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SUPPLY CHAIN INFORMATION INTEGRATION THROUGH SERVICE ORIENTED ARCHITECTURE

Abstract: *In recent years information integration became significant problem for both natural and legal persons in everyday operations. Huge amount of information are available, but insufficiently processed in order to have useful value. Choosing the right combination of tools and technologies for integration is prerequisite for requiring information from multiple heterogeneous sources and their qualitative and simple using after.In this paper, we have focused on information integration within companies which are parts of supply chain or network. This environment typically includes a various mix of sources, structured (such as relational or other databases), and unstructured (such as document repositories, spreadsheets, documents, web pages, emails and others). Effective information integration and sharing significantly enhances supply chain practices.Service oriented architecture (SOA) is an architectural style for building software applications that use services available in a network such as the web. The use of SOA to achieve inter-enterprise supply network information integration has many advantages.*

Keywords: *information integration, supply chain, service oriented architecture, SOA*

1. Introduction

Supply chain (SC) is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer. The concept of supply chains in recent years evolved into the concept of a supply network (SN) due to the rapid development of modern technology and the globalization of business.

The core of SC/SN is integration. Supply chain integration constitutes the following three dimensions: information integration, coordination and organizational linkage. Information integration (II) is the foundation of broader supply chain integration, since information integration consists of information and knowledge exchanges through information sharing, collaborative planning, forecasting and replenishment.

First appearance of term information integration can be found in (Anderson, 1982). Information Integration theory explores how attitudes are formed and changed through the integration (mixing, combining) of new information with existing cognitions or thoughts. This theory assumes the existence of three algebraic functions:

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valuation, integration and response. However, in recent years, his theory has evolved into a modern information technology concept with the same name.

Information integration concerns the sharing of information and data between supply chain members, including sharing demand information, inventory, production capacity planning, production schedule, promotion plan and the demand forecasting, etc.

The main goal of information integration systems is to combine information residing at different sources, and to provide the user with a unified view of this information. The idea is to provide transparent integrated access to relevant data, concealing information about the sources, such as their location, data model or query language.

The main goal of research presented in this paper is to indicate how information integration in supply networks can be achieved through service oriented architecture.

The main results of research aiming to presentation of several examples which can be used in supply networks.

Research limitations are related to the complexity of observed phenomena.

2. Background

Very large volumes of data are available in electronic form in many different systems and formats, such as relational databases, XML data sources, spreadsheets or documents, and on the web. The volume of data has been growing steadily over decades. This explosion of information comes with the need for advanced data management. Information integration is at the heart of needed functionalities for a large number of applications by using efficient query processing involving aggregation and group-by operations efficiently.

Information integration is becoming a critical problem for businesses and individuals alike. One critical challenge is choosing the right combination of tools and technologies to do the integration (Haas, 2007).

The ultimate success of a company will depend on how the company constructs, controls and integrates the supply chain formed with its business partners (Lambert and Cooper, 2000).

How to integrate supply chain effectively from the perspective of information integration of a value-added services supply chain could be find in (Wang and Tang, 2007).

Information integration in supply chains is beneficial to performance (Seggie *et al.*, 2006, Arsovski *et al.*, 2012). Increasingly information integration in supply chains is viewed as crucial to delivering benefits of integration (Gunasekaran and Ngai, 2004). However, information integration in supply chains is not well advanced (Sanders and Premus, 2002) despite the development of eBusiness technologies and the take-up of enterprise resource planning (ERP) systems (Mabert *et al.*, 2003).

The main barriers to supply chain information integration discussed in (Harland *et al.*, 2007) are lack of strategic alignment of information strategies in the chain, company size of some supply chain actors, lack of awareness of potential benefits of eBusiness, lack of motivation, and being in a less developed industry or regional context.

Information sharing can be divided into demand oriented and supply oriented information sharing. Demand-oriented information sharing includes the sharing of real-time point-of-sales data, sales forecasts (Cachon and Lariviere, 2001; Aviv, 2001), customer profiling, and customer relationship management (Frohlich and Westbrook, 2001). Supply oriented integration includes inventory ordering policies, inventory levels (Gavirneni *et al.*, 1999) and master production schedules (Frolich and Westbrook, 2001; Gavirneni *et al.*, 1999; Narasimhan and Das, 2001).

