

# #RP30

## **Automated Deployment and Scaling** of Named Data Networks in Cloud Environments

Sean Liao  
Supervisor: Zhiming Zhao

## Next 20 mins...

Some academic(s) arrive to tell us that (once again) they have Fixed the Internet, and (once again) it runs on top of the current actually-working internet, and (once again) if you sign up you can communicate with as many as twelve other computers.

n-gate.com *in reference to SCION*

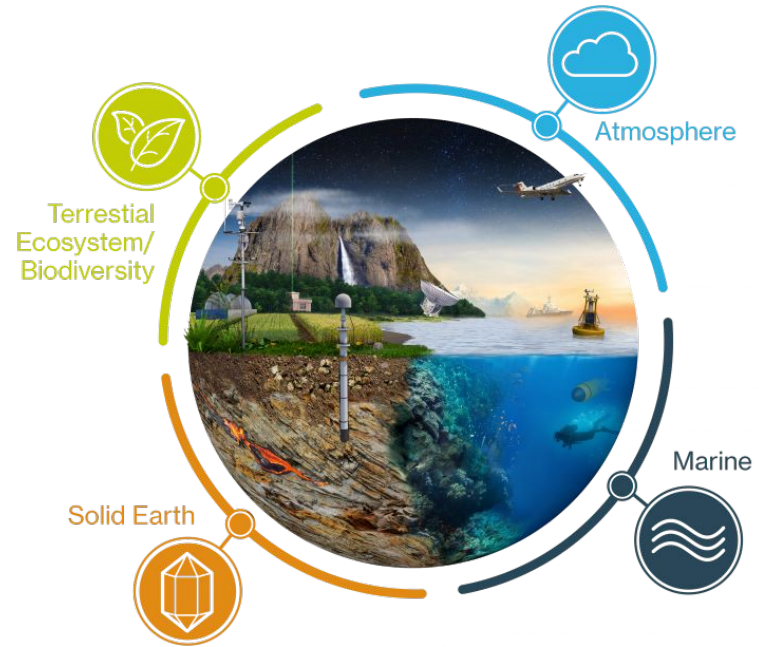
# Introduction

# ENVRI-FAIR

ENVironmental Research  
Infrastructures (ENVRI)

connection to

European Open Science  
Cloud (EOSC)



Single Domain



AnaEE  
DiSSCO  
ELIXIR  
EMPHASIS  
INTERACT



EPOS



EUROFLEETS  
EURO-ARGO  
JERICO-RI  
SEADATANET



ACTRIS  
ARISE  
EISCAT\_3D  
EUFAR  
EUROCHAMP 2020  
HEMERA  
IAGOS

Multi Domain



EuroGOOS  
ICOS  
IS-ENES  
SIOS



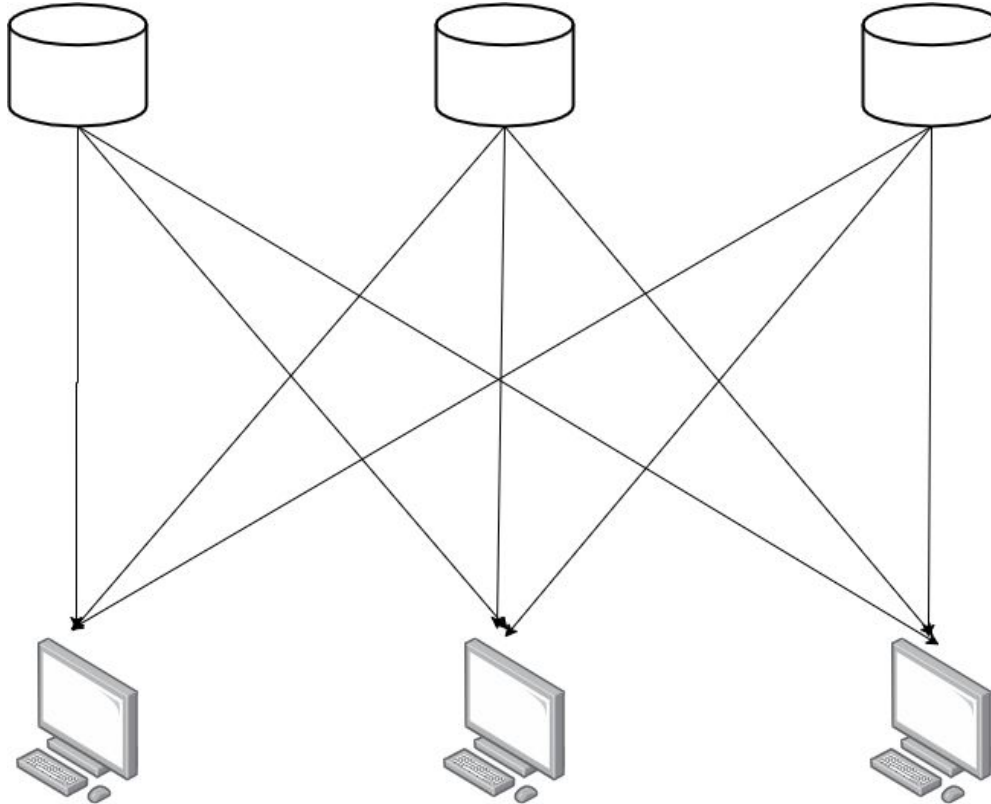
AQUACOSM  
DANUBIUS  
eLTER  
EMBRC  
LifeWatch



