

Modeling Avatar Mobility in Networked Virtual Environments

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Motivation

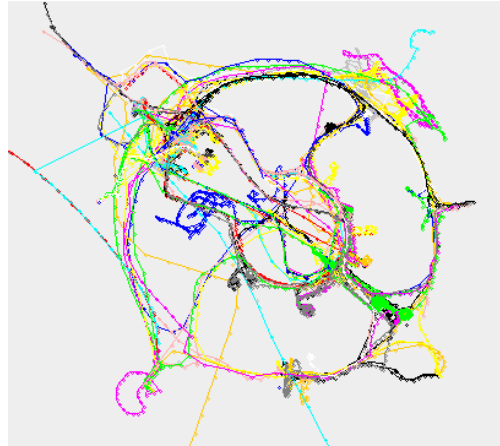
- There are two major ways to provide mobility input for the evaluation of Networked Virtual Environment (NVE) architectures
 - Mobility traces from real-world
 - Pros: credibility
 - Cons: flexibility, difficult to collect large-scale traces
 - Mobility traces generated from model
 - Pros: flexibility, easy to generate large-scale traces
 - Cons: may not well match reality
- **Generating realistic and large-scale avatar mobility trace**

Agenda

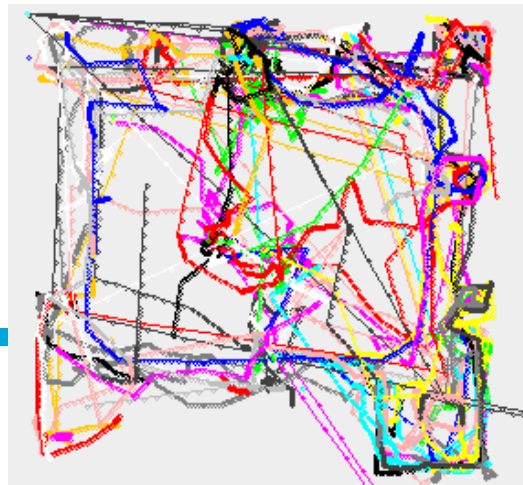
- Datasets
- Empirical modeling
- SAMOVAR
- Limitation
- Conclusion

Datasets

- One day mobility traces collected from **Ironforge, World of Warcraft**



- One day mobility traces collected by Liang et al. 2009 (NUS) from **Freebies, Second Life**



