Network automation at scale

Up and running in 60 minutes

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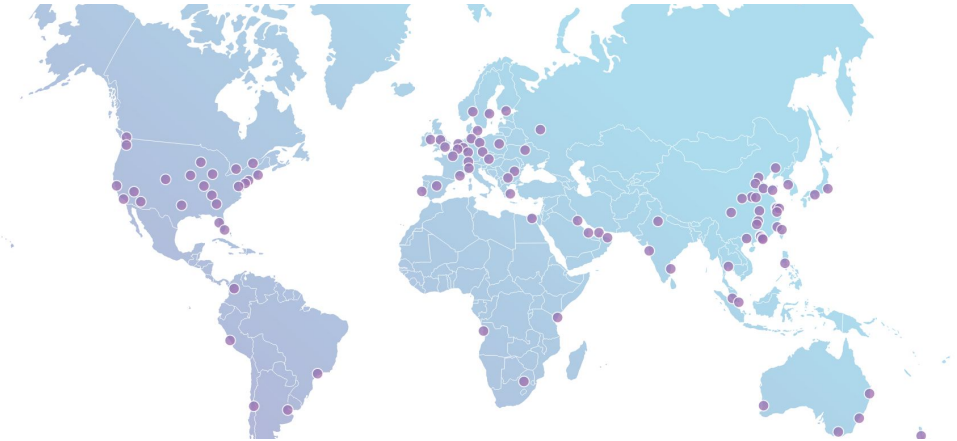
Why us?

- How big?
  - Four+ million zones/domains
  - Authoritative for ~40% of Alexa top 1 million
  - 43+ billion DNS queries/day
    - Second only to Verisign
- 100+ anycast locations globally
  - 50 countries (and growing)
  - Many hundreds of network devices



Agenda

- Meet the tools
- Install the tools
- Configure SaltStack
- CLI syntax
- Configuration management
- Advanced topics

Prerequisites

- No programming skills required (but very welcome)!
- Basic system ops
- Networking (of course)
- Basic YAML & Jinja understanding

  (6 simple rules is all you need for the beginning)

  See YAML gotchas

To automate, I have to learn Python or another programming language.

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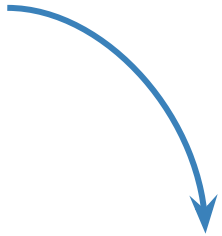
WRONG!

Do not jump into implementation.
Design first!

What’s the best tool?

Wrong question.



~~What's the best tool?~~

What’s the best tool for my network?

What's the best tool for my network?

- Mind your network
- How many devices?
- How many platforms / operating systems?
- How dynamic?
- Configuration management only?
- Triggered configuration changes?
- External sources of truth? e.g. IPAM
- Do you need native caching? REST API? etc...

Live setup

- Access to a remote server

OR

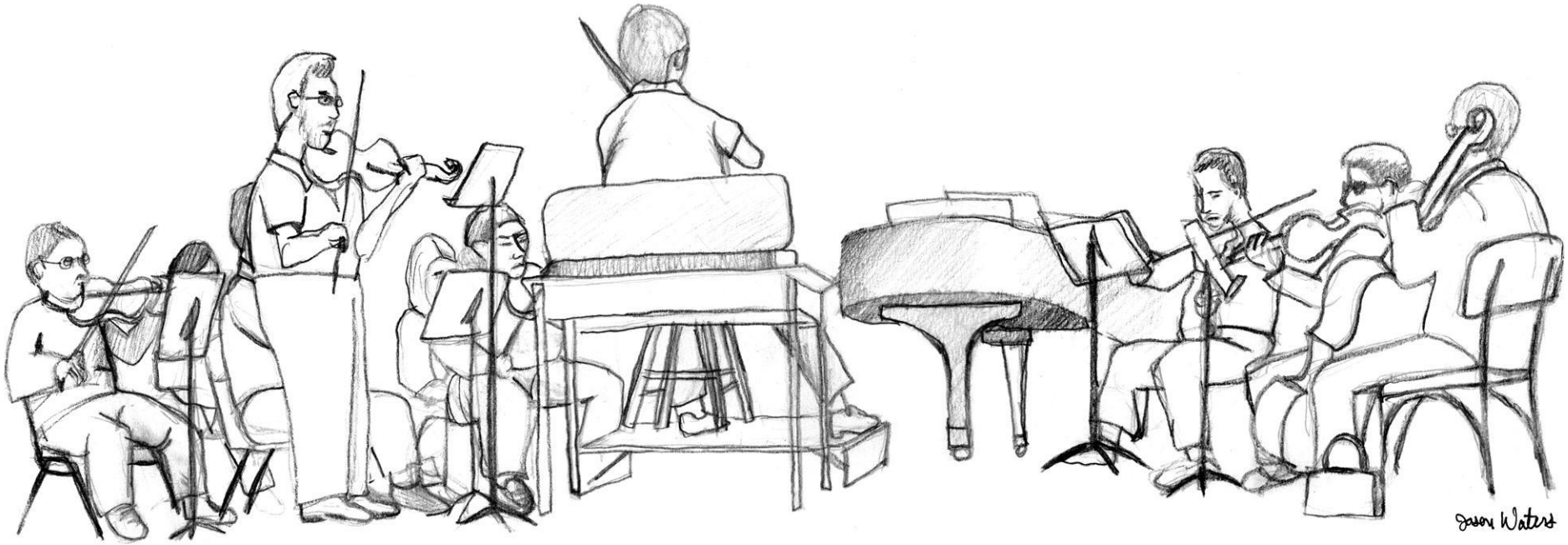
- Vagrant + VM(s) from your favourite vendor(s)

The power of Salt can be seen when managing high number of real network devices!

Why Salt?

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

Meet the Tools
Orchestration vs. Automation



Meet the Tools
Why Salt?

"

In SaltStack, speed isn't a byproduct, it is a design goal. SaltStack was created as an extremely fast, lightweight communication bus to provide the foundation for a remote execution engine.

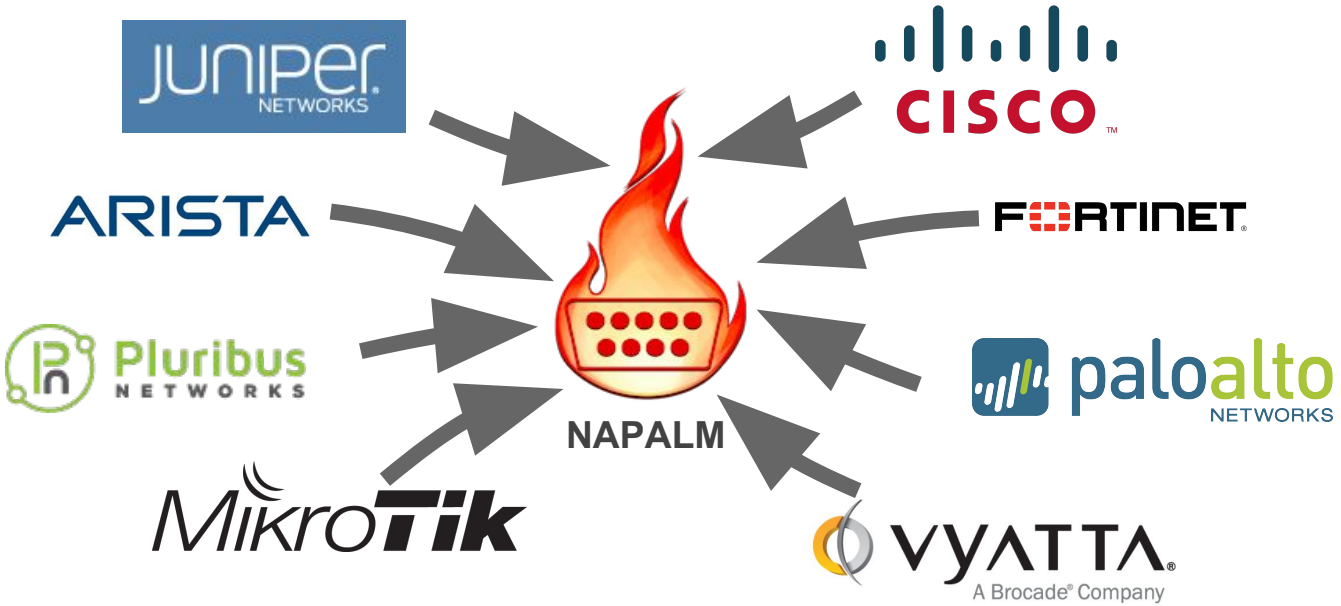
SaltStack now provides orchestration, configuration management, event reactors, cloud provisioning, and more, all built around the SaltStack high-speed communication bus.

