논문 2011-5-28

동적 AOI를 위한 P2P 기반 관리기법

A P2P-based Management Method for Dynamic AOI

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요 약 네트워크 가상 환경 (NVEs : Networked Virtual Environments)은 지리적으로 분산된 사용자들이 가상 세계에서 네트워크 메시지 교환을 통하여 서로 상호작용이 가능한 분산 시스템이다. 대규모 다중 접속 온라인 게임 (MMOGs : Massively Multiplayer Online Game)은 수백명 이상의 사용자들이 가상 세상을 경험할 수 있는 다양한 응용 중의 하나이다. MMOG에서 관심영역 (AOI : Area Of Interest)이라는 제한된 영역은 사용자 간의 메시지 교환이 유발하는 부하를 감소시킨다. VON (Voronoi-based Overlay Network) 기법은 P2P 환경에서 대역폭 소모량을 감소시키기 위해 제안되었으며, Vorocast 기법도 역시 VON 상에서 메시지 전달을 이용하는 기법이었다. 우리는 포워딩 기법으로 메시지 발생자로부터 인접 노드들에게 보내지는 위치 갱신을 넘겨줌으로써 일관성과 지연성과 같은 문제들을 해결할 수 있는 동적 AOI 관리기법을 제안한다. 제안 기법은 직접 연결 기법과 Vorocast를 결합함으로써 기존 기법들에 비하여 더 나은 일관성과 낮은 지연성을 제공한다. 하나의 사용자와 AOI 내부에 포함된 다른 사용자들 사이에는 직접적으로 연결하여 통신하고, AOI의 외부에 존재하는 사용자들과는 Vorocast 기법을 이용하여 통신한다. 또한 시뮬레이션을 통하여 제안 기법의 성능을 평가하였다.

Abstract Networked virtual environments (NVEs) are distributed systems where geographically dispersed users interact with each other in virtual worlds by exchanging network messages. Massively Multiplayer Online Game (MMOG) is one of diverse applications where more than hundreds of users enjoy experiencing virtual worlds. A limited area called area of interest (AOI) in MMOG is reduced the load caused by message exchange between users. Voronoi-based Overlay Network (VON) is proposed to reduce the bandwidth consumption in P2P environments and Vorocast also is made using message forwarding in VON. We propose a dynamic AOI management method that solves problems such as a consistency and latency due to forwarding position updates to neighbor nodes from the message originator in forwarding scheme. Our scheme provides the consistency and reduces latency by combining direct connection scheme and Vorocast scheme compared to existing schemes. The communication between a user and users existing in center circle within AOI of the user is directly connected and the communication between the user and users existing outside the center area within AOI is using Vorocast scheme. The proposed model is evaluated through simulations.

Key Words : P2P, MMOG, Networked Virtual Environment, VON, Vorocast, Direct Connection

Ⅰ. Introduction

Massively Multiplayer Online Game (MMOG) is a kind of Networked virtual environments (NVE) allowing hundreds of users to access concurrently and interact each other[1]. Most of MMOG limits the scope of interaction between users using a area of interest (AOI)[2]. AOI is a circular area located centrally at an user, and other users is called AOI neighbors in this

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접수일자 2011.8.3, 수정완료 2011.9.25
게재확정일자 2011.10.14

area.

Voronoi-based Overlay Network (VON) effectively uses network bandwidth and provides scalability and overlay topology consistency[3]. Existing models are classified by how the connections are constructed. Direct connection model allows each node to exchange messages with all AOI neighbors. This model provides small latency and robustness, but occurs high bandwidth costs.

Forwarding model is an extension to original direct connection model in VON. This model allows relaying messages by neighbor nodes, and each node directly connects to the nearest nodes called enclosing neighbors (ENs). Each node potentially sees lots of AOI neighbors and can use its bandwidth effectively by using message forwarding and data compression.

Our proposed model uses the combination of direct connection model and Vorocast improved from forwarding model, where each node may controls the size of center circle within AOI depending on its network bandwidth under the assumption of AOI size for all users being equal.

The rest of this paper is organized as follows: Section 2 describes related work about P2P based NVE. Section 3 describes our proposed model. Section 4 describes the discussion of the simulation results. Finally, section 6 is the conclusion.

Ⅱ. Related Works

When given n nodes on a 2-D plane, a Voronoi diagram is constructed by partitioning the plane into n non-overlapping Voronoi regions. In Fig. 1, Enclosing Neighbors (ENs) represented with triangles are defined as those nodes in the regions immediately surrounding a particular node A. AOI neighbors (ANs) are those nodes within the AOI which the node A got interested to. Boundary neighbors (BNs) represented with circles are defined as nodes which are node A's ANs which are patially inside A's AOI.

