Innovative R&D by NTT

ONOS/CORD meet up in Tokyo, 2018

Requirements for Switch Fabric and Expectations for Trellis

April 20, 2018

NTT Network Service Systems Lab.

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NTT Group

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NTT Group Holding Company

NTT R&D

12 Laboratories 2,500 researchers

Information Network Laboratory Group

Network Service Systems Lab.

Transport Network Innovation Project
(Core network development team)

★ I am here

Regional Communications Business

- NTT East
- NTT West

Long distance and international communications Business

- NTT Communications
- Dimension Data

Mobile Communications business

- NTT DOCOMO

System integration

- NTT DATA

Others
(real estate, finance, construction power business etc.)

- Other group companies

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Requirements for current network

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- NTT groups provide various services with **high scalability and high reliability**.
- These requirements have been realized in **a dedicated high-end routers**.

High-end core routers

◆ Example of NTT Regional Communications Business

Service			
	Basic service		Internet(IPv4, IPv6), telephone, telecast
	Scalability	**Route**	Over a few hundreds of thousands routes
		Traffic	Over tens of Tbps
	Additional functions		PPPoE, IPv6 native etc.
Quality			
	Reliability		Redundancy of each function Rapid switching for link failure
	Recovery operation		Internet: within 2 hours VoIP: within less time than internet

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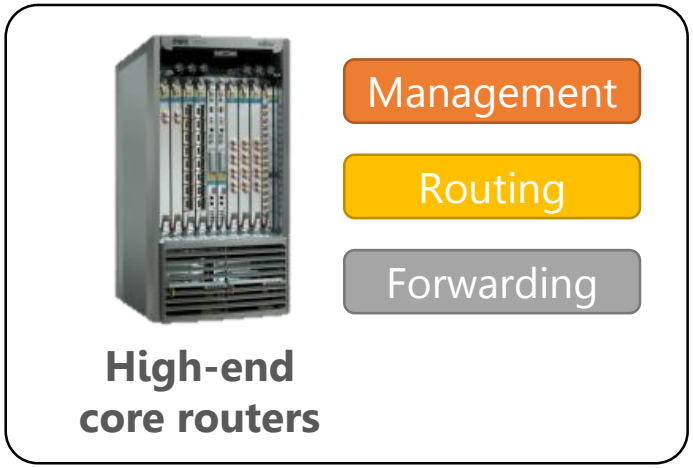
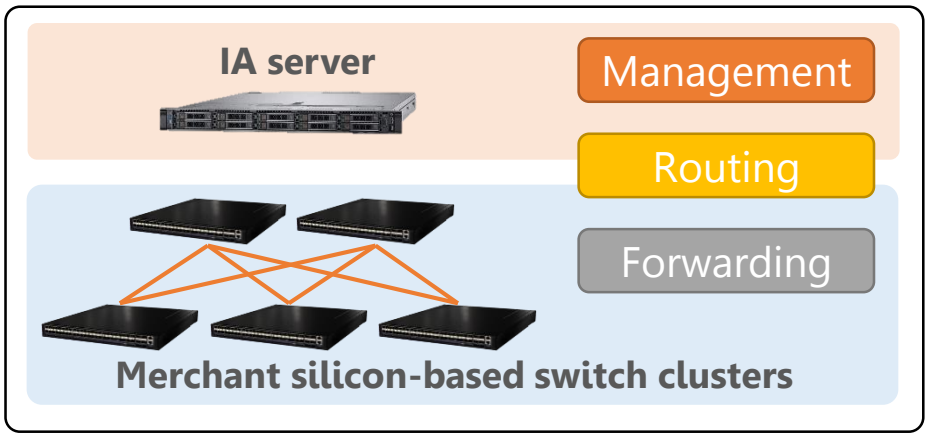
Disaggregation of high-end routers

- On the other hands, especially in OTT, a merchant silicon-based switch has great demands.
- CAPEX/OPEX savings and flexibility can be expected for a carrier with commodity products.

◆ Current



◆ Future



Disaggregation of the unified functions into commodity products

Activities

Our main activity

- ✓ Promotion of network development using commodity products

- https://github.com/multi-service-fabric/msf
- https://github.com/beluganos/beluganos

* Detail in reference

- ✓ Discussion with an open community about carrier requirements

- https://www.opennetworking.org/
- https://telecominfraproject.com/

Our working about ONOS/CORD

- ONOS/CORD verification (especially Trellis)
- Trying to close the gap between the results and our requirements

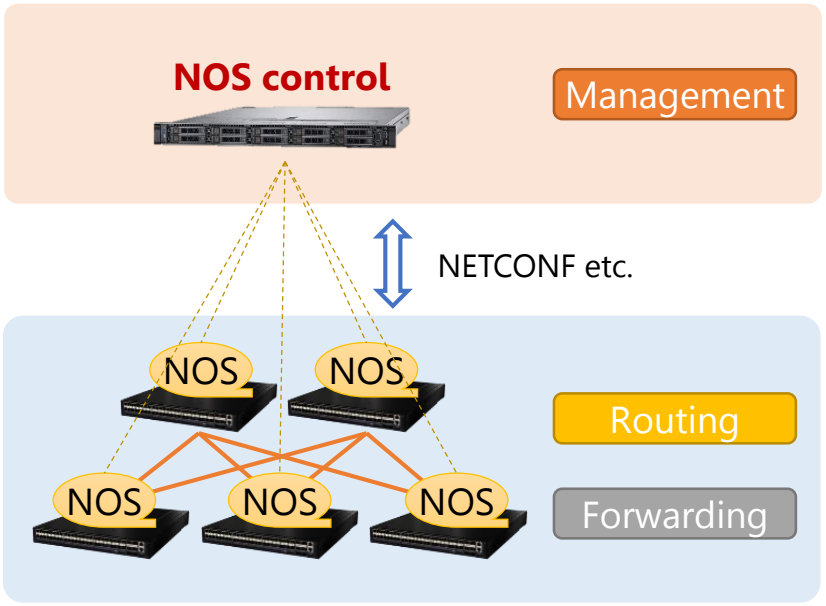
Today's topic

1. The verification results of the CORD-3.0 physical PoD
2. Proposal of new Trellis architecture for improvement of reliability

