Network Automation with Salt and NAPALM (or how we control 100's of PoPs around the world)

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May 2016

CloudFlare (a quick background)

- Once a website is part of the CloudFlare community, its web traffic is routed through our global network of 80+ locations
- How big?
  - Four+ million zones/domains
  - Authoritative for ~40% of Alexa top 1 million
  - 43+ billion DNS queries/day
    - Second only to Verisign
- 80+ anycast locations globally
  - 40 countries (and growing)
- Origin CA

Our big network challenges

- Deploy new PoPs
- Human error factor
- Replace equipment
- Monitor

Automation framework requirements

- Very scalable
- Concurrency
- Easily configurable & customizable
- Config verification & enforcement
- Periodically collect statistics
- Native caching and drivers for useful tools

Available solutions (most used)

Opinions

“The learning curve for Salt is higher and the intro docs are rough, but in the long-term **Salt’s docs are much better than Ansible’s, because they’re way more complete** (which is also why they’re much worse as intro docs).”

Ryan D Lane

“To me, Ansible was a great introduction to automated server configuration and deployment. Moving forward, **the scalability, speed and architecture of Salt has it going for it**. For cloud deployments I find the Salt architecture to be a better fit. I would not hesitate to use Salt in the future.”

Jens Rantil

Salt: the “unwanted child” of network automation

configuration agents, operators can affect configuration changes in a more programmatic way. Cisco provides various tools and frameworks to enable developers automate and program Nexus devices, including – NX-API REST (brings Model Driven Programmability (MDP) to standalone, Python, Puppet, Chef, Ansible etc.

https://opennxos.cisco.com/public/getting-started

Automation with Chef/Puppet and Ansible

by sachin vasudeva on 10-21-2014 01:29 AM

https://forums.juniper.net/t5/Automation-Programmability/Automation-with-Chef-Puppet-and-Ansible/ba-p/261773

Why?

- Old references
- No feature for net devices as of yesterday
- Not well informed
- Not suitable for tiny VM networks

Salt at CloudFlare: used for years

Many thousands of servers already using Salt

Same tool for both servers and net devices

Salt (what fits the best our needs)	**Ansible** (most used in network automation)
• Long standing sessions • 20 types of modules • Customizable • Many thousands of CloudFlare servers • Comes embedded with features and tools • Native config enforcement logic • Real-time job • Job scheduling • Runner as a module • REST API • High Availability • GPG encryption • Pull from Git, SVN	• open/close session per module • 1 type of module • Customizable • ? • Need to install separate packages (“roles”) that are not necessarily dependent • Real-time job (Tower: $$) • Job Scheduling (Tower: $$) • Runner as a class • REST API (Ansible Tower: $$) • HA (Tower > Enterprise edition: $$$$) • Security (Tower: $$) • Pull from Git, SVN (Tower, $$)

Salt module types (selection)

- Execution modules 
- Grains 
- States 
- Runners 
- Pillars 
- Returners 

Embedded execution modules (selection)

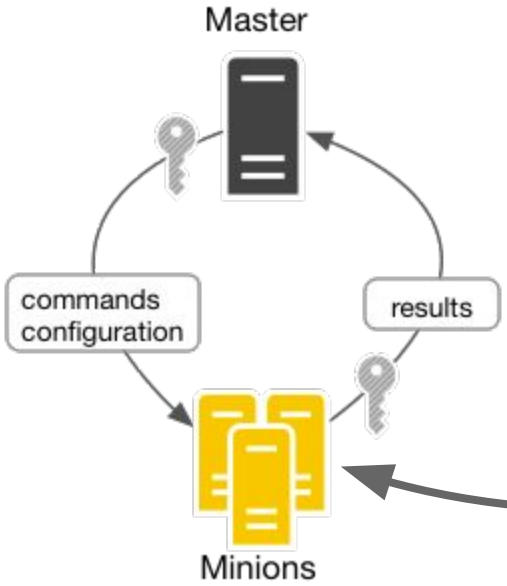
https://docs.saltstack.com/en/develop/ref/modules/all/index.html

Embedded returners (selection)

Easy to use: salt edge05.cph01 *net.facts* **--return sms**

https://docs.saltstack.com/en/develop/ref/returners/all/index.html

Architecture



Problem: you can't install minions on network devices!

