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Clustering Players for Load Balancing in Virtual Worlds

Simon Rieche, Klaus Wehrle
Distributed Systems Group
Chair of Computer Science IV
RWTH Aachen University

Marc Fouquet, Heiko Niedermayer, Timo Teifel, Georg Carle
Computer Networks and Internet
University of Tübingen

http://ds.cs.rwth-aachen.de

Content

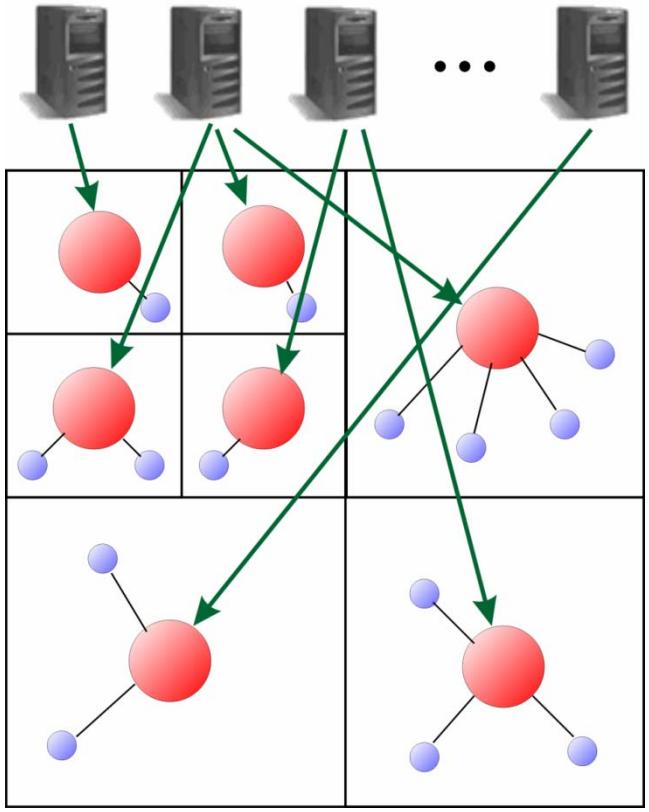
- Massively Multiplayer Online Games
- Previous Work
  - P2P-based Infrastructure
- Cluster-based Approach
  - Architecture
  - Load balancing
- Evaluation
- Conclusions

MMOGs

- MMOG
  - **M**assively **M**ultiplayer **O**nline **G**ames
- Beginnings
  - Text-based Multi-User Dungeons (MUDs) since the 1970s
- Today
  - World of Warcraft
    - 250,000 sales at the first day
    - Now more than 10 million players
- Game play
  - Player controls figure ("avatar")
    - Avatar has certain characteristics, experience...
  - Game world (map)

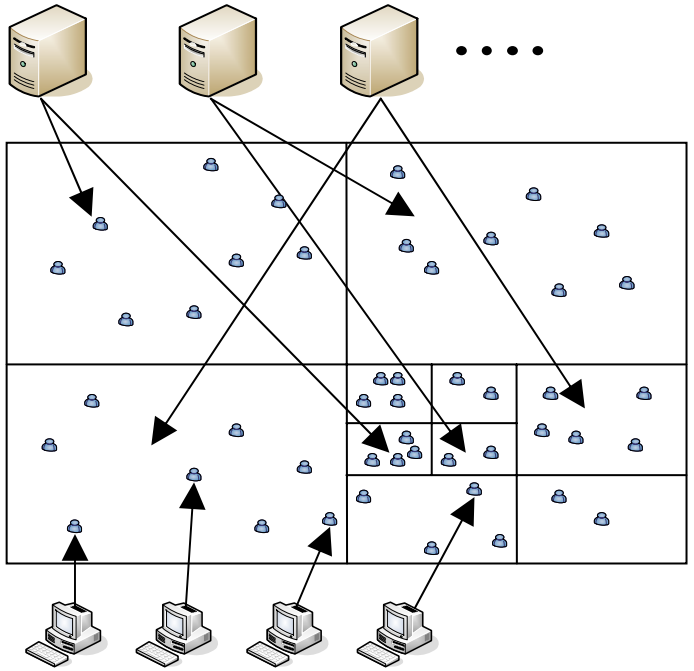
Previous Work

- P2P-based Infrastructure
  - Supernodes (servers) organized in trusted P2P network
  - Similar to CAN (Content Addressable Network)
    - Supernode know its neighbors
    - Each player is characterized by coordinates
  - Distribution of load with virtual servers



Previous Work

- Realization
  - Infrastructure peers
    - No trust problems
  - Dynamic allocation of regions
  - Use of CAN-based design
    - Game world is 2d map
    - Lookup of data