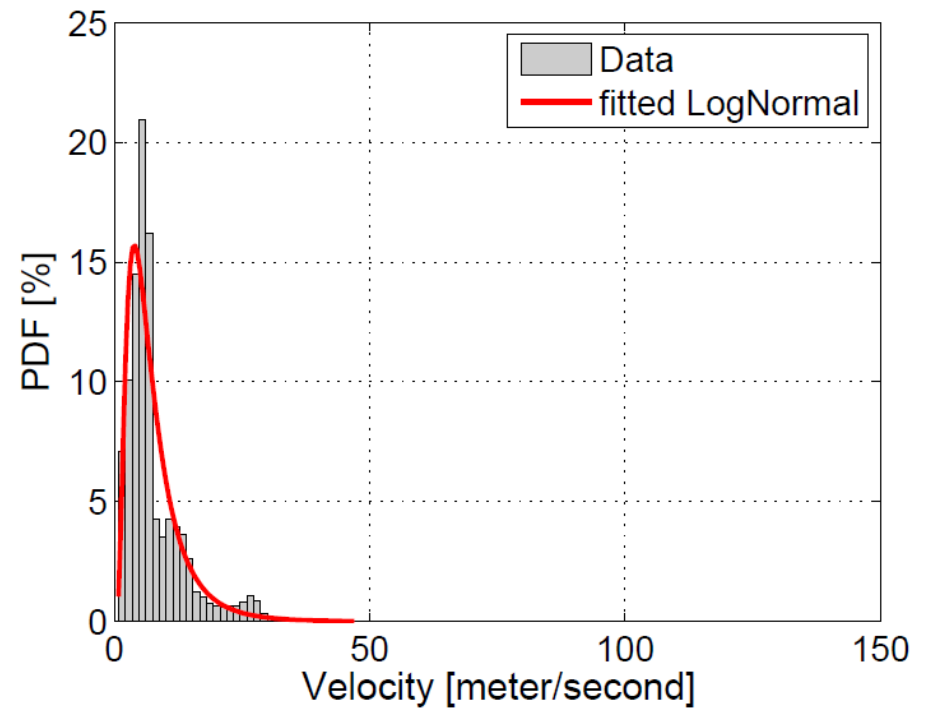
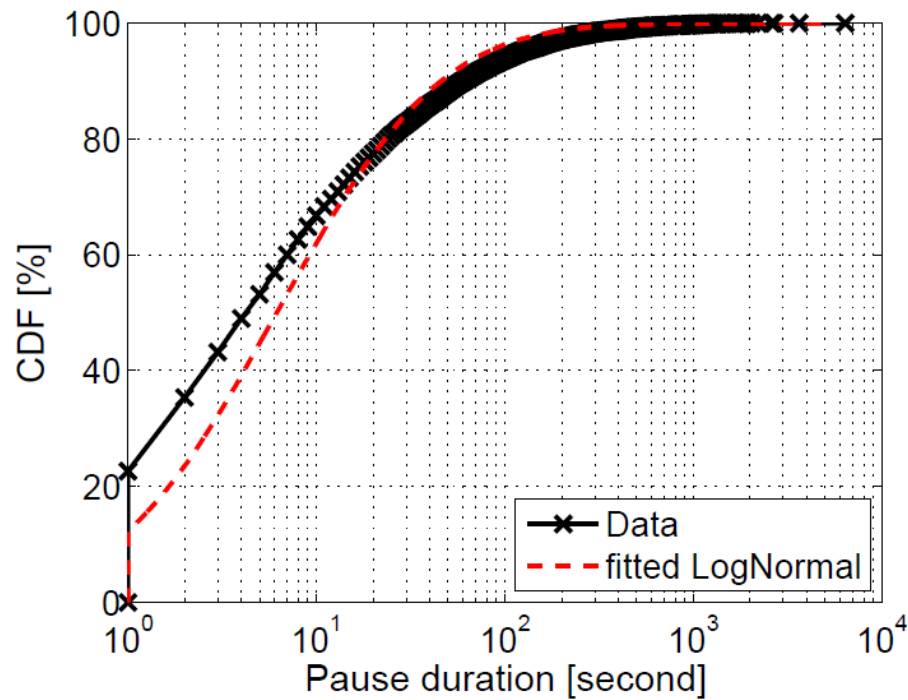
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