P2P-based Virtual Environment Research
- an overview -

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Outline

- Introduction /Motivation
- Networked Virtual Environments (NVE)
  - Types of NVEs
  - Client-/Server-Implementation
  - Requirements
  - Distributed Virtual Environments
  - P2P-Overlays: pSense, VON, Donnybrook
  - Benchmarking
- Conclusion / Discussion

Motivation

- Why are online games interesting for computer science?
  - Fast growing market for online games
  - High demanding requirements for network infrastructure
  - Online games are distributed systems
  - Many problems are not solved yet
- Why P2P-technologies?

Networked Virtual Environments

1970 1983/84 1993 1997 2003 2004 2010

History:

- Textadventure: ADVENT – W. Crowther – 1970
  - MUD1 /2 1983/84 - R.Trubshaw
- Doom - ID Software - 1993
- Ultima Online - Origin Systems - 1997
- Second Life - Linden Labs – 2003
- EVE online – CCP Games - 2003
- World of Warcraft - Blizzard Entertainment – 2004

Types of Networked Virtual Environments

- First Person Shooter (FPS)
- Sports Simulation
- Role Play Games (RPG/ORPG)
- Real Time Strategy (RTS)
- Virtual Worlds

Types of Architectures:

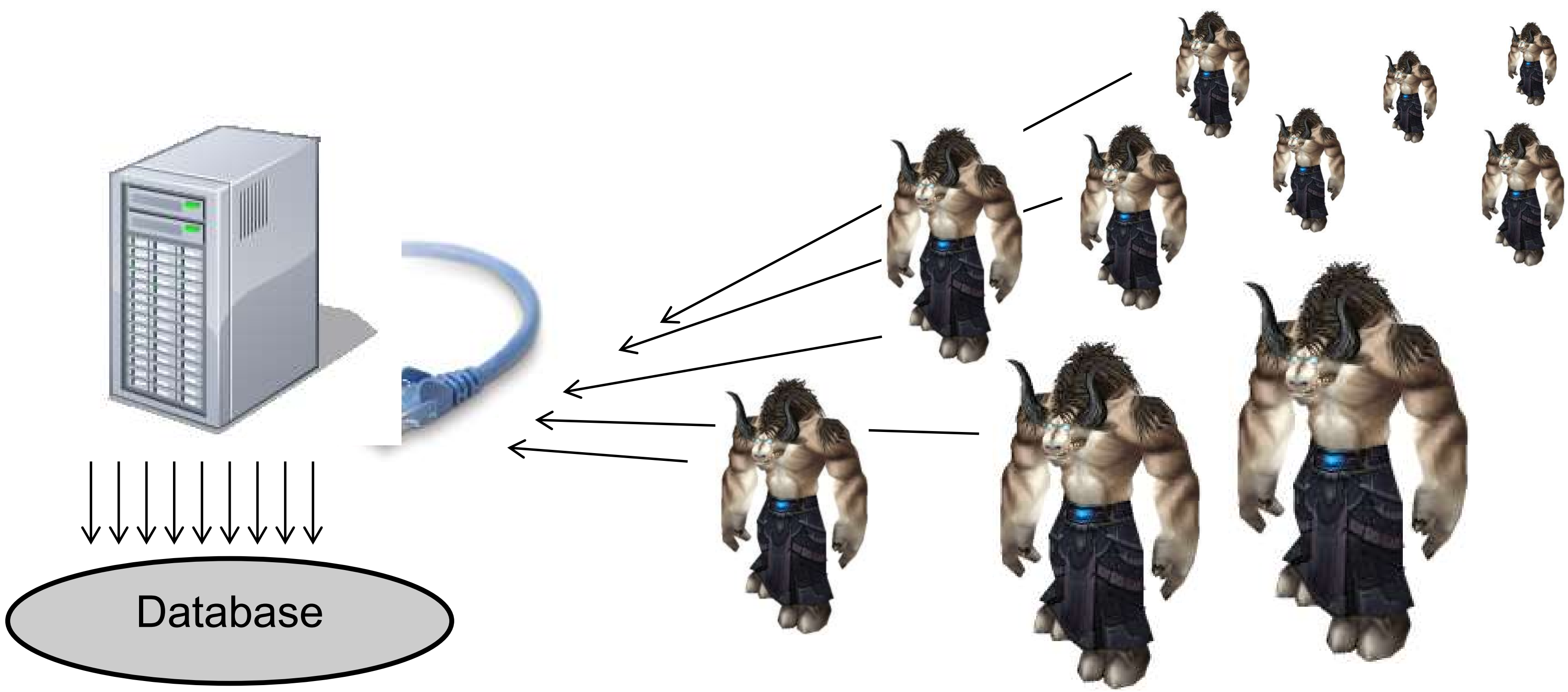
- Dedicated Server
- C/S without dedicated server
- P2P

Main difference: Level of real time requirements

Main problem for C/S architecture: Scalability

Scalability Problem

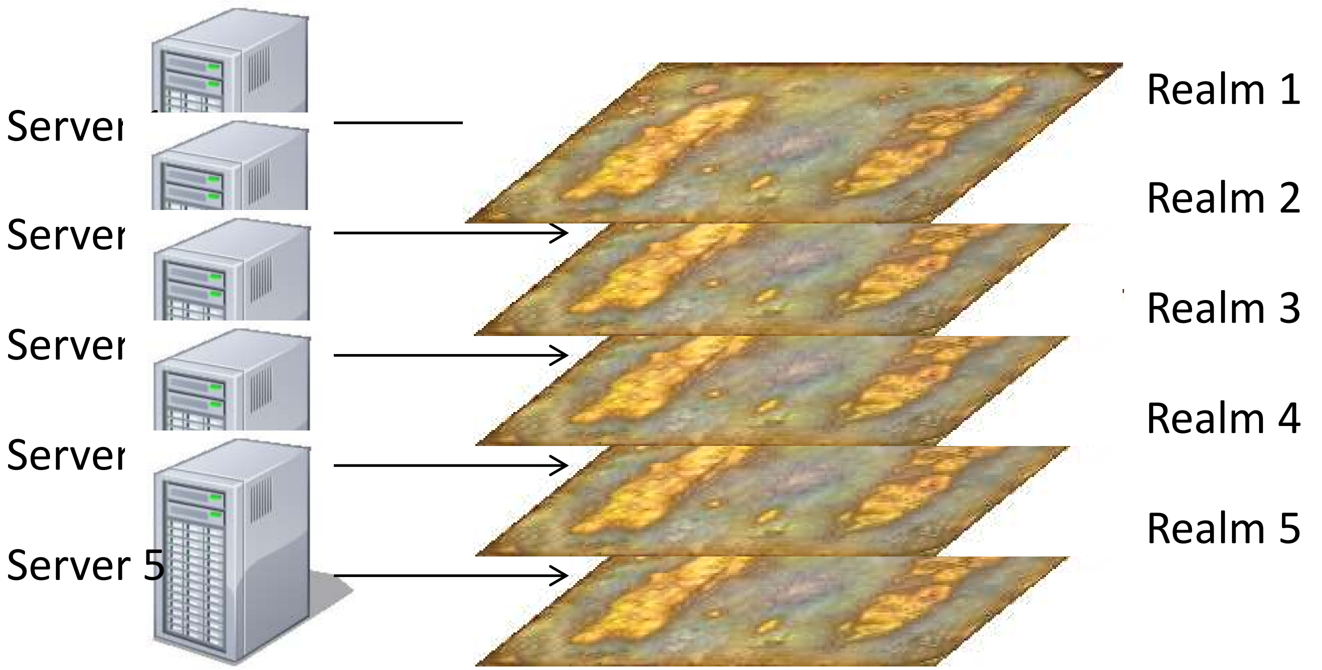
- All game updates have to be processed at a single point
- Every update is requires an database operation