https://www.digitalocean.com/community/tutorials/an-introduction-to-saltstack-terminology-and-concepts

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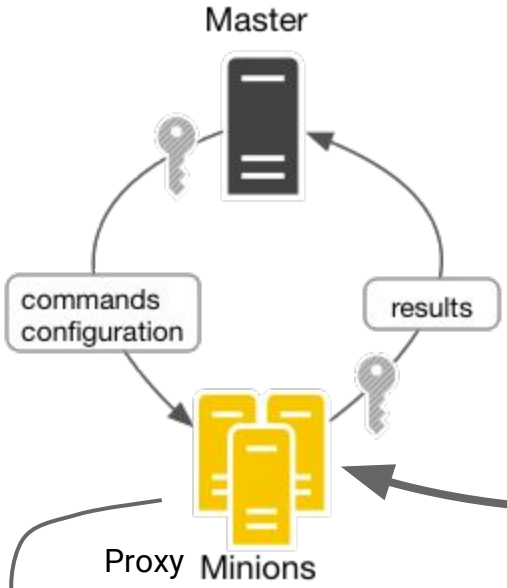
Proxy Minion



Solution:
proxy minions
They behave like minions, but
can talk to network devices

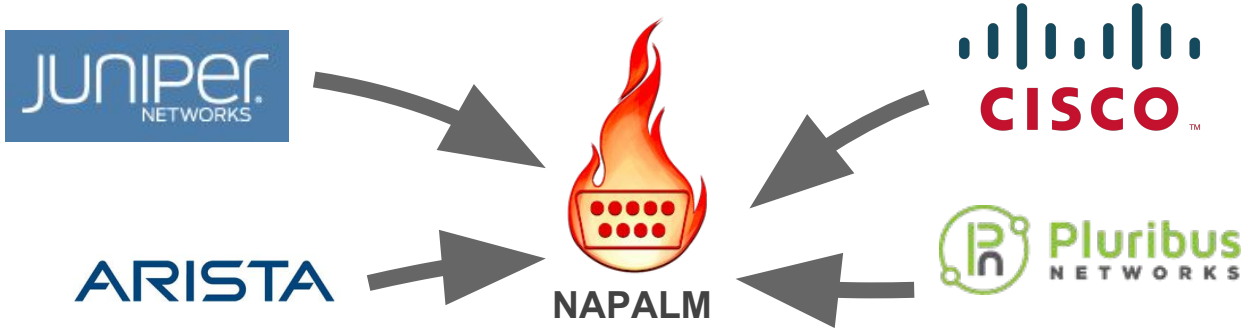
Disadvantages

- One proxy minion process / device

=> dedicated server preferred

```
  PID USER      PRI  NI  VIRT   RES   SHR S CPU% MEM%   TIME+  Command
18672 root       20   0  967M 98208 13400 S  0.0  0.1  0:43.14 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.prg01
19267 root       20   0  954M 81524 13176 S  0.0  0.1  0:47.88 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.mde01
18806 root       20   0  959M 86976 13136 S  0.0  0.1  0:48.55 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.kul01
19268 root       20   0  954M 81500 13344 S  0.0  0.1  0:44.57 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.pdx01
18772 root       20   0  965M 96228 13344 S  0.0  0.1  0:43.23 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.waw02
18794 root       20   0  956M 90192 13192 S  0.0  0.1  0:38.46 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.dme01
16573 root       20   0  957M   99M 13180 S  0.0  0.1  1:30.73 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.gru01
16638 root       20   0  802M 89644 10120 S  0.0  0.1  2:11.28 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.vie01
16803 root       20   0  802M 90032 10160 S  0.0  0.1  2:29.55 /usr/local/salt/virtualenv/bin/python2 /usr/local/salt/virtualenv/bin/salt-proxy --proxyid edge01.yyz01
```

