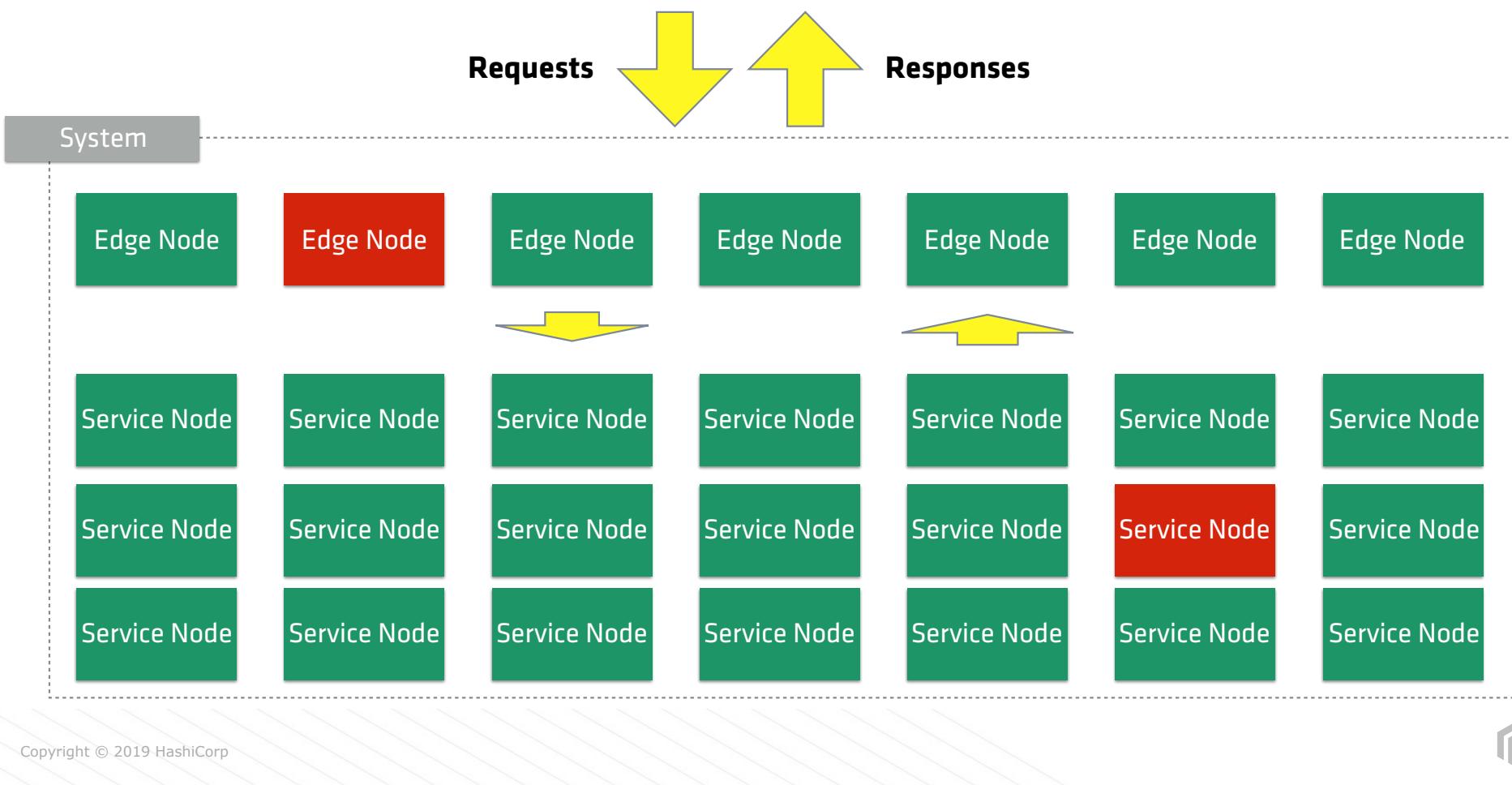


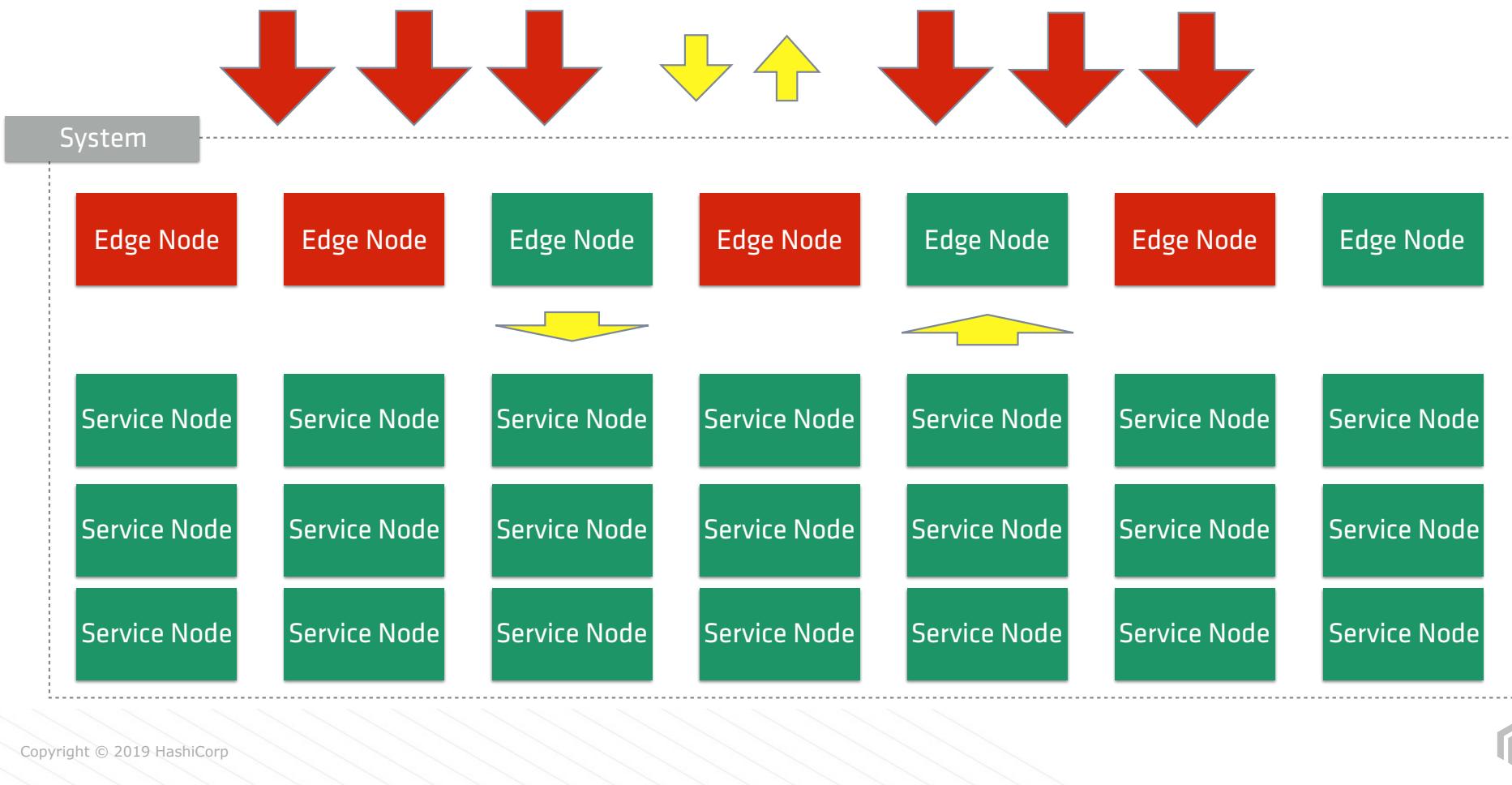
# **Using Randomized Communication for Robust, Scalable Systems**

Jon Currey, HashiCorp

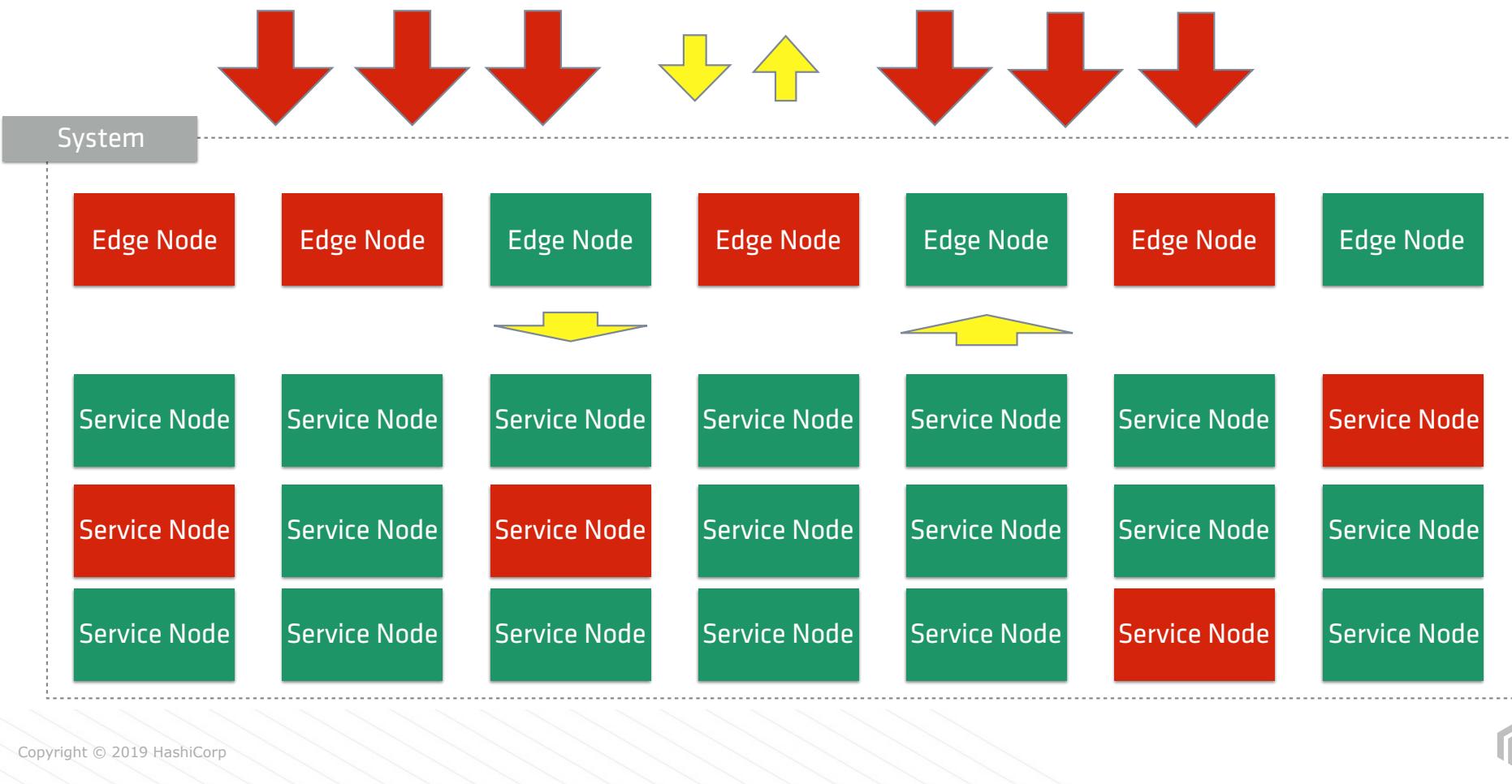
# Service Discovery and Failure Detection



