# Multi-Path Time Synchronization

**draft-shpiner-multi-path-synchronization-00**


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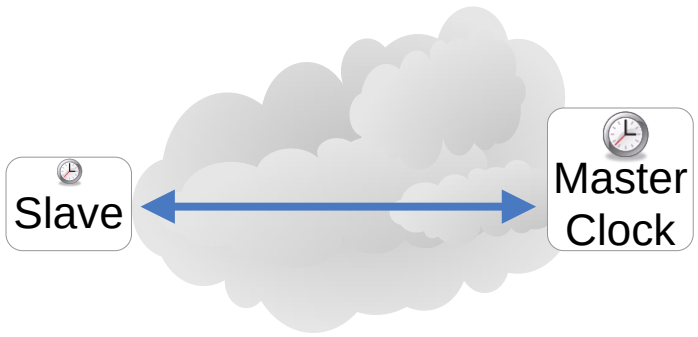
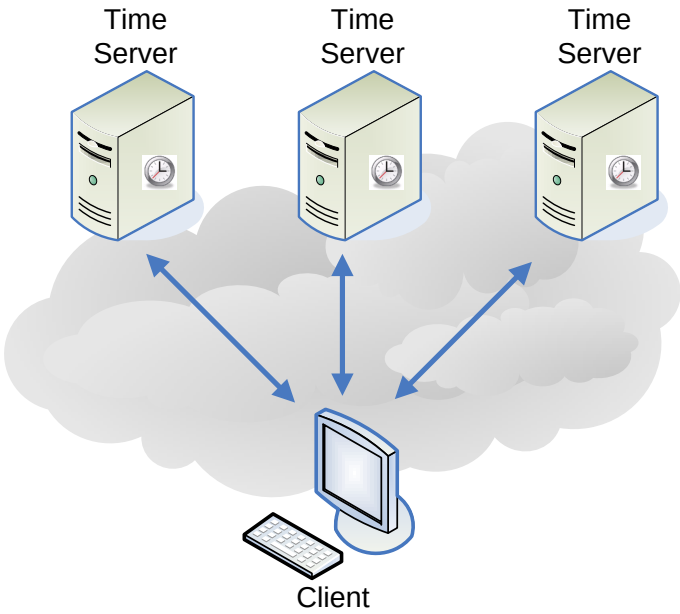
# Background: Well-Known Time Sync Paradigms