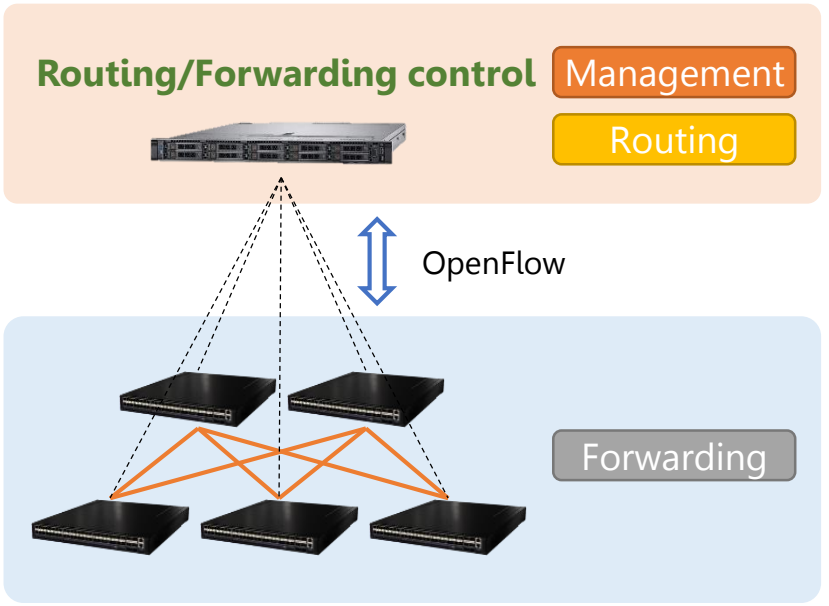
Existing network architecture

- There are two architectures regarding the deployment of the routing function.
  - ✓ Autonomous control architecture – Deploy routing functions on each switch
  - ✓ Centralized control architecture – Deploy routing functions on central controller

◆ Autonomous control architecture



◆ Centralized control architecture



Advantage

Autonomous control => **Conventional C-plane processing reliability.**

Centralized control => **Handling multiple switches as a single logical node.**

* NOS: Network operation system

Verification condition (1/2)

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Period

- ✓ Installation – 2017/6 - 2017/7
- ✓ Verification – 2017/8 - 2017/12

Verification points

		Router	Autonomous MSF (NTT Lab.)	Centralized Trellis/CORD (ONF)
Component	Hardware	Dedicated vendor Hardware	Commodity multivendor products	
	Software	Dedicated vendor NOS	Multivendor NOS + Open NOS	Open NOS
	Internal IF	Dedicated vendor IF	Standard (Routing protocols)	Standard (OpenFlow)
Redundancy of processor	Forwarding control	✓	✓	**Verification target** (especially compatibility)
	Routing control	✓	✓	
	Route update link	✓	✓	
Compatibility	A single logical node	-	N/A	
Functionality	L2 switching	✓	✓	
	IP routing	✓	✓	
	VPN	✓	✓	
Maintenance	In-service operation	✓	✓	
Scalability	Route	✓	✓	
	Traffic	✓	✓	

Verification condition (2/2)

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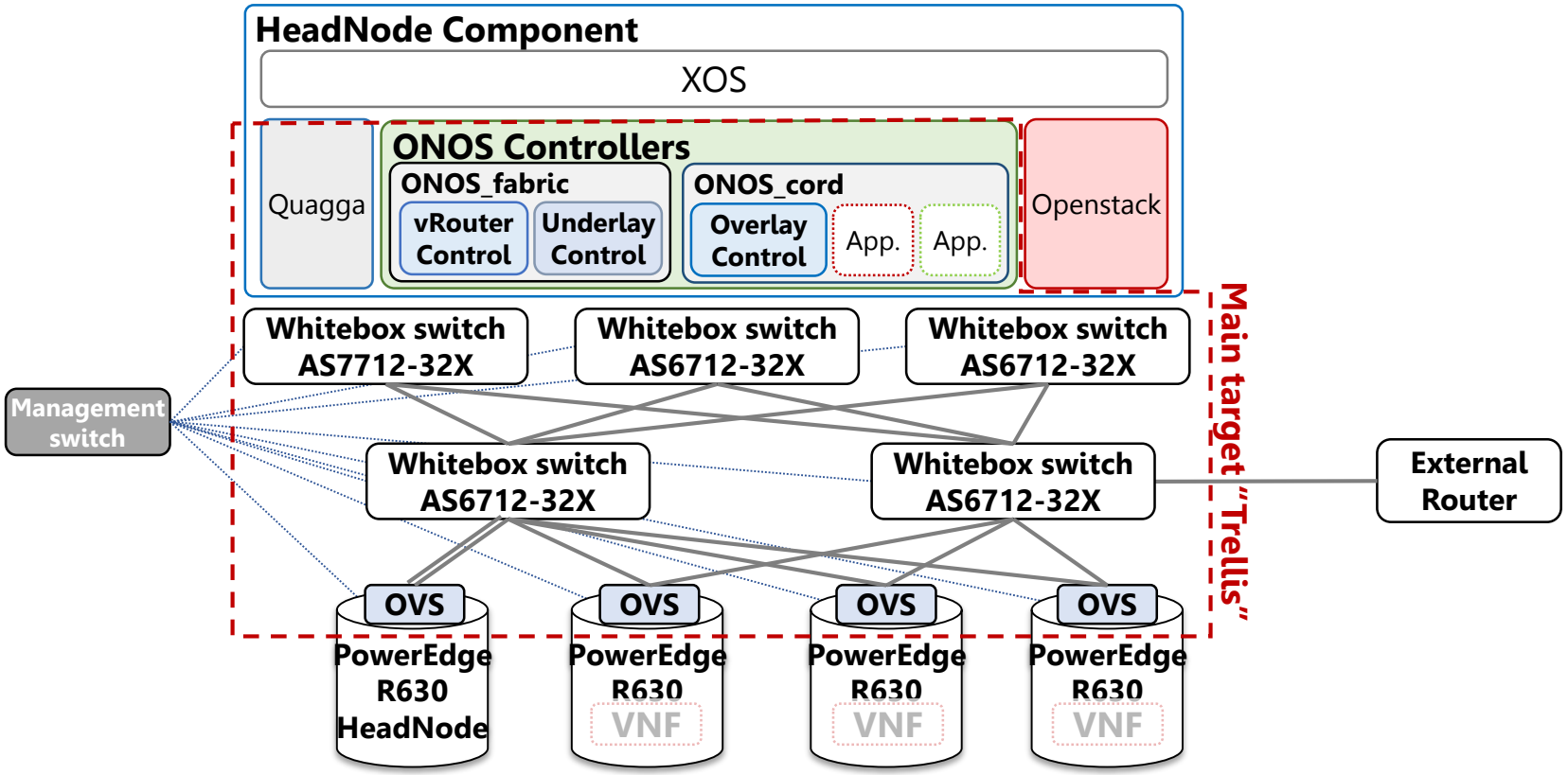
Components

- ✓ 5 switches (2 Leaf and 3 Spine) and 4 servers

Profile

- ✓ A residential profile, R-CORD (Each profile applications were not main target.)