Effective information sharing significantly enhances supply chain practices, such as supply chain planning and just-in-time production (Benton and Zhou, 2007). The types of information exchanged may include, but are not necessarily limited to, inventory and replenishment, consumer research, financial status, growth ability, overhead cost structure, production capacity, or proprietary technology (Kulp *et al.*, 2004).

Real-world data tend to be incomplete, noisy, and inconsistent. Data cleaning (or data cleansing) routines attempt to fill in missing values, smooth out noise while identifying outliers, and correct inconsistencies in the data (Chakrabarti, 2009).

Online analytical processing (OLAP) is a service that typically sits on top of a data warehouse (figure 1). The data warehouse provides the infrastructure that supplies the detailed data. Data warehouses often contain hundreds of millions of rows of historical data. Answering queries posed directly against the detailed data can consume valuable computer resources. The purpose of OLAP is to answer queries quickly from the large amount of underlying data.

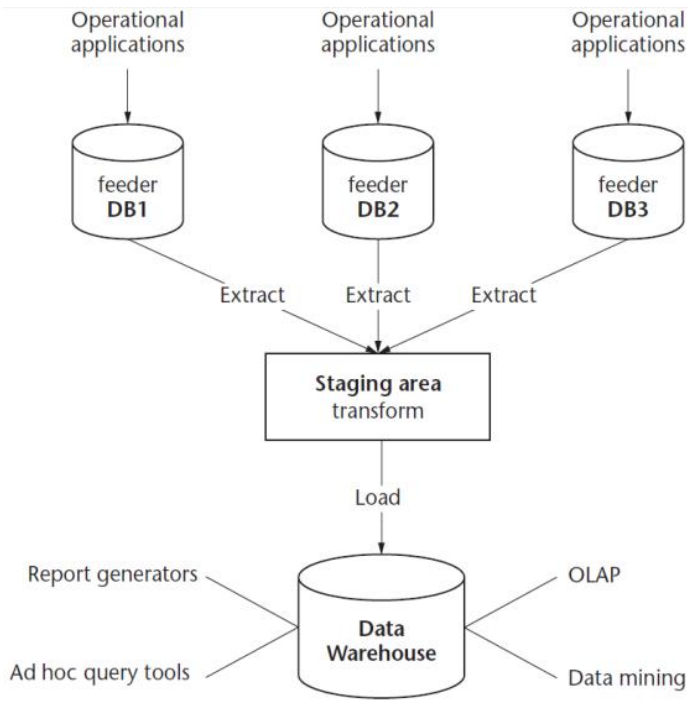

Figure 1. Basic data warehouse architecture (Chakrabarti, 2009)

Moving data from the feeder databases into the data warehouse is often referred to as an extract, transform, and load (ETL) process. Data in the warehouse can then be explored in a variety of ways, including OLAP, data mining, report generators, and ad hoc query tools.

Information is not only hard to find, but further complications such as overlapping, conflicting and incomplete information are inevitable. Usually problem occurs when different business units has information about the same business entity such as for example supplier or customer.

Researchers dealing with data management systems use information integration as an

answer to these problems. It can be said that t**he goal of information integration is to enable rapid development of new applications requiring information from multiple sources.** This simple goal hides many challenges, from identifying the best data sources to use, to creating an appropriate interface to (or schema for) the integrated data.

There is no one integration problem; the challenges vary depending on the environment. In this paper, we focus on information integration within supply network (figure 2).