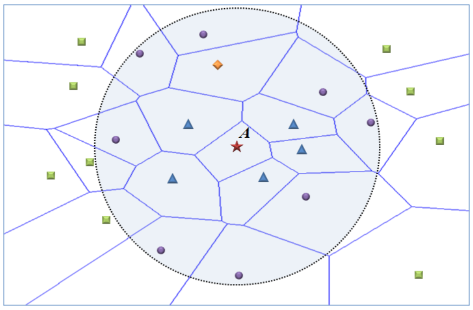

그림 1. Voronoi 다이어그램
Fig. 1. Voronoi diagram

In VON, direct connection model is an established model where nodes make a direct connection with all ANs and sends position updates to ANs at each time-step[4]. Thus, this model allows high consistency and low latency, but incurs high bandwidth consumption to maintain lots of network connection.

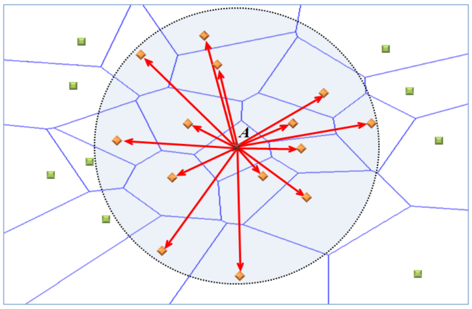

그림 2. 직접 연결 모델
Fig. 2. Direct connection model

In contrast, Forwarding model improves the problem of high bandwidth costs[5]. In this model, current user just makes a direct connection with Enclosing Neighbors (ENs). Message transmission to some nodes within AOI is done through more hops to reach. The number of network connections of a user is the same as the number of its ENs, which consumes less bandwidth. However, this model may provide redundant message disseminations.

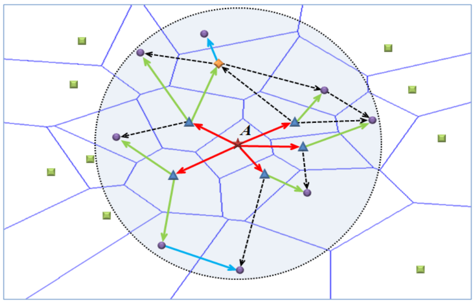

그림 3. 포워딩 모델
Fig. 3. Forwarding model

Vorocast that improves the AOI scalability in P2P NVEs organizes ANs using a Voronoi diagram where each node connects only its ENs[6]. When compared with other forwarding models, Vorocast provides non-redundant message disseminations using spanning tree constructed previously.

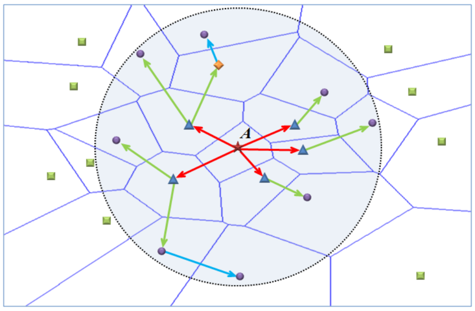

그림 4. Vorocast 기법
Fig. 4. Vorocast scheme

Finally, there can be an indispensible latency for a node to receive position update messages from a originator, even if the node is not a EN determined by Voronoi diagram in Vorocast. There should be a consideration for a node near physically to the originator to receive more attention compared to other nodes having long distance.

Ⅲ. Proposed Method

The main idea of our proposed model is a dynamic load balancing method combining direct connection model and Vorocast.

Unlike orignal Vorocast, which the center user was connected only its ENs, our approach of the proposed model connects directly ENs' one or more children within bandwidth capacity. New users connecting directly is managed by specific structure, is called *extended child list*. As creating new connections, selected EN is user's nearest neighbor in distance. In this way the message forwarding between center user and interested neighbor existing its around may have lower latency in real NVE applications. In Fig. 5, we consider situation given n points in a plane, where each point is called node. Firstly, a Voronoi diagram is constructed for each node. Then, creating the AOI is based on node A indicating star in center.

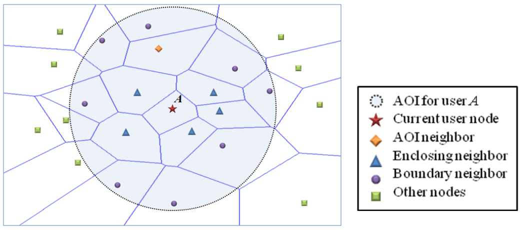

그림 5. Voronoi 다이어그램의 생성과 AOI
Fig. 5. Creating Voronoi diagram and AOI

Now, we construct spanning tree of node A with Voronoi diagram and AOI above, including important addtional procedures (called *pruning*) of our proposed model.