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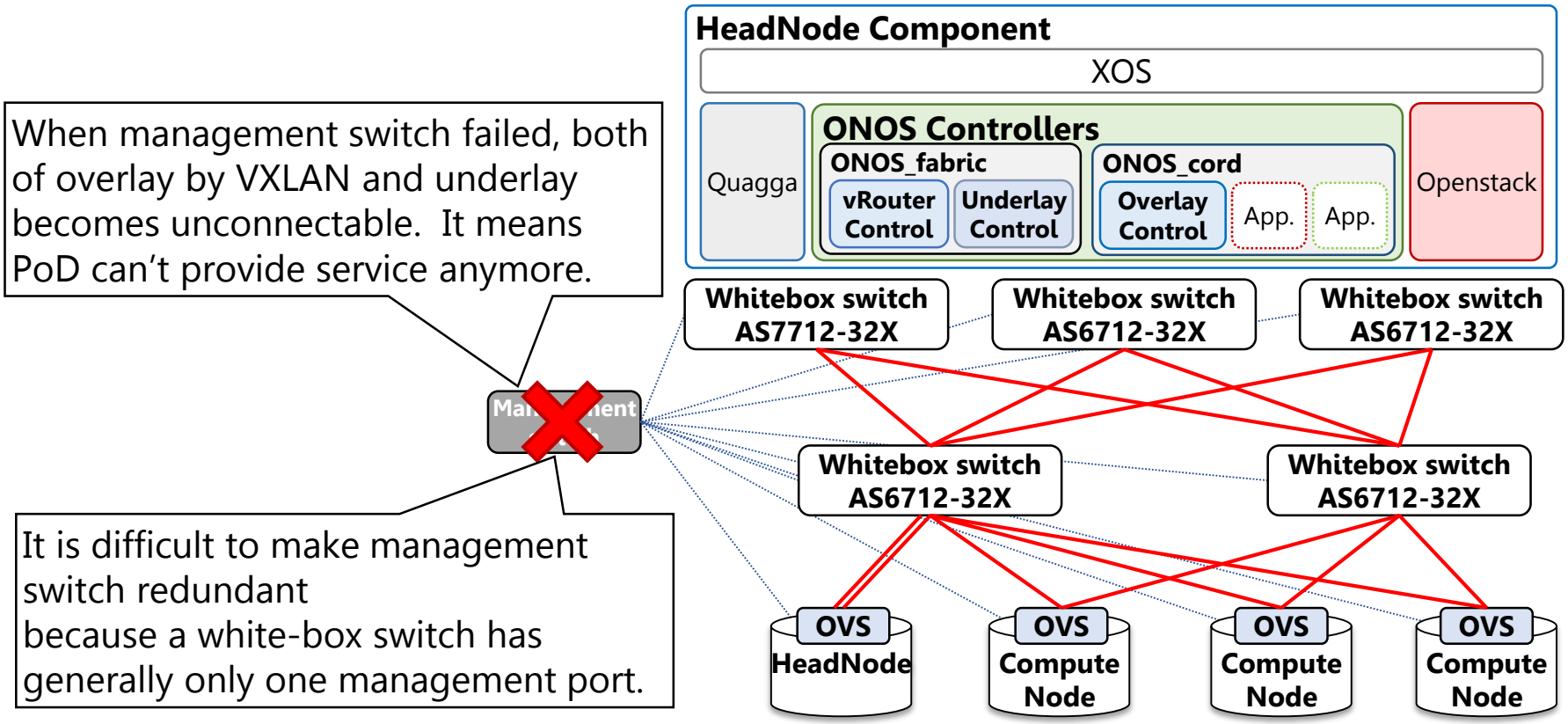
Summary of results

- We confirmed basic operation, but there ware some lack of function.
- Especially, from viewpoint of reliability, we confirmed it indispensable to improve network architecture.

		Router	Autonomous MSF (NTT Lab.)	Centralized Trellis/CORD (ONF)
Component	Hardware	Dedicated vendor Hardware	Commodity multivendor products	
	Software	Dedicated vendor NOS	Multivendor NOS + Open NOS	Open NOS
	Internal IF	Dedicated vendor IF	Standard (Routing protocols)	Standard (OpenFlow)
Redundancy of processor	Forwarding control	✓	✓	✓
	Routing control	✓	✓	N/A
	Route update link	✓	✓	N/A
Compatibility	A single logical node	-	N/A	✓
Functionality	L2 switching	✓	✓	✓
	IP routing	✓	✓	✓
	VPN	✓	✓	N/A
Maintenance	In-service operation	✓	✓	N/A
Scalability	Route	✓	✓	Not enough
	Traffic	✓	✓	✓

CORD PoD reliability

- Some essential functions are through the management switch.
  - ✓ ARP request/reply, Flow rule update, ONOS clustering connection etc.
- When the management switch failed, all connections were disconnected.



Improvement of reliability

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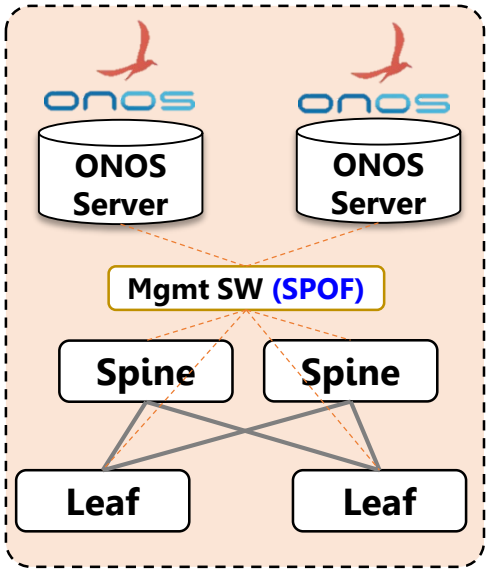
Characteristic of centralized control

- ✓ Advantages of compatibility with existing network design.
- ✓ Disadvantages of reliability at single point of failure on the management switch.

● Current architecture



A single logical node

Single point of failure

We first challenged to improve reliability with keeping the advantage of the current architecture.

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Solutions for improvement

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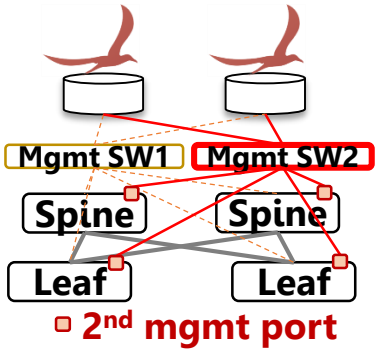
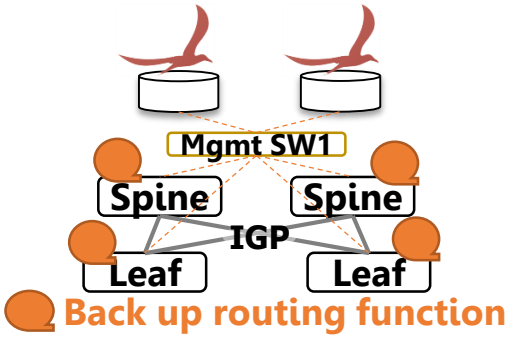
1. Expansion of management network

- An increase of management port is difficult to control by us.
  (It is hardware requirement)
- Management network design becomes complicated.



