A Study on Global Test-bed and Testing of Open Mobile Network Platform

October 10, 2014

Kyung Hee University

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Goals of Research

Goals of Research

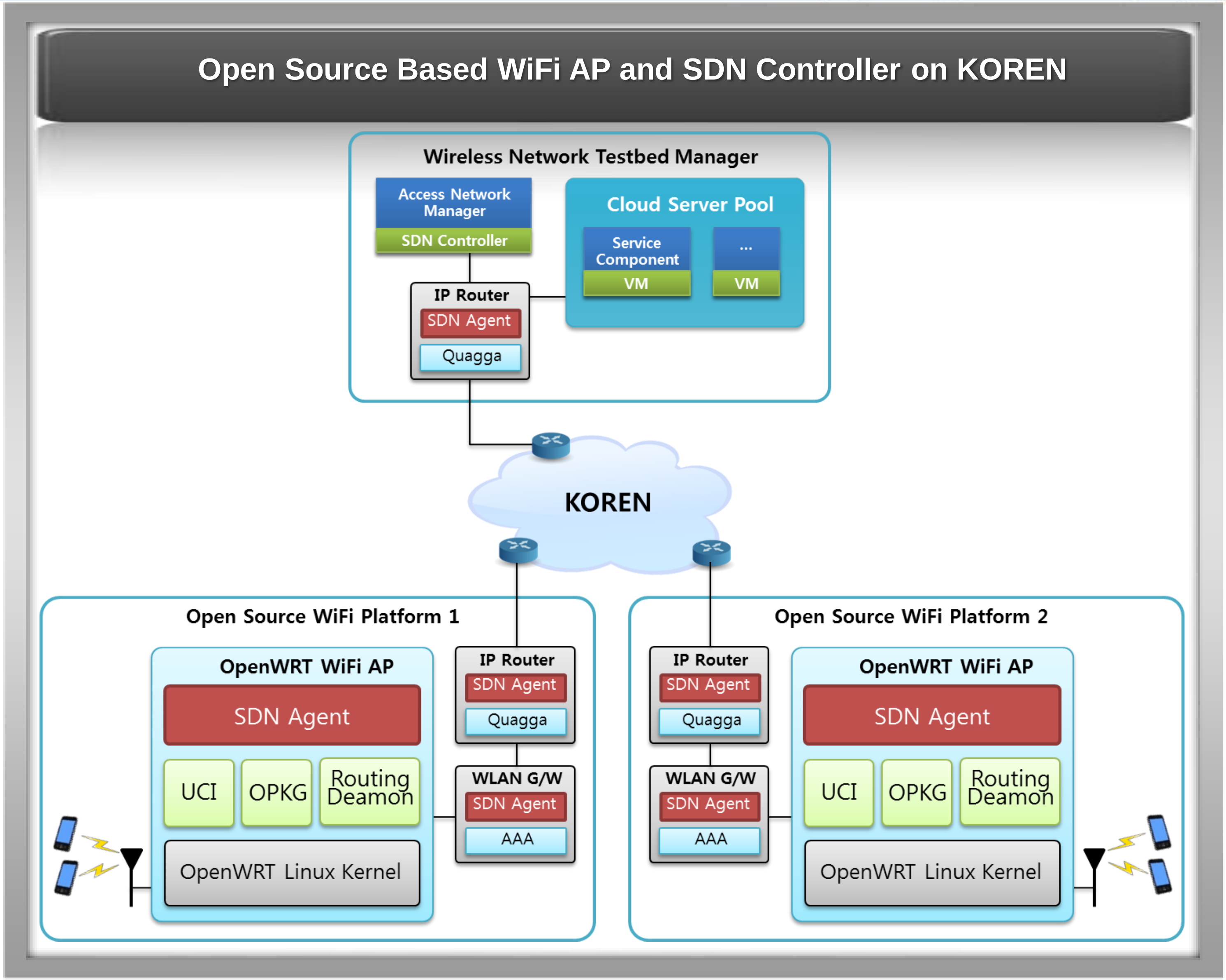
- **Development of Open Mobile Network platform based on Open Source Software and Test-bed construction**
  - Constructing Open Wi-Fi Network platform based on platform-built automation system
  - Constructing Open 3GPP Access Network platform based on platform-built automation system
  - Constructing Open 3GPP Core Network platform based on platform-built automation system
  - Constructing Open 4G LTE Access Network platform based on platform-built automation system
  - Constructing Open IP Router platform based on platform-built automation system
  - Constructing Open Cloud Service control environment based on platform-built automation system
  - Constructing SDN-based Network control environment
  - Constructing GUI-based platform-built automation system
  - Development of Agent for SDN-based control and platform-built automation