NAPALM



(Network Automation and Programmability Abstraction Layer with Multivendor support)

https://github.com/napalm-automation

Fast growing library

February 2016

_	EOS	JunOS	IOS-XR	FortiOS	IBM	NXOS	IOS
get_facts	✅	✅	✅	✅	❌	✅	✅
get_interfaces	✅	✅	✅	✅	❌	✅	✅
get_lldp_neighbors	✅	✅	✅	✅	❌	❌	✅
get_bgp_neighbors	✅	✅	✅	✅	❌	❌	✅
get_environment	✅	✅	✅	✅	❌	❌	✅
get_interfaces_counters	✅	✅	✅	✅	❌	❌	✅

_	EOS	JunOS	IOS-XR	FortiOS	IBM	NXOS	IOS	Pluribus
cli	✅	✅	✅	❌	❌	✅	✅	✅
get_facts	✅	✅	✅	✅	❌	✅	✅	✅
get_environment	✅	✅	✅	✅	❌	❌	✅	❌
get_snmp_information	✅	✅	✅	❌	❌	✅	✅	✅
get_ntp_peers	✅	✅	✅	❌	❌	✅	❌	✅
get_ntp_stats	✅	✅	✅	❌	❌	✅	✅	✅
get_mac_address_table	✅	✅	✅	❌	❌	✅	✅	✅
get_arp_table	✅	✅	✅	❌	❌	✅	✅	❌
get_interfaces	✅	✅	✅	✅	❌	✅	✅	✅
get_interfaces_ip	✅	✅	✅	❌	❌	✅	✅	❌
get_lldp_neighbors	✅	✅	✅	✅	❌	❌	✅	✅
get_lldp_neighbors_detail	✅	✅	✅	❌	❌	✅	✅	✅
get_bgp_neighbors	✅	✅	✅	✅	❌	❌	✅	❌
get_bgp_neighbors_detail	❌	✅	✅	❌	❌	❌	❌	❌
get_bgp_config	✅	✅	✅	❌	❌	❌	❌	❌
get_route_to	✅	✅	✅	❌	❌	❌	❌	❌
get_probes_config	❌	✅	✅	❌	❌	❌	❌	❌
get_probes_results	❌	✅	✅	❌	❌	❌	❌	❌
get_users	✅	✅	✅	❌	❌	✅	❌	✅

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http://napalm.readthedocs.io/en/latest/support/index.html#getters-support-matrix

Open source recipe: napalm-salt

NAPALM

https://github.com/napalm-automation/napalm-salt

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NAPALM-Salt for Public use

- NAPALM integrated in Salt Carbon
- Execution Modules
  - NET
  - BGP
  - NTP
  - Probes
- States:
  - NTP, Probes

NAPALM-Salt (examples):

1. salt *“edge*”* net.**traceroute** 8.8.8.8
2. salt *-G “os:junos”* net.**cli** “show version”
3. salt *-C “sw* and G@os:nxos”* net.**arp**
4. salt *-G “os:iosxr and version:5.3.3”* net.**mac**
5. salt *-G “model:MX480”* probes.**results**
6. salt *-I “type:router”* ntp.**set_peers** 10.1.130.10 10.1.130.18 10.1.130.22

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Targeting minions: https://docs.saltstack.com/en/latest/topics/targeting/index.html

Output example:

```
# salt --out=json edge05.cph01 net.arp

[
  {
    "interface": "ae2.100",
    "ip": "10.0.0.1",
    "mac": "00:0f:53:36:e4:50",
    "age": 129.0
  },
  {
    "interface": "xe-0/0/3.0",
    "ip": "10.0.0.2",
    "mac": "00:1d:70:83:40:c0",
    "age": 1101.0
  },
  {
    "interface": "xe-0/0/3.0",
    "ip": "10.0.0.3",
    "mac": "10:0e:7e:de:84:07",
    "age": 1276.0
  },
```

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Abstracting configurations


```
protocols {
  bgp {
    group 4-PUBLIC-ANYCAST-PEERS {
      neighbor 192.168.0.1 {
      description "Amazon [WW HOSTING ANYCAST]";
      family inet {
      unicast {
        prefix-limit {
          maximum 500;
        }
      }
      peer-as 16509;
    }
  }
}
```


```
router bgp 13335
  neighbor 192.168.0.1
    remote-as 16509
    use neighbor-group 4-PUBLIC-ANYCAST-PEERS
    description "Amazon [WW HOSTING ANYCAST]"
    address-family ipv4 unicast
    maximum-prefix 500
```

