Zenoh: The Genesis

Angelo Corsaro, PhD

CEO/CTO

angelo@zettascale.tech

zetta
scale

Historical Background

zetta scale

IoT & IIoT

We were involved in building some of the very first **IoT** and **IIoT** systems

In **2008** we were involved with the **Nice's Connected Boulevards**, one of the world first Smart Cities

In **2014** we part for the core team that build the Fog Platform for Barcelona

It was Laborious

Building these systems was laborious

We had to stitch several technologies together already to make data flow end-to-end

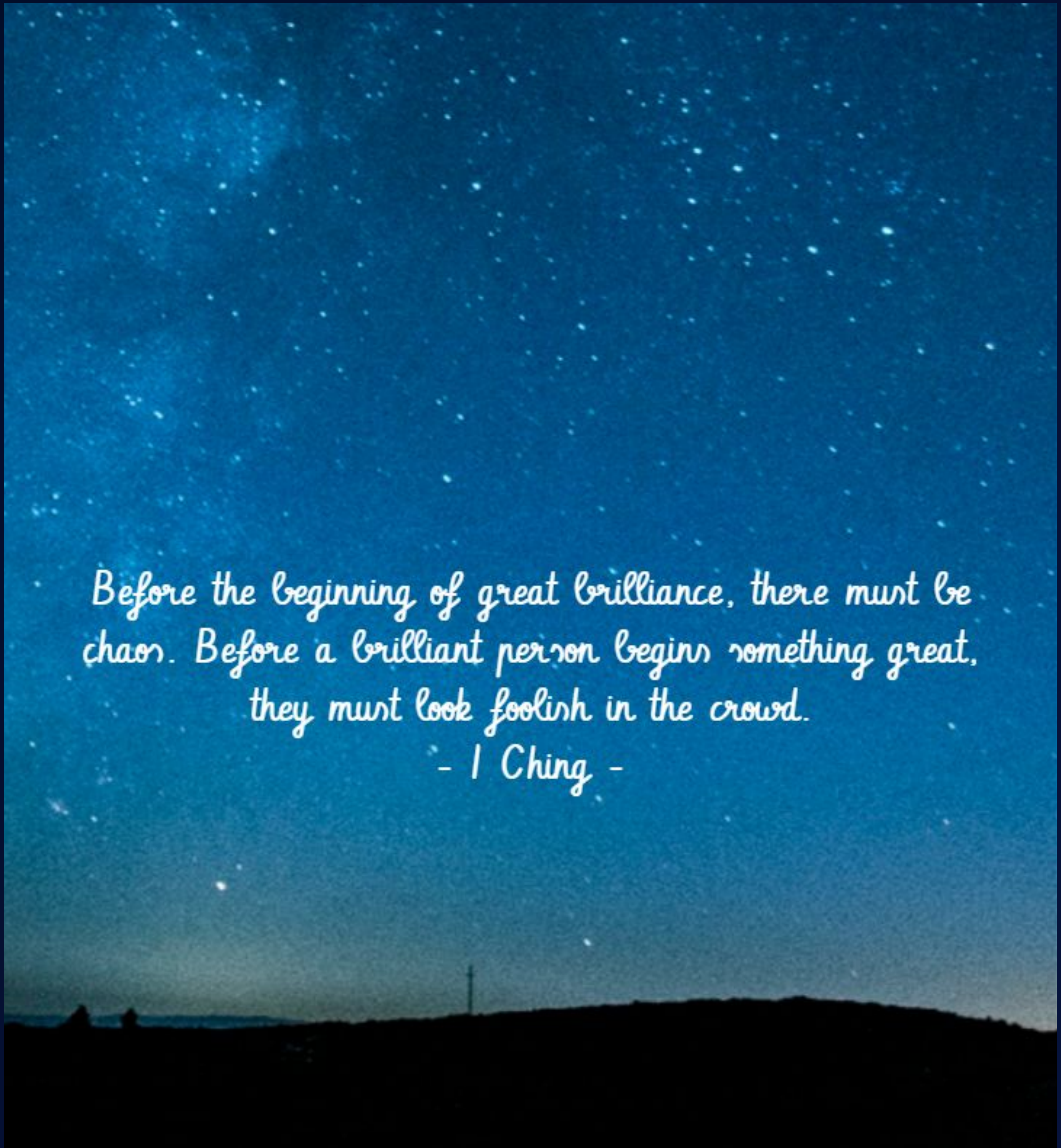
We had to stitch a few more to deal with data storage, etc.

Chaos

The situation was extremely messy, yet it seamed that just a few of us where bothered by it

Everyone was pushing for the technology they had adopted or were selling and ignoring the challenges…

We couldn’t!



Before the beginning of great brilliance, there must be chaos. Before a brilliant person begins something great, they must look foolish in the crowd.
- I Ching -

Key Limitations

Back in 2014-2015, the technologies considered as "emerging", such as MQTT, DDS, etc, were already 10+ years old, and more importantly had not been designed to address the scale nor the heterogeneity required by IoT and IIoT

Inertia...

Starting from 2015 we tried to push for a new wire protocol for the OMG DDS to address some of its short comings

Most notably its discovery overhead, and inability to scale over the Internet, its wire overhead, footprint, etc...

But inertia prevailed...

zetta scale

A New Beginning

We decided to take up the challenge to design a new protocol that could work in the Cloud-to-Device continuum

We set us-up for the additional challenge to unify data in motion and data at rest and as a consequence bring location transparency to data at rest

zetta
scale

Eclipse Zenoh

Zenoh

Unifies data in **motion**, data at **rest** and **computations** from embedded microcontrollers up the data centre

Provides **location-transparent** abstractions for **high performance pub/sub** and **distributed queries** across heterogeneous systems

Provides **universal abstractions** for **cloud-to-device data-flow programming**

“Some people want it to happen, some wish it would happen, others make it happen.” – Michael Jordan

