Avatar Mobility in SECOND LIFE®

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"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- perienced a spectacular
growth 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
  :

Scholar

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 Mutimedia, 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

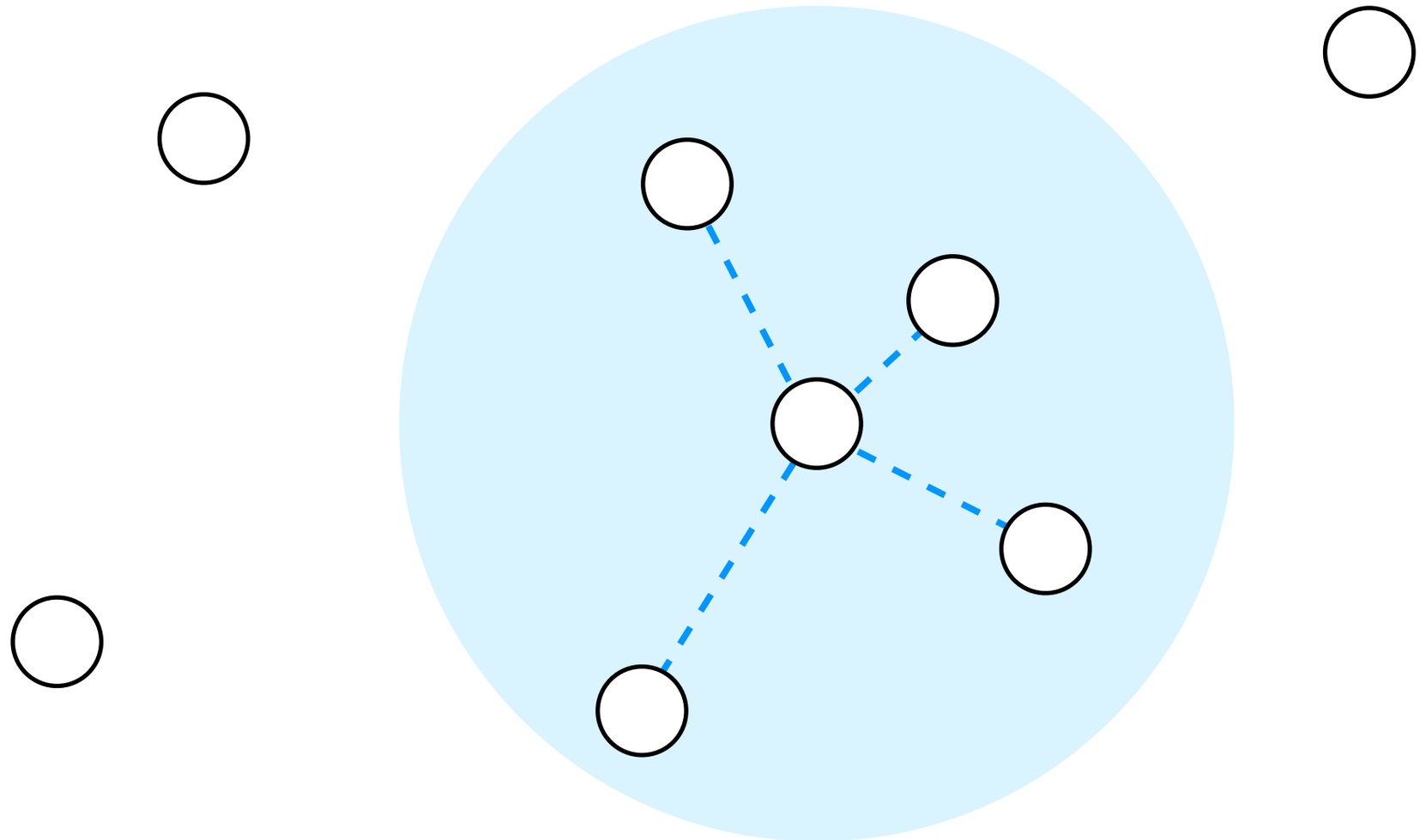
Supporting scalable **peer to peer virtual environments** using frontier sets - all 6 versions »
A Steed, C Angus - Proceedings of IEEE Virtual Reality 2005, 2005 - doi.ieeecomputersociety.org
Page 1. Supporting Scalable **Peer to Peer Virtual Environments** using Frontier Sets Anthony Steed 1 , Cameron 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, 2006
Cited 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 MUVEs in hybrid **peer-to-peer** networks, and ... of multi-user 3D games and multi-user **virtual environments** in general ...

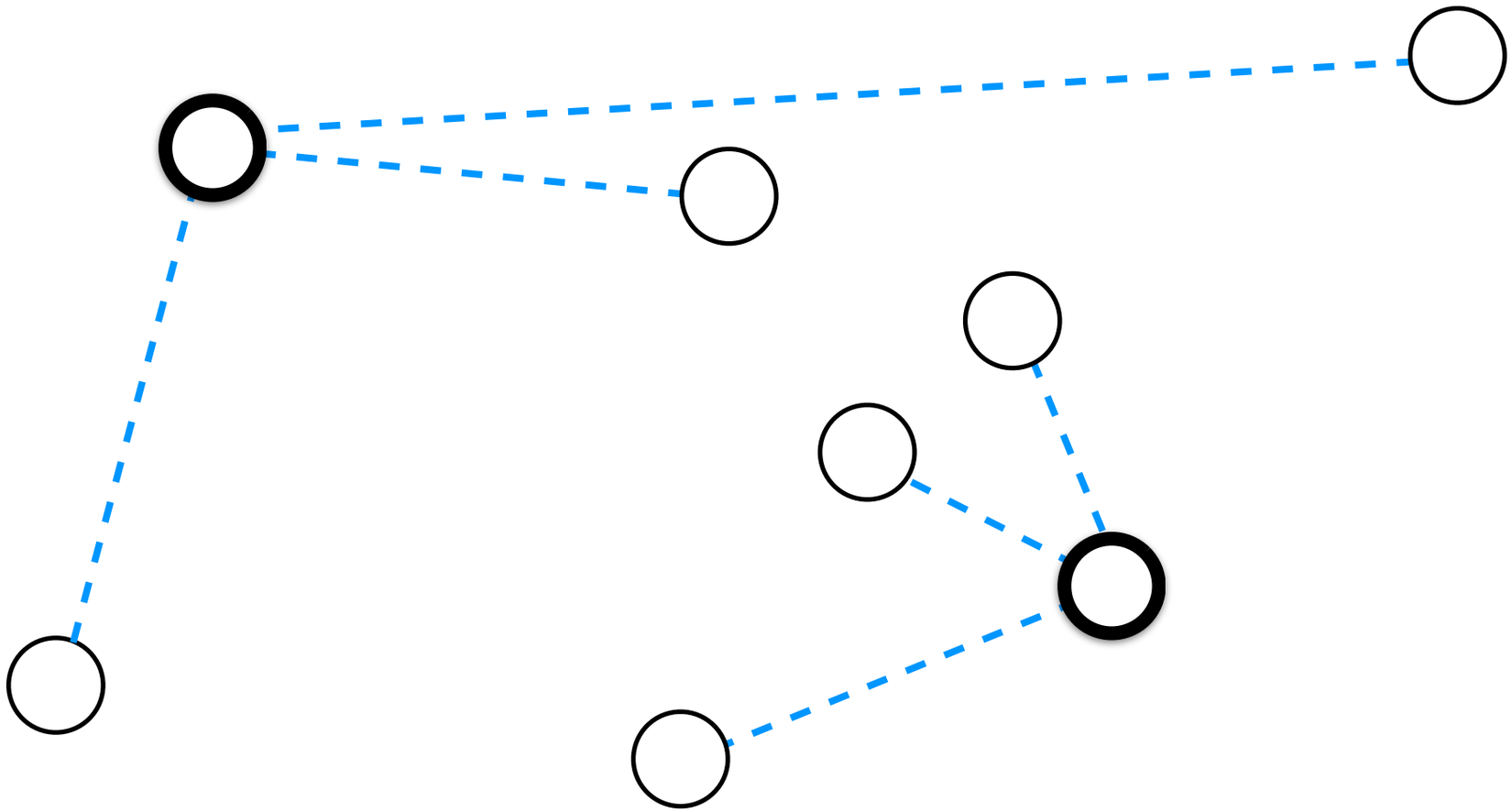
Aol-based scheme



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,

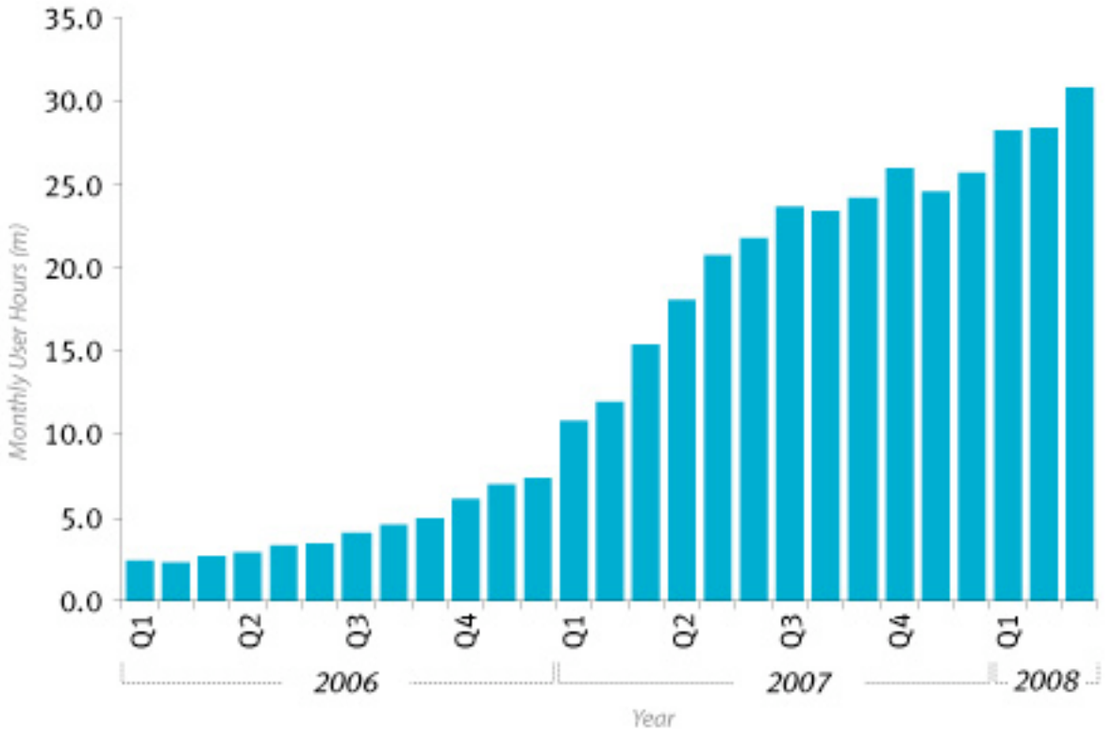
small-scale

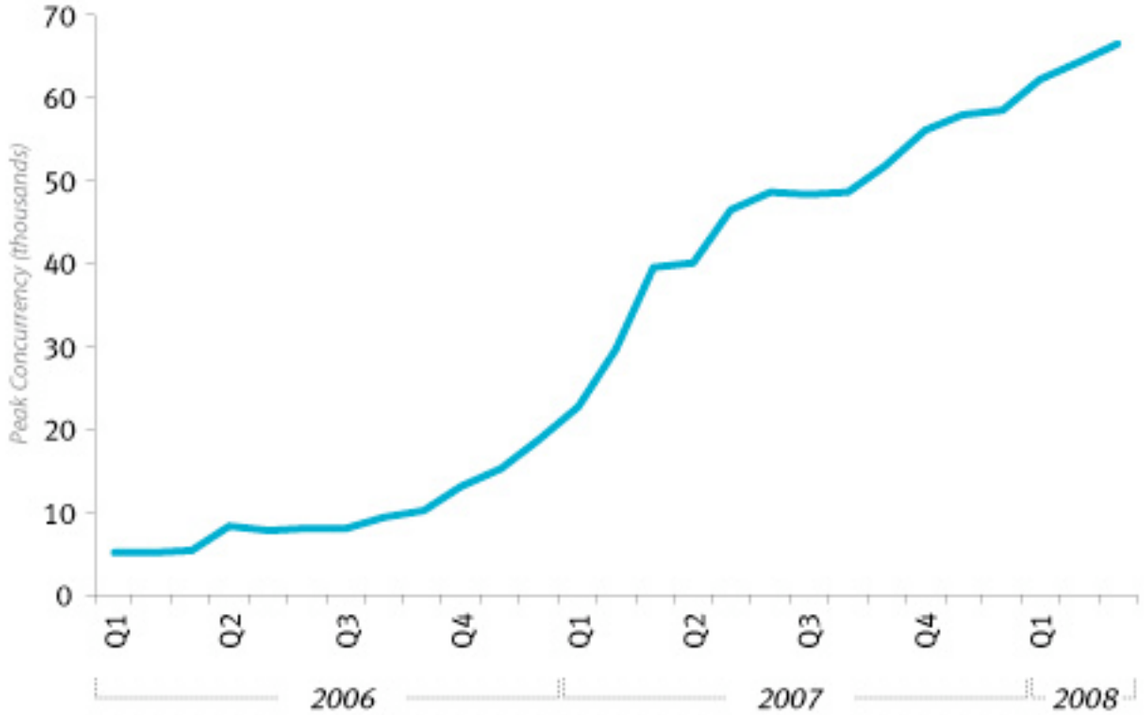
implementation

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?