Abstracted

```
bgp.neighbor:
  ip: 192.168.0.1
  group: 4-PUBLIC-ANYCAST-PEERS
  description: "Amazon [WW HOSTING ANYCAST]"
  remote_as: 16509
  prefix_limit: 500
```

Example

- Edge router with 1000 BGP peers
- Device is manufactured by *VendorA*
- Replaced by a device from *VendorB*

Most network engineers

Us

```
vi /etc/salt/pillar/edge05_cph01.sls
```

```
proxy:
  driver: VendorA
  proxytype: napalm
  host: edge05.cph01
  username: ripe
  passwd: xxxx
```

```
proxy:
  driver: VendorB
  proxytype: napalm
  host: edge05.cph01
  username: ripe
  passwd: xxxx
```

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Maintain configuration updates

Define NTP peers in the Pillar

```
ntp.peers:
  - 10.1.130.22
  - 10.1.130.18
  - 10.1.128.10
  - 10.1.131.10
  - 10.1.132.10
  - 10.2.52.10
  - 10.2.48.10
  - 10.2.55.10
  - 10.2.50.10
  - 10.2.56.10
```

Schedule config enforcement checks

```
schedule:
  ntp_config:
    function: state.sls
    args: router.ntp
    returner: smtp
    days: 1
  bgp_config:
    function: state.sls
    args: router.bgp
    hours: 2
  probes_config:
    function: state.sls
    args: router.probes
    days: 3
  users_config:
    function: state.sls
    args: router.users
    returner: hipchat
    weeks: 1
```

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NTP state output example

```
edge01.jnb01:
----------
          ID: ntp_config
    Function: netntp.managed
      Result: True
     Started: 09:50:41.228728
    Duration: 16813.319 ms
     Changes:
              ----------
              peers:
                  ----------
                  removed:
                      - 10.10.1.1
              servers:
                  ----------
                  added:
                      - 17.xxx.xx.253
                      - 40.xxx.xxx.7
                  removed:
                      - 83.xxx.xxx.118
                      - 92.xx.xxx.58
                      - 91.xx.xxx.42

Summary for edge01.jnb01
------------
Succeeded: 1 (changed=1)
Failed:    0
------------
Total states run:     1
Total run time:  16.813 s
```

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What else can I do?

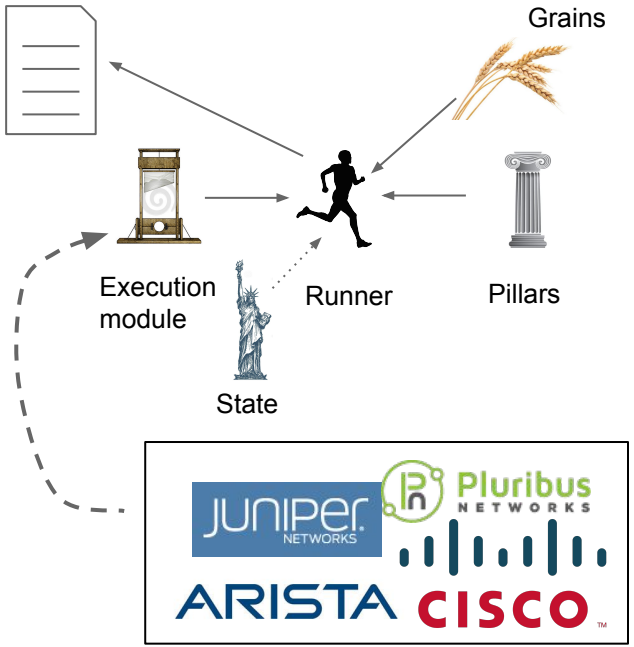
Examples:

Unique ASNs per geographic area

```
# salt-run bgp.asns_per_area

Canada : 96
Brazil : 167
Australia : 113
Peru : 4
USA : 410
Africa : 21
Asia : 362
Europe : 1004
North America : 421
South America : 183
Oceania : 162
Colombia : 5
Chile : 5
Argentina : 21

Execution time: 2.84680294991 s
#
```



