Common Infrastructure for Interchange of Information in Power Supply Companies Based on Enterprise Service Bus

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***Abstract* – In order to support their business processes, large electric power supply companies like ED Jugoistok Niš, use different information systems in almost every part of the company. However, these information systems are divided logically and physically and rely only on information available locally. These information systems in most cases generate only local subsets of data. The integration of information from local subsets would enable employees to perform complex data analysis related to company operations that would improve the company performance as a whole. This paper presents our solution for information integration in power supply companies. Our solution is based on Enterprise Bus Service and uses Web services for realization of interoperability between information systems.**

***Keywords* – Enterprise Service Bus, Service-Oriented Architecture, Web Services, Enterprise Application Integration**

I. INTRODUCTION

The rapid development of information and communication technology has provided an enormous amount of information to users of information systems that are available today [1]. Modern information systems used in utility companies have the ability to present information from a large number of distributed and heterogeneous information sources providing information about infrastructure, finances, employees etc. [2].

Electric power utility industry demands for efficient operations, high quality and reliable supply, low energy losses, customer satisfaction, along with expected deregulation and competition make it even more important to manage and operate the power supply network in an efficient and cost effective ways [3]. A typical Electric Utility system consists of Generation and Transmission/Distribution subsystems. The basic structure of Power Transmission/Distribution subsystem covers a huge network consisting of wide range of Equipments, Feeders & Facilities. In order to efficiently manage utility operations different disparate IT systems with different and unique roles exist. Typical systems used in the Electrical Utility are Customer Information Systems (CIS), Geographic Information System (GIS), Supervisory Control and Data Acquisition (SCADA), Distribution Management Systems (DMS), Automatic Meter Reading (AMR), Computerized Maintenance Management Systems (CMMS), Document Management System, etc. Such a large number of IT systems are intended to support business processes within Electric Utility system, such as maintenance and construction, records and asset management, network extension planning, customer care.

The main problem is that these IT systems have generally not been integrated, resulting in a complex and inefficient working environment for the users. Every IS vendor in ED Jugoistok (South Serbia Power Supply Company) developed each system only to comply with requirements imposed by particular department or set of users. In order to satisfy demands from various users, each vendor tried to cover broader set of functionalities for processing large scales of different data.

Cooperation between different information systems at ED Jugoistok is very low. Some information systems are integrated on database level which requires creation of additional stored procedures and views in database. This integration can be considered as point-to-point since information systems are using data stored in a database by other system. For example, in ED Jugoistok, this approach is used for integrating GIS with information from CIS and application for calculating technical losses is integrated with GIS, CIS and AMR.

The trend of adding new functionalities and data redundancy in order to cover ever-broader sets of users' demands [4] will ultimately result in the development of a single or several large-scale systems with complex maintenance issues. In addition, this could impose possible dependence on single vendor. In order to prevent this scenario, the process of integration of individual systems into a single entity needs to be introduced, with ability to preserve each system's independency.

Thus, there is a strong need for efficient integration of IT systems within Electrical Utility enterprise [3]. The new approach to integration would enable information sharing between information systems in a more effective way creating information infrastructure that will support migrating existing electric distribution network towards Smart Grid [5, 6].

This paper presents different approaches to enterprise application integration (EAI) in second chapter. Third chapter proposes our solution for information integration in Jugoistok.

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Last chapter discusses benefits gained with information integration within Jugoistok.

II. Related Work

Previous requests have resulted in the need to integrate existing information systems and applications inside and outside of the Jugoistok company (intra and inter-organizational integration). Only solution that can fulfill these requirements is infrastructure for information exchange within company. This infrastructure has to provide a common model that can be used with various technologies and platforms and needs to be flexible and expandable in order to meet any future needs.

The solution for integration of heterogeneous applications of an enterprise emerged in form of EAI. EAI is defined in [7] as the unrestricted sharing of data and business processes among any connected applications and data sources in the enterprise. EAI can be accomplished using various architectures. Three most common ones are: point-to-point, broker based and message-bus based.

In point-to-point approach, applications are connected with each-other [8]. Since each application uses its own data format, in order to communicate with other applications, it needs to transform the data from local format to the format of the destination application. The total number of transformations, if the system has N applications, is N*(N-1)/2. Point-to point architecture is very suitable for small enterprises because it is quick and easy for implementation. Problem arises with increase of number of applications in the enterprise. E.g. for N=5 different applications we have to implement 6 different data transformation points. For complex system this problem can fully prevent implementation of information exchange infrastructure.

Broker-based is a better solution taking into account the number of transformations needed for the previous architecture. In the broker-based architecture, instead of connecting every application with each other, all applications are connected trough one central point called broker and use a common data model [8]. The data that an application sends needs to be transformed into a common model established between applications. In the broker-based architecture, transformations are done at the broker. In this way, the broker simplifies integration and enables the integration of a large number of systems, including existing and new ones that will be implemented later. The number of transformations is equal as the number of application. Besides the transformation, broker is also in charge of routing. Since all data that moves between the source and target applications is routed through the broker, it tends to become a bottleneck over time and a single point of failure. This often has a harsh impact on the performance of the integration solution.