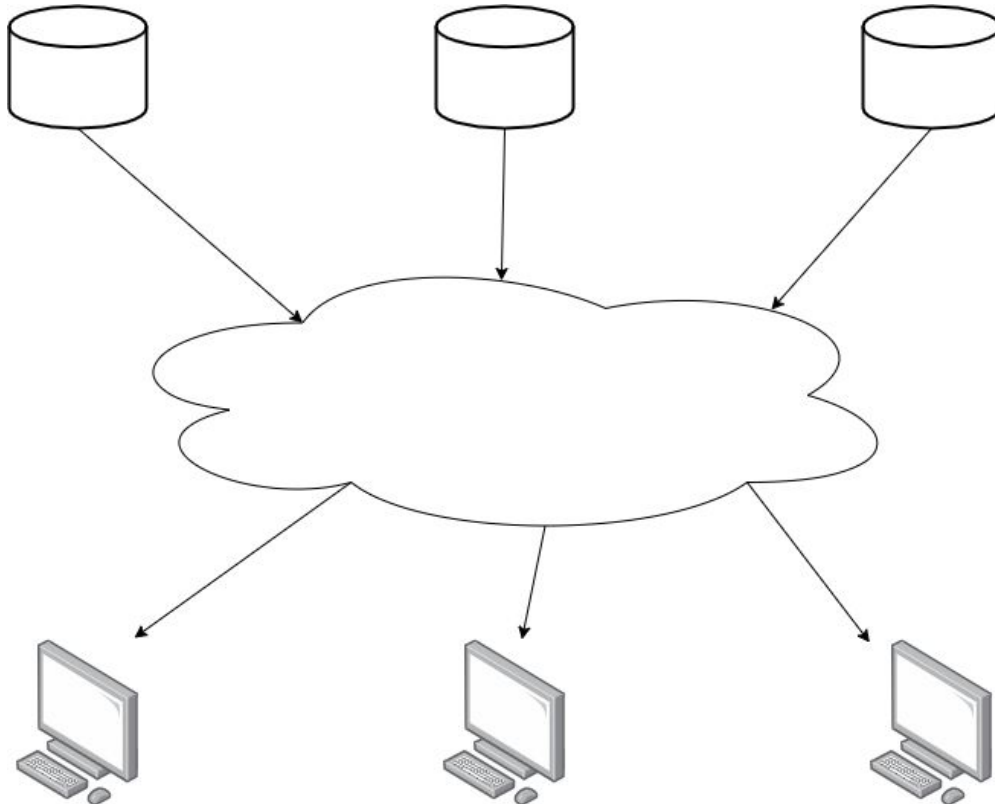
EMSO



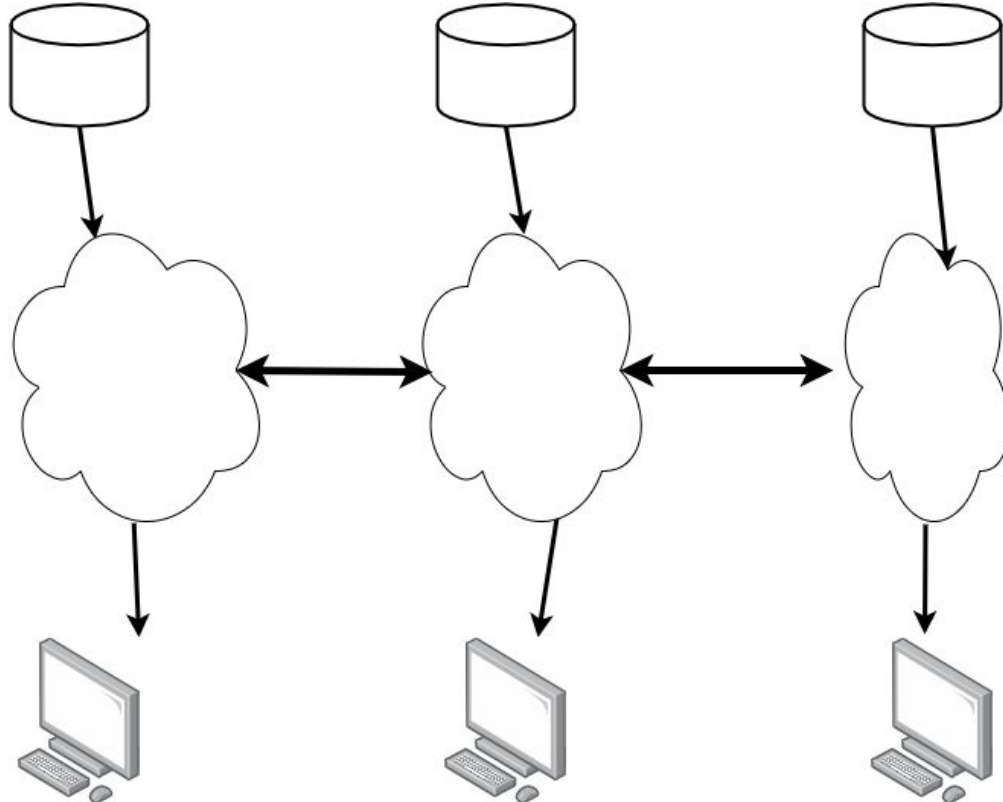
# Data distribution



# Content Distribution Network



# Federated Clouds



# Named Data Networking (NDN)



# Named Data Networking

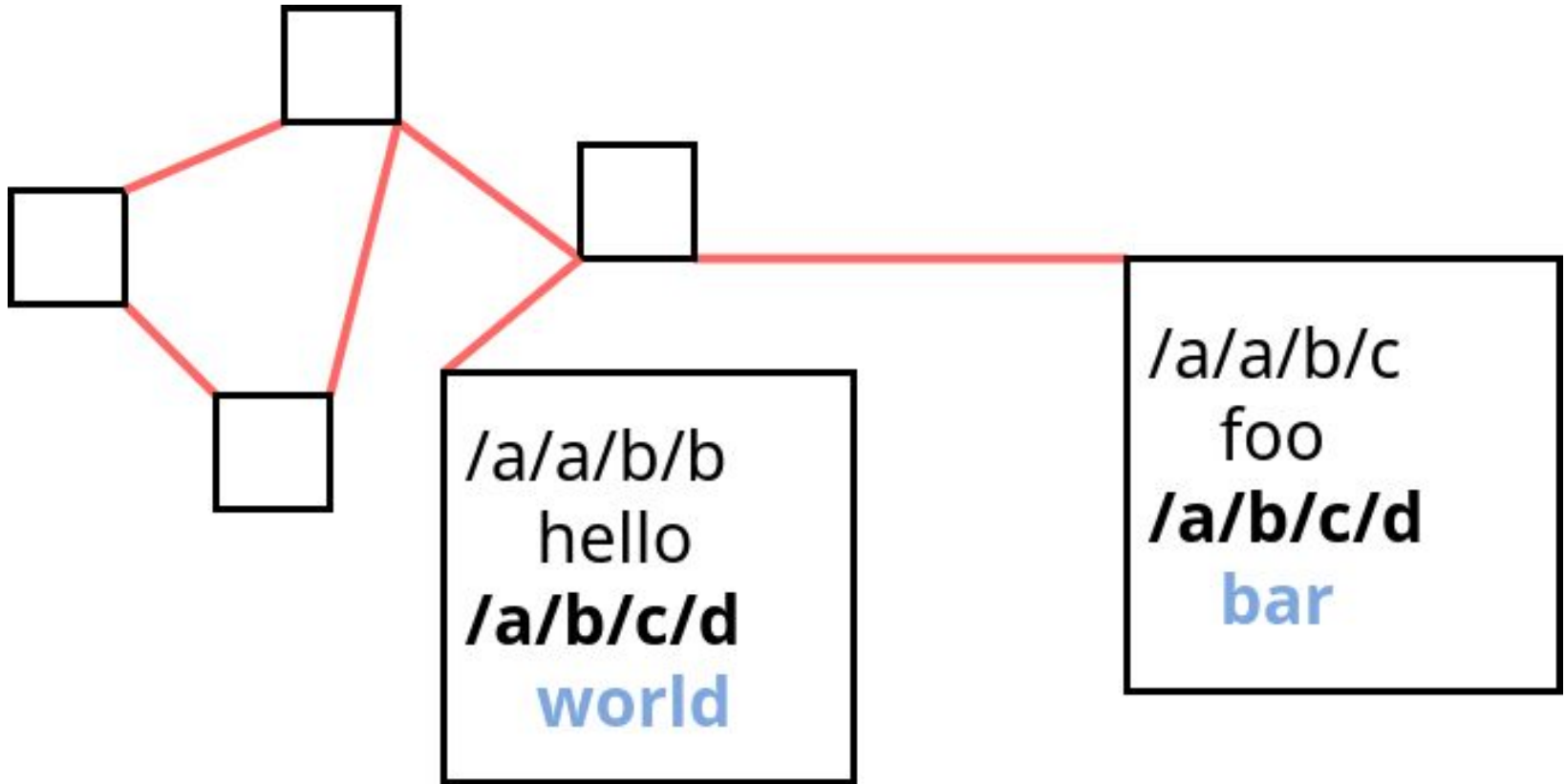
NSF Future Internet Architecture Program

Information distribution network

Potential benefits:

- content caching
- network level security of data

1.2.3.4/a/b/c/d



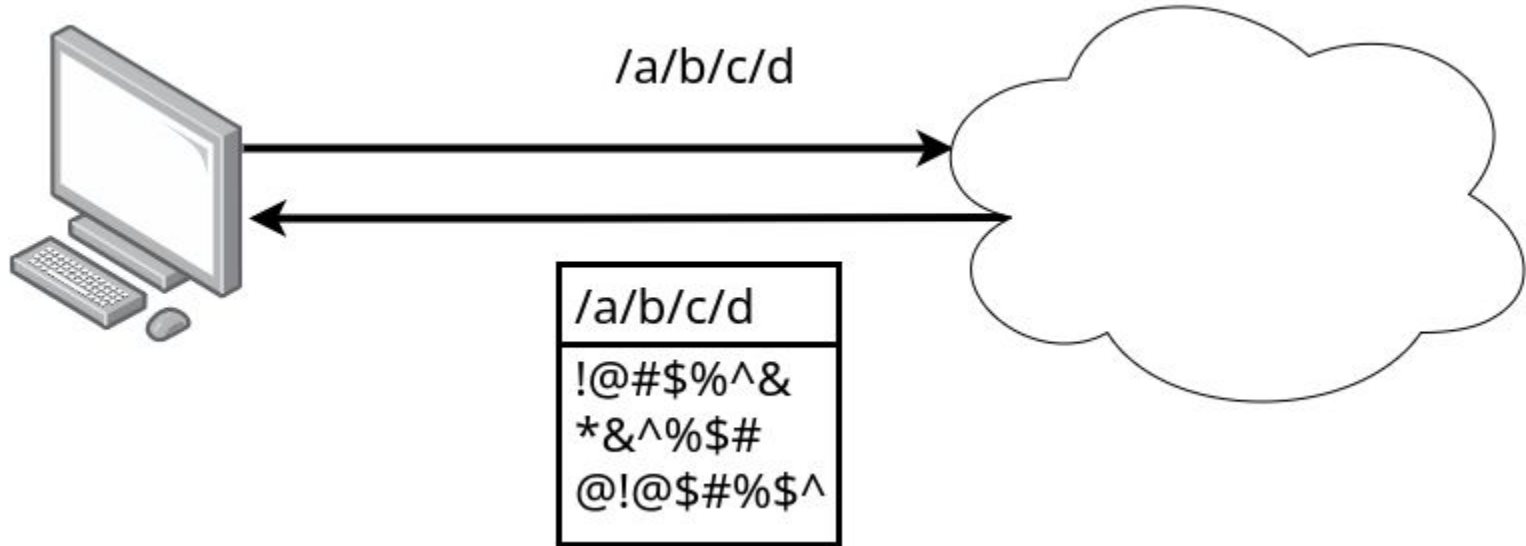
# Route directly to data

IPv4: 1.2.3.4

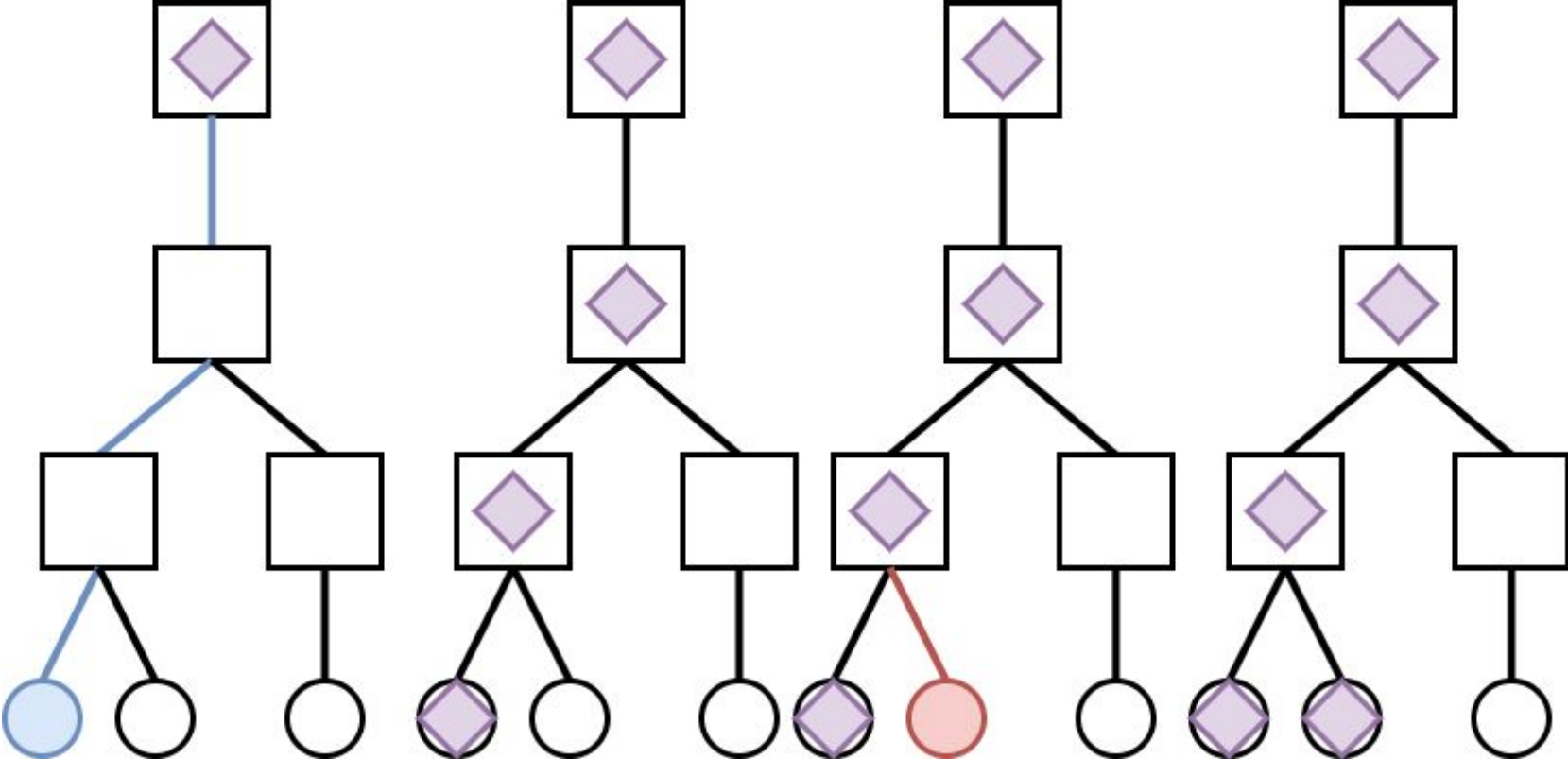
IPv6: 1:2:3:4:5:6:7:8

NDN: /arbitrary/strings/infinite/address/space

# 1-1 Request-Response (Interest-Data)



# In network caching



Run it

# In the Cloud

Overlay over IP

Simplify deployment

Scalable

## Existing Tools

Router: NFD

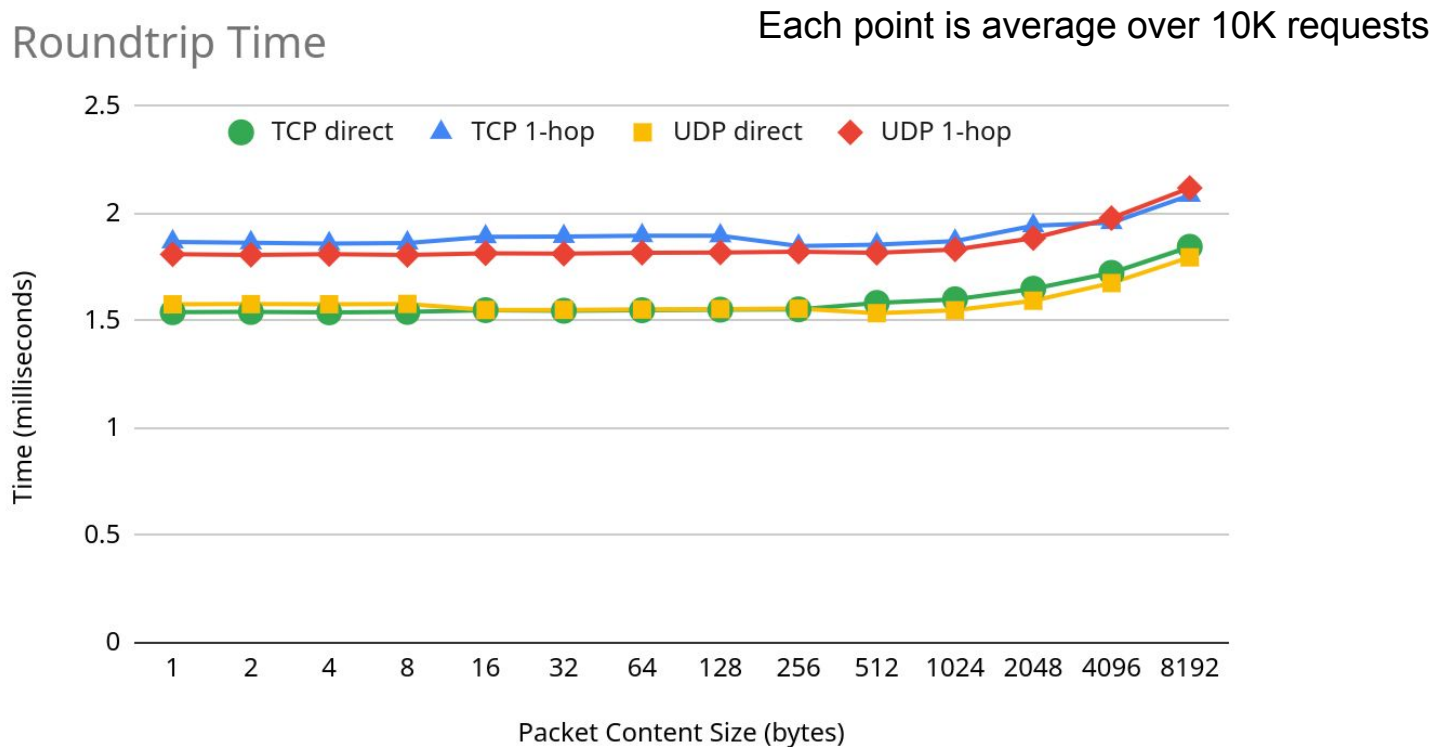