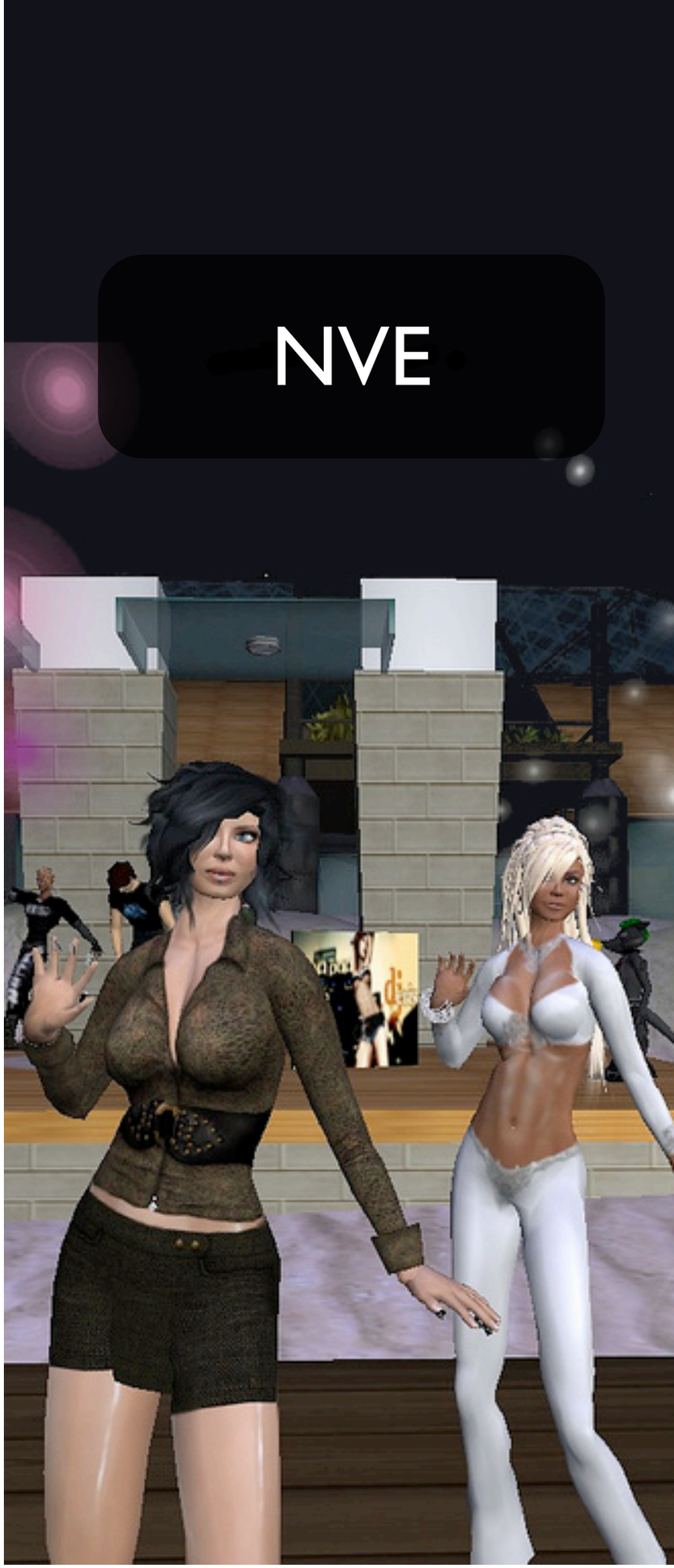
how long do they stay at a location?

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)

