How Traceroute Explains the Internet

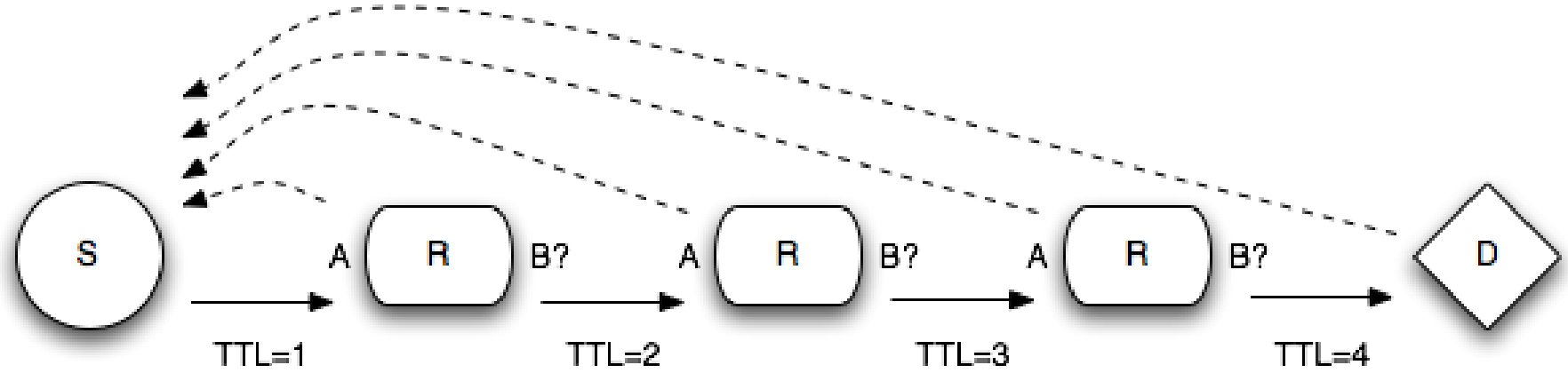
John Kristoff
jtk@cymru.com

History

- Van Jacobson releases traceroute.tar.Z

```
To: ietf@venera.isi.edu,
    end2end-interest@venera.isi.edu
Subject: 4BSD routing diagnostic tool
         available for ftp
Date: Tue, 20 Dec 88 05:13:28 PST
From: Van Jacobson
```

Traceroute Operational Review



UDP Traceroute

- Also known as UNIX traceroute
- ICMP TTL exceeded responses to ICMP messages?
- Probes initialize to an unlikely UDP destination port
  - Default begins at 33434
  - Incremented for each probe packet
- An ICMP port unreachable from the target is the goal

ICMP Traceroute

- Most commonly associates with Microsoft Windows
- Sends ICMP echo request probes
- An ICMP echo response from the target is the goal
- NOTE: ICMP TTL exceeded messages not a problem
- But filtering and probe response suppression can be

Anomaly: Multi-path

```
$ traceroute www.chinog.org
traceroute to www.chinog.org (74.208.62.118), 30 hops max,
                                              60 byte packets

...

 4  te0-3-0-2.agr22.ord01.atlas.cogentco.com (154.24.4.41)    1.422 ms
    te0-3-0-2.agr21.ord01.atlas.cogentco.com (154.24.4.37)    1.175 ms
    te0-3-0-2.agr22.ord01.atlas.cogentco.com (154.24.4.41)    1.329 ms
 5  be2524.ccr42.ord01.atlas.cogentco.com    (154.54.81.109)  1.475 ms
    be2521.ccr41.ord01.atlas.cogentco.com    (154.54.80.253)  1.710 ms
    be2522.ccr42.ord01.atlas.cogentco.com    (154.54.81.61)   1.455 ms

…

13  perfora.net (74.208.62.118)  17.273 ms  17.490 ms  17.276 ms
```

Anomaly: Missing Hop(s)

```
$ traceroute -n facebook.com
traceroute to facebook.com (173.252.120.6) ...

...

 7  31.13.25.32  34.084 ms
    31.13.25.106  34.137 ms
    31.13.27.40  33.957 ms
 8  204.15.23.247  33.548 ms
    31.13.27.133  33.785 ms
    173.252.64.65  33.694 ms
 9  * * *
10  * * *
11  173.252.120.6  33.786 ms  33.570 ms  33.614 ms
```