Link State Routing: NLSR

Dynamic route updates on static network

Connectivity: FCH

Find closest hub/gateway

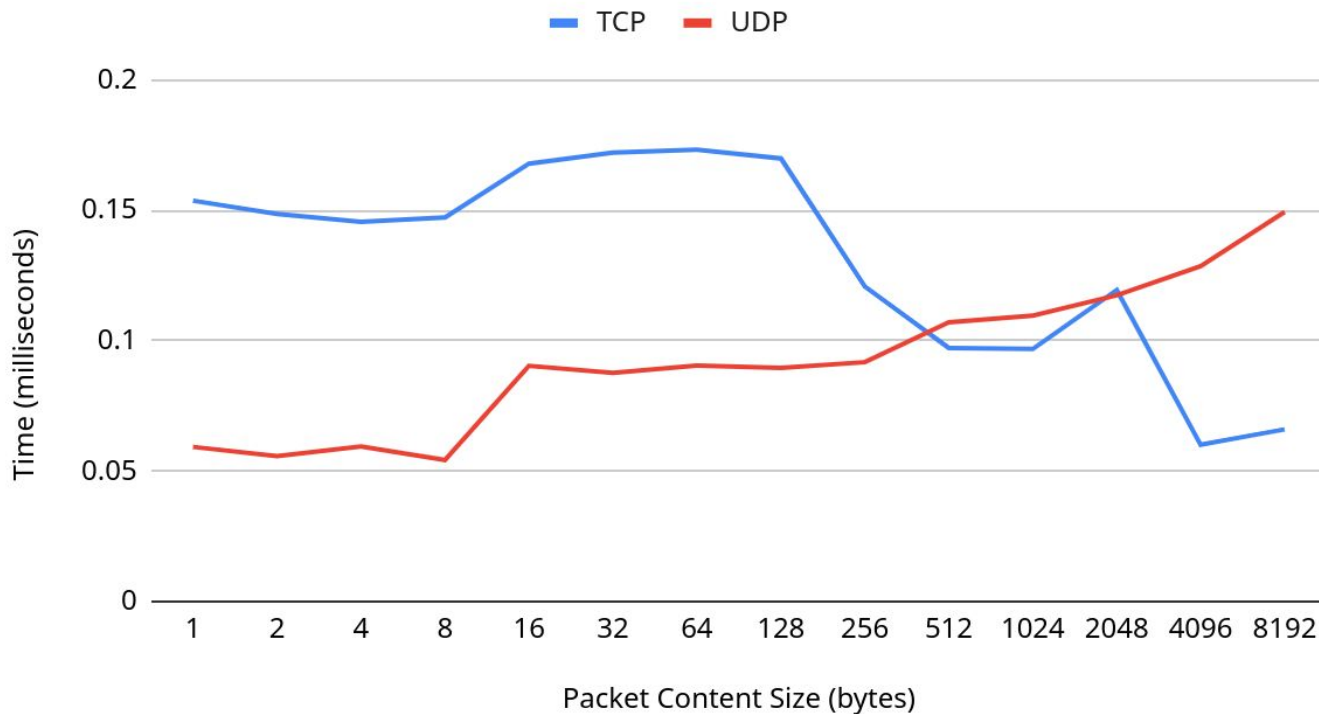
# Overlay over TCP / UDP





# Processing Overhead

Hop Processing Time Subtract network roundtrip time: 0.174ms

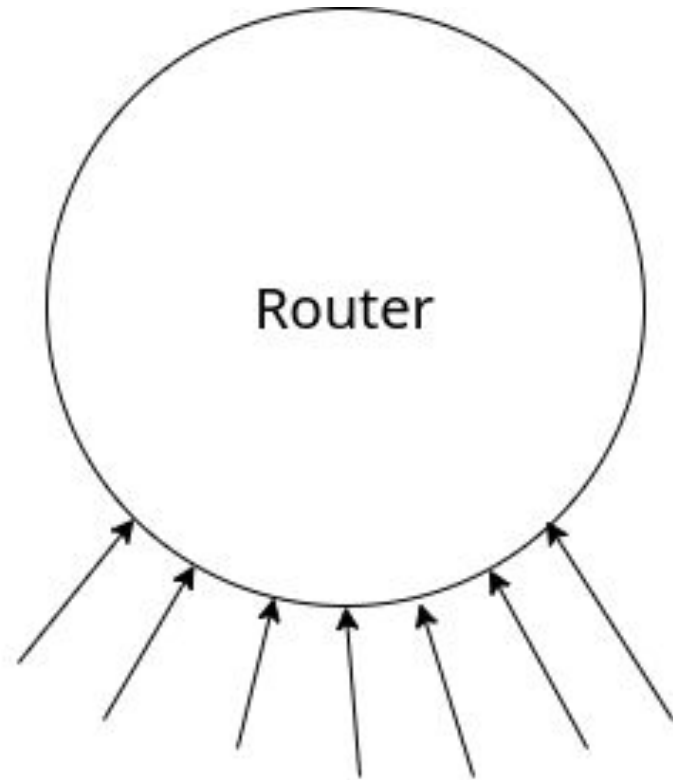
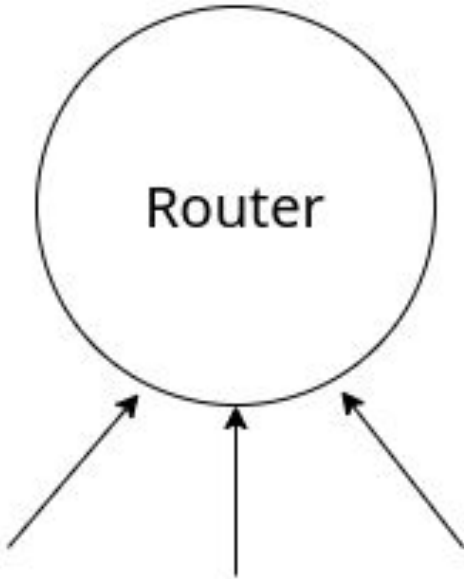


# Testing notes

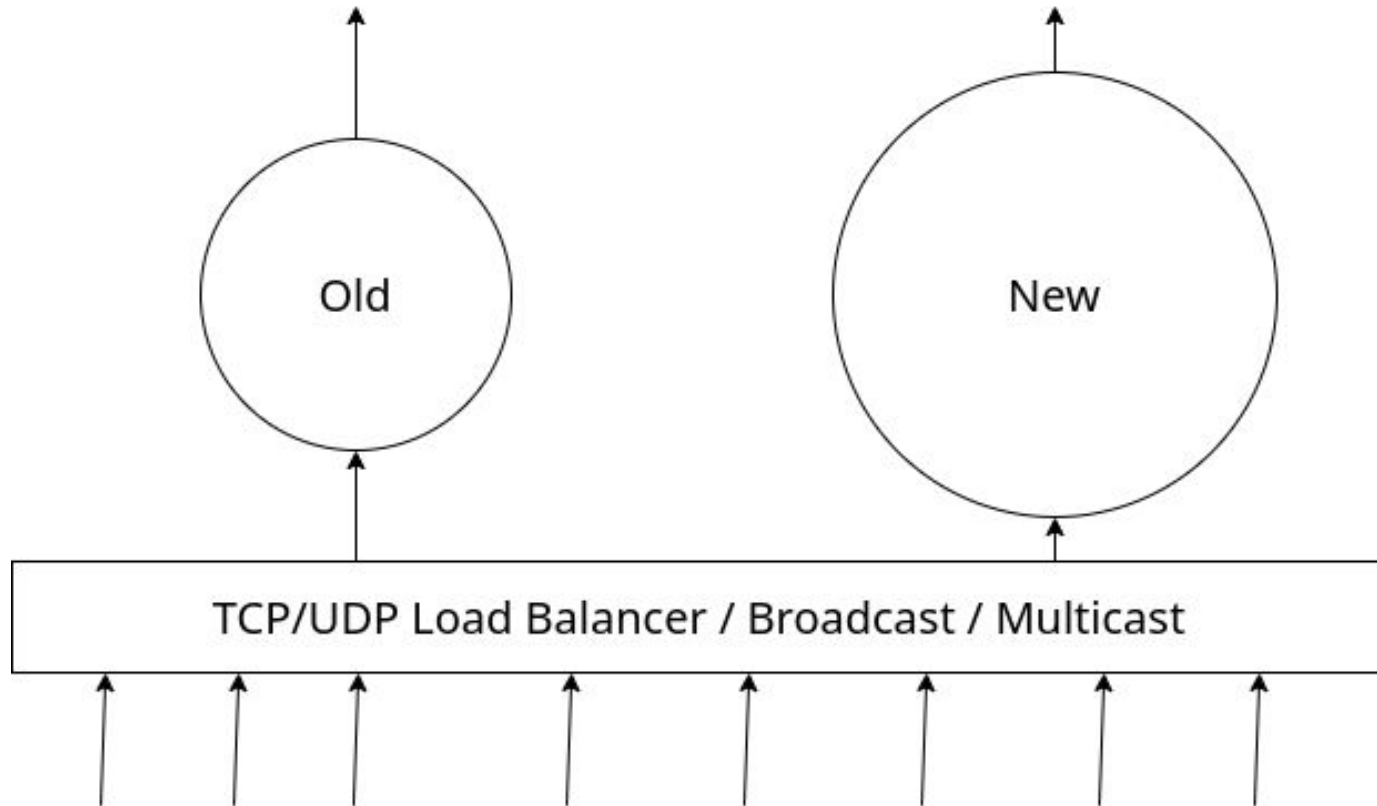
Performance severely degrades with 50000+ cached / in-flight requests

