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Multi Agent Systems and Web Services - Adaptive Workflow in E-Commerce

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ABSTRACT

In Multi-agent System (MAS), all agents communicate with each other by sending messages to each other in an expressive agent communication language. Agent communication language (ACL) [12], defines type of messages and their meaning that agents can exchange. Messages that agents communicate have semantic meanings which can be proposition, rules or actions [27]. In other words, multi-agent system is an association of synchronized, autonomous agents, which interact with each other in achieving common goals (objectives). On the other hand, Web services are the services in the shape of software components accessible on the internet, which provide useful information to users, businesses and organizations.

The Web service model uses WSDL, an XML format responsible for the service interfaces description along with the binding details to specific protocols. UDDI, a protocol responsible for publishing and finding services, services details and descriptions etc. SOAP, an XML message based envelop format which has the bindings to specific protocols (e.g. HTTP, SMTP etc). These services are invoked over the www (World Wide Web) using the SOAP/XMLP protocol.

A Workflow can be defined as "The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules" [21]. It has many advantages like improved efficiency, better process control, improved customer service, flexibility and business process improvement [7]. Due to rapid advancements in technology and growing needs of business environment, there is a need of adaptive workflow, which could accommodate itself with the changes that occur in the business processes.

Traditionally, workflow management systems have not been designed for dynamic environments requi ring adaptive response. Currently, the need for adap tive workflow is being driven by the demands of e-commerce in both B2B and B2C space.
Adaptive workflows respond to changing conditions

through adaptive change.

The aim of this thesis is to suggest an adaptive work flow model that can help in eliminating problems in e-commerce domain by using agent based approach. In e-commerce there is always a problem of searching the right item (e.g. construction material) in less time without involving the contractors etc who search for the items with the specifications told by the customers, as the current system does not support the good search. The customers search each time for the required items (e.g. construction material) and stop their search when they have found the desired item according to their budget, cost and quality attributes with up to date market cost about the required items to purchase (construction material). In e-commerce workflow system, in purchasing the required items (construction material), there are processes involved (Order Capture, Order Process, Order Fulfillment) which do not address the adaptability attribute in case of exception [38] or when there is a change in business environment which make changes in the business processes, consequences of which can be in the shape of failure of business objective (unsuccessful business transaction).

The proposed approach somehow can eliminate the problem described above and suggests an adaptive workflow system by introducing agents with each of the processes (Order Capture, Order, Process, and Order Fulfillment). A proposed way to design adaptive work flow is explained with the help of agents. Some work is done to relate this framework with web services to provide refined search and purchasing in order to take care of user needs. But still there is need of more research to explore this area of e-commerce workflow system.

Keywords: Adaptive Work Flow, Agent, Web Services.

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1 INTRODUCTION

Today's e-commerce business environments are exemplified by dynamic, uncertain and error-prone environments. In the e-commerce business, there are some processes involved in order to carry out the business tasks and to support the e-commerce business processes efficiently, there is need of such type of *workflows* [21] which can adapt themselves effectively when there is a change in business environment or business processes during the process execution. The change in business process or environment is called "exception" [38] which is deviation of processes from the normal functioning in order to achieve their tasks in the best possible way. The exception [38] can occur in the form of errors in the tasks fulfillment, disturbing or stopping the working of process execution, stopping the flow of workflow process making the buying or purchasing e-commerce stuck as a result in some cases. Also, violations of the assumptions [38] (e.g. concerning resource availability) underlying the current workflow model.

If these problems in the e-commerce business processes or environments are not handled effectively, then these exceptions can bring severe effects on the effectiveness of mutual work. Current workflow systems facilitate e-commerce business processes at some degree. In the execution of a process, it is very difficult to make changes or modify the process model. Also it is very difficult to handle all the possible failures.

In order to tackle with above problems there is need of adaptive and flexible systems for e-commerce businesses. In this thesis a frame work is proposed for e-commerce business which deals with construction material searching and purchasing. The combination of Web services and agents enhances the adaptability aspect of the system and can create highly flexible and dynamic workflow systems [7]. An adaptive workflow suggests achieving adaptability from a process, resource and task perspectives using both agents and Web Services.

The flexible and adaptive workflow systems are the demand of today's business environment which can support the different types of processes, activities and tasks. In the past this particular area has remained the discussing topic and Chen et al [32] and Van der Aalst [31] contributed their work and suggested techniques for managing adaptability presented. But very few actual implementations have been made that tackle some aspects of adaptability.

In the e-business [4] users are interested in getting information in quick and timely passion, for instance in case of construction material, and they are interested in getting the right material at low cost and with good quality with less time. Most of users hesitate to use e-commerce because they believe that it is difficult task to search appropriate construction material. One reason can be ineffective search mechanism, which makes purchasing more difficult and time consuming. By introducing agents in the existing workflow and also web services this problem can be solved. Ardisson et al [13] also discussed in their paper about the current Web services and detected that they only allow the simple communications in the shape of question answer pairs but they can't deal with the complicated environment. But in case of agents, they can deal with sharing complex information with their peers. So,

in that regard agents can provide a good solution to that problem. So, for that purpose agents are also introduced in the web service architecture to facilitate the e commerce workflow process more efficient.

The reason for choosing this area as a master thesis is because this area has not yet been explored so much and master thesis is the opportunity to explore this area.

1.1 Overview of the Thesis

The aim of this section is to give the brief overview about the chapters in this thesis. The overview section helps readers to find very brief discussions about chapters in the thesis.

Chapter 2 discusses about agents, agent systems, theory about multi agent systems, agent communication languages.

Chapter 3 includes history about the World Wide Web and W3C, the theory about Web services, Web service technologies like UDDI, Web Service Description Language (WSDL), Simple Object Access Protocol (SOAP), XML etc and Web services Orchestration and Choreography.

Chapter 4 presents the workflow; workflow systems, advantages and lacking in current e-commerce workflow system, adaptive workflow system (web services and agents), focused problem area in the context of construction material and e-business, current construction material purchasing (e-commerce) workflow system, introducing agents in Web service architecture, agent based extended construction material (e-commerce) workflow system as adaptive workflow model using agents and agents communication supporting workflow systems.

Chapter 5 will be about Discussion.

Chapter 6 discuss about Conclusions and Future work.

1.2 Related Work

The aim of this section is to discuss the work done by researchers in the area of multi agent systems, e-commerce, web services and adaptive work flow. Also, to give respect to all the authors and researchers who have done research in the past in areas mentioned above, and make grounds for new or further research. In the related work section the work of different researchers is described in short. In that regard, the work done by Kong et al [24], Castro-Lacouture et al [6], Ripper et al [20], Razali et al [22], Aberg et al [2] and Zhai et al [28] is described below. All these researchers provide the basis for the author to have concepts of different domain and technologies like e-commerce, web services, agents and workflow. The toughest part for the author was to grasp the different ideas as mentioned above and to suggest the model for the e-commerce domain by combining agents, web service in e- commerce workflow system in order to make it adaptive which was the author objective in this thesis.

In the e-commerce workflow system there are processes involved and they should be able to adapt the change. All the processes involved with in the e-commerce workflow system should be able to adapt themselves in case of changes occurred whether in business environment or at execution time in case of exception [38]. All the processes in workflow system should be able to trace back and adapt the required behaviour in order to fulfil the business objectives (successful transaction). Also, the processes should be able to provide flexibility to accommodate changes and must compensate the change in case of exception [38] occurred.

Also, in this section the author tried to summarize how his work is based on the scientific papers under this section as well as how these research papers motivate him for doing study on the topic of “multi agent systems and web services an adaptive workflow in e-commerce”. In this section the work done by previous researchers will be discussed and how their work is significant in author’s area of research.

Now the survey of work done by the different researchers will be presented below in short.

Kong et al [24]

Kong et al [24] focus on the need of electronic information sharing between different e-commerce systems to improve the business process, cost and detailed information about the construction materials. In the paper the problem of electronic information sharing and the traditional approach used for the material searching and buying is discussed. In the paper two state of art information technologies mobile agents and web services technologies are also discussed. Also, the application of e-commerce in construction material procurement and problems of non-interoperable e-commerce systems and benefits of electronic information sharing between them are also discussed in the paper. In this paper a prototype system called, E-Union is introduced which facilitates the information sharing between construction material systems.

Castro-Lacouture et al [6]

Castro-Lacouture et al [6] focus on *e work (*"eWork is the capacity to undertake any business function independent of location using information and communications technologies" [19]) and describe it as a suitable concept for the construction material management. Their work is based on recent publications on E-work model and in this paper they want to propose a set of applications which can assist the construction material management systems. The benefits achieved as well as the role of autonomous agents are also discussed.

Ripper et al [20]

Rippers et al [20] discuss the agent technology and the role played by the software agents on the behalf of customers in selling, buying etc in e-commerce domain. Further, this paper presents an object oriented frame work in designing agent mediated e-commerce systems. The paper also describes the concepts and principles which underlie virtual market and also describe and explain how the transaction categories can be defined and trade of products and services can be done effectively.

Razali et al [22]

Razali et al [22] describe the software agents and the need of software agents in the e-commerce trading. Also, the traditional business model, the Consumer Buying Behaviour (CBB) model is discussed. In this research a framework is proposed with approaches namely Automated Collaborative Filtering (ACF) and Better Business Bureau (BBB) which are merged for efficient buying that the software agents will use. It not only gives the best quality of price for good product but also from the trustworthy merchant.

Aberg et al [2]

Aberg et al [2] introduced an agent-based framework, in which web services are integrated into an organization's Workflow.

The approach used allows for publication of Web Services, process generation, discovery and composition of Web services, as well as for the integration of Web services into workflow processes. Much of the related work focuses on different aspects that relate to different agents in the framework. They also described a possible architecture and built a prototype with promising results. The implementation shows the feasibility of the knowledge management and reasoning part of the model.

Zhai et al [28]

Zhai et al [28] worked on the translating of ontology and agent behavior descriptions respectively into XML Schemas and WSDL documents. They discussed how an agent system could integrate its transport layer with Web Services. They also discussed that using Web Services technologies, agent behavior can be advertised using web services. It is found that the concept of agents is related to that of a Web

Service, Using UDDI, agent can be discovered as long it is presented as a web service.

Web services provide the convenient way to use the services on the net and the agents have the characteristics of autonomy, flexibility, openness, communication, adaptability, mobility etc. so an adaptive workflow can be obtained by combining these two services for the business depending on the nature and requirements of the business.

