Agent Negotiation in E-commerce

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Abstract

There is currently a growing need to develop intelligent agents that engage in buying and selling in virtual marketplaces, owing to exponential growth of e-commerce. For e-commerce to become reality, there is a need to develop automatically negotiating intelligent agents that can replicate human activities in virtual marketplaces. Agent negotiation in e-commerce evolved from many different disciplines such as agent technology of artificial intelligence, Internet technology and several models of economics. In this report, we introduce and discuss the notion of e-commerce, agents in e-commerce, various negotiation strategies of e-commerce and the main scientific contributions of agent negotiation in e-commerce.

Contents

Chapter 1

Introduction: Agent Negotiation in E-commerce

Ever since humanity started realizing the need to trade, commerce has been evolving. As far as the history goes, barter was the very first technique adopted in the early days of transaction. Barter enabled people to transact goods and services with each other. Although the practice of barter was sufficient at the beginning, disadvantages associated with the system led to the introduction of money in the form of Cowrie shells [147]. We have come a long way from Cowrie shells to paper and coin currencies which are utilized by every single country in the world to do businesses, both locally and internationally. As the world progresses and looks for faster and more efficient ways of accommodating rapid and long-term solutions to everyday commercial issues, especially in business transactions, electronic commerce tends to be the best solution for number of ordinary people as well as multi-billion dollar and multi-national corporations.

In recent years there has been a tremendous demand to buy and sell goods electronically over the Internet. Business Week Review estimates that the Internet-generated electronic transactions would grow exponentially from a worth of about $346 Billion in 1997 to $2950 Billion within seven years, not to mention the effects that will be imposed on world economics by the electronic commerce. Internet transactions turn out to be very economical for customers. For example, on-line trading company Brown & Co. provides online stock trades for a commission of only $5 per transaction. Other on-line brokerages, such as E*TRADE and eSchwab are providing full service securities trading for only 10% of the traditional $200 commission [87]. Another great example of commerce on the networks is Amazon.com, which has more than a million on-line titles with the delivery of items ordered on the Internet taking only three days. Apart from these traditional on-line companies, there are many other on-line buying and selling companies, selling everything on the Internet from children's toys to discount airline tickets.

Most of these electronic purchases today are non-automated. Although the information on products and vendors are easily accessible and orders and payments are dealt with electronically, humans are still involved in the loop at every stage of the buying process. Buyer is still responsible for collecting and interpreting information on products, evaluating merchants, involving in negotiation process with merchants and ultimately finishing the deal by providing purchase and payment information.

A recent approach to problem solving in complex heterogeneous systems uses the so-called electronic agents. They can entirely or at least partially take off the burden on buyers and sellers during electronic purchases over the Internet. In other words, automated electronic purchases using the agents performing the tasks of humans. Imagine the following situation described in [81] that might occur sometime in the near future:

> *You wanted to buy or sell an item and you don't want to waste your time to participate in the negotiation process. You can send your agents to buy and sell the product on your behalf and the agent would negotiate with other parties and clinch the deal for you.*

However, there are problems associated in achieving the above scenario. One major problem is that programs are written by different people, in different languages and on different platforms. As a result, they provide different interfaces which lead to heterogeneity. As per [79], software is very diverse. Even though programs provide users with significant value, interoperability is a major problem along with heterogeneity causing problems in interoperation. Agents seem to be a perfect choice for accomplishing the above-mentioned task as they are very flexible and autonomous and can work on any given environment.

Agent-based software engineering came about to facilitate the creation of interoperable software in such settings where there is heterogeneity. These agents offer to solve problem which may not be solved by existing technology such as Object Oriented Paradigms. They can also solve some problems in significantly better way than the existing technology, beyond the scope of automation. Agents represent a powerful tool for making complex systems modular. In the case of interdependent problems between the modular components, agents cooperate with each other to ensure that the interdependencies are managed properly. Therefore, Agent-based computing has the potential to significantly improve the theory and practice of modeling, designing, and implementing complex systems such as electronic commerce.

As much as agents help tackling interoperability problems, they also enable negotiation for services and resources. Agents are typically in heterogeneous systems with inherently distributed data, their own control and resources. Interactions become a core part of these agents, especially at run-time. It occurs because of agents' inter-dependencies and they manifest themselves in the form of cooperation, coordination and collaboration for interactions. Need for each other's data, logics and resources eventually crave a path for negotiation between them. Negotiation can be viewed as a process by which a group of agents communicates with one another to try and come to a mutually acceptable agreement on some matter [91]. As [100], [101], [73] and [130] presents, managing information by gathering and filtering information as per user's needs, playing an important role in electronic commerce in buying and selling goods, managing business process by handling issues such as supply chain management, and being efficient in health care by monitoring the condition of the patient, they all suggest the need for negotiation between agents. Automated negotiation is becoming an integral and important part of e-commerce. Real-world negotiations, such as buying a car, accrue transaction cost and time that is too valuable for both consumers and merchants. A good automated negotiation tool can save both time and money while leading to better deals in the current complex and uncertain electronic commerce environment [130].

In Chapter 2 we will discuss e-commerce, their properties and requirements, consumer-buying behaviour and problems associated with e-commerce negotiation. Chapter 3 discusses software agents, automation among these agents, definitions, properties and classification of the agents including multi-agents systems and mobile agents. Chapter 4 stresses the need for agent communication languages. Chapter 5 looks into the automated negotiation focusing on parameters of negotiation, negotiation process, existing automated negotiation approaches and finally the challenges in e-commerce negotiation. Finally, in Chapter 6 we present the concluding remarks about automated negotiation in e-commerce and discuss our future work plans.

Chapter 2

Electronic Commerce

We have become familiar with the term e-commerce not only from the advertisements on the radio, newspapers and television but also from the Internet. There is a huge amount of hype that surrounds the e-commerce. On the retail side alone, Forrester[1], projects $17 billion in sales over the Internet by the end of the year 2002. Worldwide Internet/Online Tracking Services (WWITS) of IntelliQuest Information Group's survey states that home is the most popular access location of the Internet and 60% of the users shop online at home. Their most popular activities include finding information about a product's price or features and determining where to purchase a product.

This Chapter looks at some important areas such as the drive for e-commerce, the concept of e-commerce, how consumer buying behaviour affects e-commerce, properties and requirements of e-commerce and at the end the current challenges faced in e-commerce.

2.1 Drive behind E-Commerce

Companies have been selling goods and services through various media for years. However, during the past few years we have been witnessing a growing rush towards e-commerce by large and small companies. There are two reasons for this phenomenon.

1. Sale conducted over the web cost companies comparatively less. For example, the company does not have to hire someone to answer the phone. Moreover, people tend to purchase more goods on the Internet. Besides, the transaction cost on the web is lower and the presentation of merchandise on the web is more inviting that encourages larger transactions; thus moving to the web is seen as a productive exercise.
2. When there is a percentage of buyers who prefer to buy over the Internet perhaps because there is more time to think before making a decision, or because comparison of multiple vendors is possible, building web site to

[1] A research company that provides guidance on customers, business strategies and technology investments.

attract these buyers, lure away customers from other vendors who do not offer better services and / or choices.

2.2 Concept of E-Commerce

Electronic Commerce (e-commerce) is defined as the conduct of commerce of goods and services with the assistance of existing technologies over the Internet [41]. E-Commerce is often used in a much broader sense, far beyond the scope of just being electronic business. It is good to note that there is a difference between e-commerce and e-business. Student enrolment system, for example, is an e-business, not an e-commerce. On the other hand, e-commerce may include buying and selling of products with digital cash via Electronic Data Interchange (EDI). E-Commerce covers variety of areas, such as:

- *Electronic catalogues*: refers to means whereby sellers can communicate their offerings to potential buyers
- *Electronic data interchange (EDI)*: refers to a particular family of standards for expressing the structured data that represent e-commerce transactions and
- *Electronic auctions*: for a particular set of mechanisms for setting prices.

E-Commerce concepts include Business-to-Business e-commerce (B2B), Business-to-Consumer e-commerce (B2C) and Consumer-to-Consumer e-commerce (C2C). B2B is the use of private networks on the Internet to automate business transactions between companies. The EDI has been the primary standard that has been used. It has typically been applied through the use of a Value Added Network (VAN) in which companies are able to do business on line after obtaining the membership to a particular VAN. Previously, the implementation costs for the technologies required excluded small businesses from using EDI. However, emergence of the Web-EDI with existing technologies allows small businesses to join in [41]. B2C e-commerce is a retail sale model or a web market. Amazon.com is an example of B2C. It enhances the previously used business models by offering:

- A global audience

- Unlimited product selection
- Portal sites that refer consumers to the actual purchasing site
- Focused marketing that can be quickly tailored to consumer

C2C e-commerce is an auction based or bargain-based systems [107]. This model allows creation of virtual marketplace community on any web site. C2C e-commerce often provides low cost consumer-to-consumer refurbished goods to reduce transaction cost. Some popular examples of C2C e-commerce sites are eBay.com, uBid.com and eWanted.com.

Large and small companies are equally using the web to communicate with their partners, to connect with their back-end data systems, and to complete transactions. According to industry estimates, during this year, nearly $4 billion will be spent world wide through on-line transactions. As the amount of business grows over the Internet, there is a need for standardizing the process of e-commerce. This process includes the following:

- Electronic presentation of goods and services
- Online order taking and bill presentment
- Automated customer account inquiries
- Online payment and transaction handling

The process mentioned above clearly indicates the need for proper investigation on the properties and requirements of e-commerce transactions.

2.3 Properties and Requirements of E-commerce transactions

Different conferences on Principles of Distributed Computing (PODC) have agreed on certain concepts that are heavily used in electronic commerce [45], [64].

- Atomic transactions.
- Providing support for a variety of transaction type including simple buying and selling, auctions and complex multi-agent contract negotiation.
- Cryptographically secure protocols.

- Providing language in which the rich array of semantic content about commerce is expressed.
- Being extensible, by third parties, so providing multi-agent contract and dynamic mediation.
- Providing a secure and private credit and payment mechanisms.
- Interoperating with other new and existing E-commerce service and
- High reliability.

Apart from the issues mentioned above, electronic commerce encompasses a broad range of issues like reputation, law, advertising, ontology, intermediaries, multimedia shopping experiences and back office management [107]. Software agents are autonomous, can be personalized, have secured communication, continuously running and move from one place to another place. These agents' properties can be used to automate several of the most time-consuming stages of the buying and selling processes while adhering to the properties and requirements mentioned above [101]. These qualities can help optimize the automation of whole buying and selling processes in e-commerce. Different models have been used to explore the roles of agents as mediators in e-commerce. One of the prominent models include the framework from MIT [101] which stems from the Consumer Buying Behavior (CBB) research and includes the actions and decisions involved in buying and selling goods and services.

2.4 Consumer Buying Behavior

In commerce and in tern e-commerce, different models of CBB share a similar list of six fundamental stages in guiding consumer-buying behavior [107]. These stages also interpret where agent technologies apply to consumer shopping experience. They allow us to more formally categorize existing agent-mediated electronic commerce systems. The six stages can be summarized in the following:

- *Need Identification*: consumer becoming aware of some unmet need.
- *Product Brokering*: Retrieval of information to help determine what to buy.
- *Merchant Brokering*: Merchant specific information to help determine who to buy from.

- *Negotiation*: How to determine the terms of transaction including price bargains, warranties etc.
- *Purchase and delivery*: It can be a signal to the termination of negotiation stage or occur sometime after the negotiation is done.
- *Service and Evaluation*: this phase involves product service, customer service etc.

From this CBB perspective we can identify the roles of agents as mediators in electronic commerce. Agents make themselves well suited for mediating behaviors involving information filtering and retrieval, personalized evaluations, complex coordination, and time-based interactions [107]. Mainly these roles correspond to Product Brokering, Merchant Brokering, Negotiation and Purchase stages of the Consumer Buying Behavior Model (CBB).

2.5 Challenges in e-commerce

There are many systems in existence with different models for Product Brokering, Merchant Brokering and Purchase stages. Recommender systems as discussed in [125] use collaborative filtering and knowledge-based approach to make recommendations to the users in purchasing decisions. There are other Recommender systems, like PersonaLogic and Firefly that help consumers find the products. Firefly recommends products using automated collaborative filtering approach. Systems like BargainFinger, Jango, and Kasbah (Chapter 6) helped in the Merchant brokering stage. But there are not many systems, which could support the negotiation stage. MIT's Kasbah [10] was one of the first systems to support the automated negotiation stage. Though it had its own drawbacks, Kasbah led the other researchers to work in this negotiation aspect more actively.

There are several challenges or reasons for not many automated negotiation systems in existence. The challenges of automated negotiation in E-Commerce applications as discussed in [47] are:

1. It is very difficult to expect an automated negotiation process that reflects the real world.
2. There is no negotiation based on diverse attributes for item.

3. There is no multi-negotiation that considers and is adapted to all counterparts participating in negotiation process simultaneously.
4. There is no personalized negotiation.

Reaching the challenges mentioned above brings in the issues like interoperation and automation. For example, to automate negotiation in buying and selling a car, there needs to be a semantically interoperable language and protocol coordinating the parties (agents) involved. Unfortunately, there is still lack of common language and ontology for e-commerce interoperation. Although HTML web-scraping may get us by for certain problems, for instance, product information retrieval in retail markets, it is not sufficiently robust to base important business processes upon [41]. Extensible Markup Language (XML) came in as a good tool in differentiating products from more than just their prices. It helped merchants to describe various services offered with the product solved, eliminated the need for web scraping by the use of XML parser and brought in the XML/EDI message format reducing the cost of transactions in e-commerce [112]. Nonetheless, there are still problems, which will take much more effort on business corporations in agreeing on Meta Tags in XML to specific semantics in accomplishing the tasks mentioned above. Business ventures are coming up with Business Interface Definitions (BDI) and Common Business Library (CBL) as domain specific ontologies to accomplish this cumbersome task [112].

So far we have discussed e-commerce, their application areas, concepts, properties and requirements during transaction, consumer-buying behavior that affects e-commerce and last but not least the challenges in e-commerce. Now it is absolutely necessary to introduce the concept of agent and show why and how agents are important in e-commerce. In the next Chapter, we will take a deeper look into agent technology and its properties.

Chapter 3

Agents, Properties and Classifications

Agent based computing is a recent approach to problem solving in complex heterogeneous systems that has been attracting great deal of attention among the Artificial Intelligence (AI) community. People have been fascinated about the idea of artificial agencies for a long time. Especially, with the inception of AI and distributed systems, computer scientists have been working on systems which could automatically perform tasks for humans. Agents integrate so many diverse disciplines of computer science, including objects, distributed object architectures, adaptive learning systems, artificial intelligence, expert systems, distributed processing and distributed algorithms to name a few.

In the previous Chapter we briefly discussed e-commerce, its properties, requirements and existing challenges. Now, we turn our attention to the history of agents, definition of agents, common properties of agents and the classification of agents. Finally we will take a deeper look into multi-agents and mobile agents to conclude this Chapter.

3.1 History of Software Agents

Since the beginning of Artificial Intelligence, Object technology and Distributed

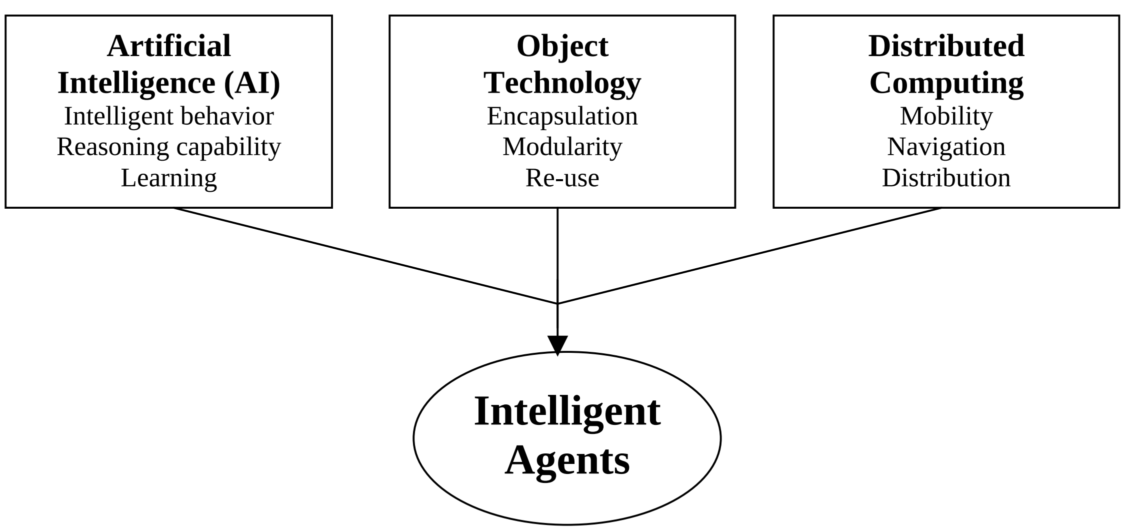

Figure 1: Evolution of Intelligent Agents

Systems, as illustrated in Figure 1, momentum has shifted from hardware to software. Researchers have been working extensively to build intelligent software agents to perform tasks that are only performed by humans.

Although the research on intelligence software agents has been taking place for about 15 years, the word 'Agents' became popular in computer magazines and journals around the year of 1995. However, the concept of a software agent can be traced back to the early days of research of Distributed Artificial Intelligence (DAI) in 1970's. The Actor model proposed by Hewitt in 1977 was a concept of a self-contained, interactive and concurrently executing object, which he termed eactori [42]. This object had a certain level of encapsulated internal state and responded to messages from other similar objects, i.e., An actor.

Nwana (1996) splits agent's research into two main strands, the first beginning in 1977 and the second around 1990. Strand one work concentrated on macro issues such as the interaction and communication between agents, the decomposition and distribution of tasks, coordination and cooperation, conflict resolution via negotiation etc. In the second strand, since 1990, there has been extensive research and rapidly growing development work on broader range of agent types. Recent emphases of agents are shifting from "deliberation to doing" and "reasoning to remote action" [51].

Even after two decades of research, some of the key concepts in agent-based computing lack universally accepted definitions. Embarrassment comes as no surprise to the Agent community, as they still cannot agree on "what is an agent". There are two main reasons why it is difficult to precisely define what an agent is. First, agent is a term that is widely used in everyday parlance as in travel agents, estate agents, etc. Second, even in the software fraternity, the word agent is really an umbrella term for a heterogeneous body of research and development. The confusion about agents led researchers to invent more synonyms including knowbots (knowledge-based bots), softbots (software robot), taskbots (task-based robots), userbots, robots, personal agents, autonomous agents (mobile agents), auctionbots and personal assistants [42].

3.2 Notion of Agency

There are two distinguished notions of the term Agent. The first one is *weak* and the second is *stronger* [81].

