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amsix
amsterdam internet exchange

BGP Parallelization

A study into the BGP protocol as well as BGP implementations to improve Route Server scalability.

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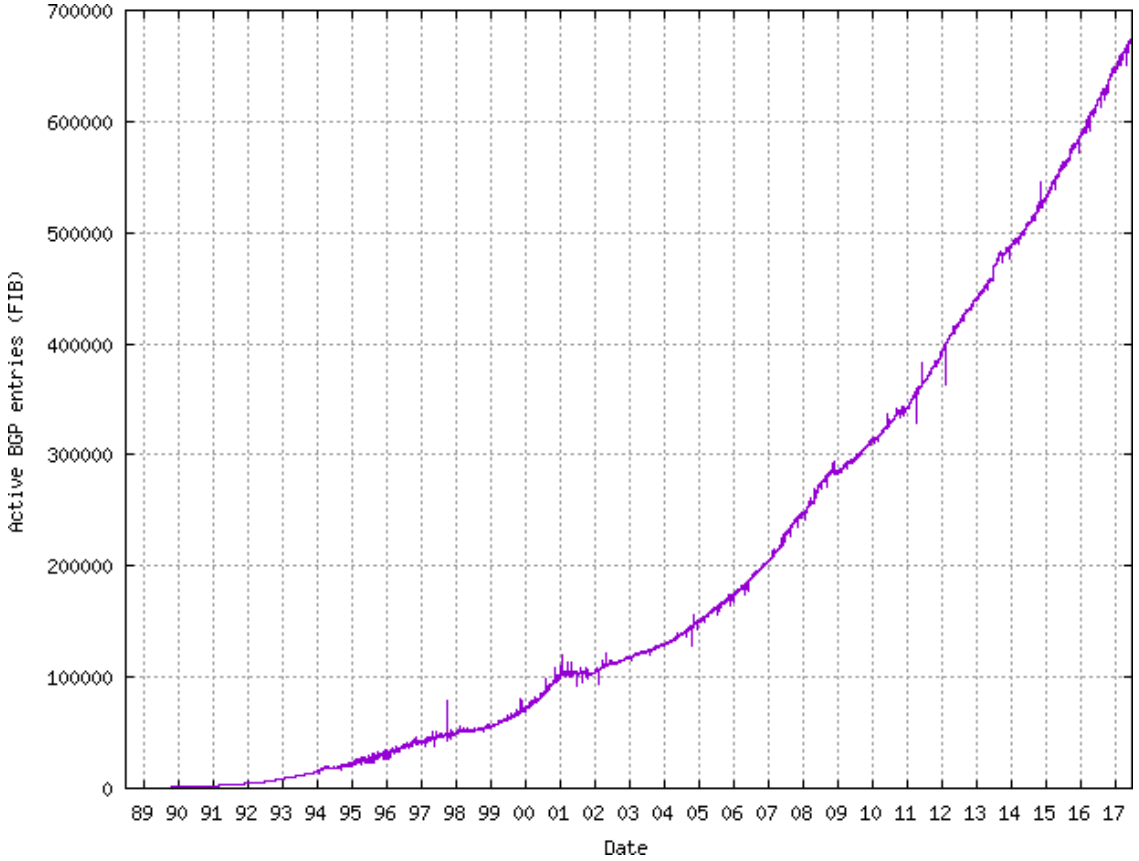
The internet is growing

Active BGP entries in FIB

From cidr-report.org



NETWORKS

More prefixes announced

- De-aggregation of prefixes
- Thus, more prefixes announced
- Currently 673,602 prefixes (03-07-17)

