A HIERARCHICAL DISTRIBUTED COMMUNICATION ARCHITECTURE FOR REAL-TIME AUCTIONS

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Abstract: This paper presents a new hierarchical distributed communication architecture, called AHS (Auction Handling System), based on clusters. This architecture uses the IRC (Internet Relay Chat) channels and protocol facilities in order to support real-time auction applications (RTA). Coordination between distributed auction servers is needed to exchange and update some relevant auction information and to resolve the winning bid within a cluster. The problem is how to determine the best location of the auction server coordinator. For this purpose, we suggest the use of the Floyd-Warshall's algorithm, which is a graph theory algorithm.

1 INTRODUCTION

Actually, online auction sites are divided into two categories: the non-real-time auctions (NRTA) and the real-time auctions (RTA) (Liu and al., 2000). The most popular online auction sites currently available on the net are NRTA (Liu and al., 2000) and (Bougouris and al., 2000), such as eBay, Amazon, AuctionWatch. These auction sites remain still different from the conventional face-to-face auctions. Indeed, they have many limitations: they suffer from sustainable hardly controlled information delays; they have usually a long cycle time which might be risky (Bougouris and al., 2000) (e.g. an airline company may want to auction the remaining seats of a flight a few hours prior the departure); they allow the phenomenon of collusion among bidders (they have enough time to cooperate and reach agreements not to outbid each other) which has the overall effect of lowering the wining bids (Liu and al., 2000); and they do not allow real-time bidding (Bougouris and al., 2000) (a bidder cannot make quick response to market dynamics even if some pseudo-autonomous bidding).

Besides the real-time features, there are also distributed concerns that must be taken into consideration. Indeed, the most well-known auction web sites, such as eBay (Ezhilchelvan and Morgan,2001), (Ezhilchelvan and al.,1999) and (Ezhilchelvan and al.,2000), Amazon (Ezhilchelvan and al.,2000), FishMarket (Esteva and Padget, 1999), AuctionBot (Wellman and Wurman, 1998a), (Wellman and al., 1998b) and (Wellman and al., 1999), Priceline, CNET and E*Trade (Ezhilchelvan and Morgan,2001), which user domains are typically large, geographically distributed, rely on only one central auction server. These auction sites have serious problems: they are restrictive and non scalable (Ezhilchelvan and Morgan,2001), (Ezhilchelvan and al.,1999) and (Ezhilchelvan and al.,2000) (too many bidders could easily overload the central auction server). This could result in performance degradation and perhaps bottlenecks, which would make the whole auction process unresponsive and unavailable. Further, an unreplicated central server would constitute a single failure point (Ezhilchelvan and al.,1999). These considerations make decentralisation in auction system design not only a desirable option but also an essential requirement.

In this paper, we consider the issues related to communication services required to support real-time auctions among distributed auction servers, which were developed and presented in a previous study(Kaabi, BenAyed and Kamoun, 2003) as a distributed communication architecture, called AHS (Auction Handling System). To support real-time auction communications, we suggested using IRC channel and protocols under the AHS architecture. The communication protocol which supports interactions between an auction server and many

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bidders is defined and implemented in a previous work (Kaabi, BenAyed and Kamoun, 2003). Here, we focus on the definition of the architecture of the distributed auction server system (ASS), which supports interactions between a set of distributed auction servers that cooperate in conducting a real-time auction.

This paper is divided as follows: Section 2 presents a definition of RTA and summarizes their principal requirements in terms of communication issues. Section 3 introduces the AHS architecture and its functional elements and communication protocols. Section 4 presents a possible architecture of the distributed Auction Server System (ASS). Section 5 describes the extended architecture of the AHS based on clusters and presents a "potential solution" for the designation of an ASA coordinator. Section 6 discusses relevant related work. Finally, section 7 provides some concluding remarks and future work.

2 REAL-TIME AUCTIONS

2.1 Auction process

Traditionally, an auction process involves three types of entities: the initiator (I), the bidders (B_i) and the auctioneer (A). It is decomposed into three principal phases (Kaabi, BenAyed and Kamoun, 2003): the starting phase, the bidding phase and the settlement phase.

The starting phase begins with the initial buyer or seller registration (authentication, exchange of cryptographic keys, etc.), the setting up of an auction event by the initiator and the auctioneer (description of the item being sold, setting up the rules of the auction, the asking price, etc.) and the access of bidders to an auction event.

In bidding phase, goods are sold in multiple rounds, governed by a clock (namely, the limited time interval to make a bid). During each round, the auctioneer collects bids from the bidders and validates them according to the auction rules. Once the clearing time expires, it evaluates all validated bids and broadcasts back to all the bidders the new price quote (PQ). At the end of a round, the auctioneer can either decide to close the auction or, to initiate the new round auction by quoting a new PQ.

The settlement phase corresponds to the auction result notification at the end of the auction. At this point in time, the auctioneer broadcasts a transaction notification (TN) to all the bidders and to the initiator informing them about the "winners" and the final result.

Here, we describe the most familiar type of auction process, a multi-round English auction. Figure 1 shows a message sequence chart for a possible exchange of bids and price quotes messages between the entities. In this type of auction, all the bidders should have always the same view of the items being sold by auction, and of the proposed bids. Further, they should have the same communication delays between them and the auctioneer, and share the same notion of time (Panzini and Shrivastava, 1999).

