FANTAIL:
Facilitating Advances in Network Topology Analysis

Young Hyun
CAIDA

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• network community has **vast amounts of traceroute data**

• CAIDA has 90+ billion IPv4 traceroutes in 39+ TB of files
  ‣ growing by 16 billion traces and 7 TB annually

• RIPE Atlas collects ~700 million IPv4/IPv6 traceroutes/month

• Measurement Lab (M-Lab) collects millions of traceroutes/day

• and more ...
Goals

- allow researchers to **more easily use** community topology data
- ... to **search** traceroute data
  - using high-level queries
- ... to perform **data processing and analysis** tasks on matching traces
  - without owning/operating a cluster
  - without learning big data programming
Workflow

query → data processing/analysis pipeline (optional) → results
Architecture

FANTAIL

client

frontend server
(interactive web interface and web API)

Elasticsearch
(storage & search)

Apache Spark
(data processing & analysis)
Querying

- User specifies high-level search criteria
- FANTAIL performs low-level Elasticsearch queries against relevant indexes and traceroute fields
### Queries (1/2)

<table>
<thead>
<tr>
<th>Query</th>
<th>Selection Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{vp} V</td>
<td>vantage point is ( V )</td>
</tr>
<tr>
<td>\text{vp_as} N</td>
<td>vantage point is located in autonomous system (AS) ( N )</td>
</tr>
<tr>
<td>\text{vp_country} C</td>
<td>vantage point is located in country ( C )</td>
</tr>
<tr>
<td>\text{vp_type} T</td>
<td>vantage point is hosted by an organization of type ( T )</td>
</tr>
<tr>
<td>\text{status} N</td>
<td>traceroute has success/failure code ( N )</td>
</tr>
<tr>
<td>\text{timestamp} \text{ op} N</td>
<td>traceroute has timestamp ( \leq ; \geq ; N )</td>
</tr>
<tr>
<td>\text{dest_rtt} \text{ op} N</td>
<td>RTT of traceroute destination is ( \leq ; \geq ; N ) ms</td>
</tr>
<tr>
<td>\text{pathlen} \text{ op} N</td>
<td>length of traceroute path is ( \leq ; \geq ; N )</td>
</tr>
<tr>
<td>\text{has_mpls} T/F</td>
<td>whether there is ( T ) or is not ( F ) MPLS in the traceroute path</td>
</tr>
</tbody>
</table>

\( \text{op} \) is \( < \; \text{or} \; \leq \; \text{or} \; \geq \; \text{or} \; > \)
<table>
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<tr>
<th>Query</th>
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</tr>
</thead>
<tbody>
<tr>
<td>dest $G$</td>
<td>traceroute destination is any address $x \in G$</td>
</tr>
<tr>
<td>hop $G$</td>
<td>traceroutes with any address $x \in G$ appearing at any hop</td>
</tr>
<tr>
<td>neigh $G_1 \ldots G_n$</td>
<td>traceroutes with $n$ distinct neighboring hop addresses $x_i \in G_i$</td>
</tr>
</tbody>
</table>

$T = \text{target address/prefix/AS/country}$

$G = \text{target group } T_1 \mid \ldots \mid T_m$
### Queries (2/2)

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</tr>
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$T =$ target address/prefix/AS/country

$G =$ target group $T_1 \mid \ldots \mid T_m$

**query:** **neigh** 10.0.0.0/8|192.168.0.0/16 AS1|AS2|AS3

matches any trace with hop addresses $x$ and $y$ such that

$$(x \in 10.0.0.0/8 \text{ or } x \in 192.168.0.0/16)$$ and $$(y \in \text{AS1} \text{ or } y \in \text{AS2} \text{ or } y \in \text{AS3})$$
• can form complex queries by combining elements with logical AND:

\[
\text{vp\_country \ .fr} \\
& \text{timestamp} > 2018-01-01 \\
& \text{timestamp} < 2019-01-01 \\
& \text{dest 1.0.0.0/8}
\]

• can use logical OR within certain elements:

\[
\text{vp\_country \ .fr| .de| .uk} \\
& \text{vp\_type business|residential} \\
& \text{dest 1.0.0.0/8|2.0.0.0/8}
\]

• must have overall form \( X \& (Y_1|...|Y_n) \& ... \& Z \)
  - only two levels of logical operators: \& at top, \| within
  - no NOT
  - need restrictions for efficient execution of queries
User specifies high-level search criteria + desired data processing/analyses to apply to matching traces
user specifies a chain of analysis modules to define the data processing/analysis pipeline
• **analysis module**: a reusable data processing or analysis step that transforms traceroute paths
  - for performing **data reduction** (to minimize the amount of data users have to download and further process)
  - for enhancing raw traceroute data with **annotations**
  - for **offloading** implementation and execution of commonly-needed analysis/data processing tasks from users
• **analysis modules:**
  - extract unique hop addresses, IP links, or IP paths
  - annotate IP addresses with aliases, hostnames, IXPs, ASes, interconnection points (bdrmapIT), presence of MPLS tunnels
  - calculate per-destination RTT distributions
Data Processing

- **analysis recipes**
  - prepackaged queries and data processing/analysis pipelines provided as a unit
  - customize via parameters, such as the target AS/prefix/country

- **samples:**
  - Find all interconnection links of a given AS in a given time period.
    - Implementation: (1) find all traceroutes that have IP addresses in the target ASes, (2) identify interconnection links in the selected traceroutes with bdrmapIT data, and (3) produce the unique set of interconnection links from these traceroutes.
  - Extract the IP/router-level graph of a target AS (that is, all routers and links that map to the AS) in a given time period.
• much development work ahead (at 6 months of 3 year funding)

• email fantail-info@caida.org if interested in very early access (pre-alpha)

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