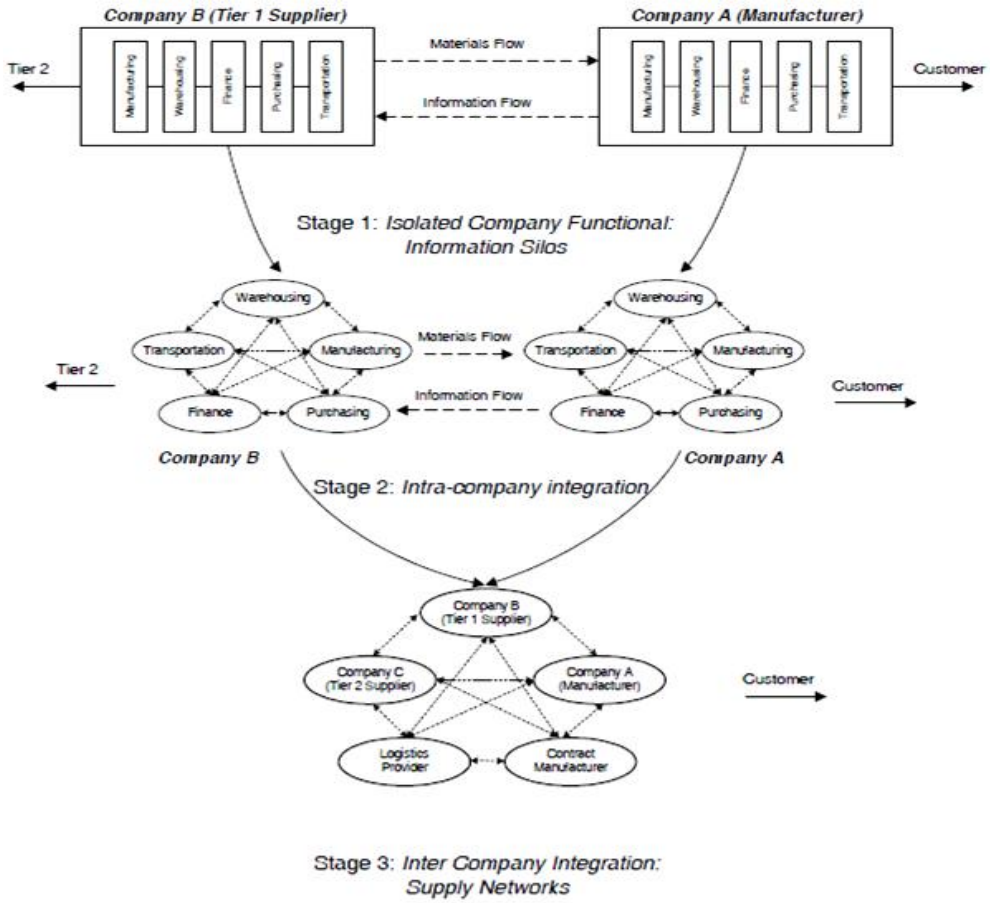

Figure 2. Supply Chain Integration Process (Milanovic *et al.*, 2011)

With many participants, supply network became mix of sources, usually structured (e.g., relational or other databases), but increasingly many unstructured (e.g., document repositories, web pages, documents, emails, etc.).

A broad range of technologies is used to create a platform on which integration tools can be built as components that interoperate through a **common repository** in order to solve II problems.

3. Information integration as a process

For businesses, information integration is

really a process, with four major tasks: understanding, standardization, specification, and execution (Haas, 2007). These tasks are iterative, interdependent and may be overlapped in practice.

Understanding includes **discovering relevant information (keys, constraints, data types, validation rules, default values, and so on)** and analysing it to assess quality.It is also important to notice possible relationships among data elements (such as foreign keys, or redundant columns).Metadata (data about data) is the result of this task.Later it will be used in following tasks in the process.

Standardization determines the best way to represent the integrated information. This includes **decision at the field level what the standard representation should be** (e.g., will supplier addresses be represented as street name and city name or only street name or what should be mask for telephone numbers, with or without country code), **and even defining the terminology and abbreviations to use** ("str" vs. "st" for "street"). Also, other rules that specify how to cleanse or repair data may be provided. For example, how to handle inconsistent or incomplete data (if multiple phone numbers exists for the same supplier, should we keep all of them, or only the most recent?) and how to identify data that refers to the same entity (is ABC the same supplier as ABC Inc.?).

