Archipelago
Measurement Infrastructure

On-Demand IPv4 and IPv6 Topology Measurements

Young Hyun
CAIDA

ISMA 2012 AIMS-4 Workshop
Feb 9, 2012

Introduction

- common need: **measure Internet topology from multiple vantage points**
  - RTT and reachability from pings
  - IP paths from traceroute

Introduction

- common need: **measure Internet topology from multiple vantage points**
  - RTT and reachability from pings
  - IP paths from traceroute
- useful for studying ...
  - network performance, outages, and censorship
  - routing stability, optimality, and resiliency
  - address space usage: routed vs. occupied
  - AS relationships and global Internet structure/evolution
  - router- and PoP-level maps
  - geolocation

Introduction

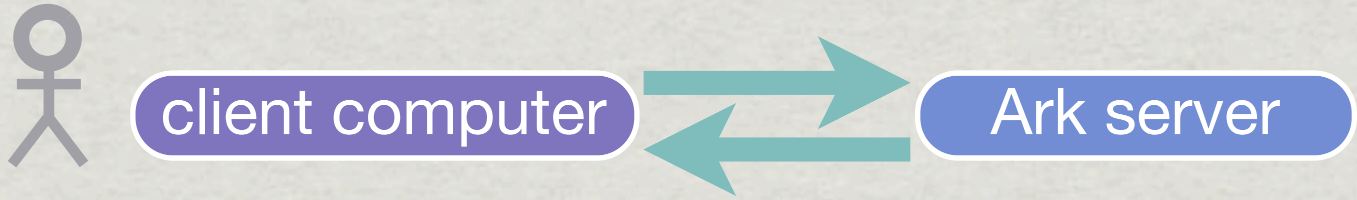
- desiderata for measurement facility
  - do not require accounts on individual monitors
    - secure, single point of access to many vantage points
  - support bulk measurements (hundreds of 1000's)
  - support varying levels of complexity
    - simple to learn and use for simpler tasks; slightly harder for harder tasks; makes complex tasks possible
  - support adaptive measurements
    - dynamic and feedback-driven
  - be scriptable: schedule probes and select vantage points and targets under program control
    - hard to design a non-scriptable scheduling system (e.g., a job submission GUI) that is flexible enough to handle complex non-uniform schedules

Introduction

* topo-on-demand (tod) service on Ark
  * scriptable interface for performing IPv4 and IPv6 traceroutes and pings
  * measurements from 57 Ark monitors (28 with IPv6)
    * globally distributed in both commercial and R&E networks
  * supports varying levels of user sophistication and needs