- **Research for providing evolved service using Open Mobile Network platform**
  - Development of Mobile VoIP Service considering QoS/SLA
  - Development of Fast Handover technique between APs based on Wi-Fi which provide real-time streaming traffic

- **Perform advanced future network research of International network and cooperative verification test**
  - Constructing Open Mobile Network test-bed platform on National Research Network(VinaREN, INHERENT)
  - Perform cooperative Mobile Network Technique verification test with KOREN-TEIN/APII-VinaREN-INHERENT

WiFi Network Platform

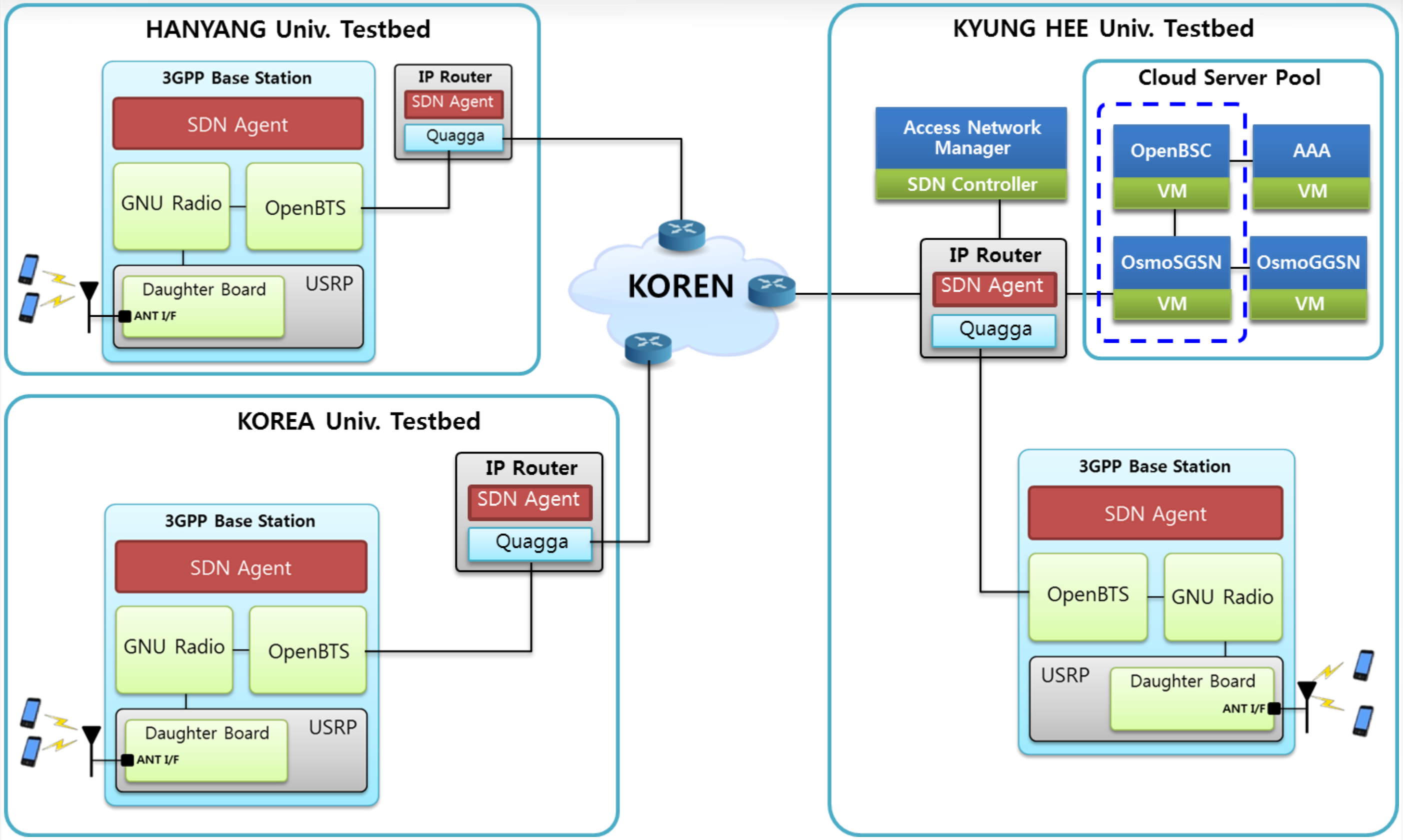
- Access Point using OpenWRT
- IP Router based on Quagga
- SDN Controller and SDN agent



