



한국정보과학회 단기강좌

SDN 테스트베드 구축

라즈베리파이를 이용하여 이더넷 스위치를 제작,
ON.Lab의 ONOS/OVX SDN 컨트롤러로 제어
Programmable Network 구축

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목차

A Table of Contents



ONOS

ONOS(Open Network Operating System) 소개, 아키텍처 분석, 설치 및 데모
Keyword : Distributed core, Hazelcast, Intent Framework, maven, karaf

OpenVirtex

OVX 소개, Network Hypervisor와 가상화 플랫폼의 기능, 설치 및 데모
Keyword : Hypervisor, 네트워크 가상화 플랫폼, Resilient, elastic

Pi Stack Switch

Raspberry Pi와 Open vSwitch를 이용한 SDN 테스트베드 구축
Keyword : Raspberry Pi, Open vSwitch, OpenFlow 스위치

Q&A

질의응답

ONOS

SDN Network Operating System & SDN Control Platform



ONOS

Open Network Operating System

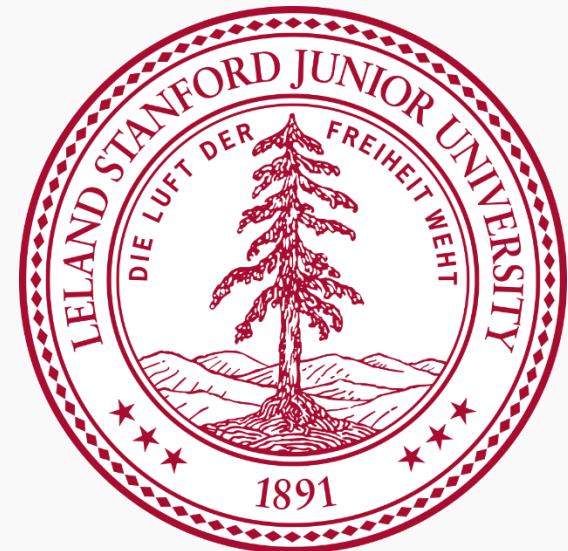
- Service Provider를 위한 캐리어급 SDN 네트워크 운영체제
- **ON.LAB**이 주도한 프로젝트



Open Network Operating System

- Service Provider를 위한 캐리어급 SDN 네트워크 운영체제
- **ON.LAB**이 주도한 프로젝트

ON.LAB



Non-profit
Tools/Platforms for SDN community

Closed Network

Closed Network







Networking For Public Good

Supporting members



ciena



NTT docomo

ERICSSON

FUJITSU

Google



Projects

ONOS

OVX

Mininet

OpenCloud

Network OS

Network Virtualization
Platform

Instant Virtual Network

Network Functions as a
Service



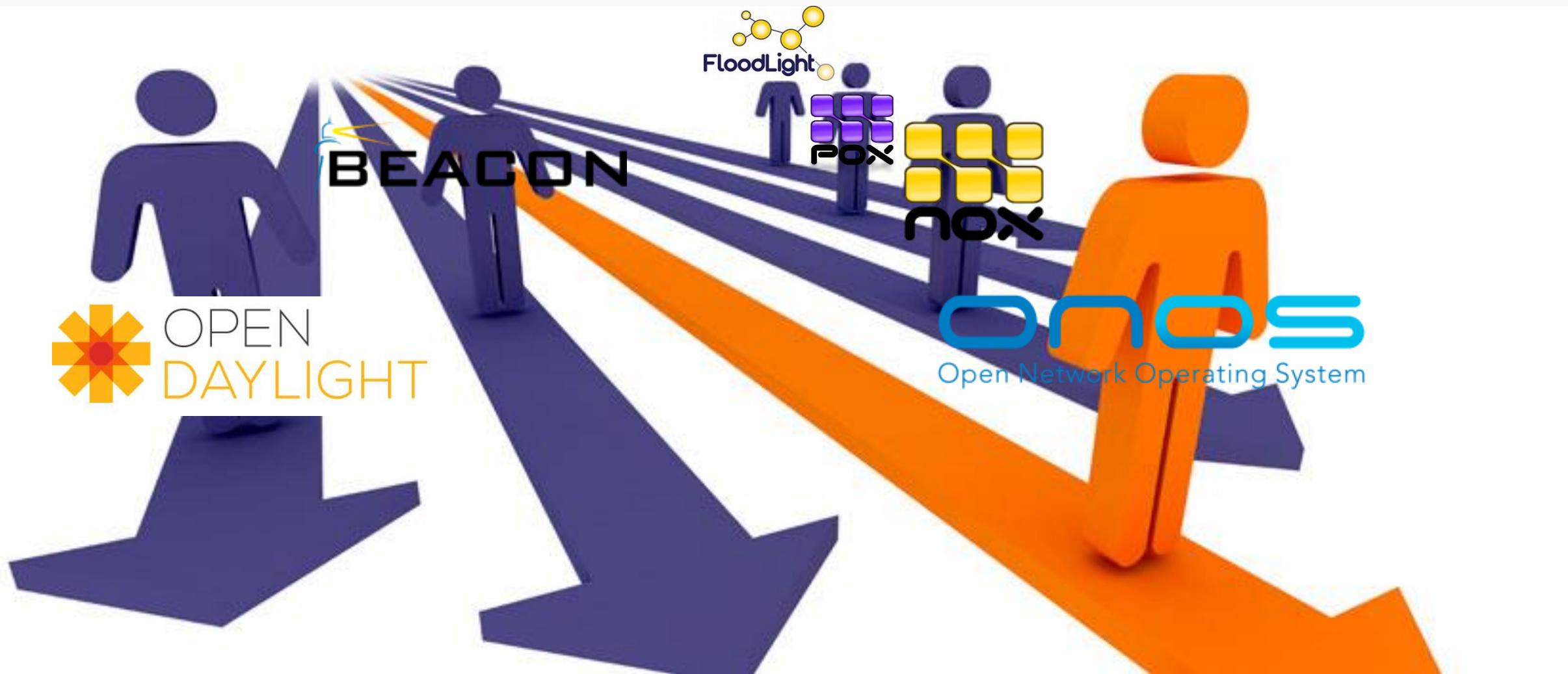
Open Network Operating System

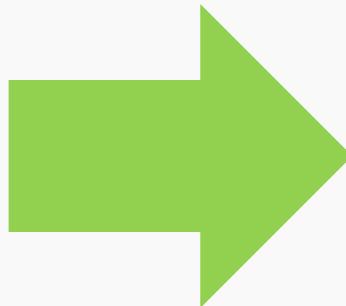
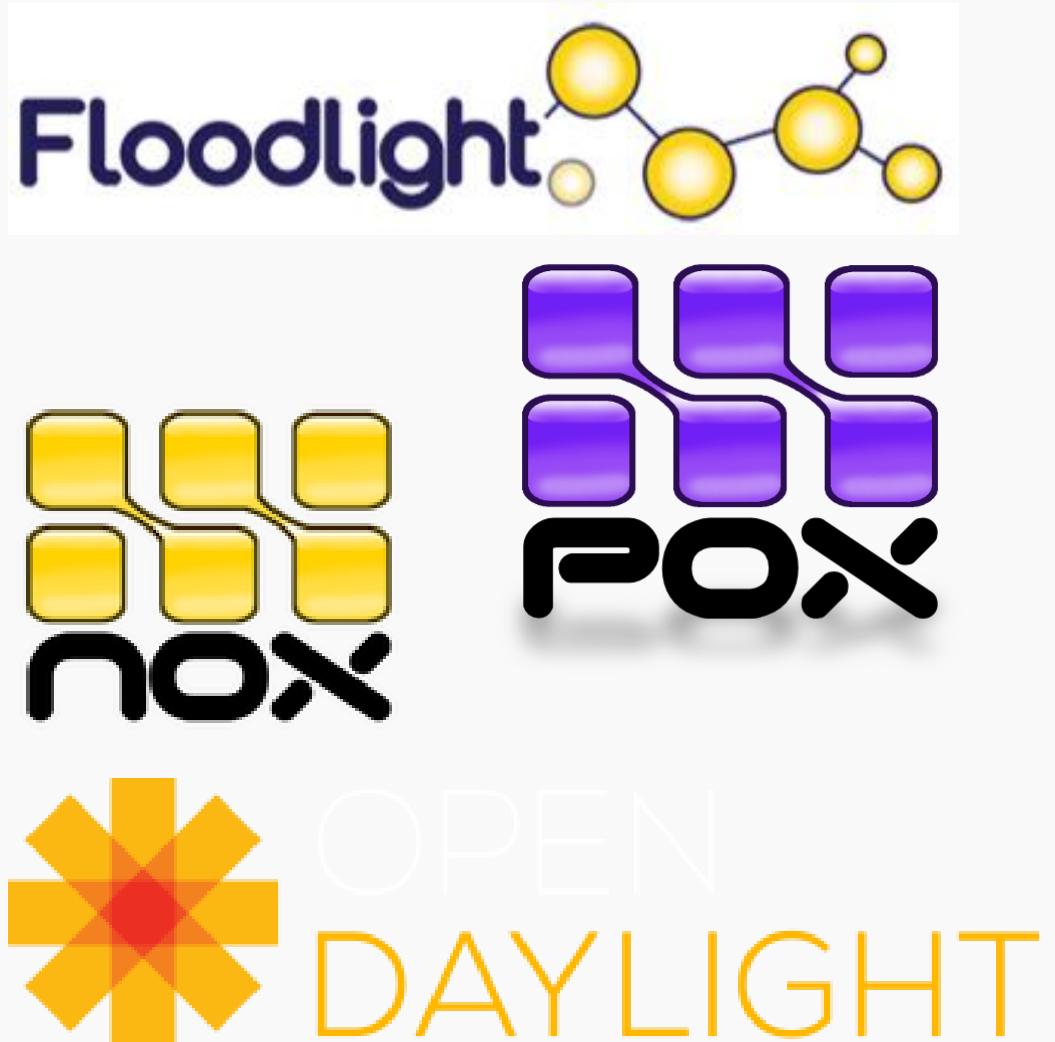
- Service Provider를 위한 캐리어급 SDN 네트워크 운영체제
- **ON.LAB**이 주도한 프로젝트

onos
Open Network Operating System

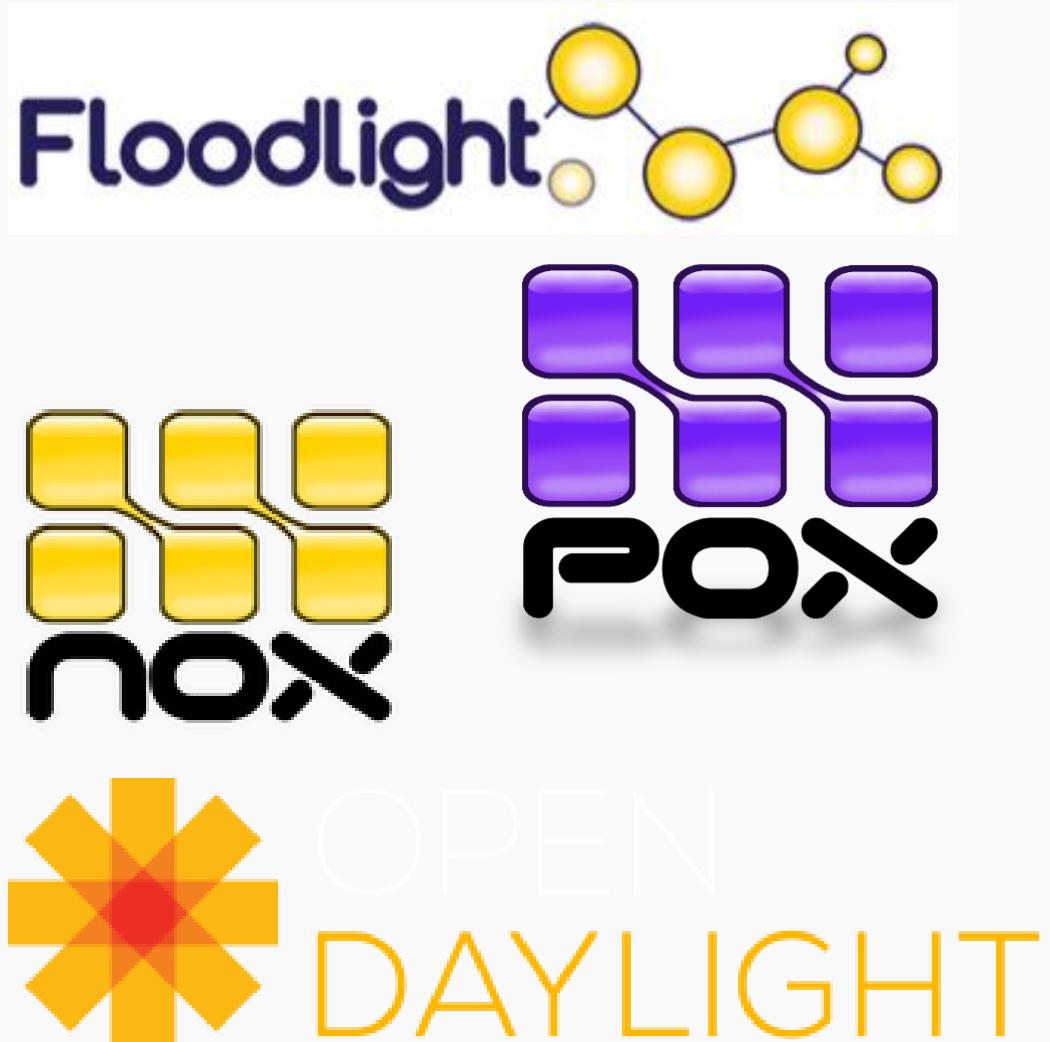


Difference of ONOS





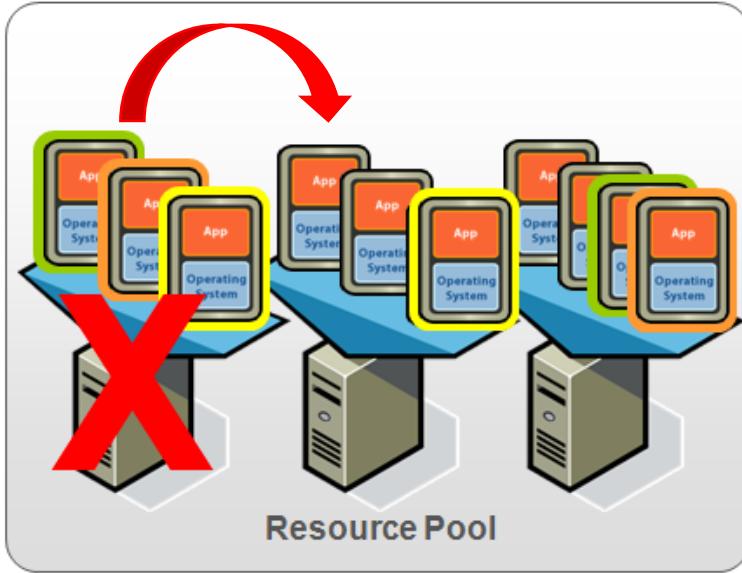
commercial
products



onos
Open Network Operating System



commercial
products



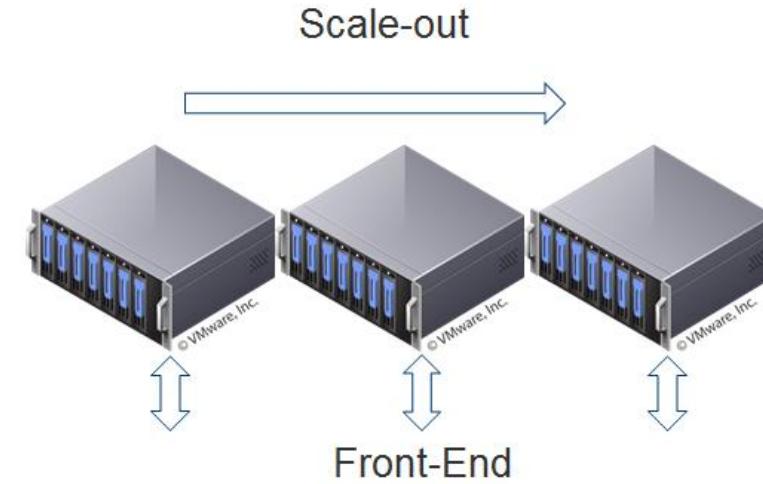
- Multiple Instance **Clustering**
- Fault tolerance using Distributed Core
- 99.999% Five Nines 수준의 가용성