World of Warcraft

Sharding:

Every server maintains a copy of the virtual world.
There is no possibility to communicate or interact with player from another realm.



Eve Online

"EVE ONLINE™ LAUNCHES LARGEST SUPERCOMPUTER IN THE GAMING INDUSTRY "

- *EVE*'s 7000+ star systems are loaded as a separate process onto any one of hundreds of IBM blade servers
- Record of concurrent users: 60,453 (Jun 7th 2010)
- Gamestate consists of more than 1,1 TB Data

Second Life

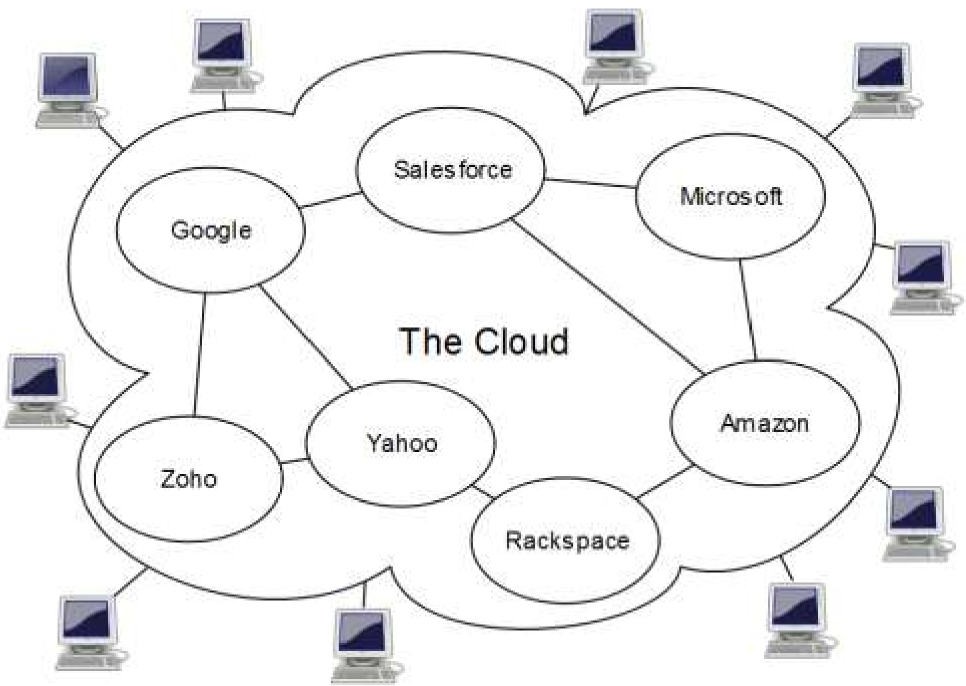
Second Life is a virtual world built and created by its users

Server:

- Each full region (an area of 256x256 meters) runs on a single dedicated core of a multi-core server
- Estimated to consume 100 terabytes of server capacity (2008)
- In Q1 2009:
- 124 Million user hours
- Peak concurrent users of 88,200
- Monthly unique users: 732,526 (march 09)
- Residents spent more than USD$120 million on virtual goods and services in Second Life

Cloud Computing

Cloud computing is Internet-based computing, whereby shared servers provide resources, software, and data to computers and other devices on demand, as with the electricity grid.(Wikipedia)



- Infiniband Network (up to 60GBit/s and latency optimized
- Login proxies
- „Unlimited resources“

Requirements of Online Games

1. Communication infrastructure (Responsiveness, Robustness)
2. Consistent world state (Consistency)
3. Persistent game data (Persistency)
4. Security / fairness
5. User generated content / data distribution
6. Costs

Pro P2P:

- Scalability
- A server is single point of failure (robustness)
- Data distribution
- Costs

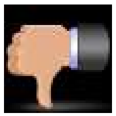
Requirements (responsiveness)

	Delay	**Bandwidth (up)**	**Bandwidth (down)**
[redacted]			
World of Warcraft	300 ms	2,1 kbit/s	6,9 kbit/s
[redacted]			

- Ping Mannheim-Hamburg ~ 25 ms RTT
- DSL 16000:
  - 16.000 kbit/s downstream
  - 1.024 kbit/s upstream

Problems of Standard P2P-Technologies

Why not use Chord ?

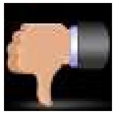
Chord: 

- Mapping between 2D / 3D Virtual World and 1D Chord ring necessary
- Frequently changing „communication structure“

  -> chord ring must be changed as well

Problems of Standard P2P-Technologies

Why not use CAN?

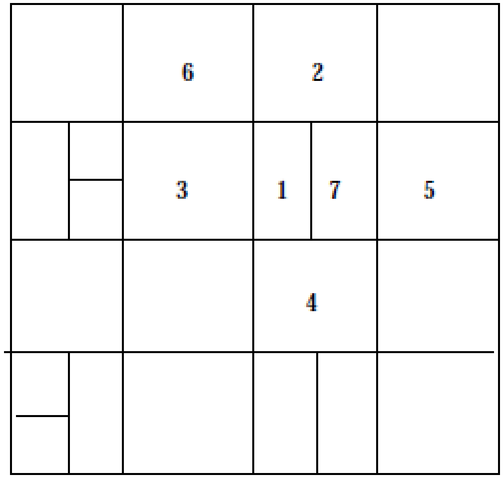
CAN: 

- Density Problem: high populated areas result in small CAN cells.

