Multi-Path Time Synchronization

draft-shpiner-multi-path-synchronization-01

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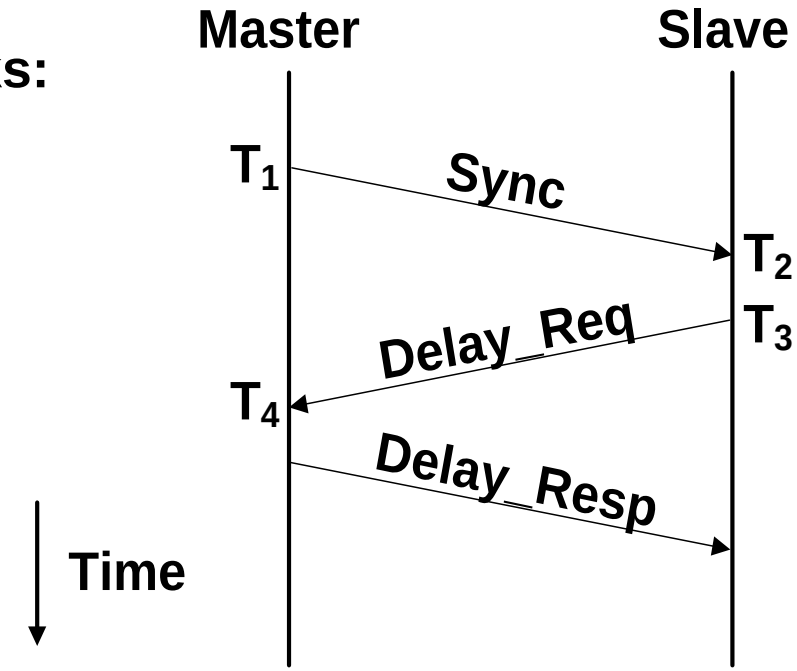
Background: Network Time Synchronization

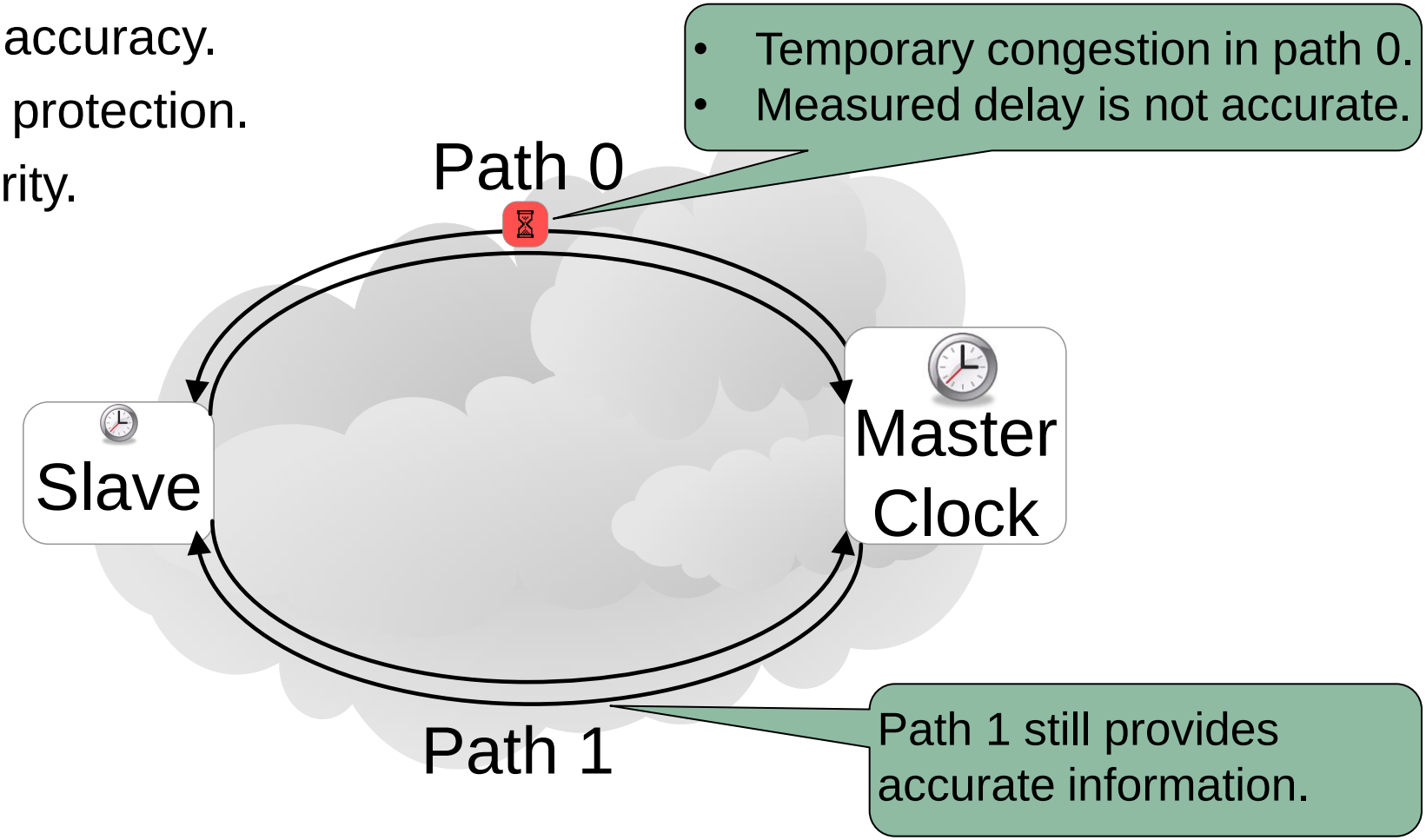
- **Common time synchronization protocols:**
  - Network Time Protocol (NTP) – RFC 5905.
  - Precision Time Protocol (PTP) – IEEE 1588.

