Chapter 1

Introduction

Today’s companies increasingly use Internet as a common communication medium for commercial transactions. Global connectivity and reach of Internet means that companies face increasing competition from different quarters. This also means companies must optimize, the way they do business, change their business processes and introduce new business processes. This has opened up new research issues and electronic or automated negotiation is one such area. The increased computing and networking power enabled through the Internet has provided new flexibility in designing negotiations while at the same time findings in computer science and information systems have fed back into models and procedures of negotiations. These studies have contributed to the development of negotiation support systems (NSS), software agents for negotiations and on-line electronic platforms for bidding and auctioning. A few companies have tried to introduce electronic auctions for procurement and trade negotiations. Most of the current business-to-business or business-to-consumer electronic commerce systems provide only limited support for automated negotiations. Negotiation is the process by which buyers and sellers in the marketplace arrive at a common agreement. However, electronic negotiations continue to evolve with new strategies and approaches. In this chapter we study the different types of electronic negotiations and auction mechanisms.

1.1 Negotiations and Bargaining

A commercial transaction between a buyer and a seller involves the exchange of goods or services and payment instruments/tokens. In this transaction the goods are transferred to the buyer or the buyer avails of the services. Economists have tried to build up models describing consumer buying behavior. The model of consumer behavior states that a commercial transaction consists of finite number of interactions between the business entities. These activities are classified into different phases.

Information Gathering Phase: In this phase, buyer obtains information about the required products. Information about vendors supplying the products and prices is also collected. In this phase the buyer tries to match his requirements with the available
products. In the electronic commerce environment, this information is collected by browsing different websites.

Intention Phase: In this phase the details of demand and supply are fixed. In this phase usually the buyer informs the seller that he intends to enter into the transaction with seller.

Agreement Phase: In this phase buyers and sellers discuss terms and conditions of the transactions. This phase is also called as Negotiation Phase. This phase can terminate either in an agreement or in abandonment of the process. In the retail transactions this phase will involve bargaining for prices. In business to business transaction it may be much more complex.

Execution Phase: In this phase the transaction is executed as per the agreed terms and conditions. In this phase both the parties fulfill their respective commitments. The seller supplies the goods or services and the buyer pays for them.

In another model of consumer behavior three phases namely information phase, negotiation phase (combining intention phase and agreement phase) and execution phase are being considered [M1995]. In another model six phases namely Need Identification, Product Brokering, Merchant Brokering, Negotiation, Purchase and Delivery, Product Service and Evaluation [GMM1998] are discussed. Even though there are different models of consumer behavior there is a general agreement about what is meant by Negotiation Phase. It is generally agreed that in negotiation phase, the terms and conditions of transactions are agreed upon between the buyers and sellers. In other words, negotiation can be described as a process through which the buyer attempts to get the optimum deal (including the price and other related attributes like delivery date) for the goods and services that he is likely to purchase. The negotiations are common occurrence in any commercial transaction.

The term negotiation is almost used interchangeably with bargaining; however the term “negotiation” is also used in a broader sense. Negotiation or bargaining is also studied in Economic Theory. The term bargaining is used to refer to a situation where the following possibilities exist.

1. Individuals have possibility of concluding a mutually beneficial agreement
2. There is a conflict of interest about which agreement to conclude
(3) No agreement may be imposed on any individual without his consent. The term negotiation is used in a much wider sense. It is the term used even though the parties involved in a negotiation process may not be involved in any commercial transaction. The negotiation between the union and management of a company for wages, between different countries on social and economic issues are examples of this. However, in any negotiation process the parties involved can reach a mutually beneficial agreement on the issues on which they differ.

1.2 Why Negotiations Take Place
The negotiation phase is a common occurrence in commercial transactions because this phase provides buyer and seller with price discovery mechanism. The dependence of the parties is one of the important conditions for negotiations. If one party is totally dependent on the other party, there will not be any negotiation. The dependent party can only react to the moves of the other party. As an example, the relationship between the company and its employee can be considered. A company can decide that it no longer needs the services of an employee and lay him off. In such a case there cannot be any negotiations. However, if the union of employees decides to fight for the employee’s job, the situation will change. This is due to the fact that the company is dependent on the union. In case of buyer seller transaction the buyer will be willing to negotiate because he may gain a better deal. In other words the negotiation takes place when both parties discover the potential for gain. This phase can help the buyer to prepare an offer tailored to individual needs. It can help him to avoid the risk of fixing price and provide the market determined price. This is especially true in the following cases.

