One-way Delay Measurement Based on Reference Delay

draft-lyy-detnet-ref-delay-measurement-00

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Background

• End-to-end one-way delay (OWD) measurement
  • E2E OWD is an important performance indicator for SLA guarantee
  • E2E OWD measurement is of great significance

• An example: HD video surveillance service scenario in 5G network
  • The end-to-end one-way delay is the sum of T1+T2+T3+T4

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+--------+ +--------+ +--------+ +--------+
+--------+ |Wireless| |Optical| |5G Core| | IP | +--------+
|Camera+-<>+|Access +<>+|Trans +<>+|Network+-<>+|Data +<>+|Server|
+--------+ |Network| |Network| | | |Network| +--------+
+--------+ +--------+ +--------+ +--------+

|<----- T1 ---->|<---- T2 --->|<---- T3 --->|<---- T4 ---->|
```

Figure 1: A Scenario for End-to-end One-way Delay
Introduction

• Existing methods
  • End-to-end deployment of accurate clock synchronization, such as PTP or GPS; but the deployment cost is high.
  • Round-trip delay (RTT) is used to estimate end-to-end one-way delay; Due to the delay asymmetry of the uplink and downlink, the accuracy is low.

• A new method
  • This document introduces a new method to accurately measure end-to-end one-way delay using reference delay without deploying clock synchronization.
  • Reference delay is bounded and has low jitter. An example for reference delay can be found in deterministic networking[RFC8655].
Network Topology

• Sender to Receiver Network:
  • End-to-end one-way delay from the sender to the receiver is measured.
  • Intermediate devices other than the sender and receiver are hidden for simplicity.

• Clock Offset
  • The sender and receiver do not deploy time synchronization.
  • the time deviation between the sender and receiver is the clock offset.

Figure 2: Topology of One-way Delay Measurement
Packets Sent and Timestamps

• Reference Packet:
  • The E2E one-way delay for reference pkt is stable and bounded, denoted as $D_{\text{ref}}$.

• Target Packet:
  • The E2E one-way delay for target pkt is the measurement target, denoted as $D_{\text{target}}$.

• Timestamping:
  • We timestamp reference and target pkt on the sender and receiver side respectively, denoted as $T_{s1}$, $T_{s2}$, $T_{r1}$ and $T_{r2}$.

![Figure 2: Topology of One-way Delay Measurement](image-url)
Proposed OWD Calculation Method

• For reference packet and target packet, we can get Equation 1 and Equation 2, respectively.

\[ \text{Tr1} - \text{Ts1} = \text{Dref} + \text{Offset1} \] (1)
\[ \text{Tr2} - \text{Ts2} = \text{Dtargwt} + \text{Offset2} \] (2)

• When sending time interval between reference and target pkt is small, Offset1 = Offset2.

• (Equation 2 – Equation 1), we get Equation 3. Now we can calculate Dtargwt.

\[ \text{Dtargwt} = (\text{Tr2} + \text{Ts1}) - (\text{Tr1} + \text{Ts2}) + \text{Dref} \] (3)

Figure 2: Topology of One-way Delay Measurement
Detailed Measurement Procedures

Sender Side Procedures for both Reference and Target Packet:

+--------+-----------------------------+-----------------------------+-----------------------------+
| Sender | Sender Side | Sender Side | Sending |
| Ready  | --- > Timestamping   | --- > Encapsulation | --- > Packet |
+--------+-----------------------------+-----------------------------+-----------------------------+

Receiver Side Procedures for Reference Packet:

+--------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+
| Reference | Receiver Side | Receiver Side | Timestamp | Query for | Packet   | --- > Timestamping | --- > Decapsulation | --- > Recorded | --- > Reference |
| Arrival   |                |               |          |          |          | --- > Arrival     | --- > Arrival     | --- > Recorded | --- > Delay |
+--------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+

Receiver Side Procedures for Target Packet:

+--------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+
| Target | Receiver Side | Receiver Side | Timestamp | One-way | Packet   | --- > Timestamping | --- > Decapsulation | --- > Recorded | --- > Delay | Calculation |
| Arrival |                |               |          |          |          | --- > Arrival     | --- > Arrival     | --- > Recorded | --- > Delay | " |
+--------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+-----------------------------+

Figure 3: Measurement steps for Sender and Receiver Respectively
Packet Header Format

- The sender encapsulates timestamp information and sender-receiver pair information in the Measurement Header of the sent packet.
- The position of the Measurement Header is in the option field of the TCP protocol header.

![Figure 4: Format of Reference or Target Packet](image-url)
• The Kind value can be 253 or 254, and the Length value is 8, which is in accordance with TCP option [RFC4727].
• The sender ID is one octet, and the receiver ID is also one octet.
• The sender side timestamp is 4 octets, which can store accurate timestamp information.
Advantages

• **No need to deploy time synchronization**
  • There is no need to deploy end-to-end accurate time synchronization, which reduces the deployment cost of accurate one-way delay measurement.

• **No impact on intermediate network devices**
  • Leveraging reference delay for assistance, only time stamping is required at the sender and receiver. So there is no extra configuration for intermediate network devices.
Next steps

• Detailed analysis on the acquisition of reference delay.

• Consider about security issues.

• More things to be done. You are also welcome to join our work!
Thanks!