The work done by Kong et al [24] motivates author to proposed the model that can overcome the problems in searching of construction material in e- commerce websites. Kong et al [24] designed E-union system using web services, which is helpful for others and future researchers to continue their work because it facilitates valid grounds for research.

Castro-Lacouture et al [6] show how agents can be used in e- commerce domain .The author have tried to merge the ideas (searching of construction material) from Kong et al[24] and Castro-Lacouture et al [6] to propose model that use both web services and multi agent systems.

The research work done by Ripper et al [20] gave the author a good understanding of agents and role played by software agents on the behalf of customers in selling, buying etc in e- commerce domain. This also motivated the author to do some kind of similar study on e- commerce and suggesting a model involving agents who search items (construction material) for customers and to make search services useful.

Razali et al [22] explained how software agents can be helpful in the e- commerce trading. They proposed a framework that can be helpful for efficient buying with agents. From their work the author motivated to suggest a framework using agents in e- commerce for searching and providing adaptive workflow in e- commerce.

Aberg et al [2] presented an agent- based framework, in which web services are integrated into an organization's Workflow. From the research work done by Aberg et al [2], the author motivated towards the workflow area targeting with two different technologies i.e. web services and agents.

The research work done by Zhai et al [28] focuses how an agent system could integrate its transport layer with Web Services. From their work, the author gets the idea that agents can be merged with in the web service architecture.

Above examples and some implementations by different scientists and researchers in the area of web services and agents shows that they provide flexible and adaptive workflows in the *workflow management systems* [18]. But it also depends on the application area, business context and goal. The main aim of these two services i.e. agent and web services, are to facilitate the users, businesses etc.

1.3 Problem Description

W3C is an International consortium [39] firstly started in 1995 by Tim Berners-Lee, who was the inventor of the Web. The W3C has some activities which are called W3C activities and these W3C activities are organized into different groups. For example, Working Groups (for technical developments), Interest Groups (for more general work), and Coordination Groups (for communication among related groups) [39]. The groups are responsible for generating results for W3C in the form of "technical reports on Web standards, open source software, and services (e.g., validation services)" but also to make ensure "coordination with other standards bodies and technical communities" [39].

The Grid is a technical community using "W3C technologies, among many others technical communities (e.g. Life Science, Mobile, e-Government, Oil Industry, Airlines, etc) [41]. The Grid platform is a user of the Web platform and grid needs the web technologies like HTTP, XML, Web Services, and Semantic Web" [41].

The Web Services architecture is still using "bottom-up style and the OGSA road map assumes stability at this level" [42]. The aim of W3C is to "deliver Open Standards (technical coordination and leadership, consensus and running code, clear patent policy, universality, persistence)" [42].

Multi-agent System on the other hand consists of different agents interacting with each other through messaging (using agent communication languages) in order to achieve the objective. Agents can also be seen as intentional systems based on *BDI* model which is beliefs (what the agents knows), desires (what the agent wants to do) and intentions (what the agent has decided to do).

The area of web services and agents seems quite interesting when it comes to merging both these two technologies in e- commerce which can provide flexible and adaptive workflow in e- commerce system but there still needs a lot of research to be done in that area. The aim of thesis is to provide an adaptive work flow model for e-commerce by using web service and agents for searching the items (e.g. construction material) and putting agents in the processes of workflow in order to make it flexible in terms of better process functioning and backtracking in case of data failure or data loss.. The research methodology used in this thesis is done by using the literature study. The questions to be studied are:

(1) Assessment of agents and web services in designing and maintaining adaptive Work flow in e-commerce

(2) Model of adaptive workflow management construction material handling providing workflow support

1.4 Research Methodology

The Research methodology used in this master thesis is mostly by studying the research papers, articles and literature. As a master student, it is a good opportunity to explore this area and do research in it. At the beginning, the author will perform a literature survey of existing adaptive work flow models and theory about multi agent systems and web services.

Since this research is done by using literature study, which involves strong foundation of theory about multi agent system, web services and adaptive work flow. The first step in literature study is to review the research articles and web resources that provide general understanding of topic. For this thesis work the author has used ebrary, ELIN as sources of information followed by endless search by using key words “adaptive work flow”, “web services”, “agent”, “e- commerce” and “construction material” etc. For example for construction material the author has used www.ebuild.com for information. The next task was to refine the text or data which is related to our research, from the large pool of information available on internet and ebrary. Further more, to narrow down the scope of research, since it is not feasible to take all the problems related to e-commerce in this master thesis due to limited time.

By using this research methodology, the author suggests an adaptive workflow model in e-commerce which can facilitate the customer in terms searching of their choice of buying items (e.g. construction material) in less time by involving agents in web service as well for making coordination between the process efficient by putting different agents with the related roles associated with the processes involved in the workflow system which can be helpful in e-commerce domain.

The main source of our information was research articles, web resources and literature books etc while other source of information are discussion forums, discussion with teachers at BTH and feedback from thesis advisor.

2 MULTI AGENT SYSTEMS

In order to address the research questions in this thesis, the area of multi agent systems is introduced here. In the start the term multi-agent system is described. In section 2.1, details information about the agents, software agents, and intelligent agents is provided. In section 2.2, the details about agent communication languages and the differences between two standard agent communication languages is provided.

A *multi-agent system* consists of number of agents, which interact with one another, typically by exchanging messages through some computer network infrastructure. In the most general case, the agents in a multi agent system will be representing or acting on behalf of users or owners with very different goals and motivations. For successful interaction, these agents will thus require the ability to cooperate, coordinate, and negotiate with each other, in much the same way that we cooperate, coordinate, and negotiate with other people in our everyday lives. In other words, multi-agent system is an association of synchronized, autonomous agents, which interact with each other in achieving common goals (objectives). In *Multi-agent Systems (MAS)*, all agents communicate with each other by sending messages to each other in an expressive agent communication language. *Agent communication language (ACL)* [12] defines type of messages and their meaning that agents can exchange. Messages that agents communicate have semantic meaning which can be proposition, rules or actions [27]. All the agents communicate with each other like object oriented approach, but in the object oriented approach there is only message passing whereas in case of agents they just not only do message passing instead they are also capable of sharing complex information like ideas, rules, propositions etc and also they have control over their internal state. The example of this can be a software agent in MAS can communicate with other agent with out any plan of action given by the outside by using set of protocols and they must implement in order to collaborate.

2.1 Agents

“An agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives” [17].

By this definition an agent is a computer system which can decide all its actions by itself and independently on behalf of its user or owner. An agent can figure out by itself all plans or tasks it is supposed to do in the accomplishment of its own design objectives or goals, without having any feed back from any other resource explicitly what to do at any given moment. Agents can also be seen as intentional systems based on *BDI* model which is beliefs (what the agents knows), desires (what the agent wants to do) and intentions (what the agent has decided to do).Intelligent agents have three things which were suggested by Wooldridge and Jennings (1995) [17], “(1) Reactivity, intelligent agents are able to perceive their environment, and respond in a timely fashion to changes that occur in it in order to satisfy their design

objectives (2) Pro-activeness, means taking initiative showing goal-directed behaviour in order to meet its design objectives, (3) Social ability, means interacting with other agents in order to satisfy their design objectives".

Software agent is "a software entity, which functions continuously and autonomously in a particular environment, often inhabited by other agents and processes" [14]. The advantages of software agents are; first they can be used to reduce the complexity of distributed computing by "embedding one or more peer agents within cooperating systems. Applications can request services through these agents at a higher level corresponding more to user intentions than to specific implementations."[14] The software agent is no longer depends on language or platform that is used in implementation. Software agents can communicate with each other though they were developed using different technologies. Second software agents can overcome the limitation of user-interface [14].Software agent development has some differences when compared with normal software development. Requirements and specifications of software agents are a little different since the quality attribute such as flexibility becomes extremely important.

Software agents are applications which "communicate with their peers by exchanging messages in an expressive agent communication language" [16]. Agent communication language (ACL) defines type of messages and their meaning that agents can exchange. Regarding the previous statement, messages that agents communicate have semantic meaning which can be proposition, rules or actions [27]. According to [27], there are two major types of ACL; Knowledge Query and Manipulation Language (KQML) and Foundation for Intelligent Physical Agents **(**FIPA).

2.2 AGENT COMMUNICATION LANGUAGES

The Agents use *ACL (Agent Communication Languages)* [12] for exchanging and sharing the data, information and knowledge that is required for the fulfilment of their desired goals and objectives [17]. The need of some communication language rose because there was no such language, protocols or platform available which could support the complex interactions between different agents, although there are some mechanisms, methods available like *Remote Procedure Call (RPC)* or *Remote Method Invocation (RMI),* to *CORBA* and *Object Request Brokers (ORB's)* provide the same goal. But then what is the difference between the ACL's and these methods? The answer is there are many differences. For example, when ACL's like *KQML (Knowledge Query and Manipulation Language)* or *FIPA (Foundation of Intelligent and Physical Agents)* are compared to *CORBA* then, the ACL's ranks high, due to some reasons like: (1) objects just do the message passing only but in case of ACL, they can deal with propositions, rules and actions, (2) In ACL message, a desired state is expressed in a declarative language, rather than a procedure or method [17]. For the agent communication, the ACL is responsible for defining types of messages and their semantics. Agents not only perform single message exchanges but they also can have conversations, i.e. task-oriented, shared sequences of messages, like a negotiation or an auction. According to [27], there are two major types of ACL; *Knowledge Query and Manipulation Language (KQML*) and *Foundation for Intelligent Physical Agents (FIPA)*.

2.2.1 Knowledge Query and Manipulation Language (KQML)

"KQML is a message-based language for agent communication" [17, pp.170-171]. The KQML has a common format for messages. A KQML message can be looked as an object in the context of object oriented programming. The format of each message has a starting performative which is like a class of the message and further it has number of parameters (attribute/value pairs) which are like instance variables.

