

Management and Operations of Networks, Services, and Systems

Device API and Automation Tools

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Data formats

- JSON, YAML, XML

- Types of Objects
 - String, integer, boolean
 - Lists and dictionaries

```
{  
  "json": [  
    "rigid",  
    "better for data interchange"  
  ],  
  "yaml": [  
    "slim and flexible",  
    "better for configuration"  
  ],  
  "object": {  
    "key": "value",  
    "array": [  
      {  
        "null_value": null  
      }  
    ],  
  },  
}
```

```
---  
json:  
- rigid  
- better for data interchange  
yaml:  
- slim and flexible  
- better for configuration  
object:  
  key: value  
  array:  
  - null_value:
```

```
<?xml version="1.0" encoding="UTF-8" ?>  
<root>  
  <json>rigid</json>  
  <json>better for data interchange</json>  
  <yaml>slim and flexible</yaml>  
  <yaml>better for configuration</yaml>  
  <object>  
    <key>value</key>  
    <array>  
      <null_value/>  
    </array>  
  </object>
```

YANG, data modeling language

- Defines a structure for the data
- Building blocks:
 - **module** – top of the hierarchy of nodes
 - **containers** – related nodes
 - **lists** – identifies nodes
 - **leaf** – individual attributes of a node
 - **type** – every leaf has an associated type

<https://en.wikipedia.org/wiki/YANG>

```
list person {  
  key name;  
  leaf name { type string; }  
  leaf birthday { type yang:date-and-time; mandatory true; }  
}
```

```
<person>  
  <name>Cristiano Ronaldo</name>  
  <birthday>1985-02-05T00:00:00-00:00</birthday>  
</person>
```

YANG for networking

<https://github.com/YangModels/yang>

- `pyang -f tree ietf-ip.yang`

```
module: ietf-ip
```

```
augment /if:interfaces/if:interface:
```

```
  +--rw ipv4!
```

```
    | +--rw enabled?      boolean
```

```
    | +--rw forwarding?   boolean
```

```
    | +--rw mtu?          uint16
```

```
    | +--rw address* [ip]
```

```
      | | +--rw ip                inet:ipv4-address-no-zone
```

```
      | | +--rw (subnet)
```

```
      | | | +--:(prefix-length)
```

```
      | | | | +--rw prefix-length? uint8
```

