Theoretical Considerations Regarding the Implementation of SOA Architecture in a Company for Electric Power Distribution and Supply

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A Distribution and Supply Electricity Company supply electricity to final customers. In our days, the electricity companies must adapt continuously to the requirements of the market and regulators. The adaptation of a company to the market and regulator electricity requirements means also changes of business processes within IT systems. In any company there is a strong link between business processes and IT applications. A business process modification will determine an alteration in the IT applications. In order to increase the alignment between business and IT and to achieve business agility, we have to create a flexible mechanism between IT applications and business processes. This mechanism will make that the adaptation to the market and regulatory changes will be made quickly and with low consumption of either human or material resources, but preserving quality customer service. Service Oriented Architecture (SOA) represents an architectural design which provides agility and satisfies the business processes in order to achieve business agility. In the IT area, SOA promises to reduce application development and maintenance costs through service reuse. SOA offers capabilities for the services to be combined together, to support and create a flexible and agile enterprise.
Keywords: *SOA, Web Services, Architecture, ESB, Electricity Networks*

1 Introduction

A Company for Electric Power Distribution and Supply (CEPDS) has to manage many electricity networks and complex business processes, which need many IT resources to manage it. Till now, most of the electricity companies have in the IT area a mixture of custom made applications and integrated applications like: ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), SCADA **(**Supervisory Control and Data Acquisition), DMS (Distribution Management System) or EMS (Energy Management System). Companies are unsatisfied because these integrated applications have a high cost of maintenance, long development cycle and inadequate output quality. To keep up all existing applications with all maintenance and enhancement requests, represents a major challenge. This challenge for the company can be translated in a need of: rapid application integration, automated business processes, multi-channel access to applications, including fixed and mobile devices. The solutions to the problems above can be solved by using SOA.

SOA brings a new way of constructing software application architectures, a new approach to rebuild available software infrastructures and the possibility for the enterprise to communicate with other enterprises by using services. SOA represents a new paradigm for both software and computing industries. Services are a fundamental element used by SOA in developing systems. Services follow the client-server or the request-response model, in which expect to receive a request from the client, to process it and finally to send back a response. In the context of SOA, a *service* is a function performed by an application. A function is coded only once and then reused wherever it is needed. The implementation of SOA is made possible through the realization of Web Services. In general, a Web service is a specific kind of service which can be identified without problems by an URI (Uniform Resource Identifier) and which uses Internet standards (such as HTTP) for transport. Web Services is a software

component representing specific set of business functions that can be described, published and invoked over the Internet using XML-based open standards such as WSDL, SOAP and UDDI.

2 SOA

SOA is essentially a distributed architecture, with systems that include computing platforms, data sources, and technologies.

A distributed architecture requires integration. Integration software provides the bridge between the legacy systems and SOA.

SOA represents a business oriented software architecture which integrates the business tasks into a set of interconnected and reusable communicating services.

„SOA establishes an architectural model that aims to enhance the efficiency, agility, and productivity of an enterprise by positioning services as the primary means through which solution logic is represented in support of the realization of the strategic goals associated with service-oriented computing" [1] SOA is an n-layer architectural model as shown in Fig. 1.

