

NOT ALL NETWORKS SUPPORT FULL ON-PATH PTP SYNCHRONISATION

Creating a wide-area PTP timing network over 3rd party fiber connectivity is a common necessity. The goal is accurate common time across sites while maintaining robustness (e.g. from local GNSS outages), privacy, security, and manageability.

PTP packets can be forwarded as data across sections of a (3rd party) network. Here PTP packets experience varying transmission delays and packet filtering is utilized.

QoS (Quality Of Service) marking and token bucket policing etc. ensure that PTP packets have strict priority over other data packets. Worst case, an “unlucky” PTP packet gets queued directly behind a maximum size (1500 byte) Ethernet frame. The maximum delay is very low on high speed links. Also with common interface units and common ingress and egress speeds, the fixed delays are mainly

Line rate Gb/s	MTU transmission time (ns)
0.1	120000
1	12000
10	1200
100	120
400	30

Packet selection is just one of a framework of tools and techniques (PTP+Squared) needed in timing networks, which are additional to PTP. The framework can be considered to include:

Network nodes: (PTP?); interface speed, QoS, latency, forwarding, multiplexing, complexity, size ...

Clocks: PTP, GNSS, Oscillators, interface speeds, integration into servers...

Management roles: Forming, maintaining, monitoring, optimizing, open integration...

MONITORING PTP TIME ERRORS

Real Accuracy, Not Just Promised Precision

Precision timing demands more than trusting the specifications of individual clocks—it requires continuous validation of how those clocks actually perform within the live network environment.

With a mesh topology, synchronisation is constantly monitored through a many-to-many comparison model. Every node evaluates its timing accuracy against all others, enabling a full-picture view of the network’s real-time timing health. This approach uncovers practical deviations caused by jitter, asymmetry, path variation, and environmental impact—factors often invisible in declared specs.

At the core of this system is an ensemble-based selection process. Rather than relying on a single reference, the system intelligently selects the best-performing clocks based on real-world behaviour:

- ▶ **Measured drift and offset**
- ▶ **Consistency over time**
- ▶ **Cumulative network path error**
- ▶ **Performance under changing conditions**

These comparisons are not static—they evolve with the network. As conditions change, the timing source hierarchy adjusts dynamically, maintaining high accuracy even in the face of faults or shifting topologies.

The result: Synchronisation based on live data, resilient by design, and always grounded in observable performance—not theoretical guarantees.