Message-bus based architecture uses a central messaging backbone for routing and data propagation between applications [8]. This architecture is also known as publish/subscribe architecture. In this approach data transformations are distributed over the application adapters. Adapters perform data transformation to a common data model that all applications understand. A main advantage of this architecture is scalability, adding new and removing existing applications does not affect the system as a whole.

The rapid development of technology in the field of IS has enabled realization of platform for the integration, such that takes into account the uniqueness of the role of each system and its need for certain information, but also provides system with possibility to connect to the common data model. This concept is based on the message-bus approach, and is known as the Enterprise Service Bus (ESB) [8].

The data that an application sends to ESB needs to be transformed into a common model established between applications. After the transformation, data is forwarded to all interested applications and then re-transformed from common model to application-specific format. The role of ESB is to carry out the transformation and routing divisible on the adapters that connect the applications or systems to the bus.

In the ESB all applications are linked in a series along a common communication backbone. ESB serves as a router of data that needs to be exchanged between systems. It doesn't own the data, data is still stored in the IS that are responsible for them. It only uses their model and business logic during accessing, transforming and routing of data.

III. ESB as a Solution for Information Systems Integration in ED Jugoistok

Various information systems are used in Jugoistok. We have divided them into five logical groups based on their functionality. Systems that will be implemented in near future were also identified, considered, and classified. Logical groups are (Fig. 1):

- Systems for analysis and monitoring
- Technical information systems
- Business information system
- Systems using Data Warehouse
- Web portal and outside partners IS

Systems for analysis and monitoring are information systems used for telemetry of electric distribution network and consist of SCADA and Sensor Network. These systems generate a large amount of data about the current status of the network. Information systems that hold technical data considering network topology, objects connected to electric network and installations are classified as Technical information systems and consist of DMS, TIS, and GIS. These systems provide support for activities like repair and maintenance, planning, creating technical documentation etc. Enterprise Resource Planning, Document Management, Asset Management, and system for supporting Human Resources belong to Business Information Systems group. These systems primary support operations that are related to employees, documents, assets etc. and are outside of the scope of primary company's business activities. Data Warehouse is used by CIS and AMR systems. It adds a new value to information through analysis and data mining over already existing customer's data and consumption data. In order to facilitate easy information retrieval from various systems, Web portal with different privileges of access needs to be introduced. Also, it is necessary to provide outside partners with single access point to ED Jugoistok information infrastructure.

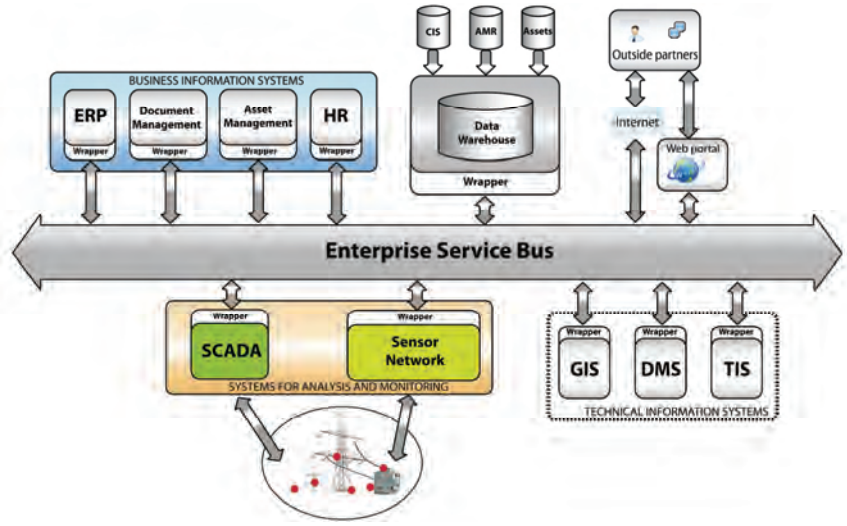

Fig. 1. Architecture of ESB in ED Jugoistok

For the purposes of integration of information systems in ED Jugoistok, in this chapter we suggest information integration architecture based on the Enterprise Service Bus (ESB). ESB provides a secure and reliable communication mechanism through the corporate network. ESB routes messages between sender and recipient. It has the ability to put messages on hold if the recipient is not available, which frees the sender's obligation of keeping and re-sending a message. Applications send messages to or receive messages from ESB through components called adapters. Adapters are application-specific interfaces to applications that provide access to other applications through the bus.

Because different applications represent data differently, transformation functions translate data from one application's data format to other, understandable to all other applications in the system [9]. After establishing communication through ESB, implementing adapters and transformation functions, and providing reliable data exchange between multiple applications, it is possible to define business processes that can use integrated information. Business process is a series of actions performed in a variety of applications.

