Simulation of Area of Interest Management for Massively Multiplayer Online Games Using OPNET

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***Abstract*— In recent years, there has been an important growth of online gaming. Today's Massively Multiplayer Online Games (MMOGs) can contain millions of synchronous players scattered across the world and participating with each other within a single shared game. The increase in the number of players in MMOGs has led to some issues with the demand of server which generates a significant increase in costs for the game industry and impacts to the quality of service offered to players. With the number of players gradually increasing, servers still need to work efficiently under heavy load and, new researches are required to improve the established MMOG system architectures. In dealing with a considerable scale of massively multiplayer online games, several client-server and peer-to-peer solutions have been proposed. Although they have improved the scalability of MMOGs in different degrees, they faced new serious challenges in interest management. In this paper, we propose a novel static area of interest management in order to reduce the delay and traffic of Hybrid P2P MMOGs. We propose to use OPNET Modeler 18.0, and in particular the custom application to simulate the new architecture, which required the implementation of new nodes models and behaviors in the simulator to emulate correctly the new architecture. The scenarios include both client-server and hybrid P2P system to evaluate the communication of games with (125, 500, and 1000) peers. The simulation results show that area of interest management for MMOGs based on the hybrid P2P architectures have low delay and traffic received compared with MMOGs based on client-server system.**

I. Introduction

A massively multiplayer online game (MMOG) is considered one of the most important online games capable of supporting typically thousands of concurrently players playing in a shared persistent game world. One of the key important features in these games is the massive number of players who play concurrently over the Internet. The huge number of players leads to a more interactive, complex, and attractive game environment. The essential requirement of MMOGs based on hybrid P2P architecture is to maintain a consistent and shared sense of virtual space between significant numbers of players with minimum resources of game server. Area of Interest Management (AoIM) is considered a conventional research topic that was initially addressed by Macedonia et al. in the mid-1990s [1], to improve scalability. The concept of AoIM originates from two assumptions: the first assumption is a single player does not need to know about what is happening in the game world as long as it does not impact him; in addition, the second assumption is a player's avatar has limited movement speed and sensing ability, and will not be able to sense (e.g. see, hear, be affected, etc…) by events beyond a certain range. In this paper, we propose a novel area of interest management technique for our hybrid P2P architecture [2] in order to reduce the delay and traffic of MMOGs even further, and avoid unnecessary communication of players' state changes. The rest of the paper is organized as follows. Section II introduces the background of subjects related to the research area. Section III presents a review of the state-of-the-art of area of interest management for MMOGs and section IV introduces area of interest management within P2P. Section V describes the propose static area of interest management system for MMOGs using Hybrid P2P architecture. Sections VI, VII introduce the experiments using OPNET simulation and the results. Section X presents the conclusion.

II. Research Background

The main goal of using interest management is to decrease the cost of data communication in a distributed game, thus reducing delay and, the amount of traffic and bandwidth. This cost relies on the underlying communication architecture, as well as the special IM scheme in use. In the next section, we discuss the concepts related to the research.

A. Hybrid Peer-to-Peer Architecture

The main idea of the hybrid P2P architecture is to combine the benefits of both client-server and peer-to-peer architectures [2]. The essential goal is to provide improved scalability compared to client-server system, lower cost of game distribution, control of the game state, and eases the deployment of the game updates over the players. In the hybrid P2P system, the centralised server is responsible for maintaining the game state and keeping it persistent and consistent, as well as, doing the main administration

operations, for example authorisation, authentication, and content initial distribution. These operations are much less resource consumption than the operations done by the server in the client server system, which in addition include the in-games communication with all the clients. Therefore, the hardware cost for these servers or adding new server would be substantially reduced [3]. The hybrid P2P architecture also has several challenges to overcome. One of the most important challenges is the capability of the system to adding new peers and allocating them to one of the region servers in the network system. Therefore, the system will need an effective way to distribute the work load between the regional servers, being able to re-distribute the load when one of the region servers becomes unavailable or overloaded.

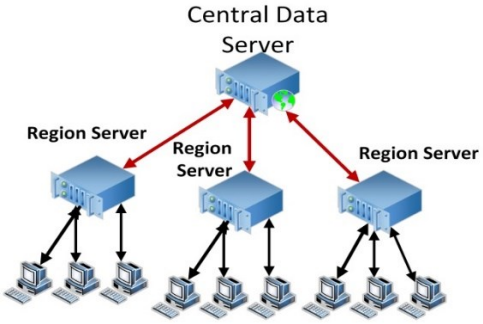

Fig. 1. Typical Hybrid P2P Architecture

B. *The Zoning Concept*

One of the most important concepts in interest management is zoning, whereby, the entire game world is divided into smaller portions, called zones or regions. This is due the difficulty of maintaining a large number of processes with a single server. Each zone can be dealing with one game server instance. Figure 2 illustrates the zoning concept. The player in the zone can only interact with the other players in the same zone. However, the AoIM of player can change as soon as the player migrates to another zone. The workload can be effectively decreased by reducing the responsibility of a server from maintaining the entire world. Thus, this mechanism offers a good approach for increasing the scalability of a game server infrastructure.

