# Explicit Flow Measurements

## draft-ietf-ippm-explicit-flow-measurements-00

https://datatracker.ietf.org/doc/draft-ietf-ippm-explicit-flow-measurements/

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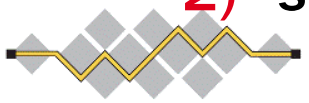
# Explicit Flow Measurements (EFM)

- Explicit Flow Measurement techniques employ few marking bits, inside the header of each packet, for loss and delay measurement (protocol independent and valuable for encrypted header protocols: e.g. QUIC)

- EPM metrics described in this draft:
  - **RTT**: Delay bit (**D-bit**) (with «the hidden RTT» option: **D^-bit**)
  - **Round Trip Packet Loss**: Spin bit (**S-bit**) + roundTrip loss bit (**T-bit**)
  - **One Way Packet Loss**, **2 options**:
    1) sQuare bit (**Q-bit**) + Loss event bit (**L-bit**)
    2) sQuare bit (**Q-bit**) + Reflection square bit (**R-bit**)



# IETF Hackathon and Implementations

- Some of the methodologies are already included in ongoing experiments and implementations:
- "QUIC Measurements" project during the last Hackathons
- EFM Implementations in production network reported by the contributors:
  - ***Telecom Italia-TIM*** *Implementation => android mobile phones probe.*
  - ***Ericsson*** *implementation => core network probes.*
  - ***Orange-Akamai*** *implementation => Akamai production CDNs and core network probes.*
  - ***Aachen University*** *implementation: ANRW paper (Packet Loss measurements: L, Q, R, T bits).*
  - ***Huawei*** *is working on the topic.*

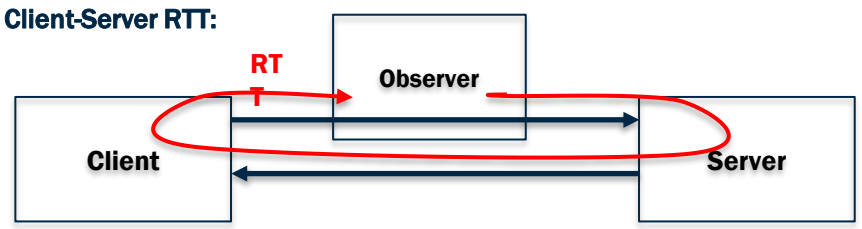
# The Hidden Bits

In case of strictly privacy concerns it could be introduced the Hidden Delay Bit or the Hidden Spin Bit.

The algorithm of the Delay Bit can be slightly modified to mask the RTT of the connection to an intermediate observer. Even the Spin Bit could be easily modified by implementing the same behaviour.

The idea is to change the Delay Bit working mechanism adding a fixed amount of time to the RTT exposed on wire. In practice, the Client does not reflect immediately the Delay Bit Sample but waits for an Additional Delay before reflecting the marking on a new packet in the opposite direction.

This leads an observer to measure a fake RTT greater than the real one.




End-to-End Round-Trip Time => RTT = Ts(DbS_2) – Ts(DbS_1) – AD

*Ts: Timestamp* *DbS: Delay bit Sample* *AD: Additional Delay*

# Draft Updates

- **IPPM WG adoption (22/10/2021) :**
- **Updated Draft publication (25/10/2021) :**
  - draft-ietf-ippm-explicit-flow-measurements-00
- **Main changes:**
  - in the Introduction paragraph, underlined the beneficial approach of the methodologies described inside the document (as per RFC9065) – Thanks to Nicolas Kuhn suggestion.
  - updated references to QUIC-TRANSPORT and TRANSPORT-ENCRYPT (now RFC9000 and RFC9065).

