Multi-agent System based Service Oriented Architecture for Supply Chain Management System (MAS-SOA-SCM)

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ABSTRACT
To make information sharing across organizational departments and information systems more effective , new technologies and architectures have emerged that provide a platform for integration. These integrating technologies use standardized protocols and data formats for sharing and exchange of information. Service-oriented architecture is an important new paradigm that supports modularized implementation of solutions. These architectures are particularly applicable when multiple applications running on varied technologies and platforms have to communicate with each other. A clear plan and company-specific standards are key prerequisites and this will ensure a systematic implementation of such architecture across enterprise. Multiagent system, Service Oriented Architecture and Supply Chain management are combined as major components of MASSOASCM. MASSOASCM model is designed and it is established how it works in a manufacturing unit. It has been argued how it reduces time of implementation, cost and managing inventory which is the major concern of any industry. Intention of our work is to develop a supply chain management application based on MAS and SOA and build a model how it can help improve SCM performance in a manufacturing unit. The Supply Chain Management application consists of three different services i.e. MAS, SOA and SCM. These services are designed, integrated and architected separately and brought them together using MAS and SOA technologies.

Keywords Multi-agent system (MAS), Service oriented architecture (SOA), supply chain management (SCM)

1. INTRODUCTION
A service-oriented architecture (SOA) is an architectural style for combining software applications that utilize available services over a network. It is an area for organizing and utilizing distributed capabilities that may be under the control of different ownership domains[5]. An SOA may support a variety of different communication protocols, but common protocols based on open standards (e.g., SOAP and WSDL) are used in general in SOA implementations . These open standards are not the only technology with which an SOA can be established and it is likely that many SOAs which are large , will also provide access to services with a combination of several technologies[6] . We look in to various MAS-SOA factors that work especially in the industry environment. When it is applied to industry, various challenges are discussed when MAS-SOA is implemented. SOA methodologies are briefly discussed. The architectural considerations are also briefed. Multi-agent systems in which multiple interacting agents interact to solve problems and how it gets integrated with SOA to solve industry problems have been taken up for our discussion . It is also an attempt to justify how MAS-SOA combination can be applied to face supply chain problems and improve its performance in a manufacturing firm. A model MAS-SOA-SCM is designed which provides how these three technologies can be clubbed in improving the information sharing, SCM performance and controlling of inventory thereby reducing the cost over supply chain. Other systems interact with SOA and MAS services and SCM are just mentioned. These technologies are standard protocols for proper communications among these three technologies .These standard technologies are SOAP messaging typically using Hypertext Transfer Protocol (HTTP) with an Extensible Markup Language (XML) serialization in conjunction with other related standards such as service registry based on the Universal Description Discovery and Integration (UDDI) standard which can be employed to publish and discover services. Consequently, the question of how to arrive at an MAS-SOA that enables the expected business benefits at an acceptable cost merits further examination and best practices need to be developed.

2. VARIOUS SOA INFLUENCE FACTORS

2.1 Industry Factors
The environment in which a firm operates will definitely vary from that of other industries. Some of these differences may be pertinent to the adoption of an SOA with Web services. Even in the case of EDI, for instance, the power relationships between firms in a specific industry have played an important role in the adoption of EDI. Therefore, the power that a relatively large and influential firm has over another firm, which has been examined in past EDI research would help to understand the major variation in the adoption of SOA in different industries[4]. In the past, firm size has also been identified as a factor influencing the adoption of new technologies. Large firms are more likely to adopt new technology than small firms. Another difference relevant to the adoption of Web services is the maturity of vertical standards for business to business exchanges [8] .

2.2 Challenge Factors

This review tries to identify the key factors that are challenges for the adoption of an SOA. An SOA involves years of effort to get its ultimate result. The trick is to not deploy SOA all at once, because by the time major work is completed , the business needs may have changed and much of the implementation will be of any use . Instead, a step by step deployment specific services in phases may be taken up , perhaps focusing on one application domain at a time or choosing projects based on business urgency. But until the underlying architecture is developed, one can't build anything. Any organization implementing an SOA should create a basic architectural model for a manageable piece of the business, and then apply that model to individual projects, using them both testing the model and to deploying the SOA in pieces. That architecture should include identifying all of the business processes, the interactions among them, the specific applications and functions and the flow of business logic and data to execute the business processes. Because SOA is ultimately about creating and managing IT processes for the business processes and its governance is critical. Step by step implementation without affecting the existing business activities is the key issue and this can be achieved only by close monitoring. A way to enforce the SOA principle of reuse is to evaluate new applications to ensure they are really needed. In an SOA, multiple services residing in multiple applications might combine to execute a business process. If each service uses different data sources or even the same data source in different purposes, the results might not be what one expects .One has to enforce strict separation between services that access and store data and those that act on the data for various business purposeses.