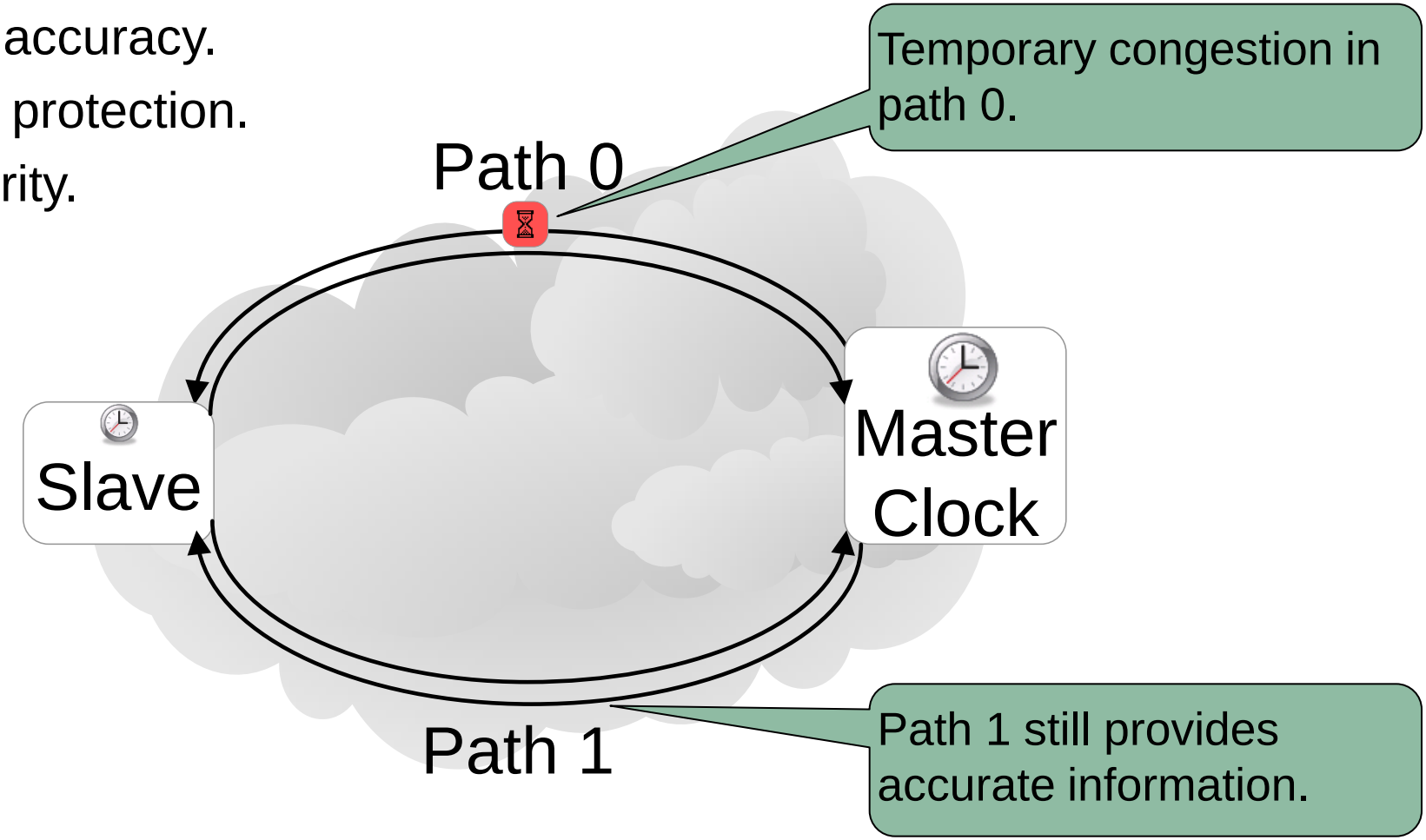

Slave is connected to a single master using a single path, e.g. PTP.




- Client combines information from multiple servers, e.g., NTP. or
- Slave connected to multiple masters. One active, others standby, e.g. ITU-T G.8265.1

# Background: Using Multiple Paths

- **Multiple paths allow Slave Diversity[1]:**
  - High accuracy.
  - Fault protection.
  - Security.



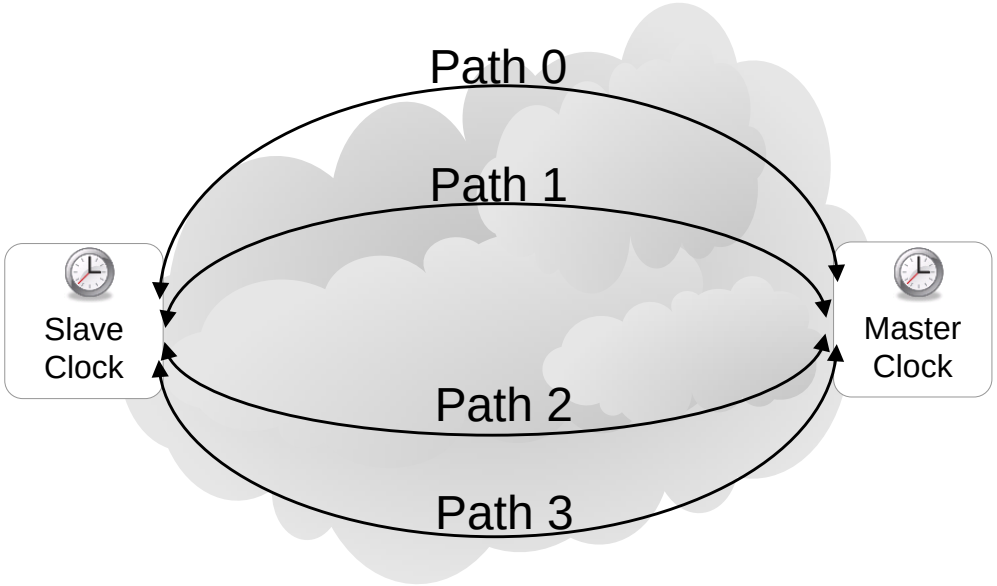

1 T. Mizrahi "Slave Diversity: Using Multiple Paths to Improve the Accuracy of Clock Synchronization Protocols", ISPCS 2012.