Here is an example KQML message [17, pp.170-171]
(ask-one
: sender customer
: content (PRICE IBM? price)
: receiver stock-server
: language LPROLOG
: ontology NYSE-TICKS
)
(tell
: sender stock-server
: content (PRICE IBM 25000)
: receiver customer
: language LPROLOG
: ontology NYSE-TICKS
)

The format of *KQML (Knowledge Query and Manipulation Language)* message is quite easy to understand, it can be seen that in this example the sender (customer) is asking about the price of IBM stock. The performative here in this example is ask-one, which an agent is using to ask question to another agent. There are different other components of this message representing its attributes. The content field is the second attribute which specifies the message content. The content simply asks for the price of IBM shares. Next is the receiver attribute, which specifies the specified language in this case LPROLOG, in which the content is being expressed. Final attribute of this message is ontology attribute which defines the vocabulary used in the message. As this is a two way communication message in this case the other agent which is sender (stock-server) replies to this message by telling the customer about the price of IBM stock. The Tell performative, tells the price of IBM shares which is in this case are 25000 and the other attributes receiver will be customer, language will be PROLOG and the ontology will be same as well. Totally, there are 41 performatives that are used depending on the contexts and scenarios by the KQML.

2.2.2 THE FOUNDATION FOR INTELLIGENT PHYSICAL AGENTS (FIPA ACL)

"In 1995, the Foundation for Intelligent Physical Agents (FIPA) began its work on developing standards for agent systems [17, pp.175-176].The centerpiece of this initiative was the development of an ACL (FIPA, 1999).This ACL is superficially similar to KQML: it defines as 'outer' language for messages, it defines 20

performatives (such as inform) for defining the intended interpretation of messages, and it does not mandate any specific language for message content. In addition, the concrete syntax for FIPA ACL message closely resembles that of KQML".

Here is an example of a FIPA ACL message (from FIPA, 1999, p.10):
(inform
: sender agent1
: receiver agent2
: content (price computer 9000)
: language s1
: ontology hpl-auction
)

In this example, the sender (agent1) sends the price of computer in this case 9000 by using the language s1 and ontology hpl-auction to the receiver (agent2) in an auction. By looking at this FIPA ACL example, it can be seen that the FIPA communication language is similar to KQML with respect to the structure of messages, attribute fields which are very common. The most important difference between the two languages is in the collection of performatives they provide. Informally these performatives have the following meaning.

ACCEPT-PROPOSAL: This performative allows an agent to state that it accepts a proposal made by another agent.

AGREE: Accept performative is used by an agent showing that it is agree to the requested action in the form of request made by another agent to carry out the requested action.

CANCEL: This performative is used by an agent to cancel the previous request message, and it on the other hand tells that it no further wish about the particular action to be carried out. The two most important communication primitives in the FIPA languages are informed and request. Infact all other primitives in FIPA are defined in terms of these performatives.

2.2.3 Difference between FIPA ACL and KQML

The difference between FIPA ACL and KQML is as follows.

KQML and FIPA ACL are nearly alike with respect to their basic concepts and the principles they observe. The main difference is in primarily in the details of their semantic frameworks.

There are many similarities in both two cases, while comparing KQML with FIPA ACL, For instance, their syntaxes are very similar, both based on speech acts (per formatives or communicative acts); they are used for the purpose of message and also present almost the same concepts and syntax. As it has seen there are many similarities between the both mentioned ACL: s but there also are differences. The differences can be divided into the two major parts:

(1) Semantic differences
(2) Facilitators differences

According to [27], another difference between the two ACL's is in their dealing of the registration and facilitation primitives. These primitives cover a range of important pragmatic issues, such as registering, updating registration information and finding other agents that can be of assistance in processing requests. In KQML these tasks are associated with performatives that are treated as first class objects in KQML. FIPA ACL, seeking a more pure ACL, does not consider these tasks to be communication primitives (CAs) in their own right and they are treated instead as requests for action; FIPA ACL, in turn, defines a range of reserved actions that covers the registration and life-cycles tasks. In this approach, the reserved actions do not have formally defined specifications or semantics and are defined in terms of natural language descriptions. Software Developer must decide which one of the two ACL's to use in implementation of software [27]. Another major and important difference between FIPA ACL and KQML is that the FIPA ACL is more suitable and favourable to the workflows as it provides the dialogues communication facility among the different workflow processes in a workflow chain whereas in case of KQML opposite is the case.

3 WEB SERVICES

To address the research questions in this thesis, the author discussed in section 3.1 about the history of World Wide Web and W3C, W3C activities, grid and web services. Further, in section 3.2 the author discussed more in detail about web services. In section 3.3 details about web service technologies are discussed. In section 3.4, the author discussed and differentiated Web Services Orchestration from Web Services Choreography.

3.1 History of Web World Wide Web and W3C

Tim Berners-Lee first invented the World Wide Web, in 1989. In October 1990, he wrote the first World Wide Web server, "httpd," and the first client program (a browser and editor) [43]. He also worked with the specifications for URIs, HTTP, and HTML [43].

Tim Berners-Lee established the World Wide Web Consortium (W3C) at the Massachusetts Institute of Technology, Laboratory for Computer Science [MIT/LCS] in association with CERN in October 1994, where the Web originated with support from DARPA and the European Commission [43].

INRIA (Institut National de Recherche en Informatique et Automatique) became the first European W3C host in April 1995. In 1996 in Asia, the next W3C host was Keio University of Japan (Shonan Fujisawa Campus). The responsibility of European W3C Host was taken over by ERCIM (European Research Consortium in Informatics and Mathematics) from INRIA in 2003 [43].

In December 2004, in Boston, Massachusetts (USA), and in June 2005, in Sophia-Antipolis, France, W3C celebrated its tenth anniversary with symposia on the history and future of the Web and W3C [43].

W3C Team is responsible for grouping the W3C activities by “domain” like “Architecture, Interaction, Technology and Society, Ubiquitous Web, and the Web Accessibility Initiative” [39]. In this thesis, the author focuses on two main W3C activities (1) URI Activity, which had for long before with the aim to provide information sharing facility in global community where any body can exchange and share information. To make this possible, there was need of single global identification system and web makes use of it. In achieving this way, URIs is a keystone of Web architecture, making available identification that is common across the Web [39]. (2) Web Services Activities, having roles in designing the infrastructure, defining the architecture and creating the core technologies for Web services [39]. Web services are responsible for exchanging and sharing information between different software applications, running on different platforms. The Grid is a technical community using W3C technologies, among many others technical communities (e.g. Life Science, Mobile, e-Government, Oil Industry, Airlines, etc) [41]. The Grid platform is a user of the Web platform and grid needs the web technologies like HTTP, XML, Web Services, and Semantic Web [41].

Web Services are the services in the shape of software components accessible on the internet, which provide useful information to users, businesses and organizations. These services model use *WSDL* [25], an XML format responsible for the service interfaces description along with the binding details to specific protocols, *UDDI*, which is also a protocol responsible for publishing and finding services, services details and descriptions etc and *SOAP* [23], an XML message based envelop format which has the bindings to specific protocols (e.g. HTTP, SMTP etc). The UDDI directory retrieves the *WSDL* description. *WSDL* descriptions are responsible for allowing the software systems to directly use and to extend the business to those of others. These services are invoked over the www (World Wide Web) using the SOAP/XMLP protocol.

3.2 What is a Web Service?

A *Web service* [8] is a service which uses standardized XML messaging system, which is independent of any operating system or any specific programming language using standard set of protocols used for the messaging e.g. XML, SOAP and HTTP.

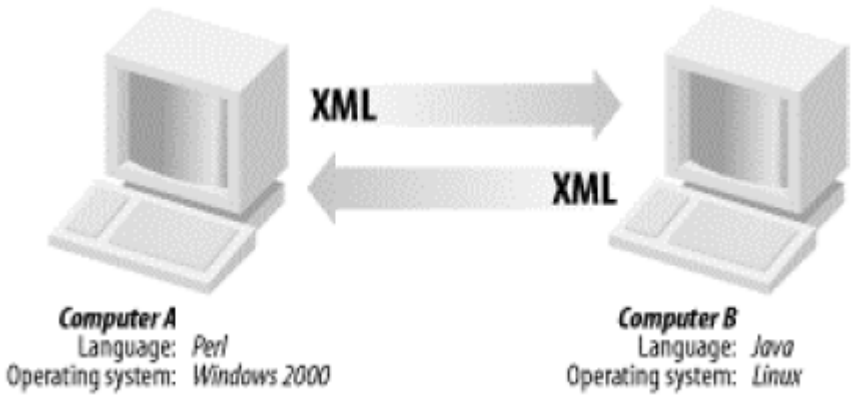

Figure 1 A Basic Web Service [8]

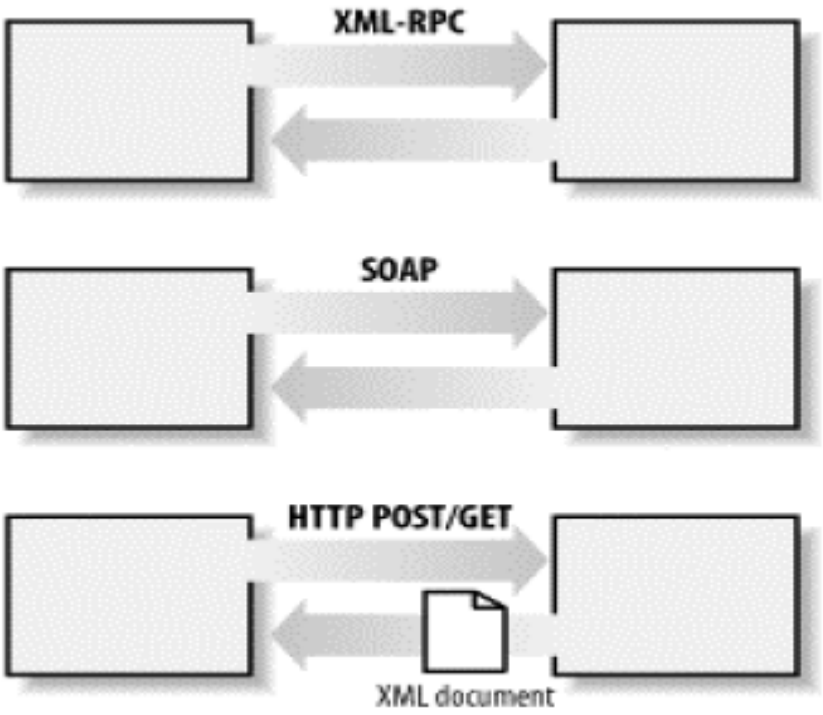

Figure2. XML messaging for Web services [8]

Practically [11] “it represents a discrete business process with supporting protocols that functions by describing and exposing itself to users of the web, being invoked by a remote user, and returning a response”[11]. It has:

1. **Describing:** Web services make easy how to use its services for other applications to use by explaining its functionality and attributes.