Integration infrastructure based on ESB using special tools provides modeling, monitoring, and optimization of business processes. Common / shareable repository is used to store business rules and definitions of business objects. These common definitions allow loose coupling between applications and make the business process independent of application-specific data formats. Information related to the description of message formats with data, is called metadata.

One of the benefits gained with implementation of information integration and definition of business rules is the possibility of connecting with outside business partners. Adapters convert internal messages to Internet-compatible protocols like XML over HTTP. Additional encryption makes information traveling through Internet secure.

Information from different applications integrated using ESB can be published through unique Web Portal [8]. Web Portal integrates information from different IS, and displays them in a consistent, user-friendly way. In this scenario, ESB acts as buffer between the portal and other systems.

ESB is most frequently implemented using Service-Oriented Architecture (SOA). SOA is a paradigm that uses services as basic building blocks for developing complex software applications and systems. Services are independent, self-descriptive, and open components that support rapid and easy composition of shared applications. Within SOA, each program component can be considered as a service, usually available as Web services [9]. Web service is identified by Uniform Resource Identifier – URI, and uses open Internet standards for its description and data transfer. By implementing SOA concepts, development environment based on Web services exceed the other service-oriented paradigms through standardization and wide availability.

During application integration, it is necessary to take into account the environment in which the systems work, and besides presented logical division into groups, existing information systems are divided into real-time systems, back office systems and front office systems.

The core of the real-time systems integration is a real-time ESB, which is a proxy for the exchange of information between the various time-critical systems. In this part of the system, there are systems like SCADA and DMS. Architecture of Web services is not suitable for connecting applications that exchange considerable amount of data in real time. During the time of peak activity data is exchanged in such a frequency that the architecture based on Web services cannot meet the needs for that exchange. The problems of wrapping large amounts of data into XML format frequently brings the problems of increased data payload needed in order to communicate. Problems of parsing large XML files in the process of transforming information in formats used by other applications are also an issue. Therefore, integration is based on binary communication architectures of the middle layer (e.g., DCOM, Corba, Message Queue). In these specific cases, the application would have to be integrated into the ESB in such a way that does not compromise the basic concept of architecture based on services.

In order to achieve maximum flexibility during implementation of the adapters (interfaces) for each system it is convenient to use interface standard such as the Generic

Interface Definition - GID. An important role also plays Common Information Model (CIM) [10] database containing physical data according to the electric power system abstract data model. As such, it represents a unique point of exchange and storage of data on the model.

In the back-office segment, ESB represents the integration platform for connecting business applications that are not time-critical systems. It is based on the communication architecture of Web Services and represents the implementation of the SOA paradigm. ESB provides additional functionality such as message format transformation, routing and orchestration of services with the aim of performing various business processes. The messages exchanged are based on a common abstract model of CIM. Systems in the back-office segment are divided into two categories. One category is the service components so-called services, and other is consisted of graphical user applications, implemented on a single Web portal. Services implement the business processes' logic, and Web Portal implements a single point of access for users accessing to all applications.

Front-office segment is for users residing outside of the company. External users can access ESB via Intranet or Internet. In both cases, it is necessary to pay attention to the security of the system. Security mechanisms such as authentication, authorization, and encryption need to be implemented. In order to provide safe access, Public Key Infrastructure (PKI) should be applied.

For example, the business process that prepares the technical report needed for connecting new customers to electricity network uses information from following systems:

- GIS - provides locations of transformer stations and customers, estimation of technical losses
- AMR – load profile diagrams
- TIS - technical data considering connection points
- Web portal – user request and report generation

After the request is created on the Web portal, ESB uses repository in order to determine which systems can provide necessary information and which Web services need to be contacted. Request towards GIS's wrapper obtains the information about closest available transformer stations that are candidates for connection based on the location of the consumer. Next, it is necessary to obtain technical information considering transformer stations, feeders, and available connection sites from TIS. Load profile diagram of similar customers is added to the report obtained from AMR. Having potential consumer's location, analysis from GIS on how new connection will affect technical losses in that part of the network is added to the report. Resulting message in XML format is offered through the portal in the form of reports in the required format. Created report can be then submitted for further analysis in other departments.

IV. CONCLUSION

The proposed solution is based on the described principles of ESB, which provide significant advantages over other systems. ESB keeps up the existing functionality of the existing IS and minimize the work on their adaptation to new working environment. Any possible future expansion, as adding of the new IS, is maximally facilitated, and the only requirement that should be met is compatibility with the common data model and the ability to exchange data from a pre-defined methods.

The key advantages of ESB are:

1. Faster and cheaper adapting of the existing systems
2. More flexibility and easier changing according to the new requirements
3. Based on global and generally accepted standards
4. Scalability, i.e. easy extension of the use of the application in the whole business system compared to the initial use of application only on a single location
5. More configuration, less coding

The proposed infrastructure is a foundation for a future development of Smart Grid in ED Jugoistok. Since the implementation of the Smart Grid will affect many existing information systems in Electric Utility Companies, presented architecture will adapt information infrastructure in ED Jugoistok for future development of electric distribution infrastructure [5, 6].

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