# Multi-Path Time Synchronization in IP Networks

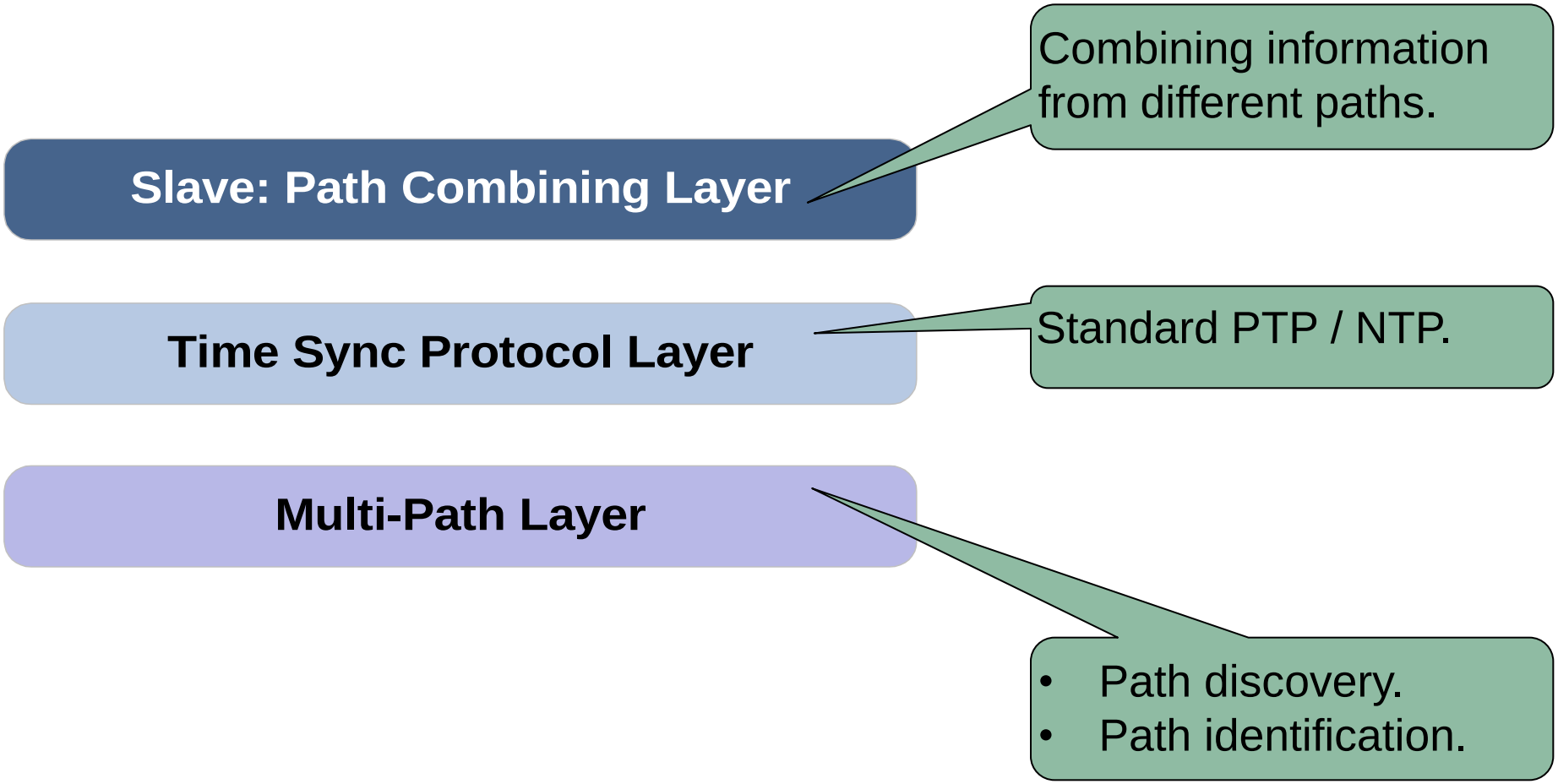
- **This draft defines two protocols:**
  - Multi-Path PTP (MPPTP).
  - Multi-Path NTP (MPNTP).