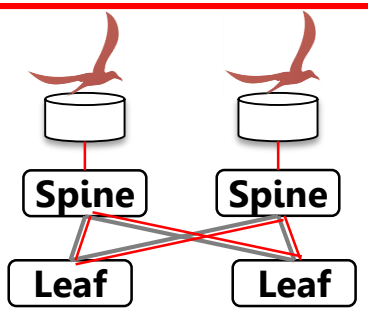
2. Implementation of back up routing function to switch

- An architecture changes from centralized to autonomous.
- Changing the NW design will affect allover network.



3. Distribution of centralized control via in-bound connection

- There are no influence outside PoD
- There are no additional hardware requirements



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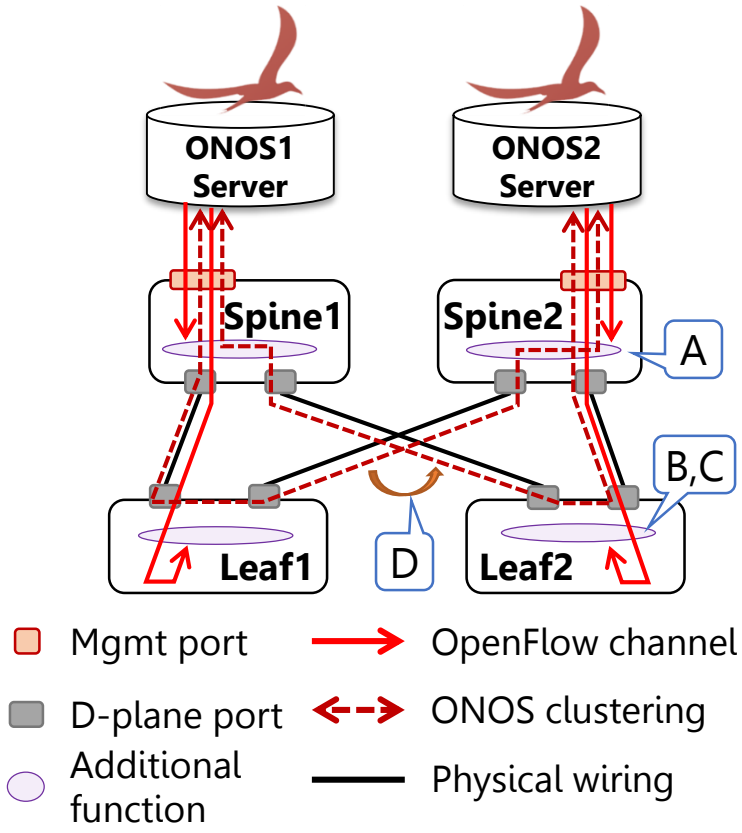
Proposed architecture overview

- Eliminate the management switch that becomes SPOF and connects it via D-plane port.
- We considered following implementation on a switch.



Implementation on a switch	
Base function	A. Connect management port to D-plane port
	B. Pick up OF channel from D-plane port
	C. Establish OF channel and update flow rules
Recovery	D. Switching management connection

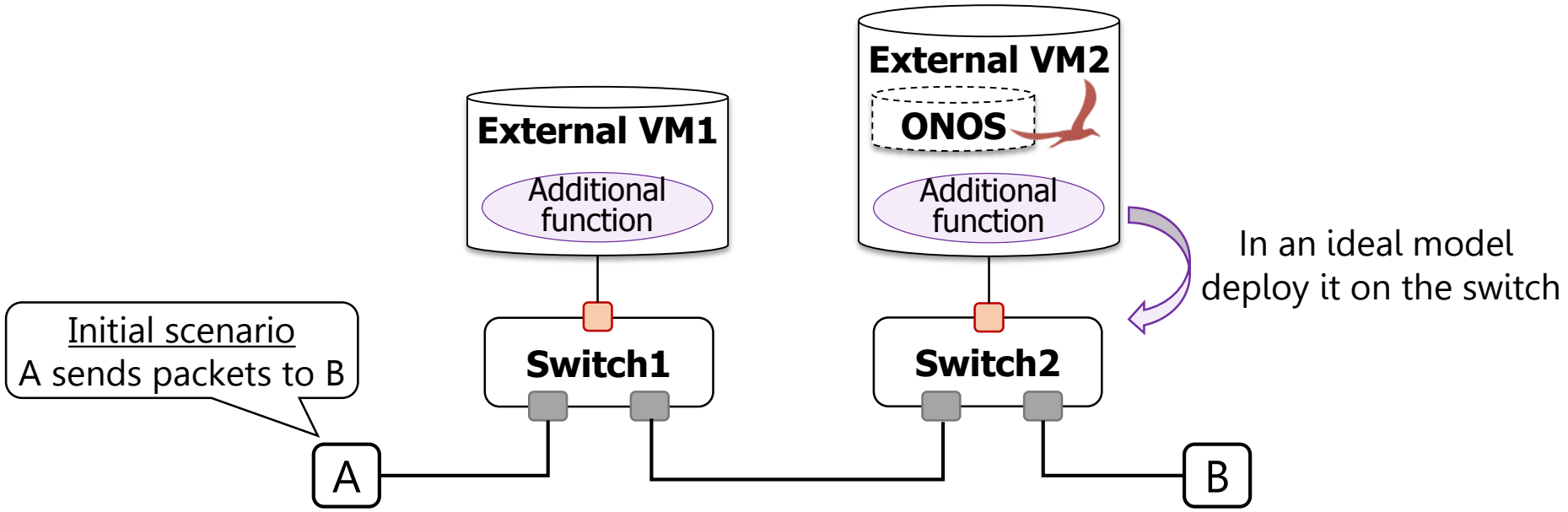
Verification point	
Basic function	Connection establishment
	Packet forwarding
	Flow rule update
Failure scenario	ONOS controller failure
	Internal link failure
	Switch node failure

Step 2

Step 1

Initial study (Step1)

- We conducted initial study of in-bound packet control using OSS.
- Component
  - ✓ Two white-box switches (AS5812-54X)
  - ✓ Additional software in external VM (It will be put on switch in future.)
    - ➢ OpenvSwitch => for abstraction of indigo agent and management port.
    - ➢ Ryu framework => for control OF channel on D-plane



Detailed packet processing (1/2)