# Scaling Up

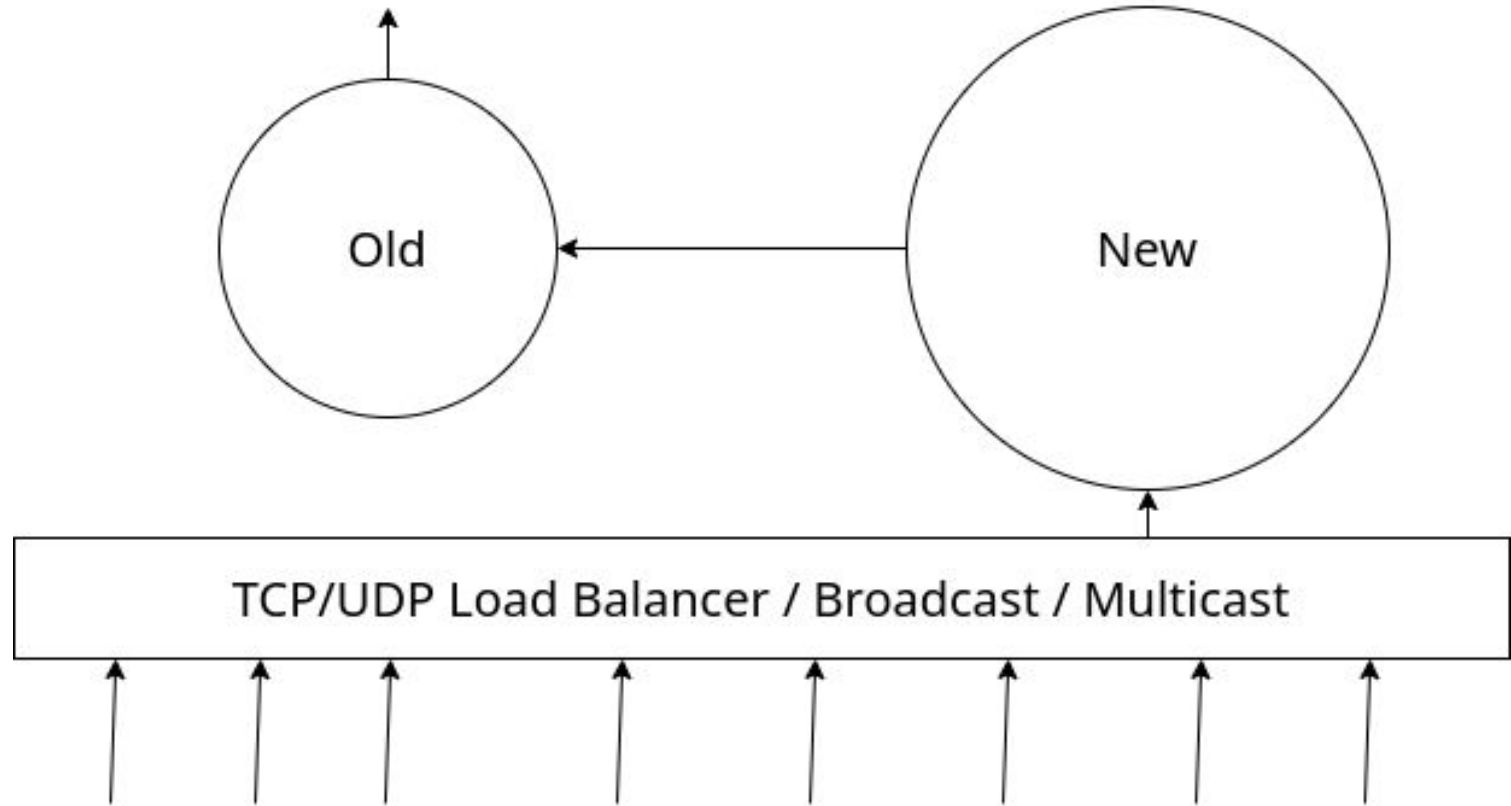
# Problem: Growing a node



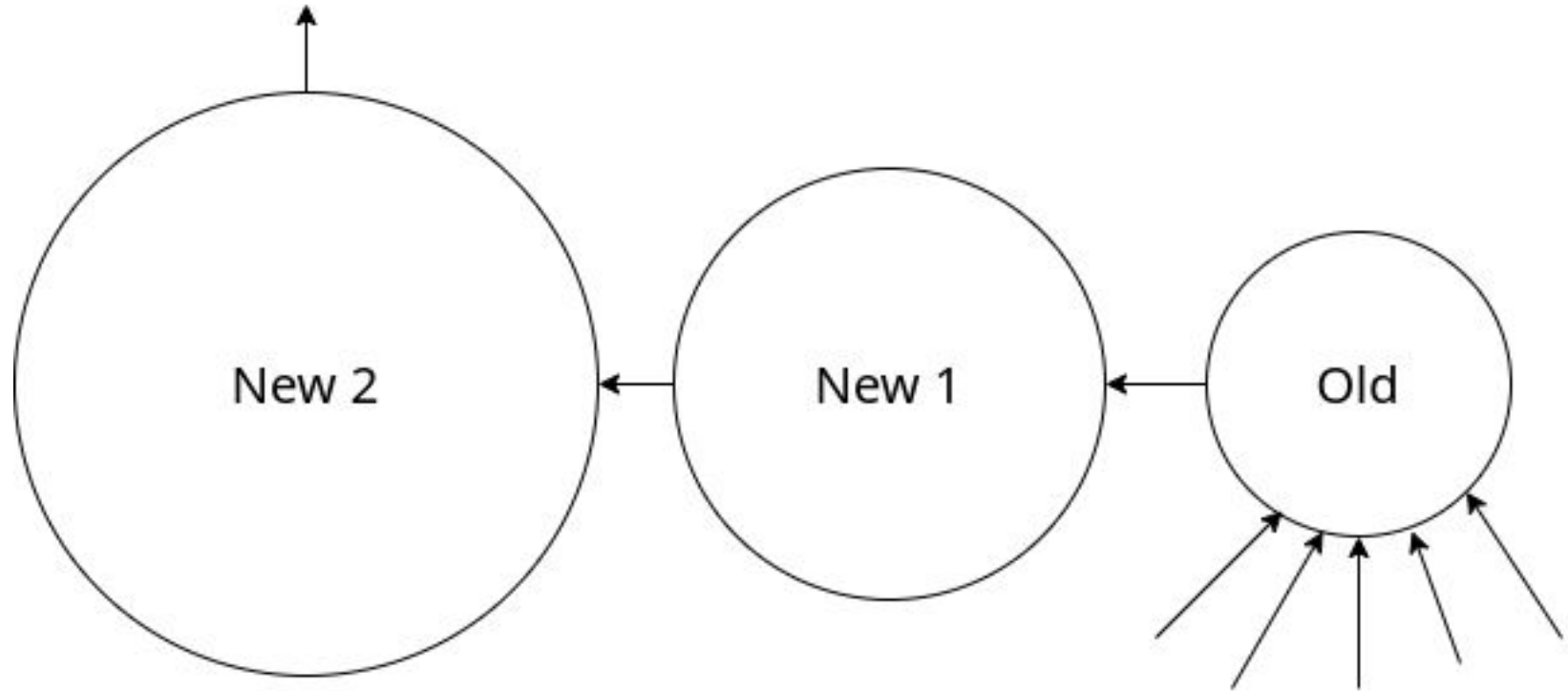
# Replace



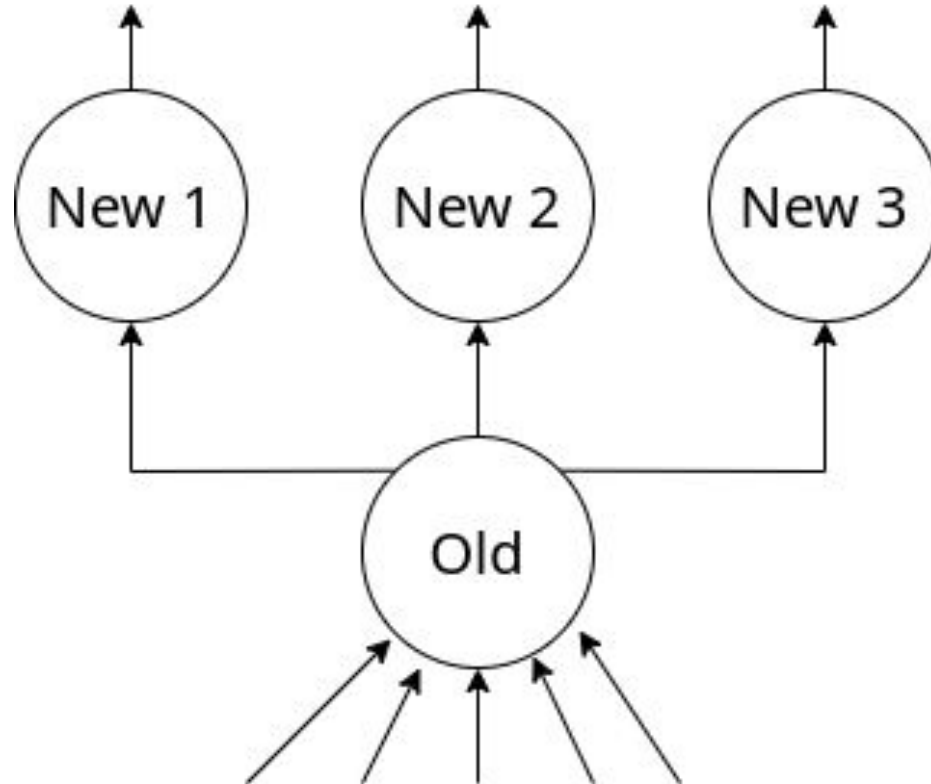
# New Node in Front



# New Node Behind (Chain)



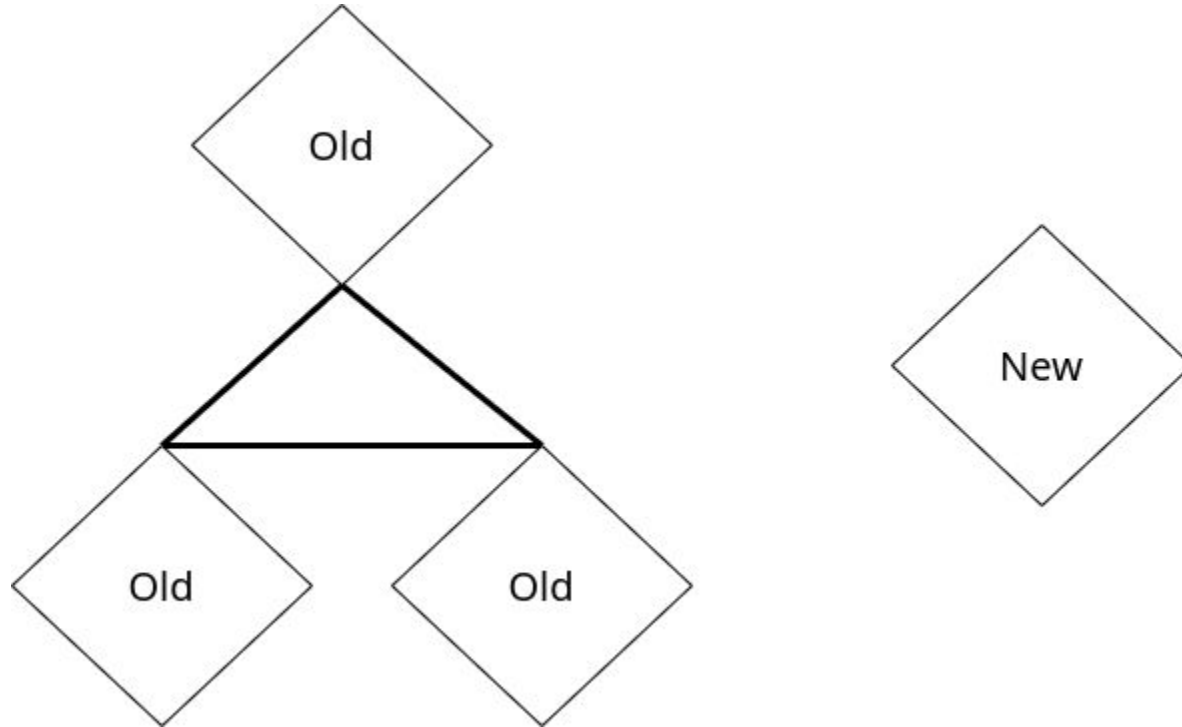
# New Node Behind (Load Balancing)