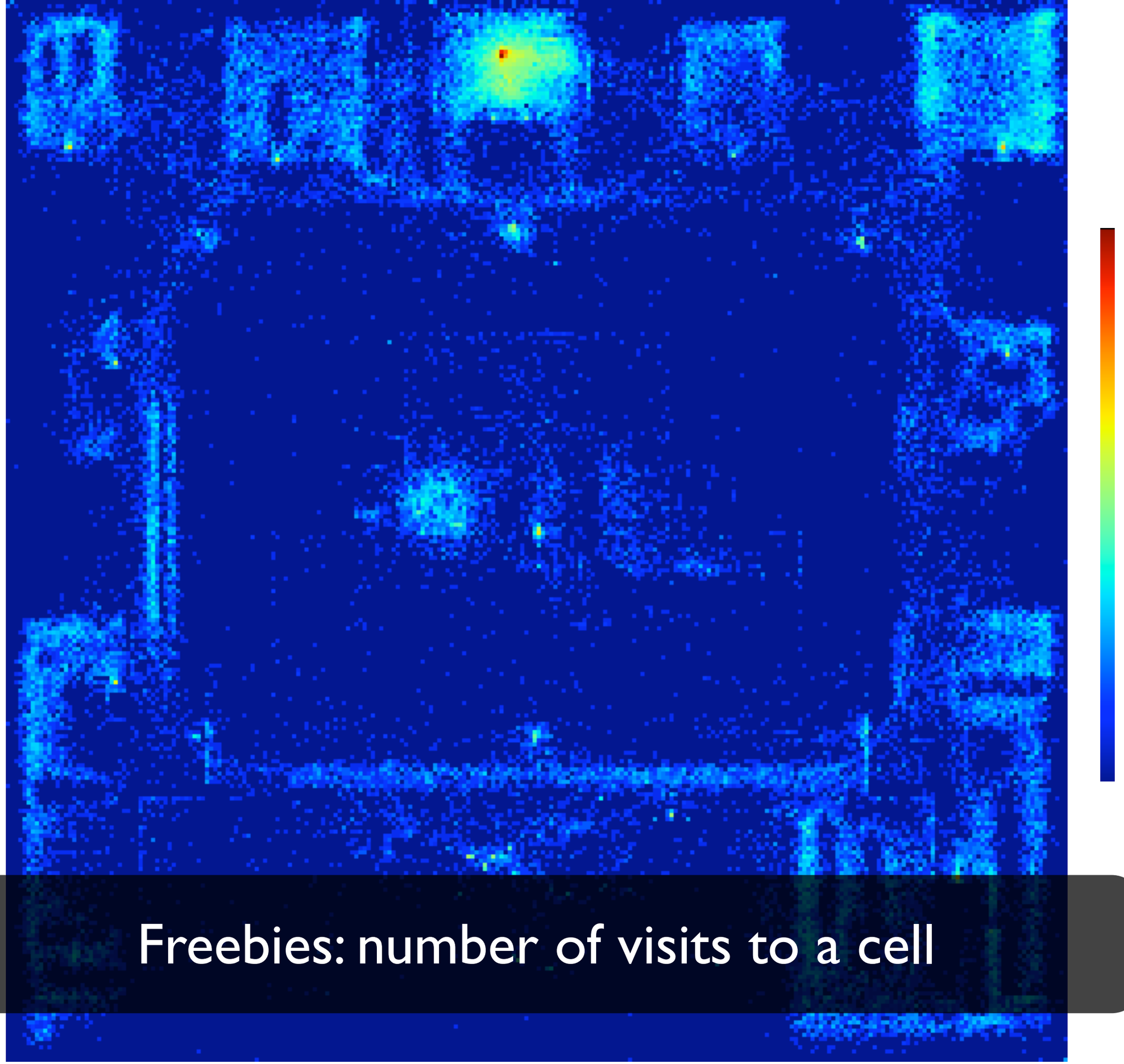
Freebies

The Pharm

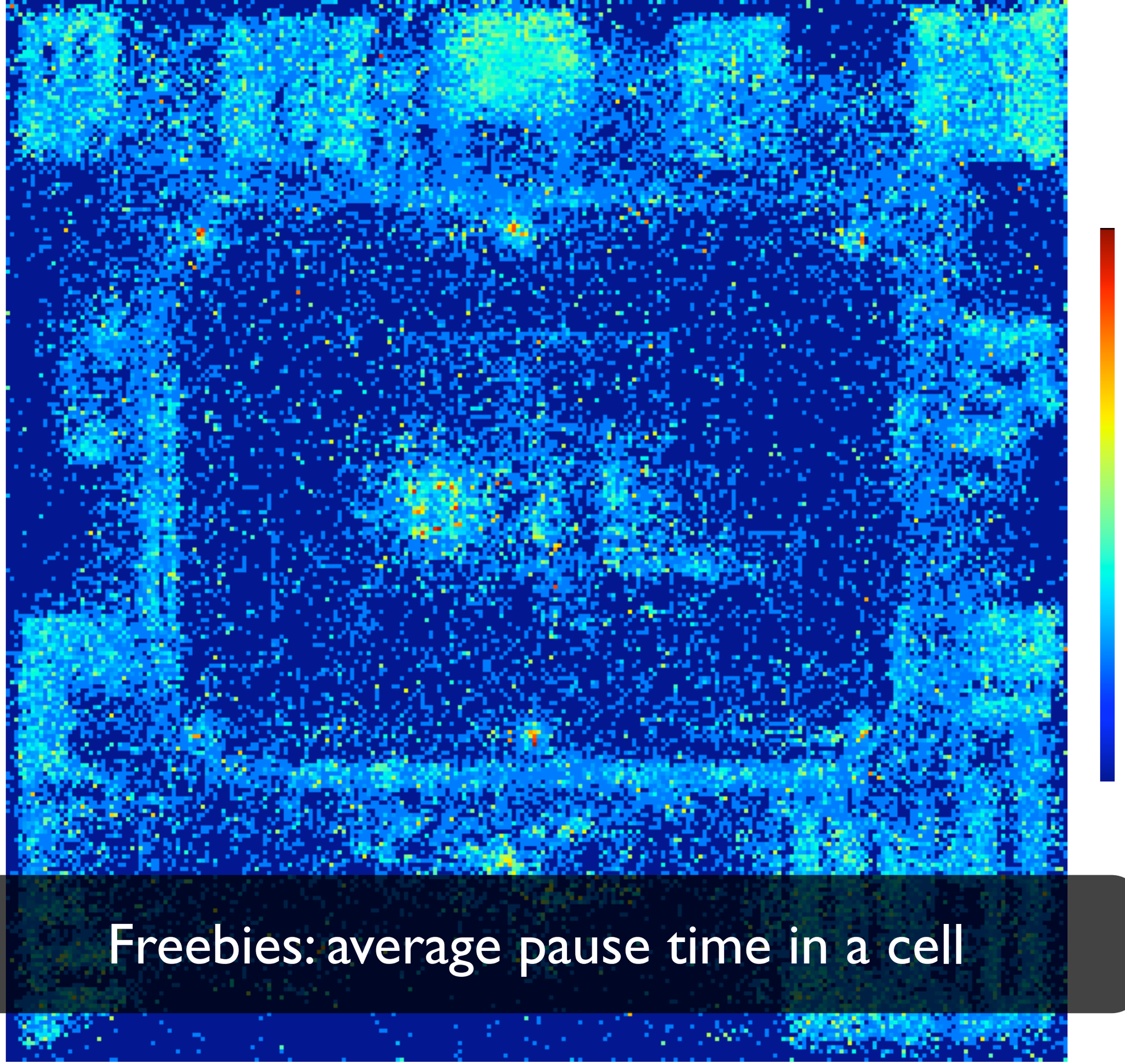
Isis

Ross

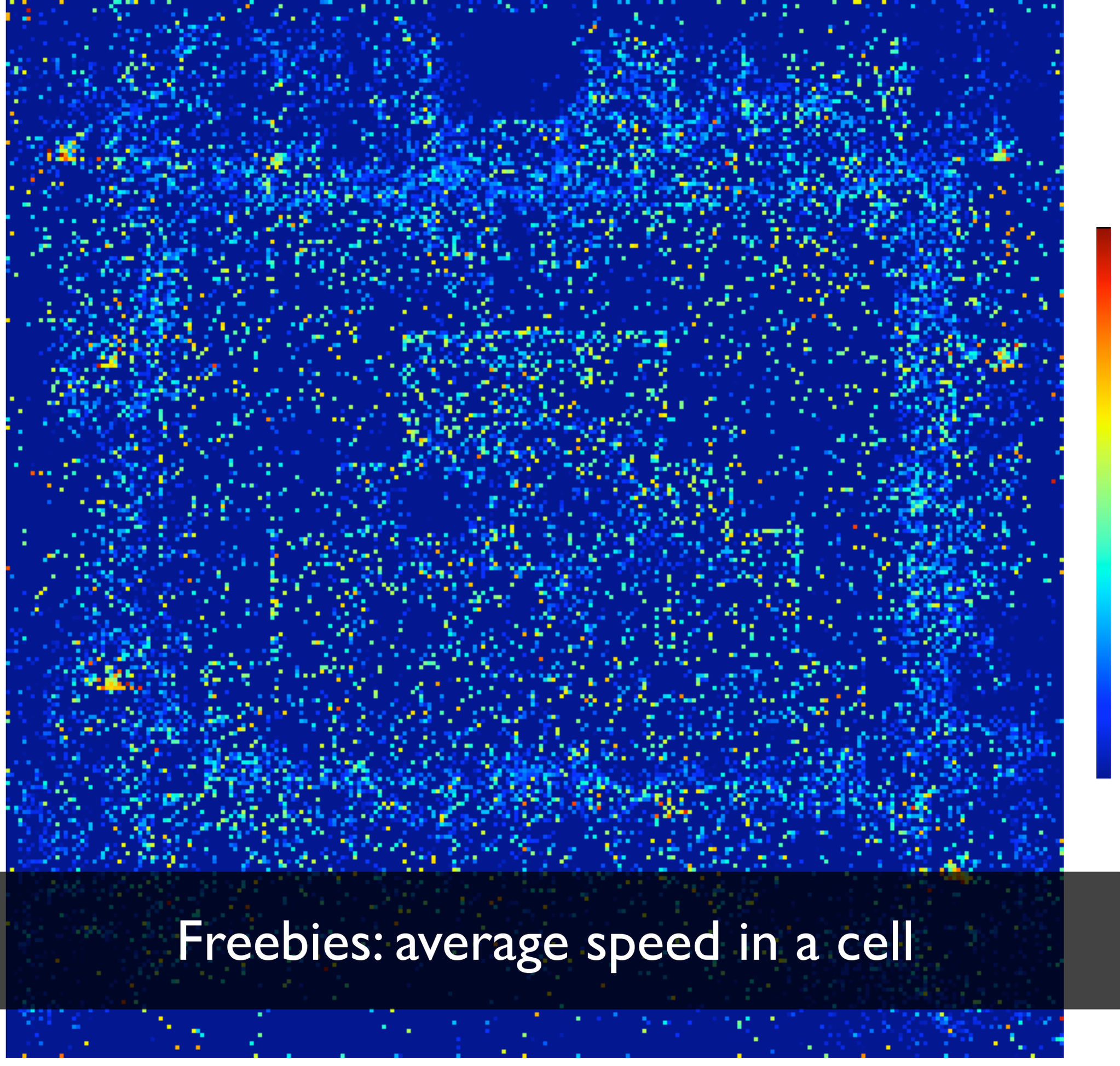
Mobility Patterns



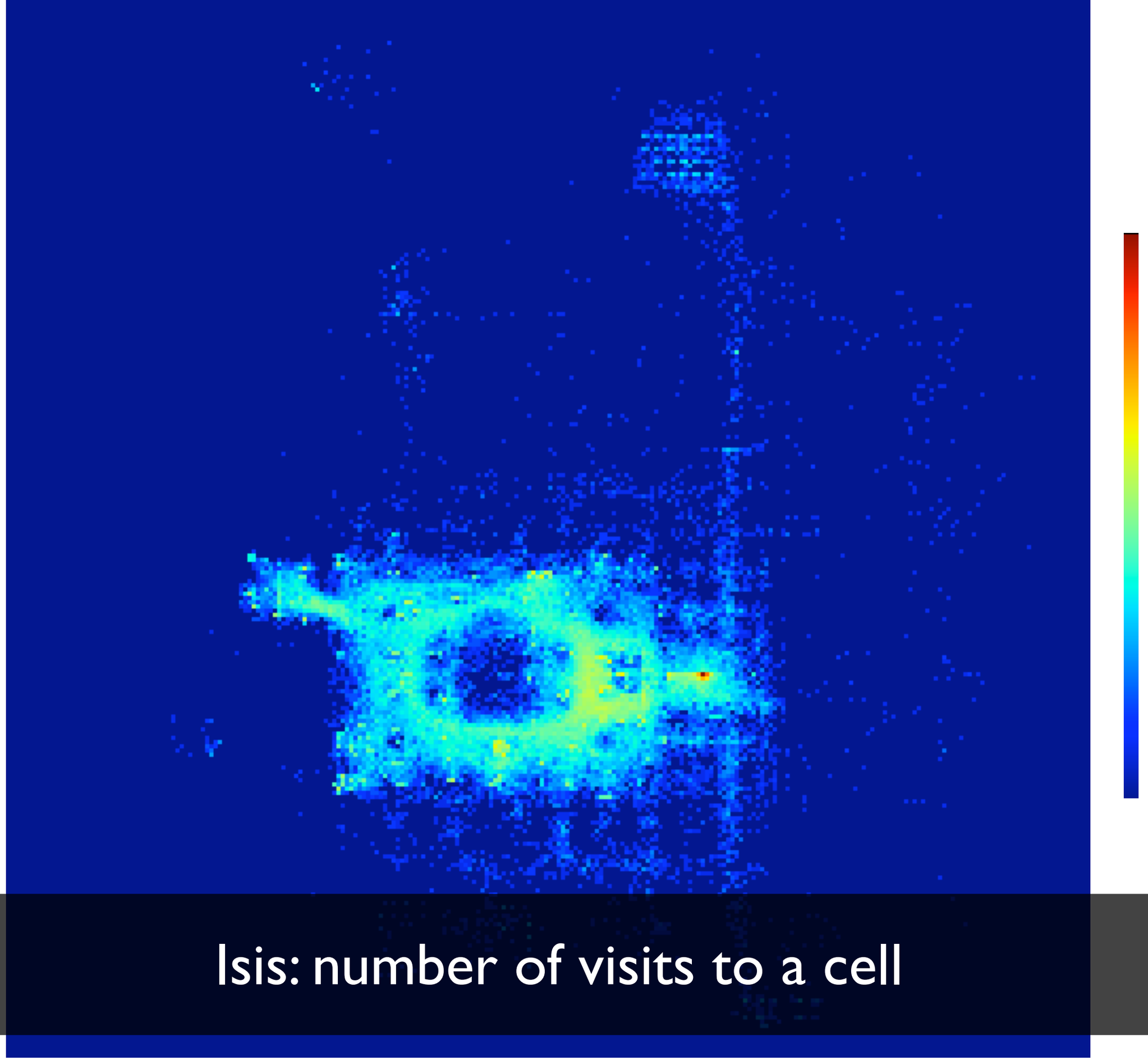
Freebies: number of visits to a cell



Freebies: average pause time in a cell

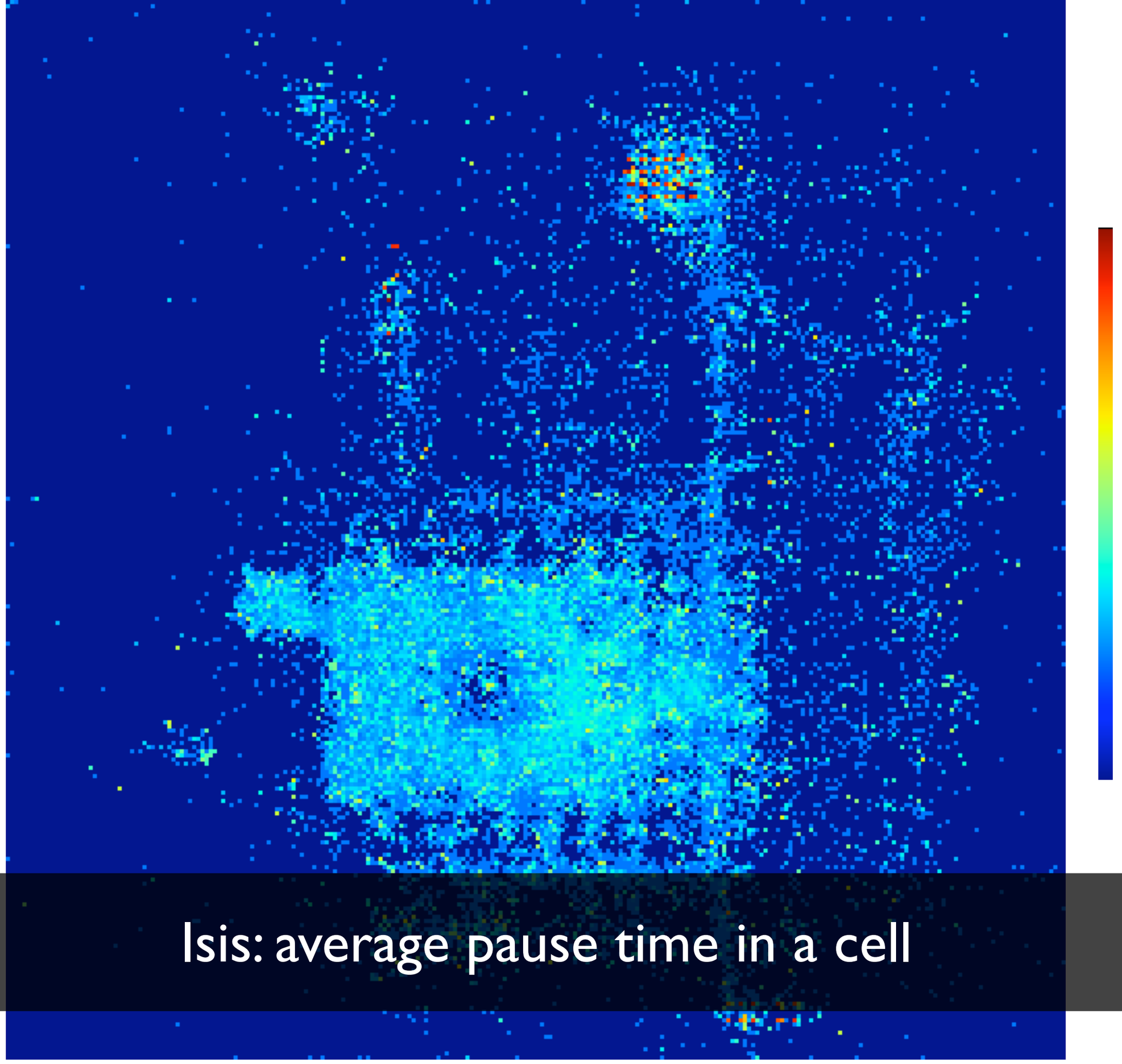


Freebies: average speed in a cell



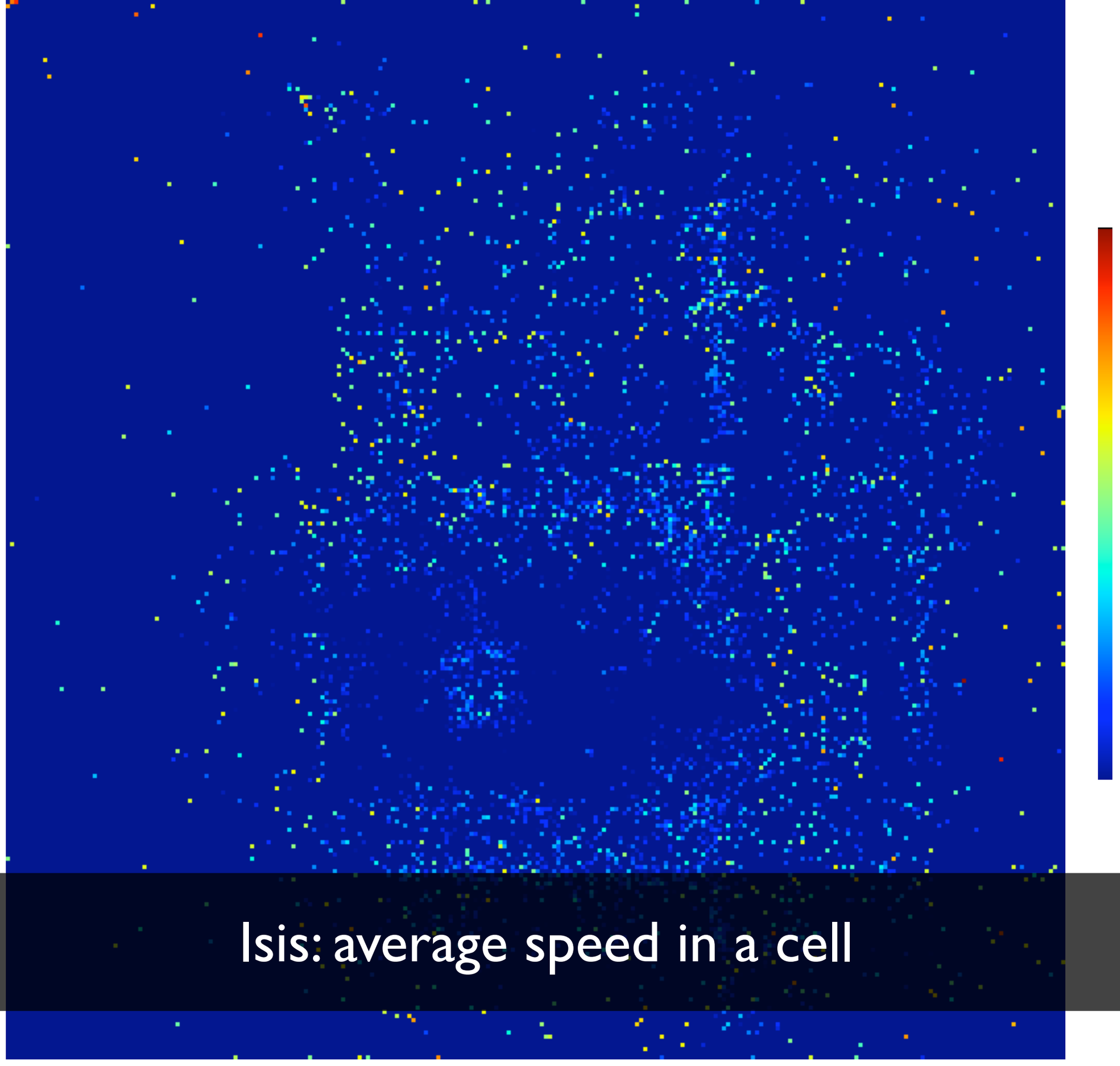
Isis: number of visits to a cell

caching/prefetching based on popularity of locations?



Isis: average pause time in a cell

pick supernodes from sticky location?

