The bridge to possible

Empowering Network Automation

Practice NSO with Python

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DEVWKS-2551

cisco Live!

Agenda

- Core Concepts
- Python API
- Playground time
- Conclusion

Hi, I’m Jesus

I’m passionate about
Network Automation,
DevOps &
SW Engineering.

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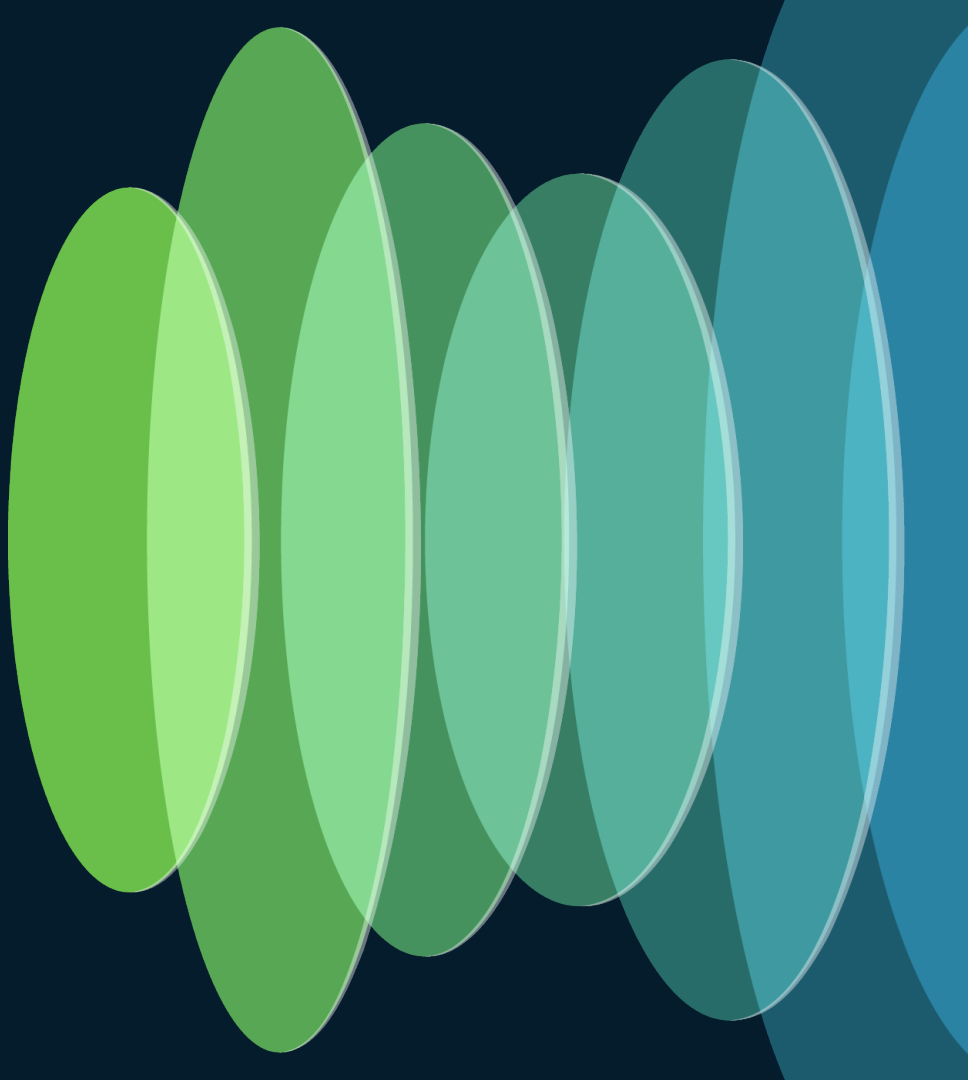
What is not covered

Workshop

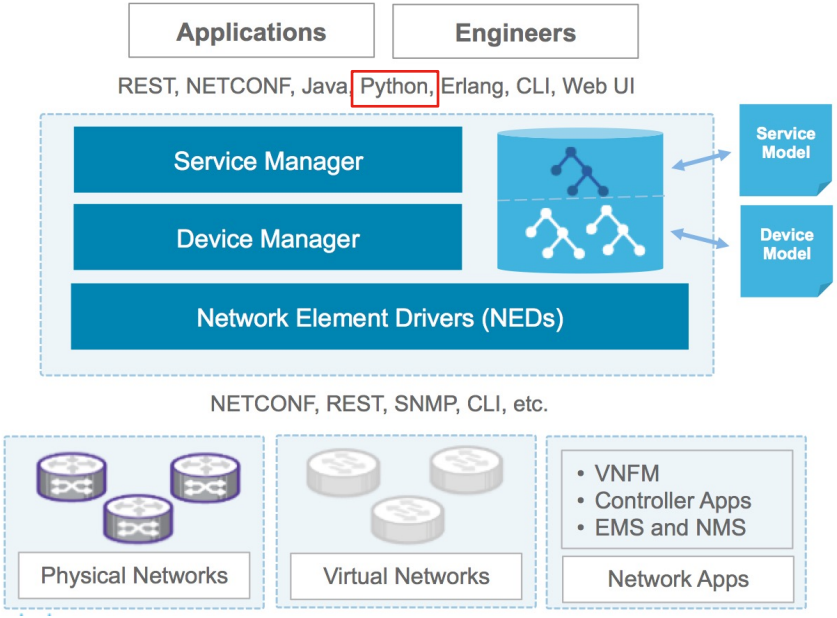
- NSO Basics. Not a 101 session.
- Python Introduction.
- Advanced NSO concepts with Python (actions, data sharing, nano services, cache, etc).

Core Concepts



NSO Architecture

Core Concepts



- Multivendor abstraction through Network Element Drivers (NEDs)
- Single datastore for all network elements under management
- Multiple interfaces including CLI, REST, Java Python
- Templates and compliance reporting
- YANG-based configuration schema

https://developer.cisco.com/docs/nso/guides/introduction-to-nso/

YANG Overview

Core Concepts

```
list router {
  key name;

  uses ncs:service-data;
  ncs:servicepoint router;

  leaf name {
    type string;
  }

  leaf-list device {
    type leafref {
      path "/ncs:devices/ncs:device/ncs:name";
    }
  }
}
```

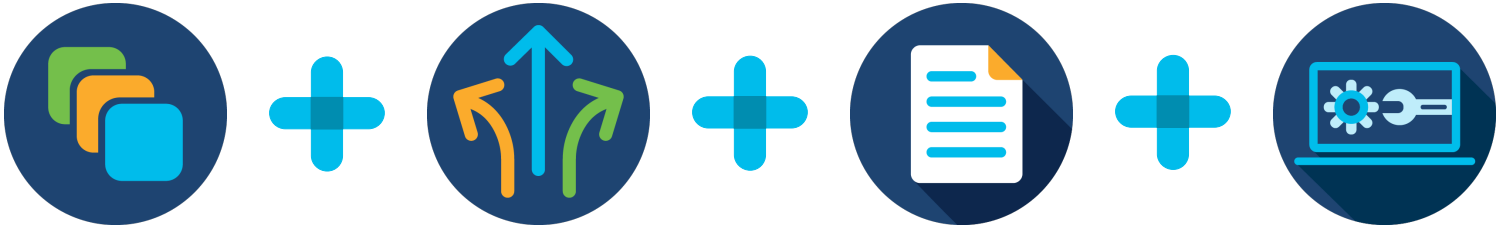
- Data modelling language for network configuration
- Human readable
- Extensible through augmentation
- Standards-based, RFC7950
- CDB schema

https://developer.cisco.com/docs/nso/guides/the-yang-data-modeling-language/

NSO services

Core Concepts

- Declarative method to abstract and automate a task you want to do repeatedly
- Customer facing and resource facing services
- Internally it maintains mapping between inputs (user intent) and outputs (infrastructure configurations)



