neutron-lan

SDN study environement @ home

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Background and Motivation

- My belief
  - SDN = software defines network
- Too many SDN definitions
  - I have been confused a lot.
  - OpenFlow, OVSDB, Netconf, BGP extensions such as FlowSpec...
  - The latest one: OpFlex (DevOps-like)
- What's the real SDN?
  - Let's develop SDN by myself and examine every definition.
- But, wait! I need a SDN study environment at home.
  - I am a poor guy, so I cannot buy expensive SDN-capable switches from Cisco, Juniper...

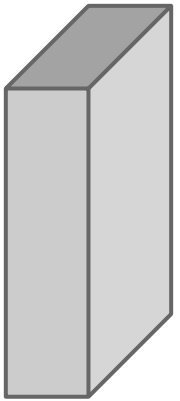
Strategy

- My budget is less than $200.
- Switches/routers I purchased in Akihabara, Tokyo
  - Three $40 broadband routers and one $40 Raspberry Pi
- And I develop all the SDN software from scratch
  - But reuse existing networking software as much as possible, such as Open vSwitch
- Base knowledge/skills
  - SDN in the past: SIP and IP-PBX
  - OpenFlow, OpenStack neutron and SaltStack
  - Java and Python
  - HTML5 and CSS (a little)
- Let’s develop neutron-like SDN for my home network ⇒ let’s call it ‘neutron-lan’

Project ‘neutron-lan’ characteristics

- Cheap routers as ‘Baremetal Switch’
  - OpenWrt, Raspberry Pi
  - u-boot for installing new firmware
- Home-made DevOps tool ‘NLAN’ from scratch
  - 100% Python implementation
  - YAML-based state rendering
  - Model-driven service abstraction
- VXLAN-based edge-overlay for network virtualization
- LXC for Network Functions Virtualization
- Open vSwitch as a programmable switch
- OVSDB as a general-purpose config database

Cheap routers as ‘Baremetal Switch’



Broadband Router
w/ u-boot boot loader

TFTP PUT

OpenWrt image

PC

OpenWrt build environment

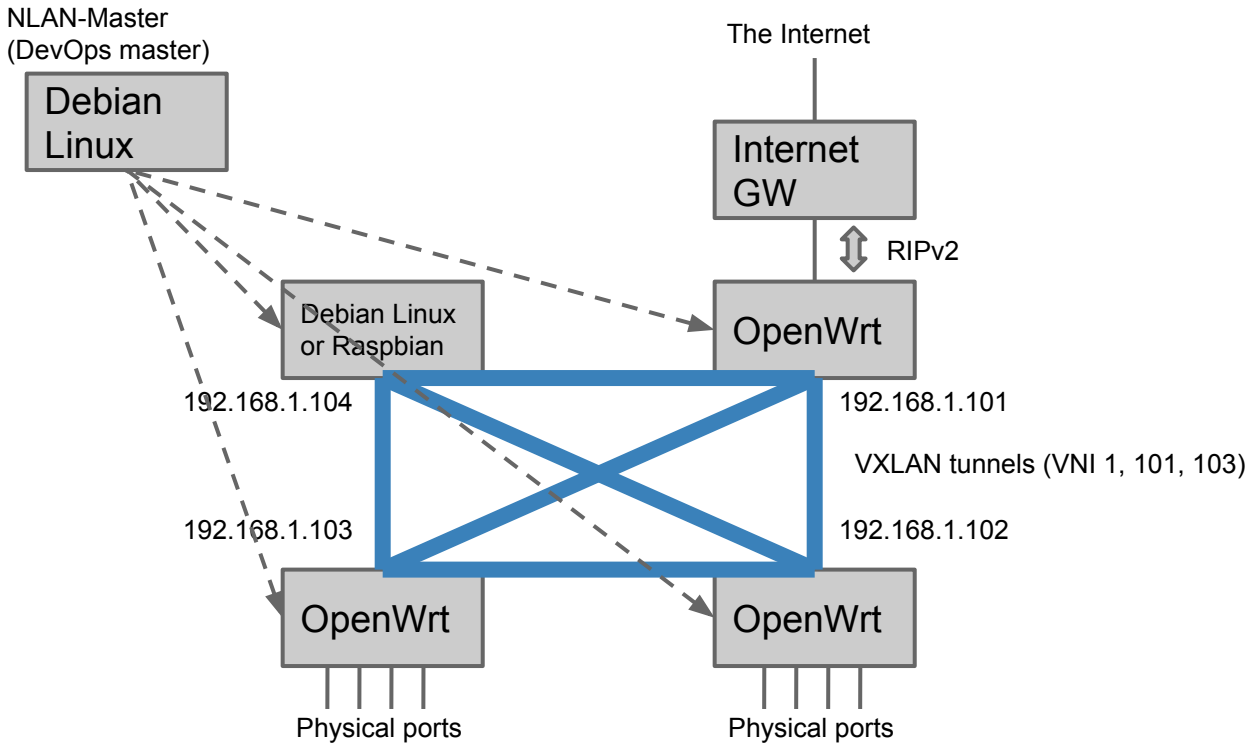
OpenWrt ‘BarrierBreaker’ image w/
- Open vSwitch 2.0.0
- Network namespaces
- Veth

Test bed (cont'd)