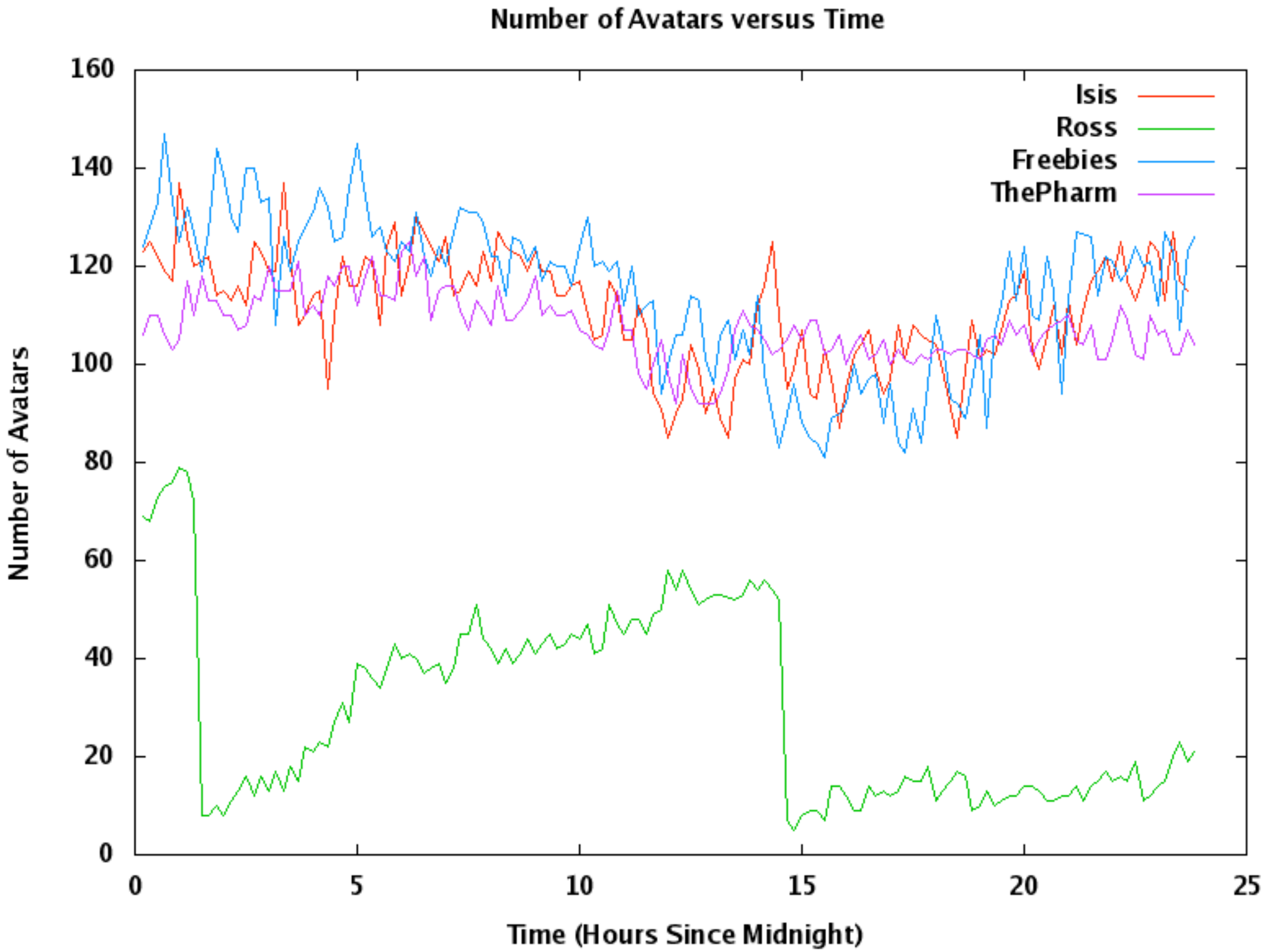


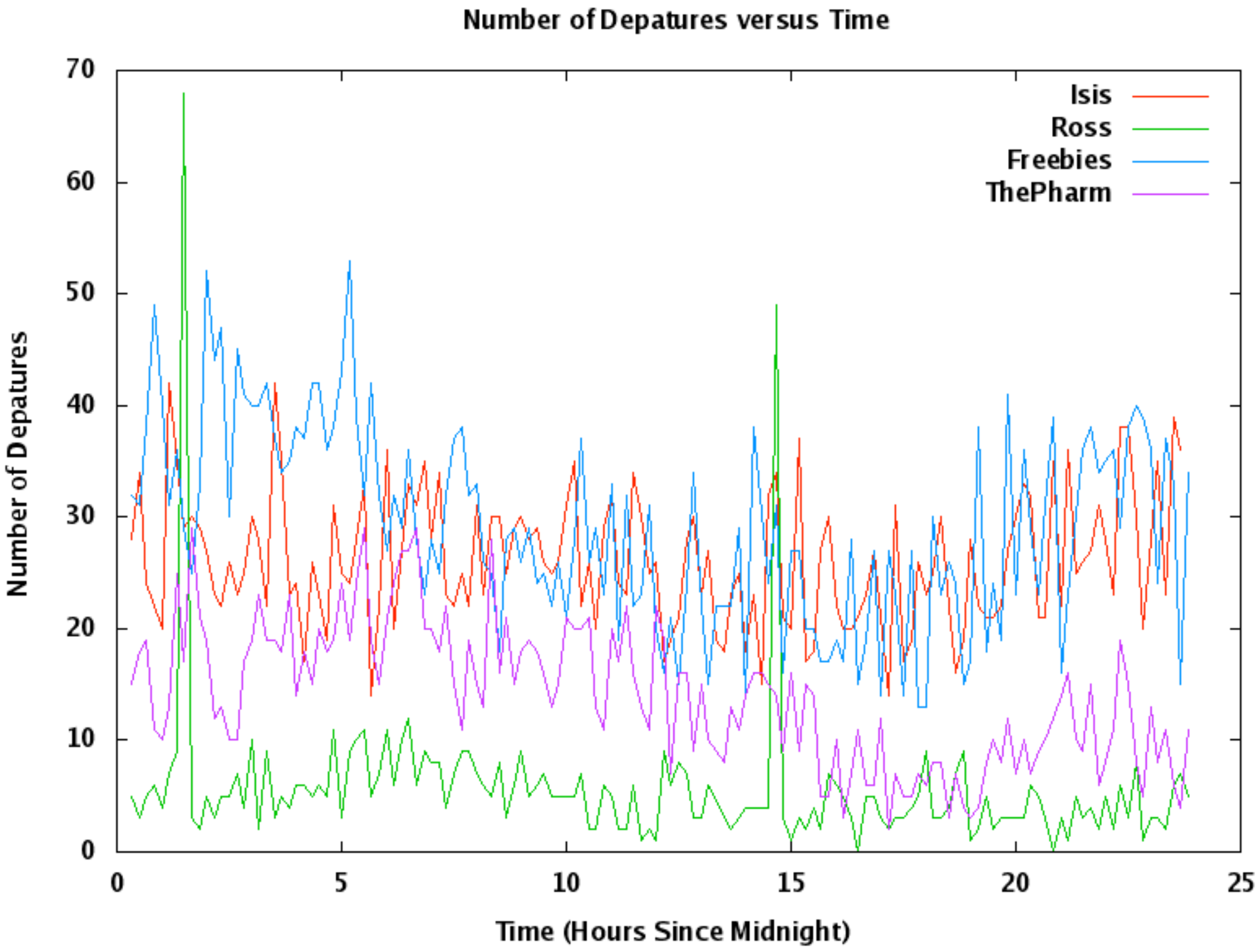
Isis: average speed in a cell

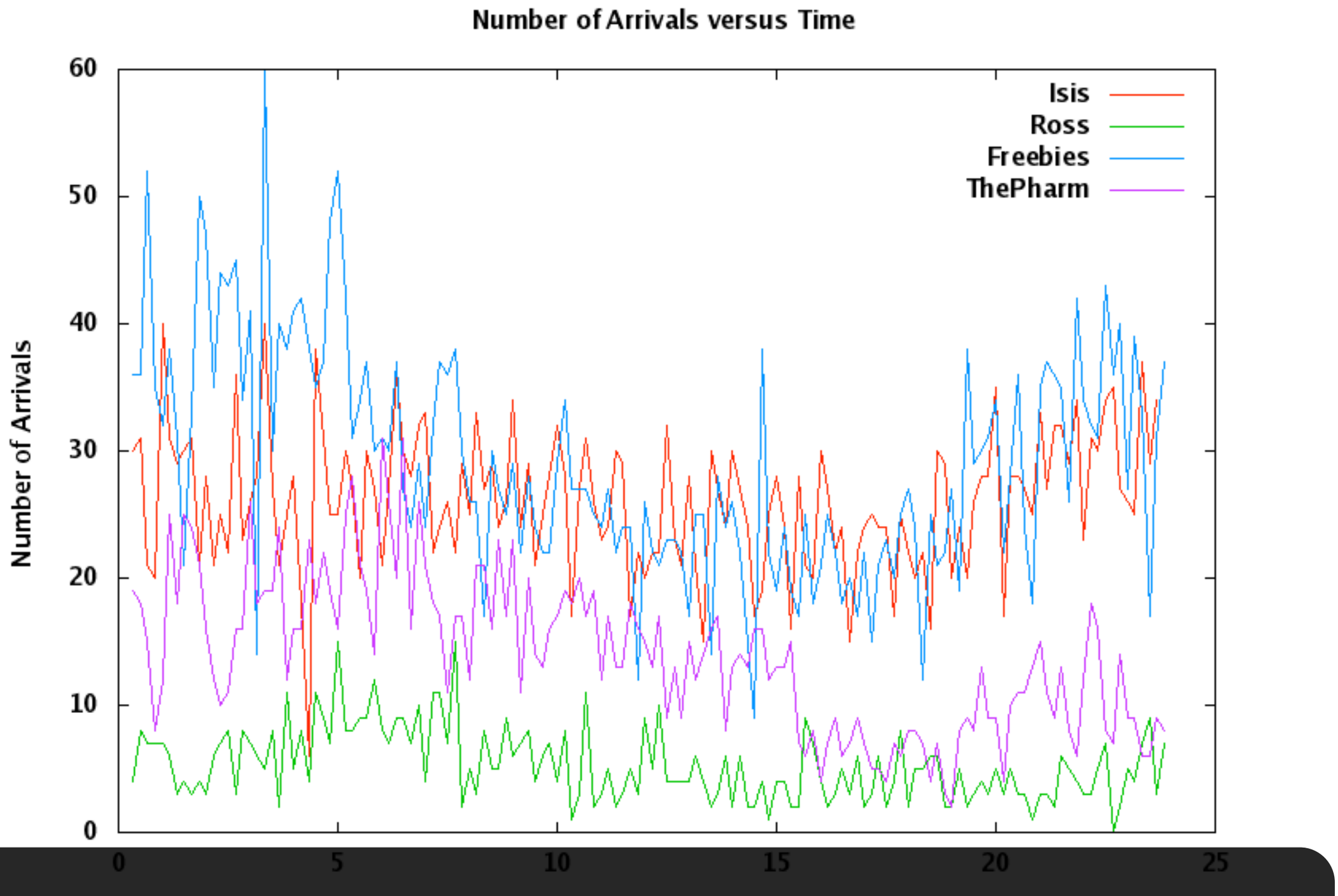
mobility model:

random walk + pathway ?

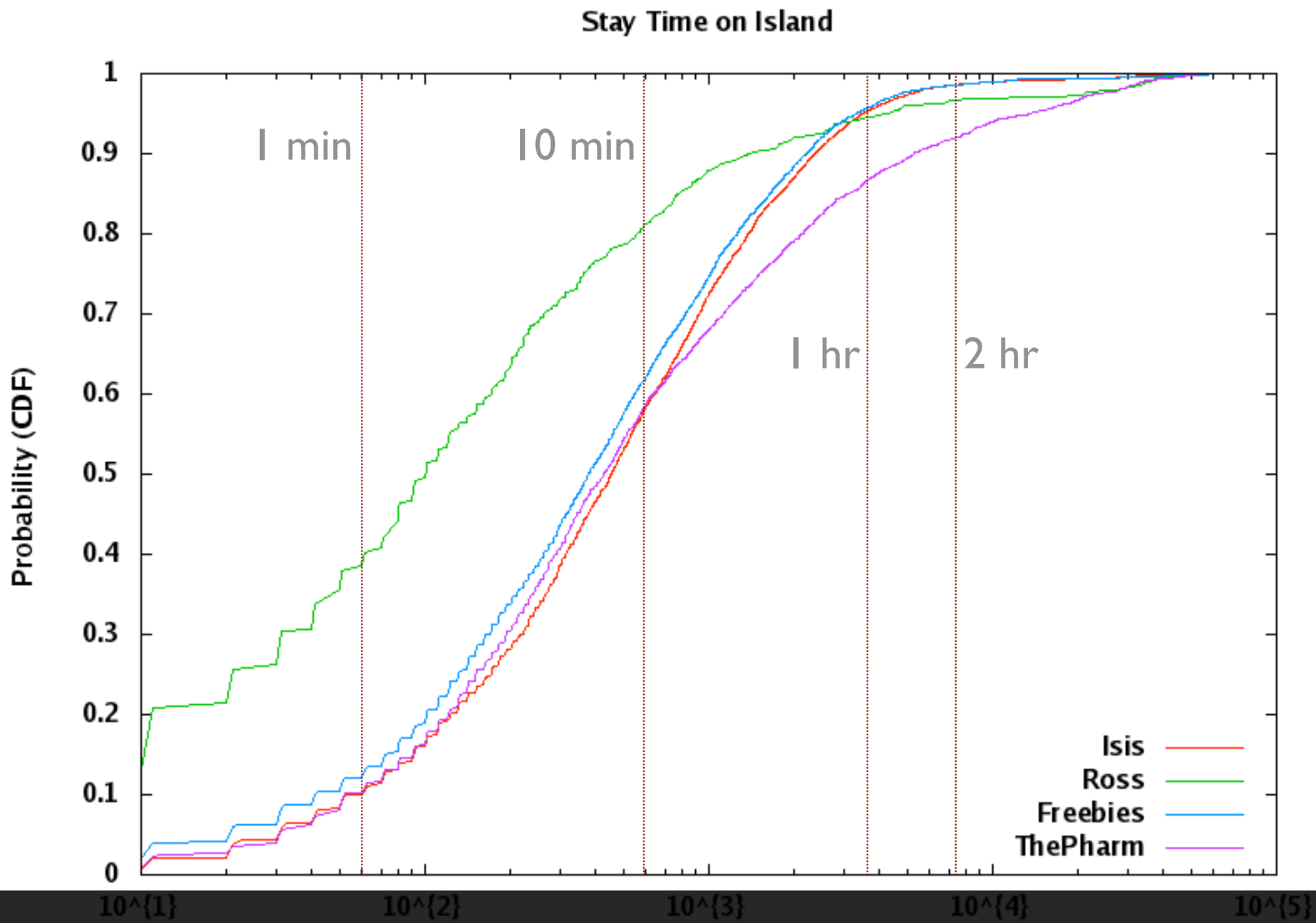
churn rate


Number of Avatars versus Time
Isis
Ross
Freebies
ThePharm
Number of Avatars
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
Time (Hours Since Midnight)


