INEX

IXP Automation

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IXP AUTOMATION

Background

- Original purpose of IXP Manager was to support route server config builds
- Designed with a structure capable of storing all participant switch configuration tokens
- Reticent about using database for network configuration
    - Cost / return ratio wasn’t right
    - Concerns about how to control configuration deployment
    - Poor tool support for interfacing with network devices

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Toolchain Problems

- “Traditional” server automation tools could not interface with network devices
- Tools of the era: RANCID, SSH, TFTP, bash + perl scripts
- No framework mechanisms available

But now it’s 2018

- Multiple automation approaches possible
- Server automation frameworks can interface with network devices
- Network Operating Systems now have APIs and / or API models
- Some NOSs support multiple APIs
- Rationale changes
  - Too much repetitive configuration: “Taking the operator out of operations”
  - Long term cost reduction

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Phase 1 Operational Goals

- Configure all IXP participant edge ports
    - Speed, dot1q framing, LAG ports, layer 2 filters

- Configure IXP core
    - Interfaces, BGP, VXLAN configuration

- Ready for service to handle INEX LAN1 forklift upgrade to Arista kit in 2017Q1

Phase 2 Strategic Goals

- Use initial automation process to learn how to do this properly
- Build functionality into IXP Manager: user interface, database, export presentation
- Ensure that abstraction model is usable across different network devices and different organisations
- Release as open source

Approaches

	Openflow	YANG	Vendor API
Abstraction Level	Low	High	Mid Range
Vendor Support	Version Dependent	In Development	Variable
Portability	High	High	Low
Cross-Platform	Low	Currently low	Needs Abstraction
Complexity	High	Mid	Low

Practical Approach

- YANG: only well supported on tiny number of NOSs
- Openflow: too low level, not loved by chipset manufacturers
- Decided to use NAPALM
    - Integrates with vendor APIs at the network device interface
    - Integrates with Ansible and SaltStack at control + provisioning DB interface
    - Long term support is likely to be good

Data Presentation

- Most vendor APIs are simply a better-structured CLI
    - mandatory authentication and security
    - XML or JSON formatting
    - commands are issued, replies received
- Drawbacks
    - Some CLIs are troublesome to automate due to non-idempotent config mechanisms
    - Many APIs / NOSs do not support basic functions like sessions / commit / rollback
    - Variable support non-service-affecting configuration merge or atomic config replace
    - API support is often NOS version specific

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NAPALM Support

[2] Hand-crafted by the API as the device doesn't support the feature.

[3] Not supported but emulated. Check caveats.

[4] For merges, the diff is simply the merge config itself. See caveats.

[5] No for merges. See caveats.

	EOS	JunOS	IOS-XR	NXOS	IOS
Config Replace	Yes	Yes	Yes	Yes	Yes
Config Merge	Yes	Yes	Yes	Yes	Yes
Config Compare	Yes	Yes	Yes[2]	Yes[4]	Yes
Atomic Change	Yes	Yes	Yes	Yes/No[5]	Yes
Rollback	Yes[3]	Yes	Yes	Yes/No[5]	Yes

https://napalm.readthedocs.io/en/latest/support/index.html

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INEX Kit Manifest

	Brocade FI	Brocade NI	Extreme	Arista EOS	Cumulus
INEX Lifecycle	EOL	EOL	Mid life	Early life	Pre-Deploy
API Support	None	Some YANG	XOS v21+	Excellent	Linux
Openflow	No	v1.3	v1.3	v1.3	No
NAPALM	No	No	*sort-of	Yes	No
Assessment	No plans	No plans	Partial support	Full Support	Full Support

~~Vi vs Emacs~~ Ansible vs SaltStack

- Lengthy evaluation process
- Careful consideration of ~~Linux and FreeBSD~~ An altStack pros / cons.
- Rationale resulted in

We Love SaltStack!