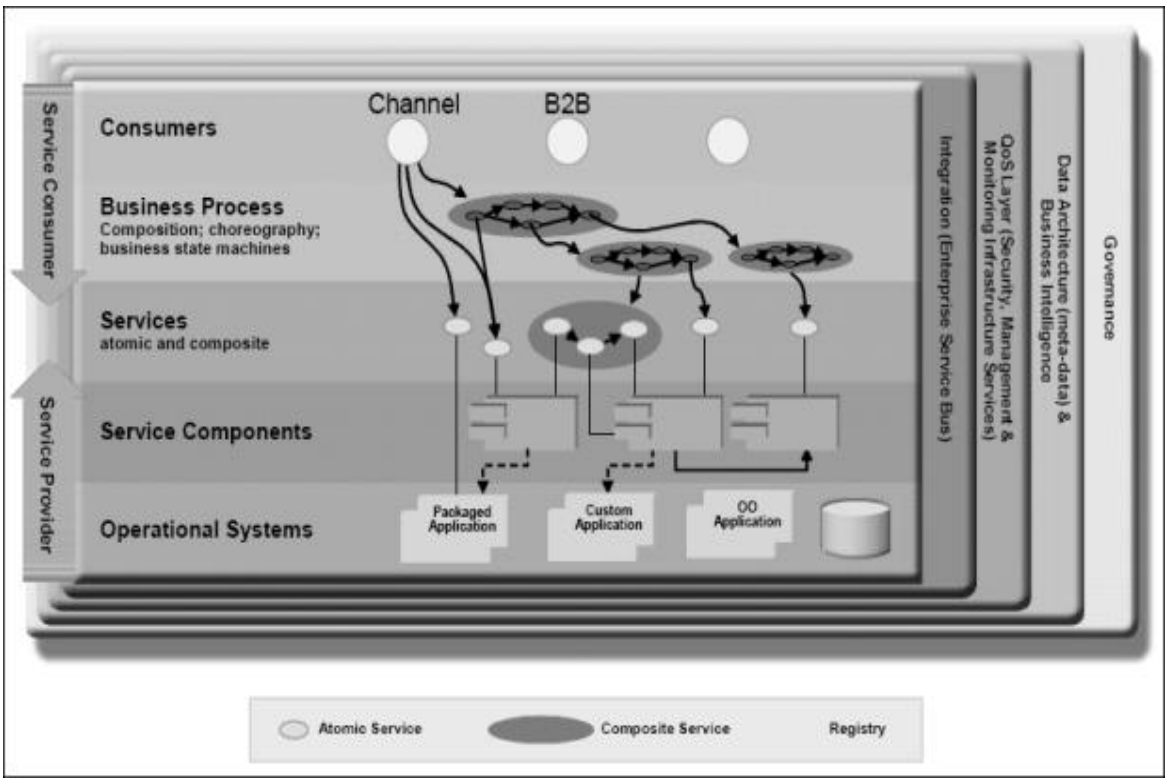

Fig. 1. SOA architectural model [2]

SOA layers are:

Operational Systems Layer: This layer contains existing applications of enterprise as object-oriented systems, business intelligence, known as Custom or Legacy application. These applications are behind of services and each of them has its own proprietary structures, databases and other system resource access. -

Enterprise Components Layer: This layer contains specialized components which provide certain functions and requirements for services.

Presentation Layer: It provides user interfaces for internal users, customers and providers of the enterprise. They are consumers of the processes and services [2] .The conceptual model of SOA and its components are shown in Figure 2.

According to [3], the main components of SOA are:

Service Consumer: it is the component of SOA that find a service to execute a required function. The consumer can be an application, another service or other type of software module that needs the service. The

location of the service is discovered either by looking up the registry, or if it is known, the consumer may directly interact with the service provider. In XML Web Services, communication between service consumer and service provider is mainly performed using SOAP messages.

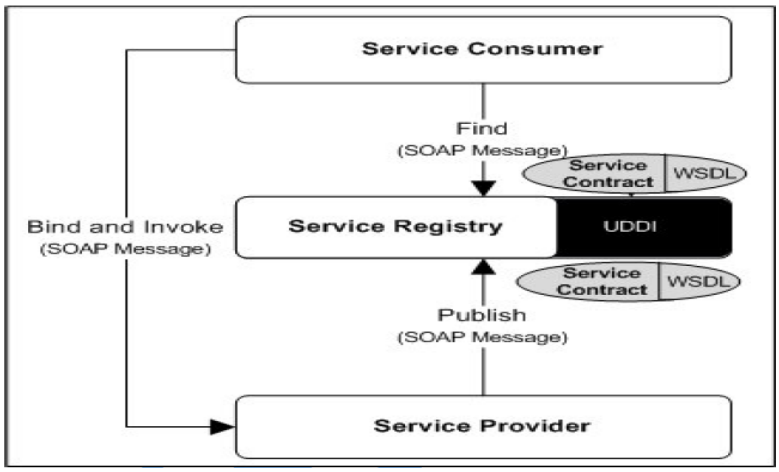

Fig. 2. Conceptual Model of SOA [4]

Service Provider: the component that accepts and executes requests from consumers. The service provider can be a component or another type of software system that fulfills the service consumer's requirements. In XML Web Services, parameters passed to any web service and results returned from it are represented as XML documents.

Service Registry: it is a directory which can be accessible through network and contains available services. The main function is to store and publish service descriptions from providers and deliver these descriptions to interested service consumers. UDDI is the main type of registries used in the world of XML Web Services allowing service consumers to query published services.

Service Contract: it holds the information that describes available services [4]. When a service provider wants to expose one new service, it must offer its contract to service registry in order to allow service consumer to find it and to know all the information and the guidelines that allows it to use the service. WSDL represents the description language that is used by XML Web Services to describe different information (both functional and nonfunctional) about available services including their URLs, ports, protocols, operations, parameters, contact information, etc.