The *weak* notion of Agency holds the following properties:

1. **Autonomy:** Agents operate without direct intervention of humans or others, and have some kind of control over their actions and internal state.
2. **Social ability:** Agents interact with other Agents via some kind of agent-communication language.
3. **Reactivity:** Agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the INTERNET, or perhaps all of these combined), and respond in a timely fashion to changes that occur within it.
4. **Pro-activeness:** Agents do not simply act in response to their environment. They are able to exhibit goal-directed behaviour by taking the initiative.

For some of the AI researchers the term 'Agent' has a stronger and more specific meaning than what was mentioned above. It is quite common in AI to characterize an agent using *mentalistic* notions, such as knowledge, belief, intention, obligation, emotion and intelligence.

3.3 Definition of an Agent

One of the most acceptable definitions for agents by two prominent researchers Jennings and Woodridge in Software Agent Technology states [89]:

> "*an Agent is an encapsulated computer system that is situated in some environment, and that is capable of flexible, autonomous action in that environment in order to meet its design objectives*."

As per this definition, Agents are: (i) clearly identifiable problem solving entities with well-defined boundaries and interfaces; (ii) situated in a particular environment and they observe the state of the environment; (iii) designed to fulfill a specific role; (iv) autonomous, have control on both their internal state and over their own behavior; and (v) capable of exhibiting flexible problem solving behaviors (see [89]).

3.4 Other definitions for agents

Stan Franklin in his paper 'Is it an agent, or just a Program?' [119] presents an elaborated taxonomy of agents that is in use among the agent community as follows:

The ***Mubot Agent***: " The term agent is used to represent two orthogonal concepts. First is the agent's ability for autonomous execution and second is the agent's ability to perform domain oriented reasoning."

The ***AIMA*** (Artificial Intelligence: a Modern Approach, an remarkably successful AI textbook used in about 200 colleges and universities) ***Agent***: "An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors."

The ***Maes*** (Pattie Maes, one of the pioneers in agents research at MIT) ***Agent***: "Autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in this environment, and by doing so realize a set of goals or tasks for which they are designed."

The ***Kidsim*** [Smith, Cypher and Spohrer, 1994] ***Agent***: "An agent is a persistent software entity dedicated to a specific purpose. 'Persistent' distinguishes agents from subroutines; Agents have their own ideas about how to accomplish tasks, their own agendas. 'Special purpose' distinguishes them from entire multifunction applications; agents are typically much smaller."

The ***Hayes-Roth*** [Hayes-Roth, Stanford's Knowledge Systems Laboratory, 1995] ***Agent***: "Intelligent agents continuously perform three functions: perception of dynamic conditions in the environment; action to affect conditions in the environment; and reasoning to interpret perceptions, solve problems, draw interfaces, and determine actions."

The ***IBM Agent***: "Intelligent agents are software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user's goals or desires.

The essence of the above definitions states that there is a unanimous agreement that the agents are *autonomous* and are situated in an *environment*. For example, a regular payroll program in a real world environment takes input(s) and acts on it to produce an output(s). This payroll program is not an agent because its output would not normally effect what it senses later. It fails the "over time" test of temporal continuity since it runs once and goes into coma, waiting to be called again. Most of the ordinary programs are ruled out as agents, because one or both of the above conditions are not met. Therefore we can infer from the above discussion that "*All software agents are programs, but not all programs are agents* " [119]. Now that we clearly distinguished the agents from just programs, we state, "*a program must measure up to several marks to be an agent*".

Discussion about the notion of agency and different definitions of agents described above give us an idea of 'what programs can be called as agents'. This discussion may also raise some questions about the functionality and environment requirements for these software agents. To answer these questions we will describe the properties and classification of software agents. Analysis of different contributions on agent technology as in [42], [81], [79], [89], [123], [12], [83] resulted in classifying agent properties into two categories. The *common properties,* which are applicable for all agents and *classifying properties,* which are used to categorize agents. Before classifying the agents, we discuss the properties of agents based on which the agents can be classified. According to [42], agents are classified based on the following properties (see [29]):

3.5 Common Properties

Life Cycle: An agent is created by an authority as an instance of a class through a creation operation. An agent can only be destroyed by the authority which created this agent, or on its behalf. An agent has a name space at any moment within which it can act. This name space consists of the names of known agents and agent systems including the agent itself.

State, Reflexivity: An agent has to be capable of reflecting its internal process and state. This is equivalent to the necessity to represent meta-knowledge about its internal structure. The state can comprise a list of messages and statements about the state of activity of the agent.

Autonomy: Autonomy means an independent and decoupled execution of tasks undertaken by an agent. The interpretations of a piece of messages, orientation etc. are determined only by the agent. Its autonomy ends where resources are depleted, and its autonomy depends on cooperation.

Locality: Each agent has knowledge, which it uses to fulfill its tasks. The local knowledge is determined by the agent's profile, its state, including the list of known agents. An agent initially does not know anything about the states of other agents.

Structural Openness: Agents can change over time and thus show a new behavior or re-organize the structure of relations between themselves and other agents, too.

Authority: The authority of an agent identifies the person or the organization for which an agent is activated. The authority has to be verifiable. Agents keep their authority during the whole life cycle.

Security: Concerning agents authorizing, communication, coordination, mobility and consumption of resources, etc., an agent application has to meet high security demands. Agents, agent connectors and agent systems are responsible for the warranty of security properties.

Goal: An agent executes undertaken tasks goal-orientedly within the scope of a schedule to achieve the goals.

3.6 Classifying Properties

Classifying properties are used to categorize agents. Not all combinations of classifying properties are possible.

Locality Affiliation and Mobility: The locality of an agent is the location where of an agent within the network. A mobile agent can change its place in the system during its work. Mobile scripts can be collected in one place, moved to another and executed. Mobile objects are moved from one place to another during run time and task execution.

Role, Service Capacity: Describes the kind of result an agent can produce. It represents its functionality for task execution. It is subdivided into action type and task type.

Communication Behavior: Each agent belonging to an instance of an agent system can communicate within its name space according to its behavior at any given moment. The behavior of an agent determines whether it carries out tasks delegated to it in cooperation with other agents or whether it is capable of doing this on its own.

Cooperation: Agents need to possess a social ability to interact with other agents and possibly humans via some form of communication language.

Negotiation Ability: Negotiation ability describes the properties of an agent to execute a task collaborating with other agents. Collaboration is achieved through negotiation. When the agent accepts a task, it is put in its working basket. The agent disposes to arrange division of work with other agents.

Delegation Ability: Taking authority into consideration, agents can place and take on tasks. Delegation means that partial tasks can be passed on to agents.

Correlation: The activities of agents can take place synchronously, asynchronously or through a rendezvous (two agents meet at a place and solve a problem together).

Learning Adaptability: The intelligence of an agent is the level of its evaluating and learning behavior. An agent learns by executing tasks and uses the acquired knowledge during task execution.

Resource Limitation: An agent can only act as it has resources at its disposal. These resources are changed by its acts, such as delegation. The resources of an agent are the technical resources it needs for its work, and informational resources it can use.

Re-Usability: Process or subsequent instances can requires to keep instances of the class 'agent' for an information hand-over or to check and to analyze them according to their results. The reusability of agents can take place in various agent systems of a different Authority.

Note that properties of communication will be dealt in detail in the following Chapter.

3.7 Classification of agents

Agents may be classified based on the mobility factor, i.e., *static* or *mobile*. Another way of classification is *deliberative* or *reactive*. Deliberative agents process an internal symbolic reasoning model and they engage in planning and negotiation in order to achieve coordination with other agents. Reactive agents do not have any internal symbolic models of their environment, and they act using a stimulus or response-type of behavior by responding to the present state of environment in which they are embedded [42].

At BT labs, agents are classified based on three properties, which were discussed in the previous section: Autonomy, Learning and Cooperation. By using these three characteristic properties four types of agents are derived: Collaborative agents, Collaborative-learning agents, Interface agents and truly smart agents.
The following figure is taken from [42].

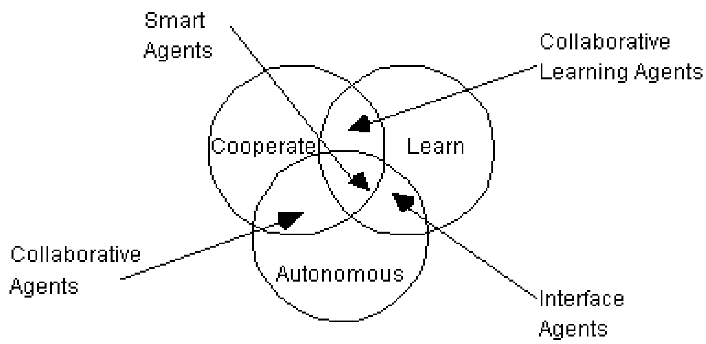

Figure 2: A part view of an agent Typology.

We can have static deliberative collaborative agents, mobile reactive agents, static deliberative interface agents, and mobile reactive interface agents by combining the two constructs, i.e. static/mobile and reactive/deliberative in conjunction with the agent typology shown in figure 2.

Agents can also be classified based on their roles. Different roles of agents include information agents, Internet agents, report agents, presentation agents, analysis agents, testing agents and help agents. Another category of agent is hybrid agents, which combines of two or more agent philosophies in a single agent. Based on different categories of agents discussed above, we can identify seven types agents altogether [42].

1. Collaborative agents
2. Interface agents
3. Mobile agents
4. Information/Internet agents
5. Reactive agents
6. Hybrid agents
7. Heterogeneous agent systems.

3.7.1. Collaborative agents:

Collaborative agents emphasize autonomy and cooperation in order to perform tasks of their owners. In order to collaborate they may have to negotiate and reach mutually acceptable agreements in some matters. The general characteristics of these agents include autonomy, social ability, responsiveness and pro-activeness. They are able to act rationally and autonomously in open and time constrained multi-agent environment. We can improve these collaborative agents' robustness, effectiveness, scalability and maintainability by implementing automated negotiation among these agents. We will discuss the automated negotiation among these agents in detail at Chapter 5.

3.7.2. Interface agents:

Interface agents emphasize autonomy and learning in order to perform tasks for their users. These agents are collaborating with the user in the same work environment. Collaborating with user may not require an explicit agent communication language as collaborating with other agents. Thus, the user agents act as an autonomous personal assistant, which cooperates with the user in accomplishing some task in the application. Their cooperation with other agents is only limited to asking for advice, not in getting into protracted negotiation deals as is the case of collaborative agents.

3.7.3. Mobile agents:

Mobile agents are computational software processes capable of roaming wide area networks (WANs) such as the WWW, interacting with foreign hosts, gathering information on behalf of its owner and coming back to the user having performed the duties. These duties may range from flight reservation to managing a telecommunication network. Mobile agents are autonomous and they cooperate, which are the most important characteristics of all agents. We will discuss mobile agents deeply in the coming section.

3.7.4. Information / Internet agents:

Information agents help the user manage, manipulate and collate information from many different distributed sources. The difference between information agents and other agents we discussed so far is that these information agents are defined by what "they do", in contrast to collaborative or interface agents which we defined by what "they are" [40].

These agents may be static or mobile. They may be non-cooperative or social and they may learn or may not learn. Hence, there is no standard mode to their operation.

Internet agents could be mobile, i.e. they may be able to traverse the WWW, gather information and report what they retrieve to a home location. The information agent may be associated with some particular indexer(s), e.g. a Spider. A Spider is an indexer with an ability to search the WWW, depth-first, and store the topology of the WWW in a database management system (DBMS) and the full index of URLs in the WAIS. Other search/indexing engines or spiders such as Lycos or Webcrawler can be used similarly to build up the index.

The user information agent, which has been requested to collate information on some subject, issues various requests to one or several URL search engines to meet the request. Some of this search may even be done locally if it has local cache. The information is collated and sent back to the user.

3.7.5. Reactive agents:

These agents do not possess internal, symbolic models of their environments. Instead, they respond in a stimulus-response manner to the present state of the environment in which they are embedded. These agents are relatively simple and they interact when the ensemble of agents is viewed globally.

There is no prior specification of the behavior of the set up of these reactive agents. A reactive agent is viewed as a collection of modules, which operate autonomously and are responsible for specific tasks. Communication between modules is minimized and is of low-level nature. The key benefit of these agents is that it is more robust and fault tolerant than other agent based systems. Very few applications based on reactive software agents currently exist. A favorite application area for these agents seems to be the games or the entertainment industry.

3.7.6. Hybrid agents:

Hybrid agents constitute a combination of two or more agent philosophies within a single agent. These philosophies include a mobile agent philosophy, an interface agent philosophy, collaborative agent philosophy, etc. The benefits of these agents would be to set the union of benefits of the individual philosophies in the hybrid that make these systems robust, response faster and adaptable.

There are very few hybrid architectures. InteRRaP architecture developed by Muller et al. at the German Research Center (DFKI) for AI is one of the few examples of hybrid agent systems architecture. This architecture can be used to construct an agent such as an autonomous robot. There are three control layers in this architecture: the behavior-based layer (BBL), the local planning layer (LPL) and the cooperative planning layer (CPL). This architecture constitutes both deliberative and reactive philosophies. Reactive part of the framework allows robustness and efficiency and reactivity is implemented by the BBL. LPL implements local goal-directed behavior while the topmost CPL enables the agent to plan and cooperate with other agents in order to achieve multi-agent plans, as well as to resolve conflicts. LPL and CPL allow for more deliberation.

Hayes-Roath's integrated architecture for intelligent agents [36] consists of two layers (i) the physical layer which performs perception-action coordination, i.e. it sense, interprets, filters and reacts to the dynamic environment in which the agent is embedded; and (ii) the cognitive which layer receives perceptual input from the physical controller to construct an evolving model, and to perform interpretation, reasoning and planning.

3.7.7. Heterogeneous Agent Systems:

These agents are an integrated setup of at least two or more agents belonging to two or more different agent classes. A heterogeneous agent system may also contain one or more hybrid agents. Genesereth & Ketpchpel [79] articulate the motivation for heterogeneous agent systems. The essential argument is that, though the software programs work in isolation, there is increasing demands to have them interoperate, with the motivation that they provide more added value than they do individually.

As discussed above, agents interact with its environment, sometimes even out of its environment (in case of mobile agents) for enhancing collaboration among them. Combing several of such agents pursuing the same goal leads to the multi-agent systems (MAS) [117]. Multi-agent systems allow for scalability, permit software reuse, handle software evolution, and promote open systems [11]. As agent technology moves to the market place, there is an increasing interest in techniques for modeling multi-agent systems and methodologies. The rest of this Chapter will discuss the roles and applications of these multi-agent systems in detail.

3.8 Issues involved in multi-agent systems

Agents in multi-agent systems must coordinate and cooperate to solve the problems. Some of the important issues involved in implementing coordination behavior in any multi-agent system include [24],

1. ***Communication:*** Enabling agents to communicate and using different types of protocols to facilitate agent communication.
2. ***Interaction:*** The type of language that should be used to interact with each other and combine their efforts.
3. ***Coherence and Coordination:*** Ensuring that the agents coordinate with each other to bring about coherent solution to the problem they are trying to solve.

A number of multi-agent systems have been developed in the past few years, addressing the issues discussed above. As discussed in the previous Chapters, these autonomously working agents communicate with each other and fulfill or hand over well-defined tasks. In order to be efficient and to be fault-tolerant, these agents must be *mobile*. That is, an agent may leave the computer where it started and resume its work on another. There may be some problems in multi-agent systems because of their mobility and autonomous properties. These problems include,

1. ***Resources:*** Usually network providers or administrators will not accept outside software (agents) to work in a distributed system without having control over them. Therefore, resource allocation of agents must be governed in order to avoid congestion or system break down.
2. ***Security:*** It is not acceptable that mobile agents can access data without restriction. Every moment of agents' lifetime, its location and action must be kept under surveillance. This can help detect any misbehavior and security violations an agent may perform.
3. ***Transparency:*** Inspection of proper execution or investigation of erroneous behavior of agent system requires monitoring and keeping track of management facilities. Otherwise managing the problems, as well as debugging of multi-agent systems will results in cumbersome exploration of the distributed system.

Apart from the issues mentioned above, the mechanisms for controlling memory and CPU usage of agents is also very important, since the server on multi-agent system might host thousands of agents that process jobs in a disorderly manner [33]. 'TabiCan' [33] is one of the systems where the agents are given a state based on the type of job and processing they are in. When the number of agents in the system exceeds a certain limit, the Agent scheduler will place the agents in the secondary memory, based on their state priority. These agents will be brought back to the memory when the system load is reduced.

3.9 Mobile Agents

As we have presented in this Chapter so far, there is a close relationship between multi-agent systems and mobile agents. Mobile agents are programs that can migrate from host to host in a network, at times to places of their own choice. The state of the running program is saved, transported to the new host, and restored, allowing the program to continue where it was left off [22]. Mobile agents are an effective choice for many applications, since they improve latency and bandwidth of client-server applications and reducing vulnerability to network disconnection. They support transactions in massively distributed environments, support systems which involve electronic cash and banking systems [55], support activities in dynamically changing environments, support mobile devices and coordination of different types of applications and resources [35]. These agents are distributed automatically or semi-automatically via some communication paths. Mobile agents should have the following properties [126]:

1. It can achieve a goal automatically.
2. It should be able to clone itself and propagate.
3. It should be able to communicate with other agents.
4. It has evolution states, including a termination state.

Mobile agents provide a single, general framework in which distributed, information-oriented applications can be implemented efficiently and easily, with the programming burden spread evenly across information, middleware and client providers [22]. These mobile agents can also be migrated over incompatible platforms and exchange messages with the agents on other platforms and lets us build platform independent agents using the techniques discussed in [102].

Java is known to be an effective implementation language for mobile agents. Most of the present Mobile agent frameworks like Ajanta [14], Concordia, Odyssey, JAFMAS [8], Voyager, MAgNET [104], Gypsy [77] and IBM's Aglets [18] are all implemented in Java. Multi platform support and the promise of write-once and run-anywhere operation make Java extremely suited for mobile agent technology [23]. Java's object serializations accomplish the conversion of an agent and its state into a form suitable for network transmission and allow the remote system to reconstruct the agent. Some Java-based mobile agents systems also provide persistent agent state information. Java also facilitates the migration of code and state via its class-loading mechanism. Java based mobile agent systems are the best choice for e-commerce applications [23].

The advantages of these mobile agents include reduction of network traffic, asynchronous interaction and remote searching and filtering. Agent based queries and distributed transactions can be more robust [35] and the process state of agent based transactions need not be stored [17]. As discussed earlier, they play a major role in e-commerce and their role in e-commerce will be discussed in detail in a later Chapter. In view of all these advantages of mobile agents, this paradigm continues to gain attention of the researchers and the industry and it shows signs of offering important qualitative advantages for network services.

The new domain of Agent-based software engineering has been invented in order to facilitate the interoperation of miscellaneous software agents. A key requirement for interoperation amongst heterogeneous agents is having an agent communication language (ACL) via which the different software agents can communicate with each other. We will discuss ACL in detail in the following Chapter.