YANG Model
Defines the service in high level terms

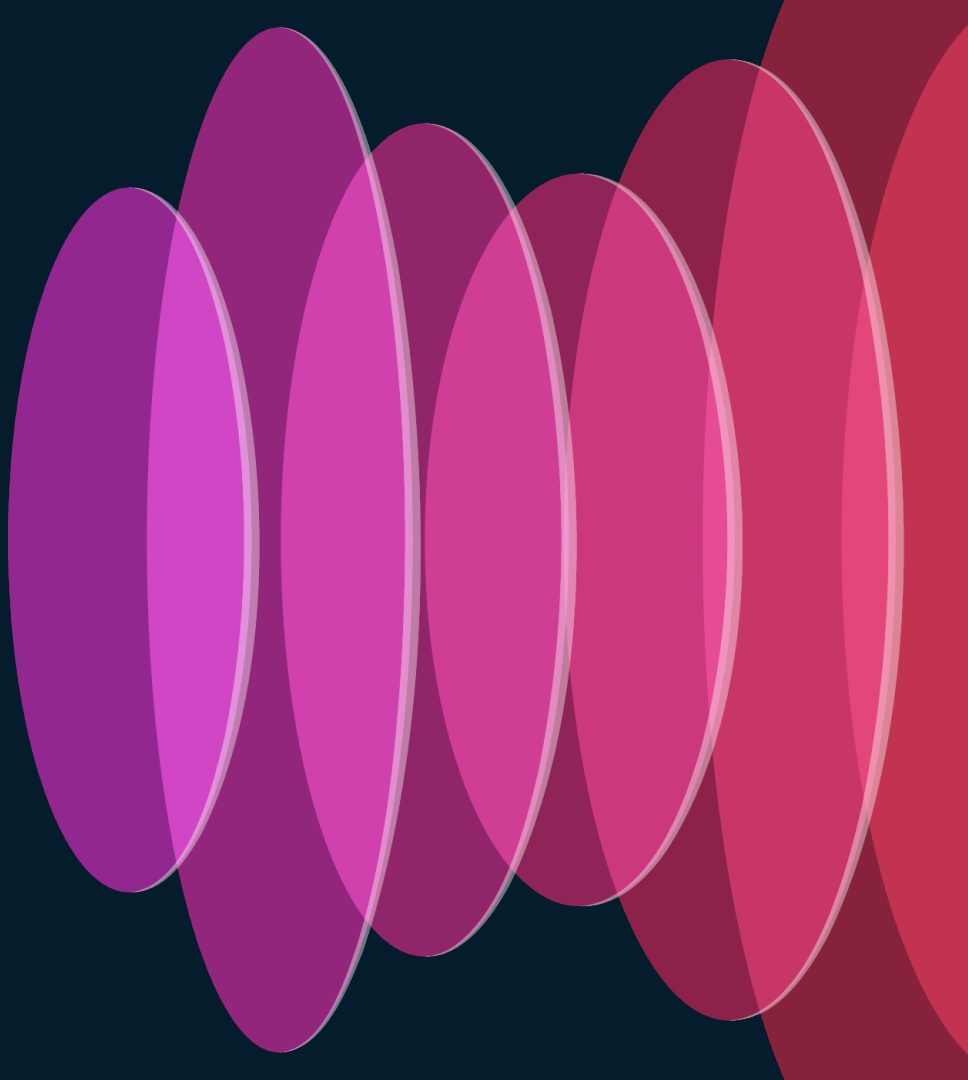
Logic
Python/Java collects info, does verification

Template
How the service is rendered on devices

Package meta data
Version requirements, components, dependencies

https://developer.cisco.com/docs/nso/guides/developing-a-simple-service/

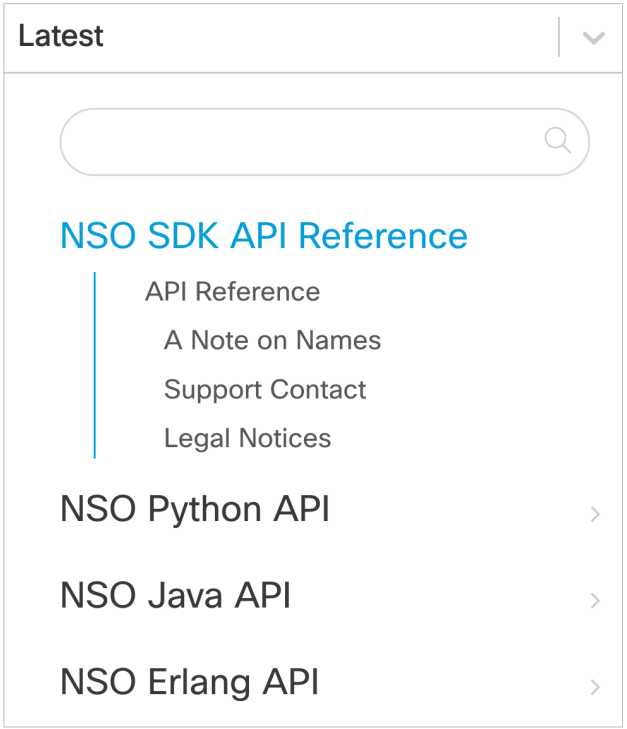
Python API



NSO Python API/SDK

Python API

- The NSO Python, Java, Erlang (and C) APIs are **SDKs** used to extend NSO.
- Typically used by applications running on the same processor/system as NSO is running.
- Uses IPC over TCP sockets to communicate with NSO for low latency.
- Not available via `pip install`



https://developer.cisco.com/docs/nso/api/nso-sdk-api-reference/

Use Cases

Python API

Scripts

- Connect directly to NSO datastore.
- *Onetime* operations.
  - Importing device configurations.
  - Generating reports from the configurations.

Services

- Perform complex calculations & external system integrations.
- Apply XML templates from Python.
- Get FASTMAP algorithm benefits.

High-level & Low-level APIs

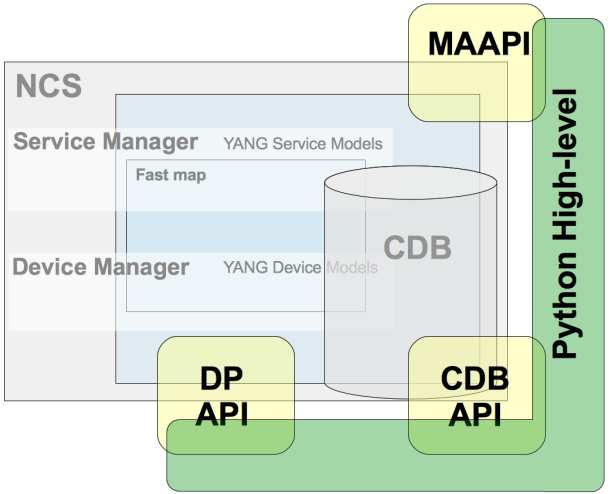
Python API

Low-level APIs are a direct mapping of the NSO C APIs, CDB and MAAPI.

- See **man** `confd_lib_lib` for more information.

High-level APIs are an abstraction layer on top of the low-level APIs.

- Easier to use.
- Improved code readability and development for common use cases.



