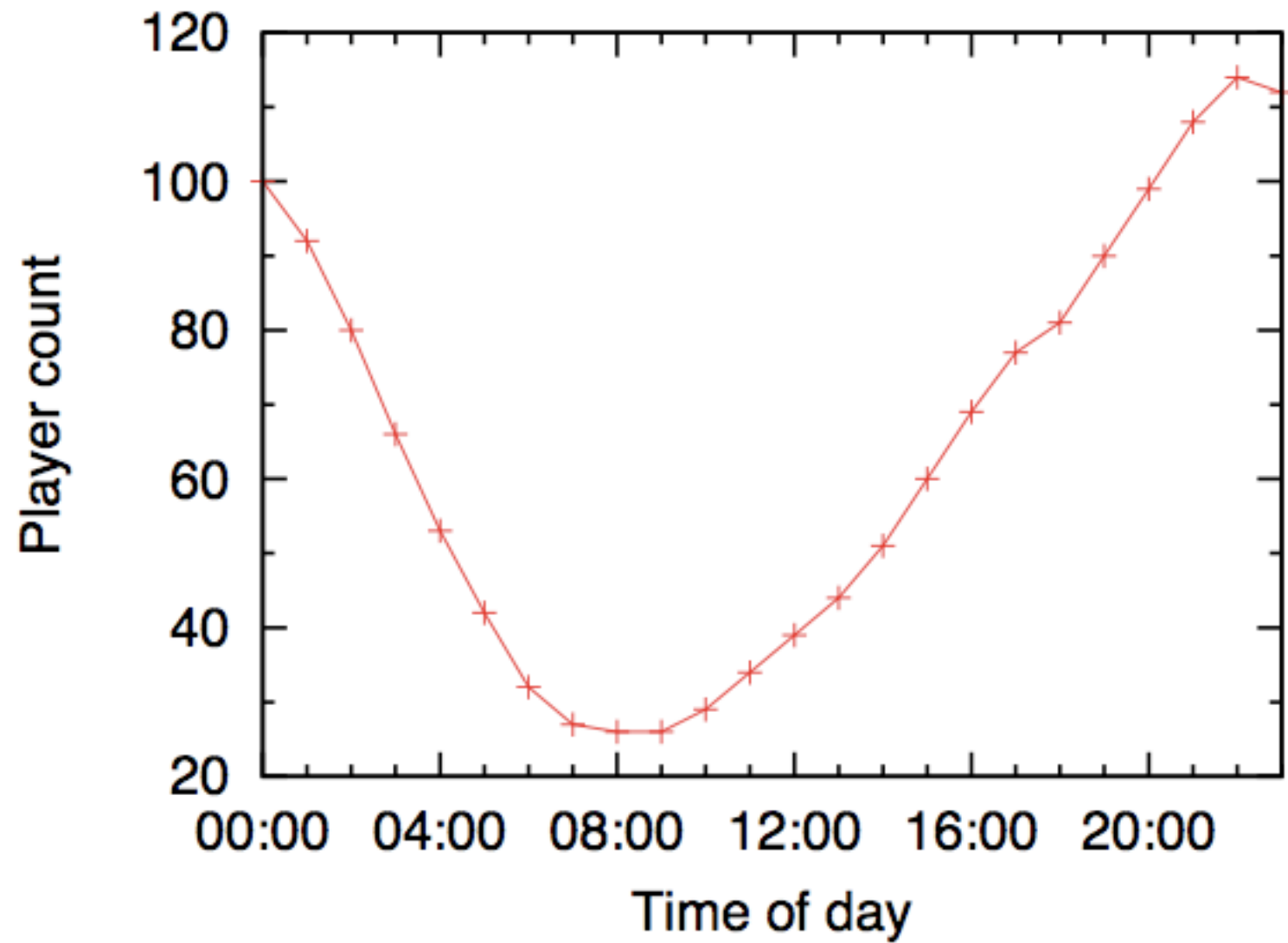


Characterizing Virtual Population in Games

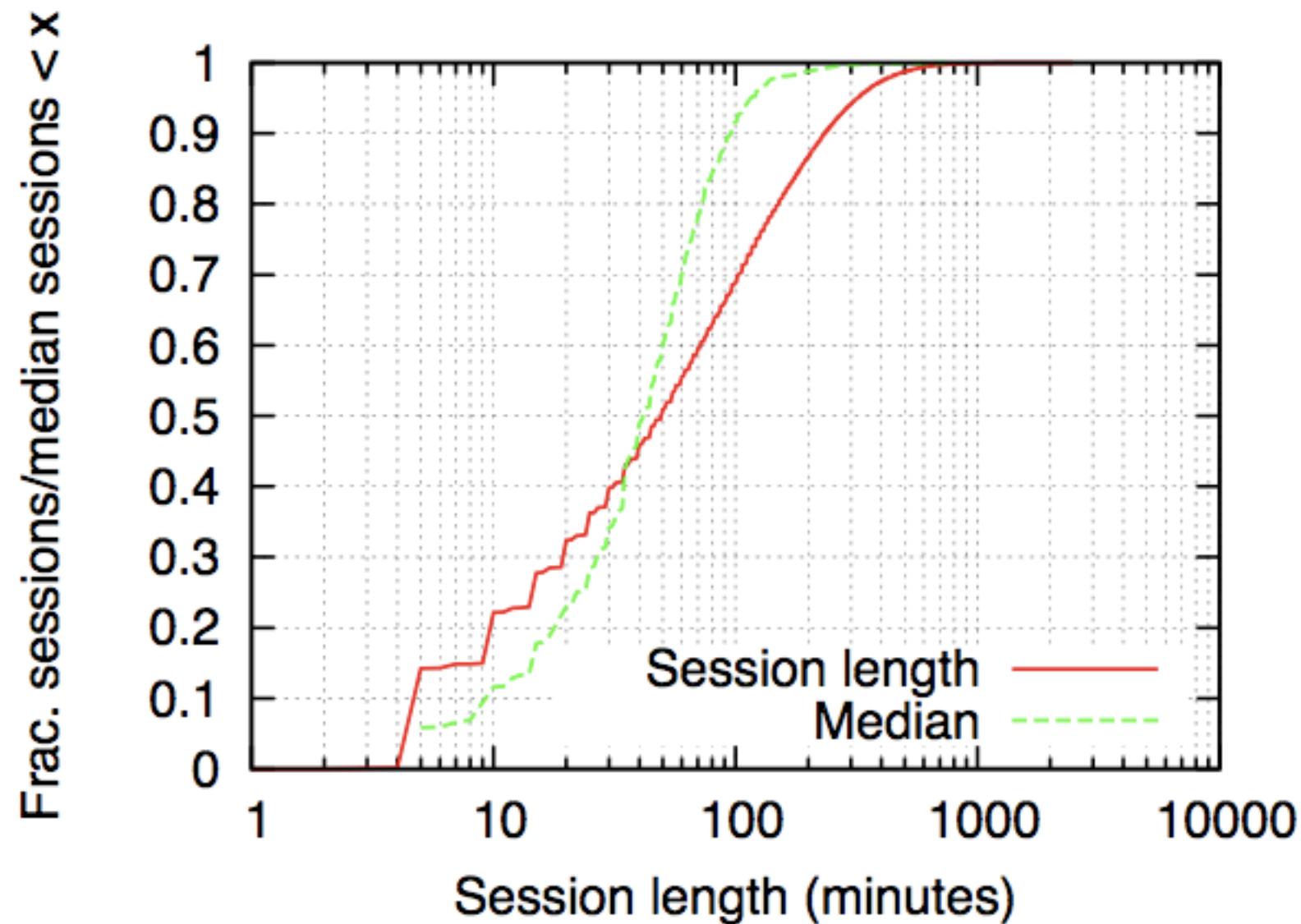
World of Warcraft

Use an add-on written in Lua

monitor
1100 random players
over 71 days

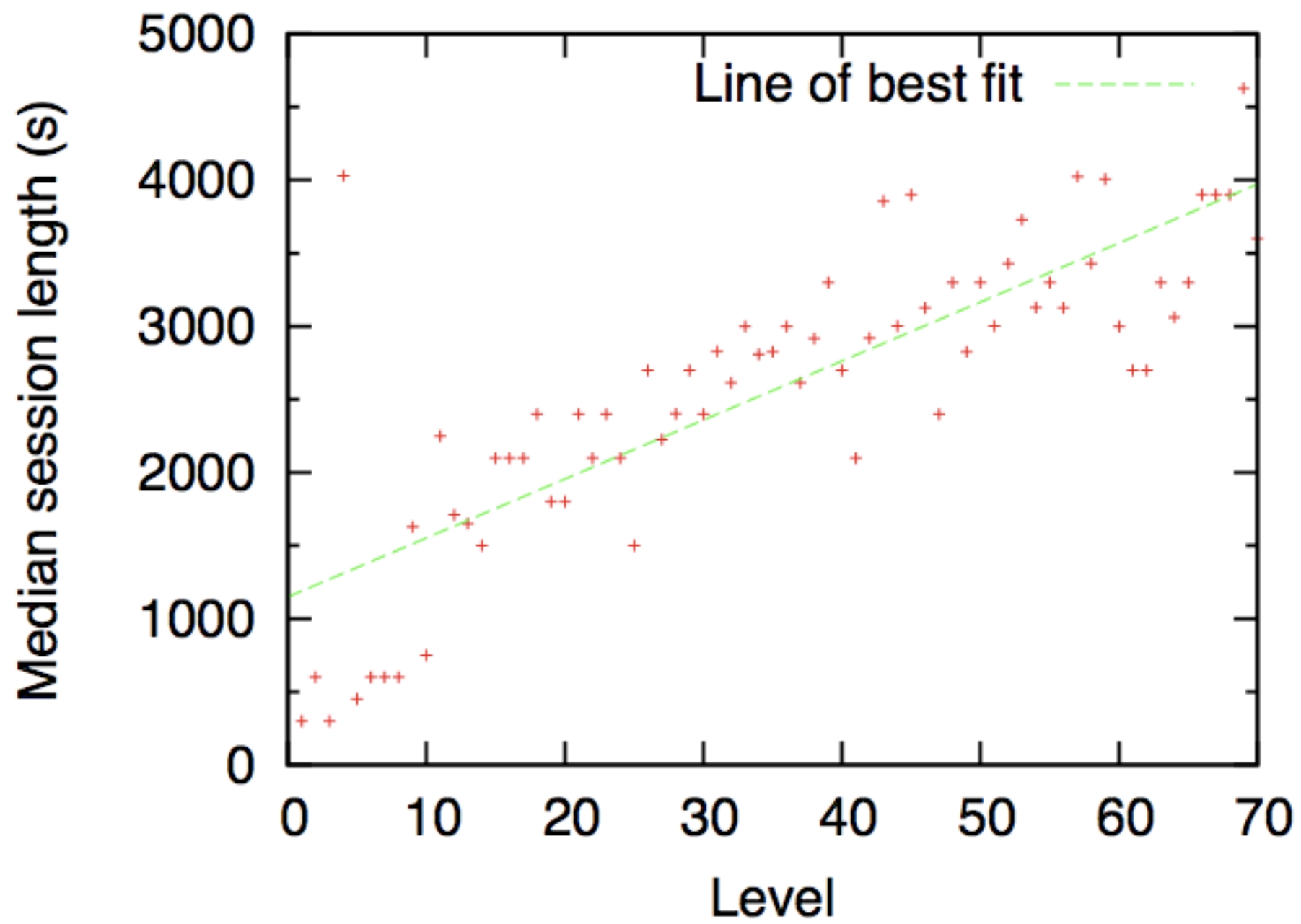


median num of players per poll
vs time of the day polled

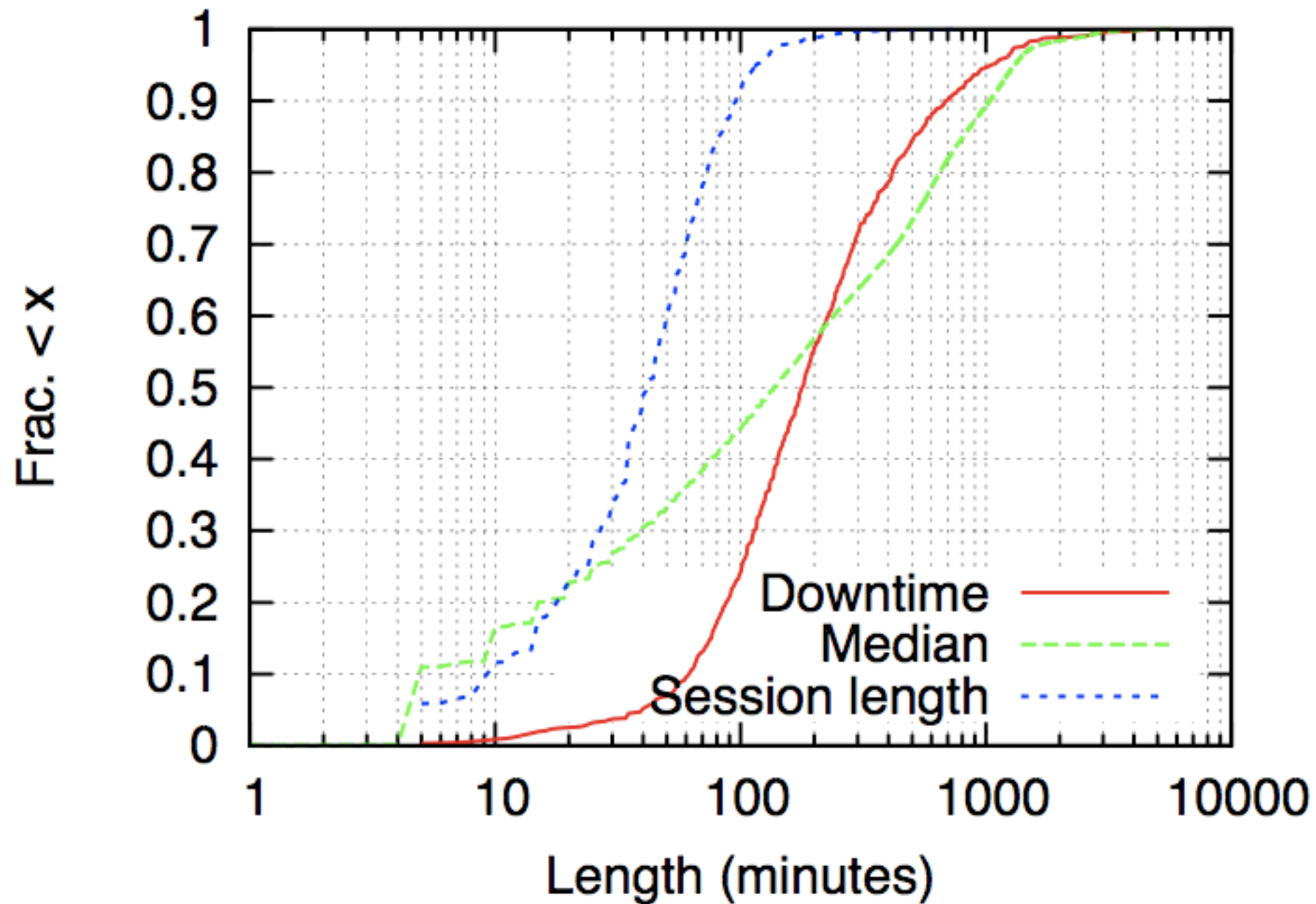


CDF of all session length, and
median session length of each player

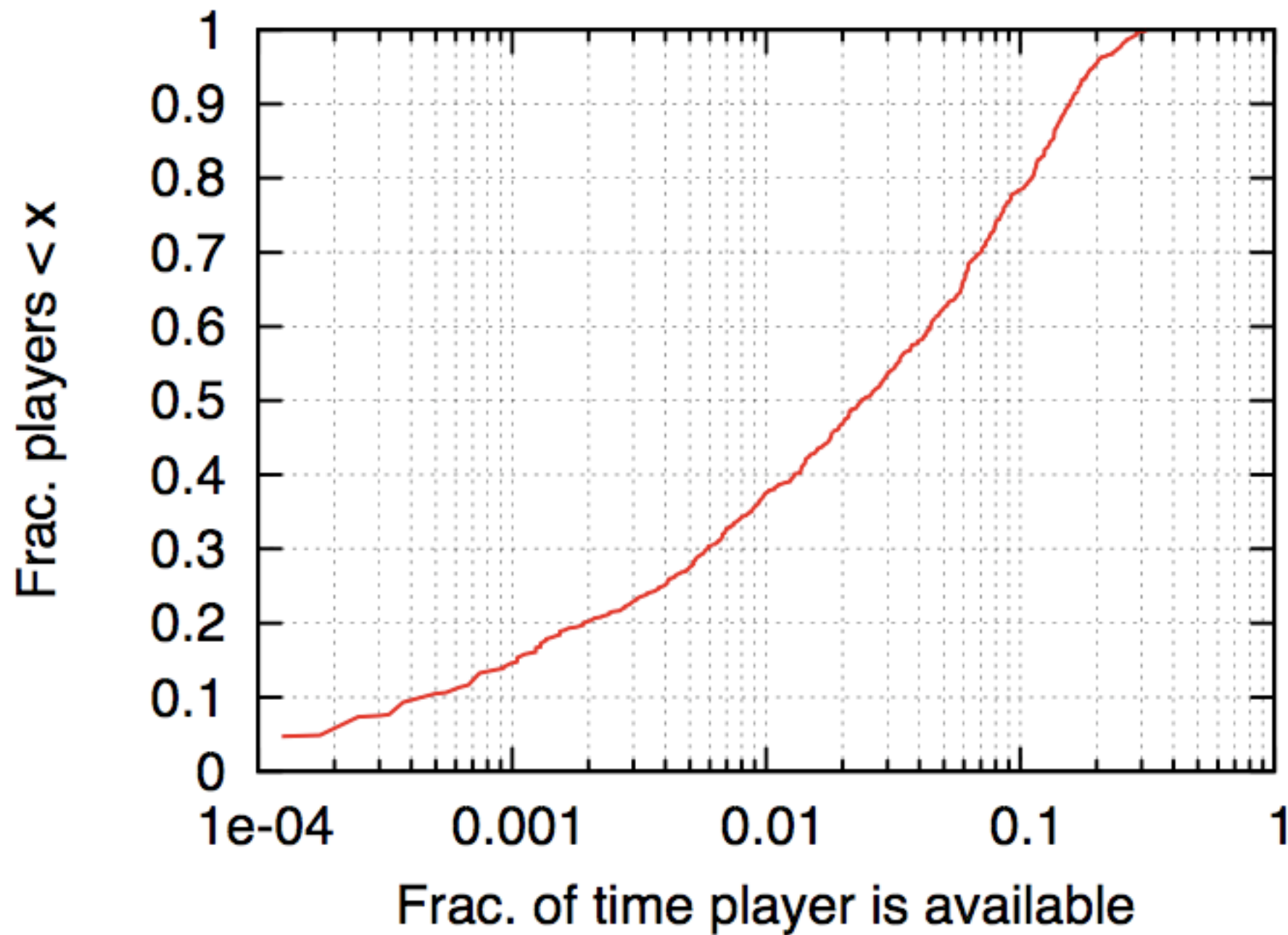