Suppose that if both bidder B_2 and B_{10} see the PQ at the same time and submit a bid, the bid from the closer bidder (B_2) may reach the evaluation process several seconds earlier on the average. Figure 1 depicts a situation in which the remote bidder (B_{10}) submits its bid before the intermediated clearing time but this bid is not delivered in time. This bid, which may be higher than the others, will not be evaluated by the auctioneer at the current round auction and may cause a loss of extra profit for the seller and a loss of ownership for the bidder. Hence, this delay influences the auctioneer's service quality and leads to frustrated bidders who could leave the auction site. Meeting the deadlines in an auction activity is not just a quality issue but a correctness issue (Peng and al., 1998). Our objective is then to give to all the bidders a fair and equal access to all of the exchanges.

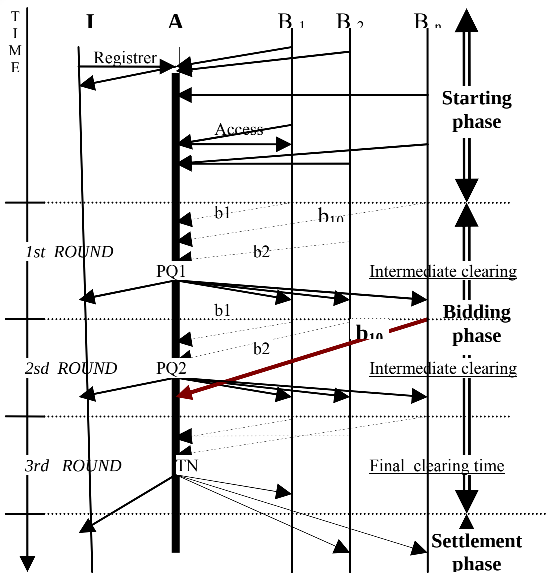

Figure1: An English auction process

2.2 Characteristics of real-time auctions

Real-time auctions form a class of online auctions which have to be processed time-and-price critical. They include the most common trading models used in real-life auctions, such as English, Dutch, Sealed-bid, CDA, and their variations (Vickrey, Yankee, etc.). Generally, they are present in all industry market places (see table 1)(Kaabi, BenAyed and Kamoun, 2002), where goods have a constantly varying price and or availability; and in stock market places (Peng and al., 1998)and (Maxemchuk and Shur, 2001), where data information from the business environment must be continuously monitored and processed in a timely manner to allow for real-time decision over the Internet.

Table 1: Examples for real-time auctions in industry market places

Kind of business	Type of auction	Sector	Description
B2B	Forward	Agriculture Any sectors	Cattle or fish auctions Any raw material market places
	Reverse	Any sectors	Tenders/pitches by public institutions
B2C	Forward	Art	Art and antique auctions

For bidders, these auction sites enforce real-time competitions among them and allow real-time decisions. For sellers, they prevent the phenomenon of collusion, as bidders do not have enough time to cooperate and reach agreements between them (Liu and al., 2000).

RTA share the following common characteristics:

- They shall be running in real-time manner(Rumpe and Wimmel, 2001). Bidders always have current bidding information visible and receive them in real-time fashion(Liu and al., 2000). This would reduce as minimal as possible the delay of transmission of bids, PQs or the TN between bidders and the auctioneer. A resource reservation protocol such as RSVP could be used to guarantee a bounded delay (Rumpe and Wimmel, 2001).
- They are all time-triggered systems (Wellman and Wurman, 1998a)and (Panzini and Shrivastava, 1999), having inherent timing constraints as well as autonomous features on when or how the operations and interactions that the participants (auctioneer, bidders or initiator) might perform. To meet deadlines, such systems must provide a predictable response time in order to guarantee the correctness of time-critical transactions (Peng and al., 1998).
- They occur in a short period of time which may vary from a few minutes (15 min) to a maximum of three hours (Rumpe and Wimmel, 2001). For example, a lot may take about 6 seconds to be sold. This means that the frequency of bids is relatively high.
- The time duration may consist of a main non extendable part and an extendable part (Rumpe and Wimmel, 2001)and 0. Indeed, the auction time is extended whenever a bid arrives shortly before the auction end. This allows other bidders to react. The provided reaction may vary, e.g. starting from 3 minutes as an initial extension down to a few seconds at the very end (Rumpe and Wimmel, 2001).

2.3 Communication requirements

Several studies have identified multiple requirements for real-time auctions. Given the fact that potential participants are distributed globally and each has a different computing capacity (operating speed, network bandwidth, etc.), such applications bring new challenges on communication issues. In this section, we highlight some basic requirements described as follows:

- **Synchronous mode** (Kaabi, BenAyed and Kamoun, 2003): such as videoconferencing, chat, etc. could enable real-time interactions between sellers, bidders and the auctioneer, which results in increasing the rapidity of decision-making process.
- **A multicast technology** (Liu and al., 2000),(Wellman and Wurman, 1998a),0and(Maxemchuk and Shur, 2001): enables one copy of digital information sent by the auctioneer such as bid, PQ and TN to be received by a group of bidders. Hence, it would require identifying the group of participants and broadcasting to them all bid messages. This would significantly minimize the number of messages sent regardless of the density and the dynamic of group membership and would also optimize the way the bandwidth is used. Still, there is no guarantee that messages would be received simultaneously and instantaneously by all members, which may cause unfair competitions. Therefore, a RTA requires using a fair multicast communication protocol.