Number of Depatures versus Time
Number of Depatures
Time (Hours Since Midnight)
Isis
Ross
Freebies
ThePharm
0
10
20
30
40
50
60
70
0
5
10
15
20
25



Reasonably high churn (up to 6/min)

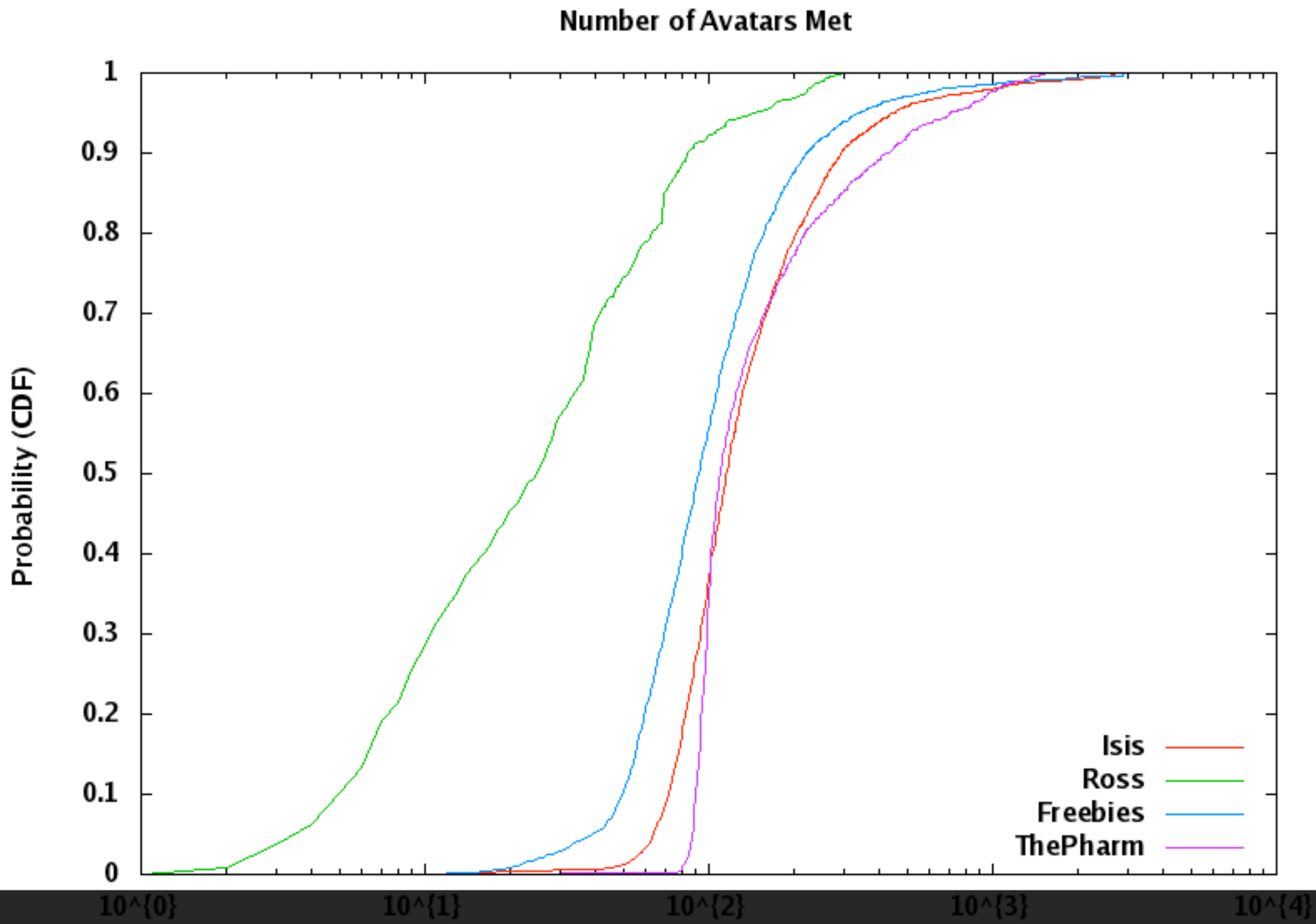


Highly skewed. Some stay for hours.

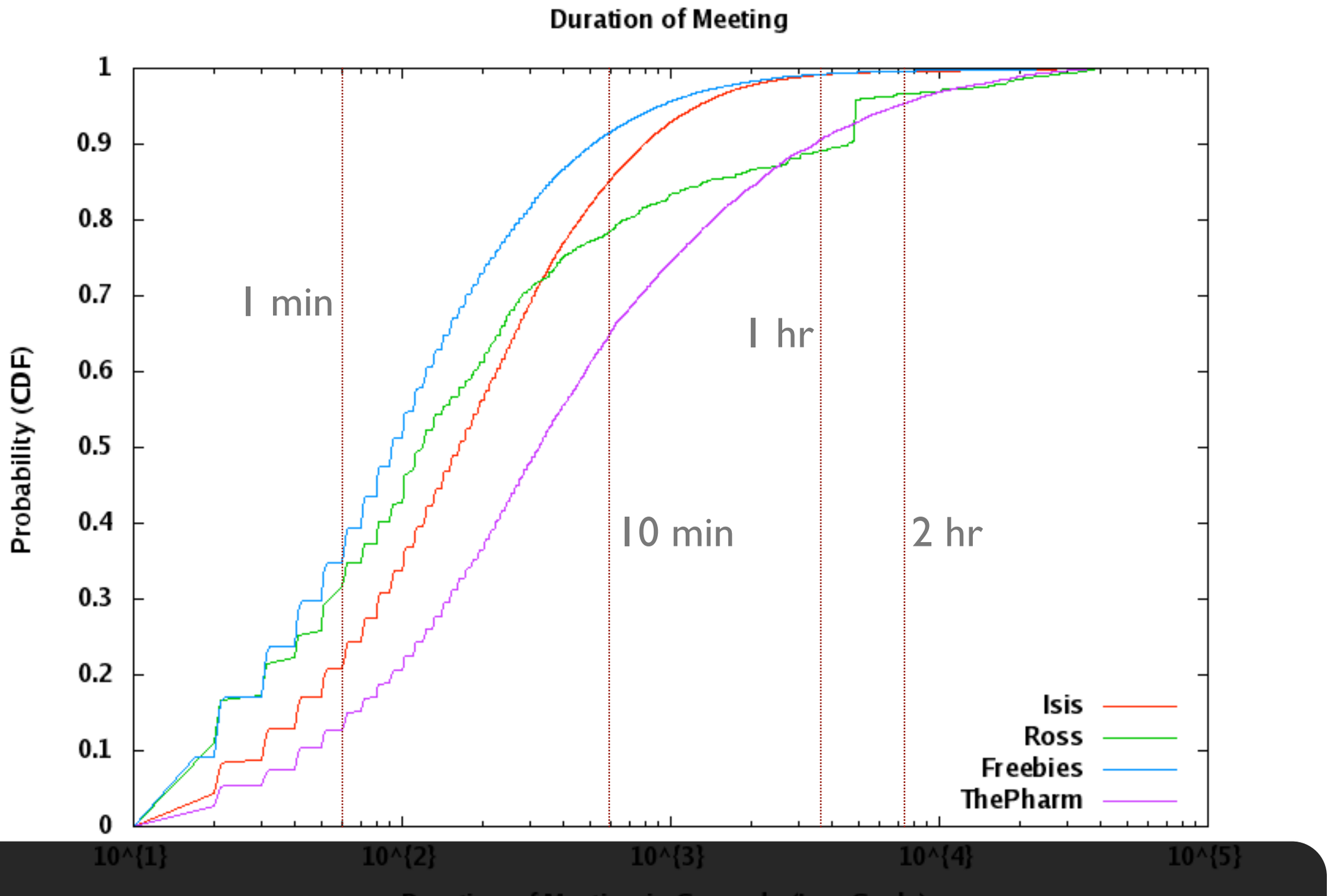
cannot pick supernodes uniformly

clustering of avatars

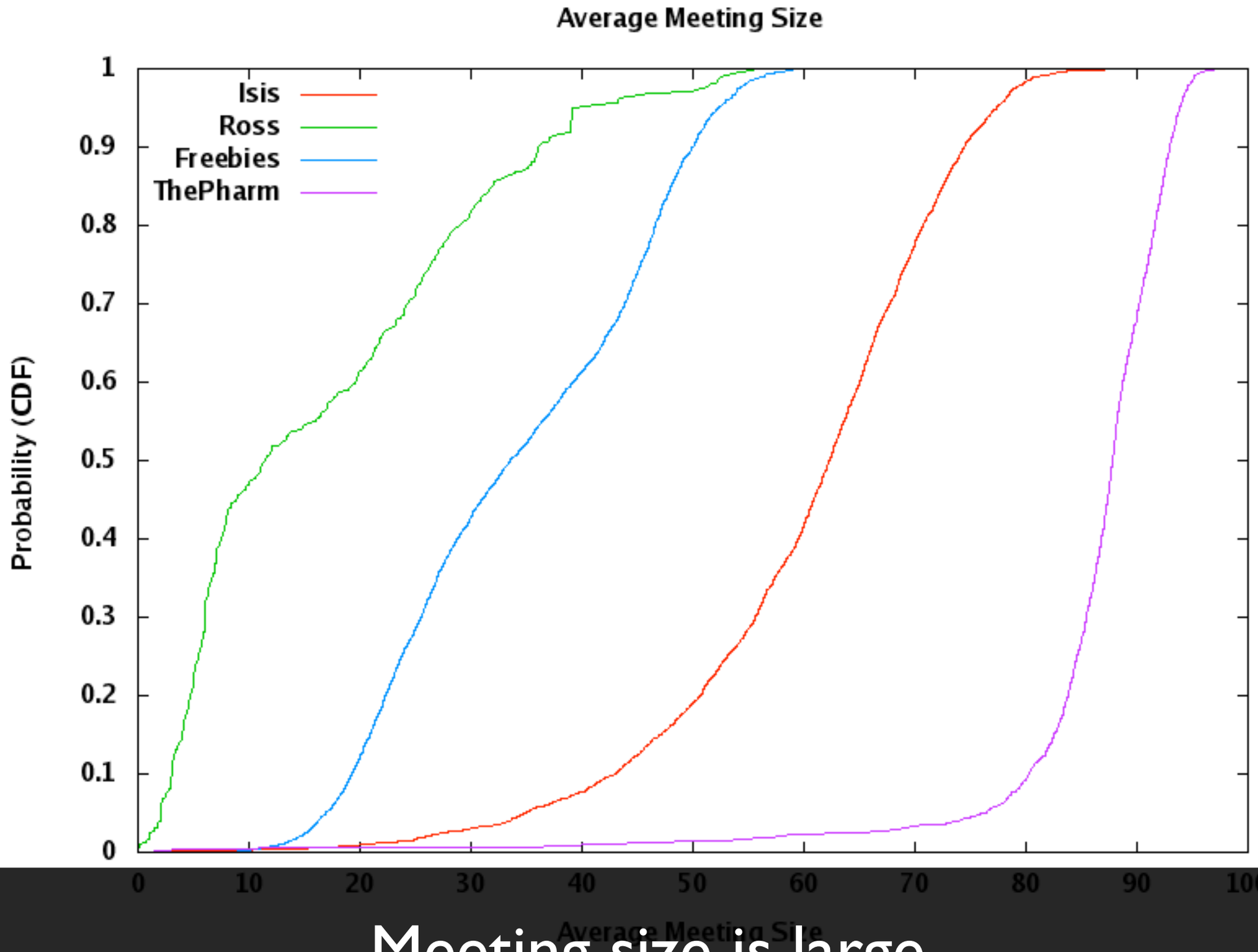
meeting: encounter between two avatars (within each other AoI)



Meet many different avatars.



Most meetings are short.