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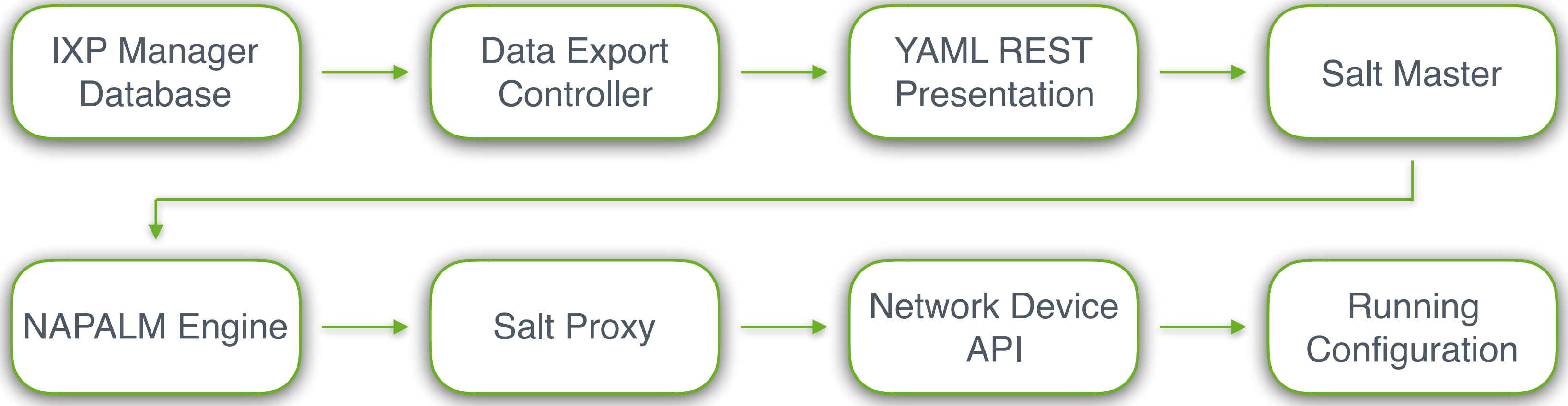
Data Flow - Traditional NOS



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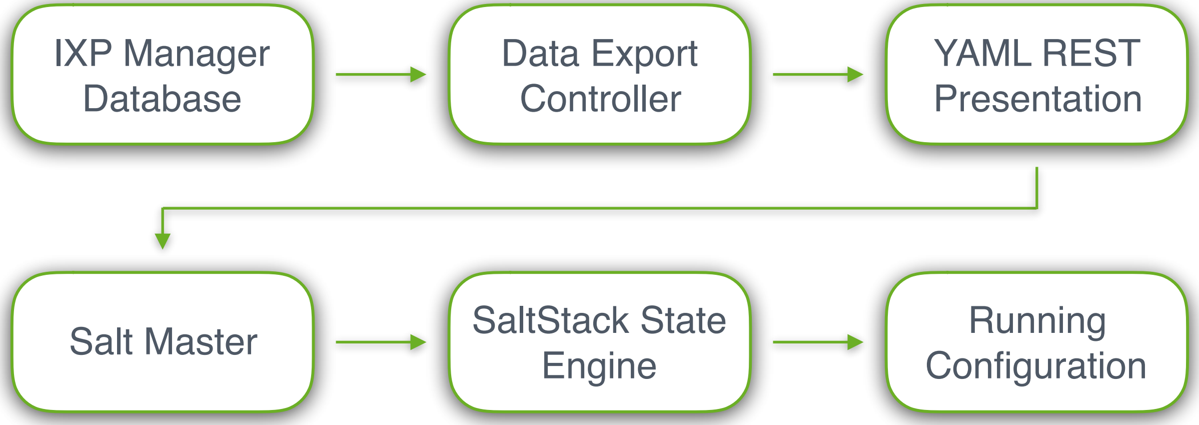
Data Flow - Cumulus Linux