… + cross-vendor network automation from 2016.11 (Carbon) "

https://docs.saltstack.com/en/getstarted/speed.html

Meet the Tools
Why NAPALM?

(Network Automation and Programmability Abstraction Layer with Multivendor support)



https://github.com/napalm-automation

NAPALM integrated in SaltStack

NETWORK AUTOMATION: NAPALM

Beginning with 2016.11.0, network automation is inclued by default in the core of Salt. It is based on the NAPALM library and provides facilities to manage the configuration and retrieve data from network devices running widely used operating systems such as: JunOS, IOS-XR, eOS, IOS, NX-OS etc. - see the complete list of supported devices.

The connection is established via the `NAPALM proxy`.

In the current release, the following modules were included:

- `NAPALM grains` - Select network devices based on their characteristics
- `NET execution module` - Networking basic features
- `NTP execution module`
- `BGP execution module`
- `Routes execution module`
- `SNMP execution module`
- `Users execution module`
- `Probes execution module`
- `NTP peers management state`
- `SNMP configuration management state`
- `Users management state`

https://docs.saltstack.com/en/develop/topics/releases/2016.11.0.html

NAPALM integrated in SaltStack: next release

Introduced in 2016.11, the modules for cross-vendor network automation have been improved, enhanced and widenened in scope:

- Manage network devices like servers: the NAPALM modules have been transformed so they can run in both proxy and regular minions. That means, if the operating system allows, the salt-minion package can be installed directly on the network gear. Examples of such devices (also covered by NAPALM) include: Arista, Cumulus, Cisco IOS-XR or Cisco Nexus.
- Not always alive: in certain less dynamic environments, maintaining the remote connection permanently open with the network device is not always beneficial. In those particular cases, the user can select to initialize the connection only when needed, by specifying the field `always_alive: false` in the `proxy configuration` or using the `proxy_always_alive` option.
- Proxy keepalive: due to external factors, the connection with the remote device can be dropped, e.g.: packet loss, idle time (no commands issued within a couple of minutes or seconds), or simply the device decides to kill the process. In Nitrogen we have introduced the functionality to re-establish the connection. One can disable this feature through the `proxy_keep_alive` option and adjust the polling frequency speciying a custom value for `proxy_keep_alive_interval`, in minutes.

New modules:

- `Netconfig state` - Manage the configuration of network devices using arbitrary templates and the Salt-specific advanced templating methodologies.
- `Network ACL execution module` - Generate and load ACL (firewall) configuration on network devices.
- `Network ACL state` - Manage the firewall configuration. It only requires writing the pillar structure correctly!
- `NAPALM YANG execution module` - Parse, generate and load native device configuration in a standard way, using the OpenConfig/IETF models. This module cotains also helpers for the states.
- `NET finder` - Runner to find details easily and fast. It's smart enough to know what you are looking for. It will search in the details of the network interfaces, IP addresses, MAC address tables, ARP tables and LLDP neighbors.
- `BGP finder` - Runner to search BGP neighbors details.
- `NAPALM syslog` - Engine to import events from the napalm-logs library into the Salt event bus. The events are based on the syslog messages from the network devices and structured following the OpenConfig/IETF YANG models.

https://docs.saltstack.com/en/develop/topics/releases/nitrogen.html

Install the tools
Install NAPALM

```
$ pip install napalm
```

See Complete installation notes

Install the tools
Install SaltStack

```
$ sudo apt-get install salt-master
$ sudo apt-get install salt-minion
```

See Complete installation notes

Installing SaltStack and NAPALM

Install the tools
E.g.: Install SaltStack on Debian

- `sudo echo 'deb http://httpredir.debian.org/debian jessie-backports main' >> /etc/apt/sources.list`
- `sudo echo 'deb http://repo.saltstack.com/apt/debian/8/amd64/latest jessie main' >> /etc/apt/sources.list.d/saltstack.list`
- `wget -O - https://repo.saltstack.com/apt/debian/8/amd64/latest/SALTSTACK-GPG-KEY.pub | sudo apt-key add -`
- `sudo apt-get update`
- `sudo apt-get install salt-master`
- `sudo apt-get install salt-minion`

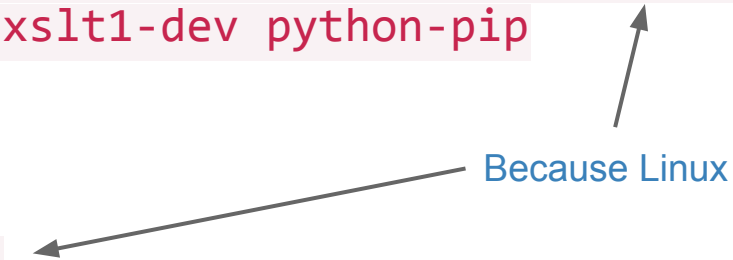
Install the tools
E.g.: Install NAPALM on Debian

Dependencies:

- `sudo apt-get install -y --force-yes libffi-dev libssl-dev python-dev python-cffi libxslt1-dev python-pip`

PyPi packages:

- `pip install --upgrade cffi`
- `pip install napalm-junos napalm-ios`



Configure Vagrant

This assumes Vagrant and VirtualBox are already installed

Vagrantfile examples:

