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CloudNativeCon

Europe 2019



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Introduction to NATS

Waldemar Quevedo
Synadia Communications, Inc

About me



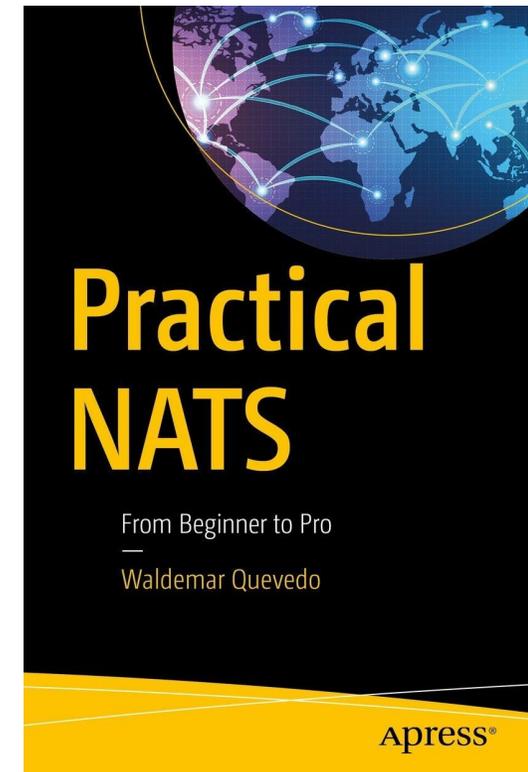
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- Waldemar Quevedo / [@wallyqs](https://twitter.com/wallyqs)
- Software Engineer at **Synadia Communications, Inc**
- NATS core maintainer
- Using NATS based systems since 2012
- Author of *Practical NATS* (Apress, 2018)



Agenda



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- Overview of the NATS project
- New features part of the NATS v2
- Demo





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NATS Overview

About NATS



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NATS is an eight year old, production proven, cloud-native messaging system made for developers and operators who want to spend more time doing their work and less time worrying about how to do messaging.

- ✓ DNA: Performance, simplicity, security, and availability
- ✓ Built from the ground up to be cloud native
- ✓ Multiple qualities of service
- ✓ Support for multiple communication patterns
- ✓ Over 30 client languages

CNCF Landscape



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CNCF Cloud Native Landscape
2019-03-09T01:21:26Z 1b93b5e

See the interactive landscape at [l.cncf.io](https://landscape.cncf.io)

This landscape is intended as a map through the previously uncharted terrain of cloud native technologies. There are many routes to deploying a cloud native application with CNCF. Projects representing a particularly well traveled path.

[l.cncf.io](https://landscape.cncf.io)

CLOUD NATIVE
Landscape

Special

Kubernetes Certified Service Provider

Kubernetes Training Partner

Joined CNCF as an incubation project in 2018

<https://landscape.cncf.io>

CNCF Landscape



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CNCF Cloud Native Landscape
2019-03-09T01:21:26Z 1b93b5e

See the interactive landscape at l.cncf.io

Database Streaming & Messaging Application Definition & Image Build Continuous Integration & Delivery Platform Observability and Analysis

App Definition and Development

Orchestration & Management

Runtime

Provisioning

Cloud

Platform

Observability and Analysis

Cloud Native Storage Container Runtime Cloud-Native Network

Automation & Configuration Container Registry Security & Compliance Key Management

Public

Kubernetes Certified Service Provider

Kubernetes Training Partner

This landscape is intended as a map through the previously uncharted terrain of cloud native technologies. There are many routes to deploying a cloud native application with CNCF. Projects representing a particularly well traveled path.

l.cncf.io

CLOUD NATIVE Landscape

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CNCF Landscape



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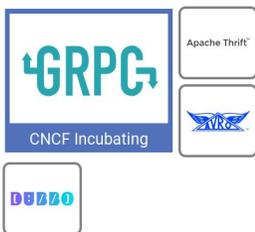
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Streaming & Messaging



Remote Procedure Call



8. STREAMING & MESSAGING

When you need higher performance than JSON-REST, consider using gRPC or NATS. gRPC is a universal RPC framework. NATS is a multi-modal messaging system that includes request/reply, pub/sub and load balanced queues.

CNCF Incubating

CNCF Incubating

Contribution stats



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- Over 1000 contributors, over 100 with more than 10 commits*
- 30+ public repos
 - 50+ releases
 - 8000+ GitHub stars across repos
- ~35M NATS server Docker Hub pulls
- ~25M NATS streaming server pulls
- 1200+ Slack members
- 20+ releases of the NATS server since June 2014, ~= 5/year

<https://nats.devstats.cncf.io/d/9/developers-summary>

History



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Derek Collison

Founder and CEO at Synadia

Founder and former CEO at Apcera
CTO, Chief Architect at VMware
Architected CloudFoundry
Technical Director at Google
SVP and Chief Architect at TIBCO

Created by Derek Collison

Derek has been building messaging systems and solutions > 25 yrs

Maintained by a highly experienced messaging team

Engaged User Community

Growing Community: NATS End Users



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Use Cases



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- Cloud Messaging
 - ✓ Services (microservices, service mesh)
 - ✓ Event/Data Streaming (observability, analytics, ML/AI)
 - ✓ Command and Control
- IoT and Edge
 - ✓ Telemetry / Sensor Data / Command and Control
- Augmenting or Replacing Legacy Messaging



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**NATS as an always available dial tone to
connect everything**



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Core of NATS: 3 Simple Patterns

Messaging Patterns



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- ✓ Publish/Subscribe
- ✓ Load Balanced Queue Subscribers
- ✓ Request/Reply

Subjects



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A subject is simply a string representing an interest in data.

- Simple subject: **foo**
- Hierarchically Tokenized: **foo.bar**
- Wildcard subscriptions
 - ✓ **foo.*** matches **foo.bar** and **foo.baz**.
 - ✓ **foo*.bar** matches **foo.a.bar** and **foo.b.bar**.
 - ✓ **foo.>** matches any of the above
 - ✓ **>** matches everything in NATS

Request/Response (1:1)



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Publish/Subscribe (1:N)