According to [5], the strategic goals and benefits of SOA are:

- *Increased Intrinsic Interoperability*- Interoperability refers to the sharing of data and more interoperable programs exchange information easier;
- *Increased Federation*- A federated IT environment is one which resources and applications are united and have individual autonomy and self-governance;
- *Increased Vendor Diversification Options*. This help enterprise to quickly change business processes to at changes of market;
- *Increased Business and Technology Alignment*
- *Increased ROI* – Services have increased reuse potential that can be realized by allowing them to be repeatedly assembled into different compositions;
- *Increased Organizational Agility* - Enterprise agility on refers to efficiency with which an organization can respond to change.

3 Enterprise Service Bus

Within an enterprise, different applications – different from point of view of usability, field, complexity – are used to fulfill its goals, requirements, cut costs and increase ROI.

These applications are developed in-house or bought from third parties or even inherited as legacy systems. In order to make them communicate and use the same resources many companies adopts the SOA as the main strategy and if implemented right they succeed in their mission.

From the IT and business perspectives a good infrastructure must be designed and implemented in order to have a correct adoption and implementation of SOA.

This infrastructure has to be able to support resources distribution, message end-points discovery, message dispatching, routing and delivery. Many companies fail in a good SOA adoption due to the fact they omit to take in consideration the installation and configuration of an ESB.

The ESB is nothing else than a pattern which uses web services, intelligent routing and message transformation and services orchestration in order to make services more flexible and re-usable. According to [6] an ESB provides functionality for five functional areas as follows, as shown also in Fig. 3.

- Architecture;
- Connection;
- Mediation;
- Orchestration;
- Change and Control.

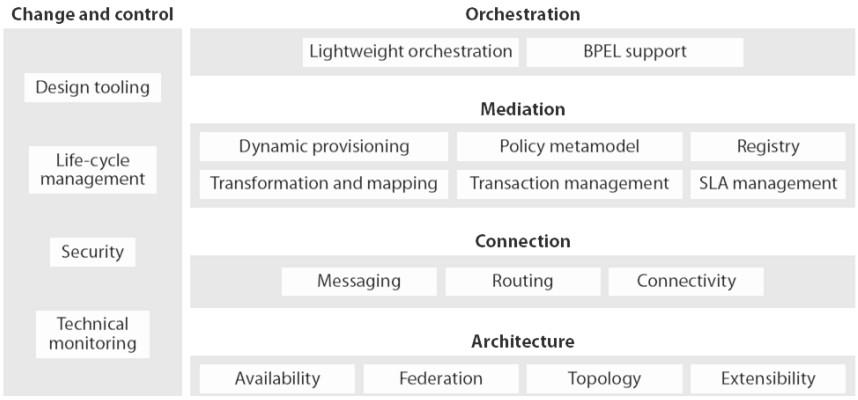

Fig. 3. ESB Architecture [6]

Some of the most important services and features of an ESB, according to [7], are:

- Transformation, Augmentation and Mapping;
- Conversion;
- Routing;
- Invocation.

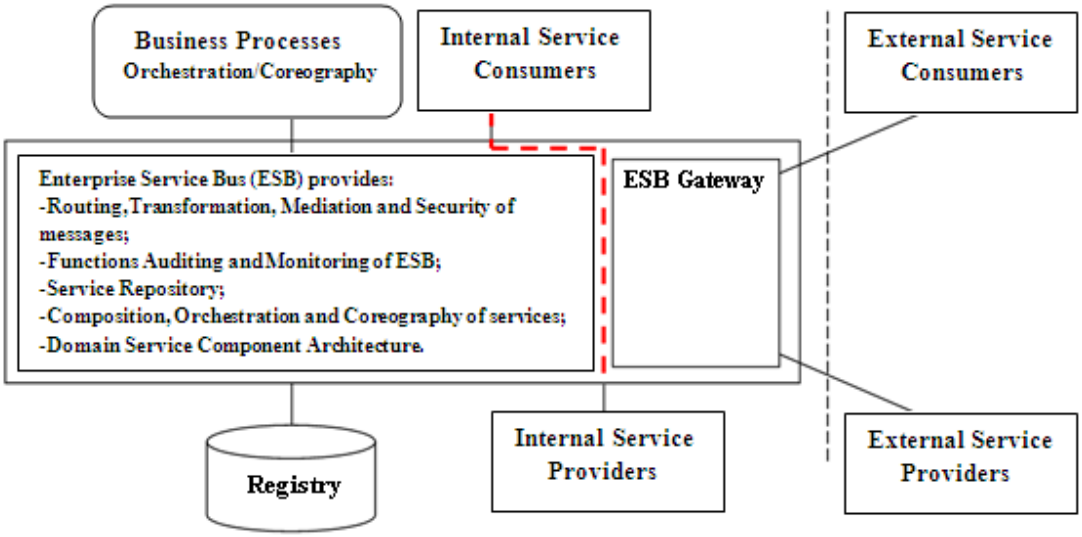

Fig. 4. An ESB Model [9]

In [8] are described the main service platform features which are supporting by an ESB, as is shown in Fig. 4:

- Service hosting;
- Service component model;
- Orchestration;
- Security;
- Service Registry;
- Auditing;
- Monitoring;
- Resource adapters;
- Composition.