High Availability



- OSGi 기반의 오픈소스 Karaf
→ 쉽고 빠른 배포

- 분산 클러스터링 지원
→ Sync, Share



High Availability

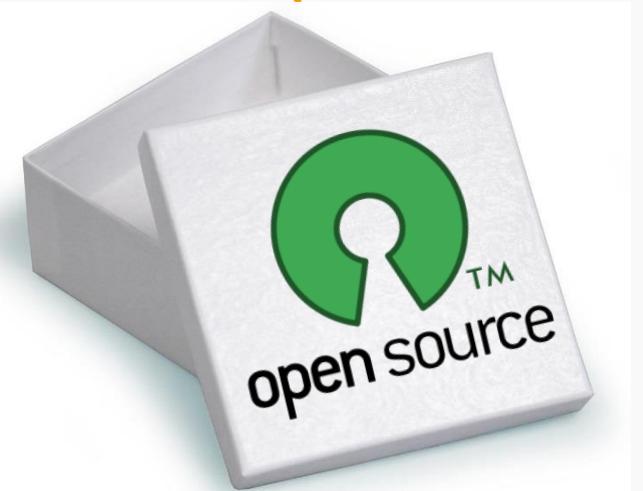
High Performance

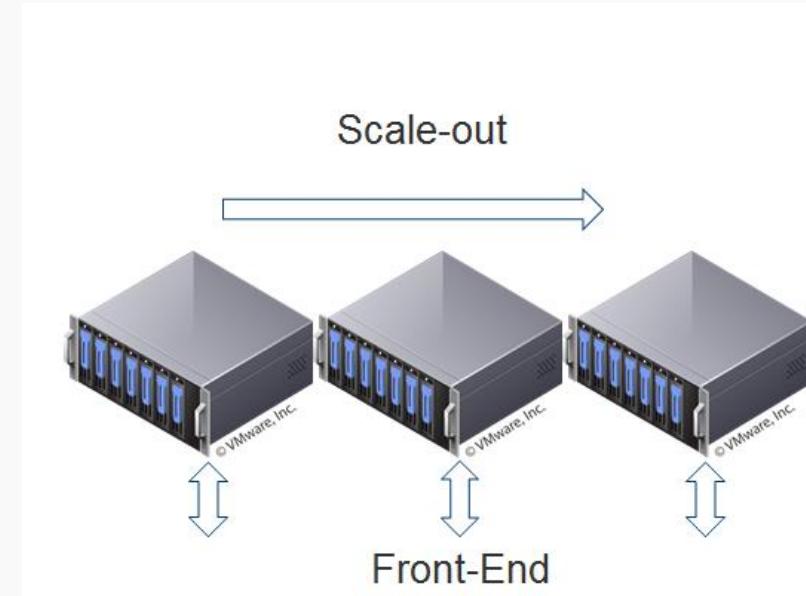
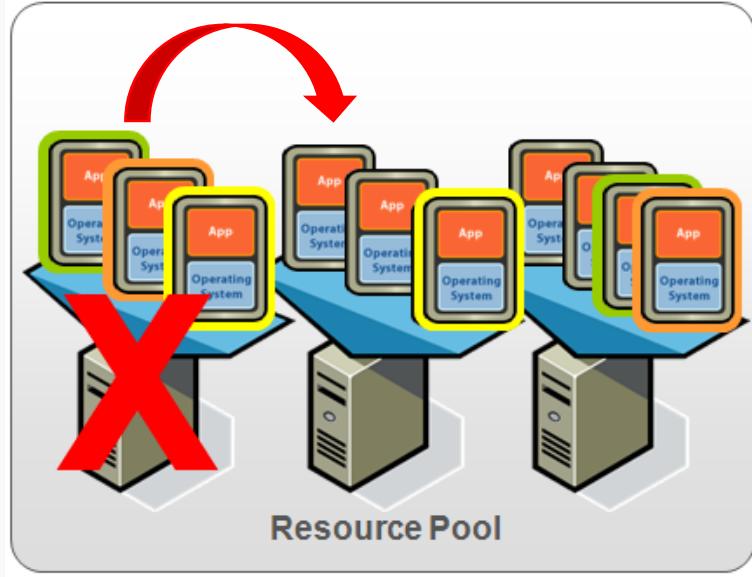
Scalability

High Availability
High Performance
Scalability
White Box (Open)

MOST COMMON LICENSES	USE	FILES	%
Apache License 2.0	<input checked="" type="checkbox"/>	8,924	99.72
Eclipse Public License 1.0	<input checked="" type="checkbox"/>	18	0.20
BSD 3-clause "New" or "Revised" Li...	<input checked="" type="checkbox"/>	4	0.04
MIT License	<input checked="" type="checkbox"/>	3	0.03

Reference : ONOS wiki





High Availability

High Performance

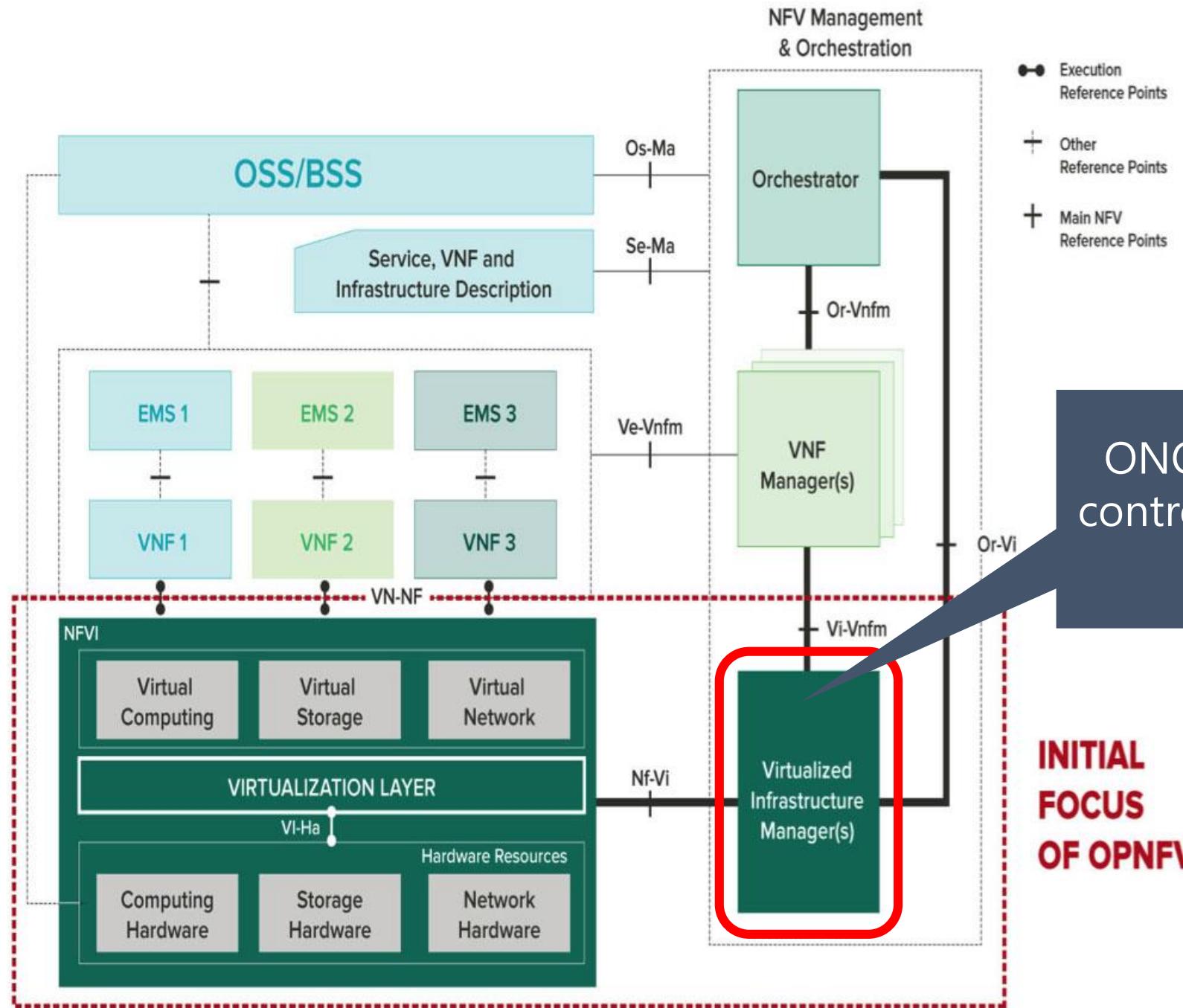
Scalability

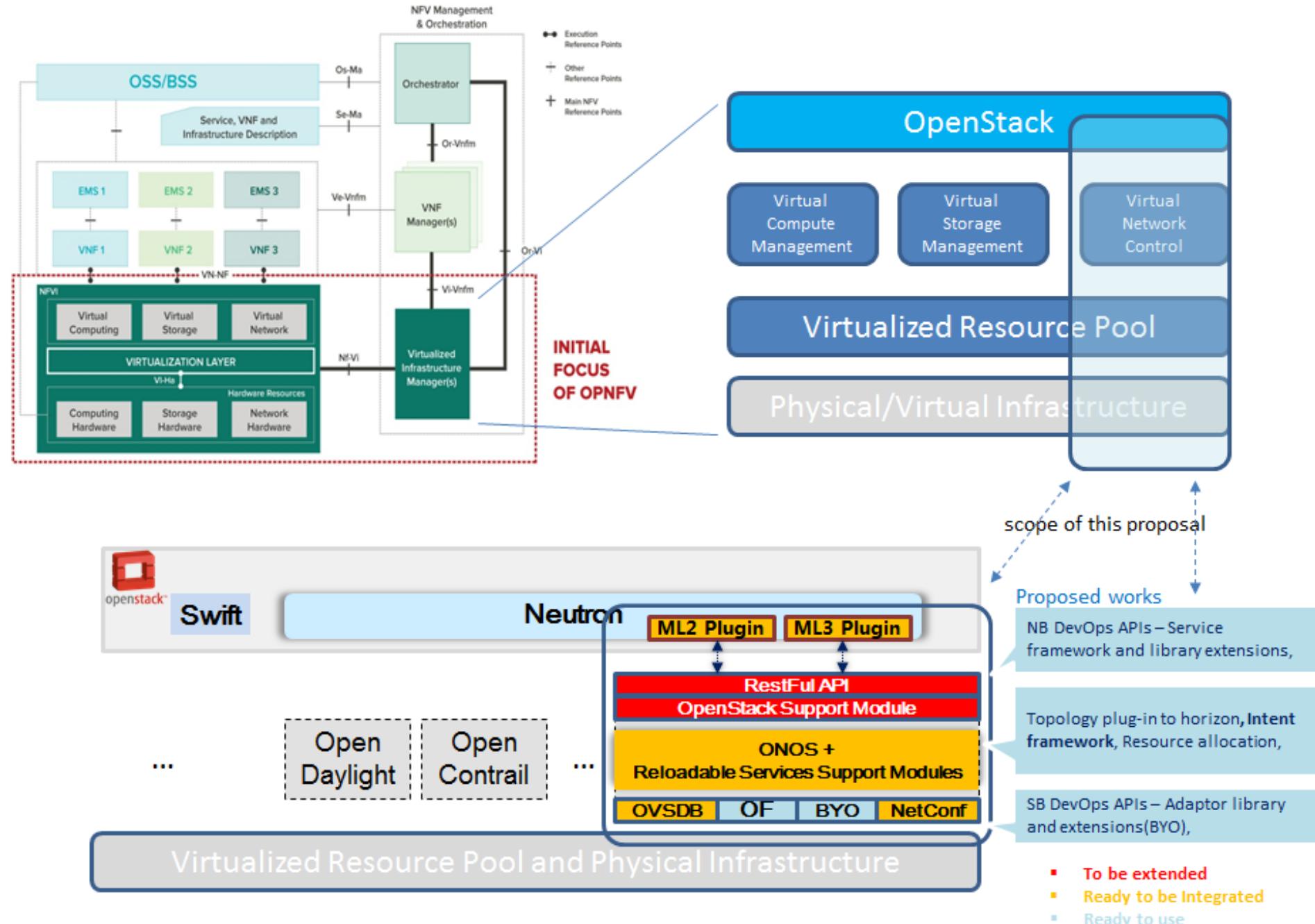
White Box (Open)



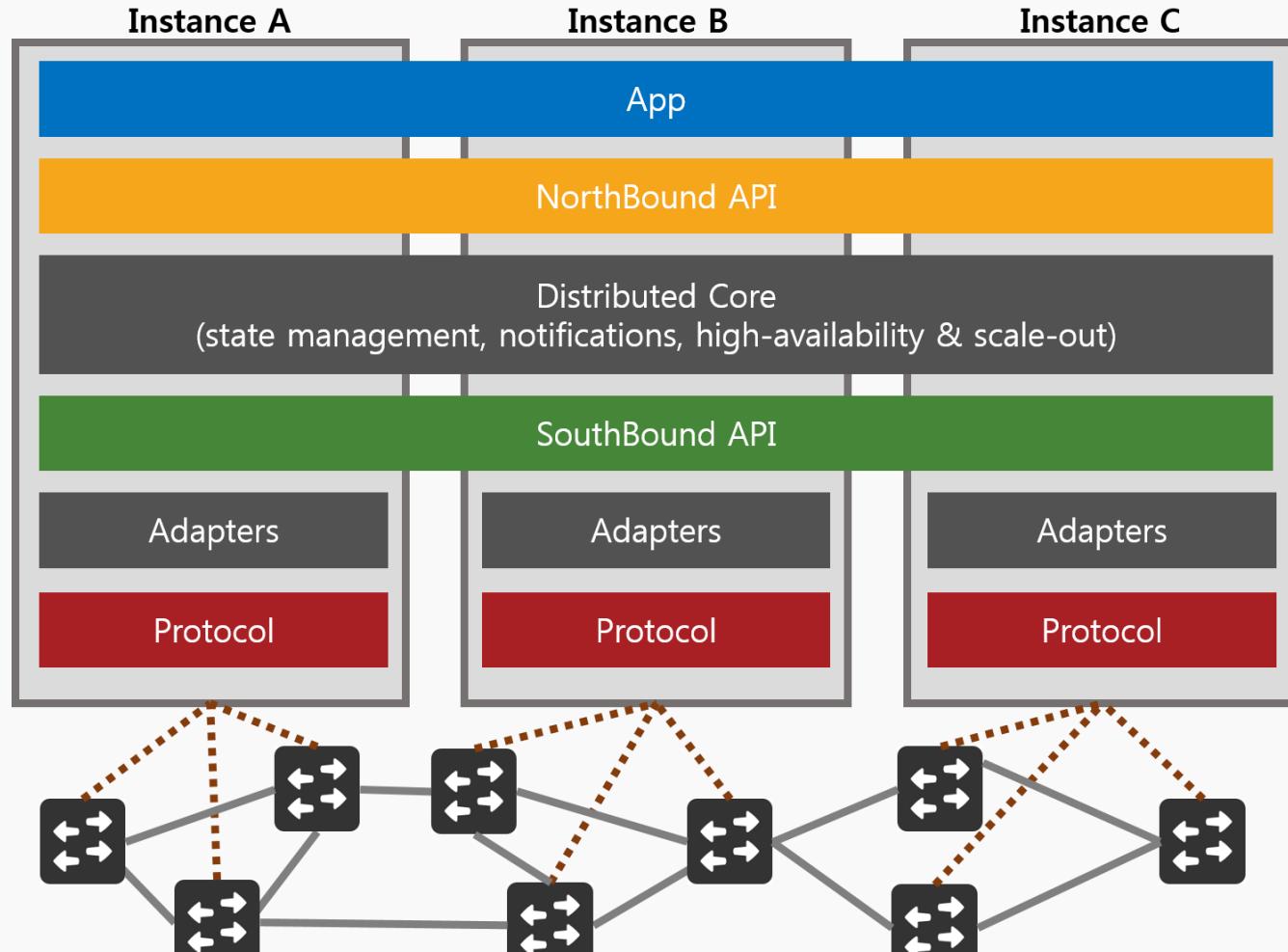
ONOS Framework(ONOSFW)