The initial state for node A's spanning tree is shown in Fig. 6, where solid line is direct connection between node A and its ENs, dash line is connection among other nodes. At this moment, ENs list of node A is {a, b, c, d, e}, and its extended child list is Ø

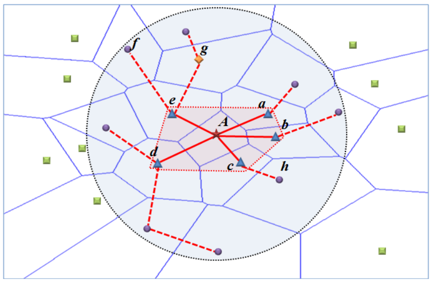

그림 6. 초기 스패닝 트리
Fig. 6. Initial spanning tree

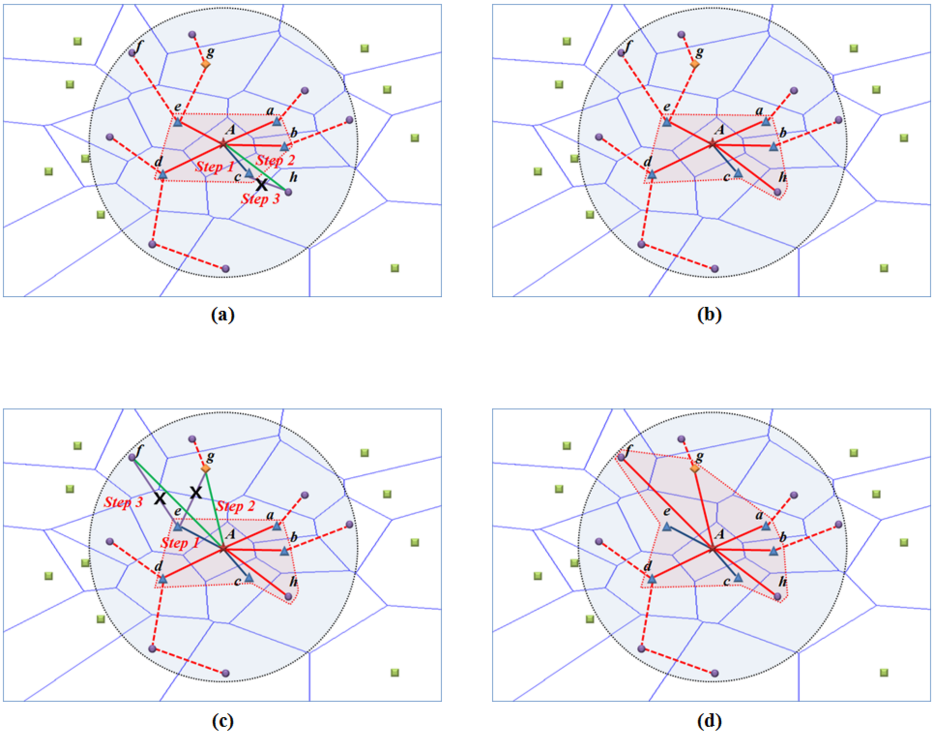

그림 7. 가지치기(Pruning) 과정
Fig. 7. Pruning processing

Fig. 7 shows some changes of spanning tree in these pruning procedures. (a) is the process of first pruning. The node c that an EN of node A was located most nearly. So the node h, which a child of node h, connects directly the root node A. At this moment, the node h is inserted to extended childe list of node A. Then node h is disconnected existing node c. (b) is shown these result. Next, (c) is the process of second pruning, and this case consider the node e near by node A next. The node f and g, which all children of node e, is connected to root node A. Also, this two nodes disconnect node e, and insert to extended child list. Then these result is shown in (d).

Now, we describe the algorithm of our proposed scheme. Fig. 8 is shown overall algorithm. For all of nodes, draw the AOI which each node treat a root node.

```
// AOI_RADIUS is radius of circular area for AOI communicating other
   users.

for each root∈all of nodes do
   Create AOI of node root with AOI_RADIUS;
   Create Voronoi diagram in AOI;
   Construct spanning tree for other user nodes in AOI;

   // Connect new node near to it directly.
   ConnectNew(root);

end for;
```

그림 8. 제안 기법의 전반적인 과정
Fig. 8. Overall procedure of proposed scheme

The AOI's size is depended on a constant AOI_RADIUS. Then current root node is created Voronoi diagram, and assigned its ANs, ENs, and BNs. Bisides, this node create initial spanning tree for itself. Next, it execute ConnectNew().