An ESB provides a loosely coupled, highly distributed approach to integration [10].
The most important feature of an ESB is that that it has the ability to be highly distributed and thus providing highly availability in such environments.

4 Business Processes

A business process is a set of specific, tasks performed by people and systems and designed to achieve a predetermined outcome. Companies are trying continuously to improve their business processes, to adapt to the market changes and to use new technologies. As tool for modeling processes, companies are adopting BPM (Business Process Management) which helps to align IT systems with business's strategic goals by creating well defined enterprise business processes, monitoring their performance, and optimizing for increase efficiencies. Each business process is modeled as a set of individual processing tasks. These tasks are typically implemented as *services* within the enterprise, as is shown in Fig. 5. BPELs are the languages for process management.

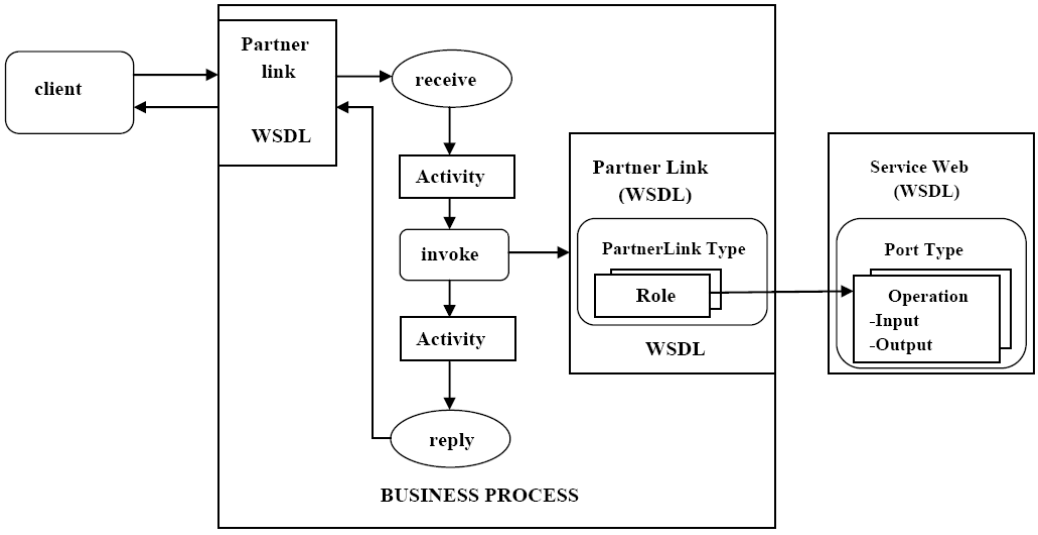

Fig. 5. A business process represented in BPEL

Business Process Execution Languages (BPELs) are XML (eXtensible Markup Language) used for modeling business processes using orchestrating, choreography, and controlling web services.
As it is shown in Fig. 6, SOA based system is composed of Service Consumer, Service Bus (Enterprise Service Bus), and Service Provider. Service Provider starts at the framework and application levels. System Applications, based on various implementations of language and platform, provide Application Services which use adapters to communicate with the ESB. Application services are exposed in Repository of ESB. Here are exposed also created services which are new services which don't use functionalities of legacy System Applications. These can be Internal services (create within enterprise) or External services (created outside the enterprise).
Business processes are composed of sub-processes and activities. If activity is simple can be executed by one service, otherwise it

can be executed by a composed service from Service Orchestration Layer of the ESB. Generally, sub-processes are executed by composed services from the Orchestration layer.

5 An overview of a Company for Electric Power Distribution and Supply (CEPDS)

The mission of a CEPDS is to take electricity from production electricity companies using electricity networks of transmission companies and to distribute this energy to all its electricity customers, either natural and legal persons who have legal territorial spaces in the area where works company, respecting quality standards, safety and efficiency.