ROUTES

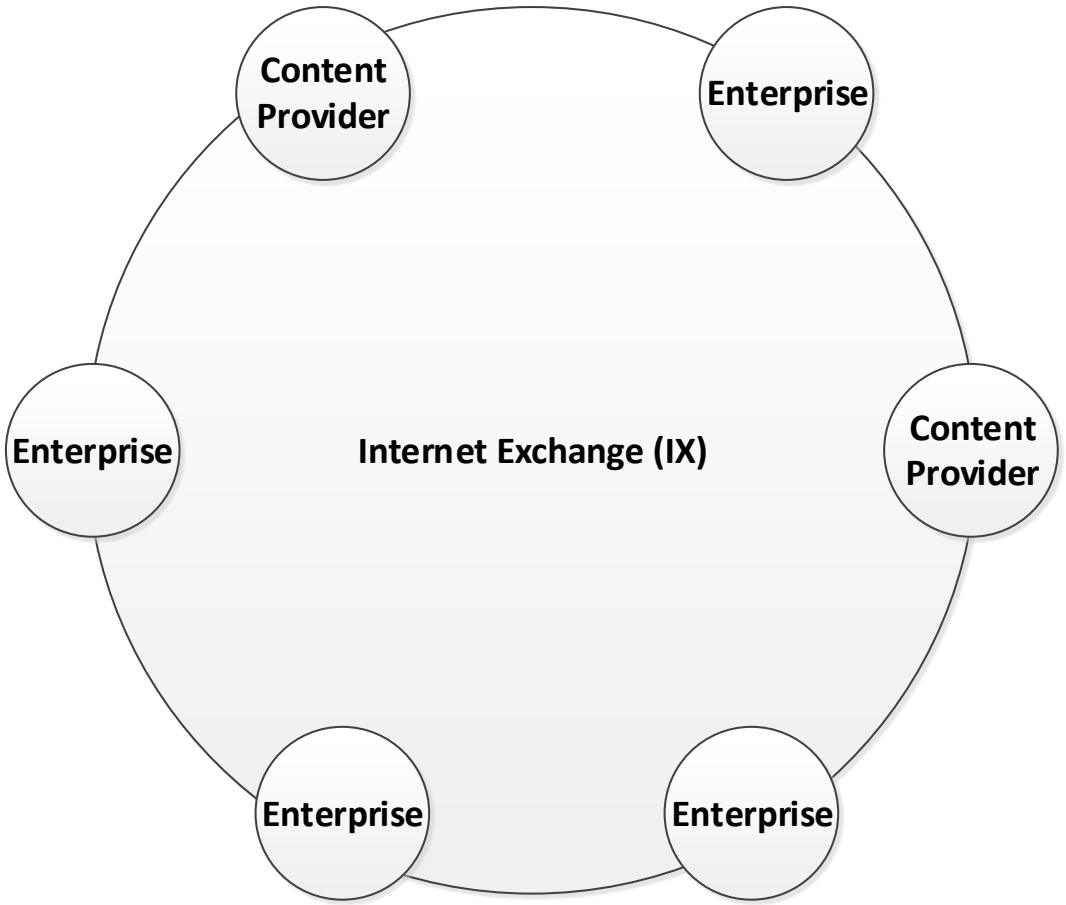
More routes to prefixes announced

- More interconnections are made

Introduction to internet exchanges

Internet Exchange

All nodes in the same layer-2 domain



IX

Benefits of IX

- Flat fee from IX
- Negotiate peering terms with neighbours

PEERING

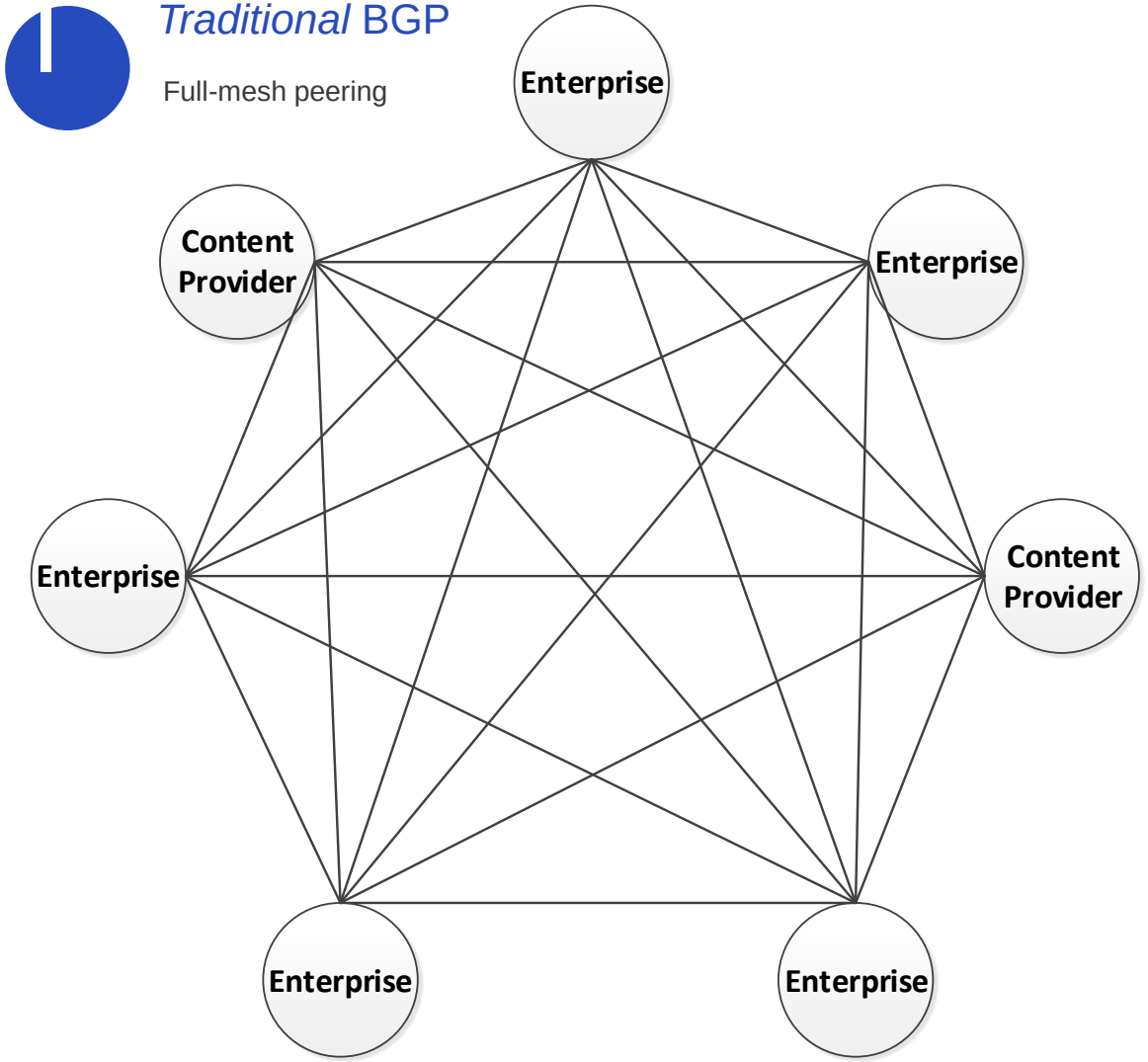
Costs of peering

- Internet Exchanges reduce peering costs and administration

Introduction to route servers

Traditional BGP

Full-mesh peering



BGP

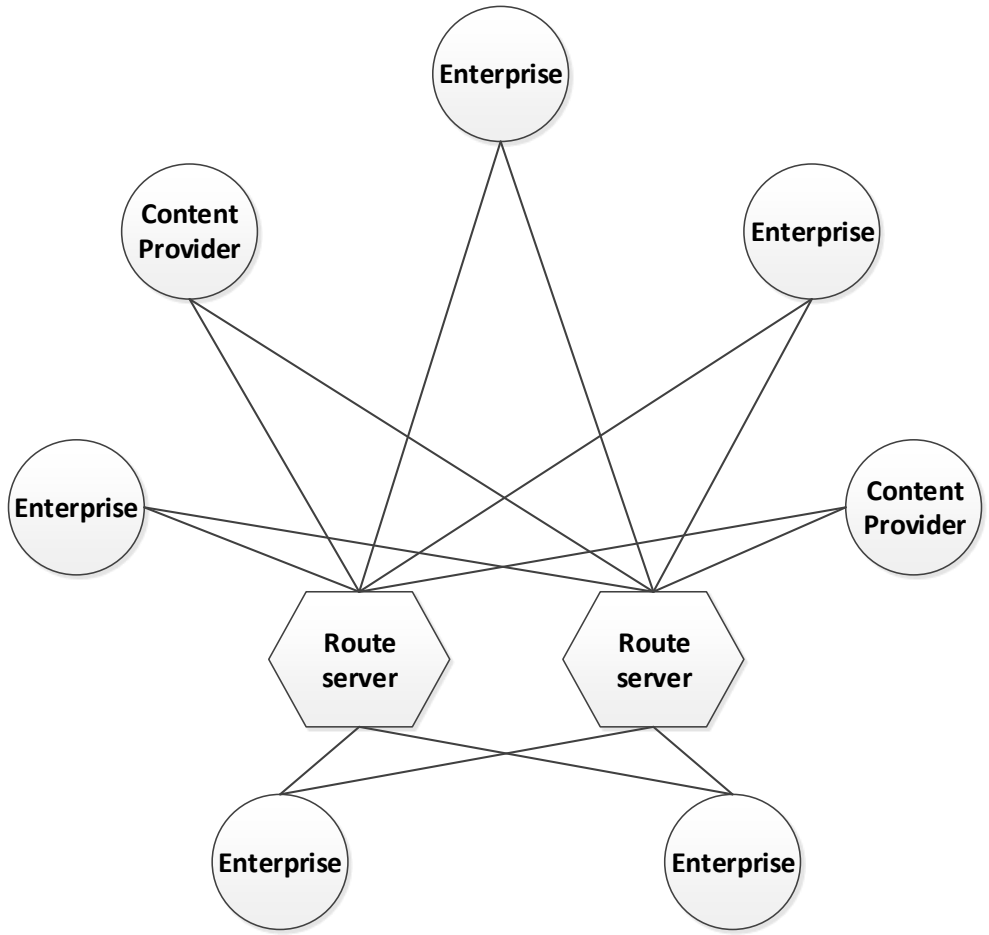
Without Route Server

- 21 Peerings in full-mesh required (*N(N-1)/2*)
- 6 sessions per node
- Same layer 2 network
- Lot of administration/configuration for all peers

