Explicit
Flow Measurements

draft-mdt-ippm-explicit-flow-measurements

November 16, 2020, IPPM WG – IETF 109

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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:
  - Precise RTT: Spin bit (**S**-bit) + Delay bit (**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)

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IETF Hackathon and Implementations

Some of the methodologies are already included in ongoing experiments and implementations:

- "QUIC Measurements" project during the last IETF 109 Hackathon (daily meetings for demos and bug fixing)
- EFM Implementations in production network reported by the contributors:
  - *Telecom Italia-TIM Implementation => android mobile phones*
  - *Ericsson implementation => core network probes*
  - *Orange-Akamai implementation => Akamai production CDNs and core network probes*

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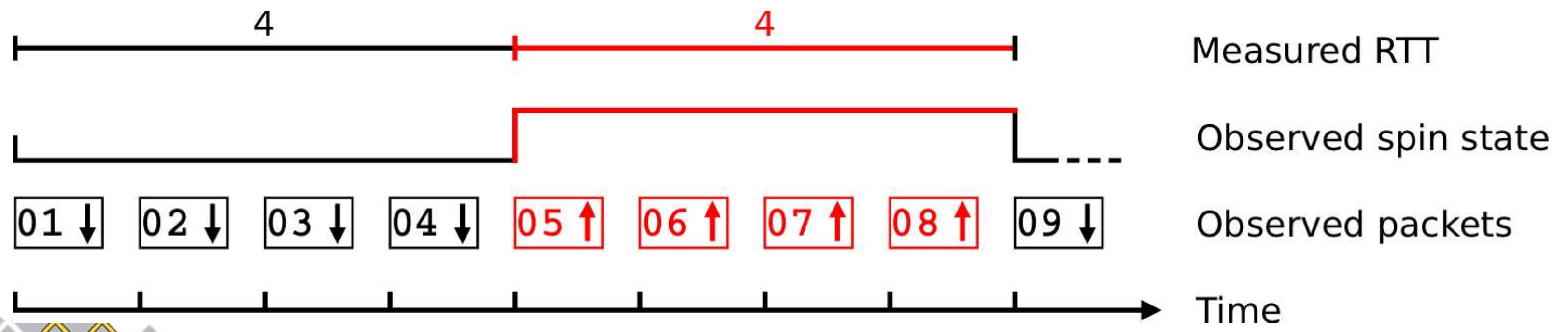
Round Trip Time: Spin bit

- Spin bit for RTT measurement was the first case of Explicit PM.
- It's implemented, optionally, in QUIC protocol (https://www.ietfjournal.org/enabling-internet-measurement-with-the-quic-spin-bit/)
- The spinbit idea is to create a square wave signal on the data flow, using a bit, whose length is equal to RTT.
- An observer in the middle (wherever is located) can measure the end-to-end RTT only watching the spinbit.



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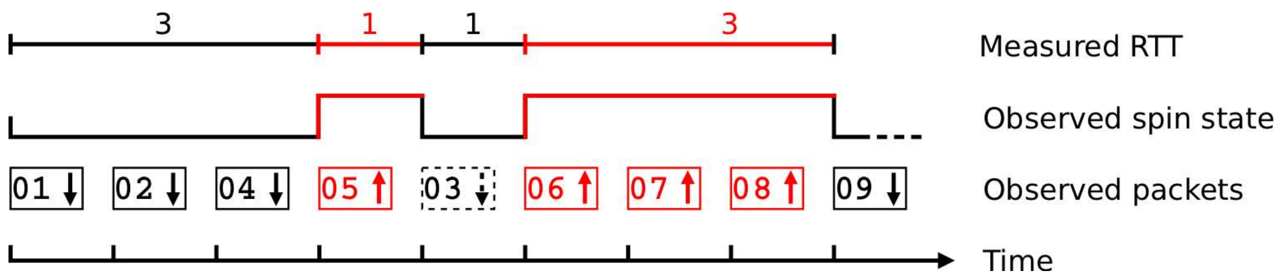
Spin bit limitations