Anomaly: Unresponsive Target

```
$ traceroute -n -q1 www.northwestern.edu
traceroute to www.northwestern.edu
(129.105.215.254), 30 hops max, 60 byte packets

...

 4  199.249.169.5  0.884 ms
 5  129.105.247.224  1.418 ms
 6  129.105.253.153  1.682 ms
 7  129.105.247.97  2.006 ms
 8  *
 9  *
10  *
11  *
12  *
```

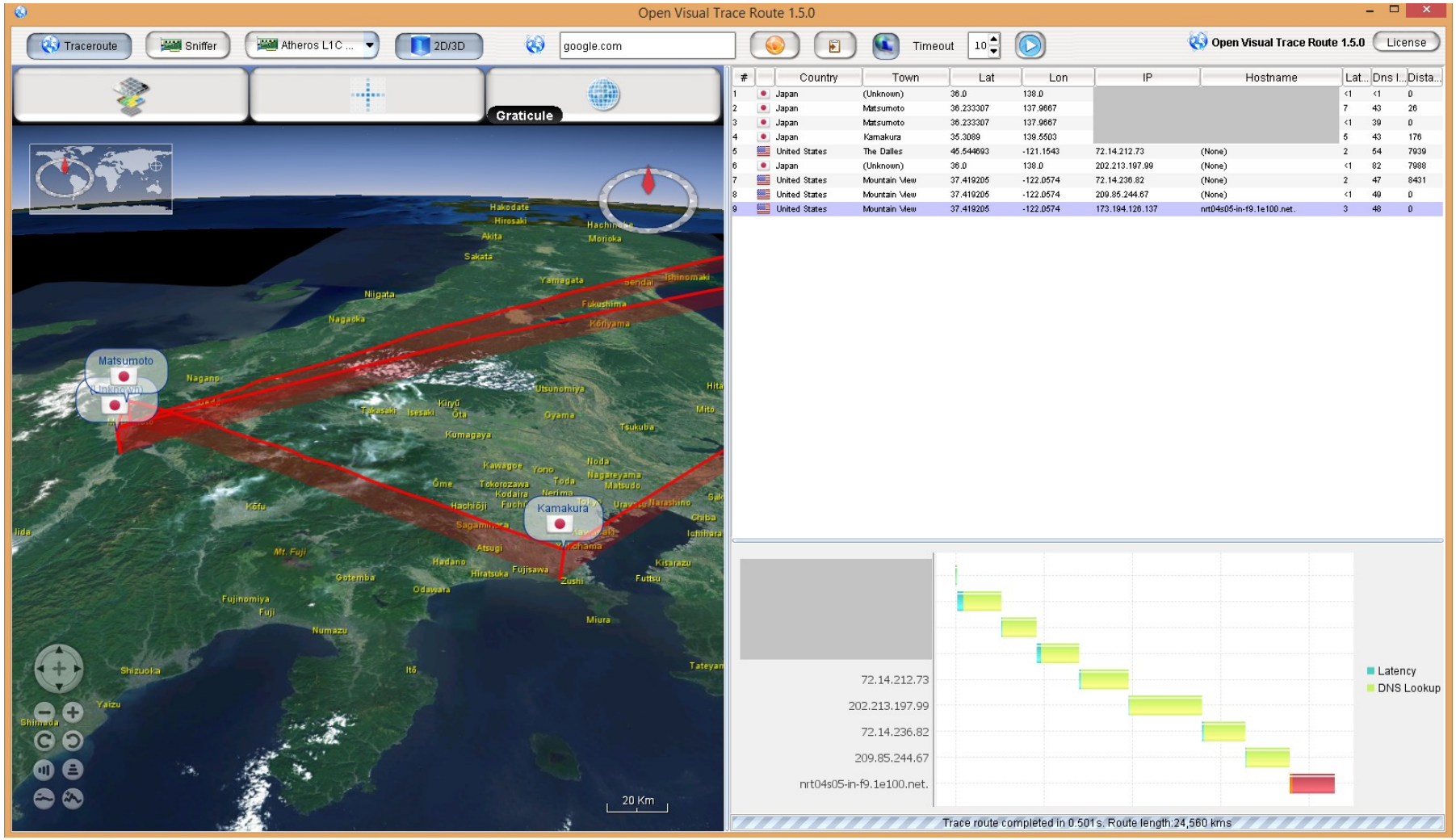
Hack: Uncovering a Target

```
$ sudo traceroute -T -n -q1 www.northwestern.edu
traceroute to www.northwestern.edu
(129.105.215.254), 30 hops max, 60 byte packets

...

 4  199.249.169.5  0.797 ms
 5  129.105.247.224  1.026 ms
 6  129.105.253.153  1.662 ms
 7  129.105.247.97  655.220 ms
 8  129.105.46.196  1.896 ms
 9  129.105.215.254  1.996 ms
```

