True link detection in the presence of per packet load balancers

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Introduction: Recent studies have shown that the traceroute tool does not provide reliable topological information when probing through load balancers [1]. Paris Traceroute was developed to correct this problem as it traces correct paths through per-flow load balancers (PFLBs) and per-destination load balancers (PDLDs). However it is unable to do so for per-packet load balancer (PPLBs).

Motivation: We propose to enhance Paris Traceroute with a new algorithm to resolve true link detection with PPLBs. When cross traffic occurs we apply statistical tests in our algorithm. Enough PPLBs are found in network paths: Augustin et al. found that PPLBs appears in 2% of the traces obtained by a list of 60000 destinations

Problem Description

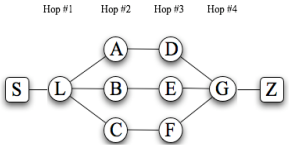

Fig 1.a: Simple diamond topology

- Paris Traceroute with the MDA algorithm [2] obtains all the interfaces that are present in the underlying topology (Fig 1.a) when L is a PPLB.
- But any of the links in {A, B, C }x{D, E, F } is possible (Fig 1.b), meaning that the true links (A, D), (B, E), and (C, F) are not explicitly detected due to the lack of an inference algorithm.

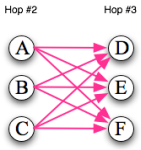

Fig 1.b: Possible inferred links

Proposed Algorithm

Our algorithm determines the true links in a PPLB diamond in two main steps:

Step 1: Discovers the estimated round robin pattern at each multi interface hop in the diamond.

	PatternProbe	PatternAnalysis
With No Cross Traffic	Sends k_L probes to each multi interface hops in the diamond.	Estimate the Round Robin pattern at each hop.
With Cross Traffic	Sends k_L probes to each multi interface hops in the diamond.	Estimate the Round Robin pattern at each hop.

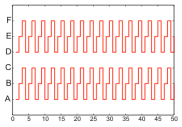

Fig 1.b: Pattern with no cross traffic

With no cross traffic, the discovered interfaces follow a periodical cycle at each hop, which indicates that PPLBs follow a round robin pattern (Fig 1.b).

Build the lateral count matrix T_i with PatternProbe results:

	A	B	C
A	0	17	0
B	0	0	17
C	16	0	0

Estimate the Round Robin pattern:

- Search the argument of the maximum value found in each row of T_i.
- Build an ordered cycle G_i with the argument value found in T_i

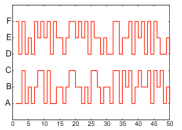

Fig 1.c: Pattern with cross traffic

With cross traffic, the observation are disrupted as the discovered interfaces don't follow the underlying periodic cycle (Fig 1.c). We need to use statistical tests to uncover the round robin pattern.

Build the lateral count matrix T_i with PatternProbe results:

	A	B	C
A	4	9	3
B	1	4	8
C	11	6	6

Estimate the Round Robin pattern:

- Use a Binomial distribution to model the transition of each individual interfaces as a result of randomness
- Reject each real transition that have a random behaviour by comparing them to the Binomial distribution results.

G_2 = (A,B,C)

G_3 = (D,E,F)

Step 2: Finds out how each hops pattern aligns with that of its neighbors.

	PairProbe	PatternAlignment
With no cross traffic we know that our observation are not disrupted.	Sends k_F back-to-back probes successively to two adjacent hops.	Estimates the alignments between the inferred round robin patterns
With cross traffic we know that our observation are disrupted.	Need to send k_F=1 back-to-back probe to find one corect forward transition.	Need to send k_F back-to-back probe in regard of the amount of cross traffic. (we plan to determine the correct number k_F in future work)

Build the forward transition matrix M_i with PairProbe results:

	D	E	F
A	0	1	0
B	0	0	0
C	0	0	0

Search the arguments of the maximum value of M_i to be one forward transition (A,E)

Due to the round robin behaviour of the PPLB, the interface E of G_3 is aligned to the next interface of A in G_2. Thus we can determine the true links in the alignment by applying the offset o=-1 to G_3.

A_2 = { (A,D), (B,E), (C,F) }

Build the forward transition matrix M_i with PairProbe results:

	D	E	F
A	3	2	0
B	1	1	4
C	0	1	2

Determine one true forward transition:

- Search the arguments of one forward transition where its value is close to the mean value of M_i.

Estimate the alignment:

- Determine the offset between 2 adjacent estimated pattern.

A_2 = { (A,D), (B,E), (C,F) }

Future work

- Validate the algorithm in a controlled environment.
- Determine the number of probes to be sent with cross traffic.
- Study PPLBs on the Internet with our algorithm.

References

[1] Fabien Vigier, Brice Augustin, Xavier Cuvellier, Clémence Magnien, Matthieu Latapy, Timur Friedman, and Renata Teixeira. Detection, understanding, and prevention of traceroute measurement artifacts. Elsevier, 2007.

[2] R. Teixeira D. Veitch, B. Augustin and T. Friedman. Failure control in multipath route tracing. In INFOCOM, 2009.

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