Infrastructure hosts

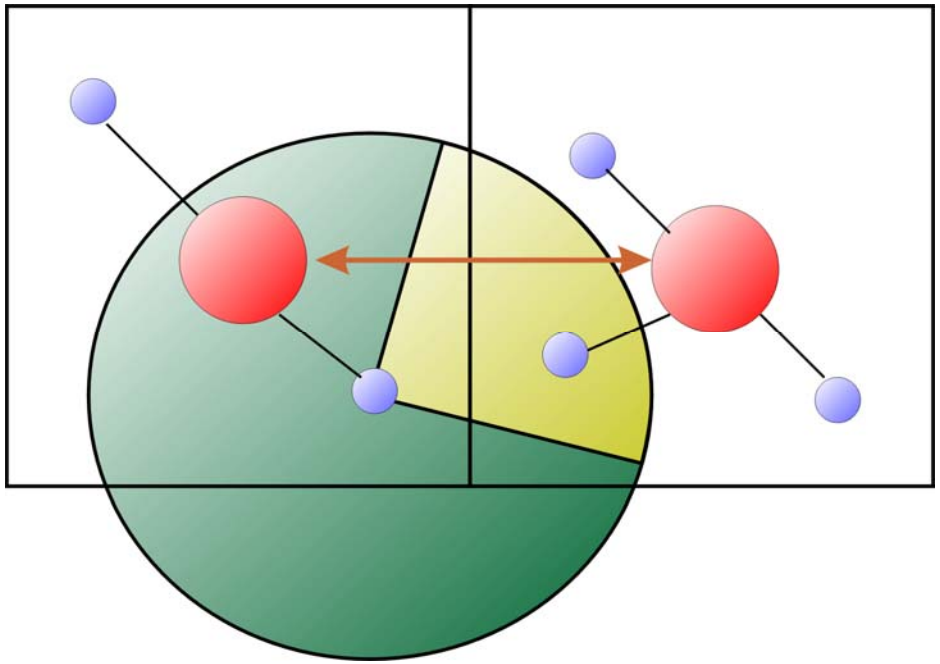
Player characters in the game world

Players

- Observation
  - Users build groups

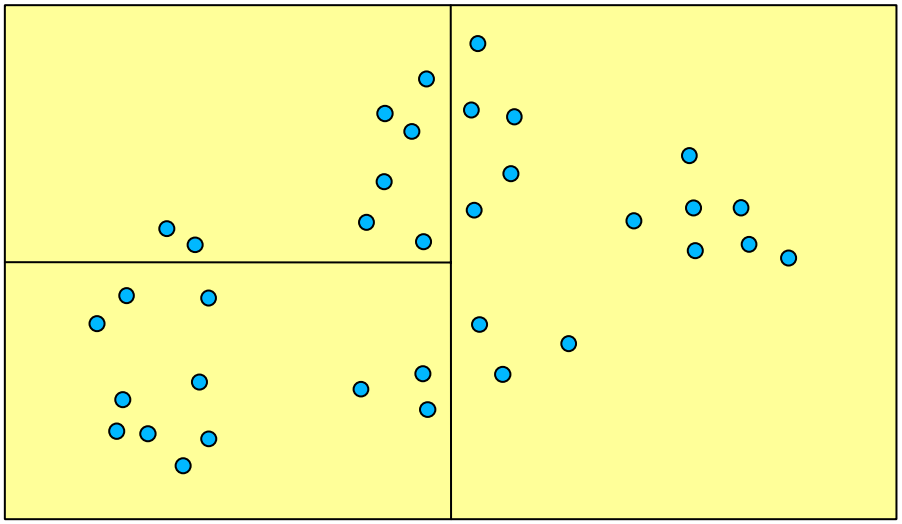
Problems

- Internal messages problematic
  - Communication at Borders
    - Using allocation algorithms to minimize amount of messages
    - Optimize distribution of load



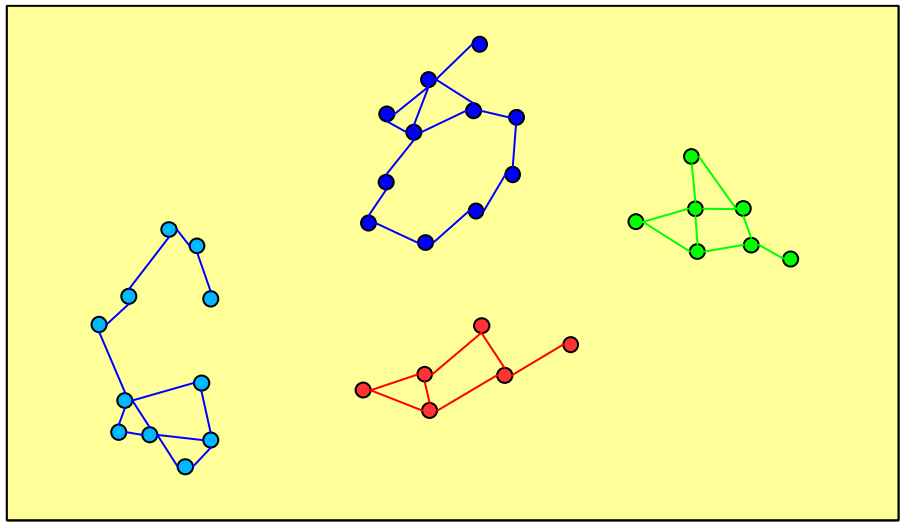
Problems

- Borders in the middle of groups of players
  - Player movements at borders must be communicated to neighbour areas
  - Player moving at borders necessarily
  - View over border increase messages