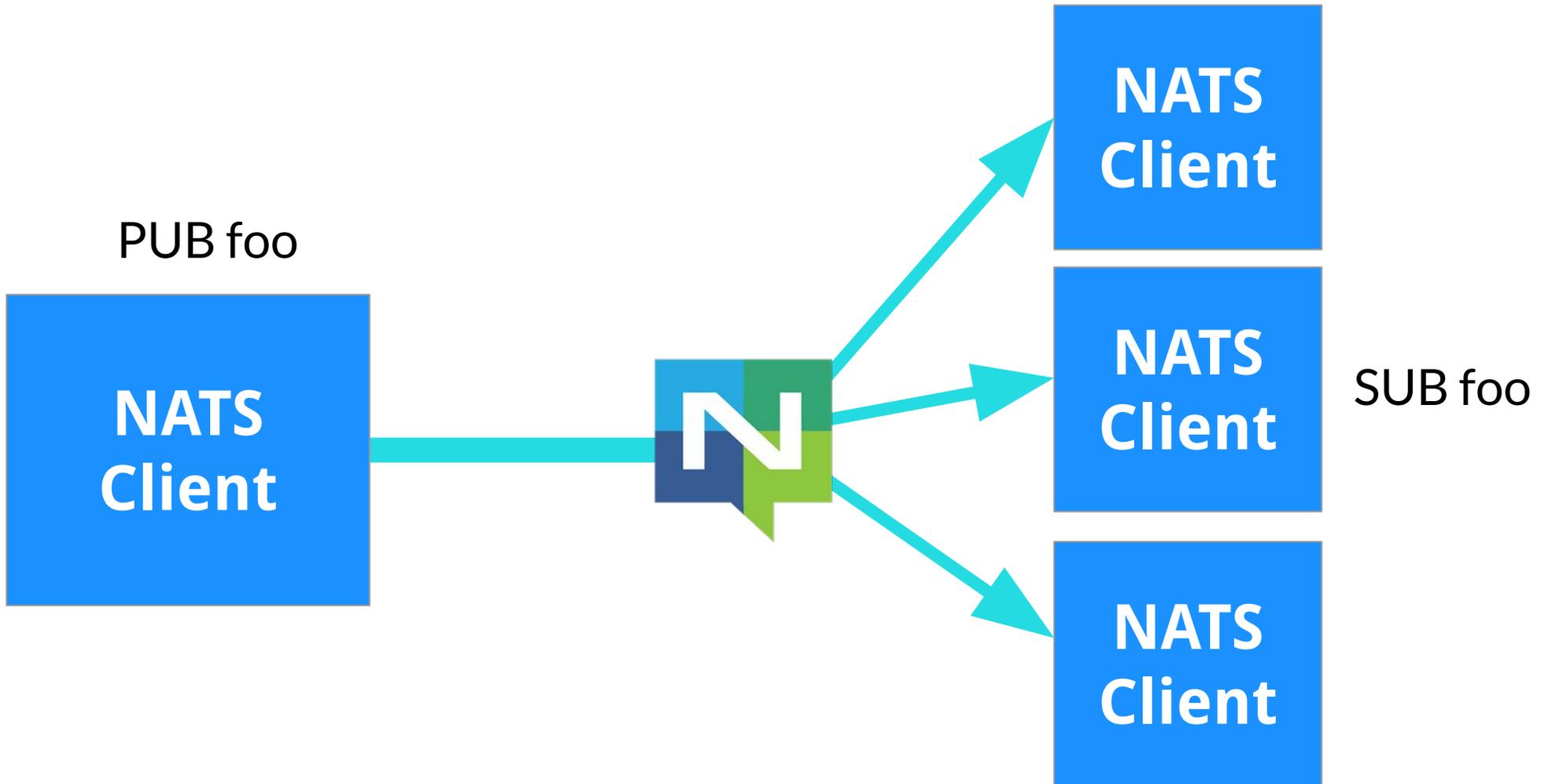


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Load Balanced Queues

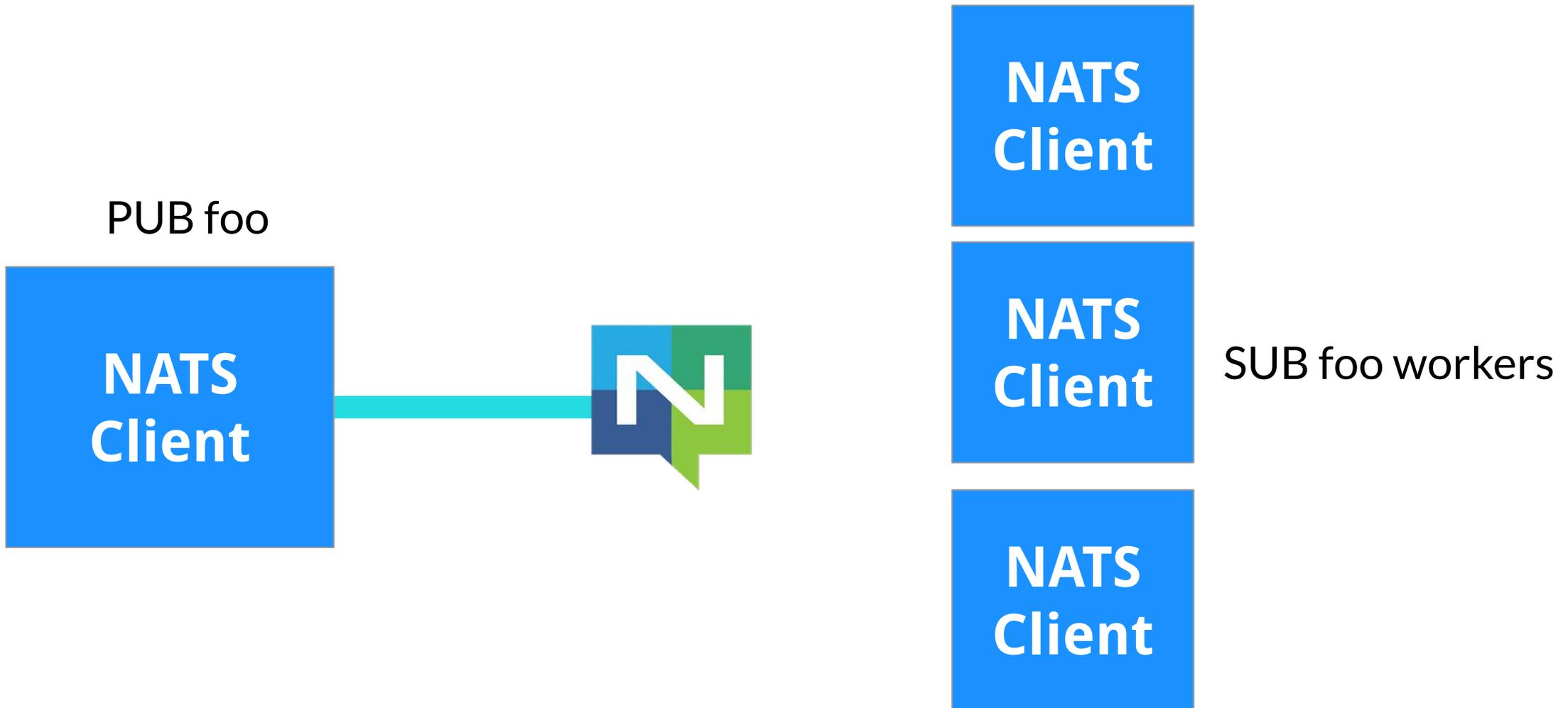


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Load Balanced Queues

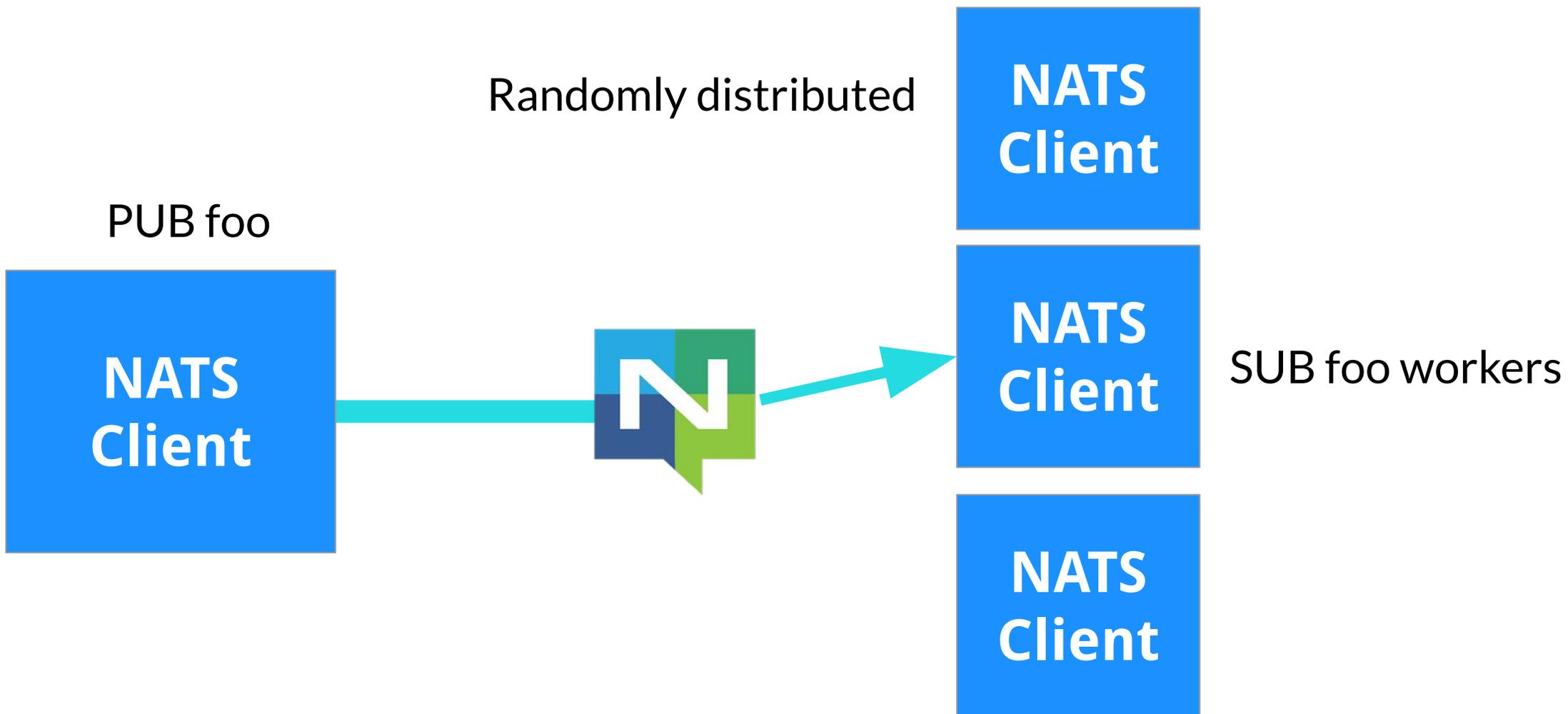


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Load Balanced Queues

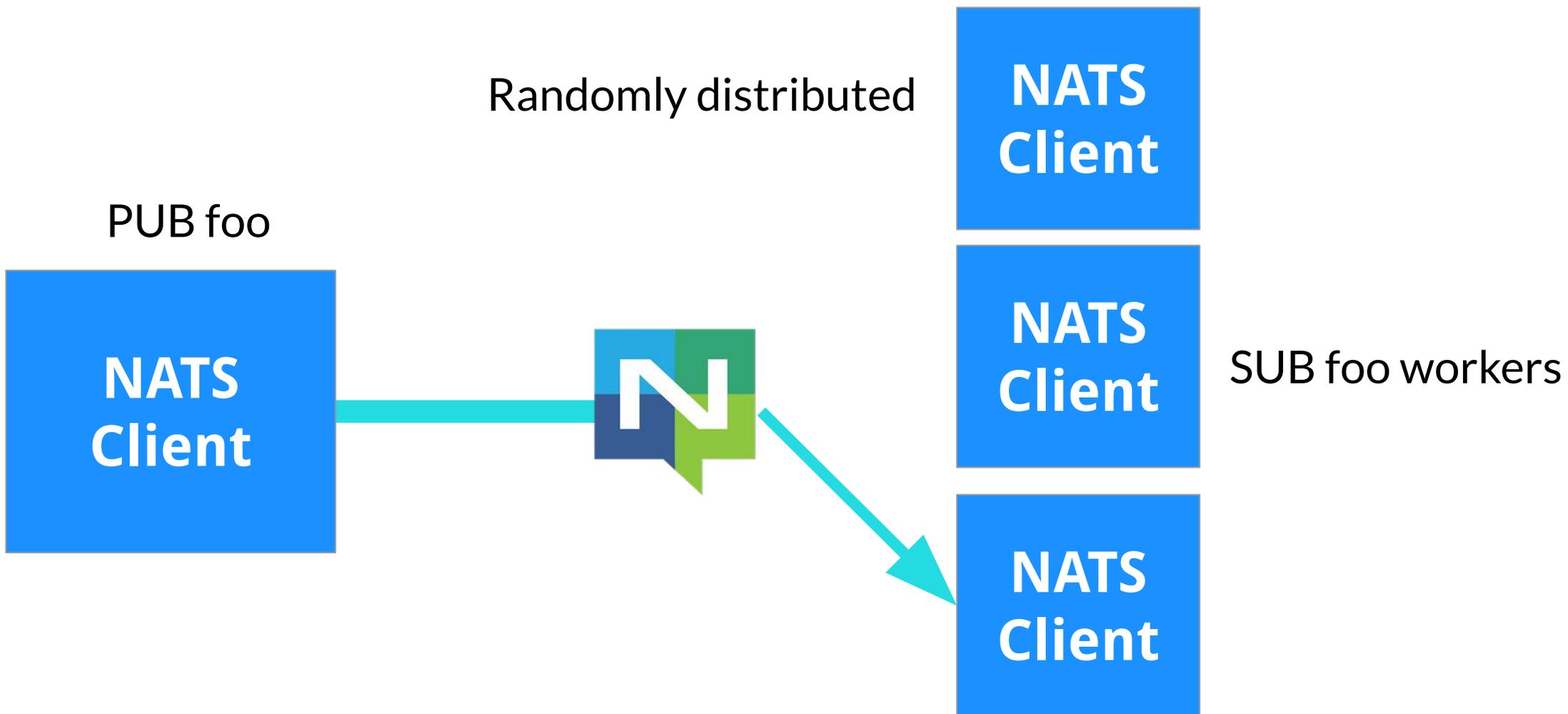


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Load Balanced Queues

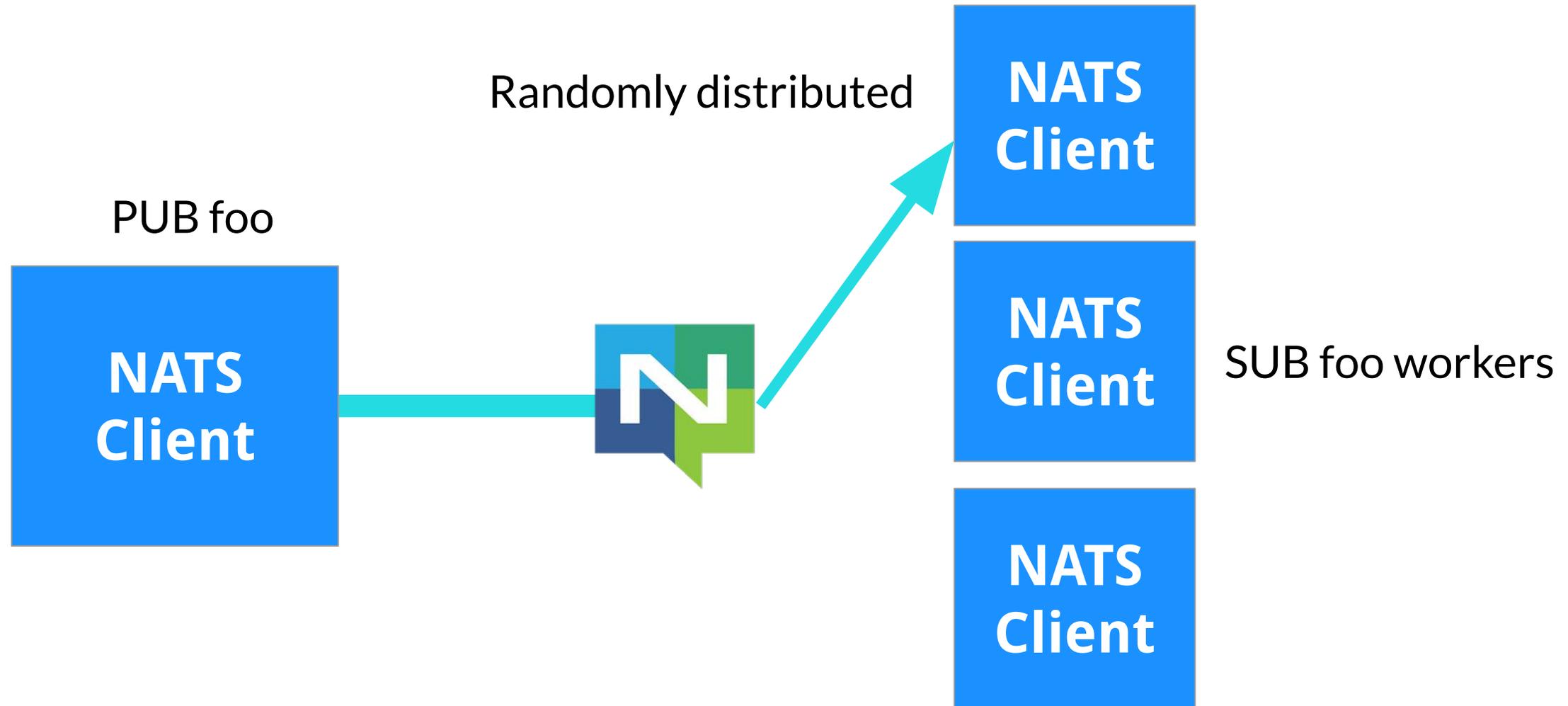


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Load Balanced Queues

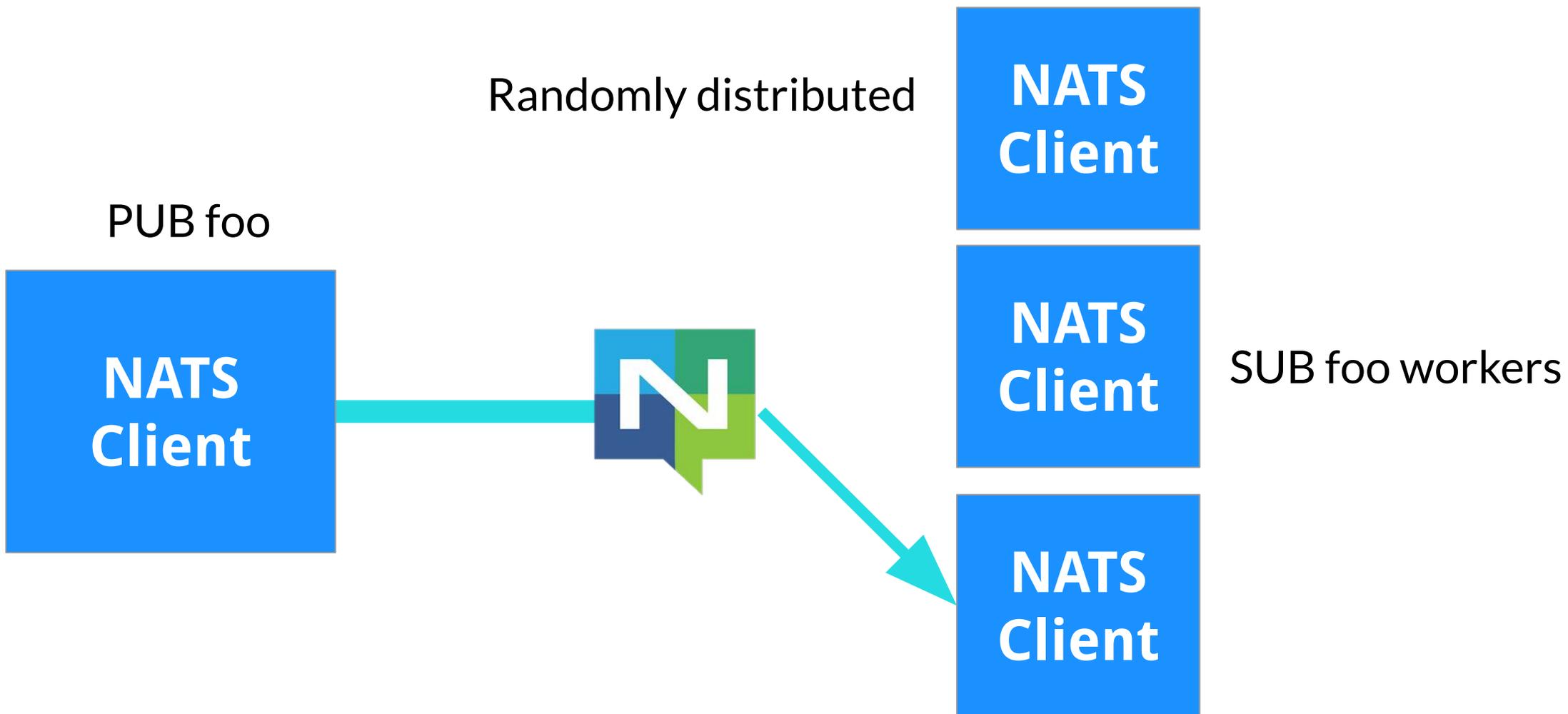


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Wildcards

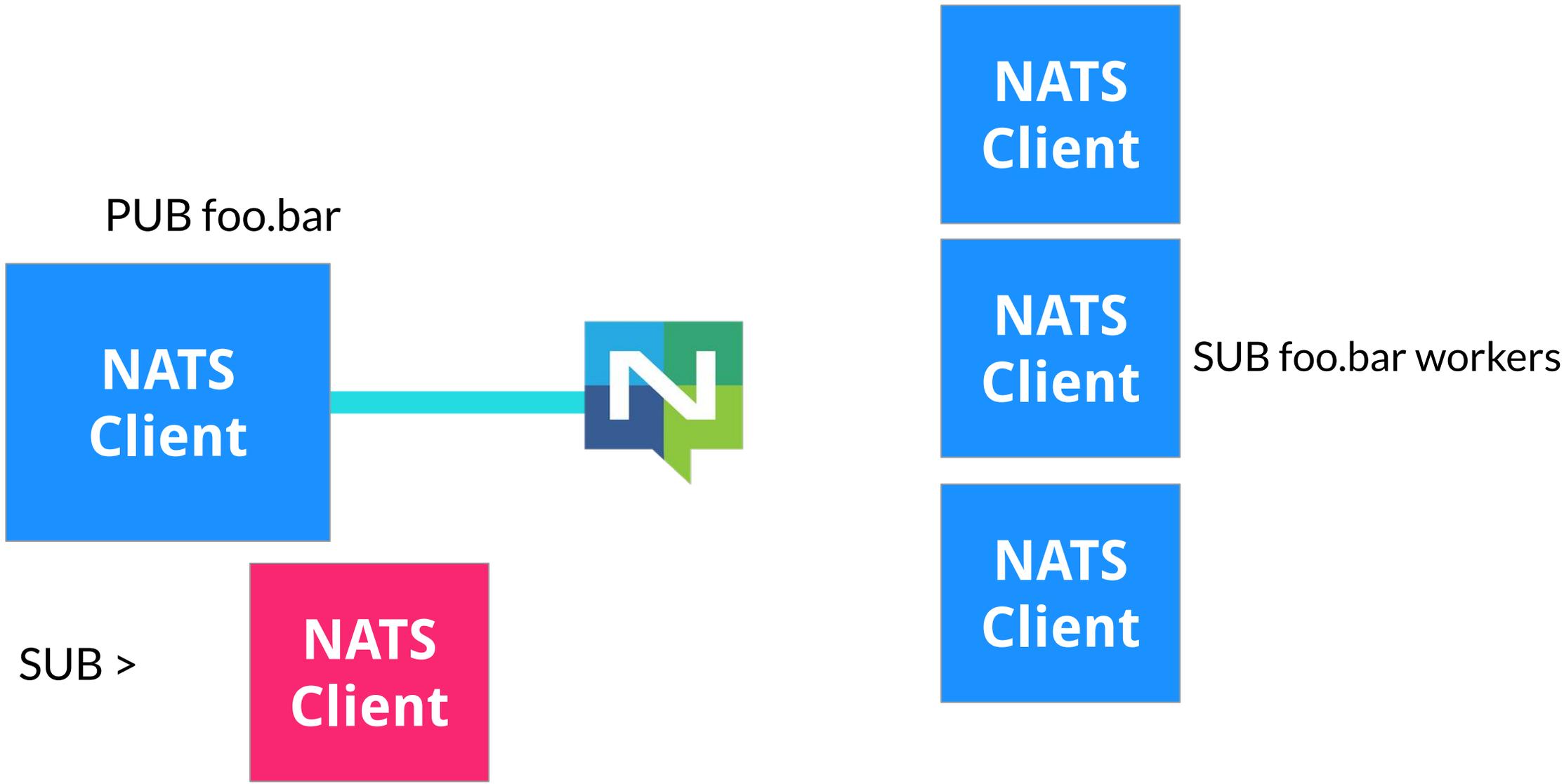


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Wildcards

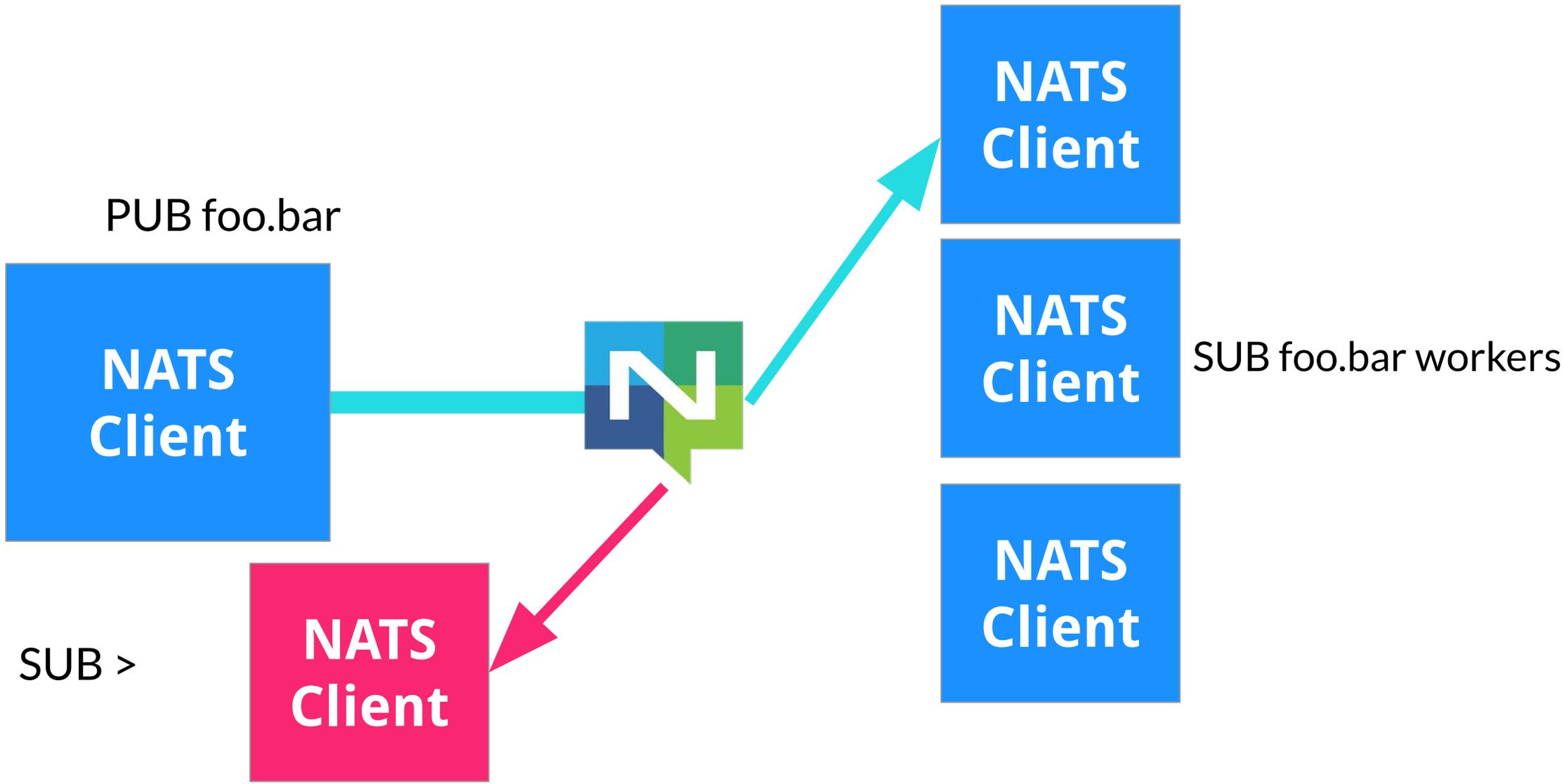


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Wildcards

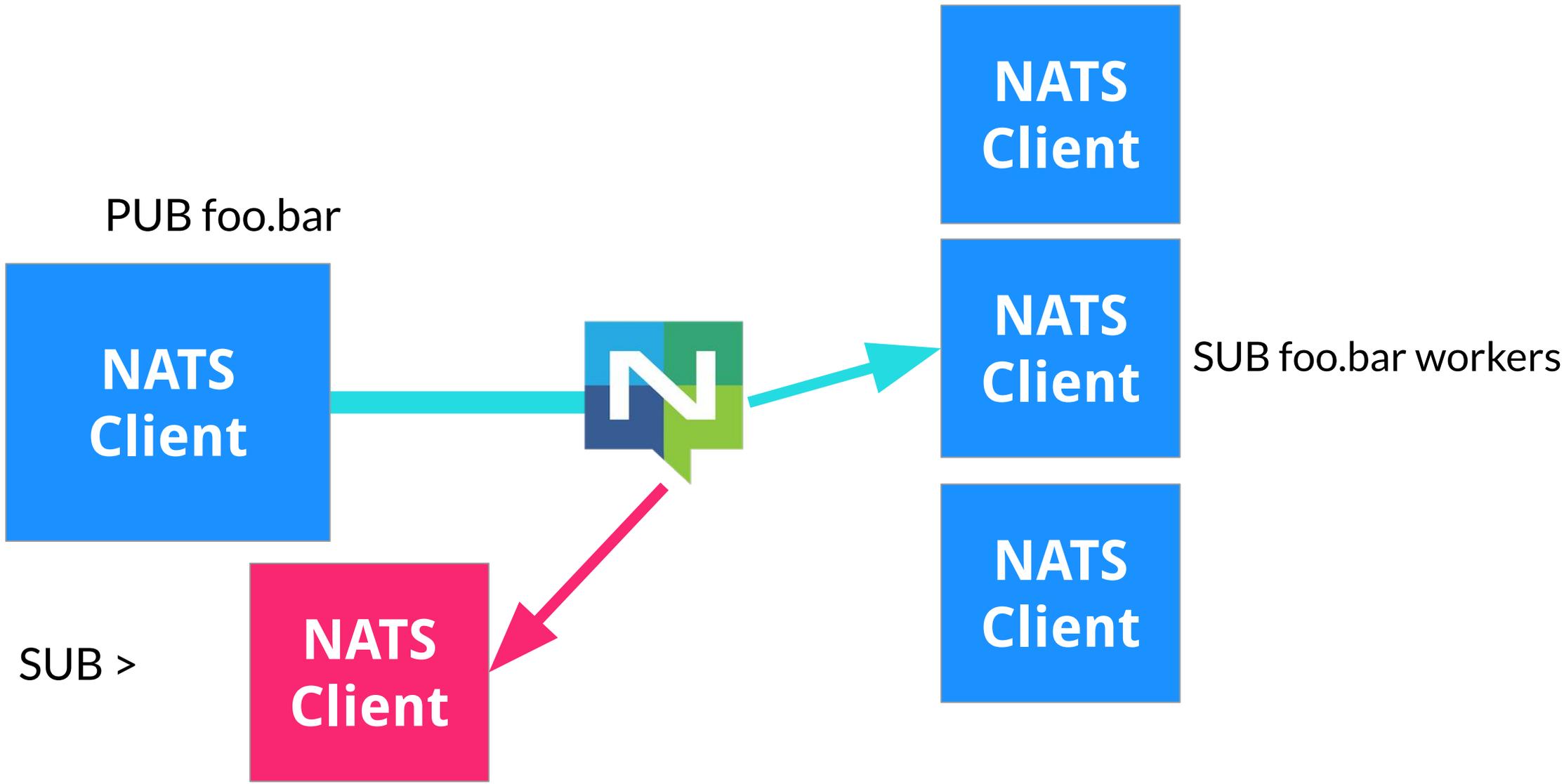


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Wildcards

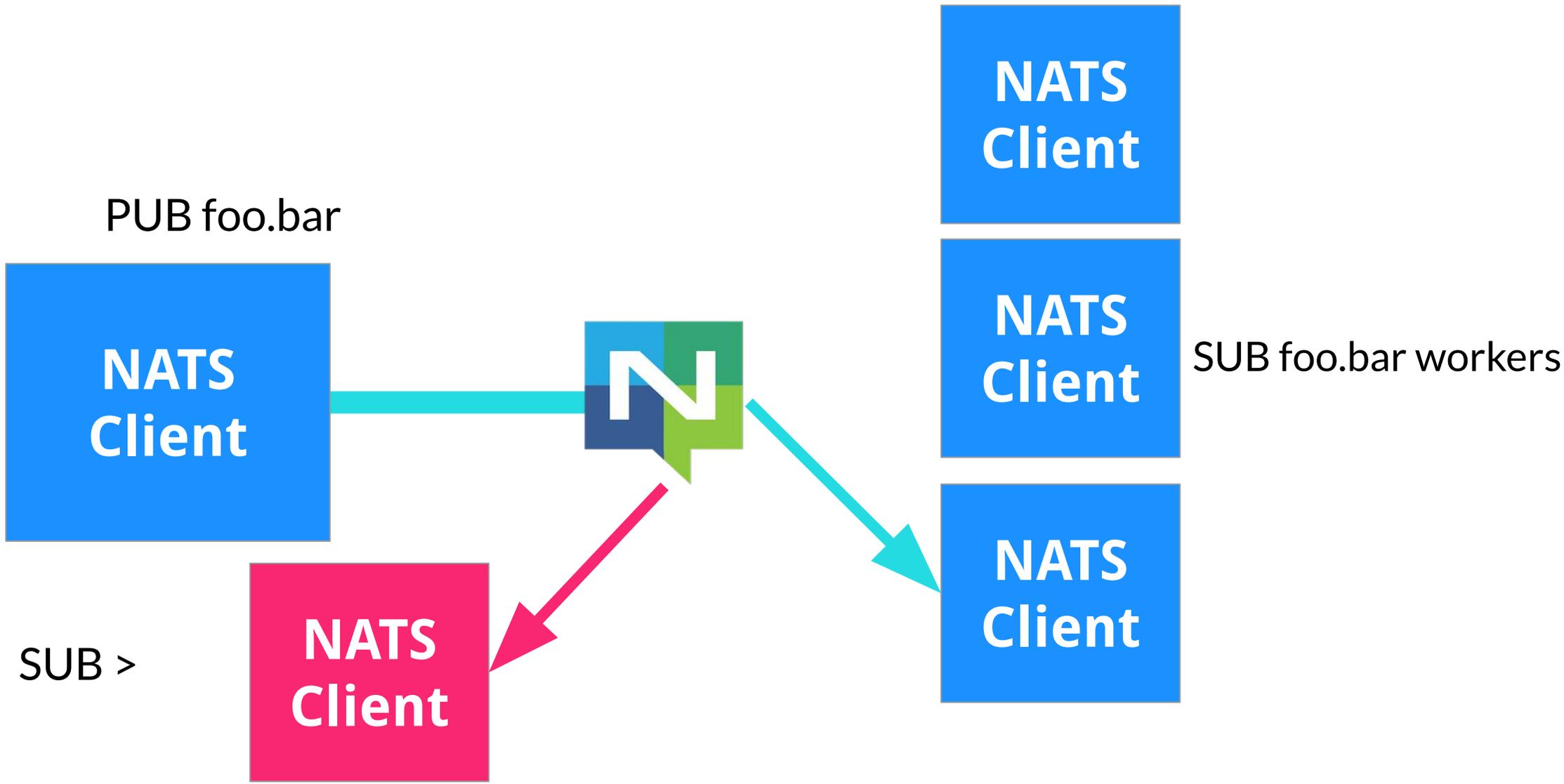


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Wildcards

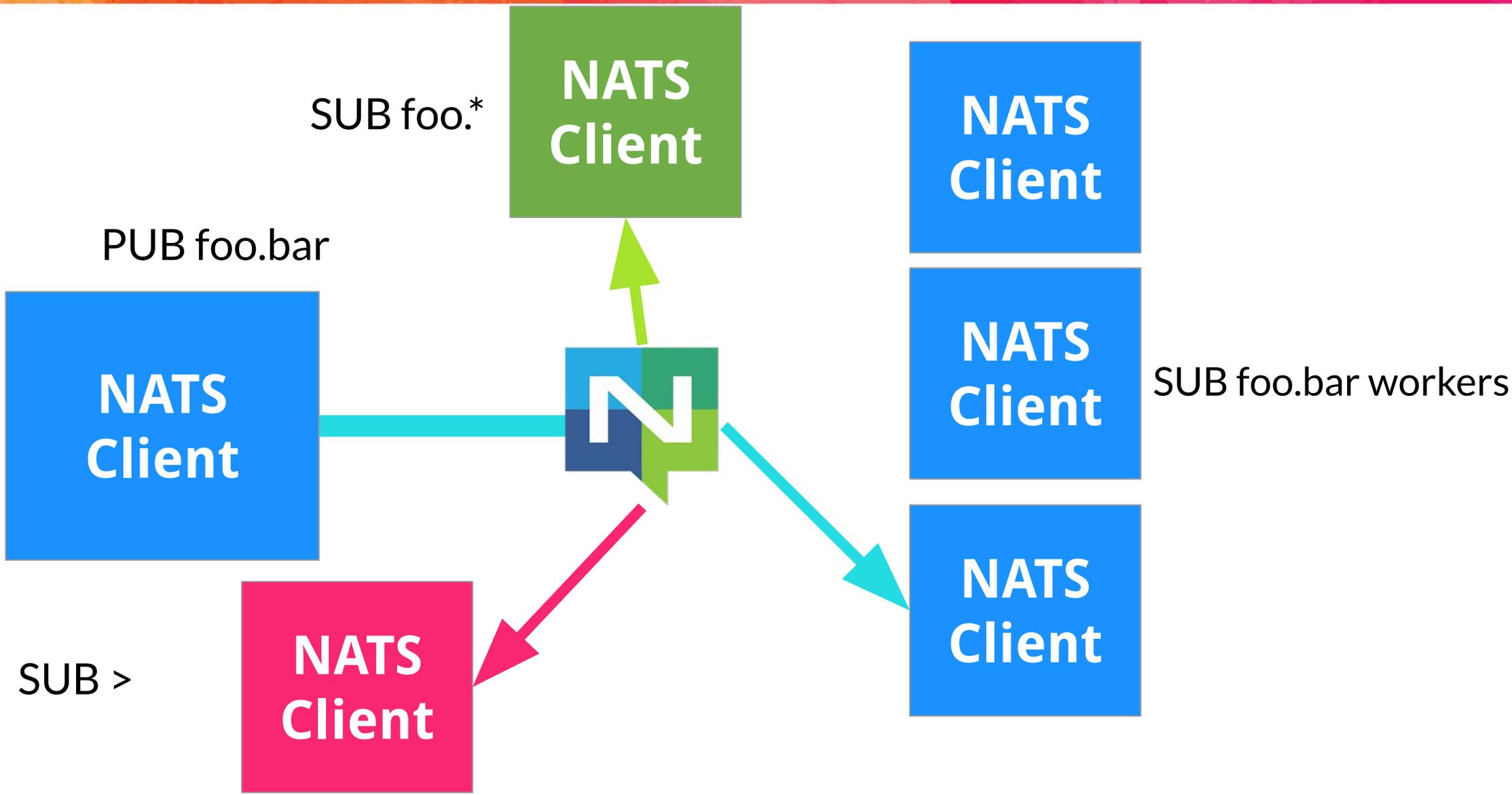


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Wildcards

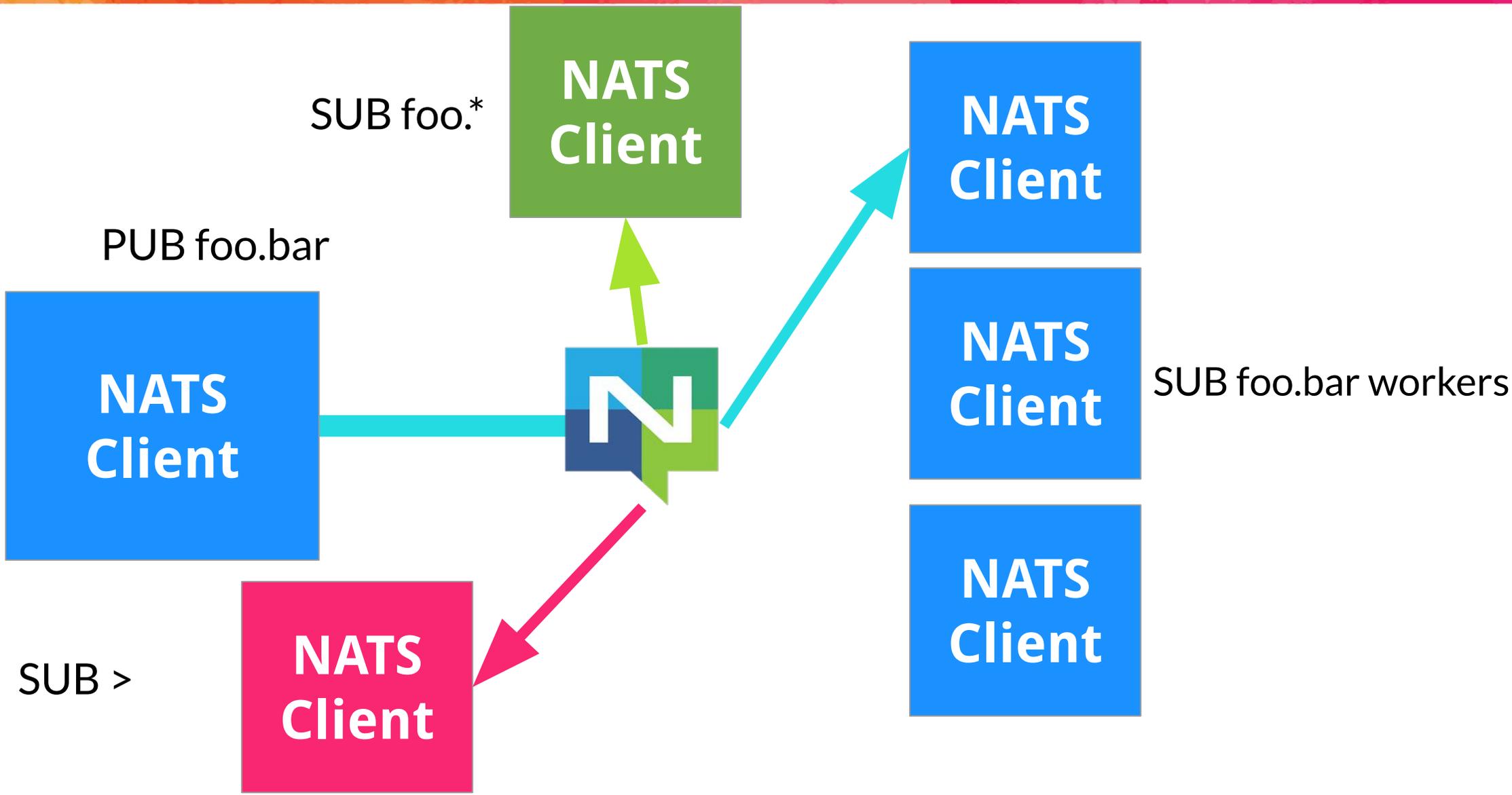


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Wildcards

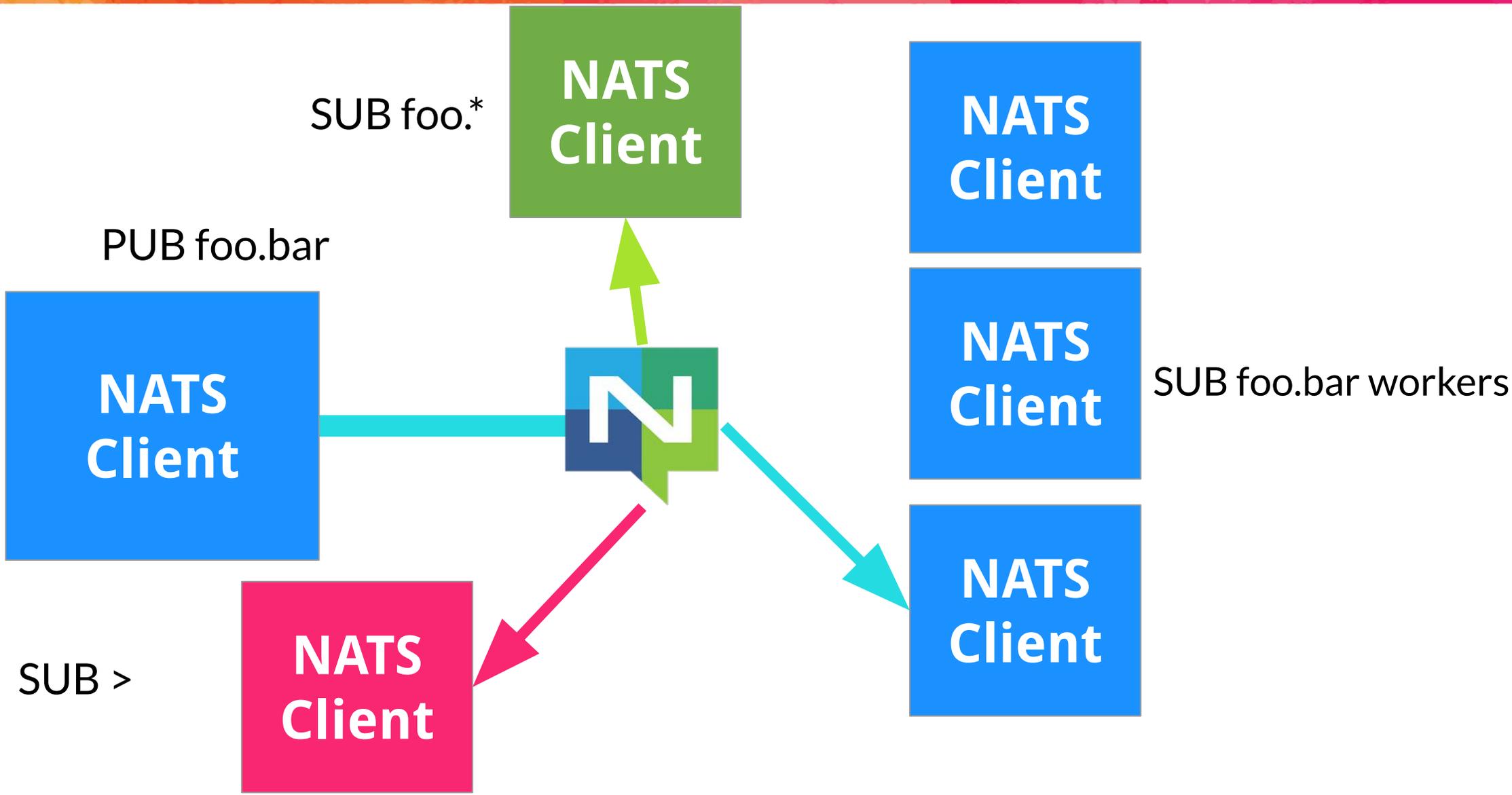


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Wildcards

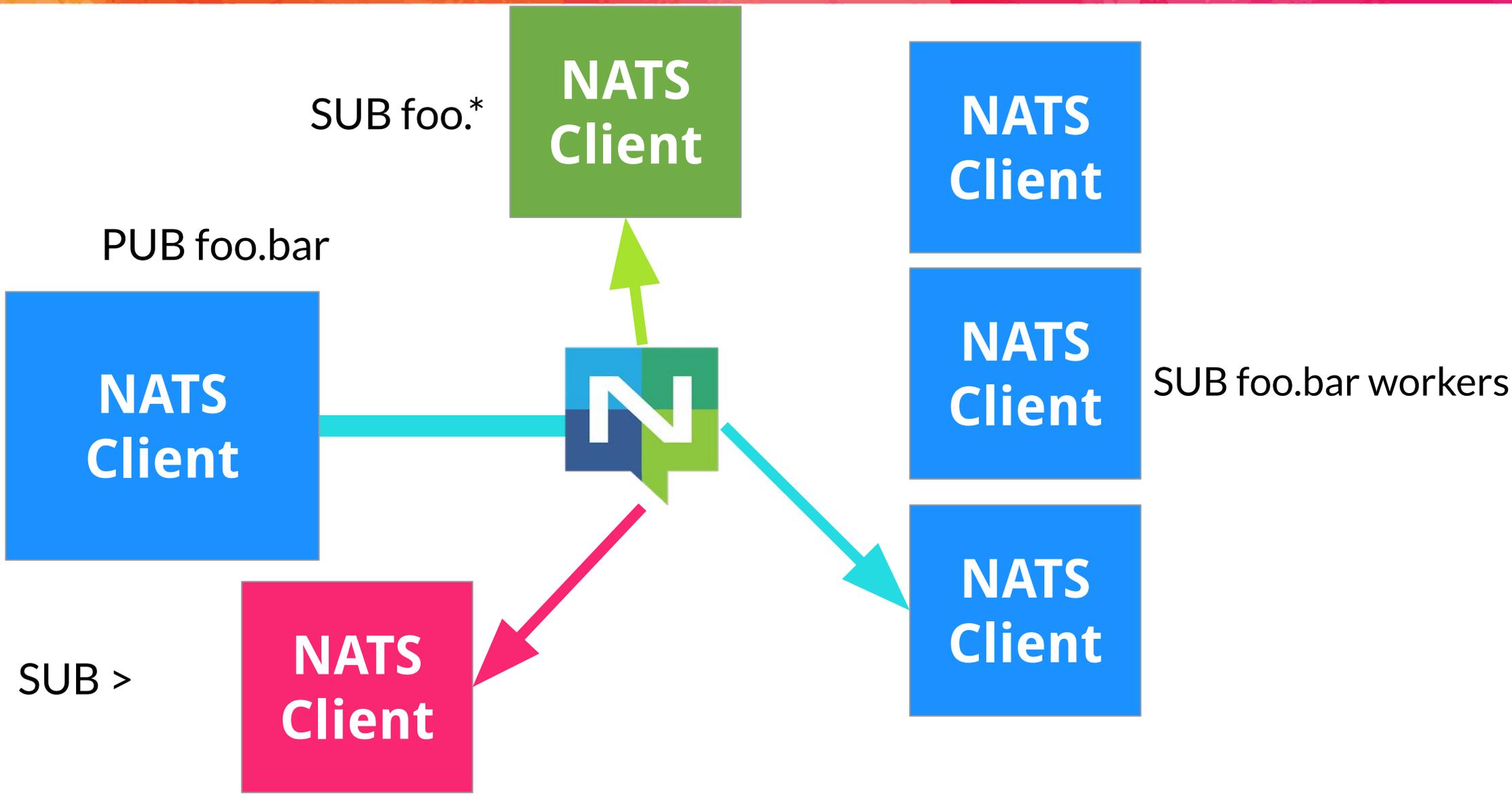


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Wildcards

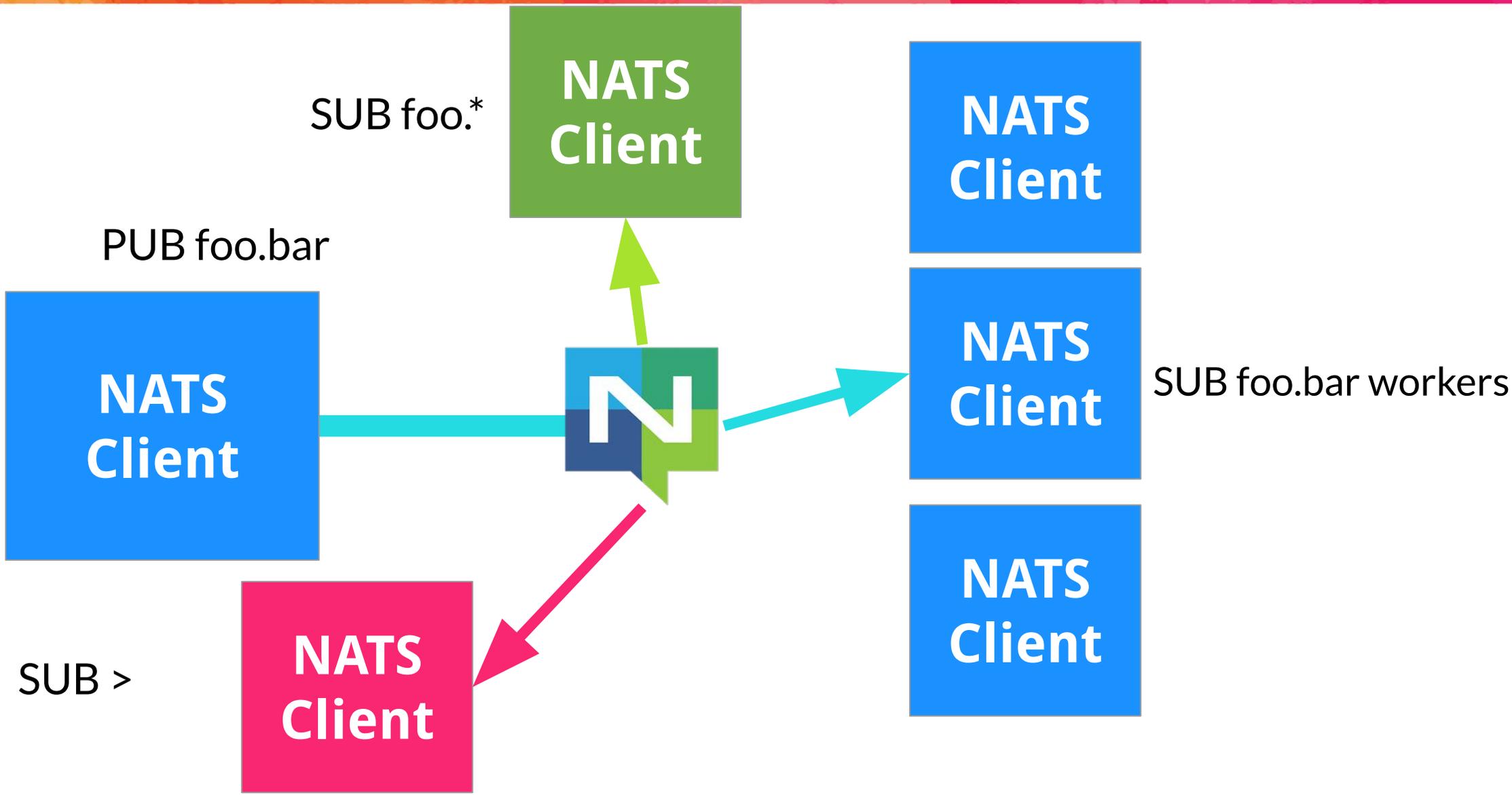


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Wildcards

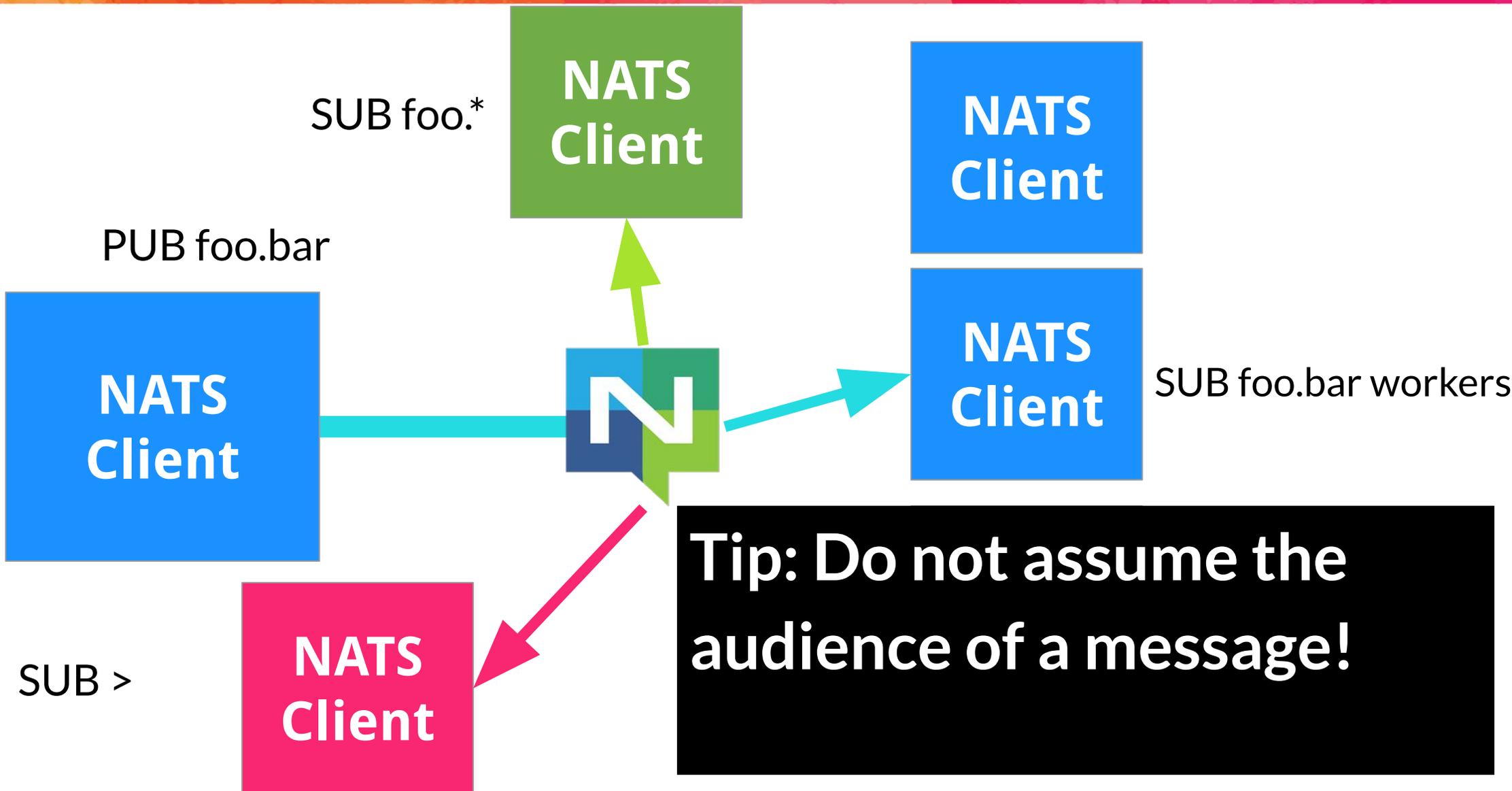


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Tip: Do not assume the audience of a message!



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Performance, Scalability, and Resilience

Performance