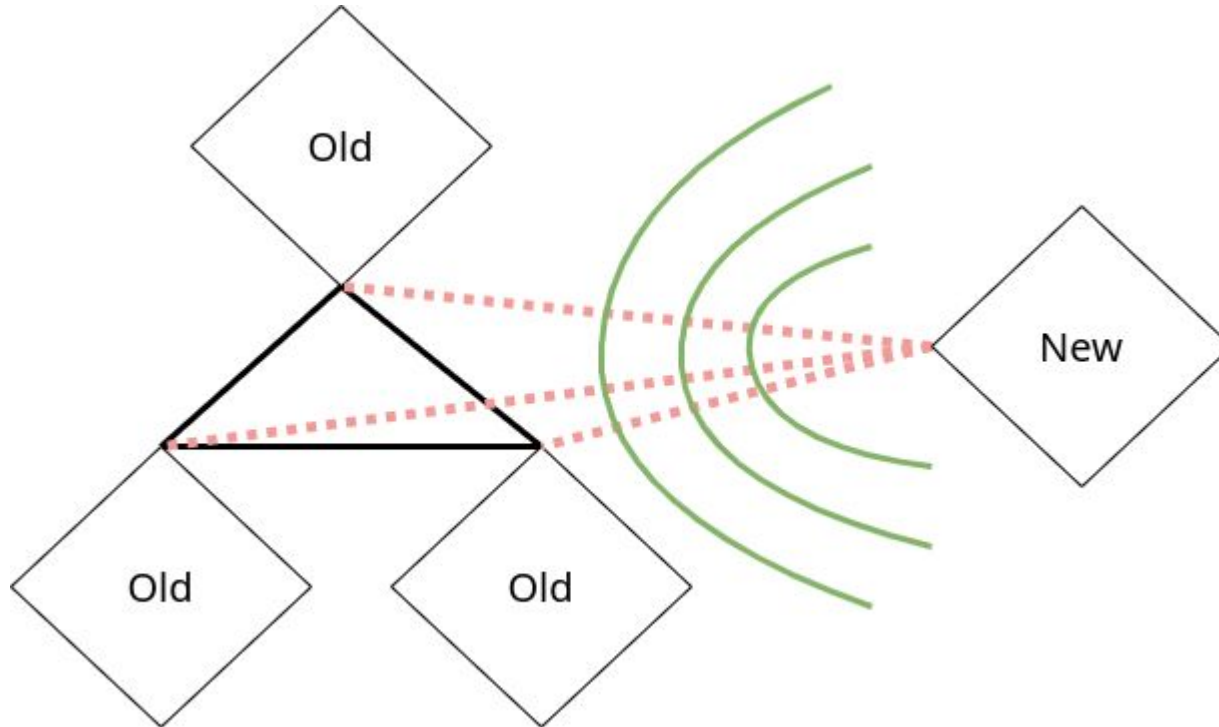


# Growing the Network

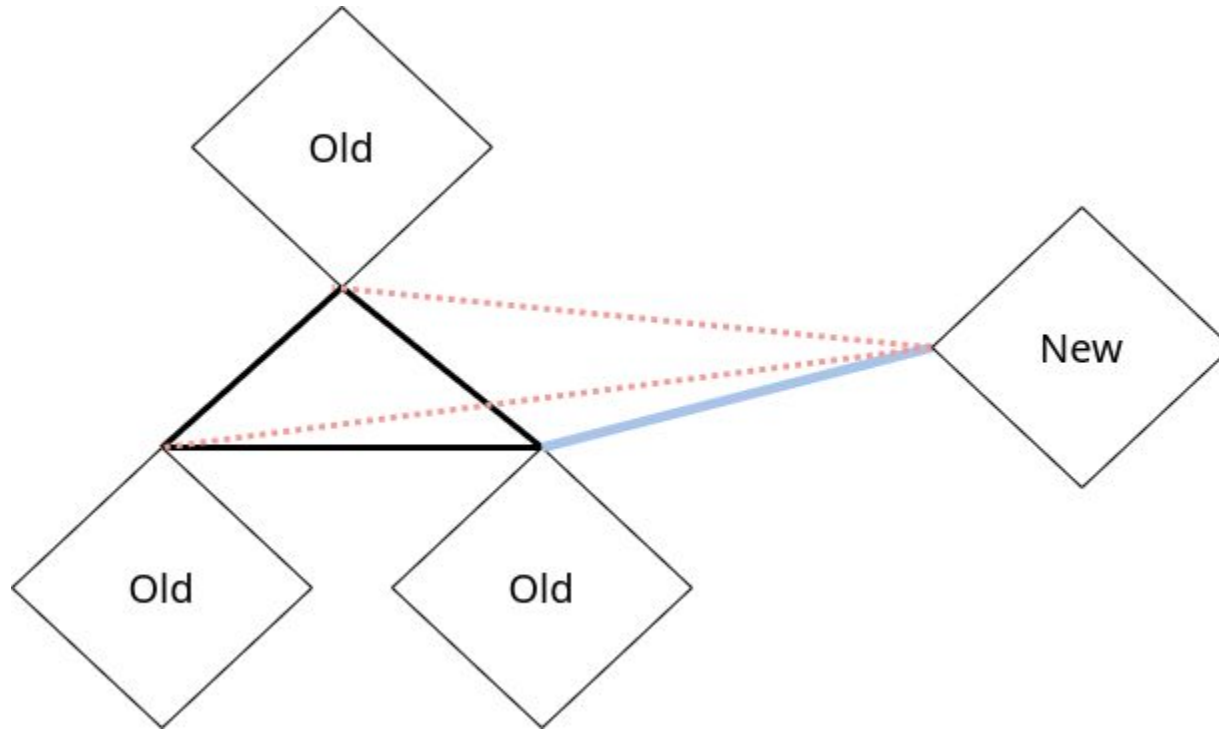
# Problem: New Node



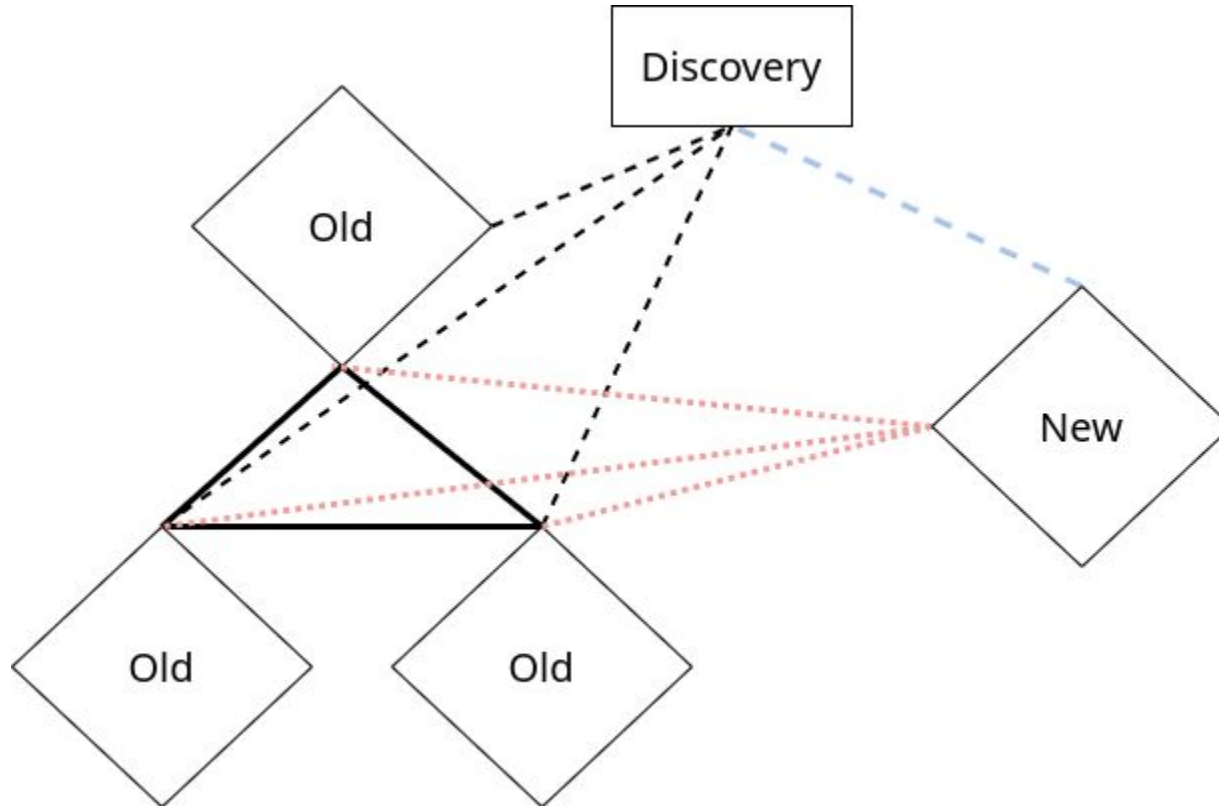
# Broadcast / Multicast



# Bootstrap Gossip

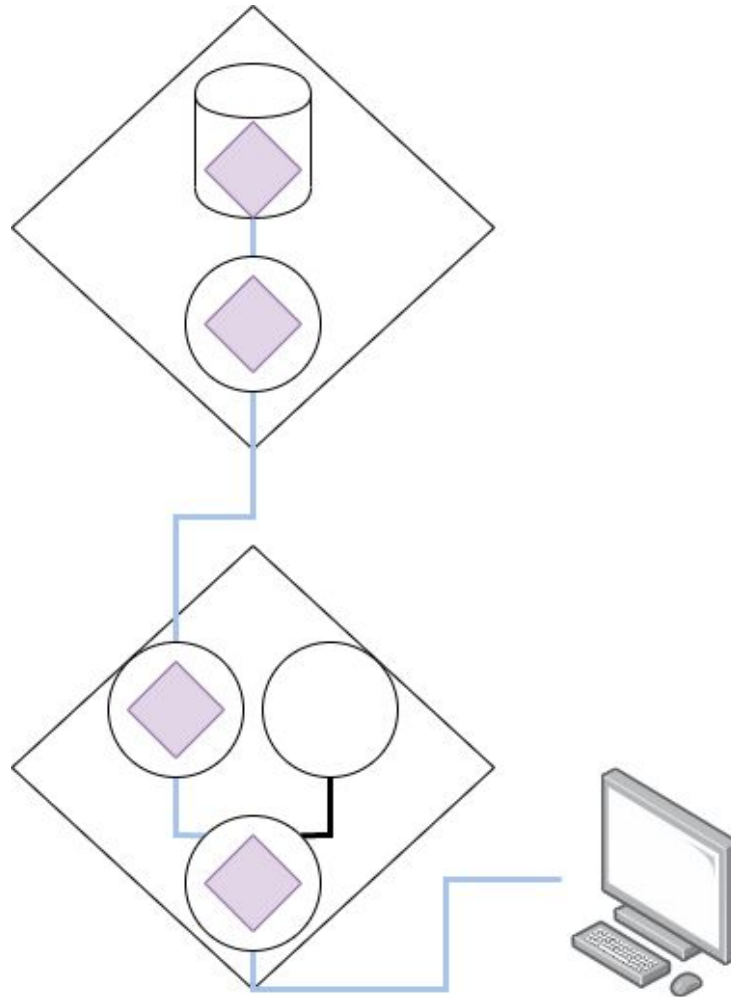


# Central Discovery Server

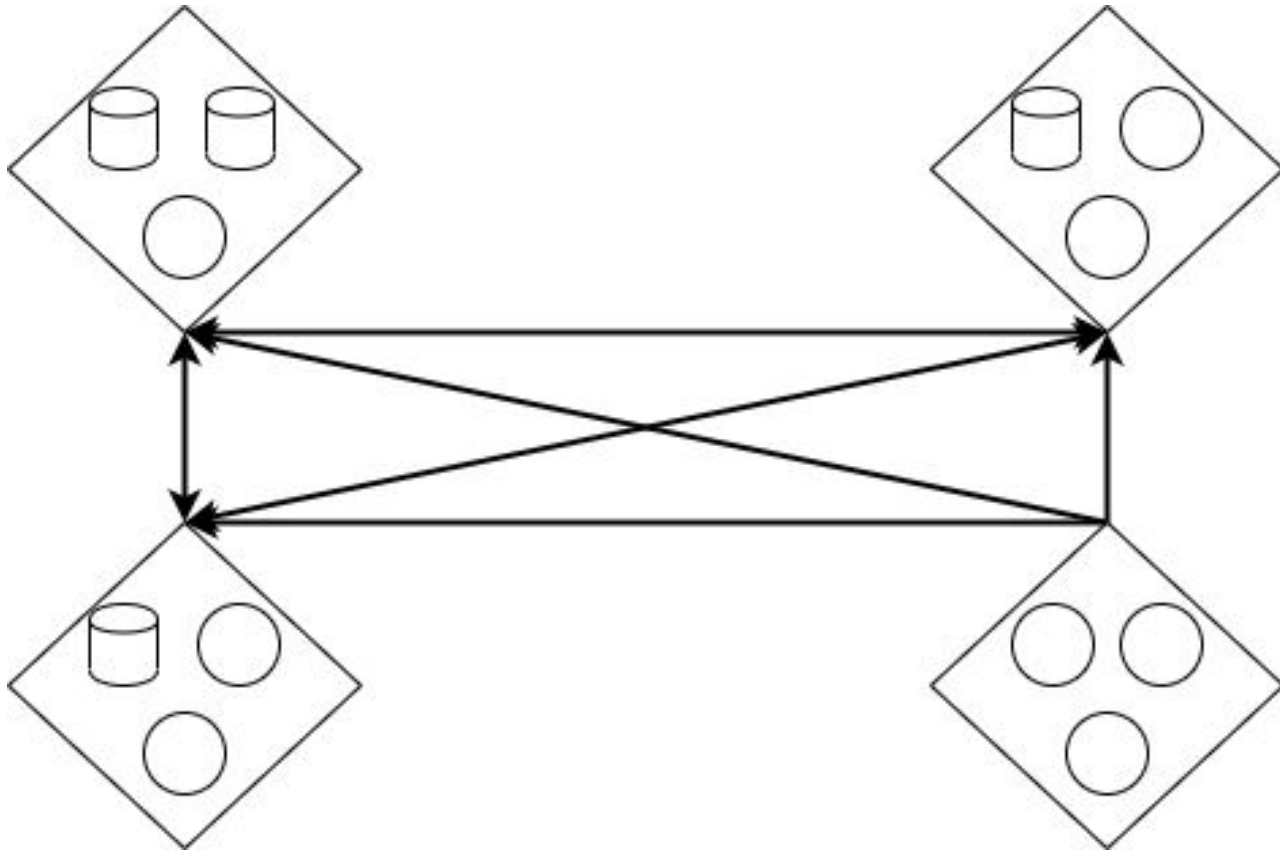


# Network Architecture

# 3 Layer Cache



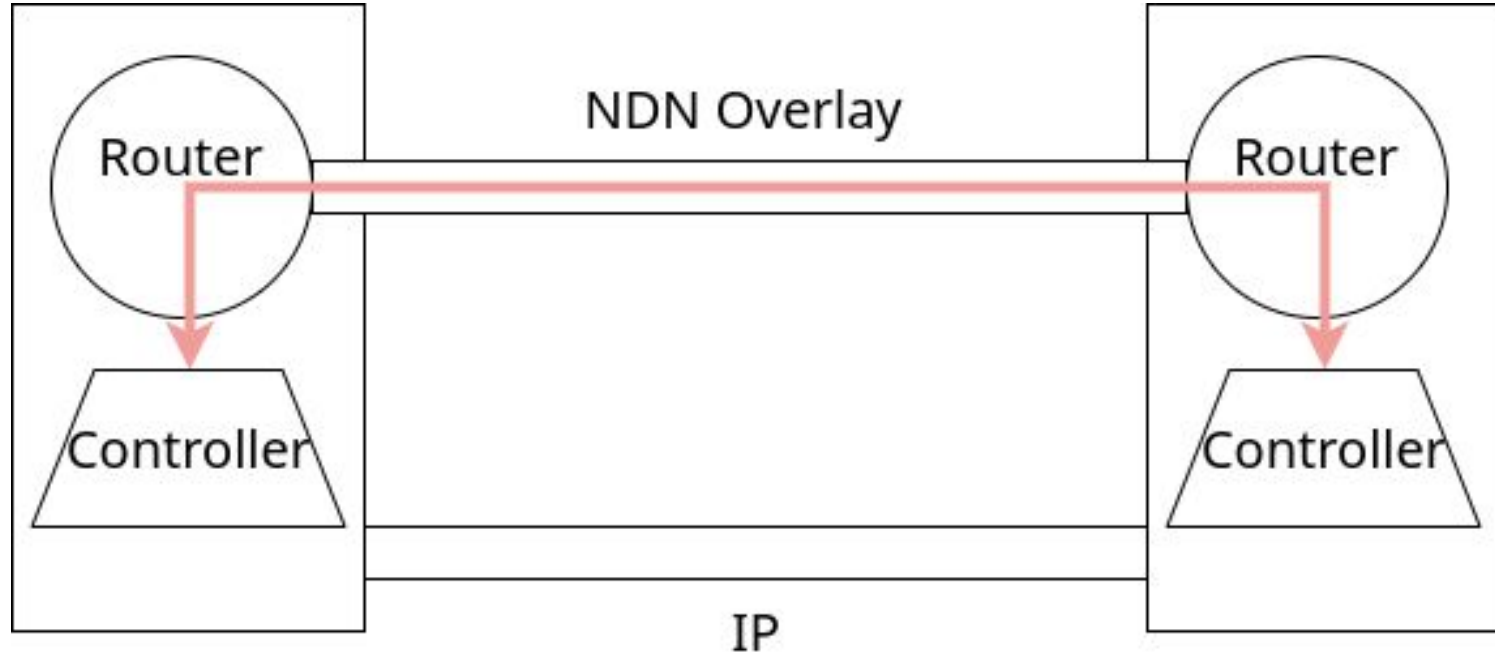
# Mesh Network



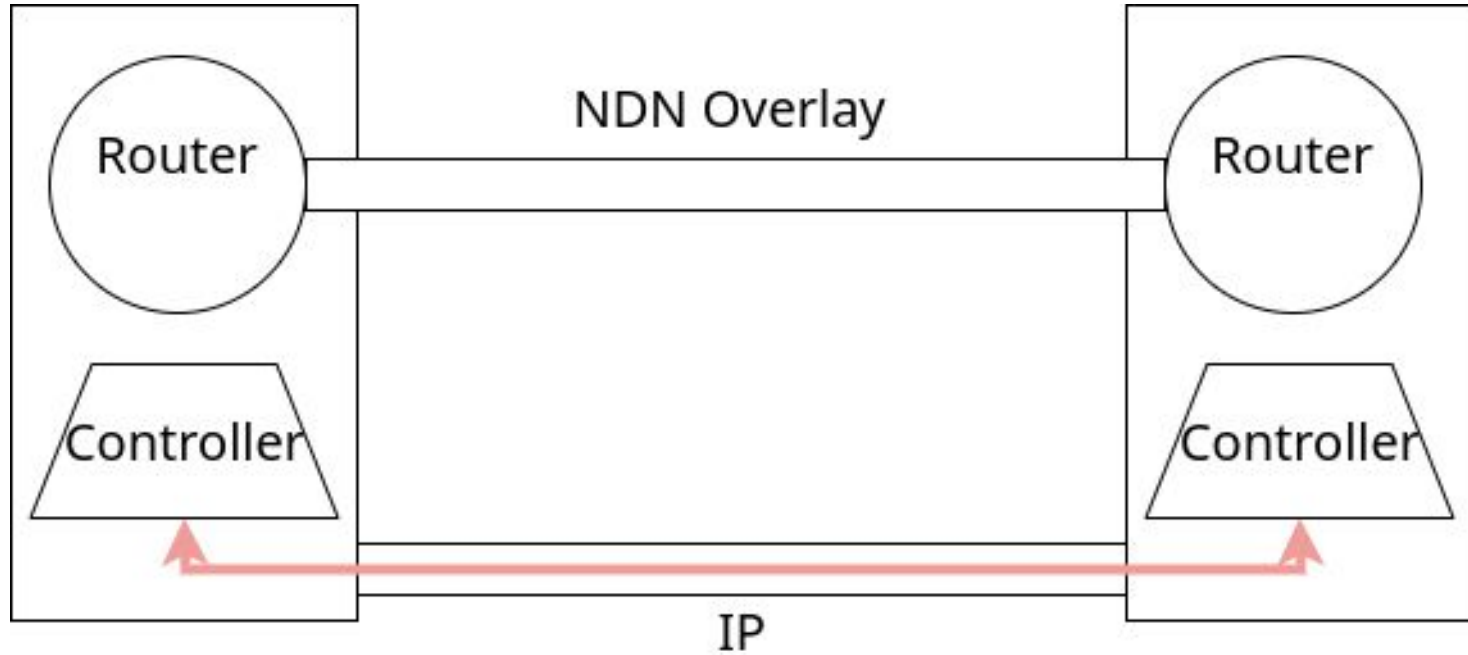


# Automation

# In-band Management



# Out of Band Management



# Proof of Concept

# Necessary Configuration

## Discovery Server

- Write down its address / Give it a preconfigured address

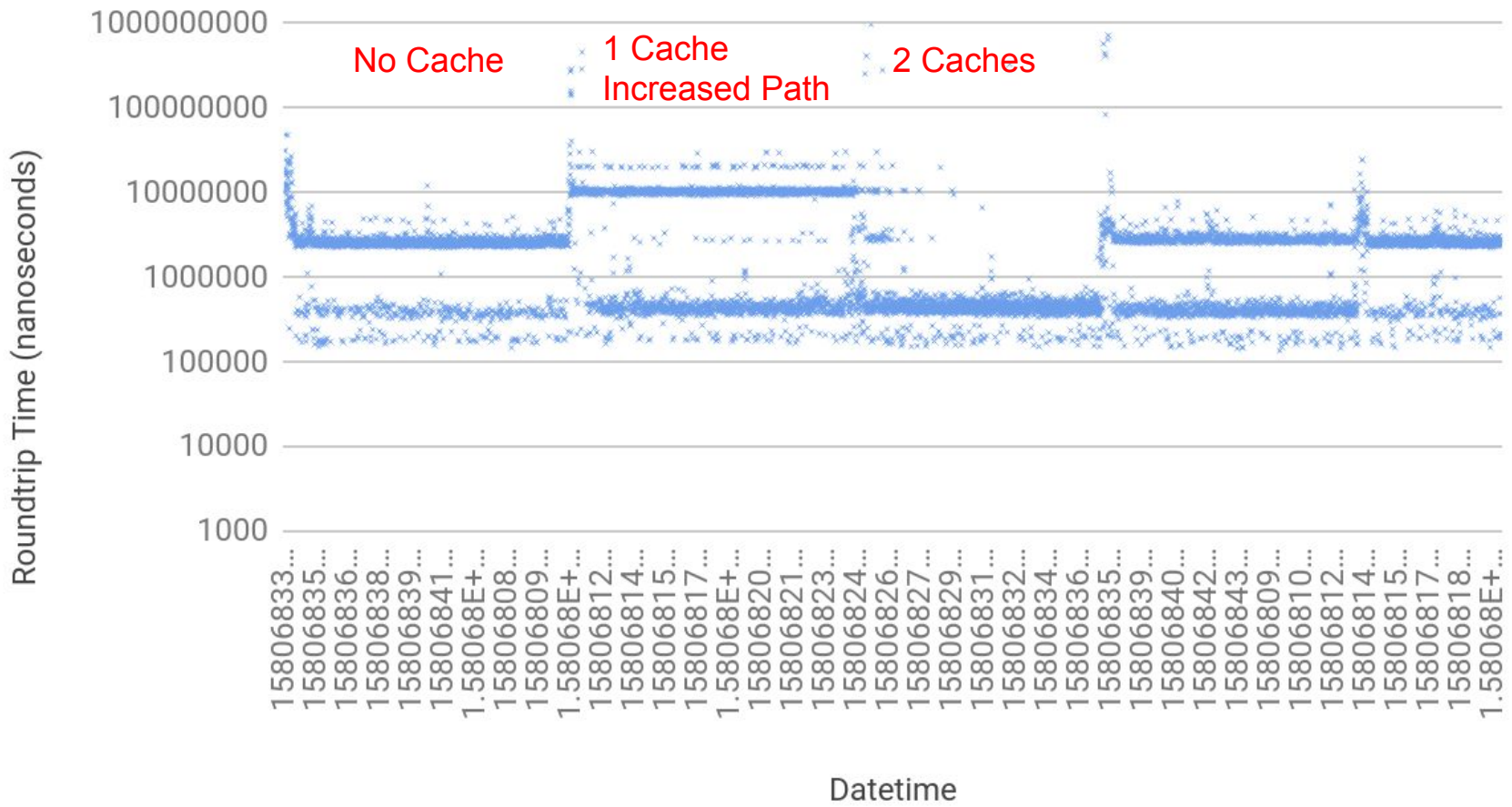
## Load Balancer

- Address of Discovery Server
- Write down its address / Give it a preconfigured address

## Caching Server

- Address of Load Balancer

# Roundtrip Time



# Proof of Concept Performance

Scraping state of router through CLI (on a timer)