Architecture

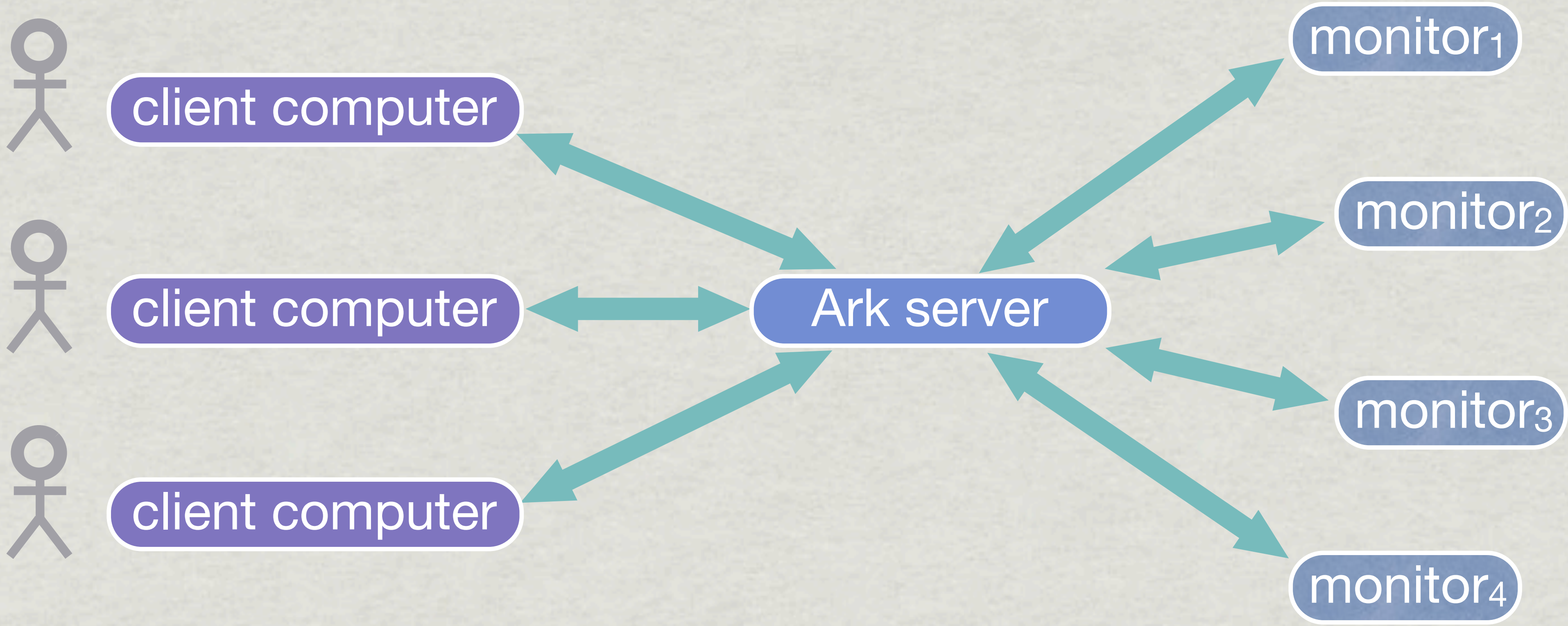
`request: ping 192.172.226.123 from ams-nl`



`result: RTT 163.355ms`

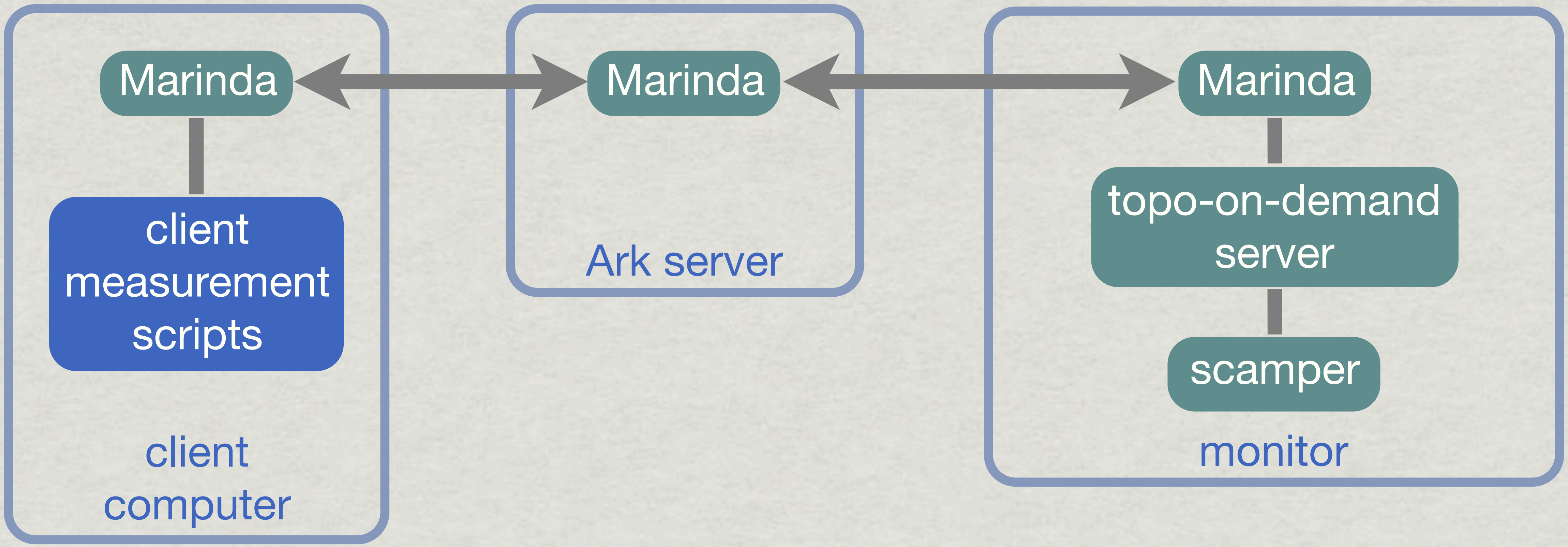
- a client accesses the topo-on-demand service through an Ark server
  - client remotely connects to a single access point
  - client requests measurement from an Ark monitor
    - can issue multiple concurrent requests
  - client receives results asynchronously