(1) Non standard transactions
(2) New products where demand is unknown
(3) Where supply is unknown
(4) Perishable items/transactions like airline tickets
(5) Different product mix required
(6) Unknown value for goods
(7) Dynamic markets
(8) Availability of price based comparison (agents which help in shopping)
(9) Special offers with focus on long term relationships
The electronic markets have distinct features like low search costs. In the electronic markets search costs are low. Buyers are better informed about the product and prices. It is very easy for the buyer to visit a few websites and compare the prices. Such markets do not show any regional, personal or product specific preferences. They are characterized by high degree of transparency. However, these markets also require features like product differentiation, price discrimination and buyer accumulation strategies. These features can give rise to more negotiated agreements than in traditional markets. The characteristics of these markets will also have impact on the negotiation process [S1999ACM],[S1999AAAI]. Online auctions mainly benefit from the features of electronic markets. So there are many successful online Auction Sites. This means that there may be more sites supporting negotiations based on bidding. However bidding based negotiations protocols cannot support the integrative or win-win negotiations. The support to these types of negotiations is necessary in electronic commerce environment. In these cases the integrative negotiation protocols must be used. Though there are not many protocols of integrative negotiation in electronic markets at present they will be required in future to provide negotiation support in electronic markets [S1999ACM]. So both types of negotiation mechanisms will exist in these markets.

1.3 Types of Negotiations
The negotiation process can be classified according to the number of participants and attributes. The different types of negotiations are as follows.

One to One Negotiation: In this type of negotiation only two parties are involved. The simple case of this type of negotiation is where the parties involved have symmetric preferences i.e. the gain of one party is loss of the other. The negotiation for price of goods for sale between the buyer and seller represents this type of negotiation.

Many to One Negotiation: In this type of negotiation one party (say buyer) negotiates with many parties (say number of sellers) at the same time. Auctions are one example of these types of negotiations. These types of negotiations can be analyzed as a number of concurrent one to one negotiations.

Many to Many Negotiations: In this type of negotiations many parties (say many buyers) negotiate with many parties (say sellers) at the same time. In this case if there
are \( n \) parties involved in the negotiation process, then there will be \( n(n-1)/2 \) simultaneous ongoing processes. These types of negotiations are hard to analyze.

Single Attribute Negotiations: In this case there is only one attribute that is involved in the negotiation process. Transactions, where buyers and sellers negotiate over the price of goods for sale, are examples for this. These types of negotiations, where one party looses while other gains, are also called as win-loose negotiations. These types of negotiations are also referred to as integrative negotiations.

Multi Attribute Negotiations: In this case, the negotiation process involves more than one attribute. The sale of car (attributes year, color, type, price etc.) is an example of this type of negotiation. In this case it is difficult to define what exactly constitutes the gain for the parties involved. In these cases a party may concede on one attribute but may gain in other attribute. Such negotiations are also referred to as distributive negotiations. In this case it is possible that no party looses in the process of negotiation. These type of negotiations are also referred to as win-all or no-win negotiations.

Combined Negotiations: These types of negotiations refer to those where the buyer negotiates for a number of interdependent items. Suppose that a customer is interested in visiting certain places. He needs to find the most optimum tour package consisting of travel tickets, hotel rooms and site tours. In this case the customer can separately negotiate with different agencies to arrive at the package. However the entities are interdependent. The customer must get the travel tickets on the days on which hotel rooms are available and site tours are available. Unless these constraints are satisfied it will not be possible for the customer to undertake the journey. These types of negotiations where all the negotiations are carried out at the same time and the interdependency is maintained are called combined negotiations [BAVK2001] and [BK2000].

In many cases, the negotiation process between two entities can give rise to a number of different negotiation processes. In a commercial transaction where terms and conditions of a large order are negotiated, it is possible that the process generates many different negotiation processes e.g., an international transaction between companies can give rise to a negotiation process with number of banks for issuing a Letter of Credit (LC), in case the LC is insisted upon by one company. This differs from the combined
negotiation in the sense that the customer does not negotiate with different entities at the same time, but other entity involved in the process initiates the negotiation process.

Service Oriented Negotiations: Another class of negotiations that has been studied in the field of Distributed Artificial Intelligence (DAI) and Multi Agents System (MA) [BG1988] are called as Service Oriented Negotiations. This class of negotiation has been studied in the context of multi agents systems. An agent is a software or hardware or combination of software and hardware like robots, which carry out certain tasks for the user. The agents are autonomous and the user does not have control over how agent executes the assigned task. The user gives only the task to be carried out to the agent. In this case it is assumed that the agents have limited resources to carry out the tasks. The agent requires services or resources from others to complete its task. Negotiation provides the mechanism for managing the interaction between these agents. These agents negotiate among themselves and arrive at mutually acceptable solution. The examples of such cases are illustrated in [CML1988] and [BG1988].

Resource Allocation and Task Distributions: A set of agents share a common resource [CML1988]. The resource can be communication lines, printers, disks etc. Only one agent can use this common resource at a time. The other agents have to wait till the resource is free. The set of agents negotiate among with each other and decide how the resource is to be allocated. The agreement or allocation of resource can be a schedule that divides the usage of resources among the agents. In this problem there can be competition among the agents in the sense that each agent may seek larger share of the resource. In the task distribution problem agents are required to carry out many tasks to fulfill the goal. In this case the common goal is achieved by distributing the tasks among the agents. The agents negotiate with each other and come to a mutually beneficial agreement. The agreement will be the list of tasks and agents responsible for the tasks. The example of task distribution problem is the delivery domain [W1992]. In this domain suppose that two agents each have to deliver the message to A and B. In this case the agents can distribute the tasks in such a way that one agent delivers all the messages to A and other delivers all the messages to B. It can be seen that in this case the additional messages can be delivered at no extra cost. Both of these problems are symmetric in nature. The agents have to reach an agreement to achieve the tasks. This
approach is very useful in designing the negotiation support systems in Electronic Commerce.