Main activities provided by CEPDS are the following:

- services specific to the electricity distribution activity;
- services specific to the electricity supply activity;

A CEPDS has as the mainly product sale the electricity which is supplied to customers on different voltage levels and also other services:

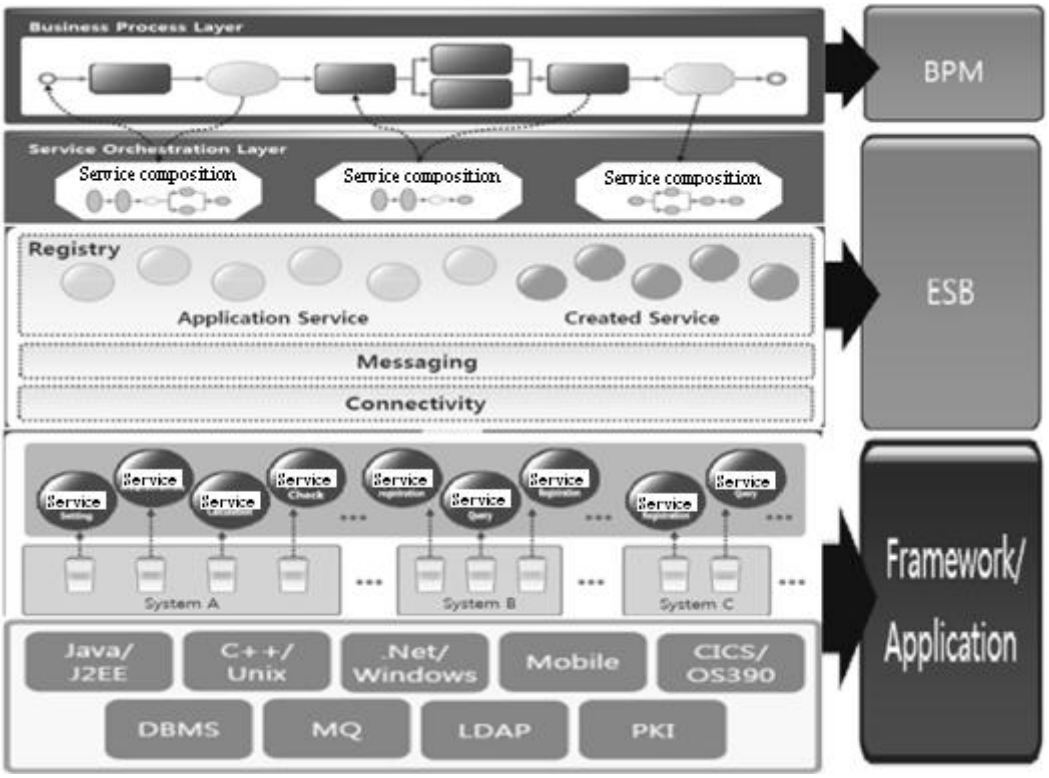

Fig. 6. SOA vision with middleware ESB and BPM [Adapted [11]]

- different types of occasional electricity links, and site organization;
- checking equipments at customer request;
- releasing approvals for to construct new electricity networks;
- rental equipments (e.g. poles, transformers);
- electricity networks maneuvers, different operational work that is performed at the request of prospective customers.

Types of installations which are managed by CEPDS are:

- high voltage underground power lines, high voltage overhead power lines, medium voltage underground power lines, medium voltage overhead power lines, low voltage underground power lines, low voltage overhead power lines;
- electric transformer stations ;
- electric transformer substations ;
- overhead and underground electrical connections;
- electricity meter groups.

Operating environment in which CEPDS works is composed (see Fig. 7) of the following components:

- electricity production which has as main actors production electricity companies which use different energy sources(e.g. coal, gas, biomass, hydro, nuclear and so on);
- transport of electricity which has as main actors transmission electricity companies from production companies to distribution electricity companies. In plus these transmission companies can also storage energy and transport it later;
- the electricity distribution has as actors the electricity distribution companies which transport electricity power to customers;
- operation – the actors here are the persons who manage electricity networks;
- regulatory authority in the Energetic Field – it is an institution that aims to create and enforce regulations needed for the good functioning of the electricity system area, in terms of efficiency and competition;
- electricity service providers; they deal with the provision of energy services for distributions and transport electricity companies and also for end users.