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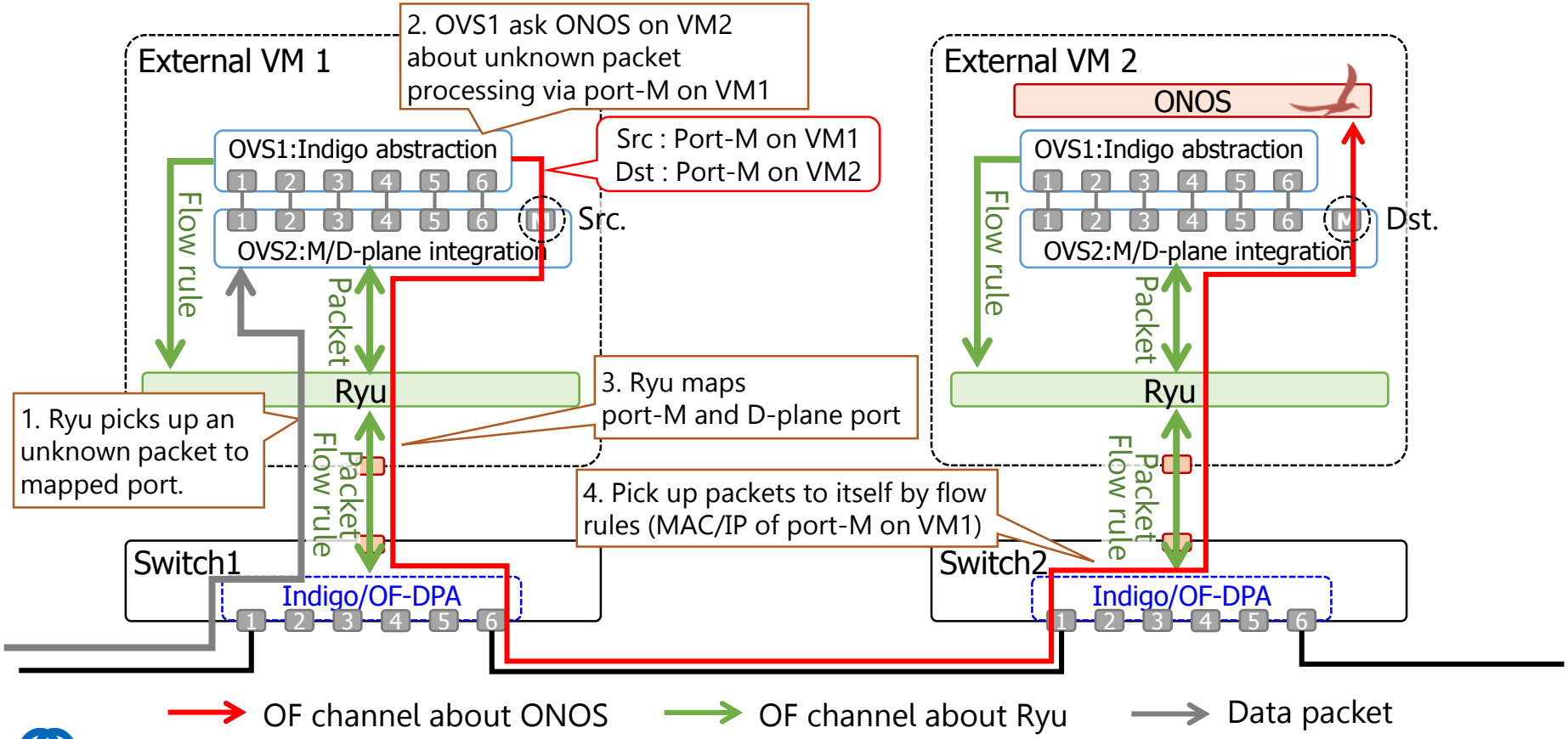
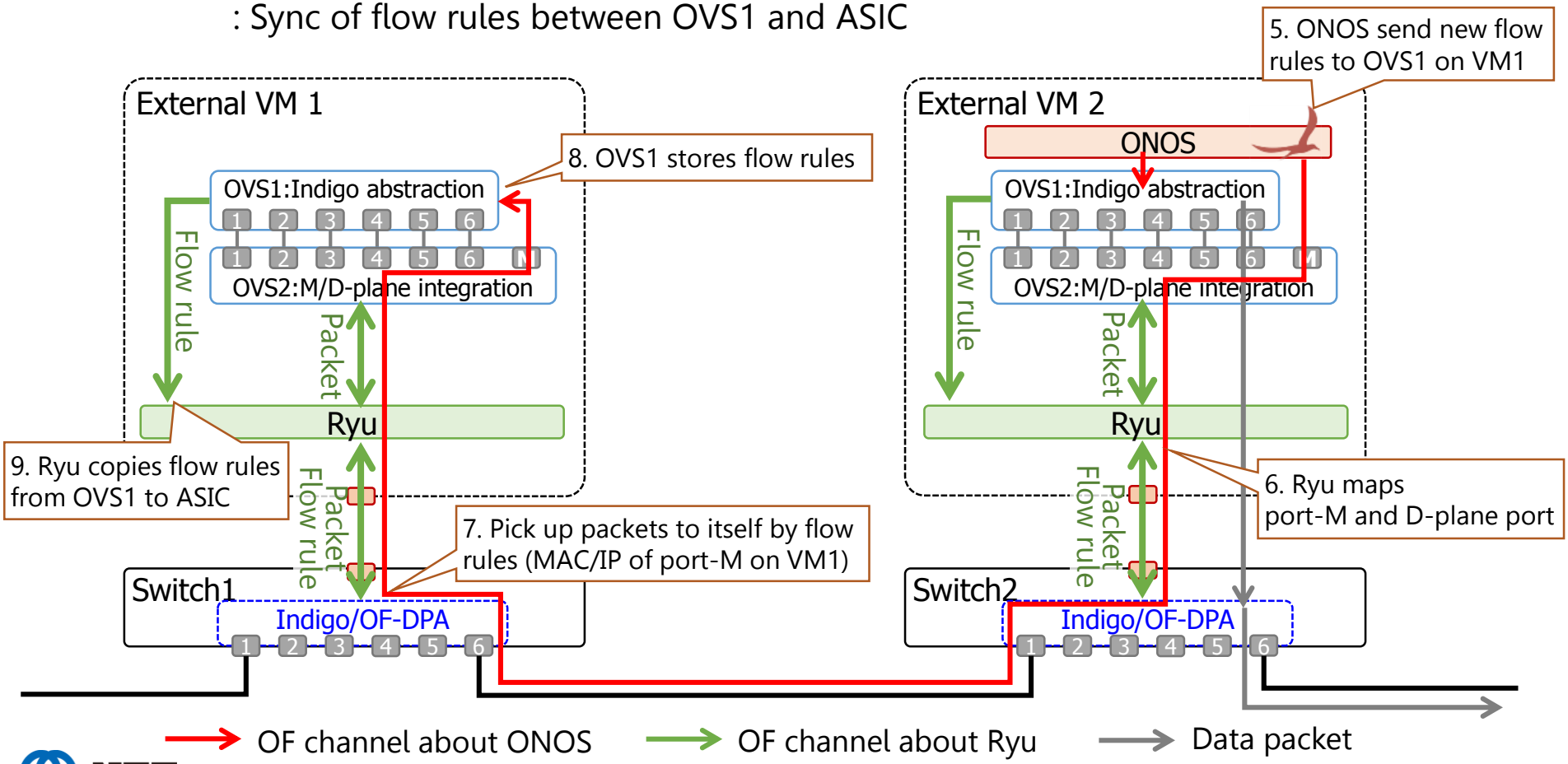
Role of each component

- ✓ OVS1 : Abstraction of indigo agent and storing flow rules from ONOS controller
- ✓ OVS2 : Connection between virtual interfaces and D-plane port on ASIC
- ✓ Ryu : Control of port mapping between OVS2 and ASIC
  : Sync of flow rules between OVS1 and ASIC



