



“Beluganos”:

Open Network OS for White-box Switches

Feb. 2019

NTT Network Service Systems Laboratories

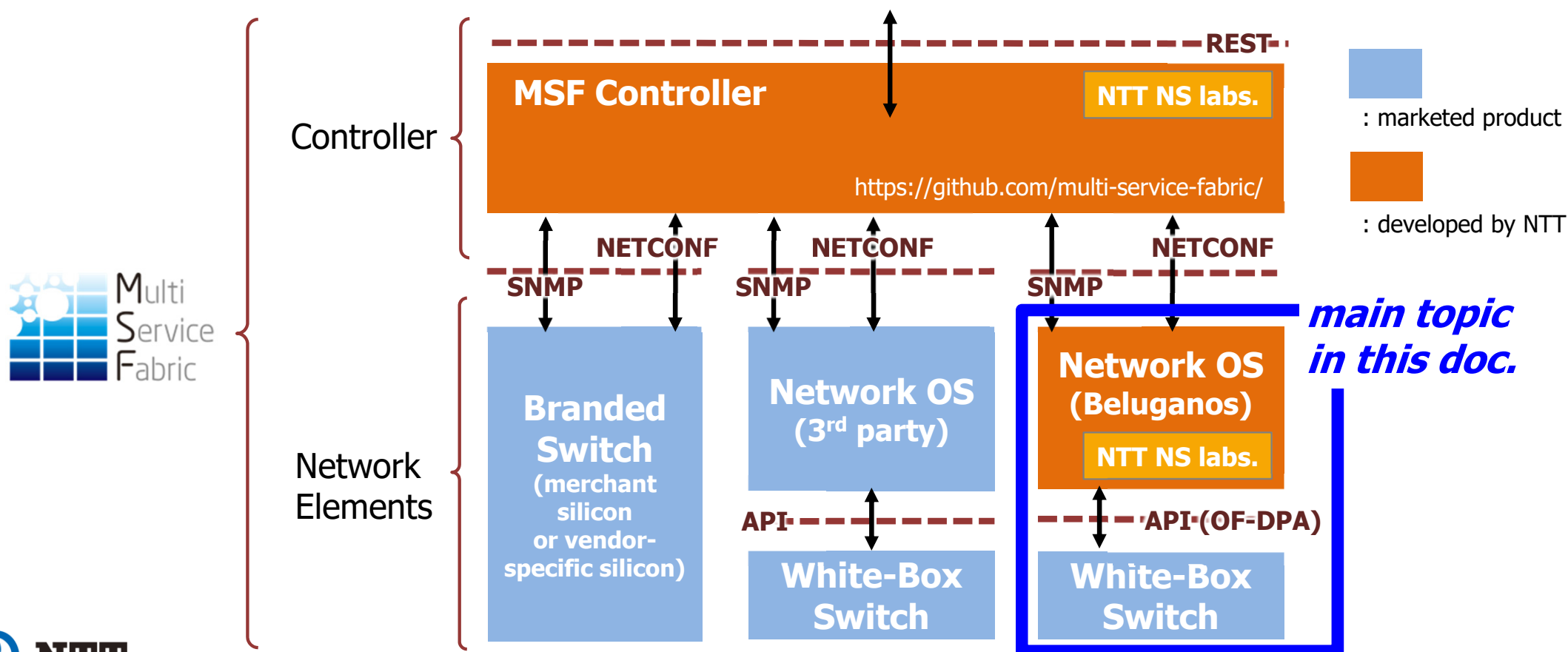
Introduction



MSF (Multi-Service Fabric)



- ◆ **MSF (Multi-Service Fabric)** is the architectural design of carrier-grade SDN that provides wide logical network slices with various type routers/switches.
- The targeted routers or switches of MSF are not only branded switches but also white-box switches. Moreover, network OS on the white-box switches is also developed by NTT, which called "**Beluganos**".



Carrier-grade open network OS designed for white-box switch

<https://github.com/beluganos/beluganos>

Interoperability

- Autonomous MPLS-VPN router
- Interoperability for current IP/MPLS router

Full hardware processing

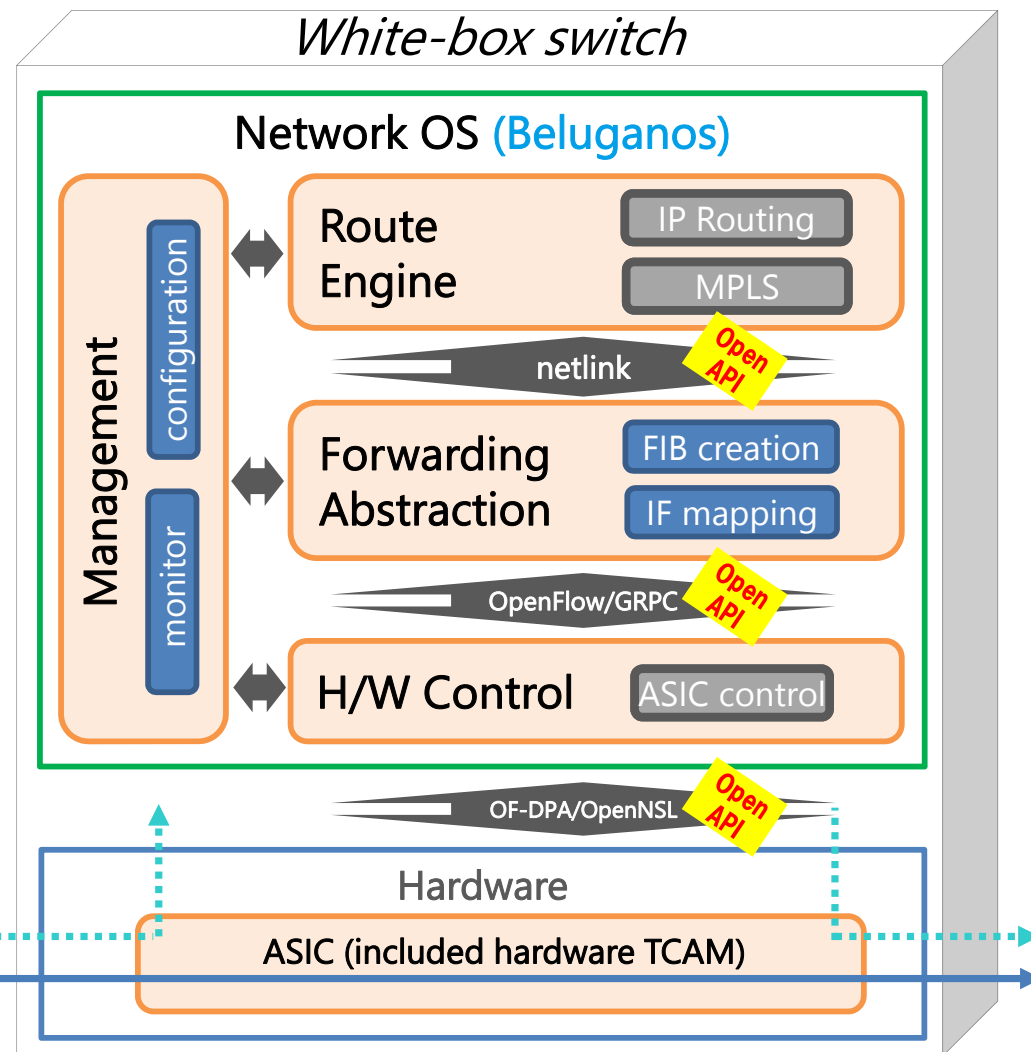
- Full hardware (ASIC) processing for data packets
- hardware TCAM