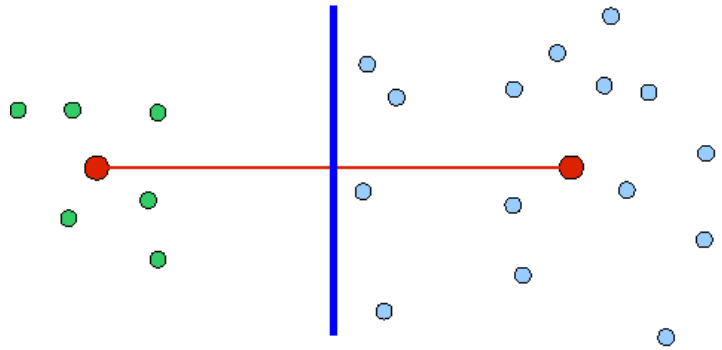
Cluster

- No static areas depending on load
- Building clusters
  - Each virtual server of a group administers a group of players
  - Virtual server moves with group on virtual map
  - Group structure dynamically

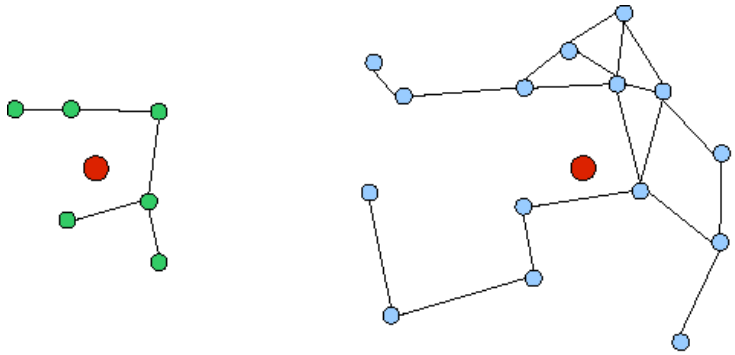


Building Clusters

- Measure the distance between the players
- Using player's distance to the centroid not optimal



- Players belong to the same group, if they have a small distance to each other

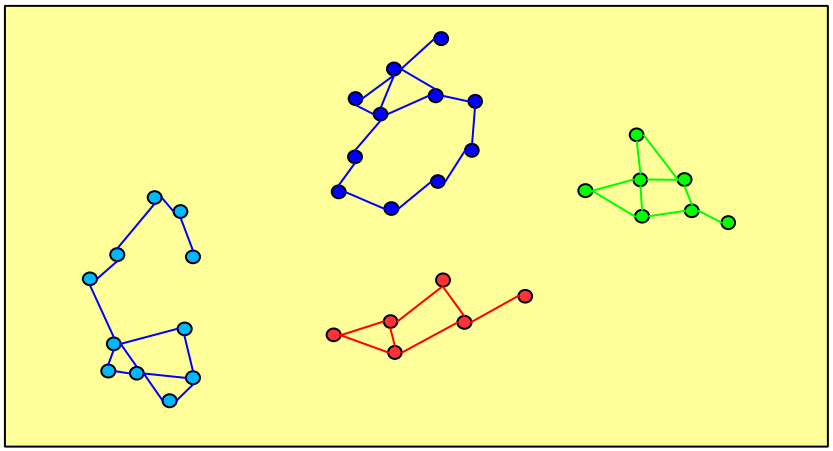


Load Balancing

- Moving Cluster
  - Moving whole clusters from one node to another.
- Moving Players
  - Moving one or some players from one cluster to another.
- Splitting Clusters
  - Splitting a cluster into two parts, and moving one of them to another physical server.