Introduction to route servers

Current BGP

Peering with route server



BGP

With route server

- 14 Peerings required (*N2*)
- 2 sessions per node, each route server has 7
- Less administration/configuration needed for peering
- Private peering possible
- Route Server reduces load on clients

Problem

Convergence time

- Maximum CPU usage on route server
- Aged routes on the clients

Problem summary

Route servers are doing the heavy lifting and pushing BGP capabilities

As a result convergence times are increasing

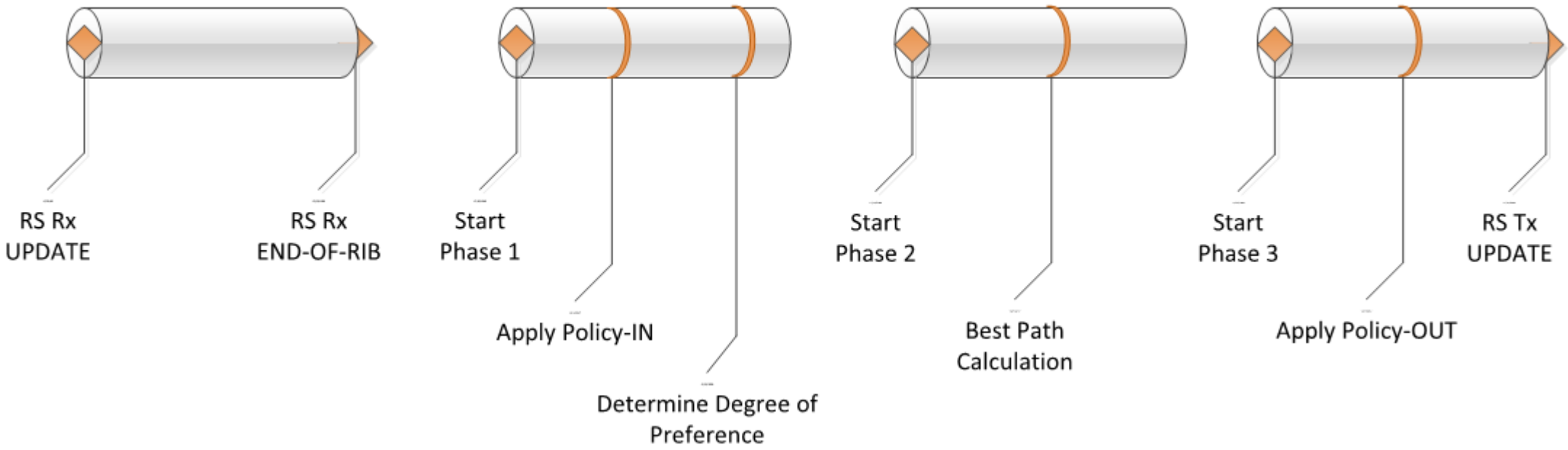
The exact cause of this behaviour within BGP is unidentified

Research question

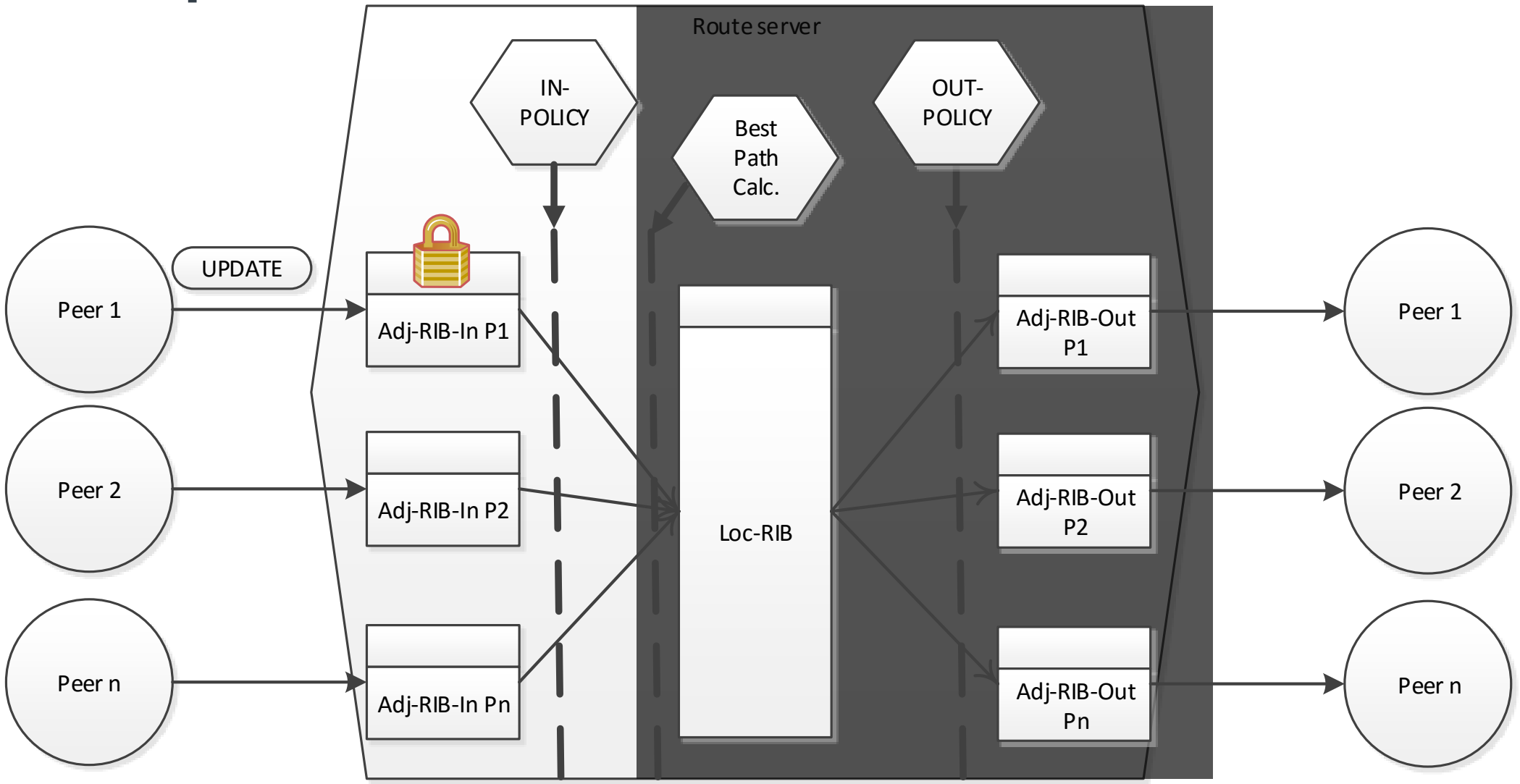
What **improvements** can be made to the **Border Gateway Protocol** (BGP) or its **implementations** to resolve current **CPU bottlenecks** when **processing updates**?