  -> game messages must be routed over many nodes

- Frequently changing „communicatio structure“

  -> CAN structure must be changed as well



1's coordinate neighbor set = {2,3,4,7}
7's coordinate neighbor set = {1,2,4,5}

Information Dissemination

Observations:

- Update messages have only to be transmitted to other peers in the vision and interaction range
- Peers in the vision range are highly dynamic
- Updates occure with a high frequency

Idea:

- Use unstructured P2P-overlays called Information Dissemination Overlays (IDO)
- Reduce communication with the Area of Interrest (AOI) concept

Neighbor Discovery

- **Server introduction**: the server maintains all nodes, notifies a peer of its AOI neighbors
- **Peer notification:** peers mutually notify each other of new AOI neighbors.
- **List exchange**: peers exchange the neighbor list they maintain to discover new AOI neighbors
- **DHT query:** peers form a DHT overlay, and search for relevant neighbors or supernodes for new AOI neighbors
- **Overlay multicast:** peers multicast their positions regularly to allow other nodes to learn of their positions.

pSense

Patric Kabus

- Create a dynamic localized peer-to-peer overlay network
- Players are mainly connected to peers that are close in the virtual world.
- Position based Multicast

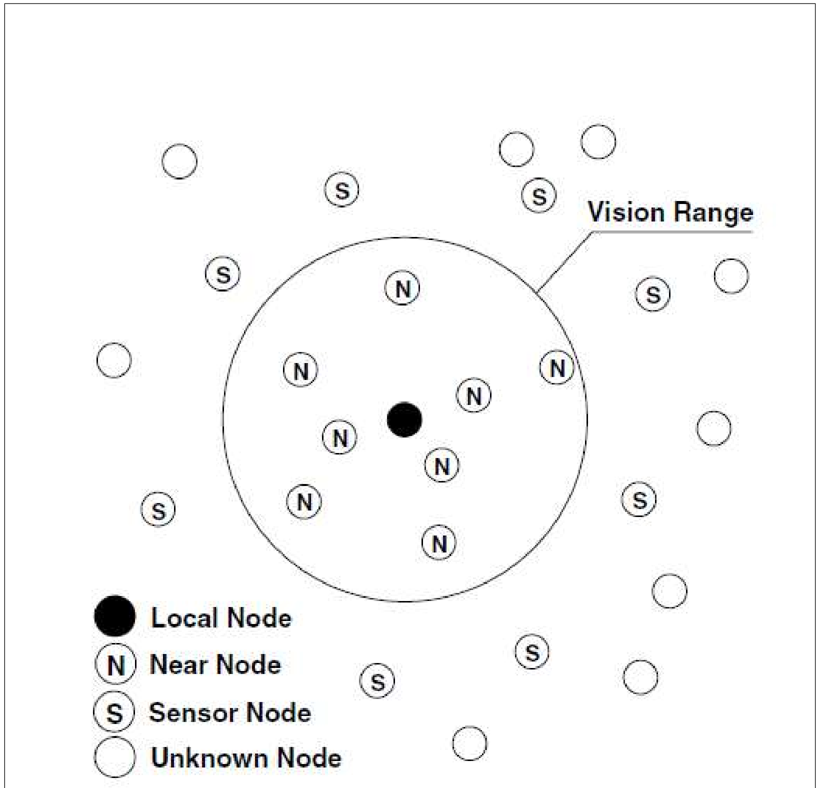
- pSense - **Maintaining a Dynamic Localized Peer-to-Peer Structure for Position Based Multicast in Games** Arne Schmieg, Michael Stieler, Sebastian Jeckel, Patric Kabus, Bettina Kemme, Alejandro Buchmann IEEE International Conference on Peer-to-Peer Computing 2008

pSense

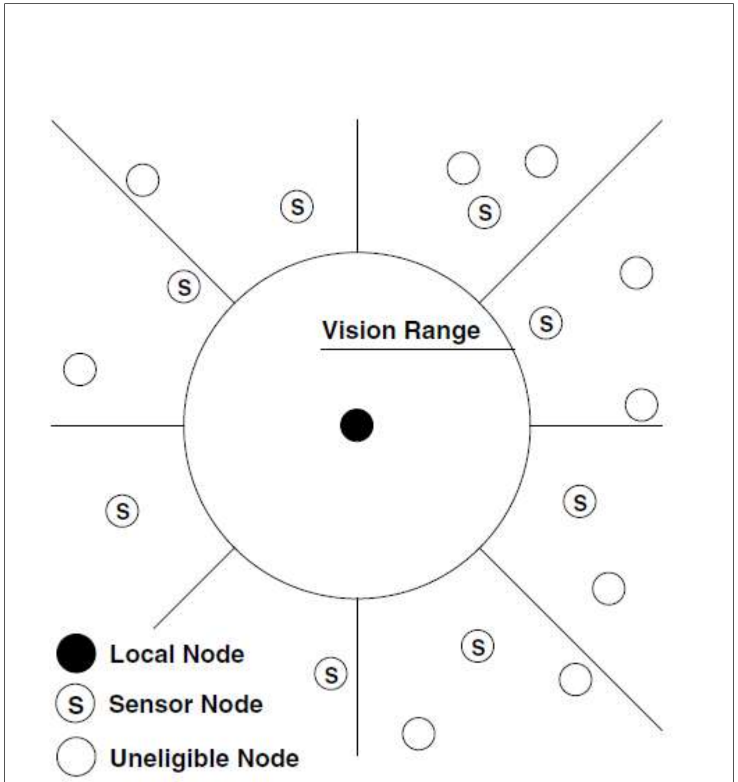
- **Near Nodes:** Peers that are within the vision range of the local node.
- Fast position updates required
- **Sensor Nodes:** To avoid network partitioning a list of nodes outside of the vision range is maintained.
- **Localized Multicast:** Update messages are directly sent to near nodes and sensor nodes. Additionally forwarding is used.