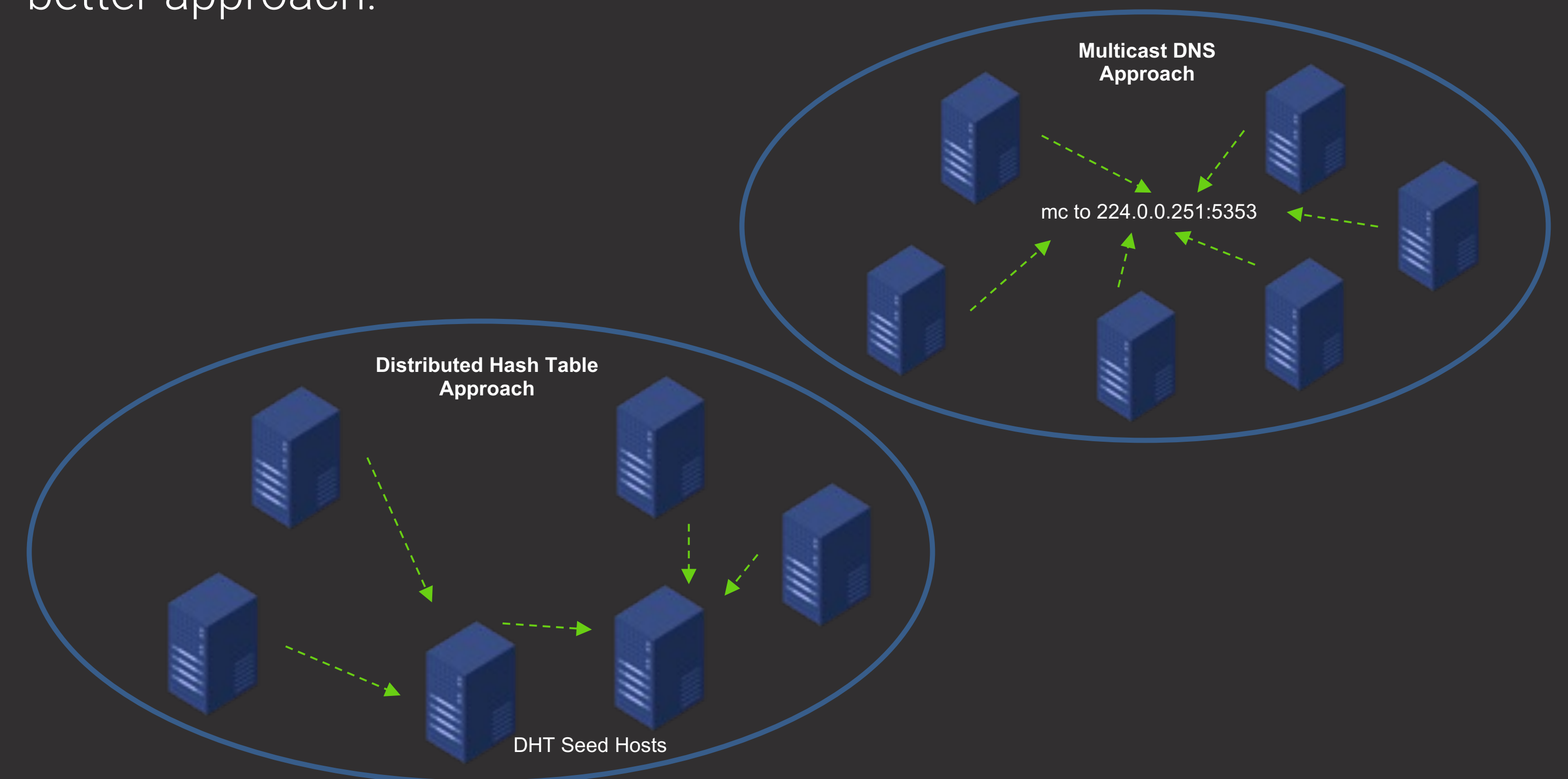
CREATING & MAINTAINING A TIME NETWORK

Paths are created dynamically using either:

Automated Provisioning

- ▶ **mDNS (rfc6762)**
 - ▶ Quick and easy: zero configuration
 - ▶ Not particularly scalable
- ▶ **DHT**
 - ▶ Requires a few nodes whose IP and public key are known
 - ▶ Highly scalable

The two approaches are not mutually exclusive and nodes can use one or both in the same PTP+Squared network, but pure DHT is nearly always the better approach.