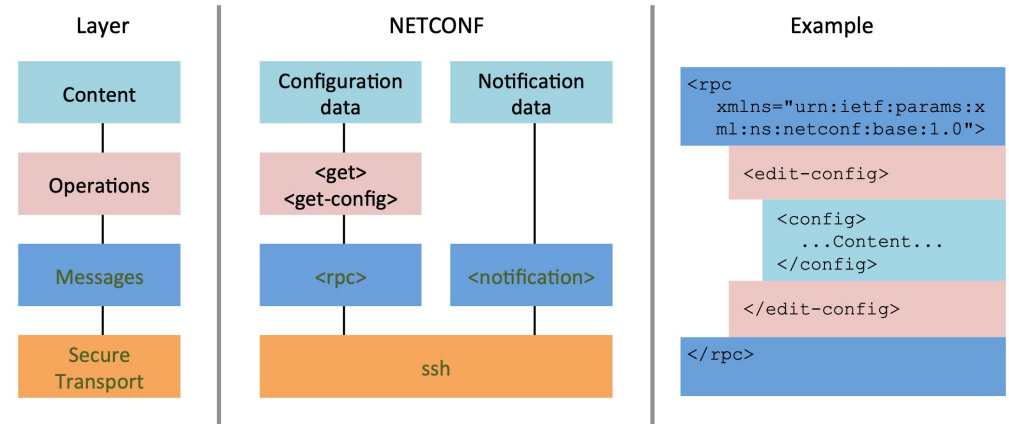
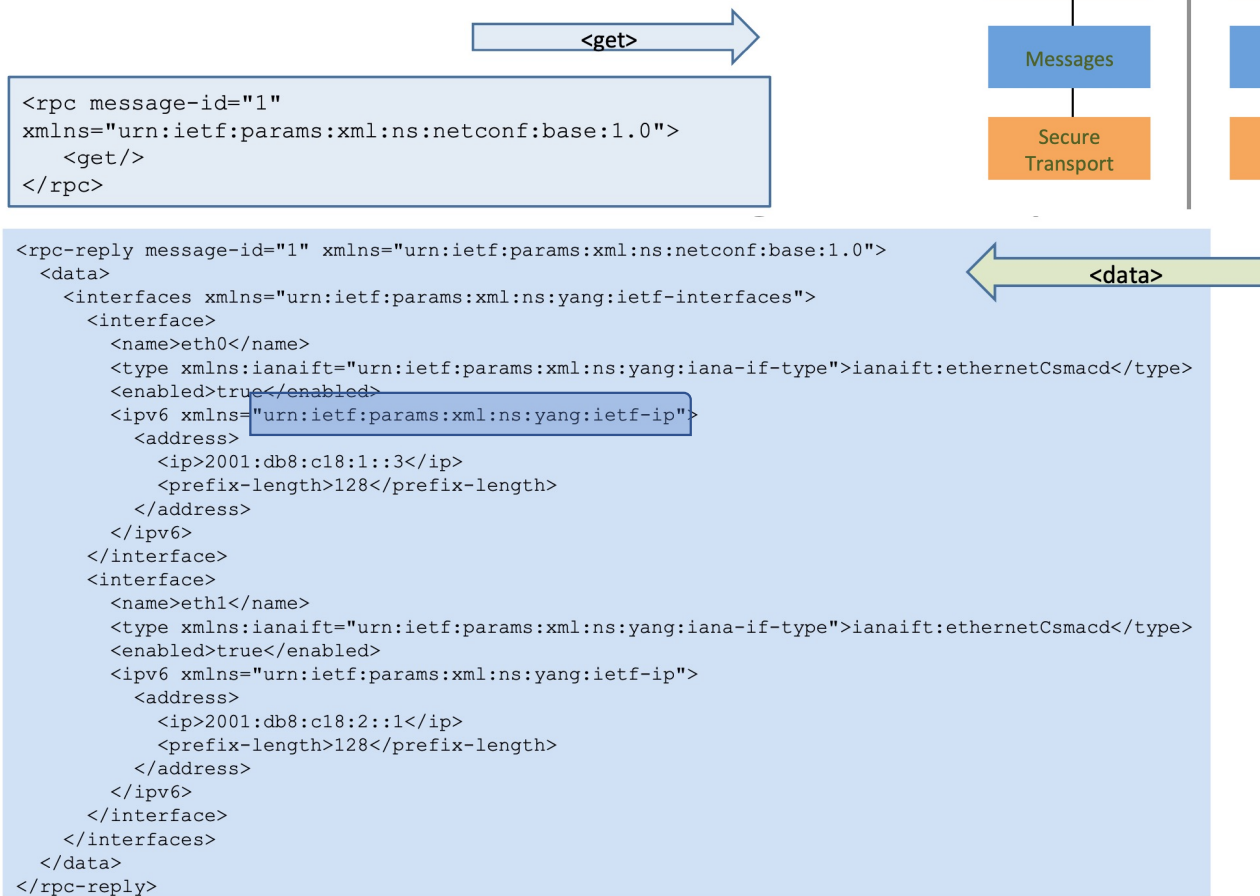
```
      | | | +--:(netmask)
```

```
      | | | | +--rw netmask?      yang:dotted-quad {ipv4-non-contiguous-netmasks}?
```

netconf

RFC6241

<https://trac.ietf.org/trac/netconf/wiki>



restconf

RFC8040

Acting on resources

```
Module my-interfaces {  
  namespace "com.my-interfaces";  
  
  container interfaces {  
    list interface {  
      key name;  
      leaf name { type string; }  
      leaf admin-status { type enum; }  
    }  
  
    rpc flap-interface {  
      input {  
        leaf name { type string; }  
      }  
      output {  
        leaf result { type boolean; }  
      }  
    }  
  }  
}
```

GET : Gets a resource

GET /restconf/data/my-interfaces:interfaces

GET /restconf/data/my-interfaces:interfaces/interface/<some name>

POST : Creates a resource or invoke operation

POST /restconf/operations/my-interfaces:flap-interface
+ JSON/XML Form Data (including name)