Architecture



* benefits of single-point of access
  * clients do not need login accounts on Ark monitors
  * clients do not need to implement software to manage a distributed system
    * issuing requests to and collecting results from remote monitors

Architecture



- topo-on-demand service is decentralized
  - Ark server only provides communication access
- client measurement scripts communicate with the topo-on-demand server on each monitor with Marinda
  - Marinda is Ark software that provides a high-level communication abstraction, a *tuple space*

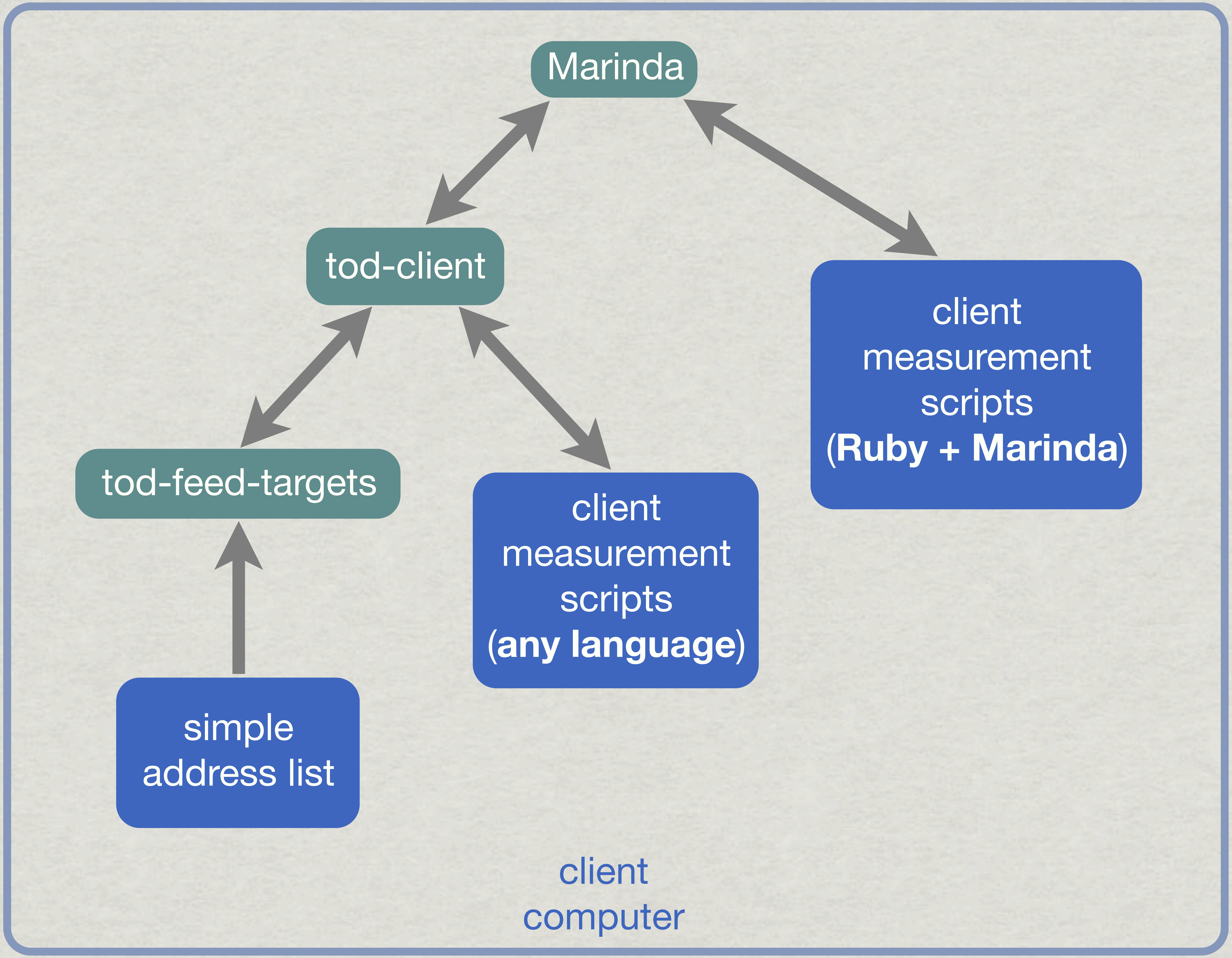
Marinda

- *tuple space:* a distributed shared memory + operations
  - clients store and retrieve tuples
    - retrieval by pattern matching
  - *tuple:* an array of values
    - strings, numbers, true/false, wildcard, nested arrays
- Marinda is used for decentralized communication and coordination
  - simplifies network programming in a distributed system
  - provides, for example,