Specification includes choice of execution engine(s) which could specify the relationship between source(s) and target(s). It could be done by **a querygenerated**to **produce data in the desired target form**.

Executionis where the integration actually happens. It can be accomplished via materialization, federation and/or indexing. ***Materialization*** creates and stores the integrated data setby using Extract/Transform/Load (ETL) jobs - extract data from one or more data sources, transform them as indicated in the job script, and then store the result in another data source. ***Federation*****creates a virtual representation of the integrated set, only materializing selected portions as needed**. ***Indexing*****creates a single *index*in a set of integrated data**. This technique is used mostly for unstructured data, since the index identifies relevant documents, which will be fetched dynamically at the user's request.

4. Service Oriented Architecture (SOA)

Web Service is a service oriented architecture that defines a set of standard protocols, which is used to define the interface, to invoke methods, to register components, and to achieve various Internet based applications (Alonso *et al.*, 2004). Figure 3 presents the service oriented architecture map.

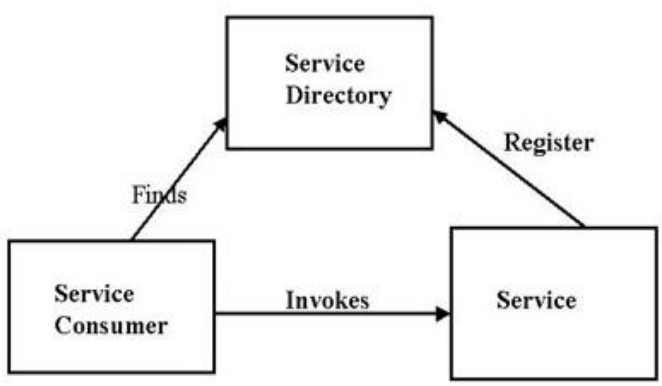

Figure 3. Service oriented architecture

SOA is an architectural style for building software applications that use services available in a network such as the Internet. It promotes loose coupling between software components so that they can be reused. Applications in SOA are built based on services and can communicate with each other in such architectures through services. A service is an implementation of well-defined business functionality, and such services can then be consumed by clients in different applications or business processes.

In web environment, services are self describing components, which can be recognized by client applications through look up from a registry (such as UDDI - Universal Description, Discovery and Integration). The client application and the service provider communicate via standard protocols (e.g. SOAP, HTTP) and exchange information using standard data formats like XML. Previous software architectures based on object-oriented approaches suffer from a lack of standards when compared to SOA.

SOA could be found everywhere, as well as in supply network. Take a purchasing of product for instance. If customer wants to buy it, it will ask for bids from suppliers and mostly all of them will give him an answer in a form of bid. It means that each supplier offers a bid service. From aspect of customer it is nice because it can replace one supplier with another if it is not satisfied. Customer can buy the same product from different suppliers since they all offer the same bid service, but the quality of service is different which depends on predefined criteria which could be price, quality of product, shipping time, quantity, etc.

Of course, customer can collect bids from suppliers and later analyse it all. But, consuming a bid service is usually cheaper and more effective than doing the work by ourselves. Also, it is better to give experts to do the work since customer can not be smart enough to be expert in everything. The same rule named "separation of concerns" applies in developing of software systems as a principle of software engineering.

4.1 SOA suites

SOA suites are comprehensive commercial software products (including tools and platforms) that support SOA. In a present state, leaders are three companies well known on software market. Short description of their software products is given bellow.

Microsoft BizTalk Server is an Enterprise Service Bus, e.g. a software architecture model used for designing and implementing the interaction and communication between mutually interacting software applications in SOA. Through the use of "adapters" which are tailored to communicate with different software systems used in an enterprise, it enables companies to automate business processes. Created by Microsoft, it provides the following functions: Enterprise Application Integration, Business Process Automation, Business-To-Business Communication, Message broker, and Business Activity Monitoring.

In a common scenario, BizTalk enables companies to integrate and manage automated business processes by exchanging business documents such as purchase orders and invoices between disparate applications, within or across organizational boundaries. Additional applications like Microsoft SharePoint server are needed forhuman-centric processes.