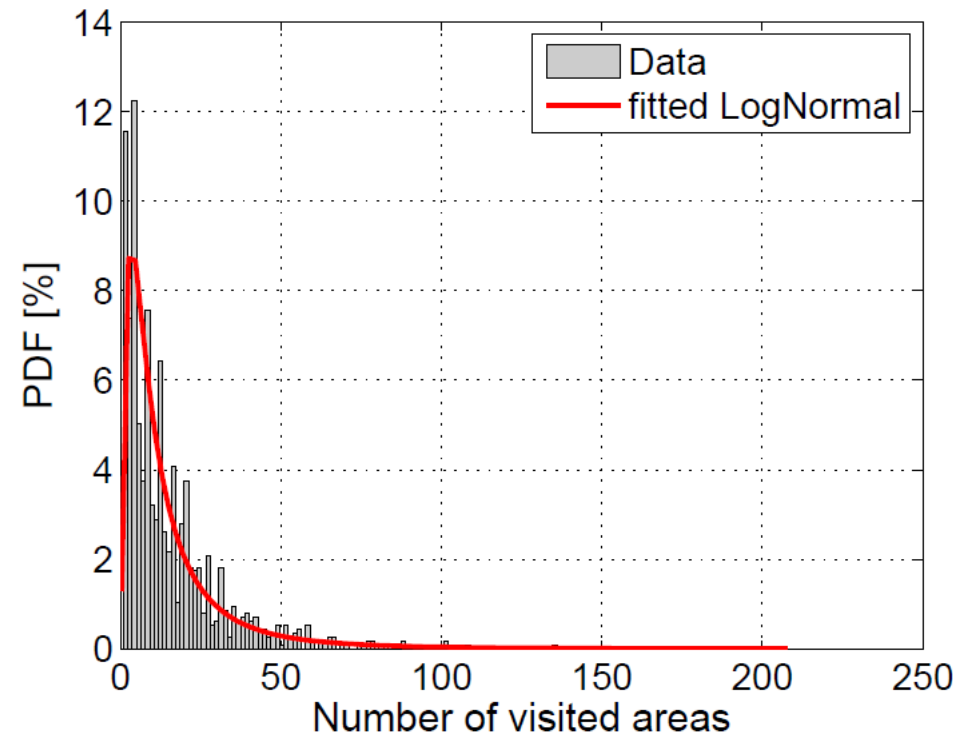
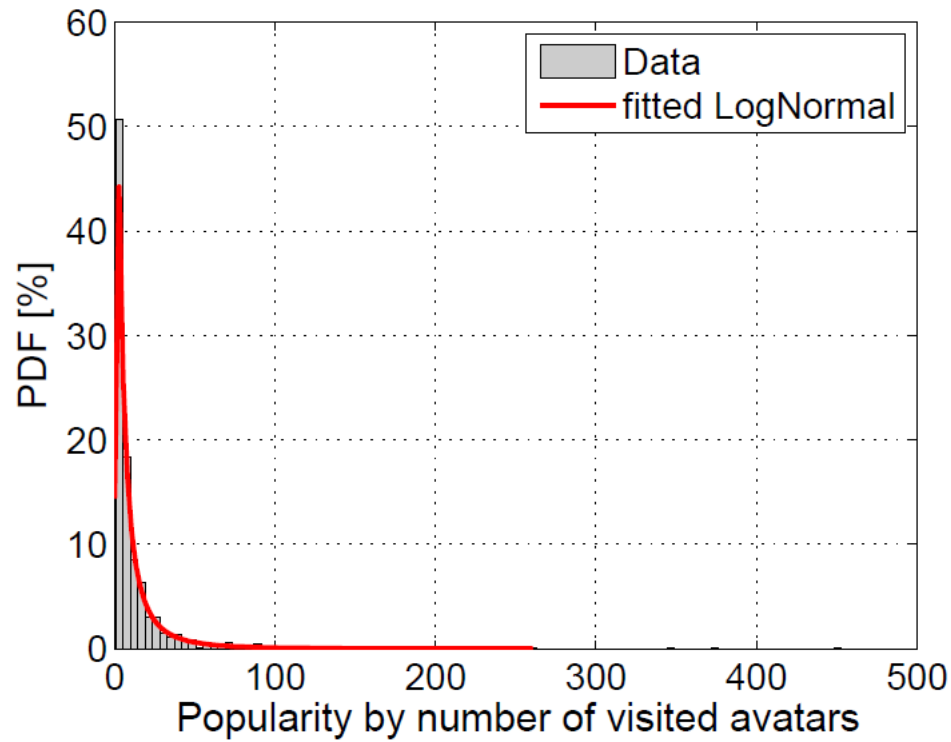
Empirical modeling

