Localized Optimizations over Path Segments

LOOPS BOF @ IETF 108
July 31, 2020

Note Well (Concise)

- You will be recorded
- Be nice, and be professional
- The IPR guidelines of the IETF apply:
  see **http://ietf.org/ipr** for details.

Repo: https://github.com/loops-wg/ietf108
Notes: https://codimd.ietf.org/notes-ietf-108-loops

Note Well

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- BCP 54 (Code of Conduct)
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Agenda

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10	Introduction, Tool fiddling, Scribe Kidnapping, and Agenda Bashing	Chairs	10	90
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What is LOOPS?

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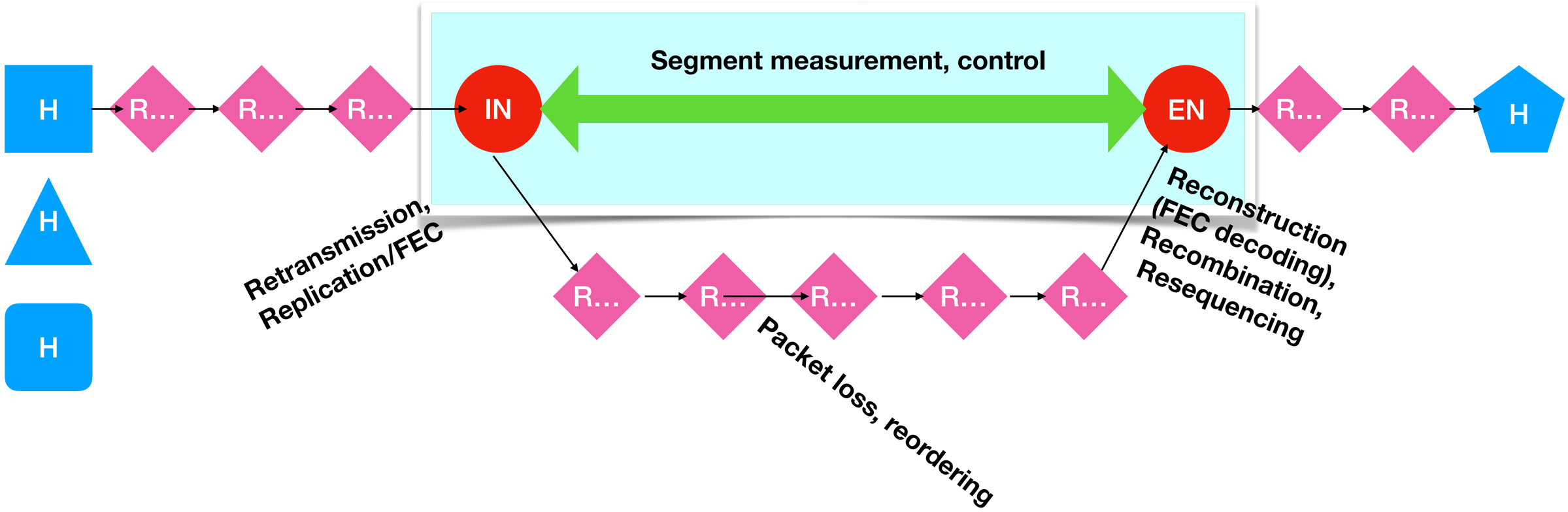
LOOPS Opportunity