“White-box software”

- Open API (netlink/OF-DPA/OpenNSL)
- Use of existing open source modules

OSS

NTT original codes

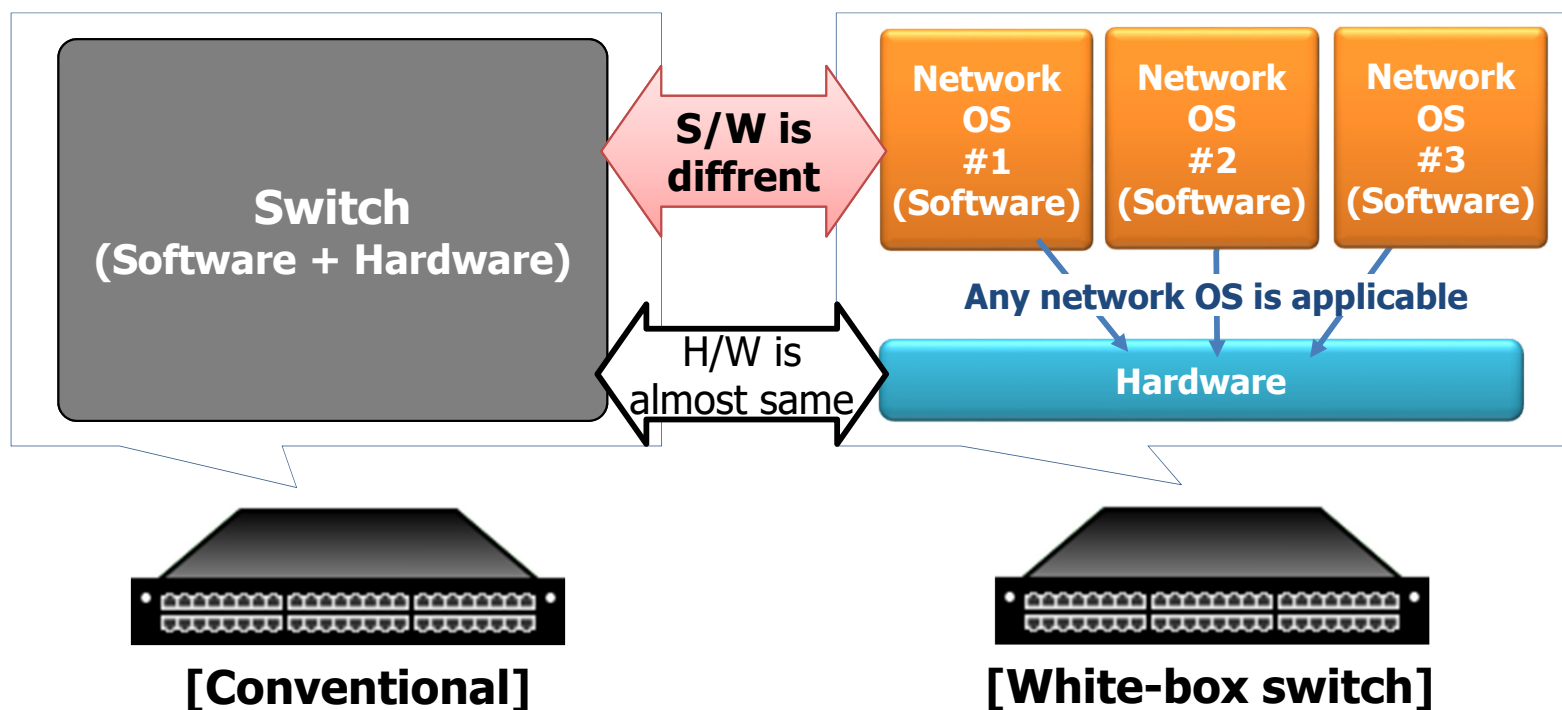




White-box switches



- ◆ Only hardware and boot loader. No network OS.
 - Low power consumption, space-saving design.



Beluganos may not pay attention to the difference of switches.