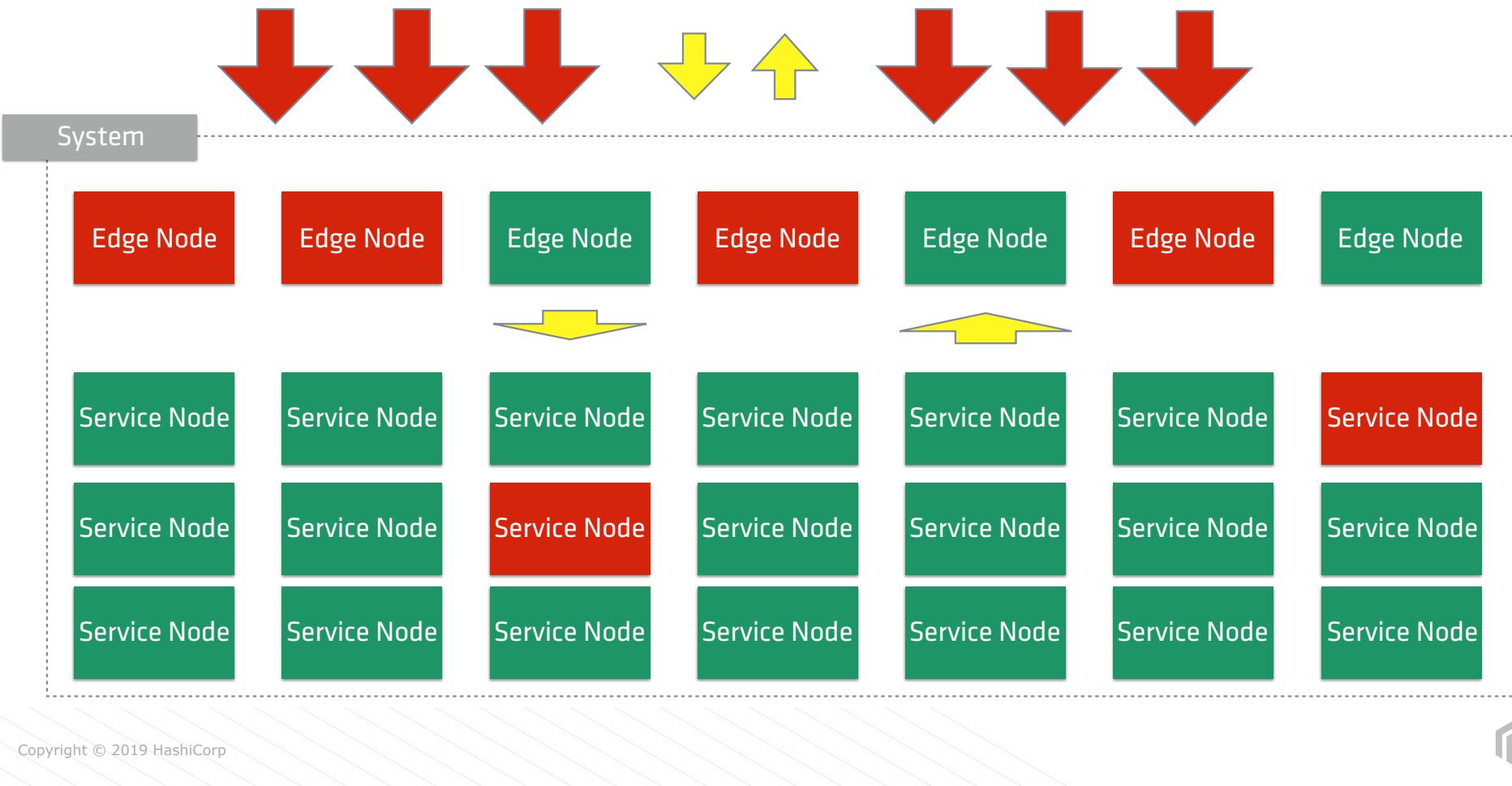
# DDoS Attack



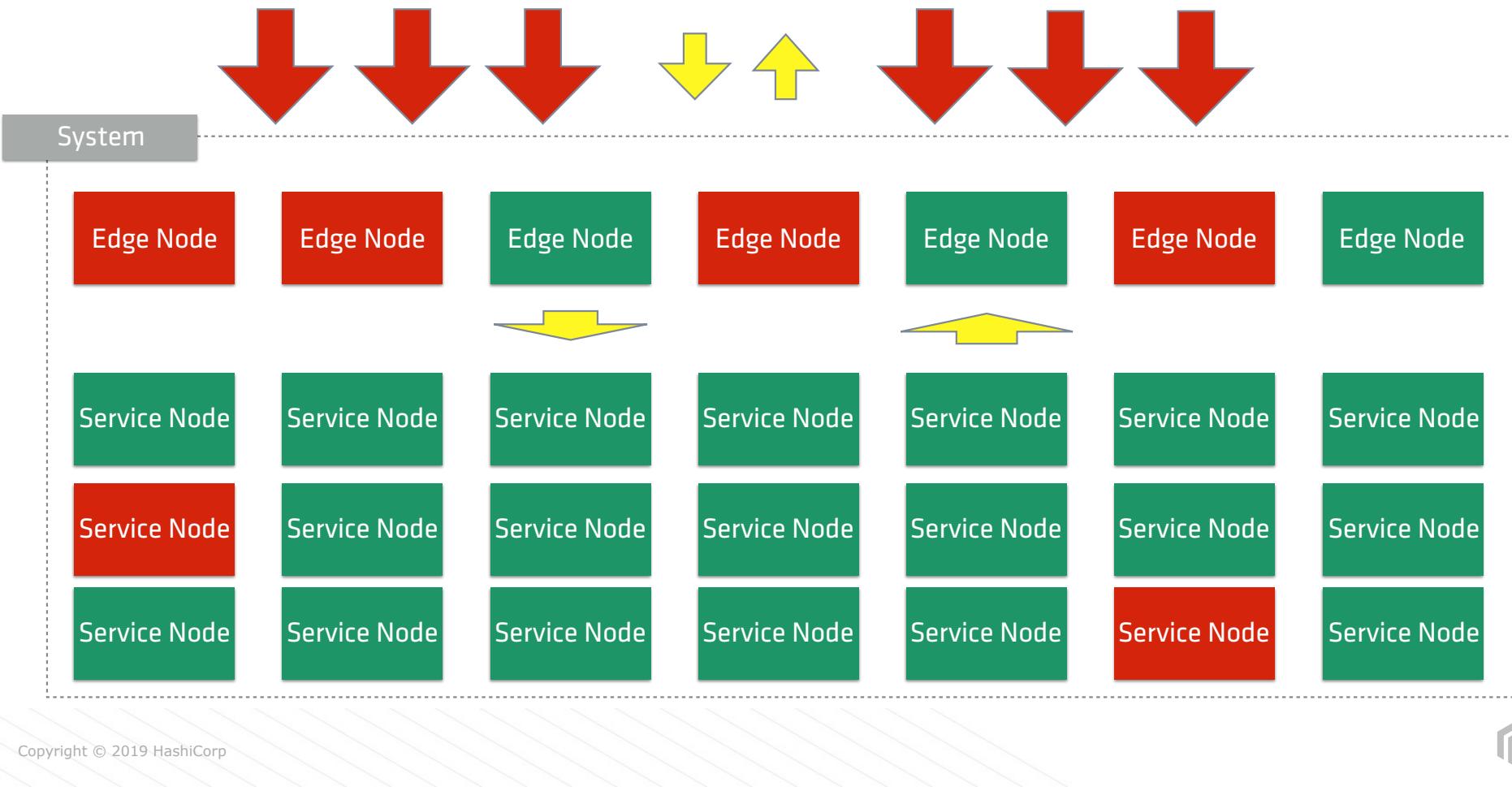
# Unexpected Behaviour



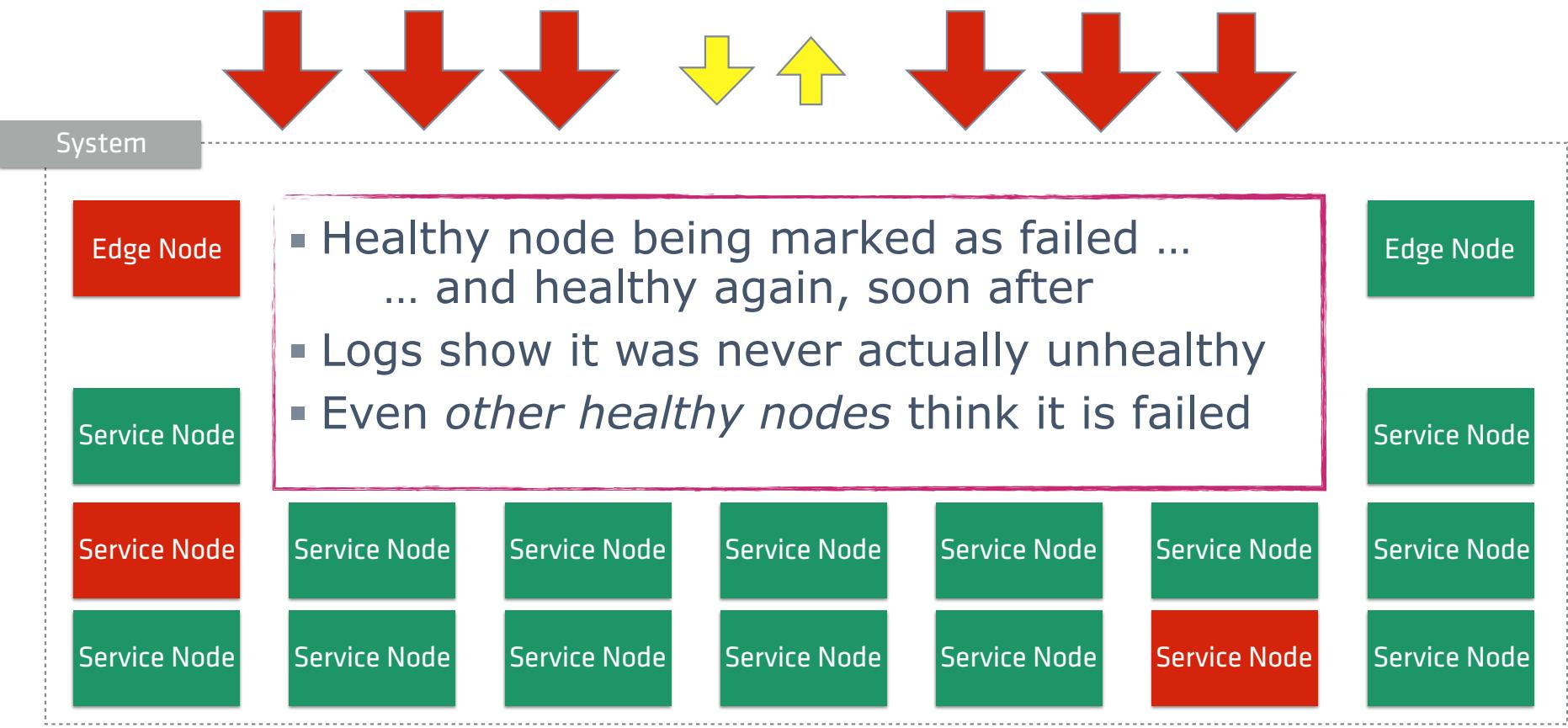
# Unexpected Behaviour



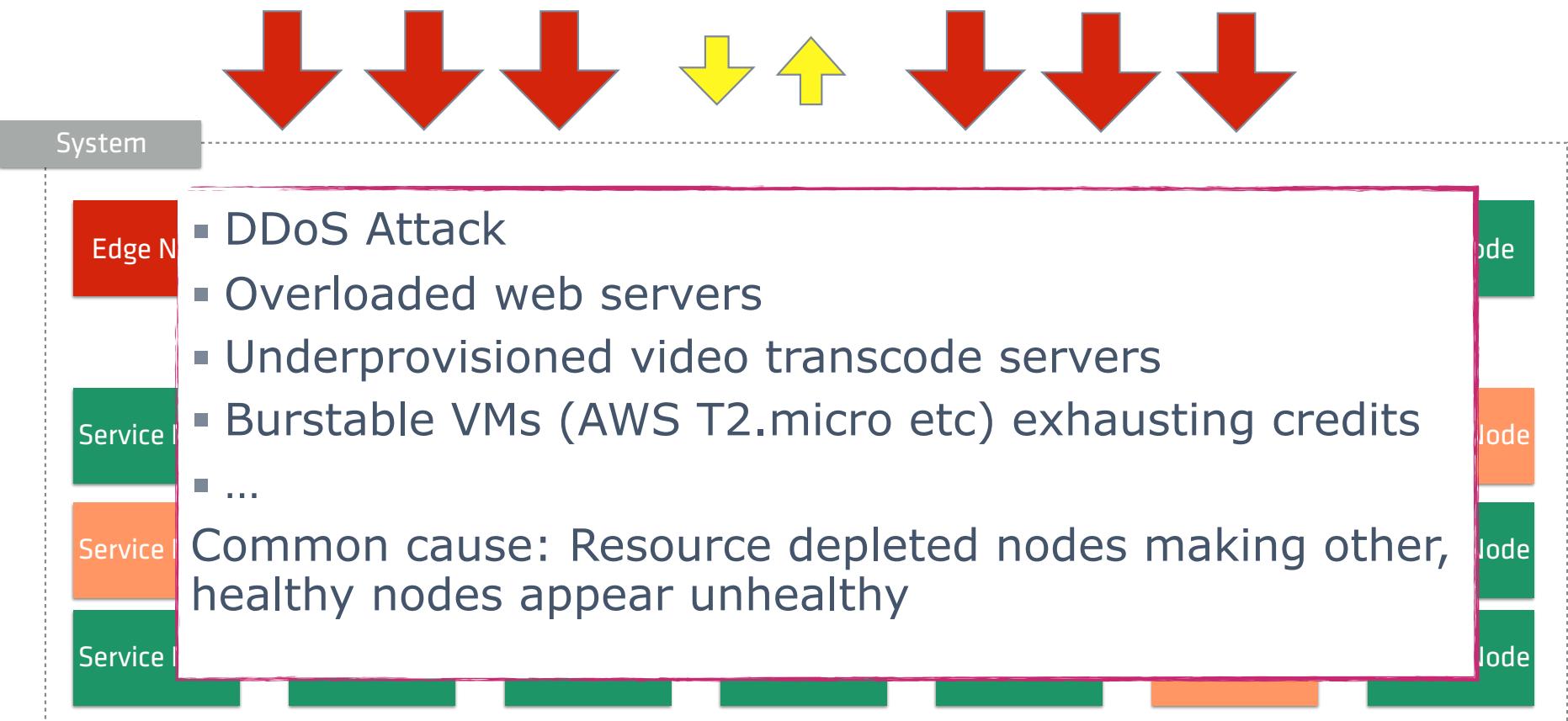
# Unexpected Behaviour



# 'Flapping' Nodes



# Many Scenarios ... Common Cause



# Agenda

**Using randomization to build robust and scalable systems**

# Agenda + Meta-Agenda

**Using randomization to build robust and scalable systems**

**Leveraging academic research in production systems**

# Jon Currey - Industrial Researcher

≡ Google Scholar



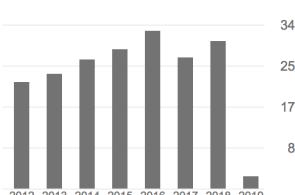
**Jon Currey**  
HashiCorp Research  
Verified email at hashicorp.com  
Distributed Systems and M...