- **Define an additional layer without modifying PTP or NTP.**

- **Interoperability with conventional PTP / NTP.**



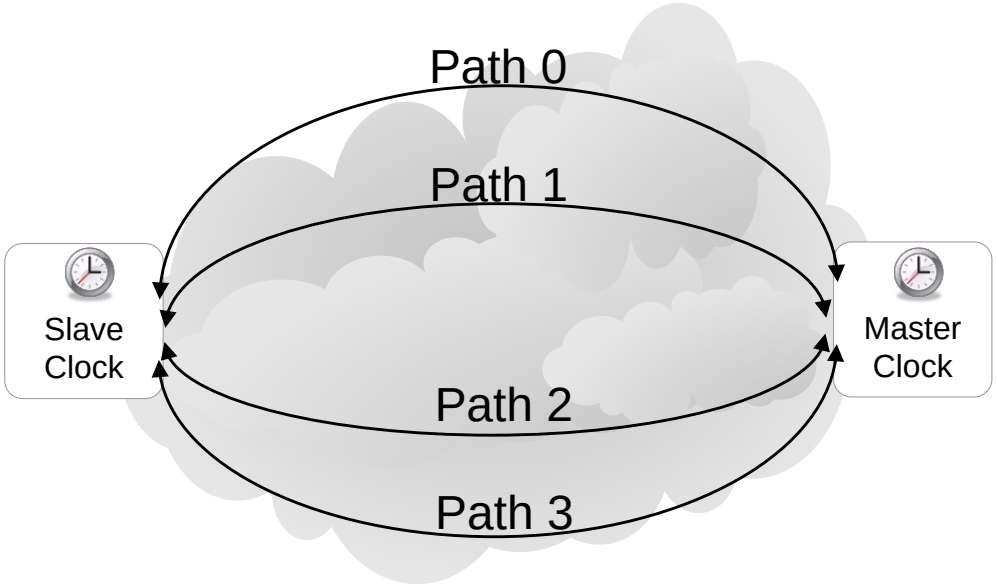
# Multi-Path Time Synchronization – Logical Layers



# Multi-Path Time Synchronization

- **Two-way multi-path synchronization:**
  - Both master and slave support multiple paths.

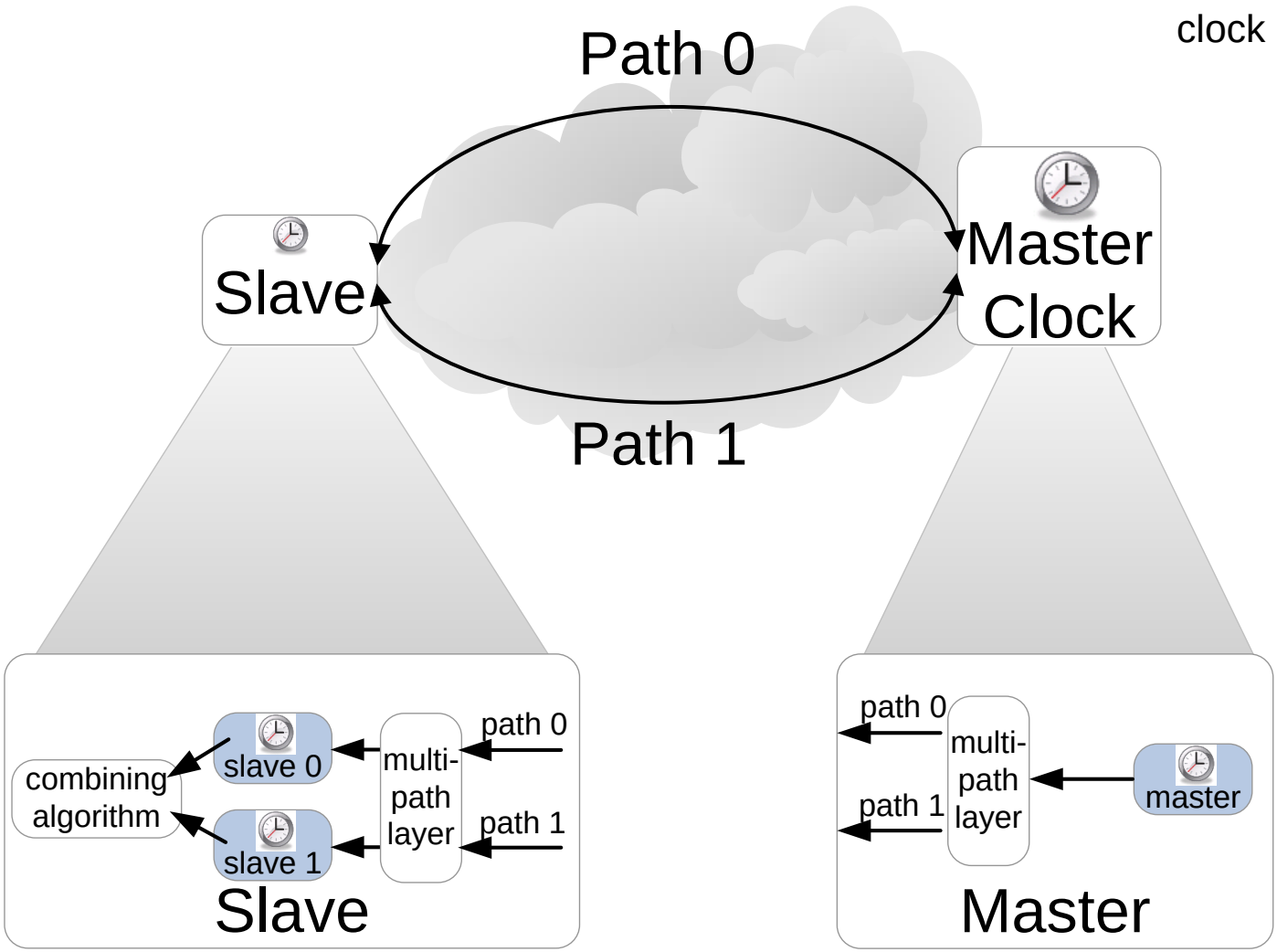
- **One-way multi-path synchronization:**
  - Only slave supports multiple paths.
  - Interoperable with conventional existing nodes.