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Find stuff (using Salt mine)

```
# salt-run net.find core01.sjc01
Pattern "core01.sjc01" found in the description of the following interfaces
================================================================================================================
|   Device   | Interface |  Interface Description   |  UP  | Enabled | Speed [Mbps] |    MAC Address    | IP Addresses |
================================================================================================================
| sw01.sjc01 |    ae0    |       core01.sjc01       | True |   True  |    40000     | 78:fe:3d:ed:02:83 |              |
----------------------------------------------------------------------------------------------------------------
| sw01.sjc01 |  xe-1/1/0 | ae0:core01.sjc01:Et3/2/3 | True |   True  |    10000     | 78:fe:3d:ed:02:83 |              |
----------------------------------------------------------------------------------------------------------------
| sw01.sjc01 |  xe-1/1/1 | ae0:core01.sjc01:Et3/2/4 | True |   True  |    10000     | 78:fe:3d:ed:02:83 |              |
----------------------------------------------------------------------------------------------------------------
| sw01.sjc01 |  xe-0/1/1 | ae0:core01.sjc01:Et3/2/2 | True |   True  |    10000     | 78:fe:3d:ed:02:83 |              |
----------------------------------------------------------------------------------------------------------------

# salt-run net.find 54:e0:32:7e:85:2d
Details for interface xe-4/0/5 on device edge01.sjc01
============================================================================================================
|    Device    | Interface | Interface Description | UP | Enabled | Speed [Mbps] |    MAC Address    | IP Addresses |
============================================================================================================
| edge01.sjc01 |  xe-4/0/5 |                       |    |   True  |    10000     | 54:e0:32:7e:85:2d |              |
------------------------------------------------------------------------------------------------------------

# salt-run net.find 00:0f:53:36:e4:50
Found ARP entry on edge05.cph01: 10.0.0.1 <-> 00:0F:53:36:E4:50
```

BGP neighbors of some ASNs

```
# salt-run bgp.neighbors 15169 16509 32934 13414


BGP Neighbors for 15169, 16509, 32934, 13414:
================================================================================================================================
|    Device     |As Number |         Neighbor Address         | State|#Active/Received/Accepted/Damped |         Policy In          |
================================================================================================================================
| edge01.dub01  | 15169    | 20                               | Established 27/48/48/0               | 6-PUBLIC-PEER-IN           |
| edge01.dub01  | 16509    | 20                               | Established 1/1/1/0                  | 6-PUBLIC-PEER-IN           |
| edge01.nrt01  | 13414    | 20                               | Established 59/59/59/0               | 4-PUBLIC-PEER-IN           |
| edge01.nrt01  | 13414    | 20                               | Established 3/3/3/0                  | 6-PUBLIC-PEER-IN           |
| edge01.nrt01  | 16509    | 20                               | Established 71/71/71/0               | 4-PUBLIC-PEER-IN           |
| edge01.nrt01  | 16509    | 20                               | Established 1/1/1/0                  | 6-PUBLIC-PEER-IN           |
| edge01.nrt01  | 32934    | 20                               | Established 26/26/26/0               | 4-PUBLIC-PEER-IN           |
| edge01.nrt01  | 32934    | 20                               | Established 14/15/14/0               | 6-PUBLIC-PEER-IN           |
| edge01.nrt01  | 15169    | 20                               | Established 331/331/331/0            | 4-PUBLIC-PEER-IN           |
| edge01.tpe01  | 15169    | 20                               | Established 331/331/331/0            | 4-PUBLIC-PEER-IN           |
| edge01.tpe01  | 15169    | 24                               1   | Established 48/48/48/0               | 6-PUBLIC-PEER-IN           |
| edge01.waw02  | 16509    | 19                               | Established 5/5/5/0                  | 4-PUBLIC-PEER-IN           |
| edge01.waw02  | 15169    | 19                               | Established 177/331/331/0            | 4-PUBLIC-PEER-IN           |
| edge01.waw02  | 15169    | 20                               | Established 22/48/48/0               | 6-PUBLIC-PEER-IN           |
| edge01.waw02  | 32934    | 21                               | Established 26/26/26/0               | 4-PUBLIC-PEER-IN           |
| edge01.waw02  | 32934    | 20                               | Established 14/14/14/0               | 6-PUBLIC-PEER-IN           |
| edge01.lhr01  | 13414    | 19                               | Established 59/59/59/0               | 4-PUBLIC-PEER-IN           |
| edge01.lhr01  | 16509    | 20                               | Established 0/1/0/0                  | REJECT-ALL                 |
| edge01.gru01  | 32934    | 20                               | Established 12/12/12/0               | 6-PUBLIC-PEER-IN           |
```

