INFORMATION
TECHNOLOGY JOURNAL

Parallel and Distributed Architecture of a Fair and Scalable Mobile Competitive System

E. Vaziripour and M.R. Khayyambashi

Department of Computer, Faculty of Engineering, University of Isfahan, Isfahan, Iran

Abstract: With the development of wireless communication and mobile computing, new ways for people to interact with each other and their surrounding environment are emerging. Mobile devices, such as Personal Digital Assistants (PDAs) with wireless communication interfaces make people able to communicate directly and compete with each other via network sessions. This study develops a mobile distributed architecture for dependable mobile competitive interactions over mobile networks, meeting the requirements of fairness, scalability and responsiveness through parallel tasks. The system considers variable communication delay of traversing intervals from users located in different situations and waiting time to obtain fairness. As can be expected, such models tend to ignore the selfish behavior of users.

Key words: Server, server zone, distributed systems, fairness, WLANs, competitive environments, QoS

INTRODUCTION

Mobile wireless computing devices provide interesting opportunities for building new styles of competitive applications such as auction, game and marketing. Among them WLAN is an immense example of this fact designed to support a network where most decision-making is distributed across the mobile stations (Caporuscio *et al.*, 2003).

It is needed to be mentioned that the most significant essential point in such large networks is lack of fairness regarding different distances of users from the central service center which provides the needed services specially in competitive applications and limited researches have been proposed in this issue, yet this paper refers to developing a competitive application over networks of this kind (Frey *et al.*, 2003).

WIRELESS LOCAL AREA NETWORKS

The wireless LAN protocol is based on the IEEE 802.11 and 802.11b standards. The standard defines a Medium Access Control (MAC) sub layer and three physical (PHY) layers. The goal of the IEEE 802.11 protocol is to describe a wireless LAN that delivers services commonly found in wired networks, such as throughput, reliable data delivery and continuous network connections. The architecture of the IEEE 802.11 WLAN is designed to support a network where most decision-making is distributed across the mobile stations (Ezhilchelvan and Morgan, 2001).

Some of the basic components of the 802.11 based networks are described below:

Station: In IEEE 802.11 network a station is the component that connects to the wireless medium. The station may be mobile, portable, or stationary. Every station supports all station services, which include authentication, deauthentication, privacy and delivery of the data (MAC service data unit).

Basic Service Set (BSS): The IEEE 802.11 WLAN architecture is built around a BSS. A BSS is a set of stations that communicate with each another. When all of the stations in the BSS can communicate with each other directly and there is no connection to a wired network, the BSS is called an independent BSS (IBSS). An IBSS, which is also know as an adhoc network, is typically a short-lived network with small number of stations that are in direct communication range. When a BSS includes an Access Point (AP), the BSS is no longer independent and is called an infrastructure BSS, or simply a BSS. In an infrastructure BSS, all mobile stations communicate with the AP. The AP provides the connection to the wired LAN, if there is one and the local relay function within the BSS.

Extended Service Set (ESS): An ESS is a set of infrastructure BSSs, where the APs communicate among themselves to forward traffic from one BSS to another. The APs perform this communication via a Distribution System (DS). The DS is the backbone of the WLAN and can be composed of wired or wireless networks (Ezhilchelvan *et al.*, 2001).

Corresponding Author: Elham Vaziripour, Department of Computer, Faculty of Engineering, University of Isfahan, Isfahan, Iran

COMPETITIVE ENVIRONMENTS

M-commerce covers a wide range of applications. Varshney and Vetter (Wellman and Wurman, 1998; Lin and Shrivastava, 2003; Kumar and Feldman, 1999; Turban, 1997; Shiha *et al.*, 2007) identified several important classes of m-commerce applications including mobile financial applications, mobile advertising, mobile inventory management, locating and shopping for products, proactive service management, wireless re-engineering, mobile auctions or reverse auctions, mobile entertainment services and games, mobile offices, mobile distance education and wireless data centers. They gave a detailed explanation of each application (Fitzek *et al.*, 2002).

Current noted competitive applications essentially rely on a centralized service center. Such an approach is fundamentally restrictive as too many users can overload the server, making the whole process unresponsive. We require a framework for such applications to be scalable, i.e., capable of providing its end users with satisfactory Quality of Service (QoS), regardless of the number of those users and their geographical distance.

Requisites: The specific requirements implied by the deployment of scalable competitive mobile applications over WLANs are included:

Security: From the point of view of a competition, all other users are called disinterested rivals. Many problems with the design of competitive environments could be solved if the users could trust system.