1.4 Negotiations in Electronic Commerce Using Different Types of Auctions
In the electronic commerce environment, auction based protocols are commonly used. It provides an easy and convenient mechanism for getting the market determined price, which is the main purpose of negotiation phase. It helps the sellers and buyers to determine the price of the transaction. In auctions the major phases are announcement of auction, opening of an auction, advertisement of offer and matching of bids to determine the winner. In auctions the negotiations occur through a sequence of bids. The process of submitting bids is continued till the auction is terminated. In this process price is the only attribute that is negotiated. There is a concept of reservation price in auctions. This price represents the minimum price in the auction.

However auctions still do not provide mechanisms for handling special and customized products, special packages or cases where more than one attributes are to be compared. In cases where more than one attribute is to be compared then it may be difficult to determine the winner. Let us suppose that a buyer sends the proposal to the seller that he is ready to buy 10 units of a product at the price of Rs. 10. The seller may send a counter proposal that he is willing to sell 20 units at that price. In such a situation it is difficult to determine the winners. In the same way auctions do not support situations like online touring plans, which include travel tickets to different destinations and hotel accommodations on different dates.

1.5 Electronic Auctions
It can be seen from the above discussion that electronic commerce systems must support both bidding type (auction based) and bargaining type of negotiations. Internet and electronic commerce have blurred the difference between auction and negotiation mechanisms. This new media provides new opportunities and mechanisms to cooperate or to compete, taking advantage of computing power and global connectivity of Internet. It has been further helped by the fact that millions of people and businesses are online simultaneously. The difference between auctions and negotiations gets blurred in the presence of two and more issues. This raises the possibility of using utility as a measure of offers and other mechanisms that have been traditionally used in negotiations (simultaneous improvements, efficiency analysis, etc.). Negotiation is a
subject that has for years been thoroughly studied in the behavioral sciences. The literature concerned with negotiations does not mention auctions as a particular type of negotiations. Indeed, some economists [R1995] view bargaining as precisely the opposite of the idealized “perfect competition” that is presumed to form the basis of market models, recognizing the importance of persuasion and other human factors in determining the nature of the process and the outcomes. The Internet and electronic commerce has generated renewed interest in electronic marketplaces and auction systems, both as dynamic mechanisms to sell items to individuals and as systems for business to business transactions. A discussion on the different types of auctions in electronic commerce can be found in the book on Electronic Commerce [B2002]. If the negotiating parties can reduce the scope of negotiation to only price negotiations, then auctions provide an efficient mechanism for price discovery.

However electronic auctions (e-auctions) provide efficient mechanism to implement one to many and many to many types of negotiation systems. These auctions also provide framework for automated negotiations in retail electronic commerce settings. In last few years there has been growing interest in Internet based market places. Ebay, uBid etc. are some of the successful Internet sites, which use auction mechanism in their operations. Internet based auction companies carry out large number of auctions every day. The success of on-line auction sites like [www.ebay.com](http://www.ebay.com), [www.ubid.com](http://www.ubid.com), [www.yahoo.com](http://www.yahoo.com), [www.freemarkets.com](http://www.freemarkets.com), [www.onsale.com](http://www.onsale.com), [www.bazee.com](http://www.bazee.com) etc. (the list is not exhaustive) have contributed to a large extent to recent studies and development in electronic auctions. Many retailers have online consumer auctions (e.g. [www.onsale.com](http://www.onsale.com)) and auction based systems are being used for procurement in supply chain (e.g. www.freemarkets.com). The growth of private electronic market places based on EXTRANET technology ([www.covisint.com](http://www.covisint.com)) have opened up new vistas for automation of negotiation processes with the promise of higher levels of efficiency, effectiveness and quality and faster emergence of agreements in complex industrial procurement scenarios. Different types of electronic procurement systems are common examples of a scenario, where one to many or many to many type of negotiation systems are required. Different types of activities like providing services, task allocation etc. can be carried out efficiently using different types of bidding
mechanisms. The process of auction and negotiation described above are almost similar. Electronic auctions have emerged as an important Internet-based tool for many business to business applications. General Electric (GE) has adopted electronic auctions for most of its procurement operations. It has conducted transactions worth 6 billion USD in the year 2000 alone [GEC2000]. This has led to the Internet Week magazine awarding the title “E-Business of year 2000” to GE. It has been estimated by Forrester Research that in the year 2004, online business to business trade in electronic marketplaces (i.e. auctions and exchanges) in USA alone was more than 10% of total business to business trade. In terms of values it will be over USD 1000 Billions in 2004. Many multi national corporations and government organizations have either used or in the process of using auction based protocols for procurement, selling of public assets, leasing rights of natural resources, bandwidth allocation and other operations. There are a few case studies about successful deployment of electronic auctions in procurement which can be found in [EK2003], [GIT2002],[HRNRDKLA2003] and [LOPST2002]. In an electronic commerce environment the objects to be auctioned need not always be homogenous, this can give rise to different types of assignment constraints. Hence in further discussion we restrict our scope to electronic auctions.