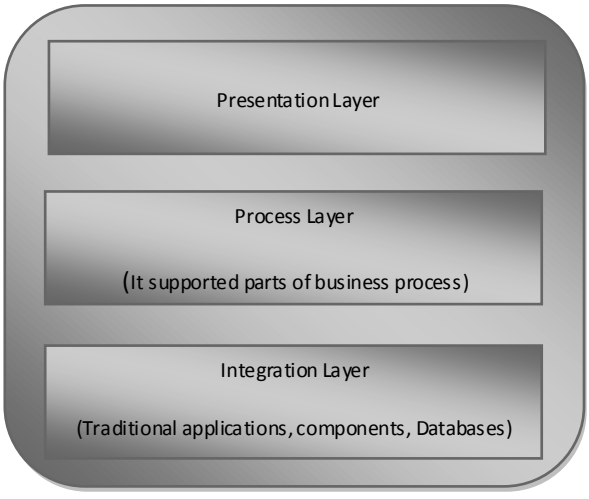

Fig. 1: SOA Layer

3 SOA METHODOLOGIES

SOA is based on layered architecture. It involves Entity, Task, Orchestrated Task and utility services. The model is shown in the fig. 1

The Fig.2 provides how the SOA is implemented in a detailed manner.[8]

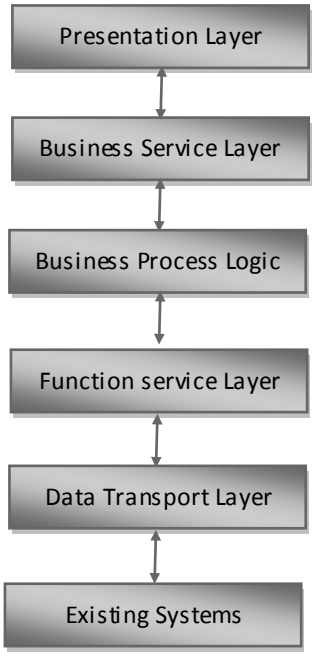

Fig 2 SOA Detailed Architecture

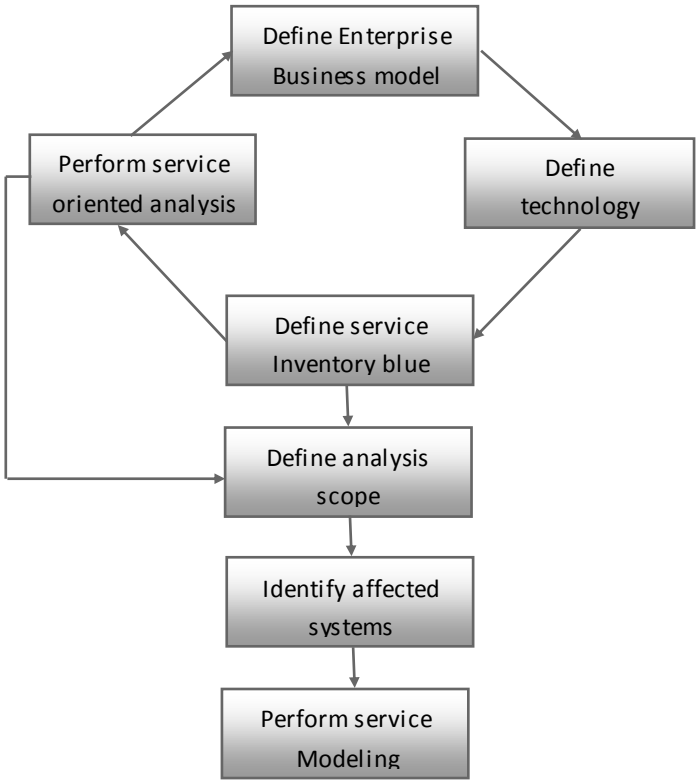

Fig 3: Service oriented Analysis

4. RESEARCH DESIGN

This study employs a multiple case research strategy to explore how organizations are approaching the adoption of a service oriented architecture. This strategy involves use of agents in implementation of SOA technology. This research addresses the factors that influence the adoption of an SOA as well as how and why these agents play a role. Agents are goal oriented. Therefore, we have decided to use a multiple case design rather than focus on a single case. [11]

We examine how agents and SOA work together effectively in Supply Chain management (SCM). SCM is a dynamic application program and therefore Multi-Agent System technology (MAS) finds excellent application in SCM. In fact next Gen SCM is based on MAS technology.