However, this may not be as simple as it seems. There are two reasons why disinterested users cannot be wholly trusted: first, the users of a game could be in coalition with some disinterested users (in other words, these users may not be disinterested at all). Second, the disinterested users could be malicious: for the sake of spoiling the competition for others (and improving their own ranking), a disinterested customer could reveal or falsify information related to the clients of the system. For this reason, the sharing of information with disinterested users must be limited to a minimum (Henderson *et al.*, 2003; Wellman and Wurman, 1998; Lin and Shrivastava, 2003; Shiha *et al.*, 2007).

Fairness: Fairness, which means that all participants should have an equal fair chance for submitting their requests and should be treated equally, is the most important challenge for every type of environments or competitions. Because in all networks clients who located in farther situation from main service center have less opportunity to process their situation and they will be informed later from the status of the system, unfair condition will be provided (Henderson *et al.*, 2003; Bonald *et al.*, 2003).

Scalability: Responsiveness and scalability are the essential requirements of large and scalable competitive systems. The responsiveness requirement, i.e., a service must be timely and available under specified load and failure hypothesis, is motivated by the observation that a service that exhibit poor responsiveness is virtually equivalent to an unavailable service. Thus, within the mobile context, an unresponsive service may discourage users from using it. The architecture used for scalable system user should receive a qualified and prompt regardless of the number of users of system (Frey *et al.*, 2003; Henderson *et al.*, 2003; Fitzek *et al.*, 2002).

Integrity: Because of the mobility of users, it is needed that they carry their history themselves via the zones they move. The history in an auction or purchasing system refers to clients' purchase basket and in a game refers to player's rank and for each application it has an especial meaning (Frey *et al.*, 2003; Ezhilchelvan *et al.*, 2001).

Speed: The key to a successful system is speed, e.g., the ability to respond without any delay related to the far distance (Ezhilchelvan *et al.*, 2001).

The problem which addressed in this study refers to proposing an optimum model for deploying a scalable, fair competitive condition over mobile networks.

THE SYSTEM ARCHITECTURE

We assume that the initial steps, included the primary user identification performs and the system is in the competitive phase.

In this proposed model, the system is made up of two layers. In one layer, mobile nodes divide in to many zones regarding their geographical position. In each zone, management of competition relies on an immobile or somehow stable node called SZ. In the underneath layer communications are intra zone and included nodes which the zone possesses. In each zone, users propose their request one by one to SZ and will be informed by that from the competition's status and rivals' position in a specific round. SZ receives requests in a serial manner and acts as an intermediate between nodes inside a zone and the main service center. However, SZs act parallel and simultaneously with each other. SZs winnow received packets and convey only the credited requests of users to the main service center which called CS. They act per case for various applications, for instance, if in auction system
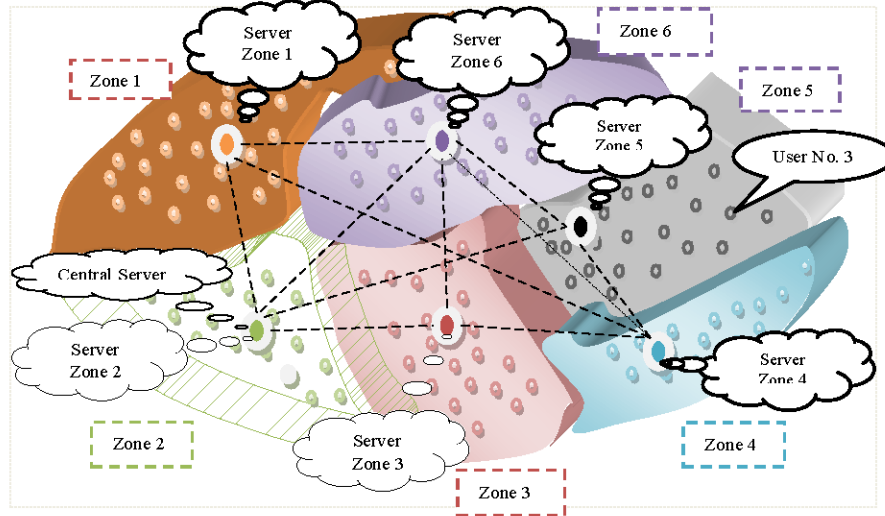
Fig. 1: Distributed architecture for competitions

the request packets are customer's bid and SZs are responsible to convey only the highest local bid to CS.