- **A time sync protocol performs 2 tasks:**
  - Time distribution.
  - Delay measurement.



Background: Using Multiple Paths

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



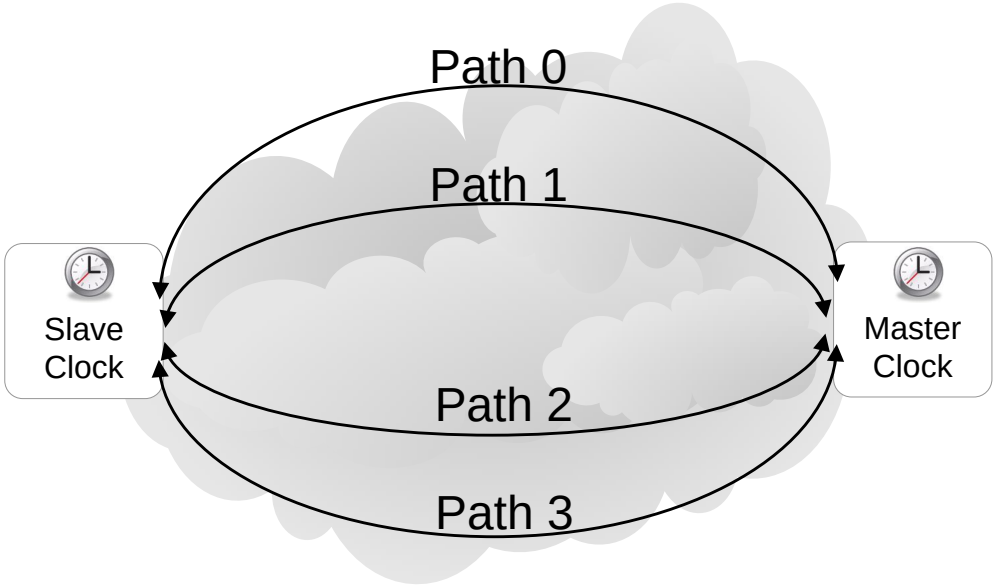
1 T. Mizrahi "Slave Diversity: Using Multiple Paths to Improve the Accuracy of Clock Synchronization Protocols", ISPCS 2012.