sufficiently long session length
good for P2P games



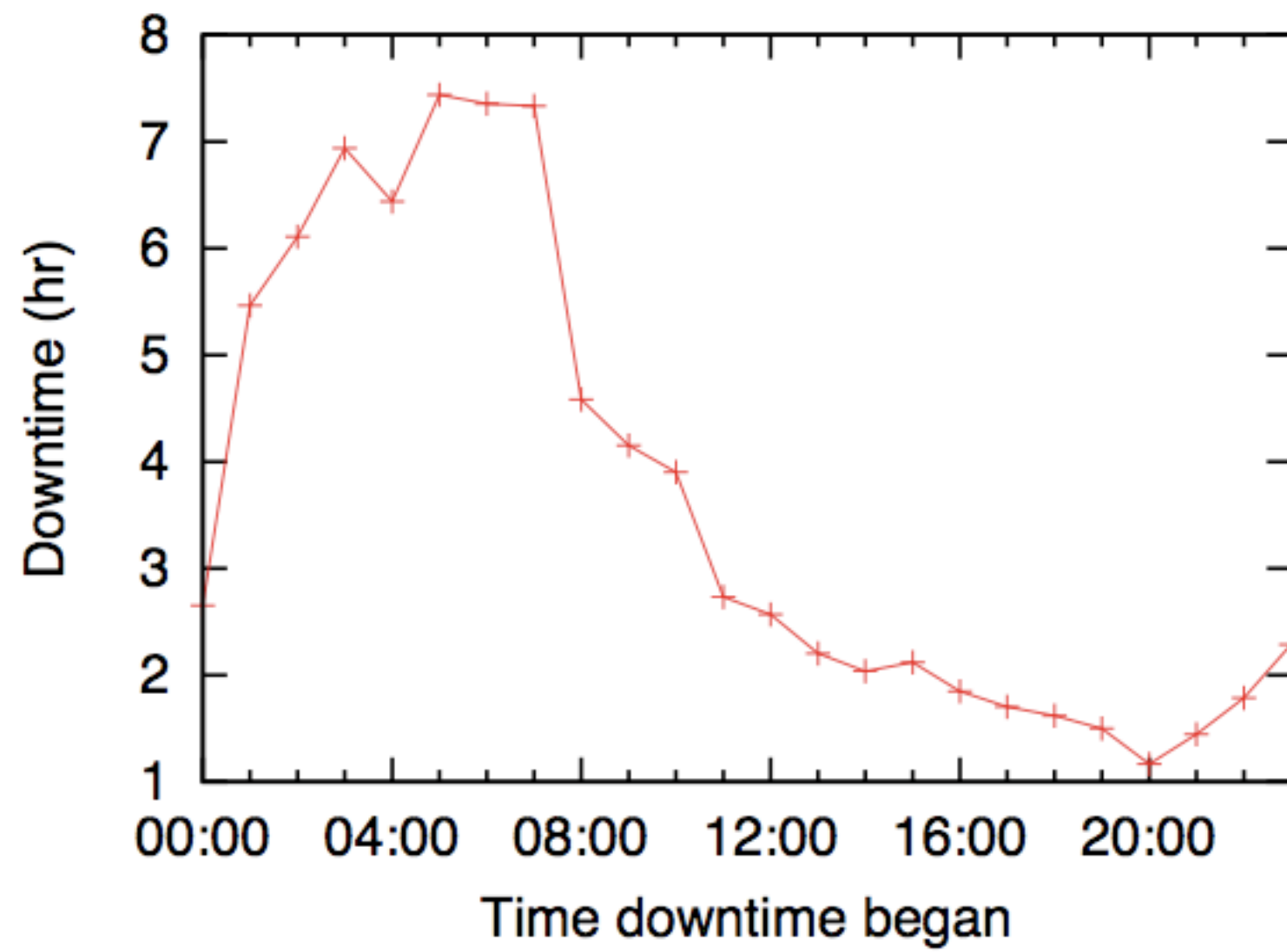
can use level to
predict session length?

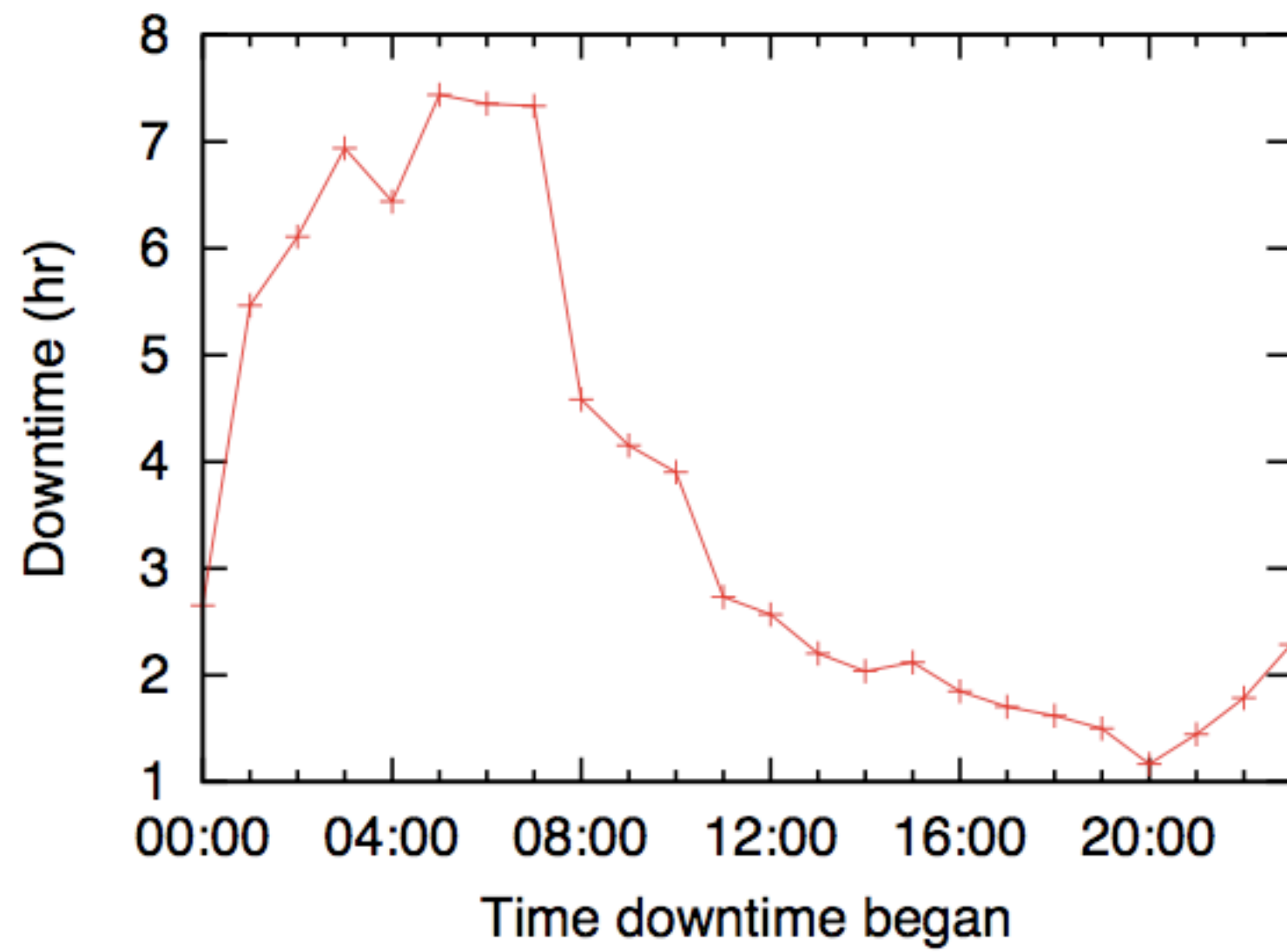


CDF of median downtimes and
median session length of each player



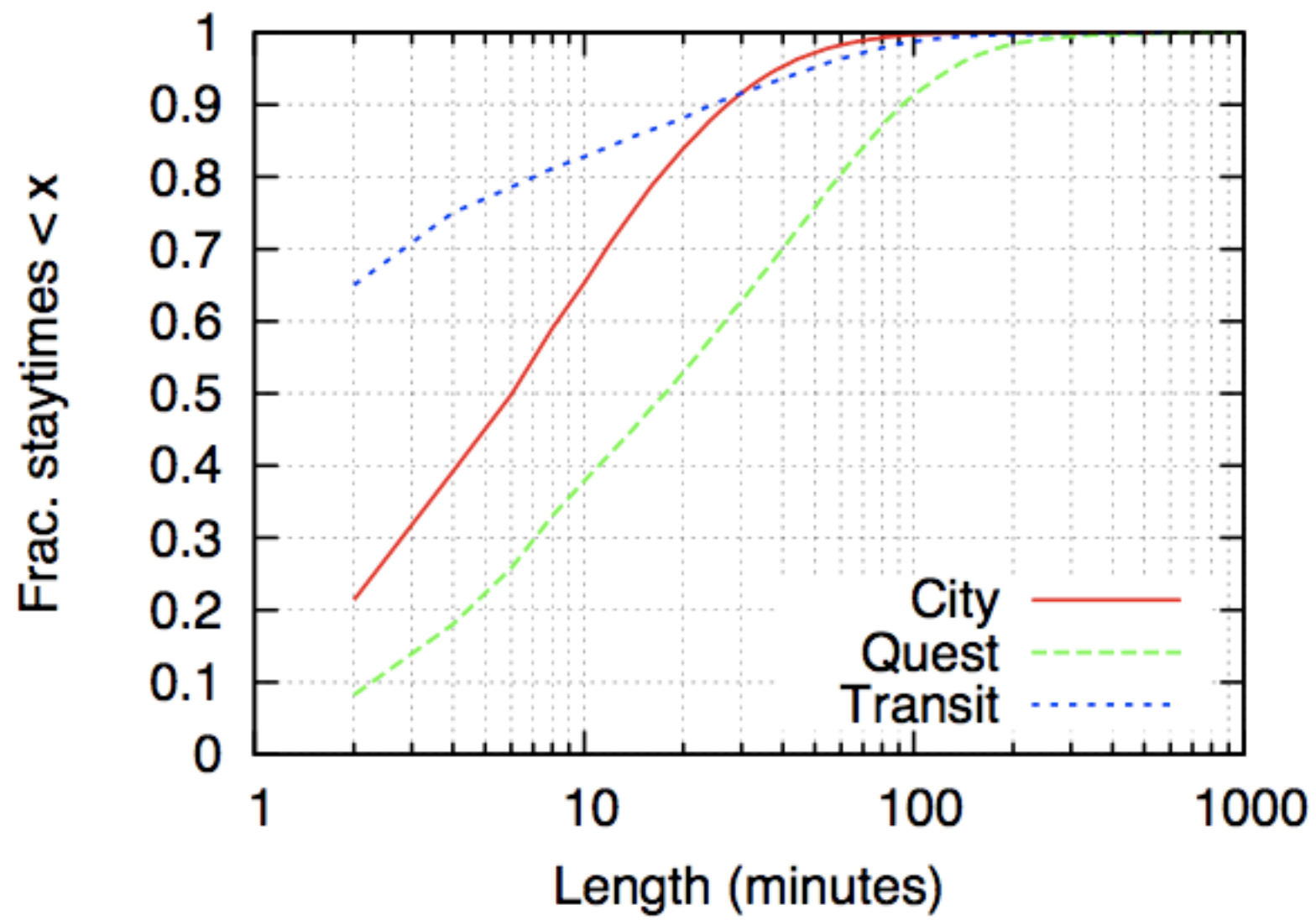
Availability of players (time online/total time)
in February 2007





monitor **3** locations

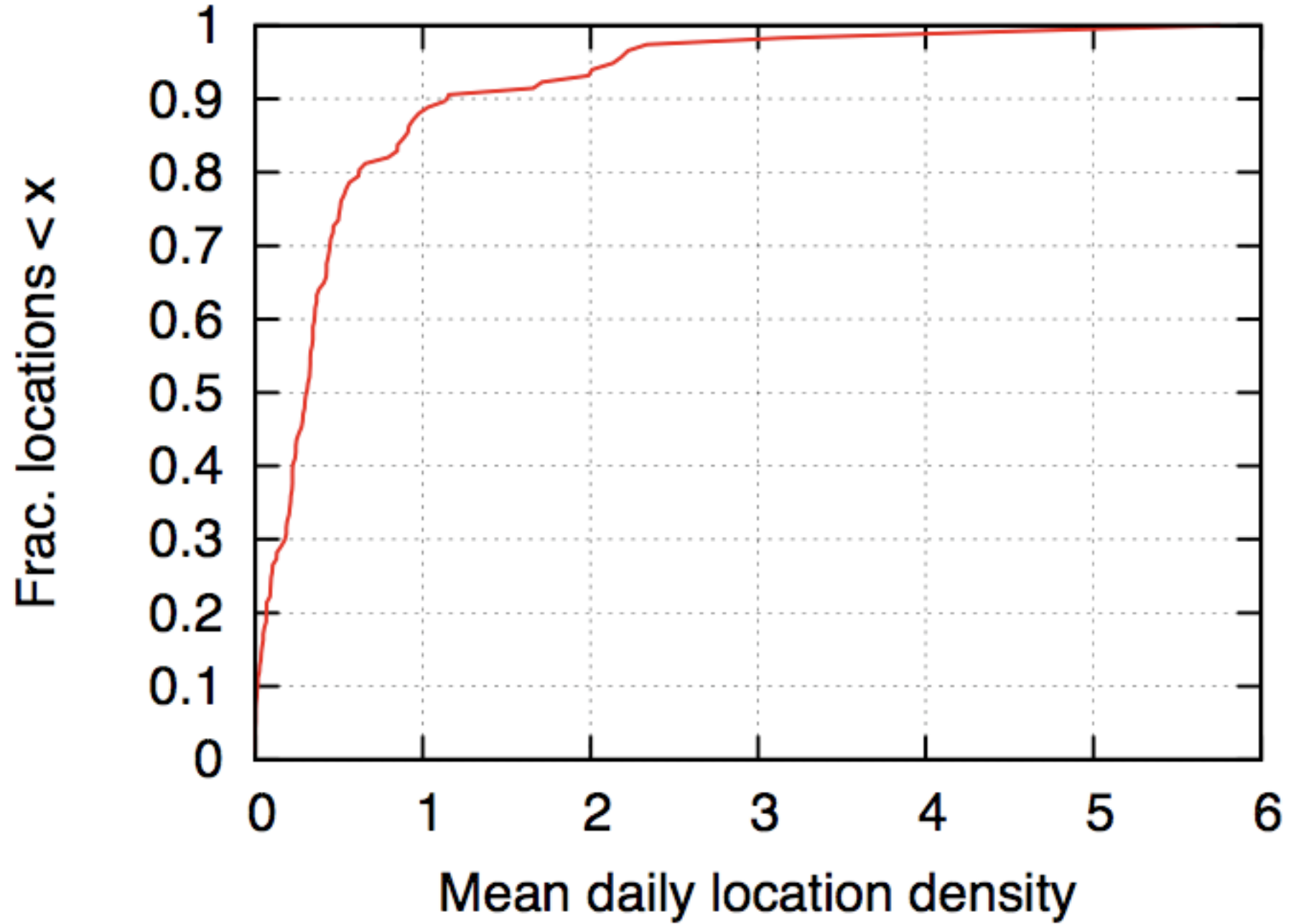
Stormwind City
Stanglehorn Vale
Burning Steppes