2. **Exposing:** A repository plays main role in exposing to which the Web services are registered. This repository contains three types of pages (1) white pages, which share basic service-provider information, (2) yellow pages which have description of services category wise and (3) green pages which provide details about making connection and using the services.

3. **Being invoked:** When describing and exposing are done and a Web service has been located, then the service can be invoked by any remote application.

4. **Returning a response:** After invoking the service, all the results are returned to the application who requested the service.

The Web services using the SOAP foundation permits people, business and companies to publish, advertise their services in order to be used for others and discover the already available services on the internet so that the particular tasks and transactions could be performed.

3.3 Web Service Technologies

There are some enabling web services technologies like XML, SOAP, UDDI and WSDL on which the web services depends upon. Following are the details of UDDI, WSDL, RDF and XML.

3.3.1 The Web Services Architecture

In the web services architecture [8], there are three main roles.
(1) Service Provider
(2) Service Requester
(3) Service Registry

The detail web service architecture is explained in section 4.3 in context of adaptive work flow.

Key Technologies: Web services relies on several key underlying technologies, in particular, UDDI, WSDL and SOAP. The detail of each of one is given as follows.

3.3.2 UDDI

A protocol which describes the Web services and acts like a platform through which different businesses, companies can register their services with an Internet directory and others can find them easily and perform their tasks. UDDI [8] at its core composed of two parts.

First one, its view as a technical specification represents that it structures a dispersed directory of businesses and web services [8]. XML format is followed in the storage of data and API at the UDDI specification gives the details how to search the already given data and how to publish the new data. Second one, the UDDI [8]Business Registry which is a global, public online directory that facilitates the businesses and companies to publish their services, find out services from other companies and details of software that implements service[8]. The UDDI was firstly originated by the Microsoft, IBM, and Ariba. Category wise the following three types of data can be placed in UDDI.

White pages

This specific category provides general information about data like company, business, and institution; for example, company name, its description and address etc.

Yellow pages

This category provides general categorization data for company, organization, business or service. Examples of this can be business, artifact, or geographic codes based on customary taxonomies.

Green pages

This category provides practical information about a web service. For example a link and address for invoking the particular web service.

3.3.3 WSDL

WSDL is the protocol standard, a specification which describes the web service. The service Interface and the implementation details are defined by the XML-based Service Interface Definition Language. *WSDL* [8] describes interface information which shows details about the public available functions, data type information of all request and response messages, binding information about the transport protocol which is to be used and address information which shows information about locating the specified service. *WSDL* is platform and language independent. Any web service can be accessed and located by client using WSDL by invoking any of its public available functions. So, WSDL is a platform for describing and automatically integrating the services [8]. It describes how we can make connection to web service providers and it has an XML format that gives information that other software use for making connection to use the services from each other. To access the web service over the internet, an XML-based syntax defines the specifications in order to access the particular web service like the type and number of parameters passed and results returned [8].

Actually, the *WSDL* gives details about binding the service and to relate with that service and previously a Web service has been discovered [8]. The WSDL specification is divided into six major elements (1) definition, which defines the name of the web service, declares all names spaces used through out the document and details of service elements etc (2) types, which defines all the data types used at the server and client sides (3) message, this element defines the name of the message and may contain no message or more message part elements which can refer to message parameters (4) port type, SOAP services use port type in which we can combine one request and one response message into a single request/response operation (5) binding, this element gives the specifications about how the service will be implemented for example, details of SOAP services etc (6) Service, this elements gives the service address for invoking a particular service[8].

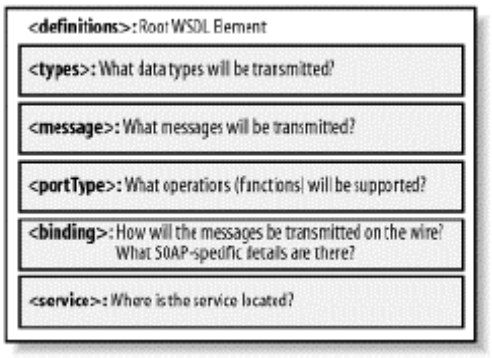

Figure 3 The WSDL Specification in a nutshell [8]

3.3.4 SOAP

SOAP is an XML-based communication protocol which allows different applications to exchange the information by invoking the object methods or functions. The *SOAP* uses the universal HTTP for request/response mechanism [8]. *SOAP* provides a convenient way to connect to remote services for client applications and invoke their remote methods. CORBA, DCOM, and Java RMI, also work in the similar passion and functionality to SOAP, but the difference is that SOAP messages are platform and language independent due to the fact that are they are written in XML [8] .For example, any *SOAP* client which is using a different platform and operating system can be connected to the any other server which is residing on different platform and operating system. For instance, a Perl client running on Solaris or SOAP java client running on Linux can connect to a Microsoft SOAP server running on Windows 2000[8]. Therefore, *SOAP* is considered a vital component in the web service architecture, which provides the services for different applications to exchange the information among each other. The specifications of the *SOAP* have three key parts.

SOAP envelope specification

The *SOAP envelope specification* [8] consists of method name, method parameters, or return values and also information about the processing of envelope content and encoding the error messages at the time of failure [8].

Data encoding rules

Data encoding rules [8] deals with some rules to encode the data which has to be shared and exchanged. To exchange data, computers must agree on rules for encoding specific data types. For example [8], “two computers that process stock quotes need an agreed-upon rule for encoding float data types; likewise, two computers that process multiple stock quotes need an agreed-upon rule for encoding arrays” [8]. SOAP [8], has its own “set of conventions for encoding data types and most of these conventions are based on the W3C XML Schema specification” [8].

RPC conventions

RPC conventions are followed in the messaging systems whether they are one way or two way messaging. In the case of two way message system [8], “SOAP defines a simple convention for representing remote procedure calls and responses”[8] and this [8] ”enables a client application to specify a remote method name, include any number of parameters, and receive a response from the server” [8].

3.3.5 XML

XML [26] is the abbreviation for the Extensible Mark up Language which is the language used for structuring the documents which holds the structured and useful information [26].
XML document contains the not only the words, animations etc but also it has different meaning and interpretation for its specific content like, [3]”content in a

section heading has a different meaning from content in a footnote, which means something different than content in a figure caption or content in a database table, etc.”[3].

XML is used now days in many applications. [3] “For our purposes, the word "document" refers not only to traditional documents, like this one, but also to the myriad of other XML "data formats. This includes vector graphics, e-commerce transactions, mathematical equations, object meta-data, server API’s, and thousands other kinds of structured information” [3].

XML [3] “is really a meta-language for describing mark up languages [3]. In other words; XML provides a facility to define tags and the structural relationships between them. Since there's no predefined tag set, there can't be any preconceived semantics. All semantics of XML document will be defined either by applications that process them or by style sheets” [3].

3.4 Web Services Orchestration and Choreography

There are two terms (1) *orchestration* and (2) *choreography* which explains two features of business process creation from composite Web services [45]. There is difference between these two terms. The term Orchestration is used for business process that is executable and interacted with both internal and external Web services [45]. The interaction is done at the message level containing business logic and task execution order. In orchestration, there is control from one party while choreography is concerned with all parties’ involvement and their roles played in interaction process [45].
Choreography is also responsible for the message sequence tracking among various parties and sources. In order to meet changing business needs in organizations, web services orchestration is required to be dynamic, flexible, and adaptable [45]. An orchestration engine is responsible for overall process flows, calling the appropriate Web services and determining what steps to complete as well as separation of process logic and Web services which support flexibility [45].

4 ADAPTIVE WORKFLOW SYSTEM

In the previous chapters (Chapter 2 and Chapter 3) the details about agents and web services are provided. To support the previous chapters in order to fully address the research questions (adaptive workflow model), the chapter of adaptive workflow is provided here. In section 4.1, the detail of workflow is provided along with the workflow systems and advantages and lacking in current e-commerce workflow system are provided. In section 4.2, need of adaptive workflow system and explanation of adaptive workflow system using two technologies Web services and agents are provided. In section 4.3 and 4.4, the focused problem area in the context of construction material and e-business, current construction material purchasing (e-commerce) workflow system is presented here in which the problem with the current workflow system in construction material (e.g. construction material searching, purchasing etc) and inefficient or lack of coordination between the processes in case of exception [38] is discussed. In section 4.5, in the web service architecture, the agents have been introduced for searching the items (material construction). In section 4.6, an adaptive workflow model using agents is suggested as a solution for construction material e-commerce workflow system which overcomes on above mentioned problems at some extent. In section 4.7, the communication among agents is explained using FIPA ACL with some examples.

4.1 Workflow and Workflow Systems

Workflow plays a vital role in the ecommerce and business environment. The *workflow* can be defined as "The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules" [21]. Workflow management systems (WfMS) automate entire work processes, rather than isolated tasks (scheduling, routing and monitoring) [33]. Following are the advantages of using the *workflow systems* [7].

- Improved efficiency – which supports the business processes in the shape of computerizing them.
- Better process control - which manages the business processes.
- Improved customer service – providing stability in business processes with respect to the customers.
- Business process improvement – aims to reforming, reorganizing and generalizing the business processes.

The above mentioned are the advantages of using the workflow systems, unfortunately, there are many workflow systems which do not provide the functionality for the support of "B2B transaction processes, such as information sharing, chained execution, and process changing, monitoring, reorganizing workflow processes" [40] in case of problem or exception [38] and workflow process receiving information from other processes[40].

These drawbacks or lacking of workflow systems suggest that there is need of an adaptive workflow system which can overcome these problems and issues in the current workflow systems. In e-commerce, these things play a vital role especially not only the customer point of view, but more on business point of view. As today's almost most of business run on e-commerce, so the workflow system of e-commerce should be flexible, efficient, it should provide better process control and utilization of processes in terms of time and fulfillment of customer needs. The adaptive workflow system can handle these things efficiently.