The base of this model relies on trust between nodes of a zone and their SZ. The best positive point for this method refers to being anonymous from the view of the CS and other rivals. As the best strategy might be hard to design, implement, or compute, the equilibrium notion is relaxed and we also consider approximate equilibrium in which every user achieves a competitive ratio that is within a known factor away from the best competitive ratio attainable by any strategy.

It is also important that CS do not have to communicate with a large number of users participated in the game, it communicates only with the SZs of all zones instead of their members. This makes the system scalable and increases the power of system responsibility.

We can consider the SZs as servers which are attached to the access points and the CS as one of these servers in WLAN networks and each access point connect to a router which makes the ring background wired network or connect to a central bridge which makes star topology.

In each zone some users can move from one zone to another zone by passing the time if access points cover the whole area together. After moving to another zone, the SZ of the new zone accepts the node and it can continue the competition in the new zone.

Figure 1 shows an example that shows many users arrange in six zones. In this example, SZ2 acts as the main service center (CS). Each customer proposes his request to the SZ related to his zone. If the suggested request seems to be right in one zone the SZ has the responsibility for sending that to the CS. In this example

if U5.3 that is the third node of zone No. 5 proposes a request which is the right at the moment, the request will be sent for SZ5 at first and it is SZ5 that consider the credit request of U5.3 solemnly. It waits for all users from users pertained to that zone and then sends the credited ones to CS.

The round duration has to be fixed and equal for each competitor such that all participants have enough time and an equally fair chance of submitting a successful request during the current round. The start point and stop point for each round duration depends on the time that user receives the message and they may be shifted toward rivals. The fairness problem in the WLANs context implies that the farthest user from the CS will always react later than the other users which may be beside the CS. This results in a lack of fairness with regard to request submission. Therefore, what is important for resolving the fairness problem relies on the correct estimation of the necessary round duration time allowing the fulfillment of defined fairness condition. The round duration time is calculated on the basis of the worst case, the case allowing the farthest node of CS to receive message and submit requests.

In each zone, SZ considers delay time for receiving all available requests from nodes pertain to that zone including the farthest node regarding the number and distance of nodes related to that zone and informs the CS from calculated time. It means CS must wait until all requests of each SZ were received. The waiting time includes local zone delay plus delay for network communication between SZs and CS. Therefore, the round duration time is the time that all SZs submit the requests of credited packets in competition to CS.

Consequently, the optimal calculated delay for assuring fairness is:

$$\text{Delay optimal} = (\text{Mhop-Mactual}) * 2 * \text{TD} \qquad (1)$$

Mhop is the maximum number of hops referring to the farthest node from the SZ. Mactual is the number of hops referring to the nearest node or the node whose suggested request arrives sooner than other rivals. The factor 2 refers to the RTT condition and the last parameter TD represents the mediocre time delay for traversing between two nodes (one hop).

This delay time may be changed by changing the number of nodes of one zone. We can assume that in each zone fairness is guaranteed, however it is needed to take in to consideration the communication delays in the second layer between SZs and CS for assuring fairness throughout the whole system. By dividing the system in to two layers, we can avoid shifting the problem of intra zones to the communication between SZs and CS. For this purpose SZs need routing tables which included the address of CS and the optimum path to that and delay for each path. It is needed to consider the different delays related to different distances between SZs and the CS.

The most positive point about this model refers to the fact that is compatible with the WLAN networks. We can conduct the competition in each BSS by attaching servers to access points and a server to the bridge in the ESS (Shiha *et al.*, 2007). The servers related to access points evaluates the content of packets before the access points forward them. Therefore, most packets are not allowed to send via the connection and decrease the traffic as well as increase the responsibility. In this way the tasks will be distributed among servers and will be done concurrently.

COMMUNICATION PROTOCOLS

Since in this model there are two principal transactions, two principal protocols are required in order to implement this model.

User-to-SZ protocol: Mobile nodes are under the control of their SZ and receive the information about system. If they have a new request, propose it to their local SZ. The SZ send the right ones to the CS, otherwise they will be ignored.

By moving one node from one zone to another, the SZ of the current zone must accept the node and register that in its database and behave it as the other node pertained to the zone.

SZ-to-CS protocol: SZs are usually fixed nodes that act as a proxy for each zone. It has a responsibility to constitute a table which includes optimum path with delay of path to all SZs and informs all of them of other zones.

When SZs receive requests that come out right from their mobile nodes, inform the CS through the optimum path. They must wait until the time that makes sure no more reaction are existed and requests from the farthest nodes are arrived. This model considers optimum Delay as the fair time. The CS considers differences in distances between SZs and itself and waits until the time that makes sure requests from the farthest SZs are received. This protocol use an atomic transaction to ensure that the request submission operation performed from the user is executed in a fair manner.