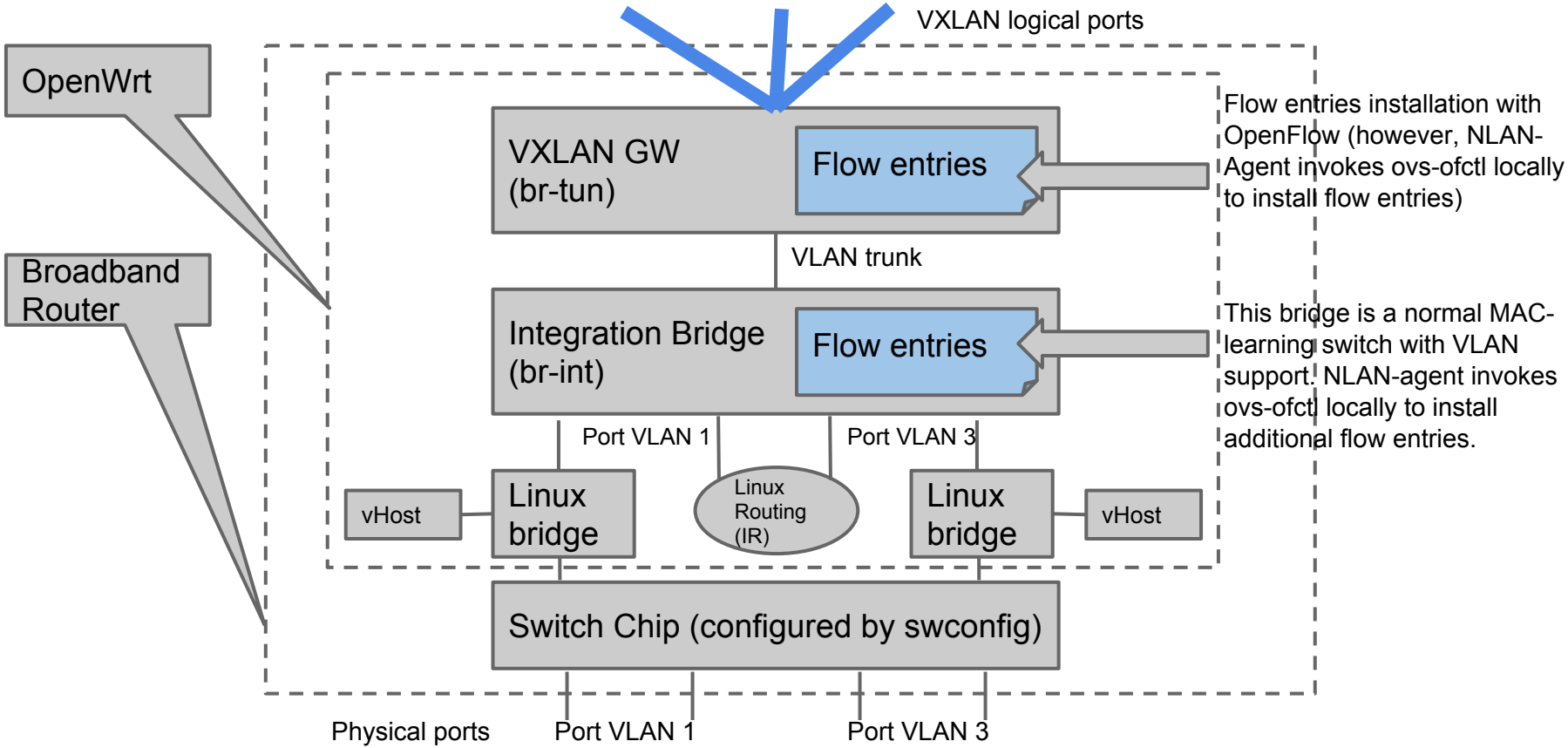
OpenWrt routers
(and Home Gateway)

Raspberry Pi

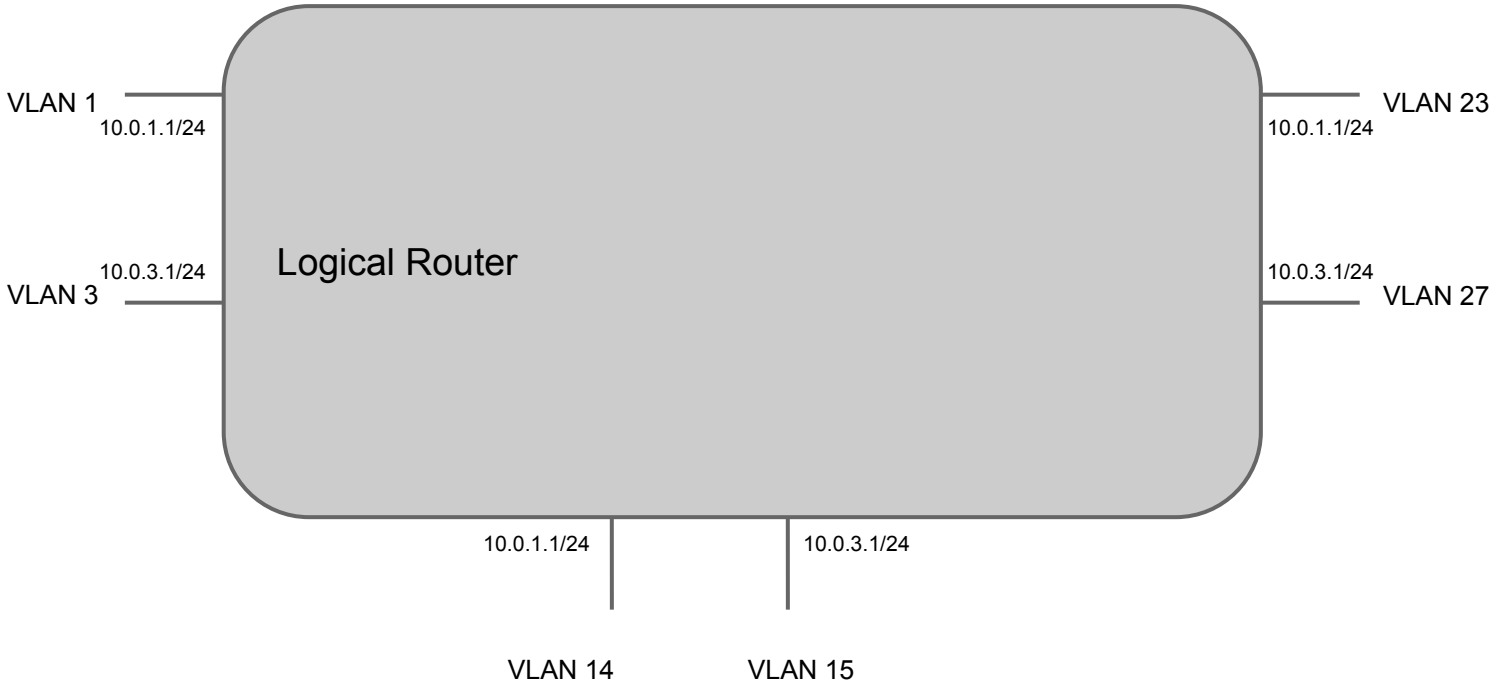
Test bed


NLAN-Master
(DevOps master)
Debian
Linux
The Internet
Internet
GW
RIPv2
Debian Linux
or Raspbian
OpenWrt
192.168.1.104
192.168.1.101
VXLAN tunnels (VNI 1, 101, 103)
192.168.1.103
192.168.1.102
OpenWrt
OpenWrt
Physical ports
Physical ports

OpenStack-neutron-like bridge configuration



Distributed Virtual Router (Logical view)