This function is enlarged its extended child list, and increased number of its direct connections in range of allowing this bandwidth.

```
// CONNECTION_BANDWIDTH is assumed that a constant for
   bandwidth consumption when connect directly new a node.
// MAXIMUM_BANDWIDTH is the maximum value to limit increment of
   bandwidth consumption by adding new network connections.
// ALPHA is bandwidth consumption to allow maximum nodes in Vorocast.
// THRESHOLD is a value of (MAXIMUM_BANDWIDTH – ALPHA).

ConnectNew (Node root_node) {
   // Get number of root_node's current network connections.
   num_en = get ENs' count of root_node;
   num_ext = get count of elements in root_node's extended child list;
   current_bandwidth = (num_en + num_ext) ×
                        CONNECTION_BANDWIDTH;
   available_bandwidth = THRESHOLD – current_bandwidth;

   // If current bandwidth is full, then this function will be exited.
   if ( available_bandwidth < CONNECTION_BANDWIDTH ) then
      return;
   end if;

   child[ ] = request child list to the nearest node X containing one or more
              children;

   // Check bandwidth consumption for all of children list child[ ].
   consumption = length( child[ ] ) × CONNECTION_BANDWIDTH;
   if ( available_bandwidth < consumption ) then
      // Exit this procedure due to the lack of available bandwidth.
      return;
   else
      num = length( child[ ] );
   end if;

   // Connect new child node directly and adjust its previous old connection.
   for i =1 to num do
      Add a node child[ i ] to root_node's extended child list;
      Modify parent node of child[ i ] to root_node;
      Eliminate child[ i ] in node X's child list;
   end for;

   // Call this function recursively.
   ConnectNew( );
}
```

그림 9. 노드 연결 과정
Fig. 9. Node connection procedure

The important function ConnectNew() is shown clearly in Fig. 9. For the parameter as root node, the sum of ENs′ count and extended child list′s length is calculated. (Initial extended child list is Ø, so its count is 0.) Then this function is achieved current bandwidth consumption using this sum. In this function, node A repeats the direct connection for nodes searched by the same way as mentioned before.

Finally, Vorocast is applied to other users outside the center circle of the node A′s AOI.

Ⅳ. Experiments

We compared bandwidth consumption and neighborship consistency for our proposed scheme, direct connection model, and vorocast. The settings of the simulation runtime environment are shown as Table 1. In results, we can see that the proposed scheme occurs about 45% degree of bandwidth less than other schemes. Fig. 11 shows ratio of consistency maintenance for how number of known AOI neighbors was fitted actual AOI neighbors. We can see that our proposed scheme guarantees more consistency than vorocast, and decreases bandwidth consumption efficiently less than direct connection model in Fig. 12.

표 1. 실험 환경
Table 1. Simulation Environments

World dimension	1000 x 1000
Simulation steps	1000
AOI-radius	200
Number of users	100 to 1000, with an increment of 100

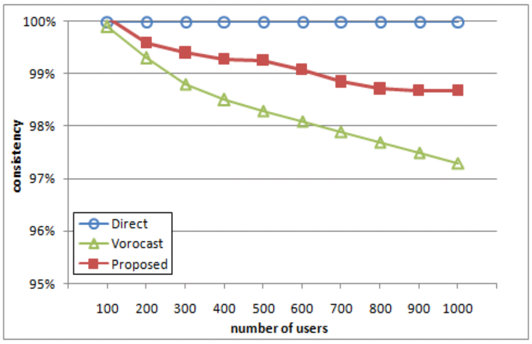

그림 10. 인접 노드간의 일관성
Fig. 10. Neighborship Consistency

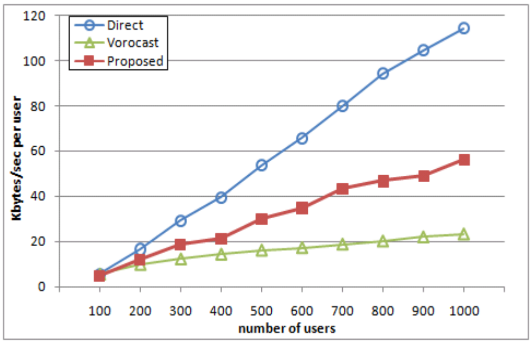

그림 11. 대역폭 소모량
Fig. 11. Bandwidth Consumption

V. Conclusion

In this paper, the proposed scheme of dynamic AOI management is explained that the communication between an user and other users existing in center circle within AOI is directly connected, and the communication between an user and others existing within AOI is using vorocast. By using combination direct connection model with vorocast, the proposed scheme behaves more effectively than existing other schemes in ratio of consistency for bandwidth consumption. In the future, we will test performance of the proposed scheme in actual system environments. Also it will be researched to become the method of load balancing efficiently.

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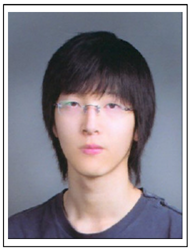

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