Response will have JSON/XML result

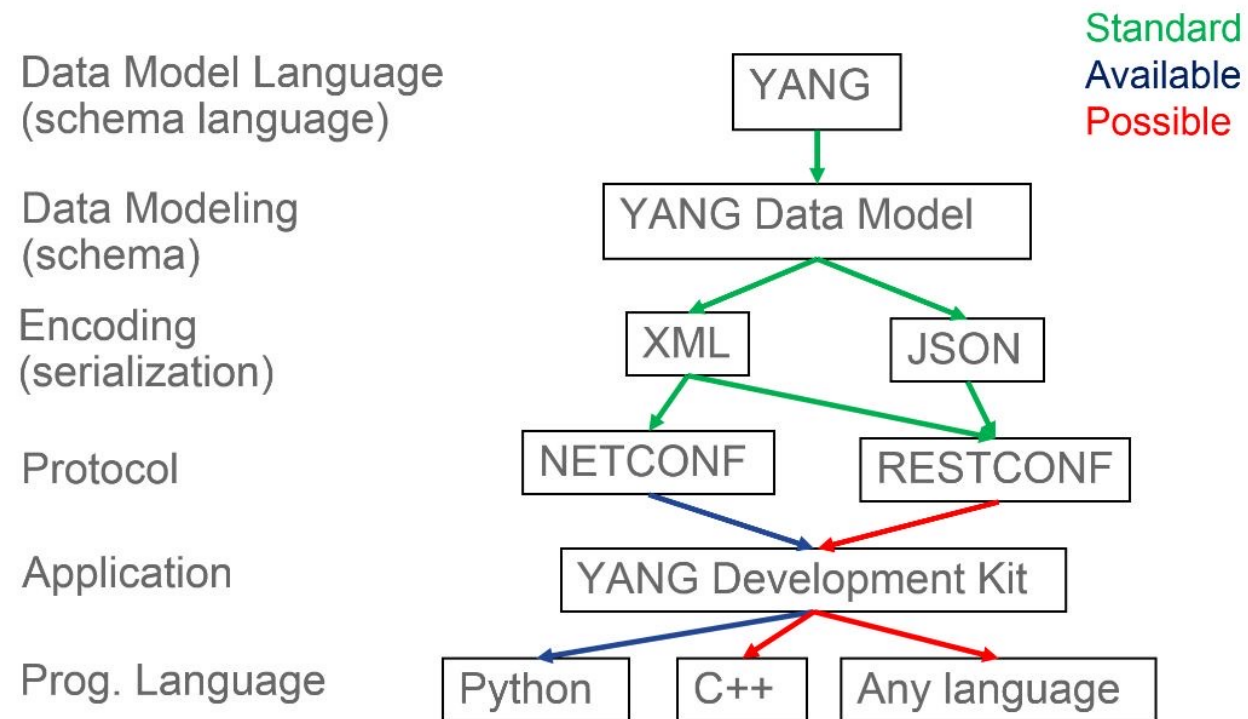
PUT : Replaces a resource

PUT /restconf/data/my-interfaces:interfaces/interface/<some name> + JSON/XML Form Data (name, admin-status)

DELETE : Removes a resource

DELETE /restconf/data/my-interfaces:interfaces/interface/<some name>

Birds'eye view



Mikrotik REST API

<https://help.mikrotik.com/docs/display/ROS/REST+API>

```
curl -k -u USER:PWD https://192.168.88.1/rest/system/resource
```

```
architecture-name:    "arm"
bad-blocks:           "0"
board-name:           "CRS326-24G-2S+"
build-time:           "Dec/21/2021 11:53:05"
cpu:                  "ARMv7"
cpu-count:            "2"
cpu-load:              "1"
factory-software:     "6.41"
free-hdd-space:       "2424832"
free-memory:          "483110912"
platform:             "MikroTik"
total-hdd-space:      "16777216"
total-memory:         "536870912"
uptime:               "3m53s"
version:              "7.1.1 (stable)"
write-sect-since-reboot: "798"
write-sect-total:     "2553"
```

```
curl -k -u USER:PWD https://192.168.88.1/rest/ip/address
```

```
▼ 0:
  .id:                  "*1"
  actual-interface:     "bridge"
  address:              "192.168.88.1/24"
  comment:              "defconf"
  disabled:             "false"
  dynamic:              "false"
  interface:            "bridge"
  invalid:              "false"
  network:              "192.168.88.0"
```


Add bridge, set IP address

```
curl -k -u USER:PWD -X PUT  
https://192.168.88.1/rest/interface/bridge --data '{"name":  
"test123"}' -H "content-type: application/json"
```

<https://192.168.88.1/rest/interface/bridge/test123>

```
.id: "*1E"  
actual-mtu: "1500"  
ageing-time: "5m"  
arp: "enabled"  
arp-timeout: "auto"  
auto-mac: "true"  
dhcp-snooping: "false"  
disabled: "false"  
fast-forward: "true"  
forward-delay: "15s"  
igmp-snooping: "false"  
l2mtu: "65535"  
mac-address: "2A:AC:ED:F4:D6:B4"  
max-message-age: "20s"  
mtu: "auto"  
name: "test123"  
priority: "0x8000"  
protocol-mode: "rstp"  
running: "true"  
transmit-hold-count: "6"  
vlan-filtering: "false"
```