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18 million messages per second with one server, one data stream.
Up to **80 million** messages per second per server with multiple data streams.

Benchmark_____Pub0b_Payload-20	30000000	55.1 ns/op	199.78 MB/s
Benchmark_____Pub8b_Payload-20	30000000	55.8 ns/op	340.21 MB/s
Benchmark_____Pub32b_Payload-20	20000000	63.4 ns/op	694.34 MB/s
Benchmark___Pub128B_Payload-20	20000000	79.8 ns/op	1766.47 MB/s
Benchmark___Pub256B_Payload-20	20000000	98.1 ns/op	2741.51 MB/s
Benchmark_____Pub1K_Payload-20	5000000	283 ns/op	3660.72 MB/s
Benchmark_____Pub4K_Payload-20	1000000	1395 ns/op	2945.30 MB/s
Benchmark_____Pub8K_Payload-20	500000	2846 ns/op	2882.35 MB/s
Benchmark_AuthPub0b_Payload-20	10000000	126 ns/op	86.82 MB/s
Benchmark_____PubSub-20	10000000	135 ns/op	
Benchmark_____PubSubTwoConns-20	10000000	136 ns/op	
Benchmark_____PubTwoQueueSub-20	10000000	152 ns/op	
Benchmark_____PubFourQueueSub-20	10000000	152 ns/op	
Benchmark__PubEightQueueSub-20	10000000	152 ns/op	

Performance Decisions



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Performance is a part of every decision we make...

- ✓ Design for scale
- ✓ Careful analysis of the fastpath

Just as important is what **NOT** to implement...

- ✗ Message guarantees in core NATS
- ✗ Transactions
- ✗ Message Schemas
- ✗ Last Will and Testament
- ✗ Message Groups

Availability



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The health and availability of the system as a whole is prioritized over servicing any individual client or server.

- ✓ NATS server “selfish optimization”
- ✓ Full Mesh clustering of NATS servers
- ✓ Server and client connections self heal

...creates a NATS dial-tone, always on, always available.

Simplicity



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- Single binary
- 7.8 MB docker image with no external dependencies
- “Text-based” protocol with just a handful of verbs