Recover Packets Locally

Reduce end-to-end packet loss

Recover locally, **where needed**, with low latency

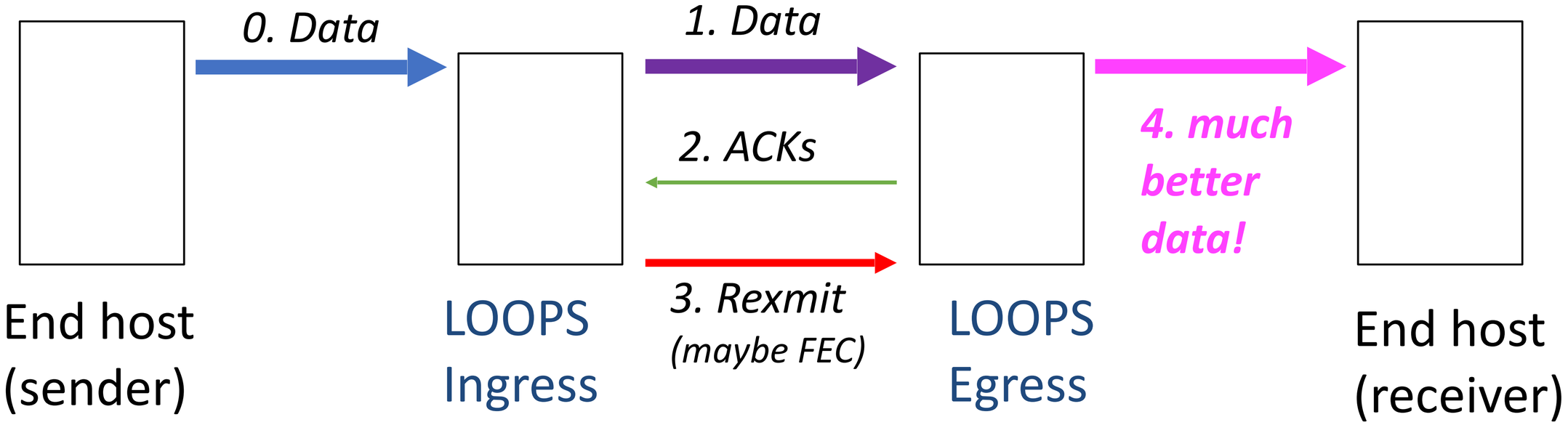
In the network

Host participation not required

Don’t look
Don’t touch

Works with any kind of IP packets

Context


0. Data
1. Data
2. ACKs
3. Rexmit
(maybe FEC)
4. much better data!
End host (sender)
LOOPS Ingress
LOOPS Egress
End host (receiver)

LOOPS development: MVP approach

- Many concepts could be included in LOOPS
- Should be delivering a workable protocol first,
  - that we have the **energy** to develop,
  - that doesn't jeopardize the **agreement** that we can deploy this,
  - that does provide enough **benefit** already.
- MVP = **minimum viable protocol**
- Can always recharter afterwards

How to recover?

- **Retransmission**
  - Reverse information needed: ACK/NACK ← **Piggyback (Tunnel), separate Packets**
  - Forward information: sequence numbering (if needed) ← **Tunnel**
- **Reconstruction** (**Forward Error Correction,** redundancy)
  - Select block size/rate (per setup, ~~dynamically~~)
  - ~~“Retransmission” also possible by adding FEC~~

~~Left to further work~~

- Aim for low setup overhead
- Keep most setup out of protocol (“controller model”)

How not to blow up the Internet

- **First, do no harm**
- Concealing losses removes important congestion signal
  - End-hosts would ramp up to higher rates, increase congestion

- Need **congestion feedback**
  - Preferred: via ECN — **drop-to-mark**
  - ~~Fallback: Selective dropping (selective recovery, actually)~~
- Host transport protocol improvements will help improve LOOPS performance, but are not prerequisite to obtaining benefit

~~**Left to further work**~~

Elements of LOOPS

- Information model for local **recovery**: in-network retransmission/FEC
  - Can be encapsulated in a variety of formats; define some of those
- Local **measurement**: e.g. segment forward delay/variation
  - To set recovery parameters
  - ~~To determine if loss was caused by congestion~~

~~Left to further work~~

- Congestion **feedback**:
  ECN ~~(or drops)~~ to inform end hosts about congestion loss

~~Left to further work~~

LOOPS vs. transport protocols

- LOOPS is separate from the end-to-end transport protocol
  - Hands-off approach: don’t meddle
  - Do not assume the end-to-end protocol is out to help us, either
  - No direct control over sending rate (cc feedback only)
- LOOPS should not just be a classical transport protocol
  - Residual loss is OK
  - More choices: Tight interaction with the path segment being optimized

Where “transport protocol” intuition may not even work

- Relatively controlled/managed environment;
  setup mechanism assumed (can supply parameters so not everything needs to be high dynamic range)
- No full reliability intended; remaining gaps are OK (and at some point must leave the focus of attention)
  - Setup might set upper bound for overhead volume (e.g., 10 %), can well be “risky” in the way that this is used
- Tunnels usually have packets in flight (possibly a large number); tail processing rarely invoked (but may still be desired); don’t need overly conservative RTO