- **Fairness** (Peng and al., 1998),(Rumpe and Wimmel, 2001), (Kaabi, BenAyed and Kamoun, 2003), (Ezhilchelvan and Morgan, 2001),(Banatre and al., 1986)and (Maxemchuk and Shur, 2001): allows bidders to have the same chance to place their bids, which should be taken into account fairly by the auctioneer. However, a bidder who is close to the central server may have faster access than a remote one, leading to unfair competitions among bidders.
- **Timely delivery and processing** (Peng and al., 1998): the real time bidding process is interactive: the auctioneer must efficiently and timely process incoming bids and send the PQ to all bidders. Each bidder has to make real-time decisions to submit rapidly a higher bid. This entails timing constraints for processing these operations on both sides as well as real-time communication between them. In the reality, these messages can take arbitrary time to reach their destinations and auctions have no control over data transmission delays (Liu and al., 2000),(Panzini and Shrivastava, 1999)and (Kaabi, BenAyed and Kamoun, 2003). Therefore, it would require guaranteeing the real-time delivery and processing of messages exchanged between bidders and the auctioneer.
- **Time-message validity** (Kaabi, BenAyed and Kamoun, 2003): usually a bid is considered time related information where is valid until a certain time and then becomes obsolete. As a result, the concept of time-message validity should be taken into consideration within the communication protocol. This would allow a waiting time while the bid is still valid.
- **Clock synchronization**(Wellman and Wurman, 1998a),(Peng and al., 1998)and0: In RTA, the synchronization of client and server times is essential. For example, the server does not close the auction if a participant still believes it is still open. Moreover, in a distributed environment, clock synchronization is essential for many real-time and fault-tolerant operations. Hence, an appropriate protocol must ensure the temporal flexibility issue, so that bidders' clock must be synchronized to auction server's clock as well as among auction servers clocks.
- **Scalability**(Panzini and Shrivastava, 1999),(Ezhilchelvan and Morgan, 2001),(Ezhilchelvan and al.,1999),(Ezhilchelvan and al.,2000)and (Banatre and al., 1986): an auction system must be extensible and capable of supporting an increasing number of users (easy insertion and removal of bidders and/or sellers), specifically in the last minutes. For example, more than two-thirds of eBay auctions had bids submitted less than an hour before the scheduled end time (about ten minutes)(Ockenfels and Roth, 2002a)and (Ockenfels and Roth, 2002b). It must also be able to provide end-users with satisfactory Quality of Service (QoS), regardless of their increasing number and their geographical distance.
- **Reliability**(Banatre and al., 1986)and (Maxemchuk and Shur, 2001): a reliable auctioning protocol should have a bounded and predictable responsive time. It must deliver the same message reliably and simultaneously to all receivers anywhere in the net. When a failure occurs, bidders and sellers must be able to continue their participation in the sales; the transaction time may be lengthened.
- **Availability**(Panzini and Shrivastava, 1999): The auction service must be "available"(operate consistently and correctly) under specified load and failure hypothesis. In a distributed system context, high availability is essential; otherwise, the system is doomed to continuously leak users to other similar systems with better availability.

All these requirements are highly correlated, but there are further features that are not described in this section which relate to issues such as security, load balancing, concurrency, anonymity, privacy, etc. Such requirements are considered important in some specific RTA applications.

3 THE AHS ARCHITECTURE OVERVIEW

The AHS (Auction Handling System) is a distributed communication architecture providing real-time auction applications with specific communication services, independently of the auction rules.

3.1 Functional components

As shown in figure 2, the AHS architecture is composed of three functional elements: the BSA (Buyer/Seller Agent), the ASS (Auction Server System) and the BS (Bids Store)0.

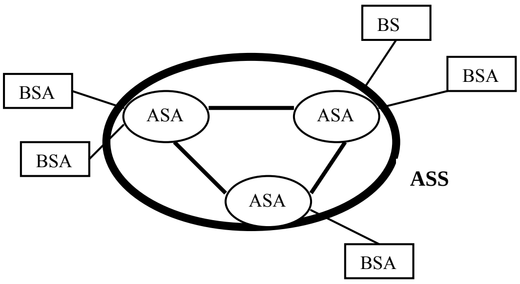

Figure 2: The AHS architecture

- The BSA is a user agent that can be associated with a Seller or a Buyer. It helps a Seller to set up an auction event and possibly to participate in the bidding process. Or it helps the bidder to participate in an auction event and submit bids. A BSA is connected to one ASA (Auction Server Agent), generally the closest one. However, several BSA may be connected to the same ASA.
- The ASS is composed by a set of distributed ASA involved in one or more auction events simultaneously. Each ASA is associated to an auction server that holds the auctioneer's activities. Cooperation between ASA is needed for the resolution of the wining bid.
- The BS provides, when required, the capacity of storing bids, PQs or TNs for further use (message tracking requirement). The physical location of the BS is not already specified: it can be situated within an ASA or a BSA or constitutes a separate entity.