pSense

- Overlay structure of pSense



Local View of the Network



Sensor Node Selection

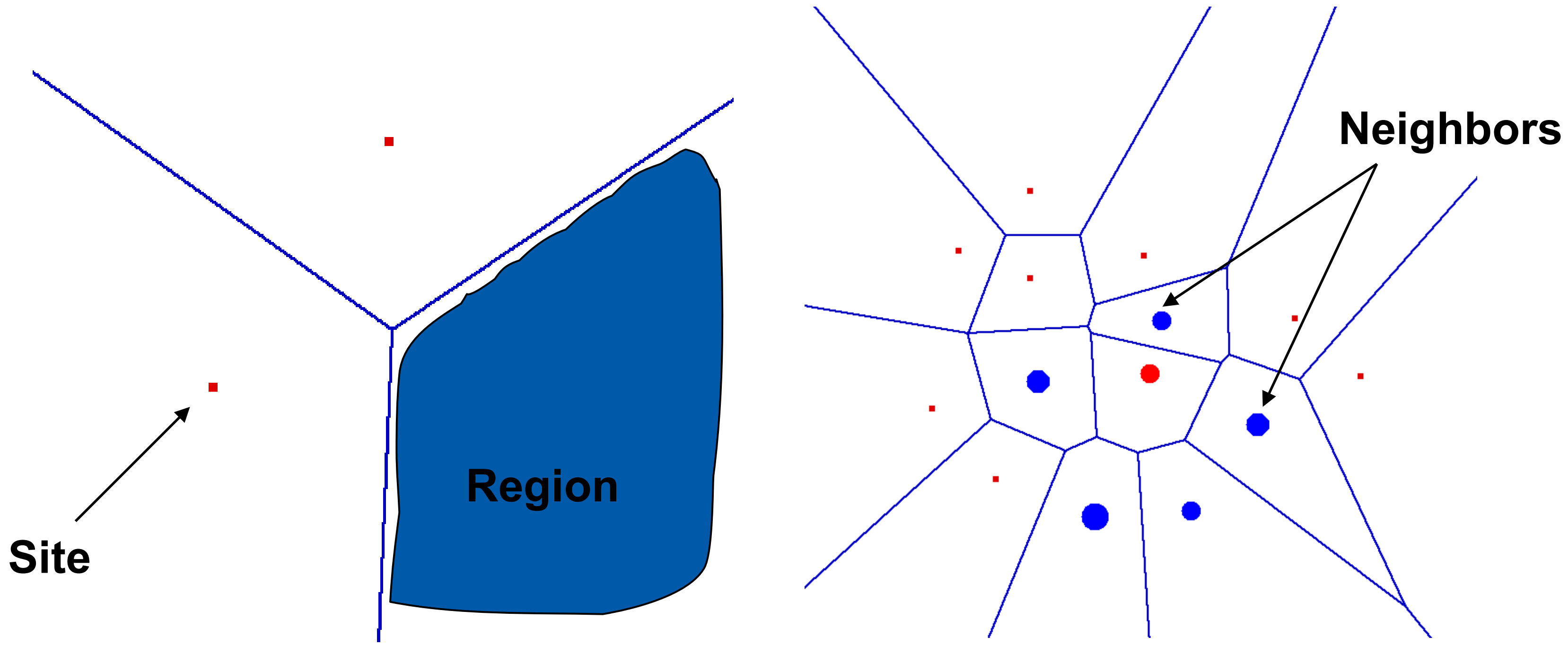
Voronoi-based Overlay Network (VON)

- Published originally at the 2004 ACM SIGCOMM workshop *Netgames* by Shun-Yun Hu
- Solving the *"neighbor discovery problem"* in a P2P environment

1. Shun-Yun Hu and Guan-Ming Liao, **"Scalable Peer-to-Peer Networked Virtual Environment,"** in *Proc. ACM SIGCOMM 2004 workshops on NetGames '04*, Aug. 2004, pp
2. Shun-Yun Hu, Shao-Chen Chang, and Jehn-Ruey Jiang, **"Voronoi State Management for Peer-to-Peer Massively Multiplayer Online Games,"** in *Proc. 4th IEEE Intl. Workshop on Networking Issues in Multimedia Entertainment (NIME)*, Jan. 2008.
3. Jehn-Ruey Jiang, Yu-Li Huang, and Shun-Yun Hu, **"Scalable AOI-Cast for Peer-to-Peer Networked Virtual Environments,"** in *Proc. 28th International Conference on Distributed Computing Systems Workshops (ICDCSW) Cooperative Distributed Systems (CDS)*, Jun. 2008.

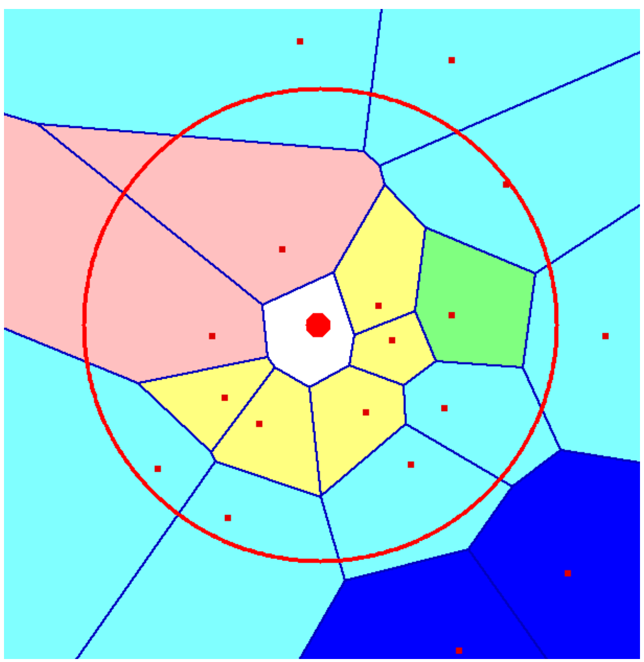
Voronoi Diagram

- Plane partitioned into *regions* by *sites*, each region contains all the points closest to its site
- Can be used to find *k-nearest neighbor* easily



Design Concept

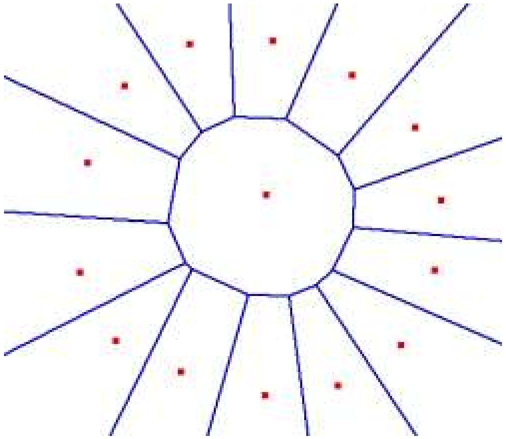
- Use Voronoi to solve Neighbor Discovery Problem
  - Identify *enclosing* and *boundary* neighbors
  - Each node constructs a Voronoi of its neighbors
  - Enclosing neighbors are maintained as the minimal set
  - Mutual collaboration in neighbor discovery



Circle	**Area of Interest (AOI)**
White	**self**
Yellow	**enclosing neighbor**
L. Blue	**boundary neighbor**
Pink	**enclosing & boundary**
Green	**other neighbor**
D. Blue	**unknown neighbor**