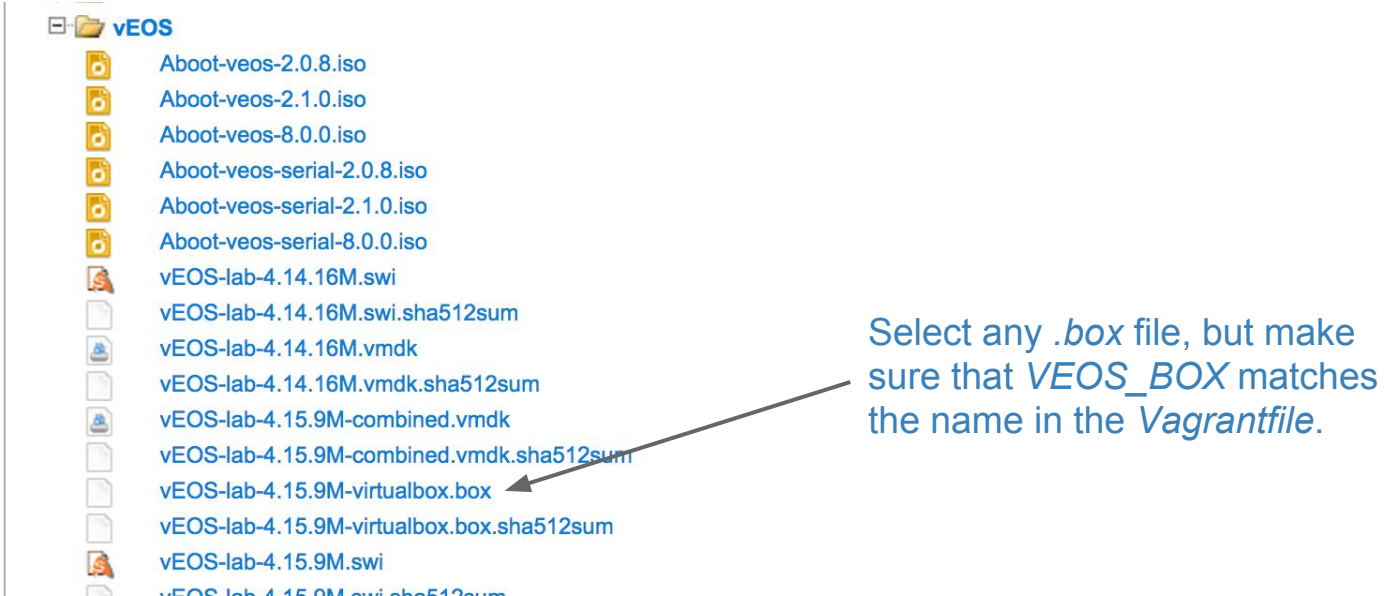
What I use

Something simpler

NOTE: skip this section if you are running in a real network environment (preferable)

Configure Vagrant
Download vEOS

Go to Arista software download (account required)



Configure Vagrant
Download vSRX

```
$ vagrant box add juniper/ffp-12.1X47-D20.7-packetmode
==> box: Loading metadata for box 'juniper/ffp-12.1X47-D20.7-packetmode'
    box: URL: https://vagrantcloud.com/juniper/ffp-12.1X47-D20.7-packetmode
This box can work with multiple providers! The providers that it
can work with are listed below. Please review the list and choose
the provider you will be working with.

1) virtualbox
2) vmware_desktop

Enter your choice: 1
==> box: Adding box 'juniper/ffp-12.1X47-D20.7-packetmode' (v0.5.0) for provider: virtualbox
    box: Downloading:
https://atlas.hashicorp.com/juniper/boxes/ffp-12.1X47-D20.7-packetmode/versions/0.5.0/providers/virtualbox.box
==> box: Successfully added box 'juniper/ffp-12.1X47-D20.7-packetmode' (v0.5.0) for 'virtualbox'!
```

Configure Vagrant
Start Vagrant boxes

```
$ vagrant up vsrx
Bringing machine 'vsrx' up with 'virtualbox' provider...
==> vsrx: Setting the name of the VM: mirucha_vsrx_1483551699725_41640
==> vsrx: Clearing any previously set network interfaces...
==> vsrx: Preparing network interfaces based on configuration...
    vsrx: Adapter 1: nat
    vsrx: Adapter 2: intnet
    vsrx: Adapter 3: intnet
    vsrx: Adapter 4: intnet
    vsrx: Adapter 5: intnet
==> vsrx: Forwarding ports...
    vsrx: 22 (guest) => 12202 (host) (adapter 1)
    vsrx: 830 (guest) => 12830 (host) (adapter 1)
    vsrx: 80 (guest) => 12280 (host) (adapter 1)
==> vsrx: Booting VM...
==> vsrx: Waiting for machine to boot. This may take a few minutes...
    vsrx: SSH address: 127.0.0.1:12202
    vsrx: SSH username: vagrant
    vsrx: SSH auth method: private key
        vsrx:
```

Configure SaltStack

New to Salt?

Pillar

Free-form data that can be used to organize configuration values or manage sensitive data, e.g.: interface details, NTP peers, BGP config…

written by the user, generally one file per device,

or use external pillar (e.g. databases, vault, etc. - see all)

Grains

data collected from the device, e.g.: device model, vendor, uptime, serial number etc.

Salt handles this, you don't need to do anything

Salt in 10 minutes: https://docs.saltstack.com/en/latest/topics/tutorials/walkthrough.html

Configure SaltStack
Master config

/etc/salt/master

```
file_roots:
  base:
    - /etc/salt/pillar
    - /etc/salt/states
    - /etc/salt/reactors
    - /etc/salt/templates
pillar_roots:
  base:
    - /etc/salt/pillar
```

Environment name

Useful to have different environments: prod, qa, develop etc.

For the beginning, let's focus only on ***file_roots*** and ***pillar_roots***. The other settings are more advanced features: https://docs.saltstack.com/en/latest/ref/configuration/master.html

Complete salt master config file

Configure SaltStack
Proxy config

/etc/salt/proxy

```
master: localhost
pki_dir: /etc/salt/pki/proxy
cachedir: /var/cache/salt/proxy
multiprocessing: False
mine_enabled: True
```

Very important!

More about proxy minions: https://docs.saltstack.com/en/latest/topics/proxyminion/index.html

Configure SaltStack
Device *pillar*

Under the pillar_roots directory (as configured in **/etc/salt/master**):

/etc/salt/pillar/device1.sls

```
proxy:
  proxytype: napalm
  driver: junos
  host: hostname_or_ip_address
  username: my_username
  passwd: my_password
```

Mandatory

Choose between: junos, eos, ios, iosxr, nxos, etc. See the complete list.

Complete documentation at: https://docs.saltstack.com/en/develop/ref/proxy/all/salt.proxy.napalm.html

Configure SaltStack
The *top* file

Under the pillar_roots directory (as configured in **`/etc/salt/master`**):

`/etc/salt/pillar/top.sls`

```
base:
  device1:
    - device1
  device2:
    - device2
```

minion ID

This is how the device will be identified from now on.
It can be anything, does **not** need to match with the *.sls* file or the hostname.

Environment name

Useful to have different envs: prod, qa, develop etc.

.sls file to be included

Specify the name of the .sls file descriptor (earlier defined).
Do **NOT** include the *.sls* extension.