3.2 The IRC protocols

A previous study [18] has compared some Internet application protocols like HTTP, IRC, E-mail and NNTP according to basic negotiation requirements in terms of communication services. It showed that the IRC protocol is best suited for real-time auctions. Further, IRC presents many advantages with regard to real-time auctions:

- It is based on a distributed architecture that defines two functional components: IRC-Server and IRC-Client (IETF, 2000a).
- It provides real-time text based conferencing between IRC clients (IETF, 2000a). This may reduce considerably the end-to-end transmission delay between the auctioneer and the bidders.
- Communications are running in a synchronous mode with a push mechanism (IETF, 2000b).
- IRC channels support multicast group communication(IETF, 2000c).
- It provides a fair distribution of messages to all IRC Clients since IRC servers set for them the same response time (2 seconds) so they are all served fairly (IETF, 2000b).
- An IRC network configuration is a spanning tree defined by a group of servers connected to each other. This logic tree-based structure allows scalability (IETF, 2000a).
- It can be used to reduce data transmission delays between auction application layer and the traffic on the Internet (Kaabi, BenAyed and Kamoun, 2002).

3.3 AHS communication protocols

The AHS architecture is structured in three layers (Kaabi, BenAyed and Kamoun, 2003) from top to bottom, as shown in figure 3: the auction application layer, the P-auction layer and the IRC layer.

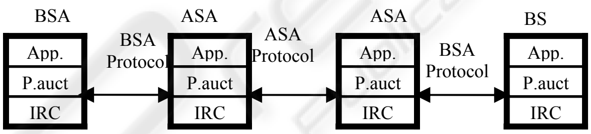

Figure3: The AHS layered model

The P-auction layer provides the auction application with the required communication services. It uses the appropriate services provided by the IRC layer.

As shown in figure 3, three communication protocols are required to implement AHS architecture: the BSA-protocol, the BS-protocol and the ASA-protocol.

- The BSA-protocol specifies the allowed interactions between a BSA and an ASA involved in an auction event. This protocol is already specified, implemented and validated in (Kaabi, BenAyed and Kamoun, 2003)and (Kaabi, BenAyed and Kamoun, 2004). It is encapsulated within the IRC-Client protocol.
- The ASA-protocol specifies the interactions between a set of ASA involved in an auction event within the ASS. It will be encapsulated within the IRC-Server protocol.
- The BS-protocol specifies the request-response interactions between a BS and a BSA. They concern the storage and the retrieval of bids to/ from the BS which induce end-to end exchange of messages through one or many ASA. This protocol will use the point-to-point communication mode provided by the IRC protocol.
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4 THE ASS ARCHITECTURE

In a previous study (Kaabi, BenAyed and Kamoun, 2003), we suggested implementing the AHS over the IRC architecture, which is a spanning tree(IETF, 2000a)and (IETF, 2000b). Every auction event will use an IRC-Channel, a BSA/ BS will be implemented over an IRC-Client and an ASA will be implemented over an IRC-Server. Figure 4 depicts the logic structure of the AHS architecture:

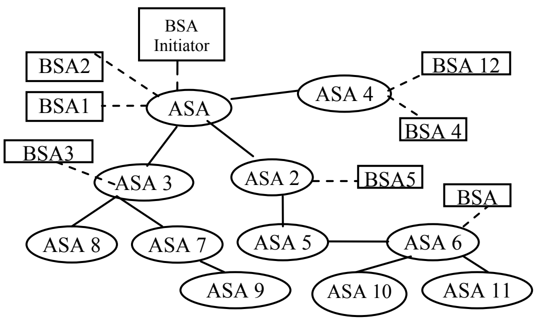

Figure 4: The AHS logic structure

For example, in figure 4, we suppose that the ASS is composed by 11 ASAs, supporting the auctioneer's activities and are simultaneously involved in many auction events.

To access an active auction, a BSA must connect to an ASA participant, if possible, the nearest one, in order to reduce the data transmission delay. During the bidding phase, every ASA (e.g. ASA_1) must serve and provide its local BSAs (e.g. BSA_1, BSA_2) with the current auction information in which they are participating. At the end of each round, all ASAs must cooperate and exchange relevant information (e.g. bids, PQs) in order to evaluate the wining bid and calculate the newest PQ.

From the bidder's side, the ASS represents a "black box" where the auction process is opaque to all BSA participants. However, inside the ASS, the control of the auctioning process is disseminated among a set of distributed ASAs, which will cooperate in order to determine together the result of the auction. From this point, we assume that the evaluation process is distributed between all ASAs being part of the ASS. The problem addressed here is how and when will the ASA participants cooperate to resolve the winning bid and calculate the newest PQ for a given auction event? Three approaches are possible: the centralized approach, the totally distributed approach and the hierarchical approach.

4.1 The Centralized Approach

The centralized approach is to consider a centralized auction server node, called "an ASA evaluator"(ASA_e). Thus, every ASA collects validated bids from their respective local BSAs and forwards them to ASA_e. When the clearing time expires, the application within the ASA_e runs the evaluation process to determine the wining bid according to the auction rules, and then multicasts back the new PQ to all ASA participants. Figure 5 illustrates the essence of this approach:

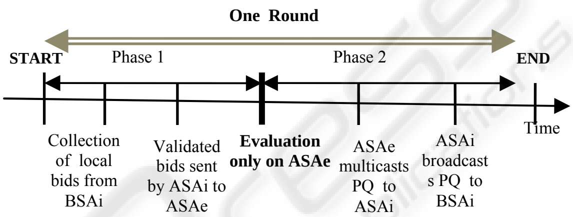

Figure 5: A Centralized approach

The advantage of this approach is the simplicity of keeping track of the auction state. Only the ASA_e will know the global auction state and the identity of the winner's BSA. The other ASAs would not have to be involved within the evaluation process.