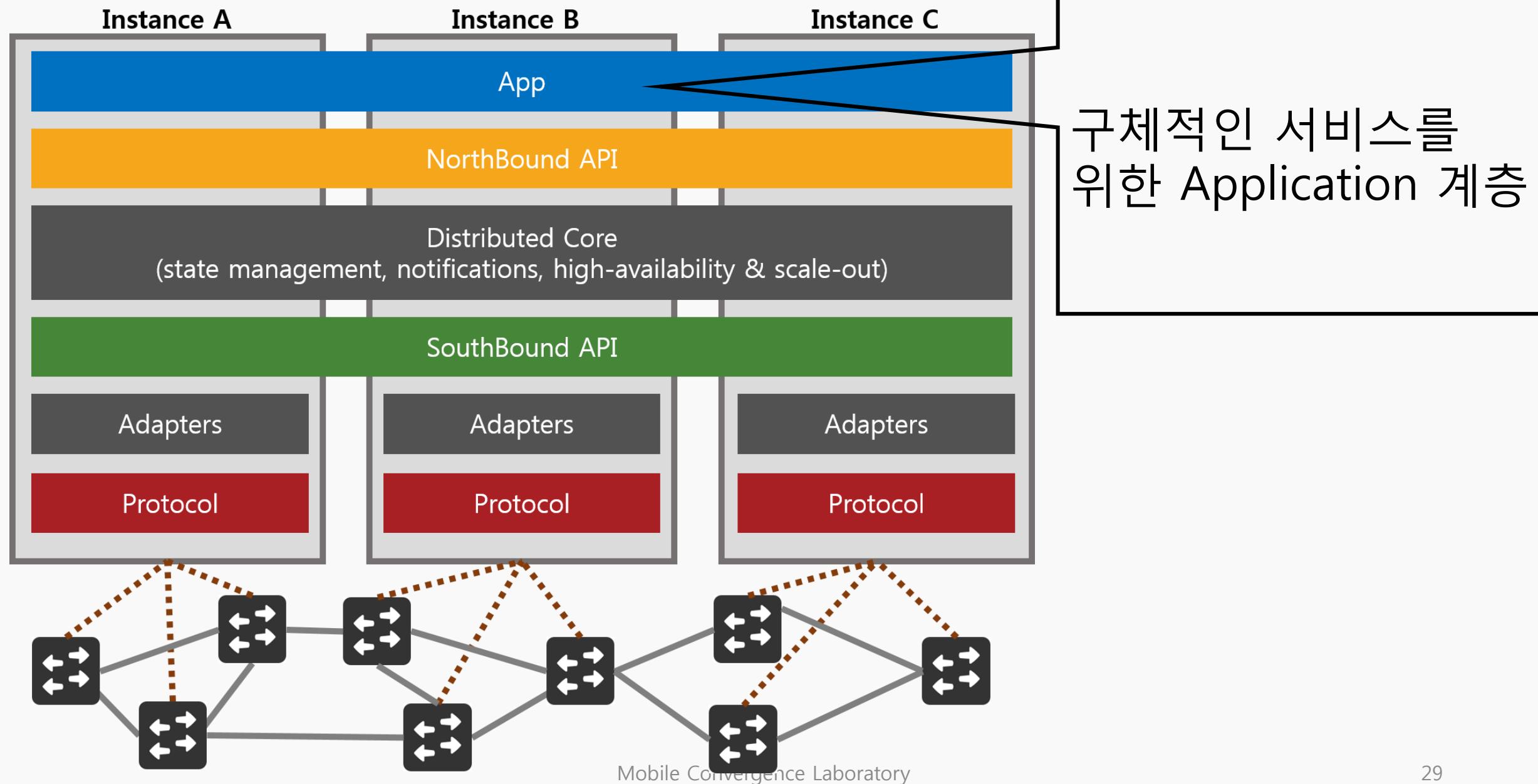


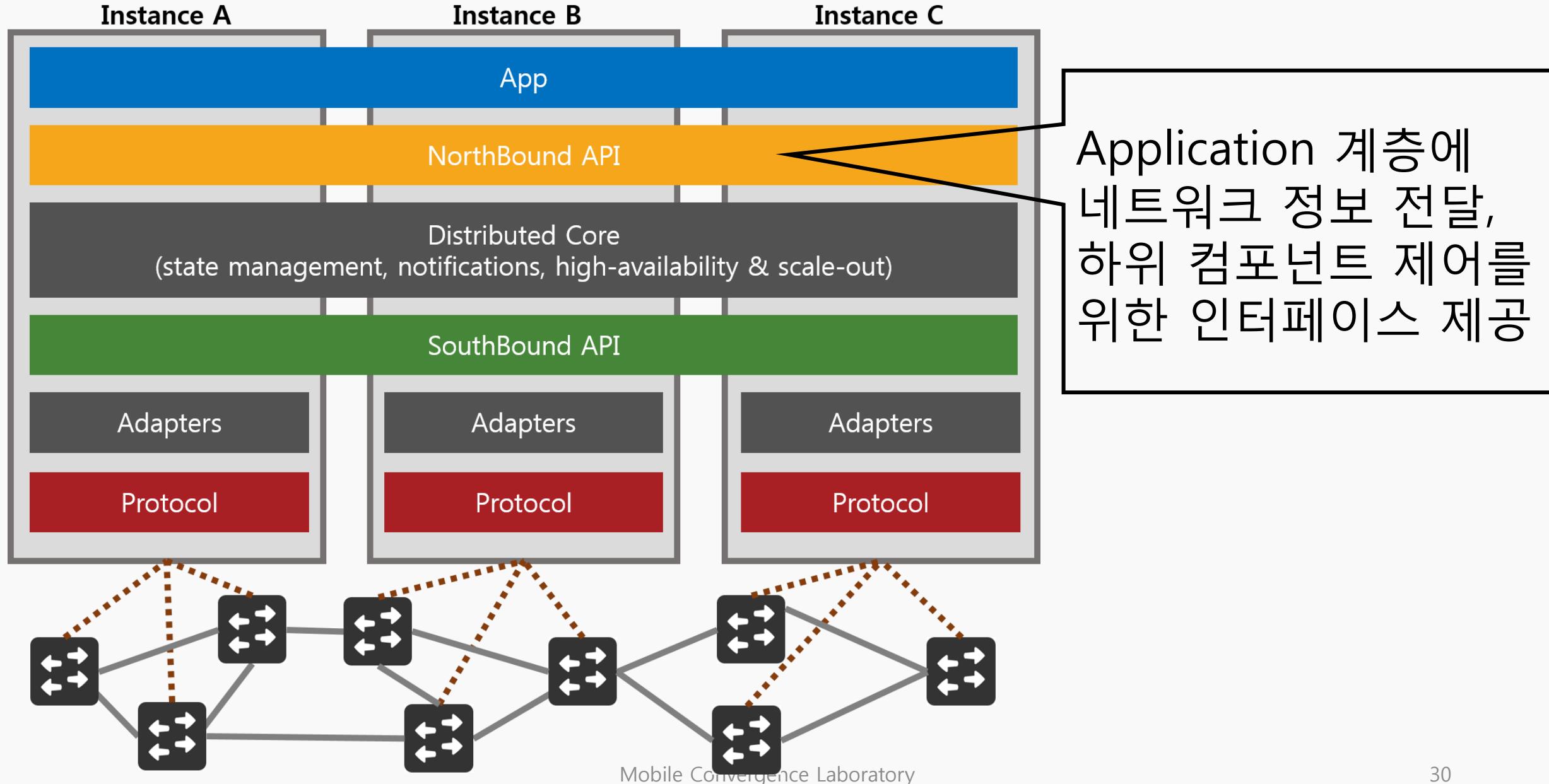


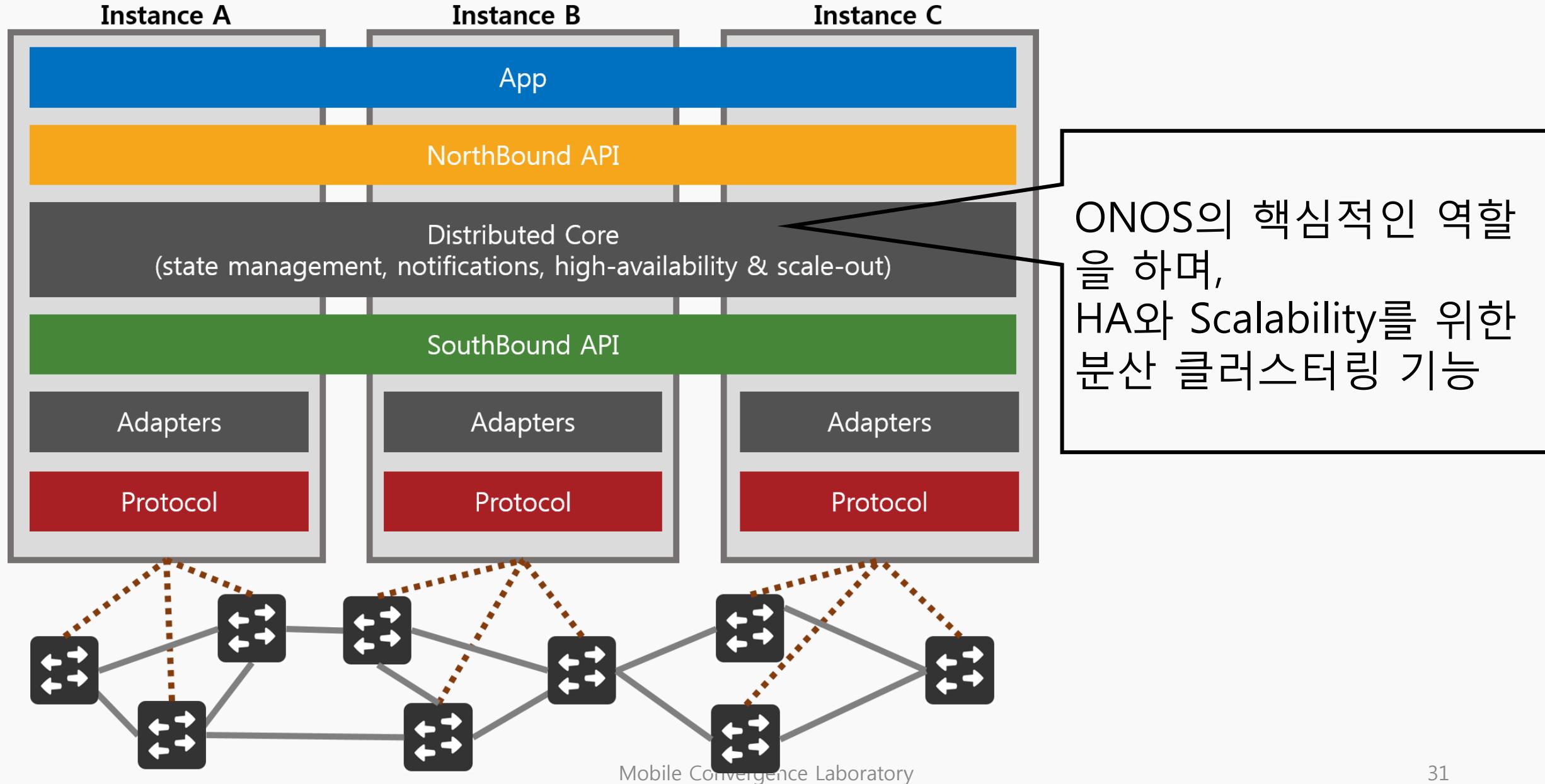


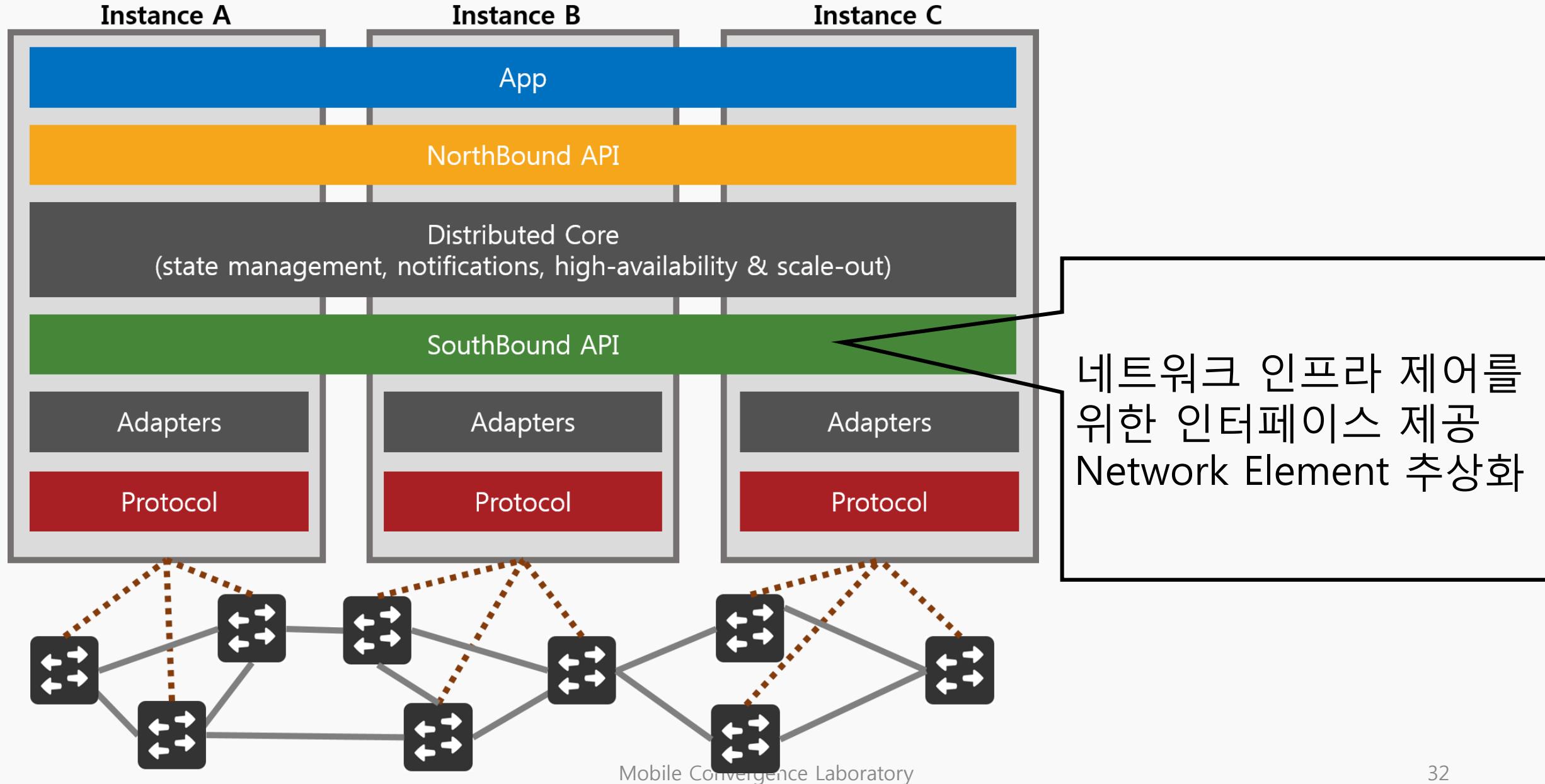
ONOS Architecture

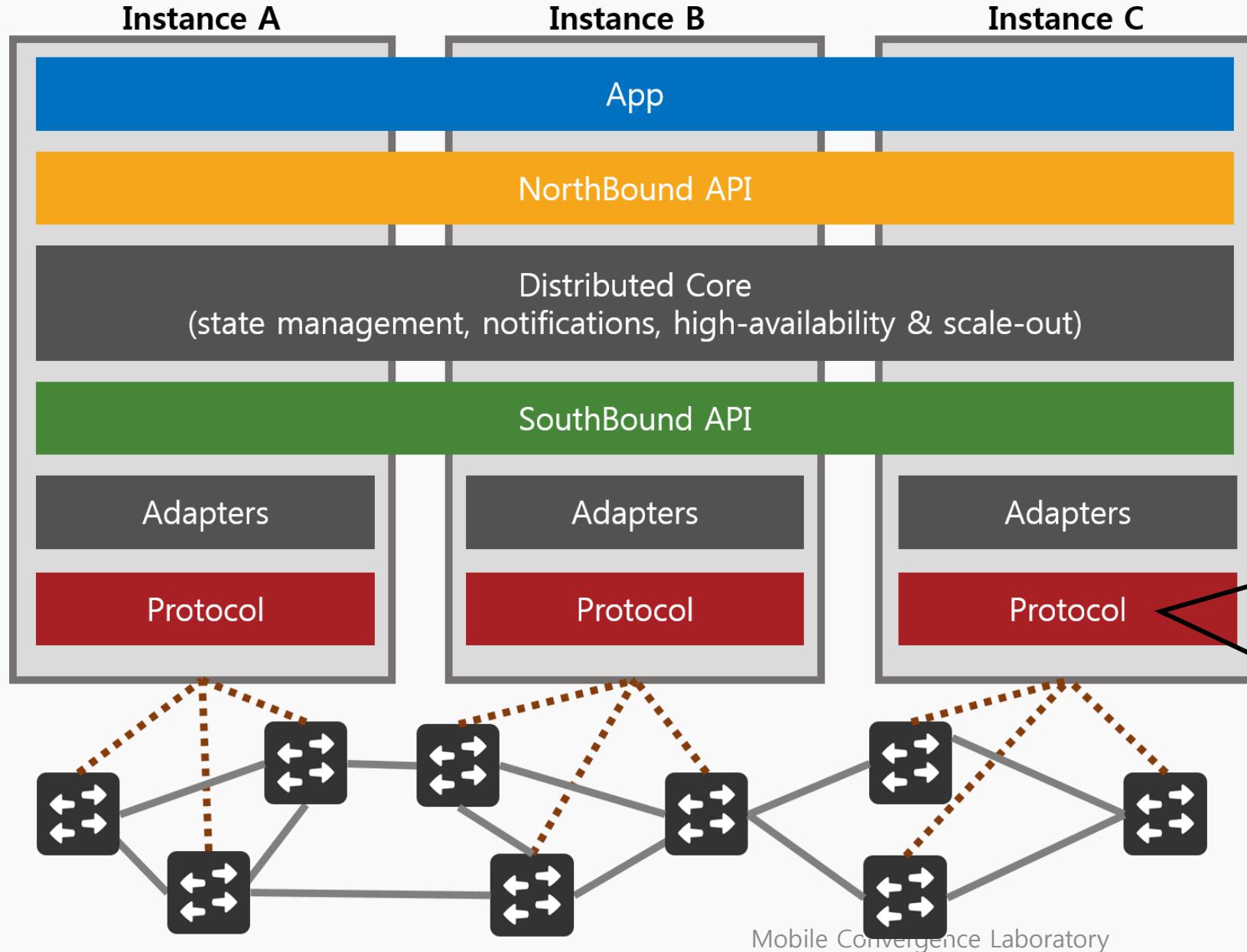










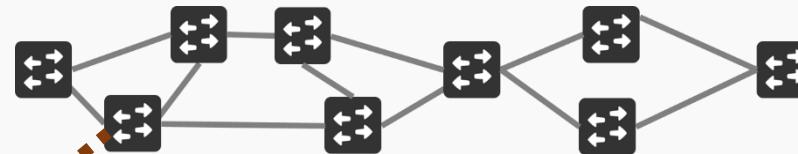


Network Element 설정
을 위한 프로토콜
OpenFlow : SDN
NetConf : Legacy

Scale-out by Distributed Core (1)

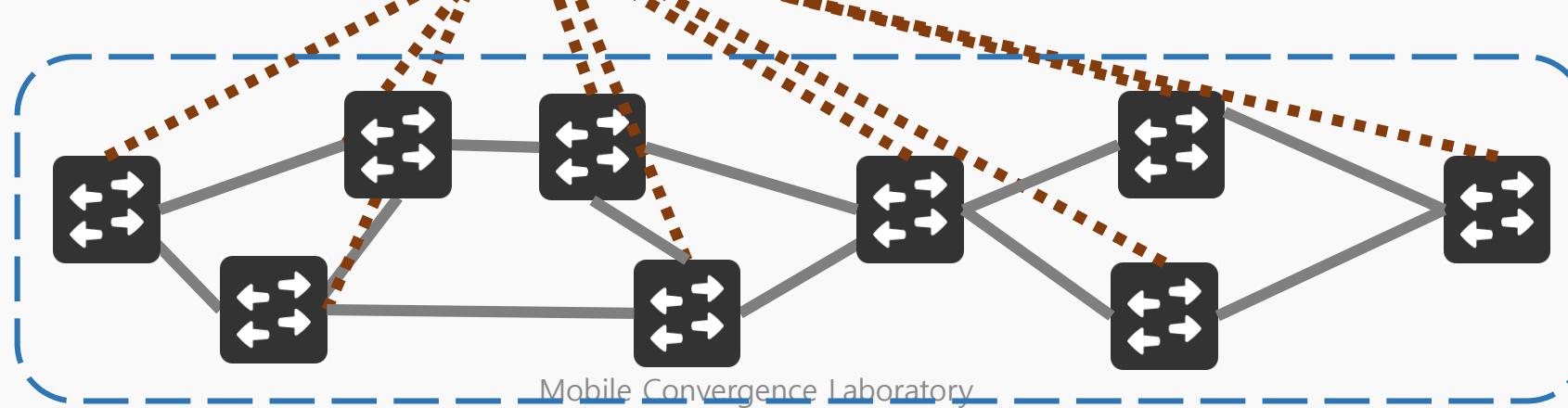
Network Graph

Global network view



Distributed Core

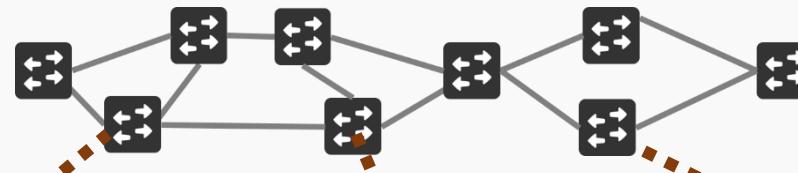
Instance 1



Scale-out by Distributed Core (2)