CREATING & MAINTAINING A TIME NETWORK

— Built on Automation, Policy, and Resilience —

Automated Provisioning

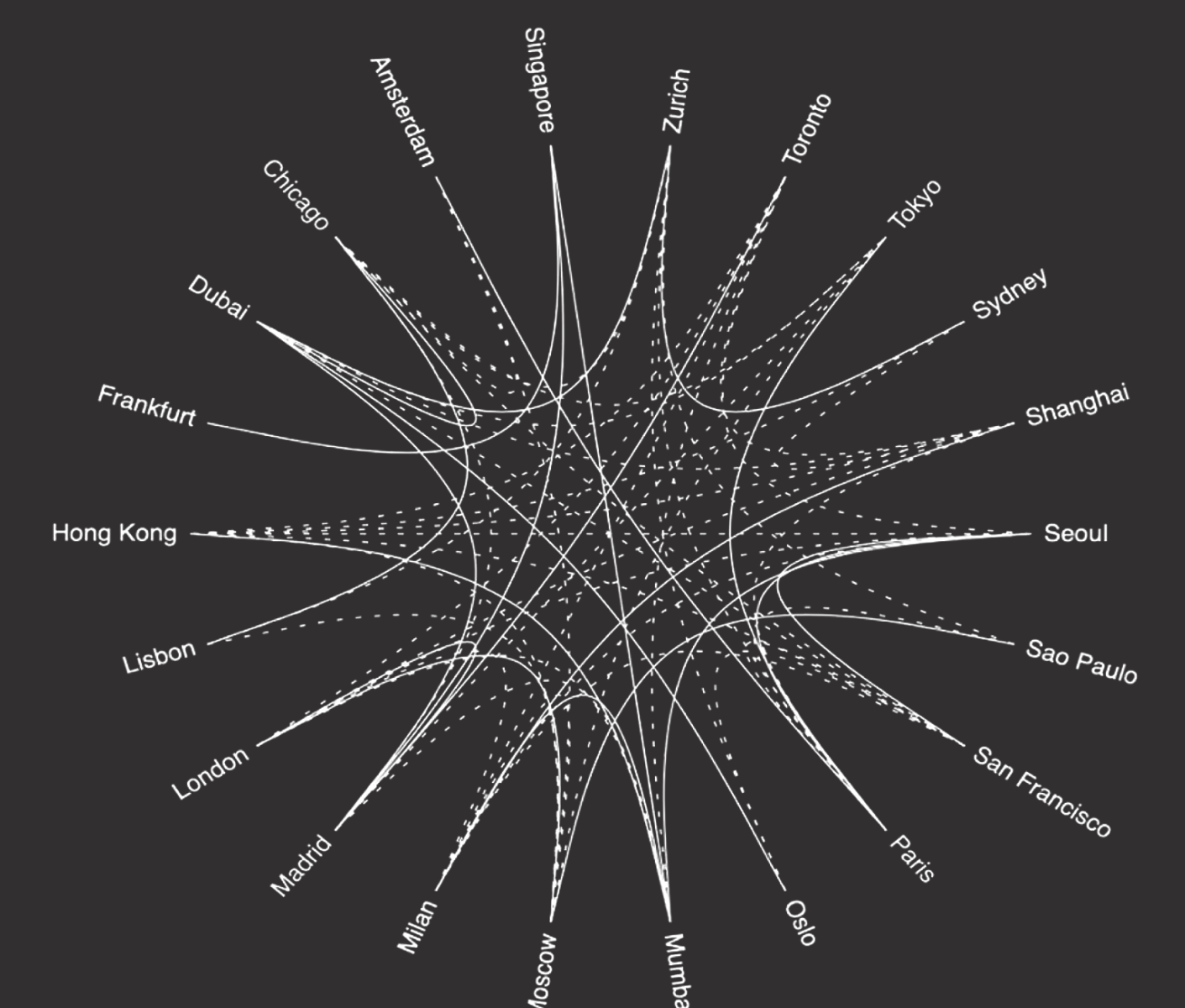
Modern timing networks benefit from the elimination of manual configuration. With automated provisioning, nodes can be deployed, integrated, and synchronised rapidly across a distributed environment. This drastically reduces operational overhead and ensures a consistent deployment model at scale.

Rules-Based Provisioning

By using a policy-driven approach, synchronisation behaviour is defined declaratively—based on topology, timing hierarchy, hop cost, and error budgets. This ensures optimal source selection and loop-free timing paths, even in dynamic or complex environments.

Mesh sync technology enhances traditional PTP with a distributed model, allowing:

- ▶ Intelligent peer-to-peer synchronisation
- ▶ Dynamic path selection based on live metrics
- ▶ Seamless scaling with auto-discovery
- ▶ Resilience through multiple independent time sources
- ▶ This is PTP, reimagined for modern infrastructure.



Robustness Without Full On-Path Support

For environments lacking ideal PTP network conditions, Lucky Packet filtering provides a proven mechanism to maintain timing integrity. When full-on-path support is not available, this technique filters for the most reliable packets—preserving time accuracy across challenging links.