Documents for this BOF

- Use cases and problem statement: “LOOPS (Localized Optimizations on Path Segments) Problem Statement and Opportunities for Network-Assisted Performance Enhancement” <draft-li-tsvwg-loops-problem-opportunities>
- Protocol: “LOOPS Generic Information Set” <draft-welzl-loops-gen-info>
- Encapsulations: “Embedding LOOPS in Geneve” <draft-bormann-loops-geneve-binding>

- Charter proposal for a LOOPS WG <https://github.com/loops-wg/charter>
- LOOPS mailing list loops@ietf.org

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From IETF105 to IETF108

- IETF105: Non-WG-forming BOF. Explore the design space
- IETF108: WG-forming BOF. Narrow down to MVP:
  - Include FEC, but only a “default scheme” initially
  - Do not try to detect non-congestion losses as such
  - Drop-to-mark approach:
    Require end-to-end ECN, CE-mark recovered packets
  - Focus on Geneve encapsulation (NVO3 WG) first

This is certainly minimum. Is it still viable?

- Initially wanted to improve throughput **and** latency
- Focusing on latency now:
  - LOOPS segment provides faster recovery: drop-to-mark
  - Useful for ants and transactional loads
- No congestion-control in congestion-control: Leave congestion signals in place

Tail loss!

Problem

- Packets get lost
- It can take a long time to recover them end-to-end (latency)

Opportunity

We know how to improve this:

- Using local recovery (retransmission or reconstruction)
  - Without host cooperation, and independent of transport protocols
- For ECN-capable traffic
  - Enables “drop-to-mark” non-invasive congestion signaling

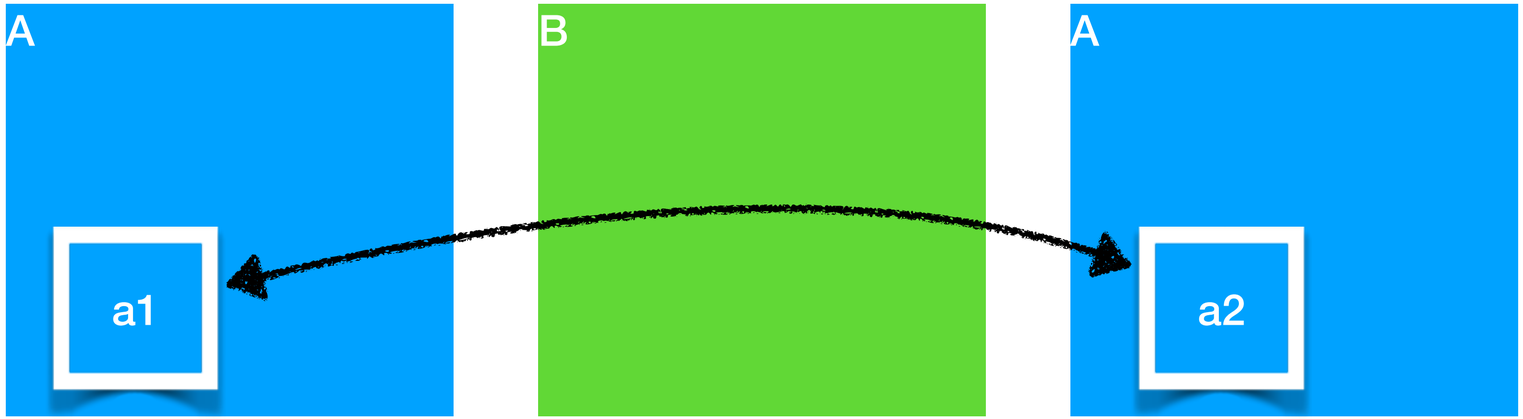
Environments that benefit

- Applications benefit that:
  - have **ECN** enabled at the end hosts
  - are ants (e.g., payment) or transactional (e.g., gaming)
- Individual to cloud: Smartphone probably already ECN-enabled
- Enterprise: ECN needs switching on — incentivized by drop-to-mark
- Where ECN is bleached by network:
  can work around those segments using LOOPS drop-to-mark
- (Side benefit: Support and encourage deployment of ECN.)

So why don’t you simply fix your network?