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TITLE	CITED BY	YEAR
DryadLINQ: A system for general-purpose distributed data-parallel computing using a high-level language YYMID Fetterly, M Budiu, Ú Erlingsson, PKGJ Currey Proc. LSDS-IR 8	891	2009
Quincy: fair scheduling for distributed computing clusters M Isard, V Prabhakaran, J Currey, U Wieder, K Talwar, A Goldberg Proceedings of the ACM SIGOPS 22nd symposium on Operating systems principles ...	830	2009
PTask: operating system abstractions to manage GPUs as compute devices CJ Rossbach, J Currey, M Silberstein, B Ray, E Witchel Proceedings of the Twenty-Third ACM Symposium on Operating Systems ...	222	2011
An introduction to computational networks and the computational network toolkit D Yu, A Eversole, M Seltzer, K Yao, Z Huang, B Guenter, O Kuchalev, ... Microsoft Technical Report MSR-TR-2014-112	215	2014
Dandelion: a compiler and runtime for heterogeneous systems CJ Rossbach, Y Yu, J Currey, JP Martin, D Fetterly Proceedings of the Twenty-Fourth ACM Symposium on Operating Systems ...	110	2013
System and method for logging messages in an embedded computer system JJ Currey, JE Rodriguez, RM Jensen, KR Black US Patent 6,769,079	35	2004
System and method for adding transport protocols in distributed middleware applications KR Black, RM Jensen, JE Rodriguez, JJ Currey US Patent 7,010,609	17	2006
Some sample programs written in DryadLINQ Y Yu, M Isard, D Fetterly, M Budiu, Ú Erlingsson, PK Gunda, J Currey, ... Tech. Rep. MSR-TR-2008-74, Microsoft Research	15	2008

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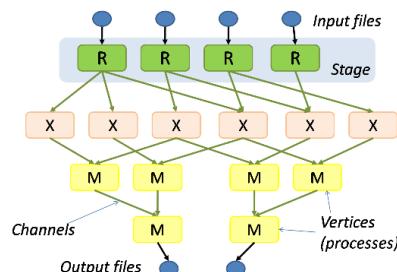
**Co-authors**

 CHRISTOPHER J. ROSSBACH University of Texas at Austin and...
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 Úlfar Erlingsson Research Scientist, Google Brain
 Michael Isard Research Scientist, Google
 Andrew V. Goldberg Senior Principal Scientist, Amaz...

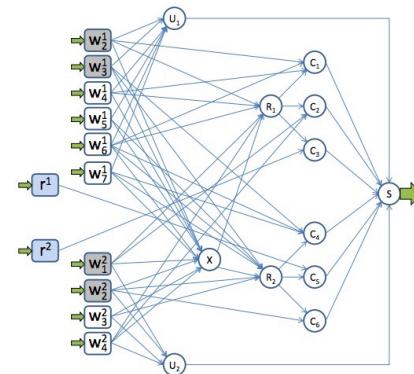
Microsoft®

# Research

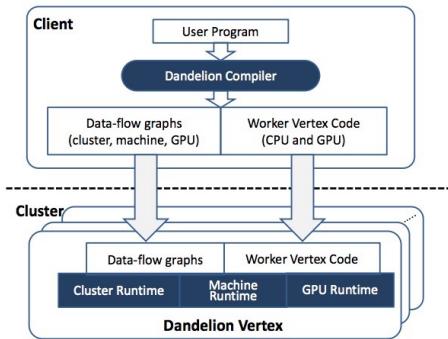
## Dryad/DryadLINQ Distributed Dataflow



## Quincy Scheduler



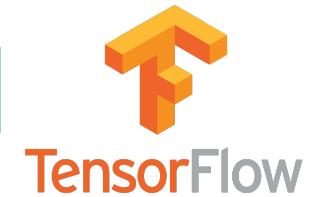
## PTask/Dandelion GPU Cluster Computation



Used by



Influenced



# Production Engineering



ORACLE®

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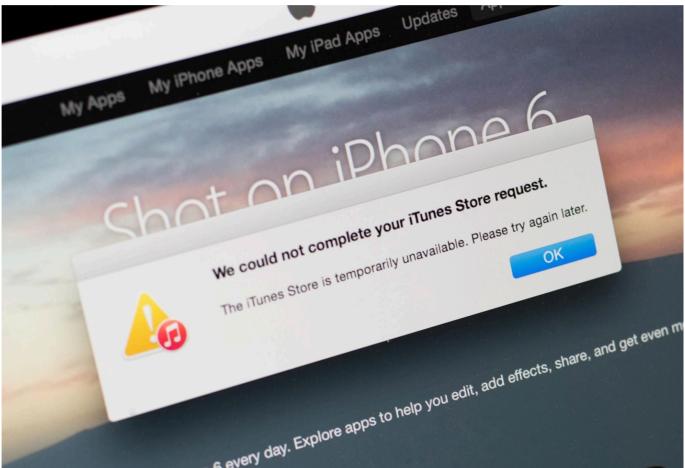
# School of Hard Knocks

IT'S NOT JUST YOU

## iTunes Store, App Store hit with extended outage [Update]

Apple is currently dealing with an extended outage for many of its online services, including its iOS App Store and its Mac App Store.

JOHN CALLAHAM 11 Mar 2015



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## Citi bond traders indicted over 'Dr Evil' trade

19 July 2007



0



0



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Italian magistrates have indicted seven former Citigroup traders on charges of market manipulation in the sale and repurchase of government bonds on the MTS electronic fixed income network three years ago.

According to a Reuters report the traders, who are no longer employed by Citigroup, will stand trial on charges of market manipulation. The trial is scheduled to begin on 30 October.

The market was thrown into confusion on 2 August 2004 when Citigroup pushed through EUR11 billion in paper sales in two minutes over the automated MTS platform. As the value of

# HashiCorp



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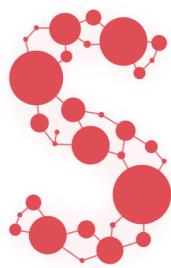
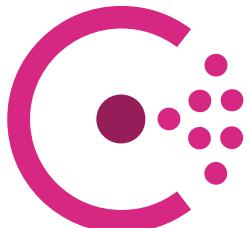
**Nomad**



HashiCorp

**Consul**

# Consul, Serf ... and memberlist too



 [hashicorp / memberlist](#)

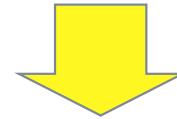
- Consul
  - KV store
  - *Strong consistency* via Raft protocol
  - mesh networking ...
- Serf
  - **Service discovery (*weakly consistent*)**
  - **Service and node health checks**
  - **Network distance**
  - ...
- memberlist
  - **Group membership**
  - **Failure detection**

# Discovery and Failure-Detection Requirements

- **Robust**
  - To both node and network failures
- **Scalable**
- **Simple**
  - Easier to implement >> Less likelihood of bugs
  - Easier to manage >> Less likelihood of misconfiguration

# **Product Requirements and Research**

**Product requirements**



**Criteria for research  
discovery and evaluation**

# Product Requirements and Research

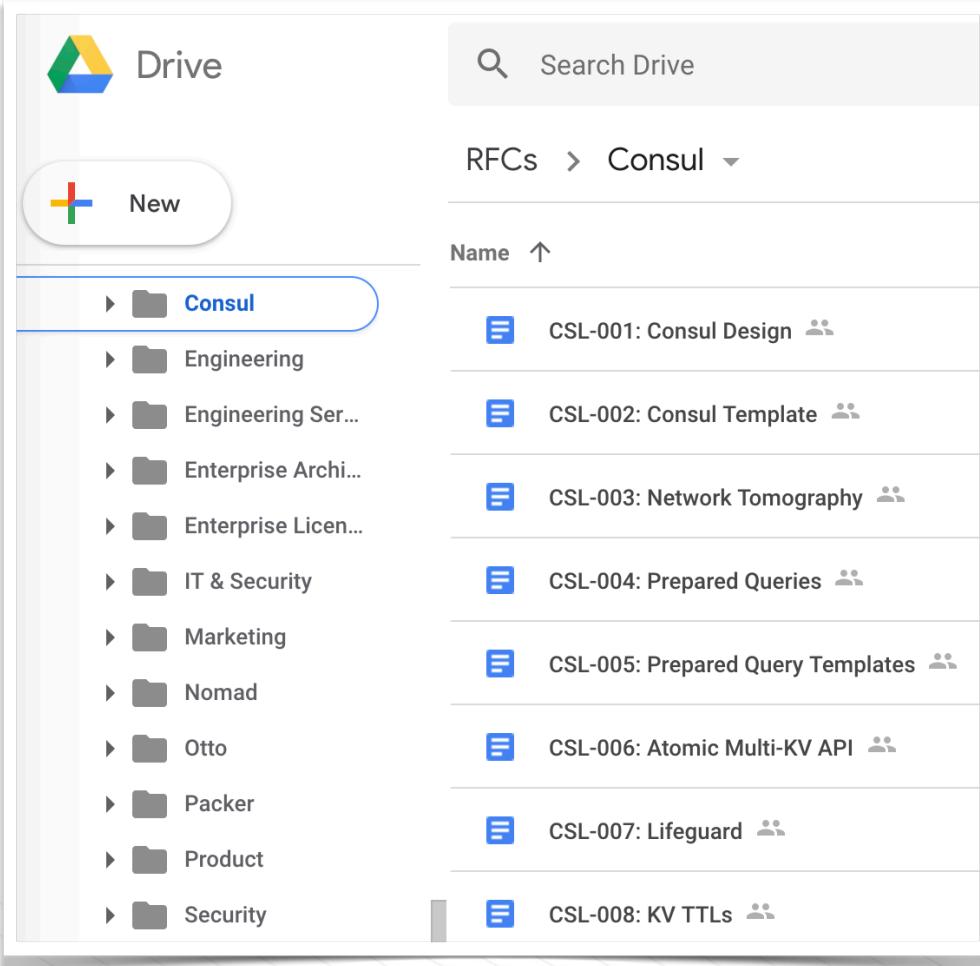
Product requirements



Criteria for research  
discovery and evaluation

*Consuming research will inform your product decisions*

# Research-Aware Design Process



- Research section in design documents (if relevant)
  - Collate papers - *with backlog*
  - Summarize
  - Pros and cons
  - Trade-offs made
- Evaluate against product requirements
- c.f. competitive and market analysis

# Research on the Internet

- **Google**
- **Research Databases** (many with *recommendation systems*)
  - arXiv, DBLP, Google Scholar, ResearchGate, Semantic Scholar ...
- **Websites**
  - Associations and publishers: ACM, IEEE, USENIX, ...
  - Labs + professors + students
  - Personal blogs
- **Twitter**

# Research as a Knowledge Graph

The screenshot shows the ResearchGraph website. At the top, there is a navigation bar with links for HOME, SCHEMA, COLLABORATORS, PUBLICATIONS, and EOI. Below the navigation bar, the title "What is Research Graph?" is displayed. A descriptive text explains that Research Graph is an open collaborative project building a capability for connecting researchers, publications, research grants and research datasets. It includes a graph database, open source tools, and cloud-based services. Below the text is a large circular knowledge graph visualization. The graph consists of numerous blue nodes connected by lines, representing entities. Three specific nodes are highlighted: a green central node, an orange node on the left, and a yellow node on the right. Below the graph, a schema diagram is shown with the following sequence of nodes and relationships: (Grant) → [Awarded To] → (Researcher) → [Author Of] → (Publication).