Network Graph

Global network view

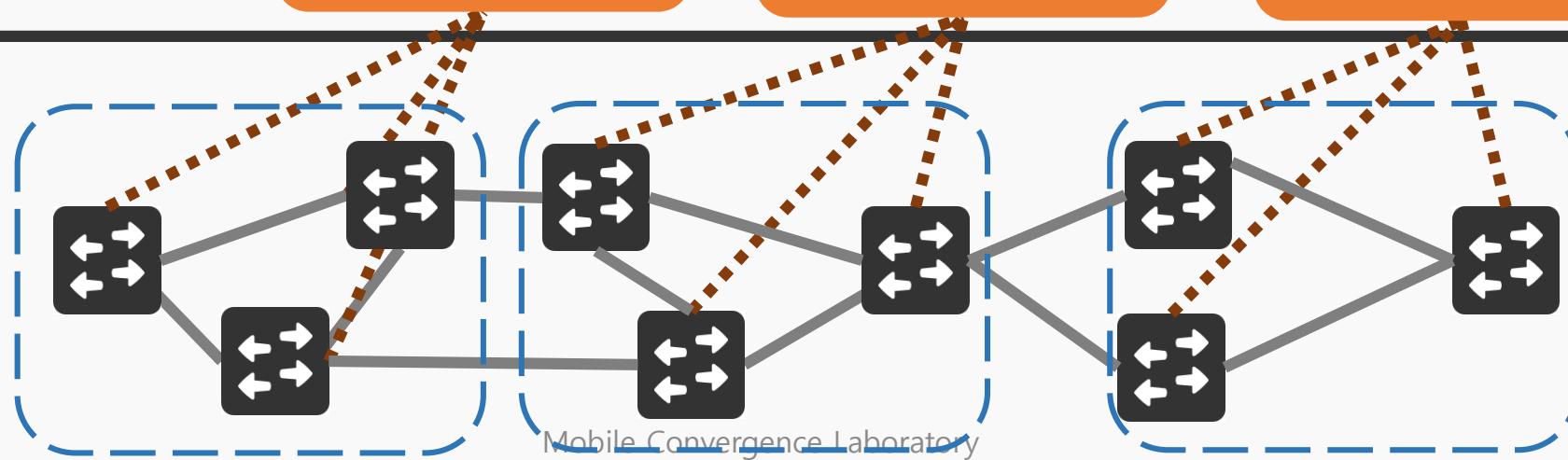


Distributed Core

Instance 1

Instance 2

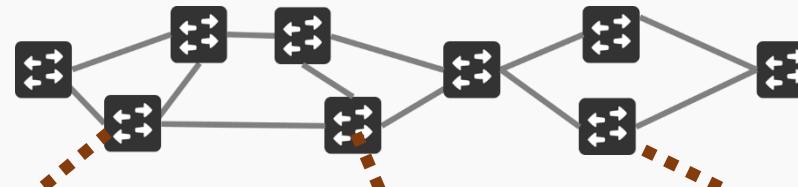
Instance 3



HA by Distributed Core (1)

Network Graph

Global network view

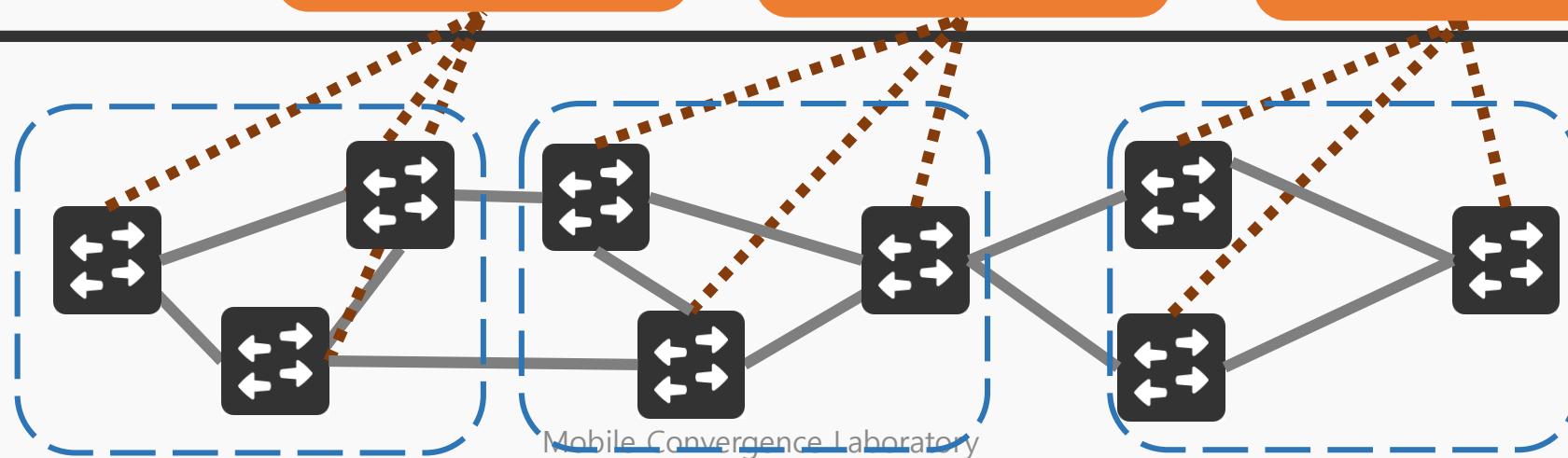


Distributed Core

Instance 1

Instance 2

Instance 3



HA by Distributed Core (2)

Network Graph

Global network view

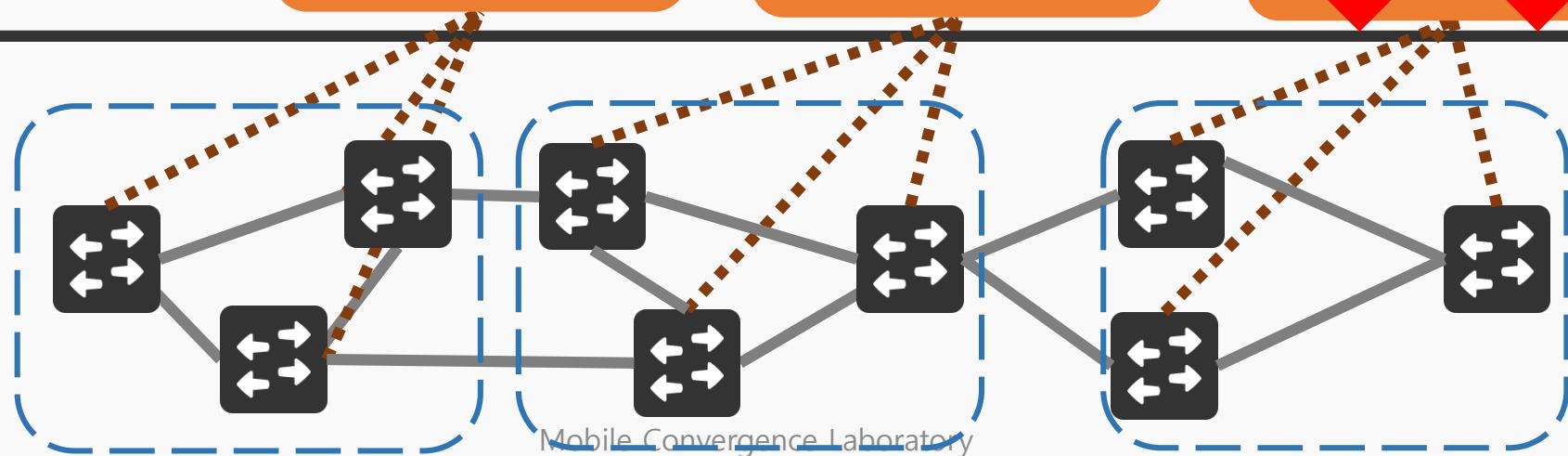


Distributed Core

Instance 1

Instance 2

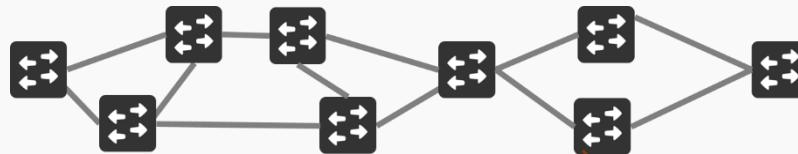
Instance 3



HA by Distributed Core (3)

Network Graph

Global network view

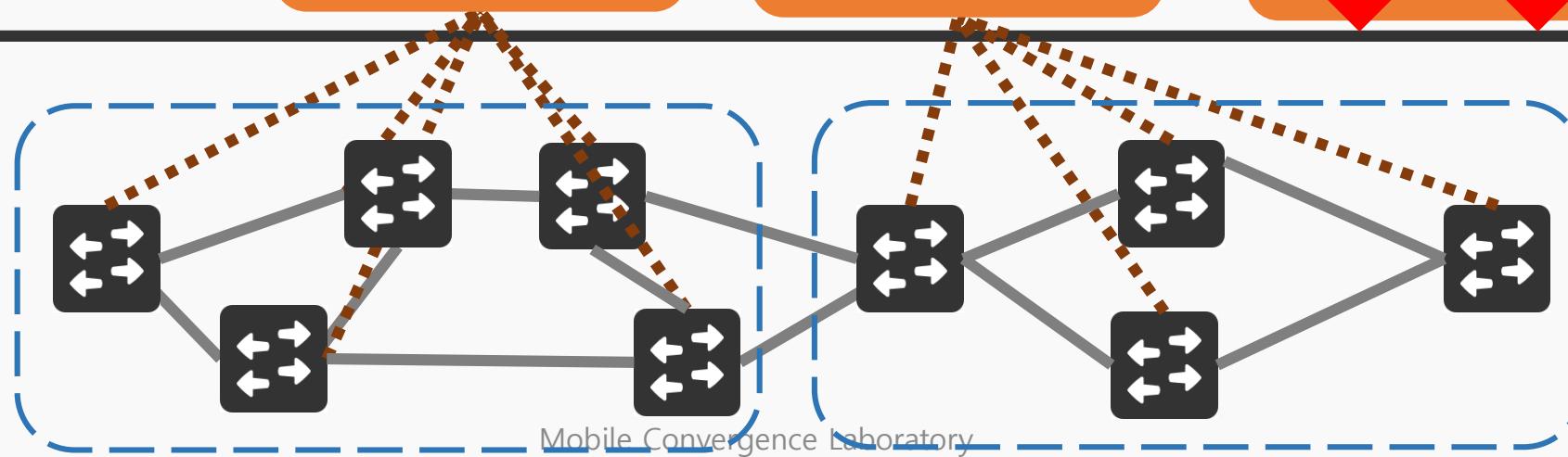


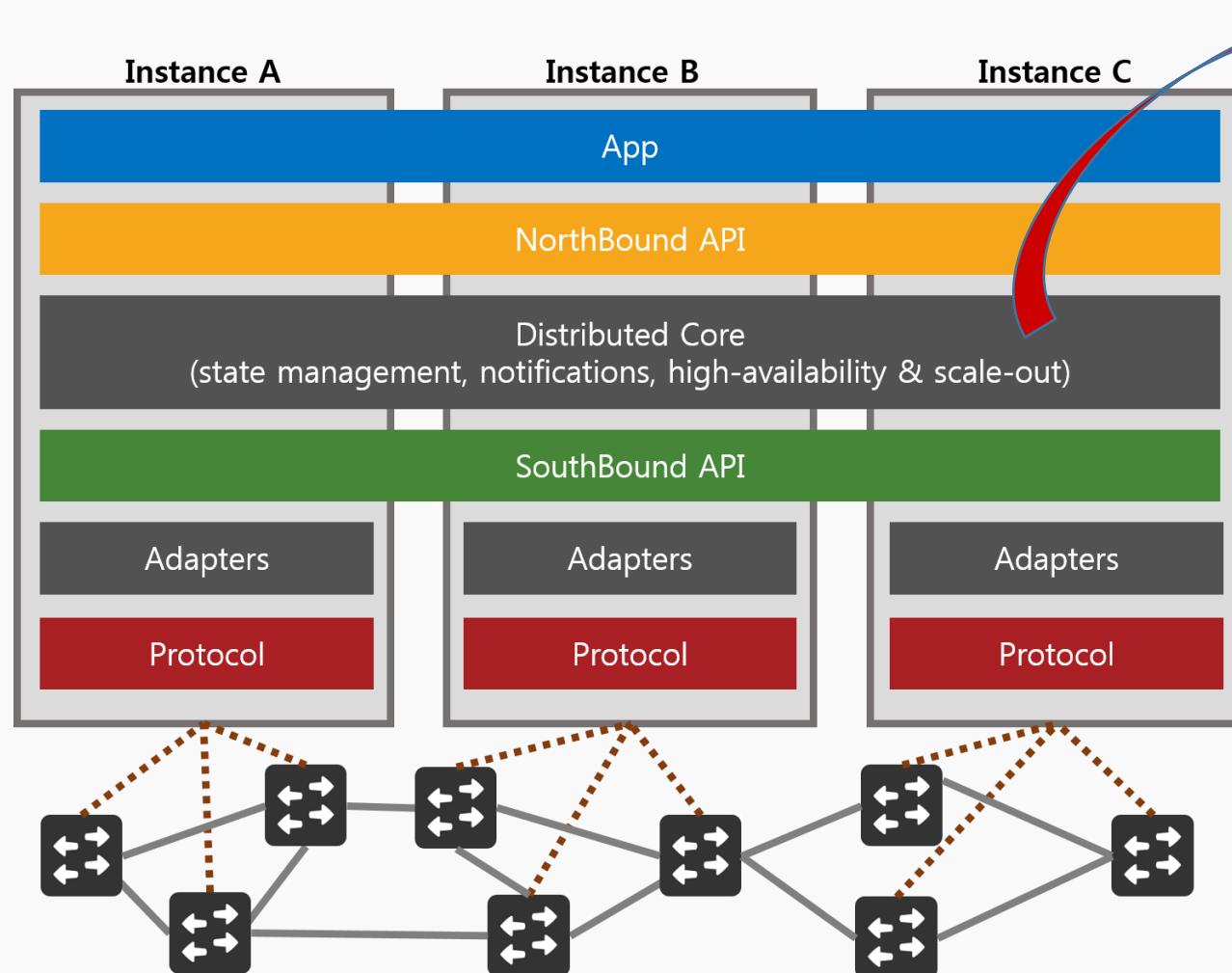
Distributed Core

Instance 1

Instance 2

Instance 3





ONOS - Install

1. Getting ONOS
2. Installing ONOS
3. Start ONOS

Prerequisites

- Ubuntu 14.04 LTS 64bits
- Java 8 JDK
- 2GB or more RAM
- Apache Maven(3.0 and later)
- 2 or more processors
- Apache Karaf(3.0.2 and later)
- 8GB or more storage
- Git

1. Install Java 8

```
$ sudo apt-get install software-properties-common -y
```

```
$ sudo add-apt-repository ppa:webupd8team/java -y
```

```
$ sudo apt-get update
```

```
$ sudo apt-get install oracle-java8-installer oracle-java8-set-default
```

1.1. Configure Java Path

- on Ubuntu

```
$ env | grep JAVA_HOME  
JAVA_HOME=/usr/lib/jvm/java-8-oracle
```

```
$ export JAVA_HOME=/usr/lib/jvm/java-8-oracle
```

2. Install Git

```
$ sudo apt-get install git-core
```

```
$ git --version
```

3. Set Maven

```
$ cd; mkdir Downloads Applications
```

```
$ cd Downloads
```

```
$ wget http://archive.apache.org/dist/maven/maven-3/3.3.1/binaries/apache-maven-3.3.1-bin.tar.gz
```

```
$ tar -zxvf apache-maven-3.3.1-bin.tar.gz -C ../Applications/
```

4. Set Karaf

```
$ cd Downloads
```

```
$ wget http://download.nextag.com/apache/karaf/3.0.3/apache-karaf-3.0.3.tar.gz
```

```
$ tar -zxvf apache-karaf-3.0.3.tar.gz -C ./Applications/
```

5. Clone ONOS

```
$ git clone https://gerrit.onosproject.org/onos/
```

```
$ cd onos
```

```
if> getting specific ONOS version
```

```
$ git checkout <ver>
```

5.1. Configure ONOS Path

```
$ export ONOS_ROOT=~/onos
```

```
$ source $ONOS_ROOT/tools/dev/bash_profile
```

6. Build ONOS

```
$ cd ~/onos
```

```
$ mvn clean install
```

```
[INFO] onos-riap-provider ..... SUCCESS [2.720s]
[INFO] onos-host-provider ..... SUCCESS [2.487s]
[INFO] onos-of-drivers .. .... SUCCESS [0.963s]
[INFO] onos-of-ctl ..... SUCCESS [2.388s]
[INFO] onos-apps ..... SUCCESS [0.532s]
[INFO] onos-app-tvne ..... SUCCESS [0.684s]
[INFO] onos-app-fwd ..... SUCCESS [0.617s]
[INFO] onos-app-ifwd ..... SUCCESS [0.649s]
[INFO] onos-app-mobility ..... SUCCESS [0.522s]
[INFO] onos-app-proxyarp ..... SUCCESS [0.548s]
[INFO] onos-app-config ..... SUCCESS [0.610s]
[INFO] onos-app-sdnip ..... SUCCESS [8.968s]
[INFO] onos-app-calendar ..... SUCCESS [0.604s]
[INFO] onos-app-optical ..... SUCCESS [3.270s]
[INFO] onos-app-metrics ..... SUCCESS [0.472s]
[INFO] onos-app-metrics-intent ..... SUCCESS [0.967s]
[INFO] onos-app-metrics-topology ..... SUCCESS [0.873s]
[INFO] onos-app-oecfg ..... SUCCESS [1.097s]
[INFO] onos-app-demo ..... SUCCESS [0.729s]
[INFO] onos-app-election ..... SUCCESS [0.720s]
[INFO] onos-features ..... SUCCESS [18.035s]
[INFO] onos-branding ..... SUCCESS [0.461s]
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] Total time: 7:32.956s
[INFO] Finished at: Fri Jan 30 15:10:46 KST 2015
[INFO] Final Memory: 101M/350M
[INFO]
[INFO] sdn@sdn:~/onos$
```