Chapter 4

Agent Communication Language

In the preceding Chapters we mentioned that agents interoperate and cooperate to execute large tasks in a distributed manner. The individual agents that encapsulate the state and the behavior functions semi-autonomously; they execute on a computer network offering their services to other agents. As we also discussed earlier, interoperability is the main concern among different agent communities and perhaps it is the biggest single obstacle that stands in the way of wider industrial acceptance of agents' technology [80]. What is needed, therefore is to make it possible for agents built by different organizations with different hardware and software platforms to communicate, cooperate, and negotiate using commonly agreed upon communication languages and protocols.

Agent communication language (ACL) has been suggested by the agent community as a tool with the capacity to integrate disparate information sources [135], since agents have to communicate among themselves to coordinate the execution of these complex tasks [71]. An agent communication language allows agents to interact with each other, while hiding the details of their internal states and behaviors. In agent communities this will result in tackling problems that cannot be tackled by individual agents [136]. According to Tim Finn et al. "software agents are applications for which the ability to communicate with other applications and share knowledge is of primary importance [67]. Michael R. Genesereth defined "Agency as the ability of a system to exchange knowledge using an ACL" [79].

Communication language standards facilitate the creation of interoperable software by decoupling implementation from interface. Software agents require three fundamental and distinct components to interact and interoperate effectively: (i) a common language; (ii) a common understanding of the knowledge (ontology); and (iii) the ability to exchange knowledge in the common language [67]. Middleware, like Remote procedure call and Remote method invocation (RPC and RMI) to CORBA would also help in exchanging information and knowledge. ACLs stand a level above CORBA for two reasons [136]:

1. ACLs handle propositions, rules, and actions instead of simple objects with no associated semantics.
2. An ACL message describes a desired state in a declarative language, rather than a procedure or method.

At the technical level, when using an ACL, agents transport messages over the network using a lower-level protocol like SMTP, TCP/IP, IIOP or HTTP. These agents not only just engage in single-message exchanges, they also involve in conversations, task-oriented, shared sequence of messages that they follow, such as a negotiation or an auction.

Once we have a standard communication language and the ability to build the agents, we can think of enhancing the collaboration between agents. Multi-agent systems can substitute large monolithic systems, which cannot automatically or even directly cooperate. These multi-agents as described in the last Chapter, becomes very handy in e-commerce applications like buying-selling process, automated negotiation, Auction-bed, etc. [53]. In this Chapter, we will thoroughly discuss ACL and the requirements for communication languages.

4.1 Origin of ACL

[The following two paragraphs are summary from [136]]

In 1990, the DARPA (Defense Advanced Research Projects Agency) initiated KSE (Knowledge Sharing Effort) to develop techniques, methodologies, and software tools for knowledge sharing and reuse at design, implementation, or execution time. The central concept of KSE was that Knowledge sharing requires communication. Therefore KSE focused on defining the common language for that communication.

According to KSE, the first layer of the common language problem is that of syntactic translation between languages in the same family or between different families of languages. The second layer is concerned with guaranteeing that tokens' semantic content is preserved among applications. In other words, object or entity must have a uniform meaning across applications even if different applications use different names to refer to it. The third layer addresses the communication between agents. Agents should be able to communicate complex intentions and attitudes about their information and content. Agents need to question other agents, inform them, request their services for a task, find other agents who can assist them, monitor values of objects and so on.

A proposal within the KSE was to use Knowledge Interchange Format (KIF), which is a Logical language, as a standard of describing things within computer systems such as expert systems, databases, intelligent systems etc. KIF is a prefix version of first-order predicate calculus with extensions to support meta-operations and definitions. KSE researchers designed KIF specifically to make it useful as an *Interlingua*, i.e., a language that is useful as a mediator in the translation of other languages. With the use of translators one could translate from language A to KIF and from KIF to language B instead of translating from A to B [113].

4.2 Requirements for Communication Languages

The requirements for agent communication languages include the following [113]: (Note that the authors of this paper are the pioneers in agent communication languages and they are very renowned in the field of agent oriented computing.)

4.2.1 Form

A good agent communication language should be declarative, syntactically simple, and readable by people. It should be concise, yet easy to parse and generate. To transmit a statement of a language from one agent to another, the statement must pass through the bit stream of the language and the underlying transport mechanism. Thus, the language should be linear or should be easily translatable into a linear form. Its syntax should be extensible, since the language will be integrated into a wide variety of systems.

4.2.2 Content

A communication language should be layered in a way that fits with other systems. A distinction should be made between the communication language, which expresses communicative acts, and the content language, which expresses facts about the domain. A commitment to a content language allows for a more restricted set of communicative acts since it is possible to carry more information at the content language level. The disadvantage here is all applications must then use the same content language.

4.2.3 Semantics

A well-defined semantic description is necessary if the communication language is intended for interaction within a diverse range of applications. The semantics of a communication language should exhibit those properties expected of the semantics of other languages. Since a communication language is intended for interaction that extends over time amongst spatially dispersed applications, location and time should be carefully addressed by the semantics.

4.2.4 Implementation

The implementation should be efficient, both in speed, and in bandwidth utilization. It should provide a good fit with the existing software technology and the interface should be easy to use. The details of the network layers that lie below the communicative acts should be hidden from the user.

4.2.5 Networking

Agent communication language should fit well with modern networking technology. The language should support all of the basic connections: point-to-point, multicast and broadcast. The language should contain rich enough set of primitives so that it can serve as a substrate upon which higher-level languages and interaction protocols can be built.

4.2.6 Environment

Since agents communicate in a very heterogeneous and extremely dynamic environment, the language must provide tools for coping with heterogeneity and dynamism. It should support interoperability with other languages and protocols. Agents must also be attachable to legacy systems.

4.2.7 Reliability

The language must support reliable and secure communication among agents. There should be provisions for secure and private exchanges between two agents and authentication of agents must be guaranteed. The language should support reasonable mechanism for identifying and signaling errors and warnings.

Existing ACLs include KQML (Knowledge Query and Manipulation language), its many dialects and variants, ACL by FIPA (Foundation for Intelligent Physical Agents), COOL (Coordination Language) [85] and telescript by General Magic. FIPA has proposed the ACL as a substitute to KQML. Since KQML is known as the Agent communication language for the past few years, we will discuss about KQML in detail in the following sections.

4.3 Knowledge Query and Manipulation Language (KQML)

KQML is intended as a general-purpose communication language for the exchange of information and knowledge between software agents. Interaction between agents is more than just an exchange of messages. It involves issues of models of agents, interaction protocols and interaction languages. KQML is intended to be a universal interaction language that supports communication through explicit linguistic actions [137]. The following are the key features of KQML [67]:

1. KQML messages are opaque to the content they carry. KQML messages do not merely communicate sentences in some language, they rather communicate an attitude about the content (assertion, request, and query).
2. A KQML message is called *performative* [131]. As the term suggests, the concept is related to speech act theory [137]. Performatives define the permissible actions that agents may attempt in communicating with each other.
3. An environment of KQML speaking agents may be enriched with special agents, called facilitators, that provide such functions as: association of physical addresses with symbolic names; registration of databases and services offered and sought by agents; and communication services.

KQML is divided into three layers, the content layer, the message layer, and the communication layer. The content layer bears the actual content of the message. KQML can carry any representation language, including languages expressed as ASCII strings and those expressed using a binary notation [67]. The message layer is used to encode a message that could be transmitted between applications. The message layer determines the kinds of interactions one can have with a KQML speaking agent. The primary function of this layer is to identify the protocol to be used to deliver the message and to supply a speech act or performative which the sender attaches to the content. The third layer, the communication layer encodes a set of features to the message which describe the lower level communication parameters such as identity of the sender and recipient, and a unique identifier associated with the communication.

KQML language and implementations of the protocol have been used in several prototype and demonstration systems. The applications range from concurrent design and engineering of hardware and software systems, military transportation logistics planning and scheduling to flexible architectures for large scale heterogeneous information systems, agent-based software integration and cooperative information access planning and retrieval. One example of the application of KQML is the Agent-based Software Integration project at Stanford University, which is applying KQML as an integrating framework for general software systems.

KQML addresses many requirements of agent communication languages discussed above. So far, KQML proved to be useful in a wide range of intelligent software agent architectures. The KQML model also addresses privacy and authentication in agent communication [15]. Apart from KQML and the other ACLs, some Java-based agent frameworks such as Java RMI, also provide secure agent migration and secure agent communication [65]. Another approach in making these ACLs Internet friendly is to take the advantage of XML (Extended Markup Language) by incorporating it into ACLs, a project currently undertaken by IBM.

Though these ACLs seem to be promising in the Agent oriented software development domain, there are certain issues needed to be addressed by the ACL community. Providing facilities such as naming and registration services for the agents along with basic brokering facilities. Another issue of concern is building basic ontologies for agents and their query answering capabilities and requirements.

Now that we have taken a closer look into E-Commerce, Agents and ACL throughout the last 3 Chapters, it is time to take an abrupt turn towards Automated Negotiation. In the next Chapter we introduce several existing theories of negotiation, negotiation process and various strategies of negotiation that enables e-commerce.

Chapter 5

Automated Negotiation

Automated negotiation is becoming an integral and important part of e-commerce. Real world negotiations in general accrue transaction costs and time that may be too much for both merchants and consumers alike. A good automated negotiation can both save time and find better deals in the complex and uncertain business environment [130]. In the Introduction Chapter, we have seen a scenario where agents can visit the virtual markets places and negotiate on behalf of user. However, current e-commerce environment only supports non-interactive buying-selling types of auction and there are no models yet for automated negotiation in E-Commerce.

Research area that merges negotiation with software-agents is the broad field of Multi Agent System (MAS). MAS and Distributed Problem Solving (DPS) are part of Distributed Artificial Intelligence (DAI). Early DAI work modeled negotiations as DPS and assumed a high degree of joint *cooperation* among agents in order to achieve a common goal. In MAS, there is no global control, no globally consistent knowledge, and no globally shared goals. They are concerned with coordinating intelligent behaviour within a collection of autonomous (possibly heterogeneous) intelligent agents. MAS assume total self-interest and a high degree of *competition* among agents during negotiations for limited resources [107]. This behaviour of MAS best suites our needs in e-commerce environments and this is one of the reasons we looked at MAS elaborately in Chapter 3.

Agents have a high degree of self-determination, since they decide for themselves what, when and under what conditions their actions should be performed. In an e-commerce environment such agents need to interact with other autonomous agents to achieve their objectives. Since agents do not have direct control over one another, they must persuade other agents to act in particular ways to achieve their goals. This concept of persuasion is called *negotiation*; a process by which agents come to a mutually acceptable decision on some matter [Jennings].

When faced with the need to reach agreements on a variety of issues, humans make use of negotiation process. Similarly, automated negotiation can become a fundamental operation for shopping agents in e-commerce. This automation of negotiation can significantly reduce the time it takes to negotiate, making large volume of transactions possible in a small amount of time. This can also remove some of the discretion of humans to engage in negotiation, for example, embarrassments and personality manipulations. For these reasons, the formalisation of negotiation has received a great deal of attention from the multi agent systems community throughout the past two decades.

This Chapter takes very closer look at negotiation theory from different disciplines, components of negotiation, properties associated with negotiation, issues involved in negotiation, negotiation process in general, importantly the existing approaches in automated negotiation and challenges in automated negotiation in e-commerce.

5.1 Negotiation Theory

Negotiation is a form of decision-making where two or more parties jointly search a space of possible solutions with the goal of reaching a consensus for their own benefits. Economics in Game Theory describe such an interaction in terms of protocols and strategies [108]. There are two important theorems exists on negotiation. One is Game theory and the other is Epistemic Logics. It is necessary to take a quick look at these theorems before we go any further.

Game Theory

Game theory views an agent as an individual, a firm or some complex organization where the functionality of the agent is profit maximizing. Game theory models do not describe how the world is or must be, but they describe how the world could be. An out come of a game is usually decided by the information in the structure and the strategy used in the game. Various criteria of individual optimality in game theory include Dominance, Nash Equilibrium, Bayesian Nash Equilibrium, trembling hand equilibrium, and sequential equilibrium. Nash equilibrium is the best-known strategy for negotiation. This theory predicts a unique solution to each game chosen by the agent. The predicted strategy of each agent must be the best response to the predicted strategies of other agents and it should maximize the utility or profit [145].

Epistemic Logics

Distribution and transfer of information among autonomous agents are essential characteristics of many environments. Representing the information and reasoning the state of the information while taking into account of the dynamics of the information is the core idea behind analyzing environments. The formalism that support such representation and reasoning are called 'epistemic logic' or 'logic of knowledge. Epistemic logics are very useful in analyzing distributed systems. State of the distributed systems could be characterized using epistemic logics in terms of availability of information to each processor, information needed by the processor and common knowledge among the processors. Dynamics of distributed systems could be characterized in terms of transfer of information among the processors through communication. In building distributed environments for software agents, there is a need to focus on epistemic logics to represents the knowledge about the system.

Another definition for automated negotiation by Jennings et al. [91] is 'the process by which a group of agents communicate with one to try and come to a mutually acceptable agreement on some matter'. Negotiation underpins attempts to cooperate and coordinate and is required both when they are self-interested and are cooperative.
Although various disciplines have proposed different theorems on negotiation, it is clear that negotiation theory covers a wide range of phenomena encompassing different approaches such as Artificial Intelligence, Social Psychology, and Game theory. Negotiation research can be considered to deal with three broad topics [91].

1. **Negotiation Protocols:** These are the set of rules that govern the interaction. These rules cover permissible types of participants, the negotiation states, the events, what can cause negotiation states to change and the valid actions of the participants' in particular states.
2. **Negotiation Objects:** The range of issues over which agreement must be reached. At one extreme, the object may contain a single issue, while on the other hand it may cover hundreds of issues, which makes the negotiation process complex.

3. **Agents' Decision Making Models:** The decision-making apparatus the participants employ to act in line with the negotiation protocol in order to achieve their negotiation objectives. The sophistication of the model, as well as the range of decisions which have to be made, are influenced by the protocols in place, the nature of the negotiation object and the range of operations which can be performed on it.

Given a wide variety of possibilities, including game theory and epistemic logics given above, there are no universally accepted approach or technique for agent negotiation. The minimum capabilities required for an automated negotiation is: (1) to propose some part of the agreement space as being acceptable; and (2) to respond to such a proposal indicating whether it is acceptable. However, if agents can only accept and reject others proposals, then negotiation can be very time consuming and inefficient. This results in the proposer having no means of ascertaining whether the proposal is unacceptable or whether the agent is neither close to an agreement nor in which direction of the agreement space it should move next.

Negotiating strategies to reach an agreement often depend on the specific issues or parameters under consideration. For instance, whether merchandise has a common value or whether it differs from agent to agent may call for different negotiation strategies to reach an agreement. Negotiation mechanism consists of a negotiation protocol coupled with the negotiation strategies for the agents involved. There are some properties that are generally considered desirable for negotiation mechanism [T. Sandholm, 99] [141] [J.S. Rosenschein, 94][141]:

- **Computational efficiency:** Concerned with the need a negotiation mechanism that is computationally efficient. In other words, computational costs carried out at run-time must be manageable.
- **Communication efficiency:** Concerned with having a mechanism that handles communication among the agents in an efficient way.
- **Individual rationality:** Mechanism that satisfies individual rationality for all the agents involved in negotiation. In other words, agent's independent interest to participate in negotiation.

- **Distribution of computation:** Mechanisms that distribute the computation over the agents are preferable to the ones in which one server is performing all the computation for the whole system. This is due to the desire to avoid the disruptive effects of a single point of failure and performance bottlenecks.
- **Pareto efficiency:** An outcome is Pareto efficient if there is no other outcome that improves the lot of one agent without making another agent worse off. All other things are being equal; Pareto efficient solutions are preferred over those that are not.

5.2 Parameters of Negotiation

We have seen in the last section that negotiation deals with negotiation protocols, negotiation objects and negotiation decision models. Negotiation objects or number of issues involved in a negotiation can play a crucial role in determining negotiation strategy. There has been a tremendous amount of effort put in identifying the parameters on which *any* type of negotiation can take place [141].

5.2.1 Cardinality of the Negotiation

There are two important issues in cardinality of negotiation parameter, namely negotiation domain and the interaction type.

- Negotiation domain: single-issue or multiple-issue; and
- Interactions: one-to-one, many-to-one, many-to-many.

Domain of negotiation can be visualized as set of tuples over which the agents negotiate to reach agreement. Each elements of this tuples may represent an issue such as price, quality, warranties, delivery time, and so on. When we have only one issue in a negotiation, for example price, the tuples are singletons. In multiple issue negotiation, different issues might be related by some publicly agreed utility function [N. Vulkan, 00][141].

Interactions between agents can be classified based on a number of agents involved in the negotiation. One-to-one negotiation in which one agent negotiates with exactly one other agent becomes important due to the business-to-business e-commerce scenarios. Many-to-one negotiation where many agents negotiate with one agent is exactly same as auction setting. In this case, one agent plays the role of the seller and the rest play the buyer's role. Many-to-many negotiation where many agents negotiate with many other agents creates the most complex scenario of all interactions [D.R. Rriedman, 93][141].

5.2.2 Agent Characteristics

In a sense we can agree that agents are nothing but computational entities that participate in negotiation processes that must be capable of rating its preferences to evaluate and choose between number of deals. Further characterizations of agents are:

- **Role:** Agent's types are the role that they play in the negotiation (buyers, sellers, or both). Usually buyers and sellers are the important roles but in case of auction negotiation, intermediaries can have an important role as well.
- **Rationality:** Rationality can be perfect or bounded. Game theory (discussed later in this Chapter) assumes perfect rationality meaning that large computations can be performed at a constant time. However, in practice, agents are forced to bid or withdraw because they do not have the computational power. Thus, negotiation models that assume perfect rationality have to use approximations in practice, whereas models that explicitly assume bounded rationality are more realistic in this sense [M.J. Osborne, 94][141].
- **Knowledge:** Private information such as internal deadline and utility functions are important parameters for agents. Whether an agent holds private information or not will directly affect the agent's bidding strategy.
- **Commitment:** When an offer is made, agents may wait until an acceptance or counter-offer is received. Alternatively, the agent can bid to other agents without waiting. Thus, there can be various levels of commitment placed in the protocol [T. Sandholm, 99][141] [P. Friedman, 93][141].
- **Social Behavior:** Agents can be self-interested entities, as altruistic units of a society or can be somewhere in between. They can play distinct entities or pursue team-formation to get better deals. Forming coalition also works for better deals in some domains [N. Vulkan, 00][141].
- **Bidding Strategy:** The most important component that decides placing or accepting offers, making counter offers or withdrawing from negotiation.

Although bidding strategy is independent from all other parameters, it is somehow related to the commitment, the knowledge, the rationality and the social behavior of an agent [P. Faratin, 98][141].