Configure SaltStack
master systemd file (optional)

/etc/systemd/system/salt-master.service

```
[Unit]
Description=Salt Master
Requires=network.target
After=network.target

[Service]
Type=forking
PIDFile=/var/run/salt-master.pid
# ***NOTE*** the virtualenv here!  Your location may vary!
ExecStart=/usr/bin/salt-master -d
Restart=on-failure
RestartSec=15

[Install]
WantedBy=multi-user.target
```

Configure SaltStack
proxy systemd file (optional)

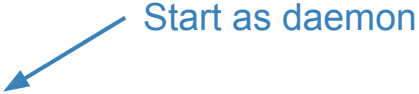
/etc/systemd/system/salt-proxy@.service

```
[Unit]
Description=Salt proxy minion
After=network.target

[Service]
Type=simple
# ***NOTE*** the virtualenv here!  Your location may vary!
ExecStart=/usr/bin/salt-proxy -l debug --proxyid %I
User=root
Group=root
Restart=always
RestartPreventExitStatus=SIGHUP
RestartSec=5

[Install]
WantedBy=default.target
```

Configure SaltStack
Start the salt-master

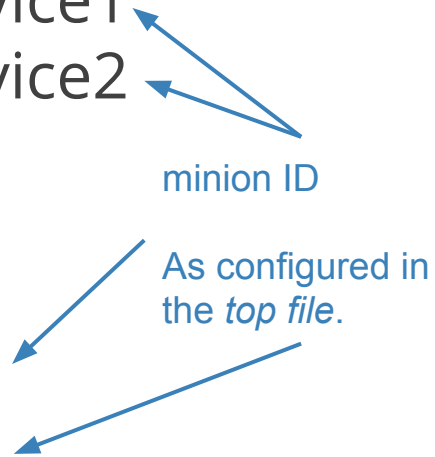
- With systemd:
  - $ sudo systemctl start salt-master

- Without systemd:
  - $ sudo salt-master -d



Configure SaltStack
Start the salt-proxy processes

- With systemd:
  - $ sudo systemctl start salt-proxy@device1
  - $ sudo systemctl start salt-proxy@device2



- Without systemd:
  - $ sudo salt-proxy -d --proxyid device1
  - $ sudo salt-proxy -d --proxyid device2

Configure SaltStack
Accept the proxies connection to the master

For each device, accept the minion key:

```
$ sudo salt-key -a device1
The following keys are going to be accepted:
Unaccepted Keys:
device1
Proceed? [n/Y] y
Key for minion device1 accepted.
```

minion ID

As configured in the *top file*.

This is due to security reasons.
More about salt-key: https://docs.saltstack.com/en/latest/ref/cli/salt-key.html
NOTE: Accepting the minion keys can be automated as well.

Done!
You are now ready to automate your network!

Salt CLI syntax

Selecting the devices we need to run the command.

Targeting can be complex:
https://docs.saltstack.com/en/latest/topics/targeting/

Function name, as specified in the module documentation.

For example if we need BGP-related commands, we'll look at the BGP module.

Other examples: dnsutil.A, net.arp, net.lldp, net.traceroute etc.

Function arguments, as specified in the module documentation.
Some functions do not require any arguments.

Salt CLI syntax
Examples

```
$ sudo salt 'edge*' net.traceroute 8.8.8.8
# execute traceroute on all devices whose minion ID starts with ‘edge’
$ sudo salt -N NA transit.disable cogent
# disable Cogent in North-America
$ sudo salt -G 'os:junos' net.cli “show version”
# execute ‘show version’ on all devices running JunOS
$ sudo salt -C 'edge* and G@os:iosxr and G@version:6.0.2' net.arp
# get the ARP tables from devices whose ID starts with edge*, running IOS-XR 6.0.2
$ sudo salt -G 'model:MX480' probes.results
# retrieve the results of the RPM probes from all Juniper MX480 routers
```

‘NA’ is a nodegroup:

https://docs.saltstack.com/en/latest/topics/targeting/nodegroups.html

Salt CLI syntax
Output example

Default output style: nested.

```
$ sudo salt edge01.iad01 net.arp
edge01.iad01:
    ----------
    out:
        |_
          ----------
          age:
              129.0
          interface:
              ae2.100
          ip:
              10.0.0.1
          mac:
              00:0f:53:36:e4:50
        |_
          ----------
          age:
              1101.0
          interface:
              xe-0/0/3.0
          ip:
              10.0.0.2
          mac:
              00:1d:70:83:40:c0
```

Salt CLI syntax
Outputters

```
$ salt --out=json edge01.iad01 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
  },
```

Using the --out optional argument, one can select the output format.

```
$ salt --out=yaml edge01.iad01 net.arp
edge01.iad01:
  comment: ''
  out:
  - age: 129.0
    interface: ae2.100
    ip: 10.0.0.1
    mac: 00:0f:53:36:e4:50
  - age: 1101.0
    interface: xe-0/0/3.0
    ip: 10.0.0.2
    mac: 00:1d:70:83:40:c0
```

Other outputters: https://docs.saltstack.com/en/develop/ref/output/all/index.html

Configuration management

Load static config

```
$ sudo salt -G 'vendor:arista' net.load_config text='ntp server 172.17.17.1'
edge01.bjm01:
    ----------
    already_configured:
        False
    comment:
    diff:
        @@ -42,6 +42,7 @@
         ntp server 10.10.10.1
         ntp server 10.10.10.2
         ntp server 10.10.10.3
        +ntp server 172.17.17.1
         ntp serve all
         !
    result:
        True
edge01.pos01:
    ----------
    already_configured:
        True
    comment:
    diff:
    result:
        True
```

Match all Arista devices from the network.

Config diff

No changes required on this device.

Configuration management

Load static config: dry-run

```
$ sudo salt edge01.bjm01 net.load_config text='ntp server 172.17.17.1' test=True
edge01.bjm01:
    ----------
    already_configured:
        False
    comment:
        Configuration discarded.
    diff:
        @@ -42,6 +42,7 @@
         ntp server 10.10.10.1
         ntp server 10.10.10.2
         ntp server 10.10.10.3
        +ntp server 172.17.17.1
         ntp serve all
         !
    result:
        True
```

Dry-run mode

Changes are discarded.

Configuration management
Load static config

Loading static config
(more changes)

```
$ cat /home/mircea/arista_ntp_servers.cfg
ntp server 172.17.17.1
ntp server 172.17.17.2
ntp server 172.17.17.3
ntp server 172.17.17.4
```

```
$ sudo salt edge01.bjm01 net.load_config /home/mircea/arista_ntp_servers.cfg test=True
edge01.bjm01:
    ----------
    already_configured:
        False
    comment:
        Configuration discarded.
    diff:
        @@ -42,6 +42,10 @@
         ntp server 10.10.10.2
         ntp server 10.10.10.3
        +ntp server 172.17.17.1
        +ntp server 172.17.17.2
        +ntp server 172.17.17.3
        +ntp server 172.17.17.4
         ntp serve all
         !
    result:
        True
```

Absolute path

Configuration management
Inline Templating

```
$ sudo salt edge01.bjm01 net.load_template set_hostname template_source='hostname {{ host_name }}' host_name='arista.lab'
edge01.bjm01:
    ----------
    already_configured:
        False
    comment:
    diff:
        @@ -35,7 +35,7 @@
         logging console emergencies
         logging host 192.168.0.1
         !
        -hostname edge01.bjm01
        +hostname arista.lab
         !
    result:
        True
```

Observe the function name is: net.load_template

Inline template

Template var

NOTE: the template is evaluated on the minion

Configuration management
Grains inside the templates

```
$ sudo salt edge01.bjm01 net.load_template set_hostname template_source='hostname {{ grains.model }}.lab'
edge01.bjm01:
    ----------
    already_configured:
        False
    comment:
    diff:
        @@ -35,7 +35,7 @@
         logging console emergencies
         logging host 192.168.0.1
         !
        -hostname edge01.bjm01
        +hostname DCS-7280SR-48C6-M-R.lab
         !
    result:
        True
```

Router model is collected from the grains

Configuration management
Cross vendor templating (1)

/home/mircea/example.jinja

```
{%- set router_vendor = grains.vendor -%}
{%- set hostname = pillar.proxy.host -%}
{%- if router_vendor|lower == 'juniper' %}
system {
    host-name {{hostname}}.lab;
}
{%- elif router_vendor|lower in ['cisco', 'arista'] %}
{# both Cisco and Arista have the same syntax for hostname #}
hostname {{hostname}}.lab
{%- endif %}
```

Hostname already specified in the pillar.