# Multi-Path Synchronization – Logical Building Blocks

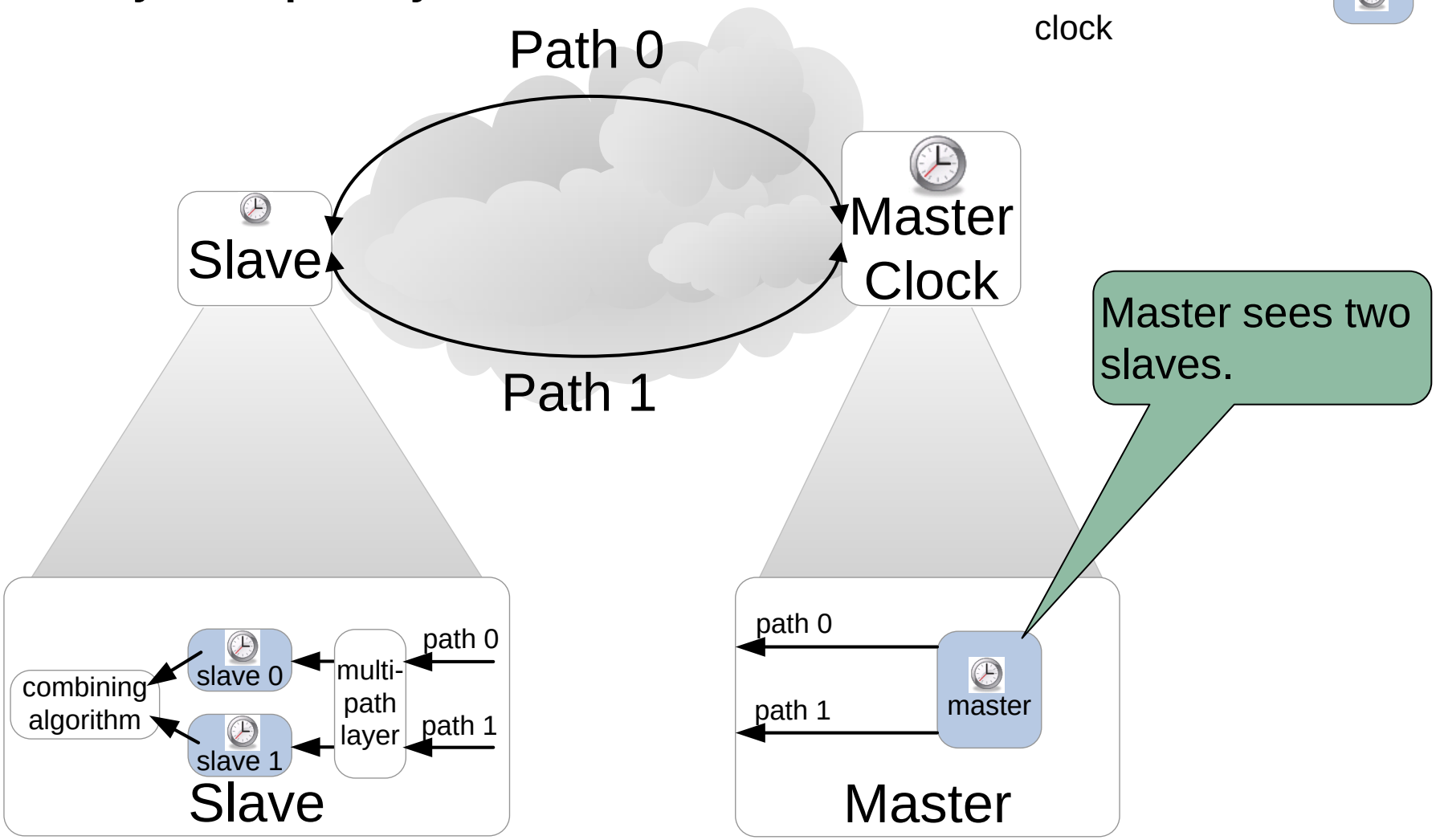
- **Two-way multi-path synchronization:**