Auctions: Auction based protocols are widely used in electronic commerce. An auction is basically a bidding mechanism, which is specified by a set of winner determination and payment obligation rules. These rules specify how the winner is determined from the set of competing bids and how much the winner has to pay. Auctions have been in use for many years. They are used for sale of variety of objects. These objects range from bonds of public utilities to perishable items like flowers. Governments of different countries use auction mechanism to sell long-term securities, treasury bonds and treasury bills to raise funds to meet their borrowing needs. Private companies use auction mechanism to sell different types of products like flowers, food grains, diamonds etc. In every day life, auction accounts for enormous volume of trade transactions. Auctions also provide useful mechanisms for resource allocation problems with autonomous and self interested agents, respecting the autonomy and information decentralizations in open systems. Such applications range from distributed task
allocation, to procurement in supply chain, to multi agents scheduling problems. The typical characteristics of such problems are local problems of agents and multiple conflicting goals. Auctions can minimize communication within a system and generate optimal or near optimal solutions that maximize the sum of value over all agents. Different auction mechanisms differ basically with respect to winner determination and payment rules. Similar mechanisms are used by public sector utilities to sell their bonds and raise money. The process of procurement using competitive bidding is another form of auction. In this case the bidders compete for right to sell their products or services. The private and state owned enterprises use different types of bidding mechanisms for procurement of variety of products like computer stationery and this practice is fairly wide spread.

It is also being used to dispose of waste and scrap materials. The rights to use material resources from public property such as mining rights, off-shore oil leases have been sold by means of auctions in different countries. Communication companies use similar mechanisms for bandwidth allocation. In real life, large numbers of transactions are carried out using different types of auction mechanisms. Auctions are helpful to seller, as they help them to avoid the risk of determining the price of an object. Auctions provide mechanism where the price is determined by others rather than by seller himself. However the seller can decide whether to accept the bids received or not.

Auctions are used mainly for the following three reasons.

- Auction helps in obtaining/revealing information about buyer’s valuations
- Auctions are also helpful to avoid dishonest dealing between buyers and sellers
- They provide speed of sale

Traditionally auctions like ascending price (English), descending price (Dutch) or Sealed bid auctions were earlier used in different economic transactions. Emergence of Internet based electronic markets in the last few years has contributed significantly to the growth of different types of auction transactions. This has resulted in significant increase in number of transactions that are being carried out using different types of auction mechanisms on the Internet. Present day electronic auctions support novel
applications like electronic procurement, bidding on air ticket etc. Different companies use electronic bidding to get market determined prices for their goods. Internet based auction companies have implemented many different types of auction mechanisms, apart from the traditional auctions like English, Dutch and Sealed Bid. Auction based protocols have been widely used in electronic commerce. Auction mechanisms are widely used in electronic commerce for carrying out negotiations.

One of the most important uses of this mechanism is to facilitate the transfer of assets from public to private hands. This has been a common phenomenon in different countries in the last two decades as a result of economic liberalization. Governments in countries like Britain and Scandinavia have used auctions to privatize transportation systems. In the former Soviet Union and Eastern European countries auctions have been used to sell public owned industrial enterprises. Auctions are being used for many years to acquire rights of use of natural resources. Such types of auctions, where government grants access rights to use natural resources or transfers the ownership of its enterprises can be considered as examples of forward and reverse auctions. When government is transferring public owned enterprise, it may be interested in seeing that ownership is distributed appropriately and not a single person or an enterprise gets ownership beyond certain percentage. While granting access to natural resources it may be interested to see that not a single person or a private enterprise acquires complete control. This can give rise to different types of constraints, while determining the winner.

1.6 Types of Auctions
Auctions can also be considered as a mechanism to allocate a set of goods to a set of bidders on the basis of received bids and asks. In a classical auction, the auctioneer wants to allocate a single object to a buyer among a group of bidders.

Classical Auctions: There are four classical auctions described in economic literature. They are (1) English or British Auction (2) Dutch Auction (3) First Price Sealed Bid Auction and (4) Second Price Sealed Bid Auction. Out of these first the two are multi round auctions, whereas others are single shot mechanisms.
(1) English Auction: This auction is also called as first price or ascending price auction. In this auction each bidder submits his bid. The winning bid is the highest price bid. The winner pays that price or the highest price.

(2) Dutch Auction: This auction is also known as descending price auction. The winning bid is the lowest price bid and the winner pays the lowest price. This type of auction is initiated by seller. The seller starts auction by setting initial price. The price is lowered continuously till some buyer accepts the price. The buyer who accepts the price is the winner and pays that price.

(3) First Price Sealed Bid Auction : This auction is similar to English auction. However the bids by other buyers are not known. The buyer knows only his bid. The winning bid is the highest price bid and the same price is paid.