TCP connections propagate routes and updates

Coarse grained partitioning of routes

# Conclusion



# Does it work?

Reuse existing router in a load balancing configuration

Minimal configuration, self connecting network

# Lessons Learned

## Now

Rapidly evolving research testbed  
for new ideas

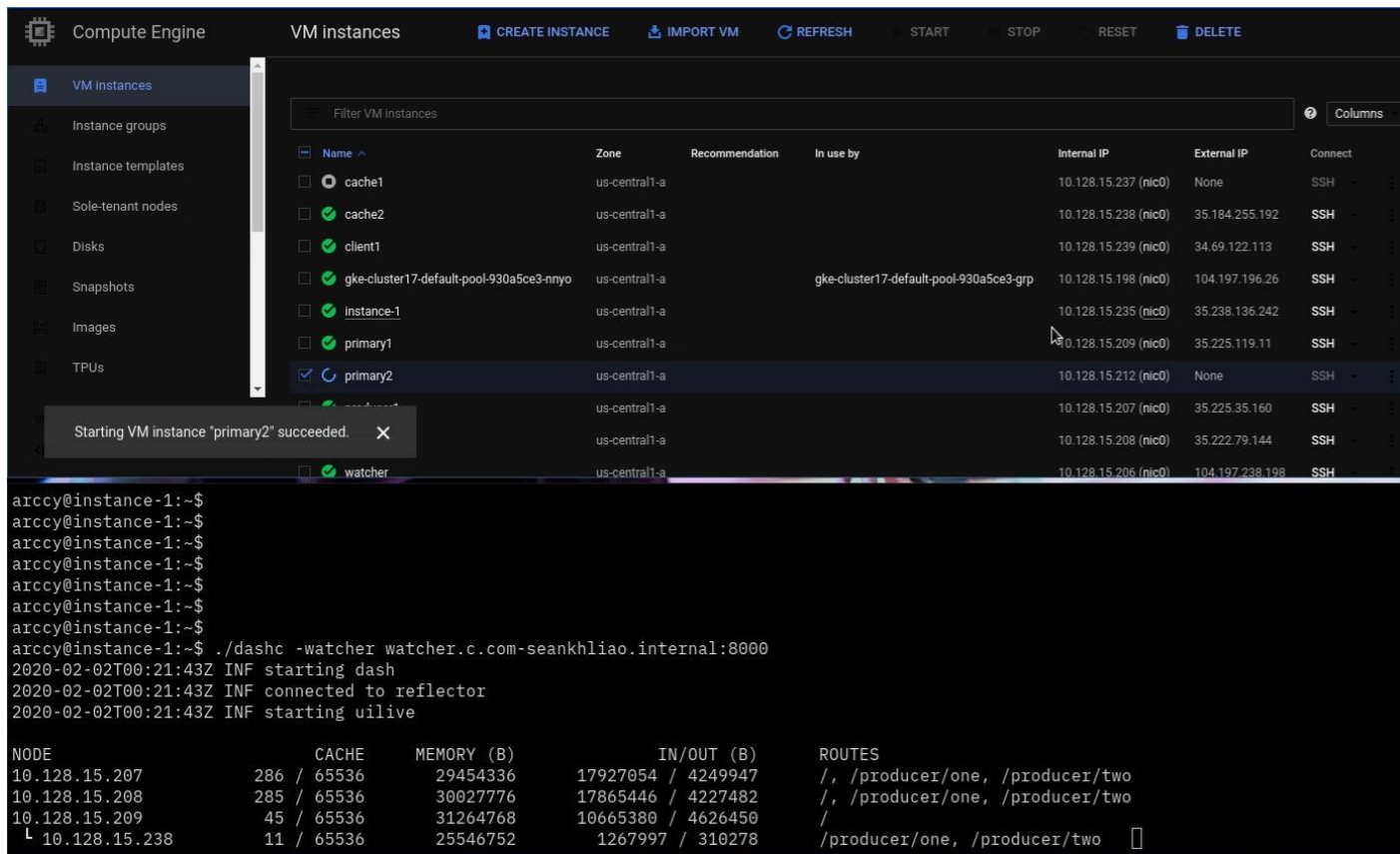
Things break or are not optimized

## Future

Some new network based  
on these ideas

Or maybe not (IPv6...)

# Demo: add load balancer (40s)



The screenshot shows the Google Cloud Platform VM instances page. The interface includes a sidebar with navigation options like 'VM instances', 'Instance groups', 'Instance templates', etc. The main area displays a table of VM instances with columns for Name, Zone, Recommendation, In use by, Internal IP, External IP, and Connect. A notification at the bottom left states 'Starting VM instance 'primary2' succeeded.' Below the table, a terminal window shows the output of a command to start a dash watcher.