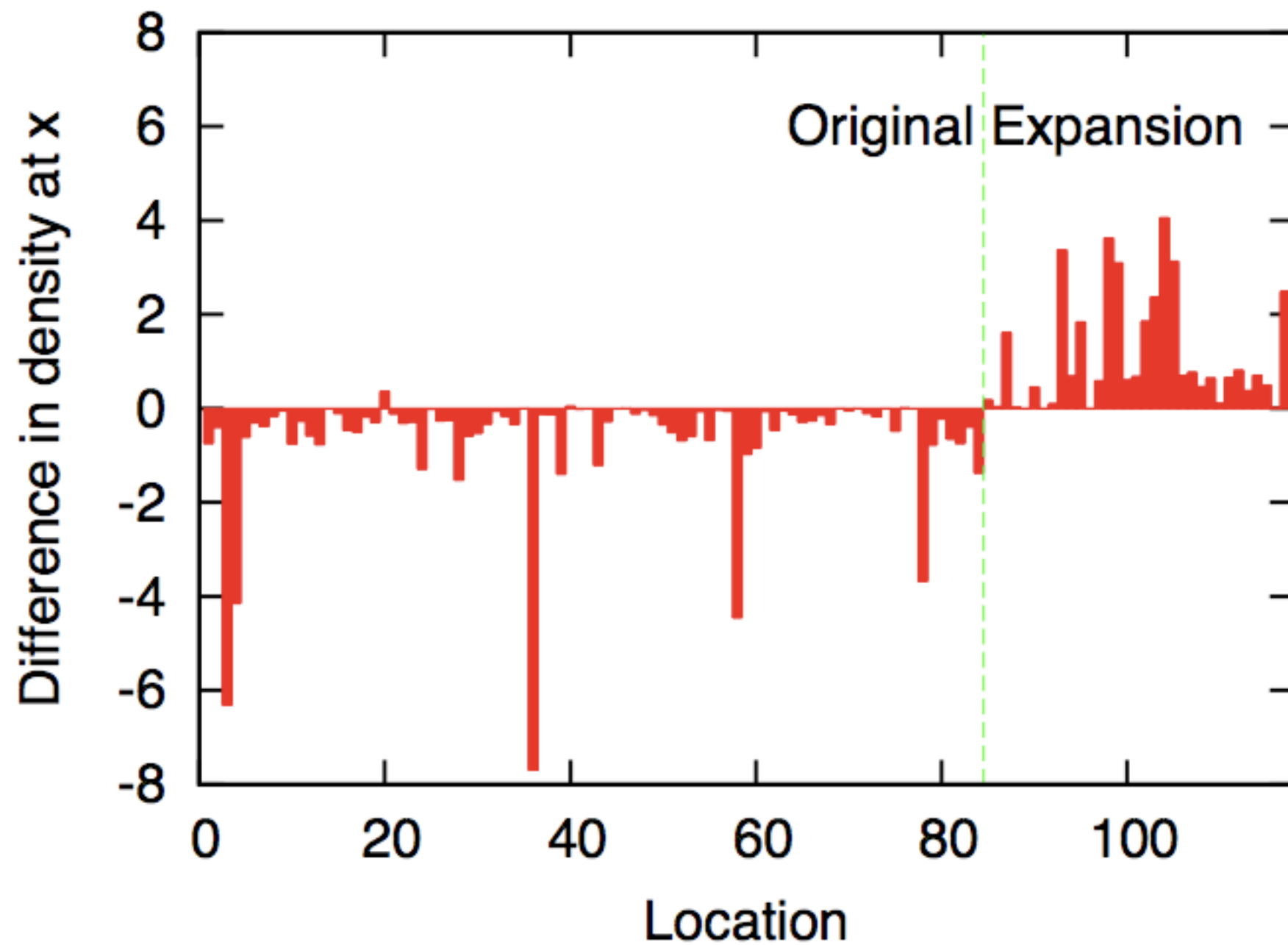
can use zone to
predict session length?

density: num of players* in a
zone

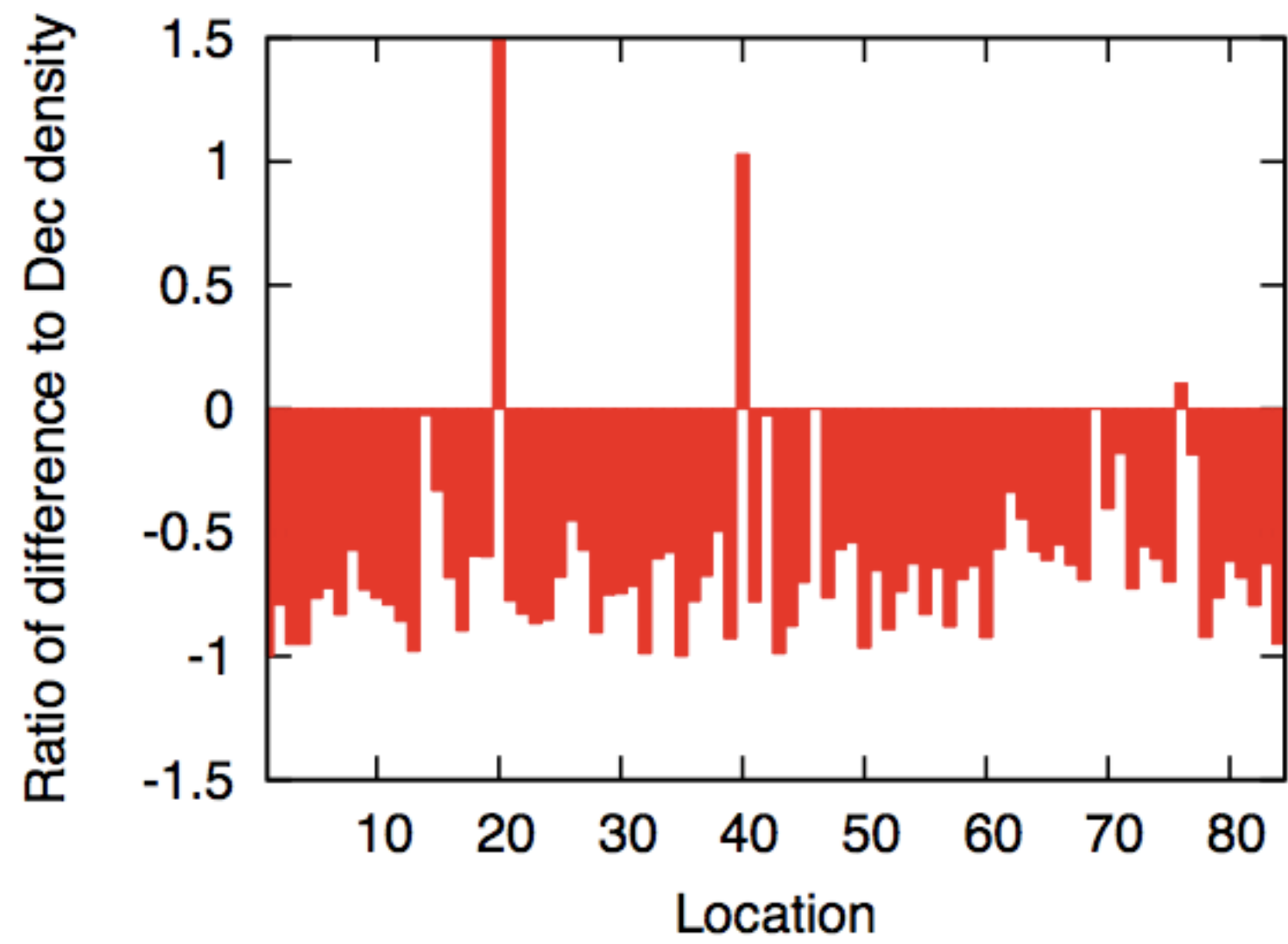
*: out of 1100 players tracked



Mean Location density of 117 locations



Difference in Density between Dec and Feb



**dynamic load balancing not
needed?**



“My life is so great that I literally wanted a second one!”
- *Dwight Schrute, The Office*



256x256 m regions.









avatar mobility:
who is where, when

why do we care?

research in systems
support for NVE

Dynamic Partitioning for a Distributed Virtual Environment - all 2 versions »

JCS Lui, MF Chan, KY Oldfield - Proc. of the 3rd High Performance Computing Asia Conference (..., 1998 - citeseer.ist.psu.edu

Dynamic **Partitioning** for a **Distributed Virtual Environment** (1998) (Make Corrections)

(7 citations) John CS Lui, MF Chan Oldfield KY So, TS Tam. ...

Cited by 29 - Related Articles - Cached - Web Search

An efficient partitioning algorithm for distributed virtual environment systems - all 2 versions »

MF Chan, JCS Lui - IEEE Transactions on Parallel and Distributed Systems, 2002 - csa.com

An efficient **partitioning** algorithm for **distributed virtual environment**

systems. MF Chan, John CS Lui IEEE Transactions on Parallel ...

Cited by 8 - Related Articles - Web Search

... Study of Modern Heuristics for Solving the Partitioning Problem in Distributed Virtual Environment ... - all 2 versions »

P Morillo, M Fernandez, JM Orduna - Proc. Int'l Conf. Computational Science and its Applications ..., 2003 - Springer

... widespread use of high performance graphic cards are making **Distributed Virtual****Environment** (DVE) systems ... One of these key issues is the **partitioning** problem. ...

Cited by 10 - Related Articles - Web Search - BL Direct

An ACS-based partitioning method for distributed virtual environment systems - all 10 versions »

P Morillo, M Fernandez, JM Orduna - Parallel and Distributed Processing Symposium, 2003. ..., 2003 - ieeexplore.ieee.org

Page 1. An ACS-Based **Partitioning** Method for **Distributed Virtual Environment**

Systems P. Morillo, M. Fernandez Instituto de Robotica ...

Cited by 8 - Related Articles - Web Search

... of evolutive algorithms for solving the partitioning problem in distributed virtual environment ... - all 2 versions »

P Morillo, JM Orduña, M Fernández - Parallel Computing, 2004 - Elsevier

... reserved. A comparison study of evolutive algorithms for solving the **partitioning**problem in **distributed virtual environment** systems. P ...

Cited by 5 - Related Articles - Web Search

[PDF] A Fine-Grain Method for Solving the Partitioning Problem in Distributed Virtual Environment Systems - all 4 versions »

P Morillo, JM Orduna, M Fernandez, J Duato - Proc. of 16th. Intl. Conf. on Parallel and Distributed ... - informatica.uv.es

... ABSTRACT **Distributed Virtual Environment** (DVE) systems have ex- perience a spectaculargrowth last years. The **partitioning** problem has been proven as the most ...

Cited by 4 - Related Articles - View as HTML - Web Search

[CITATION] An efficient partitioning algorithm for distributed virtual environment systems Parallel and ...

JCS Lui, MF Chan - IEEE Transactions on, 2002

How to **partition** a world into regions
and **assign** regions to servers considering

- communication cost
- hand-over rate
- balancing server load
- :


[Web](#) [Images](#) [Video](#) [News](#) [Maps](#) [more »](#)

allintitle: prefetching "virtual environments"

Search

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Results 1 - 5 of 5 for allintitle: prefetching "virtual environments". (0.04 seconds)

Tip: Try removing quotes from your search to get more results.**On caching and prefetching of virtual objects in distributed virtual environments - all 2 versions »**JHP Chim, M Green, RWH Lau, HV Leong, A Si - [Proceedings of the sixth ACM international conference on ...](#), 1998 - [portal.acm.org](#)

... On Caching and Prefetching of Virtual Objects in Distributed Virtual Environments

Jimmy HP Chimi hk Green: Rynson WH Lau* Hong Va Leongt Antonio Si!

[Cited by 51](#) - [Related Articles](#) - [Web Search](#)**... data management using user-based caching and prefetching in distributed virtual environments - all 9 versions »**S Park, D Lee, M Lim, C Yu - [Proceedings of the ACM symposium on Virtual reality software ...](#), 2001 - [portal.acm.org](#)

Page 1. Scalable Data Management Using User-Based Caching and Prefetching in

Distributed Virtual Environments Sungju Park Dongman Lee Mingyu Lim Chansu Yu ...

[Cited by 10](#) - [Related Articles](#) - [Web Search](#)**A hybrid motion prediction method for caching and prefetching in distributed virtual environments - all 3 versions »**A Chan, RWH Lau, B Ng - [Proceedings of the ACM symposium on Virtual reality software ...](#), 2001 - [portal.acm.org](#)

... Prefetching in Distributed Virtual Environments Addison Chan addi@cs.cityu.edu.hk

Rynson WH Lau rynson@cs.cityu.edu.hk Beatrice Ng beatrice@cs.cityu.edu.hk ...

[Cited by 8](#) - [Related Articles](#) - [Web Search](#)**[CITATION] ... Leong, and A. Si, "On Caching and Prefetching of Virtual Objects in Distributed Virtual Environments, ...**JH Chim, M Green, RW Lau - [Proceedings of ACM Multimedia](#), 1998[Cited by 1](#) - [Related Articles](#) - [Web Search](#)**Prediction-based Prefetching for Remote Rendering Streaming in Mobile Virtual Environments - all 2 versions »**S Lazem, M Elteir, A Abdel-Hamid, D Gracanin - [Signal Processing and Information Technology, 2007 IEEE ...](#), 2007 - [ieeexplore.ieee.org](#)

... Prediction-based Prefetching for Remote Rendering Streaming in Mobile Virtual

Environments Shaimaa Lazeml Marwa Elteirl Ayman Abdel-Hamid2,3 Denis Gracanin' ...