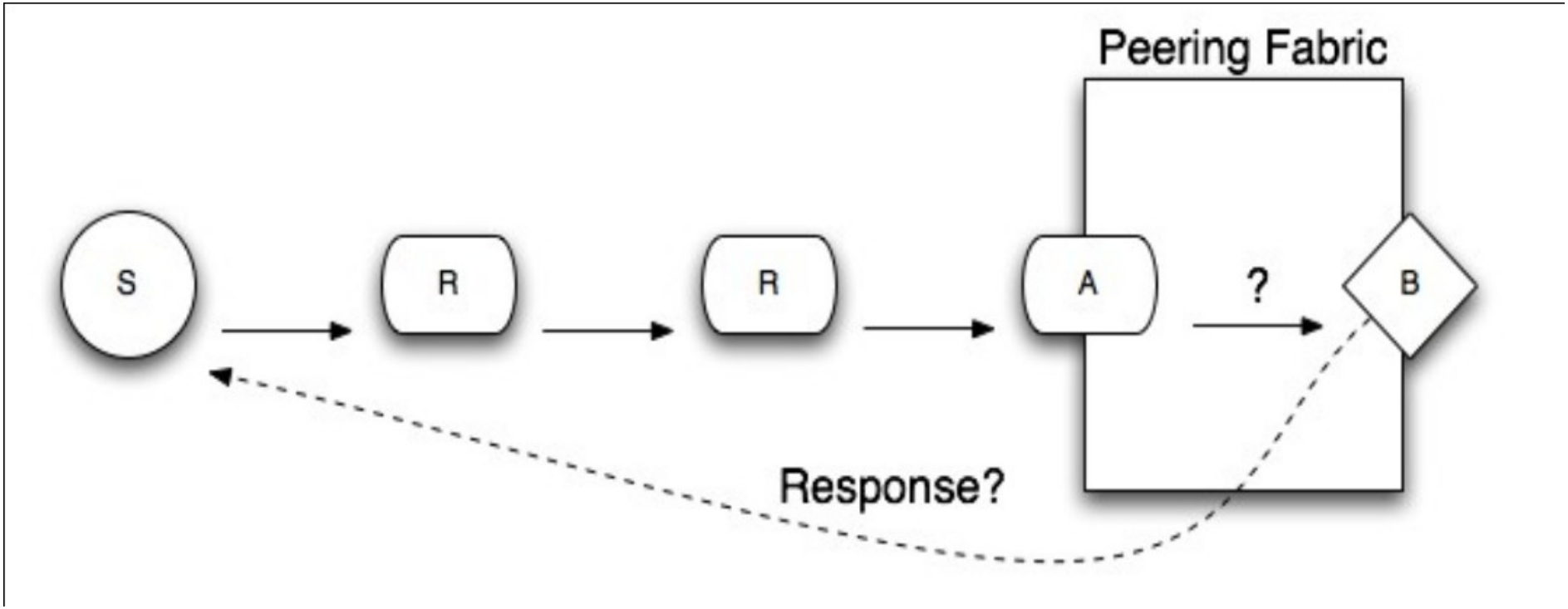
Feature: MPLS option

```
traceroute -en -q1 www.google.com
traceroute to www.google.com (64.233.160.99), 30 hops max,
60 byte packets

...

 6  209.85.254.120  1.529 ms
 7  209.85.254.238 <MPLS:L=284331,E=4,S=1,T=1>  18.373 ms
 8  209.85.251.18 <MPLS:L=319427,E=4,S=1,T=1>  18.165 ms
 9  72.14.236.1 <MPLS:L=770010,E=4,S=1,T=1>  21.186 ms
10  209.85.248.7  19.892 ms
11  64.233.160.99  16.332 ms
```