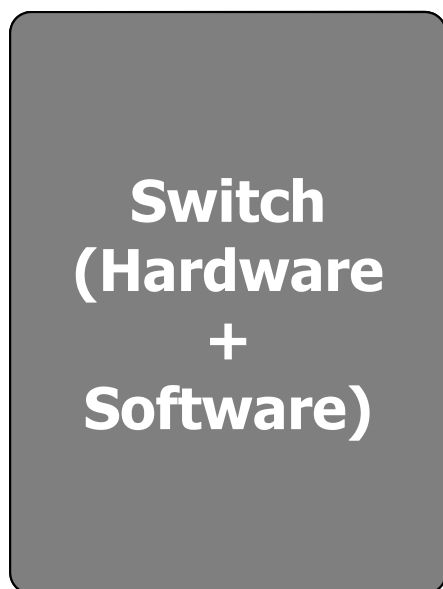
- The abstraction of ASIC : **OF-DPA/OpenNSL**
- The abstraction of H/W : **Open Network Linux**



White-box "software"



[Conventional]



Vendor-branded,
conventional switches

- ☹ Inflexibility
(especially about
new H/W or
new ASIC)

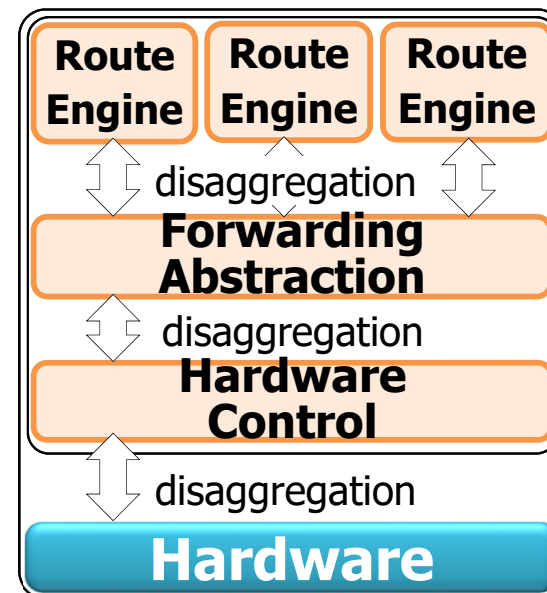
[White-box switch]



Disaggregating between
hardware and software

- ☺ Flexibility for new H/W
or new ASIC
- ☹ Remaining inflexibility
of new functions
to the software

[Beluganos]



Further disaggregation
in terms of software
(white-box software)

- ☺ **Disaggregation**
- ☺ **Commoditization**



Key technology



Beluganos which supports ASIC packet processing is achieved by ...

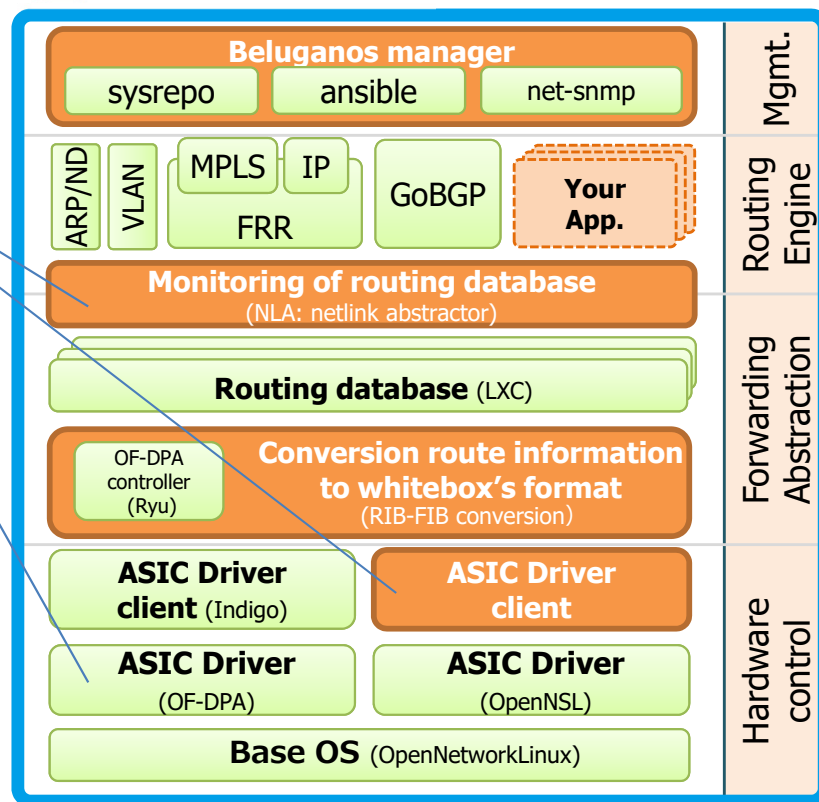
- ✓ 1: **Open API**
- ✓ 2: **Open Source Software (OSS)**

1: OpenAPI

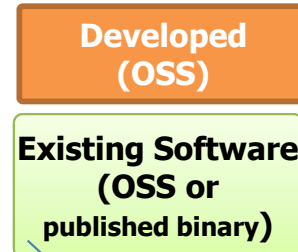
(ASIC)
OF-DPA,
OpenNSL
(Inter-process)
netlink, etc



Beluganos



[Legend]