빌드 성공

7. Start ONOS CLI

```
$ karaf clean
```

```
Welcome to Open Network Operating System (ONOS)!

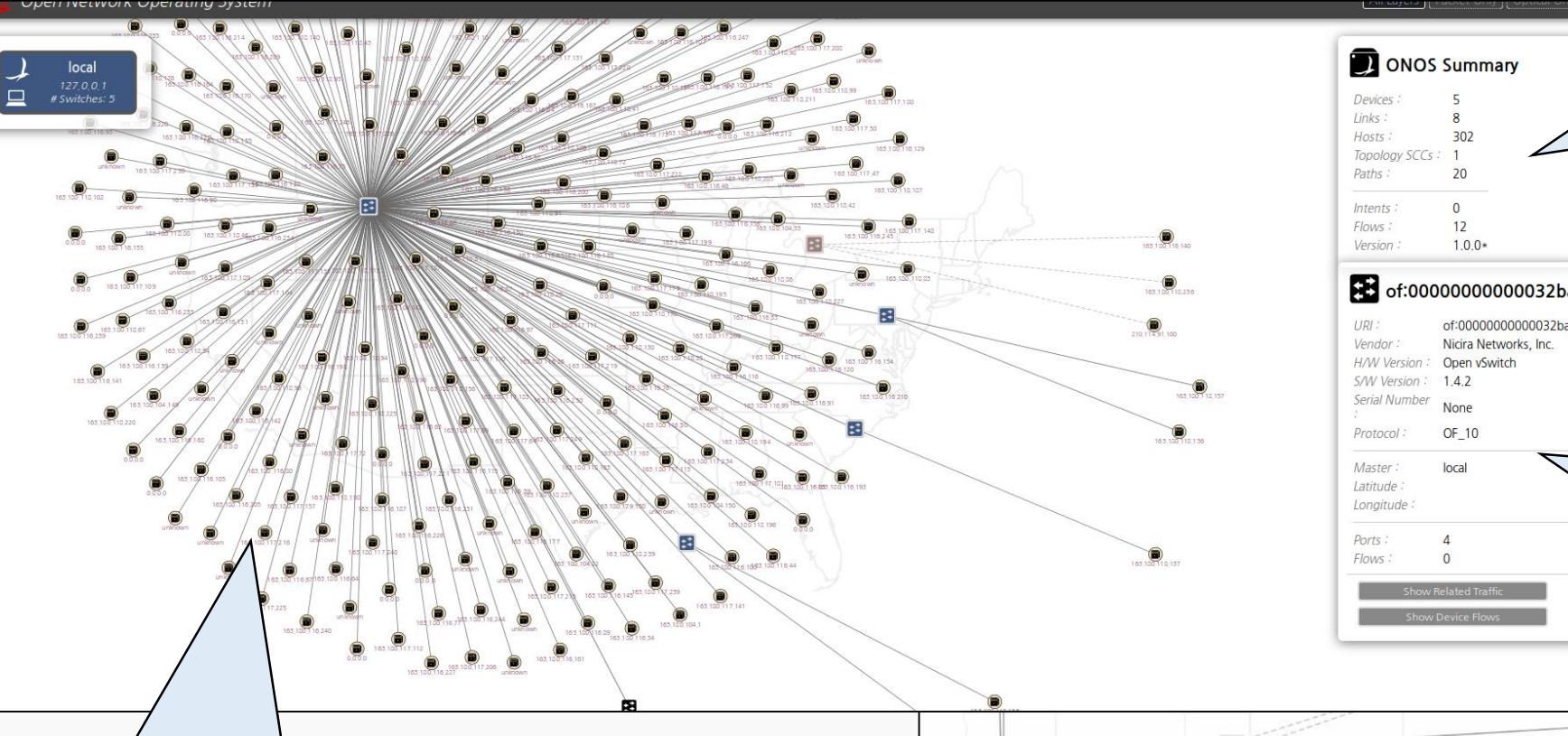
[ONOS] [ONOS] [ONOS] [ONOS]

Hit '<tab>' for a list of available commands
and '[cmd] --help' for help on a specific command.
Hit '<ctrl-d>' or type 'system:shutdown' or 'logout' to shutdown ONOS.

onos> █
```

8. Start ONOS GUI

- start ONOS (ONOS CLI)
- In web browser
- <http://localhost:8181/onos/ui/index.html>



<Network Graph>
토폴로지 GUI와 Host 정보

<ONOS Summary>
Network Element의 수
링크의 수
호스트의 수
Flow의 수...

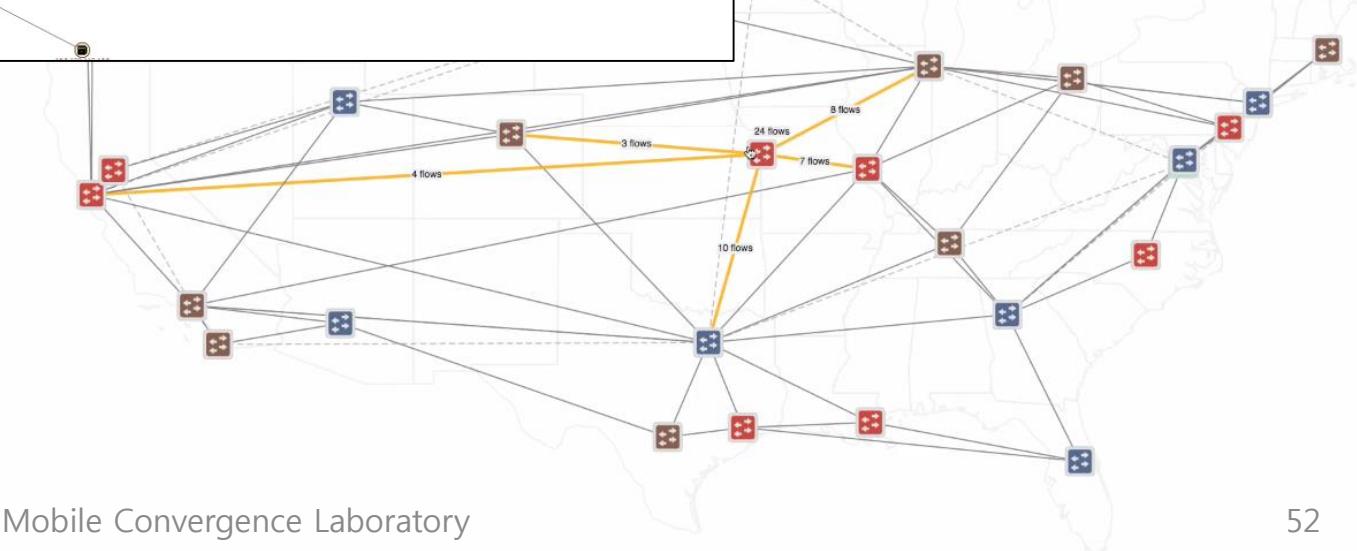
ONOS Summary	
Devices :	5
Links :	8
Hosts :	302
Topology SCCs :	1
Paths :	20
Intents :	0
Flows :	12
Version :	1.0.0*

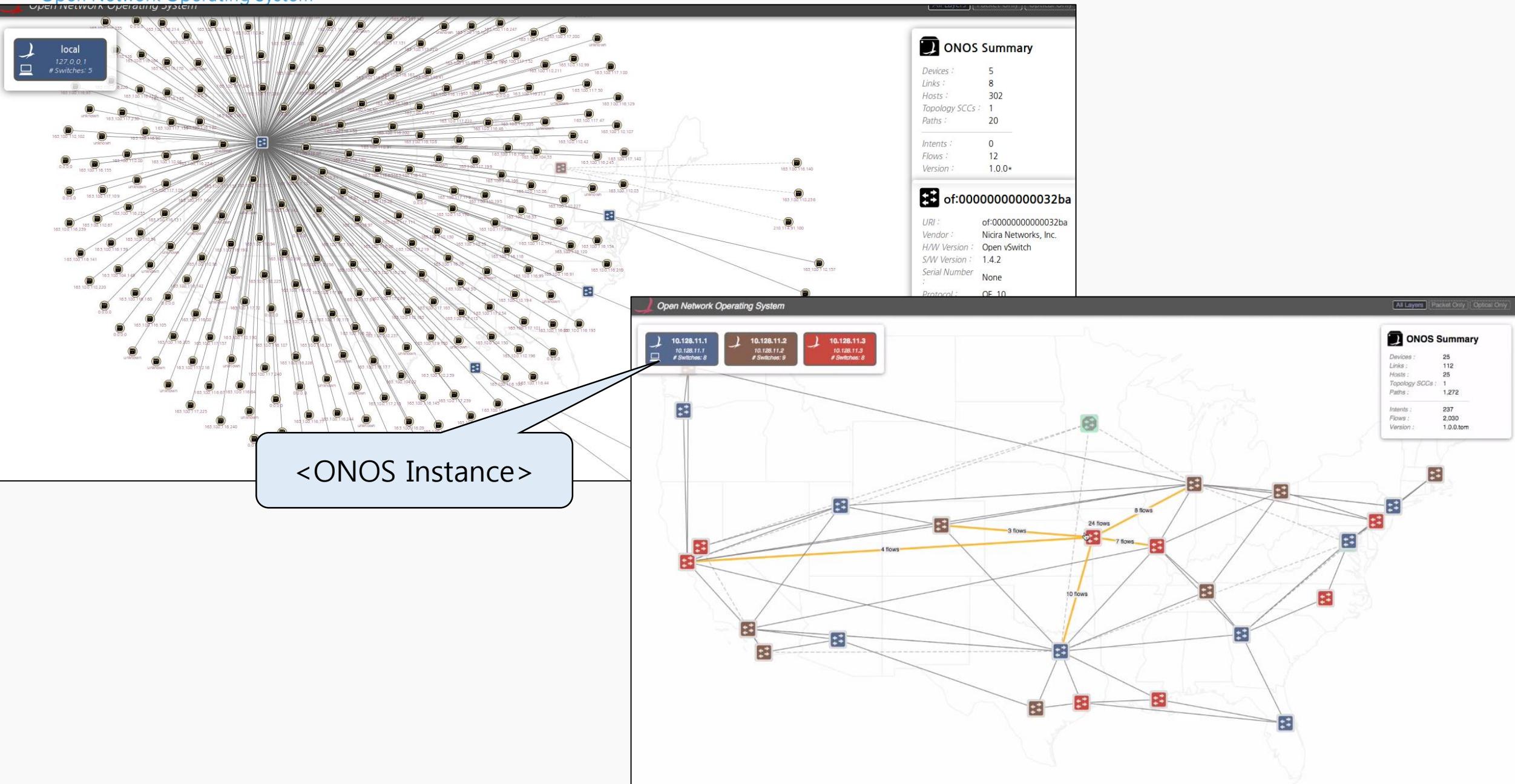
of:000000000000032ba

URI :	of:000000000000032ba
Vendor :	Nicira Networks, Inc.
H/W Version :	Open vSwitch
S/W Version :	1.4.2
Serial Number :	None
Protocol :	OF_10
Master :	local
Latitude :	
Longitude :	
Ports :	4
Flows :	0

Show Related Traffic
Show Device Flows

<Node Info>
해당 노드(스위치)의 정보
Protocol / Ports / Flow
버전 및 지리적 정보



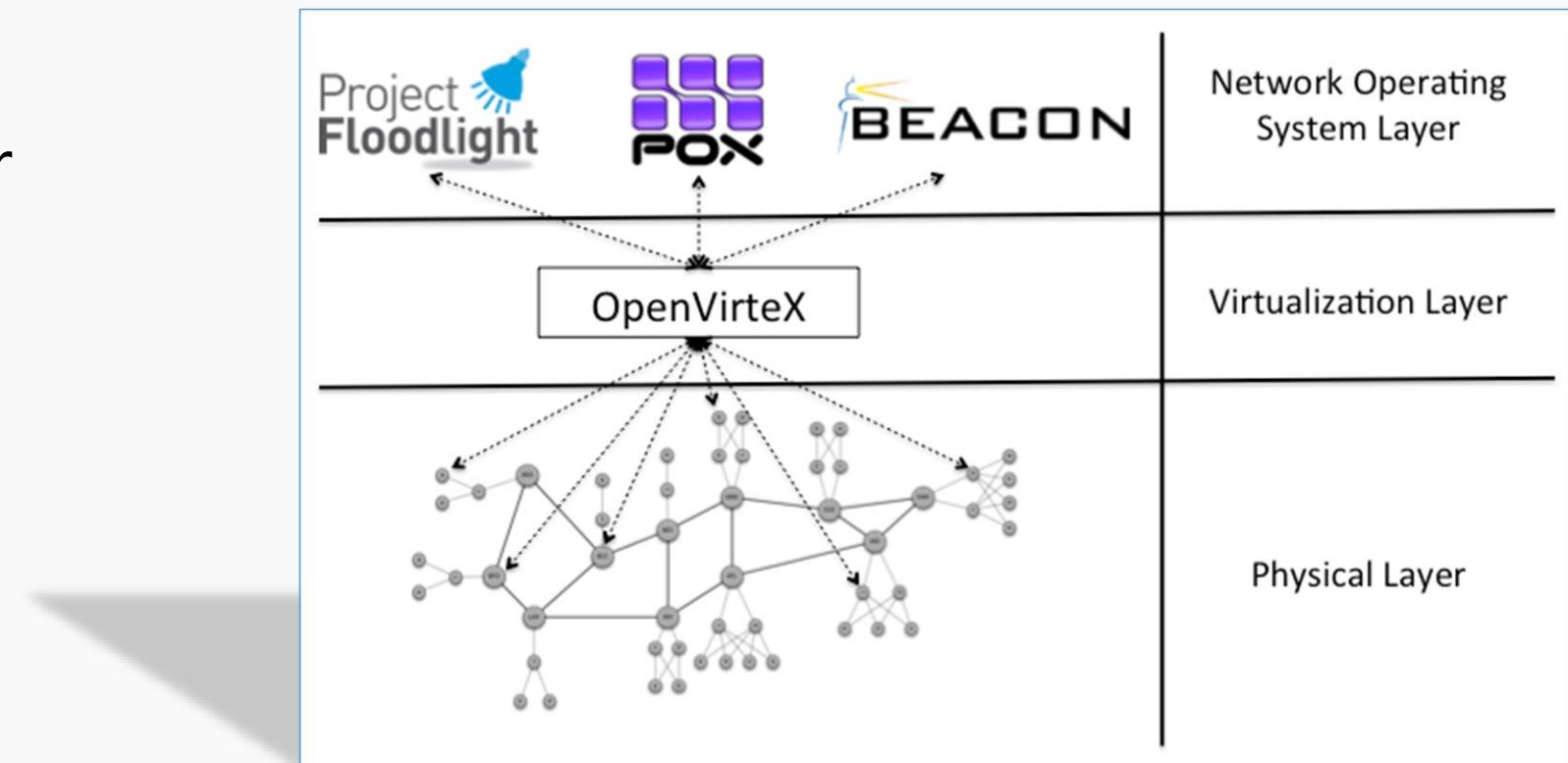


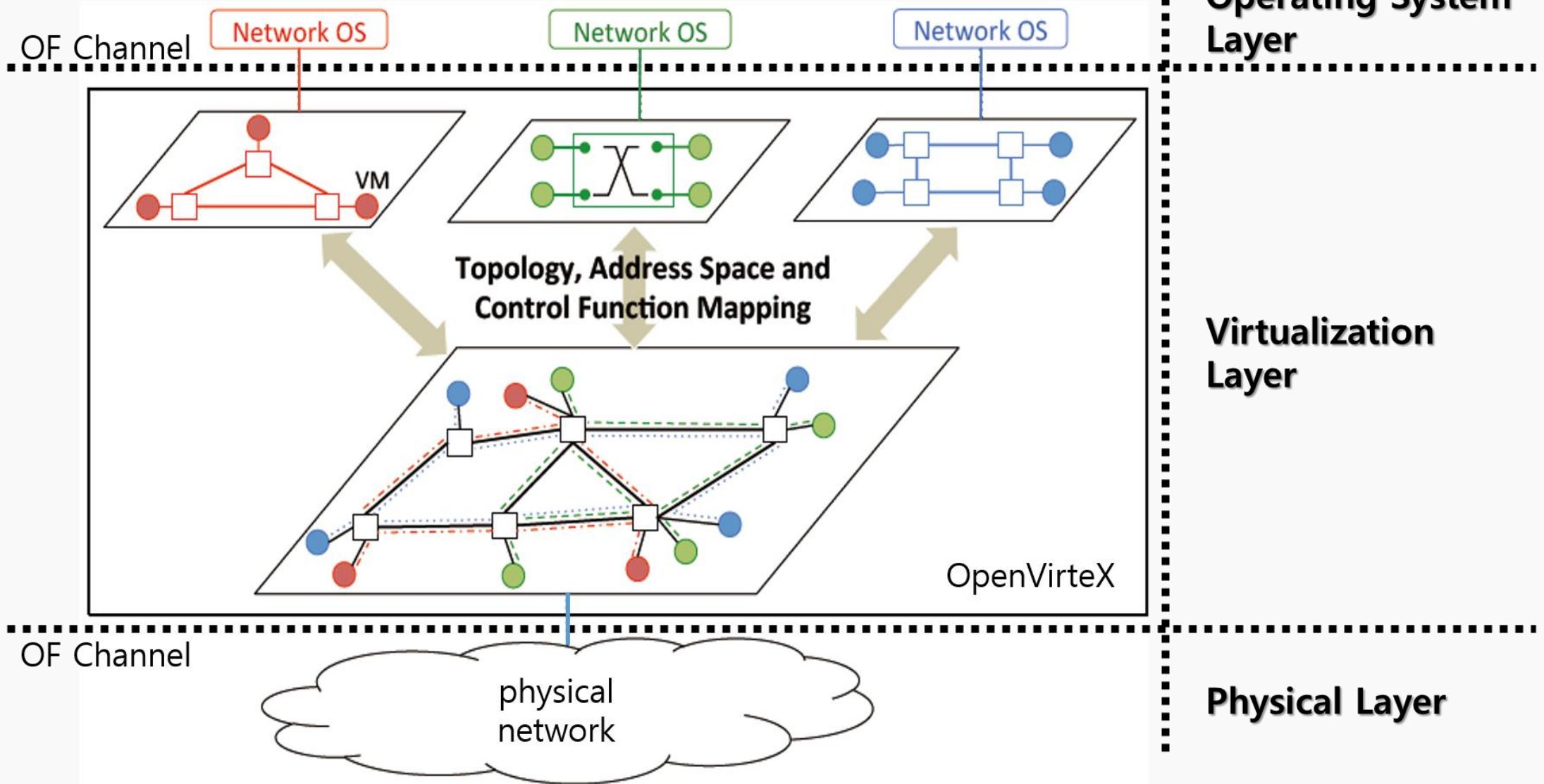
OpenVirtex

Network Virtualization Platform & Network Hypervisor

OpenVirteX (OVX)