Detailed packet processing (2/2)

- Role of each component
  - ✓ OVS1 : Abstraction of indigo agent and storing flow rules from ONOS controller
  - ✓ OVS2 : Connection between virtual interfaces and D-plane port on ASIC
  - ✓ Ryu : Control of port mapping between OVS2 and ASIC
    : Sync of flow rules between OVS1 and ASIC



Packet walkthrough

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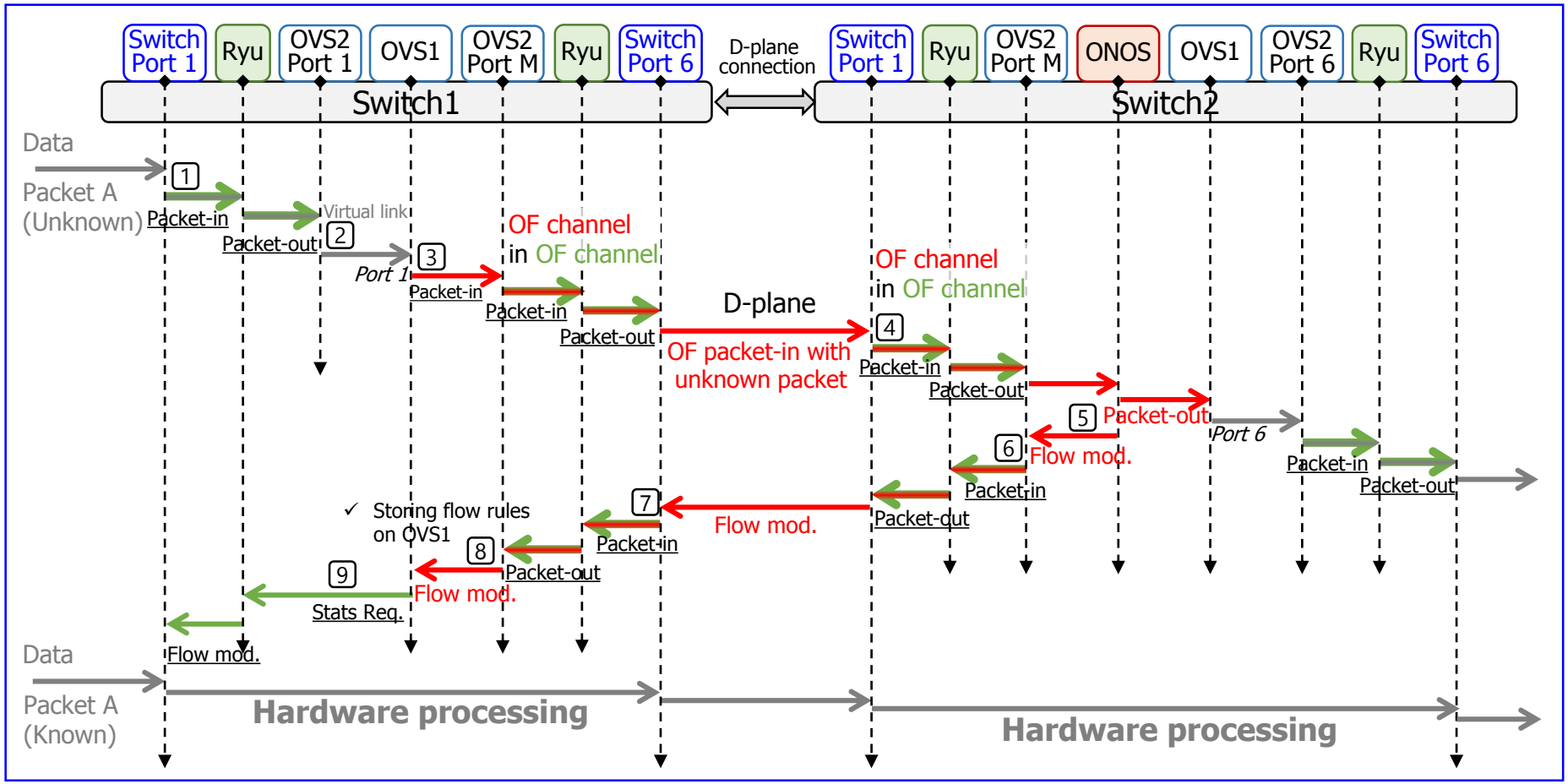
- After flow update, wideband transmission by hardware processing can be performed without any software processing.



→ OF channel about ONOS → OF channel about Ryu → Data packet

1 Icon of detailed packet processing steps

Verification and results

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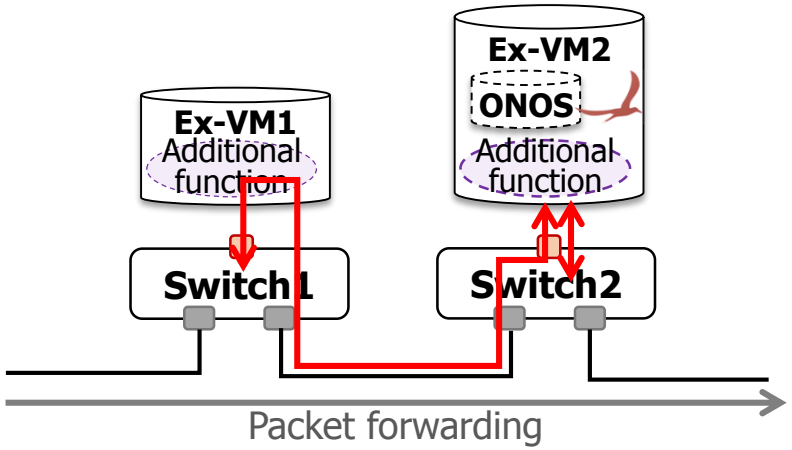
- We experimentally demonstrated basic operation in two pattern.
  - ✓ Test item 1 – OF channel connection via D-plane port
  - ✓ Test item 2 – ONOS clustering connection via D-plane port