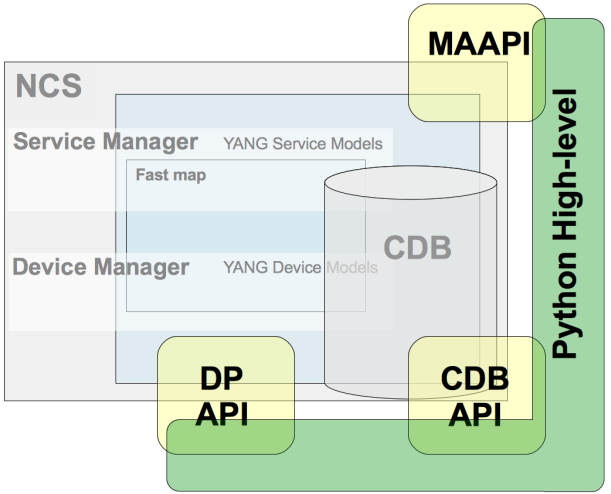
https://developer.cisco.com/docs/nso/guides/python-api-overview/
https://developer.cisco.com/docs/nso/guides/ncs-man-pages-volume-3/

MAAPI API

Python API

Management Agent API

- Transactional Northbound interface.
- User session-based interface.
- Configuration & Operational data
  - Read.
  - Written and committed as one transaction.



https://developer.cisco.com/docs/nso/guides/python-api-overview/

MAAPI API

Python API

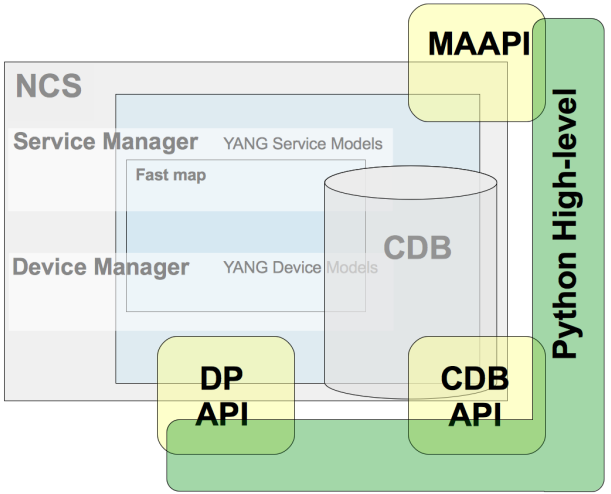
```
1  import ncs
2
3  with ncs.maapi.Maapi() as maapi:
4    with ncs.maapi.Session(maapi=maapi, user="admin", context="system"):
5      with maapi.start_read_trans() as transaction:
6        address = transaction.get_elem("/ncs:devices/device{ex0}/address")
7        print("First read: Address = %s" % address)
8
9  with ncs.maapi.single_write_trans(user="admin", context="system") as transaction:
10   transaction.set_elem2("Vegas was here", "/ncs:devices/device{ex0}/description")
11   transaction.apply()
```

https://developer.cisco.com/docs/nso/guides/python-api-overview/#high-level-maapi-api

MAAGIC API

Python API

- Manipulate data according to YANG schema
- Use standard Python object dot notation.
- Special characters are replaced with underscores
  - Element `my-address` becomes `my_address`
  - Crossing Namespaces with *double-underscore*
    - `root.myns__top.val`



MAAGIC = Management Agent API (MAAPI) + magic Python methods

https://developer.cisco.com/docs/nso/guides/python-api-overview/#maagic-api

MAAGIC API

Python API

```
# Access list item
router = root.devices.device["internet-rtr0"]

# Create list item
root.services.l3vpn.create("test-l3vpn")

# Check if list item with a key exists
"internet-rtr0" in root.devices.device

# Set leaf value
root.devices.device["internet-rtr0"].address = "10.0.0.1"

# Remove list item
del root.devices.device["internet-rtr0"]
```

https://developer.cisco.com/docs/nso/guides/python-api-overview/#maagic-api

MAAGIC Object Navigation

Python API

Action	Object Returned
`root.devices`	`Container`
`root.devices.device`	`List`
`root.devices.device["ce0"]`	`ListElement`
`root.devices.device['ce0'].device_type.cli`	`PresenceContainer`
`root.devices.device['ce0'].address`	`str`
`root.devices.device['ce0'].port`	`int`

Maagic object from a keypath:

```
node = ncs.maagic.get_node(transaction_id, '/ncs:devices/device{ce0}')
```

https://developer.cisco.com/docs/nso/guides/python-api-overview/#maagic-api
https://developer.cisco.com/docs/nso/api/ncs-maagic/

Transactions and Commits

Python API

- Use Python Context Managers (the “`with`” key word)
- Transactions are closed by default after they are applied
- Commit options can be specified
- You only need to create a write transactions for actions, not services

```
import ncs

with ncs.maapi.Maapi() as m:
    with ncs.maapi.Session(m, "admin", 'python', groups=['ncsadmin']):
        with m.start_write_trans() as t_rw:

            root = ncs.maagic.get_root(t_rw)
            device_cdb = root.devices.device["eng04-cleaf-02"]
            device_cdb.config.interface.loopback[0].description = "Done from python API"

            # Starting dry-run
            cp = ncs.maapi.CommitParams()
            cp.dry_run_native()
            dry_run_result = t_rw.apply_params(True, cp)
```

Navigate the API

Python API

Python `help()` function

```
>>> import ncs
>>> with
ncs.maapi.single_write_trans(user="admin",
context="system") as transaction:
... root = ncs.maagic.get_root(transaction)
... devices = root.devices
...
>>> help(devices)
```

```
Help on Container in module ncs.maagic object:

class Container(Node)
 |  Container(backend, cs_node, parent=None)
 |
 |  Represents a yang container.
 |
 |  A (non-presence) container node or a list element,
contains other nodes.
 |
 |  Method resolution order:
 |      Container
 |      Node
 |      builtins.object
 |
 |  Methods defined here:
 |
 |  __init__(self, backend, cs_node, parent=None)
 |      Initialize Container node. Should not be called
explicitly.
 |
 |  __repr__(self)
 |      Get internal representation.
...
```

Navigate the API

Python API

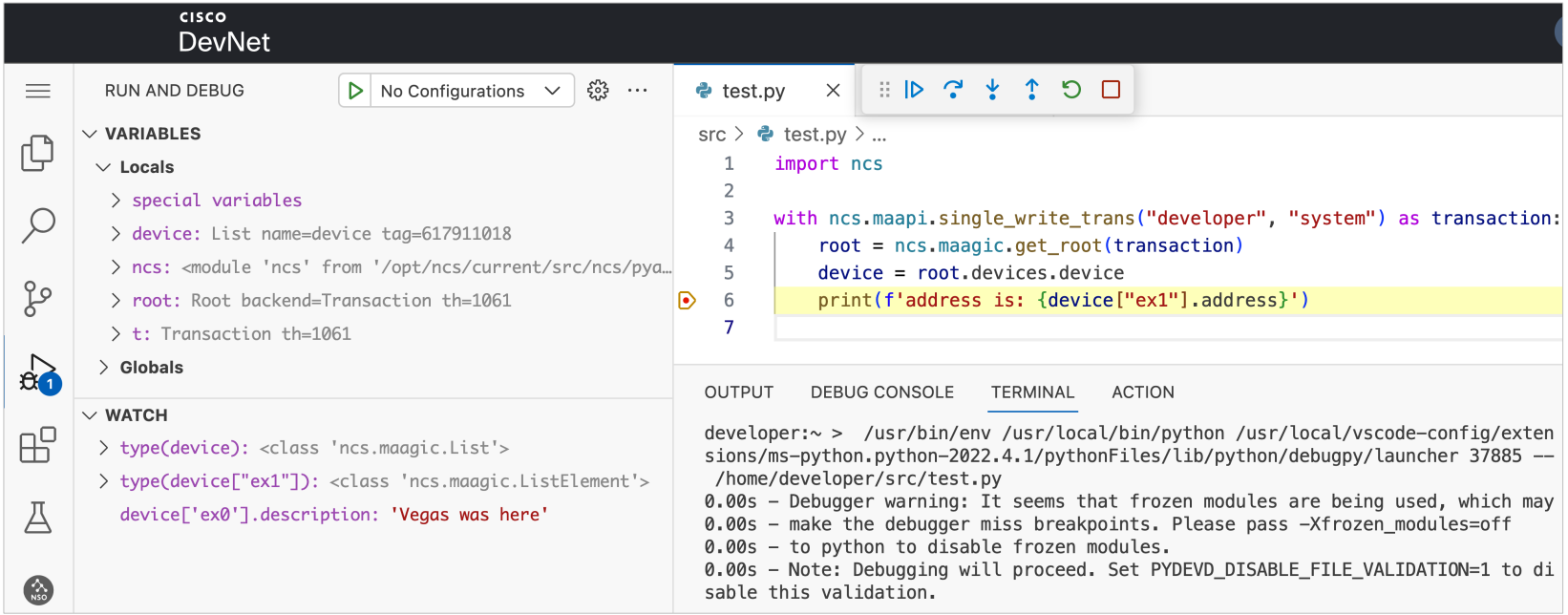

```
In [1]: for device in root.ncs__devices.device:
...: print(device.name)
...:
ce0
ce1

In [2]: device = root.ncs__devices.device['ce0']

In [3]: type(device)
Out[3]: ncs.maagic.ListElement

In [4]: device
Out[4]: ListElement name=device tag=617911018 keys={ce0}

In [5]: help(device)

In [6]: device.
device.active_settings
device.address
```