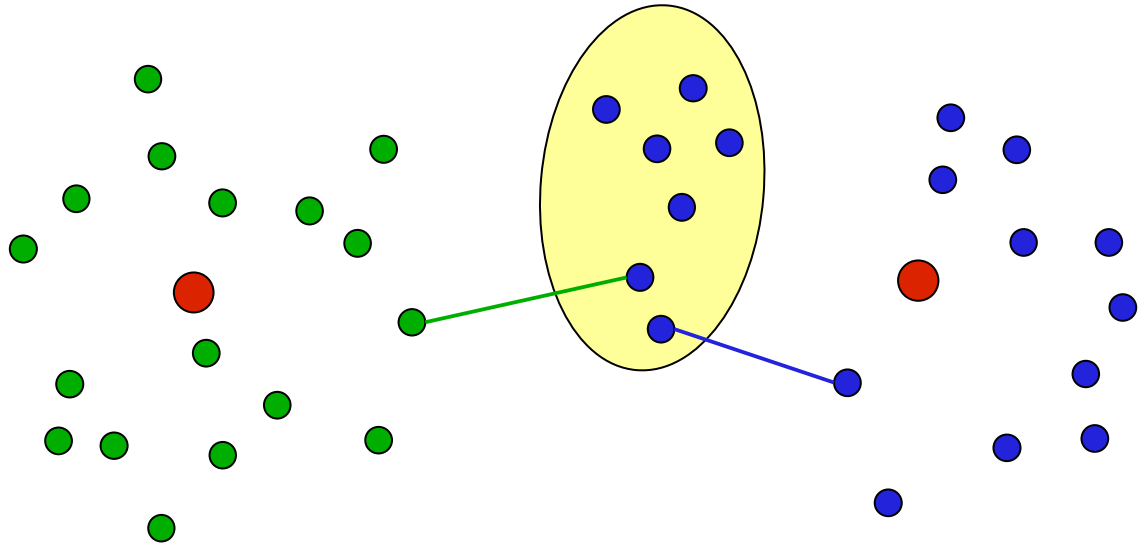
Load Balancing: Moving Clusters

- Using virtual server approach
  - Managing multiple partitions of a structured P2P address space in one node
  - A physical node act as several independent logical nodes
  - Virtual Server is an independent node in the structured P2P System
  - Simple placing and transferring virtual servers
    - This operation is similar to the standard join or leave procedure



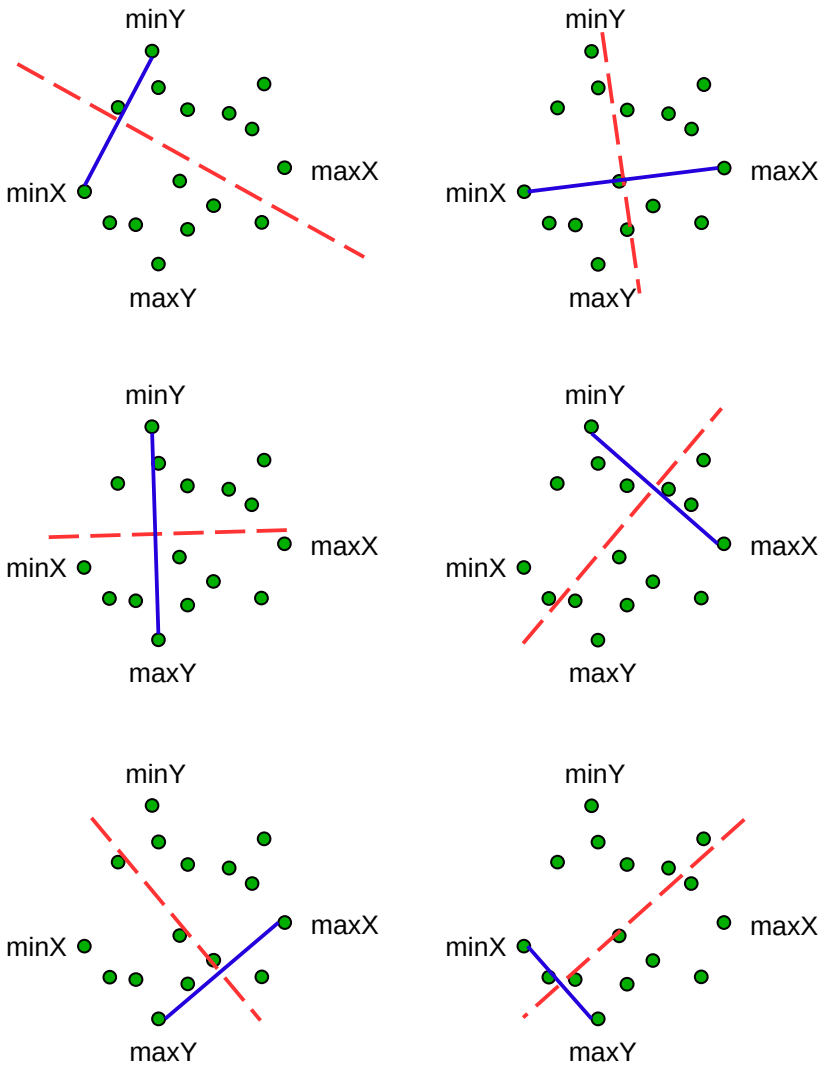
Load Balancing: Moving Players

- Move some players from one group to another
  - Single player in the middle of two groups
    - Depending on the load of each cluster the player can be moved to a group
  - If some players move together, also all of them can be moved to the new cluster together