The request submitting transaction consist 6 stages: An active node, for instance U1.1, proposes a request to the SZ of its zone (A1).
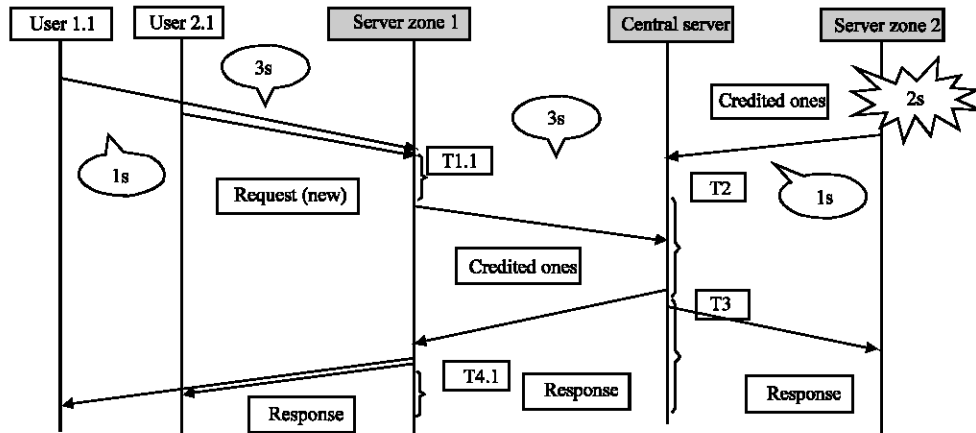

Fig. 2: Performing fairness by spotting delays and paralleling

If the received request from node N pertained to zonei is the first request that is arrived, the SZi must wait T1.i until other assumed requests from father rivals arrive.

$$T1.i = (Mhop-Mactual) *2 *TD-T(path\ from\ N\ to\ Ai) \qquad (2)$$

After collecting all requests and waiting T1.i, SZi (Ai) considers all requests and do nothing if no right suggestion occurs, otherwise forwards the right ones to the CS. For example, in Fig. 2, SZ1 wait 2 sec after receiving message of U1.1, so that if there are some requests which have not arrived yet, will be received. A1 surveys all requests locally after that and forwards the right ones to SZ2 (A2) if it is a request which must be forwarded.

If the proposed request received from zone k to CS which is the first arrived right request through the shortest path, CS will wait T2 until other SZs reveals their likely right requests.

$$T2 = max\ \{Tj.i+T(best\ path\ from\ Ai\ to\ CS)\}-(T1.k+T(path\ K-A)) \qquad (3)$$

In the expressed example, the intra delay of zone 2 is 2 sec and delay related to route between SZ2 to CS is 1 sec. It shows that it takes 3 sec to receive requests from the second zone. But it takes 6 sec to receive requests from the first zone. Therefore, the CS must wait at most 6 sec and users from zone 2 face disinterested delay, but this imposed delay makes the system fair.

If competition time is over and there is no opportunity to propose new requests, the final situation will be announced and proposing phase will be finished. Otherwise these stages will be repeated from the first one.

CONCLUSIONS

Regarding the explained restrictions related to mobile networks such WLANs, it is clear that an especial architecture is required to have a fair, scalable mobile competition over networks of this kind.

In the proposed model in this study, scalability requirement is obviated by categorizing nodes regarding their geographical situation regarding WLANs.

In addition, by considering intra delays for sending and receiving messages and preventing penetration of this kind of different network delays which make the system unfair to the second layer it is tried to construct a fair architecture.

We used OPNET.v.10.5 Modeler, An environment that used to study performance changes of networks: organizational scaling, technology changes and
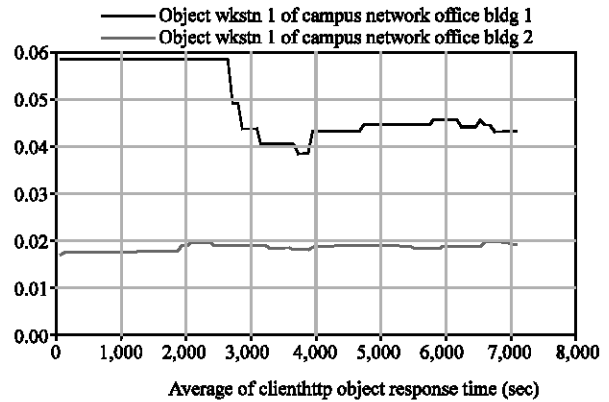