https://github.com/NSO-developer/ncs_pycli

Navigate the API

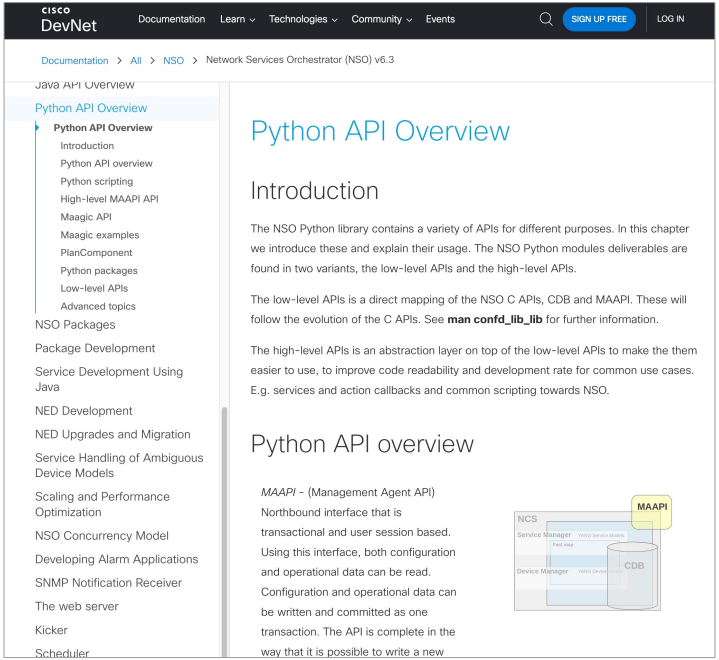
Python API

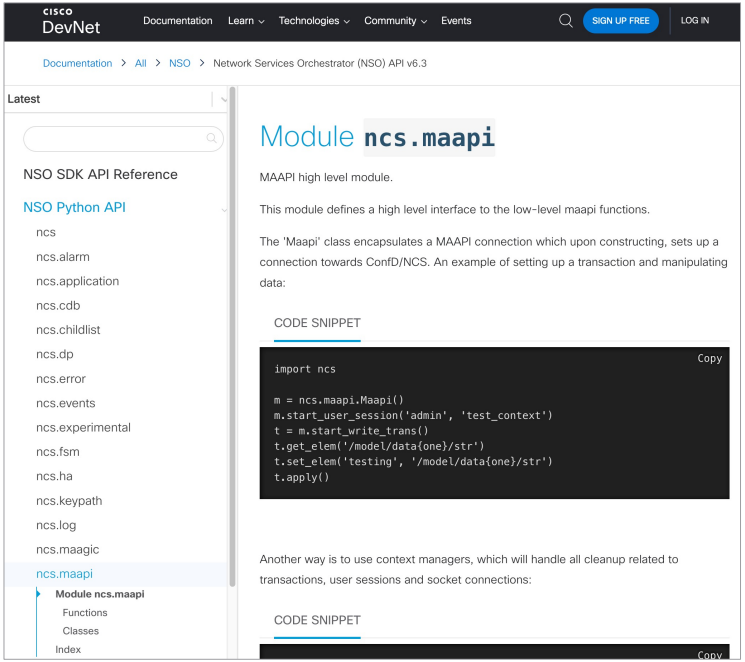
Debug



Navigate the API

Python API





https://developer.cisco.com/docs/nso/guides/python-api-overview/#python-api-overview
https://developer.cisco.com/docs/nso/api/ncs/#package-ncs
https://developer.cisco.com/docs/nso/guides/ncs-man-pages-volume-3/#man.3.confd_lib_maapi

Navigate the API

Python API

Maagic with Devtools

```
admin@ncs# devtools true
admin@ncs# show running-config devices device ex0 | display maagic
root.ncs__devices.device['ex0'].address 127.0.0.1
root.ncs__devices.device['ex0'].port 12022
root.ncs__devices.device['ex0'].authgroup default
root.ncs__devices.device['ex0'].device-type.netconf.ned-id ne-nc-1.0
root.ncs__devices.device['ex0'].config.aaa__aaa.authentication.users.user['admin']
root.ncs__devices.device['ex0'].config.aaa__aaa.authentication.users.user['oper']

admin@ncs# config
Entering configuration mode terminal
admin@ncs(config)# devices device ex0 port 10233
admin@ncs(config-device-ex0)# top
admin@ncs(config)# show configuration | display maagic
root = ncs.maagic.get_root(t)
root.ncs__devices.device['ex0'].port = '10233'
```

https://developer.cisco.com/docs/nso/guides/nso-cli/#displaying-the-configuration

Navigate the API

Python API

Logs

- `tailf-ncs-python-vm.yang` & `ncs.conf` define the python-vm container.
  - See example 26: "*The Python VM YANG model*" for full explanation.
- Some of `python-vm` nodes are by default invisible.
  - See documentation for xml and cli command needed.
- Filename: `logs/ncs-python-vm-<package-name>.log` by default.

https://developer.cisco.com/docs/nso/guides/the-nso-python-vm/#the-nso-python-vm

Navigate the API

Python API

Debug

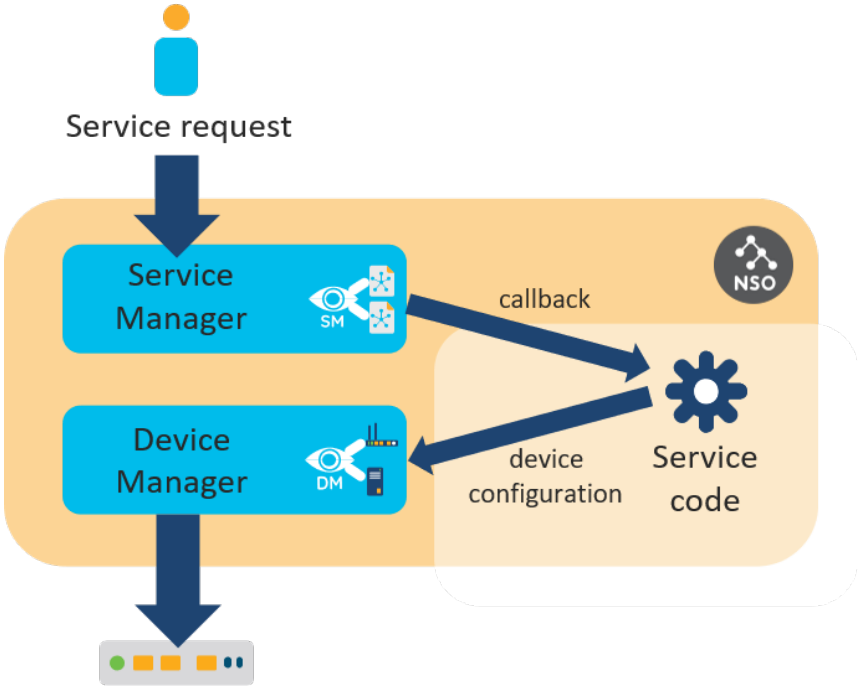
- Python packages run without an attached console.
  - Standard output collected in `ncs-python-vm.log`
- Python APIs provide logging objects based on the standard Python logging module.
- Default logging level set to info.

```
$ ncs_cli -Cu admin
admin@ncs# config
admin@ncs(config)# python-vm logging level level-debug
admin@ncs(config)# commit
```

https://developer.cisco.com/docs/nso/guides/the-nso-python-vm/#debugging-of-python-packages