- Low Configuration
 - ✓ Clients only need a url and credentials
 - ✓ Servers auto-discover
 - ✓ You can share configuration files amongst servers
- Simple and Straightforward API

Auto-Discovery



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- Auto-Discovery
 - ✓ Automatically Exchange Server Topology
 - ✓ Server ↔ Server
 - ✓ Server → Client
- No configuration updates
 - ✓ Failover to auto-discovered servers
- Great for rolling upgrades



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Delivery Modes

Delivery Modes



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NATS supports two delivery modes:

- At most once (*Core*)
 - ✓ No guarantee of delivery - messages can be lost - applications must detect and handle lost messages
- At least once (*Streaming*)
 - ✓ A message will always be delivered, but in certain cases may be delivered more than once
- ✗ Exactly once is arguably unnecessary, always complex, and inevitably slow.



NATS Streaming is a data streaming system atop core NATS

- **At-least-once** delivery
- Replay by time or sequence number
- Last/initial value caching
- Durable subscribers
- Rate matching per subscriber
- Memory, File, or Database storage
- High Availability through fault tolerant or clustered configurations
- Scale through partitioning



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NATS Server

aka. core NATS

NATS Server



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- Written in Go
- At-most-once delivery guarantees
 - No persistence of messages
- Extremely high performance
- TLS support
- Authorization and Authentication
- Full-mesh one hop clustering for HA
- Auto discovery via gossip

NATS Server



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Main project repo name has changed recently:

Before:

<https://github.com/nats-io/gnatsd>

Now:

<https://github.com/nats-io/nats-server>

NATS Clients