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.**

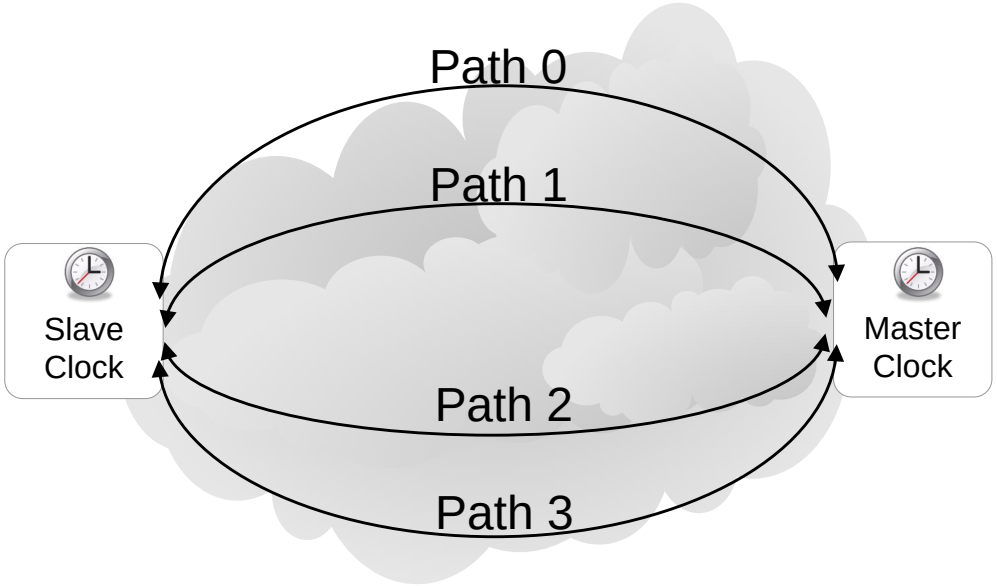
- **Interoperability with conventional PTP / NTP.**



Multi-Path Time Synchronization

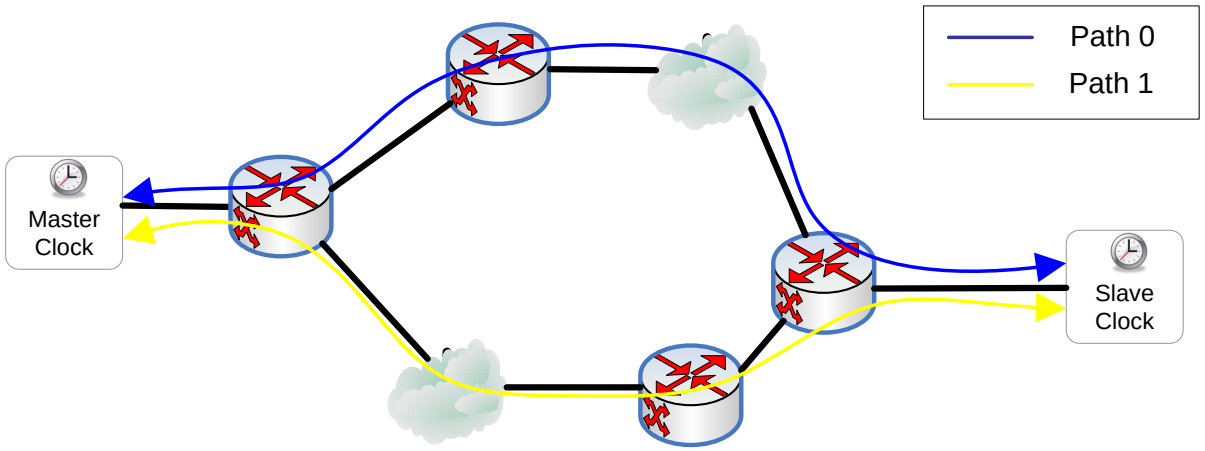
- **Dual-ended multi-path synchronization:**
  - Both master and slave support multiple paths.

