Ark Update: Present & Future

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CAIDA
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Archipelago Measurement Infrastructure
Monitor Deployment

- 107 monitors in 40 countries
  - 59 Raspberry Pi's
  - 44 have IPv6
  - 36 have RADclock

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Raspberry Pi

1st gen
- 700MHz ARMv6
- 512MB RAM

2nd gen
- 900MHz quad-core ARMv7
- 1GB RAM

both
- 100 Mbps Ethernet
- 8GB SD card
- $35 for bare board
ARCHIPELAGO MONITOR
MONITOR-INFO@CAIDA.ORG
WWW.CAIDA.ORG/PROJECTS/ARK

standard micro-USB phone charger

Raspberry Pi + SD card

HDMI to DVI-D display adapter

~$68 complete system
**Tools**

- **Marinda** distributed tuple space
  - stores tuples: arrays of strings, numbers, and sub-arrays
  - users retrieve tuples by structural pattern matching (not regex)
  - enables communication and coordination
    - persistent encrypted TCP connections with transparent reconnections
    - decentralized (peer-to-peer) or client-server communication
    - supports broadcast, RPC, publish-subscribe, Bag-of-Tasks styles
    - exactly-once message delivery
Tools

- *mper* probing engine
  - based on Matthew Luckie’s *scamper*
  - send/receive individual IPv4 ICMP, UDP, TCP packets
    - no traceroute or other high-level measurement functions
  - new control socket interface providing measurement API
    - write measurement scripts in Ruby (e.g., MIDAR)
    - Alistair King ported scamper's traceroute code to mper in Ruby
require 'mperio'

class Prober
  def initialize
    @mperio = MperIO.new 8742  # mper listening port
    @mperio.delegate = self
    @mperio.ping_icmp 1, "192.172.226.123",
                      :ttl, 3, :cksum, 0x1234, :rr, true,
                      :tsps, ["192.172.226.1", "192.172.226.2"]
    @mperio.start
  end

  def mperio_on_data(result)
    if result.responded?
      printf "%d %d\n", result.rx_sec, result.reply_ipid
    end
  end
  @mperio.stop
end
Tools

- **Dolphin**
  - conducts parallel PTR DNS lookups of IPv4 and IPv6 addresses
    - millions of lookups per day from a single host
  - retries failed lookups once per day for up to 3 days
  - ensures targets only looked up once in any 7 days regardless of TTL
    - reduces load on authoritative DNS servers
  - built on libunbound (part of Unbound by NLnet Labs)
    - a validating, recursive, caching resolver in a library; IPv4/IPv6/DNSSEC
  - hackable: single Python source file (845 lines)
    - no installation or root privileges required
Tools

- `qr`
  - similar to Dolphin but more focused
    - only DNS lookups; no retries, no suppression of repeated lookups
  - supports PTR, SOA, A, AAAA lookups
  - uses `ldns` library for low-level structured access to raw DNS response packets
    - response header flags (e.g., AA)
    - records in authority and additional sections (e.g., glue, SOA, and DNSSEC records)
  - hackable: 513 lines of Python
**Tools**

- *qr* case study: PTR lookups of routed address space
  - 2.69 billion addresses (excluding .0 and .255 in each /24)
  - 3.6k queries/sec ⇒ 317M queries/day ⇒ 8.5 days
  - did full run in Aug 2014; data available
Tools

**MIDAR**: Monotonic ID-Based Alias Resolution

- **Monotonic Bounds Test**: for two addresses to be aliases, their combined IP-ID time series must be monotonic

- 4 probing methods: TCP, UDP, ICMP, "indirect" (traceroute-like TTL expired)