- Mobility properties
 - Pause duration
 - Velocity
 - Area popularity
 - Number of visited areas
- Modeling each properties against various statistical models using Maximal Likelihood estimation
- Goodness of fit: Kolmogorov-Smirnov (KS) test and Anderson-Darling (AD) test

Empirical modeling results 1/2



Empirical modeling results 2/2



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SAMOVAR: Statistical Area-based MObility model for VirtuAl enviRonments

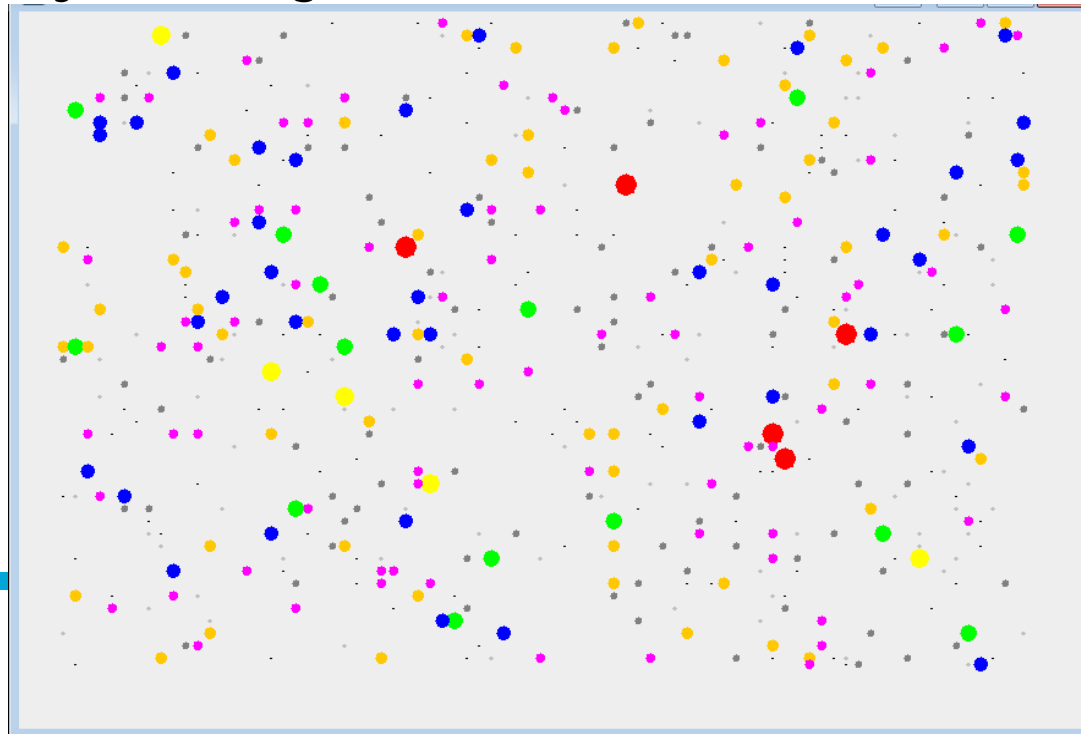
- Map generation
 - The distribution of waypoints
 - The paths between waypoints
- Walking paths generation
 - The waypoints the avatar can travels
 - How to pick waypoint and travel to it



Original picture from http://madness-gaming.cz/wow/images/photoalbum//eastern_bc.jpg