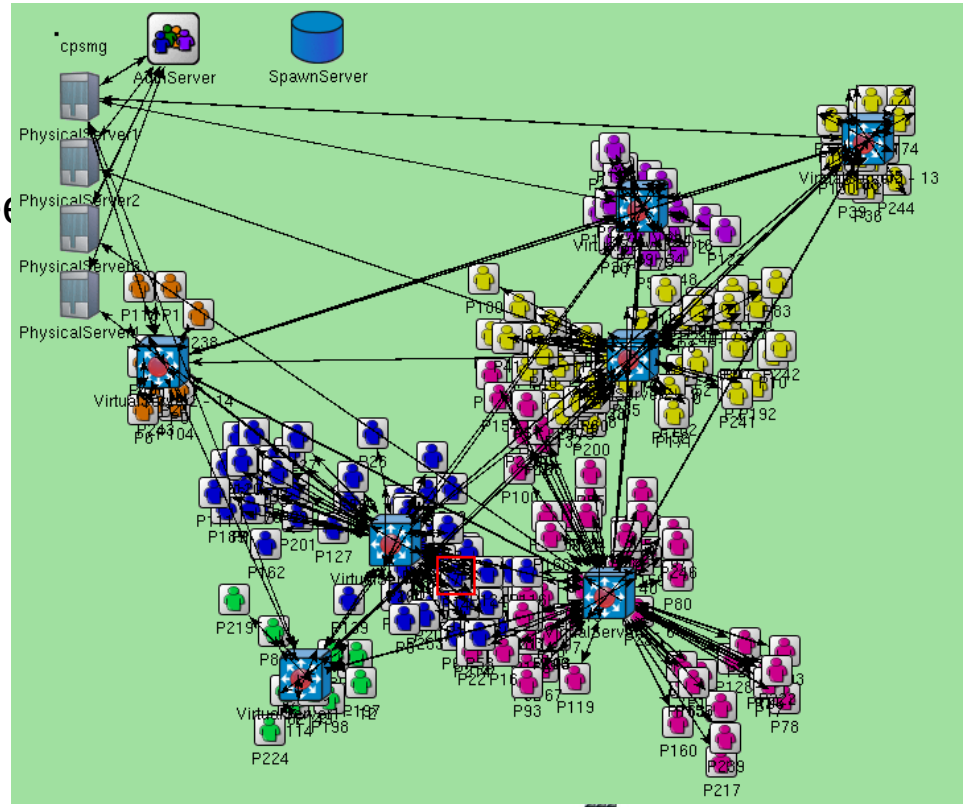
Load Balancing: Splitting a Group

- Clusters with too many players can be split
  - One part can be sent to another server
  - Selecting the 4 players with min and max X- and Y-coordinates
  - Use he combination of 2 nodes, which has the max distance between the two new groups
  - Minimize the possibility that players will move from one group to the other in future