- Network Virtualization Platform
- Network Hypervisor





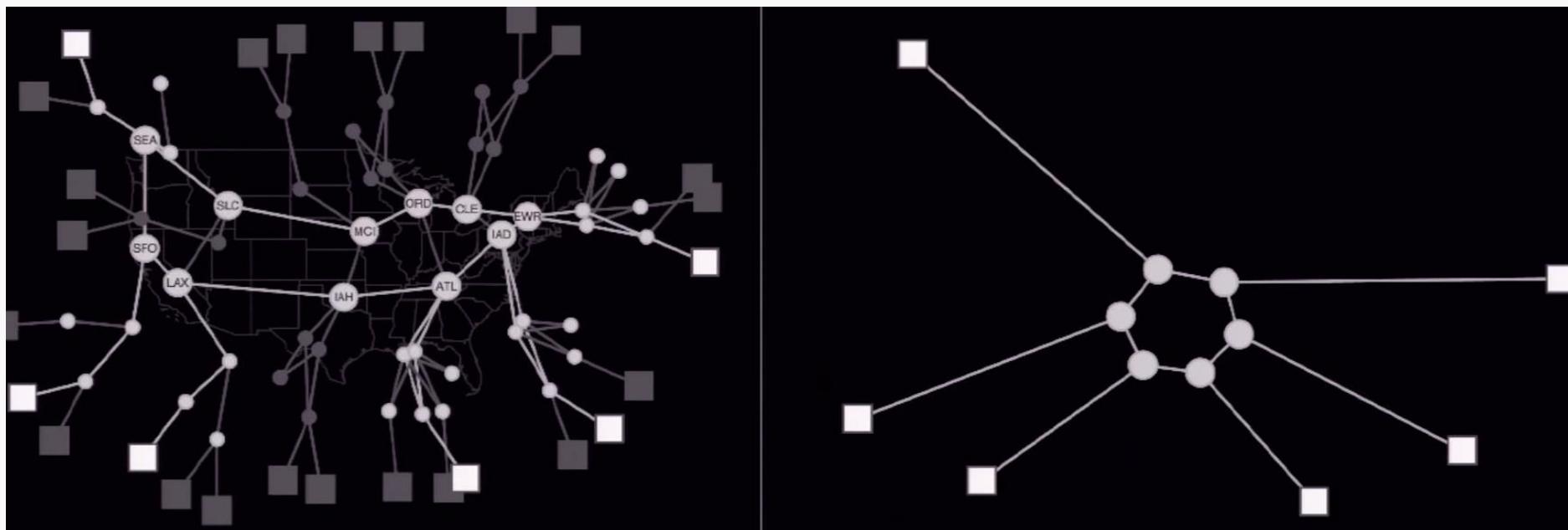
주요 기능

- Topology Virtualization
- Address Space Virtualization
- Control Function Virtualization

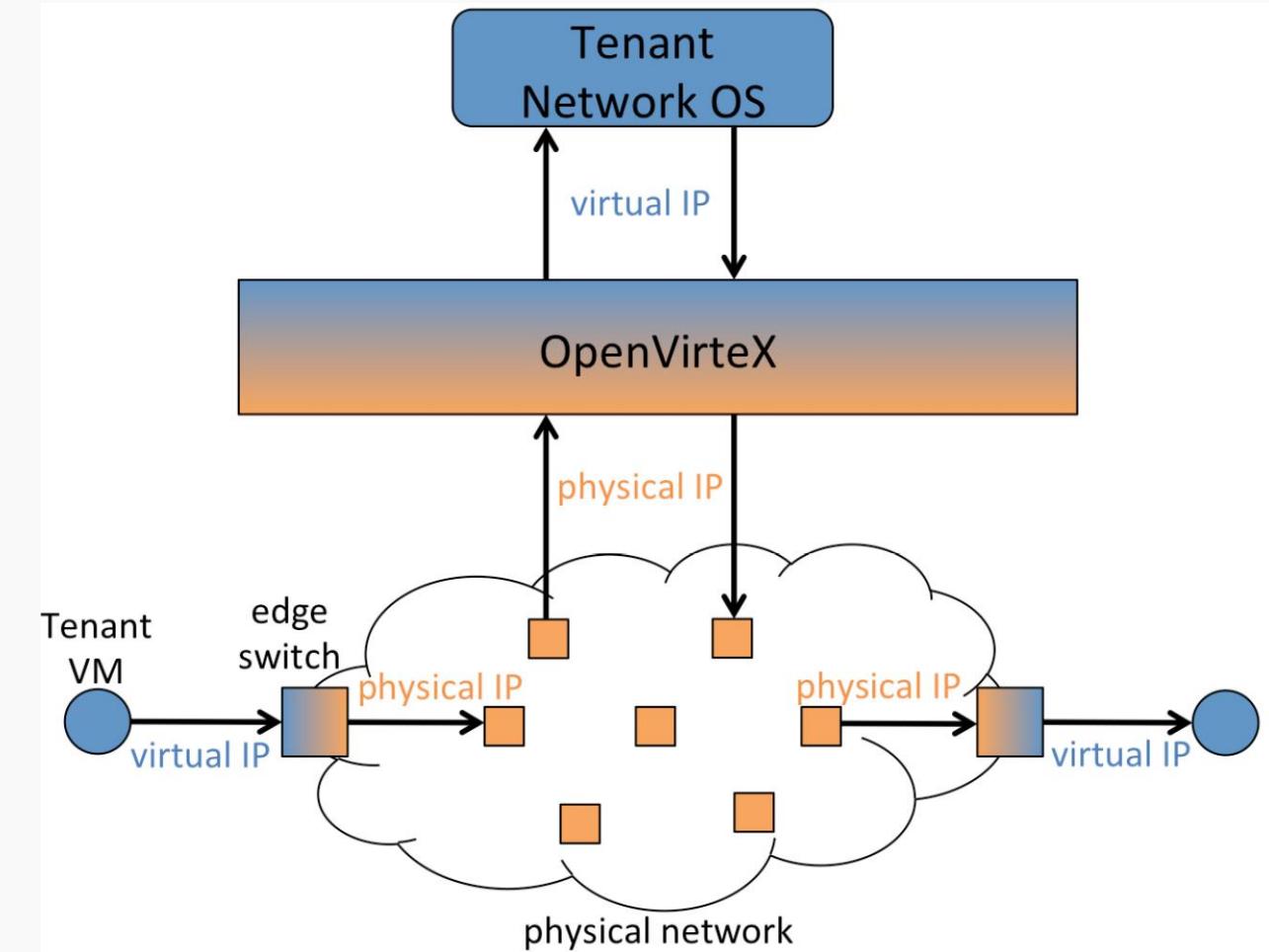
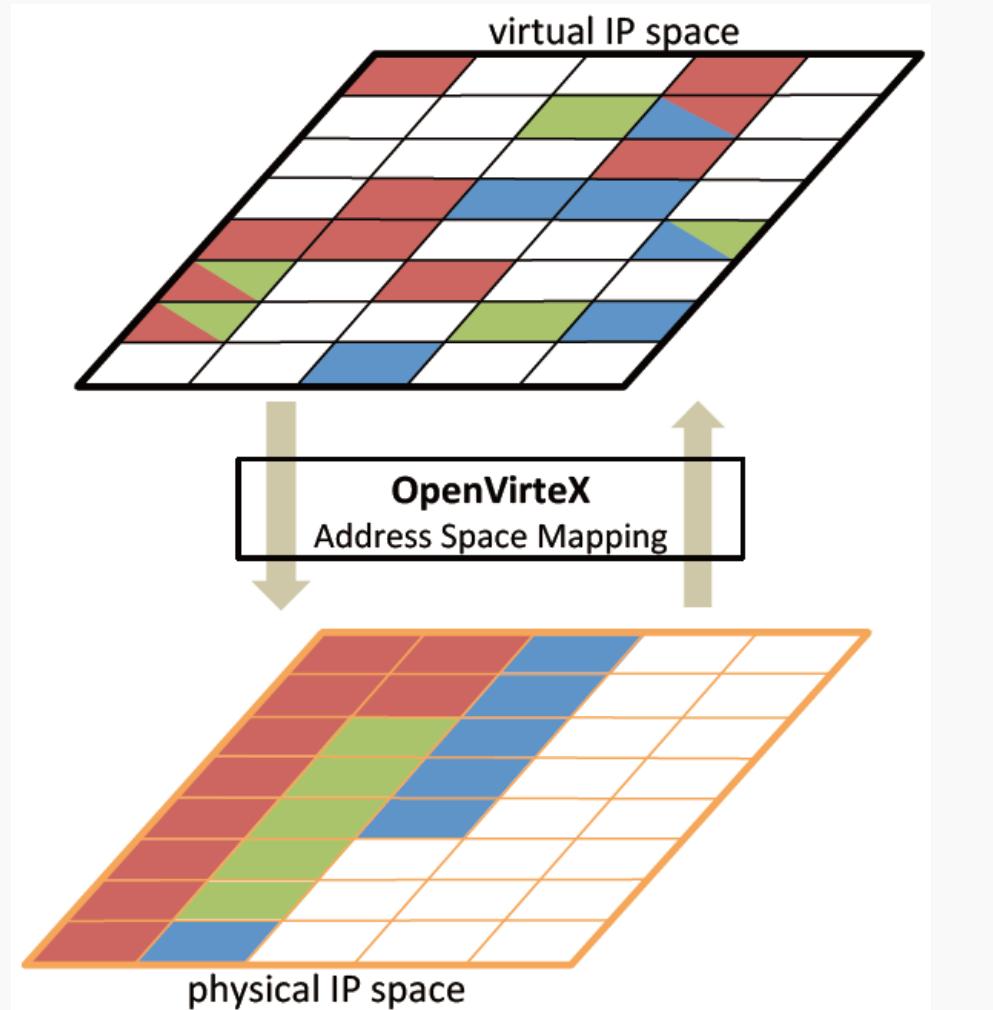


주요 기능 - Topology Virtualization

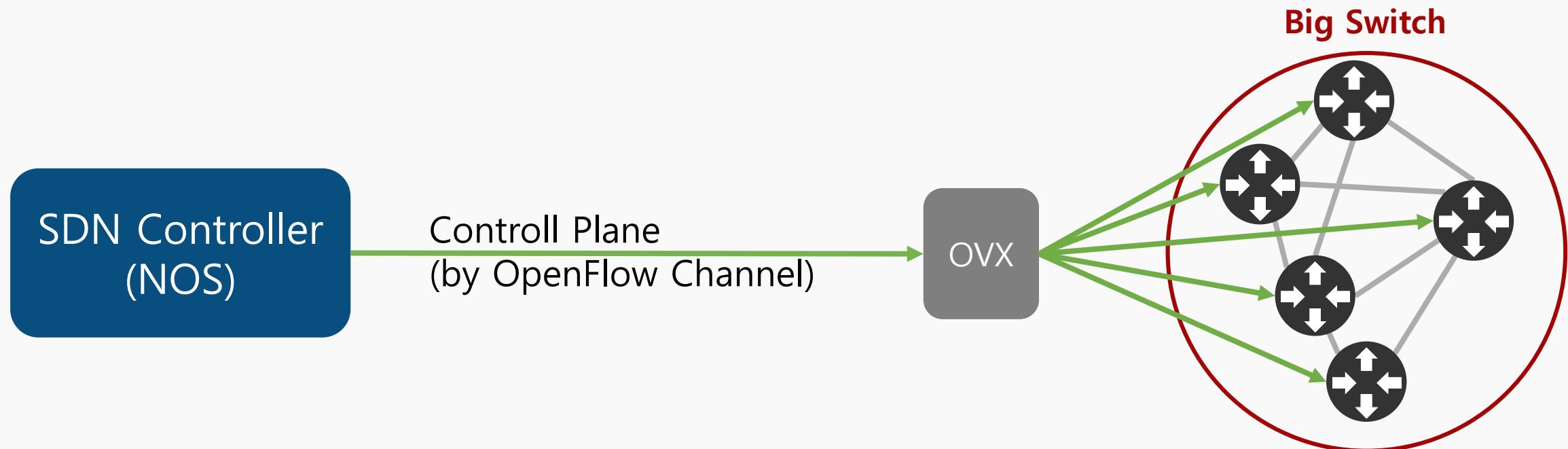
- 가상화를 통해 물리적 네트워크를 분리
- 물리 계층을 추상화
- 다수의 스위치를 묶어서 하나의 스위치로 가상화(**Big Switch**)



주요 기능 - Address Space Virtualization



주요 기능 - Control Function Virtualization



OpenVirtex - Install

Prerequisites

Recommended

- 4 Cores
- 4GB Java heap size

Minimum

- 2 Cores
- 1GB Java heap size

- Git
- Oracle Java7 (Not OpenJDK, Not Java8)
- Maven
- Python 2.7.x

1. Install Git & Maven

```
$ apt-get install git-core
```

```
$ apt-get install maven
```

2. Install Java7

```
$ sudo apt-get install software-properties-common -y
```

```
$ sudo add-apt-repository ppa:webupd8team/java -y
```

```
$ sudo apt-get update
```

```
$ sudo apt-get install oracle-java7-installer
```

3. Clone OpenVirteX

```
$ git clone https://github.com/OPENNWORKINGLAB/OpenVirteX.git -b 0.0-MAINT
```

```
$ cd ~/OpenVirteX/scripts.
```

4. Start OVX

```
$ sh ovx.sh
```

ex> 가상 네트워크 생성 및 Big Switch 생성

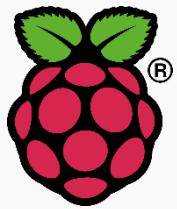
```
$ python ovxctl.py -n createNetwork tcp:localhost:30000 10.0.0.0 16
```

```
$ python ovxctl.py -n createSwitch DPID_1,DPID_2,DPID_3,DPID_4
```

<Tutorial & API Doc>

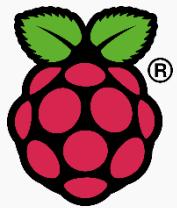
<http://ovx.onlab.us/getting-started/tutorial/>

<http://ovx.onlab.us/documentation/api/>



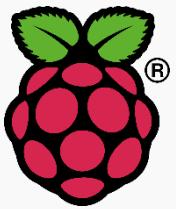
Pi Stack Switch

Raspberry Pi를 이용한 SDN 테스트베드 개발



Raspberry Pi

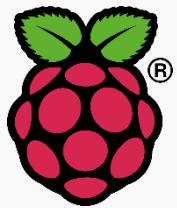
- 영국의 라즈베리파이 재단이 만든 교육용 싱글 보드 컴퓨터
- Single Board Computer
- 대략 US\$ 35
- Pi A/B, Pi B+, Pi2 출시



Raspberry Pi2의 스펙



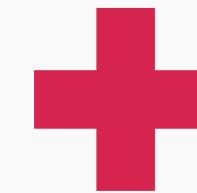
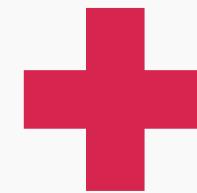
- Single Board Computer(Micro Computer)
- CPU : **900MHz ARM Cortex-A7 쿼드코어**
- RAM : **1GB**
- USB 2.0 * 4 + HDMI * 1 + Micro USB전원
- 10/100 Mbit/s Ethernet