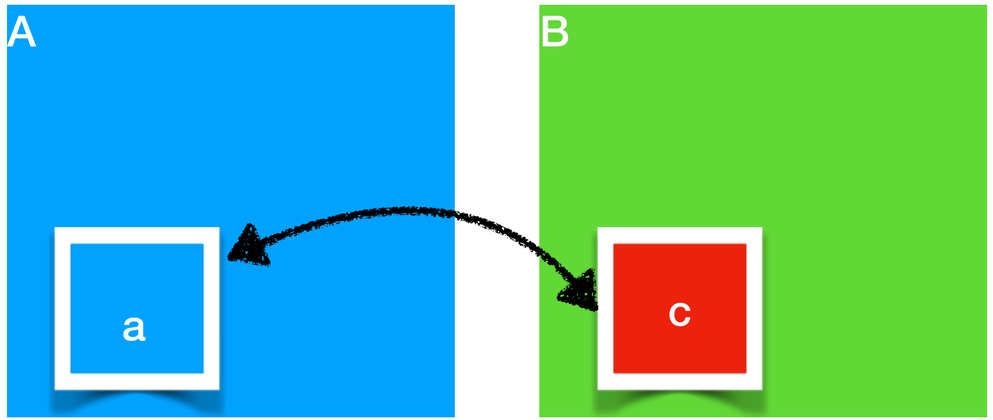
- LOOPS is particularly useful as a tool to integrate heterogeneous/hybrid environments:
  - Traffic crossing inter-operator boundaries
  - Traffic crossing legacy areas, without forklift upgrades
- Yes, please do fix your network,
  and then mitigate remaining deficiencies with LOOPS
- (Google’s internal network probably doesn’t need LOOPS)

Aa1 B Aa2 scenario (overlay network)



- Operator A provides service, utilizing operator B for part of the path
- Run LOOPS between node a1 in A and node a2 back in A
  ➔ Work around limitations in offering by operator B (or legacy network B)

Aa Bc scenario



- Operator A has end-nodes
- Operator B hosts nodes, some from operator C
- Run LOOPS between node a in A and node c in B
  ➔ Work around unfavorable conditions provided by operator B
- Aa1 B Aa2 and Aa Bc scenarios combine into more complex ones

So why standardize this now?

- Low-hanging fruit
- Overlay nodes provide the compute/space (e.g., service containers)

- So why hasn’t this been done earlier?
  - Not for everyone; most useful in specific environments
  - We now have applications for LOOPS in certain parts of the world
  - Proprietary solutions abound, but are often intrusive PEPs as well (and are often not done right [264 s])

Why standardize at all?

- Ingress and Egress might be run by different operators
  (E.g., Aa Bc case)

- Operators that run both ends may want to have a choice in buying the functionality from a set of vendors

  - Possibly even on different kinds of platforms
    (e.g., ARM-based CPE vs. operator data center at virtual PoP)

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A couple of use cases

- A number of potential use cases were discussed at the IETF 105 BOF, e.g. for and around satellite segments — not repeating this here

- Focus today on use cases of specific operators

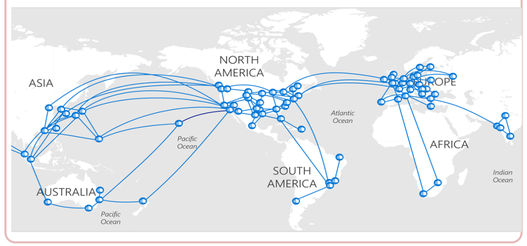
  - This is not about changing the Internet
    It is about changing the parts of the Internet that need this change