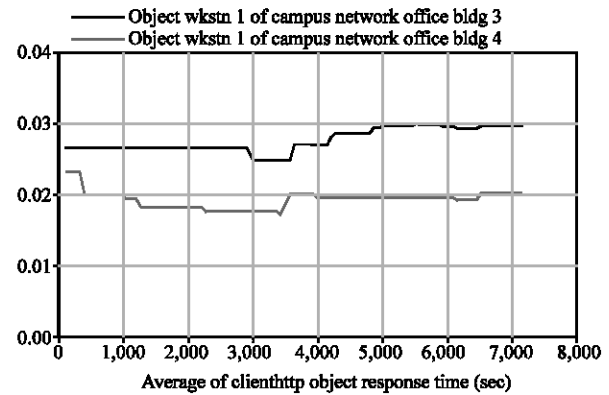Fig. 3: Compare response time before apply the proposed idea

Fig. 4: Compare response time after apply the proposed idea

application deployment, to simulate this model and study its performance. As Fig. 3 and 4 show before applying the proposed architecture, deference between response times of a node far from CS is much than when we consider and imposed the disinterested delay for nodes near to CS. Therefore by making their response time close to each other we make the system fair in competitive environments.

The most positive point about this model refers to the fact that all codes will be executed parallel; therefore the system will be scalable and fair because of the concurrent processing of customers suggested requests.

REFERENCES

Bonald, T., A. Proutiere, J. Roberts and J. Virtamoi, 2003. Computational aspects of balanced fairness. Proceedings of the 18th International Teletraffic Congress ITC-18, Aug. 31-Sept. 5, Berlin, Germany, pp: 801-810.

Caporuscio, M., A. Carzaniga and A.L. Wolf, 2003. Design and evaluation of a support service for mobile, wireless publish/subscribe applications. IEEE Trans. Software Eng., 29: 1059-1071.

Ezhilchelvan, P. and G. Morgan, 2001. A dependable distributed auction system architecture and an implementation framework. Proceedings of the 5th IEEE International Symposium on Autonomous De-Centralised Systems, Mar. 26-28, Dallas, Texas, pp: 3-3.

Ezhilchelvan, P.D., S.K. Shrivastava and M.C. Little, 2001. A model and architecture for conducting hierarchically structured auctions. Proceedings of the 4th International Symposium on Object-Oriented Real-Time Distributed Computing, May 2-4, Magdeburg, Germany, pp: 129-129.

Fitzek, F., G. Schulte and M. Reisslein, 2002. System architecture for billing of multi–player games in a wireless environment using GSM/UMTS and WLAN services. Proceedings of the 1st workshop on Network and System Support for Games, Apr. 16-17, New York, USA., pp: 58-64.

Frey, H., D. Gorgen, J.K. Lehnert and P. Sturm, 2003. A Java-based uniform workbench for simulating and executing distributed mobile applications. Proceedings of the FIDJI 2003 International Workshop on Scientific Engineering of Distributed Java Applications, Nov. 27-28, Luxembourg, pp: 1-12.

Henderson, T., G. Schulte, P. Seeling, F. Fitzek L. Badia and M. Zorzi, 2003. Mobility and stability evaluation in wireless multi hop networks using multi player games. Proceedings of the 2nd Workshop on Network and System Support for Games, May 22-23, New York, USA., pp: 77-87.

Kumar, M. and S.I. Feldman, 1999. Internet auctions. IBM Research Division T.J. Watson Research Center Yorktown Heights, New York. http://www.research.ibm.com/iac/papers/auction_f p.pdf.

Lin, N. and S. Shrivastava, 2003. System support for small-scale auctions. Proceedings of the Med-Hoc Net 2003 Workshop Mahdia, Jun. 25-27, Tunisia, pp: 1-7.

Shiha, D.H., B. Linb and S.Y. Huang, 2007. MoRVAM a reverse VIckrey auction system for mobile commerce. Expert Syst. Appli., 32: 1113-1123.

Turban, E., 1997. Auctions and bidding on the internet an assessment. Int. J. Electronic Markets, 7: 7-14.

Wellman, M.P. and P.R. Wurman, 1998. Real time issues for internet auctions. Proceedings of the 1st IEEE Workshop on Dependable and Real-Time E-Commerce Systems, June 1998, Denver, CO, USA., pp: 1-6.