Development for BizTalk Server is done through Microsoft Visual Studio. A developer can create transformation maps transforming one message type to another (for example an XML file can be transformed to SAP IDocs, etc.). Messages inside BizTalk are implemented through the XML documents and defined with the XML schemas in XSD standard. Maps are implemented with the XSLT standard. Orchestrations are implemented with the WS-BPEL compatible process language xLANG. Schemas, maps, pipelines and orchestrations are created visually using

graphical tools within Microsoft Visual Studio. The additional functionality can be delivered by .NET assemblies that can be called from existing modulesincluding, for instance, orchestrations, maps, pipelines, business rules.

Oracle SOA Suite is another comprehensive software suite to build, deploy and manage SOA. The components of the suite benefit from common capabilities including consistent tooling, a single deployment and management model, end-to-end security and unified metadata management.

The products contained in this suite are: BPEL Process Manager, Human Workflow, Adapters, Business Rules, Business Activity Monitoring, Oracle Event Processing, Oracle Service Bus, Oracle B2B, Oracle Web Services Manager and Oracle SOA Suite for healthcare integration.

IBM WebSphere ESB provides an Enterprise Service Bus for IT environments built on open standards, SOA, messaging and Web services technologies of WebSphere Application Server. WebSphere ESB is a Java centric ESB that has strong integration with Web services-based connectivity and service-oriented integration. WebSphere ESB inherits the high availability and failover capability of the WebSphere Application Server, Network Deployment edition.

WebSphere ESB supports a wide variety of protocols such as JMS, MQ, EJB, WebServices, REST, HTTP etc. Formats that are supported include XML, Text, delimited, COBOL, etc. The development workbench for creating mediation flow in WebSphere ESB is called WebSphere Integration Developer. WebSphere Integration Developer builds on top of an Eclipse workbench. You can develop the mediation flows with the graphical editor by dragging and dropping primitive nodes. WebSphere ESB has many built-in nodes that support different types of operation such as data transformation, routing, filtering, database lookup, endpoint lookup, etc. You can perform all the development, unit testing and debugging in the WebSphere Integration Developer workbench. It contains a complete unit test environment which is a real WebSphere ESB runtime server.

4.2 SOA Services

Key concepts in any service oriented architecture are services.They can be dividing into many different categories. The SOA Reference Architecture defines a standard categorization scheme for services, where services are categorized according to their purpose (though categories are not mutually exclusive).

Partitioning services into groups is a common activity in the development of the services and service portfolio in a services oriented architecture. Categories and groups of services affect how both business and IT views and understands the architecture and the portfolio of services that supports it.

The figure 4 given below shows a functional categorization scheme for services found in a typical company.

Services can be divided into two main groups: domain specific and domain independent.

Services in the middle, such as interaction services, process services, information services, etc., are considered to be domain specific. These are solution specific and require implementations unique to the domain or solution being developed. Domain specific services may be purchased, but generally require extensive customization or extension.

The remaining services categories are considered to be domain independent. These domain independent categories include development services, management services, etc. Services of this category can be used directly in many different domains or solutions. In general domain independent services are used to plan, develop, support and manage the domain specific services in the solution. Often domain independent

services can be purchased and used without extensive customization.