- Why are current BGP implementations (inherently) single-threaded?
- What past work has been done to solve this specific issue?
- What optimizations can be done to resolve this issue?

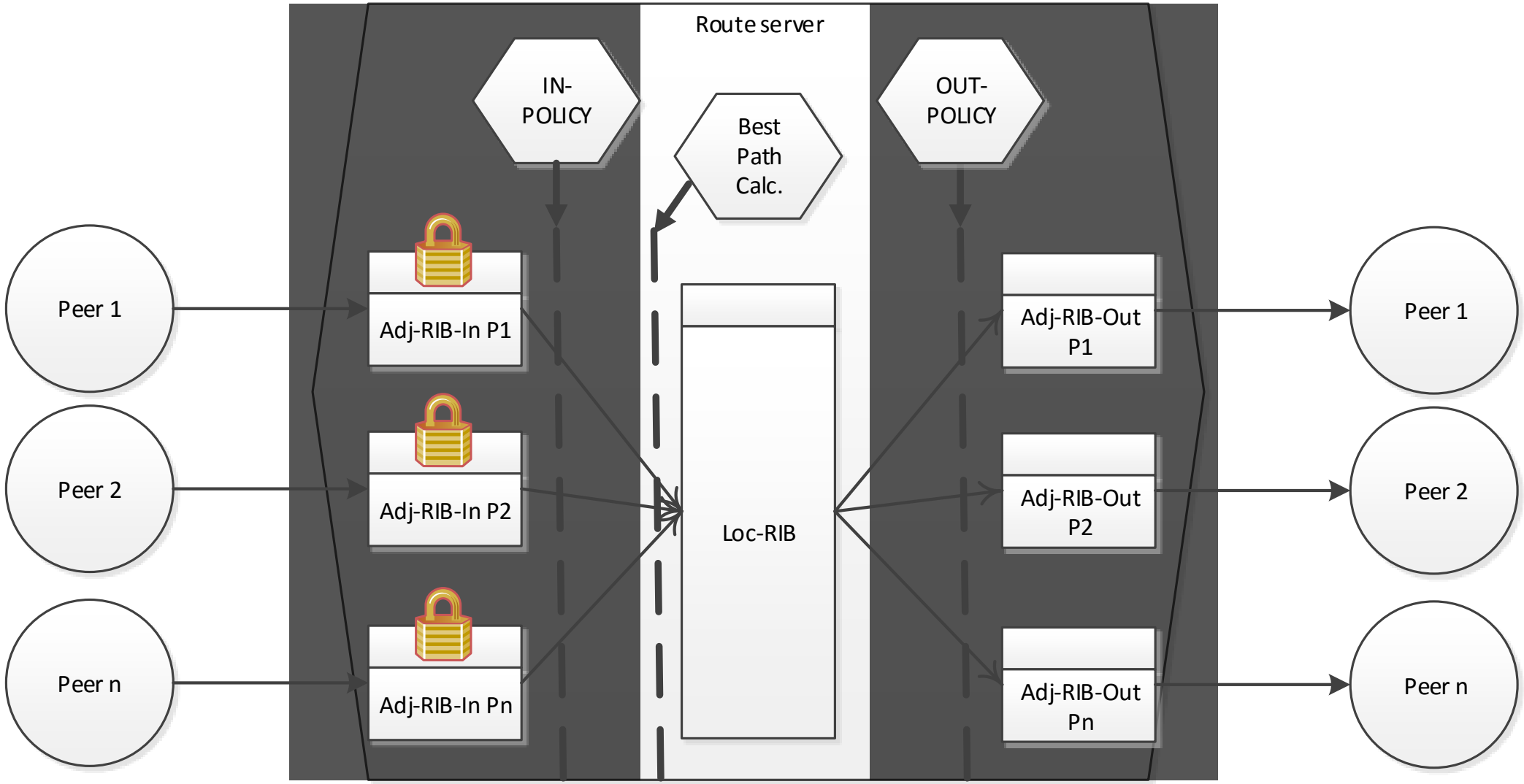
General BGP architecture



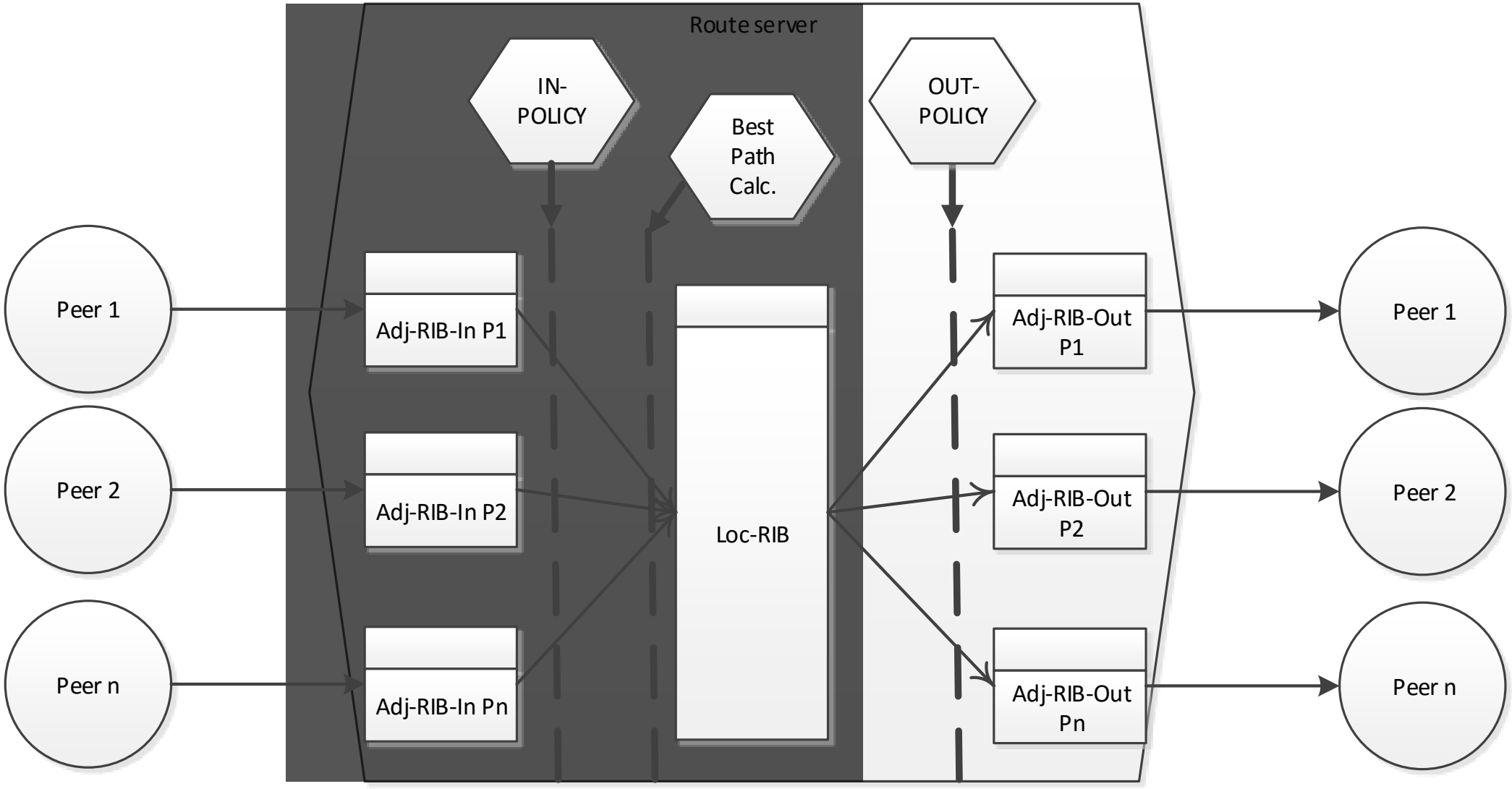
BGP specification (phase 1)



BGP specification (phase 2)



BGP specification (phase 3)

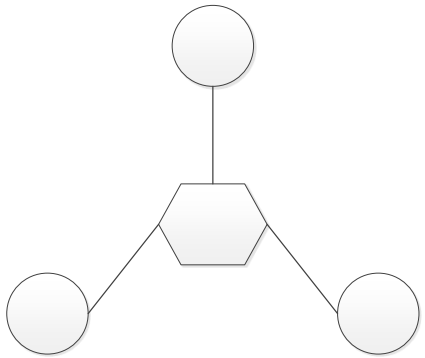


Testing scenarios

SCENARIO 1

THREE to ONE

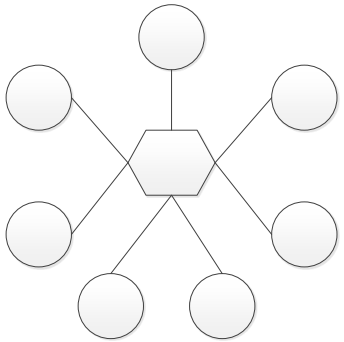
- Three peers
- One route server
- Simulate link-flap



SCENARIO 2

MANY to ONE

- Many peers
- One route server
- Simulate link-flap



SCENARIO 3

REAL WORLD

- Many peers
- One route server
- Overlapping prefixes
- Simulate link-flap

Testing scenarios

SAME

All peers **SAME** prefix