[researchgraph.org](http://researchgraph.org)

Copyright © 2019 HashiCorp

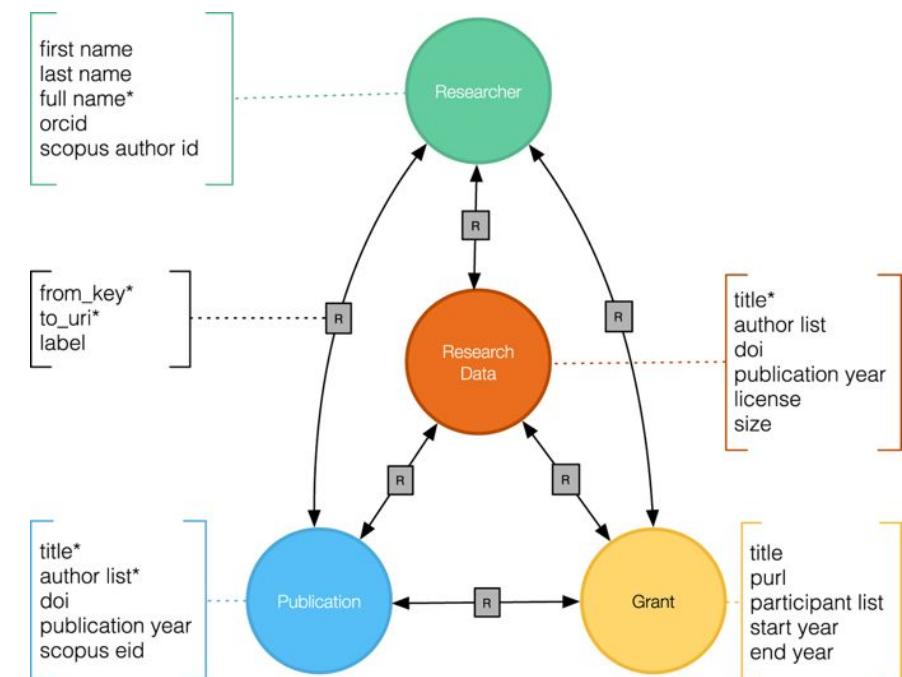
- **Entities** (graph nodes)
  - Person
    - Advisor, Student, ...
  - Institution
    - University, Company, ...
  - Paper
  - Conference
- **Relationships** (graph edges)
  - Advised by
  - Published at
  - **Cites (reference)**



# Research as a Knowledge Graph

The screenshot shows a web page from <https://www.nature.com/articles/sdata201899>. The page title is "A Research Graph dataset for connecting research data repositories using RD-Switchboard". It features a "Researcher" node (green), a "Research Data" node (orange), a "Publication" node (blue), and a "Grant" node (yellow). Nodes are interconnected by arrows labeled "R". Callout boxes provide specific field names for each node type:

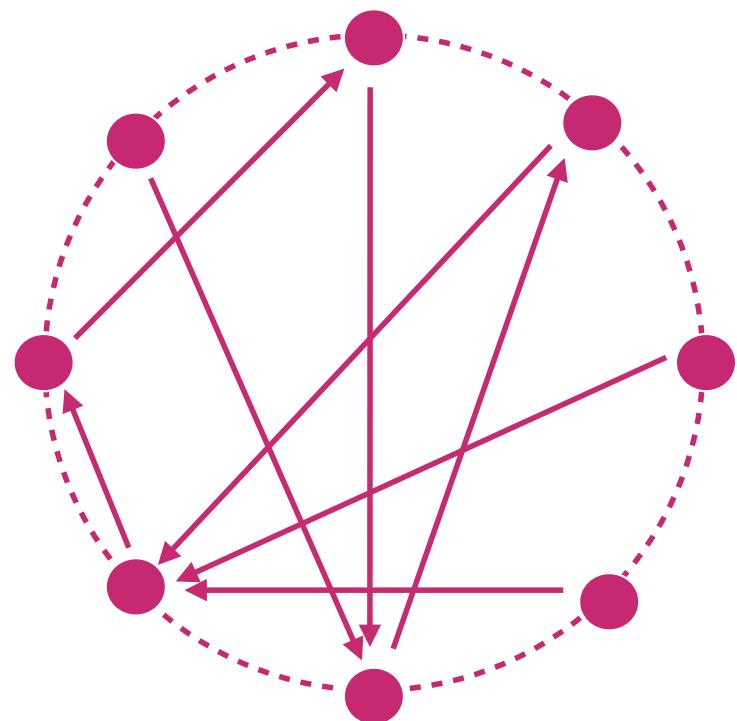
- Researcher:** first name, last name, full name\*, orcid, scopus author id
- Research Data:** from\_key\*, to\_uri\*, label
- Publication:** title\*, author list\*, doi, publication year, scopus eid
- Grant:** title, purl, participant list, start year, end year



# Group Membership Protocols

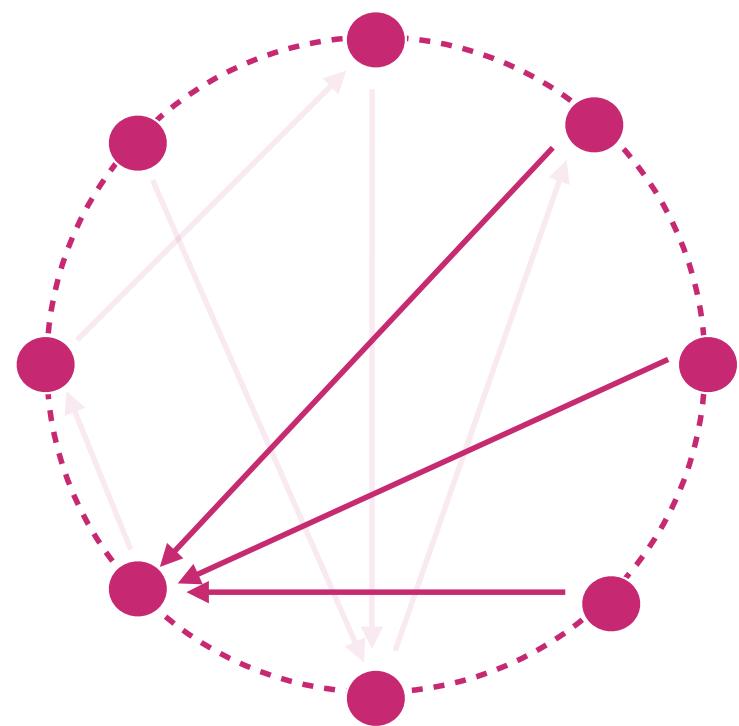
- Dynamic group of members ('processes')
- **Discovery**
  - New member joins group...
  - *Discovers* other members of the group
  - *Discovered* by other members
- **Failure Detection**

# Peer Failure Detection



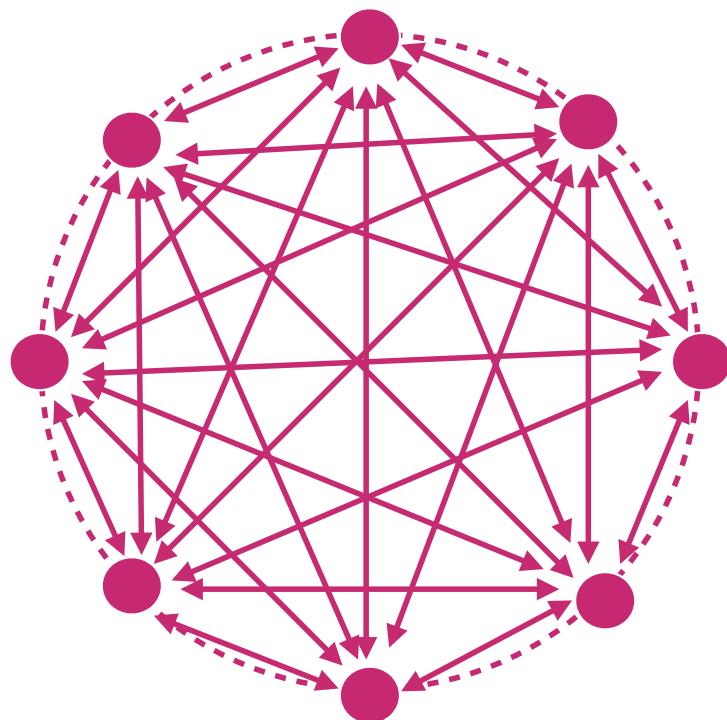
- *Processes monitor one another*
- *No special nodes to administer*

# Peer Failure Detection



- Processes monitor one another
  - No special nodes to administer
  - ***Redundant monitoring***

# Simple But Not Scalable



Heartbeat Membership and Failure Detection (circa 1996)

- Every node sends a regular heartbeat message ...  
*to every other node ('full mesh')*
- Receive a heartbeat from you?
  - "You're alive"
- Miss (a few?) heartbeats
  - "You're dead!"
- Message load  **$O(n^2)$**

# SWIM (IEEE DSN 2002)

## SWIM: Scalable Weakly-consistent Infection-style Process Group Membership Protocol

Abhinandan Das, Indranil Gupta, Ashish Motivala\*  
Dept. of Computer Science, Cornell University  
Ithaca NY 14853 USA  
{asdas,gupta,ashish}@cs.cornell.edu

### Abstract

*Several distributed peer-to-peer applications require weakly-consistent knowledge of process group membership information at all participating processes. SWIM is a generic software module that offers this service for large-scale process groups. The SWIM effort is motivated by the unscalability of traditional heart-beating protocols, which either impose network loads that grow quadratically with group size, or compromise response times or false positive frequency w.r.t. detecting process crashes. This paper reports on the design, implementation and performance of the SWIM sub-system on a large cluster of commodity PCs.*

### 1. Introduction

*As you swim lazily through the milieu,  
The secrets of the world will infect you.*

Several large-scale peer-to-peer distributed process groups running over the Internet rely on a distributed membership maintenance sub-system. Examples of existing middleware systems that utilize a membership protocol include reliable multicast [3, 11], and epidemic-style information dissemination [4, 8, 13]. These protocols in turn find use in applications such as distributed databases that need to reconcile recent disconnected updates [14], publish-subscribe systems, and large-scale peer-to-peer systems[15]. The performance



# SWIM: What's In A Name?

- **S**calable
  - *Fixed* per node number of messages, not  $\propto \# \text{ nodes}$
  - Message load  $O(n)$ , not  $O(n^2)$
- **W**eakly-consistent
  - Nodes don't all have to see same state simultaneously
  - Converge to same view (quickly)
- **I**nfection-style
  - Gossip (aka 'epidemic') spread of information
- **M**embership

# For a Detailed Explanation ...

The screenshot shows a video player interface for HashiConf '17. The main content is a slide titled "Actual Behavior: Node Flapping". The slide illustrates a cluster structure with Edge Nodes at the top level and Service Nodes at the bottom level. Red arrows point downwards from the Edge Nodes, indicating they are sending gossip. Two yellow arrows show bidirectional communication between two adjacent Service Nodes. A small circular icon with a dot and a line is in the top right corner. The video player includes a progress bar at 4:54 / 38:55, standard video controls (play, pause, volume), and the HashiCorp logo.

Actual Behavior: Node Flapping

Cluster

Edge Node Edge Node Edge Node Edge Node Edge Node Edge Node Edge Node

Service Node Service Node Service Node Service Node Service Node Service Node Service Node

Service Node Service Node Service Node Service Node Service Node Service Node Service Node

Service Node Service Node Service Node Service Node Service Node Service Node Service Node

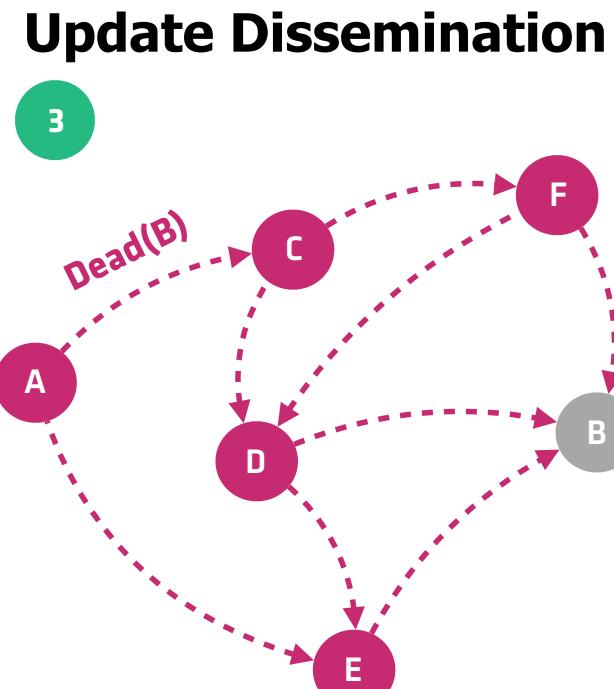
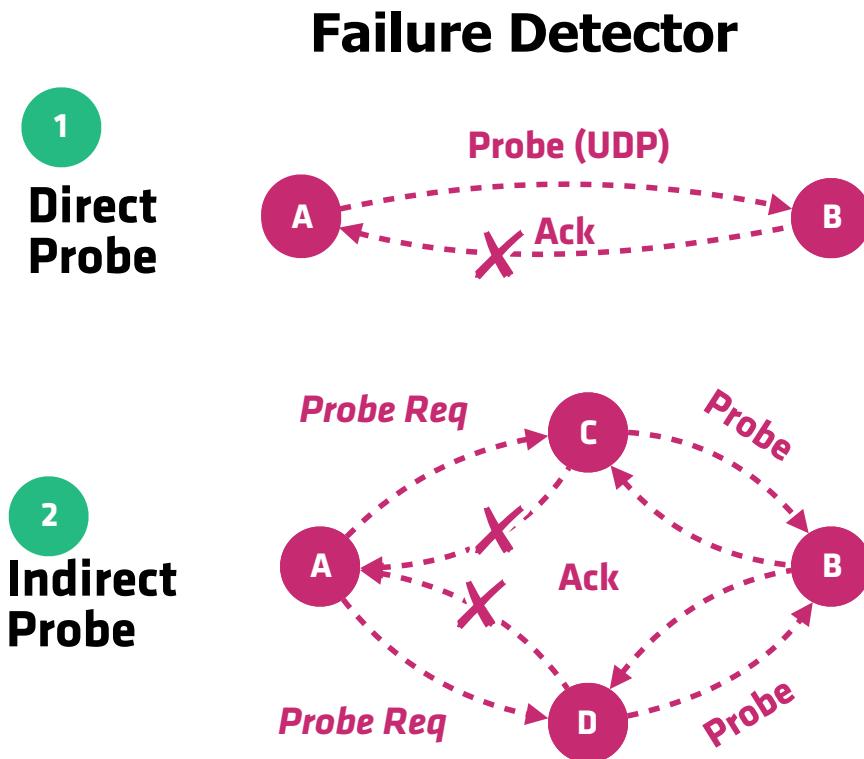
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HashiConf '17