    - message-oriented synchronous and asynchronous group communication
    - a persistent connection (reconnects transparently after loss)
    - automatic marshaling of structured data (tuples)

Client Access

- varying levels of user sophistication and needs
  - case 1: simply want to probe a set of targets in a file and save results to a file
    - for example: ping all targets from a single monitor
  - case 2: want greater control of measurements; possibly adaptive (dynamic, feedback-driven)
    - case 2a: want to use any choice of implementation language
    - case 2b: willing to use Ruby and Marinda directly

Client Access



Client Access

* case 1: simply want to probe a set of targets in a file and save results to a file
    * targets file with one address per line
    * use provided client access tools:

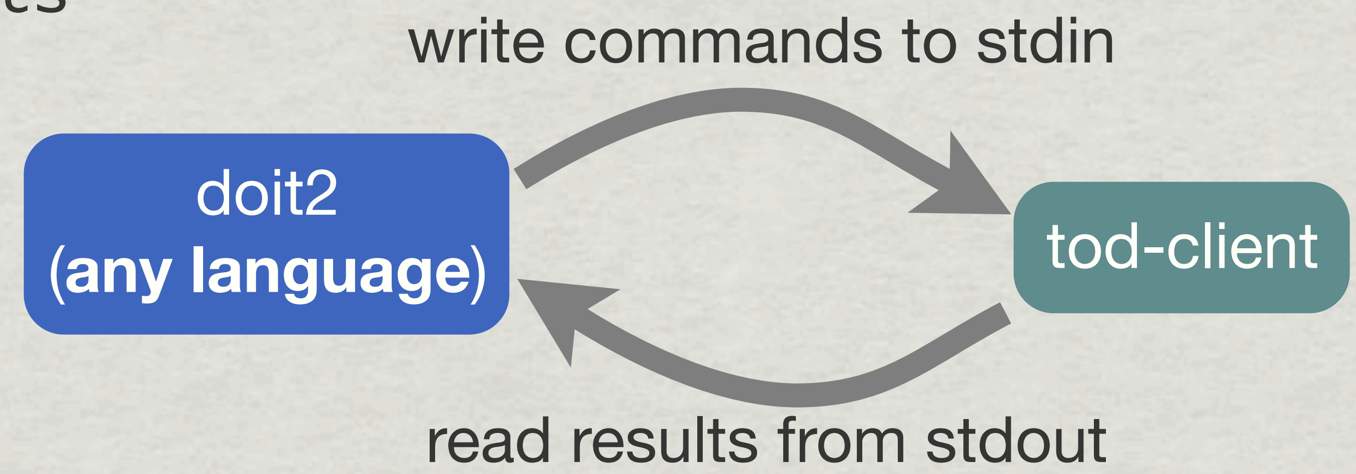
```
$ cat targets | tod-feed-targets --source=san-us
--ping --options=attempts=1 | tod-client >results
```