2: OSS

ONL, LXC, FRRouting,
GoBGP, ansible,
net-snmp, etc

Features

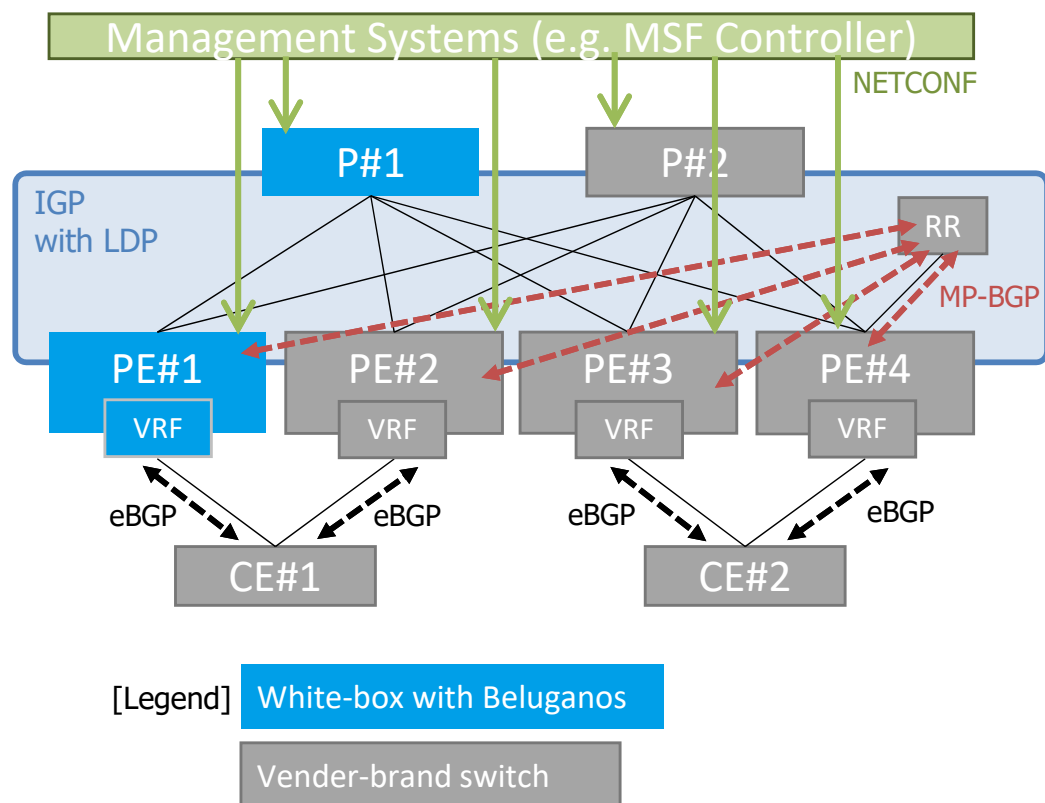


Use case & Features



<Use case example>

- ◆ Basic IP router
- ◆ L3VPN (BGP MPLS) router



<Feature list>

- ✓ IPv4/IPv6 : BGP, OSPF, IS-IS
- ✓ 802.1Q VLAN
- ✓ IP/MPLS : LDP
- ✓ VRF
- ✓ BGP MPLS-VPN
- ✓ NETCONF/YANG
- ✓ SNMP MIB

<Verification items at development>

- ✓ **Function test**
(VPN PE&P router, IPv4/v6 router, etc.)
- ✓ **Interoperability test**
(3 vendor)
- ✓ **Node/Link fault test**



Feb, 2019 Update

Note: this plan is subject to change.

Features in detail

Features		Support status		備考
Category	Items	OF-DPA	OpenNSL	
Basic	L2 switching	—	Planned	
	IPv4 unicast routing / ARP	Ready	Ready	
	IPv6 unicast routing / ND	—	Ready	
	IPv4 multicast routing / IGMP	—	TBD	
	IPv6 multicast routing / MLD	—	TBD	
	IP/MPLS forwarding	Ready	Planned	
L2	VLAN (802.1q)	Ready	Ready	Sub IF for L3 routed port
	Link Aggregation (802.3ad LACP)	Planned	Planned	
	STP、PVST	—	Planned	
	Loop avoidance (storm-control)	—	TBD	
L3 Unicast	Static Routing (IPv4/IPv6)	Ready (IPv4 only)	Ready	
	BGP (IPv4/IPv6)	Ready (IPv4 only)	Ready	GoBGP or FRRouting
	OSPFv2/OSPFv3	Ready (IPv4 only)	Ready	FRRouting
	VRRP (IPv4/IPv6)	TBD	TBD	
	ISIS (IPv4/IPv6)	Ready	Ready	FRRouting
L3 Multicast	PIM-SM/SSM	—	TBD	
L3 MPLS	LDP	Ready	Planned	
	RSVP-TE	TBD	TBD	
	Segment Routing with OSPFv2	Planned	Planned	
VPN/Tunnel	VXLAN (EVPN)	—	Planned	
	IP tunneling (IP-IP)	—	Planned	
	IP-VPN (RFC4364)	Ready	TBD	CE connection is limited at connected/static/bgp
Management/OAM	SSH login	Ready	Ready	
	ICMP (ping, traceroute)	Ready	Ready	
	SNMP (MIB, Trap)	Ready	Ready	IF counter, IF status
	NETCONF/YANG	Ready	Ready	OpenConfig (beluganos/netconf/etc/openconfig)
	SPAN/RSPAN (port mirroring)	Planned	Planned	
	Syslog	Ready	Ready	
Other	Load-balancing (ECMP)	Planned	Planned	
	Access list (ACL)	—	Planned	
	Policing	—	Planned	
	Scheduling, Diffserv	—	TBD	
	Logical node (vChassis)	—	Planned	Beyond Pbps

Information about features also described here.