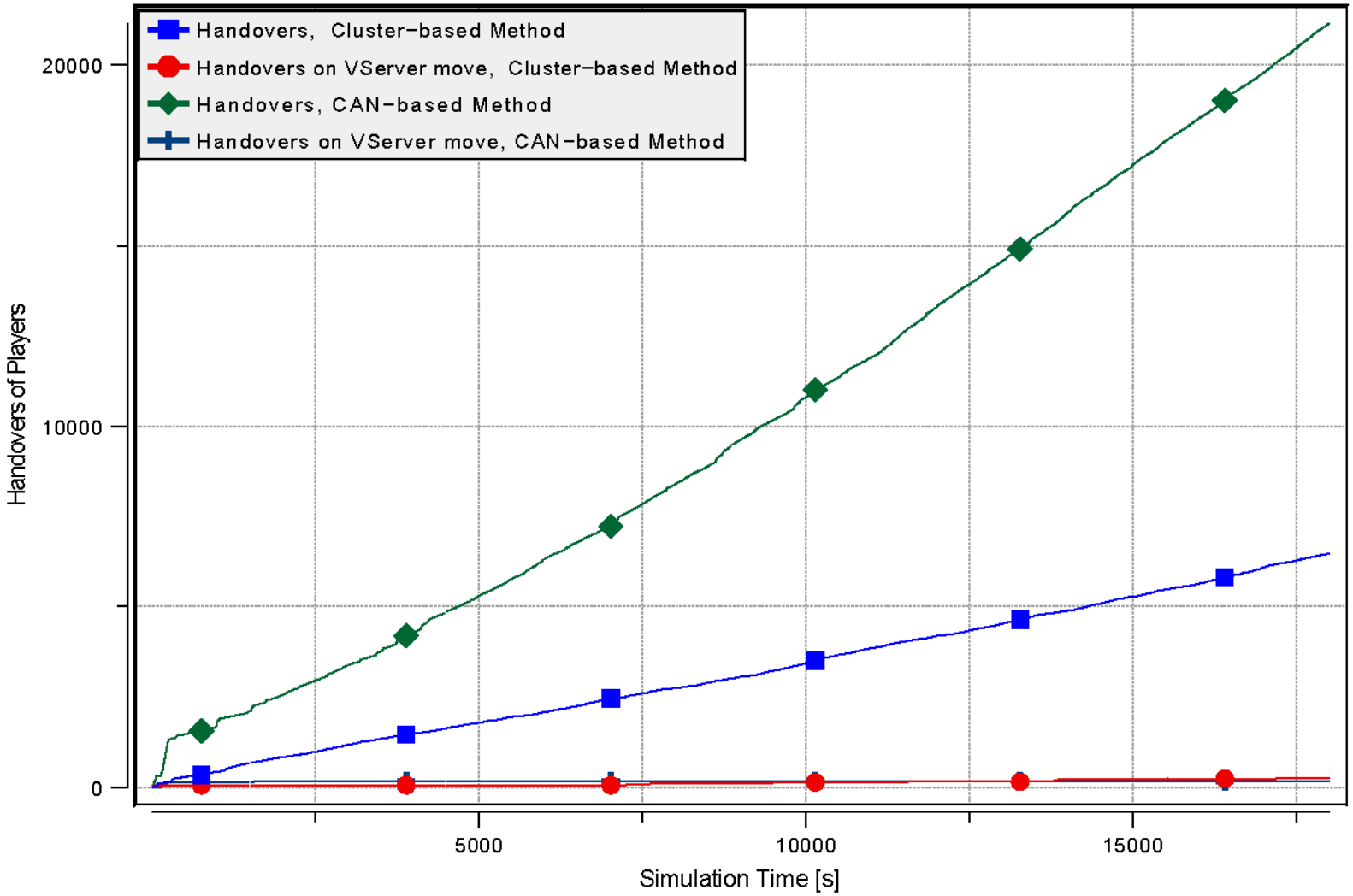


Evaluation

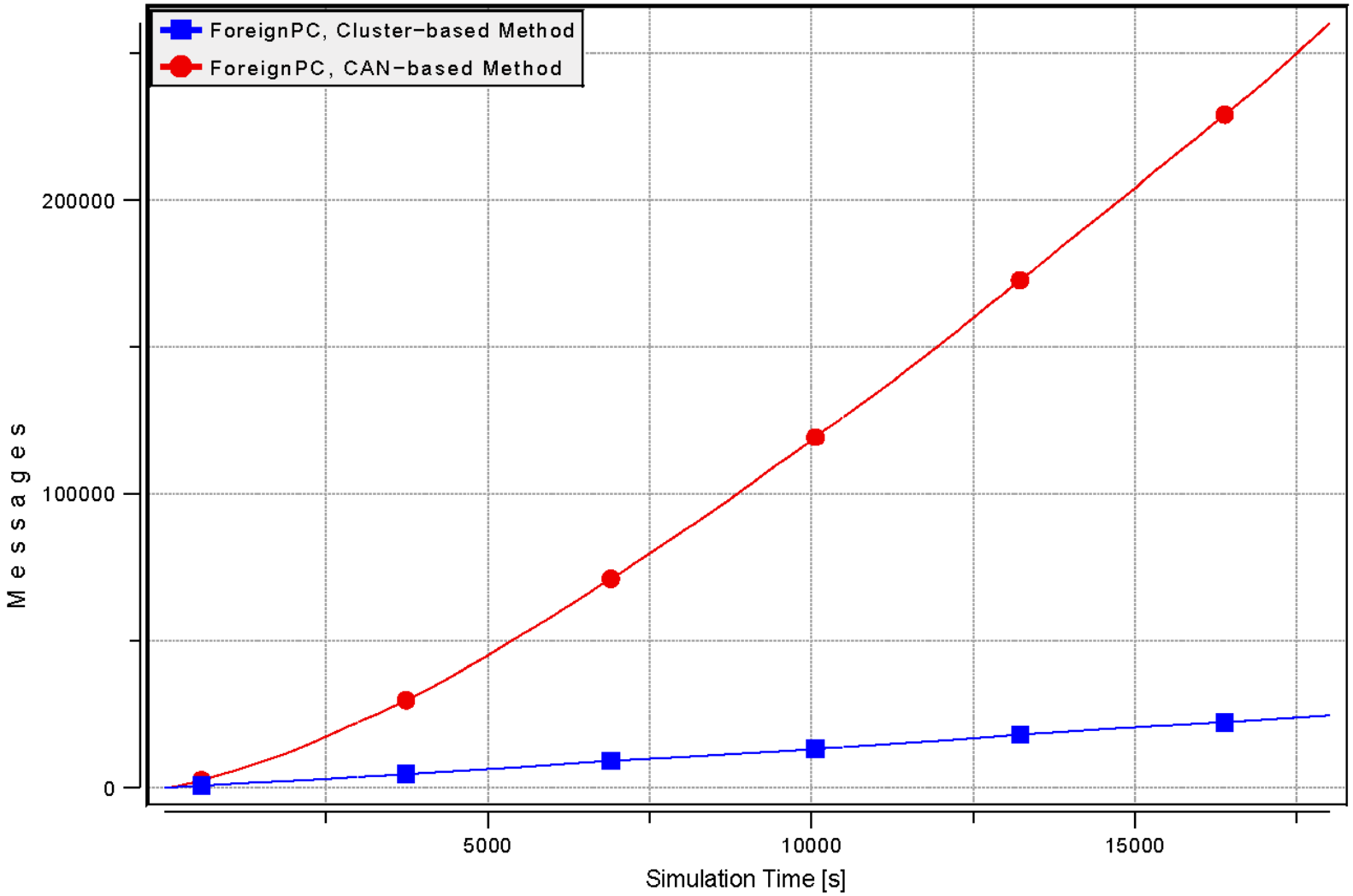
- Omnet++ simulation
- Different Trace Data
  - Random Walk
  - Random Waypoint
  - Real trace data
    - Browser-based MMORPG Free