IXP Manager Data Presentation

- API version 4 exports YAML via REST calls

- Exported data roughly breaks down as:
  - Vlans
  - Layer 2 interface information
  - Layer 3 interface information
  - Information required for routed core (bgp + vxlan)

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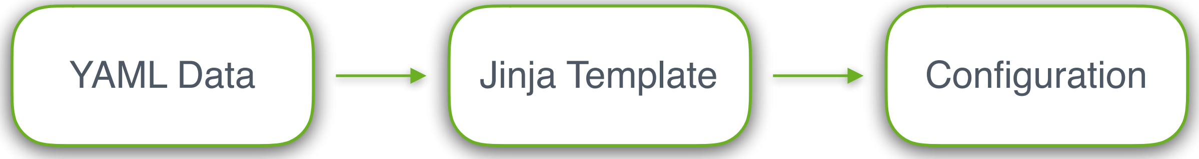
Sample YAML

```
layer2interfaces:
  - name: swp2
    type: edge
    description: “Internet Widgets Ltd"
    dot1q: yes
    shutdown: yes
    autoneg: yes
    speed: 10000
    lagindex: 1
    lagmaster: no
    fastlacp: yes
    virtualinterfaceid: 334
    vlans:
      - number: 12
        macaddress:
          - "54:1e:56:35:77:d0"
```

Sample YAML

```yaml
layer2interfaces:
  - name: swp49
    type: core
    description: "edge1-edge2"
    dot1q: yes
    shutdown: no
    stp: yes
    cost: 100
    autoneg: yes
    speed: 40000
    lagindex: 1010
    lagmaster: no
    virtualinterfaceid: 342
    vlans:
      - number: 12
      - number: 32
```

Data Templating



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Sample Jinja

```
{% if pillar.get(‘layer2interfaces') is iterable %}
{% for iface in pillar.get('layer2interfaces') %}

default interface {{ iface.name }}
interface {{ iface.name }}
 load-interval 30

{% if iface.description|default(false) %}
 description {{ iface.description }}
{% else %}
 no description
{% endif %}

[...]

{% endfor %}
{% endif %}
```

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Sample Jinja

```
{% if iface.speed == 100 %}
 speed forced 100full
{% elif iface.speed == 1000 %}
{% if not iface.autoneg|default(false) %}
 speed forced 1000full
{% else %}
 speed auto
{% endif %}
{% elif iface.speed == 10000 %}
{# speed auto #}
{% elif iface.speed == 40000 %}
 speed forced 40gfull
{% elif iface.speed == 100000 %}
 speed forced 100gfull
{% endif %}
```

Modelling Problems

- Different switches use different data models for configuration

- E.g. Link Aggregation
  - Brocade uses physical interfaces and blocks changes on non-master after initial config
  - Extreme has a separate configuration item: “enable sharing XX”
  - Other devices use a virtual interface (Port-ChannelX, bondY, etc)
    - Even then, not all the semantics are the same (channel-group vs bond-slaves)

- Lessons learned: ensure your data model is flexible enough to support substantial semantic differences between device config models, and that it can be extended easily

Operational Problems

- Beware of upgrades!
- O/S package management vs pip install
- Jinja 2.7 -> 2.9 broke lots of templates
  - undefined variables are no longer evaluated as `False`
  - iterating over a non-iterable object now returns an error rather than skipping eval
- Need to be careful with SaltStack upgrades
- Many of these problems can be solved with Containers

Jinja 2.7

```
{% for iface in pillar.get('layer2interfaces', {}) %}

interface {{ iface.name }}

{% if iface.shutdown %}
 shutdown
{% endif %}

{% endfor %}
```

IXP AUTOMATION

Jinja 2.9

```
{% if pillar.get('layer2interfaces') is iterable %}
{% for iface in pillar.get('layer2interfaces') %}

interface {{ iface.name }}

{% if iface.shutdown|default(false) %}
 shutdown
{% endif %}

{% endfor %}
{% endif %}
```

Jinja 2.9 Release Notes

- “Added policies for filter defaults and similar things.”