zetta scale

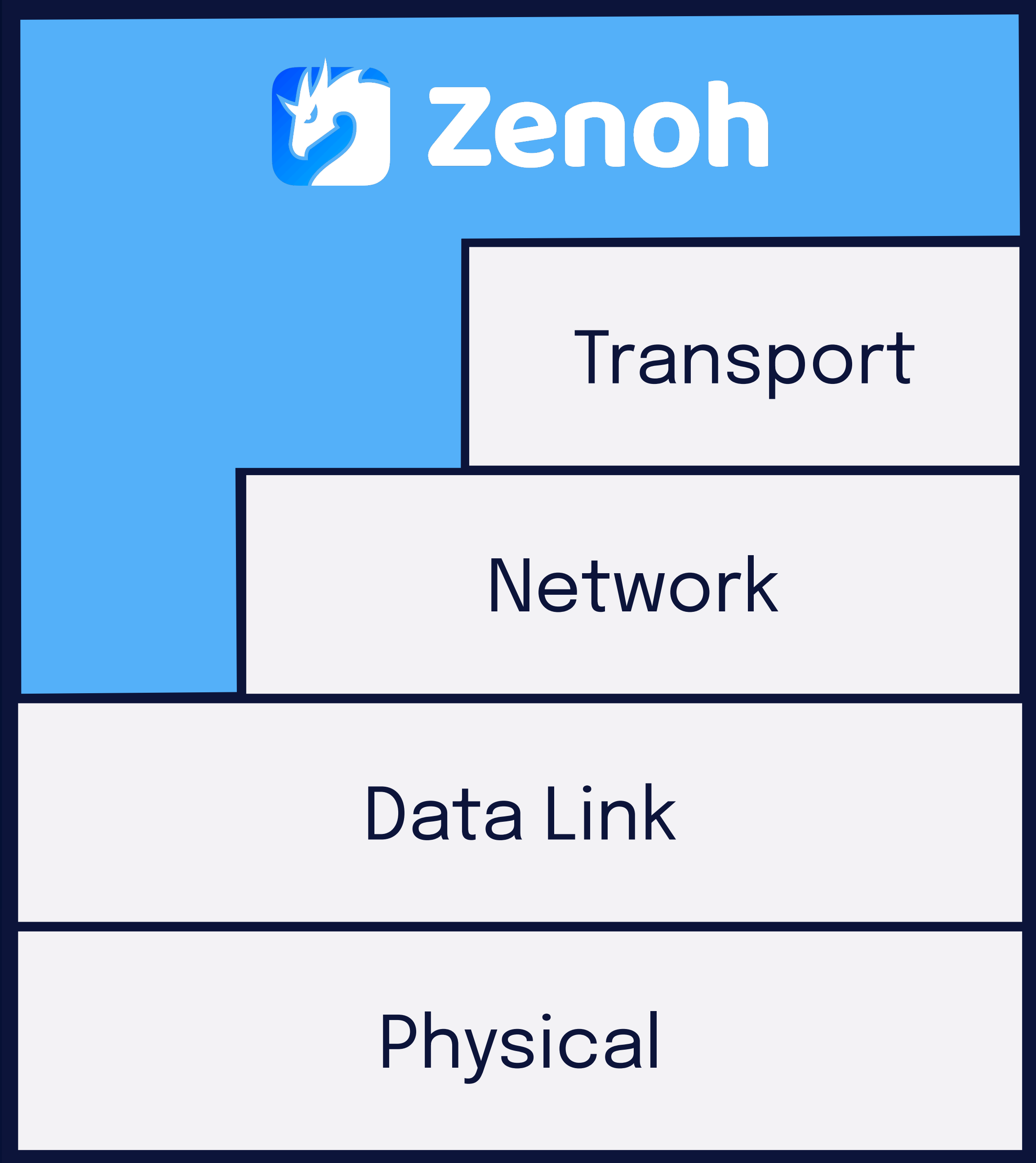
Runs Everywhere

Written in Rust for security, safety and performance

Native libraries and **API bindings** for many **programming languages**, e.g., Rust, C/C++, Python, Java, Kotlin

Supports **network technologies** from **transport layer down-to** the **data link**

Available on **embedded** and **extremely constrained devices**



Abstractions

Resource. A **named data**, in other terms a (key, value)

```
(e.g. /home/kitchen/sensor/temp, 21.5
      /home/kitchen/sensor/hum, 0.67)
```

Key expression. An **expression** identifying a set of keys

```
(e.g. /home/kitchen/sensor/*
      /home/**/temp
```

Selector. An **expression** identifying a set of resources

```
(e.g. /home/*/sensor/air?co2>12[humidity])
```

Abstractions

Publisher. A **spring** of values for a key expression

`(e.g. /home/kitchen/sensor/temp`
`/home/kitchen/sensor/* )`

Subscriber. A **sink** of values for a key expression

`(e.g. /home/kitchen/sensor/temp`
`/home/kitchen/sensor/*)`

Queryable. A **well** of values for a key expression

`(e.g. /home/**)`

Primitives

open/close – Open/Close a **zenoh** session.

declare_subscriber – Declares a subscriber with a **user provided call-back** that will be triggered when data is available.

declare_publisher – Declares a publisher and optimise the communication stack for repetitive publications. Notice that **Zenoh** does not require a publisher in order to perform publications, this is just an optimisation.

declare_queryable – Declares a queryable with a **user provided call-back** that will be triggered whenever a **query** needs to be answered.

Primitives

put – puts a value for a key expression.

pull – Pulls data for a pull subscriber.

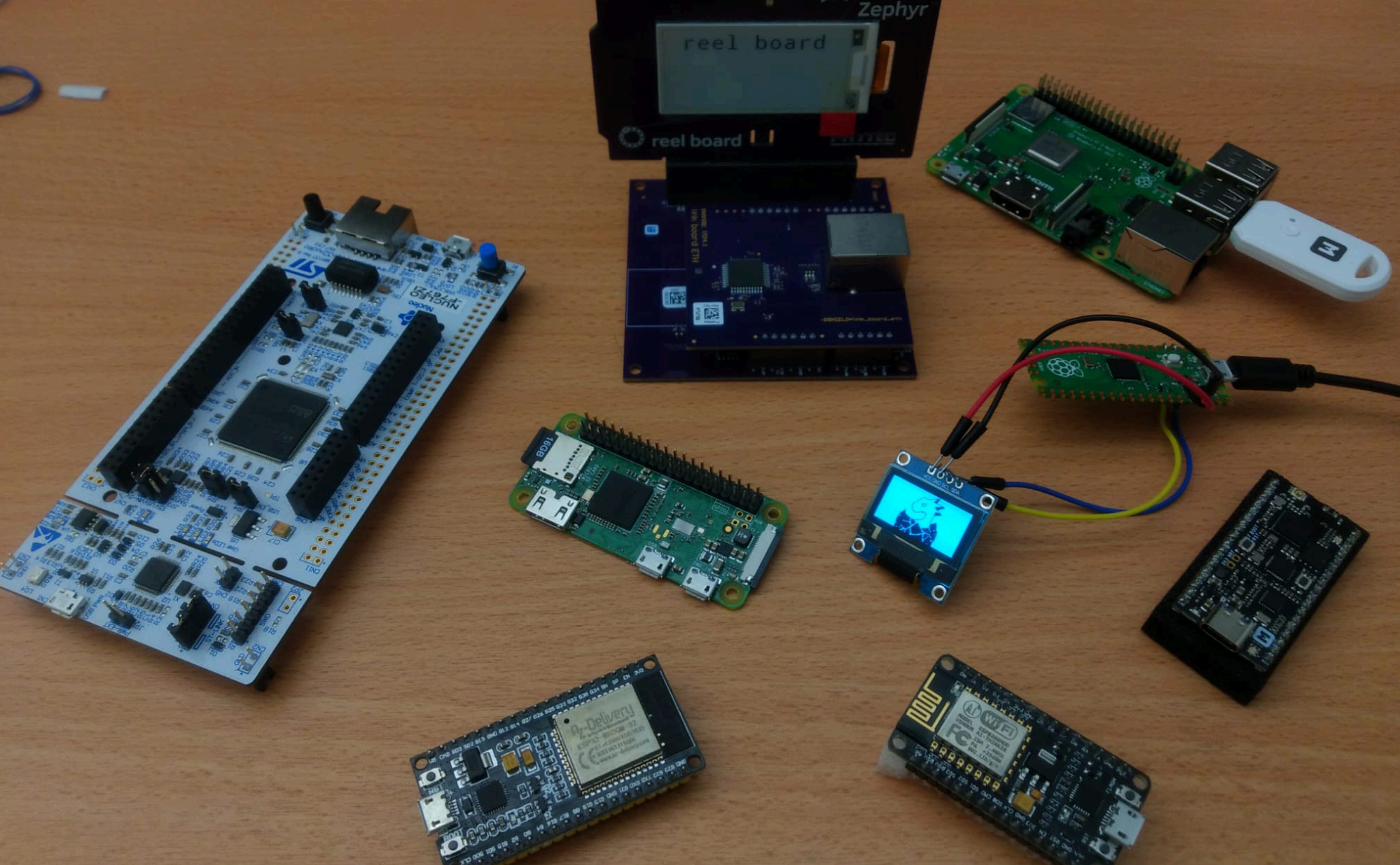
get – Issues a distributed query and returns a stream of results. The query target, coverage and consolidation depends on policies.

