regularly for EAI/BPA design purposes. The use cases document on a gross scale and include details regarding interfaces with system components while sequence diagrams graphically describe component interactions arranged in a time sequence (top-down).

The following examples illustrate the complexity of business process modeling for network update and order competition functions.

Network Update

This example provides a detailed analysis of process automation for the business function when a new network element is added. The design process begins by identifying the information to be exchanged and the elements involved. Using a generalized utility model used by WG14, the Figure 3 graphically illustrates the data flow at a high level, hiding the real complexity of such an implementation. Typically, a new network element (say a feeder segment) is first added in a GIS. From there, the information is passed to different systems at different levels of abstraction. For this scenario, the network addition information is passed to Transmission Wires and Distribution Wires databases that act as data sources for EMS, SCADA, Outage Management and Distribution Automation systems. Ideally, Transmission Wires and Distribution Wires databases are based on CIM [2]. Note also that the process of updating several databases must be part of the same transaction where all updates either succeed or fail together. It is not a good idea to allow partial updates due to the fact that several systems typically require synchronized information in order to function properly.

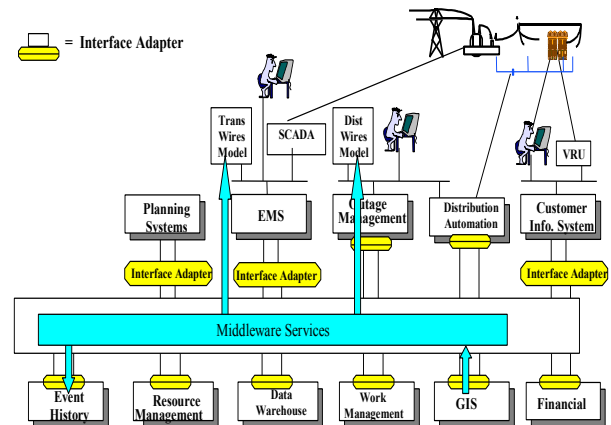


Figure 3. Network model update (Base picture - Courtesy of IEC TC57 WG14)

The task of extracting data from the GIS is, in some instances, fairly complex due to the fact that the granularity of the information contained in a GIS database is typically higher than (or at least different from) the corresponding information in the Distribution Wires DB. For example, poles and line segments between poles are represented in greater detail in a GIS DB than in a Distribution Wires (OMS/DMS/SCADA) DB [1]. In order to support GIS applications, information about each pole is needed. However, for distribution applications such detailed information is not required. Such detailed (and from the distribution network operator's perspective, overwhelming) information may jeopardize the performance of some important applications; such as a distribution power flow, voltage/var control or a distribution state estimator.

The example in Figure 4 illustrates this problem.

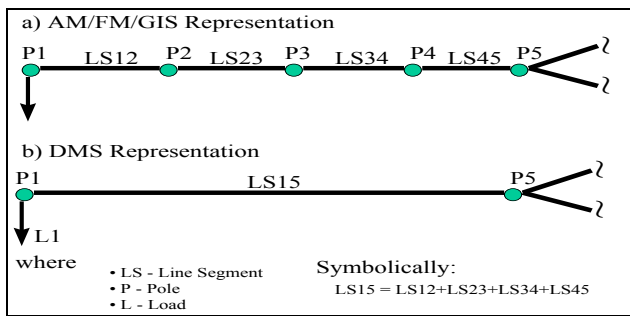


Figure 4. Network detail in GIS and OMS/DMS

This also means the logic, needs to be implemented in the form of rules in order to automate data transfer and restructure the data in flight. Note also that the timing of this transaction is coordinated by a dedicated rule, making sure that no critical processing is occurring at the same time in the systems affected.

Trouble Call Order Completion

Upon completion of power restoration work, the crew sends a power-restored message to the dispatcher. OMS puts the project in a completed state and sends the trouble call closeout notification to Coordinator for each trouble call. The Coordinator sends the list of customers to VRU along with other relevant information such as phone number. VRU calls all customers from the list and informs them about power restoration. Each individual customer is supposed to confirm the power restoration by selecting a dedicated option. A “Still Out” option is also provided for those customers who are still experiencing the power outage. VRU sends back to Coordinator the customers response. Coordinator sends a list of all customers that confirmed the power restoration to Customer Information System (CIS). CIS consequently will close all corresponding trouble tickets. Note that for those customers who are still out of power the trouble ticket in CIS remains open. For those customers who are still out of power, Coordinator sends to OMS the outage information OMS creates a new project with the original date/time stamp and identification number. This scenario is treated in OMS as a new outage.

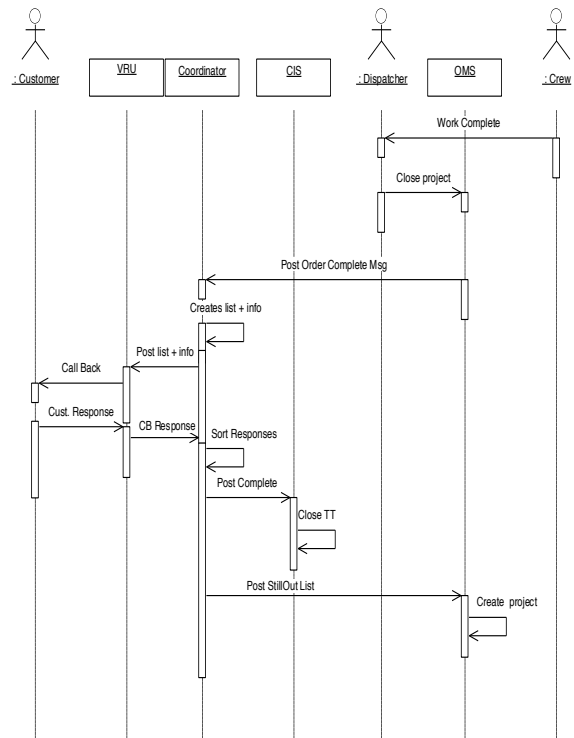


Figure 5. Sequence Diagram: Order Completion

CONCLUSION

An automated utility operational concept is promoted in this paper. For a fully integrated “digital utility” a number of other business processes need to be modeled and automated as well. Some business functions related to operations are discussed in this paper, revealing their hidden complexity in greater detail. It is obvious that process automation saves steps and time. In the past, similar processes would take several days or weeks, whereas the automated function may take mere seconds. In the future, more standardized interfaces will be used to enable remote applications to access both data and services of these applications.

REFERENCES

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3. David Linthicum, 2000, “Enterprise Application Integration”, Addison-Wesley Information Technology Series, Reading, Massachusetts, USA