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```
2017-09-04 13:42:01,662 [salt.loader][CRITICAL][794] Failed to load grains defined in grain file napalm.model in
function <function model at 0x80d0fec08>, error:
Traceback (most recent call last):
  File "/usr/local/lib/python2.7/site-packages/salt/loader.py", line 722, in grains
    else:
  File "/usr/local/lib/python2.7/site-packages/salt/grains/napalm.py", line 174, in model
    return {'model': _get_grain('model', proxy=proxy)}
  File "/usr/local/lib/python2.7/site-packages/salt/grains/napalm.py", line 102, in _get_grain
    grains = _retrieve_grains_cache(proxy=proxy)
  File "/usr/local/lib/python2.7/site-packages/salt/grains/napalm.py", line 71, in _retrieve_grains_cache
    GRAINS_CACHE = proxy['napalm.get_grains']()
  File "/usr/local/lib/python2.7/site-packages/salt/loader.py", line 1088, in __getitem__
    self.missing_modules = {}  # mapping of name -> error
  File "/usr/local/lib/python2.7/site-packages/salt/utils/lazy.py", line 101, in __getitem__
    raise KeyError(key)
KeyError: 'napalm.get_grains'
```

IXP AUTOMATION

```
2017-09-04 13:48:19,254 [salt.minion][CRITICAL][85409] Unexpected error while connecting to localhost
Traceback (most recent call last):
  File "/usr/local/lib/python2.7/site-packages/salt/minion.py", line 864, in _connect_minion
    yield minion.connect_master(failed=failed)
  File "/usr/local/lib/python2.7/site-packages/tornado/gen.py", line 1055, in run
    value = future.result()
  File "/usr/local/lib/python2.7/site-packages/tornado/concurrent.py", line 238, in result
    raise_exc_info(self._exc_info)
  File "/usr/local/lib/python2.7/site-packages/tornado/gen.py", line 1063, in run
    yielded = self.gen.throw(*exc_info)
  File "/usr/local/lib/python2.7/site-packages/salt/minion.py", line 1042, in connect_master
    yield self._post_master_init(master)
  File "/usr/local/lib/python2.7/site-packages/tornado/gen.py", line 1055, in run
    value = future.result()
  File "/usr/local/lib/python2.7/site-packages/tornado/concurrent.py", line 238, in result
    raise_exc_info(self._exc_info)
  File "/usr/local/lib/python2.7/site-packages/tornado/gen.py", line 1069, in run
    yielded = self.gen.send(value)
  File "/usr/local/lib/python2.7/site-packages/salt/minion.py", line 3124, in _post_master_init
    self.functions['saltutil.sync_all'](saltenv=self.opts['environment'])
  File "/usr/local/lib/python2.7/site-packages/salt/modules/saltutil.py", line 850, in sync_all
    ret['clouds'] = sync_clouds(saltenv, False, extmod_whitelist, extmod_blacklist)
  File "/usr/local/lib/python2.7/site-packages/salt/modules/saltutil.py", line 652, in sync_clouds
    ret = _sync('clouds', saltenv, extmod_whitelist, extmod_blacklist)
  File "/usr/local/lib/python2.7/site-packages/salt/modules/saltutil.py", line 99, in _sync
    saltenv = _get_top_file_envs()
  File "/usr/local/lib/python2.7/site-packages/salt/modules/saltutil.py", line 81, in _get_top_file_envs
    top = st_.get_top()
  File "/usr/local/lib/python2.7/site-packages/salt/state.py", line 3089, in get_top
    tops = self.get_tops()
  File "/usr/local/lib/python2.7/site-packages/salt/state.py", line 2787, in get_tops
    saltenv
  File "/usr/local/lib/python2.7/site-packages/salt/fileclient.py", line 189, in cache_file
    return self.get_url(path, '', True, saltenv, cachedir=cachedir)
  File "/usr/local/lib/python2.7/site-packages/salt/fileclient.py", line 495, in get_url
    result = self.get_file(url, dest, makedirs, saltenv, cachedir=cachedir)
  File "/usr/local/lib/python2.7/site-packages/salt/fileclient.py", line 1044, in get_file
    hash_server, stat_server = self.hash_and_stat_file(path, saltenv)
TypeError: 'bool' object is not iterable
```

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Session-Based Configuration Merge