Scouting

Zenoh supports pluggable scouting protocols as a way to “discover” zenoh runtimes on the network as well as infrastructural nodes, such as routers

At an API level a **scout** primitive is exposed to trigger scouting

The scouting protocol leveraged by zenoh depends on the underlying network


Zephyr
reel board
reel board
16GB
NUCLEO
AZ-Delivery
WiFi

zetta scale

Any Topology

Peer-to-peer

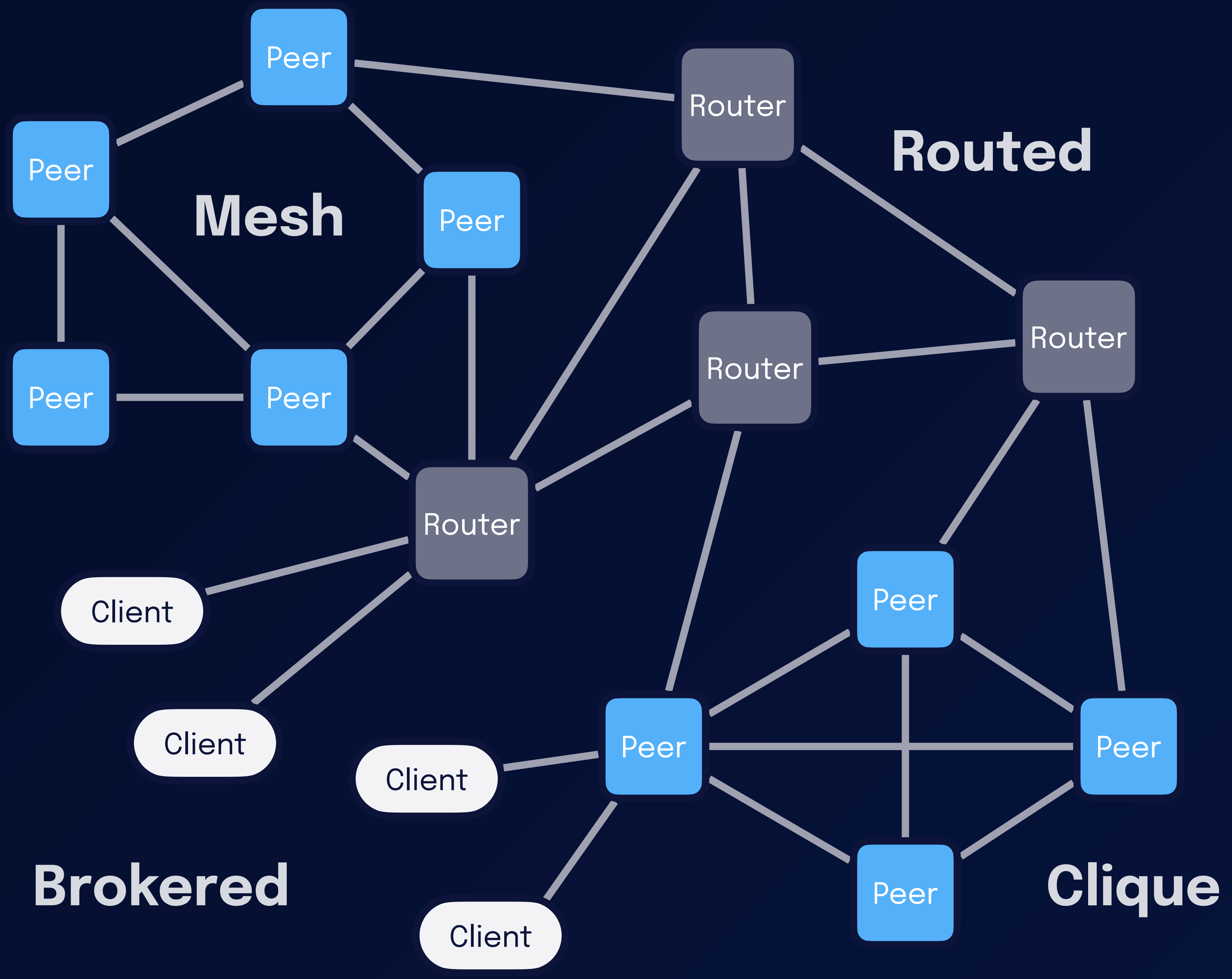
Clique and mesh topologies

Brokered

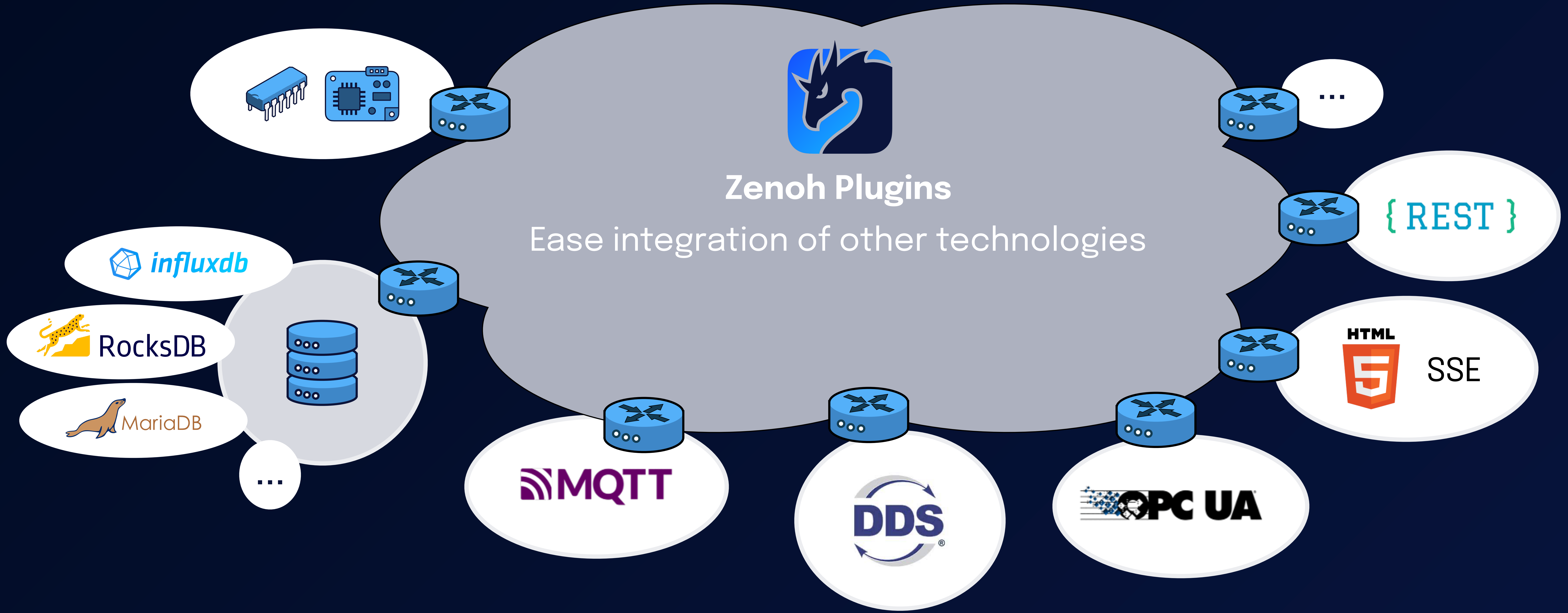
Clients communicate through a router or a peer