- Peer 1
  - 1.0.0.0/24
  - 1.0.1.0/24
  - 1.0.2.0/24
- Peer 2
  - 1.0.0.0/24
  - 1.0.1.0/24
  - 1.0.2.0/24
- Peer n
  - 1.0.0.0/24
  - 1.0.1.0/24
  - 1.0.2.0/24

UNIQUE

All peers **UNIQUE** prefix

- Peer 1
  - 1.0.0.0/24
  - 1.0.1.0/24
  - 1.0.2.0/24
- Peer 2
  - 1.0.3.0/24
  - 1.0.4.0/24
  - 1.0.5.0/24
- Peer n
  - 1.0.6.0/24
  - 1.0.7.0/24
  - 1.0.8.0/24

REAL-WORLD

REAL WORLD

- Peer 1
  - 1.0.0.0/20
  - 1.0.16.0/20
  - 1.0.32.0/20
- Peer 2
  - 1.0.4.0/23
  - 1.0.6.0/23
  - 1.0.8.0/23
- Peer n
  - 1.0.5.0/24
  - 1.0.7.0/24
  - 1.0.8.0/24

Testbed

ROUTE SERVER

ONE route server

- Intel(R) Xeon(R) CPU E3-1220L V2 @ 2.30GHz (4 cores)
- 7.7GB RAM
- BIRD BGP daemon

PEER SERVERS

EIGHT servers for peers

- Intel(R) Xeon(R) CPU L3426 @ 1.87GHz (8 cores)
- 7.7GB RAM
- Docker used for containers