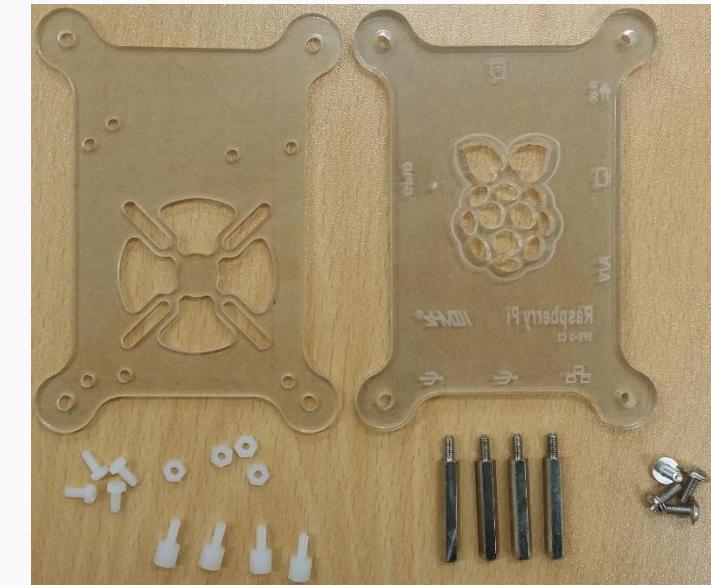
Pi Stack Switch HW구성



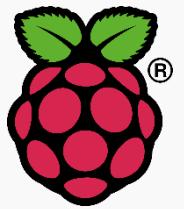
Pi2 * 4대



USB to Ether 어댑터
*
12개



Raspberry Pi
Stack Case * 4개

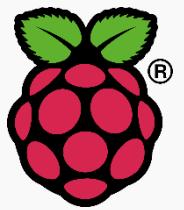


Pi Stack Switch HW구성

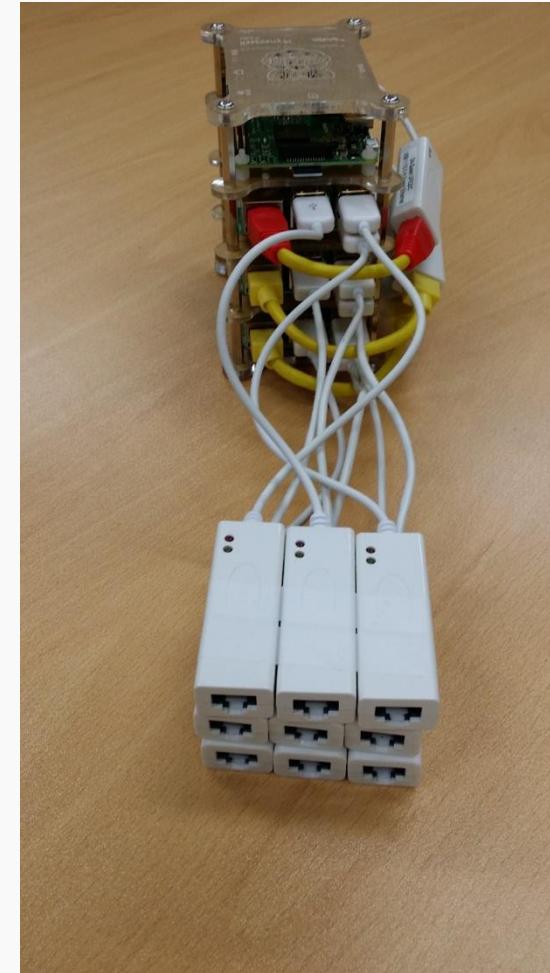
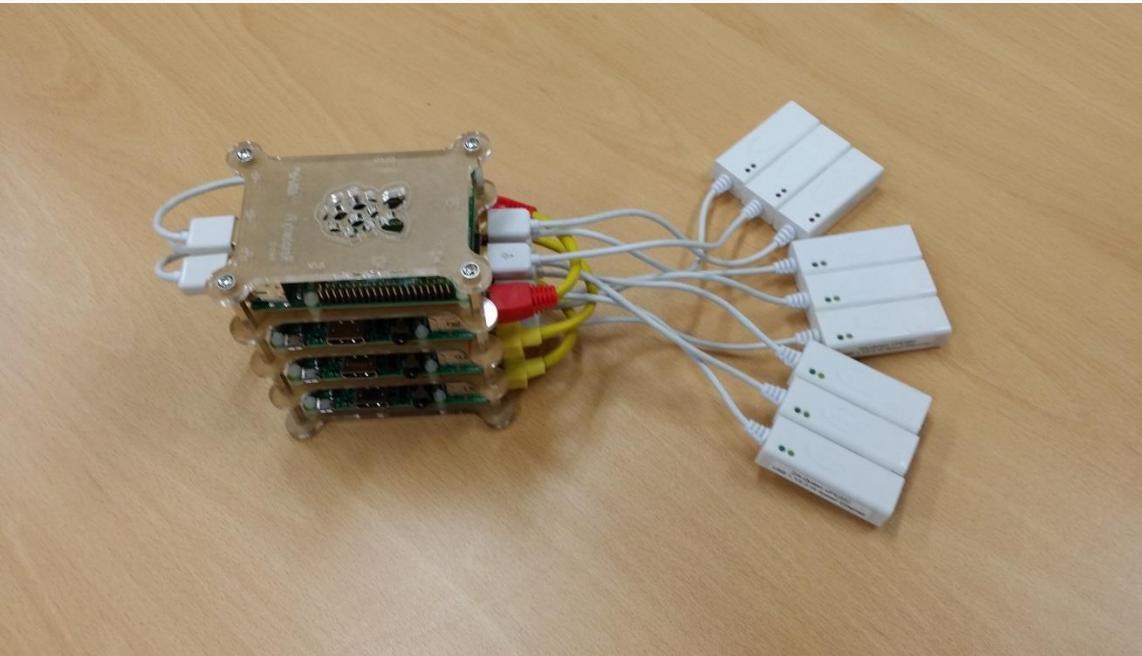


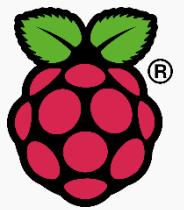
메인 스위치 x 1개 x 1포트
+
서브 스위치 x 3개 x 3포트
= **10포트 스위치**

전개도

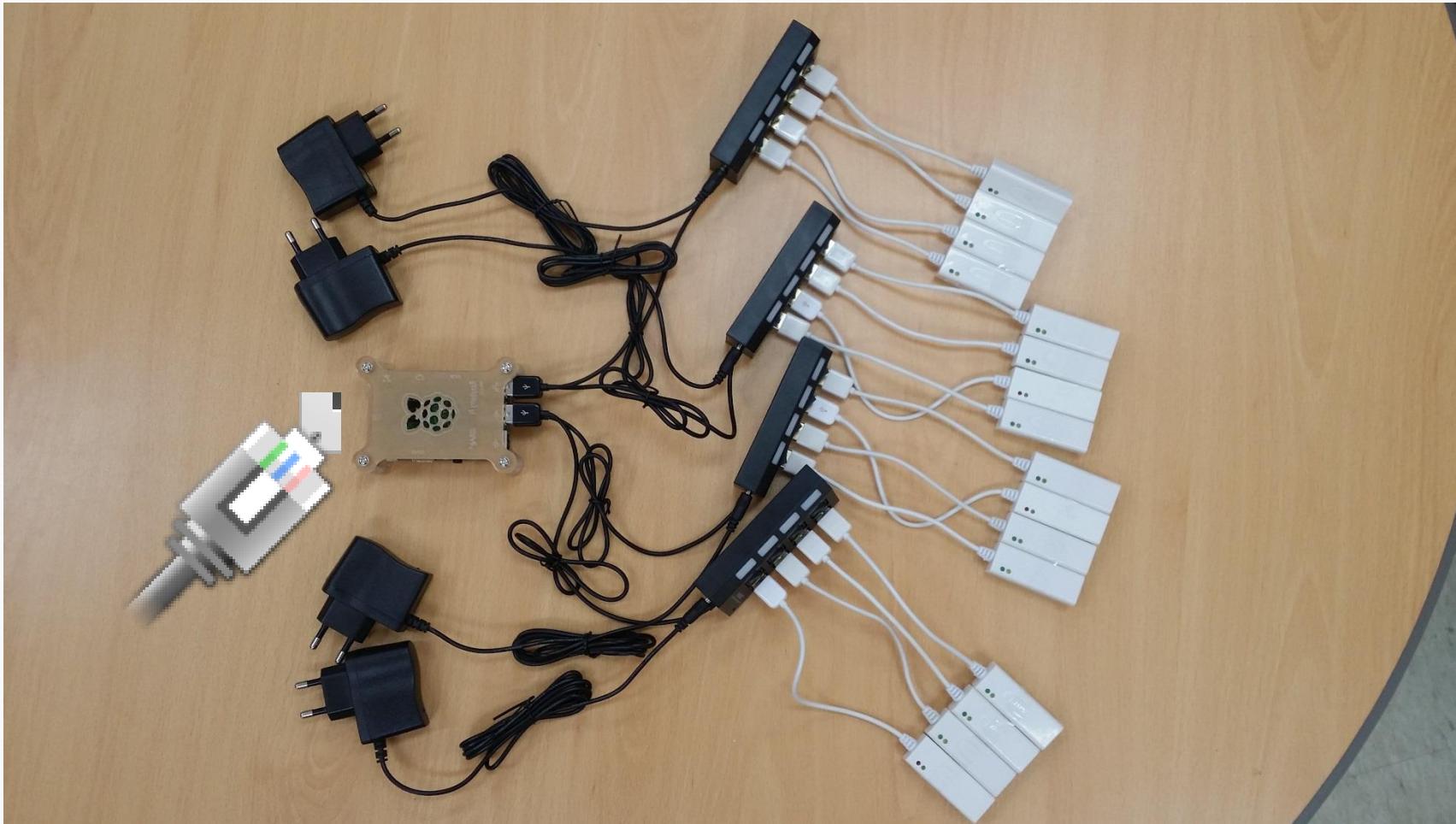


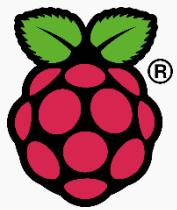
Pi Stack Switch 완성



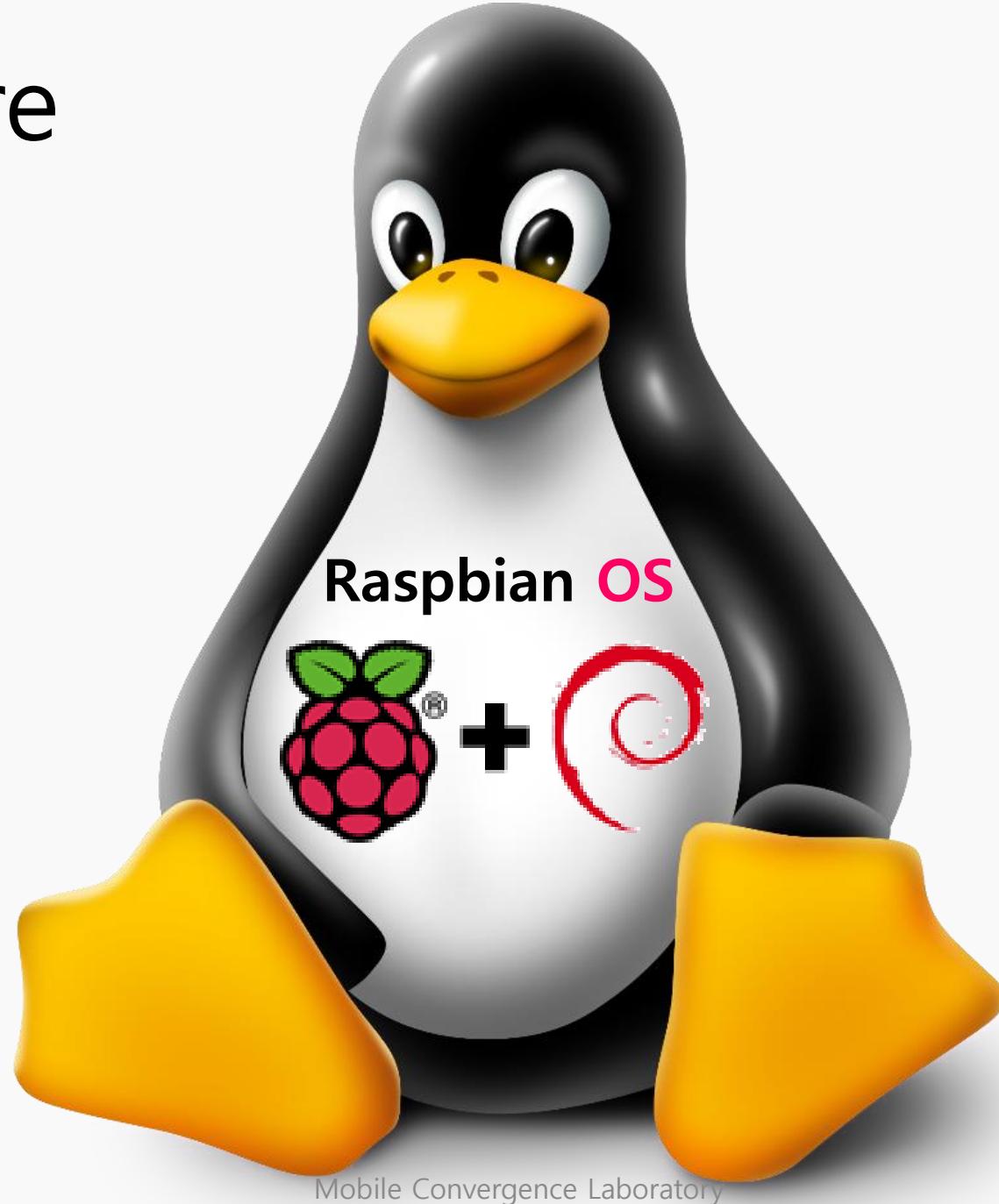


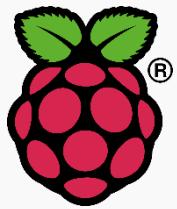
USB허브를 이용한 17포트 스위치



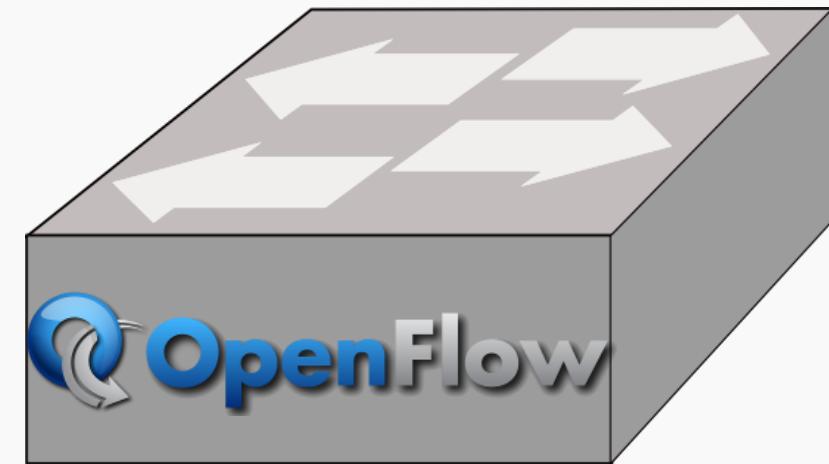
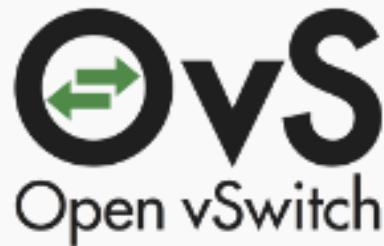
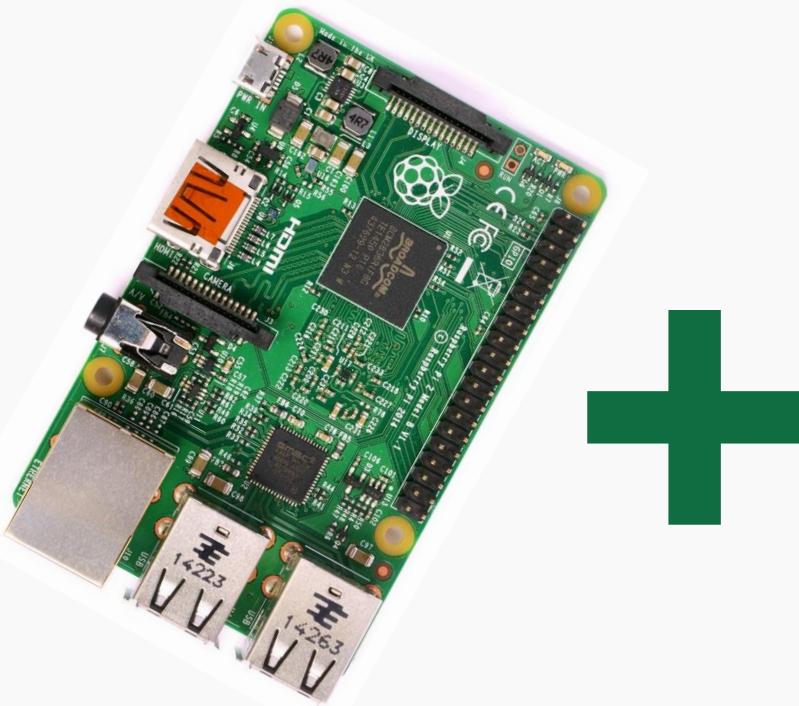


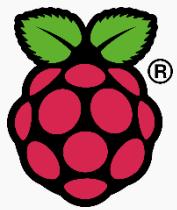
Software



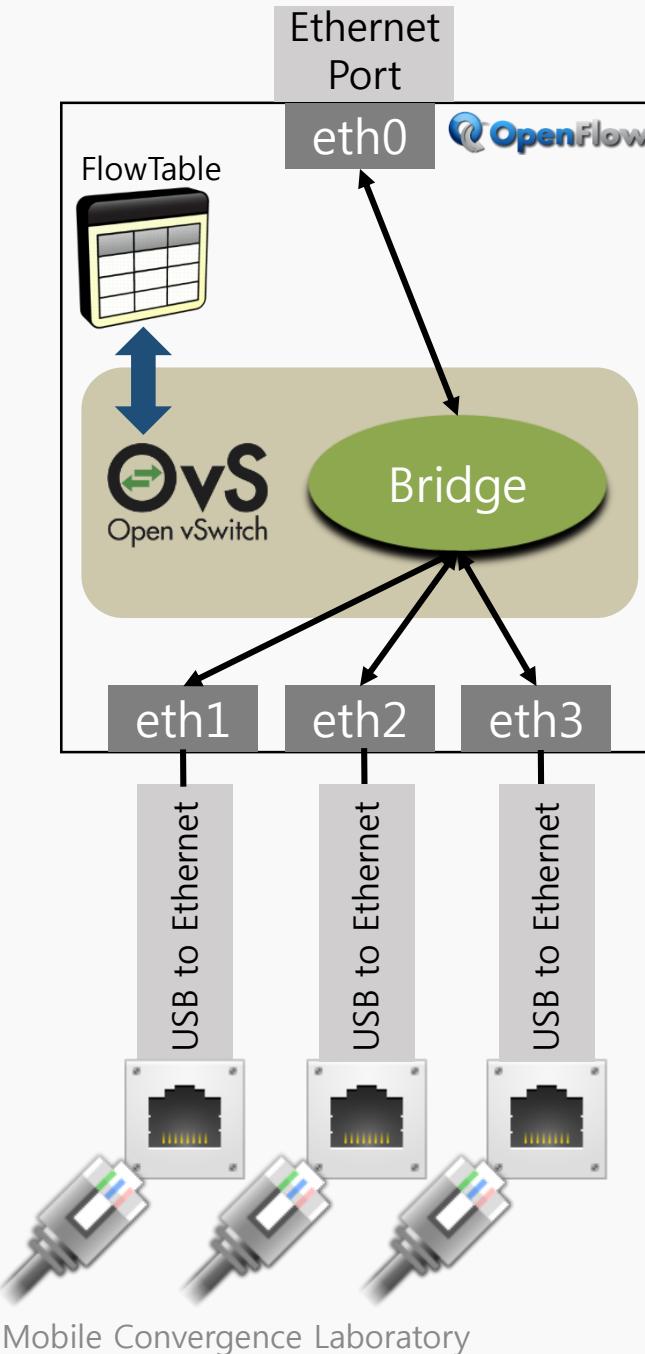


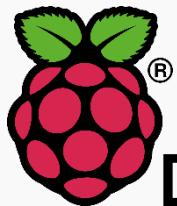
Software





System Architecture





Pi Stack Switch - Install

- OpenvSwitch 설치

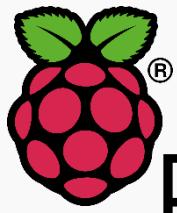
```
$ sudo apt-get install openvswitch-switch openvswitch-controller openvswitch-common
```

```
$ sudo ovs-vsctl add-br <BridgeName>
```