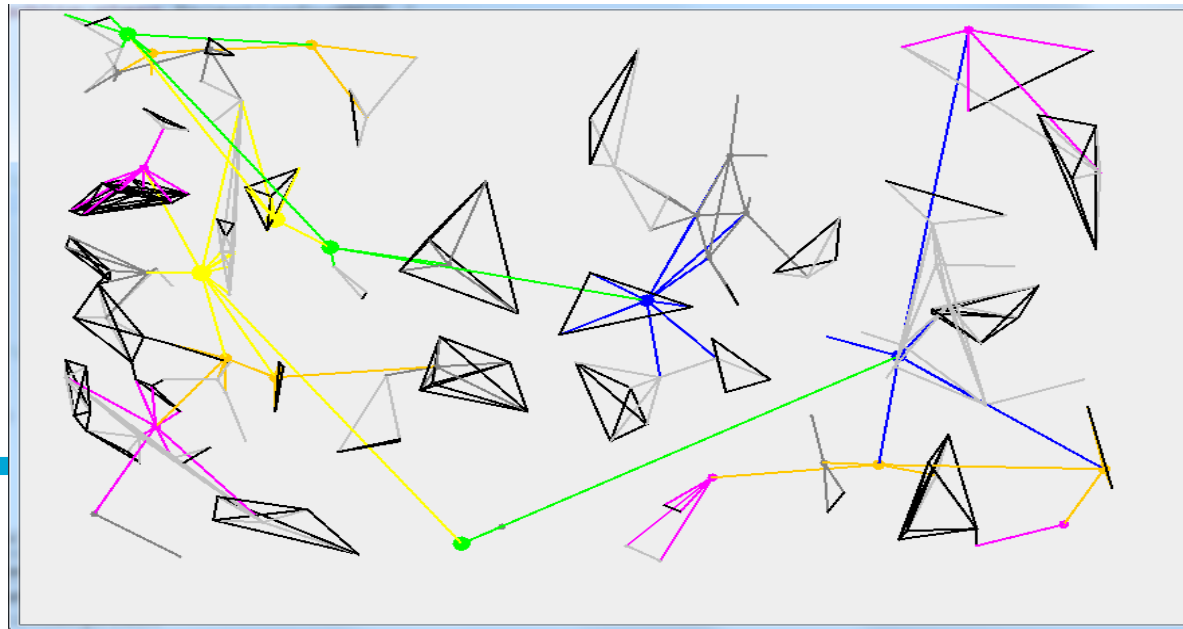
SAMOVAR: Map generation 1/2

- Partition the map into equal-size rectangular areas. Randomly selected n areas, the center points of the selected areas are the waypoints.
- Assigning each waypoint an weight according a log-normal distribution. Each waypoint is classified into a level by its weight



SAMOVAR: Map generation 2/2

- Connecting the heaviest weight waypoints with each other
- Connecting each waypoint with its closest waypoints of higher level
- Connect same-level waypoints with each other, if they are connected to same higher level waypoints.
- Connect waypoints with each other if their distance is lower than a threshold value r .