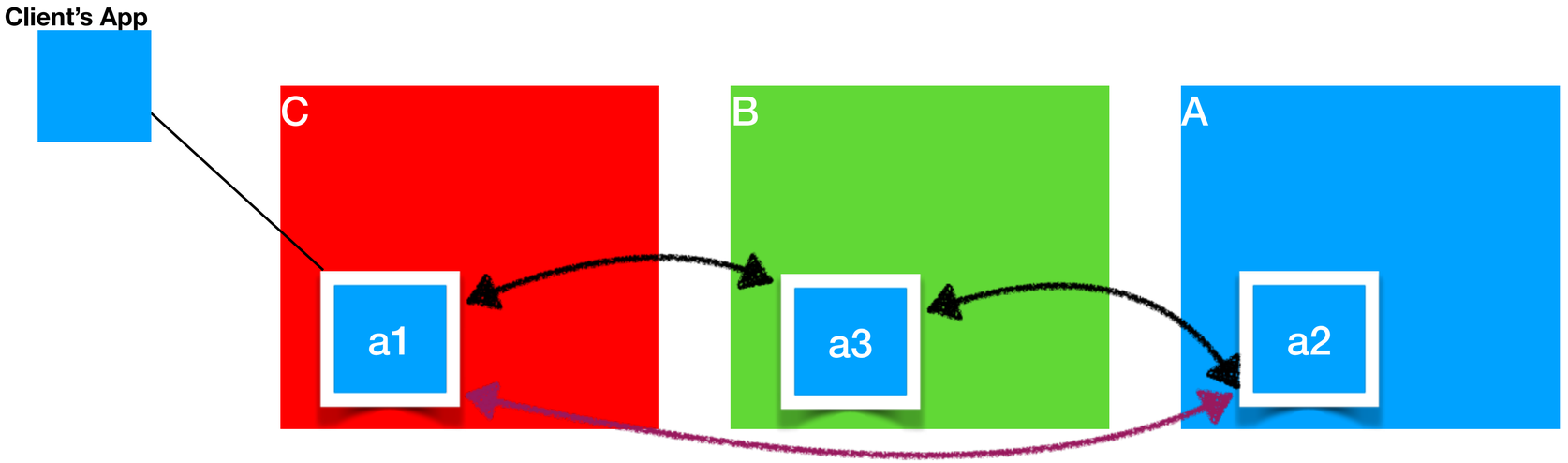
Huawei use case

Overlay Path via Cloud

VN creation on Cloud Internet

- Virtual nodes located with geographic location diversity (100-200 sites)