[Related Articles](#) - [Web Search](#)Key authors: [J Chim](#) - [R Lau](#) - [M Green](#) - [H Leong](#) - [A Si](#)

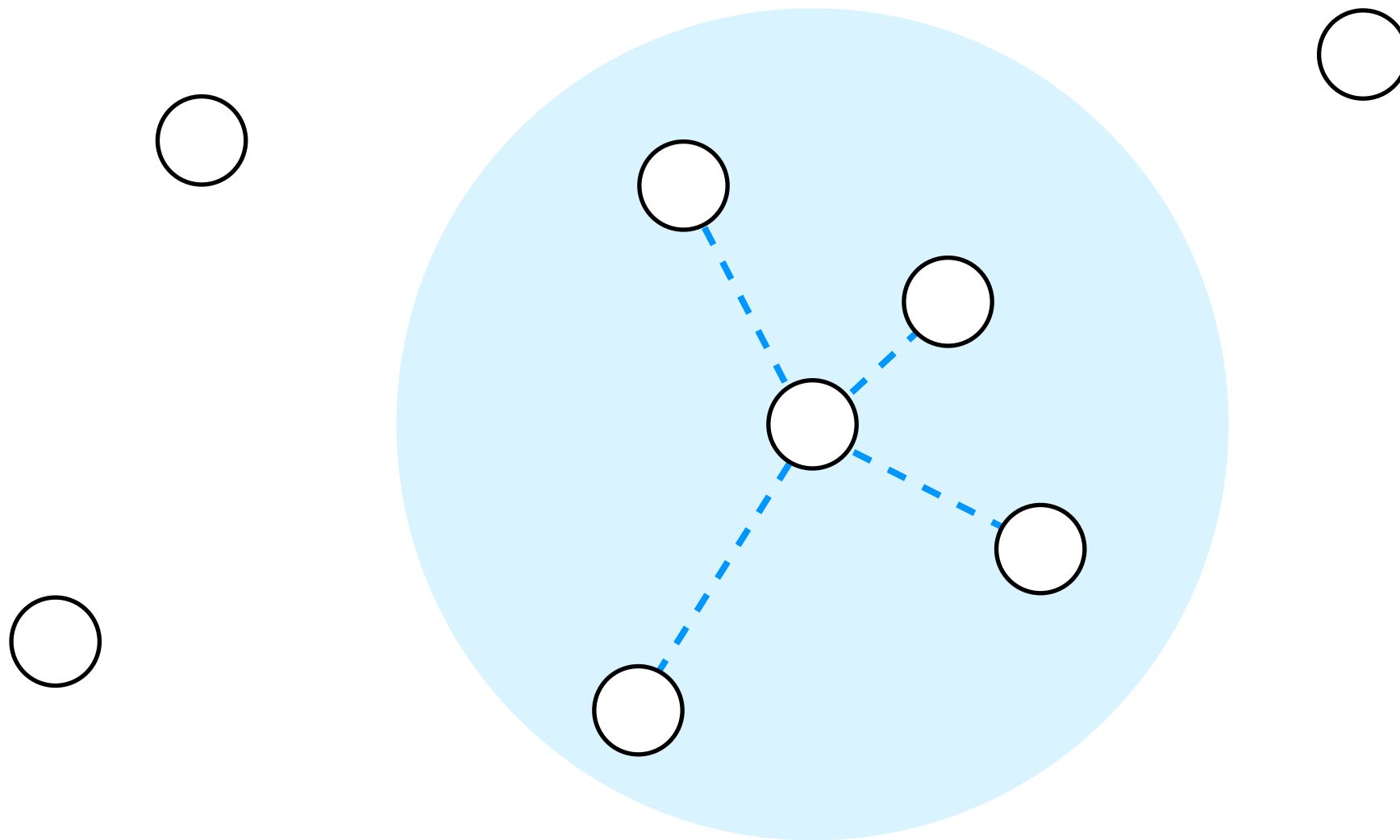
How to **predict** avatar movement (end therefore what a user will see next)?

**A Peer-to-Peer Message Exchange Scheme for Large-Scale Networked Virtual Environments** - all 10 versions »Y Kawahara, T Aoyama, H Morikawa - *Telecommunication Systems*, 2004 - Springer... [7] Y. Kawahara, H. Morikawa and T. Aoyama, A **peer-to-peer** message exchange scheme for large scale networked **virtual environments**, in: Proc. ...Cited by 39 - [Related Articles](#) - [Web Search](#) - [BL Direct](#)**VON: a scalable peer-to-peer network for virtual environments** - all 2 versions »SY Hu, JF Chen, TH Chen - *Network*, IEEE, 2006 - [ieeexplore.ieee.org](#)VON: a scalable **peer-to-peer** network for **virtual environments** Shun-Yun Hu Jui-Fa Chen Tsu-Han Chen Inst. of Phys., Acad. Sinica, Taipei, Taiwan; ...Cited by 25 - [Related Articles](#) - [Web Search](#) - [BL Direct](#)... **Mechanisms for Closely Coupled Collaboration in Multithreaded Peer-to-Peer Virtual Environments** - all 6 versions »JM Linebarger, GD Kessler - *Presence: Teleoperators & Virtual Environments*, 2004 - MIT Press... Designed for **peer-to-peer virtual environments** in which several threads have access to the shared scene graph, these algorithms are straightforward and ...Cited by 12 - [Related Articles](#) - [Web Search](#) - [BL Direct](#)**Supporting scalable peer to peer virtual environments using frontier sets** - all 6 versions »A Steed, C Angus - *Proceedings of IEEE Virtual Reality 2005*, 2005 - [doi.ieeecomputersociety.org](#)Page 1. Supporting Scalable **Peer to Peer Virtual Environments** using Frontier

Sets Anthony Steed 1 , Cameron Angus 2 Department of ...

Cited by 9 - [Related Articles](#) - [Web Search](#)**Providing full awareness to distributed virtual environments based on peer-to-peer architectures**P Morillo, W Moncho, JM Orduna, J Duato - *Lecture Notes on Computer Science*, 2006 - Springer... **Environments Based on Peer-to-Peer Architectures** ★ ... Supporting scalable **peer to peer virtual environments** using frontier sets. In *IEEE Virtual Reality-2005*. ...Cited by 6 - [Related Articles](#) - [Web Search](#) - [BL Direct](#)**[CITATION] VON: a scalable peer-to-peer network for virtual environments. Network**SY Hu, JF Chen, TH Chen - *IEEE*, 2006Cited by 4 - [Related Articles](#) - [Web Search](#)**A Hybrid Solution to Support Multiuser 3D Virtual Simulation Environments in Peer-to-Peer Networks** - all 4 versions »A Boukerche, RB Araujo, M Laffranchi - *Proceedings of Distributed Simulation and Real-Time ...*, 2004 - [doi.ieeecomputersociety.org](#)... the issues involved in the implementation of 3D MUEs in hybrid **peer-to-peer** networks, and ... of multi-user 3D games and multi-user **virtual environments** in general ...

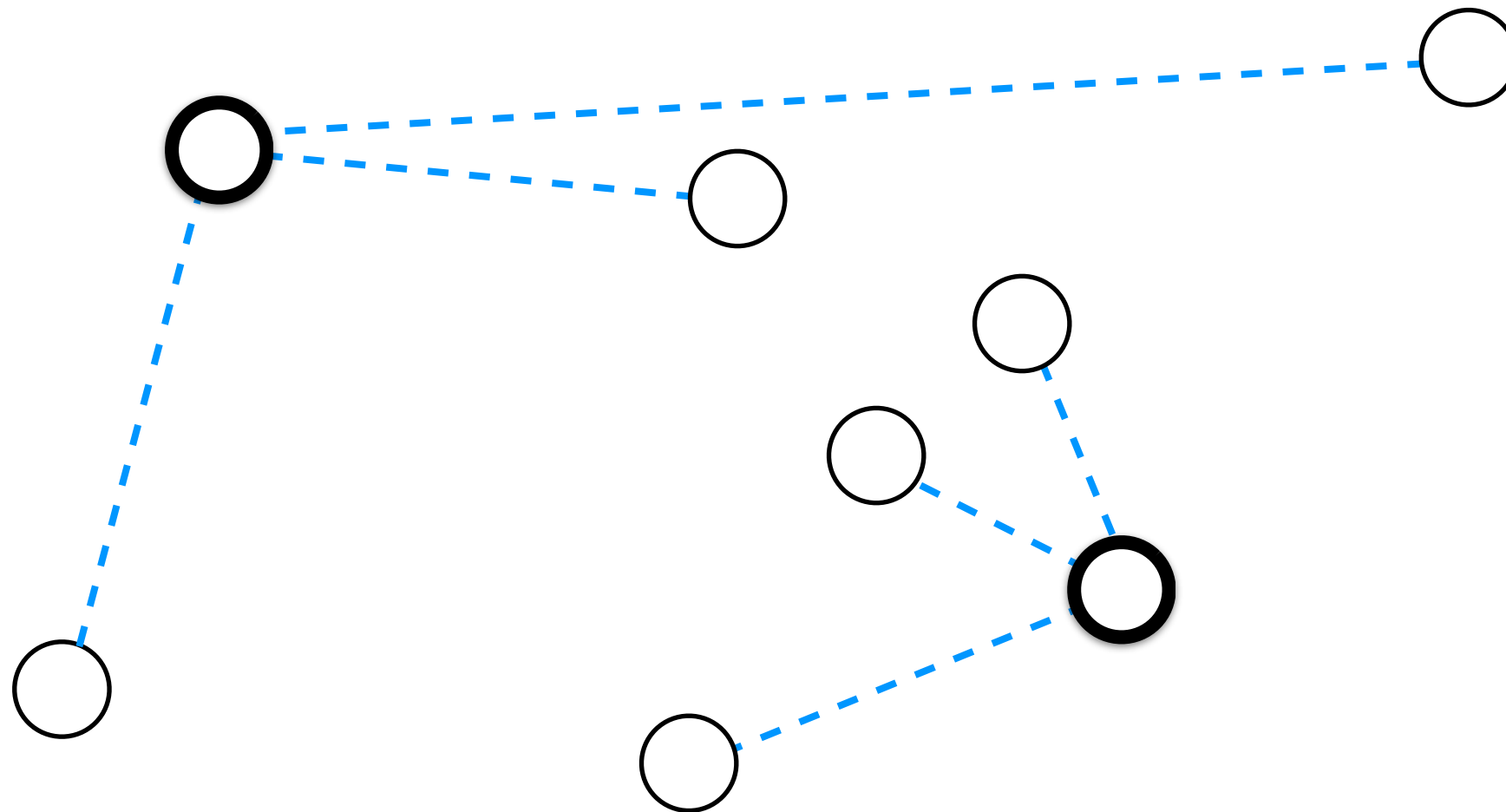
Aol-based scheme



How many connections?

How stable are the connections?

supernode-based scheme



How to pick supernodes?

How stable are the supernodes?

how to simulate
avatar mobility?

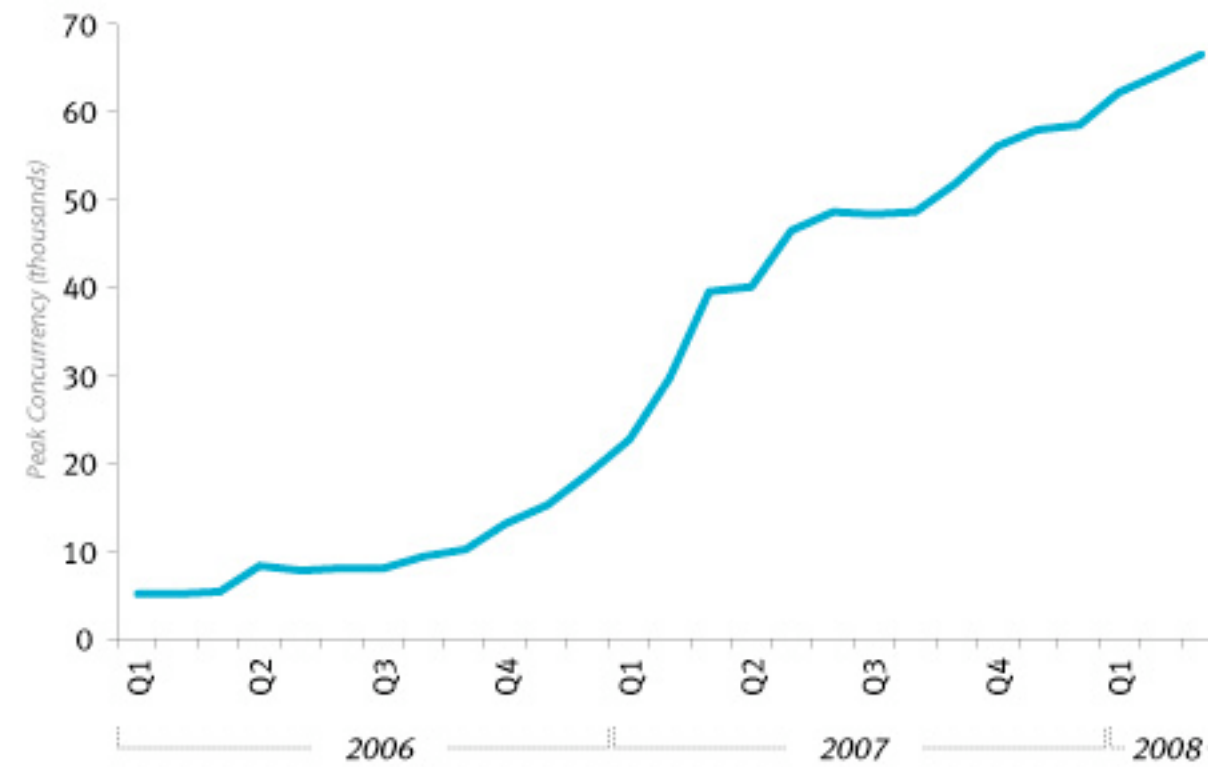
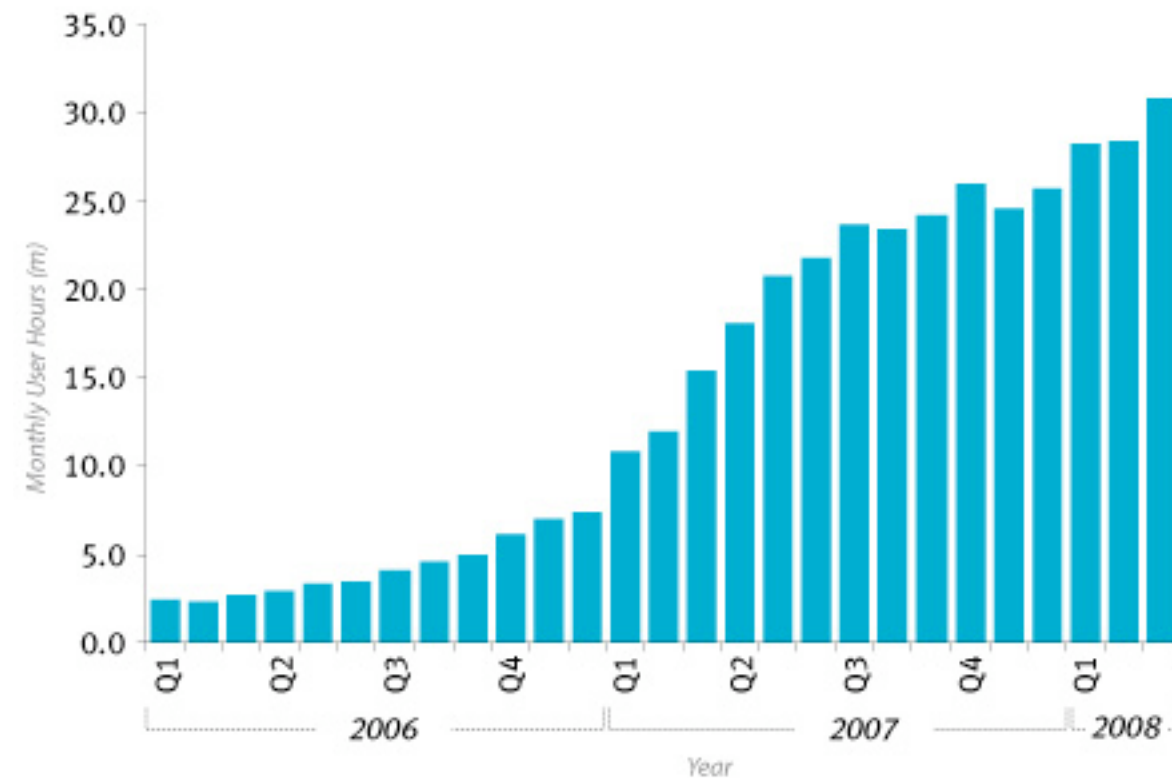
random walk
random waypoint
clustered movement
:

or,
small-scale
implementation

no large-scale NVE
available until recently

482,594

residents logged in between 2-9 June 2008



secondlife.com/whatis/economy-graphs.php

- collect mobility traces of avatars in Second Life
- what it means w.r.t. systems design for NVEs?

collecting traces

how do avatars move
inside a distributed
virtual environment?

how are avatars
distributed within a
region?

how long do they stay
at a location?

do they move in
groups?

etc.