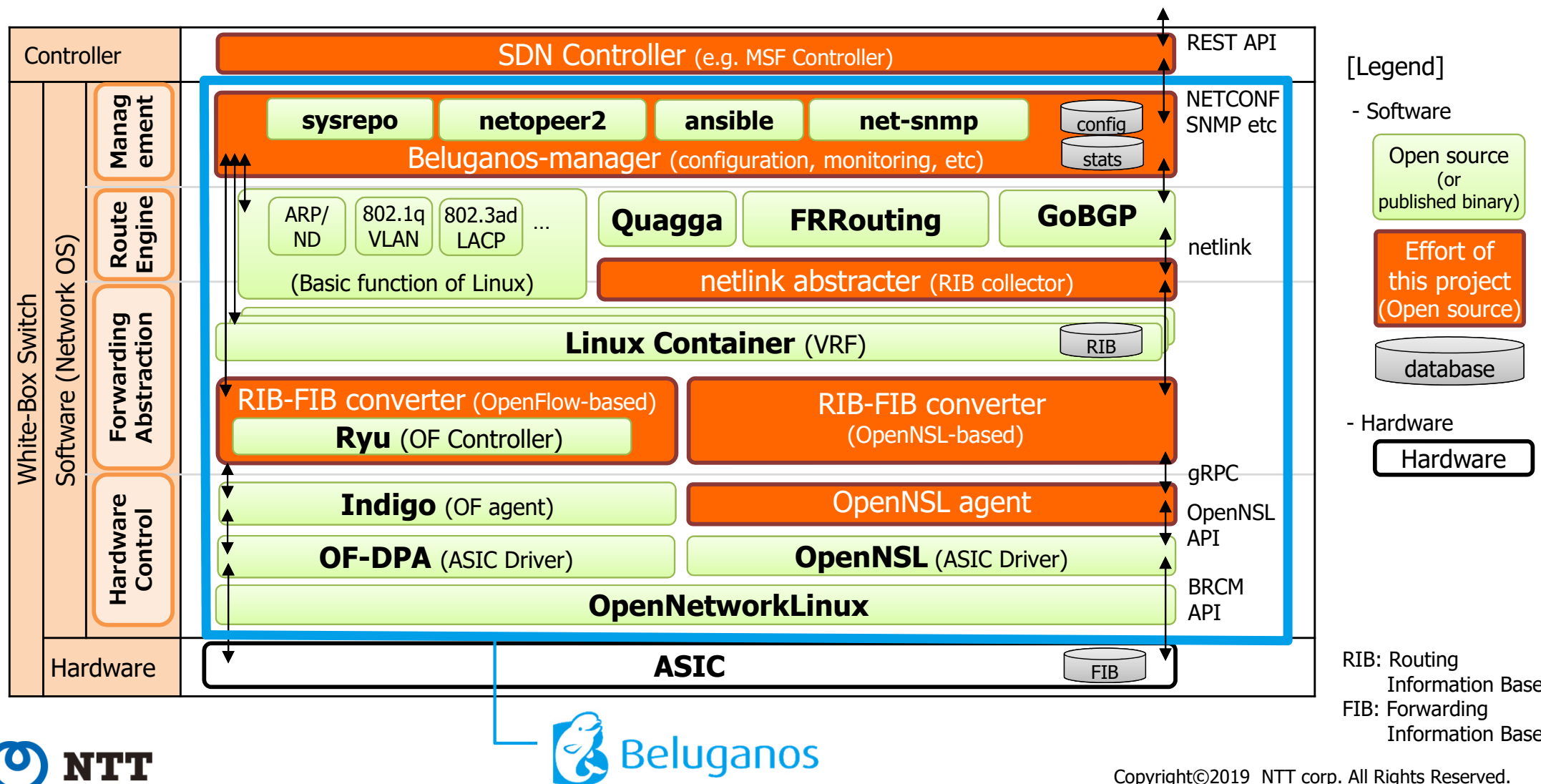
<https://github.com/beluganos/beluganos/blob/master/doc/function.md>

Technical Details



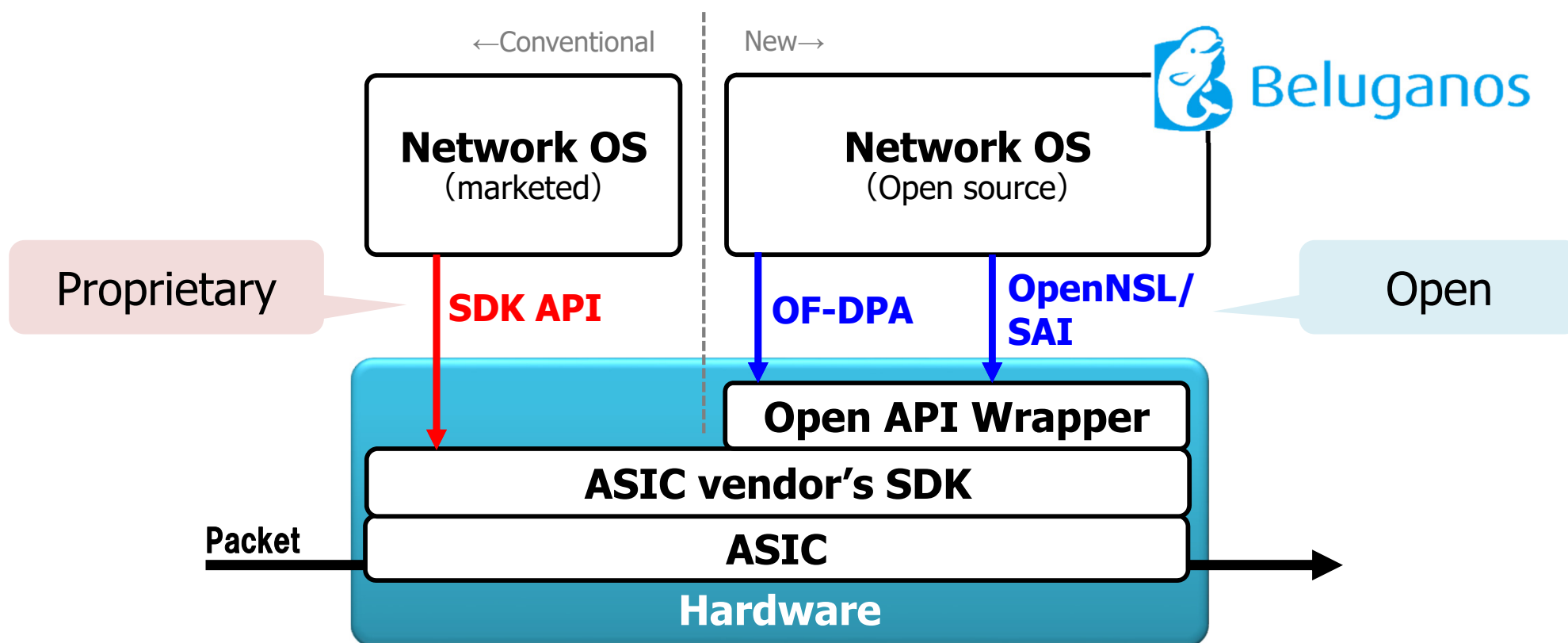
Architecture at a glance

- ◆ **Fully opened architecture** which also supports ASIC (H/W) processing
 - ❑ Point 1 : Beluganos uses only **Open API** (OF-DPA/OpenNSL).
 - ❑ Point 2 : NTT integrates **existed OSS** and our original source code.





- ◆ Calling API of ASIC realizes H/W packet processing.
- ◆ Thanks to white-box evolution, **Open APIs** are prepared to control ASIC.
→ The specification of API is published on Web site.