4.2 What is an Adaptive Workflow System?

Due to the rapid advancements in the technology and growing needs of e business environment, e businesses do need to redesign their information and process management systems. To fulfil the e business needs due to this diversity, the suggested solution can be in the form of an adaptive workflow system. Changes and enhancements in service-oriented architectures due to different business needs demands for adaptive workflow systems and in that regard the web services can also be one part of it in an adaptive workflow, because these web services provide the computational resources to fulfil the business tasks and activities. While on the other hand the agents provide the coordination framework to support all these activities.

In recent times, adapting active enterprise applications into web services have been considered in that regard and for that the word servicization [15] has been used. To accomplish this idea there is need of merging approach with the existing workflows. "The traditional programmed interactions between people and software are [being] replaced by task-focused interactions that are dynamic and flexible". [18, p. 216] Due to changes in the business environment requires alterations in the software architectures maintaining computing of dynamically-formed, task-specific and coalitions of distributed autonomous resources. The work done by Gelertner in coordination technology shows these variations as valid outcomes. It is now also been acknowledged that "Gelertner was correct when he theorized that computation was orthogonal to coordination" [5]. DeRemor understood this orthogonality by explaining it in his writing in 1976, "Structuring a large collection of modules to form a 'system' is an essentially distinct and different intellectual activity from the construction of the individual modules [themselves]" [9].
According to Leyman, "the workflow construction can be analyzed as a two level programming problem [10] and implementing these workflow activities can be thought as similar to that of traditional programming. Functionalities (low level data access routines and algorithmic processing) are embedded by the activities".

The application consists of computation and coordination and workflow is defined in terms of activities and processes which are the same according to the Gelernter's and Leymann's ideas. Agents are the necessary elements for flexible performance of enterprise systems. So it can be said that an adaptive workflow have web services and agents collection.

4.3 Focused Problem in the Context of Construction Material and E-Business

When there is talk about purchasing construction material, there can be problems in searching of suppliers and also detailed information about products. These problems have been resolved to some extent by having information available on internet particularly (company websites). But most of company websites provide only static information and do not provide facility for customers to purchase product online. The design of e-commerce needed, which can facilitate customers to purchase material online and provides mechanism for search for construction material, find update list of suppliers, create a purchase order and delivery of product. The reason for failure of most of e-commerce website is due to non effective search and limited information [24] [47] [48]. Here the focus will be on search mechanism of e-commerce construction websites. Finding the construction material is tedious, time consuming and difficult task due to lack of systems which could provide these tasks efficiently. There are many different companies, users and organizations involved in purchasing the right material and they want up to date information about the material regarding its cost, chemical attributes etc. So, agents and web service mixed framework can be suggested which could help the users, companies who want to find the right quality and material and in order to meet their preferences in the shape of budget, quality, material price etc. As Kong at al [24] focus on the need of information sharing between different e- commerce systems to improve the business process, cost and detailed information about the construction materials. In the paper the problem of information sharing and the traditional approach used for the material searching and buying is discussed.

Also, Ripper at al [20] discusses the agent technology and the role played by the software agents on the behalf of customers in selling, buying etc in e- commerce domain. Further, this paper presents an object oriented frame work in designing agent mediated e- commerce systems. The paper also describes the concepts and principles which underlie virtual market and also describe and explain how the transaction categories can be defined and trade of products and services can be done effectively.

Similarly, Razali et al [22] describe the software agents and the need of software agents in the e- commerce trading to provide efficient decision process for buying. Also, the traditional business model, the Consumer Buying Behaviour (CBB) model is also discussed. In this research a framework is proposed which approaches namely Automated Collaborative Filtering (ACF) and Better Business Bureau (BBB) are merged for efficient buying decision process that the software agents will use. It not only gives the best quality of price for good product but also from the trustworthy merchant.

The proposed framework in this thesis, uses the agents with web service for the finding the material with the parameters (user preferences) in less time. In this workflow, some agents are involved to keep track the information about the users, companies or other. As users, companies' personals which have assigned tasks for searching the right material in quick time with all other parameters putting in mind like project budget, quality attributes, right material information and up to date market material information. So, all these tasks are not very easy to fulfill and they

require a high responsibility in the fulfilment of these tasks. For example, construction materials typically account for 40-45 % of the cost of all construction work [1]. Involving agents in the e-commerce process of items (e.g. construction material) and web service architecture can be an appropriate choice for making the workflow flexible and agents in the web service architecture search for the right item (material), comparing prices, user preferences, companies' policies, budget, etc. This type of workflow will be a decent workflow for searching the right material cost etc. Also, in the searching of material, as human being have the emotions, feelings and other things so it is quite possible that at the time of searching the materials, he/she can do the mistake (may be due to time constraint persons do not have time to conduct long search and he/she purchase construction material which is not of there first or preferred choice or unable to find appropriate material due to inadequate search) whose consequences can not be beard by the company or the price exceeds than the project budget. So, all these things must be taken carefully [24]. In this whole process, there are problems [24] like the paper based catalogs provide the limited information about the suppliers and their products also these papers based are awkward to use, they require a lot of storage space. They become dated very quickly and make searching and comparison of prices and quality hazy task.

This make customers (contractors) unaware of the today‘s market conditions and to select the most suitable material and suppliers for a given project. Moreover, the paper based searching was time consuming and tedious job to do.

Also, different web sites such has ebuild.com, tradekey.com etc have different material searching and display patterns providing different attributes for construction materials. Buyers, purchasers get problems in using the different e-commerce web sites. Finding right material, at right quality at right price and in short time is always been a toughest task ever. These kinds of material finding jobs can be time-consuming and the buyer is required to keep abreast of new sites [24]. Though different methods like *EDI* [34] can be used to solve above problems but due to large amount of preliminary expenses and large amount of time that is consumed in implementation and customization they discourage most of users. Also training required to use *EDI* [34] is costly.

By using the agents and web services in frame work can assist the users to overcome the limitations of finding the right material and the selecting the right material, cost and quality attributes etc, The working of modal is described in next sections 4.4, 4.5 and 4.6.. Normally, the process of finding the material using the web service is that the users (companies, contractors etc) search for materials keeping in mind, the budget, project cost, quality attributes etc. This task is very time consuming and it requires a lot of hours and work and in keeping their information align with the market is also very necessary. So, there is no methodology which could beneficial them. Also, there are some systems which facilitate just the information sharing between the different e-commerce systems using the web services but these systems again give all these tasks to human being to do[24]. Also, these systems are unaware of users and they don't have any information about the particular user or company which is interested in what type of material to purchase usually etc. So, there is need of such frame work which can assist the users, company in that regard. By introducing the agents with web services provide solution to this problem [24].

The recent web services model has three main components [8] as shown in figure 4.

(1) Service Provider

(2) Service Requester

(3) Service Registry

(1) Service Provider

Web Service Providers are in other words the providers of services of web. These providers are in the charge of providing, developing and managing the services in order to meet the business necessities. The service providers are responsible for publishing description of its services at service registry with WSDL.

(2) Service Requester

A service requester utilizes web service from the service provider by sending the XML message to the service provider.

(3) Service Registry

A service registry acts like a logical directory having details of all services or in other words a catalog of exposing the web services. It is a central place where new services can be registered, published by providers and others (users, business, and companies) could find existing services by doing search.

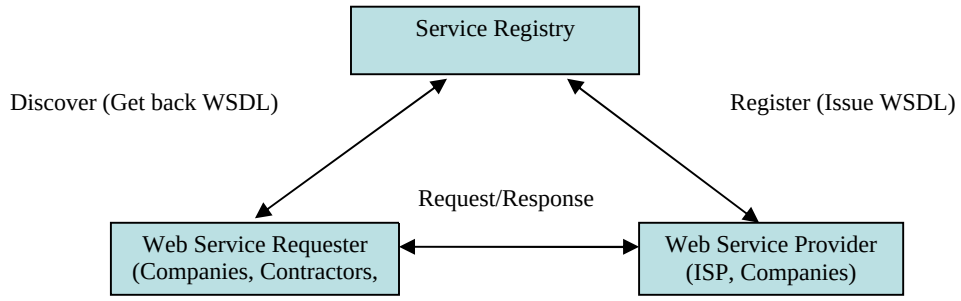

Figure 4 Existing Model of Web Services [8]

4.4 Current Construction Material (E-Commerce) Workflow System

In the construction material purchasing e-commerce work flow using the web service includes customers, companies etc who look for material information by searching different e-commerce web sites. When they found the required material then on the availability of material and depending on time constraints which best suits their business needs (i.e. Days the material order takes to reach the customer place). As shown in figure 5, using the web service they can purchase the material using the credit card, on the completion of transaction the order is taken and the price is deducted from their credit card along with the shipment charges and invoice (bill) with the material is sent to the given addresses of purchasers. But this is just the information the customer is interested in and knows. There are many processes involved in the transaction from the customer placing the order up to reaching the

material with invoice to the customer. The Construction Material (e-commerce) Workflow can be seen in Figure 6.

- As shown in figure 6, In Order Captured Process, up to date information regarding the material is provided on the web site (material availability and quantity), similarly the different material prices information is also given, also sales tax information, shipping method and price validate order, online credit card verification, order acceptance and notification customer and merchant, and all these activities are done.

- Further in the order fulfillment process, this thing is checked whether the order is which is going to be fulfilled is an internal (same region) order or external (outside region) as well as whether order will have to be fulfilled from single or multiple locations, route order (material) is checked, packing slip is printed, the order (material) is picked and packed, logistics are provided, payment is settled, order status is changed with the notification.

- In the Order Processing Process, it is determined whether partial shipments will be accepted or not, then it is also determined whether product (material) will be allocated prior to credit card authorization , the customer file is updated, inventory file is updated as well. Closed warehouse is determined, order is processed. In the Shipping Process Activity, the type of shipping is checked whether it is international, local, regional shipping etc as well integrating shipping with the third party shipping companies. Customer files are made by gathering their data through user registration and shopping habits. Payment Systems Process Activity includes setting up merchant accounts with payment processors, integration with payment processors, required types of credit card authorization (real time or batch), security (SSL, SET), certificate management, determine whether credit card authorization will be done prior to confirming inventory availability and whether alternative payment methods such as micro payments, coupons, purchase cards, proprietary cards and gift certificates will be used or not.

This type of workflow has some draw backs as follows.

(1) First, as this type of searching involves a number of hits for a material and to search different companies' profile and materials, comparing prices of materials with respect to different companies and keeping up to date information about the market is cumbersome, time consuming and tedious task.