Client Access

- case 2a: want greater control of measurements; possibly adaptive; *want to use any language*
  - write a measurement script that issues commands to `tod-client`

    ```
    $ doit1 | tod-client >results
    ```
  - for feedback-driven measurements, write a script that *popens* `tod-client`
    - that is, run `tod-client` as a subprocess that can be written to and read from

    ```
    $ doit2 >results
    ```



tod-client

- `tod-client` provides a text-based gateway to the topo-on-demand service
  - familiar Unix shell paradigm: programs communicating through pipes
  - `tod-client` accepts text commands on stdin and writes measurement results to stdout
  - designed to be run as a subprocess and to provide high throughput
    - accepts any number of commands without blocking client
    - executes measurements asynchronously and in parallel

tod-client

- example of use:
  - -h ⇒ human readable output

```
$ 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
  3:  192.172.226.123    0.166 ms  64 TTL
  4:  192.172.226.123    0.079 ms  64 TTL
```

tod-client

* example of use:

```
$ tod-client -h

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
  4.1:  137.164.47.15    9.649 ms
  5.1:  137.164.23.130    9.681 ms
  6.1:  132.249.31.6    9.903 ms
  7.1:  192.172.226.123    9.868 ms
```

tod-client

* example of use:

```
$ tod-client

1 san-us ping 2001:48d0:101:501::132 attempts=1

1 data 2001:48d0:101:501::132 P 2001:48d0:101:501::5
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
```

tod-client

- a command is a single line of structured text:

  `<request_id> <source> <command> <target> <options>`

  ```
  1 san-us ping www.caida.org attempts=1
  2 lax-us trace www.caida.org attempts=1,method=icmp-paris
  ```

  - <request_id>: arbitrary numeric value provided by client
    - used by client for probe-response matching
  - <source>: Ark monitor
  - <target>: IPv4/IPv6 address or hostname
    - hostname resolved on monitor; useful for probing anycast targets
  - <options>: scamper ping/traceroute options
    - src/dest port, initial/max TTL, probing method (TCP, ICMP, UDP, paris versions), attempts, wait time between attempts, probe size, TOS, payload bytes, etc.

tod-client

* measurement result: single line of tab-delimited fields

```
<request_id> <type> <target> <data_1> ... <data_n>
```

```
1 data www.caida.org P  192.172.226.5   192.172.226.123 0
1       1328145562      R       0.297   1       64      S
0       192.172.226.123,0.297,64
```

```
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
```

```
3 error "1234.1234.1234" "malformed target or couldn't
resolve hostname to IP address"
```

tod-client

- special command syntax:

  `<request_id> <source> <command> <target> <options>`

```
1 @any ping @prefix=192.172.226.0/24
2 @any ping @ark=san-us
3 @any:ipv6 ping @ark=san-us:ipv6
4 @any:ipv6 ping @ark=any:ipv6
```

  - `@any` ⇒ pick any Ark monitor (`@any:ipv6` ⇒ that has IPv6); pick a different monitor on each use, cycling through monitors in random order
  - `@prefix=<IPv4/IPv6 prefix>` ⇒ pick a random destination in prefix
  - `@ark=<monitor>` / `@ark=any` ⇒ use an Ark monitor as the destination (`:ipv6` ⇒ probe IPv6 address)