Virtual network topologies

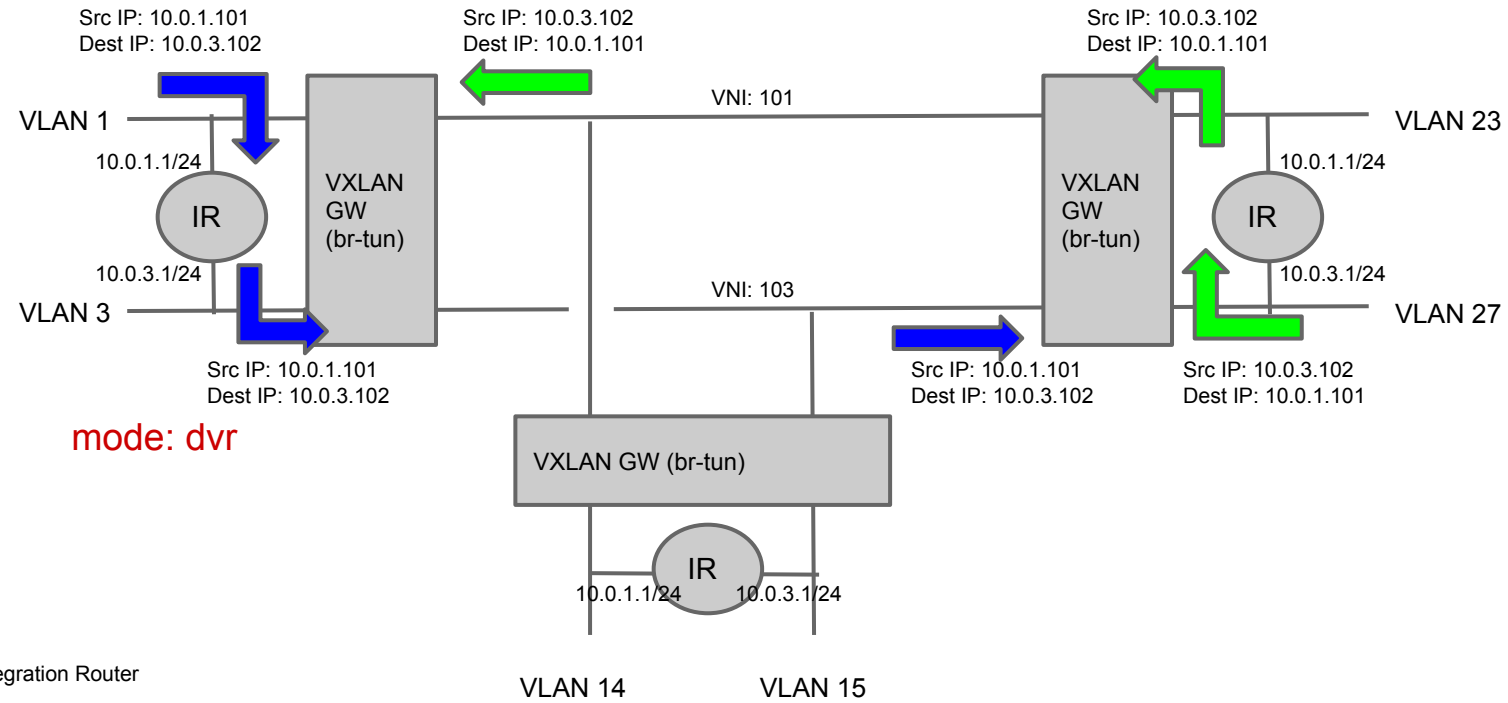
NLAN node operation mode	Virtual Network Topology
dvr	Distributed Virtual Router
hub	Hub & Spoke
spoke	Hub & Spoke
spoke_dvr	Mixtuare of DVR and Hub & Spoke

NLAN state in YAML

```
subnets:
  - vid: 1
    vni: 1001
    ip_dvr: '10.0.1.1/24'
    mode: hub
    ip_vhost: '10.0.1.101/24'
    ports:
          - eth0.1
    peers: <peers>
```

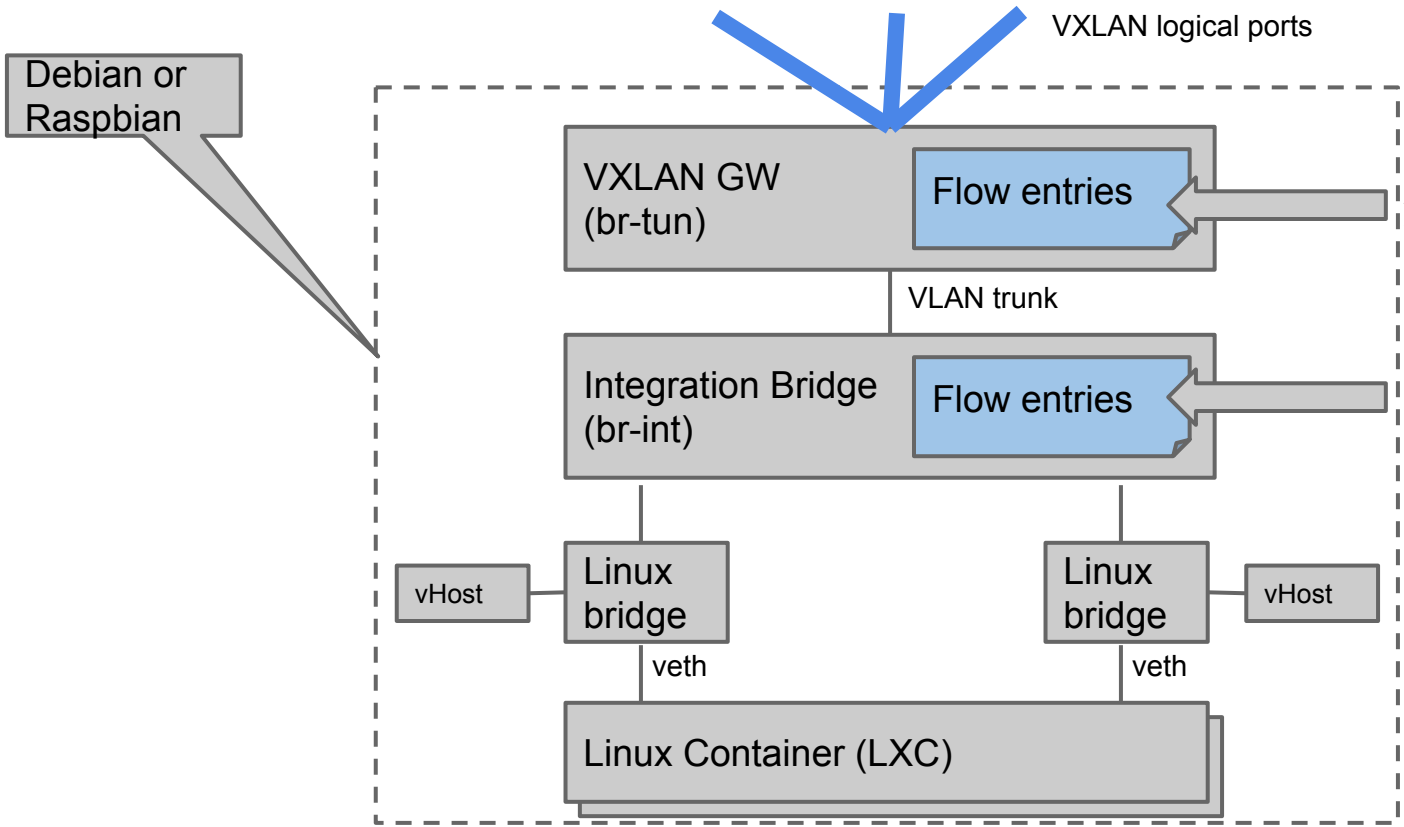
mode can be ‘dvr’, ‘hub’, ‘spoke’ or ‘spoke_dvr’

