Cpsc527 Lecture 10b
MOPAR: A Mobile P2P Overlay Architecture for Interest Management in Virtual World Games and Mobile Applications

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Scalability Issue of MMOG

• Hundreds and thousands of players interact in a Massively Multiplayer Online Games
• Scalability is the major issue in the traditional client-server model
  • It’s hard to predict the number of users when starting a service
  • Demands for the service can frustrate in the same way
Peer-to-Peer Approach

- Compared to client-server model, P2P architecture is more scalable.
  - Every game player brings more resource to the virtual environment
  - Resource consumption are decentralized
- Broadcasting messages to thousands of players can be very bandwidth inefficient.
  - Typically, each game participant has limited visibility and only interested in the activities within the area of interest (AOI).
  - Interest Management is commonly used in scaled virtual environment.
- Interest Management is straightforward in client-server model through message filtering, while it’s extremely challenging in P2P architecture.

1. Structured P2P (DHT) Approaches

- Divide the game map into fixed regions. An authoritative server is dynamically assigned via DHT for each region responsible for coordinating the game states.

Disadvantages:

- They do not address the AOI of a player that may be outside of a region. Each participant is put in an artificially partitioned region
- It’s hard to determine the size of each region and the optimal way of partitioning beforehand
- Game states communications must be relayed through coordinators, the coordinators can become a bottleneck
2. Unstructured P2P approaches

- None of them are successful on maintaining the consistent topology, or discovering neighbors.
- A participant or a group of participants can be isolated.
- Movement is the most common activities in a game. It’s not efficient to make every game participant involve in the interest management and be a “watchman” for others.

Voronoi Scheme

MOPAR: A Hybrid P2P overlay (DHT) and Unstructured Approach

- Each node in the virtual world dynamically builds network connection with its neighbors (neighbor discovery).
- Players communicate with their neighbors directly for game interaction without a server intervention.
- Purely distributed system greatly increase scalability.
- The hybrid of structured P2P overlay (DHT) and unstructured P2P communication scheme enhance both fault tolerance and efficiency.
Hexagonal Zoning

- Game map is divided into Hexagonal cells
- Hexagonal zoning has many advantages
  - Hexagons have uniform orientation and uniform adjacency.
  - Hexagonal zoning is more approximated to circle than quadrant zoning.
- The disadvantage of the traditional hexagonal zoning is that the viewing area of a player is discrete.

The gray area represents the AOI of a participant. A participant moving from one cell to another joins and leaves the same number of cells.

Master, Slave and Home Nodes in MOPAR

- **Master node** – Master nodes play the main role of neighbor discovery. Each cell has at most one master node. Master nodes exchange players list (their positions) with the master nodes in the neighboring cells.
- **Slave node** – Slave nodes get updated with the new neighbor list from master node when necessary
- **Home node** – Home node is a virtual node. Each cell is mapped to a determined home node.

A master nodes and its slave nodes are physically located in a particular cell, while the home node of a cell is virtual and determined by Pastry.
Building Hierarchical Structure using a DHT

How a home node is virtually determined?

1. A participant (Node A) uses its coordinate to calculate the cell ID. For example, a participant at position (30, 50) can be mapped to the hexagon cell ID (0, 0), if the side length of the hexagon equals to 60.
2. Hash the Cell ID to the 128-bit ID by applying the SHA-1 hash function. We call it HexId.
3. Query the Pastry overlay to obtain the node N whose Pastry ID is numerically closest to the HexId. The Node N is the home node for the cell where the Node A is currently located.

Building Hierarchical Structure using a DHT (continued)

- The home node is used for master node registration. Each cell can have at most one master node. If a newly joined node finds that there is no master node registering for this cell after querying the home node, it registers itself as the master node; otherwise, it becomes the slave node.
- After the above processes, the newly joined node then either waits for slave nodes to subscribe to it, or subscribes to a master node, depending on whether it’s a master node or slave node.
- The master node needs to query the home nodes of the neighboring cells for building the direct connections with the neighboring master nodes.
Handling the Dynamic Characteristics

- When a node first joins the environment, it can become the home node for some cells immediately. (For example, $|N0-C| < |N1-C|$, C is a hashed cell ID)
- If a newly joined node becomes a home node for some cells, the original home nodes for these cells must be the closest nodes on either or both side of N0.
- Pastry’s leaf set maintains the information about nearest left node and right node.
- A newly joined node sends a message to these two nodes for retrieving the qualified master nodes registration records.

Unstructured P2P Communication Scheme

- Only master nodes exchange neighbor list with other master nodes in the neighboring cells, and watch the new neighbors for the slave nodes.
- Slave nodes are notified only if their neighbor sets have any changes, i.e. there are some new neighbors moving into the AOI.
- Clustered group dispersed in the map do not need to be connected.
- Master nodes can provide continuous neighborhood information to every participant in its governing cell.
Neighborhood Dissemination Algorithm

- Slave nodes only need to update the corresponding master nodes when their moving functions (speed or direction) changed.
- Master nodes can predict slave nodes’ position based on their moving functions.
- Master nodes don’t need to update slave nodes unless new neighbors moving into the slave nodes’ AOI.

Implementation and Visualization

The bigger dots represent the master nodes, while the smaller dots represent the slave nodes. The circle indicates the AOI of a participant.
Analysis

- More scalable, since fewer nodes (only master nodes) involved in the interest management.
- Cluster of nodes dispersed in the map don’t have to be connected, due to the DHT support.
- More fault tolerance than the pure unstructured P2P through the use of DHT.
- More efficient message exchange scheme compared to the pure DHT approach ($O(\log(n))$ hops).
- Game state persistency and consistency can be addressed easily with the support of DHT.

Future work

- Improve load balancing. Some master nodes may master several cells at the same time (merging of cells) or populated cell can be spit. (Dynamic cell sizes)
- Dynamic AOI
- Minimize the overhead incurred by role switching between master and slave nodes.
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