Get the device vendor from the grains

Configuration management
Cross vendor templating (2)

```
$ sudo salt '*' net.load_template /home/mircea/example.jinja
edge01.bjm01:
    ----------
    already_configured:
        False
    comment:
    diff:
        @@ -35,7 +35,7 @@
         logging console emergencies
         logging host 192.168.0.1
         !
        -hostname edge01.bjm01
        +hostname edge01.bjm01.lab
         !
    result:
        True
```

Arista device

```
edge01.flw01:
    ----------
    already_configured:
        False
    comment:
    diff:
        [edit system]
        -  host-name edge01.flw01;
        +  host-name edge01.flw01.lab;
    result:
        True
```

Juniper device

Many vendors, one simple template!

Configuration management
Debug mode

```
$ sudo salt edge01.flw01 net.load_template /home/mircea/example.jinja debug=True
edge01.flw01:
    ----------
    already_configured:
        False
    comment:
    diff:
        [edit system]
        -  host-name edge01.flw01;
        +  host-name edge01.flw01.lab;
    loaded_config:
        system {
            host-name edge01.flw01.lab;
        }
    result:
        True
```

Absolute path

Debug mode

The result of template rendering.
Not necessarily equal to the diff.

Note: Jinja is painful to debug.
This option is very helpful.
See more debugging tools

Configuration management
The right way to specify the template source

```
$ sudo salt edge01.flw01 net.load_template salt://example.jinja debug=True
edge01.flw01:
    ----------
    already_configured:
        False
    comment:
    diff:
        [edit system]
        -   host-name edge01.flw01;
        +   host-name edge01.flw01.lab;
    loaded_config:
        system {
            host-name edge01.flw01.lab;
        }
    result:
        True
```

Translated to *file_roots*,
as specified in the master config file - see slide #28.

Adding */etc/salt/templates* under *file_roots*, one can beautifully structure and define the template file under the path:

/etc/salt/templates/example.jinja and call using:

salt://example.jinja

Configuration management
Remote templates

Yes, they can also be elsewhere.
Available options: *salt://*, *ftp://*, *http://*, *https://*,
version control, cloud storage providers etc.

```
$ sudo salt -G 'os:ios' net.load_template http://bit.ly/2gKOj20 peers="['172.17.17.1', '172.17.17.2']"
```

Matches all devices running IOS

Loads external template from http://bit.ly/2gKOj20 which shortens the link to the NAPALM native template for IOS.

Configuration management

Advanced templating: reusing existing data (1)

/etc/salt/templates/arp_example.jinja

```
{%- set arp_output = salt.net.arp() -%}
{%- set arp_table = arp_output['out'] -%}

{%- if grains.os|lower == 'iosxr' %} {# if the device is a Cisco IOS-XR #}
  {%- for arp_entry in arp_table %}
arp {{ arp_entry['ip'] }} {{ arp_entry['mac'] }} arpa
  {%- endfor -%}
{%- elif grains.vendor|lower == 'juniper' %} {# or if the device is a Juniper #}
interfaces {
  {%- for arp_entry in arp_table %}
  {{ arp_entry['interface'] }} {
    family inet {
      address {{ arp_entry['ip'] }} {
       arp {{ arp_entry['ip'] }} mac {{ arp_entry['mac'] }};
      }
    }
  }
  {%- endfor %}
}
{%- endif %}
```

Retrieving the ARP table using the net.arp function.

Configuration management

Advanced templating: reusing existing data (1)

```
$ sudo salt edge01.flw01 net.load_template salt://arp_example.jinja
edge01.flw01:
    ----------
    already_configured:
        False
    comment:
    diff:
        [edit interfaces xe-0/0/0 unit 0 family inet]
        +       address 10.10.2.2/32 {
        +           arp 10.10.2.2 mac 0c:86:10:f6:7c:a6;
        +       }
        [edit interfaces ae1 unit 1234]
        +      family inet {
        +          address 10.10.1.1/32 {
        +              arp 10.10.1.1 mac 9c:8e:99:15:13:b3;
        +          }
        +      }
    result:
        True
```

Configuration management
Advanced templating: reusing existing data (2)

/etc/salt/templates/route_example.jinja

```
{%- set route_output = salt.route.show('0.0.0.0/0', 'static') -%}
{%- set default_route = route_output['out'] -%}

{%- if not default_route -%} {# if no default route found in the table #}
  {%- if grains.vendor|lower == 'juniper' -%}
routing-options {
    static {
        route 0.0.0.0/0 next-hop {{ pillar.default_route_nh }};
    }
}
  {%- elif grains.os|lower == 'iosxr' -%}
  router static address-family ipv4 unicast 0.0.0.0/0 {{ pillar.default_route_nh }}
  {%- endif %}
{%- endif -%}
```

Retrieving the static route data using the route.show function.

This requires appending a new line in the device pillar:

```
default_route_nh: 1.2.3.4
```

Configuration management
Advanced templating: reusing existing data (2)

```
$ sudo salt 'edge01.oua01' net.load_template salt://route_example.jinja debug=True
edge01.oua01:
    ----------
    already_configured:
        False
    comment:
    diff:
        ---
        +++
        @@ -3497,6 +3497,7 @@
         !
         router static
          address-family ipv4 unicast
        +  0.0.0.0/0 1.2.3.4
           172.17.17.0/24 Null0 tag 100
    loaded_config:
        router static address-family ipv4 unicast 0.0.0.0/0 1.2.3.4
    result:
        True
```

Homework: other simple examples

- Using postgres.psql_query populate a table in a Postgres database with the network interfaces details (retrieved using net.interfaces)
- Using bgp.neighbors remove from the BGP config neighbors in *Active* state
- Using ntp.stats, remove unsynchronised NTP peers
- Using net.environment, push high temperature notifications in Slack

The list can be nearly infinite - depends only on your own use case.

There are thousands of functions already available:

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

Note: the examples above are implemented more elegant using states, beacons, reactors, etc.

Advanced topics
States, schedulers, reactors, beacons, API

These are advanced topics, that require the user to read carefully the documentation.

Using these types of modules, one can control the configuration based on events, either external or internal, e.g.:

- BGP neighbor down triggers a BGP configuration change
- Git pull-request merged triggers configuration update
- High temperature alert triggers a notification post in a Slack channel
- ChatOps
- etc.

Advanced topics
State

A state ensures that on the devices you have configured what you expect to be. What's not defined in the pillar, it will be removed; what's not on the device, but it's defined in the pillar, will be added.

Integrated states:

- netntp
- netsnmp
- netusers
- probes
- netconfig (very important; will be added in the next release: Nitrogen)

Advanced topics
State example: update NTP peers (1)

Append directly these lines in the device pillar, or define in external file and include:

/etc/salt/pillar/ntp_config.sls

```
ntp.peers:
  - 10.10.1.1
  - 10.10.2.2
ntp.servers:
  - 172.17.17.1
  - 172.17.19.1
```

/etc/salt/pillar/device1.sls

```
proxy:
  proxytype: napalm
  driver: junos
  host: hostname_or_ip_address
  username: my_username
  passwd: my_password
include:
  - ntp_config
```

Better to use the *include*, as multiple devices can have the same NTP peers etc.