- sliding-window probe scheduling for scalability

- multiple sources
**Tools**

- *tod-client*: on-demand topology measurements
- scriptable command-line interface for performing IPv4 and IPv6 traceroutes and pings

```
$ tod-client -h

1 san-us ping 192.172.226.123

ping from 192.172.226.5 to 192.172.226.123
 1:  192.172.226.123    0.092 ms  64 TTL
 2:  192.172.226.123    0.112 ms  64 TTL
...

2 lax-us trace 192.172.226.123

traceroute from 137.164.30.25 to 192.172.226.123
 1.1:  137.164.30.1    0.183 ms
 2.1:  137.164.46.105    0.787 ms
 3.1:  137.164.46.54    2.623 ms
...
$ tod-client

1 san-us ping 2001:48d0:101:501::132 attempts=1
2001:48d0:101:501::132 0 1 1328149101 R
0.353 1 64 S 0
2001:48d0:101:501::132,0.353,64

2 lax-us trace www.caida.org attempts=1,method=icmp-paris
2 data www.caida.org T 137.164.30.25 192.172.226.123 0
1 1328145600 R 9.766 7 58 S
0 C 137.164.30.1,0.147,1
137.164.46.105,1.045,1 137.164.46.54,2.559,1
137.164.47.15,9.750,1 137.164.23.130,17.992,1
132.249.31.6,9.886,1
#!/usr/bin/env ruby

require 'marinda'

$ tod = Marinda::Client.new "~/tmp/localts.sock",
   :port => 2000, :scope => :global

# 2 lax-us trace www.caida.org attempts=1,method=icmp-paris
$ tod.write ["TRACEROUTE", "ark", 2, "lax-us", "www.caida.org",
   [["attempts", 1], ["method", "icmp-paris"]]
result = $ tod.take ["RESULT", "ark", nil, nil, nil, nil, nil, nil]

$ ./tod-example
["RESULT", "ark", 2, "lax-us", "www.caida.org", "data", "T
 t137.164.30.25\t192.172.226.123\t0\t1\t1328226507\tR\t9.838\t7
 t58\tS\t0\tC\t137.164.30.1,0.176,1\t137.164.46.105,1.110,1
 \t137.164.46.54,3.015,1\t137.164.47.15,9.681,1
 \t137.164.23.130,10.178,1\t132.249.31.6,9.860,1"]
- **Vela**: web interface to conduct topology measurements
  - currently, ping and traceroute (ICMP, TCP, UDP)
Measurements

- IPv4 topology
  - traceroutes to random address in each routed /24
  - 570 million traces/month

- IPv6 topology
  - traceroutes to random address and ::1 in each routed prefix
  - pings to IPv6 addresses of Alexa top 1 million sites
  - 16 million traces/month

- PTR DNS lookups of observed IPv4 and IPv6 addresses
Measurements

- alias resolution
  - MIDAR: collects IP-ID time series with TCP, UDP, and ICMP
  - iffinder: elicits ICMP port unreachable with UDP
- congestion at inter-domain peering links
  - elicits ICMP TTL-expired at adjacent IP hops
  - look for jumps in RTT across links
Ark Usage

• multiple ways of using Ark
  • **simplest**: Vela
  • **more control**: tod-client
    • example: Rob Beverly's IPv6 subnet topology discovery technique
  • **full control + high packet rates**: shell access
    • standard desktop/server Unix environment (not embedded)
    • raw socket access; no modifications required (no secure raw sockets layer)
    • compile and run any existing Unix program
    • write measurements in Ruby with Ark software
    • examples: middlebox study, Speedtrap IPv6 alias resolution, Casey Deccio's cctld DNS study (with dnsget)
Future

- improve data accessibility
  - create an interface for *browsing, querying, and visualizing* the data gathered by the infrastructure
  - command-line and web interfaces

prototype viz showing differences between a traceroute path and BGP AS paths
Future

- **browsing** interface
  - view broad properties and summary statistics over multiple time scales and aggregation levels
    - example: trace counts and response rates; path-length and RTT distributions; inferred AS links

prototype view of traceroute RTTs implemented with CAIDA's Charthouse
Future

- **query** interface
  - find the most relevant historical data for one's research
    - either directly answers a question, or identifies data to download for further study
  - examples:
    - all traceroutes through a given region and time period toward/across a particular prefix/AS
    - router address aliases for a given IP address
    - all inferred links to a router identified by a given IP address
    - all routers in a given city
Thanks!

www.caida.org/projects/ark

For questions, or to offer hosting: ark-info@caida.org