5. MULTI-AGENT SYSTEM

An agent is a physical or virtual entity Which is capable of acting in a environment , can communicate directly with other agents, capable of perceiving its environment , having only a partial representation of this environment , possessing skills and offering services .Agents are autonomy that is able to do at least part of its functionality independently and follow goals autonomously. They are intelligent in the sense that agents have some specialized knowledge in one or more application fields. The agents are able to collect information or to react on conditions of its environment. They are reactive so they react appropriately to inputs from its Environment. They are Pro-activity and goal orientated. The agents change its behavior based on its previous experience. They are mobile in the sense that agents to transport themselves from one node of a network to another. The crucial features are that agents are communicative and cooperative .Multiagent systems are systems in which multiple interacting agents interact to solve problems. Agents in MAS know when and how to interact with whom. Common characteristics of multiagent systems are their inherent distribution and complexity. Distributed and flexible nature of multiagent systems leads to increased speed, robustness, scalability and reusability.[14]

In a MAS,

- *Each agent has incomplete information*
- *Control is decentralized*
- *Data is decentralized*
- *Computation is asynchronous*

At the time of designing MAS , several issues have to be addressed like when and how agents should interact – cooperate and compete – to successfully meet their design objectives , sometimes agents have to solve a subproblem collectively and in such case agents should understand other agents' capabilities , how to enable agents to decompose their tasks and goals (and allocate sub-goals and sub-tasks to other agents) and synthesize partial results , how to enable agents to communicate ,What languages and protocols to use , how to enable agents to represent and reason about the actions, plans, and knowledge of other agents in order to interact with them , how to enable agents to represent and reason about the state of their interactions , how to enable agents to recognize and handle conflicts between agents , how to ensure multiagent systems are correctly specified , how to realize agents intelligent processes such as problem solving, planning, decision making, and learning in a multiagent systems context , how to organize Multiagent systems and define roles of each agent . As the demand for more powerful, efficient and versatile agents grows, so too does the pressure on developers. At the same time making agent perform too many tasks would lead to complexity of development and increase of maintenance Agents are generally designed with a specific purpose in mind. If agents must perform more tasks, we can either increase their complexity (which increases the development effort), or we can make them work co-operatively. The cooperation among agents is absolutely necessary and to succeed, effective communication is required. We need a common language and communication medium. The language and communication medium is critical for cooperation between agents.

6. WHAT IS SUPPLY CHAIN MANAGEMENT?

A SUPPLY CHAIN is a network of supplier, manufacturing, assembly, distribution, and logistics facilities that perform the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these products to customers. Supply chains arise in both manufacturing and service organization [15] . Supply chain management (SCM) process identifies goals , objectives and outlining policies, strategies and controls for its effective and efficient implementations. SCM should be dynamic to meet any new challenges from many directions including suppliers, customers and other external and internal factors. Strong modeling technologies are required to support the complexities involved in SCM. Also business changes fast, collaboration and coordination are vital in SCM, the combination of SOA and MAS is the perfect solution for the organization to meet its objective[12]. Fig.4 is an example of a typical Supply chain in any manufacturing unit.

7. MULTI-AGENT SYSTEM BASED SERVICE ORIENTED ARCHITECTURE FOR SUPPLY CHAIN MANAGEMENT (MAS-SOA-SCM)

To compete with the rest of world in the volatile marketing environment, manufacturers can turn to MAS and SOA Technologies, for supply chain solutions to optimize supply-demand performance through superior inventory operations. MAS are meant for real time applications and SCM requires close monitoring and is to respond to any changes in the Supply chain environment. SOA based solution for demand-supply problem and inventory optimization, is designed to help manufacturers turn the process of managing inventory policies into a competitive weapon, to improve service, reduce costs and gain market share. MAS based SOA strategy helps development process quick and deployment across the business [4].Some of the key requirements of businesses in supply chain context, that are required to face the competitive business world include:

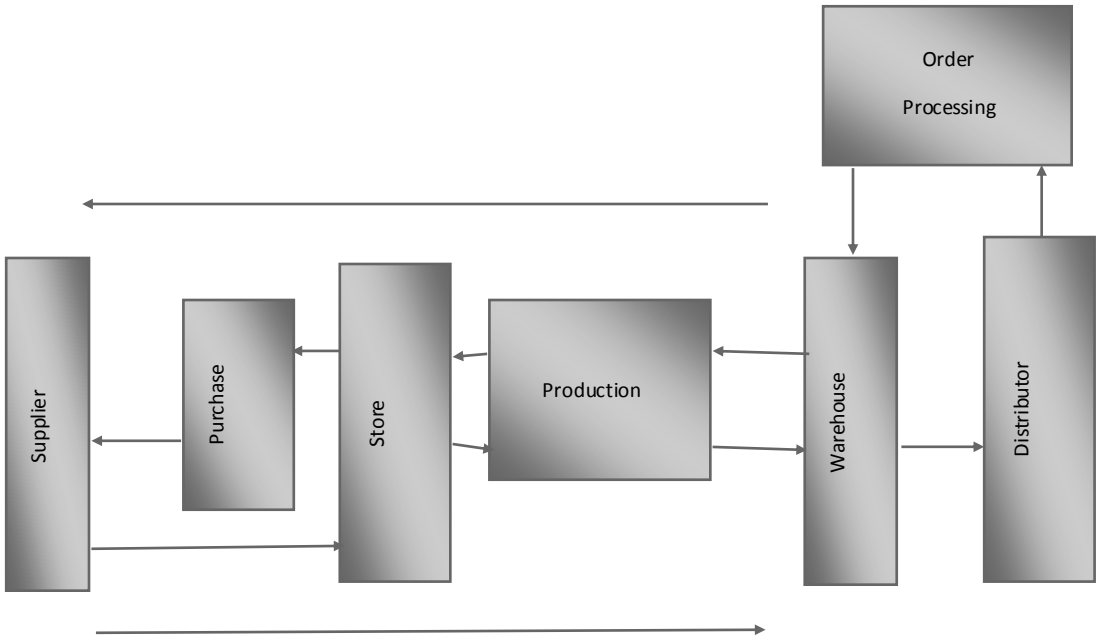

Fig. 4 A typical Supply chain in any manufacturing unit

1. Continuous Planning, and, Reporting,
2. Fast decision, Real-time. Plan, adjustment,
3. Navigation and Display performance
4. Proper and accurate documentation with help of spreadsheet and presentation tools 5. Intra-Organizational collaborative capability
6. Perfect collaboration among various functional units. 7. Customer-manufacturer-supplier relation and cooperation.

Ultimately our proposed MAS-SOA-SCM will have the following features

1. Totally automated , no requirement of training , maximizing the productivity
2. Near-zero administration
3. Customize process and Data Schema according to the needs
4. Securely integrating global operations if it is multi-site
5. Industry's much needed , most powerful , mature SCM
6. Mission critical reliability , real time and availability
7. making a Process-centric based mode [13]

MAS-SOA-SCM is based on the following hypotheses:

1. Cooperation and coordination among agents help information sharing which is associated with higher supply chain performance.
2. Less proactive which leads to complexity of the information sharing process , is associated with lower supply chain performance.
3. Collaborative approach of agents leads to positive information sharing transparency on supply chain performance is higher for firms with higher MAS-SOA adoption
4. Negative impact of information sharing on supply chain performance is lower for firms with higher MAS-SOA adoption

7.1 The MAS_SOA_SCM architecture

MAS-SOA-SCM provides a dynamic environment for customers, manufacturers and suppliers to cooperate in day-today activities. The advantage of MAS_SOA_SCM applications are that it increases business flexibility and lets business adapt more quickly to changing business needs. Moreover, it enables applications to be composed in a loosely – coupled fashion and allows services to be reused. At the manufacturer, MAS-SOA-SCM receives orders from customers and interacts with manager agent through order processing agent. Production agent fulfils the order through scheduling agent and delivery agent. In case of need more production, scheduling agent coordinates with inventory agent. Inventory agent takes care of the supply of raw materials to production or collaborates with supplier agent for further negotiation with suppliers. Most importantly, MAS-SOA-SCM aims to meet the needs of the customers on time and to eliminate the need for a large inventory at the manufacturer and thus reduce overall cost in the entire manufacturing system.