Distributed Virtual Switch and Distributed Virtual Router



IR: Integration Router

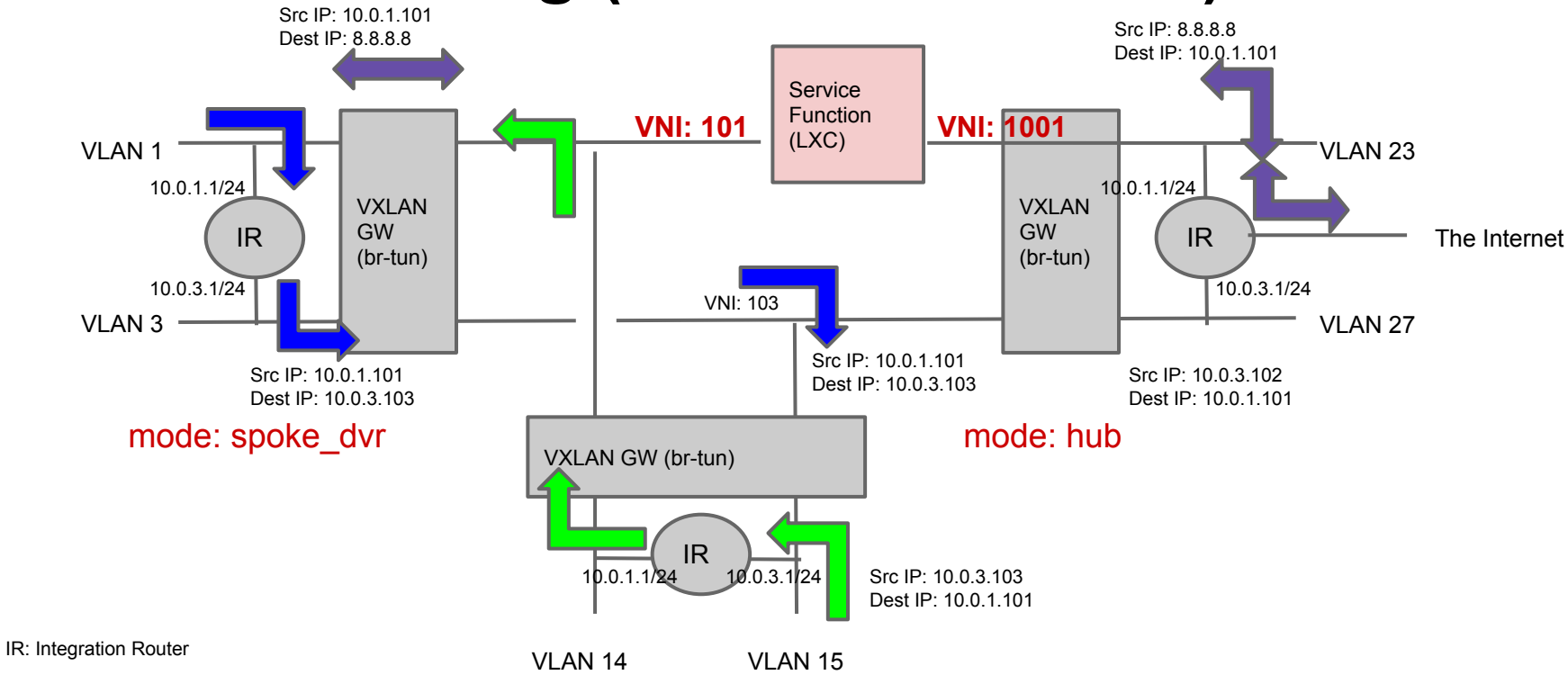
Service Function in Linux Container



Flow entries installation with OpenFlow (however, NLAN-Agent invokes ovs-ofctl locally to install flow entries)

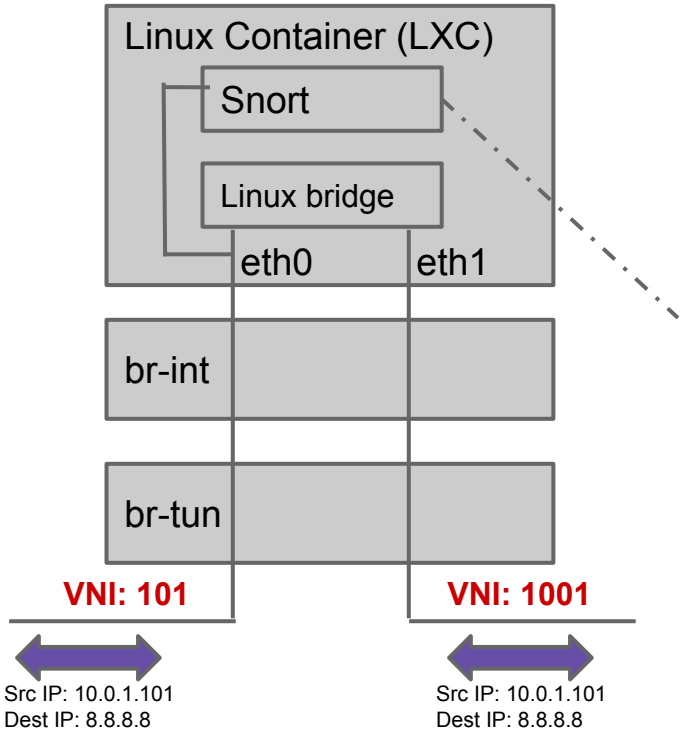
This bridge is a normal MAC-learning switch with VLAN support. NLAN-agent invokes ovs-ofctl locally to install additional flow entries.

Service Chaining (Service Insertion)