# “Delay Bits” Summary

| | Bits | Unidirectional Observer | Bidirectional Observer | # of Measurements | Impairment resiliency |
|---|---|---|---|---|---|
| S: Spin Bit | 1 | RTT | x2<br>Half-RTT | Very High | Low |
| D: Delay bit | 1 | RTT | x2<br>Half-RTT | Medium ° | High |
| D^: Hidden Delay bit | 1 | RTT^ | x2<br>Left Half-RTT^<br>Right Half-RTT | High ~ | High |
| SD:<br>Spin bit +<br>Delay bit * | 2 | RTT | x2<br>Half-RTT | Very High | High |

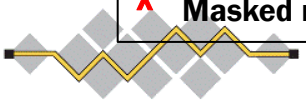
° It depends on the “application delay” threshold (e.g. E=1 ms.), causing DbS discarded, and on DbS losses. But many of these missing measurements are “errored” measurements.

~ The “application delay” threshold (e.g. E=1 ms.) is only on the Server (see previous note).

* Both algorithms work independently; an observer could use approximate spin bit measures when delay bit ones aren't available.

X2 Same metric for both directions.

^ Masked metric (real value can be calculated only by those who know the Additional Delay).



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# "Loss Bits" Summary

| Method | Bits | Unidirectional Observer | Bidirectional Observer | Proto | Measurement Fidelity | Measurement Delay |
|---|---|---|---|---|---|---|
| T<br>round Trip<br>loss bit | 1+spin | Round Trip | Round Trip<br>Half-RT x2 | * | Rate by sampling $\frac{1}{3}$ to $\frac{1}{3*ppa}$ packets over 2 RTT | ~6 RTT |
| Q<br>sQuare bit | 1 | Upstream | Upstream x2 | * | Rate over N packets<br>(e.g. N=64) | N packets<br>(e.g. B-64) |
| L<br>Loss event bit | 1 | End-to-End | End-to-End x2 | # | Loss shape and rate | Min: RTT<br>Max: RTO |
| QL<br>sQuare + Loss event bits | 2 | Upstream<br>Downstream<br>End-to-End | Upstream x2<br>Downstream x2<br>End-to-End x2 | # | → see Q<br>→ see Q\|L<br>→ see L | → see Q<br>→ see L<br>→ see L |
| QR<br>sQuare + Reflection square bit | 2 | Upstream<br>"3/4 RT"<br>Opp. Dir. E2E | Upstream x2<br>"3/4 RT" x2<br>End-to-End x2<br>Downstream x2<br>Half-RT x2 | * | Rate over $N * ppa$ packets<br>(e.g. N=64) | Upstream:<br>see Q<br>Others:<br>$N * ppa$ pkts<br>(e.g. N=64) |

| | | | | | |
|---|---|---|---|---|---|
| * | All protocols | x2 | Metric in both directions | ppa | Packets-per-Ack |
| # | Protocols with loss detection (w/ or w/o pure ACK loss detection) | | | Q\|L | See Q if Upstream loss is significant; L otherwise |

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# 2 or 3bit EFM

## If there are only 2 bits for EFM:

- Option a:
  - RTT (S-bit)
  - RT Packet Loss (T-bit)
- Option b:
  - RTT (D-bit or D^-bit)
  - OneWay P.Loss (Q-bit)

## If there are 3 bits for EFM (e.g. QUIC):

- Option c:
  - RTT (S-bit or S^-bit )
  - OneWay P. Loss (Q-bit + L-bit)
- Option d:
  - RTT (D-bit or D^-bit)
  - OneWay P.Loss (Q-bit + L-bit)
- Option e:
  - RTT (S-bit or S^-bit)
  - OneWay P. Loss (Q-bit + R-bit)
- Option f:
  - RTT (D-bit or D^-bit)
  - OneWay P.Loss (Q-bit + R-bit)

# Conclusions

- **Explicit Flow Measurements are gaining interest for encrypted transport protocols:**
  - implementation at IETF Hackathon;
  - On field implementations
  - WG adoption
- **Sibling Draft in IPPM WG**
  - https://datatracker.ietf.org/doc/draft-cnbf-ippm-user-devices-explicit-monitoring/
- **Sibling Drafts in other WGs (QUIC, TCP, COAP, …)**
  - https://datatracker.ietf.org/doc/draft-fz-core-coap-pm/
  - **…**
- **Next step: in deep IPPM WG discussion:**
  - *Welcome questions and comments.*

Thank you