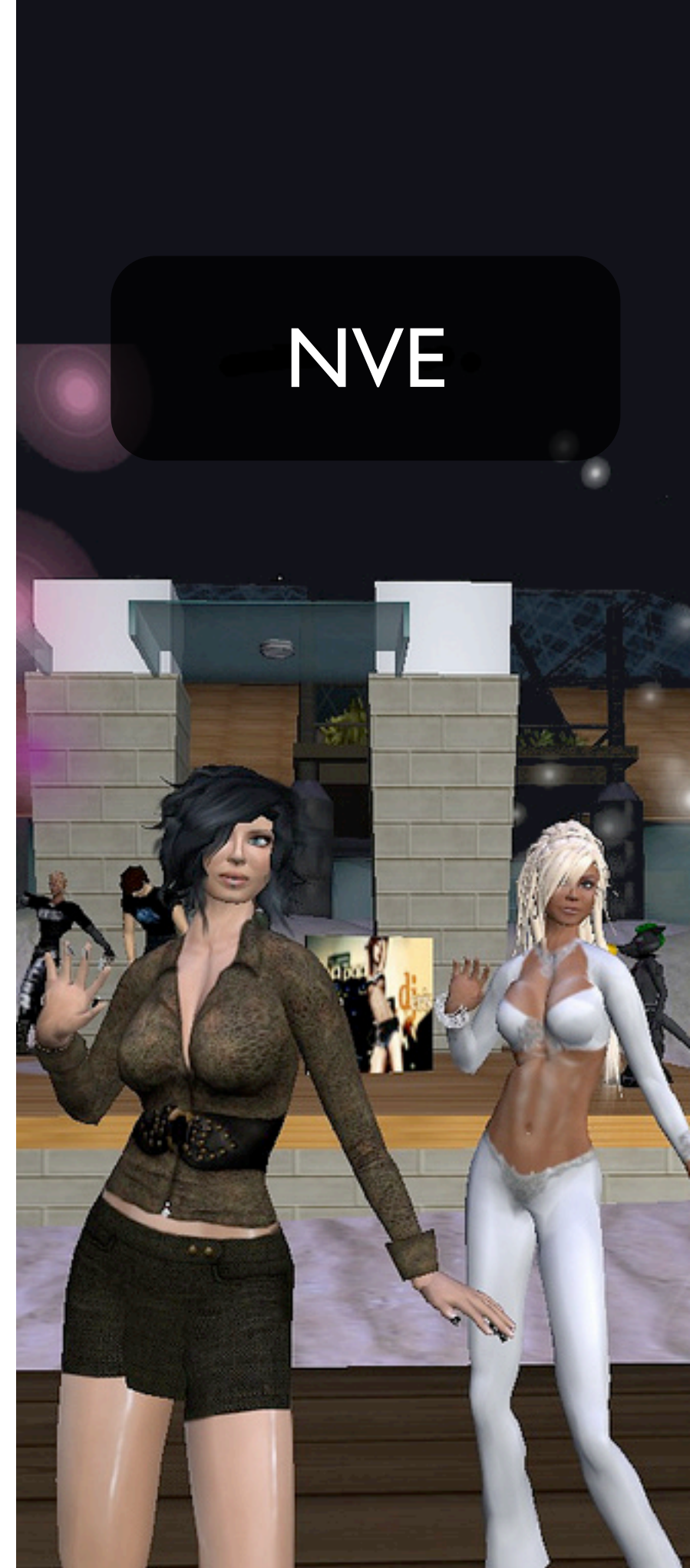
FPS

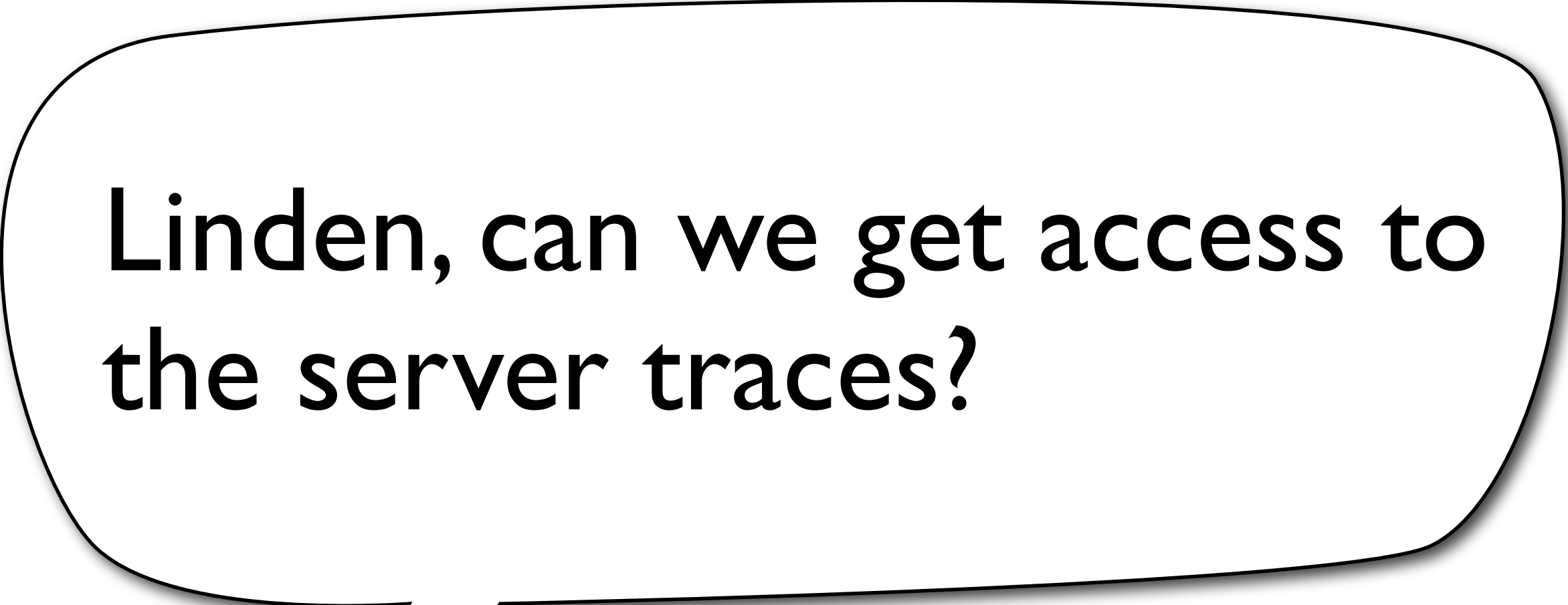


MMORPG



NVE





**Linden, can we get access to
the server traces?**



No.

- Wrote our own client
- Parses packets using *libsecondlife*
- Insert bots into regions
- Log positions of avatars every 10s

difficulties

running out of memory

anti-bots policy

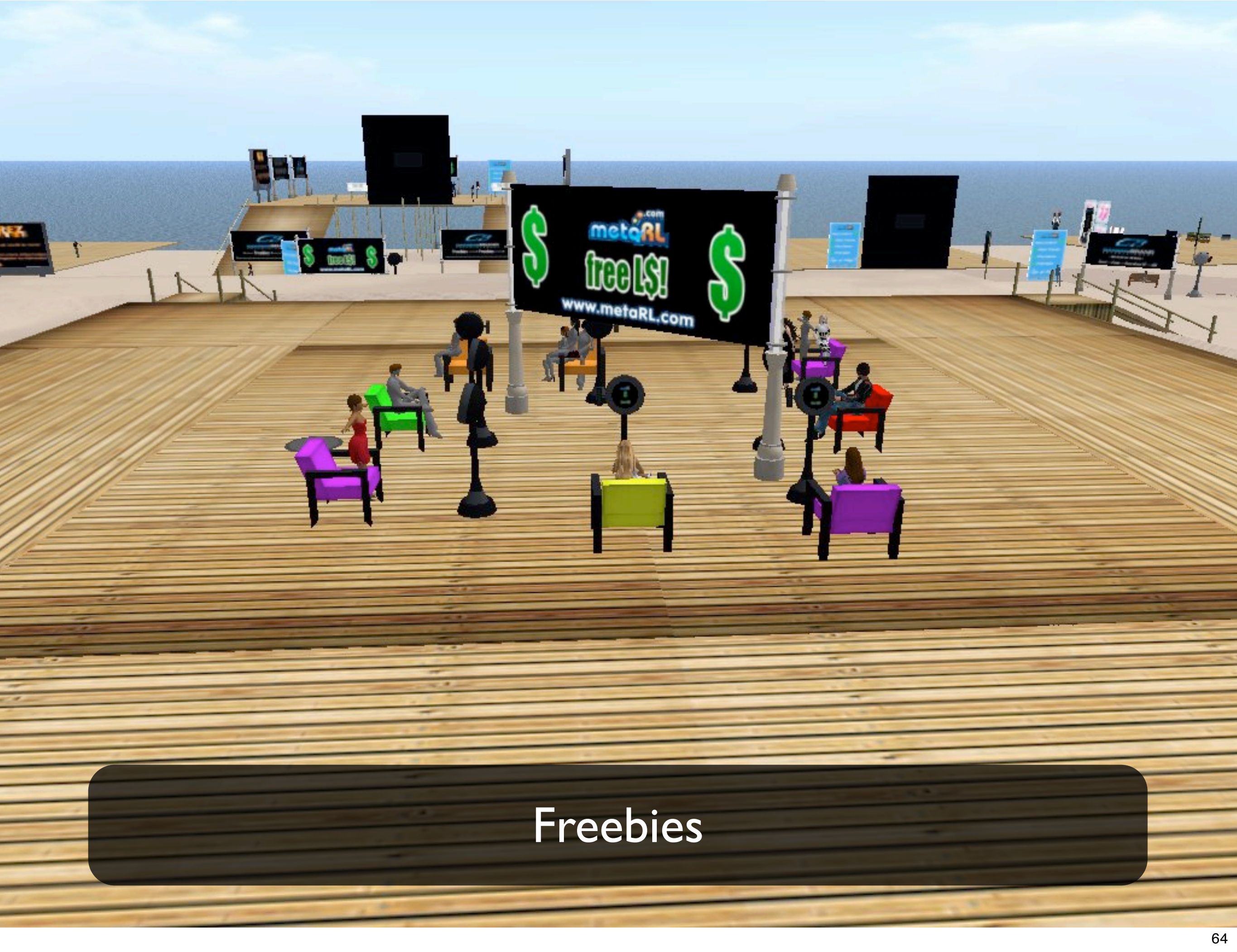
over crowded region

inter-region tracking

- Wrote our own client
- Parses packets using *libsecondlife*
- Insert bots into regions
- Log positions of avatars every 10s

who is
where,
when
(doing what)