Services with Python

Python API



https://developer.cisco.com/docs/nso/guides/python-api-overview/#python-packages

Services with Python

Python API

```python
from ncs.application import Application
from ncs.application import Service
import ncs.template

class ServiceCallbacks(Service):
  @Service.create
  def cb_create(self, tctx, root, service, proplist):
    self.log.info('Service create(service=', service._path, ')')
    # Add the service logic

class Service(Application):
  def setup(self):
    self.log.info('Worker RUNNING')
    self.register_service('service-servicepoint', ServiceCallbacks)

  def teardown(self):
    self.log.info('Worker FINISHED')
```

```
list router {
 key name;

 uses ncs:service-data;
 ncs:servicepoint "service-servicepoint";

 leaf name {
  type string;
 }

 leaf-list device {
  type leafref {
    path "/ncs:devices/ncs:device/ncs:name";
   }
 }
```

https://developer.cisco.com/docs/nso/guides/python-api-overview/#python-packages

Services with Python

Python API

```
class ServiceCallbacks(Service):
  @Service.create
  def cb_create(self, tctx, root, service, proplist):
    self.log.info('Service create(service=', service._path, ')')

    # Add the service logic >>>>>>>
    vars = ncs.template.Variables()
    vars.add('MAGIC', '42')
    vars.add('CE', service.device)
    vars.add('INTERFACE', service.unit)
    template = ncs.template.Template(service)
    template.apply('pyservice-template', vars)

    self.log.info('Template is applied')

    dev = root.devices.device[service.device]
    dev.description = "This device was modified by %s" % service._path
```

https://developer.cisco.com/docs/nso/guides/python-api-overview/#python-packages

Services with Python

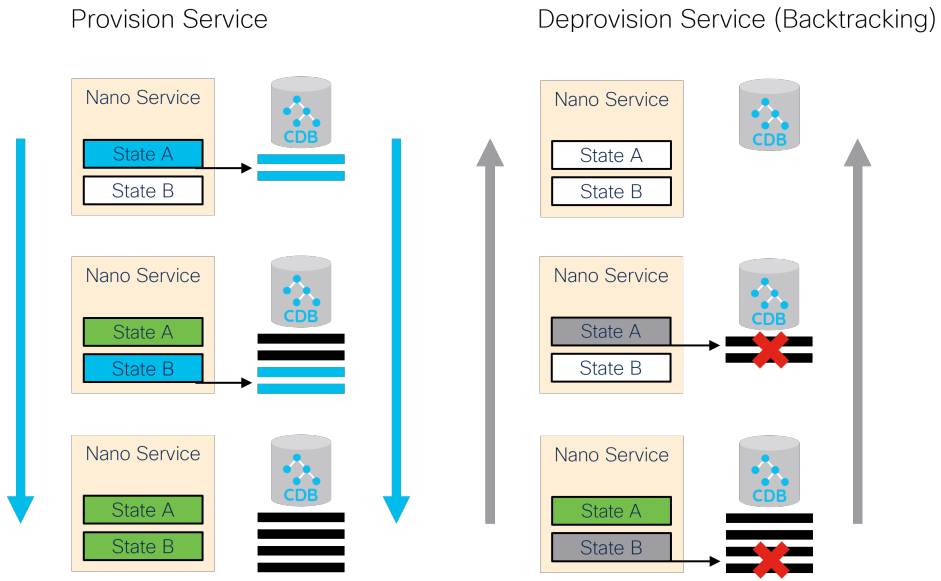
Python API

```
class ServiceCallbacks(Service):

  @Service.create
  def cb_create(self, tctx, root, service, proplist):
    self.log.info('Service create(service=', service._path, ')')


  @Service.pre_modification
  def cb_pre_modification(self, tctx, op, kp, root, proplist):
    self.log.info('Service premod(service=', kp, ')')


  @Service.post_modification
    def cb_post_modification(self, tctx, op, kp, root, proplist):
    self.log.info('Service premod(service=', kp, ')')
```

https://developer.cisco.com/docs/nso/guides/python-api-overview/#python-packages

Nano Services

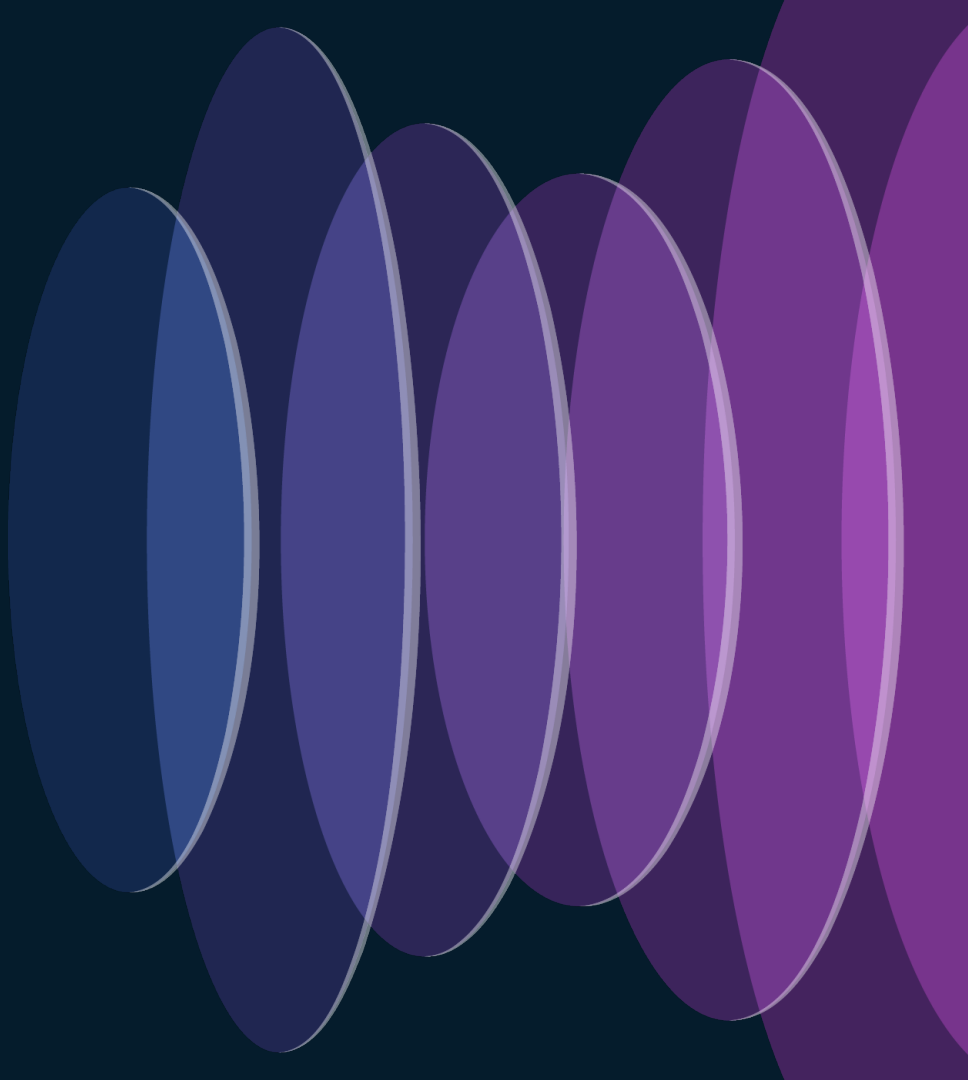
Python API



- Reactive FASTMAP (RFM)
- Provide provisioning steps.
- Handle side-effects, useful for working with external systems.

https://developer.cisco.com/docs/nso/guides/nano-services-for-staged-provisioning

Playground time!