The drawback is that all communications must go through the central node (ASA_e), roughly 2N messages are exchanged per round and per auction event (N is the number of ASA participating to an auction event). Hence, the complexity is about $\theta(N)$.

When the number of participants (BSA) and the number of auctions grow, the ASA_e would constitute a single point of failure and may become a bottleneck. This could lead to unfairness, unresponsiveness and unavailability of the auction system. Consequently, the ASS will be less scalable: suited only to small scale auction systems.

For this reason, the best approach would be to remove the central node and distribute auction services among all ASA. Two approaches are then possible: a totally distributed approach and a hierarchical approach.

4.2 The Totally Distributed Approach

In opposition to the above approach, no central ASA evaluator (ASA_e) exists. The evaluation process is decentralized and controlled by all the ASA participants. Thus, every ASA will act as an ASA_e, having a replication of all auction services. This would remove the reliance on the central node. Figure 6 shows the phases of an auction round in a totally distributed approach for each ASA involved in an auction event:

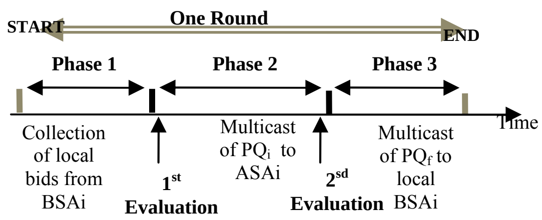

Figure 6: Totally distributed approach

Hence, there are two clearing times per round corresponding to two evaluation processes on every ASA, as shown in figure 6. At the first clearing time, every ASA must validate its incoming bids, evaluate the wining bid and forward his Intermediate Price Quote PQ_i to all adjacent ASAs. At the second clearing time, every ASA have to evaluate all the incoming PQ_i and calculate the Final Price Quote PQ_f.

In this approach, the global auction state is known by all the ASAs being part of the ASS. Consequently, it would generate a huge amount of traffic on the Internet, approximately 2 N (N-1) messages exchanged per round and per auction event. Hence, the complexity is about $\theta(N^2)$. This would also raise the problem of data replication and may require a high synchronization between the ASAs because the PQ_f has to be unique and identical on every ASA at the end of the round.

However, this approach could easily achieve the scalability, the fairness and the availability as the total load is shared among a set of distributed ASA rather then being concentrated on a single central ASA.

Therefore, we suggest an intermediate solution to reduce the number of unnecessarily sent messages and enhance system performance: the hierarchical approach.

4.3 The Hierarchical Approach

In the hierarchical approach, we assume that we have two types of ASA being part of the ASS:

- The ASA participants, who collect validated bids from their local BSAs, evaluate them, calculate their local PQ_i and then forward it to the ASA coordinator (ASA_c).
- The "ASA coordinator" (ASA_c), who collects all the incoming PQ_i, evaluates them and multicasts the PQ_f back to all ASA participants.

For example, suppose that the ASS is composed by 8 ASAs as shown in figure 7, and the ASA_c is represented by ASA_1. The latter will receive respectively all the PQ_i from all the ASA participants (ASA_2, ASA_3,.., ASA_8) before the clearing time. Then, it will calculate the PQ_f and multicast it back to them. As soon as the ASAs will receive the PQ_f, they will broadcast it respectively to their local BSAs. The phases of this approach are described in details in figure 7 below:

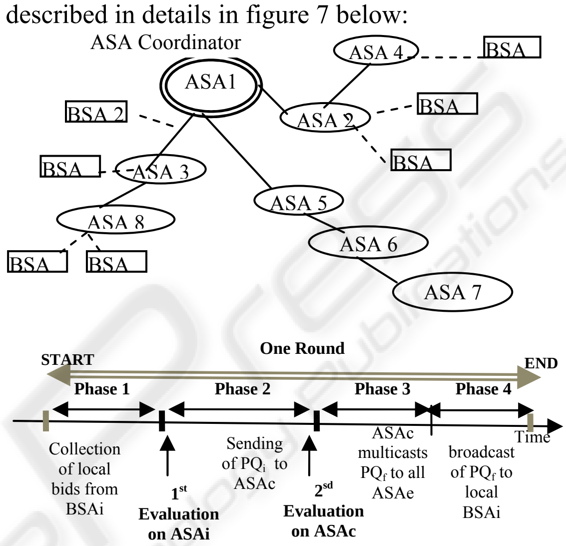

Figure 7: A Hierarchical approach

Similar to the second approach, there are two clearing times per round: the first one is on each ASA, and the second occurs only on the ASA_c. Here again, the global auction state is known by all the ASA, yet it generates less traffic then that produced in the totally distributed approach; nearly 2 (N-1) messages exchanged per round. The complexity is about $\theta(N)$. Moreover, since the auction services are replicated on all ASA, the problem of data replication is also addressed here and requires a high synchronization between the ASA participants and the ASA coordinator.

Compared to the first and second approaches, the hierarchical approach achieves better fairness as the distance between a BSA and the ASS is minimized. Therefore, we choose to apply this approach for the ASS architecture.

5 A HIERARCHICAL CLUSTERED ARCHITECTURE

When the number of bidders grows wider geographically and the size of the ASS raises, the number of ASA sending the PQ_i to the ASA_c may become important. Hence, we could fall in the situation of centralized approach as the ASA_c would constitute the failure point of the ASS. Therefore, we suggest an extended hierarchical architecture for the ASS based on clusters where the ASAs are structured hierarchically in several clusters, as shown in figure 8.