Routed

Routers forward data to and from peers and clients

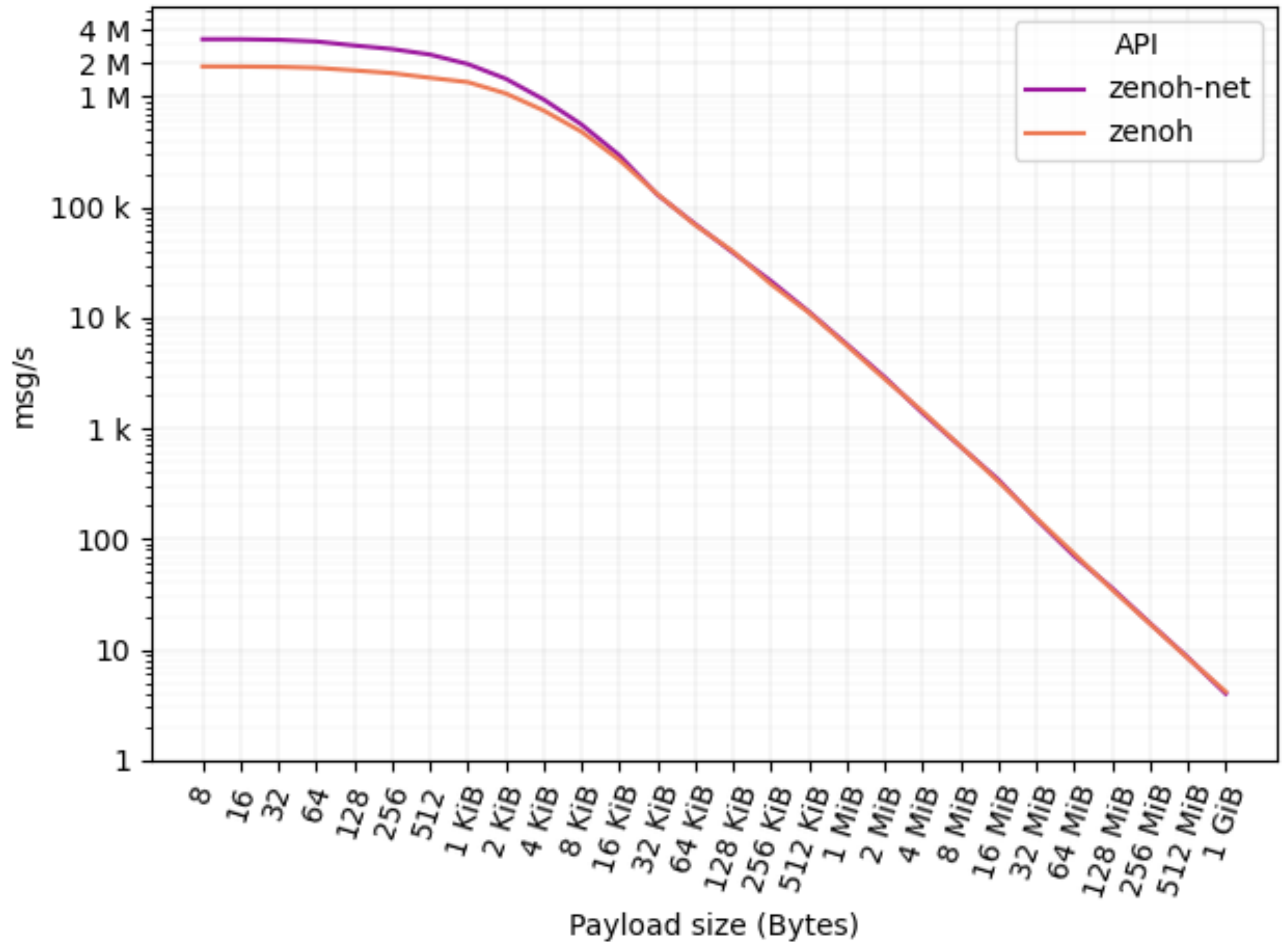


Extensible



Lorem ipsum dolor sit amet

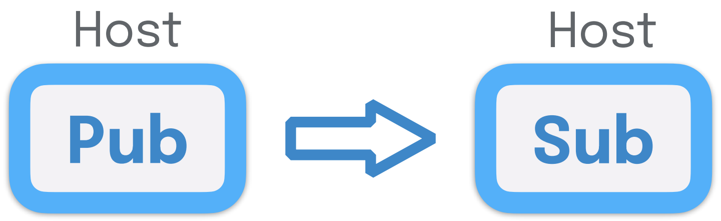
Performance



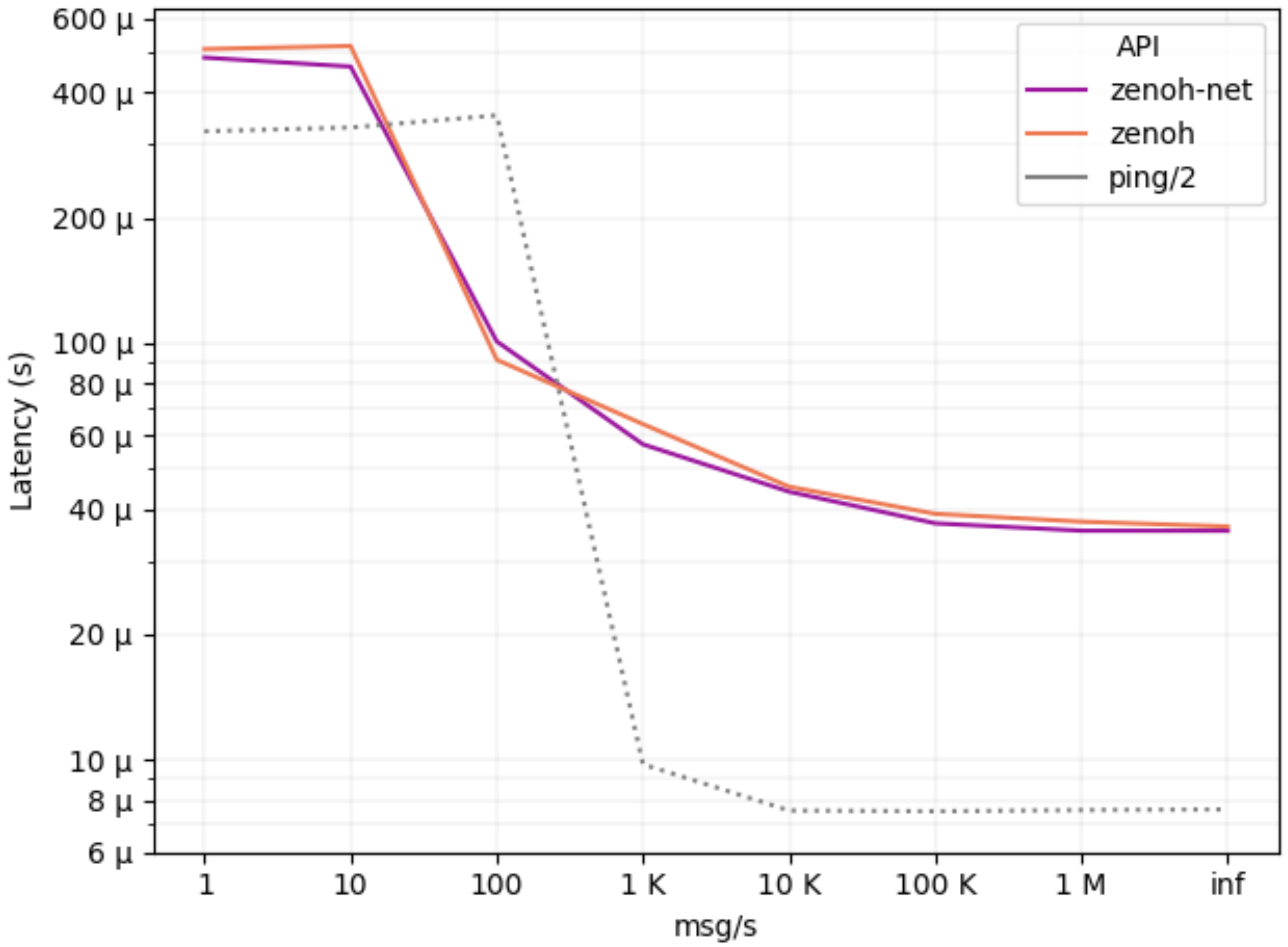
High throughput (4M msg/s – +40Gb/s)

Low latency (35 us)

Minimal **wire overhead** of **4-6 bytes**



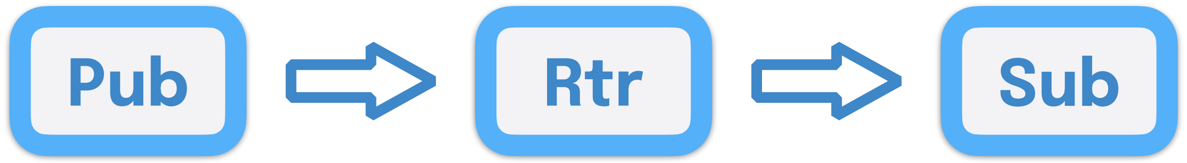
Test run on 10/07/2021 on
Ubuntu 20.04
AMD Ryzen
32GB RAM
100Gbps ETH