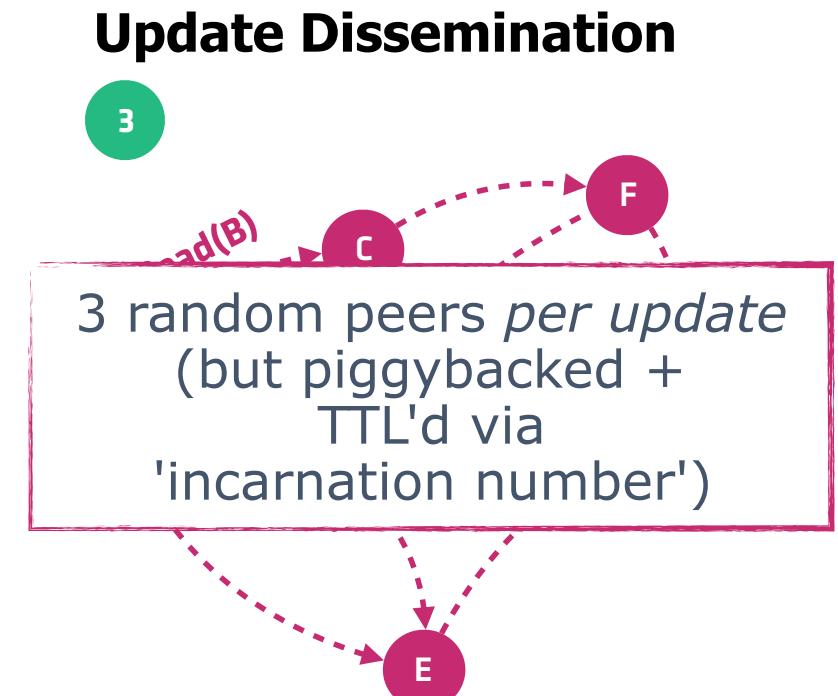
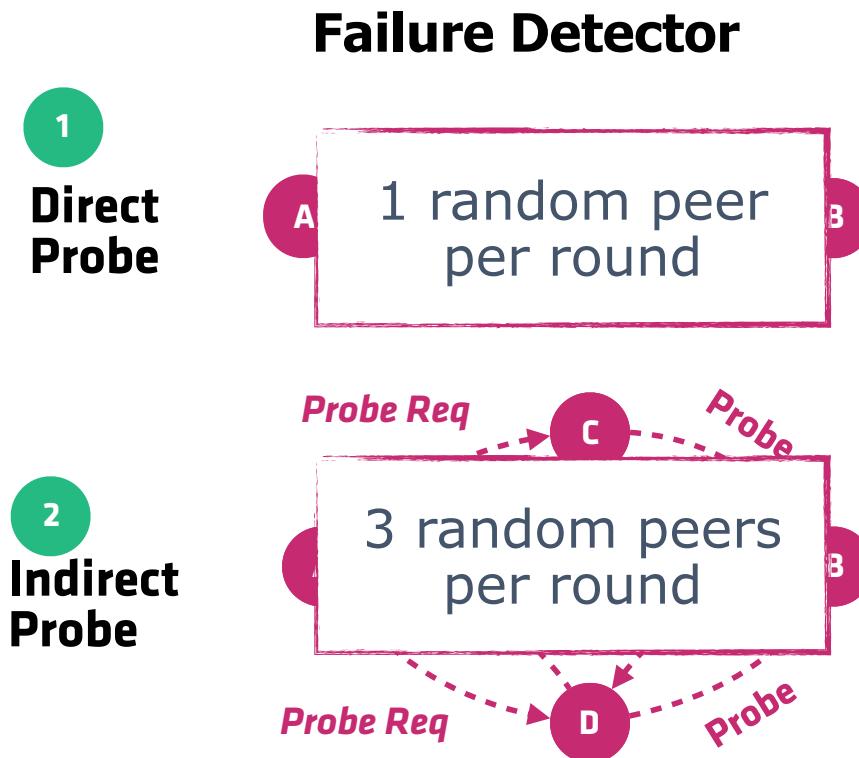
4:54 / 38:55

Making Gossip More Robust with Lifeguard

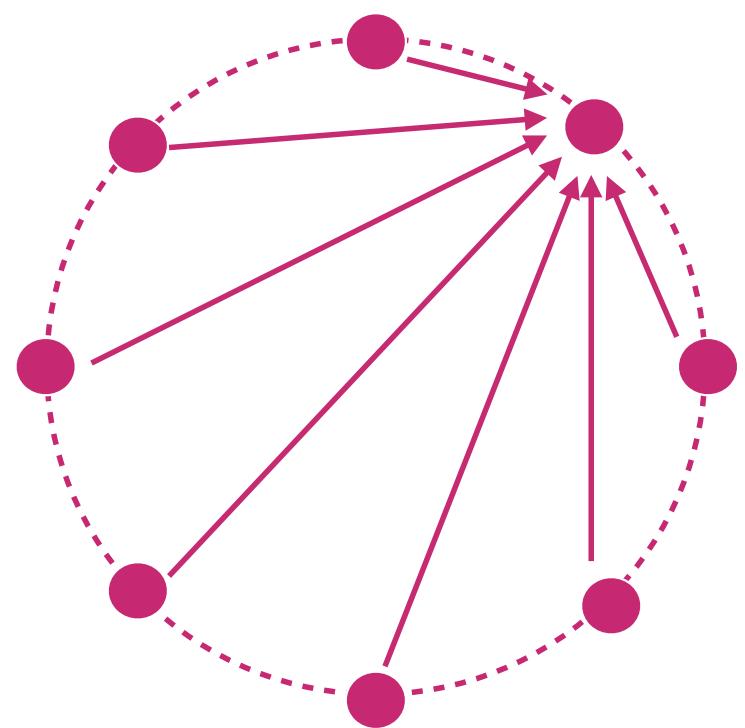
# SWIM Protocol Components



# SWIM's Use of Randomization

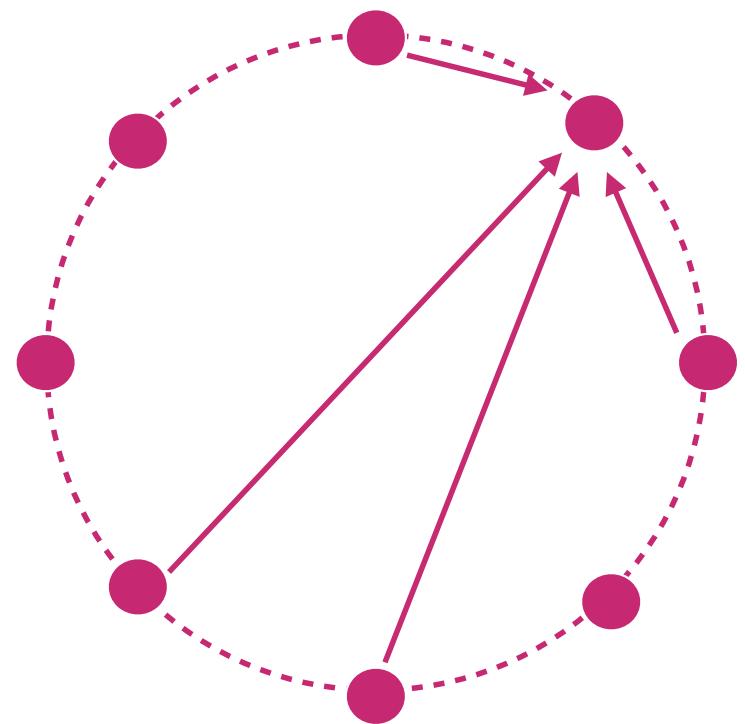


# Randomization Keeps SWIM Robust (and Simple)



Reduce communication (for scalability)  
without randomization?

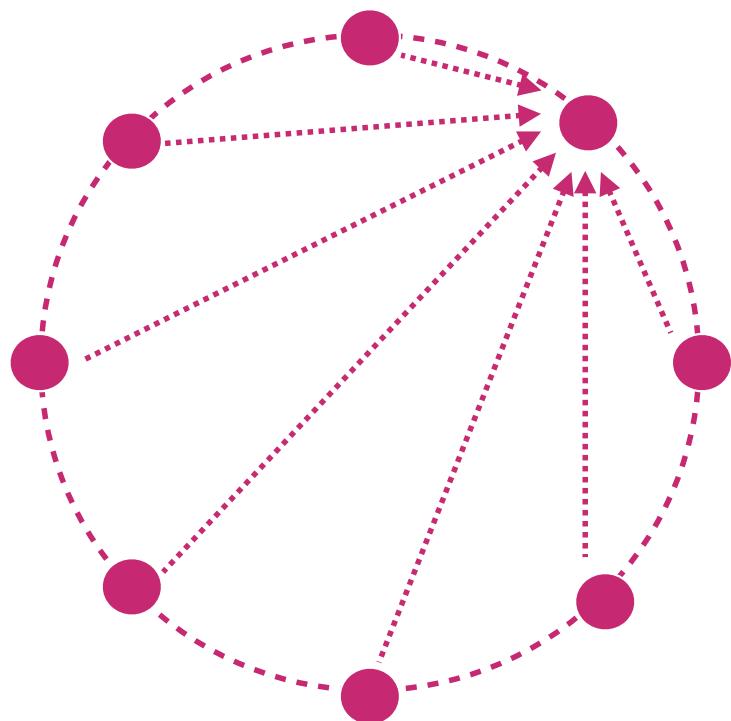
# Randomization Keeps SWIM Robust (and Simple)



Reduce communication (for scalability) without randomization?

- Greatly increased chance of missed failures (aka 'false negatives')

# Randomization Keeps SWIM Robust (and Simple)



Reduce communication (for scalability) without randomization?

- Greatly increased chance of missed failures (aka 'false negatives')

With randomization

- Each node is ***still checked by every other node*** ... just not so often
  - Much less chance of false negatives
  - No special nodes or node hierarchies to maintain after node failures

# SWIM Has Worked Out

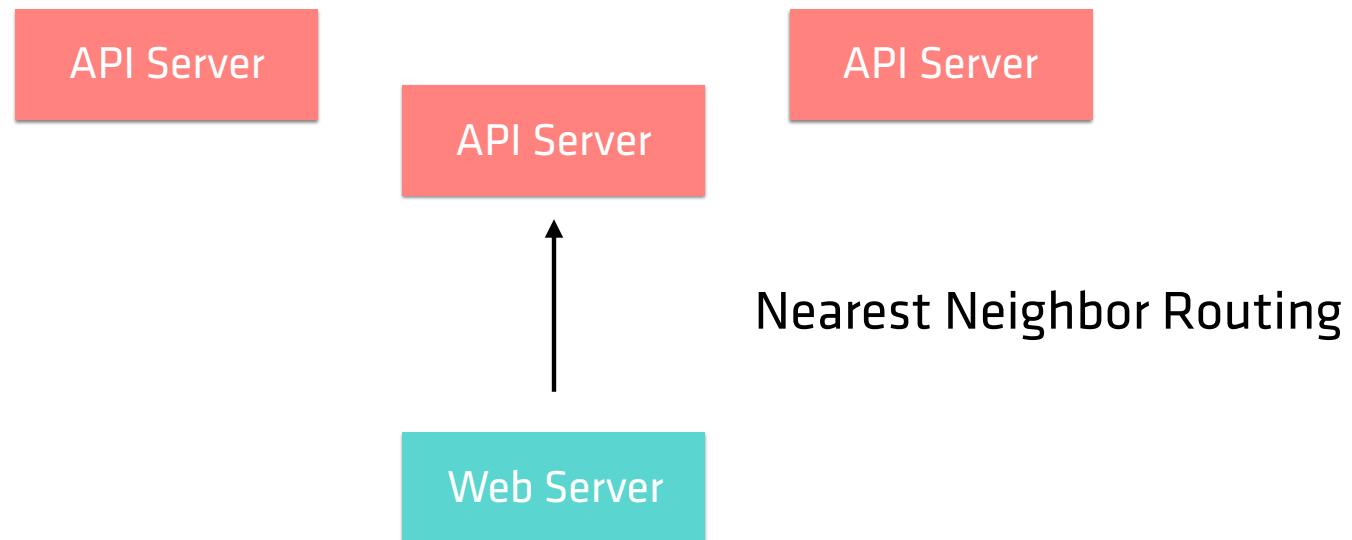
## Bloomberg's Consul Story: To 20,000 Nodes and Beyond

Hear the story of how Bloomberg used Consul to create their own service discovery SaaS for their heterogeneous IT environment.