(4) Second Price Sealed Bid Auction : This auction is similar to First price Sealed Bid Auction. The buyer with the highest price bid is the winner. However he pays the price of the second highest bid. This auction is also known as Vickrey auction. It has been proved by Vickrey that second highest price is closer to true valuation.

The above four auction formats viz., English (ascending bid), Dutch (descending bid), simultaneous (sealed bid), Vickrey (second price) are most widely discussed and studied. Even today most of the online auctions are simple variations of these four basic auction types. There are a large number of well-known intermediaries conducting different variations of these auctions. The most common examples are Ebay, Amazon and OnSale. The most important and appealing features of auctions from a theoretical standpoint are their process efficiency and the ability to simultaneously manage large numbers of bidders. However, from a user’s standpoint, the game-like aspects are often the dominant factor. Since auctions are primarily concerned with the establishment of value, most auctions focus on a single issue viz., price. The auction floors or clearing houses do not allow for the introduction and discussion about other issues than the one on the table. While the number of options and offers need not be fixed, the participants cannot add offers that are not defined by the issues (outside of the space defined by the auctioneer). Single-issue auctions are based on a fixed pie assumption and are thus
distributive. Even if the participants have several objectives these objectives cannot be
taken into account. Each participant may (and often does) have different objectives and
explicit consideration of these, if possible, would move an auction to a series of
bilateral negotiations. It has been convincingly argued in [S1992] that, “Real
auctions—in contrast to theoretical models—are not exclusively or even primarily
exchange processes. They are rather processes for managing the ambiguity and
uncertainty of value by establishing social meanings and consensus.” Auctions focus on
determining the value of objects of unknown value while negotiations are about co-
operating to create value. Auctions deal with known and well defined objects while
negotiations may be about defining these objects and collaborating in order to obtain a
common definition. Auctions are solely focused on the outcomes. The communication
process is thus oriented on the achievement of an efficient outcome (compromise)
through a low-cost process. However, auctions do not assure an efficient (Pareto-
optimal) outcome. They are oriented towards increasing competition, with the
participants not revealing their objectives and preferences. Since the outcome efficiency
is defined with objectives and preferences (utility), it is possible that the result is
inefficient. Auctions do not force the participants to reveal any information other than
bids. If these bids fully reflect utility of the bidders, then the outcome is efficient. This
is the case of single-issue negotiations with the only objective of all the parties being
the negotiated issue. Multi-issue auctions cannot assure efficiency unless there are
mechanisms that force the participants to reveal their utility. Single-issue auctions do
not provide satisfactory mechanism for most business transactions. Therefore efforts
are being made to extend the four basic auction formats.

Other Auctions: There are many variations of these classical auctions, which have been
described in literature.

1. K\textsuperscript{th} Price Auction: This auction works in the same way as Second Price Sealed
Bid Auction. However the winner pays the price of k\textsuperscript{th} highest bid. This type of
auction is basically generalization of Second Price Sealed Bid Auction.

2. Multi Unit Auctions: In the classical auctions seller has a single unit of object
or an item for sale. In multi unit auctions, seller has more than one item to sell.
In multi unit auctions there may not be a single winner.
(3) Forward Auction: This is a variation of multi unit auction. In forward auction there is a single seller having quantity q of an item to sell and there are n buyers. The object is to maximize the selling price. There may not be a single winner in this case.

(4) Reverse Auction: This is another variation of multi unit auctions. In the reverse auction, there is one buyer who requires quantity q of certain item and there are n sellers who can supply these items. The objective is minimize the cost of purchase.

(5) Combinatorial Auctions: In these auctions a seller has bundle of items to sell instead of single item. The bids are submitted on bundle of objects. The buyers can specify the items they want. In combinatorial auctions there may not be a single winner.

(6) Multi Attribute Auctions: In these auctions, price is not the only decision variable. We need to consider other attributes as well.

(7) Double Auctions: In double auctions there are multiple sellers and buyers. Double sided auctions provide mechanism for clearing markets with multiple buyers and sellers. In double auction markets buyers submit their bids and sellers submit asks. A transaction occurs if the buyer’s bid price exceeds seller’s ask price. Another name for double auctions is exchanges. These are commonly used for trading securities, financial instruments and within supply chain. Two main institutions for double auctions are continuous double auction and a clearing house or continuous call double auction. A continuous double auction is one in which many individual transactions are carried out and trading does not stop. Call markets on the other hand are periodic versions of continuous double auctions, where bids from buyers and asks from sellers are collected over a specified interval of time and the market is cleared at the end of interval. The continuous call double auction is the oldest practiced type of market for exchange of stocks and few other items.

Auctions have evolved and grown far beyond the four classical auctions. A framework for classifying auctions based on requirements has been suggested in [KP2003]. These requirements fall into following six categories.
(1) Resources: An auction involves a set of resources over which negotiation is to be conducted. The resource could be a single item or multiple items, with single unit or multiple units of each item. Another common consideration is the type of the item. It can be standard commodity or multi attribute commodity. In second case non price attributes are required to be specified. A scoring function for trade-off is also required.