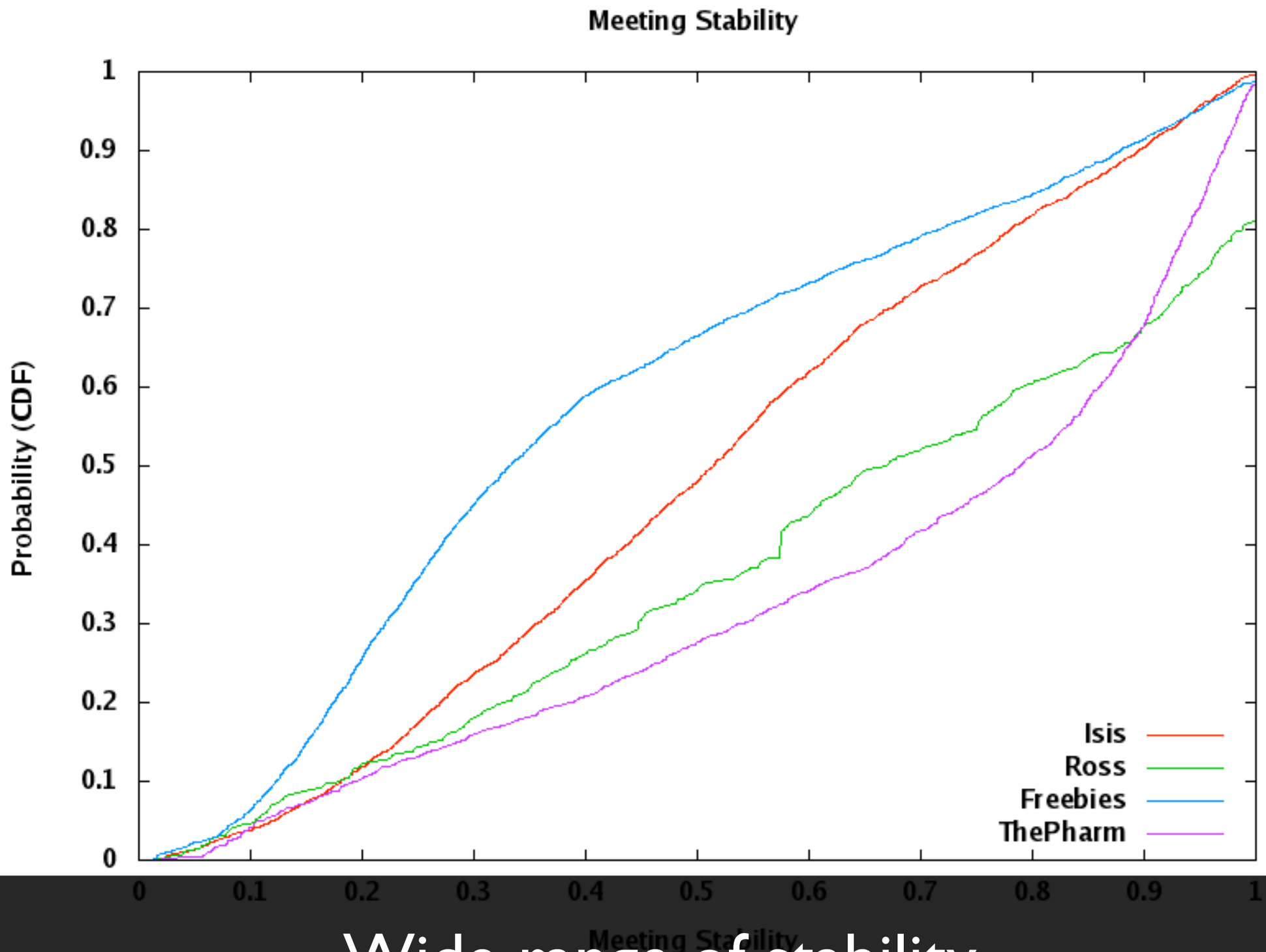


Meeting size is large.

high overhead in maintaining AoI 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?

proxy-based texture caching

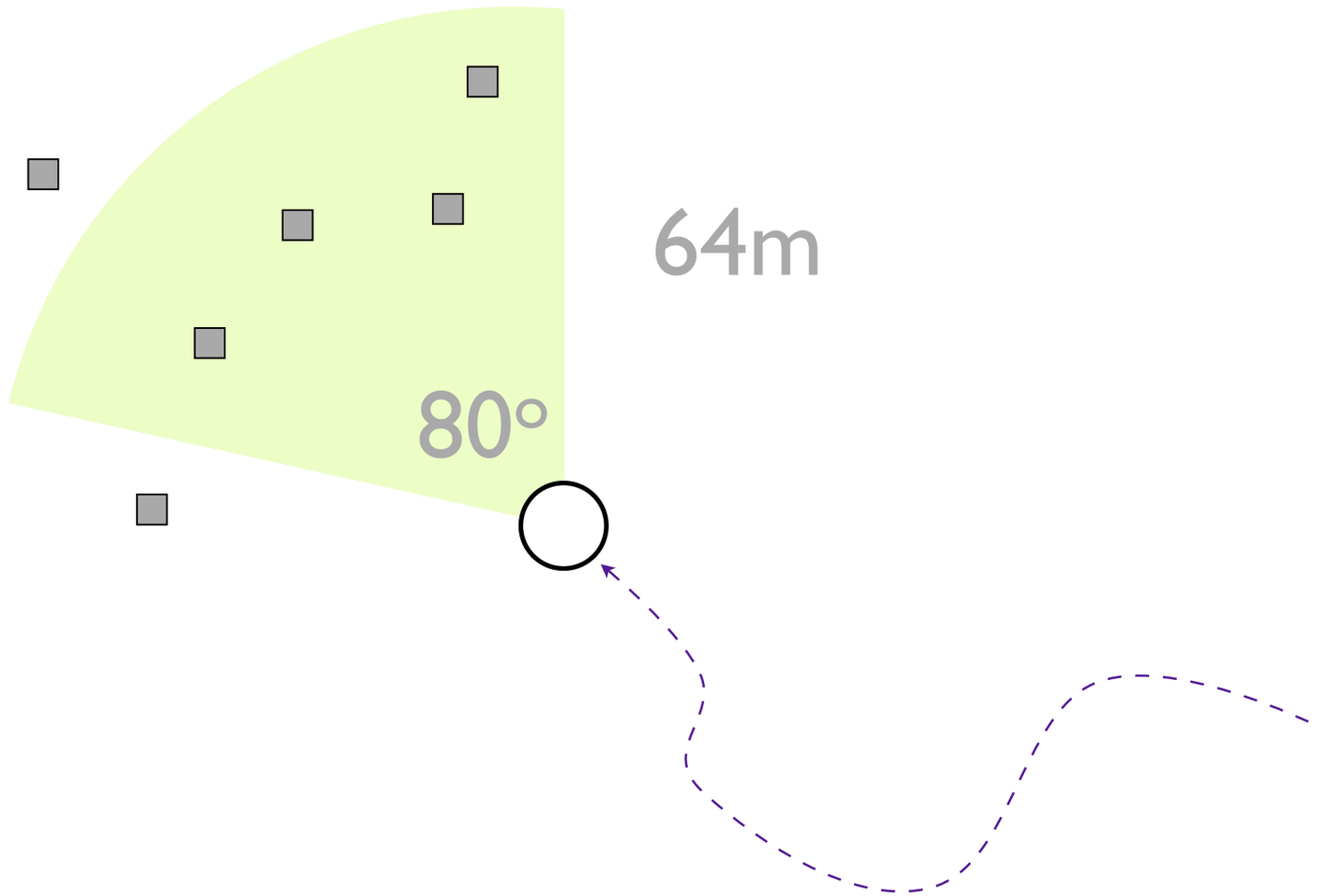
why textures?

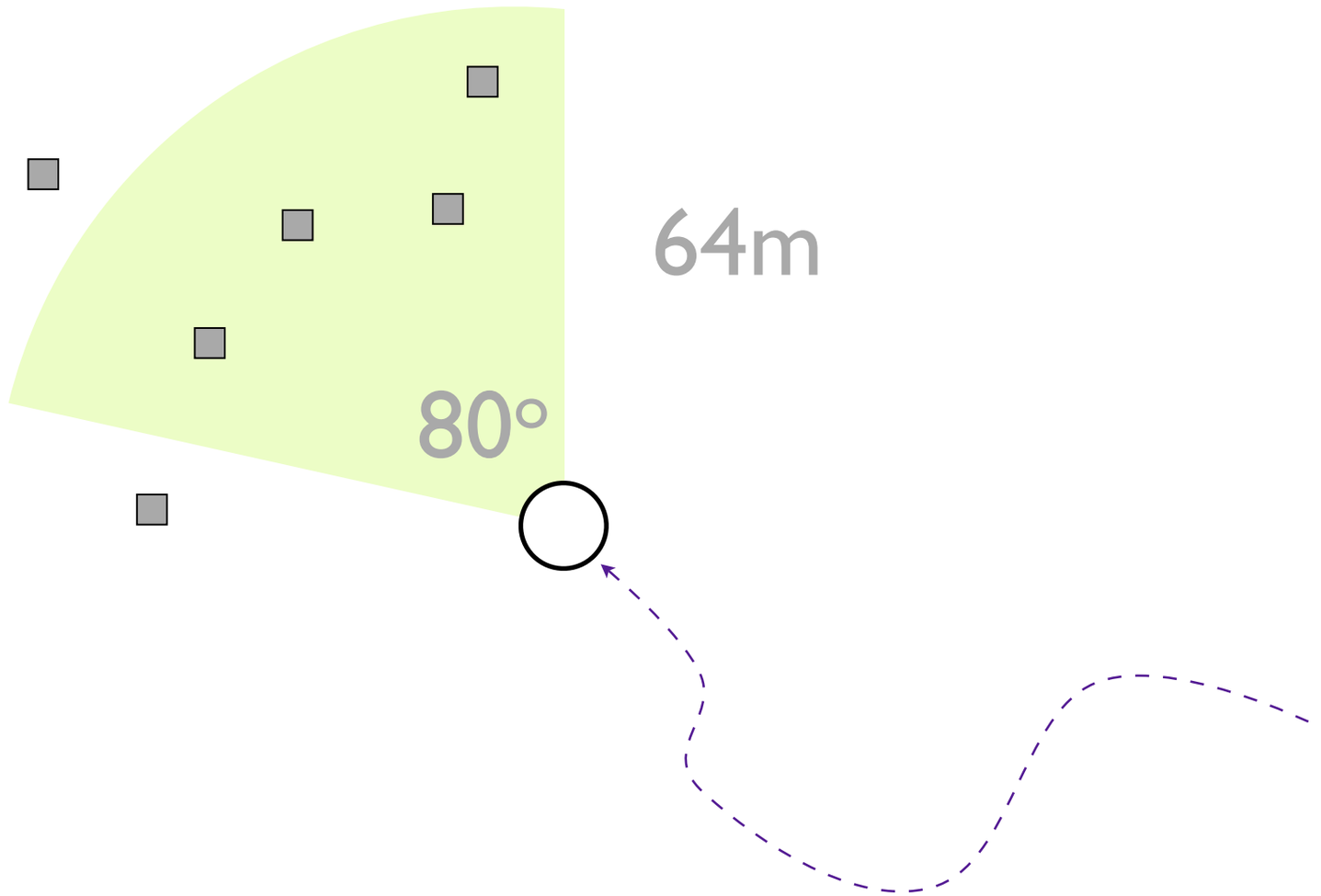
62 - 81%

of traffic are textures

316 MB

of textures in Isis


64m
80°


64m
80°

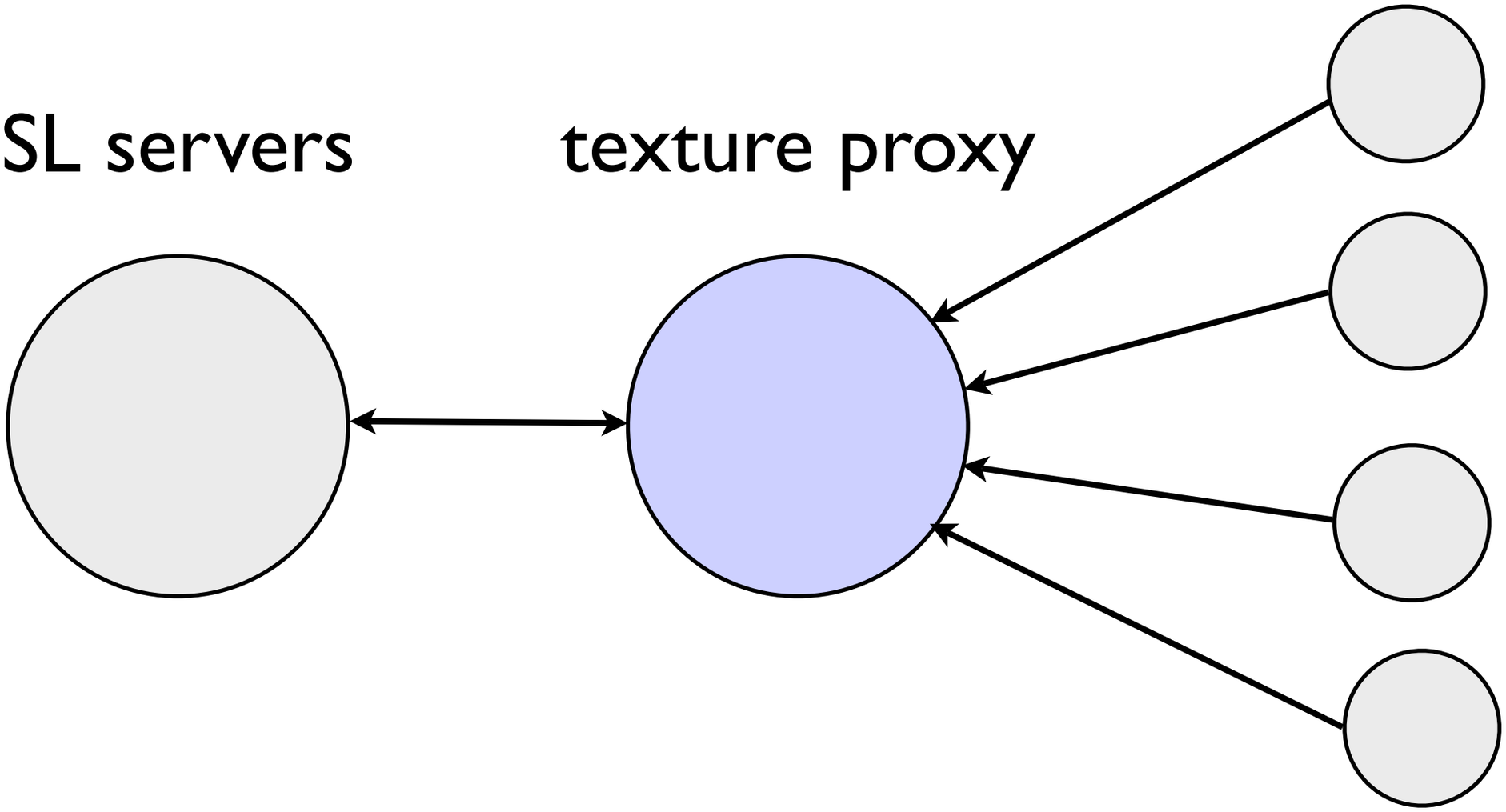
403 TB

of textures retrieved in Isis in a day

clients

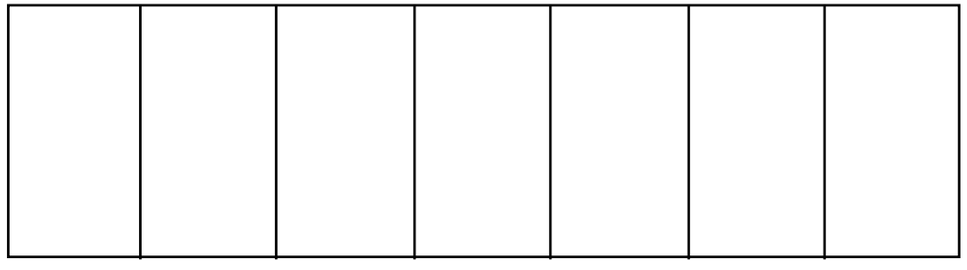
SL servers

texture proxy

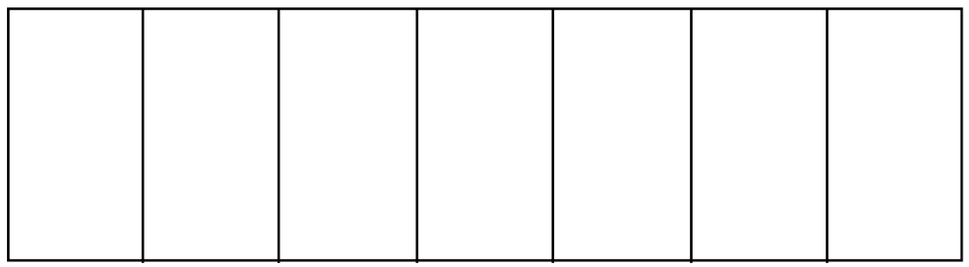


what caching algorithm to used?