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The clients repositories have also changed:

Before:

<https://github.com/nats-io/go-nats>

Now:

<https://github.com/nats-io/nats.go>

NATS Official Clients



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nats.go

Golang client for NATS, the cloud native messaging system.



go golang microservices nats cloud-native

Go ★ 2,265 🍴 303 📄 Apache-2.0 3 issues need help Updated a day ago

nats.rb

Ruby client for NATS, the cloud native messaging system.



ruby client messaging cncf pubsub nats eventmachine

Ruby ★ 823 🍴 131 📄 Apache-2.0 Updated a day ago

nats.java

Java client for NATS



java client middleware messaging nats messaging-library

Java ★ 194 🍴 68 📄 Apache-2.0 Updated a day ago

nats.ex

Elixir client for NATS, the cloud native messaging system. <https://nats.io>



client elixir nats nats-io

Elixir ★ 33 🍴 11 📄 MIT 1 issue needs help Updated 6 days ago

nats.js

Node.js client for NATS, the cloud native messaging system.



JavaScript ★ 672 🍴 96 📄 Apache-2.0 Updated 8 days ago

nats.net

The official C# Client for NATS



client visual-studio csharp messaging message-bus pubsub

C# ★ 232 🍴 63 📄 Apache-2.0 3 issues need help Updated 2 days ago

nats.c

A C client for NATS



c messaging message-bus message-queue messaging-library

C ★ 139 🍴 45 📄 Apache-2.0 Updated 7 days ago

nats.py

An asyncio based Python 3 client for NATS



aiio nats python3 asyncio cloud-native aio-nats

Python ★ 187 🍴 34 📄 Apache-2.0 Updated 4 days ago

NATS Client API: Go



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```
package main

import (
    "log"
    "time"

    "github.com/nats-io/nats.go"
)

func main() {
    nc, err := nats.Connect("demo.nats.io")
    if err != nil {
        log.Fatal(err)
    }
    defer nc.Close()

    nc.Subscribe("greetings", func(m *nats.Msg) {
        log.Println("[Received]", string(m.Data))
    })