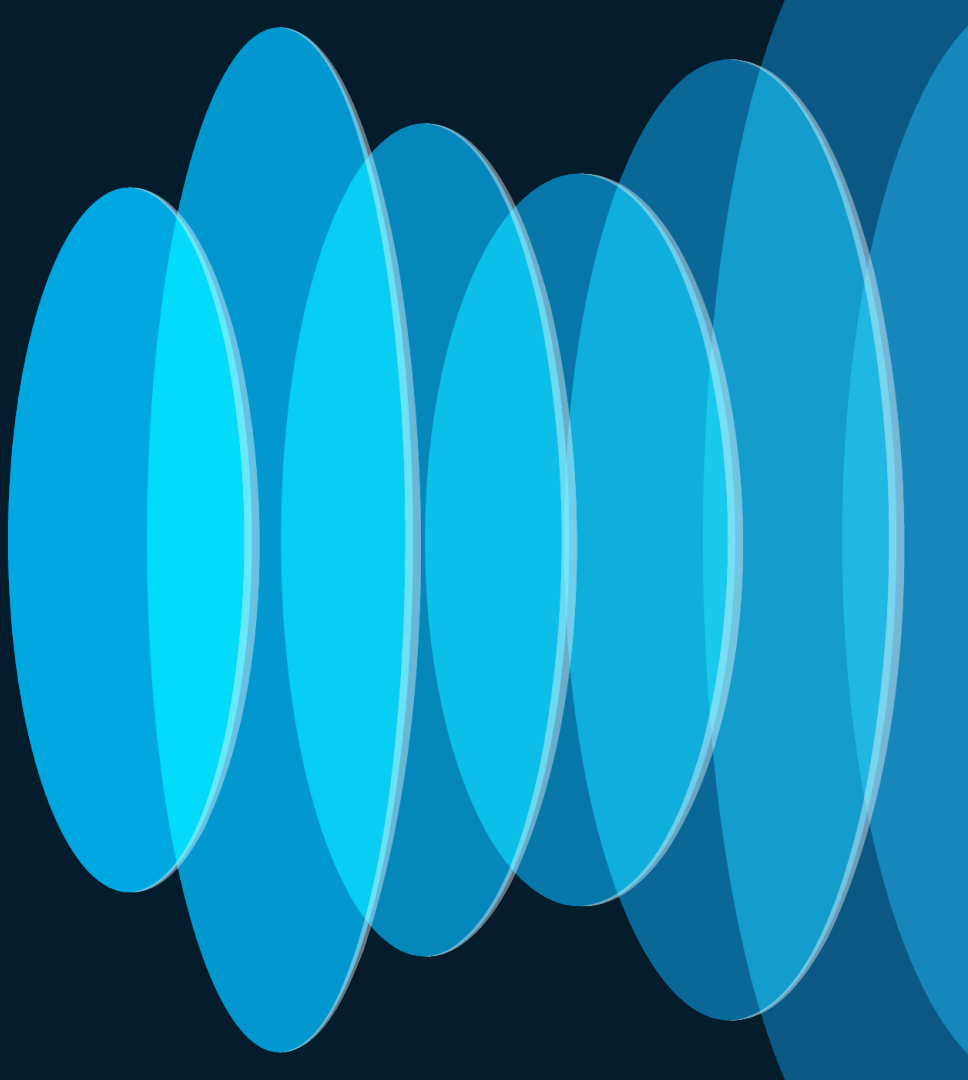
Playground

Python API

Go to

Github.com/jillesca/DEVWKS-2551

Conclusion



NSO Python API

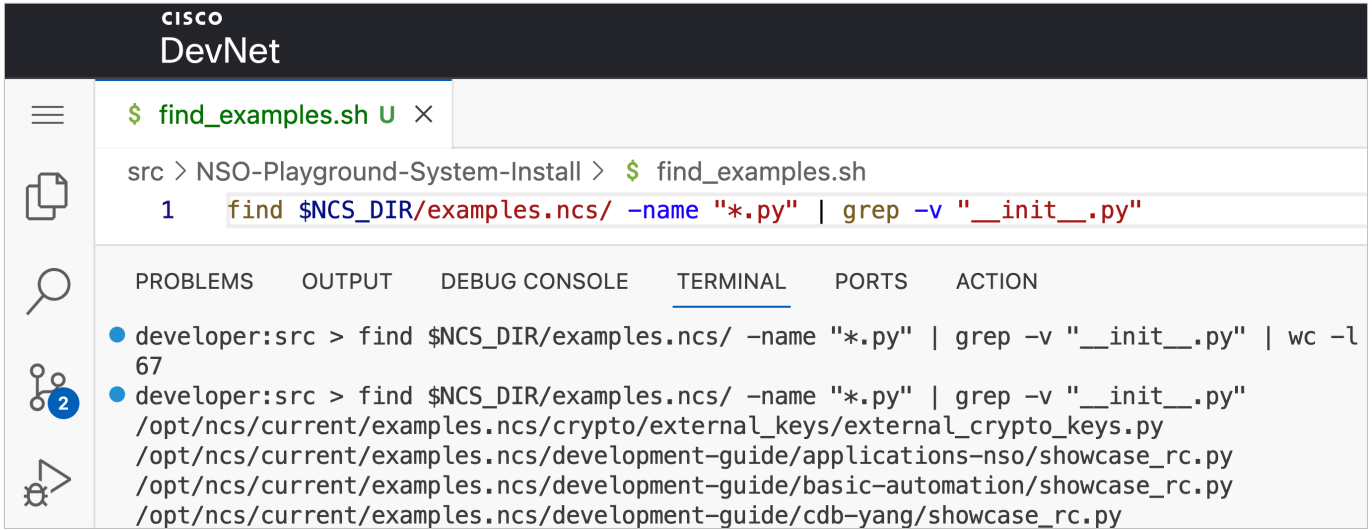
Conclusion

- NSO Python API/SDK can be used for Scripting or Services.
- Low-level & High-level Python API.
- MAAPI & MAAGIC APIs for High-level API.
- Documentation & Examples are key, read them.
- If external systems are involved, use nano services.

More Resources

NSO Built-in Python Examples

```
find $NCS_DIR/examples.ncs/ -name "*.py" | grep -v "__init__.py"
```



**rc in a filename stands for "RESTCONF"*

Call to Action

Continue your learning journey

- Expand your knowledge
  - https://developer.cisco.com/docs/nso/guides/python-api-overview
- Practice the NSO Python API
  - https://developer.cisco.com/learning/labs/service-dev-201/introduction
- Get started with NSO
  - https://developer.cisco.com/learning/tracks/get_started_with_nso
- Review best practices for service development
  - https://github.com/NSO-developer/nso-service-dev-practices

cisco Live!
DevNet

Continue your learning journey after the event with Cisco DevNet!