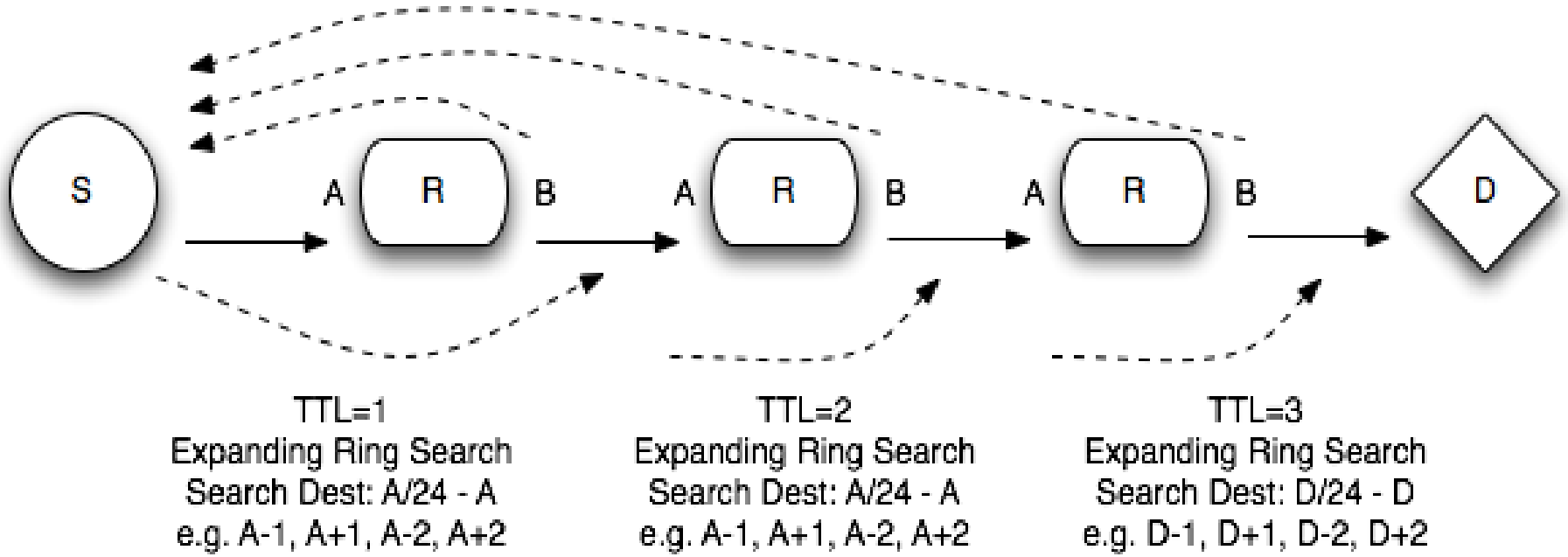
Feature: Visualization (geoloc)



Hack: Peer Discovery



Hack: Reverse Traceroute



Let's Take Stock

- Key figures, organizations, mailing lists, software
- Routers+routing, forwarding, and loop prevention
- ASNs, BGP peering policies, asymmetric paths
- UDP (TCP), source+destination ports, ICMP
- Domain name system, naming conventions
- Packet filtering and security policies
- Performance, round trip time, geo-location

...and much more

- IP headers and options
- ARP, MPLS, IPv4 versus IPv6
- An interface versus a host
- NAT
- Applications (ports)
- Router CPU protection,rate limiting
- ...and even the end-to-end argument

A bit of a stretch? Maybe not

- IP multicast
- DDoS
- Buffering, congestion avoidance and flow control
- CoS/QoS
- PKI – OK, maybe this one is a bit of a reach

Conclusion: Some References

- Richard A Steenbergen (RAS)
  - http://cluepon.net/ras/traceroute.pdf
  - A Practical Guide to (Correctly) Troubleshooting with Traceroute, ARIN on-the-road, Orlando 2015
- http://kb.pert.geant.net/PERTKB/VanJacobsonTraceroute
- Traceroute Anomalies, Martin Erich Jobst
- Traceroute Probe Method and Forward IP Path Inference, Lukie, Hyun, Huffaker
- Reverse Traceroute, Bassett, et al.