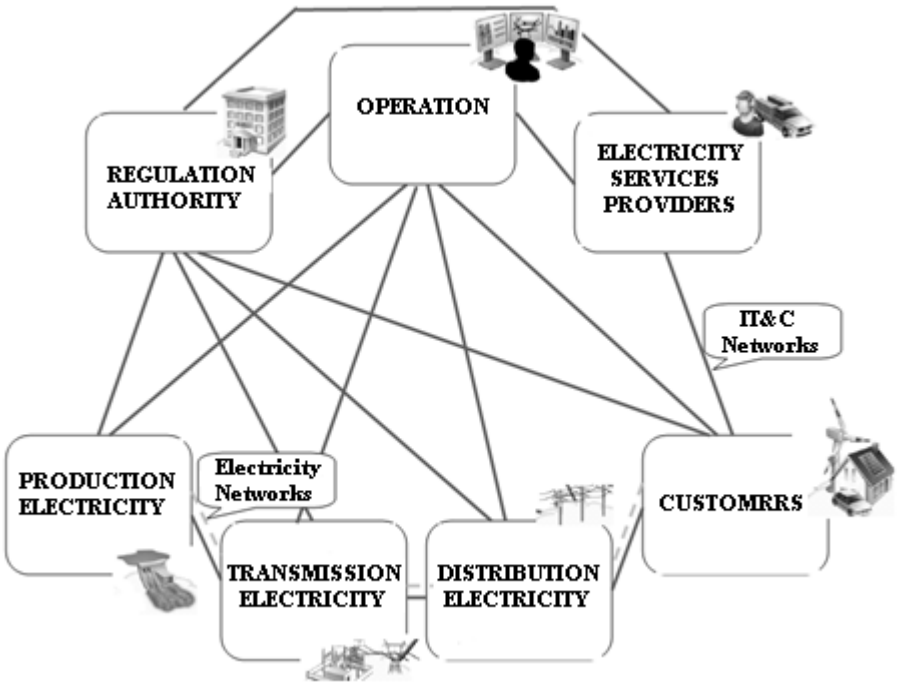

Fig. 7. Operating environment of CEPDS

6 Implementation characteristics of a SOA Architecture in a CEPDS

In a CEPDS the information is stored in all the electrical equipments, which are distributed by the logically and physically point of view: Intelligent Electronic Device (IED), Station Automation System (SAS), which are distributed belong the most important information sources. All of these can add all the information related to security, control, maintenance and also information about electricity market.

Fig. 8 represents proposed service oriented architecture for a CEPDS. This architecture can be split in external components area and internal components area.

Internal components of CEPDS are the following:

- *Operation* – component which manage main activities for distribution electricity area;
- *Communication Channels Management*, a component which contains: a management system, print templates, a

system which manage electronic signature, a system users identity management (e.g. authentication and authorization), a Web portal, a call center and customer relations points where CEPDS interface is assured by human operators;

- *Corporate activities* - component which manage all activities - non distribution or supply electricity, but with an important role in the base business processes;
- *Supply Electricity Management* - component which manages all the activities of the supply electricity business process;
- *Business Process Management* – component which manage business processes during life-cycle from heir creation to execution;
- *Identity Management* - component which manages the authentication and authorization of the users for all Web services of the CEPDS;
- *Crew Management* - component which manage all human resources from the field crew which participate to all activities for operation and maintenance of electricity distribution equipment;
- *Advanced metering infrastructure (AMI)* – this component has intelligent network meters which are mounted at final customers (e.g. industrial, home, office buildings);
- *Automation of distribution equipment remote controlled* – component which manages Station Automation Systems (SAS) and distribution cable automation. The automation of the electricity networks leads to "smart grid". A smart grid contain millions of sensors, protections, relays, circuit breakers namely IED (Intelligent Electronic Device). IED can be locally or remote controlled by automation and control equipment. IED management is made by SCADA **(**Supervisory Control and Data Acquisition) and DMS (Distribution Management Systems).

External CEPDS components are the following:

- *Regulation Authority* – component which interacts with CEPDS and sends all regulations about electricity. CEPDS send to Regulation Authority reports with specific indicators, which Authority uses to calculate distribution and supply tariffs electricity;
- *Electricity Market* – component care assure environment where CEPDS buy electricity which supply to customers and sell electricity which customers didn't consumed;
- *Providers* – means component from which CEPDS purchase materials and services for electrical networks or other services;
- *External Providers for Web Services* – component which supplies Web services which are used by CEPDS for the achievement of certain activities from business processes;
- *External Providers for Web Services* – component which supplies Web services which are used by CEPDS for the achievement of certain activities from business processes.

The activities of the CEPDS involve complex, efficient and flexible business processes, which is under a continuous optimization process. Business processes are managed by component namely *Business Processes Management*. All business processes from CEPDS are first time modeled using BPMN (Business Processes Modeling Notation).After testing and approval phases, these are deployed using BPEL (Business Process Execution Language) .Web Services used for deploying of business processes are either internal web services or external web services, supplied by *External Providers for Web Services*. Internal Web services are hosted in *Service Repository* component.