- Personalized learning modules
- Living interactive tooling
- Other resources

Scan to get started

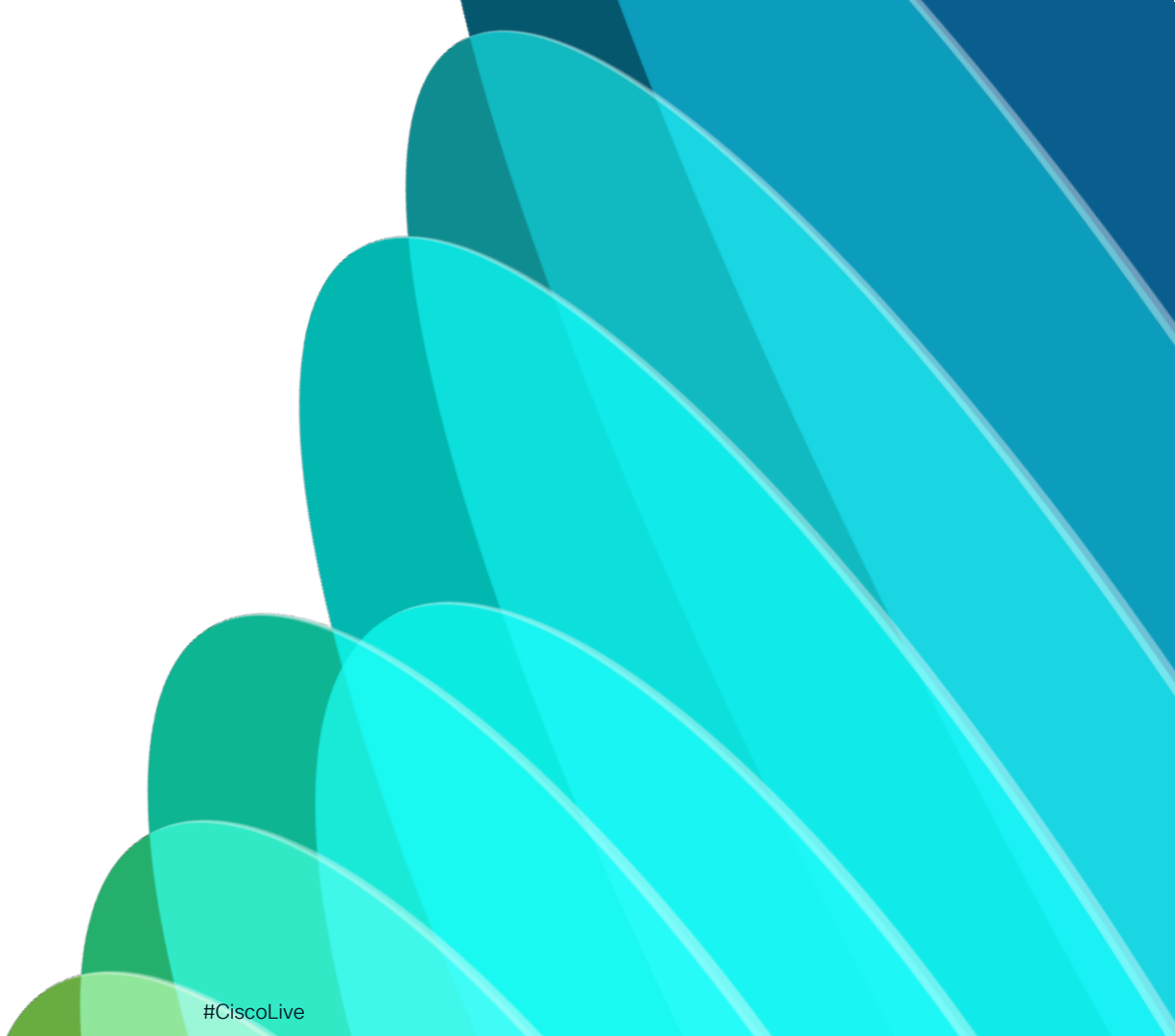
Continue your education

- Visit the Cisco Showcase for related demos
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand

Contact me at:
https://www.linkedin.com/in/jesusillescas

The bridge to possible

Thank you



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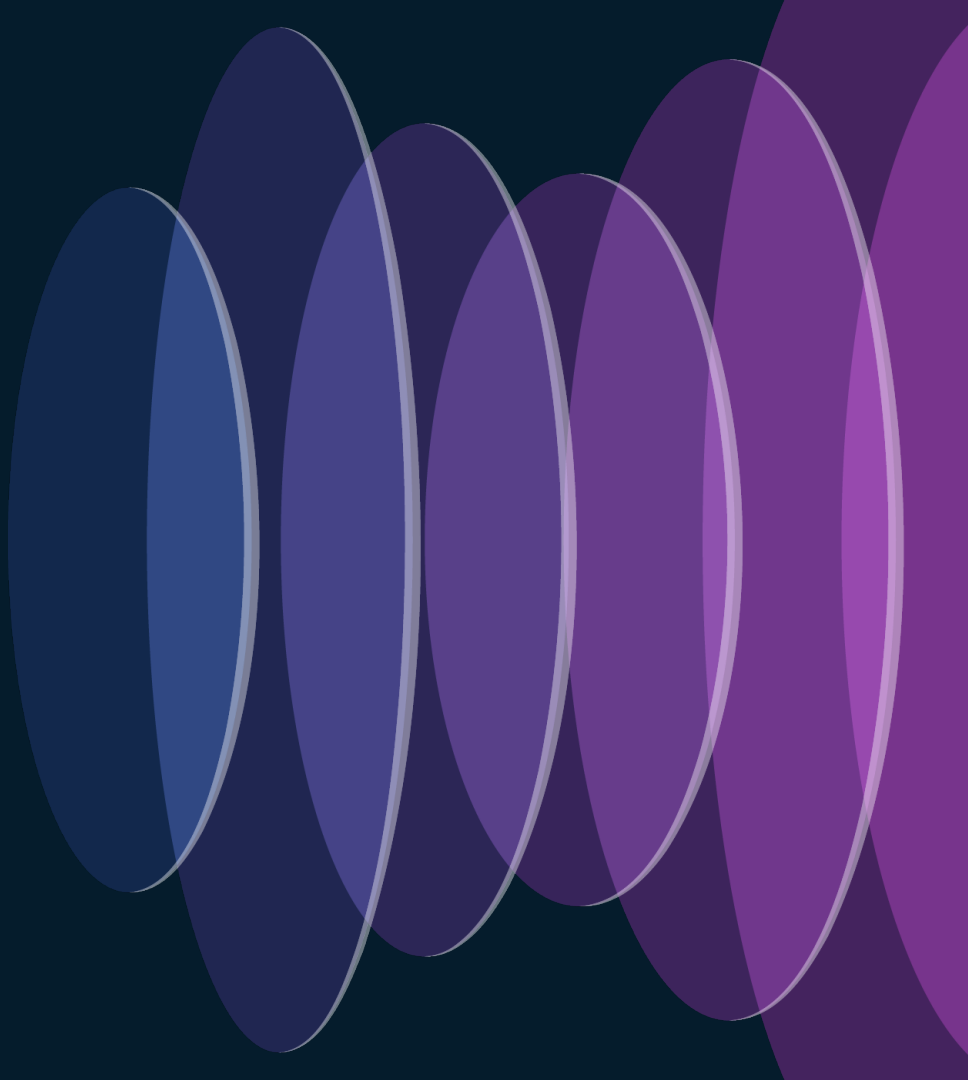
#CiscoLive

Backup Slides



Define a service and NSO will figure out the rest

Core Concepts

Create

Convert service request into valid config
Easy: need to check resource availability

Repair

Recover from arbitrary resource changes
Hard: identify/fix or migrate to new infra

Update

Config change from change in service
Medium: need to add/release resources

Delete

Remove service instance, release resources
Medium: need reference counting of resources

FastMap automatically infers lifecycle operations from the “create” definition

Individual operations don’t need to be manually coded

Execute cli/rpc on devices

Python API

- NEDs abstract the device connection
- Actions can be used to execute arbitrary CLI commands or NETCONF RPCs against devices
- Great for complex audit use cases

```
>>> device_cdb = root.devices.device["eng04-cleaf-02"]
>>> cli_any_command = device_cdb.live_status.nx_stats__exec.any
>>> show_ip_int_br_input = cli_any_command.get_input()
>>> show_ip_int_br_input.args = ["show ip interface brief"]
>>> show_ip_int_br_result = cli_any_command.request(show_ip_int_br_input)

>>> print(show_ip_int_br_result.result)


IP Interface Status for VRF "default"(1)
Interface            IP Address      Interface Status
Lo0                  123.30.164.1    protocol-up/link-up/admin-up
```