5.2.3 Environment and Goods Characteristics

The negotiation environment can be either static or dynamic. Dynamicity of the environment can affect the utility function of the agents in a delicate way. Utility function reflects the preference of an agent. While in a static environment an agent does not learn during the process and maintains a fixed utility function, this behavior would be less likely to produce a positive payoff in a very dynamic environment.

The characteristics such as private or public value of the goods also crucially define the negotiation protocol. The values of goods depend on whether it will be used for private (e.g., a cake) or public (e.g., bonds). For example, when buying a car, both the buyer's preferences and how the car will preserve its value over time should be considered if one is interested in selling the car.

5.2.4 Event Parameters

The negotiation protocol is mainly influenced by the ways in which the events take place during the negotiation.

- **Bid validity:** It specifies an important part of the protocol and it is concerned with the validity of the bids. Bids are to be valid for their time of the bid offer as well as some constraint satisfaction. For example, an English auction bids can be made when the auctioneer is calling for bids and must be progressively higher in value. Similarly, procedures for placing bids might be present during a negotiation.
- **Bid visibility:** Visibility of the bid is relevant only in the case of many-to-many or many-to-one negotiations. Bids can be either private messages passed between buyer and seller or a broadcast to all agents. Alternatively we can have subset of agents sharing visibility (useful in coalition formation).
- **Clearing schedule and timeouts:** is an event producing a temporary allocation between buyer and seller. Clears can be scheduled at random or following other events. For example, during the bidding phase of an English auction each round

terminates with a temporary allocation of the good being auctioned to the prospective buyer that meets the auctioneer's call. Timeouts determine the closing of the negotiation; therefore, they transform clears into "final clears", i.e., a final agreement between buyer and seller about the transaction.

- **Quotes Schedule:** Often third-party quotes are generated through the Recommender systems and they need to be regulated. Otherwise, too many requests for quotes can significantly slow down the negotiation mechanism.

5.2.5 Information Parameters

Information or messages other than bids can be passed between agents before and during negotiation to help buyers and sellers reach an agreement. Such messages can be beneficial in order to save computational time of the agents. Among many useful messages, we will look at two important such messages.

Price quotes: Quotes generated by potential buyers requesting an analytical price from a seller before starting a negotiation can be useful to all parties as they reduce negotiation time.

Transaction history: History of transactions given or requested by buyers and sellers can increase the credibility involved in negotiation. Together with the trusted third party quotes, transaction histories can form the basis for argumentation-based negotiation. Expert human negotiators often focus on the reasons why an offer is not acceptable and try to persuade their counterparts to the characteristics an agreement will have to include in reaching the deal. Artificial negotiators propose offers to counterpart but they do not try and motivate them to reach an agreement. This is often seen as a severe limitation that can limit the flexibility of the negotiation. Later in this Chapter, we will see a proposal by Jennings on argumentation-based negotiation where he tries to solve the problem mentioned above.

5.3 Negotiation Process

Additional feedback on a proposal that indicates more than whether an agent agrees with the proposal or not can improve the efficiency of the negotiation process. This feedback can take the form of a critique or a counter proposal. From such a feedback, the proposer should be able to bring the recipient more close to the agreement space. Achievement of reaching the agreement quickly in tern depends on the intelligence (reasoning) of the agents involved. These agents will have to follow different strategies and negotiation algorithms and a family of negotiation tactics. When we equip these agents with these negotiation techniques and tactics, they can negotiate at any place such as classified negotiation, stock market negotiation and retail auction negotiation [108]. There have been impressive results from MITs Kasbah Agent market place, where some of the negotiation strategies have been modeled and implemented [110].

There have been different approaches proposed for integrating intelligence factors like negotiation strategies, tradeoff mechanisms [96] [97], different negotiating functions [2] and tactics in these agents. *Genetic algorithms* are one of the approaches suggested for negotiating aspects where these agents learn over time by crossovers and mutations there by improving their negotiating capabilities [31] [97]. *Reinforcement learning* is another approach based on rewarding actions that turn out to be positive and punishing those that are negative [30]. *Rule based learning* is another approach for negotiating agents in a virtual market place [64] which is based on particular rules in the system that is proved to be effective. Case-Based Reasoning (CBR) is yet another approach for negotiation where we capture and reuse successful negotiating experiences. We will take a look into all the important existing and proposed strategies in the next section.

5. 4 Existing Automated Negotiation Approaches

This section briefly introduces some important existing models of automated negotiation in e-commerce. Shortly, we will look into negotiation mechanisms of Kasbah, similarity criteria to make negotiation trade-offs, experienced based negotiation approach, using influence diagrams and decision theoretic tools to predict opponent actions during negotiation.

5.4.1 KASBAH

Kasbah is an electronic agent marketplace, born in MIT Media Laboratory. Agents in Kasbah negotiate to buy and sell goods and services on user’s behalf. Negotiation strategies in this model are predetermined and the user is allowed to select a strategy in the beginning of the negotiation. For example, a selling user defines the goal of the selling agent by specifying desired price, lowest acceptable price and desired date to sell. There are three predetermined strategies namely: anxious, cool-headed and greedy which are linear, quadratic and cubic decay functions respectively as shown in the following figure [110]:

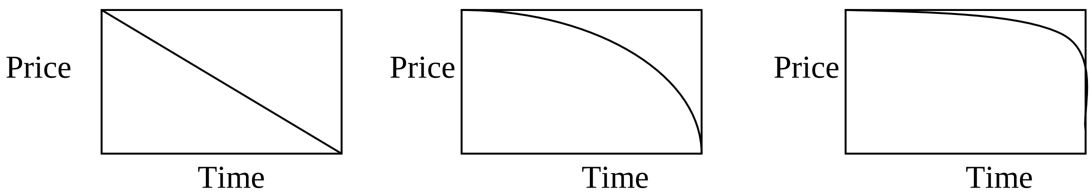

Figure 5.1: Price change in time for selling agents in Kasbah
(Left to right: anxious, cool-headed and greedy)

During the process of negotiation if the other party accepts the desired price, the process is terminated. Otherwise the selling agent lowers the price till it reaches the lowest acceptable, as per one of the above strategies. Intuitively, it works opposite way in case of a buyer.

Kasbah is one of the first systems came up to imitate real world negotiations using time, money and various negotiation strategies. Although it was a novel start that would revolutionize business in the near future, it had its own drawbacks. Agents in Kasbah are simple and there is no learning in the system. Furthermore, their decision strategies are limited and decision selection is not autonomous. Moreover, only *price* drives negotiation in Kasbah. As we have seen in the previous sections, negotiation can be done over multiple parameters, where agents can make concession over one or more issues. In summary, Kasbah does not support negotiation on multiple attributes and there is no learning in this system.

5.4.2 Experienced based learning

Learning from experience approach is based on R. Schank's *Theory of Dynamic memory*. This theory assumes that understanding takes place by the integration of new things encountered with what is already known (experience). Understanding causes us to remember old experiences, consciously or unconsciously, as we process the new ones. Also the theorem states that remembering, understanding, experiencing and learning cannot be separated from each other. Cognitively, good negotiation skills of humans seem to come from experience. Few researchers in AI use Case Based Reasoning as a learning approach in buying and selling agents [130].

Negotiating with experience (Wong 2000) uses Case-Based Reasoning (CBR) as an approach to use past experiences and strategies in developing negotiation strategies for current situation. This experience based negotiation framework provides adaptive negotiation strategies that can be generated dynamically and are context-sensitive. Architecture of this system consists of three main parts. First one is a *Case-Based Negotiator* that assists the user while negotiating with opponent agents. It matches current negotiation scenario with previous successful negotiation cases and provides appropriate counter-offers for the user based on the best-matched negotiation case. Second one is a *Case Browser* that allows user to browse a previous negotiation case repository using various queries and the third one is a *Case Maintenance component* that allows negotiation experts to moderate, maintain and to update case repository.

The agents in this model are rational. The negotiation process here is strictly monotonic. Initially the case base is populated with number of cases with relevance to the product domain of the application. Once the agent is created, it refers to the relevant previous cases from the case base and then it selects the most matched case. A concession match filter is used to match the cases. The agent then uses that previous experience in generating the solution for the current problem. If there is no match found in the case base that is similar to present case then a predefined strategy is used.

This is a very interesting approach that tries to imitate normal human negotiation process. However, this work is limited to only one particular domain and negotiation is based on single attribute, price. Moreover, the attitudes of the buyers and sellers are not taken into consideration. Attitude of a user may include many factors. Some obvious factors in an attitude could be importance of time (urgency), importance of price (price consciousness), and commitment of the user for the given transaction. Attitude of the user plays a major role in transactions along with experiences. This work is mostly concentrated on matching of cases, with less focus on and no consideration of actual proposal generation and learning from failure.

5.4.3 Similarity criteria in negotiation trade offs

Service oriented negotiation is the main focus of this model where a producer and a consumer should come to a mutually acceptable agreement over terms and conditions under which the producer will execute some problem solving activity (services) for the consumer. The terms and conditions may include issues such as price for the services, time constraint of the service, quality of the service, and penalty to be paid for reneging the agreement [29].

Agents may make trade-offs in these negotiations by accepting a service of lower quality if the price is cheaper or accepting a shorter deadline if it receives a higher price. In making a negotiation trade-off, agent tries to find a contract that has the same value to itself as the previous proposal, but more acceptable to its opponent. As the agent do not know the opponent's utility functions, it approximately estimates them using similarity functions. Fuzzy similarity concepts are used to compute similarity between the contracts.

The trade algorithm in this work performs an iterated hill-climbing search of possible contacts. This search results in generating contracts that lie closer to the iso-cure. This algorithm randomly generates the contracts by splitting the gain in utility, among the set of issues under negotiation. The agent then selects the contract that maximizes the similarity of opponent's last offering. This algorithm terminates when the last selected contract lies on the iso-curve. Thus the agents in this system generate the contracts so that there are joint gains for both parties in the process of negotiation.

This is a very interesting approach that considers trade-offs in negotiation. The similarity functions in this work addresses the issue of matching parameters under uncertainty. The trade-off algorithm generates reasonable trade-offs in contracts even when there is limited information about the opponents in negotiation. Nonetheless, there is a need to consider more parameters such as attitude in this approach for automated negotiations.

5.4.4 Multi-Agent based Learning Economy (MAGALE)

Market place for learning resources such as advice and tutoring are the main focus of this model (C. Mudgal, J. Vassileva, 2000). Price for resources can to be determined dynamically depending on urgency of the help needed and the availability of the helpers in the market. In this model, a user who possesses knowledge or resource becomes seller and the user who seeks the help or advice becomes buyer. The agents in this system decide how to increase or decrease the price for resources depending on user's preferences.

The agents in MAGALE represent the users. They maintain information about user's goals, preferences and knowledge. When user needs help, the agent gets the information about the opponent users via a matchmaker in respect to the user needs. Agents make decisions on behalf of their users to find a better deal. They involve in offer and counter-offer iteratively based on users preferences. These preferences may include importance of money, urgency and risk associated with the agent (user). When the agent is active, state of the agent can be: Accept, Reject, or Counter propose.

Although attitudes or user preferences are considered extensively, it is still an open question how the probabilistic diagrams used in this model can capture the opponent's reaction in an uncertain and dynamic environment.

5.4.5 Negotiation Model for Multiple Transaction Factors and Learning in E-Commerce

Agents in this model negotiate for diverse attributes simultaneously with the use of Black Board approach. The system uses ontology to represent knowledge; strategies in this system are environment adaptive (J. Kang 1998). The aspiration of this model is to let the Customer Agents (CAs) and Supplier Agents (SAs) to negotiate and obtain a more profitable deal on behalf of the user's goal. A buyer in this system searches for the right counter parts (SAs) and exchanges offers and counter offers. During the negotiation CAs notify the Black Board about the proceeding state of negotiation processes. Using the information on the Black Board, agents can compare and analyze all the SAs' negotiation strategies. Agents in this system learn from the information on the Black board and come up with new strategies from time to time. This helps agents to select it's own strategy safely and conveniently. This system adopts rule-based learning as learning strategy where the negotiation strategies are created by observing the environment and the opponent strategies. Creation of replicas (agent cloning) makes the system faster in this model. However, in real time e-commerce negotiations where the negotiation attributes are very dynamic and when agents tend to hide their information, the agents in this model would fail to learn from opponent's strategies.

5.4.6 Agent Negotiation in a virtual marketplace

Automated negotiation in a dynamic environment is the main concern in this model. It presents a virtual market place with experienced based buying and selling negotiation agents. Importance is stressed on the mental attitude of the user and in tern it reflects on the automatically negotiating buying and selling agents. This mental attitude is comprised of importance of price, importance of time and commitment of the user. Just as in real world negotiation how a buyer or a seller would hide his/her mental attitude to get the best deal, these agents in this market place also hides its information from opponent agents [148].

For each existing product in the virtual marketplace a public price range is given. This is used with the agent's attitude to calculate the acceptable maximum and minimum price range for a product. Having calculated the price range, agent can enter into the market place to find the seller and negotiate for the user. Notably, attitude will be the important factor in determining how a negotiation will proceed. Given an agent, it can be either in $Done^{+}$ or $Done^{-}$ or in $Done^{0}$ state representing, negotiation terminated successfully, agent failed to reach an agreement or negotiation is in progress respectively. Regardless of the out come, the results are saved as experiences in a case base for future use.

Although a mental attitude of the user is represented in a brilliant way into an agent to imitate real world negotiations, parameters that can be considered are numerous. Accordance with the parameters considered, the functions used to arrive at the minimum-maximum price range should be given a thorough study to bring this model into e-commerce environment. Moreover, letting agents to use a Black Board approach can increase the speed of the negotiation process by enabling number of agents to negotiate with number of opponent agents.

5.5 Challenges In E-Commerce Negotiation

In the last section, we took a closer look at the existing negotiating models and identified their weaknesses associated with them. As we criticized each models, it was clear that none of those models are fit to do the job of uncertain and dynamic real world negotiation. However, those are not the only challenges in automating real world negotiation.

As we have seen before, the general properties desirable for a negotiation mechanism are computational efficiency, communication efficiency, distribution of computation, and individual rationality. The former three issues pose major software engineering challenges but the last one seems to be more complex and it depended on cardinality of negotiation, agent characteristics, environments and goods characteristics, event parameters and information parameters. These parameters may vary from domain to domain. Therefore, in most cases negotiation strategies and tactics are completely domain dependant. In e-commerce set up, negotiation gets even more complex, as the parameters here are fuzzy, dynamic and vary diverse. The challenges for automated negotiation in e-commerce applications include the following [47]:

1. Very difficult to expect automated negotiation process that reflects real world.
2. There is no negotiation based on diverse attributes.
3. There is no multi-agent that considers and is adapted to all counterparts participating in negotiation process simultaneously.
4. There is no personalized negotiation.

Currently, there is only a handful number of researches working on negotiation problems and their research is mostly towards their problem domain. Notably, Dr. Jennings mentions the importance for generic framework of automated negotiation in [146]. Nonetheless, in short we can state that involvement of many parameters makes automated negotiation a really complex process and there is no universally accepted negotiation technique till now. Simply put, there is a need for research and development of better domain suited negotiation techniques.

Chapter 6

Conclusion and Future work

The emergence of e-commerce became popular with the development of Web technology. Yet, most of the businesses online are nothing but catalogs, representing a retail market. As e-businesses are populating the Internet in an increasing rate, consumers are faced with new challenges such as identifying the right product, identifying the best merchant available and negotiating with them to get a good deal on a product. Systems described in Chapter 2, namely BargainFinger, PersonaLogic, Firefly and Jango hoped to solve these problems but didn't live up the expectation as they have under estimated the dynamics of the e-commerce. Nevertheless, Tete-a-Tete system solved the first two challenges to a certain extent. Nowadays, researchers are actively working on the third issue, automated negotiation in e-commerce that would revolutionize the way we do business.

During the past few years, the idea of automated negotiation using agent technology has become very famous. Making use of the negotiating agents, researchers have been proposing many different agent models like Personal Assistant, Trip coordinator, e-mail filter, Flight Assistant and BT Agents (British Telecom Agents). It should be noted that the characteristics of these agents facilitated the proposals of these models. These agents suite themselves well in a dynamic environment and behave rationally as we discussed in Chapter 3. All of the models concerned with automated negotiation, including our scenario from Chapter 1, count on the rationality property of the agent to perform tasks for us. However, rationality alone will not solve the problem. Rationality of agents can be of no use without being able to communicate with each other. This led us to explore the agent communication language in Chapter 4. A standard communication language such as ACL has the potential to expand the automated negotiation to a higher domain, meaning integrating heterogeneous application systems.

In Chapter 5, we looked at solving the problems associated with agent negotiation in e-commerce. Specifically, we discussed the issues of creating standard protocols, parameters of negotiation and identified the need for dynamic negotiation strategies. It was clear that strategies have to change dynamically depending on the dynamicity of the parameters involved in the negotiation. Moreover, analysis of the existing approaches pointed out the areas where we must conduct more researches.

6.1 Future Work

Our plan is to extent and test metal state (attitude) of negotiating agents in virtual market place with more realistic set of relevant attributes. In automated negotiation between buying and selling agents, there are several issues to be considered:

- Rationality level to be provided to an agent
- Communication protocols to be used in implementation
- Dynamic strategies to be employed
- Making the model that beats the real world negotiation using Black Board approach
- Identifying more realistic parameters of metal attitude

In our future work, we are planning to implement a system of buying and selling agents, possibly using CORBA as the communication bridge. There is a need for building an ontology that can provide public information of a product in the e-commerce environment. This ontology will be done in a modest level for testing purposes. As agents should learn and come up with dynamic negotiation strategies, we will use case based reasoning to store and retrieve information of previous negotiation processes. We are planning to implement a system of intelligent buying and selling agents that can negotiate automatically on the user’s behalf.

Bibliography and Annotations

Please note [**] refers to milestone papers and [*] refers important papers.

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   Key words: Agents, SIM_AGENT, Tool Kit, multi-processing, reactive layer, Perceptron, deliberative process, neurons, self monitoring, long term memory.

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   Key words: Negotiation, cooperative, competitive, agents, autonomous, Time-Constrained, iterative, progressive, multi-agent, mobile agents.

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   Key words: AgentSpace, mobile agents, User interfaces, Java mobile agents, Applets, Java agent-based applications, AWT Componets.

[*] 4. Alexandros Moukas, Robert Guttman , Pattie Maes. 1998**. Agent-mediated Electronic Commerce: An MIT Media Laboratory Perspective**. *Proceedings of the International Conference on Electronic Commerce*.

   Key words: Kasbah, software agents, e-commerce applications, classified ads systems, negotiation, Agent market place, PDA@shops.

   [This paper describes the importance of software agents in electronic commerce. They discussed about an electronic market place system called Kasbah. The results of the real world experiment conducted on Kasbah with 170 participants were produced. This is the first system to introduce automated negotiation in e-commerce with predetermined strategies such as anxious, cool-headed and greedy.]

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   Key words: Multi agent system, personal agent, Agenda, distributed multi agent, service multi agents, service agent, resource agent, meeting agents, privacy preservations.