Problems of Voronoi Approach

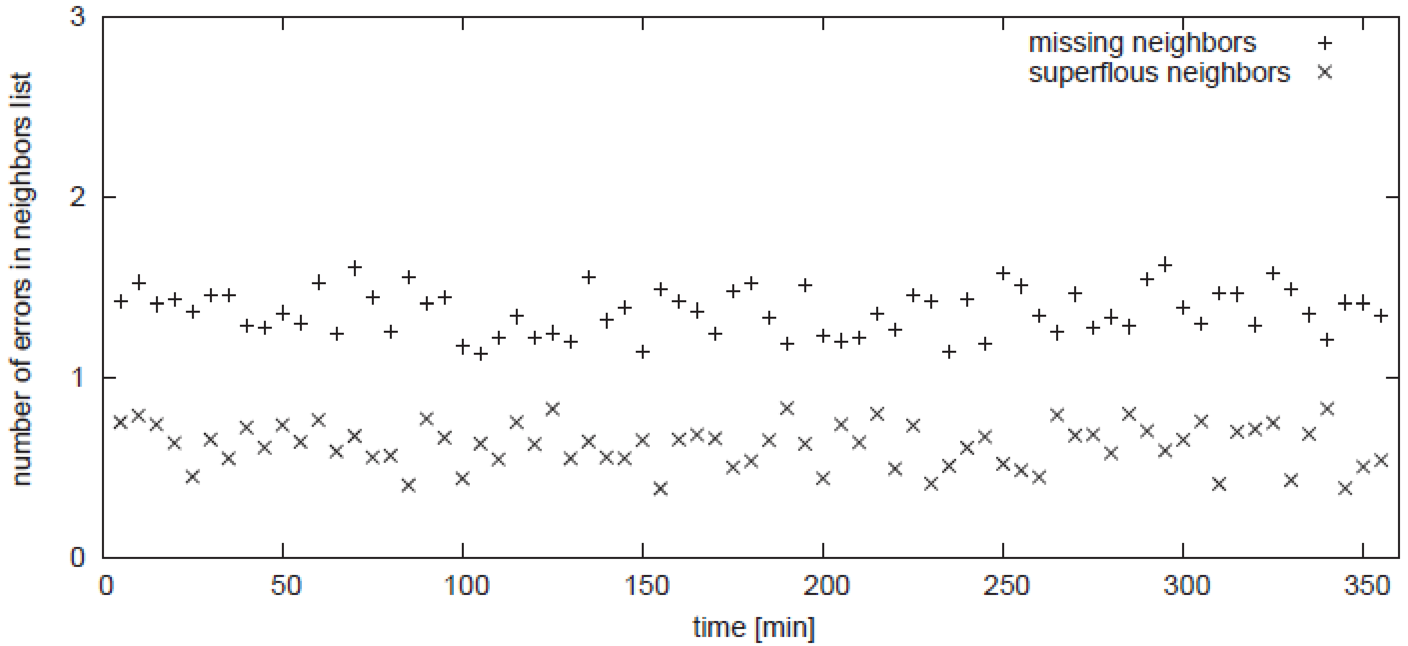
- Performance
- Circular round-up of nodes
- Redundant message sending



- Incomplete neighbor discovery
- Inconsistent / incorrect neighbor list
- Fast moving node

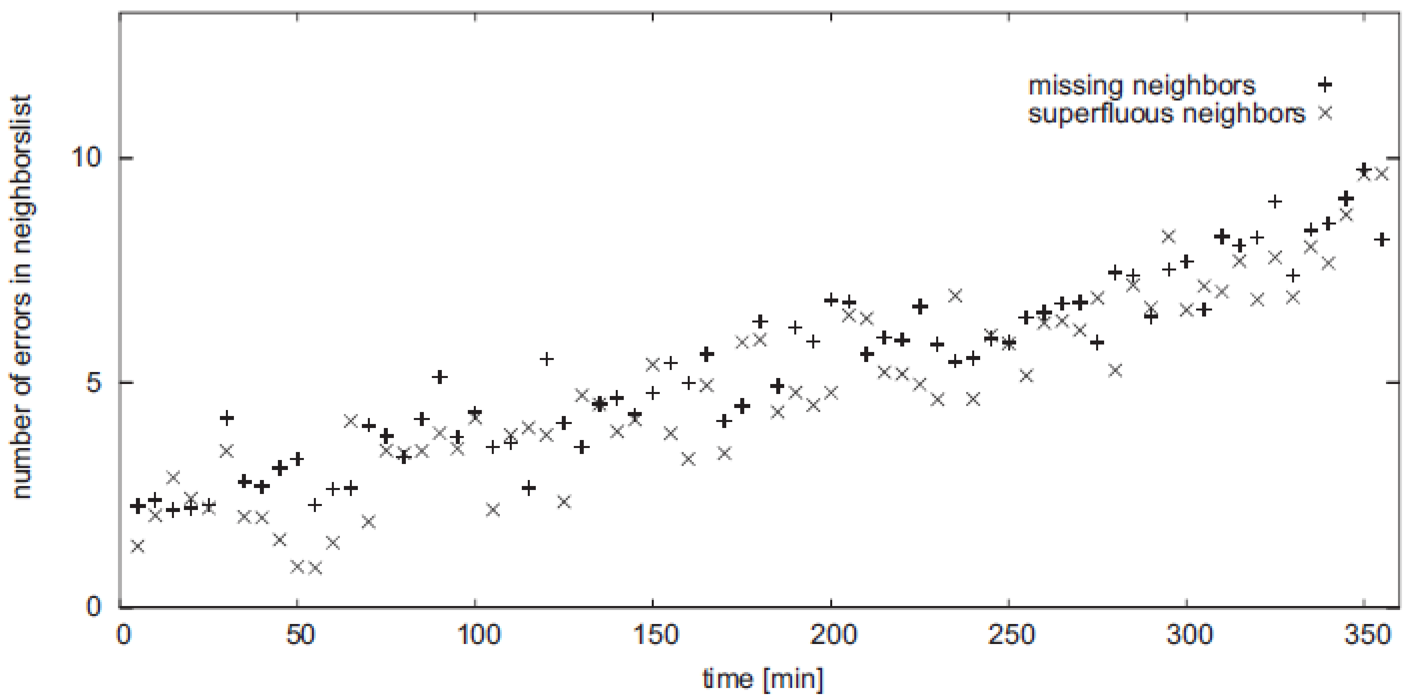
VON - Evaluation

Consistency for players in Random Waypoint mode:



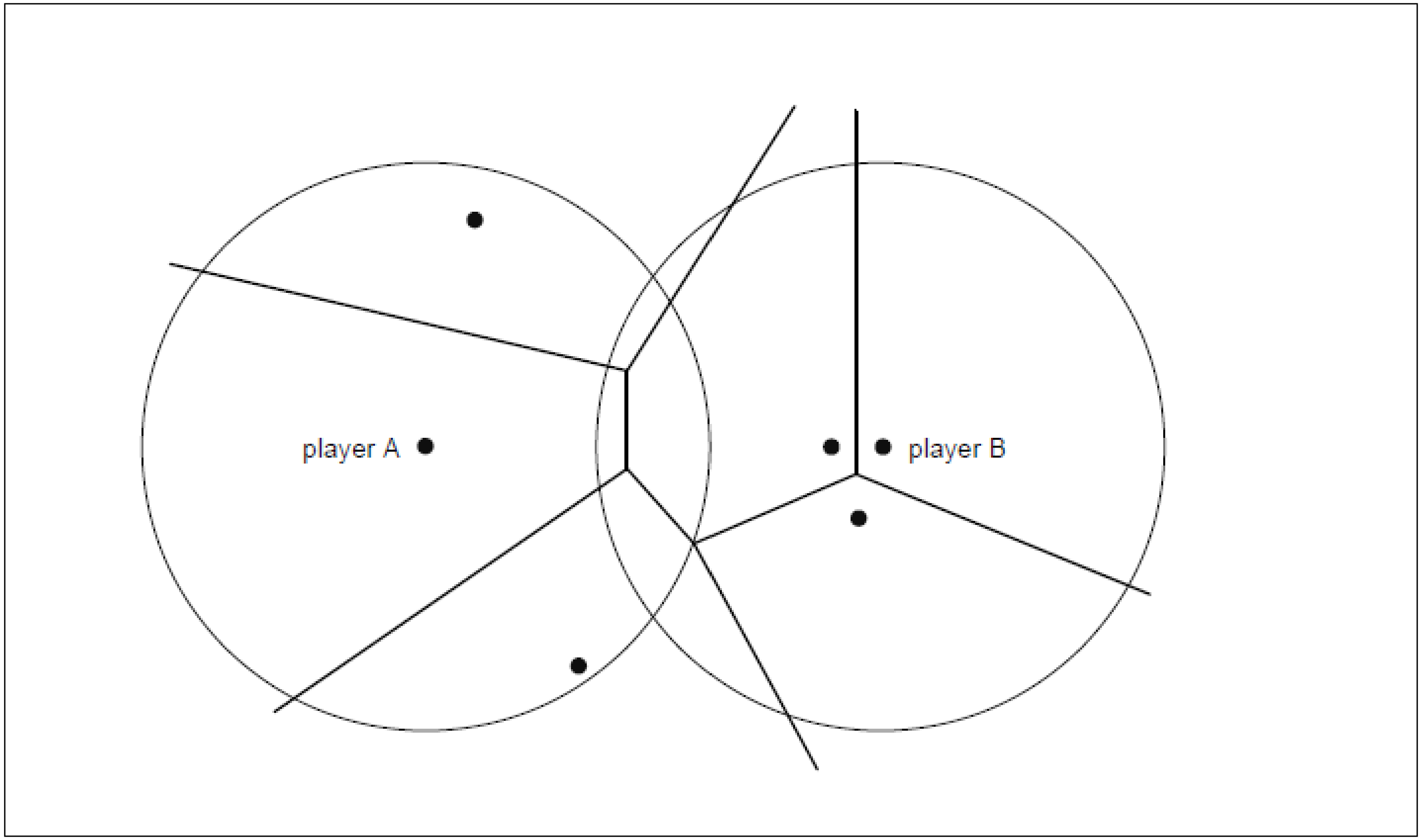
VON - Evaluation

Consistency for players in Group-based Random Waypoint mode:



VON - Evaluation

Non bilateral neighborhood:



Player A is a boundary neighbor of Player B, but not vice versa

Donnybrook

Donnybrook: enabling large-scale, high-speed, peer-to-peer games

Jeffrey Pang

Ashwin Bharambe*, John R. Douceur, Jacob R. Lorch, Thomas Moscibroda,*
Jeffrey Pang*, Srinivasan Seshan, and Xinyu Zhuang:* **Donnybrook: enabling large-scale, high-speed, peer-to-peer games** SIGCOMM 08 Comput. Commun. Rev. New York, NY, USA 2008

Donnybrook

Aim:

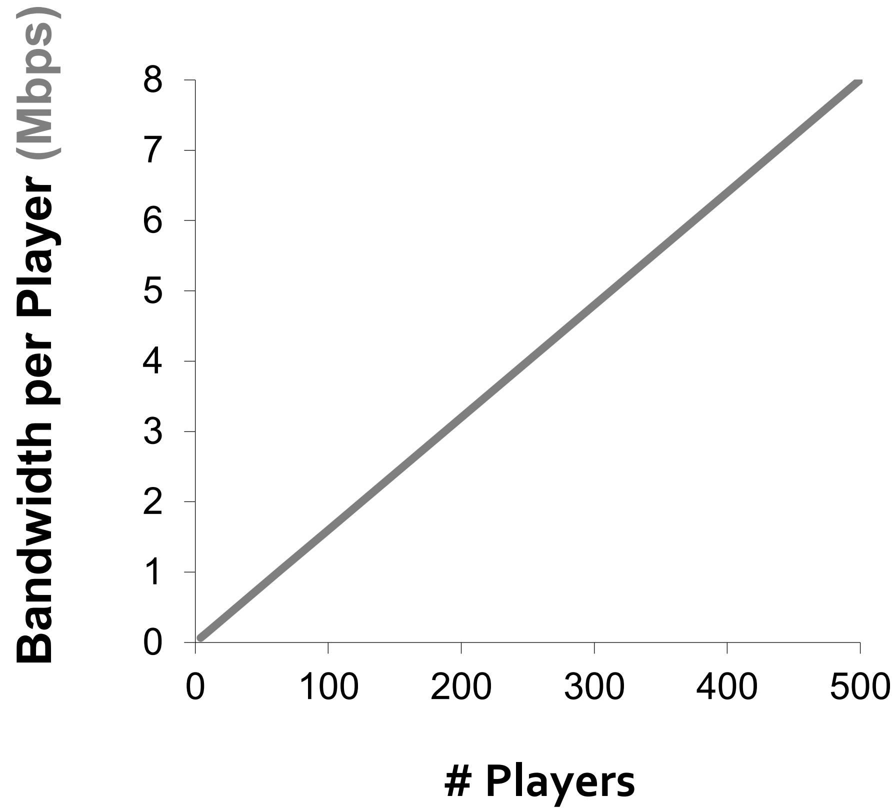
Enable a high-speed (<150ms), large scale (1000), peer hosted online game.

Naive approach:

Needs ~ 12n kbit/s for n peers (using Quake III)

Idea:

Use full mesh topologie, and reduce updates.