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



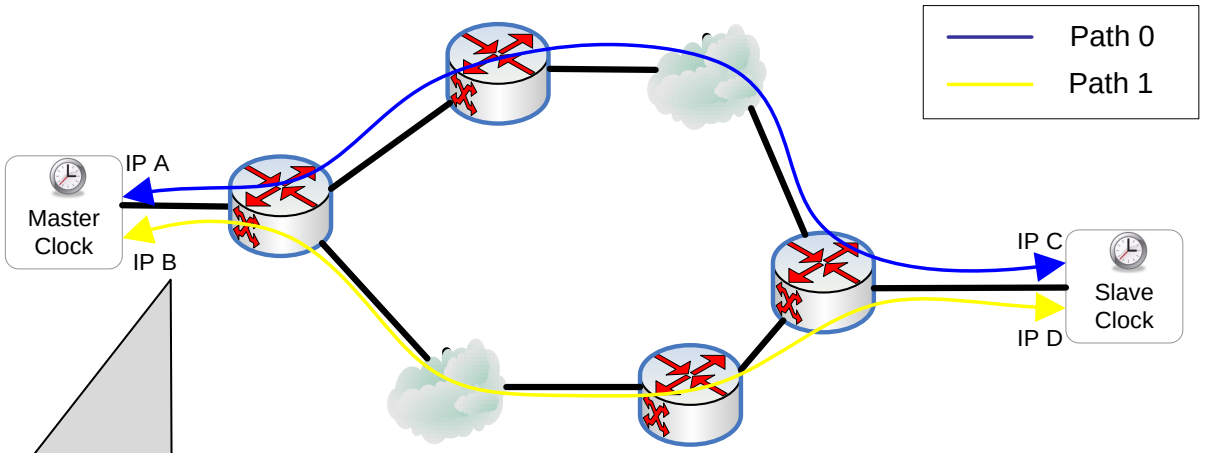
Path Discovery / Configuration

- **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.**



Dual-ended Multi-Path Time Synchronization

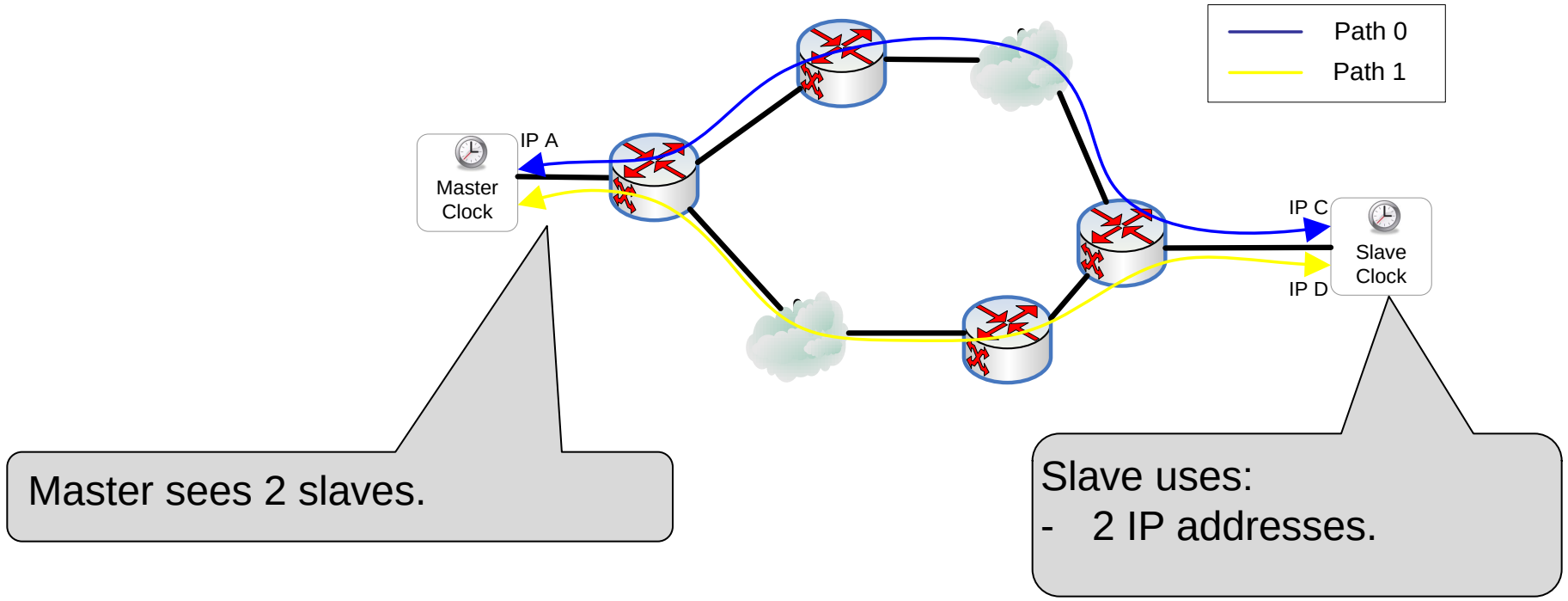
- **Each node has multiple IP addresses.**
- **Different {master IP, slave IP} pairs are used for each path.**
- **Unicast messages.**