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Key words: agents, reliable communication, KQML, mobile agents, KIF, static network, dynamic network, message source, multicasting, multiple message source.

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Key words: Agents, virtual marketplace, experiment on agents, buying-selling agents, agent communication, agent behavior, anxious, cool-head, greedy, autonomous agents.

[This paper describes the agents that buy and sell goods on behalf of people on the Internet. They conducted the testing on a slightly modified version of Kasbah system for 6 hours over a day with approximately 200 participants. The results of the experiment and analysis of the results are explained in this paper.]

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Key words: Kasbah, agents, autonomous agents, agent marketplace, buying-selling agents, internet agents, negotiation agents, intelligent agents, e-commerce agents, competitive agents.

[While there are many Web-services help users to buy and sell, none which actually try to automate the process of buying and selling. Kasbah, presented in this paper, is a virtual marketplace on the Web where users create autonomous agents to buy and sell goods on their behalf. Users can also specify parameters such as cool-headed, anxious and greedy to guide and control agent's behavior. A model is built to test the feasibility of this idea. This paper also describes about the buying and selling agents, the virtual market place and different negotiation strategies for representing the buyers and sellers interests. Implementation details about Kasbah and its performance issues and the experimental results were also given.]

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    Key words: agents, classification of agents, mobile agents, multi agents, internet agents, software agents, softbots, actionbot, competitive agents, cooperative agents.

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    Key words: agents, applications, web agents, monitoring agents, communities, cooperation, competition, protocols, agent decision making, problem solving, negotiation agents.

    [As the name suggests this paper gives a brief and high level introduction to software agents and their features. The challenges in agent systems and what type of applications can be modeled as agent systems are also discussed. This was the first paper to identify domains of applications according to the properties of software agents.]

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Key words: Secret agents, security, KQML, ACL, KQML architecture, authenticator agent, application agents, cryptographic techniques, cipher attacks.

[KQML came as a communication language for agents. This paper describes an enhanced security feature for KQML language. They also described few cryptographic techniques used and the security model with the self and user authentication between KQML specking agents. The proposed architecture would allow agents to have private conversations more effectively.]

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Key words: mobile agents, agents toolkit, safety, privacy, navigatability, communication, learning, robustness, agent applications.

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[This paper describes the automation of negotiation in business contracts. The details included are representation of information to allow automatic inference of negotiation structures, how to make these automated negotiations work on realistic automated platform, and use of the results to form auction contracts using rule based techniques. Contribution of this paper includes the development of domain dependent system with high-level negotiation structure.]

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Key words: JAFMS, agent, multiagent, e-commerce, negotiation, java based agents, mobile agents, internet agent, marketplace.

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Key words: KQML, LIM, ARPI TIE, CoBASE, ISI, agent performance, Loral system, USC SIMs, information agent.

[This paper describes a component (LIM) that supports persistent storage and retrieval of plans including integration of knowledge-based representation with reasoning systems. It also defines a new standard for interface languages. This paper describes information agents and the architecture of these agents using KQML. Knowledge structures are represented using ontology in this model. Contribution of this paper would be the LIM model.]

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Key words: agents, software agents, agent application systems, properties of agents, mobility, security, co-ordination of agents, object-oriented methodology, prefabrication.

[This paper describes the properties as well as the object-oriented models of software agents. Some of the properties are revisited and discussed in terms of agent technology. The properties are classified in to two categories viz., Common properties and Classifying properties. Contribution includes clear differentiation and identification between simple object models and agent models.]

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Key words: multi agent, mobile agent, e-commerce, architecture of mobile agent, architecture of multi agent, internet agents, architecture of internet agents, e-marketplace, middleware in e-commerce agents.

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Key words: agents, mobile agents, distributed agents, transaction of distributed agents, e-commerce, internet agents, cooperative distributed agents.

[This paper proposes a mechanism that uses multiple mobile agents to implement distributed transactions in a wide area network where the resources change over time. Using mobile and autonomous agents resources are monitored and resources are managed accordingly. This paper also describes about Object Transaction services which is used in the proposed model.]

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Key words: agents, intelligent agents, adaptive agents, architecture for adaptive agents, intelligent systems, comprehensive AI agents, AIS niches, perceptions, reasoning models.

[This paper describes the architecture for building powerful agents that function effectively in challenging environments. These agents dynamically constructs explicit control plans to guide its choice among situation-triggered possible actions. The architecture has been used to build experimental agents for several AIS niches. This paper illustrates the architecture and it supports for adaptation with examples from Guardian, an experimental agent for ICU monitoring]

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Key words: agents, agent technology, standards in agent technology, FIPA, KQML, ACL, KIF, vocabulary in ACL, framework of FIPA, agent integration.

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Key words: agents, e-commerce, agent mediator, issues in e-commerce, challenge in e-commerce, view point of e-commerce, panel discussion on agents, requirement of agents to e-commerce.

[This paper gives the viewpoints of the most prominent researchers in agents in electronic commerce. They describe the important issues such as challenges, requirements, security concerns, trust relationships, warranties by third parties, consequences that will be created by electronic commerce, standards need to be established and scalability in electronic commerce. Contribution of this paper establishes what future works should be done on agent technology.

[**] 42. Hyacinth S. Nwana. 1996. **Software Agents: An Overview.** *Knowledge Engineering Review, Vol. 11, No 3, pp. 1-40, Sept 1996.*

Key words: agent, agent definition, smart agents, DAI, MAS, intelligent agents, types of agents, topology of agents, history of software agent, investigating agents.

[Name 'Agent' has been a buzzword because it is both a technical concept and a metaphor as in sales-agent or travel agent. In the name of 'agent research', there has been a diverse area of research taking place. This paper comes as a milestone paper in that it brings in all such areas together; it identifies and classifies them accordingly. It presents the history of the software agents, definition of an agent, typology of agents, and the rationality of these software agents. Then it gives an overview of different types of agents like collaborative agents, interface agents, mobile agents, information agents, reactive software agents etc.]

[*] 43. Hyacinth S. Nwana, Divine T. Ndumu. 1999. **A Perspective on Software Agents Research.** *The Knowledge Engineering Review, Vol 14, No 2, pp. 1-18.*

Key words: agents, software agents, agent research, evaluation of agent research, JAMAS, PAAM, MAS, problems of KQML, agent coordination problem, Mobile information agent.

[This paper is a review of 5 years research in software agents field. It discusses the promises the multiagent systems offer and also focus on the progress of these multiagent systems in the past 5 years. Details of personal agents, information

agents and mobile agents given. The contribution of the paper is the overview of 5-year work.]

44. J. Alfredo Sanchez, John J. Leggett, John L. Schnase. 1994. **HyperActive: Extending an Open Hypermedia Architecture to Support Agency.** *ACM Transactions on Computer-Human Interaction, Vol 1, No 4, December 1994, Pages 357-382.*

    Key words: Hyperactive, agents, notion of agency, architecture for hyperactive, classification of interface agents, agent-aware hyperbases, open hypermedia systems, CNRI's knowbots, Envoy networks, LSM server.

45. J.D. Tygar. 1998. **Atomicity in Electronic Commerce.** *Mixed Media, April/May 1998, pages 32-43.*

    Key words: agents, atomicity of agents, e-commerce, autonomous agents, issues of atomicity in e-commerce, security, transction protocols, SSL, NETBILL, Cryptographic indicia.

46. Jackie Rees, Gary Koehler. 1999**. Brainstorming, Negotiating and Learning in Group Decision Support Systems: An Evolutionary Approach.** *Proceedings of the Thirty-second Annual Hawaii International Conference on System Sciences. Maui, Hawaii, USA.*

    Key words: negotiation, agents, learning, learning in agents, negotiating agents, decision support system, GDSS, genetic algorithm, methodology of GDDS for negotiation.

47. Jae-Yeon Kang, Eun-Seok Lee.1998. **A Negotiation Model in Electronic Commerce to Reflect Multiple Transaction Factors and Learning.** *Proceedings of the 13th International Conference on Information Networking (ICOIN '98).*

    Key words: e-commerce, negotiation strategies, learning strategies, negotiating agents, agents in e-commerce, environment adaptive or dynamically changing agents, negotiation process, negotiation mechanism, ontology for agent negotiation.

48. James E. Hanson, Jeffrey O. Kerphart. 1998. **Spontaneous Specialization in Free-Market Economy of Agents.** *Artificial Societies and Computational Markets Workshop at the Second International Conference at Autonomous Agents, Minneapolis/St. Paul, May 9, 1998.*

    Key words: agents, e-commerce, free-market economy and agents, self-motivated agents, broker agent in dynamic e-commerce environment, competitive web agents.

49. James Hendler. 1999. **Is There an Intelligent Agent in Your Future?** *Nature Web Matters, March 11, 1999.*

Key words: agents, intelligent agents, research areas of intelligent agents, XML's role in e-agents, internet agent, autonomous agent, state of the art agent design, ontologies for e-agents.

[*] 50. Janet Kolodner. 1994. **Case-Based Reasoning**. *Morgan Kaufmann Publishers. ISBN 1-55860-237-2, Artificial Intelligence.*

[This book describes the importance of case based reasoning in AI. It also describes certain techniques and steps involved in reasoning with cases like case representation, case indexing, case retrieval, case adaptation, and case update. Also discussed were, different current existing applications that use case based reasoning including e-commerce applications.]

[*] 51. Jeffery M. Bradshaw. 1997. **Software Agents**. *MIT Press, ISBN 0-262-52234-9*

[This is one of the important books on software agent research. This book constitutes various important topics by the most prominent researchers in software agent research. This book covers broad area of topics from definition of an agent to most recent applications in agent technology.]

52. John C. Doppke, Dennis Heimbigner, Alexander L. Wolf. 1998. **Software Process Modeling and Execution within Virtual Environments.** *ACM Transactions on Software Engineering and Methodology, Vol. 7, No. 1, January 1998, Pages 1-40.*

Key words: software, modeling in virtual environments, multi user dimensions, virtual environments, MOO, PROMO, tools, virtual environment, software process, negotiation.

[*] 53. John Collins, Ben Youngdahl, Scott Jamison, Bamshad Mobasher, Maria Gini. 1998. **A Market Architecture for Multi-Agent Contracting.** *Autonomous Agents '98, Minneapolis, MN, USA.*

Key words: agent, multi agent, agent contacting, e-commerce, virtual market, MAGNET, TRACONET, auctionbot, ontology, bidding strategies, usage of CORBA in agent contracting.

[This paper describes an implementation of a generalized market architecture called Multi Agent Negotiation Bed. This systems provides support for various types of transactions from simple buying-selling agent to multi-agent contract negotiations; another contribution of this paper is the proposed model that attempts to control the fraud aspects in the e-commerce.]

54. John Collins, Maksim Tsvetovat, Rashmi Sundareswara, Joshua van Tonder, Maria Gini, Bamshad Mobasher. 1999. **Evaluting Risk: Flexibility and Feasibility in Multi-Agent Contracting.** *Autonomous Agents '99, Seattle, WA, USA.*

Key words: intelligent agents, electronic commerce, agents for e-commerce, negotiation in contacting, multi agent models, buying-selling agents, multi agent market place.

55. Jonathan Bredin, David Kotz, Daniela Rus. 1998. **Market-based Resource Control for Mobile Agents.** *Autonomous Agents '98, Minneapolis, MN, USA.*

Key words: mobile agents, e-market, resource management agents, mobile agents, protocols for transactions, auction model, D'agents, maximizing traveling salesman profit with e-agent.

56. Jorg P. Muller, Markus Pischel. 1999. **Doing Business in the Information Marketplace.** *Autonomous Agents 1999, Seattle, WA, USA.*

Key words: agents, autonomous agents, information agents, marketplace, buying-selling agents, multi agent market place, virtual environment, software process, negotiation.

57. José Parets-Llorca, Paul Grünbacher. 1998. **Capturing, Negotiating, and Evolving System Requirements: Bridging WinWin and the UML.** *Proceedings of the 25Th Euromicro Conference.*

Key words: agents, negotiation strategies, autonomous agents, information agents, marketplace, buying-selling agents, multi agent market place, virtual environment.

58. Juan A. Rodriguez-Aguillar, Francisco J. Martin, Pablo Noriega, Pere Garcia, Carles Sierra. 1998. **Competitive Scenarios for Heterogeneous Trading Agents.** *Autonomous Agents, Minneapolis, MN, USA.*

Key words: agents, heterogeneous agents, competitive agents, buying-selling e-commerce agents, negotiation strategies, multi agent models, market place.

59. Kara Warburton. 1999. **A Database of E-commerce Terms: Implemention and Benefits in Producing Internationalized Software.** *Proceedings on the seventeenth annual international conference on Computer documentation' 1999, Pages 120 – 126.*

Key words: terminology, data categories, software, usability, standards, e-commerce, e-commerce terms.

60. Kay Neuenhofen, Matthew Thompson. 1998. **A Secure Marketplace for Mobile Java Agents.** *Autonomous Agents '98, Minneapolis, MN, USA.*

Key words: agents, mobile agents, e-commerce, KQML, ACL, KFI, XML, negotiation mechanism.

61. Kim K., Paulson B. C., and Petrie C. J. 2000. **Agent-based electronic markets for project supply chain coordination**. *Proceedings of the AAAI-2000 Workshop on Knowledge-based Electronic Markets (KBEM), July, Austin, TX, AAAI Press, July, pp. 37-41.*

Key words: agents, e-markets, Multilateral negotiation, protocols for e-markets, e-market ontology, multi agent e-market, KQML, ACL.

62. Kirstie L. Bellman. 1997. **A Note on Improving the Capabilities of Software Agents**. *Autonomous Agents'97, Marina Del Rey, California USA.*

Key words: agents, design of software agents, autonomous agents, information agents, multi agent market place, virtual environment, software process, negotiation strategies.

63. L. Ardissono, C. Barbero, A.Goy, G. Petrone. 1999. **An Agent Architecture for Personalized Web Stores**. *Autonomous Agents'99. Seattle WA USA.*

Key words: agents, architecture for web stores, autonomous agents, multi agent market place, virtual environment, software process, negotiation strategies

[*] 64. L. Esmahi and P. Dini, J.C. Bernard. **Toward an Open Virtual Market Place for Mobile Agents**. *Proceedings of the IEEE 8th International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises.*

Key words: Intelligent agents, mobile agents, virtual market place, E-commerce, negotiation, KQML, FIPA, ACL, buyer-seller agents.

[This paper mainly focuses on the issues involved with the interaction of multiple mobile agents. This paper describes an architecture for information market place where buyer agents and seller agents cooperate with the mediator agent that manages the buyers and sellers in the system. Further contribution by this paper includes different reasoning strategies used in the model.]

65. Larry Korba. 1998. **Towards Secure Agent Distribution and Communication**. *Proceedings of the Thirty-second Annual Hawaii International Conference on System Sciences. Maui, Hawaii USA.*

Key words: Agent, Java, Object Communication, Mobile agent, security, agent monitoring and control.

66. Lisa Cingiser DiPippo and Ethan Hodys, Bhavani Thuraisingham. 2000. **Towards a Real-Time Agent Architecture; A Whitepaper.** *Proceedings of the Fifth International Workshop on Object-Oriented Real-Time Dependable Systems.*

Key words: agent, agent architecture, real time agent design, real time communication, CORBA for real time communication, agent architecture.

67. Blake, M.B. 2000. **KOJAC: Implementing KQML with Jini to Support Agent-Based Communications in Emarkets**. *AAAI-2000 Workshop on Knowledge-based Electronic Markets (KBEM) at the 17th National Conference on Artificial Intelligence, Austin, TX, july 2000.*

Key words: Kojac, KQML, ACL, Jini, agents, communication with KQML on Jini, agent on Jini, java technology on agents, AI and agents.

68. M.T. Tu, C. Seebode and W. Lamersdorf. 1998**. A Dynamic Negotiation Framework for Mobile Agents.** *Proceedings of the First International Symposium on Agent Systems and Applications Third International Symposium on Mobile Agents.*

Key words: agents, negotiation agents, dynamic framework, mobile agents, negotiating mobile agents, agent strategies and actors.

69. Manisha Mundhe and Sandip Sen. 2000**. Evolving agent societies that avoid social dilemmas**. *Proceedings of GECCO-2000, July 8--12, 2000 in Las Vegas, Nevada.*

Key words: agents, genetic algorithm on agents, evolving agent societies, social dilemmas by agents, Gas and Braess paradox.

70. Manoj Kumar, Stuart I. Feldman. 1998. **Business Negotiations on the Internet.** *Technical Papers, IBM Institute of Advanced Commerce. http://www.ibm.com/iac/reports-technical/reports-bus-neg-internet.html*

Key words: auction agents, existing auction types, negotiation in auction, e-commerce agents, models of negotiation, classification of auctions, auction process.

71. Marian Nodine and Damith Chandrasekara. 1999. **Agent Communication Languages for Information-Centric Agent Communities**. *HICSS - Hawaii International Conference on System Sciences'99 (HICSS '99).*

Key words: ACL, KQML, KIF, InfoSleuth system, MCC, information-gathering agents, FIPA, specifications on the ACL.

[*] 72. Mario Lenz, Brigitte Bartsch-Sporl, Hans-Dieter Burkhard, Stefan Wess. **Case-Based Reasoning Technology From Foundations to Applications**. *Lecture Notes in Artifcial Intelligence 1400. ISBN 3-540-64572-1.*

[This is one of the important and recent books about research in case based reasoning. This book constitutes various important topics by the most prominent researchers in case based reasoning. It describes different techniques involved in case based reasoning and its applications. Various models presented in this book are very helpful to identify and apply this field in different environments.]

73. Mark E. Nissen and Anshu Mehra. 1999. **Some intelligent software supply chain agents.** *Proceedings of the third annual conference on Autonomous Agents, 1999, Pages 374 –375. ACM.*

Key words: Internet, agents, multi agents, mobile agents, security, e-commerce, intelligent agents, autonomous agent.

74. Mark Klein and Chrysanthos Dellarocas. 1999. **Exception handling in agent systems.** *Proceedings of the third annual conference on Autonomous Agents, 1999, Pages 62 – 68.*

Key words: agents, agents systems, exceptions capable agent systems, limitations of agent-local approaches, avoiding 'human in loop' in agents syetems.

75. M. Beer, M. d'Inverno, M. Luck, N. R. Jennings, C. Preist and M. Schroeder. 1999. **Negotiation in Multi-Agent Systems**. *Knowledge Engineering Review 14 (3) 285-289.*

Key words: negotiation, negotiation objective, negotiation models, multi agent systems, resource management, KQML, ACL, FIPA standards for multi agent communication.

76. Matthew Hohlfeld, Bennet Yee. 1998. **How to Migrate Agents**. *A report. UC SanDiago.*

Key words: agents, mobile agents, transport mechanism in mobile agents, locus and Tacoma, capturing state during agent migration, agent migration and threads.