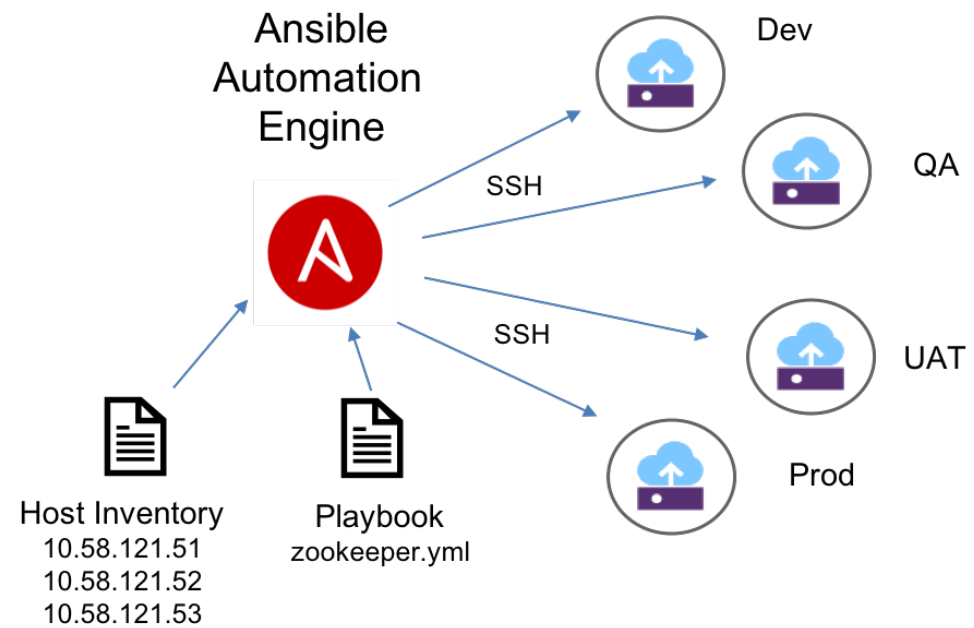
```
#curl -k -u USER:PWD -X PUT  
https://192.168.88.1/rest/ip/address --data '{"address":  
"192.168.111.111", "interface": "test123"}' -H "content-  
type: application/json"
```

<https://192.168.88.1/rest/ip/address>

```
▼ 0:  
.id: "*1"  
actual-interface: "bridge"  
address: "192.168.88.1/24"  
comment: "defconf"  
disabled: "false"  
dynamic: "false"  
interface: "bridge"  
invalid: "false"  
network: "192.168.88.0"  
  
▼ 1:  
.id: "*2"  
actual-interface: "test123"  
address: "192.168.111.111/32"  
disabled: "false"  
dynamic: "false"  
interface: "test123"  
invalid: "false"  
network: "192.168.111.111"
```

Automation tools

- Ansible, Salt, Puppet, Chef
- Host inventory
- Playbook



Ansible quick start

- On the config host
 - apt install ansible
 - ansible.cfg
 - [defaults]
 - inventory = /home/gors/ansible/hosts
 - hosts
 - [targets]
 - m-gors-B
 - m-gors-C

```
gors@gors-A:~/ansible$ ansible all --list-hosts
hosts (2):
  m-gors-B
  m-gors-C
```

```
gors@gors-A:~/ansible$ ansible all -m ping
m-gors-B | SUCCESS => {
  "ansible_facts": {
    "discovered_interpreter_python": "/usr/bin/python3"
  },
  "changed": false,
  "ping": "pong"
}
m-gors-C | SUCCESS => {
  "ansible_facts": {
    "discovered_interpreter_python": "/usr/bin/python3"
  },
  "changed": false,
  "ping": "pong"
}
```

Ansible upload configuration files

```
- hosts: targets
  tasks:
    - name: Copy file with owner and permissions
      ansible.builtin.copy:
        src: my-config-file
        dest: ~/foo.conf
        owner: gors
        group: gors
        mode: '0644'
```

```
gors@gors-A:~/ansible$ ssh m-gors-B 'ls ~/foo.conf'
/home/gors/foo.conf
```

```
ansible > ≡ my-config-file.j2
1 This is {{ inventory_hostname }}
2
```

```
ansible > ! deploytemplate.yml
1 - hosts: targets
2   tasks:
3     - name: deploy template
4       template:
5         src: my-config-file.j2
6         dest: ~/foo2.conf
7
```

```
gors@gors-A:~/ansible$ ssh m-gors-B 'cat ~/foo2.conf'
This is m-gors-B
```

Ansible napalm

- pip install napalm-ansible
- pip install napalm-ros
- ansible.cfg
 - [defaults]
 - library =
LIBHOME/napalm_ansible/
LIBHOME/napalm_ros/

```
- hosts: switches
  connection: local
  gather_facts: no
  tasks:
    - name: get facts from device
      napalm_get_facts:
        hostname: "{{ inventory_hostname }}"
        username: "USER"
        dev_os: "ros"
        password: "PWD"
        filter: "facts"
      register: result
    - name: print results
      debug: msg="{{ result }}"
```

```
TASK [print results] *****
ok: [m-sw1] => {
  "msg": {
    "ansible_facts": {
      "discovered_interpreter_python": "/usr/bin/python3",
      "napalm_facts": {
        "fqdn": "",
        "hostname": "MikroTik",
        "interface_list": [
          "br-client",
          "br-server",
          "bridge",
          "ether1",
          "ether2",
```

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