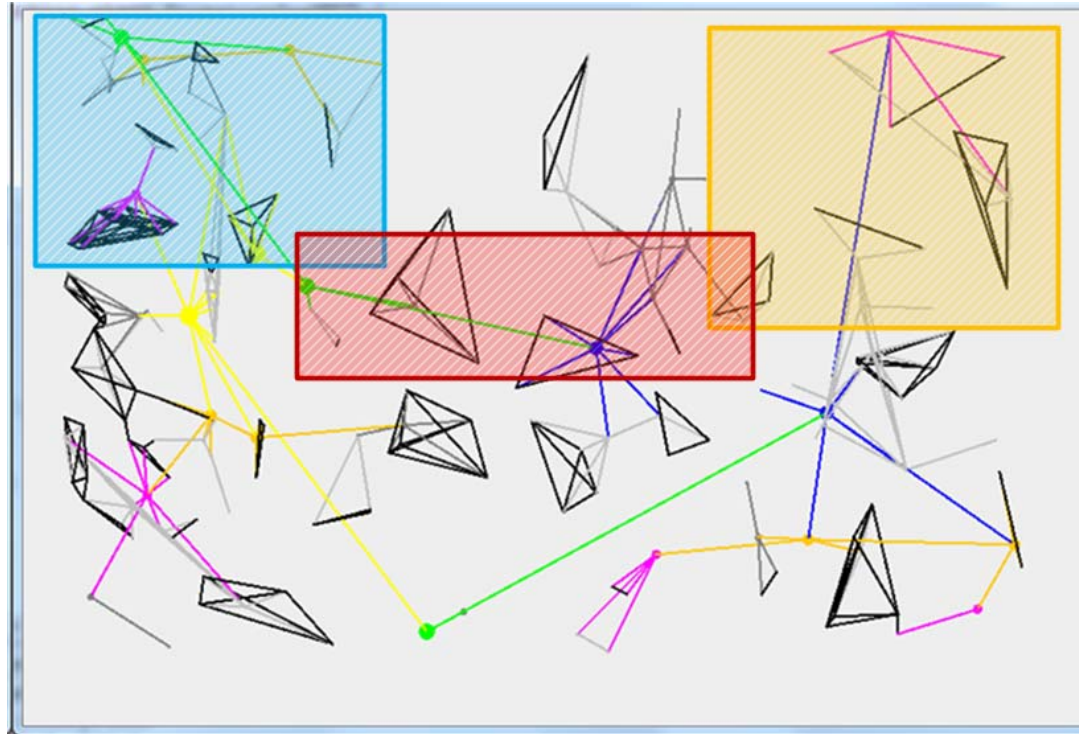


SAMOVAR: Walking path generation

1/2

- Assign to each avatar the number of waypoints this avatar can visit, k , sampled from a LogNormal distribution.
- Assign to each person a start waypoint
 - *SAMOVAR-U* assigns the start waypoint randomly
 - *SAMOVAR-W* assigns the start waypoint according to the weight
- For each avatar, iteratively add the waypoints neighboring the already assigned waypoints, until the number of waypoints reach k

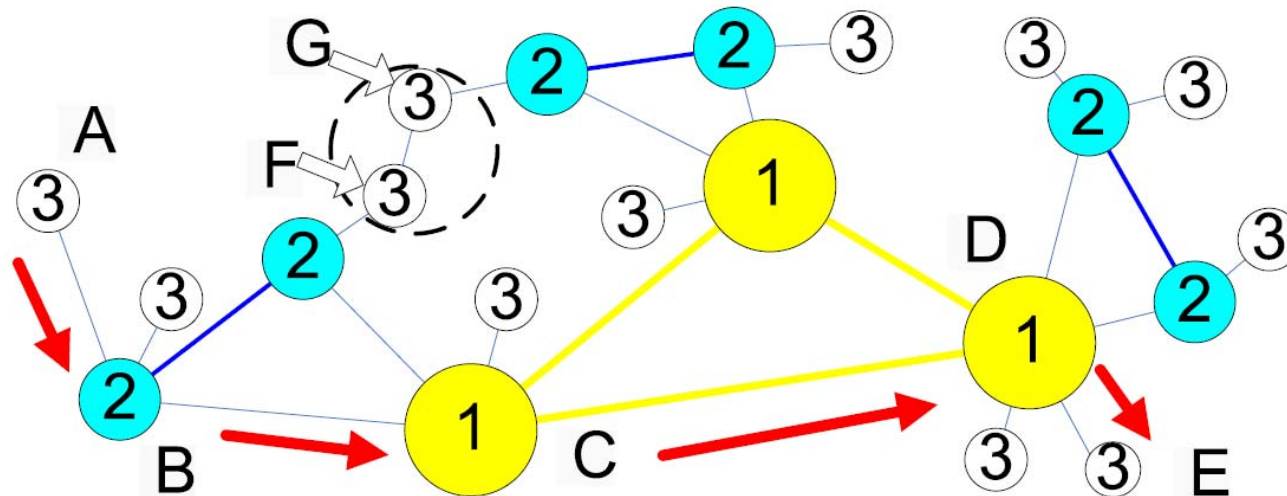
Waling Path Generation Example



- Hatch area enclose the waypoints avatar travels
- Different colors for different avatars

SAMOVAR: Walking path generation 2/2

- Each avatar will select its next waypoint to go according a personal weight, and walk to the waypoint using a sampled velocity.
- Shortest path
- Upon arrival, pause for a sampled duration