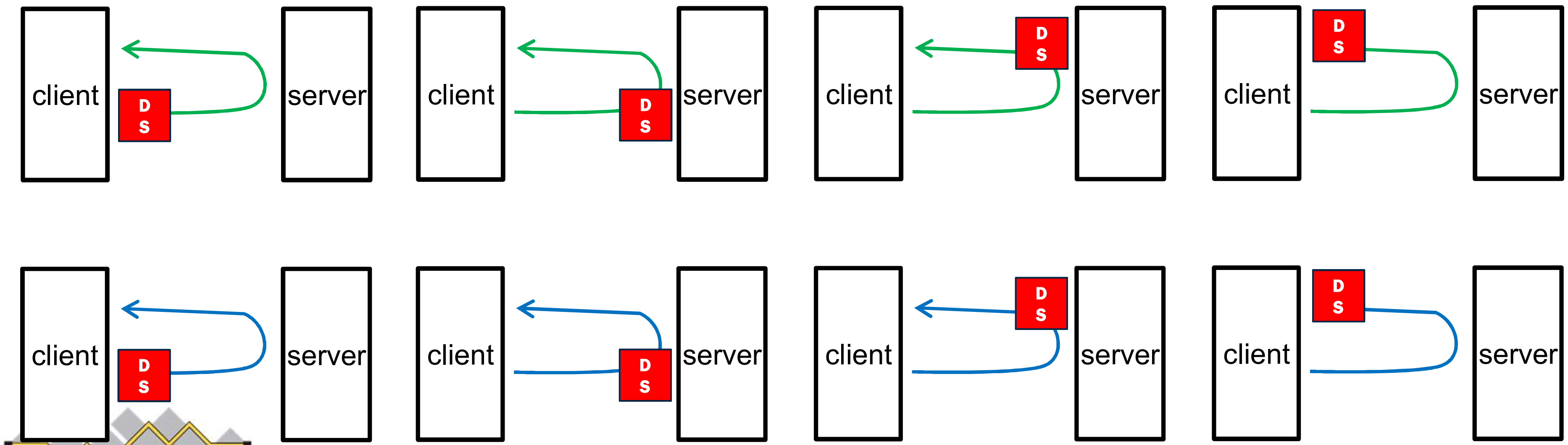
- Packet loss will tend to cause wrong estimates of RTT due to period width changes.
- Reordering of a spin edge will cause drastic underestimates of RTT since it will cause multiple edges to be observed per RTT. So we need an extra instrument to correctly recognize periods, eluding overlapping.



- “Holes” in the traffic flow can introduce delay in the edge reflection.

Precise RTT: Spin bit (S-bit) + Delay bit (D-bit)

- The idea is to have a single packet, with a second marked bit, called «Delay Bit», that bounces between client and server. This is the Delay Sample (DS).
- Only one Delay Sample «inside» each Spin Bit period (created by the Client when the measurement starts and regenerated by the Client only when the Delay Sample is lost).
- The Delay Sample is a reference for every precise round trip calculation (in addition to Spin bit signal used for an approximate RTT calculation when the Delay Sample is not present).



Delay Sample red, Spin Bit green or blue

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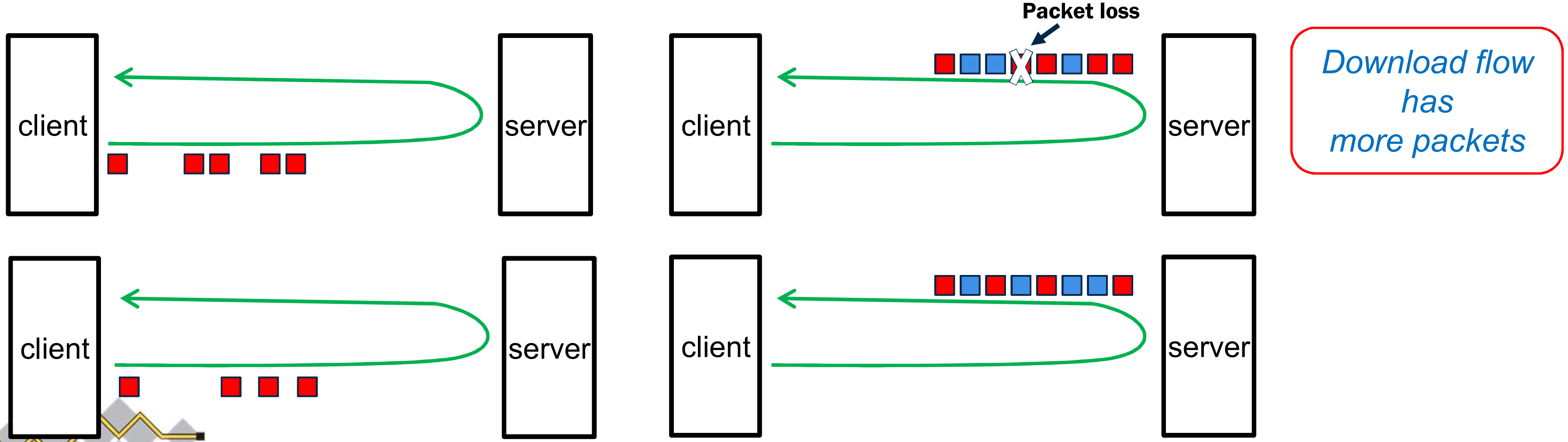
round Trip packet loss: T-bit