77. Mehdi Jazayeri and Wolfgang Lugmayr. 1998. **Gypsy: A Component-Based Mobile Agent System**. *Proceedings of the 8th Euromicro Workshop on Parallel and Distributed Processing.*

Key words: Gypsy, dynamically extendable multi agent system, distributed execution of agents, supervisor agent model, building multi language extensible distributed agent system.

78. Mecheal N. Huhns, Anuj K. Malhotra. 1999. **Negotiating for Goods and Services**. *IEEE Internet Computing, july-aug'99.*

Key words: Negotiation, envy free protocol, requirements of negotiation, agent based e-commerce negotiations, internet computing.

[*] 79. Micheal R. Genesereth. 1994. **Software Agents**. *Communications of the ACM, july 1994/vol. 37, No.7.*

Key words: agent based software engineering, agents, agent communication protocols, agent communication languages, cooperative agents, competitive agents, KQML, ACL, agent not just an object, architecture for multi agent system.

[This paper is one of the milestone papers in agent technology. This paper describes many aspects of agent technology right from agent communication language to multi agent systems. It focuses on agents, agent communication languages and multiagent systems]

[*] 80. M. Wooldridge. 1999. **Verifying that Agents Implement a Communication Language**. *Proceedings of the Sixteenth National Conference on Artificial Intelligence (AAAI-99), Orlando, FL, July 1999.*

Key words: Communication standards, KQML, ACL, semantic conformance model, FIPA, epistemic temporal logics, semantics for agent communication languages, multi agent systems.

[This paper presents an expressive agent communication language (L_c) and semantics for the language developed. The techniques described here are drawn upon those used to give semantics to reactive systems. These semantics are based on Quantified Epistemic Temporal logic. This language has two parts, an outer language and content language.]

[**] 81. M. Wooldridge and N.R. Jennings. 1995**. Intelligent Agents: Theory and Practice.** *The Knowledge Engineering Review, 10 (2), pp. 115-152, 1995.*

Key words: AI, agent, models of agent, DAI, MAS, agent properties, agent classifications, agent languages, important issue on agents, various applications on agents, notion of agency, belief desire and intension architecture of angnts.

[This is a milestone paper in agent technology. This paper starts off with the hype of agents. Then it goes on to describe the theoretical and practical issues involved with the design and construction of intelligent agents. In the first section, properties of the agents are described. In second and third sections agent architectures and agent communication languages are described respectively. It also describes the potential applications of agent technology, which would give an insight for the researchers in agent technology. Identification of domains where agent technology should not be used and the pitfalls of using it is presented accordingly.]

82. M. J. Wooldridge and N. R. Jennings. 1998**. Pitfalls of Agent-Oriented Development.** *Proceedings of the 2nd Int. Conf. on Autonomous Agents (Agents-98), Minneapolis, USA, 385-391.*

Key words: agents, applications on intelligent agents, choosing the right domain for agent system, problems associated with agent paradigm, multi agent system development and its application area, recommendation of application domain for agent systems.

[*] 83. M. Wooldridge, N. R. Jennings, and D. Kinny. 1999. **A Methodology for Agent-Oriented Analysis and Design**. *Proceedings for the 3rd Int Conference on Autonomous Agents (Agents-99) Seattle, WA, 69-76.*

Key words: agents, agent design, analysis phase of agent system design, characters of agents, roles or models of agents, business process management on in agents model.

[This paper serves as a guideline for building agents systems. Domain characteristics, conceptual framework and its analysis are described in the initial sections. Design phase issues such as in agent model, services model, and acquaintance model are discussed. Finally a case study about a business process management system is illustrated.]

84. Mihai Barbuceanu. 1999. **A negotiation shell**. *Proceedings of the third annual conference on Autonomous Agents, 1999, Pages 348 –349. ACM.*

Key words: negotiation, agent negotiation, mobile agents, multi agents, negotiation strategies on agent design, argumentation based negotiation.

[*] 85. M. Barbuceanu, M. S. Fox. 1995. **COOL: A Language for Describing Coordination in Multi-Agent Systems**. *Proceedings of the First International Conference on Multi-Agent Systems, AAA Press/The MIT Press, june 1995, pp 17-25.*

Key words: COOL, communication language in agents, coordination of multi agents, intelligent agents, integration of heterogeneous agent system, KQML, ACL, FIPA, KIF.

[This paper presents a communication language for multi agent systems, COOL (Coordination Language). This language relies on speech act based communication. The basic elements of this language are, conversation objects, conversation rules, error recovery rules, continuation rules etc. Comparatively

standards are pretty much same as ACL but design of the system is totally different.]

86. Mona Singh, Anuj K. Jain and Munindar P. Singh. 1999. **E-commerce over communicators: challenges and solutions for user interfaces**. *Proceedings of the first ACM conference on Electronic commerce,1999, Pages 177 – 186. ACM.*

Key words: e-commerce, user interfaces in e-commerce, designs on interfaces, agents autonomously identifying user interfaces, delivery methods of user interfaces.

87. Moses MA. 1999. **Agents in E-commerce**. *Communications of the ACM, March 1999/ Vol. 42, No.3.*

Key words: agents, e-commerce, medium of action in e-commerce, role of XML in e-commerce.

[*] 88. N. R. Jennings. 1999. **Agent-based Computing: Promise and Perils**. *Proceedings of the 16th International Conference Artificial Intelligence (IJCAI-99), Stockholm,Sweeden. (Computers and Thought award invited paper) 1429-1436.*

Key words: agents, perils of agent methodology, agent based computing, promises, agent support systems, interaction between agents, dynamicity and complexity of agent systems.

[This paper describes a systematic analysis of agent systems stating why these systems are so appealing and powerful conceptual model. The disadvantages of adopting agent oriented paradigm in a wrong domain is clearly defined. The merits of agent based decomposition and suitability of agent oriented abstractions are explored. Finally it describes the down side of the agent-oriented paradigm.]

[*] 89. N. R. Jennings. 1999. **Agent-Oriented Software Engineering**. *Proceedings of the 12th Int Conference on Industrial and Engineering Applications of AI, Cairo, Egypt, 4-10. (Invited paper). [Also appearing in Proc. 9th European Workshop on Modelling Autonomous Agents in a Multi-Agent World (MAAMAW-99), Valencia, Spain 1-7 (Invited paper)]*.

Key words: agents, software design, agent oriented approaches, agent lifecycle, specifications of agents, pitfalls of agents.

[This paper strongly supports agent oriented paradigm with interesting arguments in favor of it. The conceptual model of agent systems is well suited for building complex systems and agent-oriented approaches represent the current advanced state of representing complex systems. There is a good discussion about agent oriented software life cycle in this paper.]

[*] 90. Nicholas R. Jennings, Michael J. Wooldridge. 1998. **Agent Technology: Foundations, Applications, and Markets**. *Publication Date: February 25th, 1998. Publishers. Springer and Unicom. ISBN: 3540635912.*

Key words: agents, agent technology, various applications of agents, existing e-commerce environments of agents, agents models that are on research.

[This book introduces the concept of agents and agent based systems; further it looks into main application areas of agent technology, current agent based applications that has been built till date, problems and challenges in agent based systems and the main obstacles that lie in way of building agents based system.]

[*] 91. N. R. Jennings, S. Parsons, C. Sierra and P. Faratin. 2000. **Automated Negotiation**. *Proceedings of the 5th International Conference on the Practical Application of Intelligent Agents and Multi- Agent Systems (PAAM-2000), Manchester, UK, 23-30.*

Key words: negotiation models, e-commerce, agents, agent negotiation in e-commerce, applications of agent negotiation in e-commerce, framework for negotiation, negotiation techniques, game theoretic models, heuristic approaches, argumentation based approach.

[This paper presents the negotiation model which include negotiation protocols, negotiation objects and agent decision models. Then it describes a general framework for negotiation framework. Finally some of the negotiation models like game theoretic models, heuristic approaches and argumentation-based approaches are viewed. Notably, authors are stressing mainly on argumentation-based approaches.]

92. N.R.Jennings, S. Parsons, P. Noriega and C. Sierra. 1998. **On Argumentation-Based Negotiation**. *Proceedings of the International Workshop on Multi-Agent Systems, Boston, USA.*

Key words: negotiation techniques, argumentation based negotiation, negotiation protocols, negotiation issues, negotiation decision models.

[*] 93. N. R. Jennings, P. Faratin, T. J. Norman, P. O'Brien and B. Odgers. 2000. **Autonomous Agents for Business Process Management**. *International Journal of Applied Artificial Intelligence 14 (2) 145-189.*

Key words: agents, AI, autonomous agents, business process management and e-commerce, agents in business management, ADEPT.

[This paper describes the motivation, conceptualization, design and implementation of a novel agent-based business process management system. In this system different components of business process are delegated to different agents. These agents negotiate with other agents to accomplish their goals. Need for a detail study on the functionality of these agents are stressed in this paper.]

94. Neeran M. Karnik and Anand R. Tripathi. 1998. **Agent Server Architecture for the Ajanta Mobile-Agent System**. *Proceedings of the 1998 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'98), pages 66-73, July 1998.*

Key words: mobile agents, distributed computing, Java, security, Ajanta, architecture of Ajanta, secure agent transfer using Ajanta.

95. Oren Etzioni, Daniel S. Weld. 1995. **Intelligent Agents on the Internet: Fact, Fiction, and Forecast**. *IEEE Expert. August'95.*

Key words: agents, virtual marketplace, internet agents, autonomous agents, softbot, actionbot, types of agents, goal oriented agents, properties of agents, e-commerce.

96. P. Faratin, C. Sierra, N. R. Jennings and P. Buckle. 1999. **Designing Responsive and Deliberative Automated Negotiators**. *Proceedings of the AAAI Workshop on Negotiation: Settling Conflicts and Identifying Opportunities, Orlando, FL, 12-18.*

Key words: negotiation, agent architecture, deliberative agents, types of negotiation agents, FIPA, negotiation protocol, agent negotiation architecture, Evaluation mechanism, responsive mechanism, deliberative mechanism of negotiating agents.

[*] 97. P. Faratin, C. Sierra and N. R. Jennings. 2000. **Using similarity criteria to make negotiation trade-offs**. *Proceedings of the 4th International Conference on Multi-Agent Systems (ICMAS-2000), Boston, USA, 119-126.*

Key words: tradeoff mechanism, implementing similarity functions in agents, agents, mechanisms for trade offs, fuzzy logic and similarity matching in agents.

[This paper addresses the issues involved in software agents making tradeoffs during automated negotiations in which they have information uncertainty and resource limitations. There is an interesting algorithm developed to perform the tradeoffs for multidimensional goods. The algorithms uses the notion of fuzzy similarity to find the negotiation solutions.]

98. P. Faratin, N. R. Jennings, P. Buckle, and C. Sierra. 2000. **Automated negotiation for provisioning virtual private networks using FIPA-compliant agents**. *Proceedings of the 5th Int. Conference on the Practical Application of*

Intelligent Agents and Multi- Agent Systems (PAAM-2000), Manchester, UK, 185-202.

Key words: FIPA OS agent framework, virtual networks, agents, compliant agents, negotiation agents, MAS, building PCA, agent negotiation, responsive mechanism, trade-off mechanisms.

99. Panos K. Chrysanthis, Taieb F. Znati, Sujata Banerjee and S. K. Chang. 1999. **Establishing Virtual Enterprises by means of Mobile Agents**. *Proceedings of the Research Issues in Data Engineering (RIDE) Workshop, pages 116--125, Sydney, Australia, March 1999.*

Key words: agents, mobile agents, e-commerce, workflow systems, mobile agents, decentralized management agent systems, virtual enterprises and e-agents, aglets in virtual enterprises.

[*] 100. Pattie Maes. 1994. **Agents that reduce work and information overload.** *Communications of the ACM. Volume 37, No. 7 (Jul. 1994).*

Key words: agents, interface agents, personal agents, buying-selling agents, e-mail filtering agents, entertaining agents, meeting scheduling agents, network proving agents, functionality of agents, approach to building agents, training agents, existing agents.

[This is a paper on agent technology. This paper mainly focuses on approaches in building interface agents. It also presents the results from several prototype agents that were built using the approaches discussed in this paper. Interface agents like personalized digital assistant which handle meeting scheduling, email handling and electronic news filtering etc.]

[*] 101. Pattie Maes, Robert H. Guttman and Alexandros G. Moukas. **Agents that buy and sell**. *Communications of the ACM, Volume 42, No. 3 (Mar. 1999).*

Key words: e-commerce, agents in e-commerce, agent negotiation in e-commerce, models exist in e-commerce environment, CBB of e-commerce, pros and cons of existing e-commerce systems.

[Unlike the above paper, this paper mainly describes about the agents that can be involved in e-commerce transactions. These agents can buy or sell goods and services on their users behalf. They negotiate representing their users interests. Number of existing agent systems such as Firefly, BargainFinder, ActionBot, Kasbah, Tete-a-Tete etc. are also evaluated in this paper.]

102. Pauli Misikangas, Kimmo Raatikainen. 2000. **Agent Migration Between Incompatible Platforms.** *In the 20th International Conference on Distributed Computing Systems (ICDCS 2000), 10-13 April 2000, Taipei, Taiwan, Republic of China.*

Key words: agents, mobile agents, different platform agents migrating, building platform independent service agents, API of different agent problems, message delivery between different platforms in agents, use of RMI.

103. Prasad Chalasani, Somesh Jha, Onn Shehory and Katia Sycara. 1998. **Query restart strategies for Web agents.** *Proceedings of the second international conference on Autonomous agents, 1998, Pages 124 –131.*

Key words: agents, internet agents, information retrieving agents, query answering agents, statistic model for reissue query in query-agents.

[*] 104. Prithviraj Dasgupta, Nitya Narasimhan, Louise E. Moser, P.M. Melliar-Smith. 1999. **MAgNET: Mobile Agents for Networked Electronic Trading**. *IEEE Transactions on Knowledge and Data Engineering, Vol.11, No.4. july/august 1999.*

Key words: mobile agents, electronic trading, Magnet, use of mobile agent, java mobile agents, network trading, negotiation mechanisms in mobile agents, java agents and negotiation.

[This paper describes MAgNET, a system for networked electronic trading that is based on the java mobile agent technology called aglets. Aglets are dispatched by the buyer to the various suppliers to negotiate orders and deliveries and returns to the buyer for approval of their deals. The results of the experiment demonstrated in this paper show the feasibility of using aglet technology for electronic commerce.]

105. Qiming Chen, Parvathi Chundi, Umeshwar Dayal, Meichun Hsu. **Dynamic software agents for business intelligence applications.** *Proceedings of the second international conference on Autonomous agents, 1998, Pages 453-454.*

Key words: agents, dynamic software agents, intelligent agents, business application of agents, dynamic behavior of agents, use of CORBA, RMI agent software.

106. Ralph Peters, Andreas Graeff and Christian Paul. **Integrating agents into virtual worlds.** *Proceedings of the workshop on New paradigms in information visualization and manipulation, 1998, Pages 69 – 74.*

Key words: agents, training tool, learning in agents, agents in virtual environment, environment agents, integrating different type of agents.

[*] 107. R. Guttman, A. Moukas, and P. Maes. 1998. **Agent-mediated Electronic Commerce: A Survey**. *Knowledge Engineering Review, Vol. 13:3, June 1998.*

Key words: agents, electronic commerce, consumer buying behaviour role by agents, mediator role of agents, product brokering agents, merchant brokering agents, negotiation agents.

[This paper describes several of the agent mediated electronic commerce systems by describing their roles in the context of consumer buying behaviour model. Notably, urgency on developing negotiation strategies in CBB is stressed. A variety of AI techniques described to support agent mediation and there is foresight on future directions of agent mediated electronic commerce.]

108. R. Guttman and P. Maes. 1998. **Cooperative vs. Competitive Multi-Agent Negotiations in Retail Electronic Commerce**. *Proceedings of the Second International Workshop on Cooperative Information Agents (CIA'98), Paris, France, July 3-8, 1998.*

Key words: agents, corporative agents in multiagent systm, competitive agent, negotiation agent, e-commerce, retail market negotiation, multi attribute utility theory in e-commerce.

[*] 109. R. Guttman and P. Maes. 1998. **Agent-mediated Integrative Negotiation for Retail Electronic Commerce**. *Proceedings of the Workshop on Agent Mediated Electronic Trading (AMET'98), Minneapolis, Minnesota, May 1998.*

Key words: agent, e-commerce, negotiation in e-commerce, CBB, Bargainfinder, auctionbot, multi utility negotiation, use of distributed constrain satisfaction in agent negotiation.

[This paper analyzes the approaches of distributed negotiation from economic, behavioral, and software agent perspectives. There is a proposal for an integrative negotiation as a more suitable approach. Promising techniques like multi-attribute theory, distributed constraint satisfaction, and conjoint analysis for agent negotiation are discussed. Number of existing e-commerce applications are also briefly discussed.]

[*] 110. R. Guttman, P. Maes, A. Chavez, and D. Dreilinger. 1997. **Results from a Multi-Agent Electronic Marketplace Experiment**. *Proceedings of Modeling Autonomous Agents in a Multi-Agent World (MAAMAW'97), Ronneby, Sweden, May 1997.*

Key words: agent marketplace, Kasbah, experimental results of Kasbah, multi agent e-commerce.
[This paper describes the results of a multi-agent electronic market place experiment on a system called Kasbah, in MIT. These experiments involved

about two hundred participants. Agents have three different selling strategies viz., greedy, anxious, and cool-headed. Experiment results show the dynamics of the e-commerce even with only one parameter, i.e., price.]

111. Roberto A. Flores-Mendez. 1999. **Towards a Standardization of Multi-Agent System Frameworks.** *ACM CrossRoads Student Magazine. Summer-1999,5.4.*

112. Robert J. Glushko, Jay M. Tenenbaum and Bart Meltzer. 1999. **An XML framework for agent-based E-commerce.** *Communications of the ACM, Volume 42, No. 3 (Mar. 1999).*

Key words: XML and agent technology, XML in e-commerce, e-commerce, communication path as XML, XML/EDI message format, CORBA loosing e-commerce, CBL, OBI.

113. Ross M. Miller. 1998. **Market automation: self-regulation in a distributed environment.** *Conference Sponsored by ACM SIGOIS and IEEECS TC-OA on Office information systems, 1988, Pages 299 – 308.ACM.*

Key words: e-commerce, agent automated e-commerce, FIPA, KAoS, agents overview, object vs. agent, multi agent system overview, agent interaction.

114. Rune Gustavsson. 1999. **Agents with power**. *Communications of the ACM Volume 42, No. 3 (Mar. 1999).*

Key words: agent based software engineering, agents, agent communication protocols, cooperative agents, competitive agents, KQML, ACL.

115. S. K. Das, J. Fox, D. Elsdon and P. Hammond. 1997. **Decision making and plan management by autonomous agents: theory, implementation and applications**. *Proceedings of the first international conference on Autonomous agents, 1997, Pages 276 – 283.*

Key words: agents, autonomous agents, decision strategies, management agents.