PEERS

800 peers max

- ExaBGP daemons

Definitions

CONVERGENCE

What defines **CONVERGED** state

- Either
  - Got END-OF-RIB for last peer
  - Stops sending UPDATES

LINK FLAP

All peers **UNIQUE** prefix

- Simulate flapping link
  - Bring link to RS down

METRICS

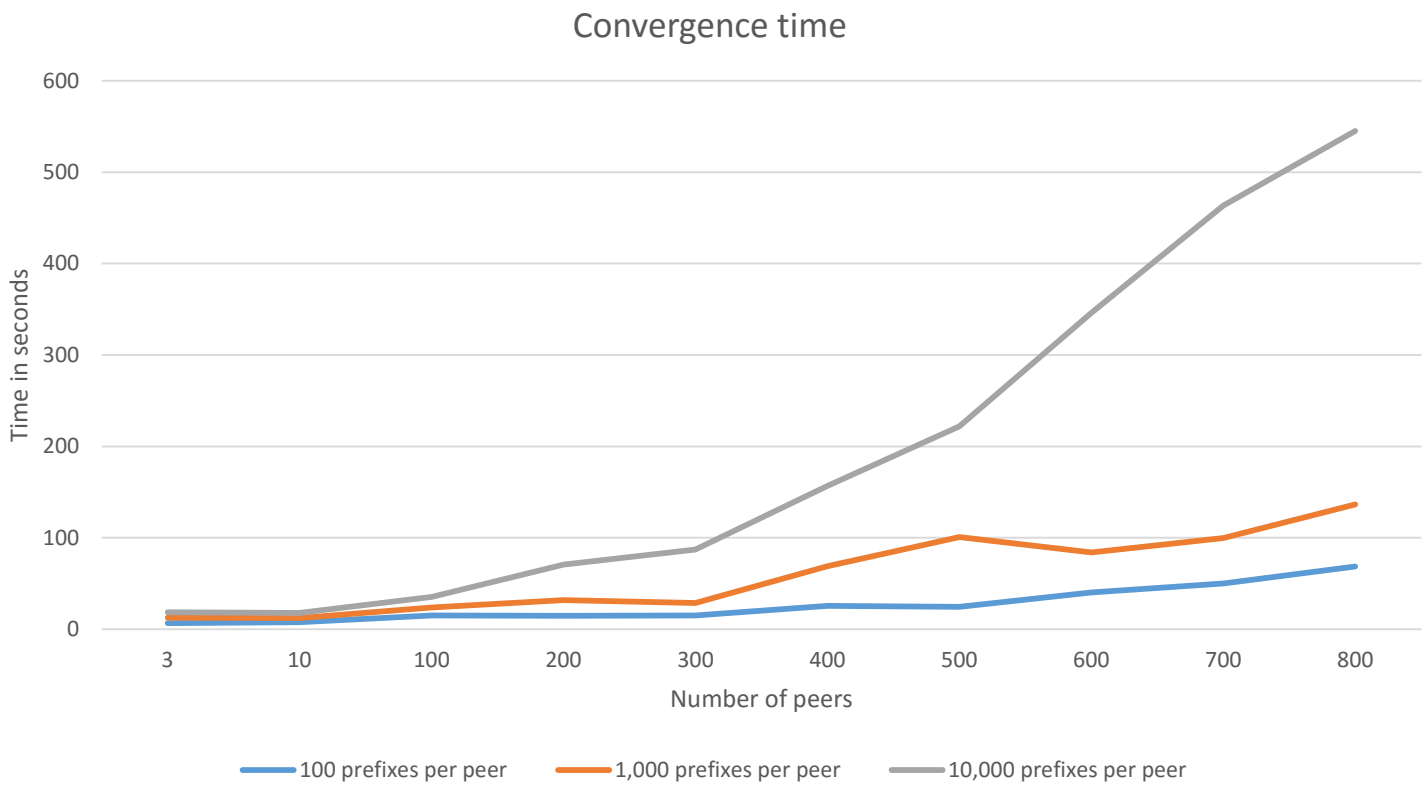
What was **MEASURED**

- CPU Utilization
- Memory Utilization
- Bandwidth

Observations

Convergence time

Convergence time vs number of peers



RESULTS

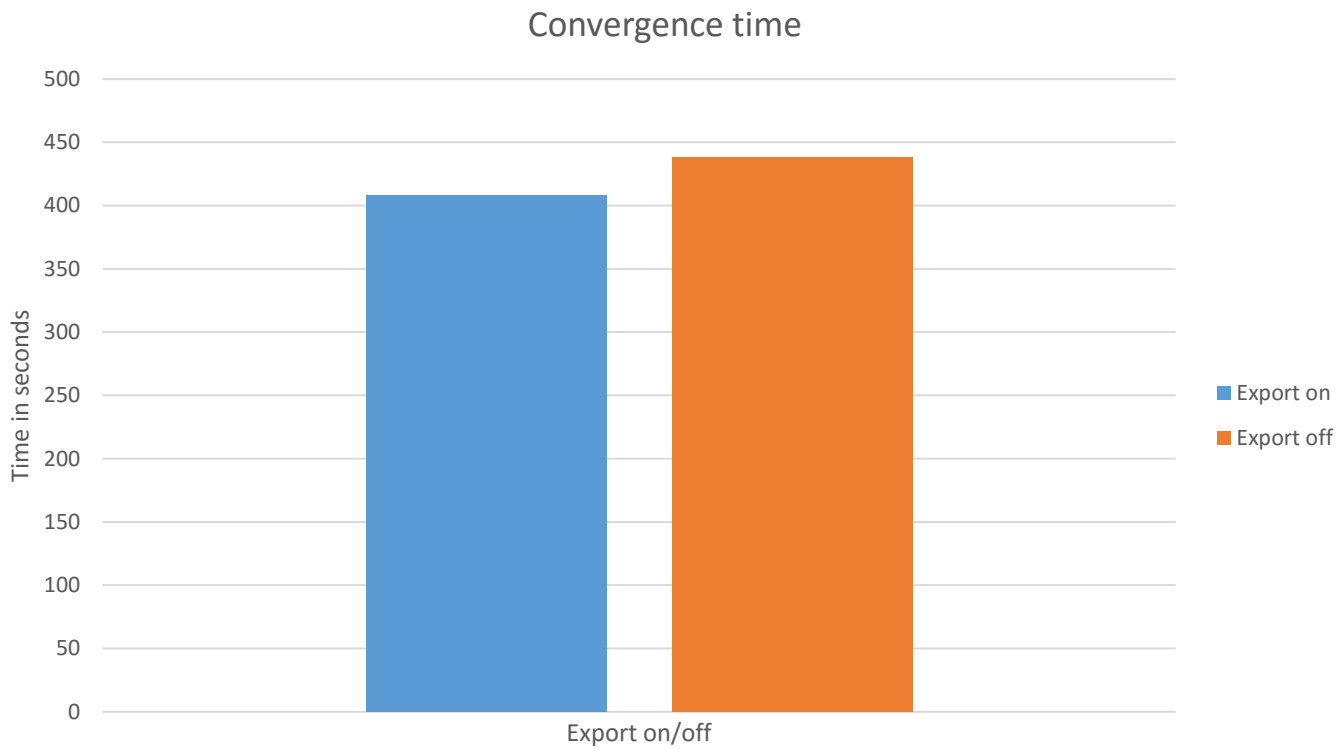
Convergence times

- Lower numbers show lower convergence times
- Higher numbers show increasingly higher times

- 10,000 prefixes with 800 peers significantly higher

Observations

Turning off export of routes



NO EXPORT

Phase 3

- Sending UPDATES disabled
- “export none”

- No significant difference
- Phase 3 (sending UPDATES) can not be the issue

- Unable to conclusively rule out remaining phases

Solutions

PROTOCOL

PROTOCOL improvements

- Snapshot of Adj-RIB-In
- Sorted on prefix

- Calculate hash on peer side
- With OPEN message send hash
- RS compares hash
- If hash is the same no need for full UPDATE