(2) Market Structure: An auction provides a mechanism for negotiation between buyers and sellers. There can be different combinations in market like one buyer many sellers, one seller many buyers and many buyers many sellers. Forward auctions, reverse auctions and double auctions characterize these scenarios.

(3) Preference Structure: The preference structure of buyers and sellers (participants - also called as agents) in an auction is an important feature. It has impact on many other factors. The preferences define the utility for different outcomes for participants. In case of multiple units, the participants may indicate a decreasing marginal utility for additional units. The preference structure is important in case of multi attribute auctions for designing scoring rules.

(4) Bid Structure: The structure of bids within the auction defines the flexibility with which buyers can express their resource requirements. In case of single unit, single commodity, the bids are simple statements of willingness to pay and accept. In case multi unit identical items, price and quantity are required to be specified. In some cases price can be a function of quantity. So volume discounts can be allowed. In case of combinatorial auctions, the bid structure may be more complicated.

(5) Matching Supply to Demand: A key aspect of auction is matching supply to demand. It is also referred to as winner determination or market clearing. The matching can be done in many different ways. There can be single sourcing, where pairs of buyers and sellers are matched or multi sourcing where multiple suppliers can be matched with single buyers and vice versa. The type of matching can influence the complexity of winner determination.

(6) Information Feedback: An auction protocol may be a direct mechanism or indirect mechanism. In direct mechanism such as sealed bid auction, the bids
are submitted without receiving feedback. In an indirect mechanism, such as descending price auction, the buyers can adjust bids in response to information feedback from auction. Feedback about the state of auction is usually characterized by a price signal and provisional allocations. It provides sufficient information about winning bids. It also helps in redefining bids. In complex settings such as multi unit auctions with bundled bids, a direct mechanism may not provide sufficient information about preferences. The focus in the design of indirect mechanism is to identify how much preference information is sufficient to achieve desired economic properties.

1.7 Approaches to Auction Based Automated Negotiations

It can be seen from above discussion that bidding or bargaining type of negotiation can be described as an iterative communication and decision making processes between two or more parties like buyers, sellers or their representatives like software agents. Each individual cannot achieve his objective alone. Due to this they engage into the process of exchanging information using offers, bids, counter offers and search for a compromise decision [BKS2003]. The process of decision making in negotiation will depend upon the attributes and information collected. It may evolve as more and more information is collected. This has lead to classification of negotiation into integrative and distributive types [KNJ2000]. In order to automate auction based negotiation, three types of approaches have been proposed.

1. Negotiation Support System (NSS): It is a software program, which is specifically oriented towards helping human negotiators make better decisions. It represents first step towards automated negotiation [BS1997] and [DHR2002]. These systems require constant human input and the final decision is left to human beings. As many of these systems are not capable of intelligent decisions, they provide only limited support to automated negotiations. The web based prototypes of negotiation support systems can be found at www.business.carleton.ca/inspire or www.business.carleton.ca/interneg/tools/inss/. These systems mainly support integrative negotiations.

2. Intelligent Agents: Intelligent software agents which participate in electronic marketplaces typically operating on principles of economic design have been
proposed in [MS2001], [CM1996] and [ZS1996]. These software agents, each
with their own agenda [T2000], electronically negotiate with each other in an
environment governed by rules. The strategies for negotiation may be explicitly
and completely built into an agent or agents can learn themselves. KASBAH
[CM1996] is a marketplace where software agents negotiate for purchase and
sale of goods is an example of an agent, where strategies are programmed. The
strategies are specified by the users using a web based front end. The users also
retain control over agents through out their life cycle. The agent BAZAAR
[ZS1996] is a software agent, which can learn. In this agent negotiation is
modeled as sequential decision making tasks. It uses Bayesian learning as
underlying mechanism. The soft computing techniques like genetic algorithms
have also been proposed for learning in negotiations and bargaining situations.
These technologies essentially substitute the human element in negotiation with
well defined ontology covering products, messages and decision rules. These
agents typically address the automation requirements of bidding process, which
when used in conjunction with the mechanisms within the marketplace
infrastructure provide solutions for distributive negotiations.

(3) Economic Mechanism Design and Online Auctions: Economic mechanism
design is concerned with the design of the rules of interaction, using the tools of
economics and game theory, for economic transactions that will, in principle
yield some desired outcome. In the context of electronic auctions, we require
rules governing (1) bidding, (2) attributes and issues to be considered for winner
determination, (3) winner determination and (4) payments to be made. It can
be seen that classical auctions like English, Dutch, First Price Sealed Bid
Auctions etc. are well understood and widely used economic mechanisms. In
these cases, rules of interaction are well laid out. These mechanisms have been
automated and form core constructs on which online auctions like
order to automate different types of auction mechanisms, a number of technical
issues from computational and economic perspectives are required to be
understood and addressed through proper design of auction mechanism.
In our present work we have basically worked on the third approach.

Asymmetry of Information: One more important aspect of auction mechanism is the type of model being considered. The two most common models with respect to bidder’s valuations are (1) Independent private values model and (2) Common values model. These two models actually represent two extreme cases. This aspect is also known as asymmetry of information and is a crucial element in any type of auction. In many electronic auctions, it is unreasonable to expect every bidder to possess the same amount of information. There will be differences between the valuation of item and set of items.