Name	Zone	Recommendation	In use by	Internal IP	External IP	Connect
cache1	us-central1-a			10.128.15.237 (nic0)	None	SSH
cache2	us-central1-a			10.128.15.238 (nic0)	35.184.255.192	SSH
client1	us-central1-a			10.128.15.239 (nic0)	34.69.122.113	SSH
gke-cluster17-default-pool-930a5ce3-nnyo	us-central1-a		gke-cluster17-default-pool-930a5ce3-grp	10.128.15.198 (nic0)	104.197.196.26	SSH
instance-1	us-central1-a			10.128.15.235 (nic0)	35.238.136.242	SSH
primary1	us-central1-a			10.128.15.209 (nic0)	35.225.119.11	SSH
primary2	us-central1-a			10.128.15.212 (nic0)	None	SSH
watcher	us-central1-a			10.128.15.207 (nic0)	35.225.35.160	SSH
	us-central1-a			10.128.15.208 (nic0)	35.222.79.144	SSH
	us-central1-a			10.128.15.206 (nic0)	104.197.238.198	SSH

```
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$ ./dashc -watcher watcher.c.com-seankhliao.internal:8000
2020-02-02T00:21:43Z INF starting dash
2020-02-02T00:21:43Z INF connected to reflector
2020-02-02T00:21:43Z INF starting ulive

NODE          CACHE      MEMORY (B)      IN/OUT (B)      ROUTES
10.128.15.207 286 / 65536    29454336        17927054 / 4249947  /, /producer/one, /producer/two
10.128.15.208 285 / 65536    30027776        17865446 / 4227482  /, /producer/one, /producer/two
10.128.15.209 45 / 65536     31264768        10665380 / 4626450   /
└─ 10.128.15.238 11 / 65536     25546752        1267997 / 310278   /producer/one, /producer/two
```

# Demo: remove load balancer (16s)

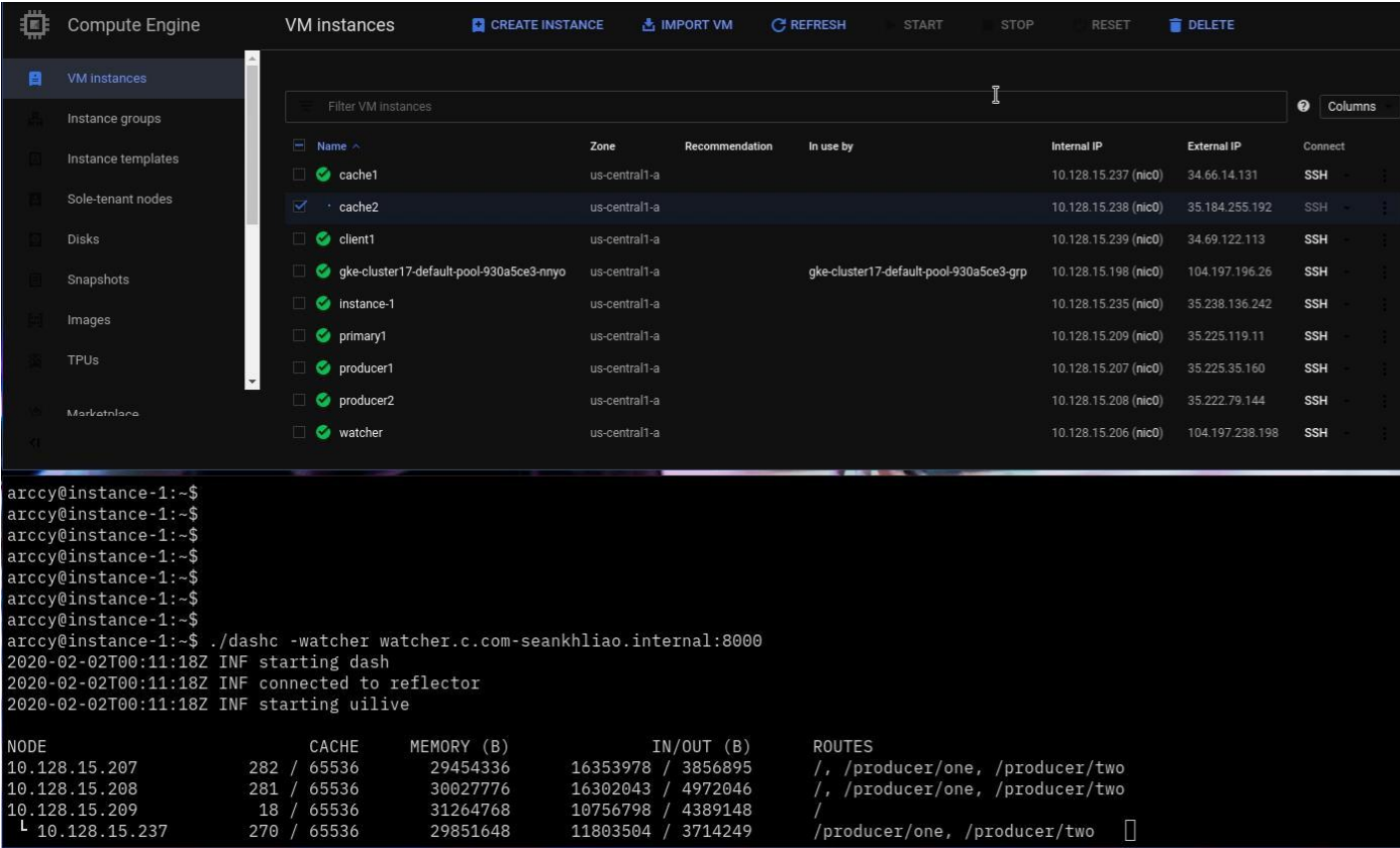
The screenshot shows the Google Cloud Platform console for VM instances. The left sidebar contains navigation options: VM instances, Instance groups, Instance templates, Sole-tenant nodes, Disks, Snapshots, Images, TPUs, and Marketplace. The main area displays a table of VM instances with columns for Name, Zone, Recommendation, In use by, Internal IP, External IP, and Connect. The 'primary2' instance is selected. Below the table is a terminal window showing the execution of a 'dash' script and the resulting network statistics.

Name	Zone	Recommendation	In use by	Internal IP	External IP	Connect
<input type="checkbox"/> cache1	us-central1-a		Stop VM instance	10.128.15.207 (nic0)	None	SSH
<input type="checkbox"/> cache2	us-central1-a			10.128.15.208 (nic0)	35.184.255.192	SSH
<input type="checkbox"/> client1	us-central1-a			10.128.15.209 (nic0)	34.69.122.113	SSH
<input type="checkbox"/> gke-cluster17-default-pool-930a5ce3-nnyo	us-central1-a		gke-cluster17-default-pool-930a5ce3-grp	10.128.15.198 (nic0)	104.197.198.26	SSH
<input type="checkbox"/> instance-1	us-central1-a			10.128.15.205 (nic0)	39.226.120.212	SSH
<input type="checkbox"/> primary1	us-central1-a			10.128.15.209 (nic0)	35.225.119.11	SSH
<input checked="" type="checkbox"/> primary2	us-central1-a			10.128.15.212 (nic0)	34.66.14.131	SSH
<input type="checkbox"/> producer1	us-central1-a			10.128.15.207 (nic0)	35.225.35.160	SSH
<input type="checkbox"/> producer2	us-central1-a			10.128.15.208 (nic0)	35.222.79.144	SSH
<input type="checkbox"/> watcher	us-central1-a			10.128.15.206 (nic0)	104.197.238.198	SSH

```
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$ ./dashc -watcher watcher.c.com-seankhliao.internal:8000
2020-02-02T00:21:43Z INF starting dash
2020-02-02T00:21:43Z INF connected to reflector
2020-02-02T00:21:43Z INF starting ulive

NODE          CACHE      MEMORY (B)      IN/OUT (B)      ROUTES
10.128.15.207 287 / 65536    29454336        18070730 / 4286053  /, /producer/one, /producer/two
10.128.15.208 286 / 65536    30027776        18008575 / 4263004   /, /producer/one, /producer/two
10.128.15.209 45 / 65536    31264768        10752940 / 4645834   /
└─ 10.128.15.238 13 / 65536    25817088        1400604 / 343074   /producer/one, /producer/two
10.128.15.212 11 / 65536    18161664        119308 / 39773    /producer/one, /producer/two
```

# Demo: add Cache (44s)



The screenshot shows the Google Cloud Platform interface for VM instances. The left sidebar lists navigation options: VM Instances, Instance groups, Instance templates, Sole-tenant nodes, Disks, Snapshots, Images, TPUs, and Marketplace. The main area displays a table of VM instances with columns for Name, Zone, Recommendation, In use by, Internal IP, External IP, and Connect. The instance 'cache2' is selected. Below the table is a terminal window showing the execution of a 'dashc' command to add a cache.

Name	Zone	Recommendation	In use by	Internal IP	External IP	Connect
<input type="checkbox"/> cache1	us-central1-a			10.128.15.237 (nic0)	34.66.14.131	SSH
<input checked="" type="checkbox"/> cache2	us-central1-a			10.128.15.238 (nic0)	35.184.255.192	SSH
<input type="checkbox"/> client1	us-central1-a			10.128.15.239 (nic0)	34.69.122.113	SSH
<input type="checkbox"/> gke-cluster17-default-pool-930a5ce3-nnyo	us-central1-a		gke-cluster17-default-pool-930a5ce3-grp	10.128.15.198 (nic0)	104.197.196.26	SSH
<input type="checkbox"/> instance-1	us-central1-a			10.128.15.235 (nic0)	35.238.136.242	SSH
<input type="checkbox"/> primary1	us-central1-a			10.128.15.209 (nic0)	35.225.119.11	SSH
<input type="checkbox"/> producer1	us-central1-a			10.128.15.207 (nic0)	35.225.35.160	SSH
<input type="checkbox"/> producer2	us-central1-a			10.128.15.208 (nic0)	35.222.79.144	SSH
<input type="checkbox"/> watcher	us-central1-a			10.128.15.206 (nic0)	104.197.238.198	SSH

```
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$ ./dashc -watcher watcher.c.com-seankhliao.internal:8000
2020-02-02T00:11:18Z INF starting dash
2020-02-02T00:11:18Z INF connected to reflector
2020-02-02T00:11:18Z INF starting ulive

NODE          CACHE      MEMORY (B)  IN/OUT (B)  ROUTES
10.128.15.207 282 / 65536 29454336    16353978 / 3856895  /, /producer/one, /producer/two
10.128.15.208 281 / 65536 30027776    16302043 / 4972046   /, /producer/one, /producer/two
10.128.15.209 18 / 65536   31264768    10756798 / 4389148   /
└─ 10.128.15.237 270 / 65536 29851648    11803504 / 3714249   /producer/one, /producer/two
```

# Demo: remove Cache (17s)

The screenshot shows the Google Cloud Platform interface for VM instances. A table lists several instances, with 'cache1' selected. A modal dialog indicates that 'cache1' is being stopped. Below the table, a terminal window shows the execution of a 'dash' command, which outputs system statistics including cache, memory, and routes.

Name	Zone	Recommendation	In use by	Internal IP	External IP	Connect
cache1	us-central1-a			10.128.15.237 (nic0)	34.66.14.131	SSH
cache2	us-central1-a			10.128.15.238 (nic0)	35.184.255.192	SSH
client1	us-central1-a			10.128.15.239 (nic0)	34.69.122.113	SSH
gke-cluster17-default-pool-930a5ce3-nnyo	us-central1-a		gke-cluster17-default-pool-930a5ce3-grp	10.128.15.198 (nic0)	104.197.196.26	SSH
instance-1	us-central1-a			10.128.15.235 (nic0)	35.238.136.242	SSH
primary1	us-central1-a			10.128.15.209 (nic0)	35.225.119.11	SSH
producer1	us-central1-a			10.128.15.207 (nic0)	35.225.35.160	SSH
producer2	us-central1-a			10.128.15.208 (nic0)	35.222.79.144	SSH
watcher	us-central1-a			10.128.15.206 (nic0)	104.197.238.198	SSH

```
Stopping VM instance "cache1" X
https://console.cloud.google.com/#
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$
arccy@instance-1:~$ ./dash -watcher watcher.c.com-seankhliao.internal:8000
2020-02-02T00:11:18Z INF starting dash
2020-02-02T00:11:18Z INF connected to reflector
2020-02-02T00:11:18Z INF starting ulive
NODE                CACHE      MEMORY (B)      IN/OUT (B)      ROUTES
10.128.15.207       285 / 65536    29454336        16627390 / 3928689    /, /producer/one, /producer/two
10.128.15.208       284 / 65536    30027776        16572803 / 5040816    /, /producer/one, /producer/two
10.128.15.209       40 / 65536     31264768        10948720 / 4438910    /
└─ 10.128.15.237     275 / 65536    29851648        12052764 / 3779058    /producer/two
   10.128.15.238     7 / 65536      16896000        65702 / 24320        /producer/one
```