Standard PTP/NTP clock



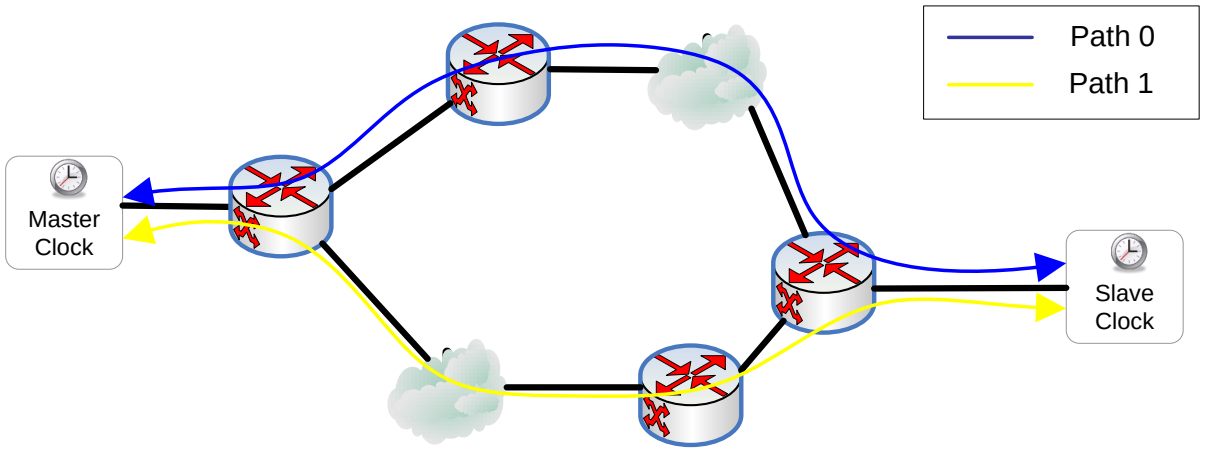
# Multi-Path Synchronization – Logical Building Blocks

- **One-way multi-path synchronization:**



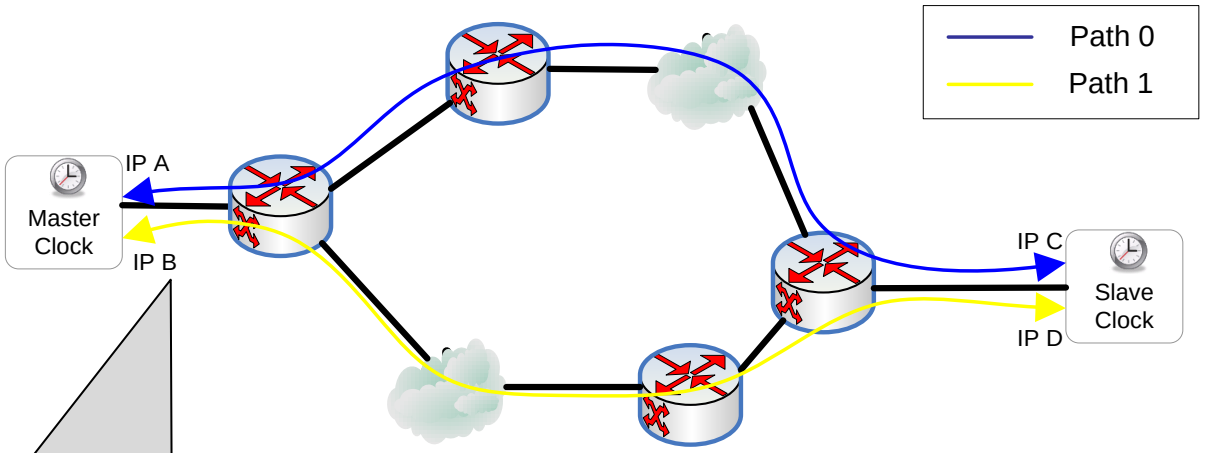
# Path Discovery / Configuration

- **The multi-path layer discovers all possible paths between the current clock and the peer clock.**
- **Multiple paths:**
  - Traffic engineered.
    or
  - Discovered using Traceroute (e.g. Paris Traceroute: path discovery by scanning IP address / IPv6 flow label).
- **Path discovery / configuration is a function of the network's load balancing mechanisms.**