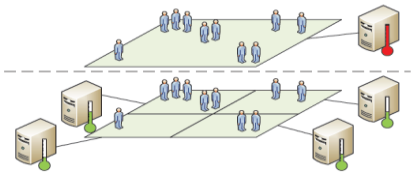

Fig. 2. The zoning Concept [4]

One of the simpler approaches is for the AoIM to be a sub-area of the whole zone. Typically, it is a fixed-radius circle or sometimes sphere around the player in the zone. Player's AoIM moves accordingly, when the player migrate to another zone. So, interest management must be determined for each players and objects in the zone. Figure 3 displays an example of the sub-area method.

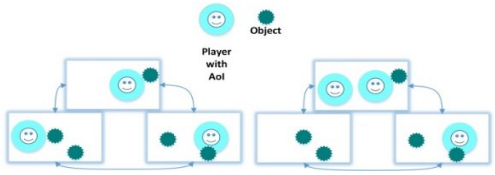

Fig. 3. The sub-area AoI Approach

III. Related Work

In this section, we present a review of some research related to the area of interest management for MMOGs.

A. *Publish-Subscribe Area of Interest Management*

This model proposes to support MMOGs based on P2P system using coarse-grained AoIM. In this model, the virtual game world is divided into static regions and the recipient of updated message is limited to just participants who reside within the same area of interest. In this case, AoIM can be done by using a publish/subscribe model, in which publishers are objects that produce events, and subscribers are objects that consume events [5]. An object, for example a player's avatar, can be both a publisher and subscriber. One of the most important responsibility of Publish-Subscribe AoIM is to determine the area of interest for players in the game world, as well as, to form the area-of-subscription from the union of the intersected regions [5]. The main advantage of publish-subscribe AoIM model is to be simple, easy, and cheaper to compute a player's area of interest management.

B. *Spatial AoIM*

One of the simple AoIM called spatial interest management. it is the mechanism for defining spatial areas or volumes around the player's location in the virtual world [6]. The benefit of a spatial model is that it allows fine-grained interest management in which just indispensable messages are transmitted among relevant players [3]. However, a significant cons is that it requires all objects to interchange positional update information in order to identify when AoIM collisions happen. There are two key abstractions: aura and nimbus [7]. The "aura" refers to the area that bounds the location of an object in space; however, the "nimbus" means the reciprocal awareness levels between two objects. Thus, each object should start to communicate with other objects that exist within its nimbus, in order to get ready for potential interactions. In its simplest model both the aura and nimbus can be represented by fixed-size circles around the object [7]. The essential advantage of a spatial model is that it allows fine-grained Interest Management in which only requisite messages are transmitted between relevant peers [3]. However, a

significant obstacle is that it requires all objects to exchange current update information in order to identify when AoIM collisions happen.

C. *Voronoi Based AoIM*

One of the most important technique allocated for Area of Interest Management in P2P networks is based on the concept of a Voronoi diagram [8]. A Voronoi diagram is built by dividing the plane into n non-overlapping regions that include exactly one site in each region. Therefore, each region contains all the points closest to the region's site than to any other site. The entire plane is divided into arbitrary sizes in a deterministic method [9]. Figure 4 shows a Voronoi diagram, which can be used to locate the k-nearest neighbours of a specific site.

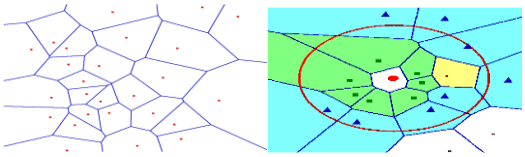

Fig. 4. (left) a Voronoi diagram. (Right) Square (□): enclosing neighbors, triangle (Δ): boundary neighbors [9]

Voronoi diagrams have significant advantage in the virtual world, due to they allow the distinction to be made between two different kinds of neighbouring peer; Enclosed and Boundary [9]. Enclosed neighbours are inhabit a region and share a common edge with a given node's own region. Nevertheless, boundary neighbours indicated to the regions that overlap with the node's AoIM boundary. When a peer moves from one position to another, position updates are sent to all neighbours recorded in the Voronoi diagram. When the receiver is a Boundary neighbour, an overlap check is performed. The receiver reviews if the mover, with its new AoIM, or would enter into any of its Enclosing neighbours' Voronoi regions. The receiver just reports the mover if a new overlap occurs. This style allows the moving peer to be conscious of potentially visible neighbours outside its AoIM.