116. Sandip Sen, Partha Sarathi Dutta, Rajatish Mukherjee. 2000. **Agents that represent buyer's interests in E-commerce.** *AAAI 2000 KBEM Workshop - July 30-31, Austin.*

Key words: buyer agents design, agents, e-commerce, interaction of buying-selling agents, lure of e-commerce, buyer constrained agents.

117. Sebastian Abeck, Andreas Köppel, Jochen Seitz. 1998. **A Management Architecture for Multi-Agent Systems.** *Proceedings of the IEEE Third International Workshop on Systems Management.*

Key words: agent, multi agent, KQML, KIF, ACL, agent management, mobile agents, multi-agent systems, virtual entreprise, application management, java agents

118. S. Parsons, C. Sierra, N. R. Jennings. 1998. **Agents that reason and negotiate by arguing**. *Journal of Logic and Computation 8 (3) 261-292.*

Key words: agents, reasoning agents, negotiation in agents, argumentation based agents, BDI agents, multi context BID agents, agents and argumentation.

119. Stan Franklin, Art Graesser. 1996**. Is it an Agent, or just a Program?: A Taxonomy for Autonomous Agents.** *Proceedings of the Third International Workshop on Agent Theories, Architectures, and Languages, Springer-Verlag, 1996.*

Key words: agent, taxonomy of autonomous agents, multiagents, mubot agents, AIMA Agents, essence of agents, notion of agents.

120. Subrata Das, Alper aglayan and Paul Gonsalves. 1998. **Increasing agent autonomy in dynamic environments.** *Proceedings f the second international conference on utonomous agents, 1998, Pages 309-316.ACM.*

Key words: agent, agents in dynamic environments, strategies in dynamic environments.

121. Sunju Park, Edmund H. Durfee and William P. Birmingham. 1999. **An adaptive agent bidding strategy based on stochastic modeling.** *Proceedings of the third annual conference on Autonomous Agents,1999, Pages 147 – 153.ACM.*

122. Papaiannou, T, Edwards JM. **Mobile Agent Technology in Support of Sales Order Processing in the Virtual Enterprise**. *pp 24-32, published in "Intelligent Systems for Manufacturing", Edited by L.M.Camarinha-Matos, H. Afsarmaneshand V. Marik, Kluwer Academic Publishers, 1998, ISBN 0-412-84670-5.*

Key words: Virtual Enterprise, Mobile Agents, System Integration, Agile Systems

123. Ted Selker. 1994. **COACH: a teaching agent that learns**. *Communications of the ACM Volume 37, No. 7 (Jul. 1994).*

Key words: COACH, learning agent, dynamic learning strategies, communication protocols, KIF.

124. Thomas F. Porta, Ramachandran Ramjee, Thomas Woo, Krishan K. Sabnani. 1998. **Experiences with network-based user agents for mobile applications**. *Mobile Networks and Applications 3 (1998) 123-141.*

Key words: PCS, agents, mobile agents, mobile applications with agents, network protocols and agent communication, user agents, W-DCPA, CORBA as user agents.

125. Thomas Tran, Robin Cohen. 1999. **Hybrid Recommender Systems for Electronic Commerce.** *Knowledge-based Electronic Markets a AAAI'00 Workshop (KBEM'00) Monday, July 31, Austin TX, USA.*

Key words: recommender agents, hybrid systems, e-commerce, collaborative filtering in agents, interactive interface agents.

126. Timothy K. Shih. 1999. **Agent Communication Network - A Mobile Agent Computation Model for Internet Applications**. *Proceedings of the Fourth IEEE Symposium on Computers and Communications (ISCC'99), Red Sea, Egypt, July 6 - 8, 1999.*

Key words: search engine, information retrieval, internet, evolution computing, mobile agent, intelligent agent.

127. Dejan Milojicic. 1999. **Trend Wars: Mobile agent applications**. *IEEE Concurrency, jul-sept 1999.*

Key words: mobile agents, transport protocols, scripting languages, aglets, concodia, killer application.

128. Sandholm, T. and Vulkan, N. 1999. **Bargaining with Deadlines**. *National Conference on Artificial Intelligence (AAAI), pp. 44-51, Orlando, FL.*

Key words: negotiation, distributive negotiation, mixed strategies of offer and counter offer, rational agents, negotiating agents, multi agent systems, automated negotiation, bargaining model.

129. Tzvetan Drashansky, Elias N. Houstis, Naren Ramakrishnan and John R. Rice. **Networked agents for scientific computing**. *Communications of the ACM Volume 42, No. 3 (Mar. 1999).*

Key words: agents, network agents, resource management, PYTHIA agents, SciAgents, multiagent architecture.

[*] 130. W.Y.Wong, D.M.Zhang, and M. Kara-Ali. 2000. **Towards an experience-based negotiation agent**. *Proceedings of the 4th International Workshop on Cooperative Information Agents, CIA-2000, Boston.*

Key words: agents, experienced based agents, Case base reasoning, framework for experienced negotiation.

[This paper presents a negotiation framework, which applies Case-based reasoning techniques to capture and reuse previously successful negotiating experiences. Issues such as case selection, identification of similar cases, and case updation are briefly discussed in this paper. This framework is illustrated with used car trading domain.]

[*] 131. Yannis Labrou and Tim Finin. 1997. **A Proposal for a new KQML Specification**. *TR CS-97-03, February 1997, Computer Science and Electrical Engineering Department, University of Maryland Baltimore County, Baltimore, MD 21250.*

Key words: KQML, communication between software agents, performative language, KQML syntax, conversation performance, facilitators.

[This paper proposes a new specification for the Knowledge Query Manipulation Language (KQML). KQML is a communication language for software agents adapted by Agent Communication Language community with Knowledge Interchange Format and domain specific ontology called Vocabulary. KQML offers variety of performatives that express attitude regarding the content of the exchange.]

[*] 132. Yannis Labrou and Tim Finin. 1994. **A semantics approach for KQML- a general purpose communication language for software agents**. *CIKM'94. Nov'94, Gaitherburg MD USA.*

Key words: KQML, ACL, KIF, agents of AI, speech act of KQML, KQML mediators, software agents and KQML.

[This paper describes the semantics of Knowledge Query Manipulation Language and a semantic framework for the language. Moreover, it describes semantics for the basic set of KQML performatives. This paper also suggest that KQML can offer an all purpose communication language for heterogeneous software agents.]

[**] 133. Tim Finin, Yannis Labrou, and James Mayfield. 1995. **KQML as an agent communication language**. *Invited chapter in Jeff Bradshaw(Ed.), ``Software Agents'', MIT Press, Cambridge (1995).*

Key words: KQML, ACL, KIF, KSE, communication protocol, role of KQML, KQML facilitators, KQML mediators.

[This paper describes the design of and experimentation with the Knowledge Query and Manipulation Language (KQML), a language and protocol for

exchanging information and knowledge. Part of the goal of KQML is to develop techniques and methodology for building large-scale knowledge bases, which are sharable and reusable. These techniques are presented with the explanation to performative acts that can perform acts at runtime. Notion of communication language and its desired features are elaborately described. Currently, KQML is being tested in models that support concurrent engineering, intelligent design and planning and scheduling models. These models are briefly explained.]

134. Whitfield Diffie. 1998. **E-commerce and Security**. *StandardView Vol.6, No.3, September/1998.*

Key words: Crypto-Politics, decoding new encryption standard, e-commerce, security issues in e-commerce, transaction mechanism, authentication mechanism.

135. Yannis Labrou, Tim Finin, Yun Peng. 1998. **The Interoperability Problem: Bringing Together Mobile Agents and Agent Communication Languages.** *Proceedings of the Thirty-second Annual Hawaii International Conference on System Sciences, Maui, Hawaii, USA.*

Key words: ACL, KQML, concepts of ACL, FIPA, platforms supporting FIPA ACL, mobile agents.

[*] 136. Yannis Labrou, Tim Finin, Yun Peng. 1999. **Agent communication Languages: The Current Landscape.** *IEEE Intelligent Systems, March/April 1999.*

Key words: ACL, KQML, KIF, concepts of ACL, origin of ACL, FIPA, platforms supporting FIPA ACL.

[This paper introduces the origin of agent communication languages (ACL) with briefly introducing Vocabulary, Knowledge Interchange Format, and Knowledge Query and Manipulation Languages (KQML). ACL supporting systems and applications are also discussed in this paper. Few concepts of agent communication languages and KQML are compared and contrasted in this paper.]

137. Yariv Aridor, DannyB. Lange. 1998. **Agent design patterns: elements of agent application design.** *Proceedings of the second international conference on Autonomous agents, 1998, Pages 108 – 115. ACM.*

Key words: agent design patterns, agent application, reuse, mobile agents, classification of design patterns.

138. Michael Georgeff, Barney Pell, Martha Pollack, Michael Wooldridge. 1998. **The Belief-Desire-Intention Model of Agency.** *Proceedings of the 5th International Workshop on Intelligent Agents 5: Agent Theories, Architectures, and Languages.*

Key words: BDI agents, agents, decision model using BDI, dynamic decision model in agents, intension, belief, decision, panel discussion on BDI.

139. Walid Saba. 2001. **Linguistically-Competent Intelligent Information Agents: Towards a Digital Agora.** *2nd International Conference on Advances for Infrastructure for Electronic Business, Science, and Education on the Internet*

Key words: natural language understanding, ontology, agents, commonsense reasoning, intelligent information agents, e-commerce agents, buying-selling virtual marketplace.

140. Walid Saba. 2001. **Modeling Mental States in Agent Negotiation.** *Negotiation Methods for Autonomous Cooperative Systems 2001 Fall Symposium, Pages 142 – 147, AAAI Press.*

Key words: Dalia, agents, negotiation agents, e-commerce, cooperative, competitive agents, dynamic environment negotiation models, mental attitude agents, learning CBL.

[**]141. Alessio Lomuscio, Michael Wooldridge, Nicholas Jennings. 2000. **A classification scheme for negotiation in electronic commerce.** *Journal of Group Decision and Negotiation 19 – 33.*

Key words: negotiation, automated negotiation, negotiation space, parameters of negotiation space, Q-Learning algorithm, dynamic logic.

[Well over a decade, Business-to-Business transactions are taking place over the intranets. Recent years this trend caught up to Business-to-Consumer market on the Internet as the Internet became popular. However, these e-markets are still at the beginning stage of electronic catalogues. Clearly it fails to make use of the potential of electronic commerce by not using automated negotiation. This paper stands as a classic and milestone as it identifies the main parameters on which any automated negotiation depend. This paper analysis several existing models and the parameters involved in negotiations in those models. Finally, negotiation space is presented as the main idea and several important parameters are categorized - making a way for general automated negotiation and protocol in the future.]

142. H. Vogler, A. Spriestersbach and M-L. Moschgath. 1999. **Protecting Competitive Negotiation of Mobile Agents.** *The Seventh IEEE Workshop on Future Trends of Distributed Computing Systems. IEEE.*

Key words: agents, negotiation, mobile agents, competitive agents, security feature in negotiation agents, negotiation for e-commerce, X-TRA as protecting agents.

143. Kim K., Paulson, B. C., Petrie, C. J., and Lesser, V. R. 2001. **Compensatory negotiation for agent-based project schedule coordination.** *Proceedings of the Fourth International Conference on Multiagent Systems, IEEE Computer Society Press, July, pp. 405-406.*

Key words: agents, negotiation agents, compensation negotiation methodology, coordination of agents, agent model for compensatory negotiation methodology.

144. Wong, W. Y., Zhang, D. M., and Kara-Ali, M. 2000. **Negotiating with experience**. *Knowledge-Based Electronic Markets, Technical Report WS-00-04, PP. 85-90. AAAI 2000.*

Key words: agents, experience based agents, negotiation and experience, representation of negotiation, process of negotiation, matching negotiation case, reuse previous negotiation case.

145. Vulkan N., Binmore K. 1997. **Applying game theory to automated negotiation.** *DIMACS Workshop on Economics, Game Theory and the Internet, 1997.*

Key words: negotiation, e-commerce, game theory negotiation, agent marketplace, bargaining types, type of negotiation.

146. N.R. Jennings, P. Faratin, A. R. Lomuscio, S. Parsons, C. Sierra and M. Wooldridge 2001. **Automated negotiation: prospects, methods and challenges.** *International Journal of Group Dexision and Negotiation 10 (2) 199-215.*

Key words: negotiation, types of negotiation, automated negotiation, agent negotiation, e-commerce negotiating agents, challenges in negotiation, negotiation models.

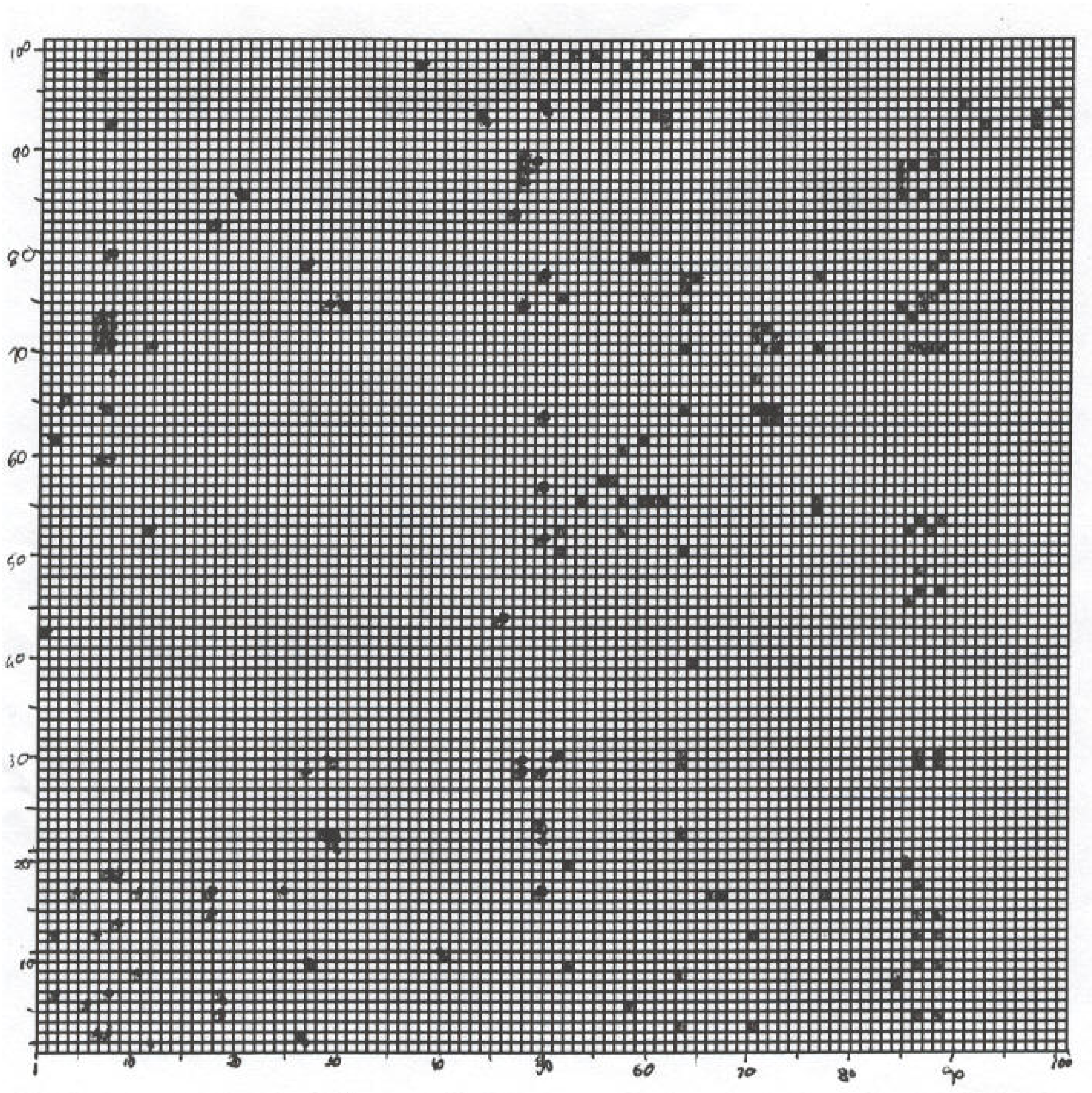
147. Davies, Glyn. 2002. **A History of money from ancient times to the present day, 2nd. Edition.** *Cardiff: University of Wales Press,* ISBN 0-7083-1773-1.

148. Walid S. Saba and Pratap Sathi. 2001. **Agent Negotiation in a Virtual Marketplace.** *In Proceedings of the 2nd Asia-Pacific Conference on Intelligent Agent Technology, 2001, pages 444-453. IAT.*

Key words: agent, e-commerce, negotiation strategy, virtual marketplace, case-based reasoning, buying selling agents, autonomous agents, similarity functions, ontology.

Appendix A

Cross Reference Graph



Note: X-axis and Y-axis refers to research paper numbers assigned in the Bibliography section. Not all the 148 papers are used to do the cross-reference graph, as some of the papers are not *very* relevant to my work.

Appendix B Letter to Leading Researcher

B.1 Letter to Leading Researcher (Wrong letter - Submitted in Class)

March 7th 2002

Dear Dr. Georgeff,

I am graduate student at the university of Windsor, Ontario, Canada and I am doing research on Agent negotiation in e-commerce. During my research, I found that one of your papers "BDI agents (98)" being very helpful. But I have some problem understanding the concept of BDI agents in connection with negotiation of agents. I will be really grateful if you could let me know of any materials that could help me understand the connection.

I am anxiously waiting for your reply.

Thanking you in advance.

Sincerely,
Osmand Christian

Graduate Assistant OOP
Computer Science Department
University of Windsor
Ontario, Canada

B.2 Re-written Letter as per the requirements

April 2nd 2002

Dr.Georgeff,

I have been following your published work on agents ever since I started my research on ‘agent negotiation in e-commerce’. Specifically, BDI agents (‘98) and BDI Model of Agency (’99) papers were astonishing as you brought problem solving in a dynamic environment closer to reality.

In my masters thesis, I am planning to incorporate and implement the ideas of BDI agents. I will be grateful if you could give me or refer me to any materials that combine BDI agents and negotiation processes.

Thanking you in advance.

Sincerely,
Osmand Christian

Graduate Assistant OOP
Computer Science Department
University of Windsor
Ontario, Canada

Appendix C

Names and Addresses of Researchers in the Area

Dr. Pattie Maes

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Tel: +1-617-253-7442
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Email: pattie@media.mit.edu
URL: ***http://agents.www.media.mit.edu/people/pattie/***

Justification

Dr. Pattie Maes is an Associate Professor at MIT's Media Laboratory, where she founded and directs the Software Agents Group, and is principal investigator of the e-markets Special Interest Group. Her areas of expertise are Artificial Intelligence, Human Computer Interaction, Computer Supported Collaborative Work, Information Filtering and Electronic Commerce. Pattie Maes is one of the pioneers in Software Agent research area.