Freebies



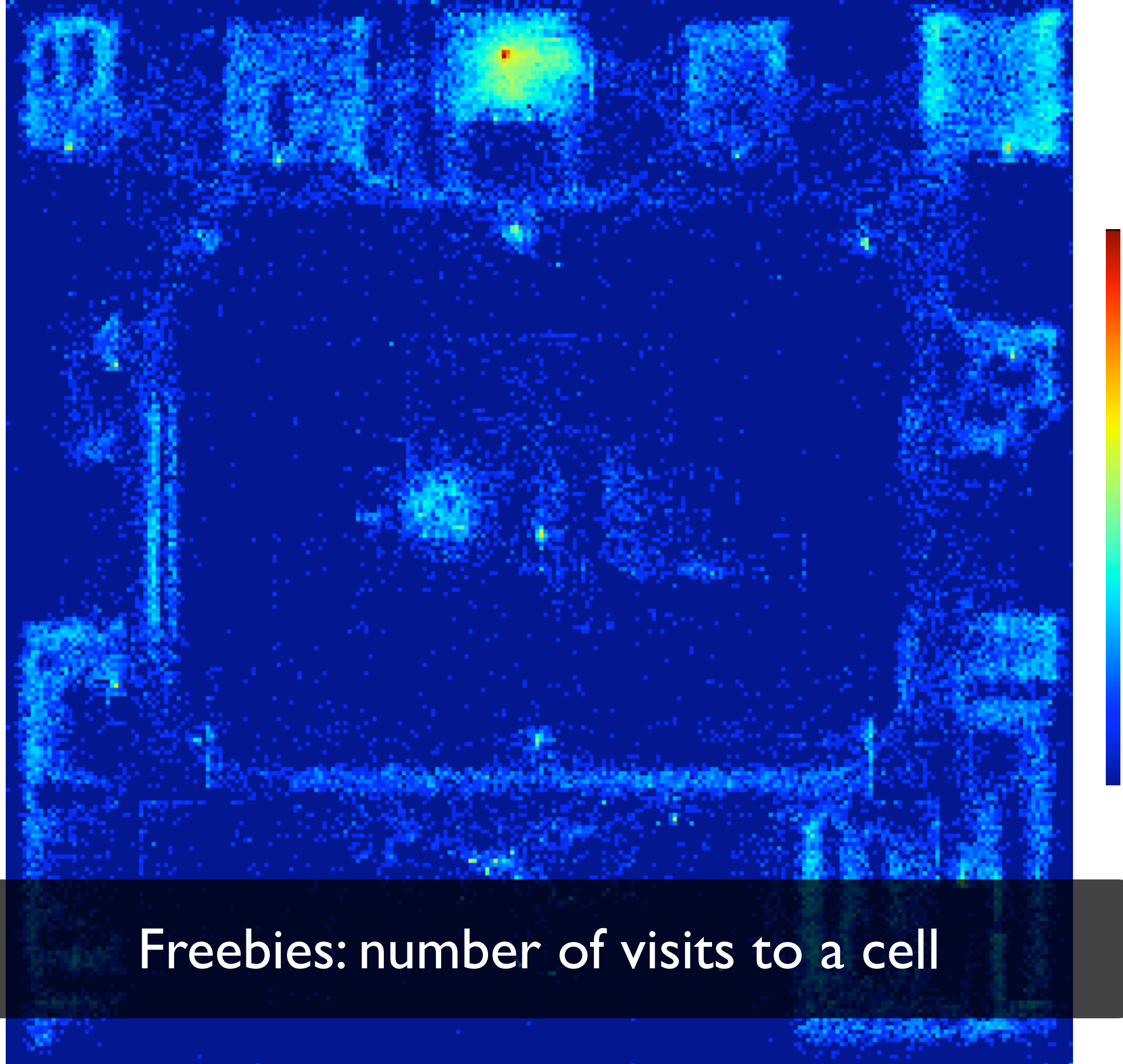
The Pharm

Isis

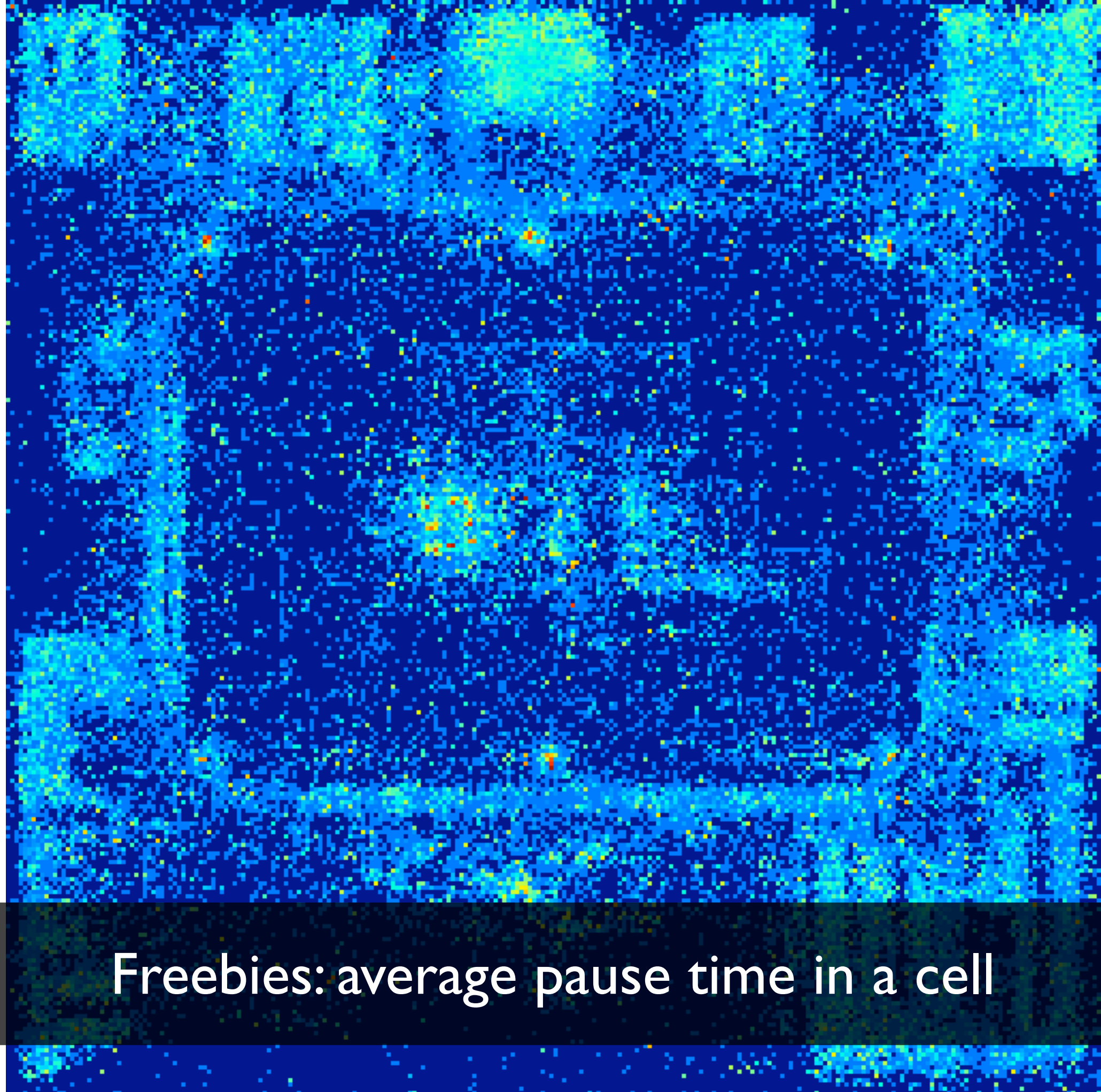


Ross

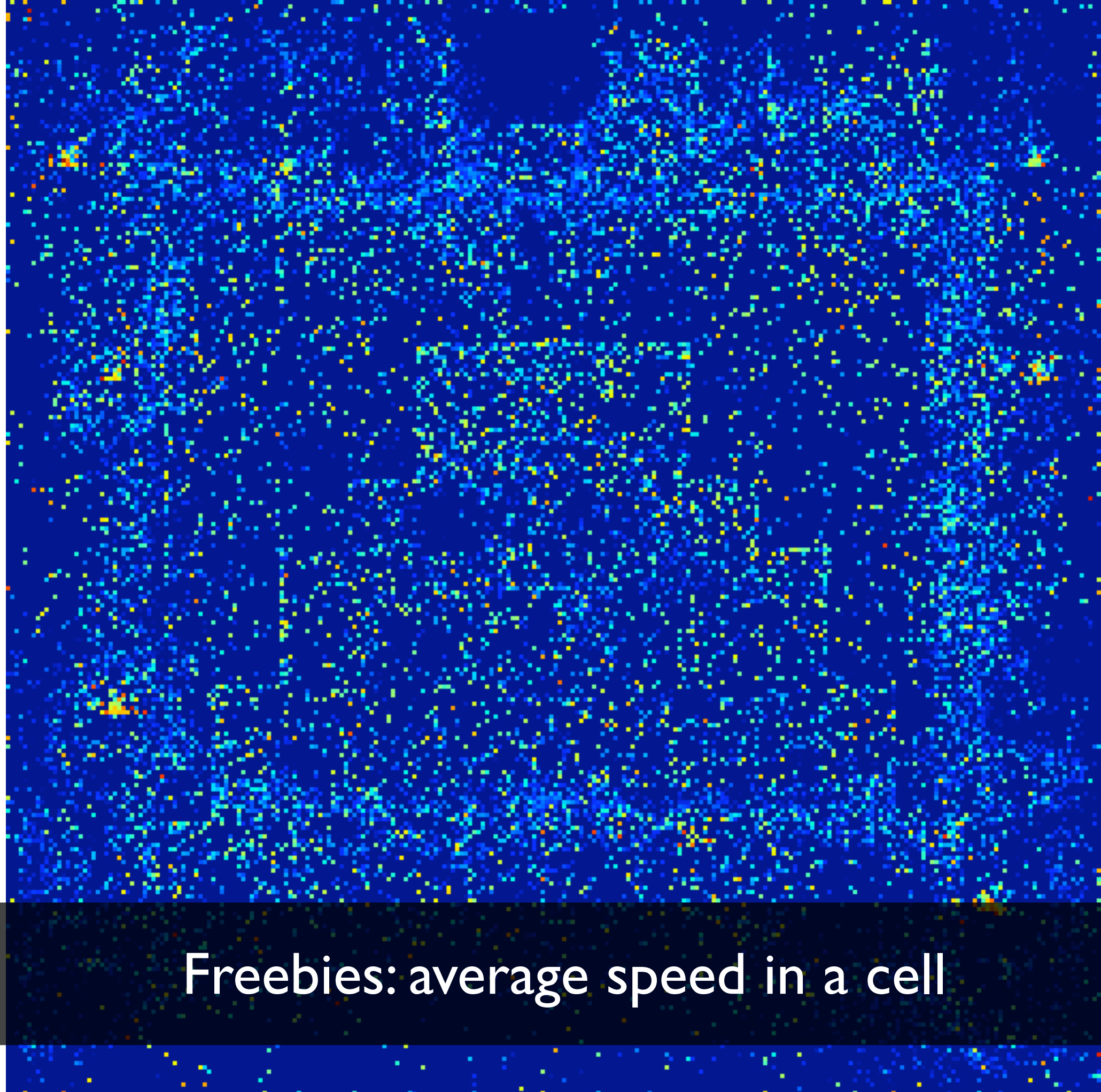
Mobility Patterns



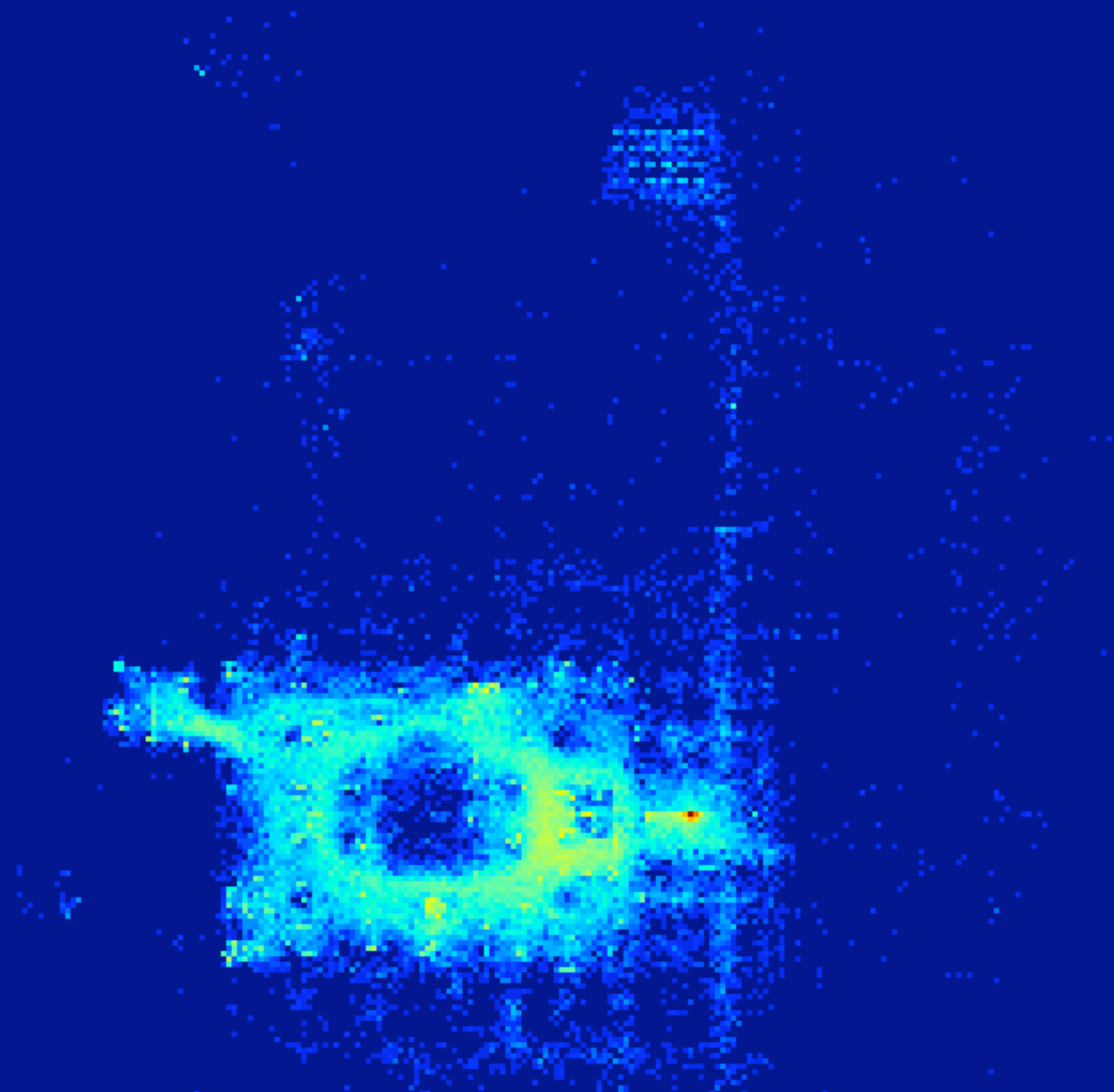
Freebies: number of visits to a cell



Freebies: average pause time in a cell

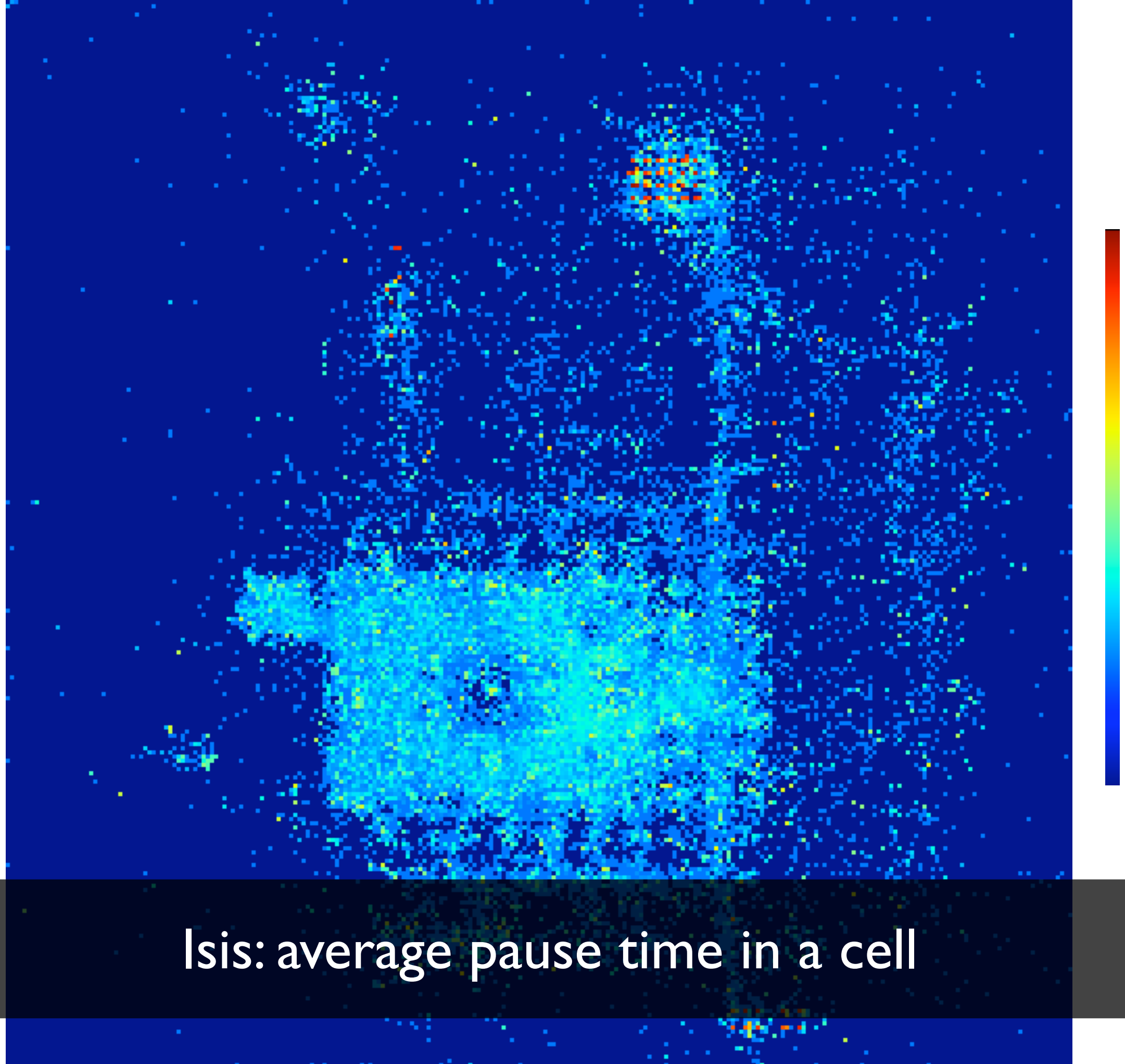


Freebies: average speed in a cell



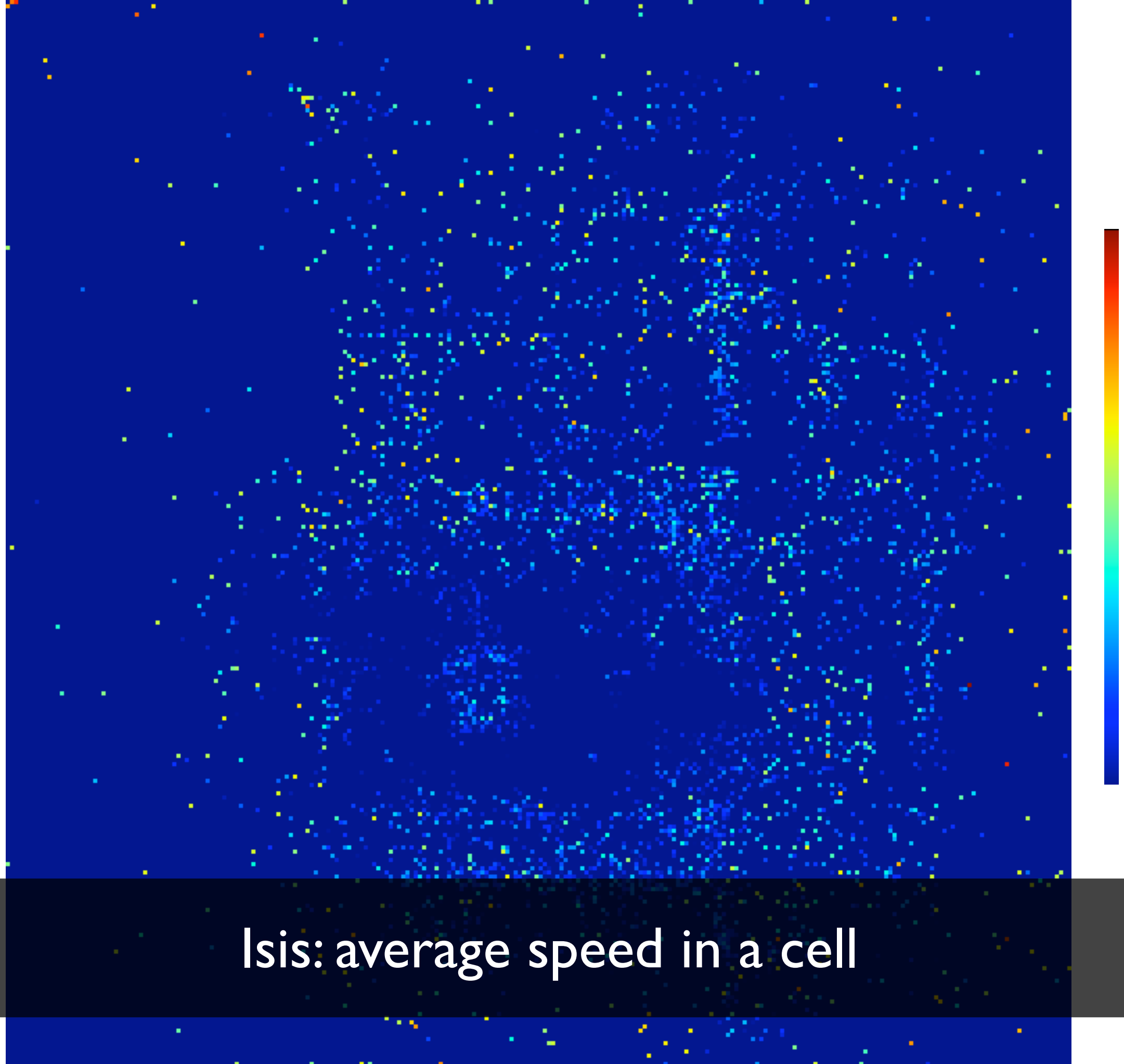
Isis: number of visits to a cell

caching/prefetching
based on popularity of
locations?