(1) Independent Private Values Model: In the independent private values model, each bidder knows precisely how he values the item. He does not know the valuation of other bidders for this item. He perceives valuation of other bidders as drawn from some probability distribution. It is assumed that the valuation of \( i^{th} \) bidder is \( v_i \), which is drawn from a distribution with distribution function \( F_i \). The valuation \( v_i \) is known to the \( i^{th} \) bidder. All other bidders know only distribution function \( F_i \). The valuations of any pair of bidders are mutually independent.

(2) Common Values Model: In this model, the item has single objective value. However the true value is not known. The bidders have access to different information sources and have different estimates of item’s valuations. Let \( V \) be the true value of the item. Each bidder has estimated or perceived value \( v_i \). It is assumed to be drawn from a common distribution with distribution function \( H \). All bidders know the distribution function.

In the present work we basically work on Independent Private Values Model.

1.8 Properties Desired from an Auction

The main important properties desired from an electronic auction mechanism are solution equilibrium, efficiency, individual rationality, budget balance, incentive compatibility, solution stability, revenue maximization or cost minimization, low transaction costs, fairness and failure freeness.

(1) Solution Equilibrium: The solution of a mechanism is in equilibrium, if no buyer, seller or agent wishes to change its bid, given the information it has
about others. Many types of equilibrium can be computed given the assumptions about the preferences of agents, rationality and information availability. They include Nash equilibrium, Bayesian Nash equilibrium, and dominant strategy equilibrium. The detailed discussion about these aspects can be found in [MWG1995].

(2) Efficiency: A general criterion for evaluating a mechanism is Pareto efficiency. It means that no buyer or seller can improve his allocation without making at least one other buyer or seller worst off. Another commonly used metric of efficiency is efficiency of allocation. It is achieved when the total utility of the winners is maximized. In this case the items are allocated to the agents who value them the most.

(3) Individual Rationality: A mechanism is individually rational if its allocations do not make any agent worse off than had the agent not participated in the mechanism. In other words this property means that every agent gains non negative utility by being the participant in the mechanism.

(4) Budget Balance: A mechanism is said to be weakly budget balanced if the revenue to auctioneer or the exchange is nonnegative. It is said to be strongly budget balanced if this revenue is positive. Budget balance ensures that auctioneer or exchange does not make losses.

(5) Incentive Compatibility: A mechanism is incentive compatible, if the agents optimize their expected utilities by bidding their true valuations for the goods. This is a desirable feature because an agent’s decision depends only on its local information and it gains no advantage in expending effort to model other agents’ valuations. It is desirable that the truthful bidding by the agents should lead to a well defined equilibrium such as dominant strategy equilibrium. In this case the mechanism is said to be strategy proof.

(6) Solution Stability: The solution of a mechanism is stable, if there is no subset of agents that could have done better, coming to an agreement outside the mechanism.

(7) Revenue Maximization and Cost Minimization: In an auction where a seller is auctioning a set of items, the seller would like to maximize total revenue earned.
On the other hand in procurement auctions, the buyer will like to procure at minimum cost. Due to difficulties in finding equilibrium strategies, designing a cost minimizing or revenue maximizing auction is not easy.

(8) Low Transaction Cost: The buyers and sellers would like to minimize the costs of participating in auctions. Delay in concluding auctions is also transaction cost.

(9) Fairness and Failure Freeness: This influences bidder’s willingness to participate in auctions. Winner algorithms, especially those based on heuristics, could lead to different sets of winners at different times. Since there could be multiple optimal solutions, different sets of winners could be produced by different algorithms used. Bidders who lose even though they could have won with a different algorithm could end up feeling unfairly treated. The property of failure freeness means that auction designs should work as intended under all but most extreme conditions. The transparency is important because (1) it simplifies bidders understanding of the situation and eases their own decision making (2) increases their trust in the auction process by improving their ability to verify that the auction rules have indeed been followed.

Auctions have been widely studied in economic literature; however most of these models cannot be directly applied in electronic auctions. This is due to the following reasons.

(4) In an electronic exchange, the object being sold may not be exactly identical (e.g. cotton with different grades).

(5) In an electronic procurement system, the object to be procured is required in different specification or sizes (e.g. paper of different widths).

(6) In case of privatization of government owned enterprises, there may be certain policies of government, which may constrain the ownership beyond certain percentage for group of buyers.

These requirements give rise to auctions with different types of constraints. Auctions with different types of constraints have not been widely studied. There are few studies of auction models where buyers have budget constraints. However in our work, constraints arise due to nature of electronic auctions. In an electronic exchange the
object being sold may not be exactly identical (e.g. cotton with different grades). In an electronic procurement system, the object to be procured is required in different widths. In case of privatization of government owned enterprises, there may be certain policies of government, which may constrain the ownership beyond certain percentage for group of buyers. All these requirements give rise to auctions with constraints, which have not been studied widely. In this work the auctions with different types of constraints have been studied. We have basically addressed two problems (i) finding out optimum assignment of bids and asks, in case of auctions with different types of constraints and (ii) determining how much each participant has to pay/receive, so that our auction mechanism has desirable properties.