Interaction and integration of Web services is achieved using *Enterprise service Bus (ESB)*.Rules used by business processes are managed BRMS (Business Rules Management System).Business rules are provided by way of Web Services by Regulation Authority. Rules provided are

based on energy legislation and regulations issued by the Regulation Authority.

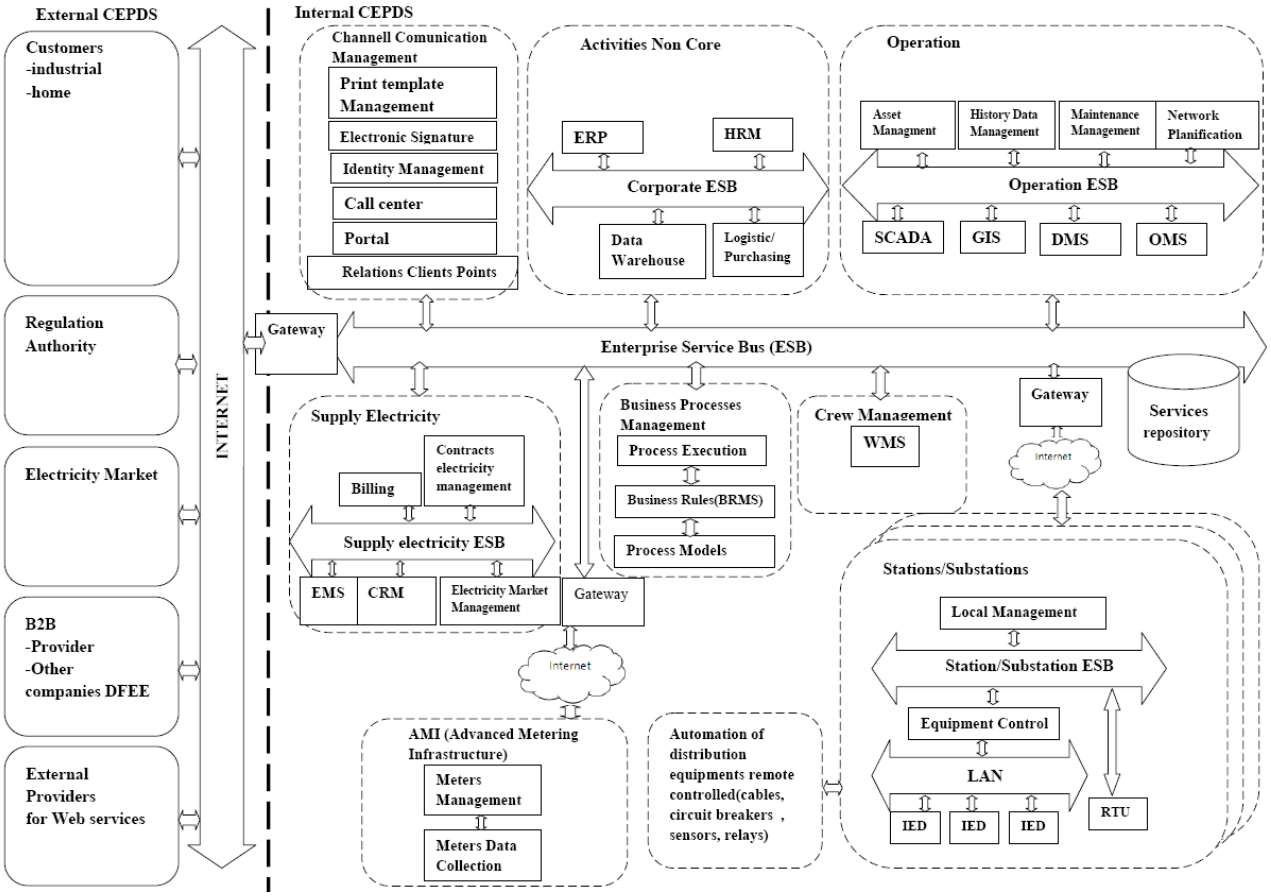

Fig. 8. An example regarding implementation of SOA Architecture in a distribution and supply electricity architecture

Component *Communication Channels Management* offers two Web services, which are used which are shared by all business processes of CEPDS, but also by external components. These are:

- *Print templates management* – this service manages CEPDS print forms, required for internal use and also in relation to external components (e.g. connection to the electricity network at demand of a customer), and forms that require external components to CEPDS for business relationships (e.g. the service provider send your form to CEPDS which can make an request for supply with materials or services);
- Electronic signature - this service manage signatures which CEPDS send to on print forms to external components and also signatures from print templates which CEPDS receive from external components.