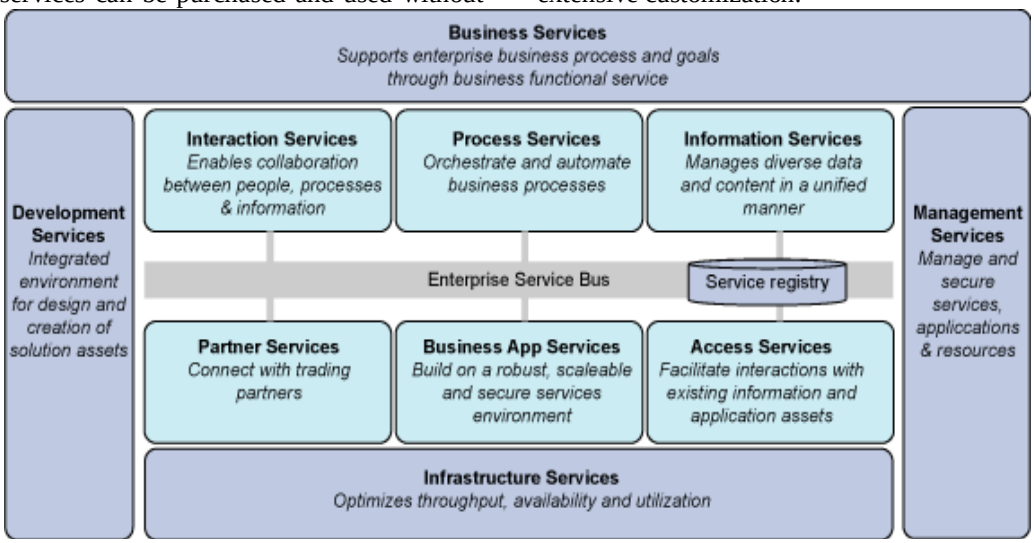

Figure 4. Types of Services

Service categories are:

- Interaction Services – supports the interaction between applications and end-users and provide the presentation logic of the business design.
- Process Services - include various forms of business process flows.
- Information Services - provide the data logic of business design, in a way to access the original business data, support data composition, and provide their own sub-architecture for managing the flow of data across the organization.
- Access Services - integrate legacy applications and functions into the service oriented architecture solution.
- Business Application Services - implement core business logic where the implementations are created specifically within a business model.
- Partner Services - capture the semantics of partner interoperability that have a direct representation in the business design.
- Lifecycle Service – support managing the lifecycle of SOA solutions and all of the elements that comprise them across development and management ranging from strategy to infrastructure.
- Infrastructure Services - provide efficient utilization of resources, ensure the integrity of the operational environment, and balance workload to meet service level objectives, isolate work to avoid interference, perform maintenance, secure access to confidential business processes and data, and simplify overall administration of the system.
- Asset and Registry Services - provide access to the assets that are part of the overall architecture. This includes service descriptions, software services, policy, documentation and other assets or artefacts that are essential to the operation of the business.
- Management Services - provide the set of management tools and metrics used to monitor service flows, the health of the underlying system, the utilization of resources, the identification of outages and bottlenecks, the attainment of service goals, the enforcement of administrative policies and recovery from failures.
- Development Services – supports the entire suite of architecture tools,

modelling tools, development tools, visual composition tools, assembly tools, methodologies, debugging aids, instrumentation tools, and discovery agents needed to construct an SOA solution.

- Business Services - capture the business function and are offered to as course-grained services to external consumers.
- Strategy and Planning Services - supports creating vision, blueprint and transition plan for improving business outcomes, along with the services that process the strategies of the business to create an implementation roadmap covering both business and IT.
- Mediation Services - responsible for binding service consumers with service providers – transparently resolving location to achieve an optimal routing of requests across the network and meet the goals of the business. Mediations typically add additional value by doing some useful activity, like logging or translation, in addition to the connectivity.
- Security Services - address protection against threats across the vulnerable dimensions of an SOA. They are responsible for protecting interactions between service consumers and service providers as well as protecting all of the elements that contribute to the architecture.

4.3 Prerequisites for SOA implementation

Companies want to be shure that their supply networks are efficient. There's a real need for companies to think about their information supply chain and their underlying data, particularly when they start to implement SOA.

Information supply chains accept the information and data flowing into a company from a wide variety of sources, manage it and use it both within and external to a company.

If we observed one specific segment of the information supply chain, the part that deals with information about products, one of the problems could be that product data isn't necessarily easy to manage.

If product data needs to be recognizable and shared across systems, problem can arise, since product data can be presented in so many different formats, categories, and forms. As a result, product data integration isn't easy. Even though, companies still trying to do it. Some existing solutions are described bellow.