In this work, we have reviewed important basic literature of auction theory. We have reviewed the different types of problem formulations and how the solutions are obtained. We have also studied the desirable properties of auction mechanism.

We have studied Double Auctions under different types of constraints, which provide an efficient mechanism to implement bidding based many to many negotiations. Double auctions are widely used in electronic exchanges and financial markets. In these auctions, sellers and buyers submit asks and bids respectively, which are matched and cleared periodically. Efficient algorithms exist to match these asks and bids in case there are no assignment or any other constraints. However in many practical situations there can be different types of constraints in matching these bids and asks. These constraints can be of the form, where an ask can be matched with only certain types of bids and vice-versa. In some cases the supply from different asks cannot be combined to fulfill a demand. Such constraints are known as indivisible demand bid constraints. The matching problems in case of indivisible demand have been formulated as generalized assignment or multiple knapsack problems, which require solution of NP-Hard optimization problems. In this work we investigate the problem of matching under different types of constraints. We have formulated this problem as nonlinear integer programming problem and developed set of new results, which form the basis of our algorithm. We have developed two algorithms to obtain optimum assignments of bids and asks in case of different types of constraints like assignment and indivisibility constraints. It is shown that the time complexity of our algorithm is always polynomial.
We then develop algorithm to compute VCG Payoff from the optimum solution without solving set of optimization problems. A payment mechanism, which is efficient, budget balanced and individually rational is designed. We also study the effect of changing bid price by buyer and set of buyers and its effects. It has also been shown that group of buyers cannot affect our system by changing their respective bid price. The gains of the buyers are always bounded.

Further we study truthful Double Auctions under different types of constraints. In electronic auctions, property of incentive compatibility can be very important. Incentive compatibility ensures that truthful bidding is the dominant strategy. Other important properties in electronic auctions are Budget Balanced (BB) and Individual Rational (IR). The former ensures that auction does not run in loss, whereas the later ensures voluntary participation. However these can be achieved only after sacrificing efficiency. In this chapter we consider double auctions under different types of constraints, where truthful bidding is the dominant strategy. We design a mechanism which is strategy proof, individually rational and budget balanced. Here it is assumed that buyers and sellers have their private valuations independent of each other. The buyers and sellers submit their respective bids and asks depending upon their respective private valuations. In this case a part of bid and ask is public information, remaining part is private. In this chapter multi unit double auction (MDA) mechanism is generalized to handle different types of constraints. It has been shown that mechanism is budget balance, strategy proof and individually rational. The bounds on efficiency loss are established. It has been shown that efficiency loss tends to 0 as number of buyers or sellers become large. Then we have developed discriminatory mechanism. It has been shown that this mechanism is budget balanced, strategy proof and individually rational. It has been shown that in this mechanism also efficiency loss is bounded and asymptotically goes to 0. It has been shown that this mechanism is false-name proof. It means that buyer cannot improve his gains by submitting bids with false identification. This property is very important property in electronic auctions. It has been shown that buyer does not have incentive to reduce the demand. The conditions for the existence of desirable mechanism are also worked out. Then the case where, mechanism is strategy proof, individually rational and efficient but not budget
balanced, is considered. We attempted to introduce participation fees to cover up deficit. The cases of efficiency loss are also worked out.

An auction mechanism for privatization of state owned enterprises; a very important application of electronic auctions in many countries, in the financial domain has been studied. Traditionally auction based mechanisms have been used for leasing of mining rights, bandwidth allocation etc. In this work, we consider different types of auctions, which can be used in financial domains for Initial Public Offering (IPO) of Government owned companies. We also consider the scenario with different types of constraints.

We have formulated IPO problem as an optimization problem. The format proposed is single object multi unit auctions with different types of constraints. It has been shown that, some of the single object multi unit auction formulations, which have been studied earlier are particular cases of our formulation. We have derived new results to obtain optimum assignment. An algorithm, which computes the optimum solution, has been developed. The algorithm generates optimum solution with polynomial time complexity. Then an algorithm to compute VCG Payoff from the optimum solution without solving set of optimization problems has been developed. We generalize uniform price mechanism to handle different types of constraints. It has been shown that our mechanism is efficient, strategy proof and individually rational. Then we have developed discriminatory mechanism, which is efficient, strategy proof and individually rational. It has been shown that this mechanism is false-name proof. It means that buyer cannot improve his gains by submitting bids with false identification. So this property is very important in electronic auctions. It has been shown that the buyer also does not have incentive to reduce the demand.

1.9 Outline of the Thesis
The outline of rest of the thesis is as follows.

In chapter 2, basic important basic literature review is presented. In chapter 3, efficient Double Auctions under different types of constraints are studied. In chapter 4, truthful Double Auctions under different types of constraints are studied. In chapter 5, single object multiunit auctions under different types of constraints have been studied. In chapter 6, a banking application of auctions with constraints is presented. The conclusion and future work are discussed in chapter 7.