(2) Second, although credit card purchasing is very common and popular but it is also not very secure purchasing using the internet, because of hackers and other threats. On getting credit card information one can easily misuse the card (declining purchase) and misusing the credit card for his/her own shopping.

(3) Third, the current web services do not facilitate the users with good services and fast searching. Also, there exist inefficient or lack of coordination between the processes (order capture process, order processing process, order fulfillment process) in case of exception [38].

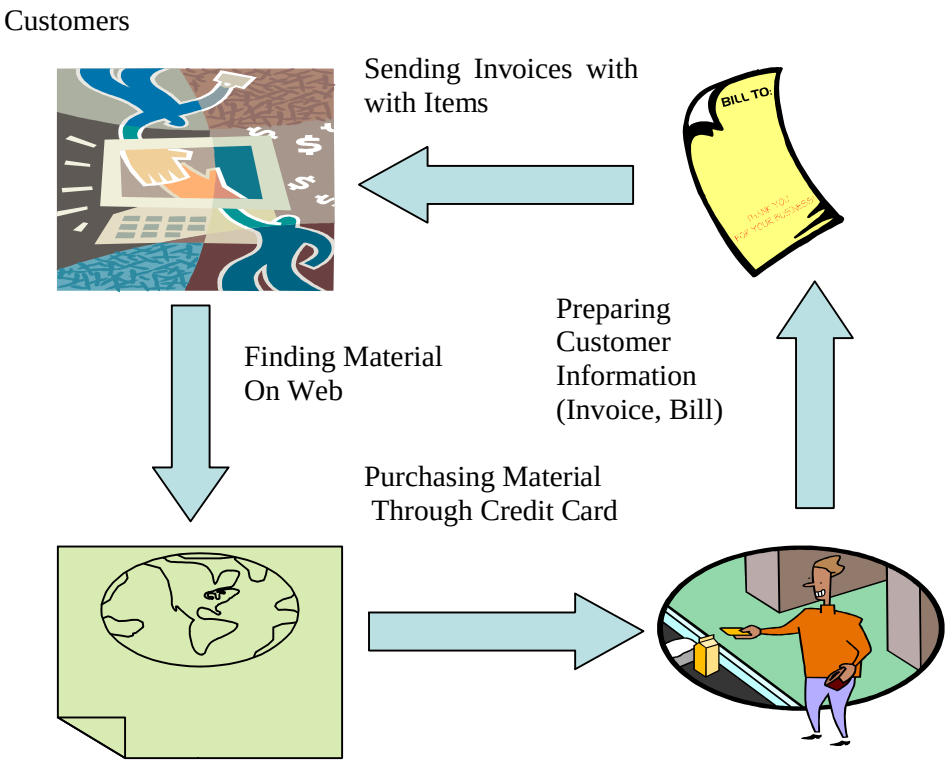

Figure 5 Material Finding and Purchasing E-Commerce Work Flow

By keeping in mind these things, the need of agents arises which could assist this workflow by making it adaptive using agents and web services. The proposed framework focuses on problem 1 and 3 and solves them efficiently. But still future research is needed to deal with second problem,

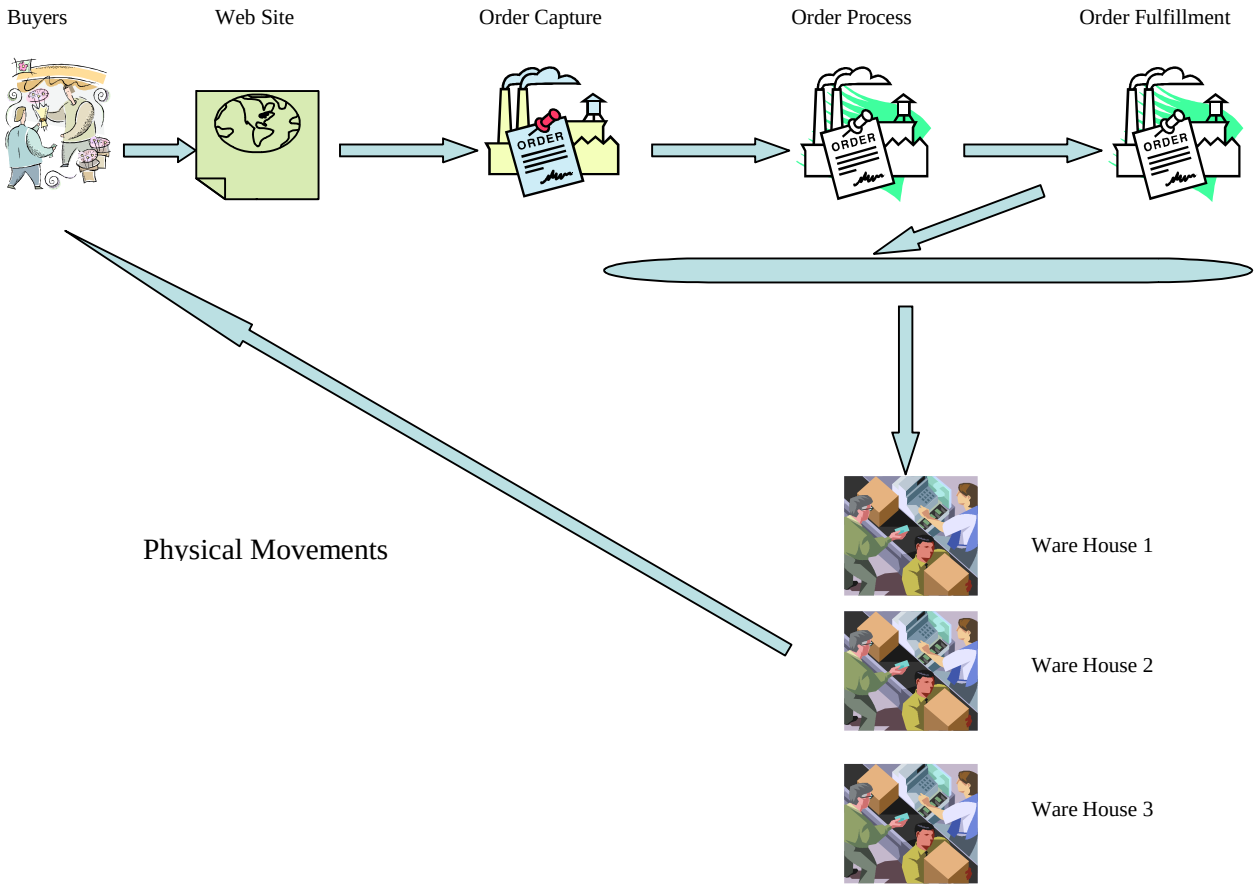

Figure 6- Construction Material (E-Commerce) Workflow System [35] [44]

4.5 Introducing Agents in the Web Service Architecture

Introducing agents in this workflow can make users easy to find the construction materials for purchasing fast and in less time. The role and services that agents will play will be like services for web services in the process of searching and finding the construction material fast by keeping all information regarding the user preferences about the material construction and getting back the results in less time for the right material which has to be purchased later on. In the web service architecture agents can be introduced as active agents, which interact with each other in order to process the inquiry (search) and process it and then return the results back to the requester who made the request. So agents can be deployed in the web service architecture for searching as well as introducing them in this e-commerce workflow, to make it adaptive.

This approach can facilitate customers and reduce the time consumption and complex job of searching for construction materials as well as their purchases and order fulfillment processes. Similarly, the security aspects can not be ignored as well in that regards while making the transactions.

In accessing the right and quick web service for the construction material or any other application it is necessary that all the requirements and user needs, preferences must be specified in order to get the right web service in no time. But this can not be done in this flow and the current architecture of web service. In order to avoid these things and make the workflow and users, company's task efficient, the agents can be placed in the current architecture so that it can overcome the problems that have been faced by the most customers. The users can't really express their preferences in searching a particular construction material. There is some lacking in the existing web service architecture as well.

The first thing is that the registry should be filled properly having all information of e-commerce web sites without any lost or broken service pointers and should have updated information about the business market which the service providers should provide this facility. Second issue is as there is no such database (a knowledge repository) which could provide and assist the users preferences, for that purpose an agent can be placed having its own database which keeps the information about the customers with the history and customers files as well as searching, maintaining previous histories and making new files with linking them and having the information about the customers preferences and every time the customer make search for particular construction material. All the summary information is provided in the database with the customer information whenever they search and purchase construction materials. There may be some customers who have special agreements with the companies or some new things offered when they purchase the materials.

Another approach can also be provided in agent that as well the agent has the database, an intelligent feature like machine learning technique or algorithm (Neural Net Works, Decision Trees etc) can also be placed in an agent as its learning capability for the remembering the customers and their preferences and what they searched and purchased last time and usually what do they purchase so often etc.

Similarly, as purchasing the construction material through credits cards etc are not considered as secure transactions done over the internet or using the web service due to lot of threats like hacking, password cracking techniques (algorithms) etc and for the secure transaction and for security purpose another agent can be introduced whose work will be to provide the secure transactions to prevent from loss of money etc. Also, this thing can be again reported to the to the agent who is residing in the registry to update the database as well as to the customer and in any case if the transaction is unsuccessful or for any un eventful reason it again reports both to agents that are dealing with users as well as the agent that is at the registry.

Now the author will explain agents that have been used in e-commerce workflow system in order to achieve the desired functionality. Later on the whole e-commerce work flow system will be discussed.

There are two agents namely, Service Registry Agent, Service Requester Agent, that will take part in this E-business workflow for the web services.

(1) Service Requester Agent

As shown in figure 7, Service Requester Agent will have the responsibility of serving the desired functionality in quick time as the service requester wants. It will take all the requirements from customers, companies etc which not only describe their functional as well as non functional requirements and it will provide these details to

the Service Registry Agent who will be responsible for processing these requests, the service registry agent will look in to their database and UDDI.

(2) Service Registry Agent

As shown in figure 7, the Service Registry Agent will get the information as the service provider will provide the list and specifications of the services at UDDI registry. The specification of web services will be under UDDI but the agent will have also an access to these services and also it will have its own database which will have the users s' preferences as well and link will be provided to the specified services so that the specified services can be used or fulfilled. Also, it has its own search which will be fast in its database for example if a requester asks for some one request which has to deal with some quite searching by themselves so the agent in this matter will do the fast search by just looking into its database and returning the values to the service requester through service requester agent. When the user requester has found its required service then he/she can invoke the service simply.