First approach to managing product data is through manual effort. This approach can work, but it's expensive, not very scalable and should typically be considered a one-time fix. Problem is even biger when organizations need to manage many thousands of products.

Writing a custom code is second approach. If the product data is very simple or very consistent, this can be a solution expensive to develop and hard to maintain. It is also possible that incorrect information about products can appear.

ETL is third approach. It can work well, depending on the complexity of the data. Structured data sets could be managed without problems, unlike to unstructured data.

All three presented approaches have implementation problems - low efficiency, more time for implementation and less cost effectiveness over the longer term. The wrong solution to product data management also probably won't scale very well and may thus limit an organization's ability to respond to business change.

The automation of a company's information supply chain it will make a company more flexible and will enable it to create scalable solutions for business problems. The company will also be better able to take advantage of new business opportunities. In addition, in practice, even the best SOA strategy will not work if the underlying data and information that feeds into the various

services isn't reliable and standardized.

5. SOA solutions

For supply chain partners, their internal information systems can manage their own data very well. However, as the supply chain alliance members, their information sharing from each other is necessarily needed.

A network model of information flow in supply chain is illustrated in figure 5.

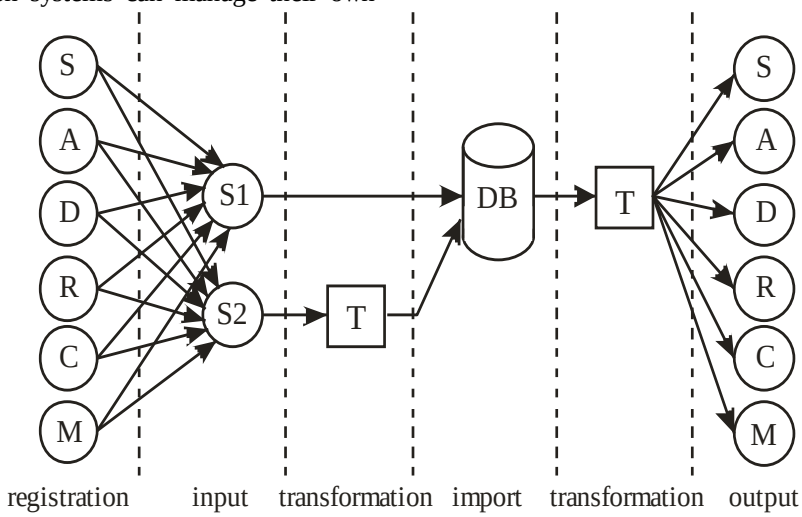

Figure 5. Physical (network) model of information flow in supply chain (Milanovic*et al.*, 2012)

Following simbols were used on figure 5 for modeling of information flow through supply chain: S – suppliers, A – assemblers, D – distributors, R – retailers, C – customers, M – manufacturers, S1 – request for information, S2 – information for upload, T – queries or filters, DB – database (information junction, e-hub).

It is noticeable that the entire communication between the partners in the supply chain actually operates through an information hub and, in contrast to the horizontal movement of products, has the character of the vertical connectivity. In Figure 5 one can see the entire supply chain on the left and right area of the physical model.

Two kinds of services present in each supply chain will be discussed in addition: product purchasing and customer orders.

Take a purchasing of product for instance(Milanovic*et al.*, 2010). If customer wants to buy it, it will ask for bids from suppliers and mostly all of them will give him an answer in a form of bid. It means that each supplier offers a bid service. From aspect of customer it is nice because it can replace one supplier with another if it is not satisfied. Customer can buy the same product from different suppliers since they all offer the same bid service, but the quality of service is different which depends on predefined criteria which could be price, quality of product, shipping time, quantity, etc.

In both examples the business case is to create a new application that can place purchasing of product or customer order, but with the criteria to reuse existing back-end solutions (Figure 6 and Figure 7).

The SOA solution is built of the following reusable blocks:

- Basic Data Service – CRUD operations.
- Composed Services – business logic.
- Process Services – complex business logic.