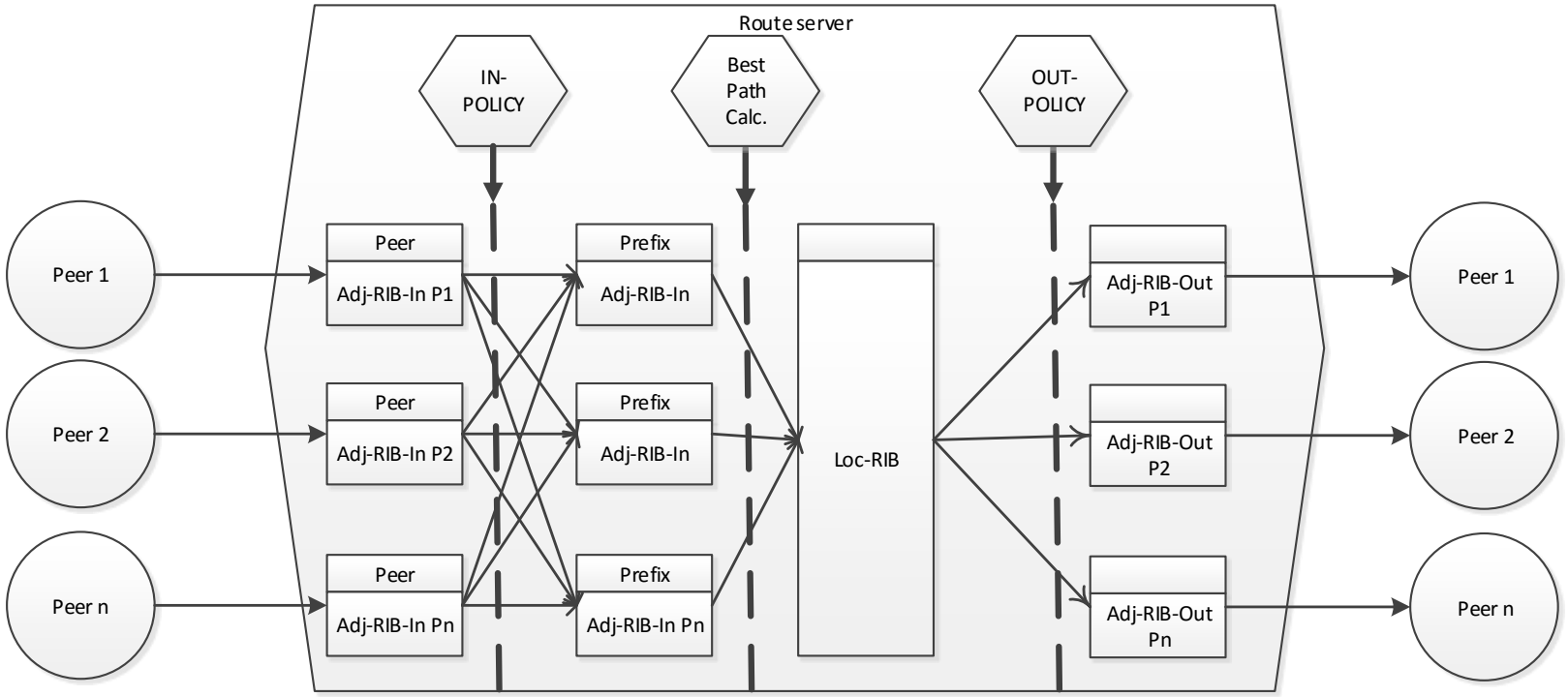
IMPLEMENTATION

IMPLEMENTATION improvements

- Load balance route servers
- Single endpoint for customers
- iBGP for internal convergence
- eBGP for peering

Protocol solution

Protocol modifications



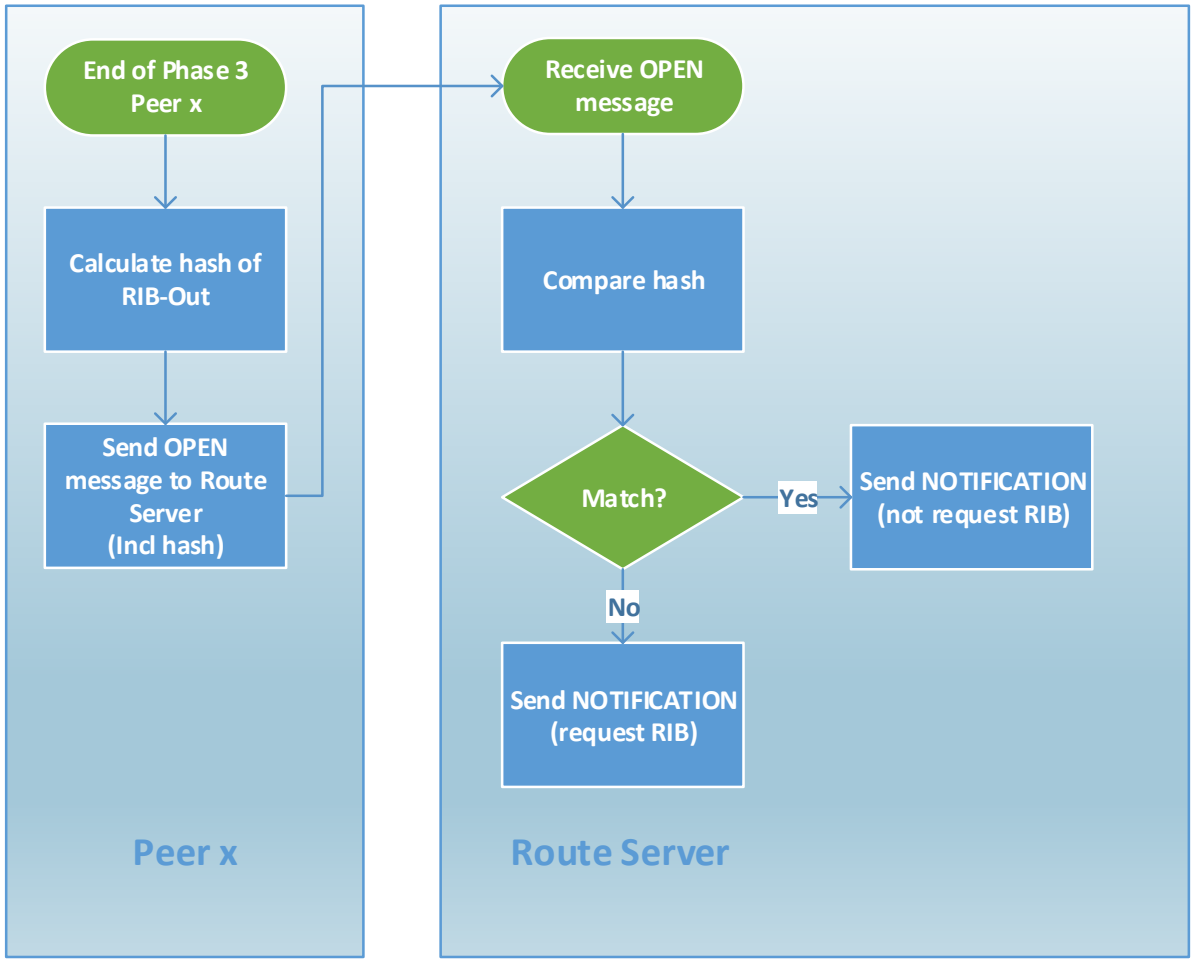
PREFIX BASED

Create prefix based RIB-In

- Create table per prefix
- Add all paths to that prefix
- When starting Phase 2 calculation *only* lock that specific RIB