In order to process the request submitted by Service Request Agent from users, companies etc the Service Registry Agent will use that information in order to provide the best service available. It will use the user preferences and functional requirements that he/she is interested to purchase. The Agent Registry Agent will look into its database as well as into the Service Registry. Similarly, if the user is a proper customer then the agent will see user's companies' preferences and making files regarding its customers with full details of their preferences and also will see whether special customers and companies may have granted some kind of discounts or special offers further in prices etc or any package. When Service Registry Agent has selected the best one service then it will send to the Service Request Agent (Service Requester).

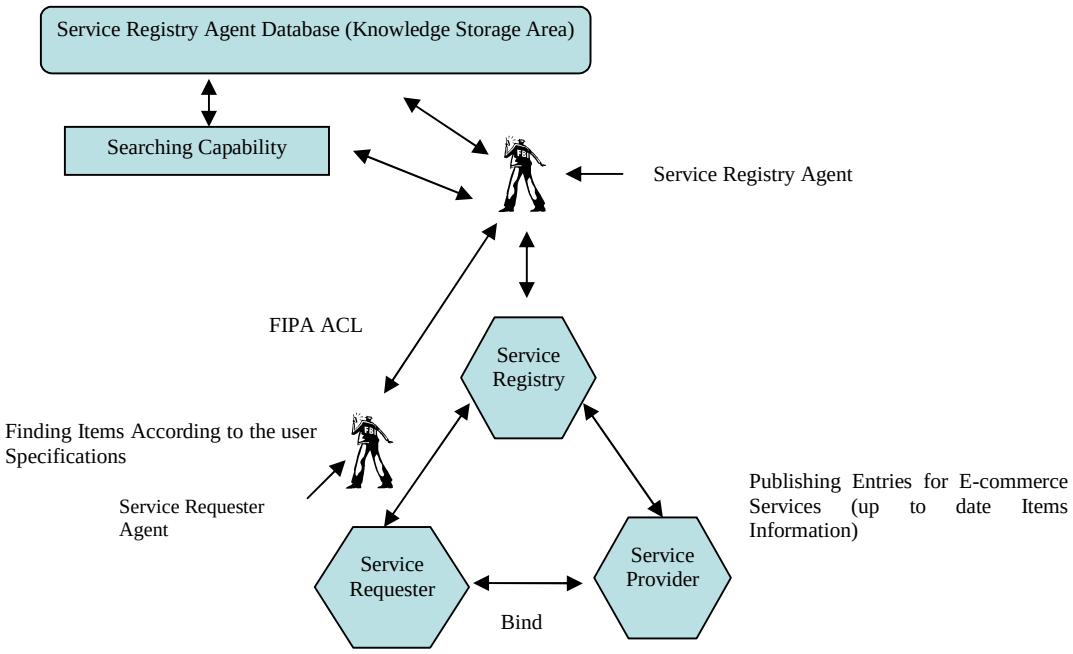

Figure 7 [2] [46]

Searching the Construction Material using Agents in Web Services for Customers

4.6 Agent based Material Construction (E-Commerce) Workflow System

In this e-commerce workflow, the whole process of construction material is illustrated in the figure 8. As shown in figure 8, agents and web services have been involved in this workflow. There are two main things in this workflow.

1. Agents have been involved in the web service architecture to locate and search for the construction material and to purchase it. These tasks are known to user side.

2. The tasks carried out for customers for their order fulfillment, have been introduced by agents in the processes, order capture, order process and order fulfillment by placing agents for these tasks which are capture agent, process agent and fulfillment agent.

These agents will be interested in the real work which will be done for the order fulfillment of users, companies etc. The capture agent will be responsible for capturing the orders submitted by the customers (users, companies etc) and it will work with the order capture for that purpose. It will have information from the web service agent about material (material price information, quantity, sales tax information etc), shipping method and online credit card verification, order acceptance and notification customer.

After this process, the shipment and credit card information will be passed to the next agent which is in that case Process Agent that deals with the order process and it is determined whether about the partial shipments will be accepted or not and it is also determined that whether construction material will be allocated prior to credit card authorization, customer file is updated, inventory file is also updated. This information is then passed onto the next agent who is in that case is Order Fulfillment Agent who deals for the fulfillment of orders placed by companies, users etc.

In Order Fulfillment Process this thing is checked whether order is an internal (same region) order or external (outside region) as well as whether order will have to be fulfilled from single or multiple locations, route order (material) is checked, packing slip is printed, the order (material) is picked and packed, logistics are provided, payment is settled, order status is changed with the notification. All these activities come under Order Fulfillment Process.

For the shipment (international, local, regional shipping etc as well as integrating shipping with the third party shipping companies) and material supply, there are three more agents named Storage3 Agent, Storage2 Agent and Storage 1 Agent which have the duty to check the availability of construction material in near warehouses, providing route information and logistics information etc to the Order Fulfillment Agent to perform all these activities. The order department has all the customer files having the record of their registration details and preference etc.

The Payment System Process includes setting up merchant accounts with payment processors, integration with payment processors, required types of credit card authorization (real time), security (SSL, SET), and also it is determined whether credit card authorization will be done prior to confirming inventory availability and

whether alternative payment methods such as micro payments, coupons, purchase cards, proprietary cards and gift certificates will be used or not. All these details also come under the Order Fulfillment. The Order Fulfillment sends invoices, destination details of customers to the warehouses for order fulfillment. The ware houses etc have the duty of packing etc the construction materials and they send the construction material with the invoices using suitable traveling media like bus, airplane etc.

The communication language used between the agents will be FIPA ACL by the Foundation for Intelligent Physical Agents, which is a standardization consortium [36]. The different systems using the FIPA standards are (1) The JADE Agent Platform [37], and JACK. The reason for choosing the FIPA ACL is that it is more powerful with composing new primitives and has different semantics than KQML which is another agent communication language. The dealing of agent management and administration primitives in FIPA ACL is different than KQML e.g. registering and un-registering information details are etc are treated as request for action with having reserved meaning , while KQML is not committed to content langauge.

These agents communicate with each other using the FIPA ACL communication language as standard. At each stage when a process is performed then the previous agent is acknowledged so that the workflow information can be save at each place and in case of any problem or mistake the agents could deal with the situations and update their information and correct it and send them back and stop the process where it got stuck. So, these agents using web service as part of this workflow provide an adaptive workflow if any change comes in the system, they deal with it.

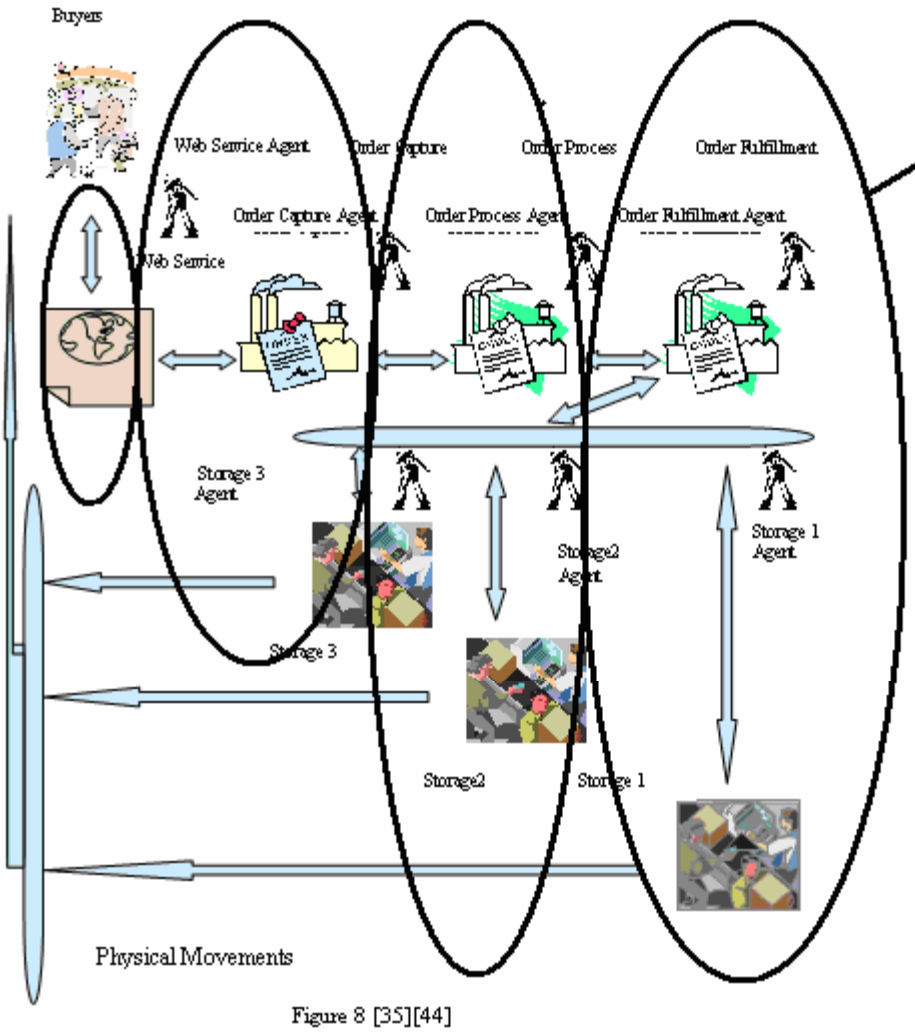

Figure 8 [35][44]

Agent based Extended Construction Material (E-Commerce) Workflow System

4.7 Agents Communication Supporting Workflow System

There are different agents which are involved in this e-commerce workflow in order to facilitate the processes in terms of data transfer information passing through one agent to another agent. The purpose of introducing the agents in this e-commerce workflow is to support the chances of data loss in terms of any exception happening in this e-commerce workflow. The agents not only provide the coordination framework, as the agents have control over their internal states as well so they keep their state alive during the information exchange as well as maintain their logs so that the information could be retrieve incase of e-commerce workflow failure. All the agents in this e-commerce workflow are activated and monitoring and storing the information details associated with each process and responding to the requests submitted by the other agents.