    for range time.NewTicker(1 * time.Second).C {
        nc.Publish("greetings", []byte("Hello!"))
    }
}
```



Receives all the messages published on the *greetings* topic that have been published since it registered interest.

Full mesh NATS Cluster

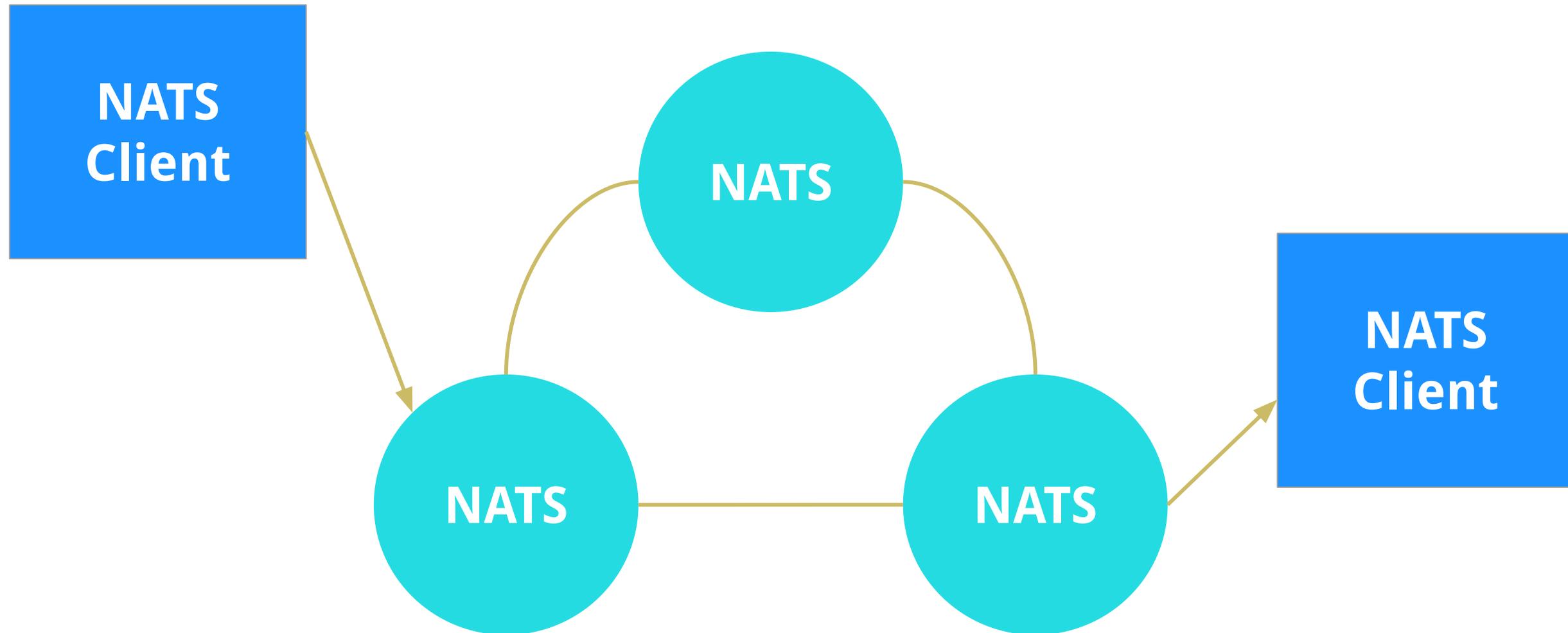


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Full mesh NATS Cluster

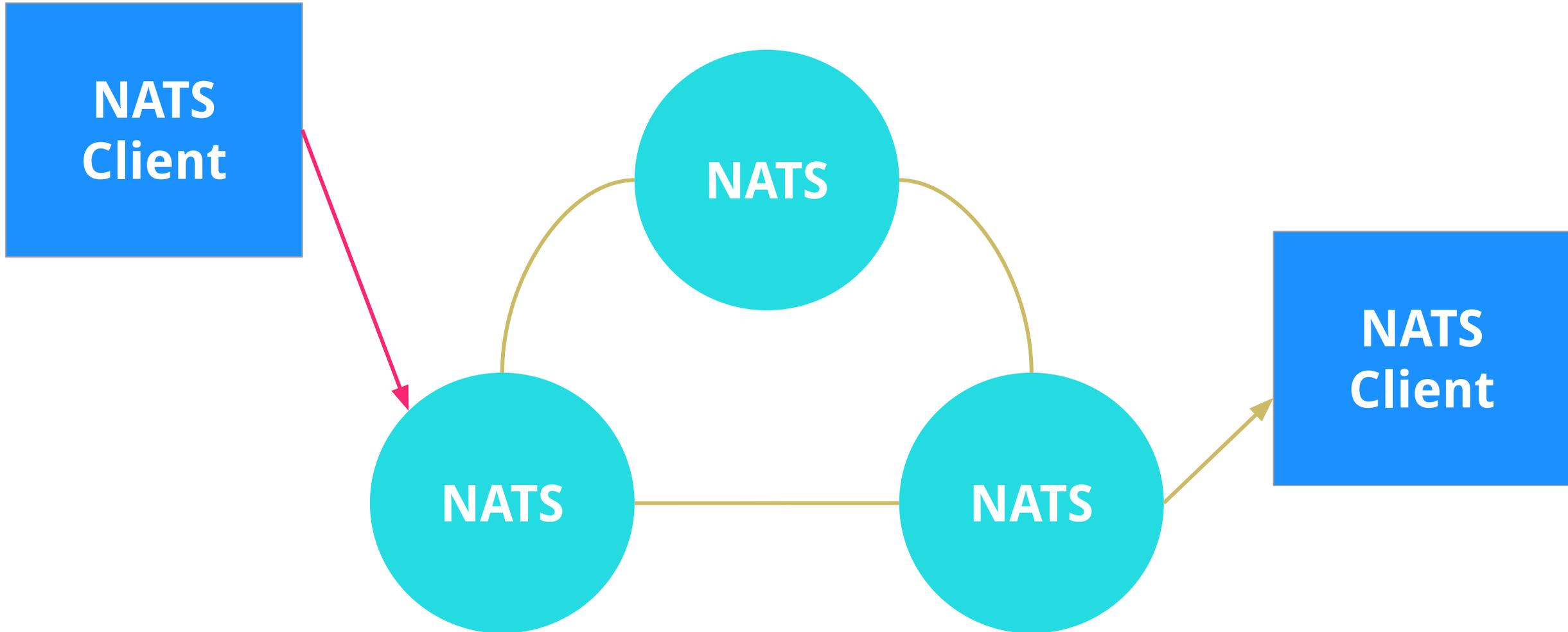


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Full mesh NATS Cluster

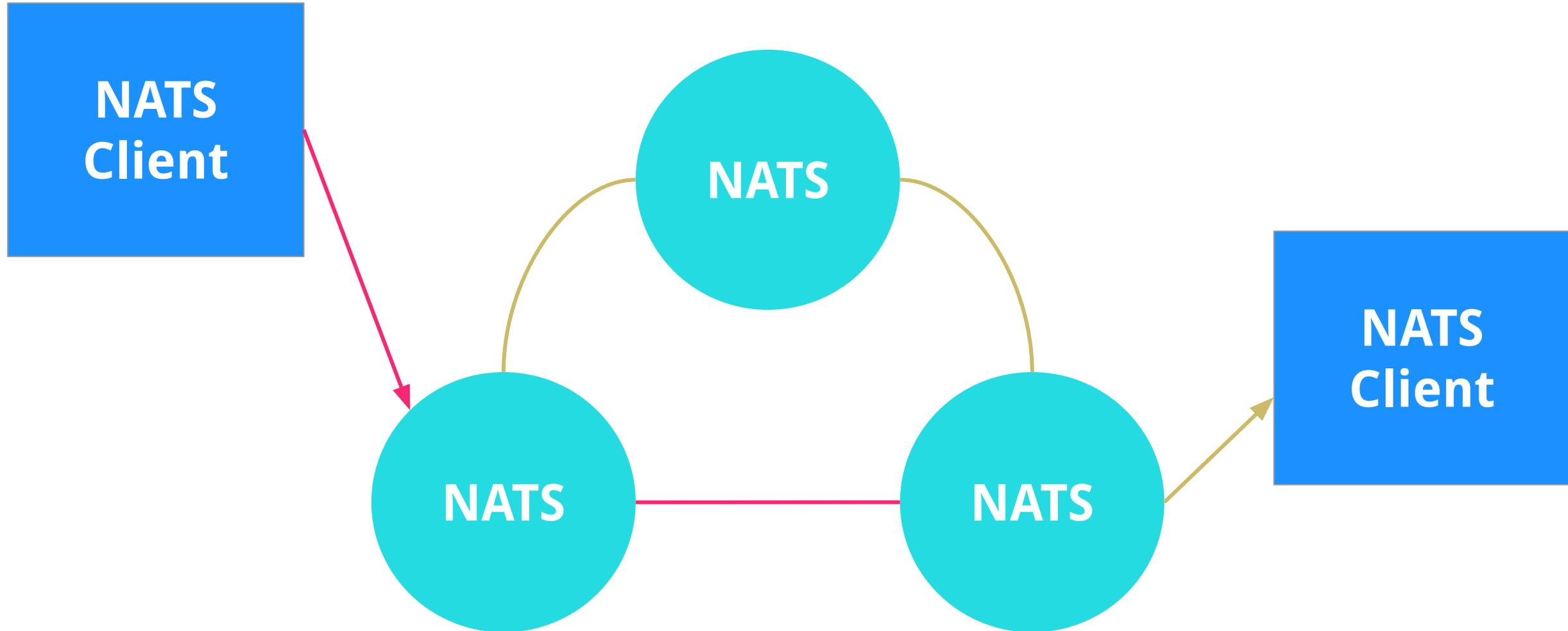


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Full mesh NATS Cluster

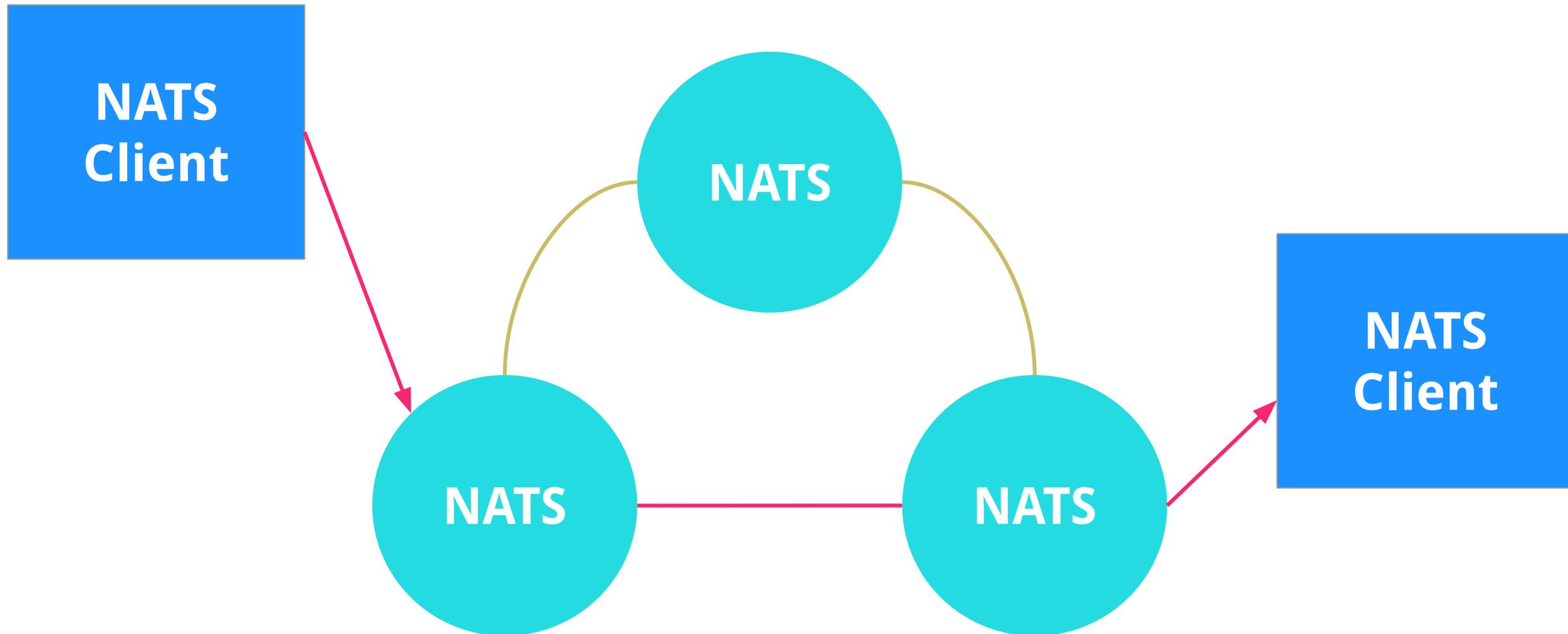


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NATS Streaming

aka. STAN

NATS Streaming (STAN)



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- Supports *at-least-once* delivery guarantees
<https://github.com/nats-io/nats-streaming-server>
- Persistence of messages / 'Message replay'
- Raft based replicated log for clustering
- Protocol based on NATS Request/Reply

STAN Clients



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The nats-streaming clients repositories have also changed:

Before:

<https://github.com/nats-io/go-nats-streaming>

Now:

<https://github.com/nats-io/stan.go>

STAN Official Clients



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stan.go

NATS Streaming System



● Go ★ 371 🍴 70 📄 Apache-2.0 Updated 2 days ago

stan.js

Node.js client for NATS Streaming



● JavaScript ★ 143 🍴 34 📄 Apache-2.0 Updated 2 days ago

stan.net

The official NATS .NET C# Streaming Client



nats nats-streaming nats-messaging streaming-client natsio

● C# ★ 74 🍴 30 📄 Apache-2.0 Updated 8 days ago

stan.java

NATS Streaming Java Client



● Java ★ 62 🍴 21 📄 Apache-2.0 Updated 8 days ago

stan.py

Python Asyncio NATS Streaming Client



python nats asyncio nats-streaming

● Python ★ 52 🍴 6 📄 Apache-2.0 Updated 2 days ago

stan.rb

Ruby NATS Streaming Client



ruby nats nats-streaming

● Ruby ★ 16 🍴 2 📄 Apache-2.0 Updated 8 days ago

STAN Client API: Go



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```
package main

import (
    "log"
    "time"

    "github.com/nats-io/stan.go"
)

func main() {
    sc, err := stan.Connect("test-cluster", "client-123")
    if err != nil {
        log.Fatal(err)
    }
    defer sc.Close()

    go func() {
        for range time.NewTicker(1 * time.Second).C {
            sc.Publish("greetings", []byte("Hello!"))
        }
    }()

    sc.Subscribe("greetings", func(m *stan.Msg) {
        log.Println("[Received]", string(m.Data))
    }, stan.DeliverAllAvailable())

    select {}
}
```

Receives all the messages
ever published on the
greetings topic.



STAN on top of NATS

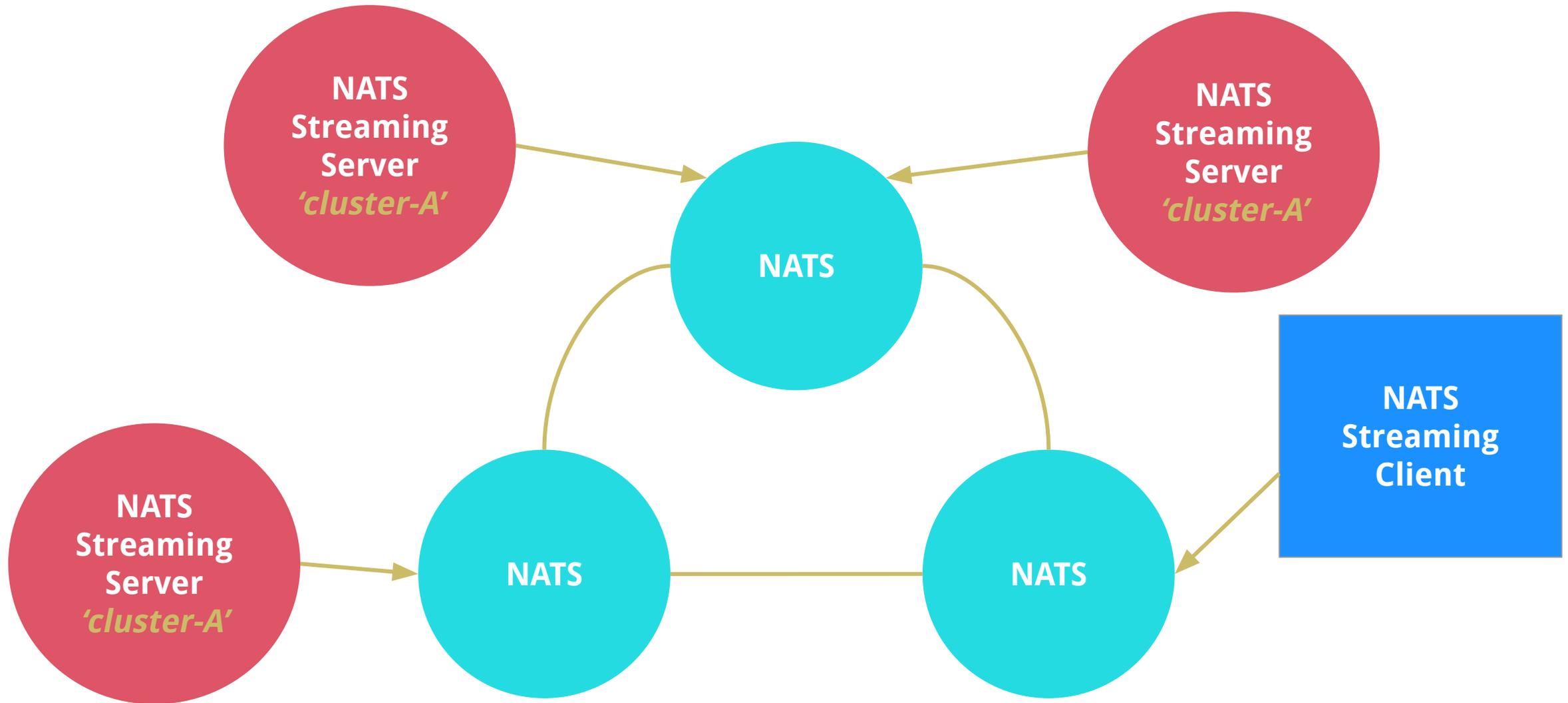


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The NATS v2 Release

NATS v2



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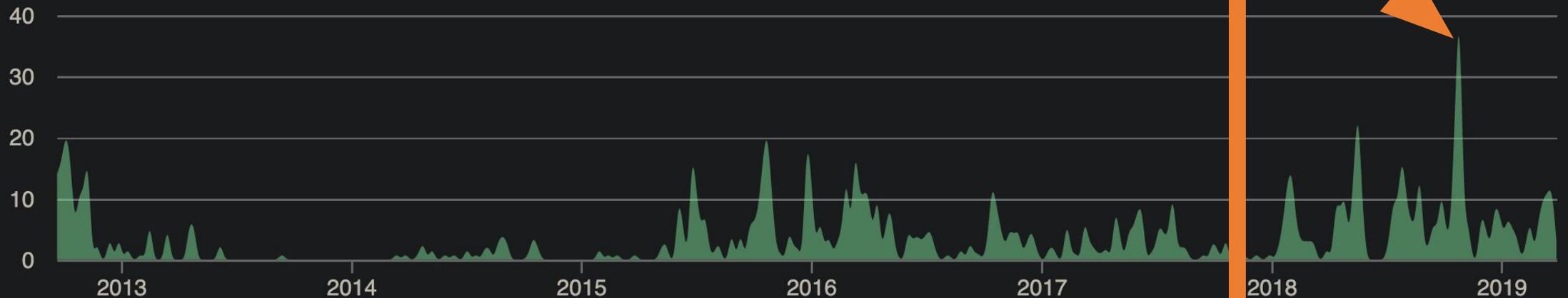
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Biggest release of the project since it started.