"One of the things I love about music is live performance." - Yo-Yo Ma

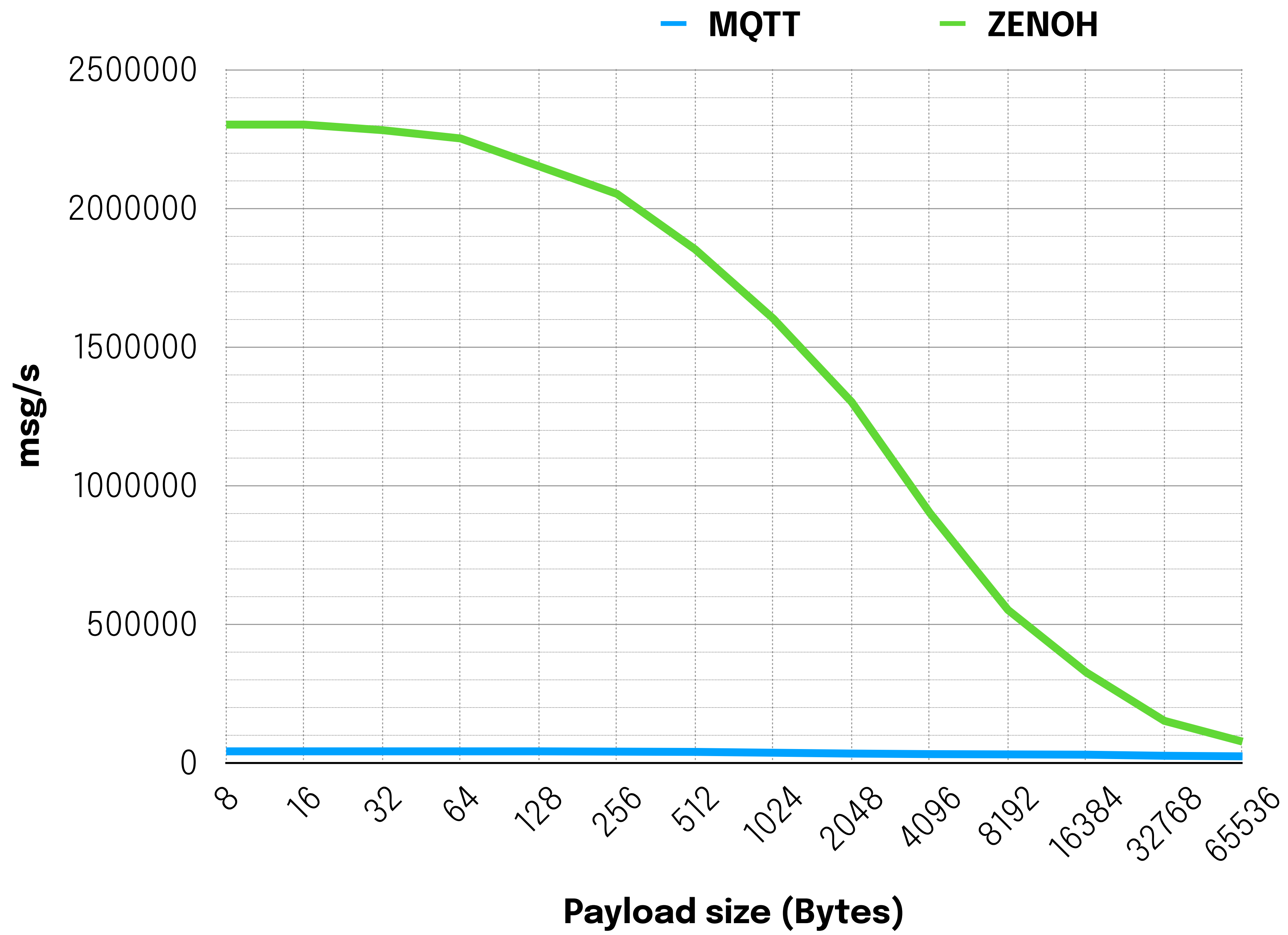
Throughput in perspective…

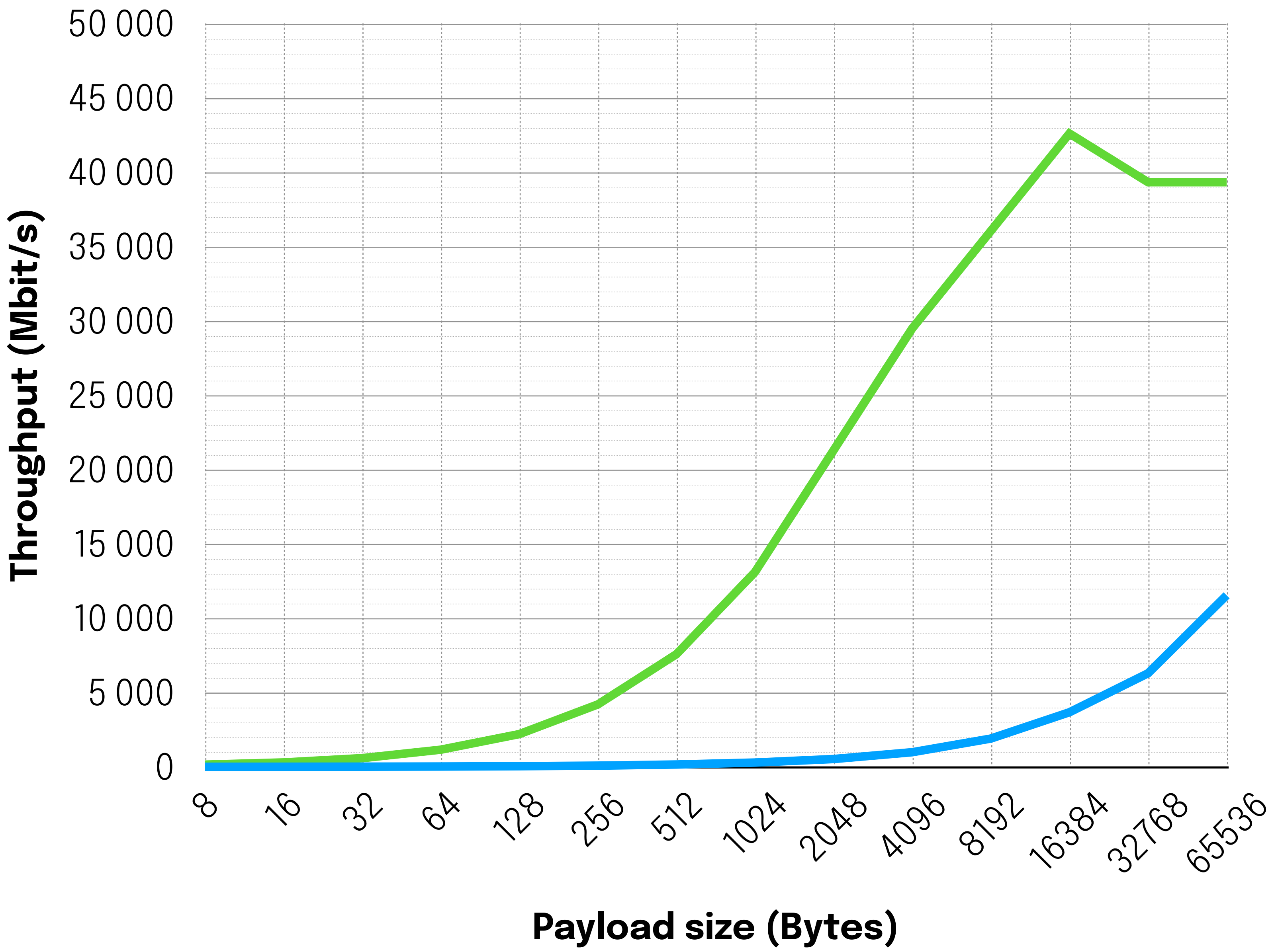
Zenoh is far more performant than MQTT for both **small** and **large** messages