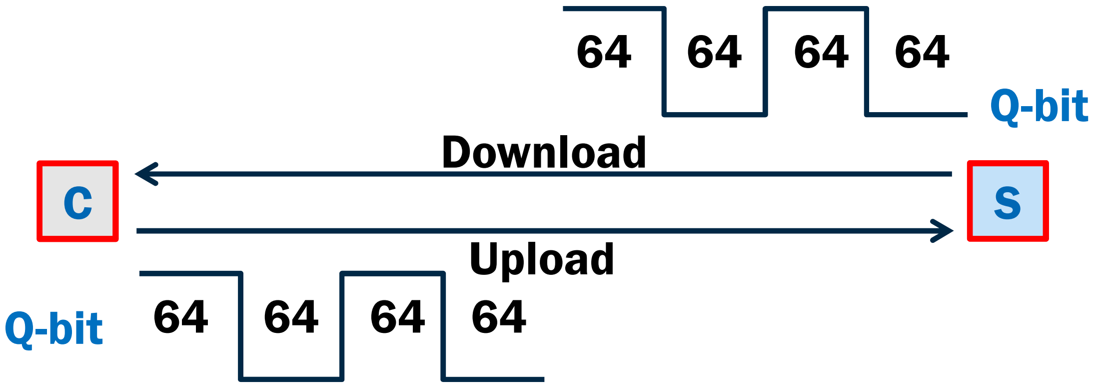
- The Client generate a «train» of market packets (using the T-bit)
- The Server «reflects» these packets (marking production packets flowing in the opposite direction). The Server inserts some not marked packets if download flow has more packets than upload flow.
- The Client reflects the marked packets.
- The Server again reflects the marked packets (two complete Client-Server rounds, so an intermediate Observer can see the «train» twice and compare the marked packets number to measure the RT Packet Loss).
- The Client generate a new train of market packets and so on.

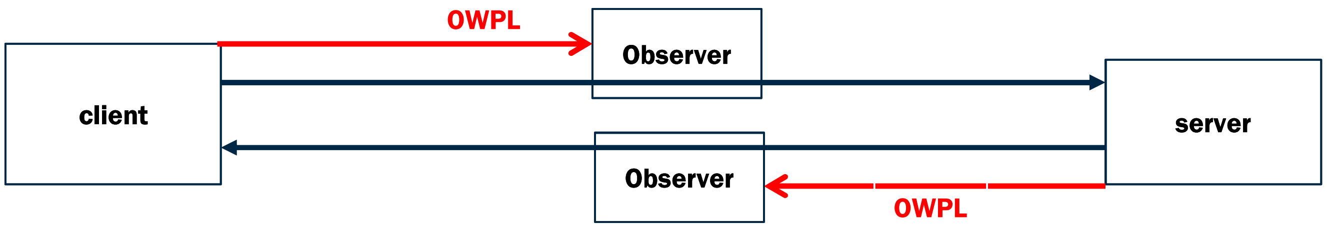


Marked packets: red,
Not Market packets: blue

One-Way Packet Loss: sQuare bit (Q-bit)

- The Q-bit (firstly described in draft-ferrieuxhamchaoui-quic-lossbits) creates square waves of a known length (e.g. 64 packets) as defined in the Alternate Marking RFC 8321