Monitor your network

```
# Redis details:
redis.host: localhost
redis.port: 6379

# Schedulers
schedule:
  traceroute_runner:
    function: traceroute.collect
    hours: 2
```

```
2071) "traceroute:edge01.sjc01-edge01.lhr01-Tata-4"
2072) "traceroute:edge01.iad02-edge01.sjc01-GTT-4"
2074) "traceroute:edge01.fra03-edge01.sea01-Cogent-4"
2075) "traceroute:edge01.yul01-edge01.lax01-Cogent-4"
2076) "traceroute:edge01.zrh01-edge01.fra03-GTT-4"
2077) "traceroute:edge01.mxp01-edge01.ams01-GTT-4"
2078) "traceroute:edge01.mia01-edge01.lhr01-GTT-4"
2079) "traceroute:edge01.msp01-edge01.scl01-Telefonica-4"
2080) "traceroute:edge01.fra03-edge01.mia01-Telia-4"
2081) "traceroute:edge01.lim01-edge01.scl01-Telefonica-4"
2082) "traceroute:edge01.arn01-edge01.mia01-GTT-4"
2083) "traceroute:edge01.prg01-edge01.lax01-GTT-4"
2084) "traceroute:edge01.osl01-edge01.lhr01-GTT-4"
```

Traceroute diff

```
Current:

----------------  -------------  -------------  ----------
time              src            dst            probe loss
10:22:46 14-05-16  1.1.1.1        2.2.2.2        26
                   edge01.phx01   edge01.lax01
----------------  -------------  -------------  ----------
---  ------  ------  ------  -------------  ------------------------------------  ---  ------------------------------------
hop  rtt 1   rtt 2   rtt 3   ip             host                                  asn  asn description
1    29.663  29.705  30.057  [redacted]     be2929.ccr21.phx02                    [redacted]  [redacted]
2    41.987                                 be2932.ccr22.lax01
             42.604  41.051                 be2931.ccr21.lax01
3    41.912          42.036                 be2179.ccr23.lax05
             41.685                         be2180.ccr23.lax05
4    66.714  66.504  66.329  2.2.2.2        2.2.2.2
---  ------  ------  ------  -------------  ------------------------------------  ---  ------------------------------------

Previous:

----------------  -------------  -------------  ----------
time              src            dst            probe loss
08:32:15 14-05-16  1.1.1.1        2.2.2.2        0

----------------  -------------  -------------  ----------
---  ------  ------  ------  -------------  ------------------------------------  ---  ------------------------------------
hop  rtt 1   rtt 2   rtt 3   ip             host                                  asn  asn description
1    29.71                                  be2929.ccr21.phx02                    [redacted]  [redacted]
             30.569  30.092                 be2930.ccr22.phx02
2    41.453  43.002                         be2931.ccr21.lax01
                     41.272                 be2932.ccr22.lax01
3    43.856                                 be2180.ccr23.lax05
             42.465  41.741                 be2179.ccr23.lax05
4    41.433  42.812  41.479  2.2.2.2        2.2.2.2
---  ------  ------  ------  -------------  ------------------------------------  ---  ------------------------------------
```

How can you use it?

apt-get install salt-master (install guide)
pip install napalm

Examples:
https://github.com/napalm-automation/napalm-salt

How can you contribute?

GitHub

- NAPALM Automation: https://github.com/napalm-automation
- SaltStack https://github.com/saltstack/salt

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Need help/advice?

Join https://networktocode.herokuapp.com/
rooms: #**saltstack** #**napalm**

By email:

- Mircea Ulinic: mircea@cloudflare.com
- Jerome Fleury: jf@cloudflare.com

Questions

By email:

- Mircea Ulinic: mircea@cloudflare.com
- Jerome Fleury: jf@cloudflare.com