IR: Integration Router

Example: Snort (in IPS mode) as Service Function



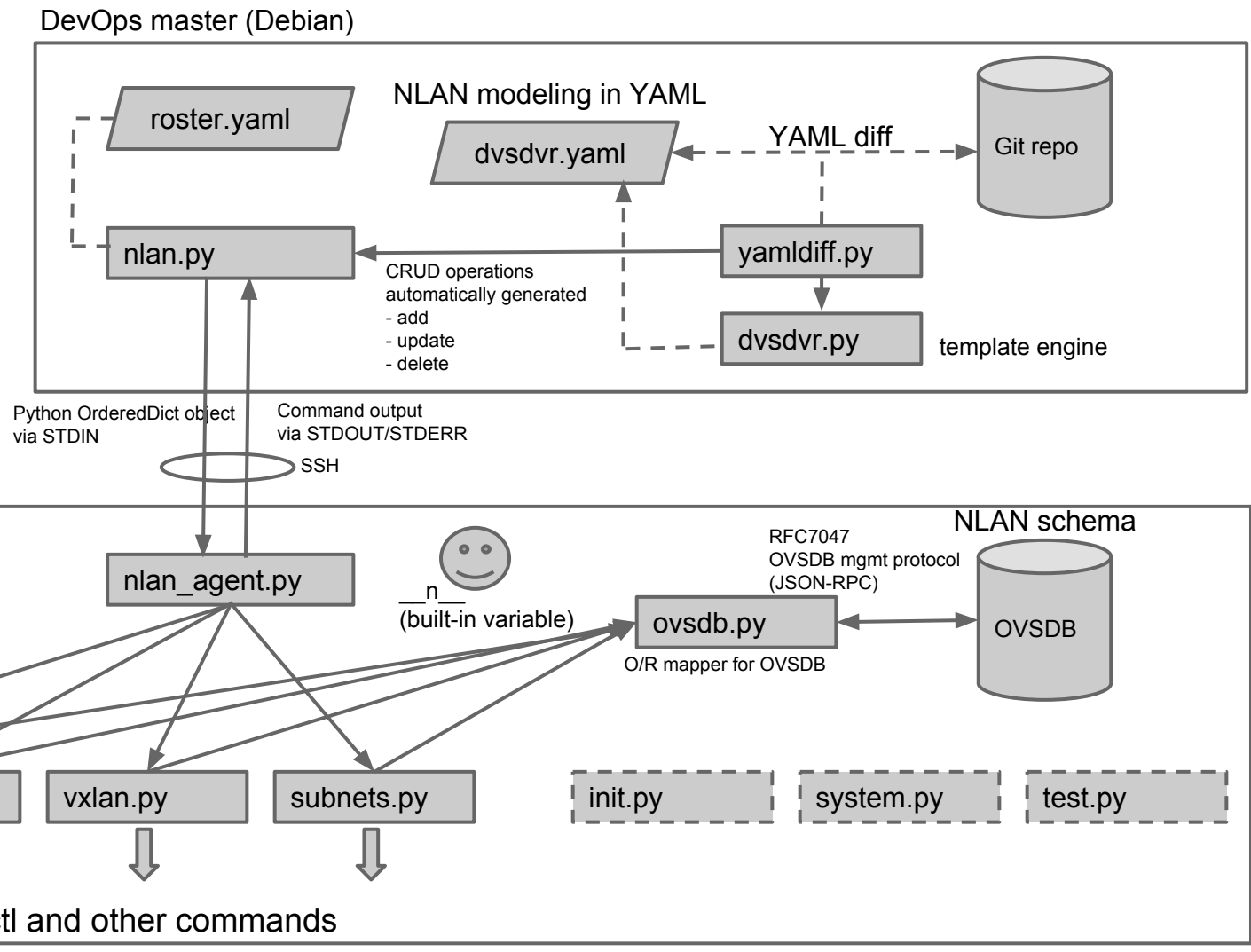

```
04/13-23:16:32.859385 10.0.1.102 -> 8.8.8.8
ICMP TTL:64 TOS:0x0 ID:11745 IpLen:20 DgmLen:84 DF
Type:8  Code:0  ID:49496   Seq:25  ECHO
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

04/13-23:16:32.861970 8.8.8.8 -> 10.0.1.102
ICMP TTL:63 TOS:0x0 ID:38077 IpLen:20 DgmLen:84
Type:0  Code:0  ID:49496  Seq:25  ECHO REPLY
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

04/13-23:16:33.861151 10.0.1.102 -> 8.8.8.8
ICMP TTL:64 TOS:0x0 ID:11746 IpLen:20 DgmLen:84 DF
Type:8  Code:0  ID:49496   Seq:26  ECHO
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

04/13-23:16:33.862906 8.8.8.8 -> 10.0.1.102
ICMP TTL:63 TOS:0x0 ID:38078 IpLen:20 DgmLen:84
Type:0  Code:0  ID:49496  Seq:26  ECHO REPLY
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
```

Home-made DevOps tool ‘NLAN’

- 100% Python implementation
- Borrwed a lot of ideas from SaltStack
  - Model-driven procedure
  - YAML-based states w/ a simple template engine
- Works with OpenWrt with minimal Python
  - opkg install python-mini
  - opkg install python-json
  - sshd only
- OVSDB as a local config mgmt database

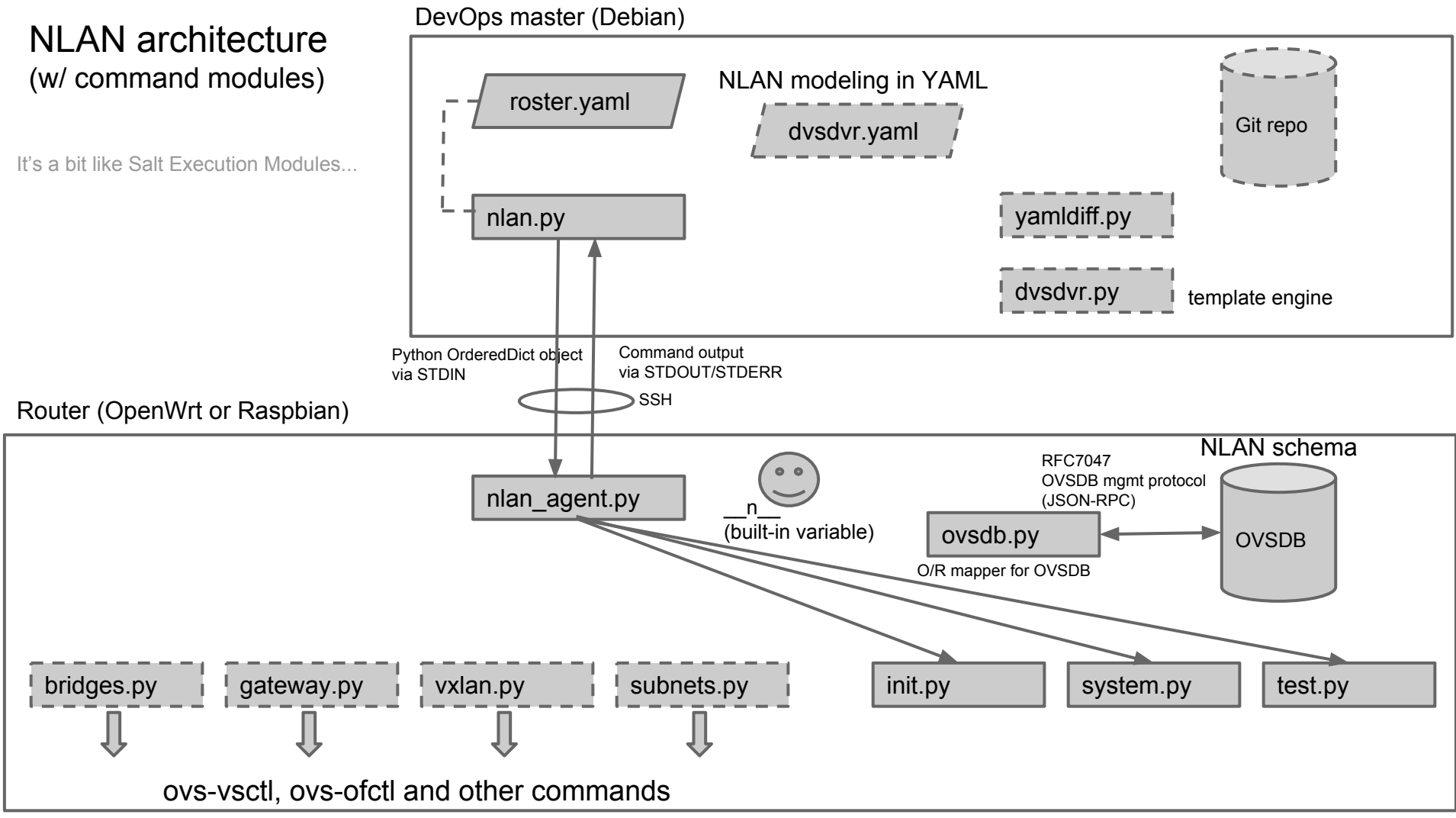
NLAN architecture
(w/ config modules)

It's a bit like Salt State Modules...