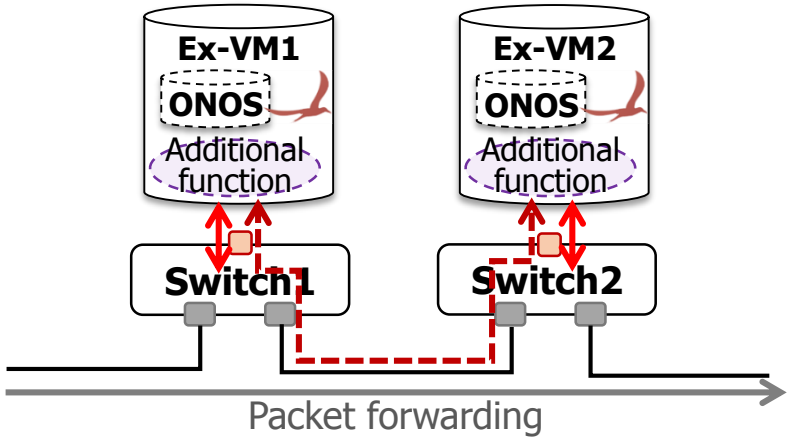
OpenFlow channel

ONOS clustering

✓ Test item 1 – OF channel



✓ Test item 2 – ONOS clustering

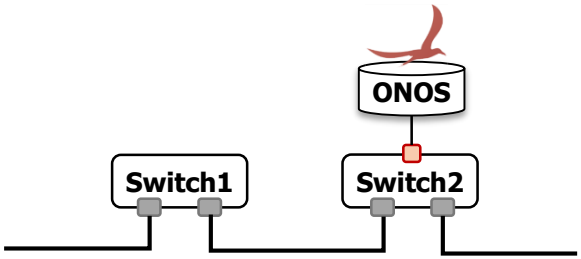


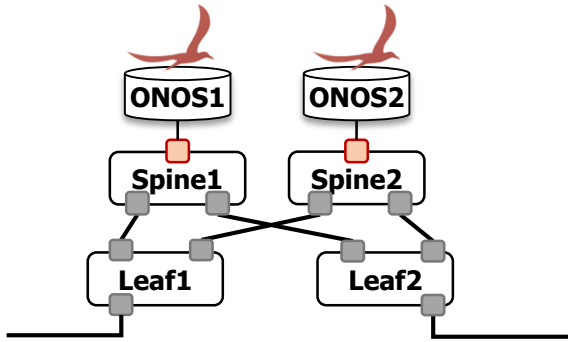
Verification point		Test item 1	Test item 2
Basic function	Connection establishment	✓	✓
	Packet forwarding	✓	✓
	Flow rule update	✓	✓
Failure scenario	ONOS controller failure	–	✓

Successfully completed!

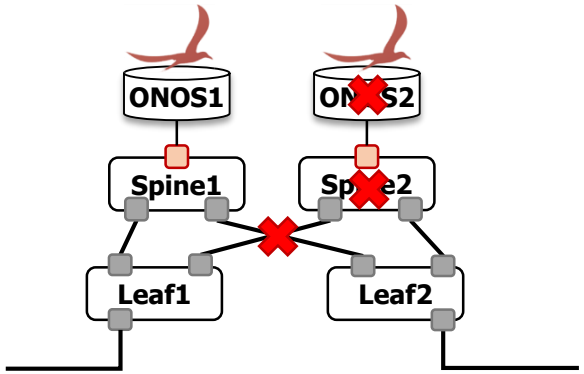
Next steps

- Implementation of Step 2 (Switching management connection)
- Expansion to CLOS topology (undergoing)





- Verification of failure scenario
  - ✓ ONOS controller failure **(done)**
  - ✓ Internal link failure
  - ✓ Switch node failure



- Further study
  - ✓ Add L2/L3 VPN function
  - ✓ Redundancy of routing function (Quagga)

Expectations for Trellis

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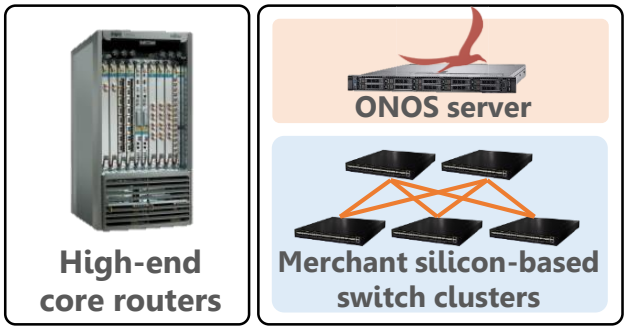
- We expect Trellis to expand further functions and the scale in the future.



		Router	Centralized Trellis/CORD (ONF)
Redundancy of processor	Route update link	✓	N/A => ✓
	Forwarding control	✓	✓
	Routing control	✓	N/A*
Compatibility	A single logical node	-	✓
Functionality	L2 switching	✓	✓
	IP routing	✓	✓
	VPN	✓	N/A
Maintenance	In-service operation	✓	N/A
Scalability	Route	✓	Not enough
	Traffic	✓	✓

Architecture design

RIB/FIB control software
- FRR (Quagga) enhancement
- ONOS enhancement

Handling ASIC
- OF-DPA
- Native SDK
- **P4 (Stratum)**

* There is no redundant technique to keep a single logical node not.

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For a high-reliable network

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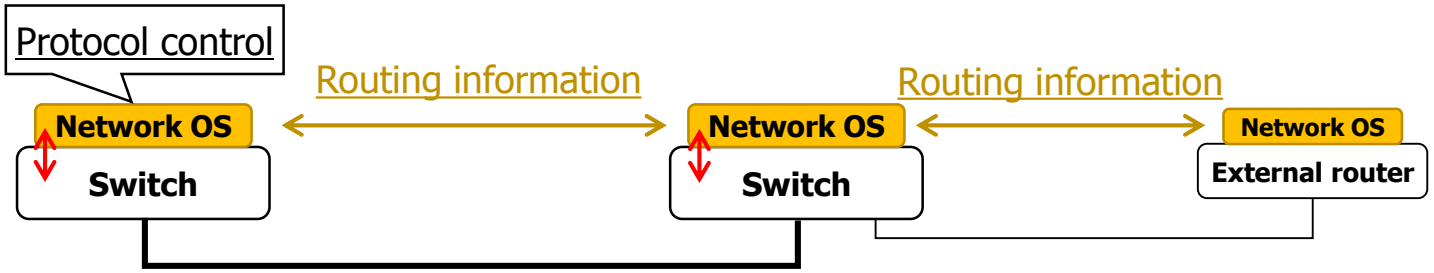
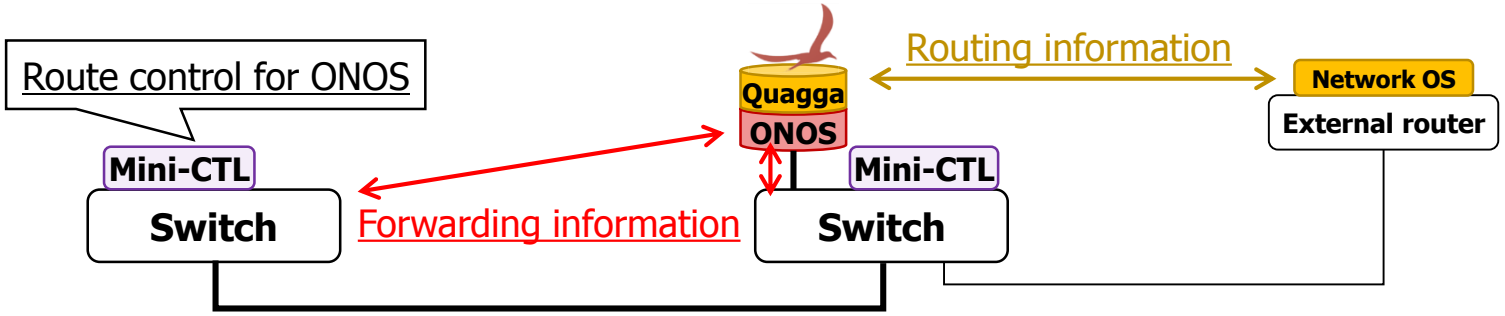
- In order to realize the high-reliable network without single point of failure, we believe that **some functions should be implemented on a switch device**.
  - Conventional architecture
    – Autonomous D-plane control by network OS)



  - The proposed architecture
    – Autonomous OpenFlow/ONOS clustering control on D-plane by mini controller



- We believe it is important to utilize lightweight platform that can run on a switches. That's why we applied Ryu framework this time.