```
{% if bgp.local_as|default(false) %}
no router bgp {{ bgp.local_as }}
router bgp {{ bgp.local_as }}
   no bgp default ipv4-unicast
   bgp always-compare-med
[...]
{% endif %}


{% for iface in pillar.get(‘layer2interfaces') %}
default interface {{ iface.name }}
interface {{ iface.name }}
 load-interval 30
[...]
{% endfor %}
```

Deployment Workflow

- NAPALM supports config test, config load, commit and rollback
- SaltStack and Ansible support multiple deployment environments
    - e.g. lab / production, etc
- Good idea to use these mechanisms on production systems

IXP AUTOMATION

```
root@saltmaster:~ # salt swi1-pwt1-1 saltutil.refresh_pillar
[...]
root@saltmaster:~ # salt swi1-pwt1-1 net.load_template \
         /srv/napalm/templates/eos/configure_cust_interfaces.j2 saltenv=production test=true
swi1-pwt1-1:
    ----------
    already_configured:
        False
    comment:
        Configuration discarded.
    diff:
        @@ -500,7 +500,7 @@
            10 permit 30:b6:4f:e4:f8:f6 00:00:00:00:00:00 any
         !
         mac access-list l2acl-ixp-viid325
        -   10 deny any any
        +   10 permit 01:23:45:67:89:ab 00:00:00:00:00:00 any
         !
         mac access-list l2acl-ixp-viid326
            10 deny any any
    loaded_config:
    result:
        True
root@saltmaster:~ #
```

IXP AUTOMATION

```
root@saltmaster:~ # salt swi1-pwt1-1 net.load_template \
         /srv/napalm/templates/eos/configure_cust_interfaces.j2 test=true saltenv=production commit=false
swi1-pwt1-1:
    ----------
    already_configured:
        False
    comment:
    diff:
        @@ -500,7 +500,7 @@
            10 permit 30:b6:4f:e4:f8:f6 00:00:00:00:00:00 any
         !
         mac access-list l2acl-ixp-viid325
        -   10 deny any any
        +   10 permit 01:23:45:67:89:ab 00:00:00:00:00:00 any
         !
         mac access-list l2acl-ixp-viid326
            10 deny any any
    loaded_config:
    result:
        True
root@saltmaster:~ #
```

IXP AUTOMATION

```
root@saltmaster:~ # salt swi1-pwt1-1 net.load_template \
         /srv/napalm/templates/eos/configure_cust_interfaces.j2 test=true saltenv=production commit=true
swi1-pwt1-1:
    ----------
    already_configured:
        False
    comment:
    diff:
        @@ -500,7 +500,7 @@
            10 permit 30:b6:4f:e4:f8:f6 00:00:00:00:00:00 any
         !
         mac access-list l2acl-ixp-viid325
        -   10 deny any any
        +   10 permit 01:23:45:67:89:ab 00:00:00:00:00:00 any
         !
         mac access-list l2acl-ixp-viid326
            10 deny any any
    loaded_config:
    result:
        True
root@saltmaster:~ #
```

IXP AUTOMATION