OWPL: One Way Packet Loss

2Point Interdomain Packet Loss (Q-bit)

- Observer2-Observer1 OWPL:

Observer2-Observer1 One-Way: OWPL2 – OWPL1 = OWPL3

- Observer1-Observer2 OWPL:

Observer1-Observer2 One-Way: OWPL1 – OWPL2 = OWPL3

OWPL: One Way Packet Loss

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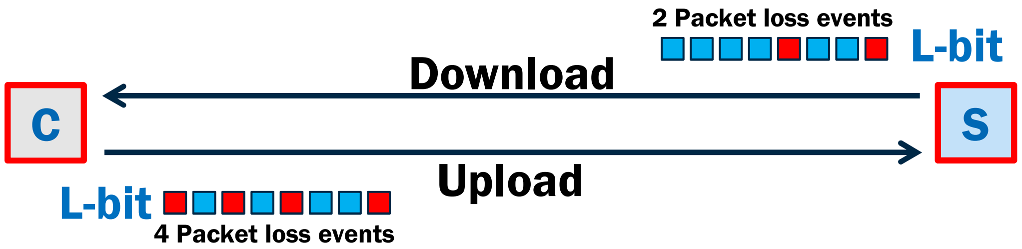
One-Way Packet Loss: Q-bit+L-bit (Loss event bit)

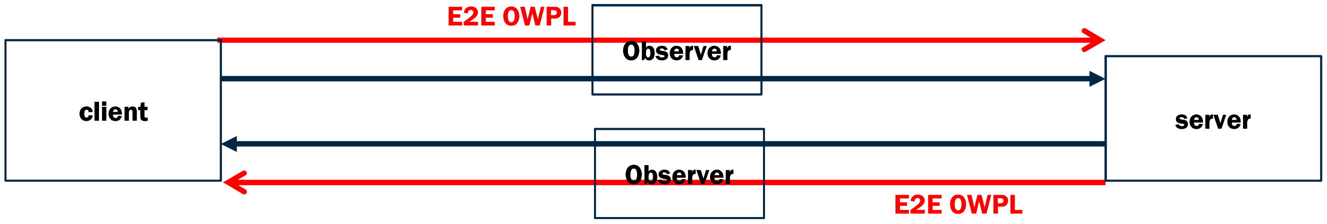
This method uses 2 bits: the sQuare bit (Q-bit) and Loss event bit (L-bit).

- The L-bit (firstly described in draft-ferrieuxhamchaoui-quic-lossbits) marks a packet each time the protocol detect a loss packet event.

L-bit Marked packets: red,
L-bit Not Market packets: blue



- L-bit measurement:



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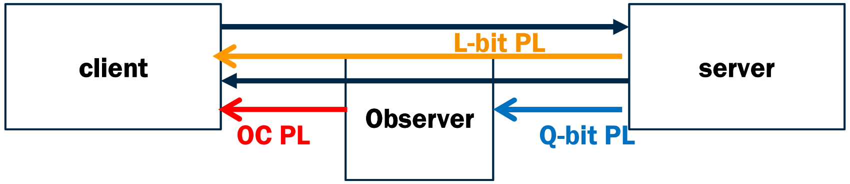
OWPL: One Way Packet Loss

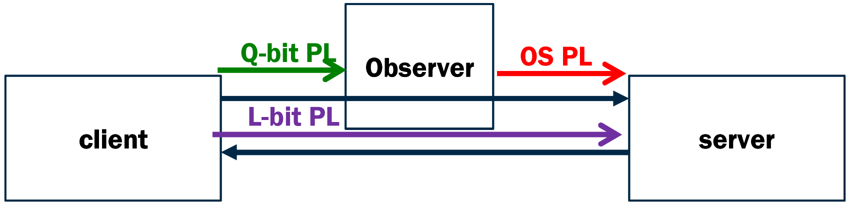
One direction Observer (Q-bit + L-bit):

- Download Observer:



Observer-Client PL = L-bit PL Down – Q-bit PL Down

- Upload Observer:



Observer-Server PL= L-bit PL Up – Q-bit PL Up

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OW Packet Loss: Q-bit+R-bit (Reflection square bit)