Donnybrook

Observation:

Humans can only focus on a constant number of objects.

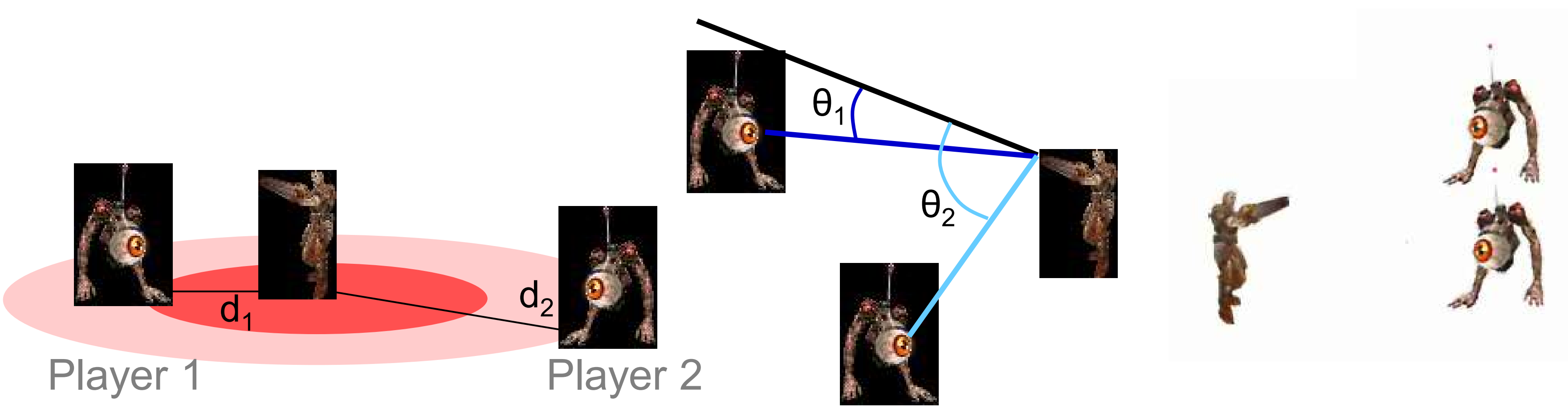
Concept:

1. Determine the focused objects and use a high update rate for this „interest set“.
2. Use a very low update rate for other objects.

Interest Set

- Estimation of human attention:

$$\text{Attention}(\mathbf{i}) = f_{\text{proximity}}(d_i) + f_{\text{aim}}(\theta_i) + f_{\text{interaction-recency}}(t_i)$$



Interest Set

Benchmarking

Observation:

Many research groups are developing P2P-infrastructures for online games.

Question:

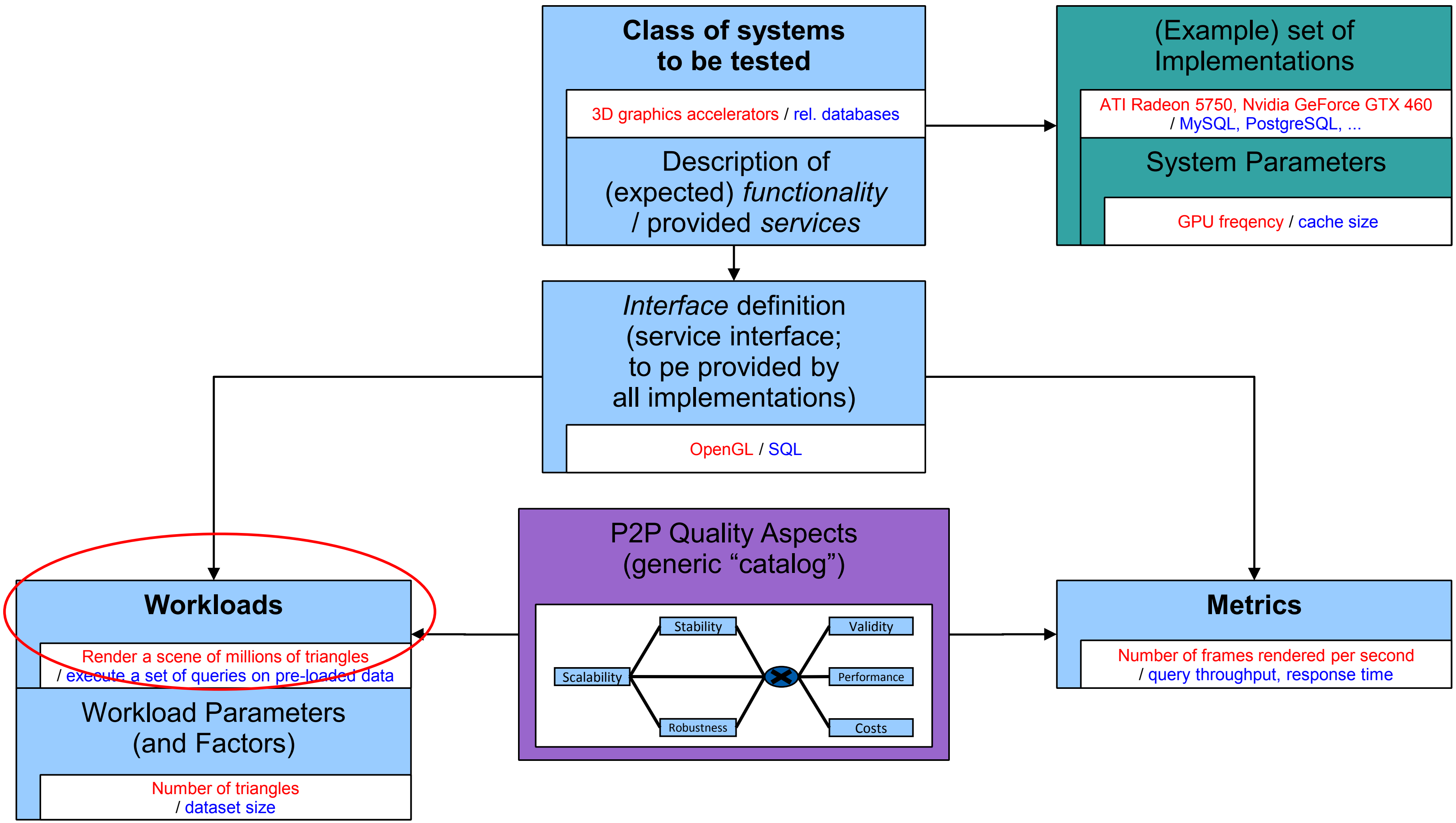
How can be determined if an approach is good or not.

Answer:

Create a P2P-Gaming Benchmark.

