Multi-Path Time Synchronization

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Alex Shpiner  Technion – Israel Institute of Technology
Richard Tse  PMC-Sierra
Craig Schelp  PMC-Sierra
Tal Mizrahi  Marvell

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Background: Network Time Synchronization

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

- **A time sync protocol performs 2 tasks:**
  - Time distribution.
  - Delay measurement.
Multiple paths allow Slave Diversity:\(^1\):

- High accuracy.
- Fault protection.
- Security.

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.
The multi-path layer discovers all possible paths between the current clock and the peer clock.

Multiple paths:
- Traffic engineered.
- 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.
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 \(\rightarrow\) master path.

Master sees 2 slaves.

Slave uses:
- 2 IP addresses.
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

- **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.

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