Protocol solution

Protocol modifications



HASHING

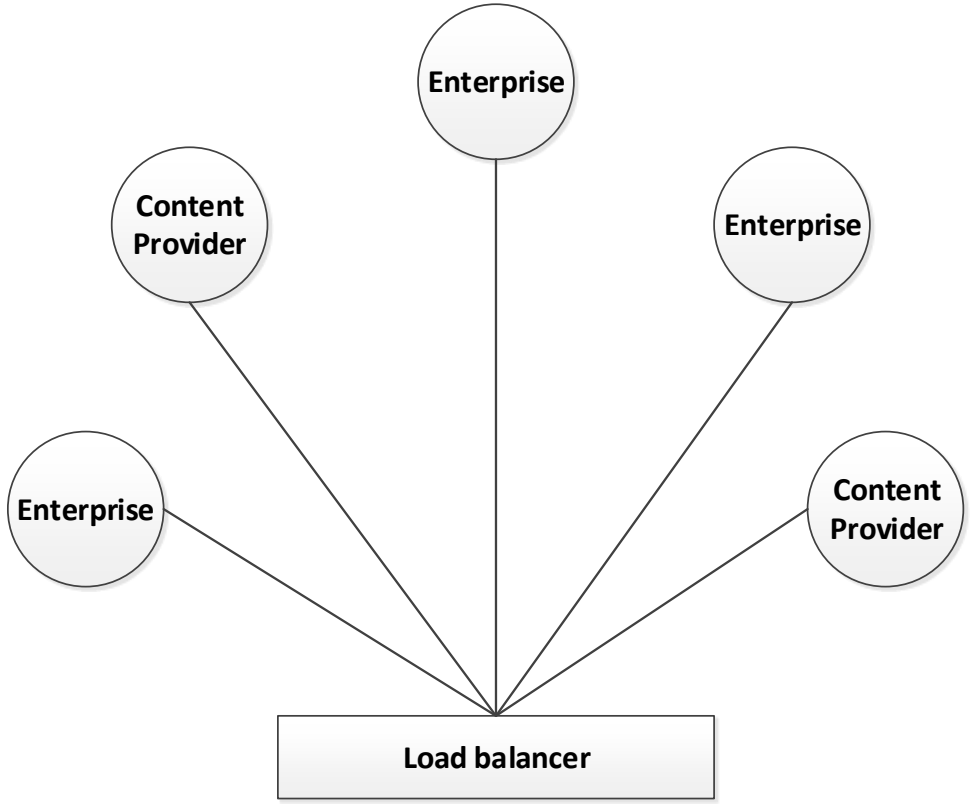
Compare hash before full UPDATE

- Calculate hash of RIB on peer-side
- After link-flap send hash in OPEN message
- RS compares hashes, if match, no need for full UPDATE

Implementation solution

Load balancing

Customers do peering with load-balancer



BEFORE LB

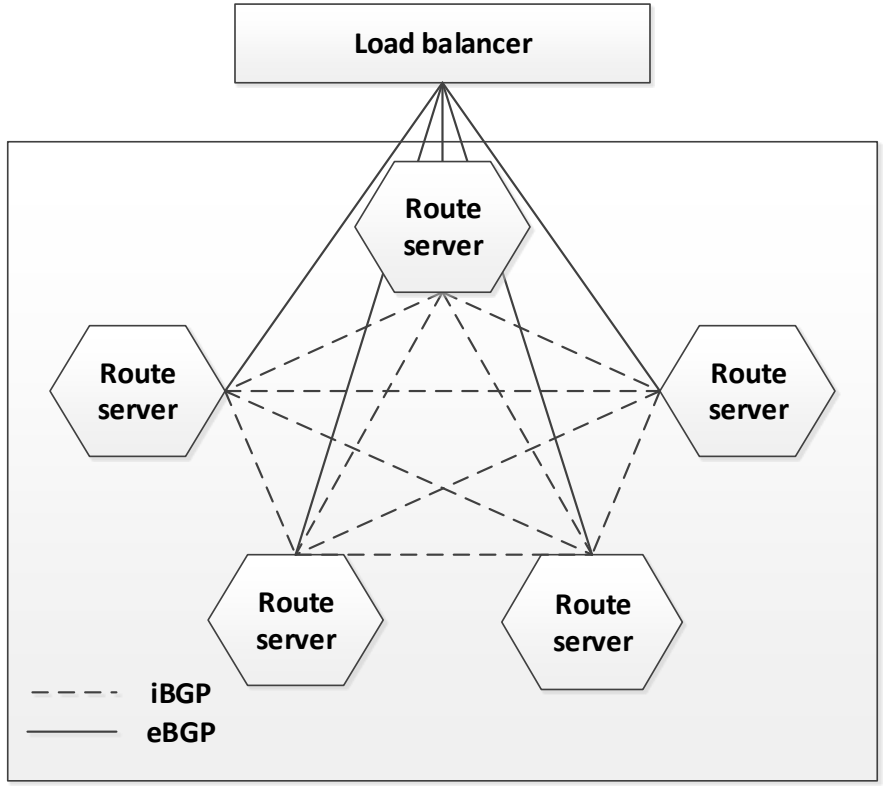
eBGP

- Customers peer through load balancer
- Peer with route server behind load balancer

Implementation solution

Load balancing

Load-balancer balances between route servers



BEHIND LB

iBGP

- iBGP full mesh
- eBGP to load-balancer

Future work

1

Rule out phase 1

Narrow down the problem as much as possible

Good chances phase 1 is also not the issue

2

PoC of hashing mechanism

Set up a proof of concept of the proposed hashing mechanism

1

Benchmarking of code

Go through (open-source) code

Put timestamps, find delaying pieces of code

Narrow down bottleneck

2

PoC of load balancing

Set up a proof of concept with load balancing

Measure convergence time gain

Find any caveats not identified yet

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THANK YOU

Any further questions?

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THANK YOU

Any further questions?

Let’s have a beer