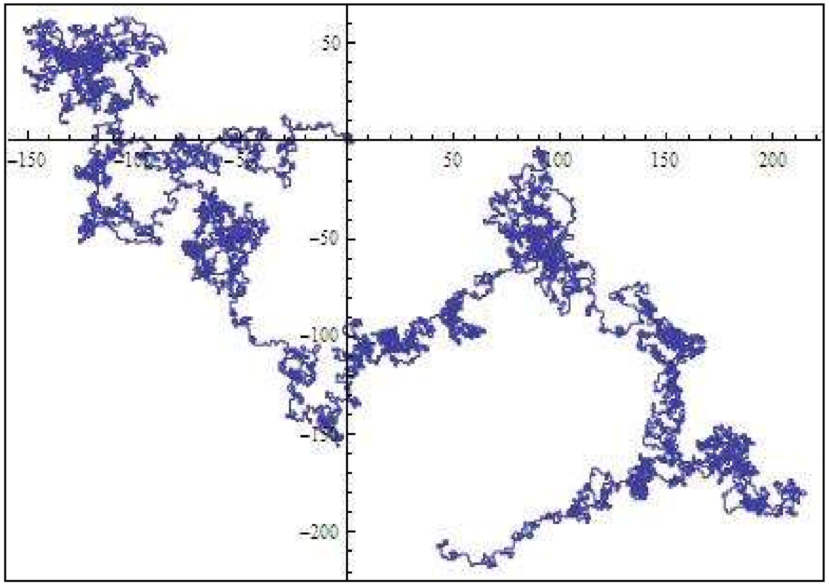
-> Forschergruppe QuaP2P 2

QuaP2P Gaming Benchmark

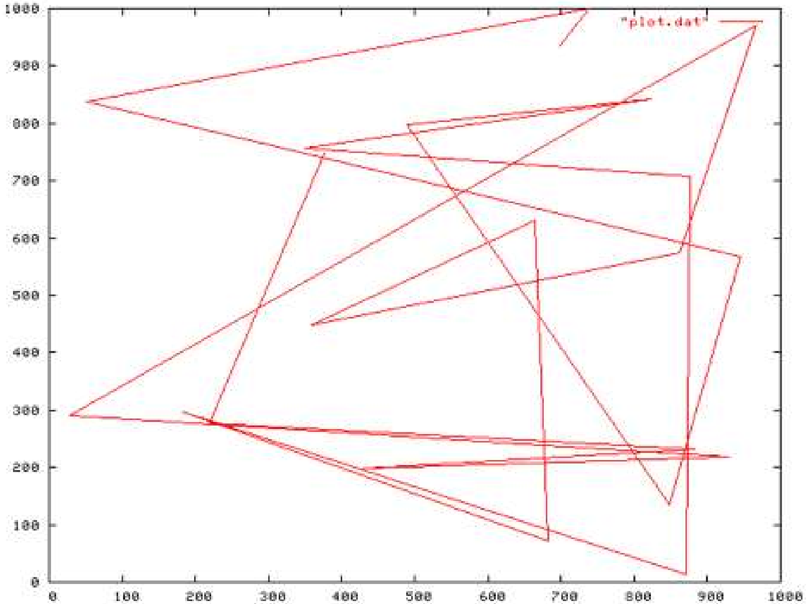


Generation of Workload

- Mobility Models (Random Walk,Random Waypoint,…)
- Traces
- Bots



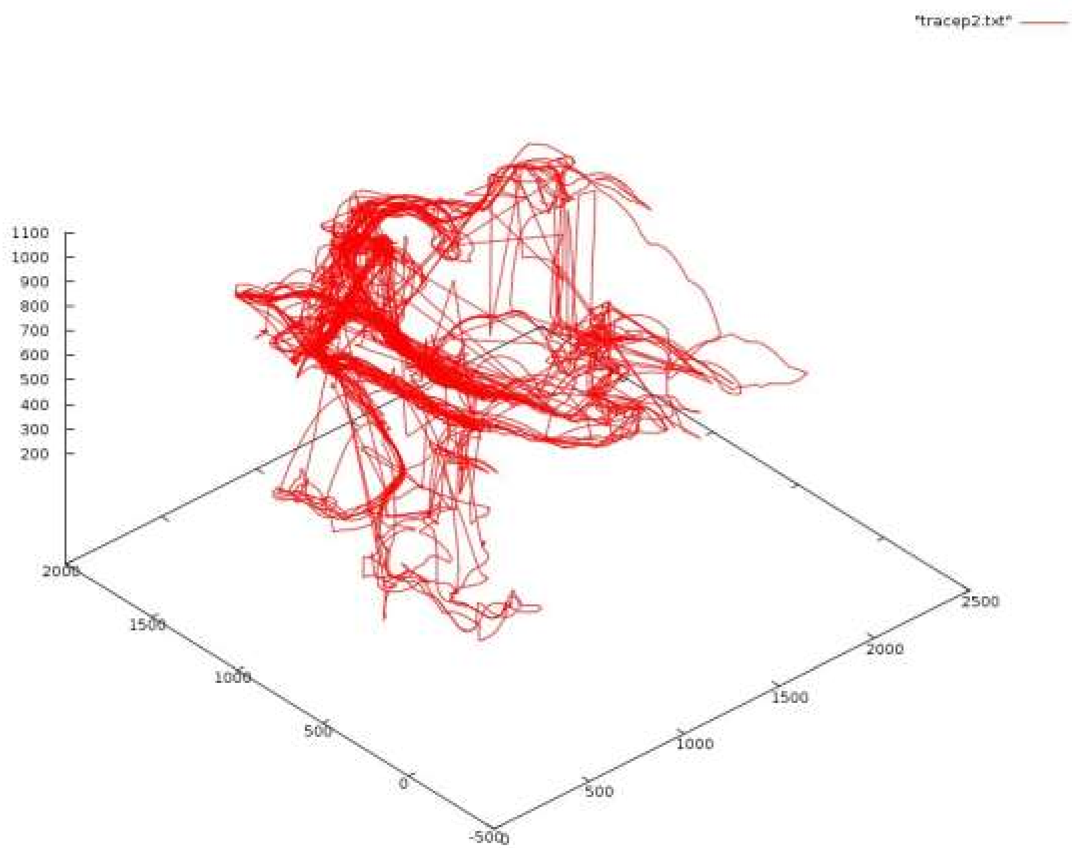
Random Walk



Random Waypoint

Generation of Workload with Traces

- Example Trace from Quake 2:



Generation Workload with Bots

Conclusion

- P2P-technologies can be used to create „scalable " online games
- P2P-technologies can be used to reduce hardware and maintenace costs
- P2P-technologies can be used to create high-speed online games

But……the task is very challenging

Questions?