Test run on 02/03/2022 on
Ubuntu 20.04
AMD Ryzen
32GB RAM
Localhost

"Harder, Better, Faster, Stronger." - Daft Punk

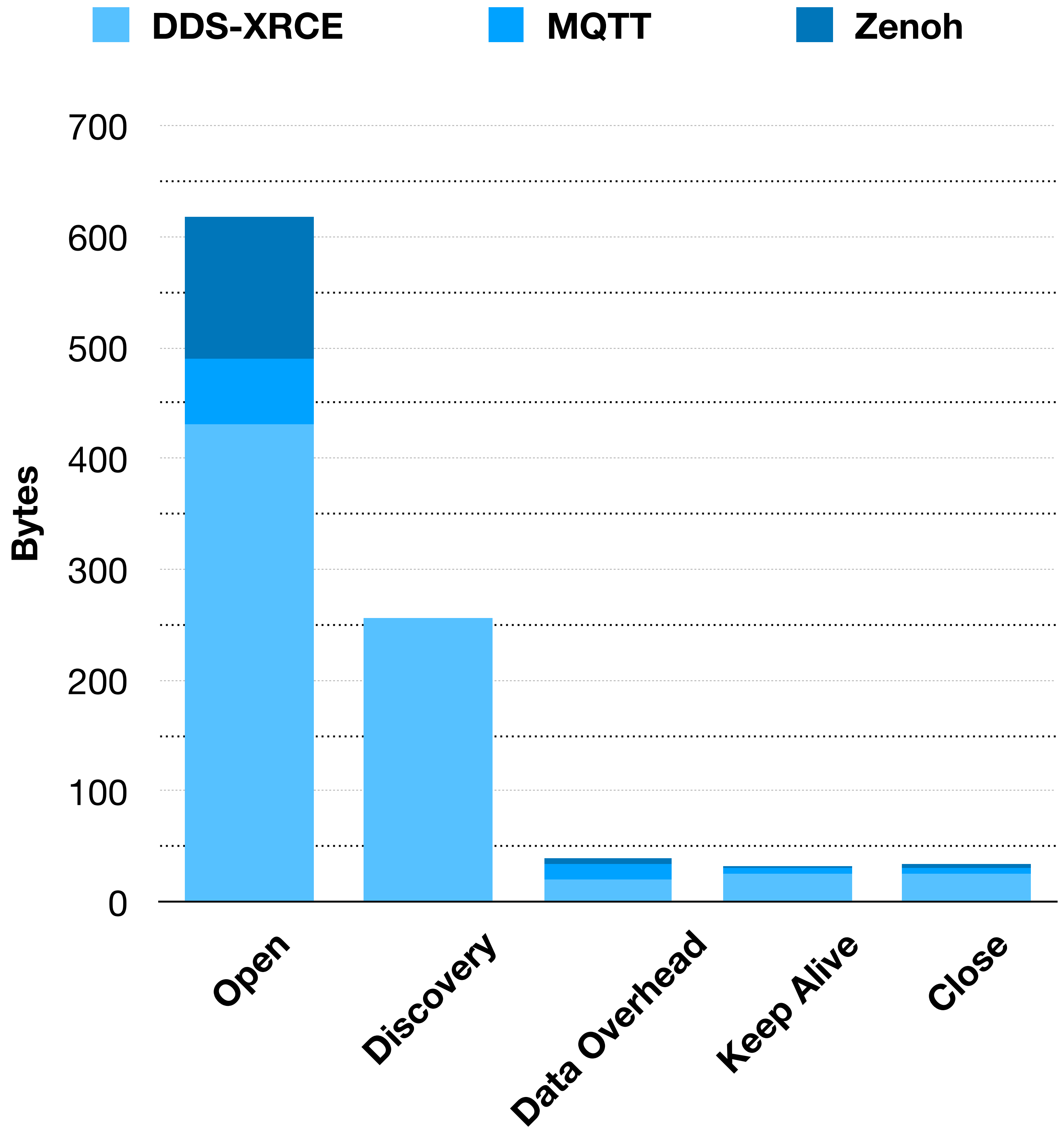




Bandwidth efficiency in perspective…

Zenoh is far more efficient than DDS-XRCE and definitively more efficient than MQTT