When including, strip the *.sls* extension!

Advanced topics

State example: update NTP peers (1)

As configured under *file_roots*

/etc/salt/states/router/ntp.sls

```
{% set ntp_peers = pillar.get('ntp.peers', []) -%}
{% set ntp_servers = pillar.get('ntp.servers', []) -%}

update_my_ntp_config:
  netntp.managed:
    - peers: {{ ntp_peers | json() }}
    - servers: {{ ntp_servers | json() }}
```

Take the NTP peers/servers from the pillar (earlier defined)

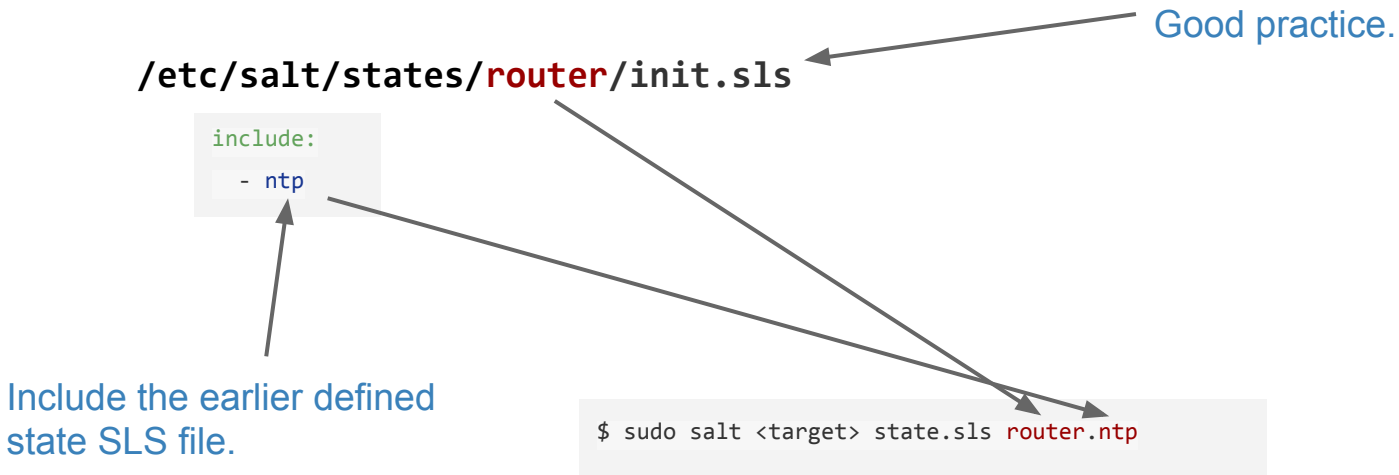
Pass them as state arguments

Best practice:

Although not mandatory, use the json() filter to explicitly serialize objects.

This is the state virtualname, more doc:
https://docs.saltstack.com/en/latest/ref/states/all/salt.states.netntp.html

Advanced topics
State example: update NTP peers (3)



Advanced topics

State output example: update NTP peers (3)

```
$ sudo salt 'edge01.jnb01' state.sls router.ntp
edge01.jnb01:
----------
          ID: update_my_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:
                      - 172.17.17.1
                      - 172.17.19.1
Summary for edge01.jnb01
------------
Succeeded: 1 (changed=1)
Failed:    0
------------
Total states run:     1
```

Advanced topics
Schedule a state

Ensure the configuration is consistent, without running commands manually.

/etc/salt/proxy

```
schedule:
  keep_ntp_config_updated:
    function: state.sls
    args: router.ntp
    days: 1
```

The previous command will be executed automatically every day and ensures the NTP config is as expected.

Advanced topics
Salt event system

Salt is a data driven system. Each action (job) performed (manually from the CLI or automatically by the system) is uniquely identified and has an identification tag:

```
$ sudo salt-run state.event pretty=True
salt/job/20170110130619367337/new {
    "_stamp": "2017-01-10T13:06:19.367929",
    "arg": [],
    "fun": "probes.results",
    "jid": "20170110130619367337",
    "minions": [
        "edge01.bjm01"
    ],
    "tgt": "edge01.bjm01",
    "tgt_type": "glob",
    "user": "mircea"
}
```

Advanced topics
Reactor

Using the job tags, you can identify events (triggers) and react (action):

/etc/salt/master

```
reactor:
  - 'salt/job/*/ret/*':
    - salt://example.sls
```

Unique job tags (regular expression): in this example will match any job returns

When this event occurs, execute this reactor descriptor.

/etc/salt/reactors/example.sls

```
invoke_orchestrate_file:
  runner.state.orchestrate:
    - mods: orch.do_complex_thing
    - pillar:
        event_tag: {{ tag }}
        event_data: {{ data | json() }}
```

Advanced topics
Beacon

Beacons let you use the Salt event system to monitor non-Salt processes.

/etc/salt/proxy

```
beacons:
  inotify:
    /etc/salt/pillar/ntp_config.sls:
      mask:
        - modify
    disable_during_state_run: True
```

Will fire an event when updating */etc/salt/pillar/ntp_config.sls* (using the same example as in slides #52-#54)

Uses the *inotify* beacon. *

* see doc: requires inotify-tools and python inotify

Advanced topics
Beacon event tag example

This event is fired when a change is made and saved to */etc/salt/pillar/ntp_config.sls*:

```
salt/beacon/device1/inotify//etc/salt/pillar/ntp_config.sls       {
 "_stamp": "2017-01-09T15:59:37.972753",
 "data": {
     "change": "IN_IGNORED",
     "id": "device1",
     "path": "/etc/salt/pillar/ntp_config.sls"
 },
 "tag": "salt/beacon/device1/inotify//etc/salt/pillar/ntp_config.sls"
}
```

Using the reactor system, one can match these event tags and take actions when they happen.

Advanced topics
Beacon event tag example

React when the */etc/salt/pillar/ntp_config.sls* is changed

/etc/salt/master

```
reactor:
  - 'salt/beacon/*/inotify//etc/salt/pillar/ntp_config.sls':
    - salt://run_ntp_state_when_file_changed.sls
```

/etc/salt/reactors/run_ntp_state_when_file_changed.sls

```
run_ntp_state:
  local.state.sls:
    - tgt: {{ data['id'] }}
    - arg:
      - router.ntp
```

This is how the reactor system knows that a state execution is required.

Run the state against the minion ID that triggered the event

Run the ntp state defined earlier.

Beacon event tag example

… and that's it!
From now on, whenever you update */etc/salt/pillar/ntp_config.sls*,
it will automatically update your routers' config.

And you maintain entities of data, not pseudo-formatted text files,
regardless on the device vendor.