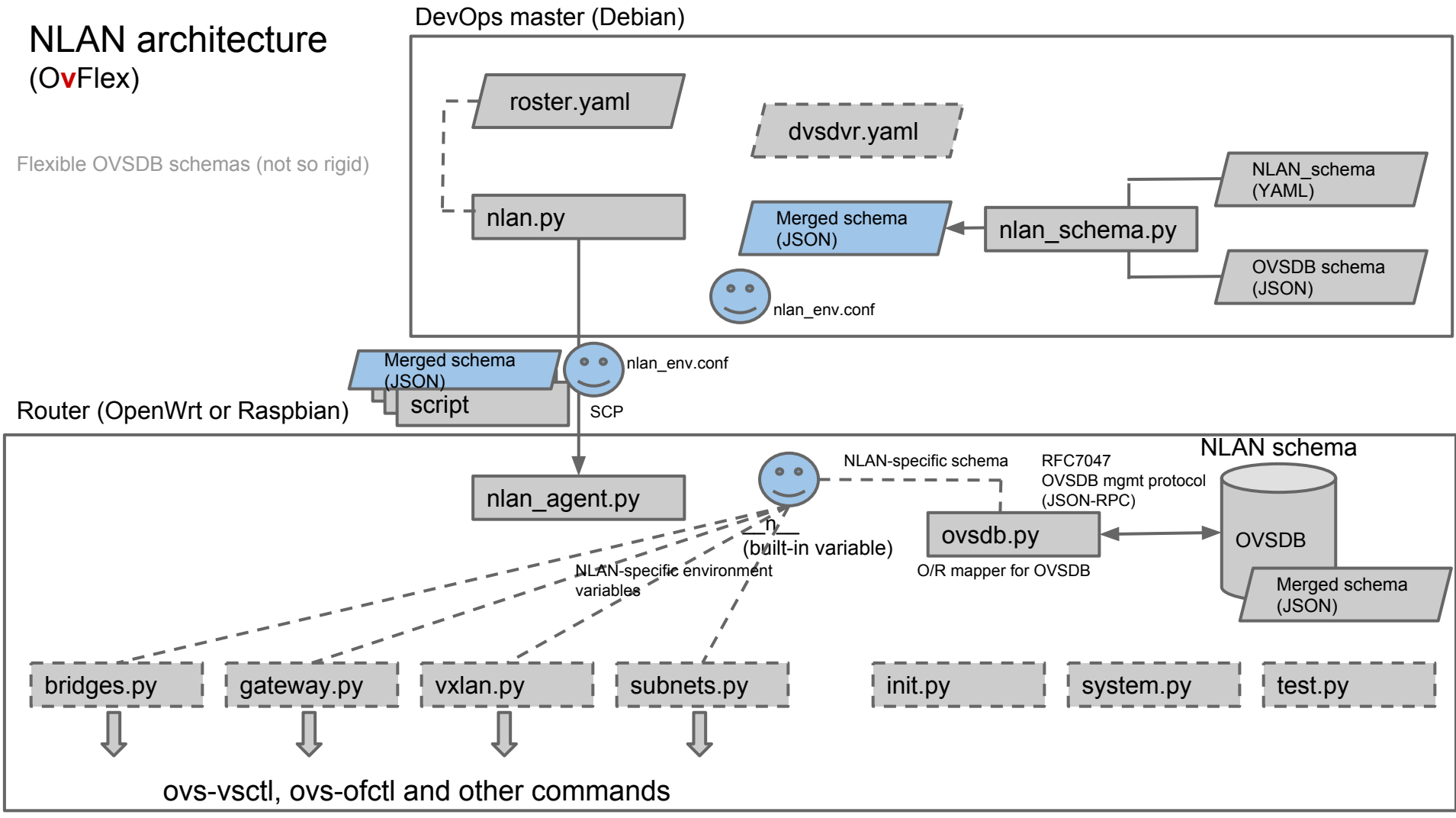
NLAN architecture
(w/ command modules)

It's a bit like Salt Execution Modules...



NLAN architecture
(OvFlex)

Flexible OVSDB schemas (not so rigid)



OvFlex -- Flexible OVSDB schemas

OpFlex:

http://www.cisco.com/c/en/us/solutions/collateral/data-center-virtualization/application-centric-infrastructure/white-paper-c11-731302.html

OvFlex:

“It uses dynamic, flexible schemas for interaction with devices, effectively increasing the network to a higher common denominator feature set. The Open vSwitch Database (OVSDB) management protocol allows configuration of high-level abstract data models as well as basic primitives such as ports and bridges, and can support SDN geeks’ innovations”

OVSDB schema (Open_vSwitch database)


```
{"name": "Open_vSwitch",
 "version": "7.4.1",
 "cksum": "951746691 20389",
 "tables": {
  "NLAN": {
   "columns": {
    "bridges": {
     "type": {"key": {"type": "uuid",
                      "refTable": "NLAN_Bridges"},
              "min": 0, "max": 1}},
    "services": {
     "type": {"key": {"type": "uuid",
                      "refTable": "NLAN_Service"},
              "min": 0, "max": "unlimited"}},
    "gateway": {
     "type": {"key": {"type": "uuid",
                      "refTable": "NLAN_Gateway"},
              "min": 0, "max": 1}},
    "vxlan": {
     "type": {"key": {"type": "uuid",
                      "refTable": "NLAN_VXLAN"},
              "min": 0, "max": 1}},
    "subnets": {
     "type": {"key": {"type": "uuid",
                      "refTable": "NLAN_Subnet"},
              "min": 0, "max": "unlimited"}}},
   "isRoot": true,
        :
```


"Basic primitives"