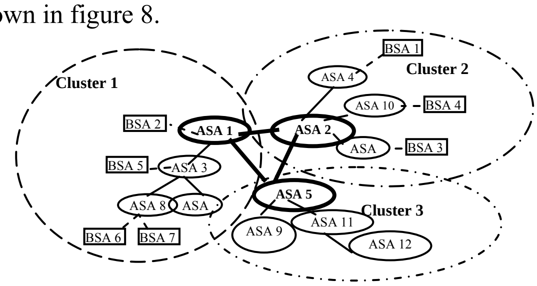

Figure 8: Hierarchical architecture based on clusters

So that, when the size of ASS becomes important, it will be divided into many clusters, where each cluster spans a limited network area gathering a set of ASAs and one ASA_c. The global auction system would be constituted by a set of clusters, shown as circles in figure 8, interconnecting through their respective ASA_c (ASA_1, ASA_2 and ASA_5).

To the outside world, each cluster appears to be a single system and thus the ASA-ASA communications will be reduced. Indeed, each cluster, through its local ASAs, will provide its end-users with the auction services, which are in its geographical zone. The rules fixing the number and the size of clusters will be studied further.

One of the main ideas of cluster computing is to offer load-balancing, high availability and scalability. We suppose that this extended architecture would facilitate the coordination between all the ASAs being part of the ASS. However, it would require an inter-communication ASA-protocol between clusters and an intra-communication ASA-protocol within each cluster. The specification of these protocols is under study as well as the experimentation and the simulation of the three approaches.

Furthermore, we need to designate one ASA as a coordinator within a given cluster. The problem is then how to determine the best location of the “ASA coordinator”?

5.1 How to designate the ASA coordinator?

To designate the ASA coordinator- ASAc, two approaches are possible: The first consists in dedicating an arbitrary ASA as a coordinator; the second is to assign an ASA as a coordinator. The first approach is rejected for many reasons: the location of the ASAc changes dynamically according to the number of bidders and the number of auction events which are drastically increasing. Consequently, a dedicated ASA will certainly face request congestion and may become a bottleneck.

That’s why we opt for the second approach. In this case, we assign dynamically an ASA as coordinator among all the ASAs being part of the ASS and within a given cluster. The problem switches to how to determine the best location of the ASA coordinator?

5.2 All-pairs shortest-path problem

Based on the IRC architecture, the ASS is a spanning tree. Hence, it can be viewed as a weighed connected undirected acyclic graph, noted by G = (V,E) where V(G) is the set of nodes (ASAs) and E(G) is the set of arcs (communication links between ASA).

We denote by (u,v), the arc that connects two ASAs, u and v of V and we define the weighed function $W : V \rightarrow IR$ which associates a weight to each arc (u,v). We assume that each link joining two ASA is weighted by the value of the round trip time/2.

The minimum number of communication links required to connect all the ASAs is |V|-1. Further, the path of a message being delivered is the shortest path between any two ASA on the spanning tree(IETF, 2000b).

To find the best location of the ASA coordinator, we consider one assumption described as follows: within the ASS spanning tree, the ASA coordinator (ASA_c) must be the nearest node to all the other nodes (ASAs). In other words, the ASA_c must always have the shortest round trip time with all other ASA in the ASS. This means that we should resolve a problem of all-pairs shortest-path.

In a dynamic programming domain, a variety of algorithms can be applied to resolve the all-pairs shortest path problem, such as Dijkstra's single-source shortest-path algorithm, Floyd-Warshall All-Pairs-Shortest-Path algorithm, Bellman-Ford algorithm, a Slow-All-Pairs-Shortest-Path algorithm, etc. For our purpose, we choose to use Floyd-Warshall’s algorithm for several reasons (Corman and al.,1994). Compared to other algorithms(Faure and al.,2002), it uses an adjacency matrix representation and has the best run time, roughly $\theta(V^3)$, which can be reduced down to $\theta(V^2)$.

Assume that we have an ASS composed of 7 ASA involved in a RTA, forming a spanning tree as a logical structure, as shown in figure 9 below. The nodes of the ASS graph are V = {ASA_1, ASA_2, ASA_3, ASA_4.,ASA_5,ASA_6 ASA_7}.

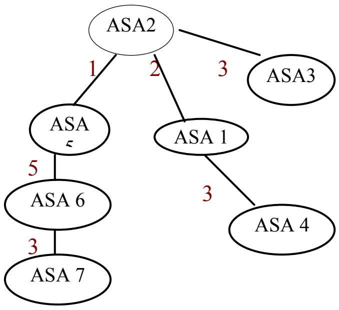

Figure 9: The ASS graph

G is represented by the D_0's adjacency matrix an 7x7 adjacency matrix with the weights of the arcs, as shown in figure 10.

To determine the best location of the ASA_c, we apply the F-W algorithm to the ASS graph and we assume that each link joining two nodes (ASAs) is weighed by the value of the round trip time/2. The demonstration of this algorithm is illustrated below by the figure 10.