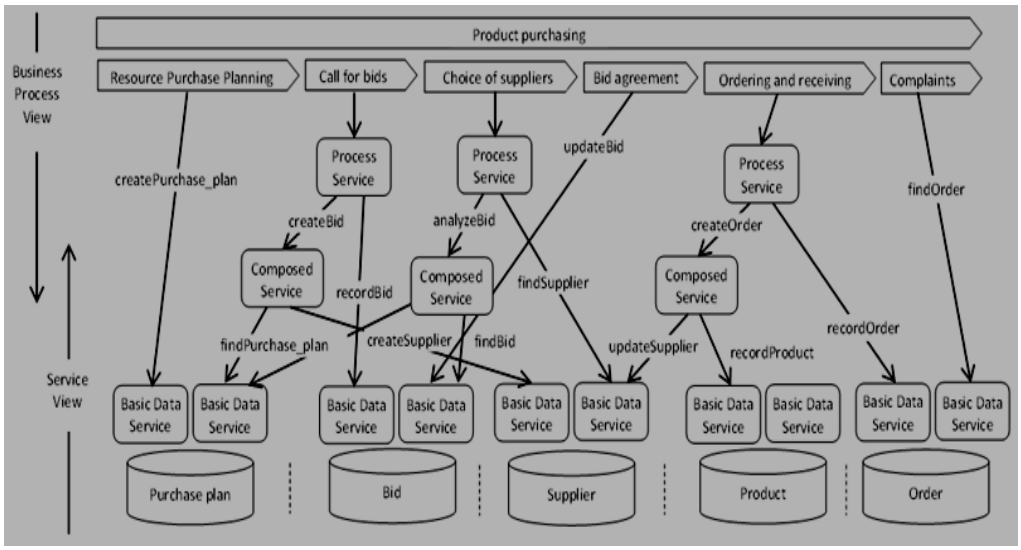

Figure 6. Product Purchasing

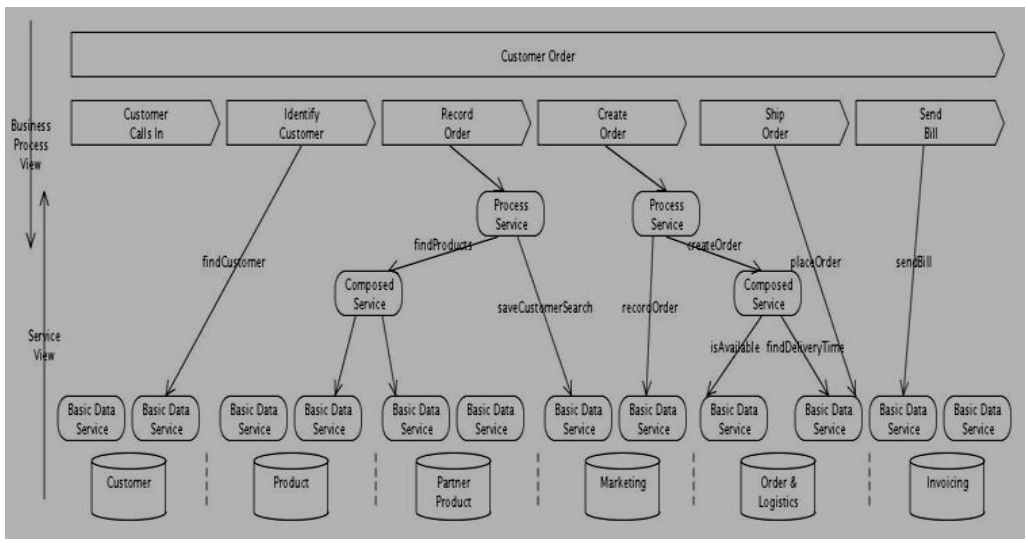

Figure 7. Customer Order

6. CONCLUSION

After doing research on SOA frameworks technology and how it can be used for information integration in supply chain companies, in this paper, we proposed two solutions which are based on SOA. Both solutions should be further analized in details in order to eliminate posible imperfections.

In our future work many other services will be designed in order to simplify information integration of new partners in supply network.

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