```
root@saltmaster:~ # salt swt-cwt1-edge1 state.apply cumulus.configure_bgp saltenv=lab test=true
swt-cwt1-edge1:
----------
          ID: /etc/frr/frr.conf
    Function: file.managed
      Result: None
     Comment: The file /etc/frr/frr.conf is set to be changed
     Started: 08:51:09.367960
    Duration: 89.872 ms
     Changes:
              ----------
              diff:
                  ---
                  +++
                  @@ -16,12 +16,6 @@
                    neighbor pg-ebgp-ipv4-ixp description eBGP IXP session policy
                    neighbor pg-ebgp-ipv4-ixp timers 3 10
                    neighbor pg-ebgp-ipv4-ixp capability extended-nexthop
                  - neighbor 10.37.4.1 remote-as 65302
                  - neighbor 10.37.4.1 peer-group pg-ebgp-ipv4-ixp
                  - neighbor 10.37.4.1 description swt-cwt1-edge2
                  - neighbor 10.37.4.3 remote-as 65302
                  - neighbor 10.37.4.3 peer-group pg-ebgp-ipv4-ixp
                  - neighbor 10.37.4.3 description swt-cwt1-edge2
                    neighbor 10.37.2.2 remote-as 65311
                    neighbor 10.37.2.2 peer-group pg-ebgp-ipv4-ixp
                    neighbor 10.37.2.2 description swt-cwt1-mlnx1
----------
```

IXP AUTOMATION

```
[...]
----------
          ID: /etc/frr/frr.conf
    Function: service.running
        Name: frr
      Result: None
     Comment: Service is set to be reloaded
     Started: 08:51:09.803190
    Duration: 314.587 ms
     Changes:

Summary for swt-cwt1-edge1
------------
Succeeded: 5 (unchanged=2, changed=1)
Failed:    0
------------
Total states run:     5
Total run time:   1.872 s
root@saltmaster:~ #

root@saltmaster:~ # salt swt-cwt1-edge1 state.apply cumulus.configure_bgp saltenv=lab test=false
[...]
```

IXP AUTOMATION

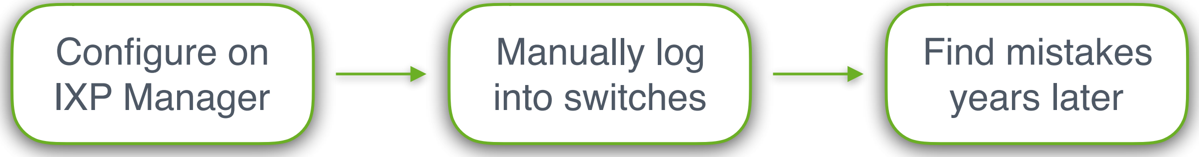
Phase 1 Results

- Configure all IXP participant edge ports [in service using production DB]
- Configure IXP core [in service using pilot model data source]
- Handled INEX LAN1 forklift upgrade successfully
- Operations workflow changed to be safer, simpler and more reliable
- Single source of authoritative data about network configuration

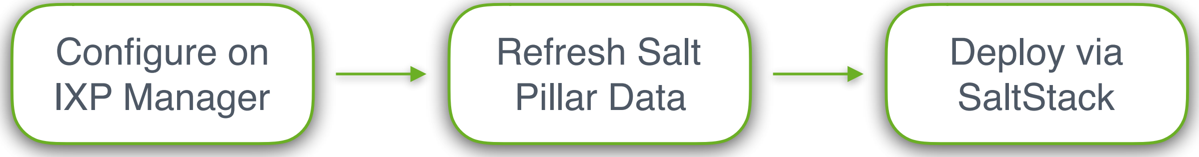
Phase 2 Progress

- Data abstraction model complete, refactoring complete, awaiting review
- IXP Manager: coding nearly complete, needs refactoring
- Templating for NAPALM / SaltStack: Arista: 100%, Cumulus: 97%
- Release candidate in production at INEX (still ironing out bugs!)
- Release as open source: planned in 2017Q4
- Documentation and creation of suggested operational workflow procedures

Operations Then



Operations Now



THANK YOU!

Internet Society

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github.com/inex/ixp-manager