2Q

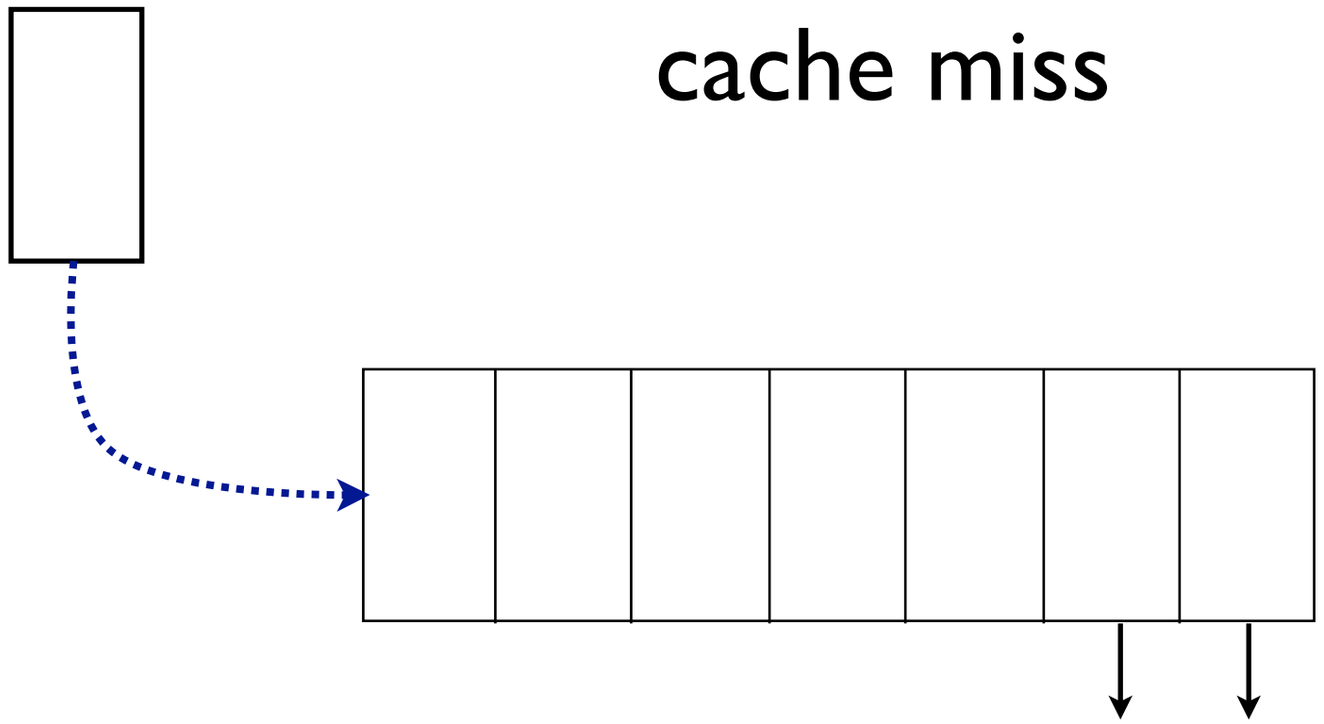


FIFO

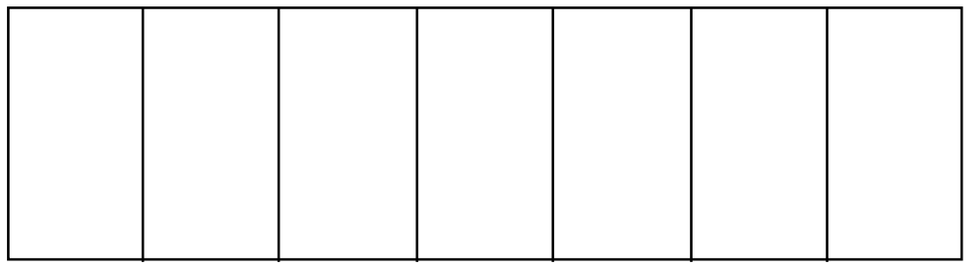


LRU

cache miss

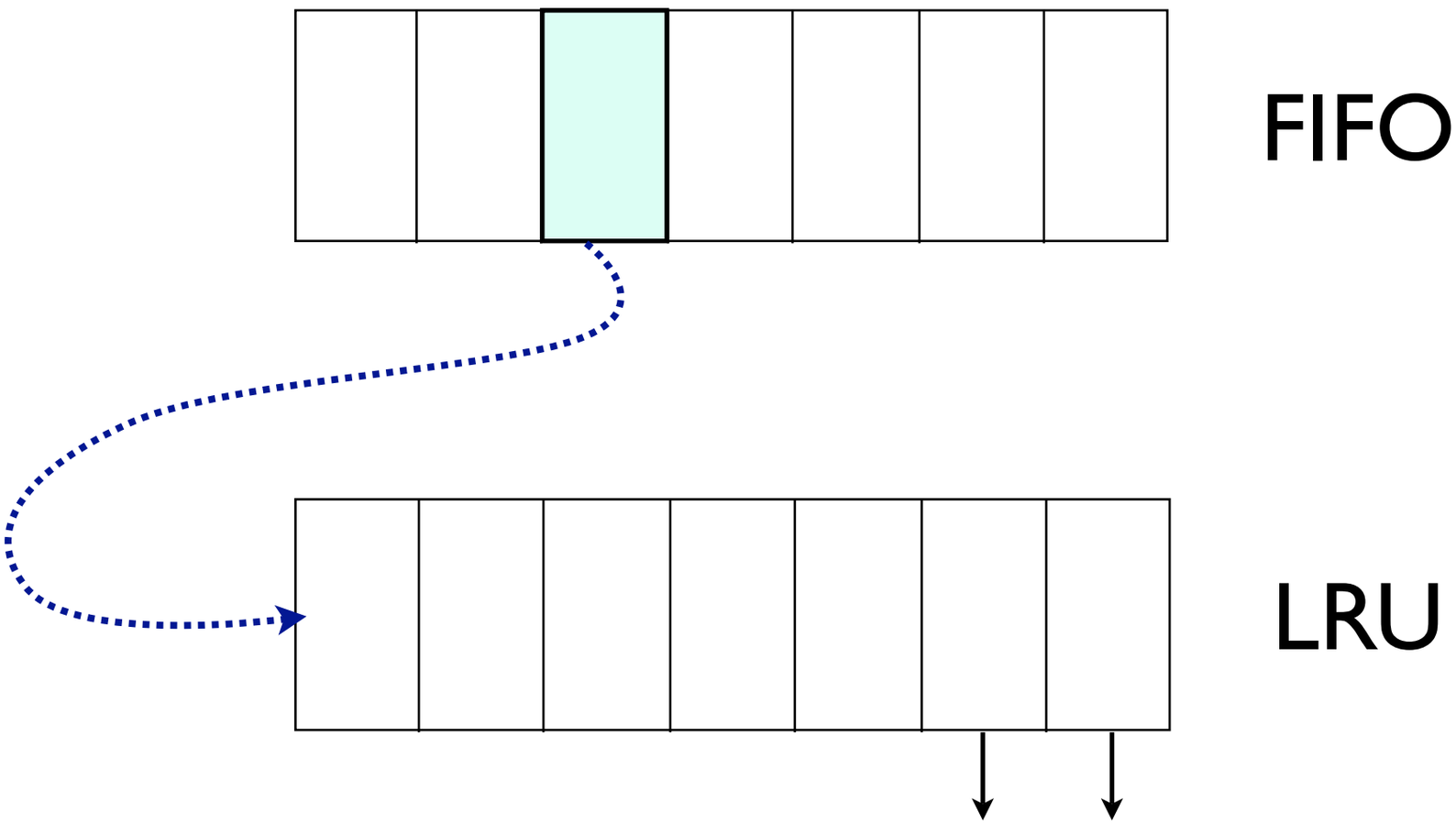


FIFO

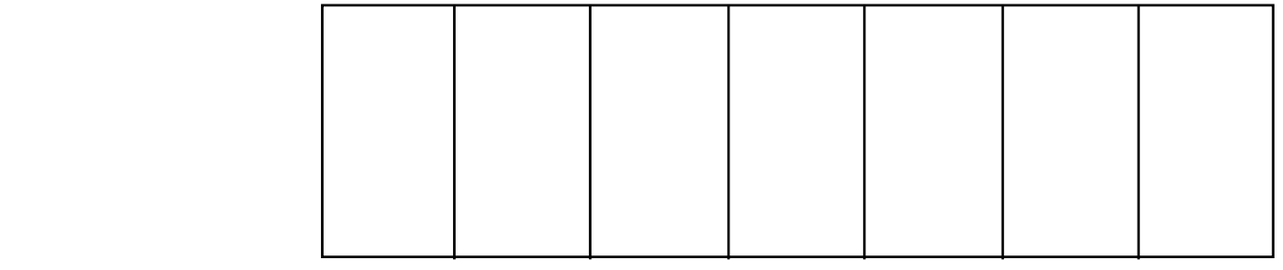


LRU

cache hit



cache hit



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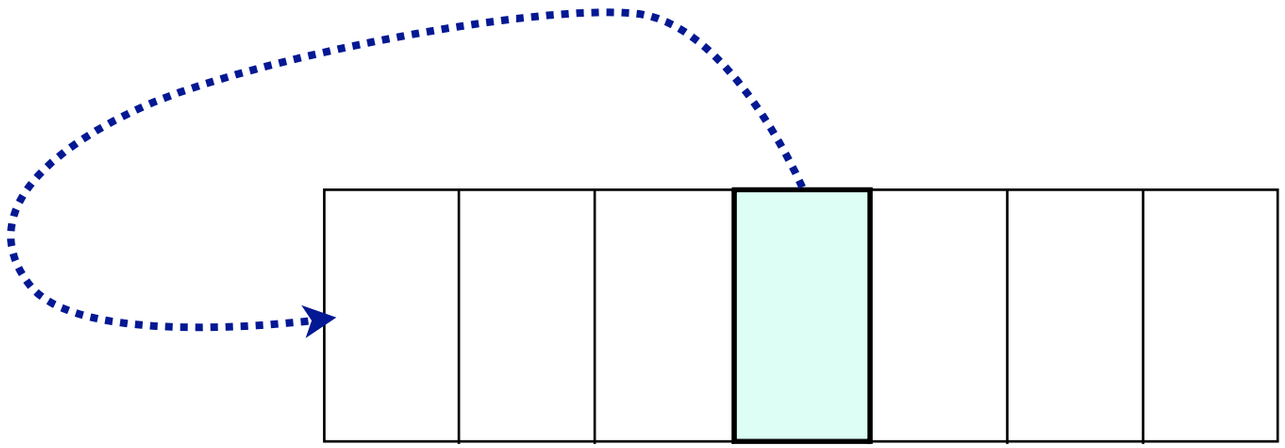
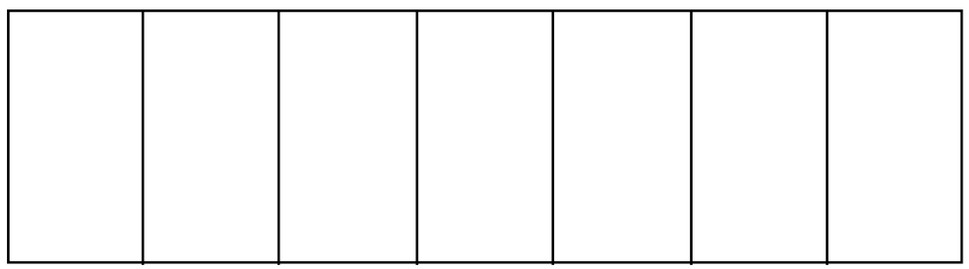