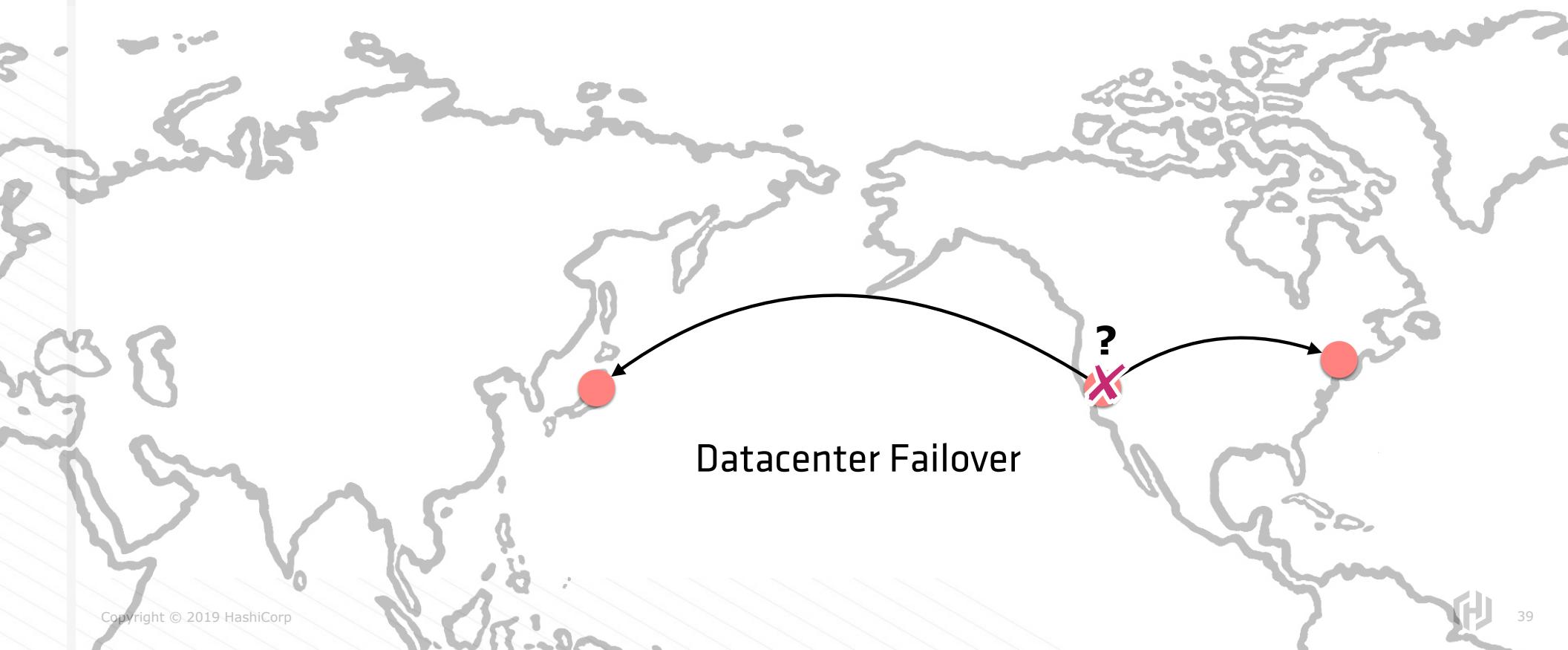


# 18 Months Later ...

# Network Distance for Load Balancing



# Network Distance for Disaster Recovery



# Network Distance

## Consul RTT

Command: `consul rtt`

The `rtt` command estimates the network round trip time between two nodes using Consul's network coordinate model of the cluster.

See the [Network Coordinates](#) internals guide for more information on how these coordinates are computed.

## Usage

Usage: `consul rtt [options] node1 [node2]`

At least one node name is required. If the second node name isn't given, it is set to the agent's node name. These are the node names as known to Consul as the `consul members` command would show, not IP addresses.

# Vivaldi: Network Coordinates

## Vivaldi: A Decentralized Network Coordinate System

Frank Dabek, Russ Cox, Frans Kaashoek, Robert Morris

MIT CSAIL  
Cambridge, MA

fdabek,rsc,kaashoek,rtm@mit.edu

### ABSTRACT

Large-scale Internet applications can benefit from an ability to predict round-trip times to other hosts without having to contact them first. Explicit measurements are often unattractive because the cost of measurement can outweigh the benefits of exploiting proximity information. Vivaldi is a simple, light-weight algorithm that assigns synthetic coordinates to hosts such that the distance between the coordinates of two hosts accurately predicts the communication latency between the hosts.

Vivaldi is fully distributed, requiring no fixed network infrastructure and no distinguished hosts. It is also efficient: a new host can compute good coordinates for itself after collecting latency information from only a few other hosts. Because it requires little communication, Vivaldi can piggy-back on the communication patterns of the application using it and scale to a large number of hosts.

An evaluation of Vivaldi using a simulated network whose latencies are based on measurements among 1740 Internet hosts shows that a 2-dimensional Euclidean model with *height vectors* embeds these hosts with low error (the median relative error in round-trip time prediction is 11 percent).

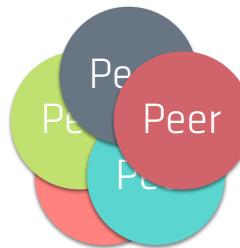
synthetic coordinates in some coordinate space such that distance between two hosts' synthetic coordinates predicts the RTT between them in the Internet. Thus, if a host  $x$  learns the coordinates of a host  $y$ ,  $x$  doesn't have to perform an explicit measurement to determine the RTT to  $y$ ; instead, the distance between  $x$  and  $y$  in the coordinate space is an accurate predictor of the RTT.

The Internet's properties determine whether synthetic coordinates are likely to work well. For example, if Internet latency is dominated by speed-of-light delay over links, and the Internet is well-enough connected that there is a roughly direct physical path between every pair of hosts, and the Internet routing system finds these direct paths, then synthetic coordinates that mimic latitude and longitude are likely to predict latency well.

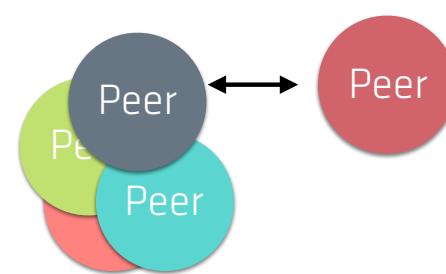
Unfortunately, these properties are only approximate. Packets often deviate from great-circle routes because few site pairs are directly connected, because different ISPs peer at a limited number of locations, and because transmission time and router electronics delay packets. The resulting distorted latencies make it impossible to choose two-dimensional host coordinates that predict latency perfectly, so a synthetic coordinate system must have a strategy for

# Spring 'Dynamic Relaxation' Model

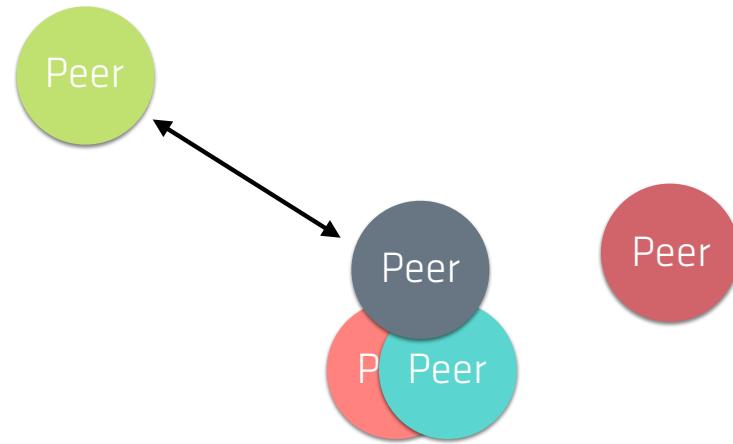
- Imagine each pair of peers connected by a spring...
- Compressed together ...
- But natural length of each spring is RTT between those two peers...



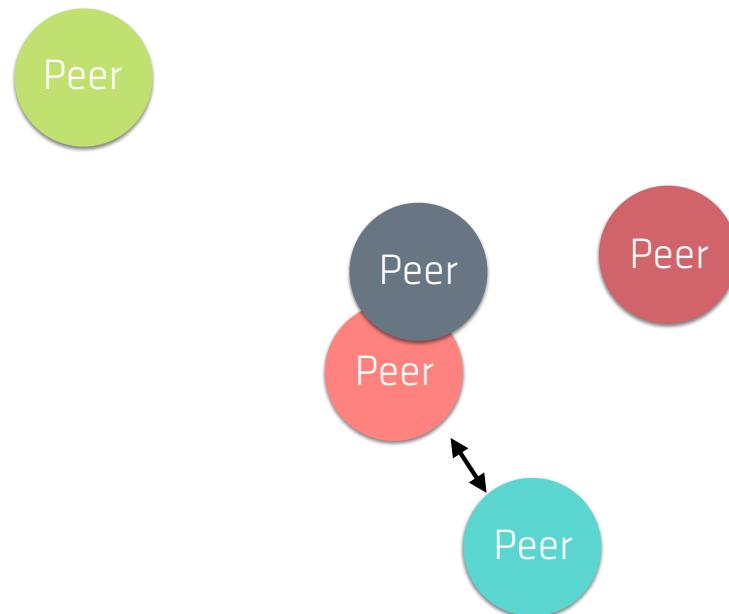
# Spring 'Dynamic Relaxation' Model



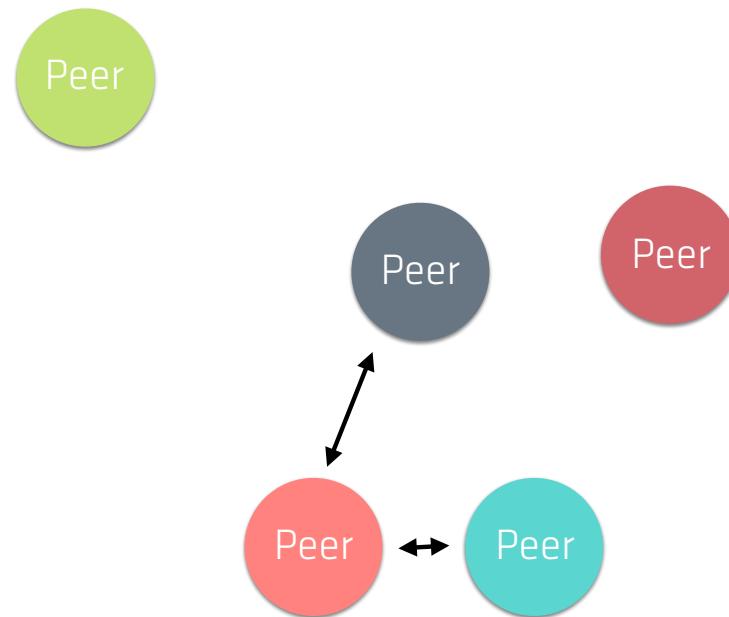
# Spring 'Dynamic Relaxation' Model



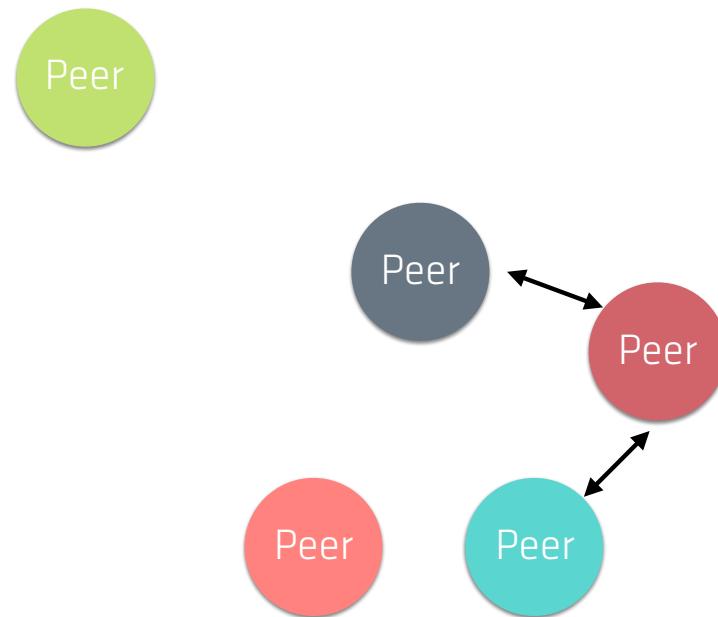
# Spring 'Dynamic Relaxation' Model



# Spring 'Dynamic Relaxation' Model



# Spring 'Dynamic Relaxation' Model



# SWIM Probe Messages Give Us RTT For Free

- Random pattern of communication really helps
  - Ring or tree topology would measure only a fraction of the paths

# Randomization: Two Ways We Win

- SWIM's *simple*, robust scalability
- RTT's for Network Distance for free

# Mining the Research Graph

- Found multiple alternative solutions
- Some papers were follow up work ('responses') to Vivaldi
  - Found via *citations* (Google Scholar)
  - Helped identify issues Vivaldi originally missed
  - Provided a toolkit of possible extensions
  - Defined metrics we could use to evaluate the alternatives

# Vivaldi In Consul/Serf In Depth

The image shows a YouTube video player interface. At the top, there's a navigation bar with a menu icon, the YouTube logo, and a search bar containing the text "armon dadgar hashicorp vivaldi papers we love". Below the video player is a presentation slide with a black header and footer. The main content area of the slide has a light gray background with a faint floral watermark. The title "Euclidean Coordinates" is centered at the top of the slide. Below the title, there are two code snippets. The first snippet defines two points  $p1$  and  $p2$  as objects with properties  $x$ ,  $y$ , and  $z$ . The second snippet shows the formula for calculating the distance between  $p1$  and  $p2$  using the Pythagorean theorem. A small video thumbnail of a man speaking is visible on the left side of the slide. At the bottom of the slide, there's a "HASHICORP" logo. The YouTube player interface includes a play button, a progress bar showing "30:27 / 1:19:35", and various sharing and download icons.