Validation against C/S NVE 1/2

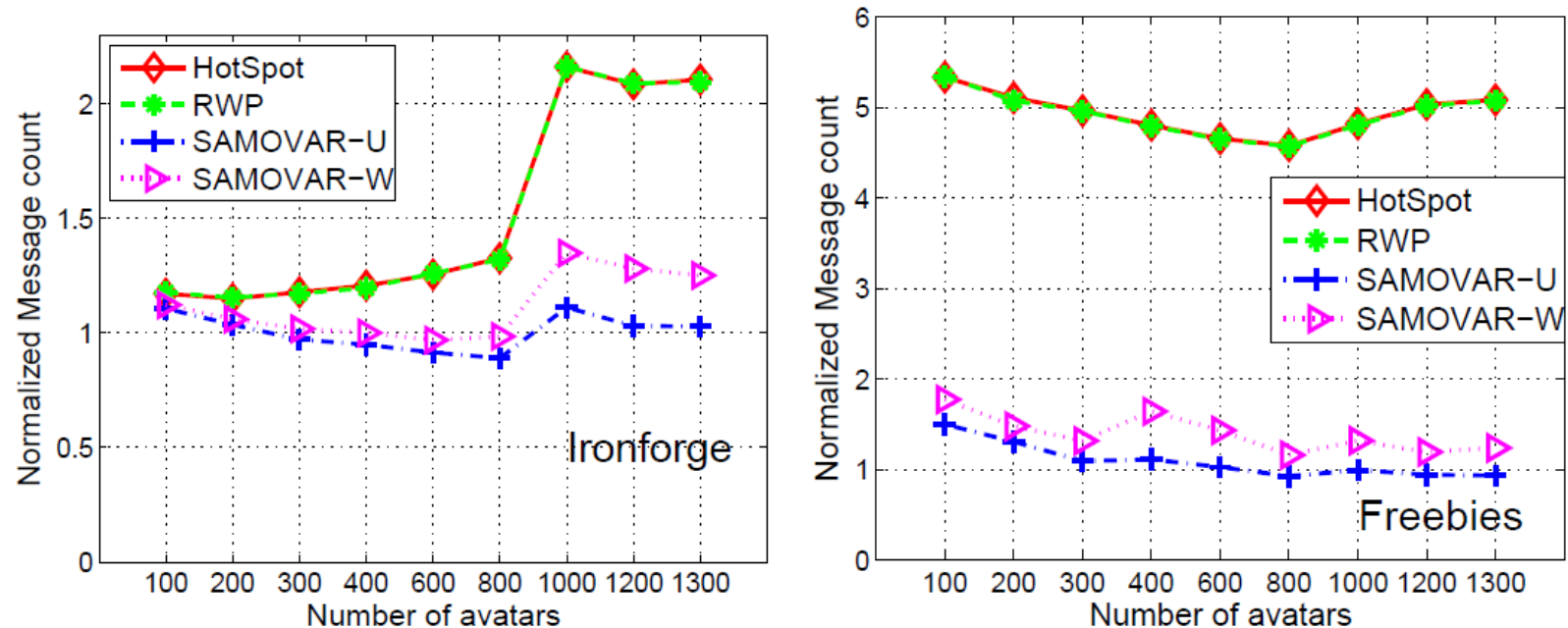
- Replaying the generated trace in a Client/Server-based NVE
- Each avatar will receive all the other avatars' updated positions within its Area-of-Interest
- Not death-reckoning
- Sampling the session time from real trace

Name	Values
World size	$791m \times 528m$
Number of avatars	1,302
Number of waypoints n	1,378
Number of levels m	9
Connection range r	20
Area of Interest range R	100 meters

Table 3: Parameters for simulation.

Validation against C/S NVE 2/2

- Replaying the traces of Ironforge and Freebies in a multi-servers client/server NVE
- The results of SAMOVAR are very close to real traces



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Limitations

- Do not model the distance between hotspots
- Do not model the session time
- Only validate against two games: WoW and SL
- City scenarios
- Evaluating in C/S architecture without any optimization

Limitations

- *"All models are wrong, but some are useful. "*
- *"Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful?"*
- By statistician [George Box](#)