Typically our MAS-SOA-SCM follows two types of flows:
1. Product flows: Movement of goods from a supplier to a customer as well as customer returns.
2. Information flows: Transmitting orders and updating the status of delivery.
It helps in leveraging exiting IT infrastructure to enable users to automate their supply chains.
Our MAS-SOA-SCM provides a service (Registry) that allows manufacturer to discover the existing suppliers, to select supplies dynamically and to find alternative supplier on demand .Fig .5 represents the proposed MASS-SOA-SCM model.

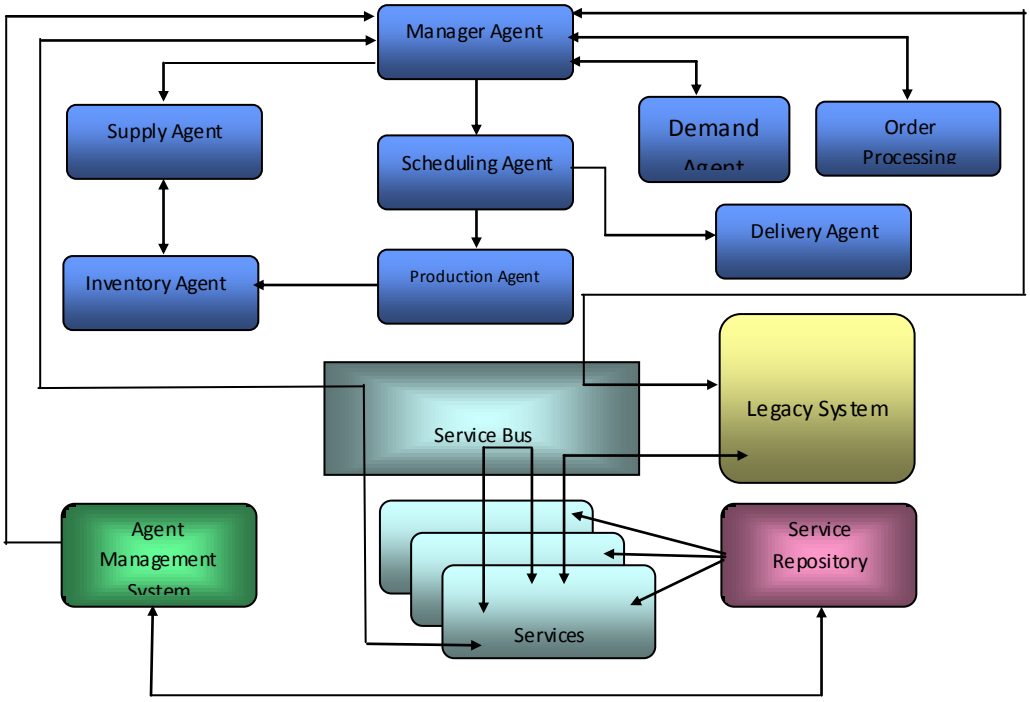

Fig. 5 Proposed MASS-SOA-SCM Models.

8. CONCLUSIONS

This research work is a systematic attempt of how Multi-agent system and service oriented architecture can be combined to handle an industrial project such as supply chain management system to improve the efficiency of manufacturing functions at the same time reducing the cost by controlling the inventory, reducing the impact of demand – supply problems, setting up proper negotiation policy in the case of supplier selection process. MASSOASCM will take shape according to the needs of manufacturers. The manufacturer as a user will communicate to the Services of SOA through common protocols based on open standards (e.g., SOAP and WSDL) which are used in general in SOA implementations. Of course SCM model may vary depending upon the size of industry from small to large work it is shown how to implement a simple SOA-based application. Also some more requirements such as security mechanisms need to be addressed. This will provide enough scope for further research in this area. For the design approach, BPEL language is generally used in the business logic part of the system. However, it still has some weaknesses as BPEL is still evolving and SOA developer's tools are not mature enough for solving some integration problems between user interface and business logic part... MASSOASCM can also be improved to develop a simple to complex supply Chain management application based on SOA using Web Service technologies units. This has to be addressed to Services of SOA. Services of SOA must have a Model management system.

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