Euclidean Coordinates

```
p1 = {x: 1, y: 2, z: 3}  
p2 = {x: 4, y: 5, z: 6}
```

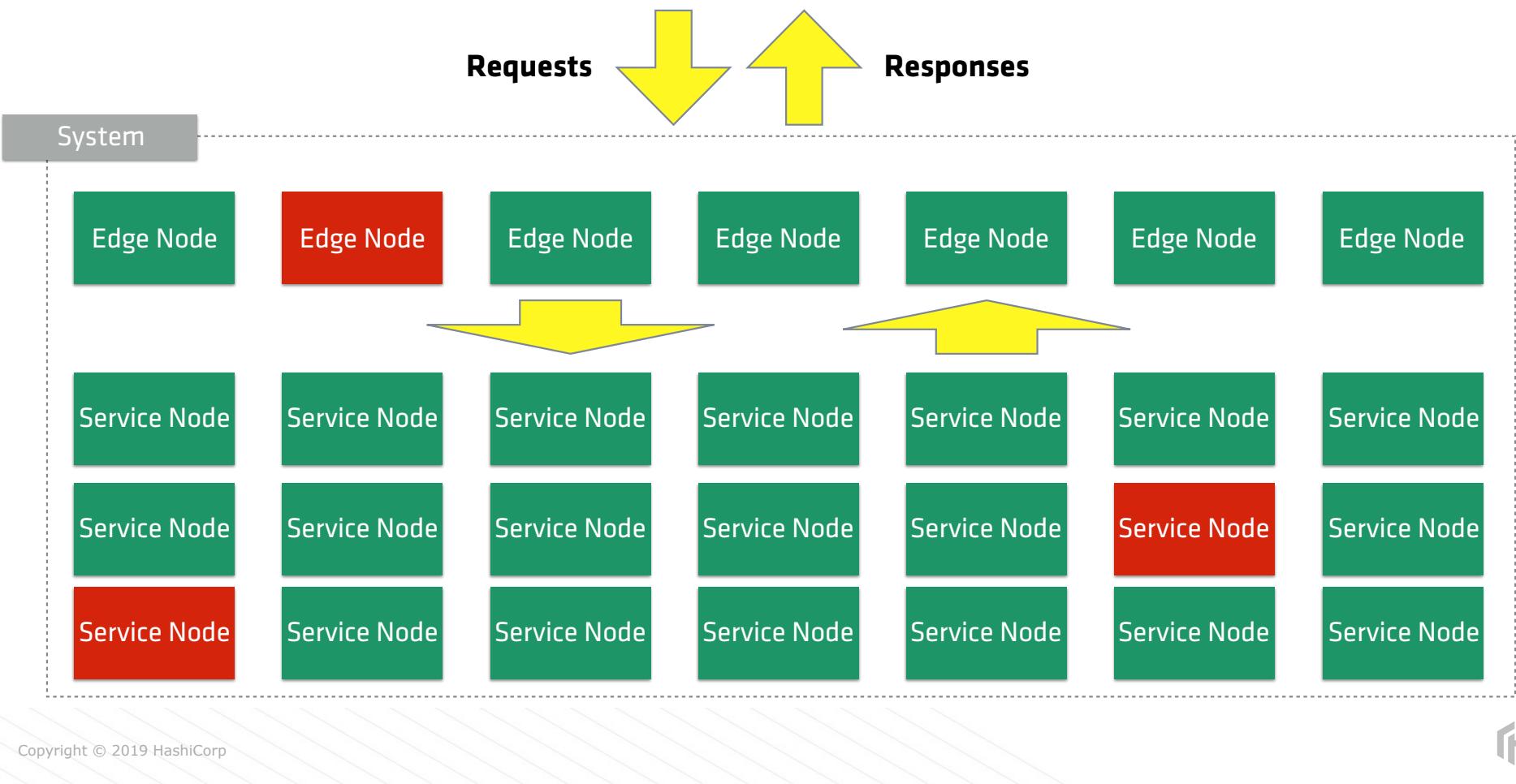
$$\text{dist}(p1, p2) = \sqrt{(p2.x-p1.x)^2 + (p2.y-p1.y)^2 + (p2.z-p1.z)^2}$$

Armon Dadgar on Vivaldi: Decentralized Network Coordinate System

1,325 views

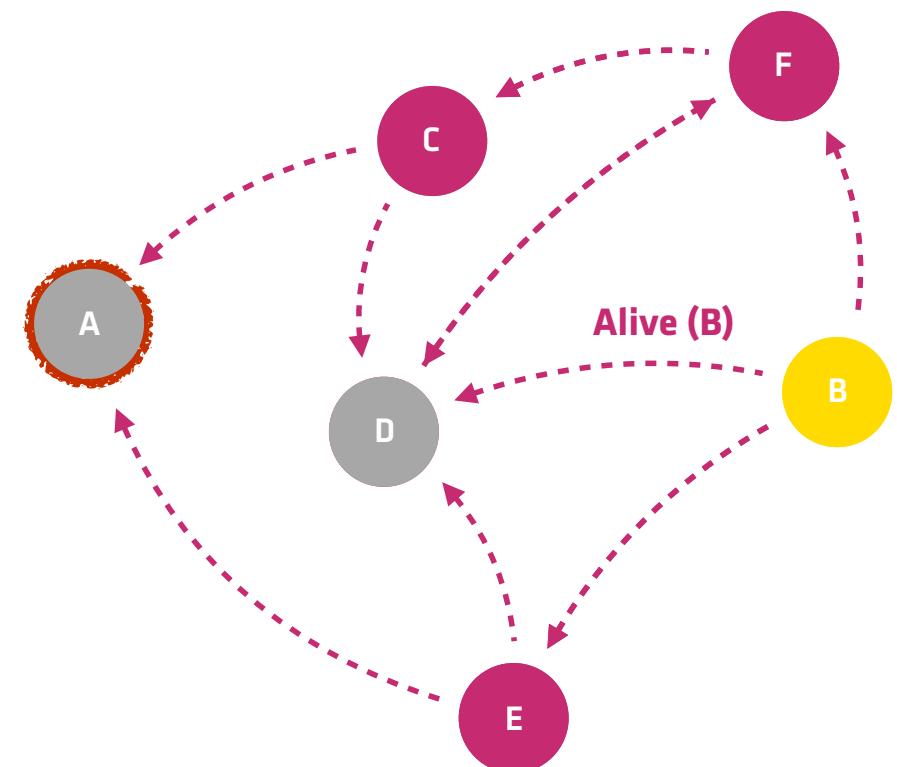
1 like 24 dislikes 1 share 1 save ...

# Wait ... What About the Flappers?



# SWIM's Achilles Heel

Works around slow/dead  
intermediaries...

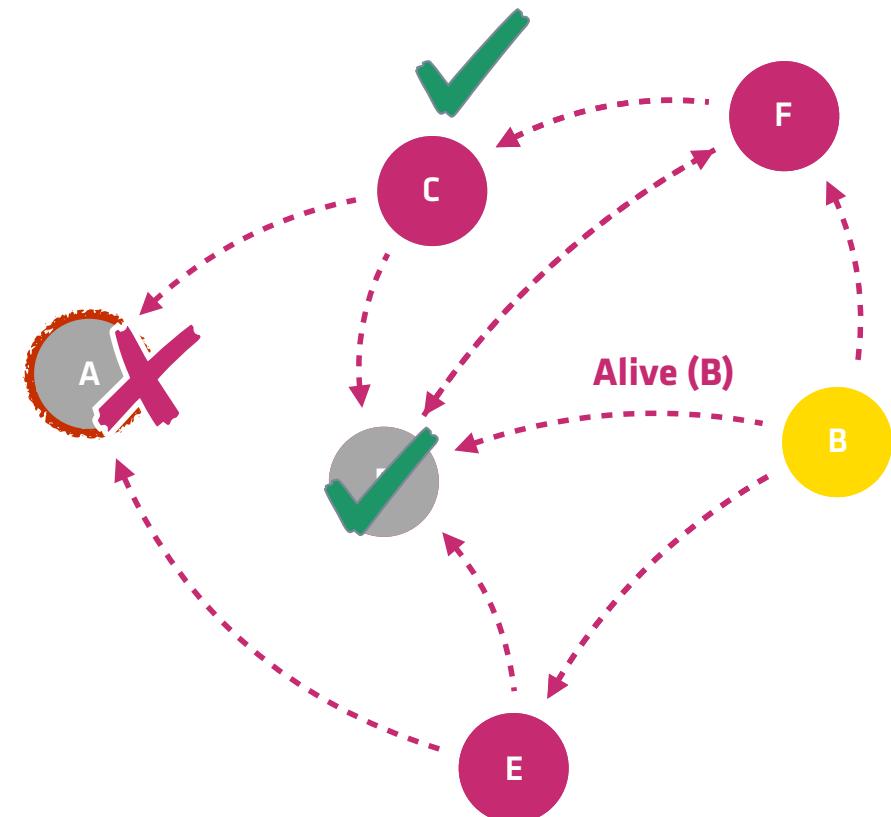


# SWIM's Achilles Heel

Works around slow/dead intermediaries...

But **still assumes some messages are processed in a timely manner**

- No slow node originating a probe or suspicion
- Must process Ack and Alive messages



# For a Detailed Explanation ...

The screenshot shows a video player interface. The main content is a slide titled "Actual Behavior: Node Flapping". The slide features a diagram of a "Cluster" structure. At the top, there are seven red downward-pointing arrows above a row of seven boxes labeled "Edge Node". Below this is a dashed-line box containing a 3x7 grid of boxes. The first six columns of the grid have three rows labeled "Service Node" (top two are green, bottom is orange). The last column has three rows labeled "Service Node" (all are orange). Two yellow double-headed arrows point between the third and fourth columns. To the right of the grid is a circular icon with a dot and a dot connected by a line. A copyright notice "Copyright © 2017 HashiCorp." is at the bottom left. A navigation bar at the bottom includes a play button, a progress bar showing "4:54 / 38:55", and other video controls.

**Actual Behavior: Node Flapping**

Cluster

Edge Node Edge Node Edge Node Edge Node Edge Node Edge Node Edge Node

Service Node Service Node Service Node Service Node Service Node Service Node Service Node

Service Node Service Node Service Node Service Node Service Node Service Node Service Node

Service Node Service Node Service Node Service Node Service Node Service Node Service Node

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▶ ⏪ 🔍 4:54 / 38:55

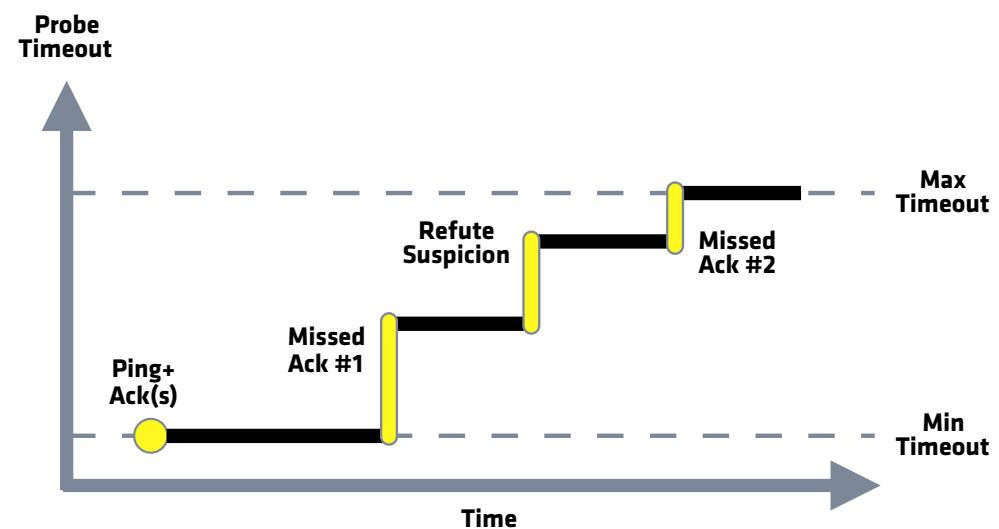
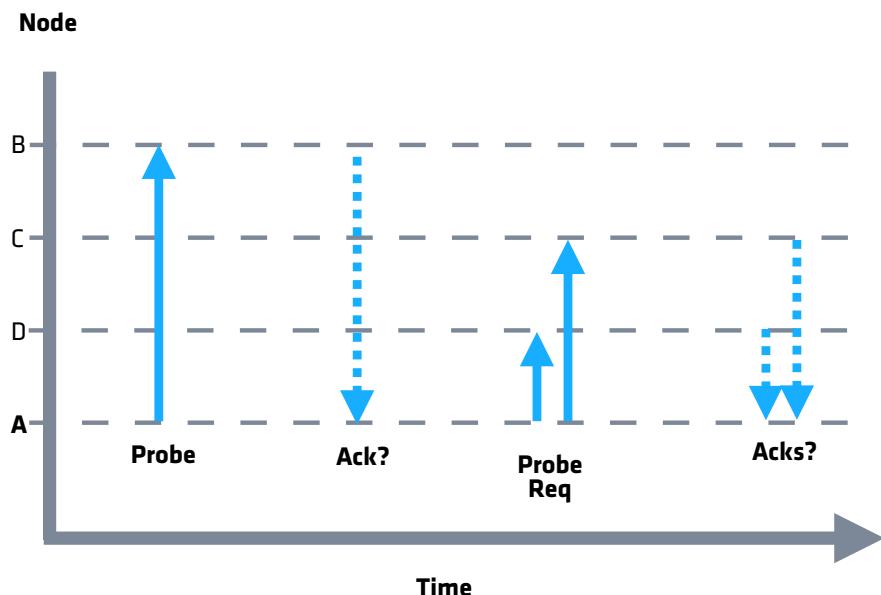
**HashiConf '17**