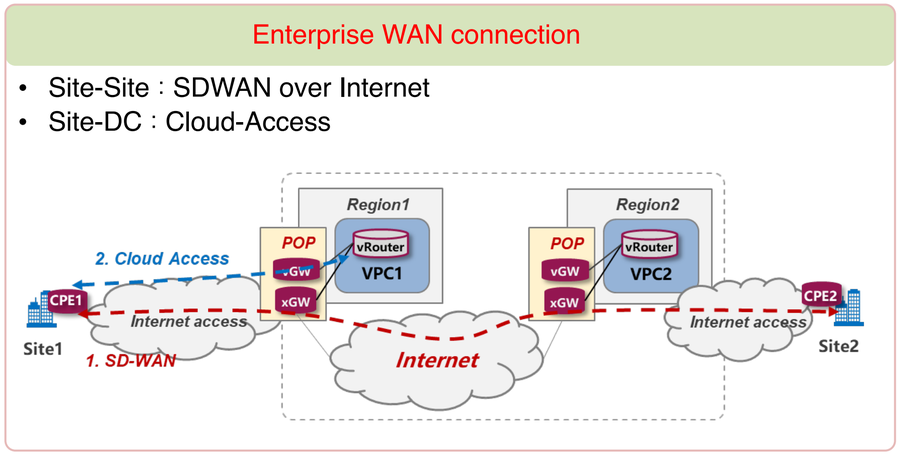


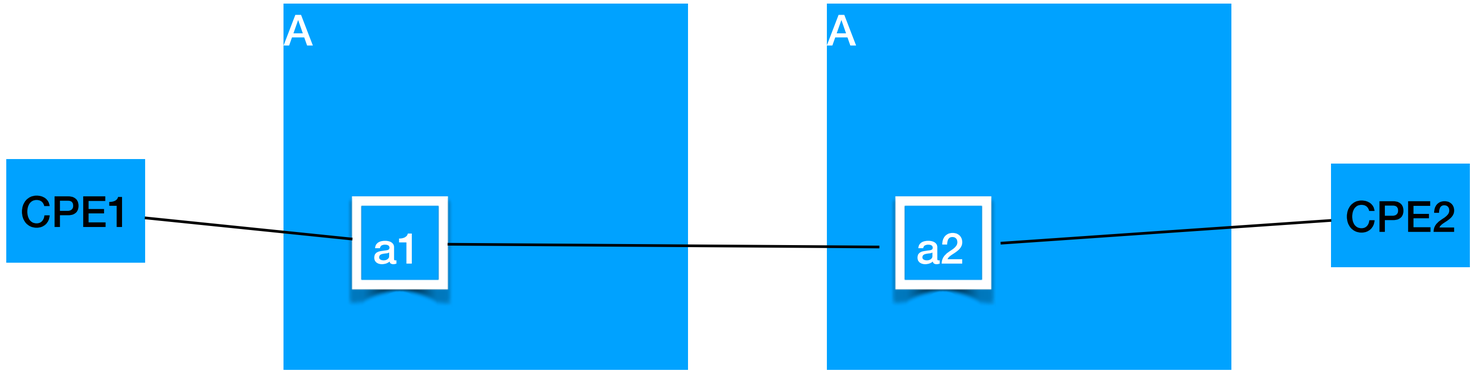


- Combination of Aa1 B Aa2 and Aa Bc
- Virtual nodes (a1, a2, a3…) around the world from cloud providers
- A selected path may consist of multiple path segments which have different loss characteristics
- LOOPS can be enabled over specific segments to recover loss, e.g. a1-a3, a3-a2 or a1-a2

China Telecom Use Case

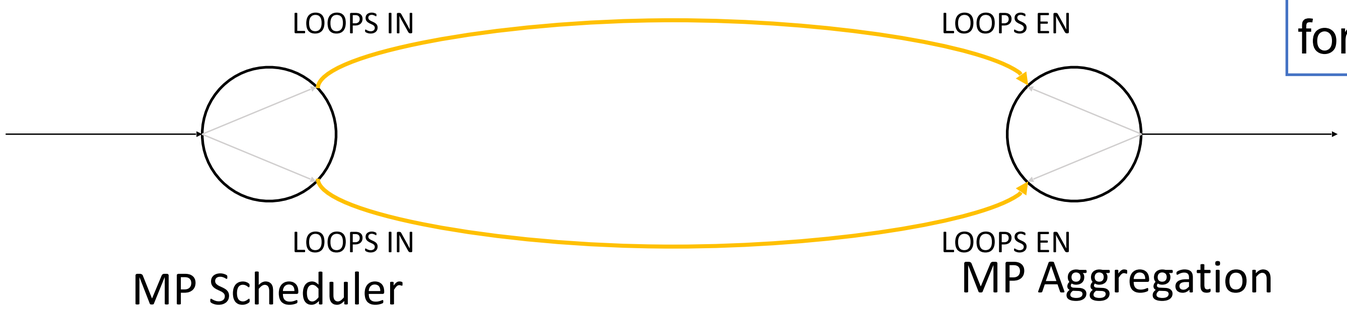
SD-WAN based branch office interconnect



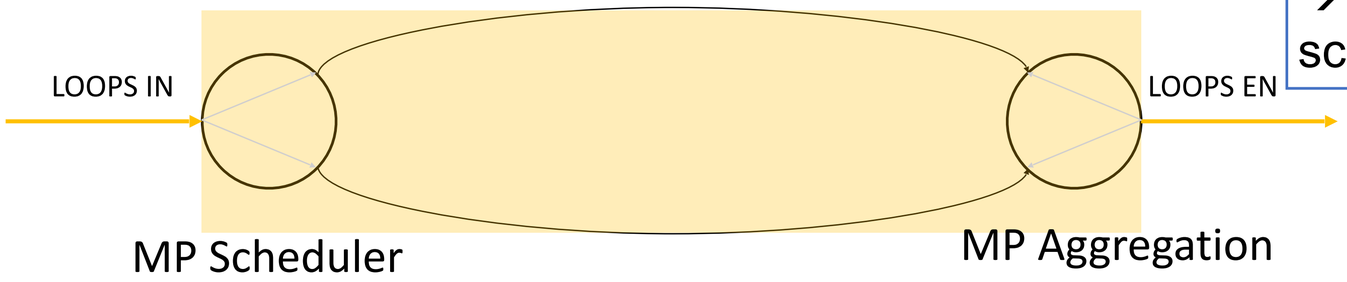


- Enterprise branch offices in different cities interconnect.
- a1 & a2 are PoP (Point of Presence)/vPoP
- A 3-segment overlay path in between branch office CPEs
- LOOPS is enabled over segments to recover loss in best effort network

Improve multipath (MP)* – DT use case



LOOPS on path level between multipath endpoints
→ Improves individual path robustness fine grained for a sustainable overall multipath session



LOOPS end-to-end overlaying multipath
→ Compensate multipath caused imperfections like scheduling or aggregation mismatch

*MVP: no LOOPS↔MP integration required

Preferred applicable to MP protocols for unreliable transport
https://tools.ietf.org/html/draft-amend-tsvwg-multipath-dccp-03
https://tools.ietf.org/html/draft-amend-tsvwg-multipath-framework-mpdccp-01

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RFC 5434 Question

- Does everyone understand the problem that has been presented?
- If not, please ask questions now that would be helpful to make this clearer.