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Expectation for Stratum

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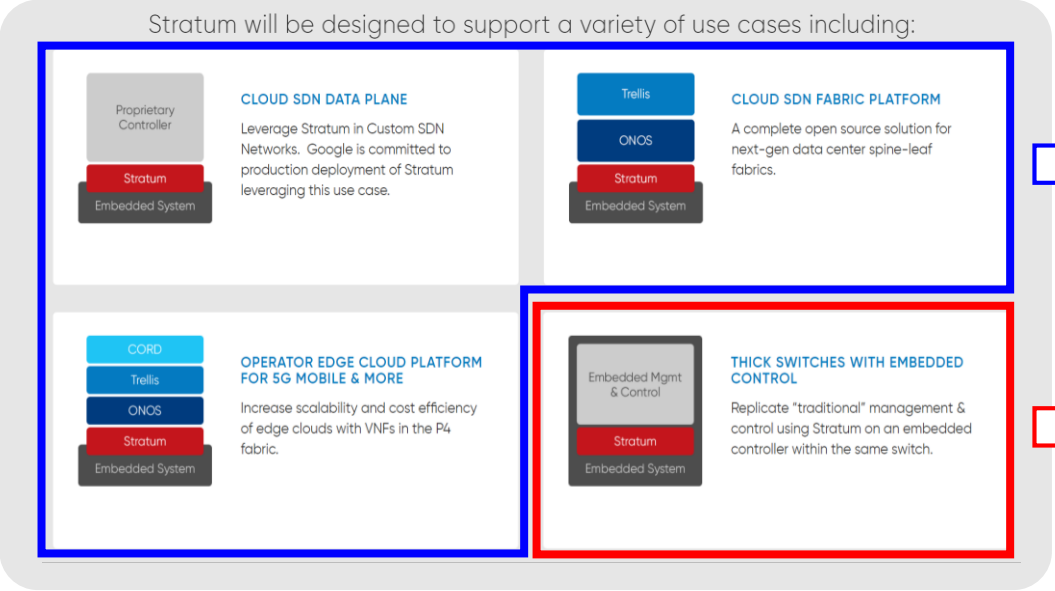
- We're also interested in Stratum to realize a widely adaptable network.



Thin model

for more flexible D-plane control

- Build forwarding table directly
- C/D separated architecture

Thick model

for more an autonomous network

- Autonomous route construction
- Distributed processing

Focusing on both models, we will continue to research a better network

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Thank you for listening

We are looking for collaborators who can discuss such an approach.
Please contact us if you are interested.

Reference: Multi Service Fabric

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◆ An activity of our carrier-grade SDN architecture.

MSF is the architectural design of carrier-grade SDN that provides wide logical network slices with commodity products including a white-box switch.

□ Newly updated on 4/16 !!!

https://github.com/multi-service-fabric/msf/tree/msf2017
https://github.com/multi-service-fabric/fabric-controller/tree/msf2017
https://github.com/multi-service-fabric/element-controller/tree/msf2017
https://github.com/multi-service-fabric/element-manager/tree/msf2017

Supported functions

- Controller-independent autonomous control architecture
- L2(VXLAN)/L3(MPLS) VPN control
- Multi clusters control
- In-service operation
- High-reliability (There is no SPOF to stop services.)
- Switch set-up automation

etc.

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Reference: NTT's activity about network OS

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◆ An activity of our open network OS

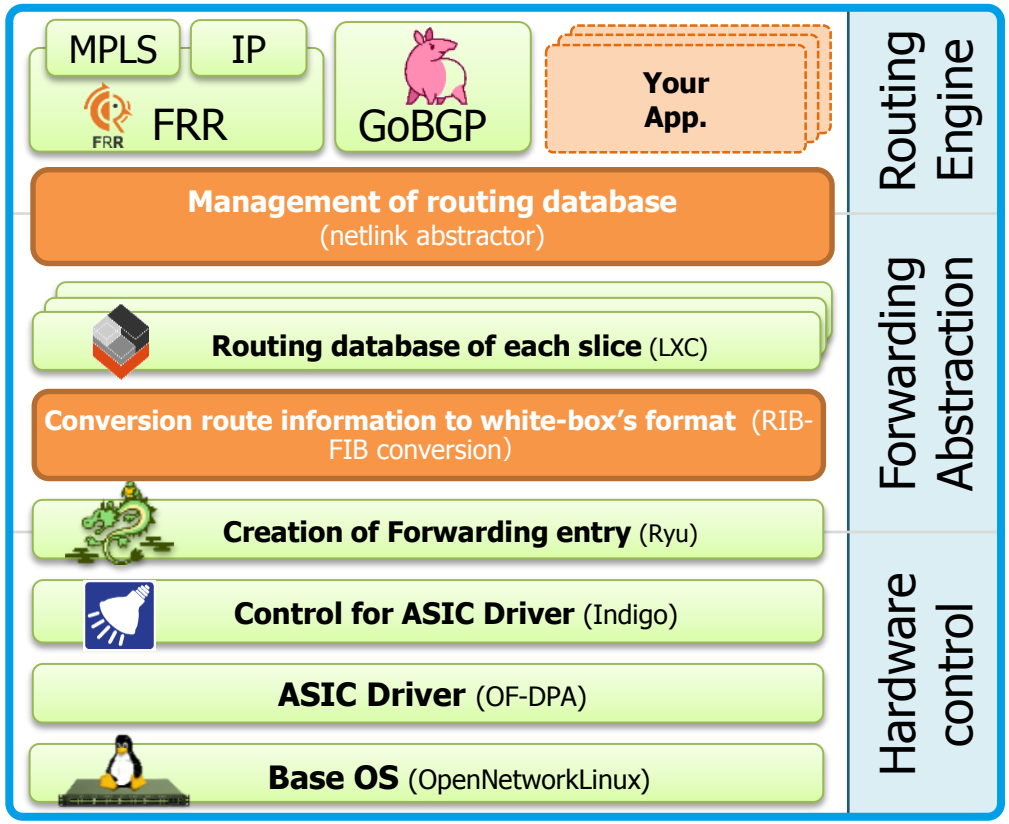
Beluganos

The prototype of carrier-grade NOS based on open technology (OSS/Open API) with IP/MPLS capability

[Legend]

Existing Software (OSS)

Developed (OSS)



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