D. *Geographic AoIM*

Geographic AoIM referred to the segmentation of the virtual world and, is commonly used to distribute players in MMOGs across several servers. This is a much more fine grained approach in the P2P networks, because massive reduction in computational and networking resource is obtainable on a single peer. In general, there are two types of segmentations: Uniform and Non-Uniform. Uniform methods are used to sub-divide the virtual world into same sized areas; however, non-uniform methods are used to divide the virtual world into varying sizes. There are four types of Geographic AoIM and these are described in the following subsections.

E. *Tile-Based Geographic AoIM*

The tile-based and commonly so called cell-based method is used to involve a static uniform division of the game world into same size squares, and usually used in MMOGs based on P2P [6], [29],[12]. There are many ways of building the area of interest by using the tile-based technique. The key approach is that players who are within the same tile are interested in each other.

F. *Triangular Geographic AoIM*

In this method, the virtual world is divided into triangles. Triangular approaches can be both uniform and non-uniform segmentation. A commonly used method is to use Delaunay triangulation [3]. The Delaunay triangulation has the possibility for maximising the minimum angle in every triangle in the triangulation; and avoid obtained on thin triangular regions. Also, we put a limitation on the maximum triangle area output by the triangulation as showing in figure 5.

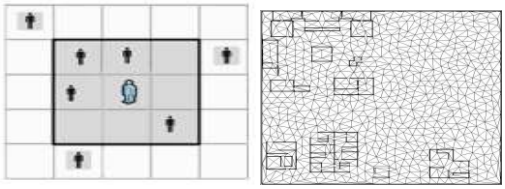

Fig. 5. Geographic AoIM (Tile, Delaunay triangulation) [3]

G. *Hexagonal Geographic AoIM*

The Hexagonal AoIM technique is used to divide the virtual world into uniform hexagonal pattern [13] [14]. This constrains the number of neighbouring regions and provides an optimal approximation of a radial AoIM surrounding a player.

H. *Hierarchical AoI*

This method is used to divide the virtual world into hierarchical divisions in order to introduce dynamism and non-uniformity into geographic AoIM [15]. This approach usually applied using a tree-structure, also a method used within the game engine to administer three-dimensional scenes by using techniques for instance Binary Space Partitioning (BSP) [16], QuadTrees and Octrees [17]. Figure 6 gives good illustration of this approach.

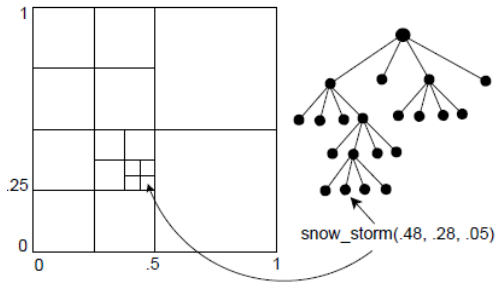

Fig. 6. Hierarchical AoIM using Quad Tree [17]

IV. Area of Interest Management within P2P

Providing relevant information to each player in the game world is an efficient method for consistency management. The aim of using AoIM) is decreasing the number of transmitted messages by specifying the potentially interested receivers [18]. This allows communicating the minimum amount of information that a peer needs to interact with other peers in the game world, in order to display an accurate state of the world to the players. This idea is not only related to P2P MMOGs, but has also been used in client/server architecture for virtual environment [19] and in distributed environment [20]. However, interest management becomes an inherent part of the network organisation, when used in conjunction with P2P infrastructures. This method is used with the aim to organise the connections between players in the game world so that they are only contacting with players who possess information pertinent to themselves. The next section describes the zoning concept in interest management.

V. Static Area of Interest Management for MMOGs

With the considerable increase of player's number in MMOGs, Area of interest management become one of the most significant features in MMOGs field. Several researches have been proposed to address the area of interest management. However, to the best knowledge of the authors, there is no research which has proposed to deal with the area of interest management of MMOGs based on hybrid P2P architecture. We proposed a static area of interest management for MMOGs based on P2P system. The main idea of proposed system is creating a list of players inside the region. The list consists of a number of peers in the same vicinity. The game update sent by game server or region super peer will be sent only to the players in the list instead of sending to all the players in the game world. We can note that Hybrid P2P architecture already organise the peers in regions, and in some way is similar to providing AoIM using zoning [4]. However in order to exploit further the ability of AoIM to improve scalability, we propose to refine the model further and use AoIM inside each individual regions the discriminate the messages communication from one to only those nodes who are in its list within a region.