# Two-Way Multi-Path Time Synchronization

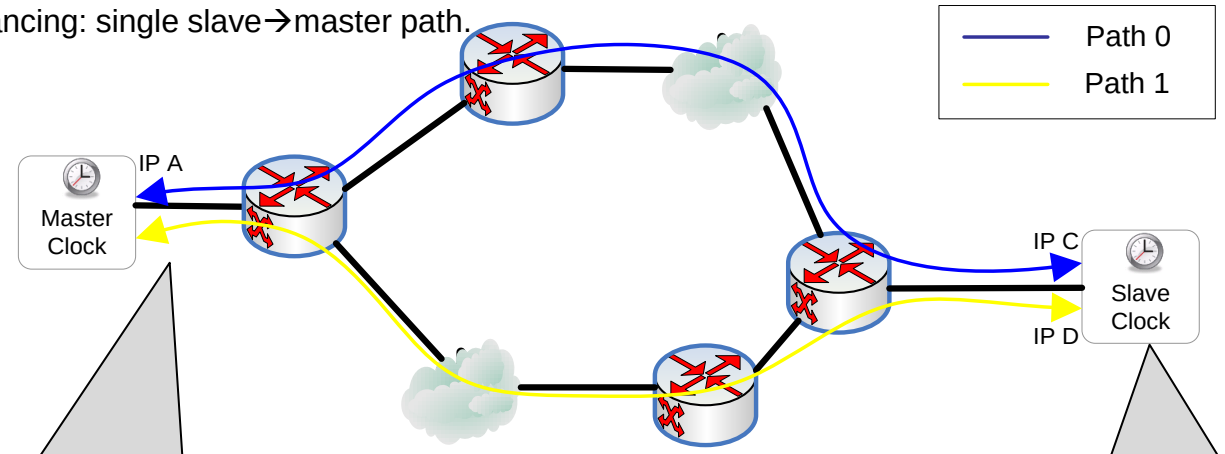
- **Each node has multiple IP addresses.**
- **Different {master IP, slave IP} pairs are used for each path.**
- **Unicast messages.**




Master / slave use {master IP, slave IP} pairs to identify path ID.

# One-Way Multi-Path Time Synchronization

- **Each node has multiple IP addresses.**
- **Different slave IP addresses are used for each path.**
  - PTP: also different clock identity for each path.
- **Pros:**
  - Interoperable with multi-path unaware master.
- **Cons:**
  - May produce less diverse paths than the two-way variant.
    - Destination based load balancing: single slave→master path.

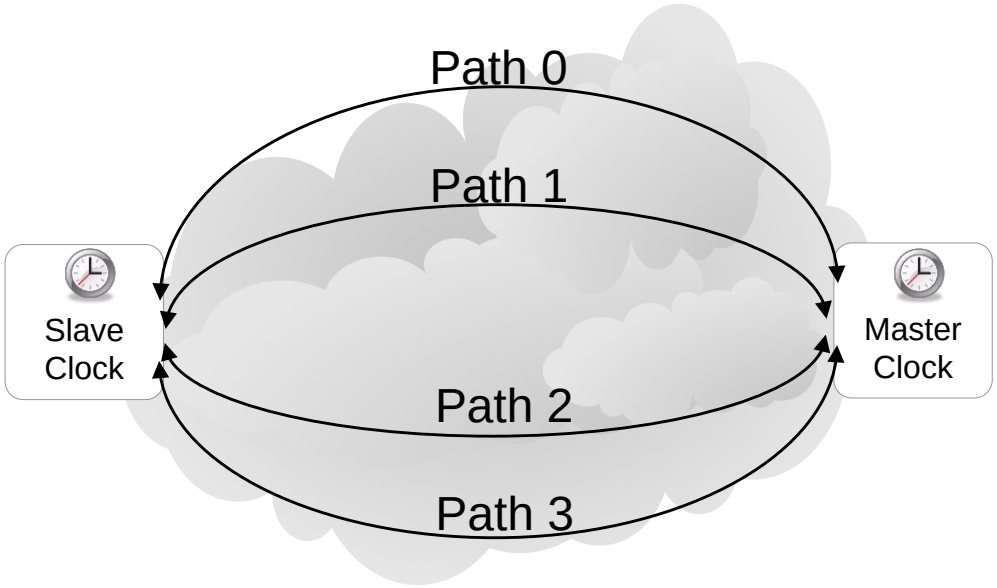



Master sees 2 slaves.

Slave uses:
- 2 IP addresses.
- PTP: 2 Clock IDs.