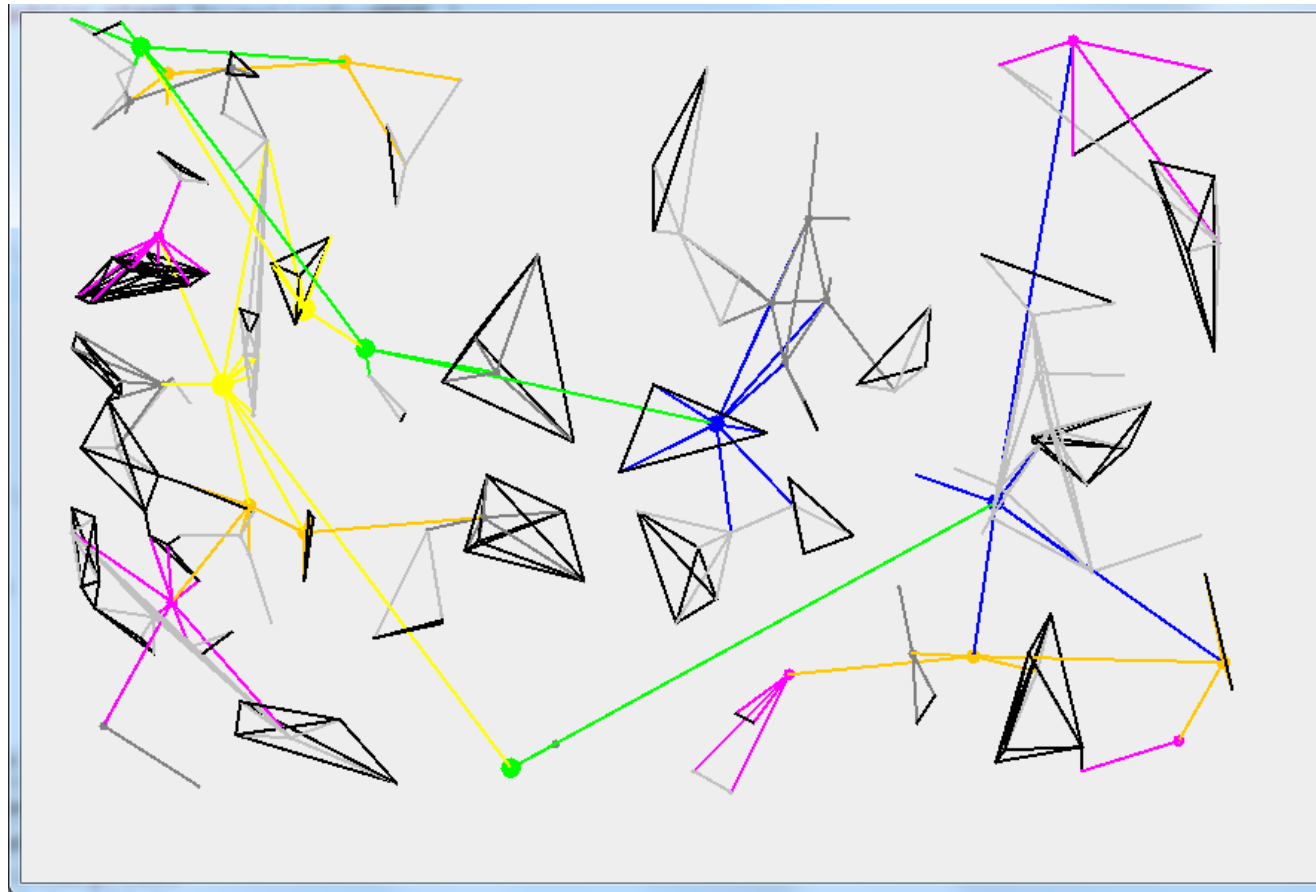
Conclusion

- SAMOVAR: an avatar mobility model to generate realistic avatar movement trace.
 - Modeling pause duration, velocity, area popularity, visited areas
 - Map generation
 - Waling path generation

- Thanks for your attention.
- Any questions, comments, suggestions?

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- Scalability of RTS/RPG
- Game social network & matchmaking
- Resource scheduling of cloud resources

An example of generated waypoints and paths



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