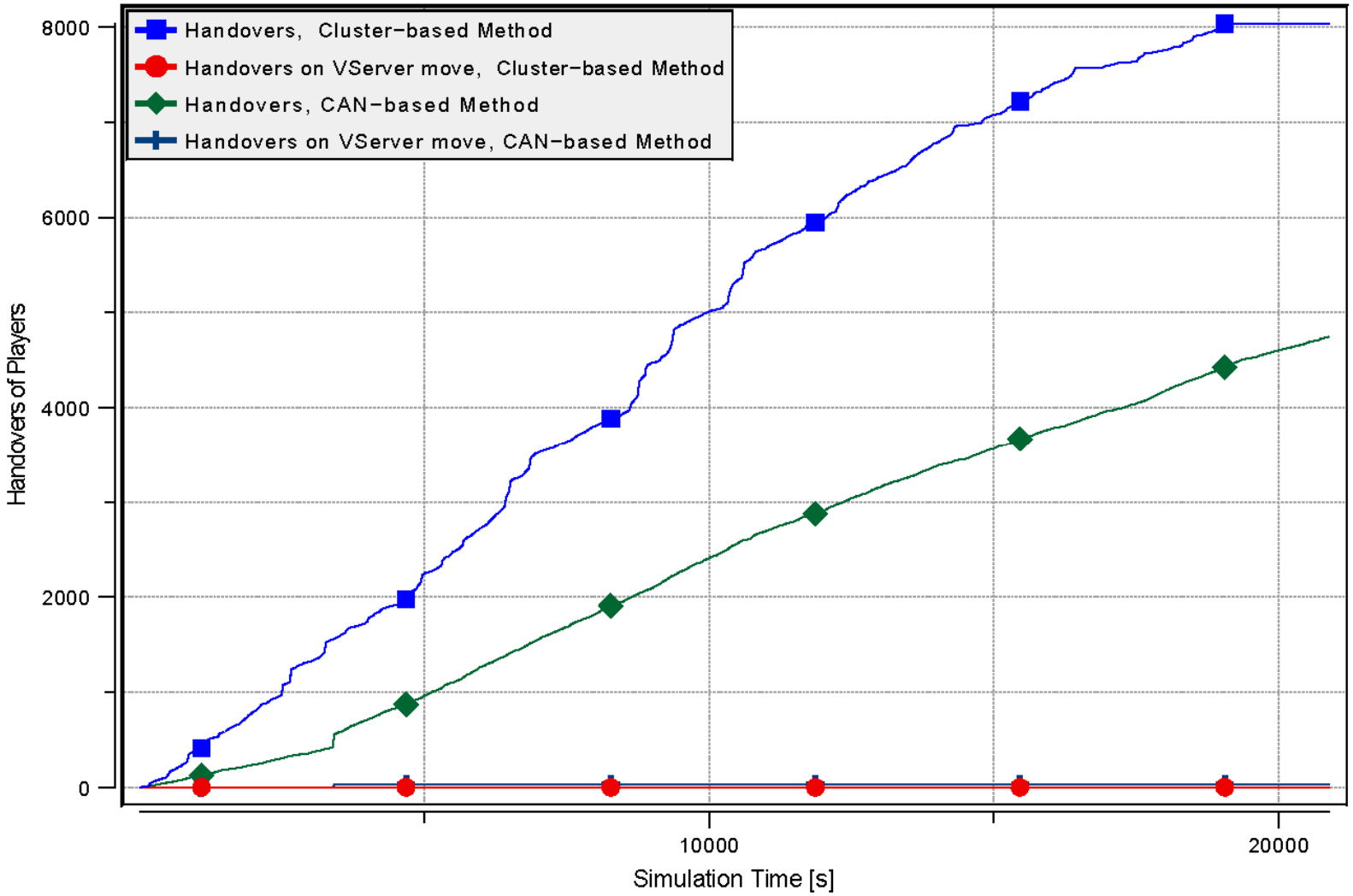
Evaluation: Player Handovers with Random Walk