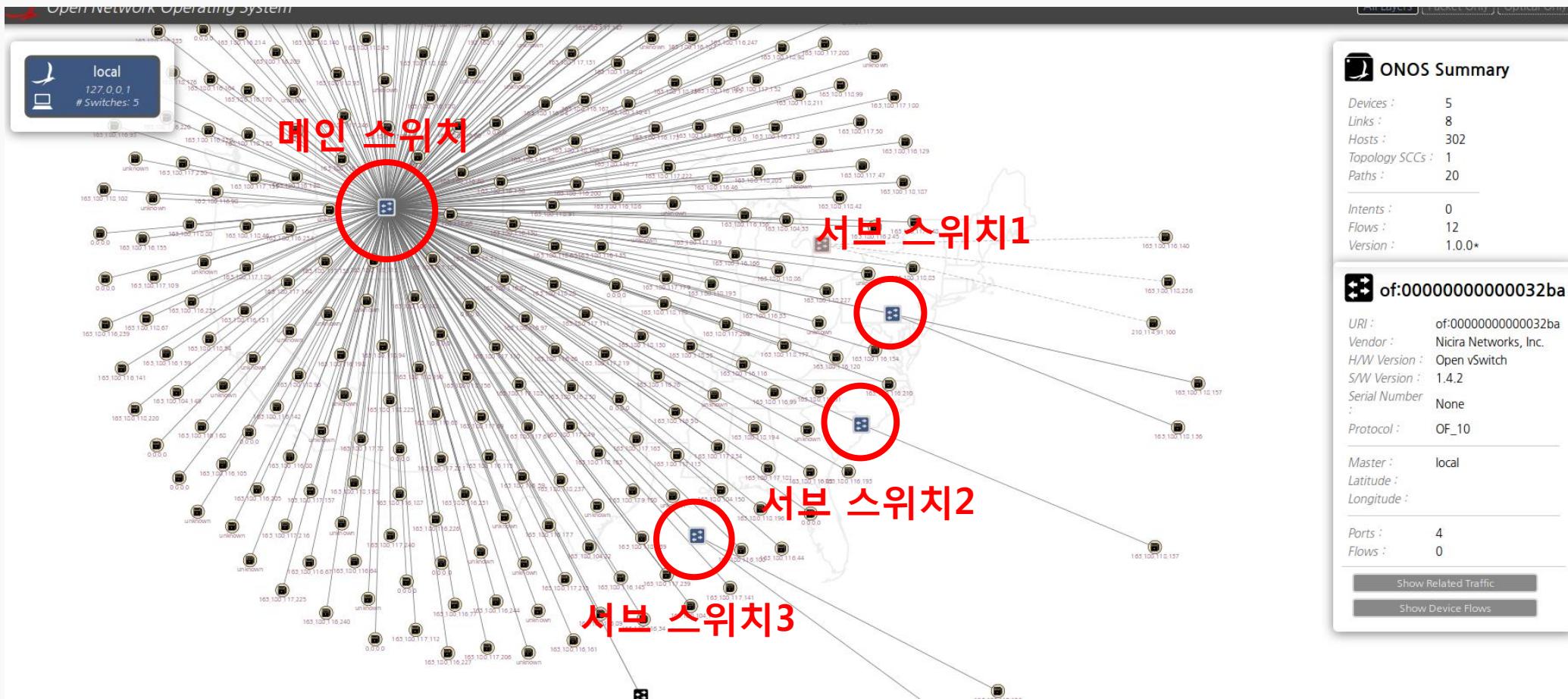
```
$ sudo ovs-vsctl add-port <BridgeName> eth_n
```

```
$ sudo ovs-vsctl set-controller <BridgeName> tcp:Ctrl_IP:6633
```

<https://github.com/MobileConvergenceLab/pi-switch>



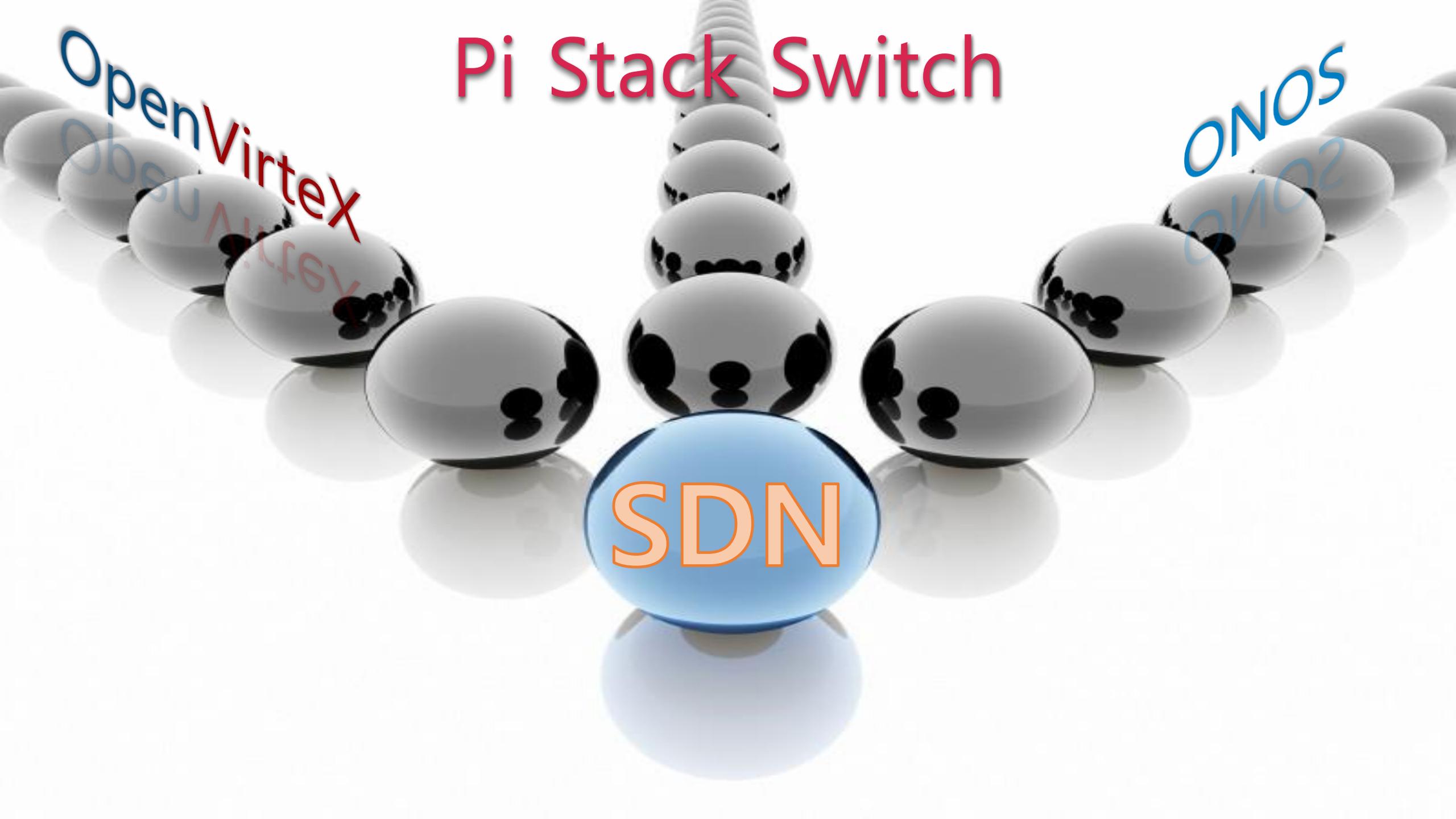
Pi Stack Switch와 ONOS 연결



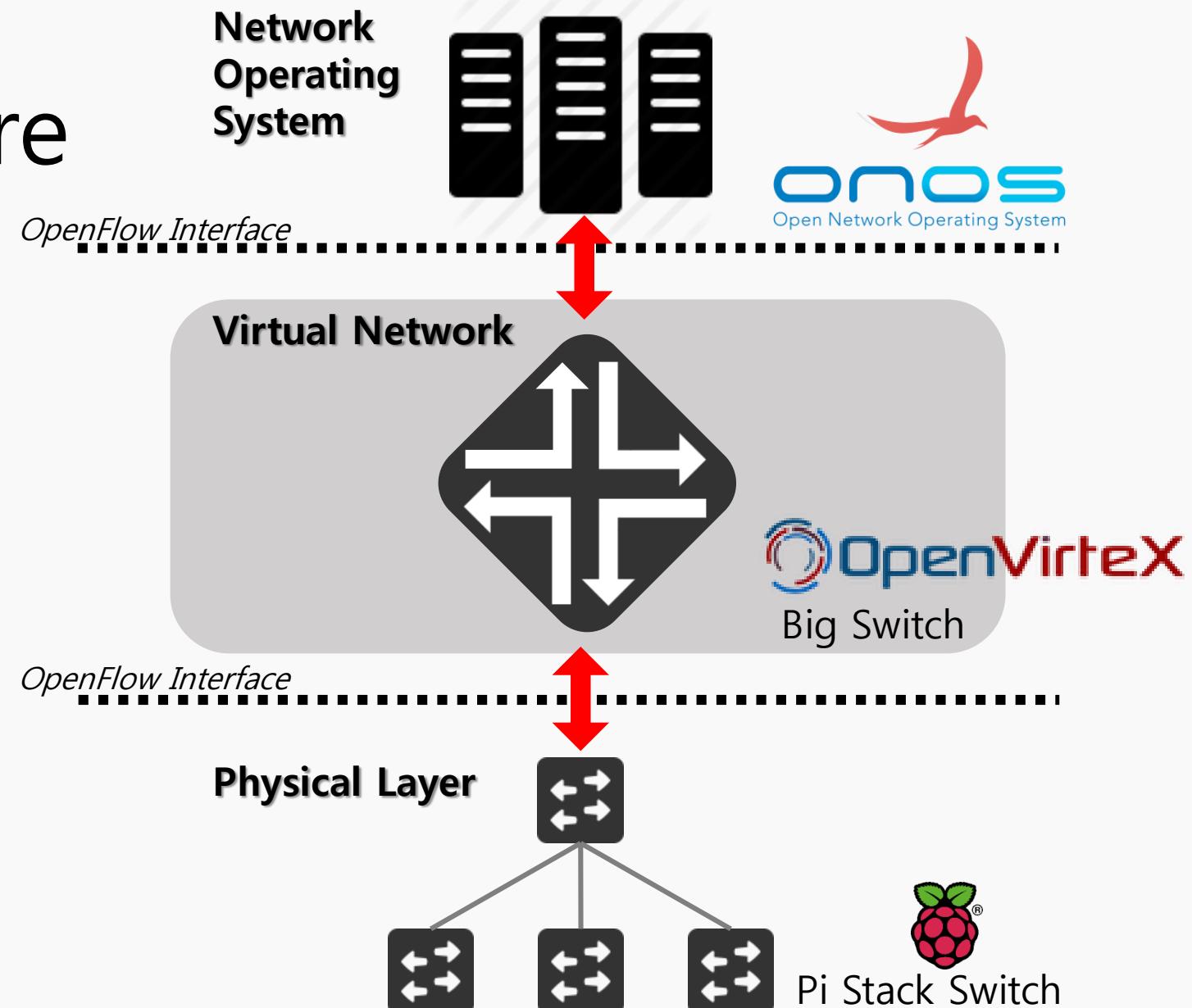
SDN Network 구축

SDN 테스트베드와 하이퍼바이저 그리고 SDN 컨트롤러

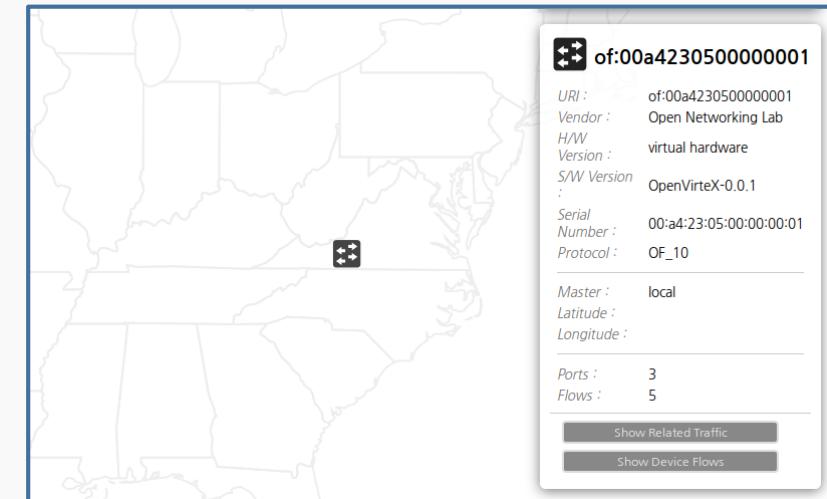
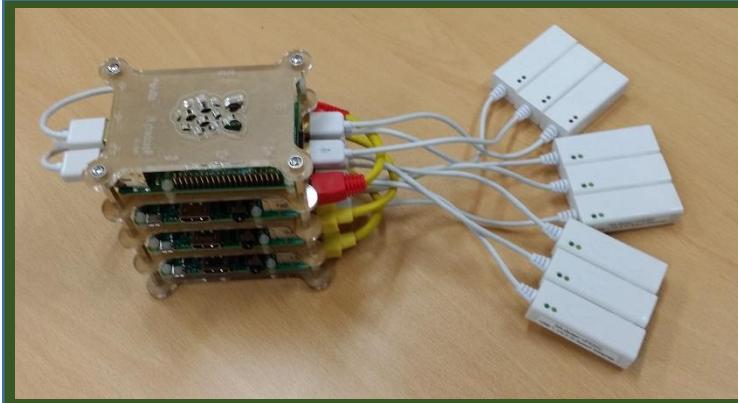
Pi Stack Switch



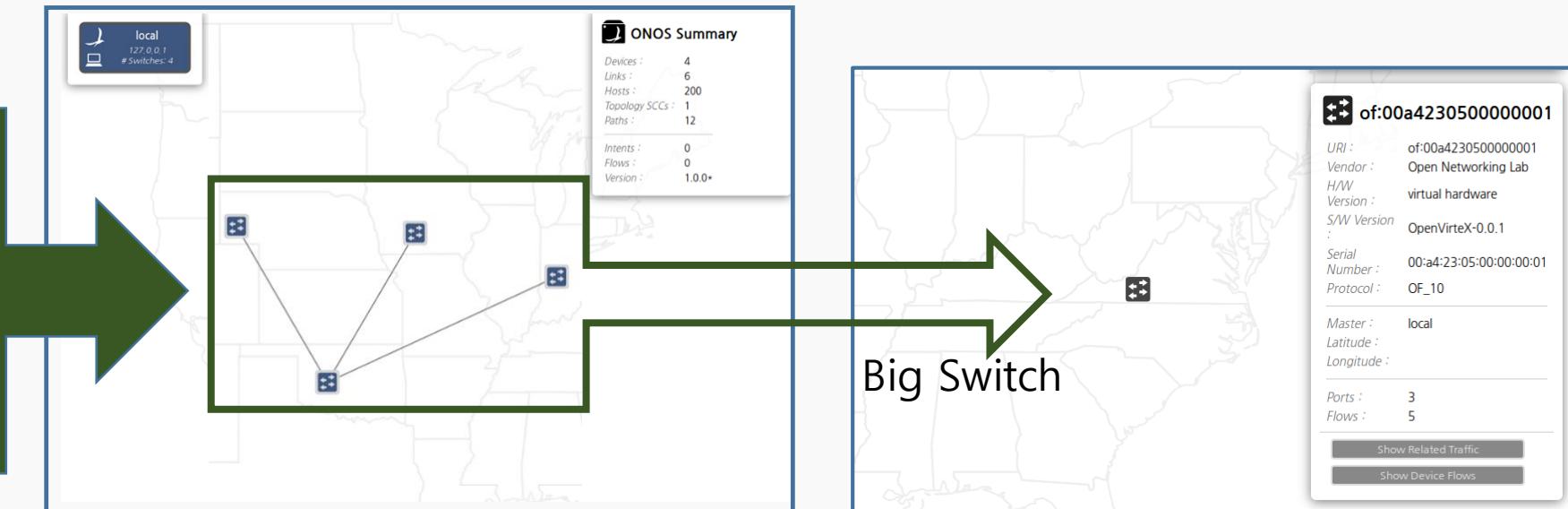
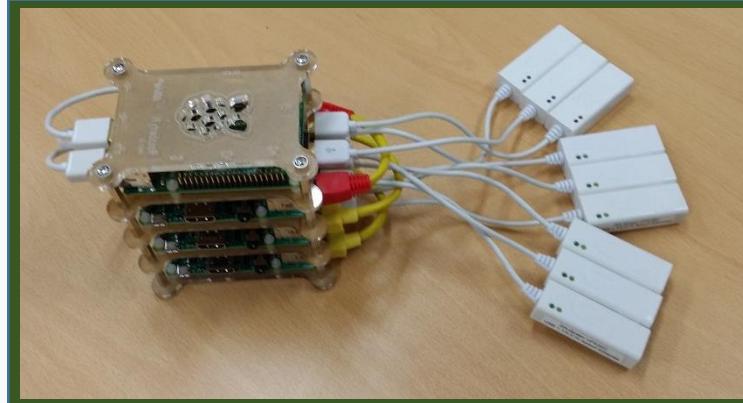
Network Architecture



Network Element Mapping

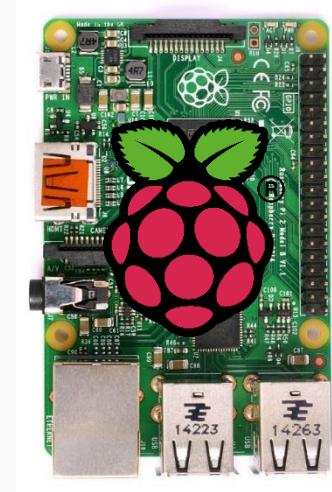


Network Element Mapping



Reference

- ONOS
 - <http://onosproject.org/>
 - <https://wiki.onosproject.org/> 공식 Wiki
 - <https://wiki.onosproject.org/display/ONOS/ONOS+from+Scratch>
 - <https://wiki.onosproject.org/display/ONOS/Installing+and+Running+ONOS>
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 - Pankaj Berde and others, "ONOS: Towards an Open, Distributed SDN OS", HostSDN 2014
- OpenVirteX
 - <http://ovx.onlab.us/>
 - Ali Al-Shabibi and others, "OpenVirteX: Make Your Virtual SDNs Programmable", HotSDN 2014
- OpenvSwitch
 - <http://www.openvswitch.org/>
- Raspberry Pi
 - <https://www.raspberrypi.org/>
 - http://en.wikipedia.org/wiki/Raspberry_Pi



Q&A