VI. Simulation Design

Using OPNET Modeler 18.0 custom application [21] to implement and simulate the proposed system by creating a static list of players for MMOGs based on hybrid P2P architecture and compare the results with the traditional architecture client-server system. In hybrid P2P architecture, we have created a lists of interest player by using both region super-peer and clone-super-peer. The game updated for the player done by send the update for all the players in the list of interest not for the all players in the game world. However, the lists of interest in client-server architecture have created by using the game server. All the game updated and the player's communication done by the server. When the players exist in two different list of interest, they will received game updated twice. When new players joining the games, the super-peer in hybrid P2P system or the server in client-server system will add them to the suitable list of interest. However, when the players leave the game world, they will remove from the list of interest. The criteria used for selecting the players for list is the player location in the game world. The communication between the players inside the region will be responsible from the region super peer for the hybrid P2P architecture. Every game updates must be sent to the region super peer to be able to send them to the players inside the region. The idea of using static area of interest management is to send the game updates just to the players in the list instead of send them to all players in the region or in the game world. The network topology consists of two main scenarios for each architecture which are explained in the previous work [2]. The experiments will be carried with scenarios using 125. 500 and 1000 peers consecutively, and evaluating architectures based on client/server, client/server with AoIM, Hybrid P2P and Hybrid P2P with AoIM. The number of players peer list are around 20-30 players.

VII. Simulation Results

With the scenarios that have been introduced previously, we have got the following simulation results:

A. Overall delay

This parameter is defined as the overall end-to-end delay for all packets received by the station. End- to-end delay for the application used during the simulation is measured from the time from source to destination. End-to-end delay refers to the time it takes to send a packet from source to destination over a network. Figures 9, 10 and 11 show the overall delay results for the MMOGs based on hybrid P2P architecture with and without AoIM and compare the results with MMOGs based on client-server architecture also with and without AoIM. The figures below illustrate a small variation of delay when using hybrid P2P system with AoIM compared with the system without using AoIM. However, the variation of delay is more significant when using client-server system. Nevertheless, the overall delay for MMOGs based on hybrid P2Psystem with AoIM is very small when compared with the MMOGs based on client-server architecture.

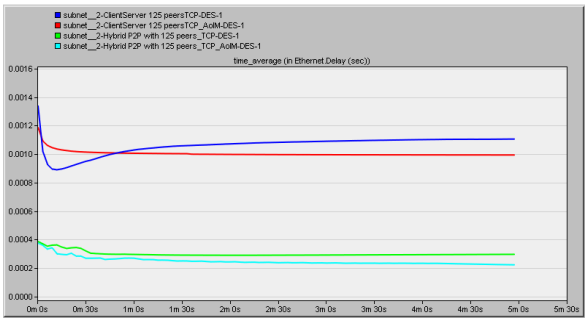

Fig. 9. Overall Delay for Client/Server and Hybrid P2P with 125 peers TCP Protocol

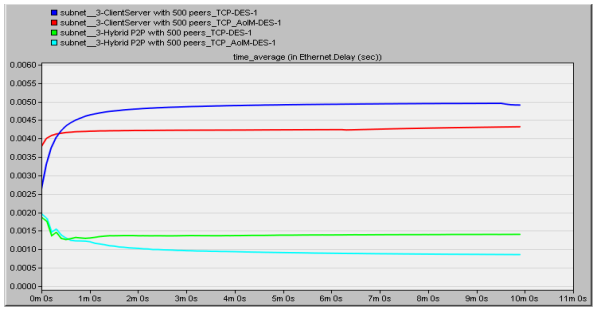

Fig. 10. Overall Delay for Client/Server and Hybrid P2P with 500 peers TCP Protocol

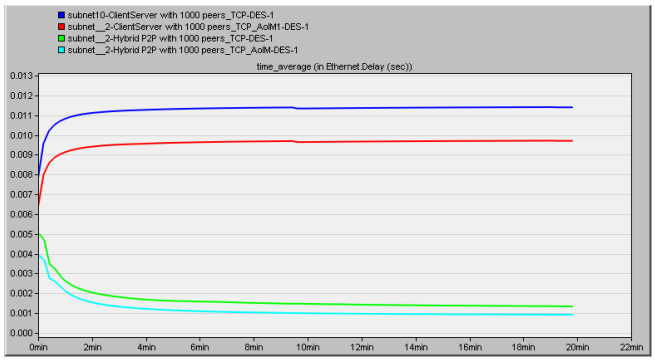

Fig. 11. Overall Delay for Client/Server and Hybrid P2P with 1000 peers TCP Protocol