Isis: average pause time in a cell

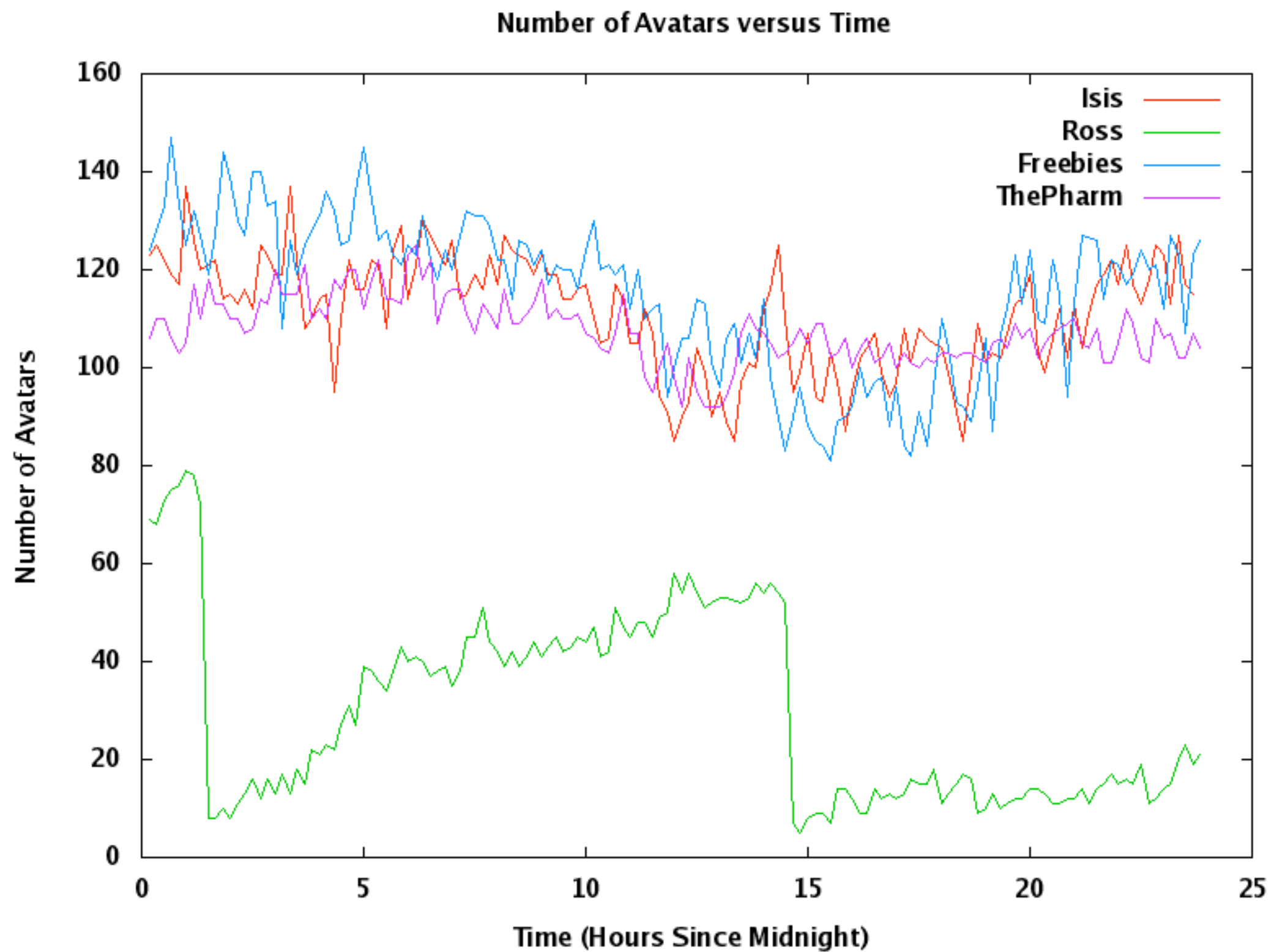
pick supernodes from
sticky location?

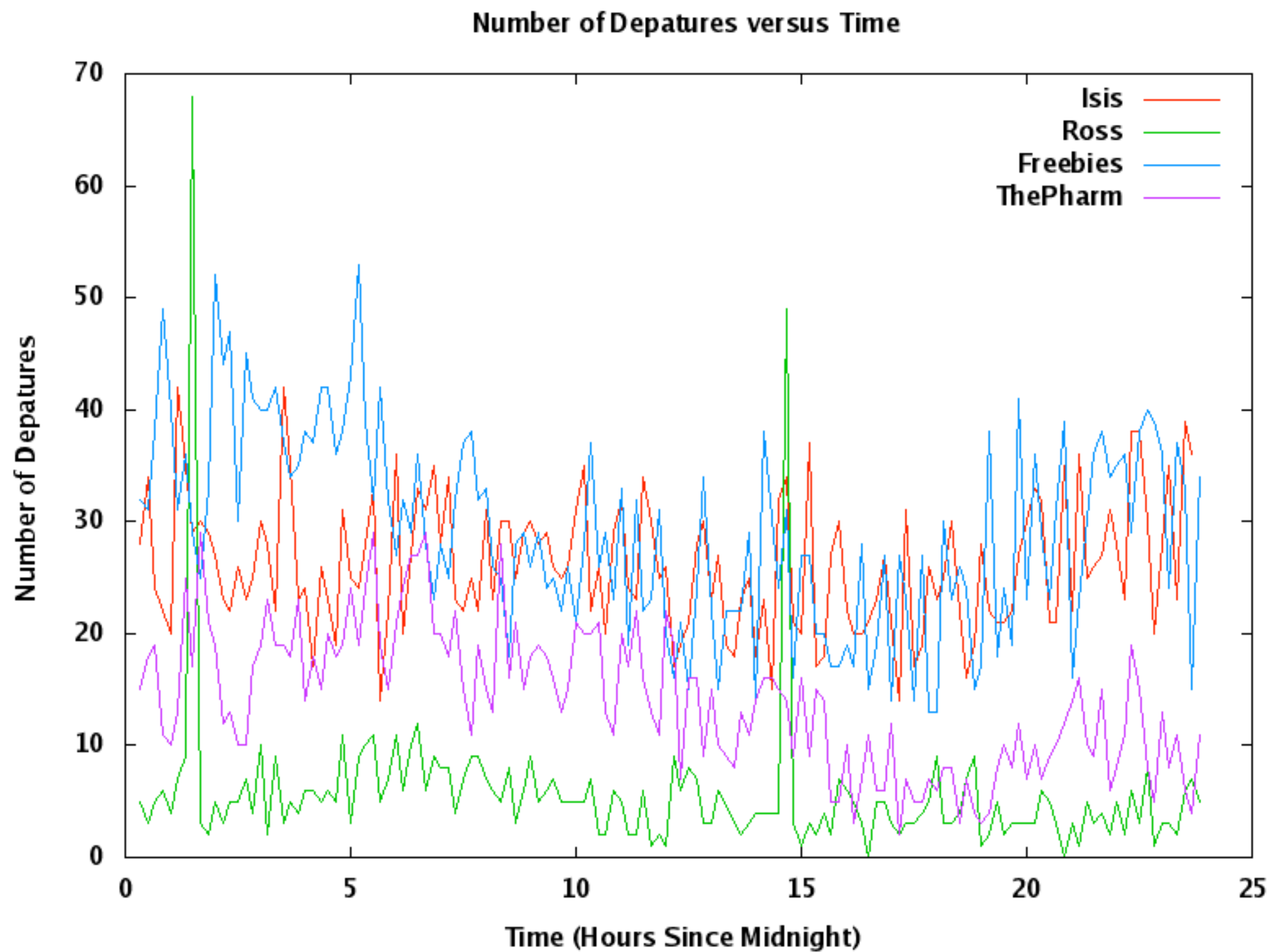


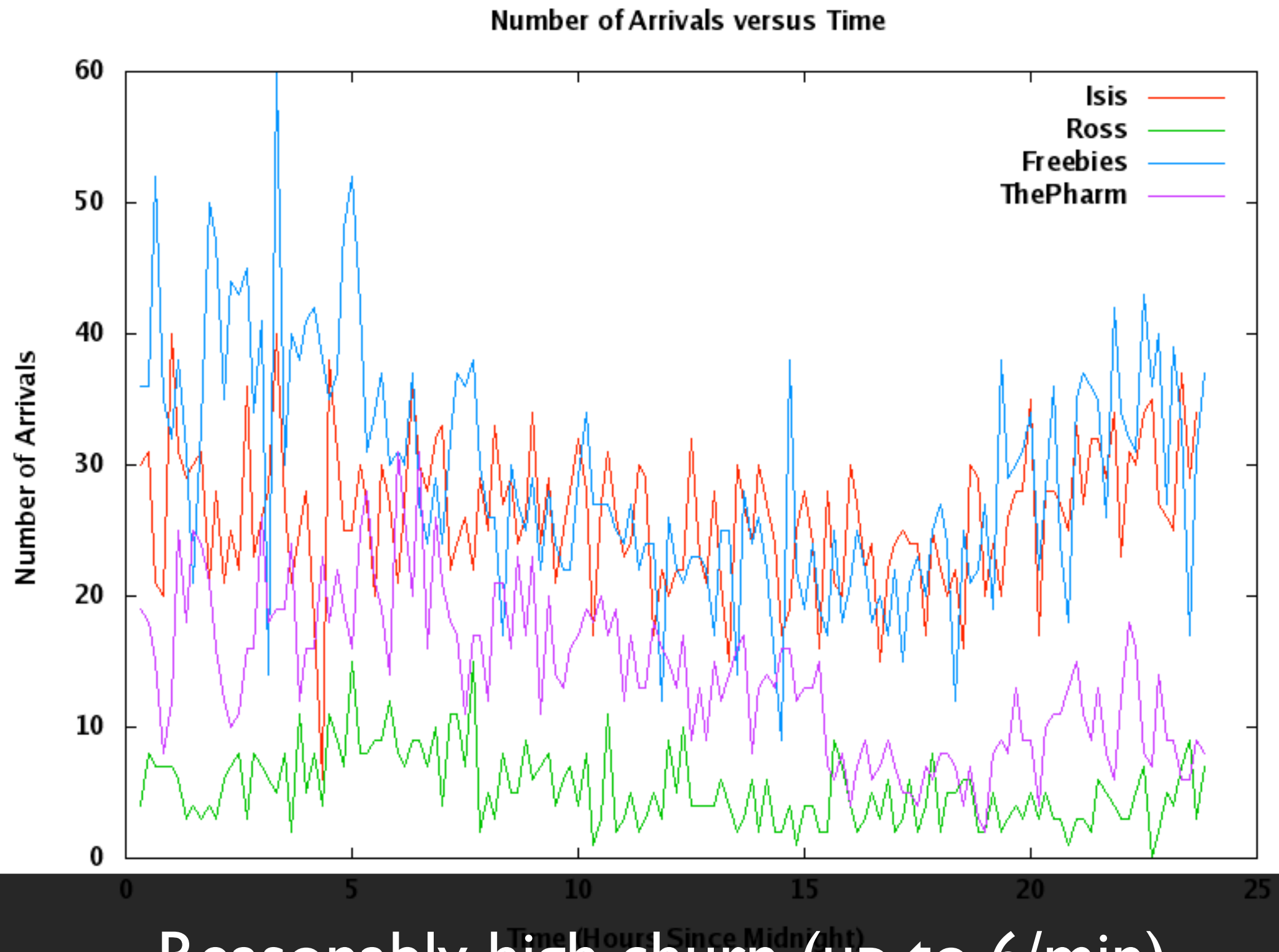
Isis: average speed in a cell

mobility model:
random walk +
pathway ?

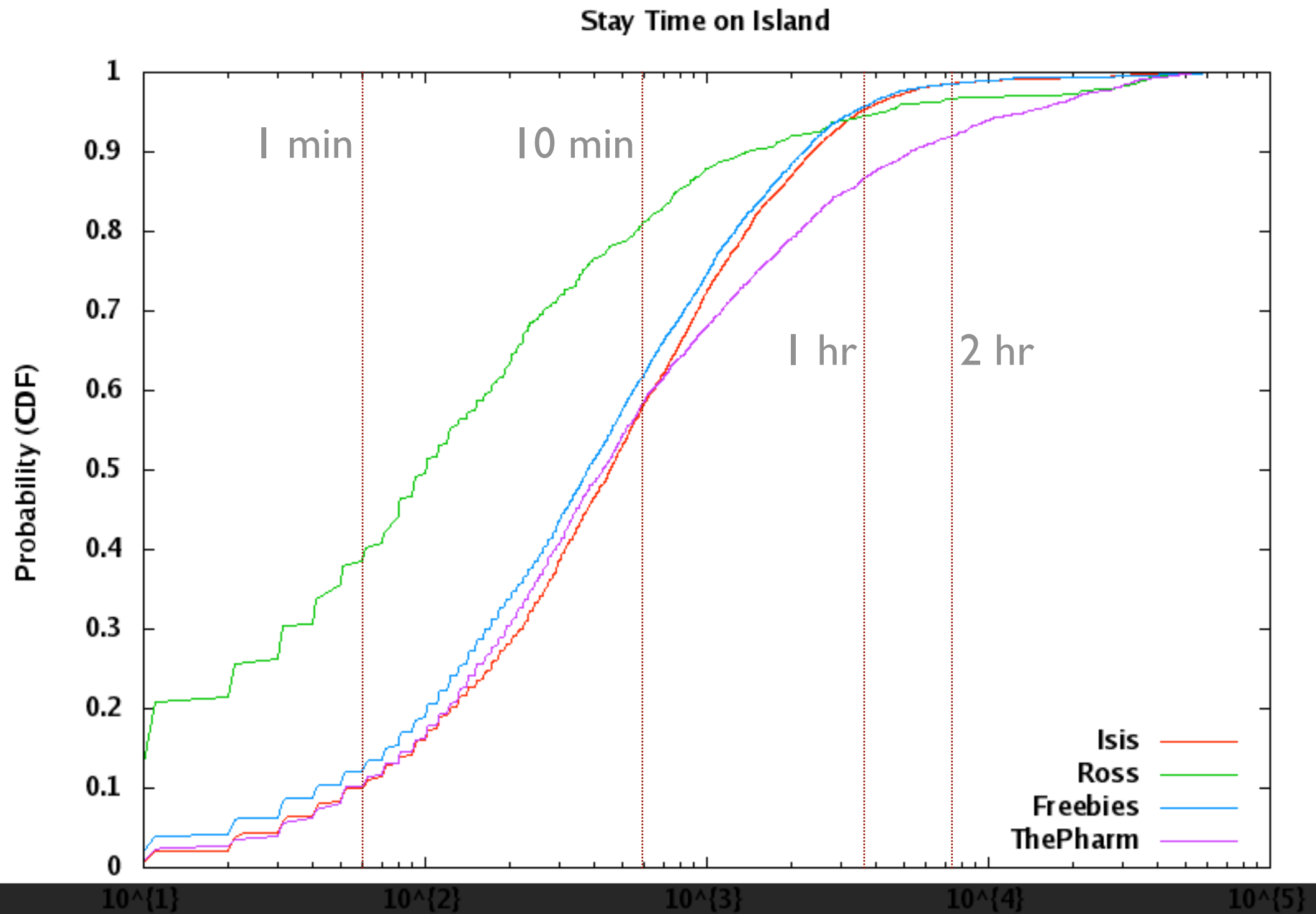
churn rate







Reasonably high churn (up to 6/min)