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Charter text (v. 0.5) (1/4)

Background

- The Internet has a long history of employing performance enhancing proxies (PEPs, RFC 3135) to improve performance over paths with links of varying quality. Today's PEPs often interact deeply and "transparently" (intrusively) with end-to-end transport and application layer protocols. This practice is coming to an end with increasing deployment of encryption.
- At the same time, networks are becoming more complex, and network nodes are becoming more powerful. It is becoming more viable to trade processing power in network nodes against path quality, in particular for expensive path segments. Transport protocols and their implementations are moving towards playing better with forwarding node functions such as ECN marking and AQM.

Charter text (v. 0.5) (2/4)

LOOPS

- LOOPS (Local Optimizations on Path Segments) attempts to capture opportunities opened by these developments, enabling optimizations within some segments of an end-to-end path. Typically, these segments will be delimited as tunnels maintained by dedicated overlay nodes (tunnel endpoints), which allows a local optimization protocol to run between these nodes. Many end-to-end flows can be aggregated into each such tunnel flow being optimized.
- Initially, LOOPS will focus on path segments that do not include either end host. Also, multipath forwarding will not be specifically addressed and is left for future consideration.
- The selection of the segments to be optimized and the nodes that will run LOOPS optimization is deployment-specific and is out of scope; the assumption is that this will be performed as part of the network configuration, which can also supply further parameters controlling LOOPS. LOOPS will define a simple key/value configuration data set that can be used by configuration protocols.

Charter text (v. 0.5) (3/4)

The functions to be addressed by LOOPS include:

- Local recovery: Packet losses on the path segments are recovered autonomously, removing the need to burden the entire end-to-end path with the recovery, and decreasing the latency by which these recoveries can be effected. The protocol will be designed so that local recovery can be based on forward error correction (FEC) and/or (non-persistent) retransmission. The initial focus will be on retransmission, but a "default" FEC scheme will be included in order to exercise the protocol mechanisms for selecting FEC and a specific FEC scheme (more state-of-the-art FEC schemes can then be registered later).
- Local measurement: To properly parameterize the LOOPS algorithms (e.g., RTO, FEC rate) and to trigger state transitions, measurements are continuously performed of the path segment between the tunnel endpoints.
- Interaction with end-to-end congestion control: As well as Congestion Experienced (CE) events on the path, losses are relayed as congestion events to the end-to-end congestion control. Initially, LOOPS will focus on the use of ECN for this and therefore only supports ECN-enabled end-to-end flows. Circuit breakers (RFC 8084) will be employed on the LOOPS tunnel to further protect against congestion collapse.

Charter text (v. 0.5) (4/4)

- The LOOPS protocol will need to run embedded into a tunneling protocol. Initially, this will be Geneve (Generic Network Virtualization Encapsulation, NVO3 WG). To facilitate future support of further encapsulations, LOOPS will be defined with a separation in mind between a generic information model level, and a set of protocol bindings that will start out as the Geneve embedding.

Relationship to IRTF RGs

- LOOPS will actively consult ICCRG, for congestion control issues, and NWCRG, for FEC encoding and encapsulation issues. In particular, documents of the latter will serve as a basis for the FEC-based components of LOOPS.

Relationship to IETF WGs

- In addition to NWCRG mentioned above, TSVWG will be consulted with respect to their FEC-related work. (TSVWG and TCPM will also be important sources of information on recent developments on mechanisms used in LOOPS itself, such as ECN, time-based recovery, as well as, with QUIC and AVTcore, on the characteristics of end-to-end transport flows.) LOOPS will interact (in a user role) with NVO3 as the home of the Geneve tunneling protocol.

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RFC 5434 Questions

- Is this a problem that should be solved in the IETF?
- Is the draft charter, as presented here, ready for the ADs to take forward?
- If not, is the draft charter "close enough" to polish on the LOOPS mailing list and during the chartering process reviews?