D_0=

	1	2	3	4	5	6	7
1	0	2	+∞	3	+∞	+∞	+∞
2	2	0	3	+∞	1	+∞	+∞
3	+∞	3	0	+∞	+∞	+∞	+∞
4	3	+∞	+∞	0	+∞	+∞	+∞
5	+∞	1	+∞	+∞	0	5	+∞
6	+∞	+∞	+∞	+∞	5	0	3
7	+∞	+∞	+∞	+∞	+∞	3	0

D_1 =

	1	2	3	4	5	6	7
1	0	2	+∞	3	+∞	+∞	+∞
2	2	0	3	5	1	+∞	+∞
3	+∞	3	0	+∞	+∞	+∞	+∞
4	3	5	+∞	0	+∞	+∞	+∞
5	+∞	1	+∞	+∞	0	5	+∞
6	+∞	+∞	+∞	+∞	5	0	3
7	+∞	+∞	+∞	+∞	+∞	3	0

D_2=

	1	2	3	4	5	6	7
1	0	2	5	3	3	+∞	+∞
2	2	0	3	5	1	+∞	+∞
3	5	3	0	8	4	+∞	+∞
4	3	5	8	0	6	+∞	+∞
5	3	1	4	6	0	5	+∞
6	+∞	+∞	+∞	+∞	5	0	3
7	+∞	+∞	+∞	+∞	+∞	3	0

D_3=

	1	2	3	4	5	6	7
1	0	2	5	3	3	+∞	+∞
2	2	0	3	5	1	+∞	+∞
3	5	3	0	8	4	+∞	+∞
4	3	5	8	0	6	+∞	+∞
5	3	1	4	6	0	5	+∞
6	+∞	+∞	+∞	+∞	5	0	3
7	+∞	+∞	+∞	+∞	+∞	3	0

D_4=

	1	2	3	4	5	6	7
1	0	2	5	3	3	+∞	+∞
2	2	0	3	5	1	+∞	+∞
3	5	3	0	8	4	+∞	+∞
4	3	5	8	0	6	+∞	+∞
5	3	1	4	6	0	5	+∞
6	+∞	+∞	+∞	+∞	5	0	3
7	+∞	+∞	+∞	+∞	+∞	3	0

D_5=

	1	2	3	4	5	6	7
1	0	2	5	3	3	8	+∞
2	2	0	3	5	1	6	+∞
3	5	3	0	8	4	9	+∞
4	3	5	8	0	6	11	+∞
5	3	1	4	6	0	5	+∞
6	8	6	9	11	5	0	3
7	+∞	+∞	+∞	+∞	+∞	3	0

D_6=

	1	2	3	4	5	6	7	Σ
1	0	2	5	3	3	8	11	32
2	2	0	3	5	1	6	9	26
3	5	3	0	8	4	9	12	41
4	3	5	8	0	6	11	14	47
5	3	1	4	6	0	5	8	27
6	8	6	9	11	5	0	3	42
7	11	9	12	14	8	3	0	57

Figure 10: Demonstration of F-W's algorithm

This algorithm permits to determine the optimal node, which is the nearest to all other ASAs and has the less weight with all nodes. For our case, the node ASA_2 is then the optimal node so that it would be designate as the ASA coordinator within this ASS.

6 RELATED WORK

Several studies deal with distributed system architectures for online auctions. In the following, we present two surveys that we think are most closely related to AHS.

In (Panzini and Shrivastava, 1999), Panzieri and Shivastra present a replicated auction service architecture, duplicating the auction services across a number of distributed auction servers. They define two communication protocols required for the implementation of their architecture, namely Browser-to-Server Protocol (BSP) and Server-to-Server Protocol (SSP). The former specify the allowed interactions between bidders and an auction server and the latter manages the information exchange among auction servers. The implementation of these protocols is not presented in this paper; however several approaches of implementing them are suggested. For the SSP, they propose a transactional approach or a group approach. They also show how they can achieve the goals of data integrity, responsiveness and scalability, but they do not discuss the fairness issue.

In (Ezhilchelvan and Morgan, 2001), Ezhilchelvan and Morgan present a hierarchical auction architecture for conducting auctions over a set of distributed auction servers meeting the requirements of scalability, responsiveness and service integrity. Auction servers are hierarchically structured into a number of interconnected local market servers. This minimizes inter-server communications and maintains fairness. Moreover, auction servers are logically structured into a tree, rooted on a single server in order to ensure the inter-server communication scalable and the termination detection efficient. They are partitioned into multicast groups in order to facilitate dissemination of shared data. Cooperation between auction servers is needed to ensure data integrity. To achieve some reliability issues, the authors propose a framework for a fault-tolerant implementation of this architecture by using replication and group management techniques.

In both studies, the authors define similar requirements for distributed auction architectures and address the issues related to online auctions in general without considering the real-time features. However, we focus on distributed real-time auction systems. Moreover, these architectures use the HTTP protocol, which is considered as a poor protocol for real-time auctions as discussed in (Kaabi, BenAyed and Kamoun, 2003)and (Kaabi, BenAyed and Kamoun, 2004). Furthermore, they support some specific types of auctions such as sealed-bid auction, open-cry auction and Dutch auction while the AHS architecture is generic and handles varieties of real-time auction protocols.

7 CONCLUSION AND OPEN PROBLEMS

In this paper, we have presented a distributed communication architecture, called AHS (Auction Handling System) for real-time auctions. This architecture is intended to be deployed in a large scale network and to support real-time interactions between bidders and a set of distributed auctioneers. To reach our goals, we chose the use of the IRC channels and protocol facilities in order to reduce the data transmission delay and the traffic on the Internet. Furthermore, we adopted a hierarchical approach based on clusters because it is supposed to offer scalability, load-balancing, client fairness, high availability and reliability. This approach would facilitate the collaboration between all the ASAs being part of the ASS. Indeed, within a cluster, one of the ASAs is designated as a coordinator, who receives PQ_i from ASAs for evaluation and multicasts the PQ_f. To determine the best location of the ASA coordinator, we suggest using Floyd-Warshall's algorithm, a graph theory algorithm in order to resolve an all-pairs shortest-path problem.