A. Traffic Received

Traffic received is the average number of bytes per second received by all the nodes in the network. In other words, network traffic is the amount of data moving across a network at a certain point of time. Network traffic is one of the main ingredient for measuring network traffic, network traffic control and simulation. The proper regulation for network traffic helps to ensure the quality of service for the network. Figures 12, 13 and 14 show the traffic received results for the MMOGs based on hybrid P2P with AoIM and compare the results with MMOGs based on hybrid P2P without AoIM. As well as, the same for MMOGs based on client server architecture. The figure below illustrates a small variation of traffic received when using hybrid P2P system with AoIM compare with the system without using AoIM. However, the variation of traffic received be significant when using client-server system. Nevertheless, the traffic received for MMOGs based on hybrid P2Psystem is very small compare with the MMOGs based on client-server architecture.

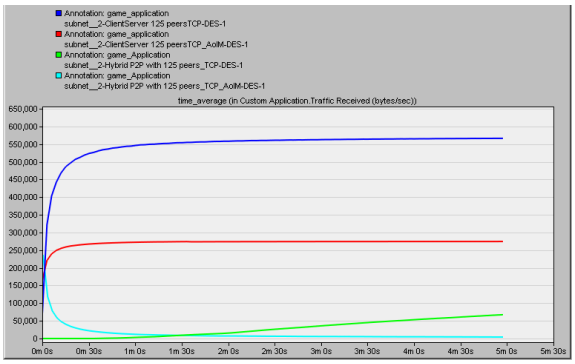

Fig. 12. Traffic Received for Client/Server and Hybrid P2P with 125 peers TCP Protocol

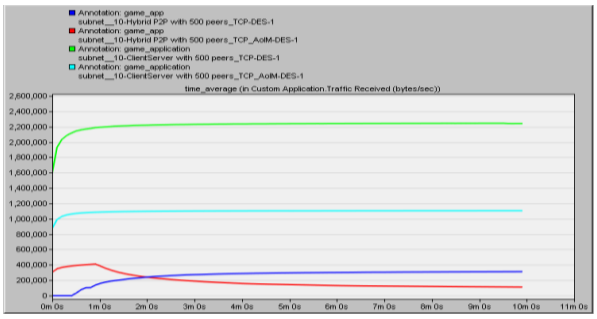

Fig. 13. Traffic Received for Client/Server and Hybrid P2P with 500 peers TCP Protocol

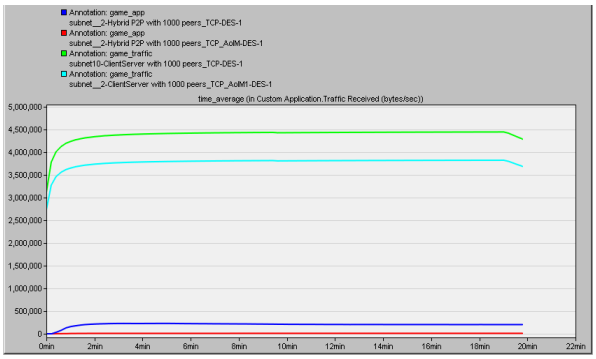

Fig. 14. Traffic Received for Client/Server and Hybrid P2P with 1000 peers TCP Protocol

VIII. CONCLUSIONS

In this paper, we have introduced the subjects and issues related to our research and explained the main contributions of the paper. We have also reviewed the research related to the area of interest management for MMOGs based on both client-server and Hybrid P2P

architecture, as well as explained the advantages and limitation of these researches. We use OPNET Modeler 18.0 to model and simulate the new area of interest management system. We have used OPNET simulation to enable the networks construction, study of communication infrastructure, design of individual devices, and simulation of protocols and applications. The results illustrate that the hybrid Peer-to-Peer system with a static AoIM scheme produce low delay and low traffic received in the network topology when compared with both client-server and hybrid Peer-to-Peer system without AoIM for all scenarios used in the simulation, The static AoIM is an interesting academic exercise to highlight the benefit of the approach, however dynamic AoIM should provide an even more efficient approach and more fitting with MMOGs, in which peers can join, leave, fail, and migrate to other regions. A scheme taking into account all these requirements is important, and will be combined with dynamic load balancing, and part of our future work.

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