This component provides Web services for the following communications channels for external components:

- *Call center* – any request from a customer is transformed automatically or manually by a human operator in a request of a Web service, which then is used in a business process to satisfy demand that customer;
- *Portal CEPDS* – transform a remote customer request in a request of a Web service, which then is used in a business process to satisfy demand that customer;
- Relations Clients Points has same behavior like Call center.

The component External Providers for Web services provides Web services to request of CEPDS, other than those services internally

implemented within the company. Such a service could be for example service for authentication and authorization of users. This service is used in a centralized manner for all users CEPDS and for all users from external environment (customers, suppliers, regulators, etc.), which must be allowed when using Web services provided by CEPDS through *Channel Management Component Communication.* Another example of Web service that can be purchased externally is electronic signature service.

The component *Operation* is mainly dealing with process monitoring and control and process maintenance for equipment and distribution electricity networks. The process for monitoring and control using services is provided by *SCADA* which collect data from IED from stations/substations level and electricity networks. These data are processed using services provided by Historical Data Management and base on it can make decisions on reconfiguring electrical networks. After processing the data and services provided by the *GIS* (geographic location) and network planning (network model), can be delivered services by SCADA together DMS (Distribution Management System) to *Automation of distribution equipment remote controlled* for to manage automated equipment to change the configuration of electricity network. For the maintenance process will be provided the following services:

- a service of storing network configuration before failure, provided by *History Data Management*, a service for fault isolation provided by *SCADA* and *GIS;*
- a service for verification load of networks which are close fault location provided by *GIS* and *History Data Management;*
- a service for determination field crew that is the geographically closest to the fault location, service provided by *GIS* and *WMS* (work management System);
- finally a service re-configuration of the grid, in configuration before failure, provided by *GIS, History Data Management* and *Network Planning*.

The *Supply Electricity* component manages the following services:

- Web services for purchase electricity from producers, through external component *Electricity Market*;
- Web services for selling electricity non consumed to other electricity suppliers, through the external component *Electricity Market*;
- Web services provided by EMS (Energy Management System) to monitor energy balance;
- Web services management contracts of electricity (in relation to electricity producers and in relation to end consumers);
- Web services for billing electricity for end customers(this service can transmit electricity bill to the customer instantly by intelligent electricity meter;
- Web services which respond to customer requests and customer claims.

The *AMI (Advanced Metering Infrastructure)* component manages Web services which communicate with intelligent meters. The main feature of these intelligent meters is that they communicate with the CEPDS in two ways namely:

- A way that the customers receive mainly electricity from CEPDS through electricity networks. By these means the customer receives information (from the *Supply Electricity* component) from EMS by a Web service. For example, the information may contain specifications of the tariffs plan for electricity supplied, the time intervals for interruptions electricity supply for maintenance or reconfiguration of distribution networks, acceptance from CEPDS to supplement power to customer request, interruption of power supply in case of default or fraud and other information necessary to the end customer to optimize own electricity consumption;
- A second way to communicate at *Supply Electricity* component from CEPDS, through a Web service from intelligent meter, mainly electricity consumption of end customer. Also by this way the end

customer send to *Supply Electricity* component from CEPDS tariffs plan data hourly accepted, confirmation electricity supply for end customer to CEPDS, after rectification an defect in power distribution network and other information necessary to electricity supplier for improvement quality and reliability in the power supply of end customers.

7 Conclusions

CEPDS are companies which are managed by complex business processes; they contain many heterogeneous equipments and IT systems. In order that the business processes, equipments and IT systems to communicate each other, their integration is needed. A good solution for such integration is represented by service oriented architecture (SOA). In such architecture, the services provide the functions supporting company's business processes.

To implement business processes using BPMN and BPEL need to use Web services exposed by IT systems. BPM and SOA provide a good combination for the enterprise. BPM provides a tool for defining business processes and also other important possibilities of monitoring and managing these processes.

Web services need a lot of information from the field equipment of the electricity networks. In order to acquire this, the equipment of the electricity networks have to be automated and remote controlled. There is also needed a system to collect these data and expose Web services to share these data with business processes. Because IT systems are heterogeneous, Web services exposed by them have to be integrated using Enterprise Service Bus (ESB). In the end, the infrastructure (ESB) and SOA capabilities for services have to be combined to support and create an agile and flexible company.

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