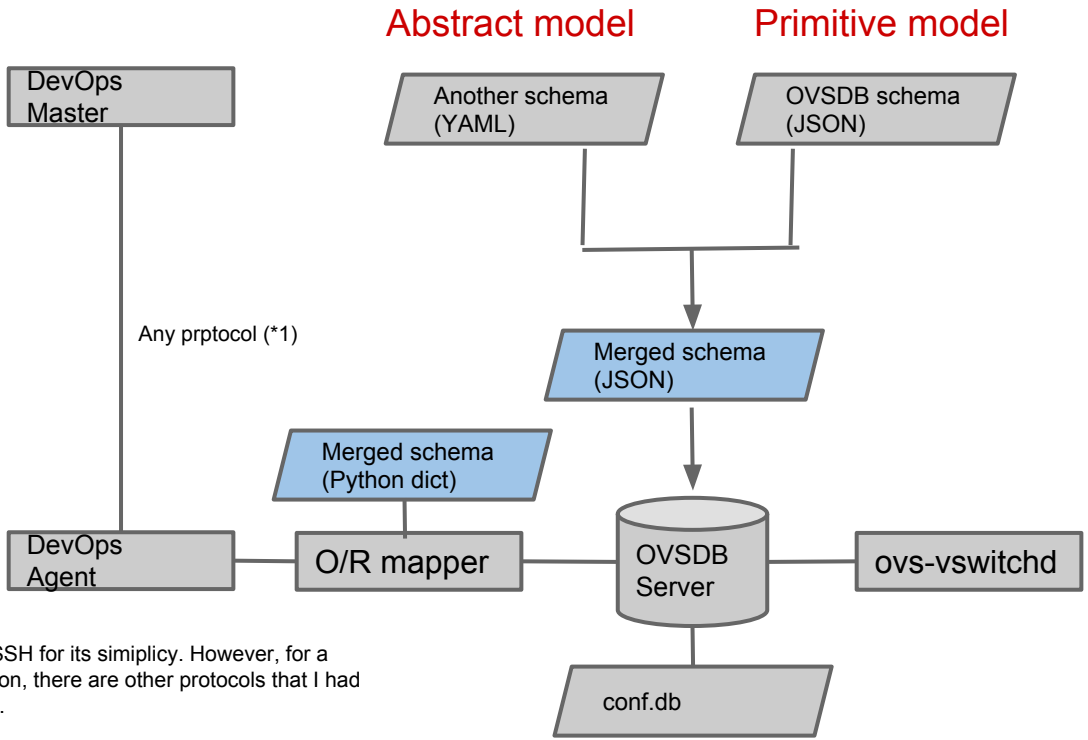

```
cksum: 951746691 20389
name: Open_vSwitch
tables:
  Bridge:
    columns:
      controller:
        type:
          key: {refTable: Controller, type: uuid}
          max: unlimited
          min: 0
      datapath_id:
        ephemeral: true
        type: {key: string, max: 1, min: 0}
      datapath_type: {type: string}
      external_ids:
        type: {key: string, max: unlimited, min: 0, value: string}
      fail_mode:
        type:
                        :
```


Also possible to convert it into JSON format by using some libraries.

Merging schemas

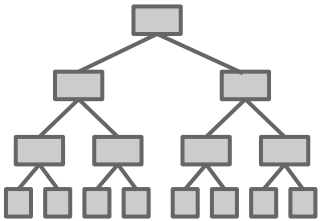
OVSDB schema can also express more abstract data models.

```
    :
NLAN_Service:
  columns:
    chain:
      type:
        key: {type: string}
        min: 0
        max: unlimited
    name:
      type:
        key: {type: string}
        min: 1
        max: 1
  indexes:
  - [name]
    :
```

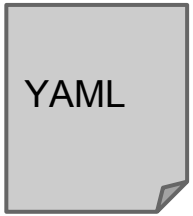


(*1) I just use SSH for its simiplicy. However, for a scalability reason, there are other protocols that I had better consider.

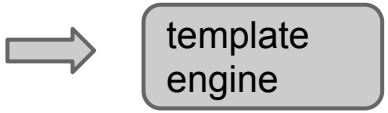
Model-driven service abstraction (cont'd)



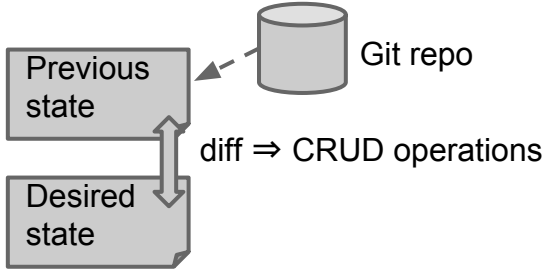
Step1: define network service model



Step2: write the mode as "desired state" in YAML format w/ some placeholders for a template engine

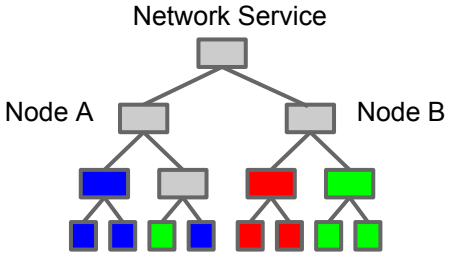


Step3: write a template engine to fill out the placeholders.



Step4: NLAN-Master generates CRUD operations comparing the desired state with the previous state

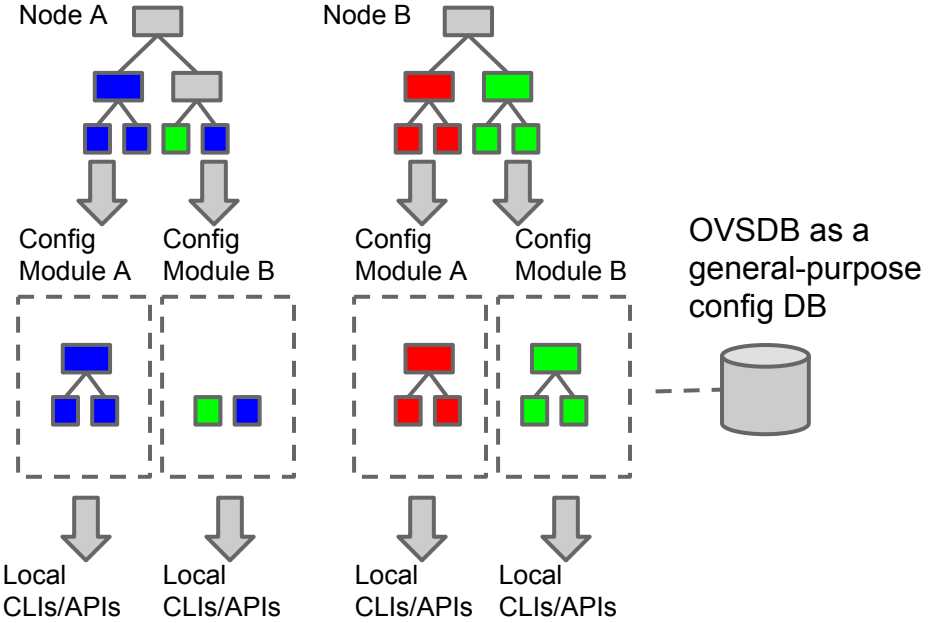
Model-driven service abstraction



Add
Update
Delete

Step5: Now CRUD-operations (= difff of the previous and the desired states) are in the form of Python OrderedDict object

Step6: NLAN-Agent routes the CRUD operations to corresponding nodes/modules



Template and placeholders example

```
#!template.dvsdvr
openwrt1:
        :
  vxlan:
        local_ip: <local_ip>
        remote_ips: <remote_ips>
  subnets:
        - vid: 1
        vni: 101
        ip_dvr: '10.0.1.1/24'
        ip_vhost: '10.0.1.101/24'
        ports:
        - eth0.1
        peers: <peers>
        :
```