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

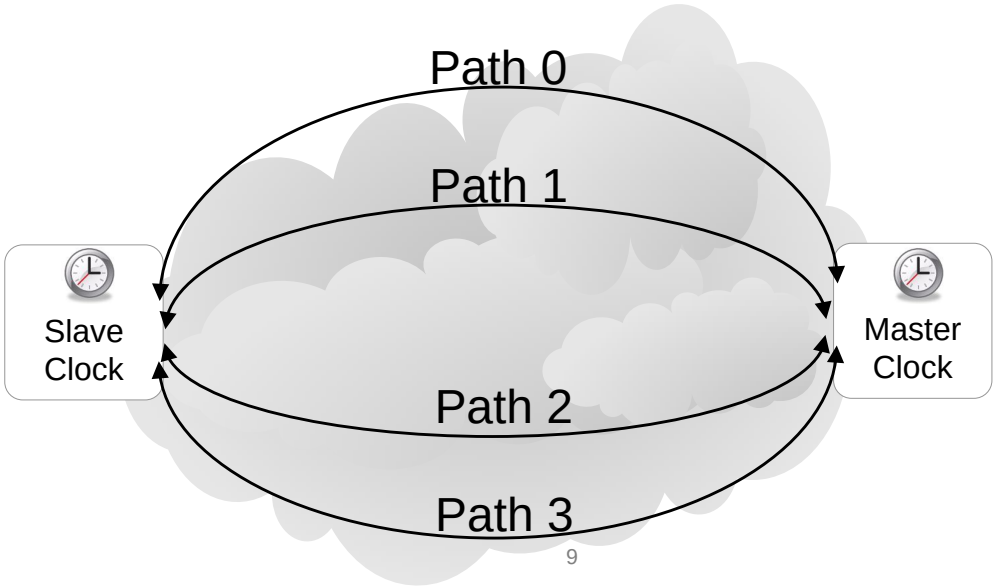
Single-ended Multi-Path Time Synchronization

- **Different slave IP addresses are used for each path.**
- **Pros:**
  - Interoperable with multi-path unaware master.
- **Cons:**
  - May produce less diverse paths than the dual-ended variant.
    - Destination based load balancing: single slave→master path.