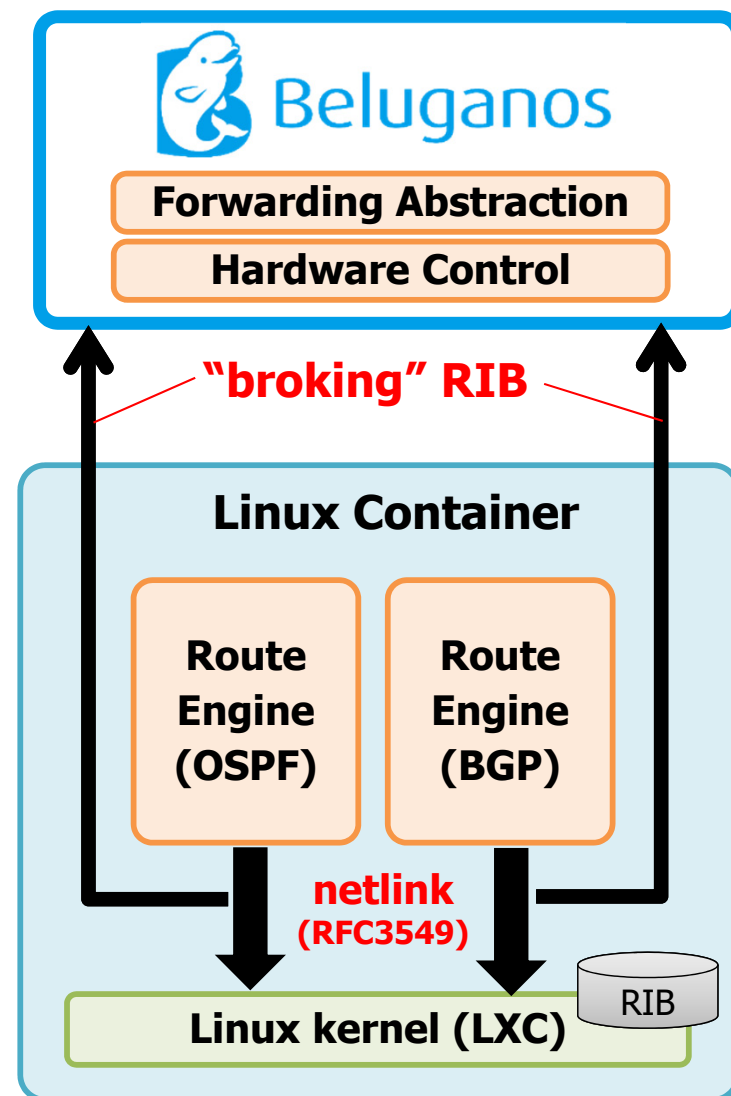


◆ netlink (RFC3549)

- ❑ Linux's standard protocol for networking between Linux kernel space and user land.
 - After Linux 4.1, not only IP networking but also **MPLS networking** is supported.
- ❑ In Beluganos, netlink is used for broking RIB information from Linux protocol stack (FRRouting/GoBGP).

◆ Linux Container (LXC)

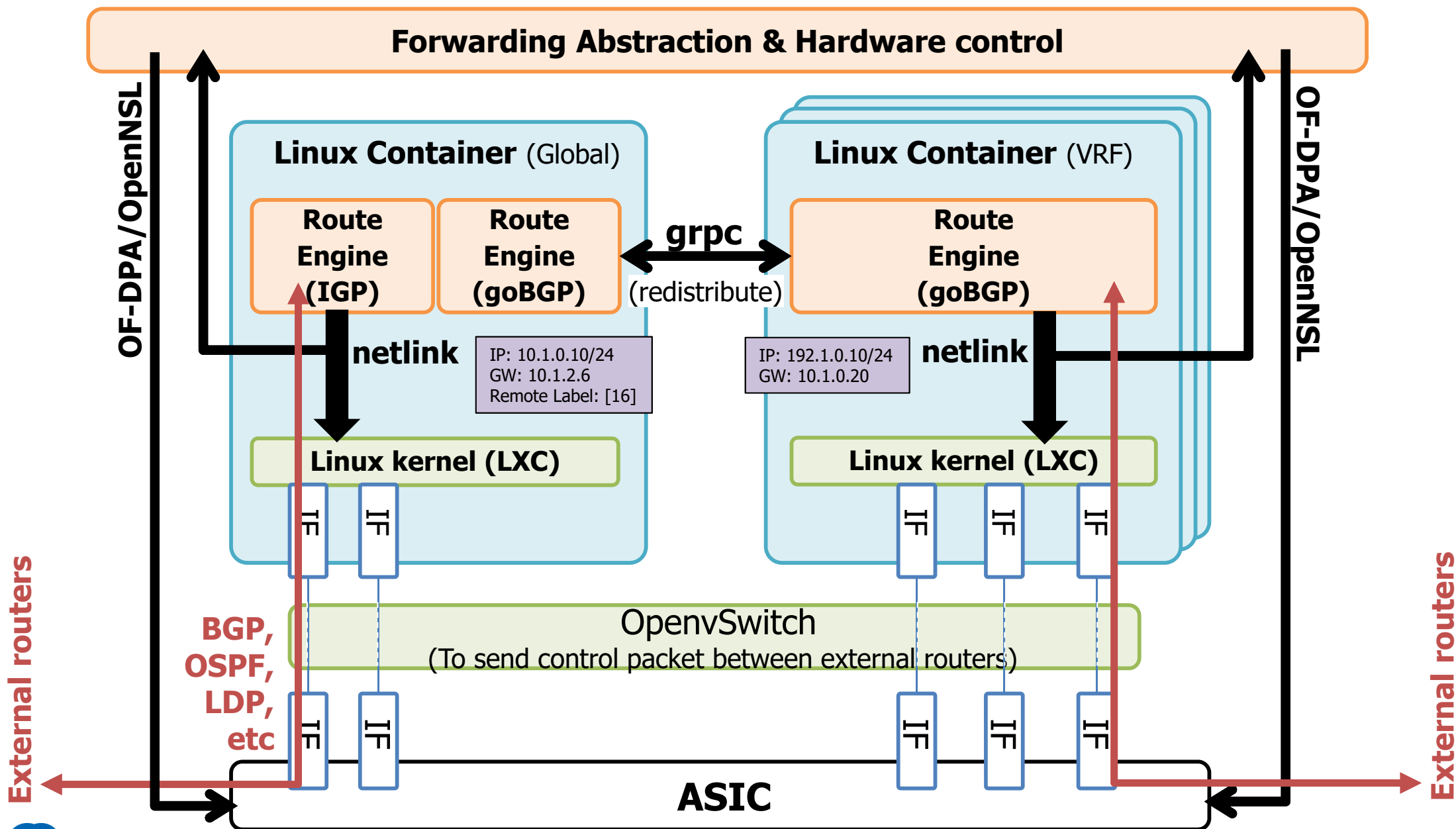
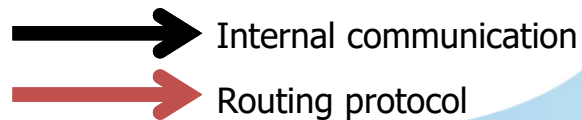
- ❑ Virtualization technology for Linux OS.
- ❑ In Beluganos, the **routing table of Linux kernel** is used as RIB. Routing calculation is operated at global LXC.
 - Multiple LXC is only used for **VRF implementation** (Beluganos also implements route redistribution).