Here is the example how the agents will communicate with each other using FIPA ACL, the full example can be seen in Appendix-A.

```
(request
:sender     order capture agent
:receiver   web service agent
:content     (name material  ?)
:language   p1
:ontology   hpl-trading
)

(inform
: sender web service agent
: receiver order capture agent
: content (name interior door)
: language p1
: ontology hpl-trading
)
```

In this example first the interaction between two agents' web service agent and order capture agent is shown which use FIPA (Foundation for Intelligent Physical Agents) as standard agent communication language for their interactions. In this example, the sender (order capture agent) sends request to receiver (web service agent) for asking the name of material using the language p1 and ontology hpl-trading and the (web service agent) in that case becomes sender and accomplish its request by sending the name of the material i.e. interior door to the receiver (order capture agent) using the same language and ontology.

- Similarly, the order capture agent sends request to web service agent for asking the quantity (how many items in numbers) of material, price of material, credit card verification number of customer, shipment method selected by customer using the language p1 and ontology hpl-trading and the sender (web service agent) accomplishes its requests by sending the quantity of the material interior door that is in that case 100, price of interior door for

100 quantity 2000000 dollars, credit card verification number 52346797893567 and shipment method by air selected by customer to receiver (order capture agent) using the same language and ontology.

- Next, the order process agent sends requests to order capture agent for asking the credit card verification number and shipment method and the order capture agent accomplishes its requests by sending the credit card verification number 52346797893567 and shipment method by air to order process agent. Next, the order fulfillment agent sends requests to the order process agent for asking customer updated information and inventory information and the order process agent accomplishes its requests by sending the customer file and inventory file to the order fulfillment agent.

- Similarly, the order fulfillment agent sends requests to the storage1 agent, storage2 agent and storage3 agent for asking the information about material and the requests are accomplished by the storage1 agent, storage2 agent and storage3 agent by sending the material file which is helpful for order fulfillment to decide from which storage place the required material can be sent out depending on the availability of materials.

5 DISCUSSIONS

The real challenge in this thesis was to suggest an adaptive e-commerce workflow system which could accommodate with the changes occurring whether in the business processes or in the business environment. Today's workflow systems do not provide the required support to B2B transaction processes, such as information sharing, chained execution, and process changing, monitoring, reorganizing and receiving workflow processes in case of problem or exception from other processes. Also, there was a main issue of security which needs more attention in order to prevent from the unauthorized or misused access control from outside.

Adaptive work flow framework facilitates customer to overview cost, time and business value also by introducing the agents in the e-commerce processes make the working of processes more accurate, persistent, backtracking in case of data loss through agents which are coupled with the process etc. In this report the author focuses mainly on three major areas i.e. multi agent systems, web services and adaptive work flow.

The structure of adaptive work flow framework illustrates that agent based methodology facilitates the exiting work flow in e-commerce domain. The reasons for this is principles on which agent methodology is based i.e. flexibility to adapt to the environment and abide the changes that occur in work flow.

Further it facilitates the customers to perform search and purchase. Web services are integrated with agents to provide refined and better search, which can be helpful for customers in purchasing the item (e.g. construction material).

Agent based approach is more favorable to the e-commerce than expert systems and based on dynamic implementation, since most of projects still dependent on the other available approach. Expert systems like Mycine are not favorable to use agents because are not designed for reactive, proactive behavior also they are not coupled to their environment [30].

Though the scope of this work flow system is limited to the agents that are available or present in that particular domain or work flow, it is not possible to interact with agent that are not part of that particular domain or work flow.

Having different agent collaboration for e-commerce, the suggested adaptive e-commerce workflow system has the following novel features:

- Process Control- In the suggested e-commerce workflow model each process having agents has control over its internal state which is useful whenever an exception occurs or if there is change in the business environment.

- Backtracking/Traceability- The suggested e-commerce workflow model support the backtracking/traceability facility in terms of real time transaction in case of process failure which provide surety to customer point of view that either transaction has been made or not.

- Flexibility- The suggested model provides flexibility which is key element and having significant impact on the business as well the business environment.

5.1 Performance

The performance of suggested model can be measured in terms of its process time, process completion and traceability/backtracking of data from one process to another process. The suggested model provides an agent based approach which may facilitate backtracking/traceability in case of data loss, better process control using agents associated with each process and process completion (one process sending acknowledgement to another process) as shown in the figure 8 [35][44] and described in section 4.6 in previous chapter. There may be some factors involved like internet bandwidth, type of network connection the customer or business have, which may become hindrance and reason in achieving the business goals, delaying process cycles and process fulfillment.

6 CONCLUSIONS AND FUTURE WORK

In this section the author will discuss his findings in the shape of solution to the problem and focus on the future work that is needed in this area of research.

6.1 Conclusions

In this thesis, the problem of achieving the adaptive work flow in ecommerce i.e. agents and web services combination is discussed. The author also discussed about how this adaptive workflow can be beneficial to some business, enterprise and user objectives.

Purchasing of construction material is tedious and time consuming task. The wrong selection of construction material affects the performance of system, business objectives and reputation of company. Also it may cause delay in time to market and loss of money. To circumvent this problem, many solutions have been proposed to assist in the e-commerce work flow in past. But the author focuses particularly on agents and web services to address the problem.

The agent based framework proposed in this thesis addresses to some, if not all of the issues of e-commerce. The author illustrates a novel way of expressing adaptive work flow by using agent based framework to overcome the obstacles faced in e-commerce domain. Also, such architecture can facilitate the work flow and make it adaptive to accommodate the changes in environment.

It can be concluded that agent based framework offers dynamic solution to the above mentioned problem. It provides flexibility by transferring details of one process from one agent to another agent sequentially and also it provides acknowledgement when the transfer is complete. Further, the model provides efficient way of searching and providing construction material, which is helpful in purchasing the material from user point of view.

The design of framework reveals that it is indeed possible to have a framework that provides adaptability with respect to business processes, flexibility and ease of use. It should have ability to address most of the shortcomings of the existing work flow models, like searching, coordination between processes involving agents as well as be able to accommodate the transaction loss in case of exception. With the proposed framework, the organizations can benefit in terms of cost and time.

6.2 Future Work

Talking about future, it is very difficult to predict but statistical studies conducted on industry projects [29] have shown that trend in software industry last for not more than five to six years. The methodologies are improved or changed to overcome the existing problems. The problems that are faced by IT industry now days are financial, technological, structural, and educational issues. In our area of research the problem mostly concerns about technological, business and development issues in field of e-commerce.

Proposed Agent based framework has ability to adapt changes which occur in the processes providing backtracking with no data loss in case of error or exception in processes and it also provides efficiency with respect to time, also acknowledges when the data has been properly transferred.

Design of Adaptive frame work is suggested in this thesis, based on literature and research articles study. The author recommends that suggested model should be validated and measured in terms of its performance with respect to its process time, process completion and traceability/backtracking of data from one process to another process. As, this framework is in its initial stages, and not been reviewed by researchers. First step the author suggests that it requires careful evaluation by researchers working in this area from many years and further modification in the model if needed. Secondly, the author recommends that once the model is reviewed and updated according to the suggestions provided by researchers. Next step is to build prototype of this framework model and it should be developed and implemented in small industry for pilot testing.

The author believes that the results from pilot testing will help in revealing the outcome of study. Based on the results it is recommended that reverse engineering should be applied to evaluate design of framework to results. For instance, this model can be implemented in small construction material organization; once it is implemented the results from the model should be related to goal of study which will help researchers to identify whether the particular model is functioning properly or not. Further, the artifacts business objectives, time, cost and complexity involved must be measured corresponding to the design.

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Park, PA 16801, USA, Supply Chain and Information Systems, The Smeal College of Business, The Pennsylvania State University, University Park, PA 16801, USA Received 11 April 2005, Available online 24 October 2005.

APPENDIX-A

(request
:sender order capture agent
:receiver web service agent
:content (quantity number ?)
:language p1
:ontology hpl-trading
)

(inform
: sender web service agent
: receiver order capture agent
: content (quantity 100)
: language p1
: ontology hpl-trading
)

(request
:sender order capture agent
:receiver web service agent
:content (price interior door price)
:language p1
:ontology hpl-trading

(inform
: sender web service agent
: receiver order capture agent
: content (price interior door 2000000)
: language p1
: ontology hpl-trading
)

(request
:sender order capture agent
:receiver web service agent
:content (credit card verification number number ?)
:language p1
:ontology hpl-trading
)

(inform
: sender web service agent
: receiver order capture agent
: content (credit card verification number 52346797893567)
: language p1
: ontology hpl-trading

)

(request
:sender order capture agent
:receiver web service agent
:content (shipment method name ?)
:language p1
:ontology hpl-trading
)
(inform
: sender web service agent
: receiver order capture agent
: content (shipment method by air)
: language p1
: ontology hpl-trading
)
(request
:sender order process agent
:receiver order capture agent
:content (credit card verification number number ?)
:language p1
:ontology hpl-trading
)

(inform
: sender order capture agent
: receiver order process agent
: content (credit card verification number 52346797893567)
: language p1
: ontology hpl-trading
)

(request
:sender order process agent
:receiver order capture agent
:content (shipment method name ?)
:language p1
:ontology hpl-trading
)

(inform
: sender order capture agent
: receiver order process agent
: content (shipment method by air)
: language p1
: ontology hpl-trading
)

(request

: sender order process agent
: receiver order fulfillment agent
: content (customer information ?)
: language p1
: ontology hpl-trading
)

(inform
:sender order fulfillment agent
:receiver order process agent
:content (customer customer file)
:language p1
:ontology hpl-trading
)

(request
: sender order process agent
: receiver order fulfillment agent
: content (inventory information ?)
: language p1
: ontology hpl-trading
)

(inform
:sender order fulfillment agent
:receiver order process agent
:content (inventory inventory file)
:language p1
:ontology hpl-trading
)

(request
:sender order fulfillment agent
:receiver storage1 agent
:content (material information ?)
:language p1
:ontology hpl-trading
)

(inform
: sender storage1 agent
: receiver order fulfillment agent
: content (material material file)
: language p1
: ontology hpl-trading
)

(request

:sender order fulfillment agent
:receiver storage2 agent
:content (material information ?)
:language p1
:ontology hpl-trading
)

(inform
: sender storage2 agent
: receiver order fulfillment agent
: content (material material file)
: language p1
: ontology hpl-trading
)

(request
:sender order fulfillment agent
:receiver storage3 agent
:content (material information ?)
:language p1
:ontology hpl-trading
)

(inform
: sender storage3 agent
: receiver order fulfillment agent
: content (material material file)
: language p1
: ontology hpl-trading
)