Her group in MIT pioneered the use of machine learning to build agents and invented a range of new algorithms such as collaborative filtering that we presented in the report. Her team built the first successful prototypes of agents for personalized information filtering, eager assistant agents, agents that buy and sell on behalf of a user, matchmaking agents and remembrance agents. We have noted one of her paper as a milestone paper in the bibliography (paper numbered 10) section.

Maes is frequently quoted in the popular press and on television as an expert in this increasingly important application area. She is one of the organizers for the leading conferences in this area such as the annual 'Autonomous Agents' conference and the annual 'ACM Electronic Commerce Technologies' conference. She is a founder and board member of the Agent Society, an international industry and professional organization established to assist in the widespread development and emergence of intelligent agent technologies and markets. Because of her contributions to the Agent and e-commerce research area, we present her as a well-known and well-done researcher in these areas.

Dr. Nick Jennings

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Justification

Dr. Nick Jennings is a Professor at Southampton University where he carries out basic and applied research in agent-based computing. He is also the head of the Intelligence, Agents, Multimedia Group at there. Jennings helped pioneer the use of agent-based techniques for real-world applications; developing systems in the domains of: e-commerce, telecommunications network management, virtual laboratories, and scientific data interpretation. These systems represent some of the first real-world applications of multi-agent technology. The application-oriented work he led during his career enabled him to focus his research on the field of agent-based software engineering. On the theoretical side, he has made contributions to the areas of automated negotiation and auctions, cooperative problem solving, and socially rational decision-making. We have marked more than three papers as important paper in the bibliography section.

Professor Jennings has been an invited speaker at number of national and international conferences. He initiated two major international conferences namely, The Practical Application of Agents and Multi-Agent Systems (PAAM) and Autonomous Agents, and initiated the Agent Theories, Architectures and Languages (ATAL) workshop series. He was the recipient of the 'Computers and Thought Award' (the premier award for a young AI scientist) in 1999 for his contributions to practical agent architectures and applications of multi-agent and the recipient of an IEE Achievement Medal in 2000 for his work on agent-based computing. Based on his achievements and contributions to agent community, we include him as a well-know researcher in this field.

Dr. Michael Wooldridge

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Justification

Dr. Michael Wooldridge is a Professor and Head of the Department of Computer Science at the University of Liverpool, England. In addition he is the head of the Agent Applications, Research, and Technology group (Agent ART), which carries out both pure and applied research in the area of autonomous agents and multi-agent systems. He has published over a hundred articles in the theory and practice of agent-based systems, and has published ten books in the area.

His main interest is in the use of formal methods of specifying and reasoning about multi-agent systems. Other interests and research of Dr. Wooldridge includes agent-oriented software engineering and negotiation. We have explained his work on 'negotiation parameters' extensively in Chapter 5. He proposed a generalizing method for negotiation space that would enable a common protocol for any negotiation agents or so to speak any negotiation system. He also works closely with 'Foundation for Intelligent Physical Agents' to brining common communication languages between autonomous agents, focusing on the semantic aspects of the content passed between agents. This is part of his research on problems associated with KQML and ACL that we explained in detail in Chapter 4. For his achievements and contributions to the several areas in AI and in particular multi-agent reasoning and negotiation strategies, we justify him as a well-known researcher in our area.

Dr. Hyacinth S. Nwana

Intelligent Systems Research
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Justification

Hyacinth S. Nwana is a principal research scientist and a technical group leader in the Applied Research and Technology (ART) department at Adastral Park, London. His specialization in Artificial Intelligence led him to work explicitly on Software Agents. In 1991, he won the DEC European AI prize. In 1997, he led British Telecom agents-based project (ABW-ZEUS) which won the prestigious British Computer Society top award for innovation. He is a member of the British Computer Society and a Chartered Engineer. He currently runs the Future Technologies group investigating novel biologically motivated computing models, software agents, believable interface agents, cognitive systems, and the application of such techniques to telecommunications and other computing problems.

Hyacinth's paper on 'Software Agents: An Overview. 1996' made him a well known and a well-respected researcher in the Agent Community. We have marked his paper as milestone paper in the bibliography (paper number 42). He has published several other important papers in conjunction with Dr. Jennings and Dr. Wooldridge, another two pioneers in Agent research.

Dr. Carles Sierra

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Justification

Dr. Carles Sierra is a researcher at the Artificial Intelligence Research Institute (IIIA) of University of Barcelona. He is the president of the Catalan Artificial Intelligence Society (ACIA). His research area is mainly in Artificial Intelligence in Medicines. He has been leading the development of applications of the medical domains for the three last years. He has been working on Common-Acquired pneumonia, of medical science.

There is a series of medical topics he is interested in and working with several physicians to implement the system. He is well known for the literatures he has published in negotiating agents. Accompanied with Dr. Jennings and Wooldridge he has published dozens of papers on negotiating agents. He is a reviewer of several AI journals. He is very famous for his work on Knowledge systems such as MILORD that is being used in several Medical and Industrial monitoring. He a prominent researcher in Formal semantics based on Dynamic logics, temporal reasoning and multi-agent system. His contributions in terms of theoretical and practical work justifies us to note him as a good researcher.

Dr. Walid Saba

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Justification

Dr. Walid S. Saba is a young motivated professor at the University of Windsor who is interested in not only linguistic models but also in agents in e-commerce. Within two years of his career as a professor, in his research, he has published about twenty papers in famous journals such as Studia Logica, Springer verlag, IEEE and AAAI. He has been invited to many conferences in his research field to give a speech on his distinguished work of Agent Negotiation in a Virtual Marketplace. Before he joined University of Windsor he was working in IBM, AT&T Bell Labs and Cognos. His main research interests include commonsense reasoning, natural language understanding and intelligent agents.

Although Dr. Saba is not famous as the others we have mentioned above, given five years he will bring in a break through in linguistic models as well as e-commerce through the system he has been working on, called DALIA (an environment for Distributed, Artificial and Linguistically component Intelligent Agents). With many thanks to him for the motivation he has given to all his students, predicting his success in his research area, we conclude Dr. Saba to be a famous researcher in the near future.

Appendix D

List of Forthcoming Conferences

Please note that among many other factors, interested-topics of a conference is *primarily* taken into consideration in scoring a conference. In our case, it is ‘Agent negotiation in e-commerce’.

[1]

Title: The Fifth International Conference on Electronic Commerce Research (ICERC 5).

Location: Montreal, Canada

Program Committee:
Professor Karl Aberer (Chair), EPFL, Switzerland
Professor Benoit Aubert, HEC - Montréal, Canada
Dr. Jörn Altmann, Hewlett-Packard Laboratories, USA
Professor Philipp Afèche, Northwestern University, USA
Professor Kemal Altinkemer, Purdue University, USA

Sponsor: Cox School of Business, Southern Methodist University, CRT - Centre for Research on Transportation, U of Montreal, ATSMA, HEC - Montreal Canada.

Some Topics: Electronic market design, Economic models, Game theory, Combinatorial auctions and market design, Global E-commerce, Government electronic services, E-contracts.

Important Dates:
Deadline for paper (extended abstract) submission: May 15th, 2002
Deadline for panel and session proposals: May 15th, 2002
Deadline for acceptance notification: July 1st, 2002
Deadline for early registration: July 31st, 2002
Deadline for final manuscripts and panel and session descriptions: September 15th, 2002
Conference: October 23-27, 2002

SCORE: **4 / 5**

<u>Justification</u>

The chair of the committee, Professor Karl Aberer from Switzerland and Professor Benoit Aubert, from Montréal are well known researchers in the field of Electronic

Commerce. Their presents as well as some of the topics to be presented in the conference such as Electronic market design, Economic models, Game theory and E-contracts makes this conference a worthwhile one to be in. Moreover, analyzing the topics and the sponsors we could see that this conference is highly concerned with solutions for everyday practical issues.

Location of the conference, time intervals provided for the paper submission and the conference date are some other factors that makes this conference a good one. As this conference is in Montreal and the entrance fee is only two hundred dollars, virtually anyone in North America can attend without any hesitant. Besides the traveling and entrance cost, there is a four month gap between initial submission of the paper and final conference date. This would enable the guest speakers to give a very organized and clear presentation during the conference. Although it is an ideal conference that any graduate student can attend, it doesn’t include many other topics that are very closer to my research topic. For this reason I have given only 4 (fourth one in the list) out of 5 for this conference.

[2]

Title: The Third International Workshop on AGENT-ORIENTED SOFTWARE ENGINEERING (AOSE-2002)

Location: Palazzo Re Enzo, Bologna, Italy

Program committee:
Professor Nicholas Jennings (UK)(Chair), Dr. Bernard Bauer (Germany), Professor Federico Bergenti (Italy), Professor Scott DeLoach (USA), Professor Marie-Pierre Gervais (France), Dr. Paolo Giorgini (Italy), Dr. Olivier Gutknecht (France), Professor Michael Huhns (USA).

Sponsor: The ACM Special Interest Group for Artificial Intelligence (SIGART) and the International Foundation for Multi-Agent Systems (IFMAS)

Some topics: Methodologies for agent-oriented analysis and design
Relationship of AOSE to other SE paradigms (e.g., OO)
UML and agent systems
Agent-oriented requirements analysis and specification
Refinement and synthesis techniques for agent-based specifications
Verification and validation techniques for agent-based systems
Software development environments and CASE tools for AOSE
Standard APIs for agent programming
Formal methods for agent-oriented systems, including specification and verification logics
Model checking for agent-oriented systems
Engineering large-scale agent systems
Experiences with field-tested agent systems
System deployment using standards such as FIPA, JASS
Best practice in agent-oriented development
Market and other economic models in agent systems engineering

Important Dates:
Submissions due - Monday 22 April 2002
Notifications sent - Monday 27 May 2002
Workshop date - Monday or Tuesday15 or 16 July 2002

SCORE: **3.5 / 5**

<u>Justification</u>

Dr. Jennings, the chair of this conference is a pioneer in agent technology. He is a very well known person in Artificial Intelligence community. Although his presence makes this conference somewhat appealing, the interested topics are not very wide in terms of

Electronic Commerce or Negotiation. Nonetheless, this is a good conference for the people who are interested in engendering or design of agents.

Italy may be a nice place for vacation but for educational purpose a student in Canada may find it very expensive. Location of the conference suggests me that this conference is aimed at a narrow audience, not for wide rang of researchers. For the above reasons I have given only 3.5 (last one in the list) out of 5 for this conference.

[3]

Title: Sixth International Workshop CIA-2002 on COOPERATIVE INFORMATION AGENTS (Intelligent Agents for the Internet and Web)

Location: Universidad Rey Juan Carlos, Madrid, Spain

Program committee:
Dr. Matthias Klusch, Sascha Ossowski (Universitat de Rey Juan Carlos in Madrid, Spain), Onn Shehory (IBM Research Center Haifa, Israel), Wolfgang Benn (TU Chemnitz, Germany), Federico Bergenti (University of Parma, Italy), Sonia Bergamaschi (University of Modena, Italy), Cristiano Castelfranchi (NRC Rome, Italy), Brahim Chaib-draa (Laval University, Canada), Rose Dieng (INRIA, France).

Sponsor: ACM Association for Computing Machinery SIGCOMM

Some topics: Rational Information Agents for Electronic Commerce: Models of economic rationality and trust for e-commerce. Privacy of communication, security, and jurisdiction for agent-mediated trading.
Systems and Applications of Information Agents: Architectures, prototypes and fielded systems of information agents.
Issues of programming information agents: Agent-Based Knowledge Discovery and the Semantic Web. Application of techniques of knowledge discovery for agents acting in open, distributed and dynamically changing environments. Information agents for the Semantic Web (thorough technology surveys, applications)
Mobile Information Agents: Applications of mobile information agents, Prototypes, experiments, studies, and experiences. Intelligent Interfaces for Information Agents.
Advanced user-profiling for collaborative information agents.
Self-organizing information agents.
Computation and reasoning of information agents with limited resources and under uncertainty.

Important Dates:
Submission of Papers: April 24, 2002
Notification about Acceptance: June 3, 2002
Workshop Start: September 18, 2002

SCORE: **4.3 / 5**

<u>Justification</u>

The chair of the committee, Dr. Matthias Klusch from Spain is a well-known researcher in the field of Cooperative Information Agents. His presents as well as some of the topics to be presented in the conference such as Rational Information Agents for Electronic Commerce, Issues of programming information agents and Computation and reasoning of information agents makes this conference a good one. Moreover, from my experience I have seen that papers published in this conference were very helpful during my research. They were clear, precise and well presented with enough empirical information. This gives me one more reason to say ‘it is a good conference’.

Although Spain is far away and it could be costly to go for a conference, the topics and the invited guest speakers of the conference suggests that it will be a good conference. So, I have given only 4.3 (third one in the list) out of 5 for this conference.

[4]

Title: AAAI-2002 Workshop on Agent-Based Technologies for B2B Electronic Commerce.

Location: Edmonton, Alberta, Canada

Program committee:

M. Brian BlakeGeorgetown. University and The MITRE Corporation, Fahim Akhter, Zayed University, Christoph Bussler, Oracle Corporation, Monique Calisti , Swiss Federal Institute of Technology, Maria Gini, University of Minnesota, Hassan Gomaa, George Mason University, Zakaria Maamar, Zayed University.

Sponsor: American Association for Artificial Intelligence.

Some topics: Modeling, designing, and developing software agents-oriented workflow for B2B interoperability .
Agent-based coordination and communication languages for electronic markets.
Software agent architectures for B2B coordination.
Industrial applications using agents in B2B settings.
Agent-based B2B Applications for the integration of e-markets.
Agent-based domain-enhanced search and discovery.

Important Date:

Manuscripts DUE: March 15, 2002
Author Notifications: April 20, 2002
Camera-ready Papers Due: May 3, 2002
AAAI-Workshop on AgentB2B: July 28, 2002

SCORE: **4.6 / 5**

Justification

The researchers and the organizations involved in this conference speak for it-self. They are all highly committed on today's practical problems and to bring in better solution for future generation. Some of the big vendors and famous researches are getting together in this conference to address several serious issues that we have in modeling, designing, and developing software agents and their workflow in interoperability. Moreover there will be some other important issues presented in this conference like Agent based coordination and communication, Industrial application of B2B e-commerce and Agent based search and discovery. From my experience, without hesitant I can say that papers published in this conference were very helpful during my research. They were clear, precise and well presented with enough empirical information.

Location of the conference, time intervals provided for the paper submission and the conference date are some other factors that makes this conference an excellent one. As this conference is in Alberta and the entrance fee is only few hundred dollars, virtually anyone in North America can attend without any hesitant. Besides the traveling and entrance cost, there is more than four month gap between initial submission of the paper and final conference date. This would enable the guest speakers to give a very organized and clear presentation during the conference. This is an ideal conference that any graduate student can attend; it includes many other topics that are very closer to my research topic. For the above reasons I have given 4.6 (first one in the list) out of 5 for this conference.

[5]

Title: AAAI-02 Workshop on Meaning Negotiation (MeaN-02) *held in conjunction with* Eighteenth National Conference on Artificial Intelligence.

Location: Edmonton, Alberta, Canada.

Program committee:

Paolo Bouquet (Chair)
Vrije University of Trento

Deborah McGuinness
Stanford University

John Mylopoulos
University of Toronto (Canada)

Sponsor: American Association for Artificial Intelligence.

Some topics: Formal, computational, game-theoretic, cognitive, epistemological, social models of MN; multi-agent communication languages and protocols; role of mental attitudes (e.g., beliefs, intentions); semantic interoperability; ontology integration/mapping; integration/matching of structured and semi-structured data; context-based approaches to MN; natural language processing techniques for MN; coordination/cooperation strategies for MN; innovative scenarios for MN (e.g., Semantic Web, Knowledge Management, E-business, Marketplaces, Personal Digital Assistants, mobile applications).

Important Date:

Deadline for WS submissions: March, 15, 2002
Notification of acceptance to authors: April 26, 2002
Deadline for camera-ready workshop: May 12, 2002
Workshop on Meaning Negotiation: July, 28, 2002

SCORE: 4.5 / 5

<u>Justification</u>

The researchers involved in this conference are highly committed to find solutions for practical problems. Main topics of this conference are Cognitive science, epistemic logical, multi-agent communication languages and protocols, role of mental attitudes (e.g., beliefs, intentions); Ontology, E-business, Marketplaces and Personal Digital Assistant. This conference papers are also well written and helped me a lot in during my research.

Location of the conference, time intervals provided for the paper submission and the conference date are some other factors that makes this conference an excellent one. As this conference is in Alberta and the entrance fee is only few hundred dollars, virtually anyone in North America can attend without any hesitant. Besides the traveling and entrance cost, there is more than four month gap between initial submission of the paper and final conference date. This would enable the guest speakers to give a very organized and clear presentation during the conference. This is an ideal conference for those who are in the several area of AI research and any graduate students in AI. Although this conference includes several issues related to my thesis work, for example E-business, Ontology, BDI agents and Marketplaces, I wouldn't rate this as the best conference in my list because it doesn't cover the most important area of my research. Nonetheless, this is a very good conference too. I have given 4.5 (second one in the list) out of 5 for this conference.

[6]

Title: 3rd International Symposium on Multi-Agent Systems, Large Complex Systems, and E-Businesses (MALCEB'2002)

Location: Erfurt/Thuringia, Germany

Program committee:
Prof. H. Tianfield, Glasgow Caledonian University
Prof. Dr. H. Czap, Universitat Trier
Prof. R. Unland, University of Essen

Sponsor: GI: Gesellschaft fur Informatik, and Sun Microsystems.

Some topics: Intelligent/mobile/autonomous agents
Economics principles for multi-agent systems
Multi-agent communication, co-ordination, and collaboration
Multi-agent systems organisation (macro versus micro centralisation and decentralisation)
Organisational principles for multi-agent systems
Federated/cooperative information/data bases
Federated/cooperative decision-making
Federated/co-operative computing
Social/organisational learning, social computing
Organisation, architectures and modes of CSCW, groupware
Co-operation and competition
Game theory
E-enterprise
Agents - virtual communities agents
Agents - virtual office

Important Date:
Submission of formatted manuscripts: June 30, 2002 (24:00 o'clock GMT)
Notification of acceptance/rejection: July 30, 2002
Completed registrations and final papers: August 30, 2002
MALCEB'2002 Symposium: 8-10 October 2002

SCORE: **3.8 / 5**

<u>Justification</u>

This conference is mostly concerned with agent technology. Main topics of this conference are Multi-agent communication, cooperative decision-making, Cooperation and competition dialogues of agents and E-enterprise. Many papers from this conference helped me understand agent technology during my research.

Although Germany is far away and it could be costly to go for a conference, the topics and the invited guest speakers of the conference suggests that it will be a good conference. This is an ideal conference for those who are in the agent technology field. For the reasons mentioned above I am giving 3.8 (fifth on in the list) out of 5 for this conference.