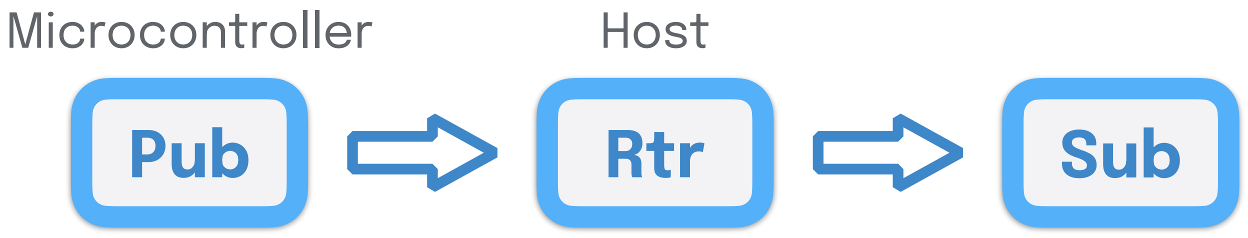
Test run on 22/02/2022 on
Ubuntu 20.04
AMD Ryzen
32GB RAM
Localhost



"Even the largest avalanche is triggered by small things." - Vernor Vinge

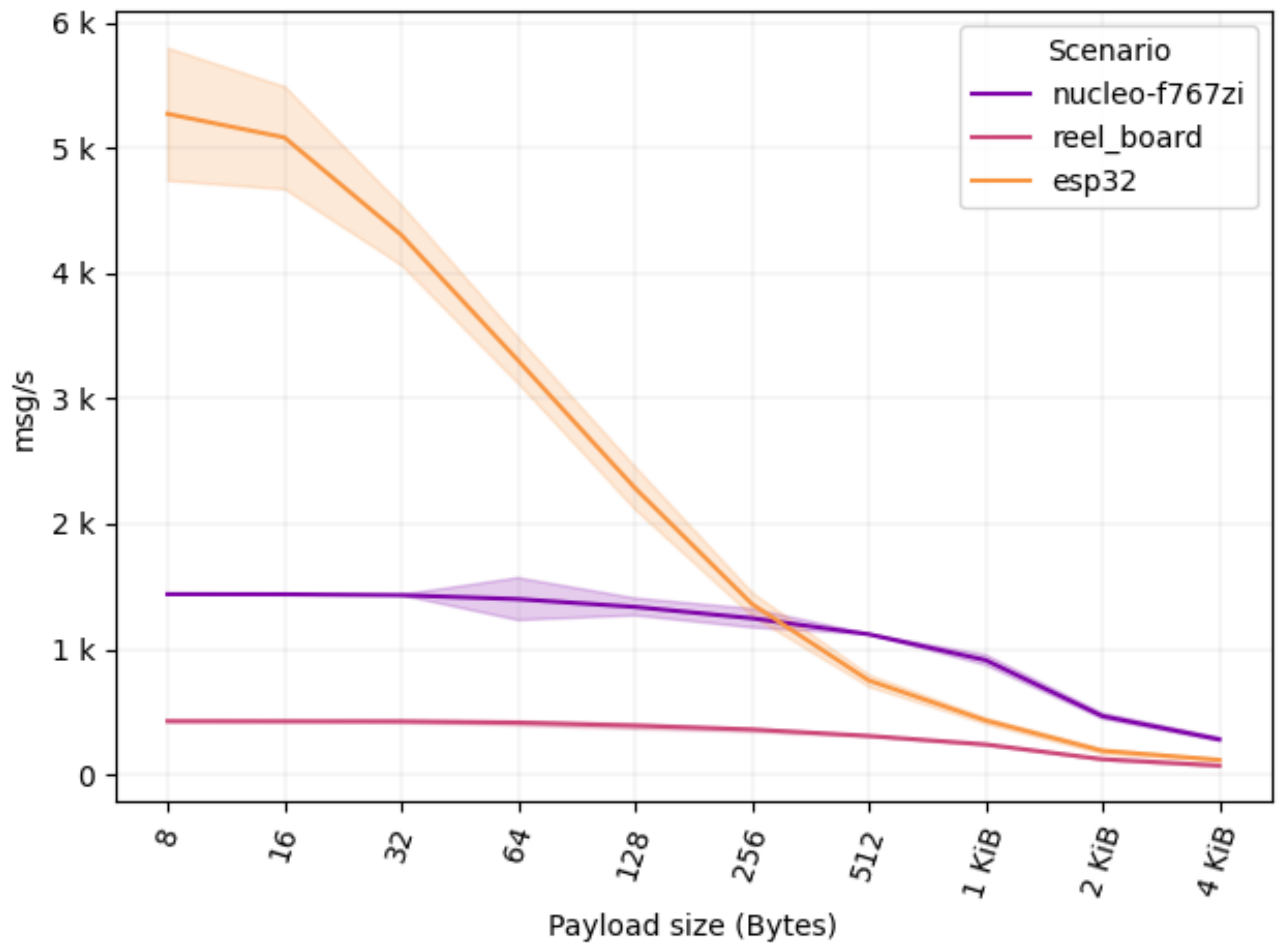
Performance in microcontrollers

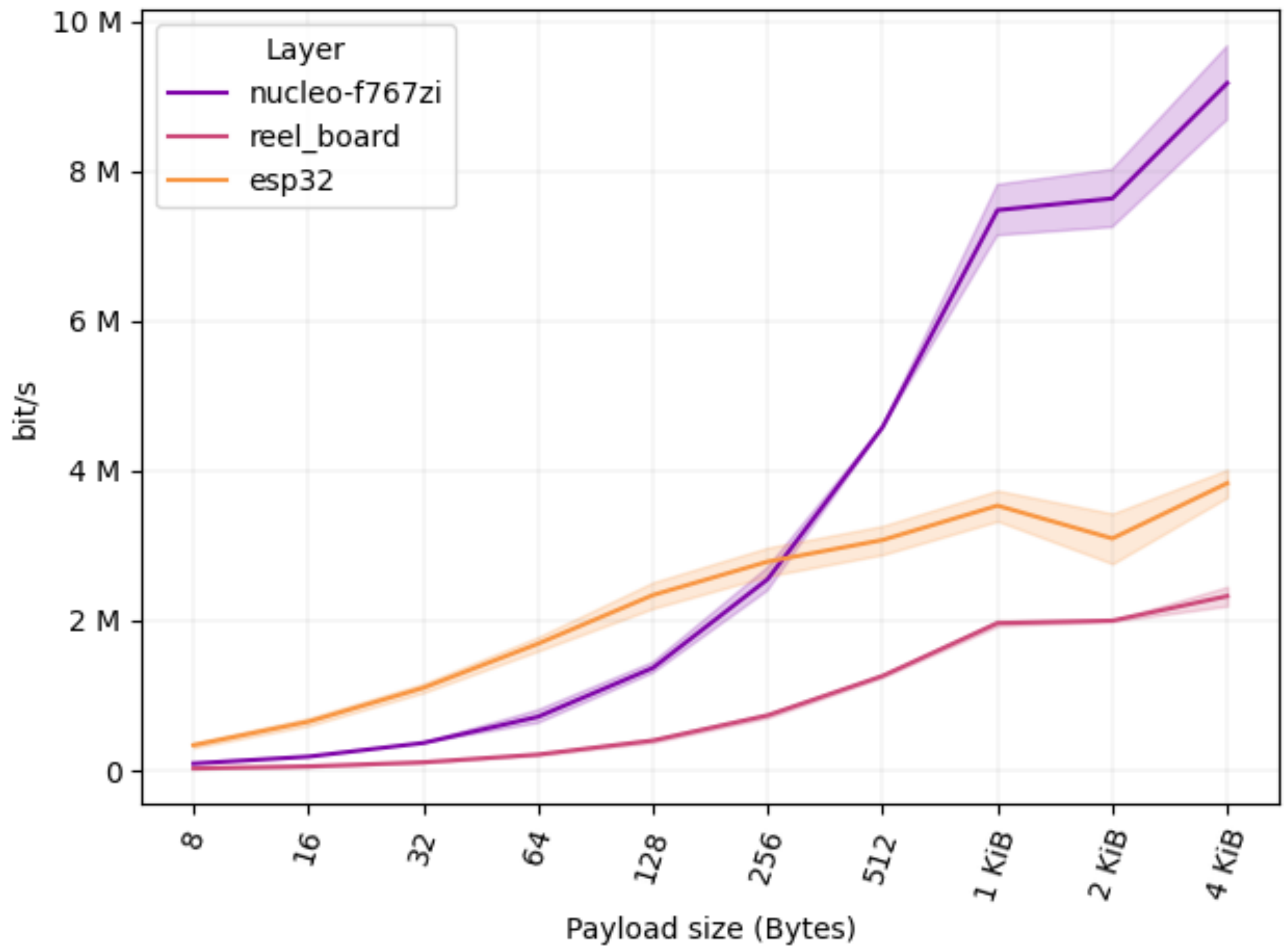
Zenoh-pico	reel_board (Zephyr)	nucleo-f767zi (Zephyr)	ESP32-D0WDQ6 (Arduino)
Build-in Flash	1 MiB	2 MiB	4 MiB
Empty Binary	68166 bytes	127344 bytes	385859 bytes
Zenoh Publisher	164654 bytes	186942 bytes	423161 bytes



Test run on 21/09/2021 on
Zenoh-pico
Various platforms
10Mbps ETH

“Even the largest avalanche is triggered by small things.” - Vernor Vinge





zetta scale

Protocol Highlights

Most wire/power/memory efficient protocol in the market to provide connectivity to extremely constrained targets