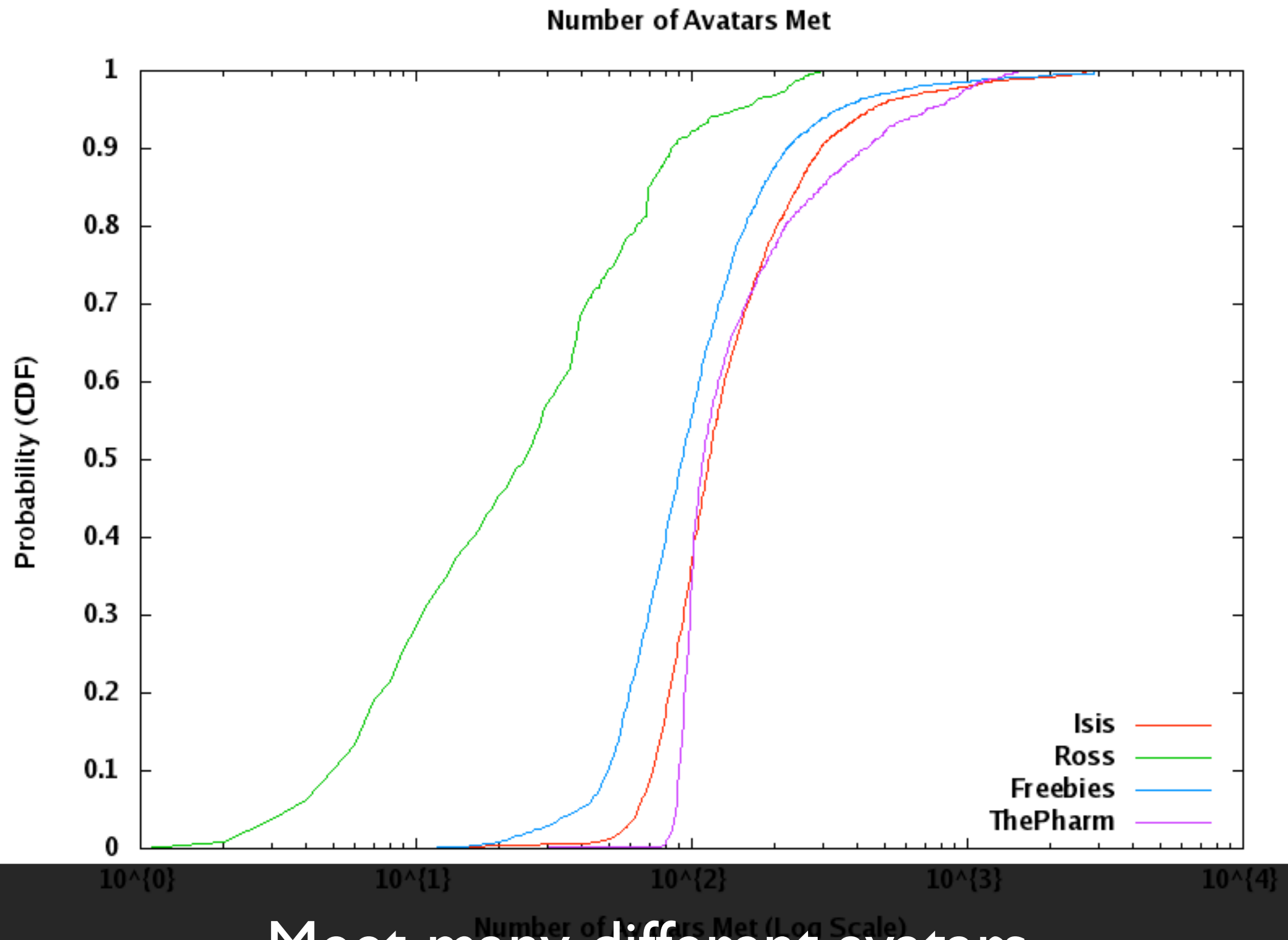


Highly skewed. Some stay for hours.

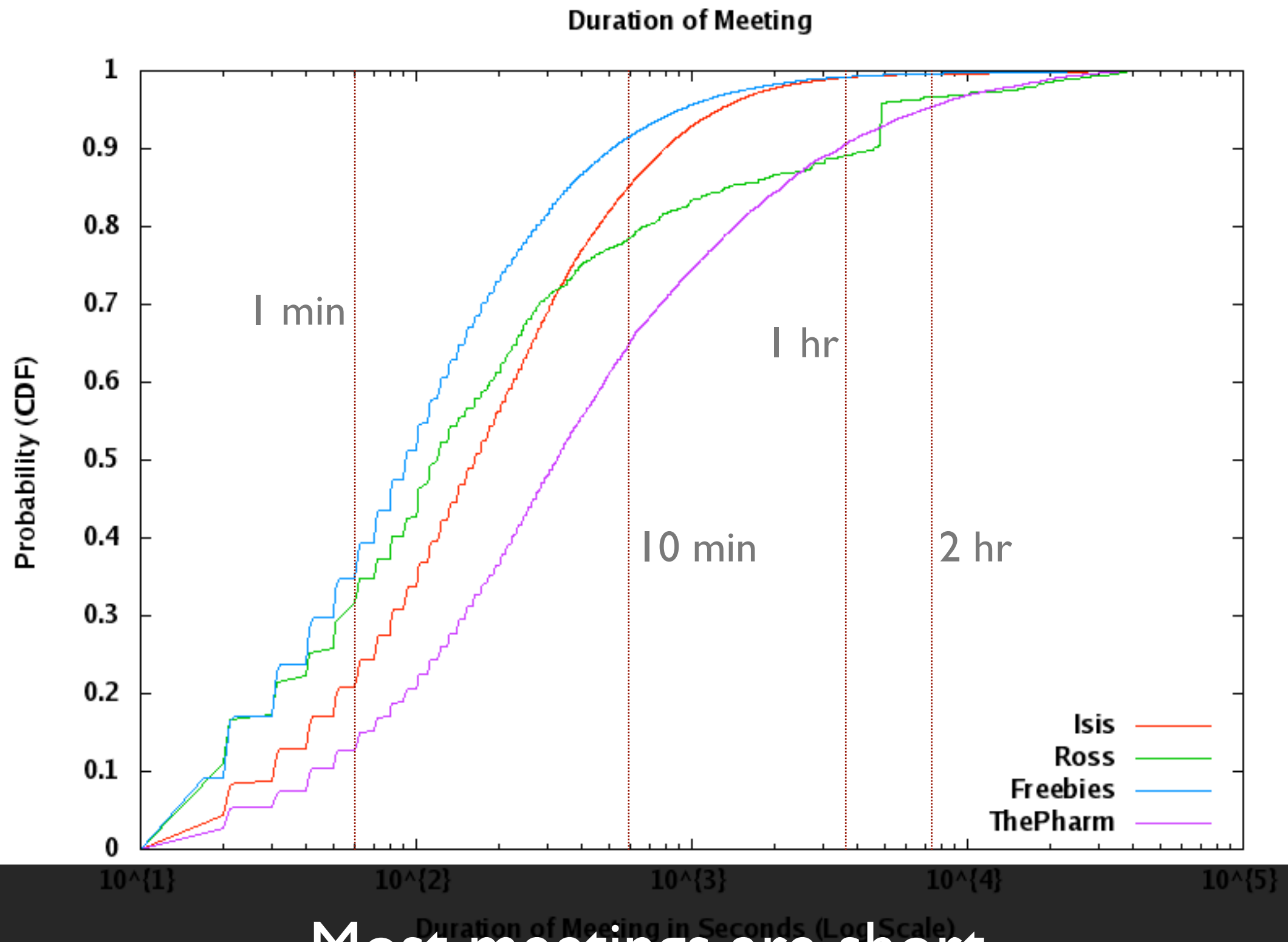
cannot pick
supernodes uniformly

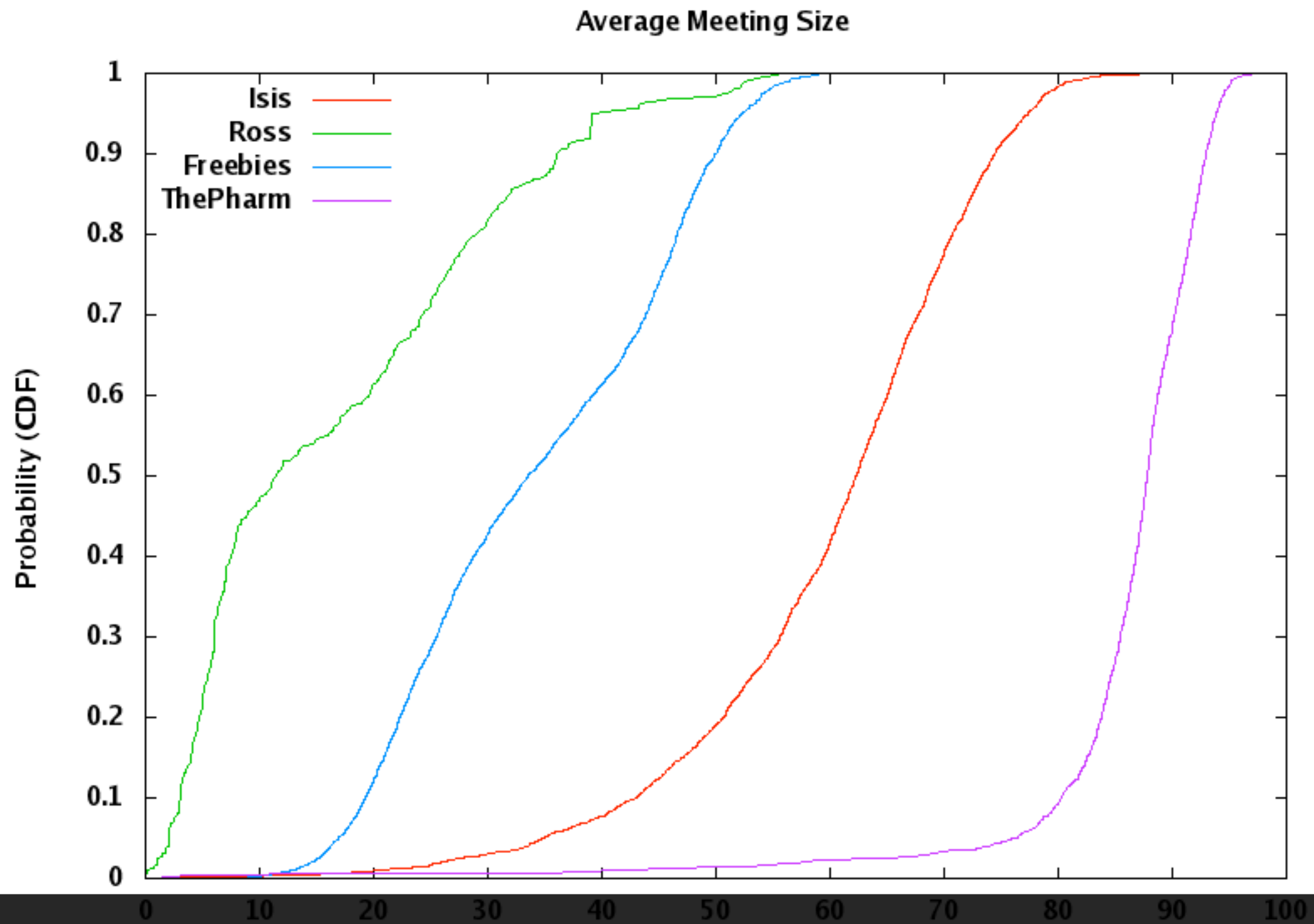
clustering of avatars

meeting: encounter
between two avatars
(within each other Aol)



Meet many different avatars.





Meeting size is large.

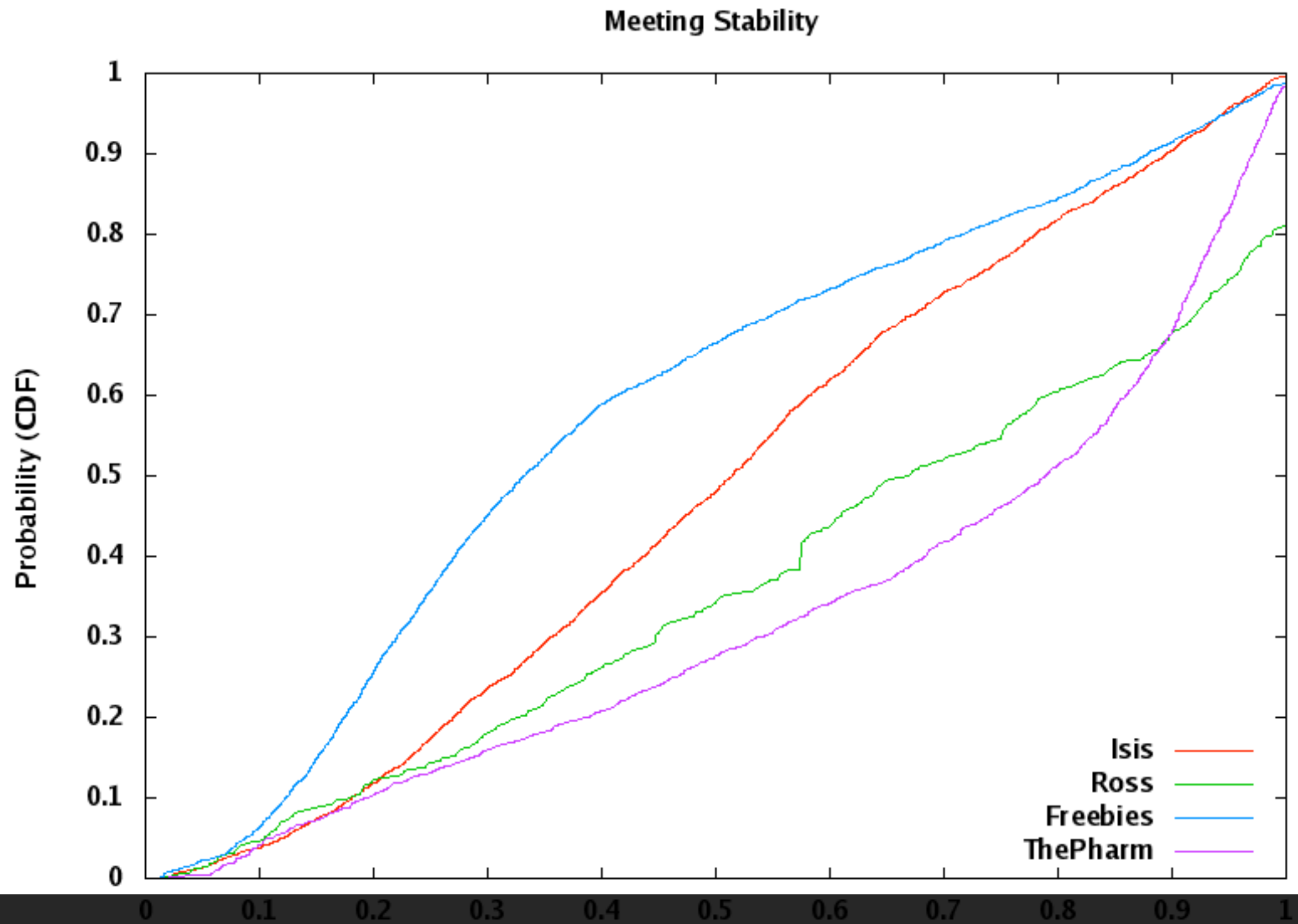
high overhead in
maintaining Aol
neighbors

meeting stability:

avg meeting size

over

num of avatars met



Wide range of stability

other tidbits

little temporal variations

can use historical information
to predict future

rotate 18% of the time

Second Life's prefetching is
wasteful

25-35% revisits the same
region in a day

region-based caching?