MAAGIC API

Python API

Anything modelled in YANG is available in the python API

Same concept as an SDK, but driven by YANG models

Common types

- List
- List Element
- Container

Common attributes

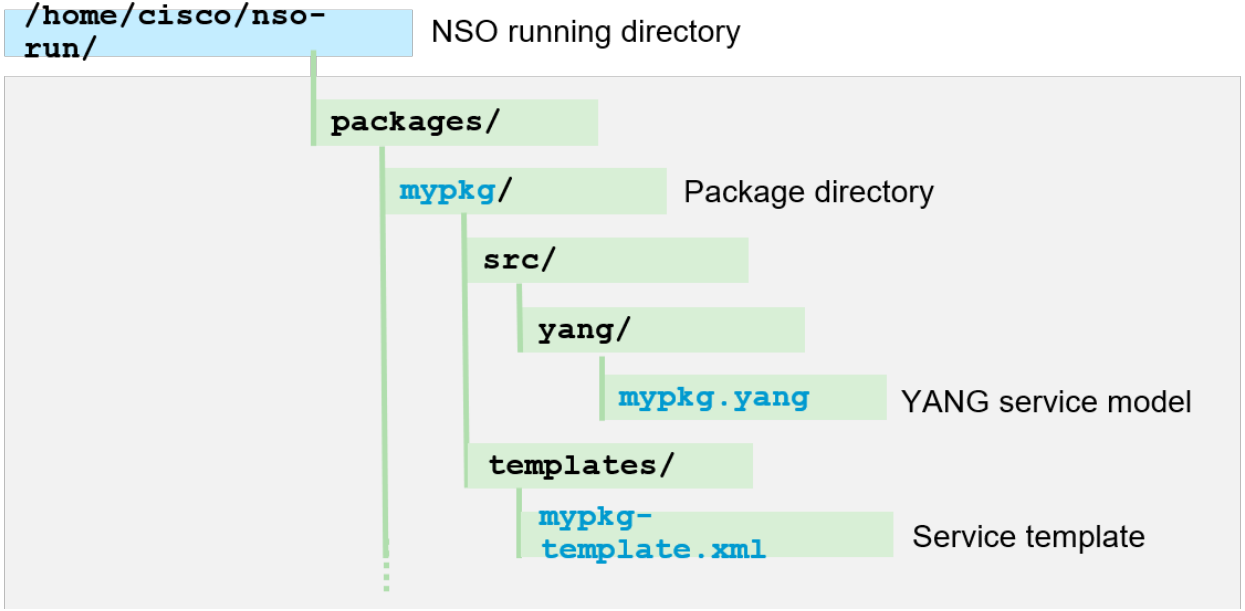
- _parent
- _path

```
>>> root = ncs.maagic.get_root(t_rw)
>>> type(root)
<class 'ncs.maagic.Root'>
>>> type(root.devices)
<class 'ncs.maagic.Container'>
>>> type(root.devices.device)
<class 'ncs.maagic.List'>
>>> type(root.devices.device["eng04-cleaf-02"])
<class 'ncs.maagic.ListElement'>
```

https://developer.cisco.com/docs/nso/api/ncs-maagic/

Service Package Architecture

Core Concepts



Service Challenges

Create → Modify → Delete → Repair

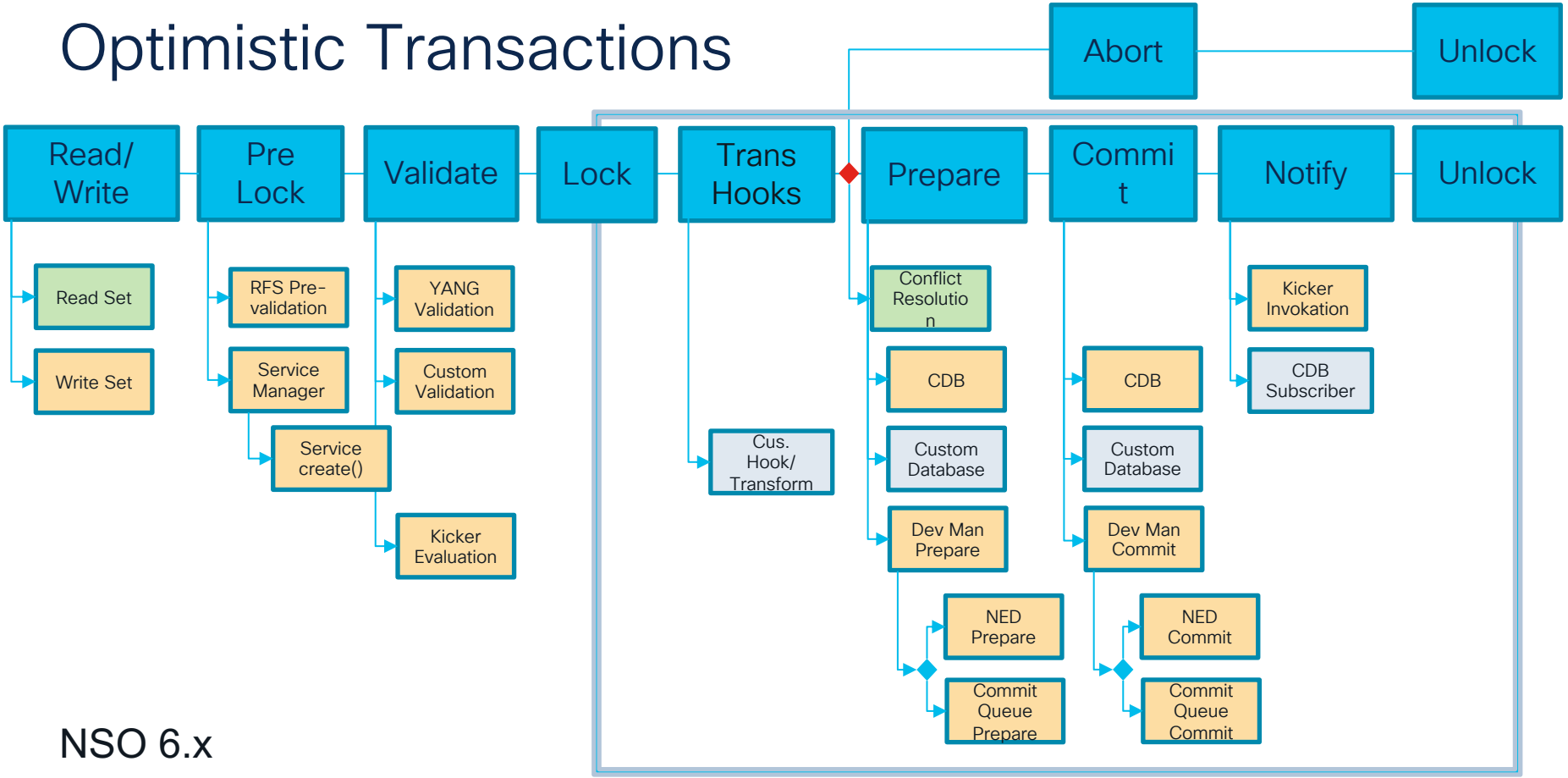
- Easy
- Given a set of service-level inputs, provide a known and valid output to network
- May require some additional resource collection to fulfill the configuration set

- Challenging
- Allow arbitrary changes to the network service
- May require collecting or handing back resources to fulfill the configuration set

- Hard
- Delete any given instance of a service and clean up the resources
- May require reference counting for shared resources

- Almost impossible
- Recover from any arbitrary resource changes
- Identify and fix any anomalies
- Migrate to new infrastructure

Optimistic Transactions



NSO 6.x