There are a variety of questions left unanswered by the work described here. Below, we list few directions for further work in this area. Work is under way on the specification and the implementation of the ASA communication protocol. The interactions between different types of ASA involved in a distributed real-time auction will be clarified. The experimentation and the simulation of the three approaches are under study.

The future direction of this study will include time synchronization issue, the identification of load parameters for the creation of clusters and the implementation of the hierarchical approach.

REFERENCES

Liu, H., Wang, S. and Teng, F., 2000. Real-Time Multi-Auctions and the Agent Support. Journal of Electronic Commerce Research, VOL. 1, NO. 4, 2000.

Bougouris, C., Koukopoulos D. and Kallas, D.,1998. A real-time auction system over WWW, from Internet at: http://diogenis.ceid.upatras.gr/~koukopou/cnds.ps., visited in July 2004.

Wellman, M.P and Wurman, P.R.,1998a. Real time issues for internet auctions. The 1st IEEE workshop on dependable and real-time e-commerce systems (DARE-98), Denver, CO, USA, June 1998.

Peng, C.S., Pulido, J.M., Lin, K.J. and Blough, D.M.,1998. The design of an internet-based Real-Time auction system. First IEE workshop on dependable and real-time e-commerce systems (DARE-98), Denver, CO, USA, June 1998, pp.70-78.

Rumpe, B. and Wimmel, G.,2001. A Framework for Real-time Online Auctions, available at : http://www4.in.tum.de/~rumpe/papers/RW01/RW01.pdf, visited in Marsh 2004.

Panzini, F. and Shrivastava, S.K.,1999. On the provision of replicated internet auction services. Proceeding of the 18th IEEE international symposium on reliable distributed systems, Lausanne, October 1999, pp 390-395.

Kaabi,S.,BenAyed,H. and Kamoun, F.,2003. Specification of a communication protocol, based on IRC for real time auctions. Sixth international Conference on Electronic Commerce Research ICECR6, Dallas Texas, pp 129-138.

Ezhilchelvan,P. and Morgan,G., 2001. A dependable distributed auction system: architecture and an implementation framework. Proceeding of the 5th IEEE international symposium on Autonomous de-centralized systems, Dallas, Texas, April 2001.

Ezhilchelvan,P., Morgan,G., Khayambashi,M.R. and Palmer,D., 1999. Measuring the cost of scalability for Internet-based server-centred applications, issued from Internet.

Ezhilchelvan, P., Shrivastava, S.K. and Little, M.C.,2000. A model and architecture for conducting hierarchically structured auctions. May 2000. Available at www.cs.ncl.ac.uk/people/paul.ezhilchelvan/home.formal/published/hierarchicFP.ps

Esteva,M. and Padget, J.,1999. Auctions without auctioneers: distributed auction protocols, available at http://www.maths.bath.ac.uk/~jap/Papers/amec99.ps, visited in July 2004.

Wellman, M.P, Wurman, P.R. and Walsh, W.E.,1998b. The Michigan Internet AuctionBot: A configurable auction server for human and software agents. The 2nd ACM International conference on autonomous agents, pp.301-308.

Wellman, M.P, Wurman, P.R., Walsh, W.E.,and O'Malley, K.A.,1999. Control architecture for a flexible internet auction server.

Banatre,J.P.,Banatre,M.,LapalmeG., and Ployette, F.,1986. The design and building of Enchere, a distributed electronic marketing system. CACM Vol.29(1), 1986, pp19-29.

Maxemchuk, N.F. and Shur, D.H., 2001. An Internet Multicast system for the stock market. ACM Transactions on computer systems, Vol 19 N°3.

Kaabi,S.,BenAyed,H. and Kamoun, F.,2002. Evaluation of HTTP, E-mail, NNTP with regard to negotiation requirements in the context of electronic commerce,

ICECR4-06, the fourth international conference of electronic commerce research, Dallas, Texas.
Ockenfels, A.and Roth, A., 2002a. The timing of bids in internet auctions: market design, bidder behavior and artificial agents. Artificial intelligence magazine, July 2002.
Ockenfels, A.and Roth, A., 2002b. Last minute bidding and the rules for ending second price auctions: evidence from eBay and Amazon auctions on the Internet. American Economic Review, September 2002, 92(4), 1093-1103.
IETF,2000a. Internet Relay Chat: Architecture, www.ietf.org, RFC 2810.
IETF,2000b. Internet Relay Chat: Server Protocol, www.ietf.org, RFC 2813.
IETF, 2000c. Internet Relay Chat: Channel Management, www.ietf.org, RFC 2811.
Corman, T.H., Leiserson, C.E., and Rivest, R.L., 'Introduction to Algorithms', section 26.2, p. 558-562. 1st edition Dunod, 1994.
Faure, R., Lemaire B. and Picouleau,C.,2002. Précis de recherche opérationnelle, 5th edition Dunod 2002.
Kaabi,S.,BenAyed,H. and Kamoun, F.,2004. A Prototype of a communication protocol for Real-Time Auctions. Seventh international Conference on Electronic Commerce Research ICECR7, Dallas Texas.