Oct 28, 2012 – May 7, 2019

Contributions: Commits ▾

Contributions to master, excluding merge commits



NATS v2



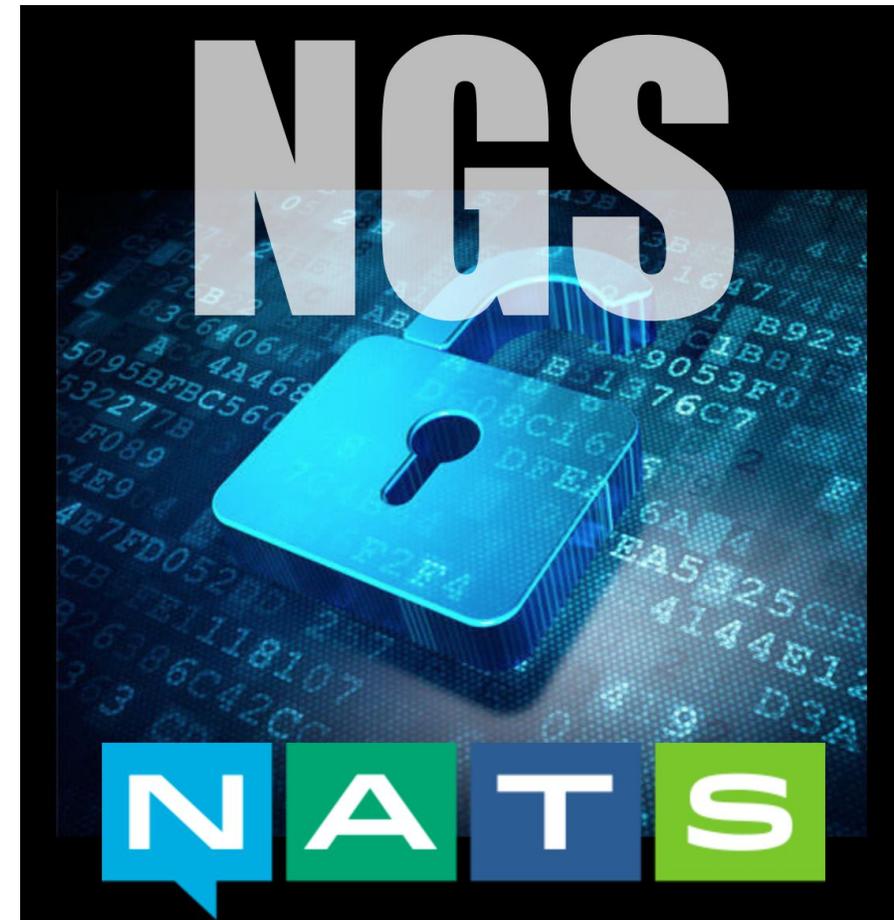
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Expands the security and project capabilities of the server to become a core component used to build a global communication network.



<https://synadia.com/ngs>

NATS v2



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- Gateways, Super clusters & Leafnodes
- New clustering protocol
 - Client protocol is 100% backward compatible
- Accounts isolation
- Like containers for messaging
- NKEYS (ed25519 based keys)
- Decentralized authorization with JWTs
- System Accounts
- Graceful shutdown
- TLS certs DN/SAN based auth

Accounts



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- Accounts are isolated communication contexts allowing secure multi-tenancy
- Bifurcate technology from business driven use cases
 - ✓ Data silos are created by design, not software limitations
- Easy, Secure and Cost Effective
 - ✓ One NATS deployment for operators to manage
 - ✓ Decentralized - organizations can self-manage
- Share data between accounts
 - ✓ Secure Streams and Services
 - ✓ Only mutual agreement will permit data flow

Streams & Services



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Service: A secure RPC endpoint

- Export a service to allow other accounts to import
- Import a service to allow requests to be sent and **securely, seamlessly, and anonymously** to another account

Stream: Data flow between accounts

- Export a stream to allow egress
- Import a stream to allow ingress

Zero client configuration or client API changes!

Streams & Services



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```
accounts {
  synadia {
    users = [
      {user: nats, password:
$2a$10$BYItxVAGPCbHakeKXegN7uGNJQB45p5sQT4D5Jrlb/gOI13Orx.RK}
      {nkey:
UC53TQCCXLUYSYTJ7PHSHDAORV6OSON7SNZQAWVMJUGM5JC3GR2AA
D2M}
    ]

    # For sharing streams and services with others.
    exports = [
      # Network status updates available for anyone.
      {stream: "cloud.network.status"}

      # Service to request developer statistics
      {service: "private.devstats", accounts: [CNCF]}
    ]
  }
}
```

Streams & Services



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```
accounts {
  synadia {
    users = [
      {user: nats, password:
$2a$10$BYItxVAGPCbHakeKXegN7uGNJQB45p5sQT4D5Jrlb/gOI13Orx.RK}
      {nkey:
UC53TQCCXLUYSYTJ7PHSHDAORV6OSON7SNZQAWVMJUGM5JC3GR2AA
D2M}
    ]
  }
}
```

For sharing streams and services with others.

```
exports = [
  # Network status updates available for anyone.
  {stream: "cloud.network.status"}

```

```
# Service to request developer statistics
{service: "private.devstats", accounts: [CNCF]}

```

```
]
}
}
```

NKeys and JWTs



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A new NATS Identity authentication and authorization system.

- ED25519 based encoded keys made simple
 - Fast and resistant to side-channel attacks
 - Sign and Verify
- NATS servers **never see private keys**
 - Server sends nonce during connect, verifies client signatures
- JWT associate users with accounts and permission sets



JWTs are used to represent identities in NATS

- User, Account, Cluster, or Server

User JWTs Contain

- Account NKey (Issuer)
- Public NKey (Subject)
- Friendly Name
- Permissions
- Limits
- Not Before and Expiration

JWTs



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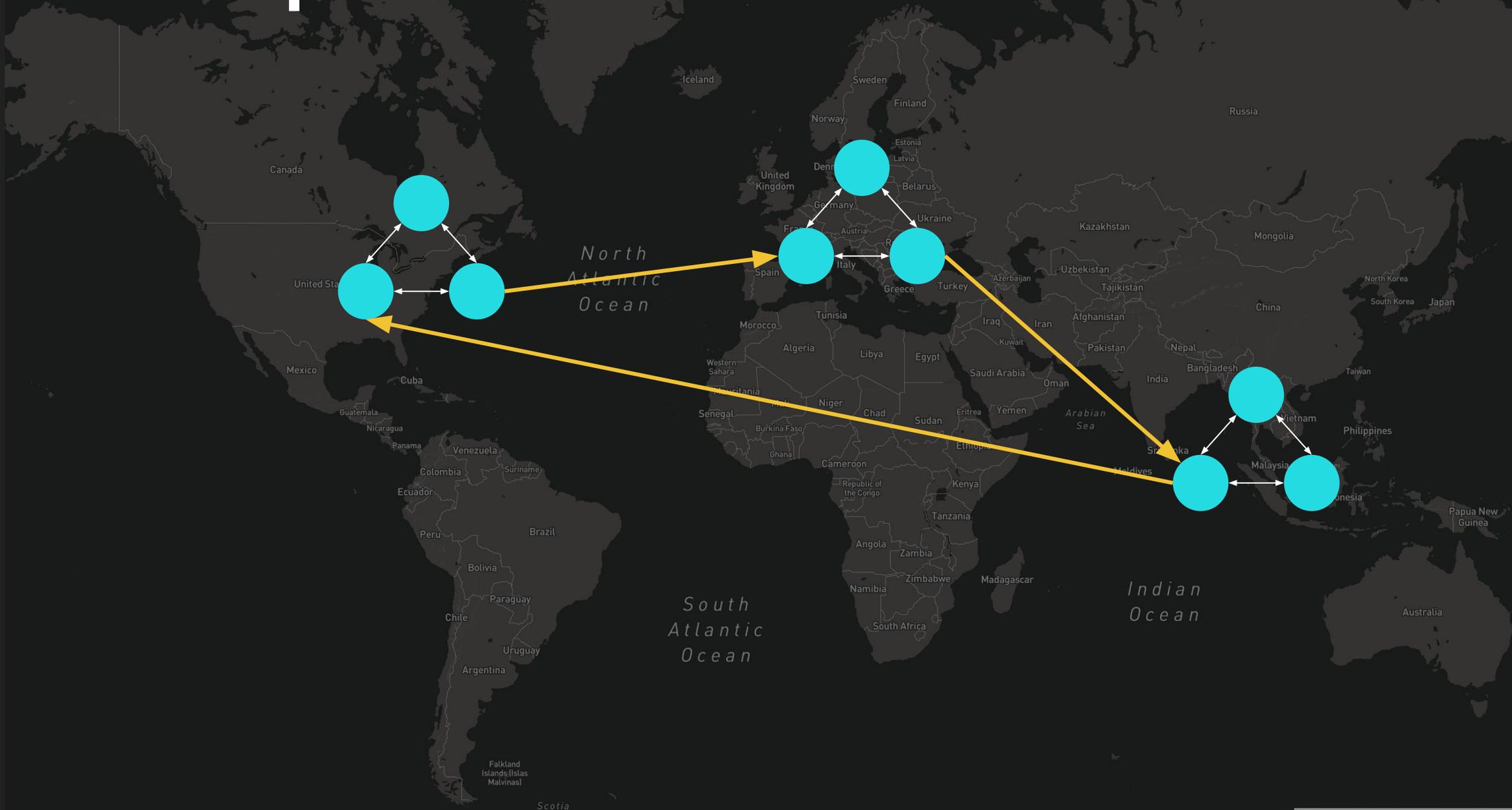


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```
{
  "jti": "3Y2OIRCSQLHOZI2KWXP57JCRIR5BT5ZGZ5G74VHFCEMUJAZUPCYCA",
  "iat": 1544140248,
  "iss": "ADQO262SKHLYIQTIBU3VG2K4GWRVO4TXYYJDH7QBMWYW6HACLQZIVB",
  "name": "Waldemar",
  "sub": "UCZRG6WDXWMIKDPLUMMRS2UAO2NSA5GOU2WCTXQLK7TRUWLLQ2CAXY7M",
  "type": "user",
  "nats": {
    "pub": {
      "allow": [
        "public.>"
      ]
    },
    "sub": {
      "deny": [
        "private.>"
      ]
    }
  }
}
```

NATS Super Cluster



NATS Super Cluster



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```
NATS $ telnet ams.nats-super-cluster.global 4222
Trying 206.189.109.60...
Connected to ams.nats-super-cluster.global.
Escape character is '^]'.
█
```

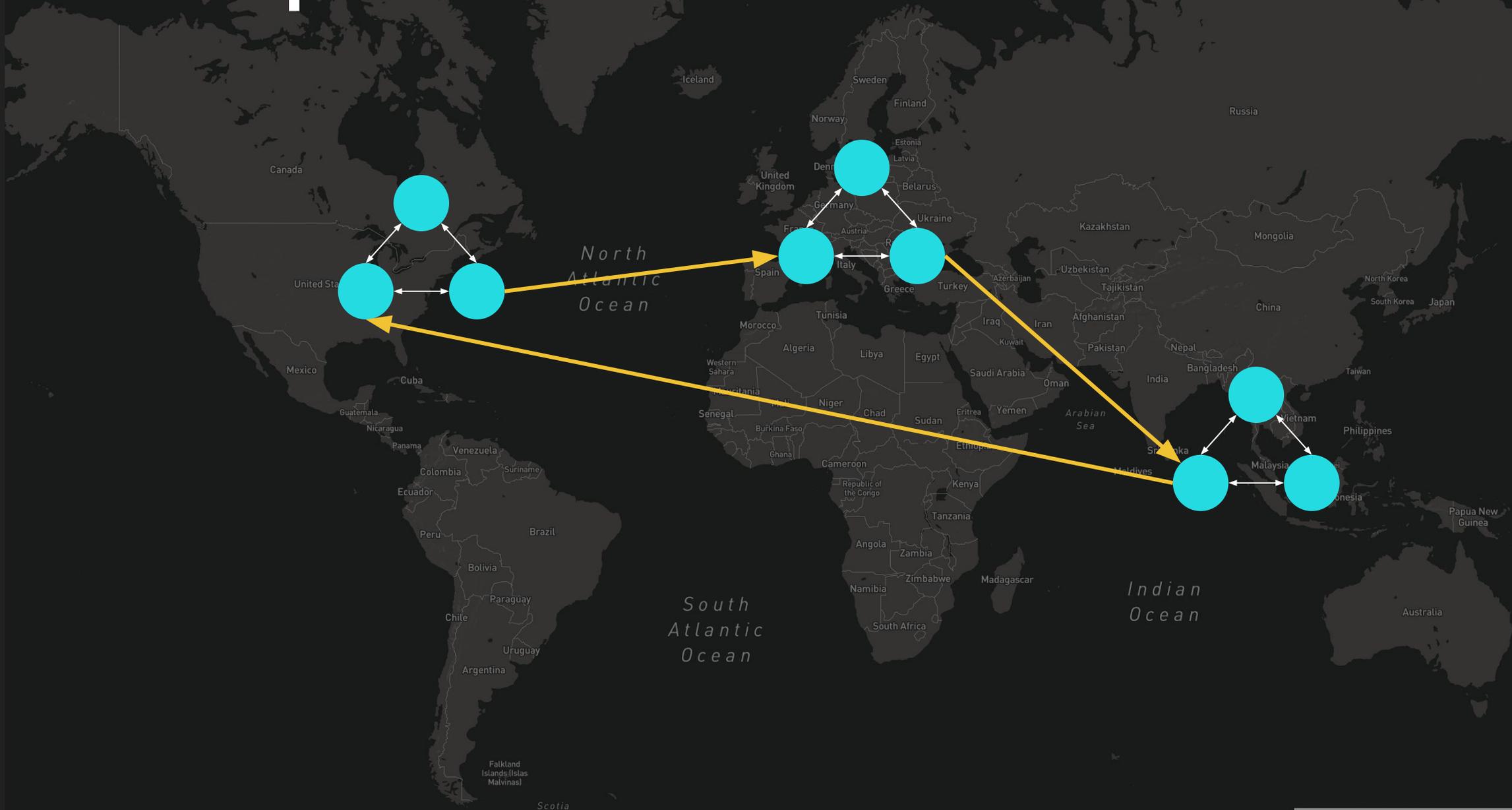
0 bash

```
NATS $ telnet nyc.nats-super-cluster.global 4222
```