Architecture: Life of routing info.

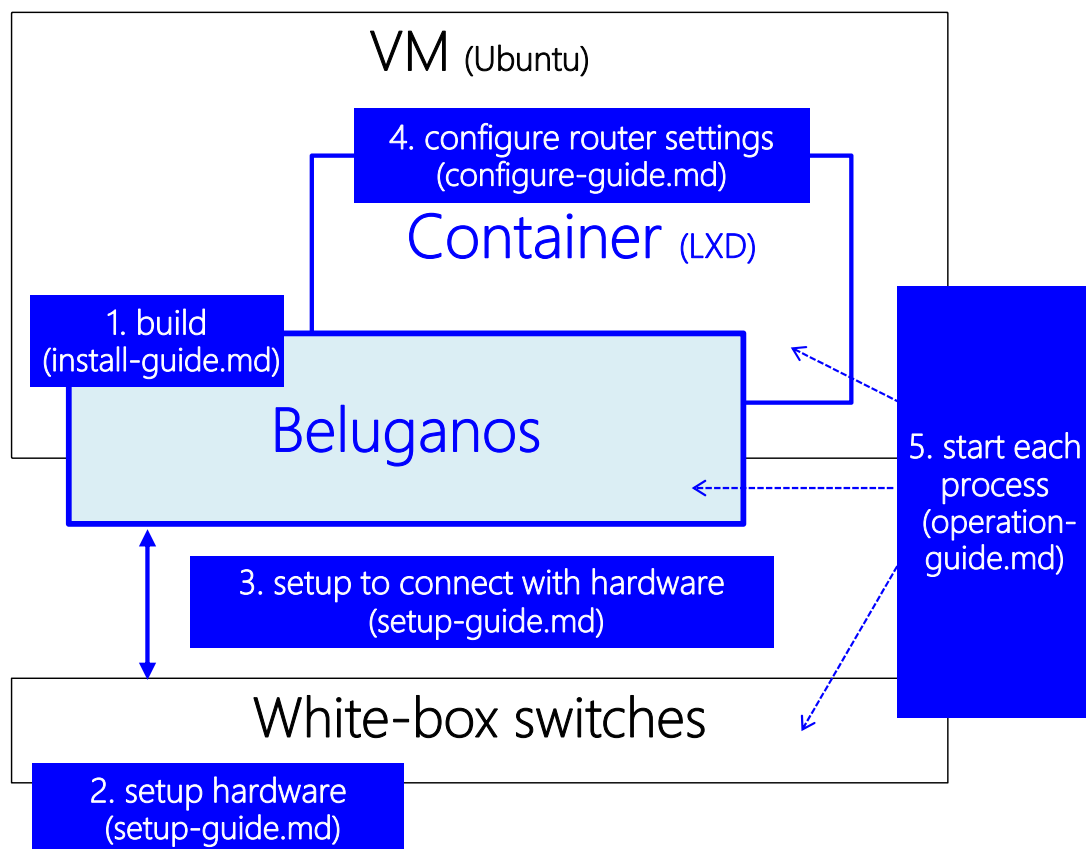
[Legend]



Getting Started



Task list to start Beluganos



[Task list]

First time

1. Build (install-guide.md)
2. Setup hardware (setup-guide.md)
3. Setup hardware connection (setup-guide.md)
4. Configure (configure-guide.md)
5. Start (operation-guide.md)