Supports **push** and **pull pub/sub** along with **distributed queries**

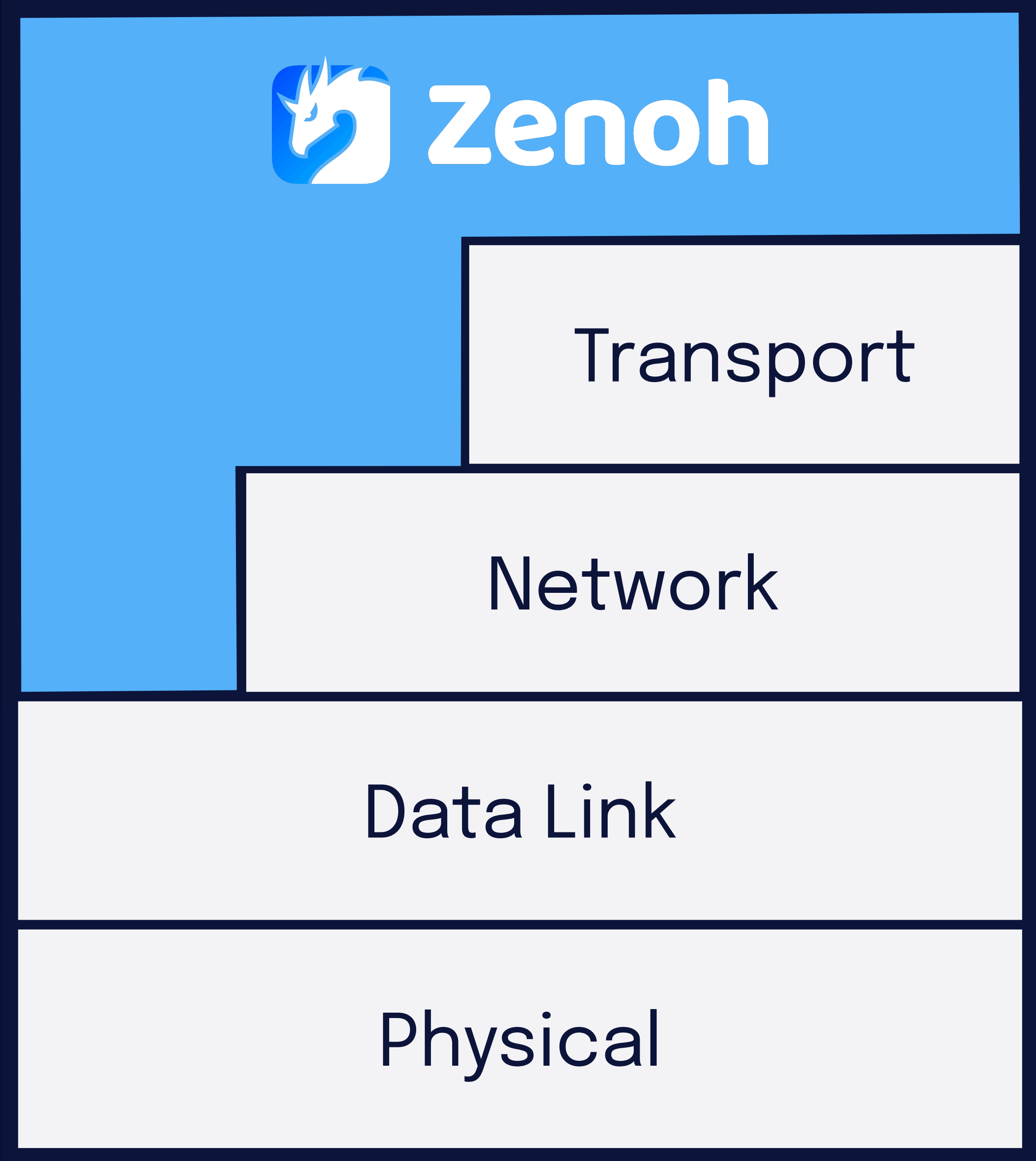
Resource keys are **represented as integers** on the wire, these integer are **local to a session** => good for wire efficiency

Supports for **peer-to-peer** and **routed communication**.

Support for **zero-copy.**

Ordered reliable data delivery and **fragmentation**.

Minimal **wire overhead** for user data is **4-6 bytes**



zetta scale

In Summary

Final Thoughts

Zenoh was designed ground up to deal with data management from the Cloud-to-thing continuum

It unifies data at in movement and data at rest

It delivers incredible performances and can run on just about anything