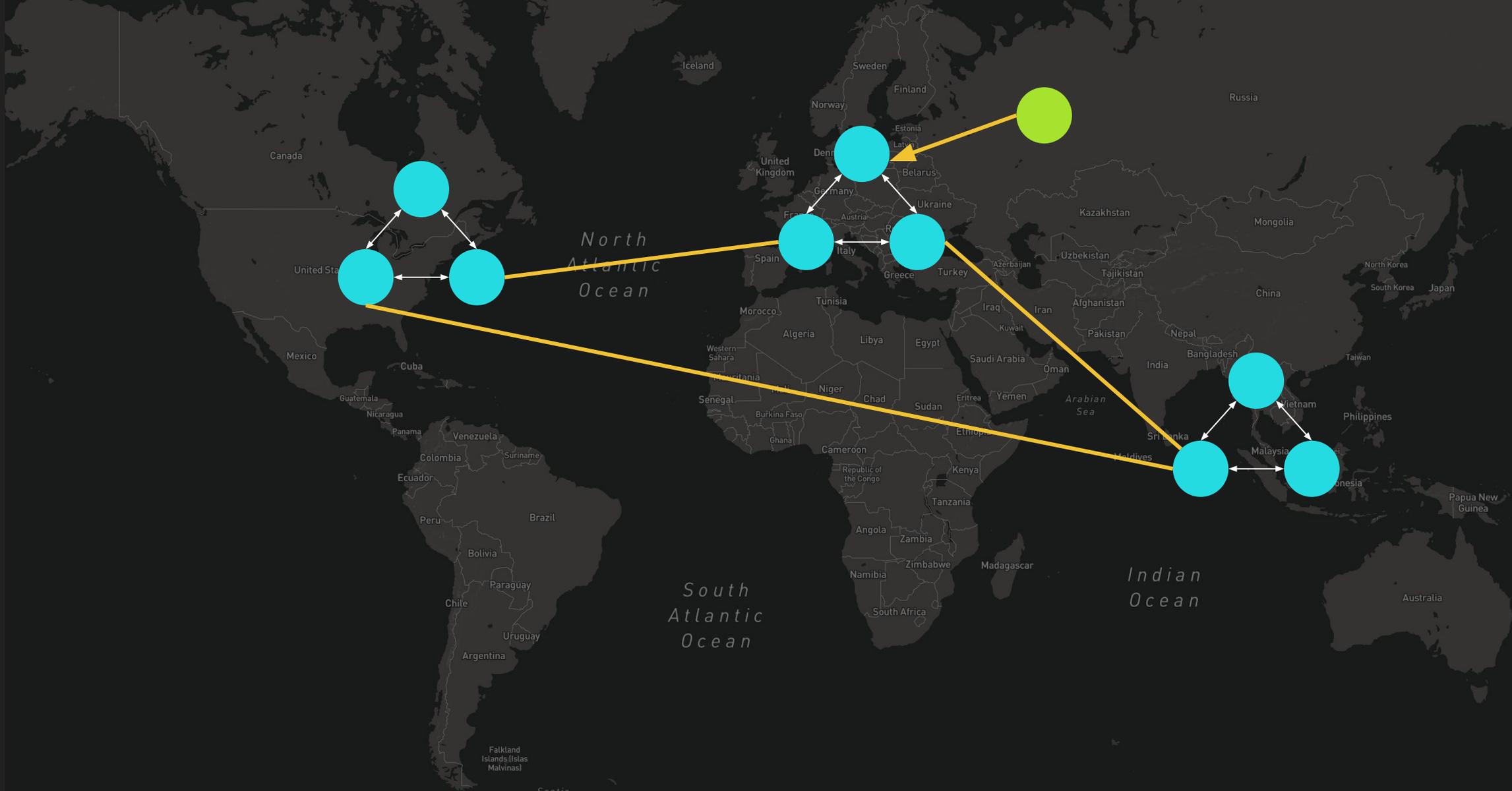
1 bash

```
NATS $ telnetblr.nats-super-cluster.global 4222
```

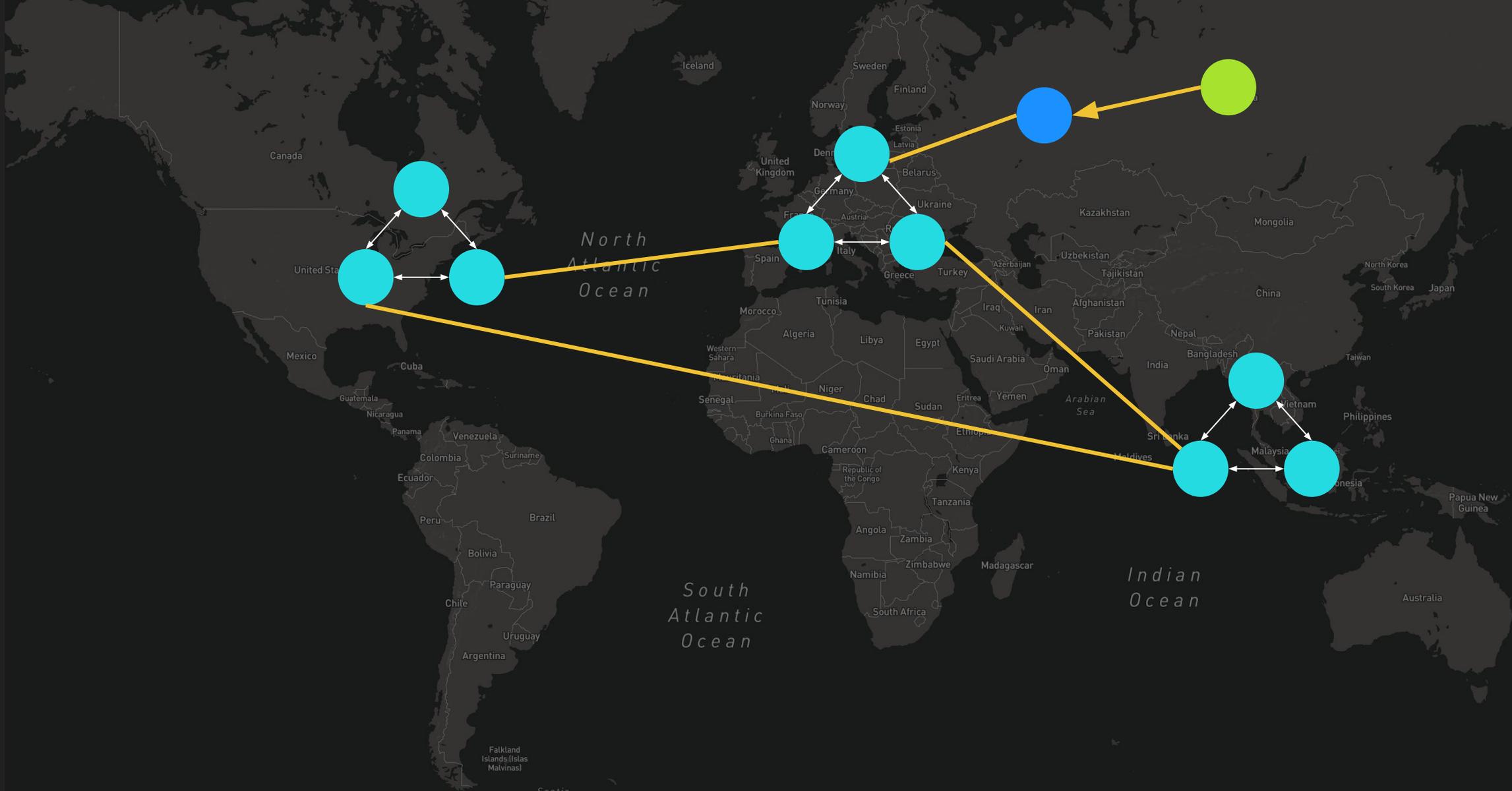
NATS Super Cluster



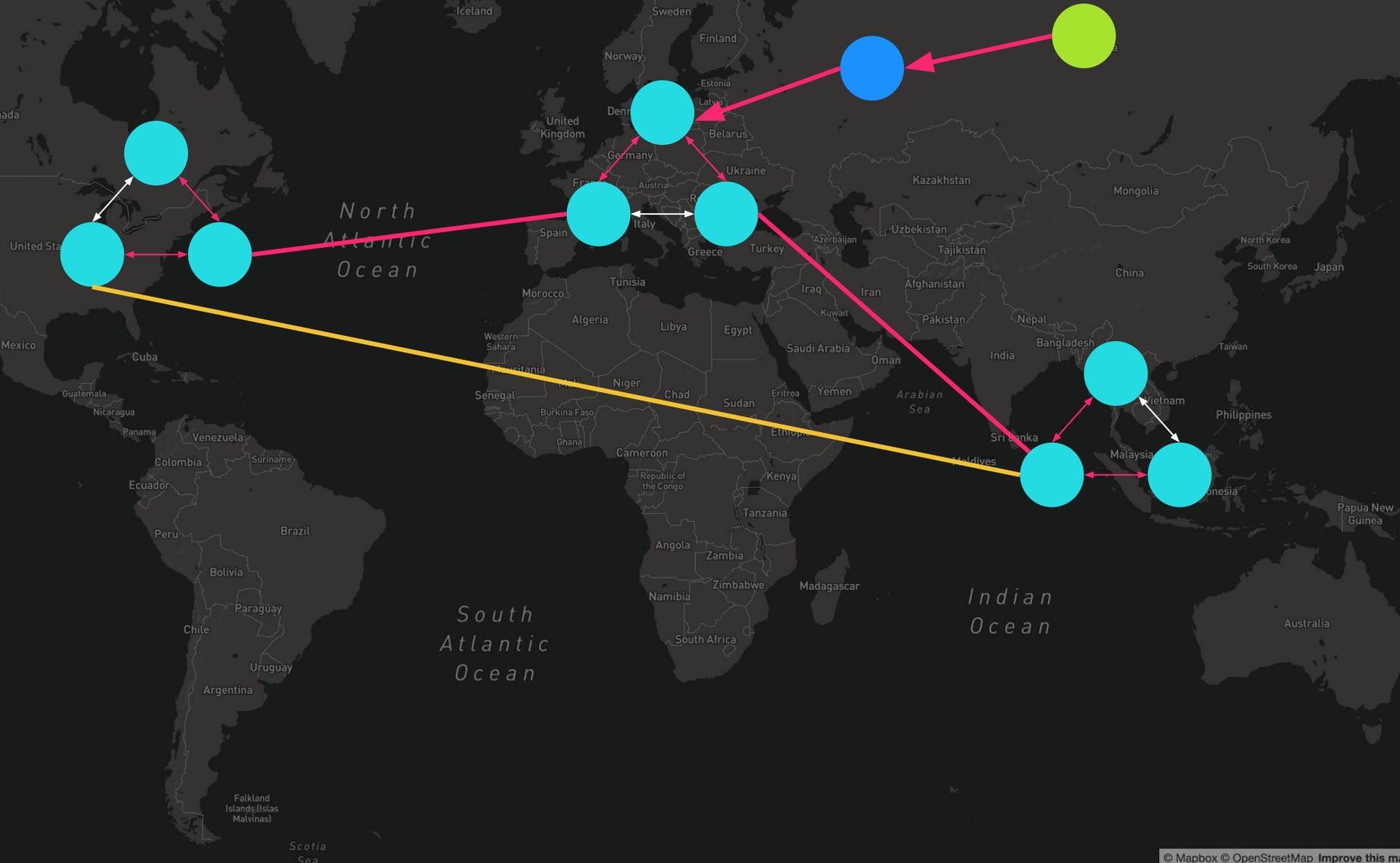
NATS Super Cluster



NATS Super Cluster + Leafnodes



NATS Super Cluster + Leafnodes





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NATS Ecosystem

NATS Operator



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The recommended way of running NATS on Kubernetes

<https://github.com/nats-io/nats-operator>

```
apiVersion: nats.io/v1alpha2
kind: NatsCluster
metadata:
  name: example-nats-cluster
spec:
  size: 3
  version: "1.4.0"
```



NATS Prometheus Exporter



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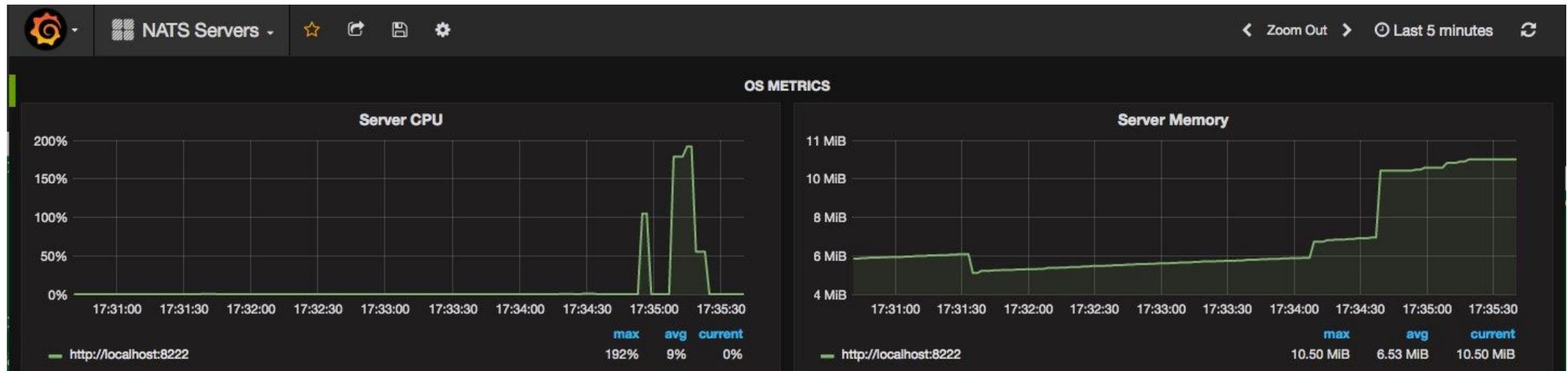
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- Maintained by the NATS team

<https://github.com/nats-io/prometheus-nats-exporter>

- Core NATS + NATS Streaming support



NATS Account Server



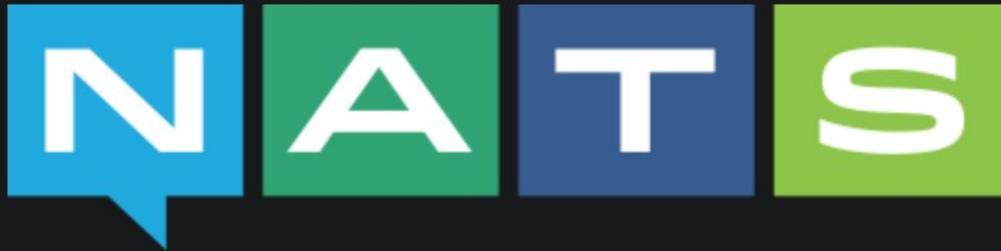
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<https://github.com/nats-io/nats-account-server>



nats-account-server

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A simple HTTP server to host account JWTs for [nats-server 2.0](#) account authentication.

NATS 2.0 introduced the concept of accounts to provide secure multi-tenancy through separate subject spaces. These accounts are configured with JWTs that encapsulate the account settings. User JWTs are used to authenticate. The nats-server can be configured to use local account information or to rely on an external, HTTP-based source for account JWTs. The server in this repository is intended as a simple to use solution for hosting account JWTs.



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Demo

Deploying a NATS v2 Super Cluster on Kubernetes with the NATS Operator



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Questions?



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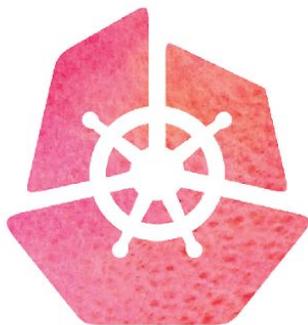


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Thanks!



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