Once install finished

4. Configure (configure-guide.md)
5. Start (operation-guide.md)



The basic idea of network configuration

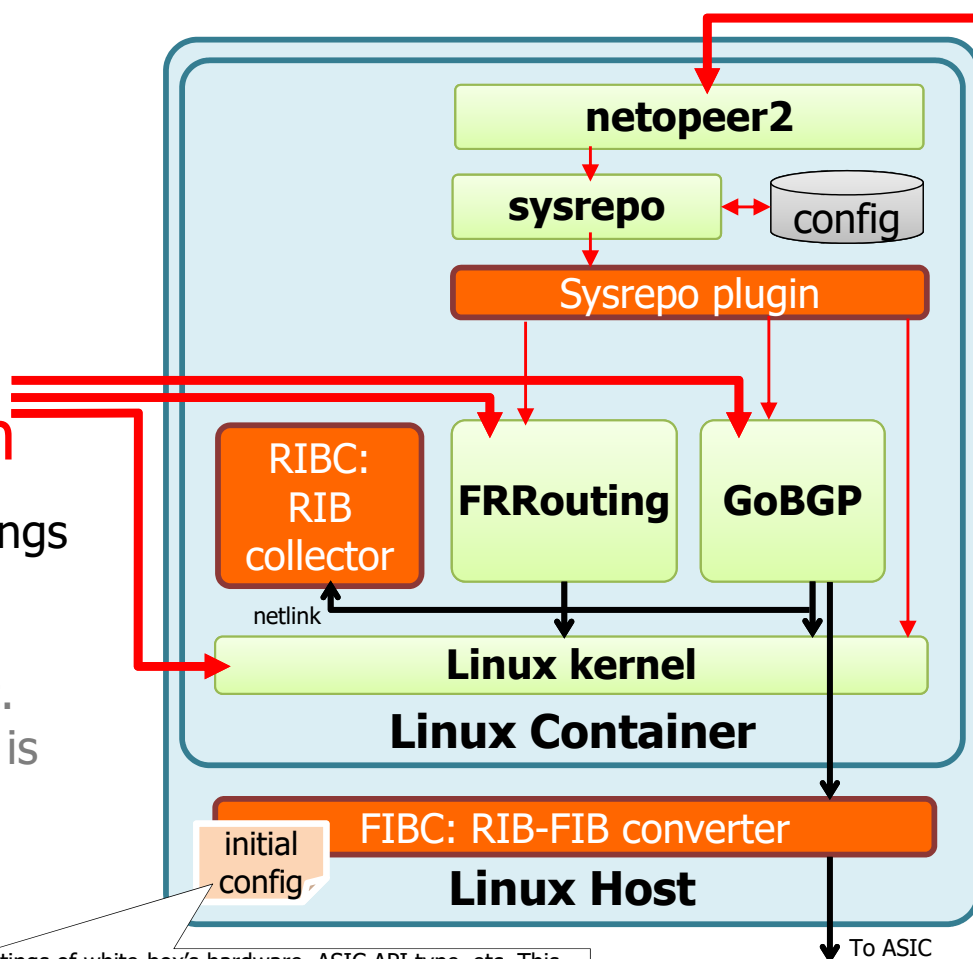


Almost all network configuration (IP address, routing protocol, etc.) **should be set to Linux container**, not Linux host OS.

[Method 1] Directly configuration

Legacy, but all settings can be changed

- ✓ vtysh, ip link, etc.
- ✓ ansible playbook is also prepared



Note: settings of white-box's hardware, ASIC API type, etc. This configuration can be changed by ansible playbook, but you don't have to change it once you set up for the first time.

[Method 2] NETCONF via sysrepo

NOT all feature is finished to implement yet

- ✓ Openconfig based yang
- ✓ 2 data store (running, candidate)

Yang files:

<https://github.com/beluganos/netconf/tree/master/etc/openconfig>

[Legend]

Datapath

→ RIB info.

→ Config info.

Component

OSS

Beluganos's component (OSS)



Quick start



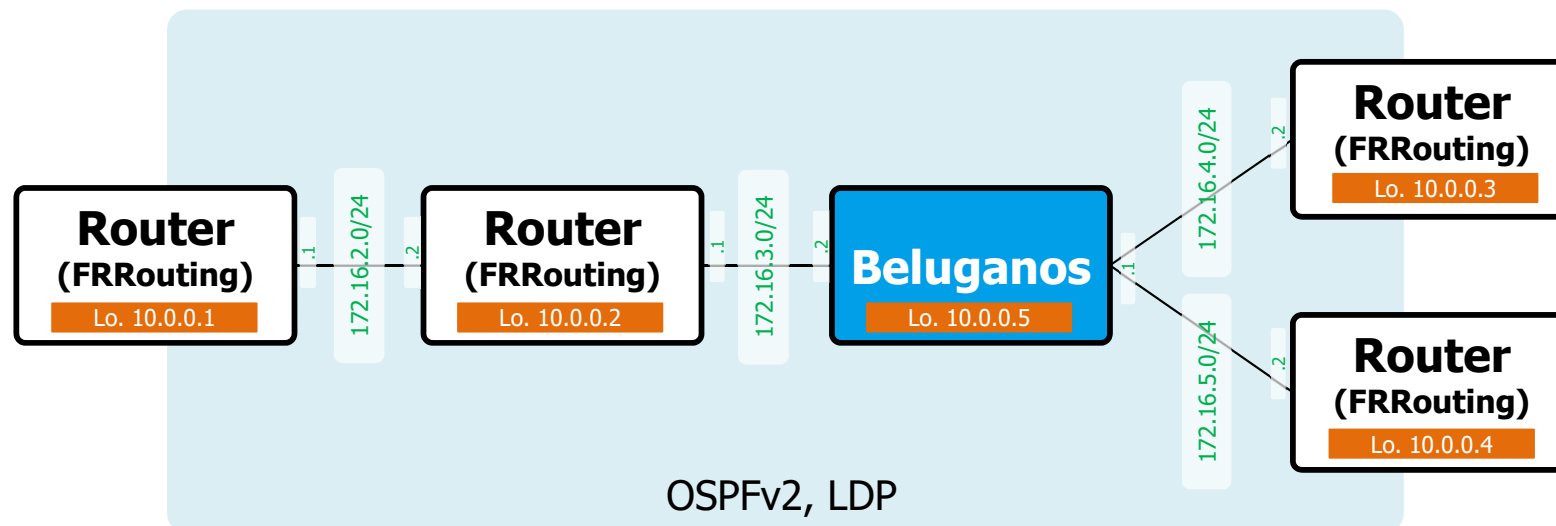
Example case can install and configure automatically **not only Beluganos but also other routers** to connect with Beluganos.

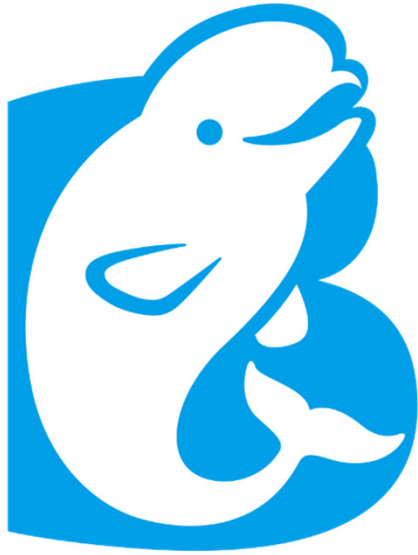
<https://github.com/beluganos/beluganos/blob/master/doc/example/case1/case1.md>

Note: You do **NOT required** to prepare white-box switches in this case.
OVS is used instead of white-box switches.

Note: You do **NOT required** to check other document like "install-guide.md" in this case.
All required process is described at "case1.md".

[Case 1]





Beluganos