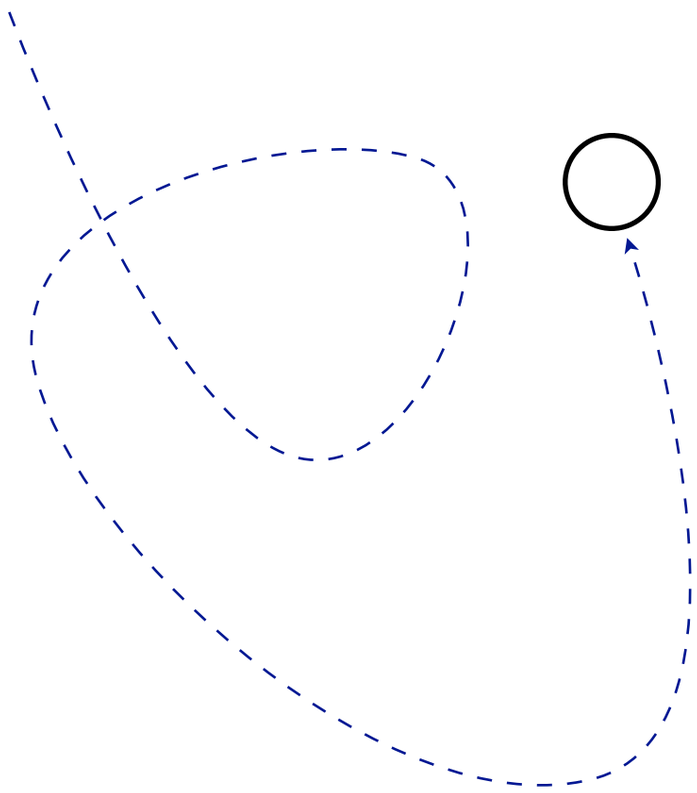
LRU

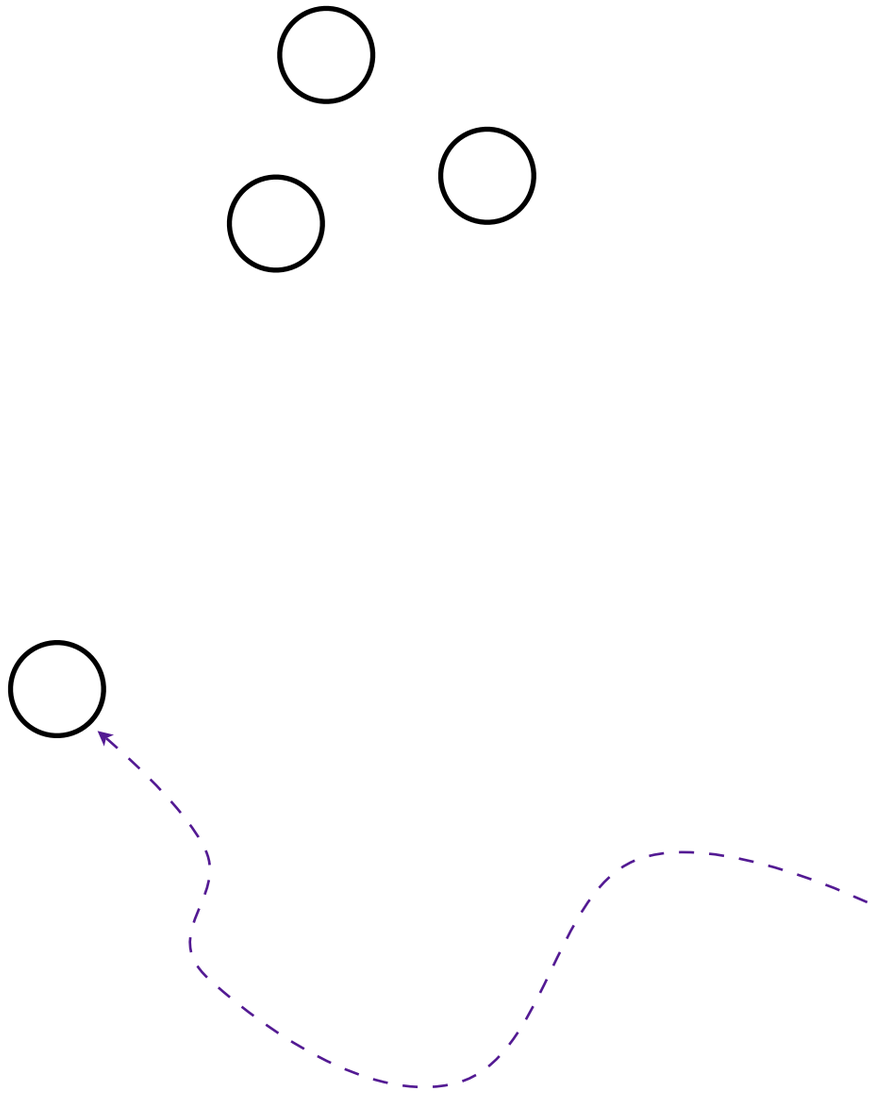
scan resistant

FIFO



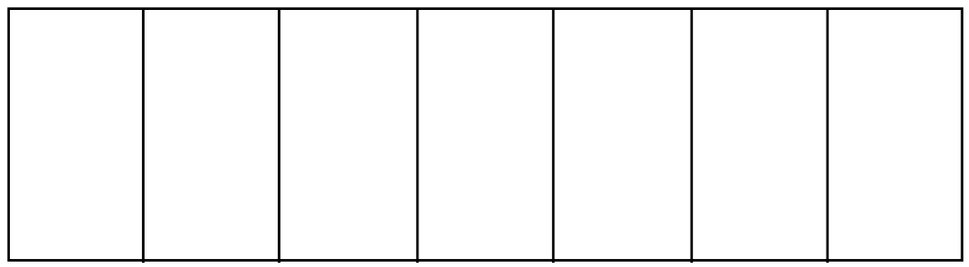
LRU





3Q

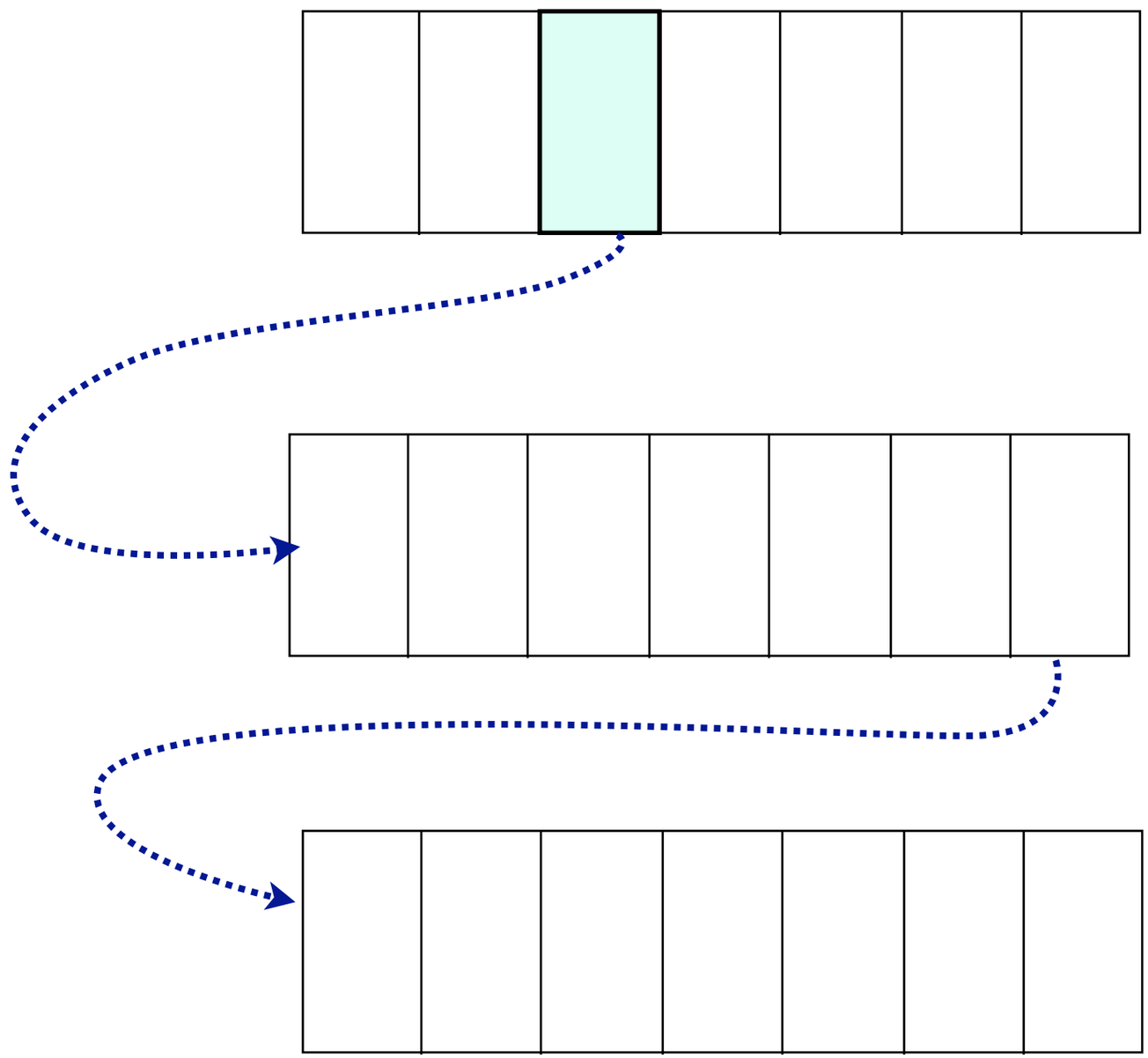
FIFO



LRU

Victim Buffer

cache hit



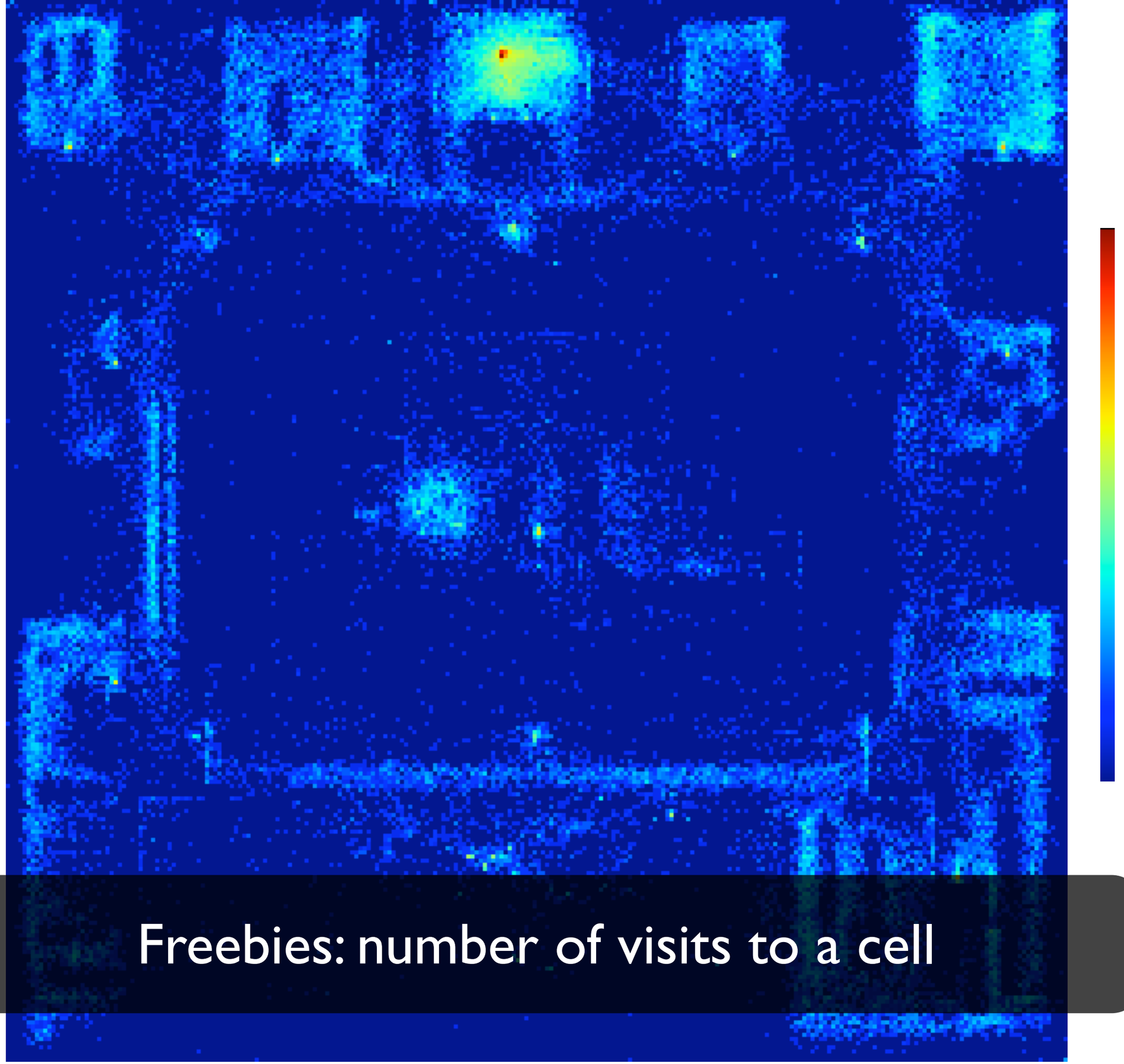
FIFO

LRU

Victim Buffer

(sorted by popularity)

how to define popularity of texture?



Freebies: number of visits to a cell

little temporal variations

can use historical information to predict future

popularity of texture =

popularity of cell

Per-byte Hit Rate

		2Q	3Q	OPT
Ross	50 MB	0.58	0.62	0.70
Ross	25 MB	0.28	0.36	0.47
Freebies	50 MB	0.48	0.50	0.68
Freebies	25 MB	0.21	0.33	0.50

conclusion

understanding real avatar mobility is crucial to design good NVEs

謝謝

歡迎發問及指教

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