CC HD

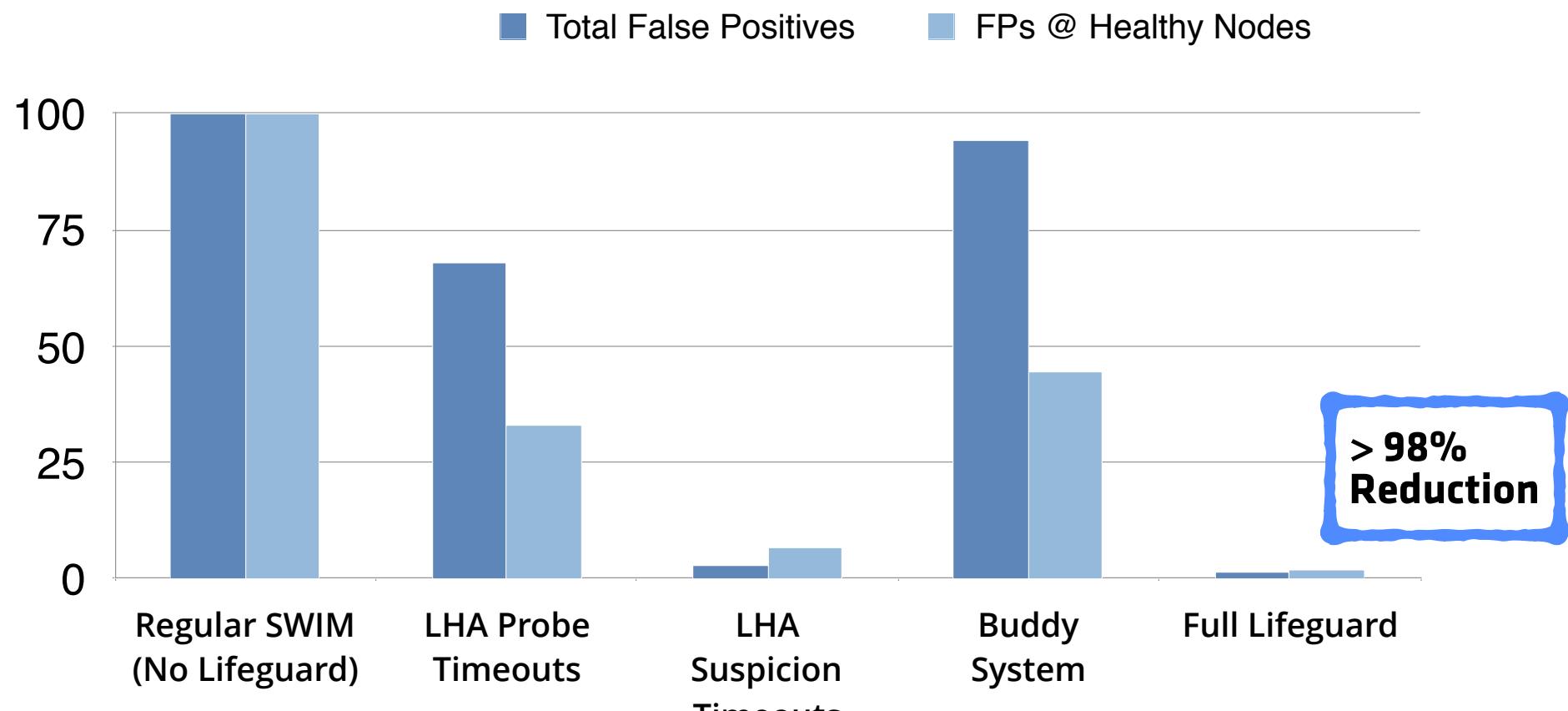
Making Gossip More Robust with Lifeguard

# Lifeguard Heuristics Based On 'Local Health'

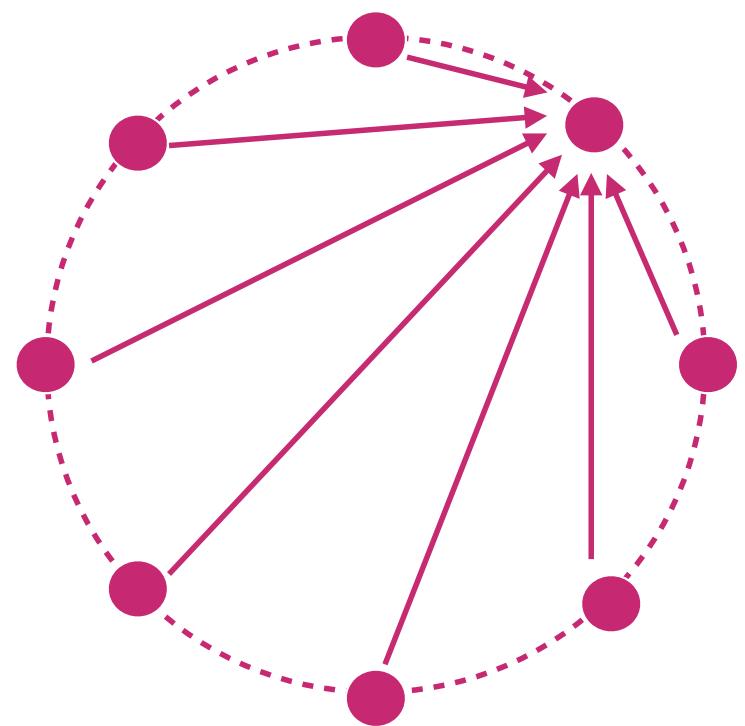
- Failure Detector has *expectations* about messages it will receive
- Use *absence of expected messages* to increase timeouts at slow members



# Reduction in False Positives

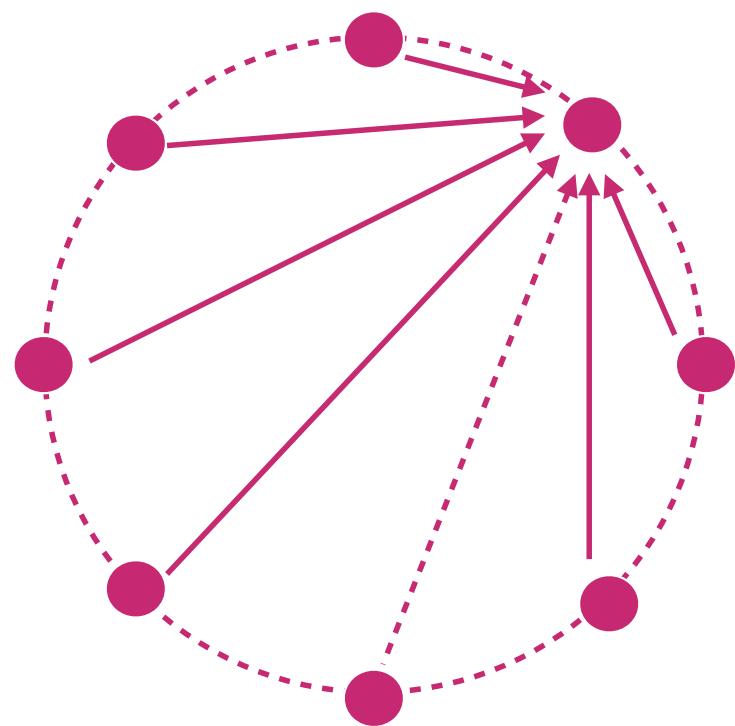


# Randomization Is Key To Lifeguard Too



- Every node checked by every other node... just not so often

# Randomization Is Key To Lifeguard Too



- Every node checked by every other node... just not so often
- If we **slow down 3 out of 100 nodes, 97 nodes are still checking all 100 of them**
  - Graceful degradation
  - Gets *better* as group size increases

# Randomization: Two Three Ways We Win

- SWIM's *simple*, robust scalability
- RTT's for Network Distance for free
- Lifeguard's defense against SWIM's weak spot

# Research Also Helped With Lifeguard ... Eventually

- Picked up literature search thanks to backlog
- No one had reported on this issue but...
  - **Gave us the metrics** to use to investigate
  - **Showed us good benchmarking** experiments
- Benchmarks have persistent value
  - Regression testing, competitive analysis, ...
  - Backbone of a paper

# Lifeguard (arXiv and IEEE DSN 2018)

## Lifeguard: Local Health Awareness for More Accurate Failure Detection

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HashiCorp Inc.  
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*Abstract*—SWIM is a peer-to-peer group membership protocol, with attractive scaling and robustness properties. However, our experience supporting an implementation of SWIM shows that a high rate of false positive failure detections (healthy members being marked as failed) is possible in certain real world scenarios, and that this is due to SWIM’s sensitivity to slow message processing. To address this we propose a set of extensions to SWIM (together called Lifeguard), which employ heuristic measures of a failure detector’s *local health*. In controlled tests, Lifeguard is able to reduce the false positive rate by more than 50x. Real world deployment of the extensions has significantly reduced support requests and observed instability. The need for this work points to the fail-stop failure model being overly simplistic for large datacenters, where the likelihood of some nodes experiencing transient CPU starvation, IO flakiness, random packet loss, or other non-crash problems becomes high. With increasing attention being given to these *gray failures*, we believe the local health abstraction may be applicable in a broad range of settings, including other kinds of distributed failure detectors.

However, our experience supporting Consul and Nomad shows that, even with the Suspicion subprotocol, slow message processing can still lead healthy members being marked as failed in certain circumstances. When the slow processing occurs intermittently, a healthy member can oscillate repeatedly between being marked as failed and healthy. This ‘flapping’ can be very costly if it induces repeated failover operations, such as provisioning members or re-balancing data.

Debugging these scenarios led us to insights regarding both a deficiency in SWIM’s handling of slow message processing, and a way to address that deficiency. The approach used is to make each instance of SWIM’s failure detector consider its own health, which we refer to as *local health*. We implement this via a set of extensions to SWIM, which we call Lifeguard. Lifeguard is able to significantly reduce the false positive rate, in both controlled and real-world scenarios.

Looking at the bigger picture, we see that SWIM follows the majority of the literature of distributed failure detectors

# Lifeguard (arXiv and IEEE DSN 2018)

Lifeguard: Local Health Awareness  
for More Accurate Failure Detection

**Developed iteratively** over 18 months...

- Internal benchmarking report
- Internal white paper (engineering, sales, ...)
- [arXiv.org](https://arxiv.org/) 'pre-print'
- Published version
- Blog posts, Tweets, conference talks ...

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Looking at the bigger picture, we see that SWIM follows the majority of the literature of distributed failure detectors

# Publication Has Embedded Us In the Graph

## Lifeguard: Swim-ing with situational awareness

Search within citing articles

### [PDF] Multisource Rumor Spreading with Network Coding

[YD Bromberg](#), [Q Dufour](#), [D Frey](#) - INFOCOM 2019, 2019 - hal.inria.fr

[PDF] [inria.fr](#)

The last decade has witnessed of a rising surge interest in Gossip protocols in distributed systems. In particular, as soon as there is a need to disseminate events, they become a key functional building block due to their scalability, robustness and fault tolerance under high ...

  Related articles All 8 versions 

### [PDF] Membership Service for Large-Scale Edge Systems

[FM Magalhães](#) - 2018 - asc.di.fct.unl.pt

[PDF] [unl.pt](#)

Distributed systems are increasing in scale and complexity. Cloud-based applications need more resources to be able to continue satisfying the user requirements. There are more users and devices with Internet access and therefore, more data to process and store. There ...

  Related articles 

# Benefits of Research (Tell Your Boss ...)

- **Better algorithms**
- **Relevant metrics**
- **Talent**
  - Interns and full-time
- **Reputation**
  - Customers and potential customers
  - Internal >> employee satisfaction

# Where to Begin?

- *Papers We Love* (PWL)
  - Github repo + Meetups
- *The Morning Paper* by Adrian Colyer
  - Blog + email
- At work
  - Reading group
  - Brownbag PWL
  - Colleagues with research experience?

# Getting Involved in Research

- Ask questions
  - Email, Twitter
- Attend conferences
- Discuss your open problems
  - Blog
  - Twitter
- PhD candidate interns
- Employees with research experience
  - PhD, Masters or started graduate school?

# PhD Candidate Interns

- Mutual benefit
  - Your (relevant) problem/data == **goldmine** for their work
  - Work done during internship is your company's Intellectual Property
  - (Work done after they return to university is harder to patent)
- Approach students and advisors
  - Poster sessions at conferences
  - Email

# Researchers are People Too!

 **Sarah Knowles**  
@dr\_know

Follow

Is it genuinely a thing that ppl don't email academics for their papers because they think we get paid for them?

We actually pay to make them free (I'd try to explain this but it's... a mess.) And we're happy and allowed to distribute copies. Hit us up!

5:31 AM - 9 Feb 2019

1,540 Retweets 4,772 Likes



88 1.5K 4.8K

 **Madelen** @m4delen · Feb 9  
Replying to @dr\_know @BipolarBlogger  
Yes. I am always too shy to email researchers when it says email researchers for a copy. I worry they will be annoyed and think I am a very busy researcher who

 **Sarah Knowles** @dr\_know · Feb 9  
Most researchers reaction would be "😍😍 a random stranger wants to read my stuff!"

5 6 251

 **Rheumatoid Patient** @rheumpatient · Feb 10  
Yep, please read my stuff I spent hours working on and writing up!

1 18

 **Dr. David Mills** @DTL · Feb 9  
Replying to @dr\_know  
I'm more than happy to email out copies of my work, but there are papers I don't even have a copy of now and can't access because we don't subscribe to the journal.  
Thankfully sci-hub has most of them.

23

 **GeePaw Hill** @GeePawHill · Feb 10  
Replying to @dr\_know  
not to mention that \*actual\* \*interest\* in one's work usually makes one's day. i've written many scholars over the years. never found them to be anything but gracious and grateful and helpful, about reprints or anything else.

18

# Thank you.



**HashiCorp**

[www.hashicorp.com](http://www.hashicorp.com) hello@hashicorp.com

# Controlled Use of Randomization

- Pseudo-randomization
  - Go math/rand
  - Seeded from /dev/urandom
- Each node *cycles through all the nodes it knows about*
  - Only then talk to same node a second time
- New nodes *inserted into its memberlist at random position*



sean- / seed

# Weak Consistency Is Sometimes Enough