Client Access

- case 2b: want greater control of measurements; possibly adaptive; *willing to use Ruby and Marinda*
  - write a measurement script that interacts directly with the topo-on-demand servers via Marinda
    - allows for maximum flexibility and control
  - actually fairly easy to do ... sample code in next slide

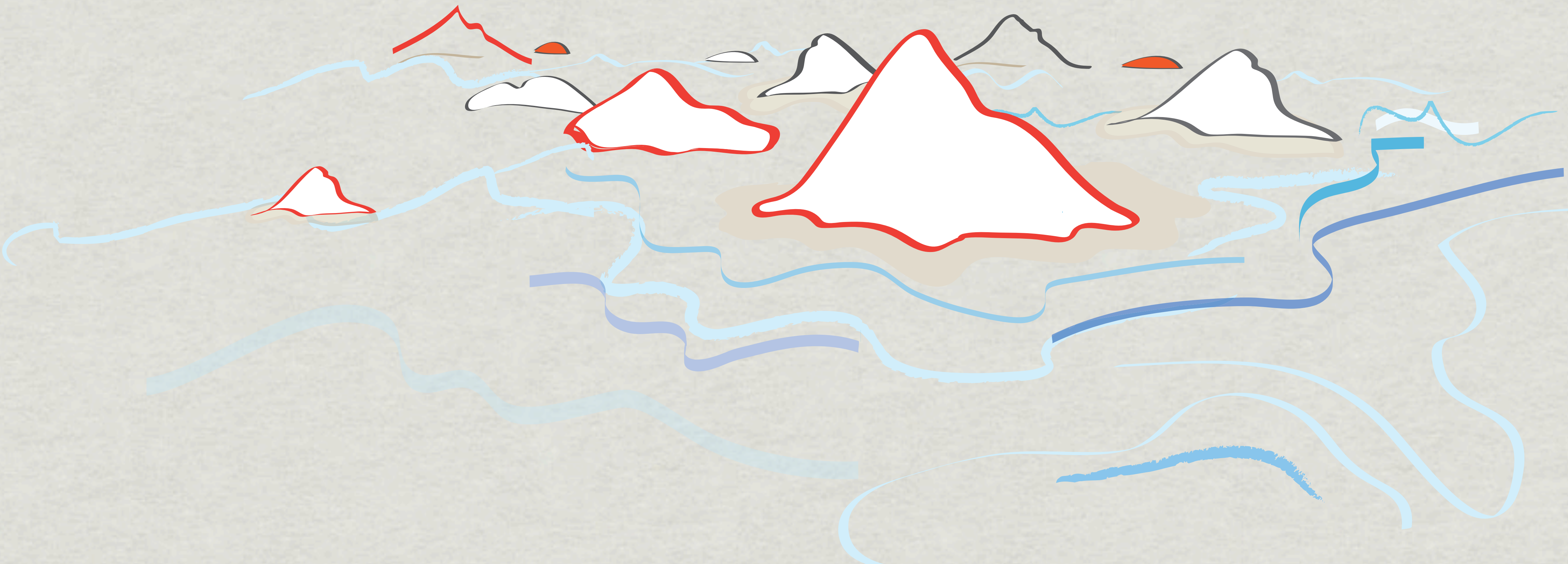
```ruby
#!/usr/bin/env ruby

require 'rubygems'
require 'marinda'

$c = Marinda::Client.new(UNIXSocket.open("/tmp/localts.sock"))
$c.hello
$tod = $c.open_port 2000, true

# 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]
p result
```

```
$ ./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"]
```

Future Work

- web interface to topo-on-demand service
- possibly give accounts on a CAIDA box to conduct topo-on-demand measurements
  - remove need to install software by users
- possible support services
  - BGP queries (e.g., current route to a given destination)
  - pick random destination in an AS/country/organization
  - IP to AS/prefix mapping
  - IP to router mapping (via ITDK)
  - geolocation lookups (via MaxMind's free database)

Thanks!



For more information or to request data:

www.caida.org/projects/ark

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