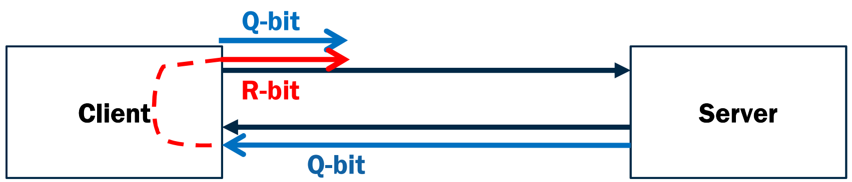
This method uses 2 bits: the sQuare bit (Q-bit) and Reflection square bit (R-bit).

The idea is to reflect the Q-bit in the opposite direction using the R-bit.

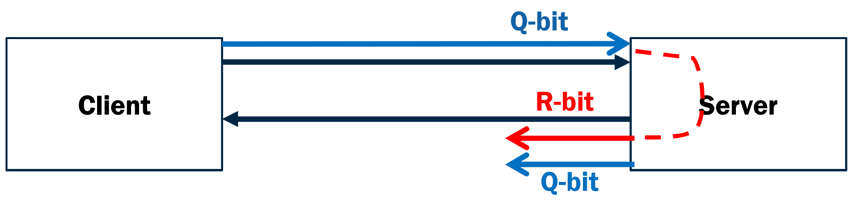
The sizes of the transmitted R-bit blocks are the "average sizes" of the received Q-bit blocks.

This idea allows to have continuous alternate marked packet blocks in both directions.

The Client generates the Q-bit signal and reflects the received Q-bit signal using the R-bit signal:



The Server does the same in the opposite direction:



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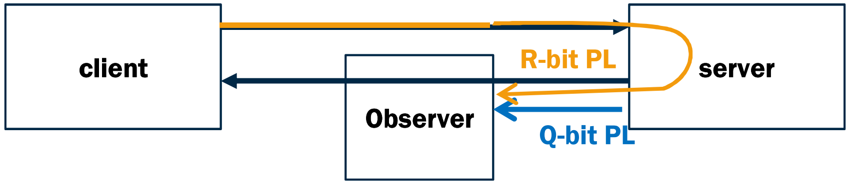
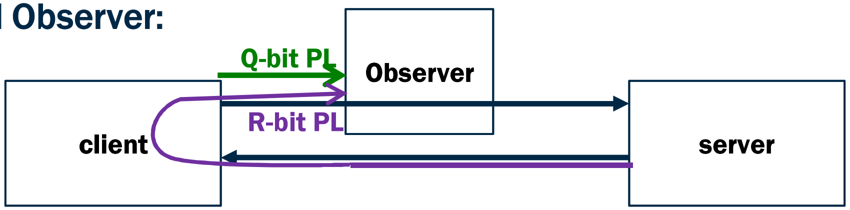
One direction Observer (Q-bit + R-bit):

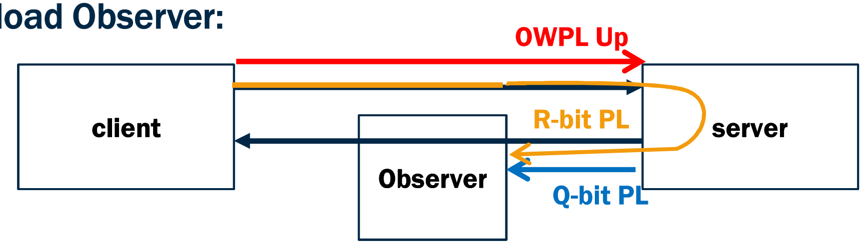
- Download Observer:



- Upload Observer:

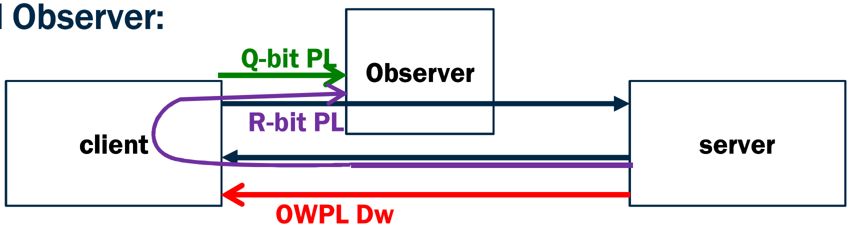


- Download Observer:



OWPL Up = R-bit PL Dw – Q-bit PL Dw

- Upload Observer:

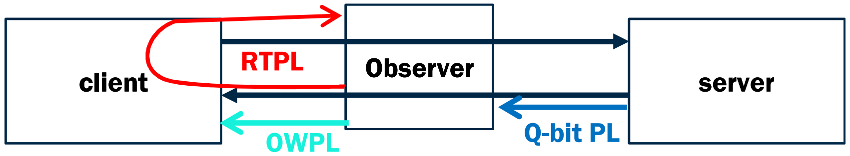


OWPL Dw = R-bit PL Up – Q-bit PL Up

OWPL: One Way Packet Loss

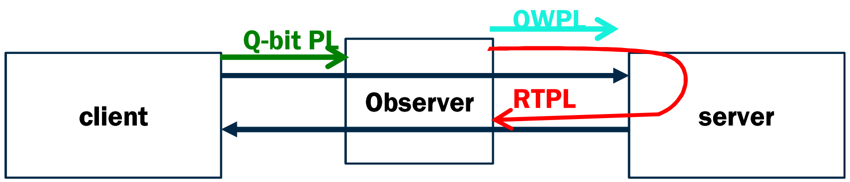
Two direction Observer (Q-bit + R-bit): :

- Observer-Client RTPL and OWPL:



RTPL =R-bit PL Up – Q-bit PL Dw ➡ RTPL – Q-bit PL Up= OWPL

- Observer-Server RTPL and OWPL:



RTPL =R-bit PL Dw – Q-bit PL Up ➡ RTPL – Q-bit PL Dw= OWPL

RTPL: Round Trip Packet Loss
OWPL: One Way Packet Loss

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Loss Bits Summary

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

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

- Option 1:
  - Precise RTT (S-bit + D-bit)
  - RT Packet Loss (T-bit)
- Option 2:
  - RTT (S-bit)
  - One-Way Packet Loss (Q-bit + L-bit)
- Option 3:
  - RTT (S-bit)
  - One-Way Packet Loss (Q-bit + R-bit)

Draft next steps

- **Explicit Flow Measurements are gaining interest for encrypted transport protocols:**
  - already discussed in TSVWG and QUIC WG;
  - implementation at IETF Hackathon;
  - thread on the IPPM mailing list.
- **Joined previous drafts**
- **WG adoption requested**
- **Welcome questions and comments.**

Thank you

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User Devices Explicit Monitoring

draft-cnbf-ippm-user-devices-explicit-monitoring

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Proposal: EFM Probes on user devices

- **The draft proposes to put the Explicit Flow Measurements probe also on the user device (e.g. mobile phones, PCs).**
- **"User device EFM rules":**
  1. **The device owner decides whether to mark his traffic.**
  2. **The device owner decides whether to share his performance data.**
- **Strenghts:**
  1. **Scalability**. On the user device there are few connections to monitor.
  2. **More precise measurements**. Client application delay can be measured.
  3. **Both directions monitoring.**
  4. **Network monitoring equipment savings**. Network probes can monitor only impaired connections through "**user device and network probes coordination**". *It's possible to set alarm thresholds on the user device (and to signal to network probes to monitor only the sessions with impairments, in order to segment the performance measurements and to locate the faults). In this case network probes, also embedded into network nodes, need to monitor only a limited number of connections.*

Device owner activates Explicit PM

- The decision whether to activate the marking (e.g. Spin Bit) or not should be made by the device owner configuring the applications (e.g. browsers) based on client-servers protocols that supports Explicit Flow Measurements (e.g. QUIC).
- All applications should provide for the activation or deactivation of packet marking (providing a user interface or exposing API).
- So, during the Client-Server handshake, the Client will decide whether the marking is active or not within a session and the Server should follow.

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Who will see the Performance Data?

- Performance information is displayed on the device and possibly sent to "external bodies" if the owner agrees.
- The main recipient would be the Internet Service Provider (see “User device and network probes coordination”), but these data could also be of great interest or requested by the national regulatory authorities or others authorized subjects.

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