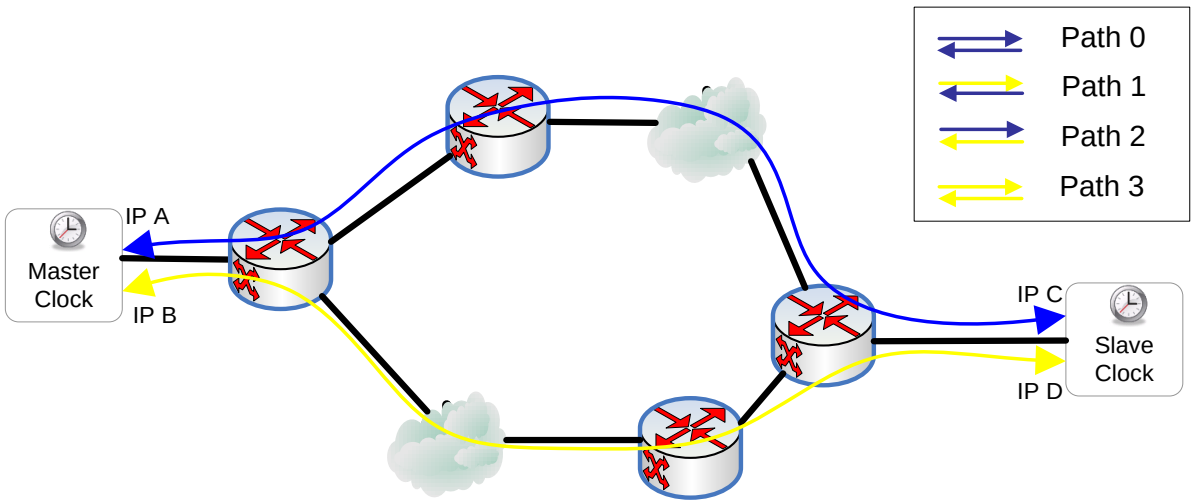
# Next Steps

- **Feedback from the WG.**
- **Request WG adoption.**



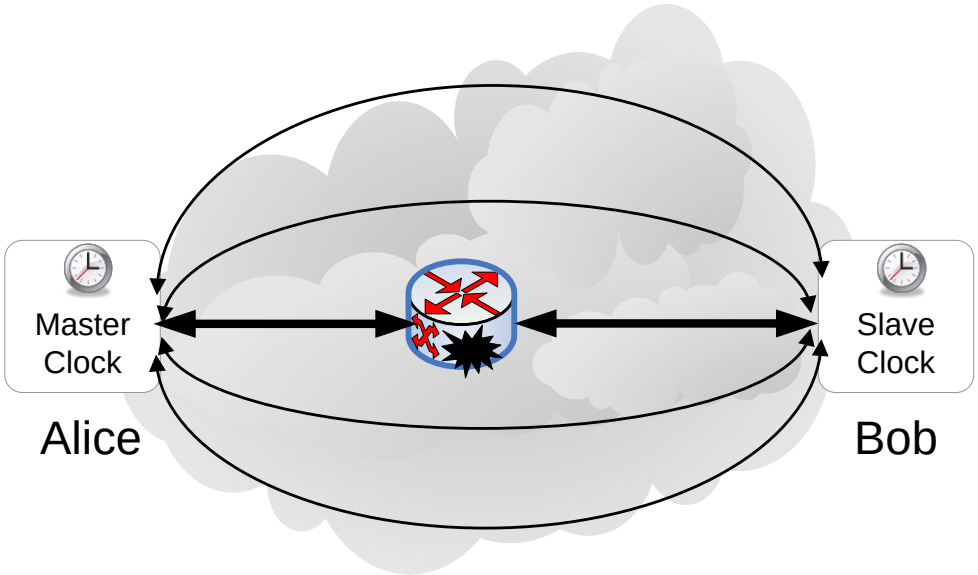
# Thanks

# IP: Multiple Paths over IP



# Mitigating MITM Attacks using Multiple Paths[1]

- **Slave algorithm:**
  - Bob computes $TOD_0$, $TOD_1$, … $TOD_{N-1}$ (TOD = Time Of Day) Corresponding to path 0, 1, … , N-1
  - If $TOD_j$ is significantly different than $Average_{i \neq j}(TOD_i)$, then assume $TOD_j$ is based on false information, and ignore path j.
  - Bob's TOD is $Average(TOD_i)$ of the TOD values from the paths that have not shown faulty behavior.
- **A similar algorithm can detect m>1 attacked paths.**




1 T. Mizrahi, "A Game Theoretic Analysis of Delay Attacks against Time Synchronization Protocols", ISPCS, 2012.