- generates a local ip address
- generates VXLAN remote ip addresses
- generates broadcast tree per VNI

```
#!template.dvsdvr
openwrt1:
        :
  vxlan:
        local_ip: '192.168.1.101'
        remote_ips: [‘192.168.1.102’, ‘192.168.1.103’, ‘192.168.1.104’]]
  subnets:
        - vid: 1
        vni: 101
        ip_dvr: '10.0.1.1/24'
        ip_vhost: '10.0.1.101/24'
        ports:
        - eth0.1
        peers: [‘192.168.1.102’, ‘192.168.1.104’]
        :
```

Python OrderedDict

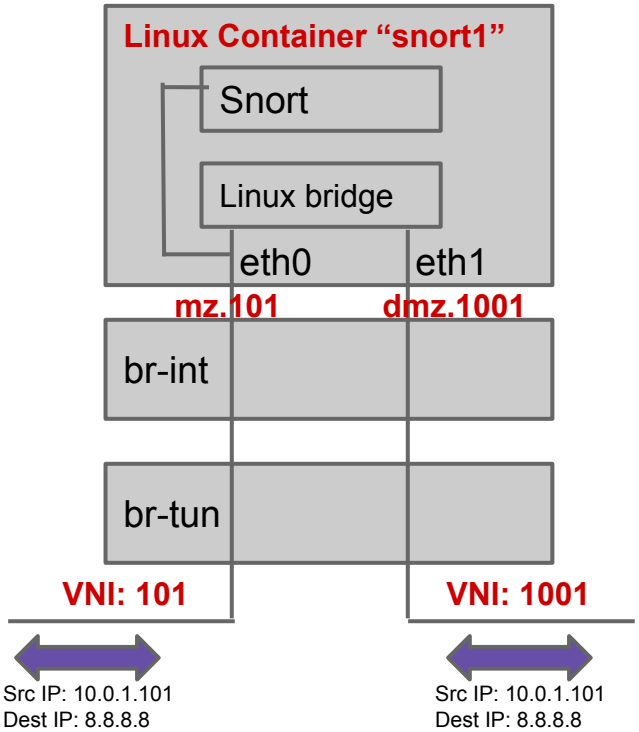
- NLAN-Master sends Python OrderedDict to NLAN-Agent via ssh STDIN.
- To be exact, string form of an OrderedDict object

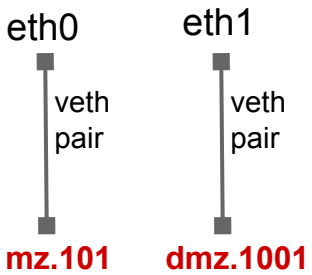
"OrderedDict([('bridges', {'ovs_bridges': 'enabled'}), ('gateway', {'network': 'eth0.2', 'rip': 'enabled'}), ('vxlan', {'remote_ips': ['192.168.1.103', '192.168.1.102', '192.168.1.104'], 'local_ip': '192.168.1.101'}), ('subnets', {('vni', 1): {'ip_vhost': '192.168.100.101/24', 'ip_dvr': '192.168.100.1/24', 'peers': ['192.168.1.102', '192.168.1.103'], 'vid': 2, 'vni': 1}, ('vni', 103): {'peers': ['192.168.1.102', '192.168.1.103', '192.168.1.104'], 'vid': 3, 'ip_vhost': '10.0.3.101/24', 'vni': 103, 'ip_dvr': '10.0.3.1/24', 'ports': ['eth0.3']}, ('vni', 101): {'peers': ['192.168.1.102', '192.168.1.103', '192.168.1.104'], 'vid': 1, 'ip_vhost': '10.0.1.101/24', 'vni': 101, 'ip_dvr': '10.0.1.1/24', 'ports': ['eth0.1']}})])"

- I don’t use JSON, since NLAN is 100% Python implementation.

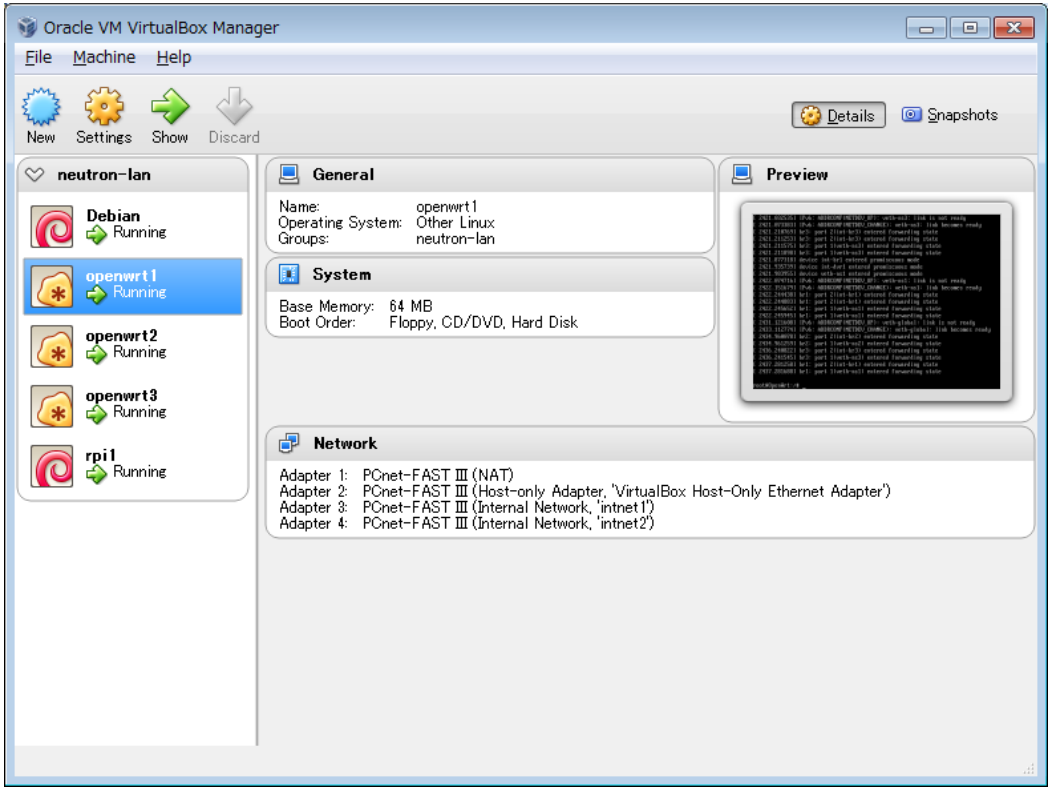
Service Function Chaining in YAML

```
rpi1:
  bridges:
    ovs_bridges: enabled
  services: # Service Functions
    - name: snort1
    chain: [mz.101, dmz.1001]
  vxlan:
    local_ip: <local_ip>
    remote_ips: <remote_ips>
  subnets:
    - vid: 111
    vni: 1001
    peers: <peers>
    ports: <sfports>
    - vid: 1
    vni: 101
    peers: <peers>
    ports: <sfports>
```





NLAN Software Development on VirtualBox



- OpenWrt image for x86
  - Very light-weight Linux supporting Open vSwitch 2.0.0
- Network adapters
  - Internet access: “NAT”
  - Management: “Host-Only”
  - NLAN underlay: “Internal”