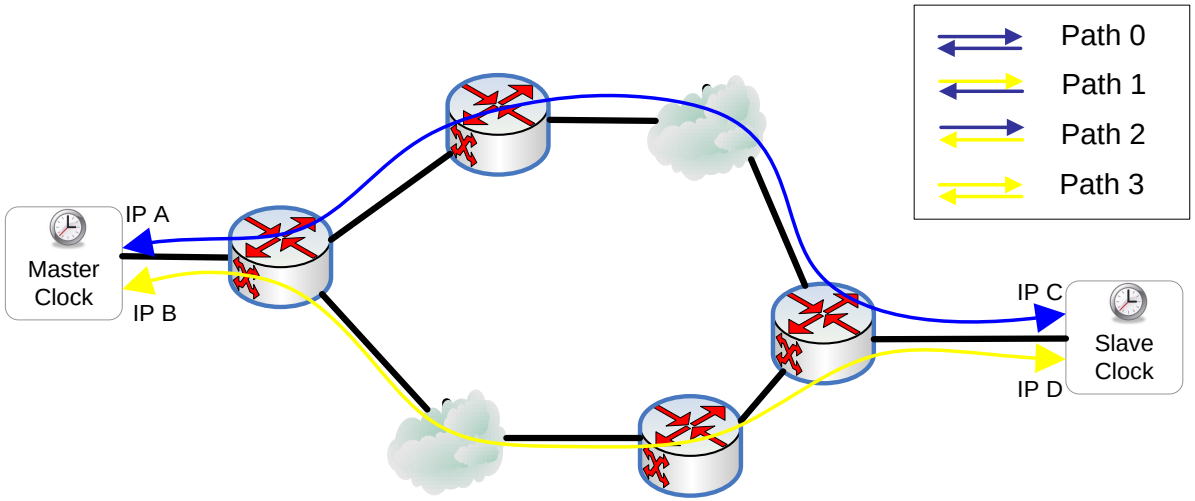
Why is this draft presented to MPTCP WG?

- **This draft is being discussed in the TICTOC WG.**
- **Multi-path time sync and MPTCP seem to be using some common tools.**
- **What are we looking for?**
  - Feedback from MPTCP.
  - Experimental / simulation data about # paths and path diversity when using multiple IP addresses.



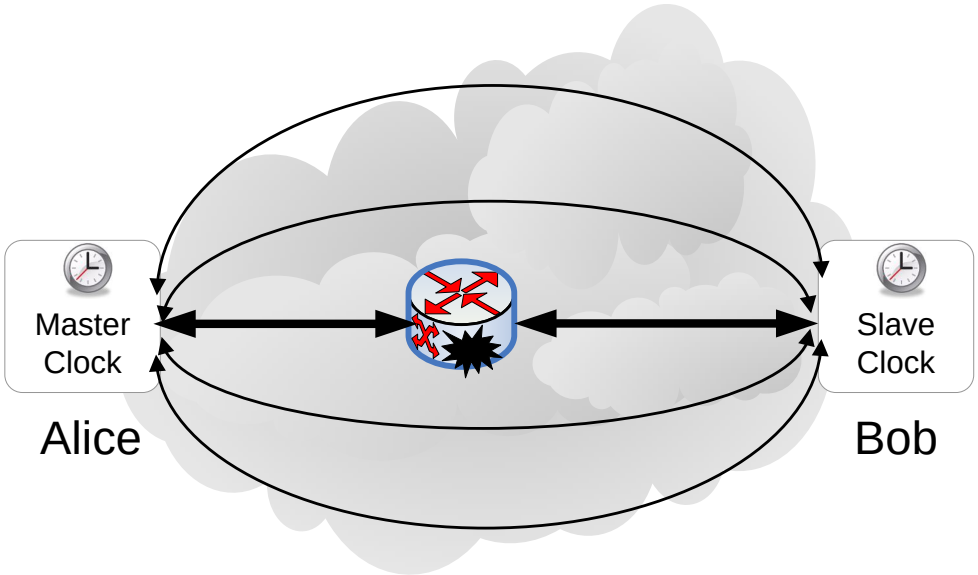
Thanks

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.