Advanced topics
Mine

Embedded caching

/etc/salt/pillar/device1.sls

```
mine_functions:
  net.interfaces: []
  net.lldp: []
  net.arp: []
mine_interval: 5
```

What to cache

How often to update (in minutes)

Read more: https://docs.saltstack.com/en/latest/topics/mine/

Advanced topics
The Salt API

You can also execute commands remotely, via HTTPS

Easy to setup, easy to use

/etc/salt/master

```
rest_cherrypy:
  port: 8001
  ssl_crt: /etc/nginx/ssl/my_certificate.pem
  ssl_key: /etc/nginx/ssl/my_key.key
```

```
curl -sSk
https://salt-master-ns-or-ip:8001/run \
    -H 'Content-type: application/json' \
    -d '[{
        "client": "local",
        "tgt": "<target>",
        "fun": "net.arp",
        "username": "my username",
        "password": "my password",
        "eauth": "pam"
    }]'
```

More advanced topics

- Orchestration: define complex workflows
  https://docs.saltstack.com/en/latest/topics/orchestrate/index.html
  See also: https://docs.saltstack.com/en/develop/ref/states/requisites.html
- Publish events to external services (e.g.: logstash, hipchat)
  https://docs.saltstack.com/en/develop/ref/engines/all/index.html
- Pillar: load data from external services, not just static
  https://docs.saltstack.com/en/develop/ref/pillar/all/
- Custom authentication methods for the minions
  https://docs.saltstack.com/en/develop/ref/auth/all/index.html
- Forward outputs in external data systems on runtime
  https://docs.saltstack.com/en/develop/ref/returners/all/index.html

Real world example:
Cloudflare’s self-resilient network

Monitoring carriers (transit providers)

```
mircea@re0.edge01.iad01> show configuration services rpm | display set | match 1299 | match probe-type
set services rpm probe transit test t-edge01.scl01-1299-12956-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.eze01-1299-6762-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.lax01-1299-1299-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.eze01-1299-12956-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.mia01-1299-1299-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.lhr01-1299-1299-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.ams01-1299-1299-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.fra03-1299-1299-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.dfw01-1299-1299-4 probe-type icmp-ping
set services rpm probe transit test t-edge01.sea01-1299-1299-4 probe-type icmp-ping
```

JunOS: RPM
https://www.juniper.net/documentation/en_US/junos12.1x46/topics/concept/security-rpm-overview.html

IOS-XR: ISPLA
http://www.cisco.com/c/en/us/td/docs/ios/ipsla/command/reference/sla_book/sla_02.html

How many probes?

```
$ sudo salt-run transits.probes show_count=True

Generated 7248 probes.
```

Generated using:

- net.ipaddrs
- net.interfaces
- bgp.neighbors
- bgp.config

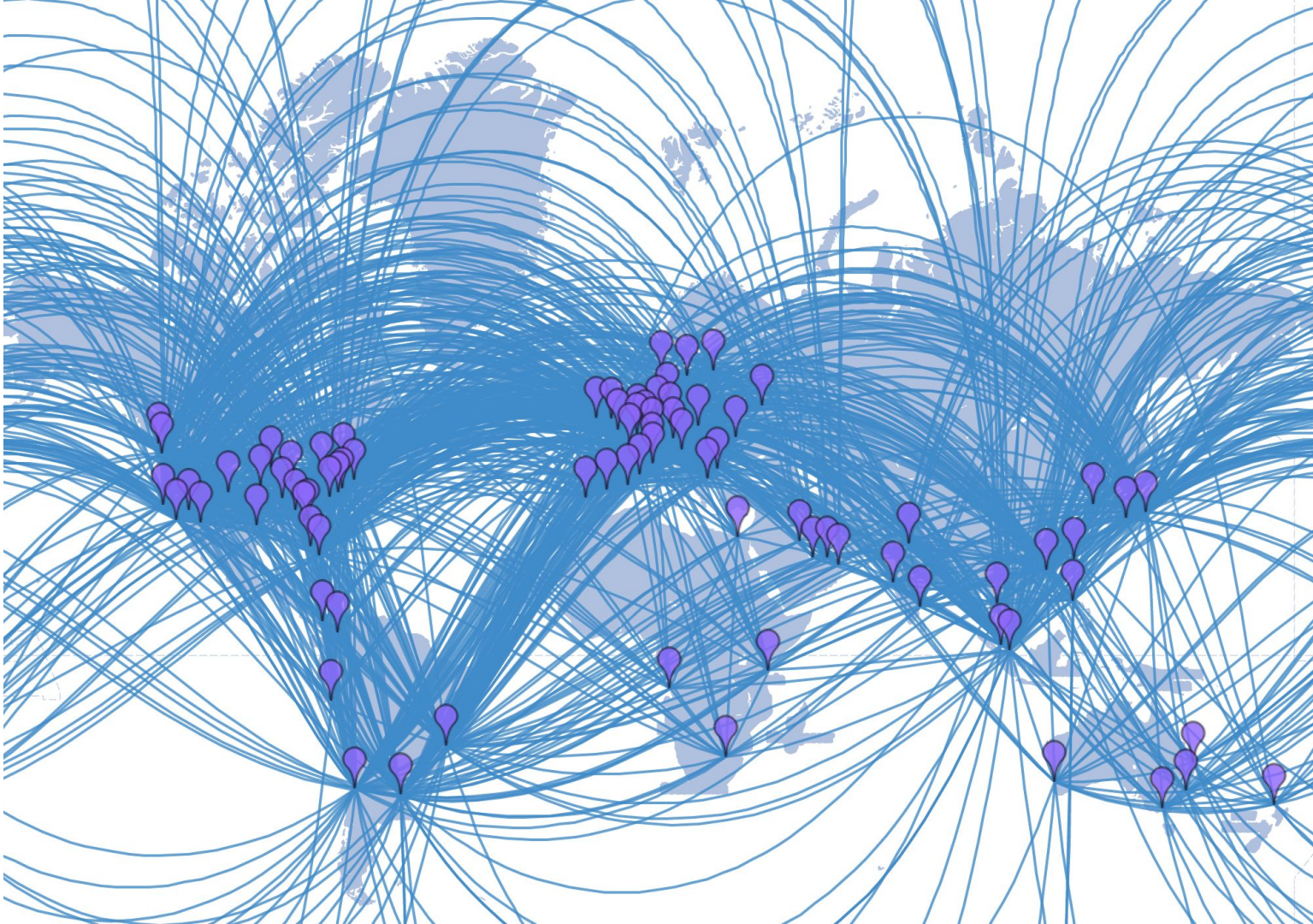
All integrated by default in SaltStack.

How are they installed?

```
$ cat /etc/salt/pillar/probes_edge01_dfw01.sls
probes.config:
  transit:
    t-edge01.sjc01-1299-1299-4:
      source: 1.2.3.4
      target: 5.6.7.8
    t-edge01.den01-1299-1299-4:
      source: 10.11.12.13
      target: 14.15.16.17
    t-edge01.den01-174-174-4:
      source: 18.19.20.21
      target: 22.23.24.25
    t-edge01.den01-4436-4436-4:
      source: 26.27.28.29
      target: 30.31.32.33
```

```
$ sudo salt 'edge*' state.sls router.probes
edge01.dfw01:
----------
          ID: cf_probes
    Function: probes.managed
      Result: True
     Comment: Configuration updated
     Started: 23:00:17.228171
    Duration: 10.206 s
     Changes:
              ----------
              added:
                  ----------
                  transit:
                      ----------
                      t-edge01.sjc01-1299-1299-4:
                          ----------
                          probe_count:
                              15
                          probe_type:
                              icmp-ping
                          source:
                              1.2.3.4
                          target:
                              5.6.7.8
                          test_interval:
                              3
              removed:
                  ----------
              updated:
                  ----------
```