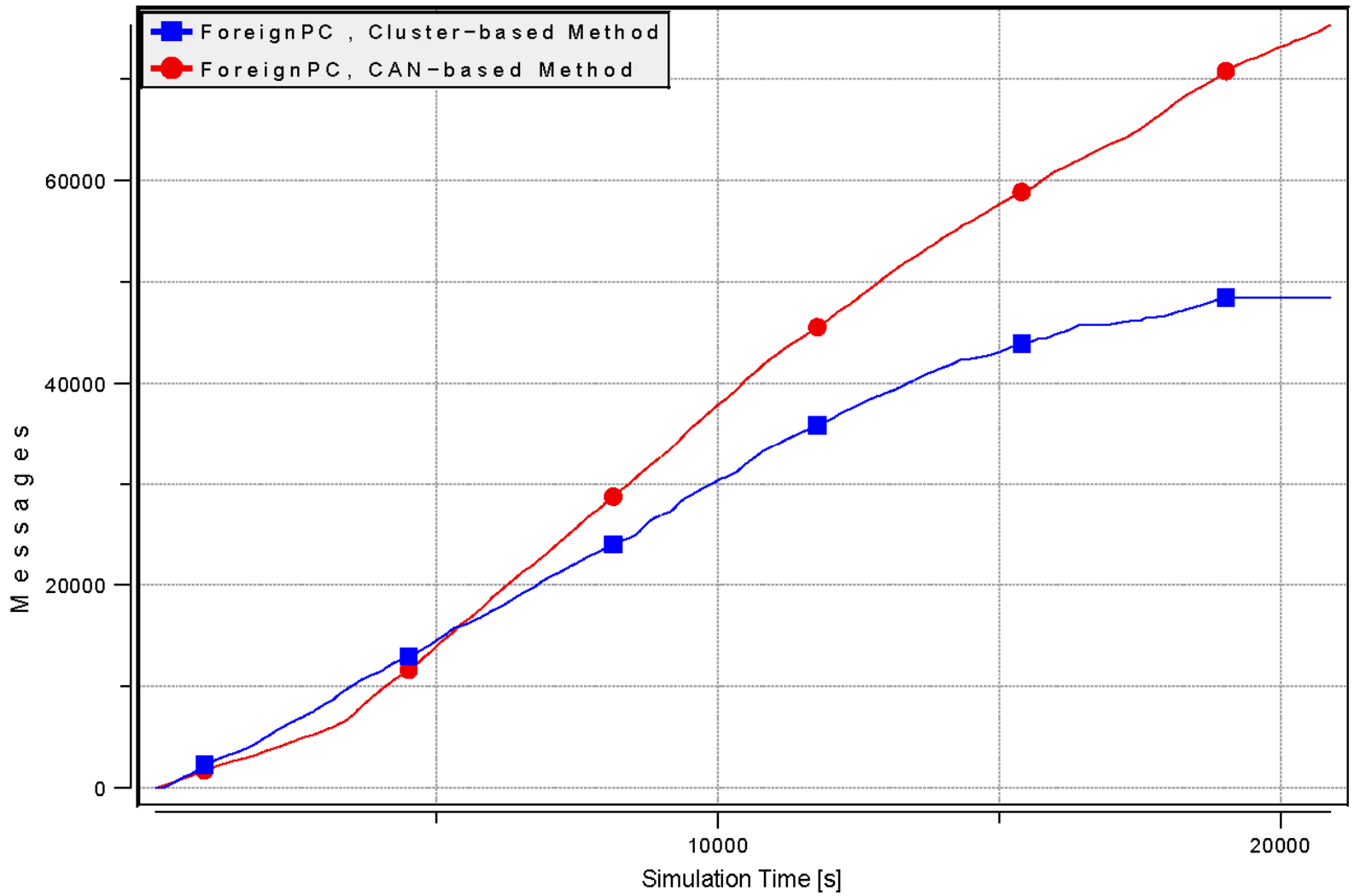
Evaluation: FPC Messages with Random Walk



Evaluation: Player Handovers with Freewar Trace



Evaluation: FPC Messages with Freewar Trace



Evaluation

Trace	Players Moved		Foreign Position Change	
	Number	Rating	Number	Rating
random walk	6 730	+	24 500	+
	21 312		260 076	
freewar	8 038	-	48 441	+
	4 813		75 325	
group random walk	13 093	+	90 528	+
	18 467		280 210	
random waypoint	14 889	+	79 492	+
	28 198		379 392	
group random walk 2	5 540	+	26 687	+
	12 457		130 778	
Cluster-based				
CAN-based				

Conclusions

- P2P-based Infrastructure
  - Good scalability
  - Redundancy and reliability
  - Prevent from cheats possible

- Using a cluster-based approach
  - Split the game world in groups of players
  - Not in rectangular disjunctive zones
  - The system is able to dynamically adapt to the current state
  - Handle uneven distributions of the players in the game world
  - The cluster-based approach performs mostly better

Thanks for your attention!

Questions?