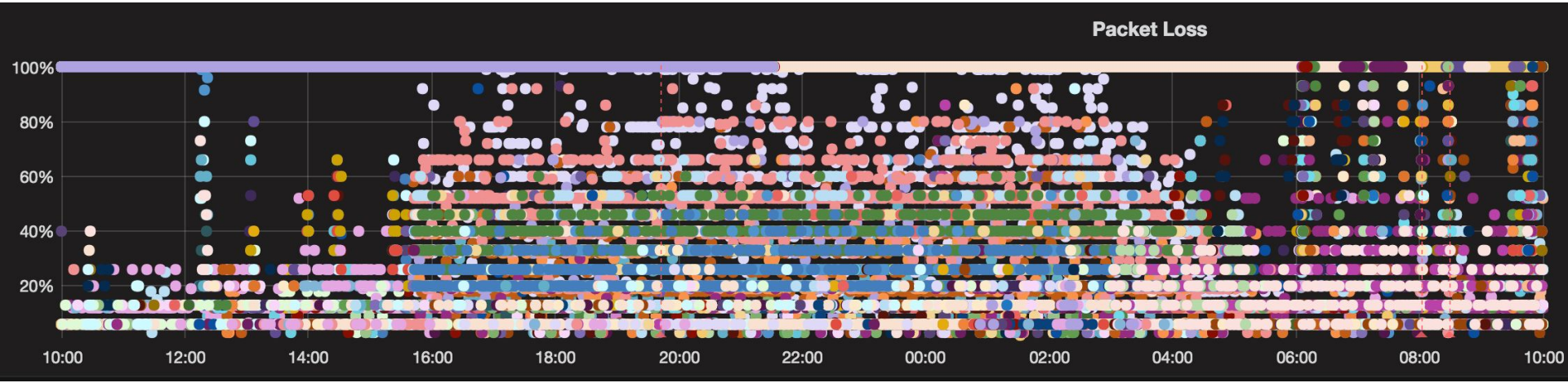
Spaghetti



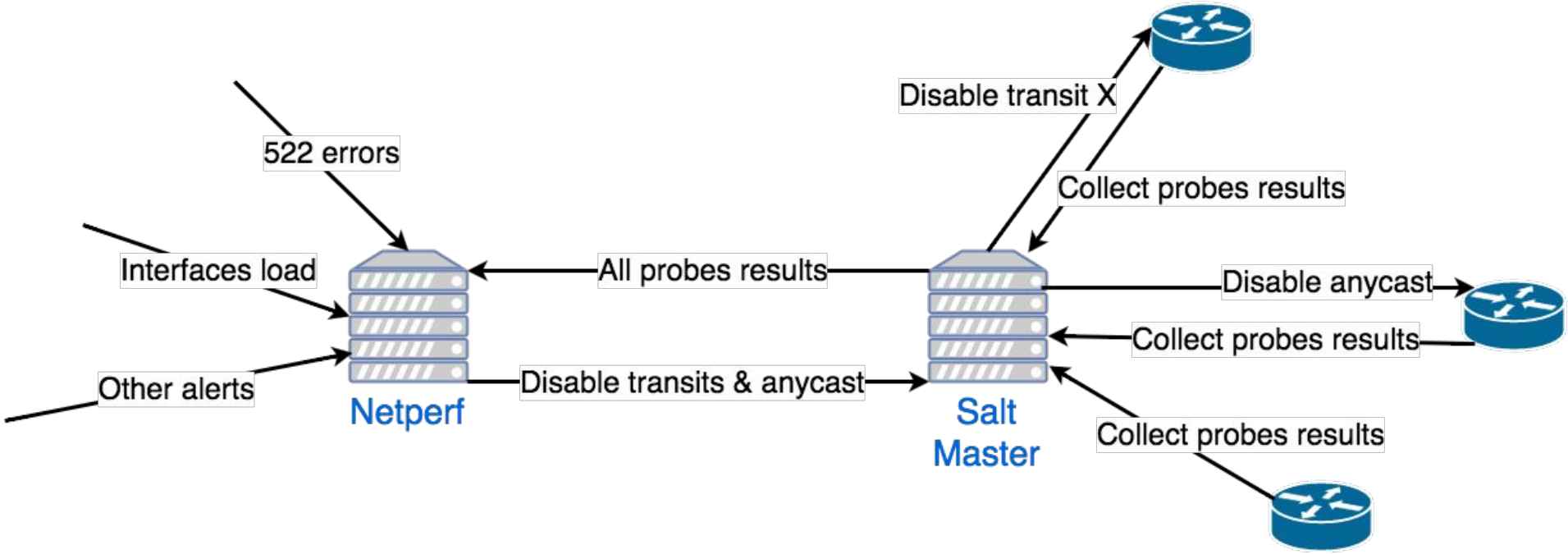
Retrieving probes results

```
$ sudo salt ‘edge*’ probes.results

edge01.dfw01:
    ----------
    out:
        ----------
        transit:
            ----------
            t-edge01.sjc01-1299-1299-4:
                ----------
                current_test_avg_delay:
                    24.023
                current_test_max_delay:
                    28.141
                current_test_min_delay:
                    23.278
                global_test_avg_delay:
                    23.936
                global_test_max_delay:
                    480.576
                global_test_min_delay:
                    23.105
```

How the Internet looks like nowdays



Self-resilient network



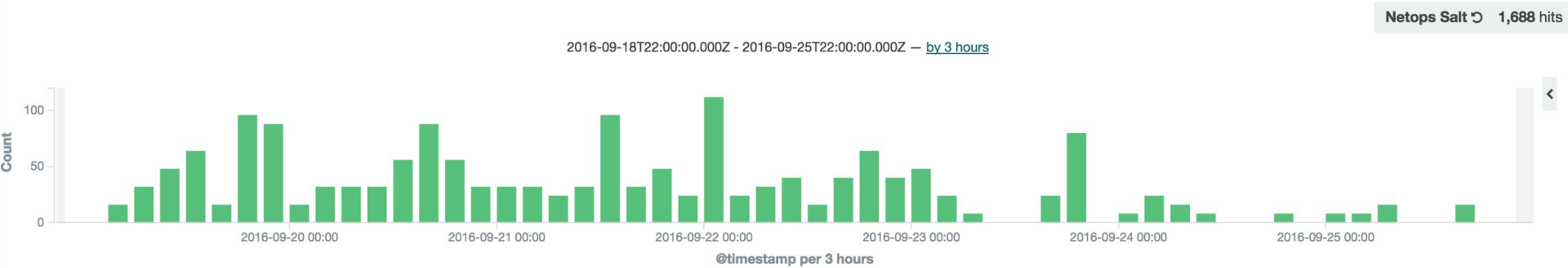
Self-resilient network: HipChat alerts

event-action-script · Sep-30 07:37
Cogent: Disabled in EU
Current alerts per router:
  Routers and their active alerts on transit:
    edge01.cdg01: 5
    edge01.otp01: 5
    edge01.man01: 5
    edge01.sof01: 5

netperf · Oct-5 10:36
[netperf] Anycast disabled on edge01.mde01

event-action-script · Oct-1 17:26
Comcast: Disabled in NA
Current alerts per router:
  Routers and their active alerts on transit:
    edge01.dfw01: 3
    edge01.bos01: 6
    edge01.den01: 4
    edge01.phl01: 4
    edge01.atl01: 2

How often?



1688 request-reply pairs during a random window of 7 days
~ 120 config changes / day in average
0 human intervention

How can you contribute?

GitHub

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

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

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Engines
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