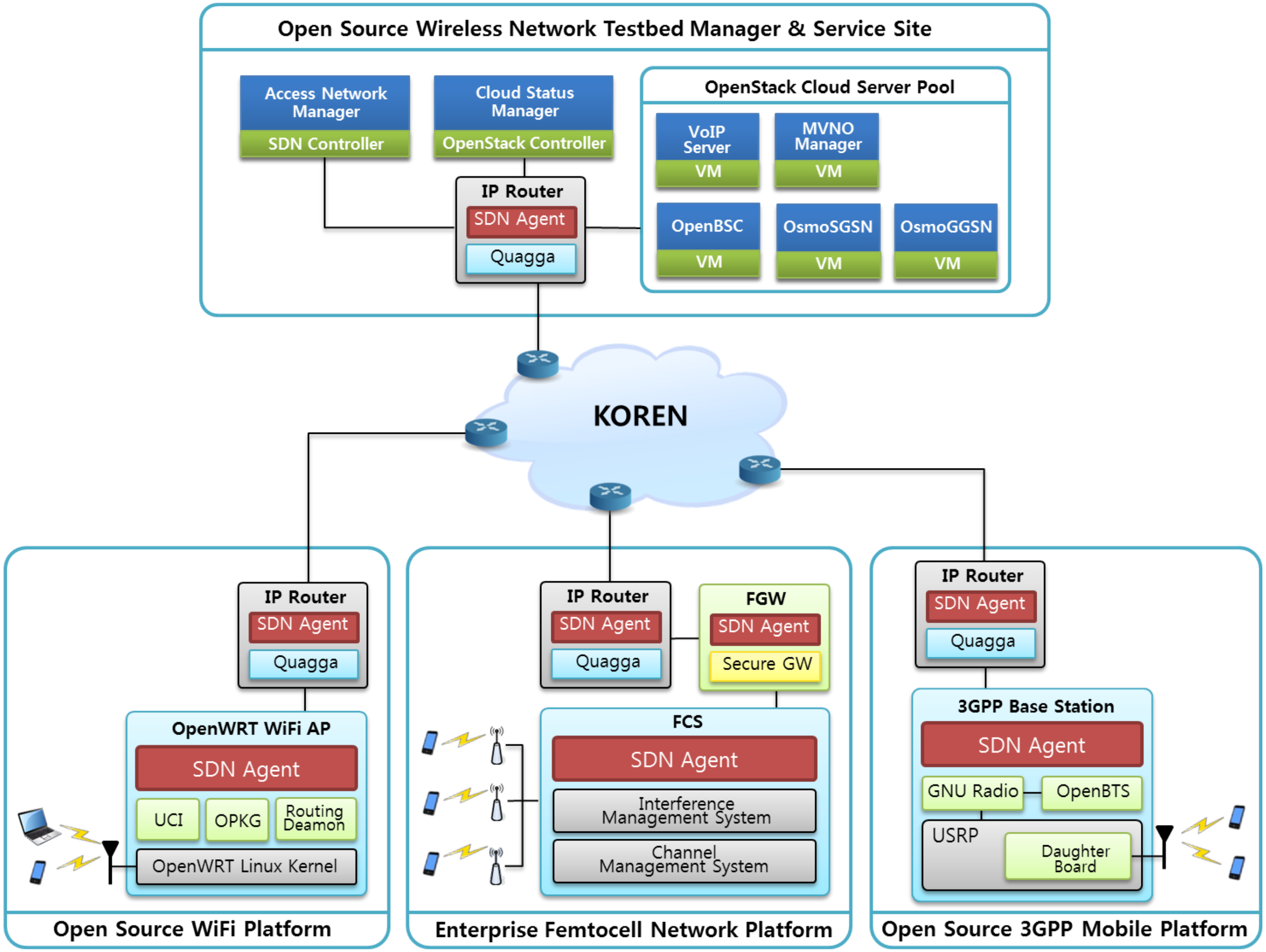
3GPP Access and Core Environments

- Implemented using USRP OpenBTS
- IP Router based on Quagga
- Define protocol between BS based on USRP/OpenBTS and mobile core components based on Osmo
- SDN Controller and SDN agents

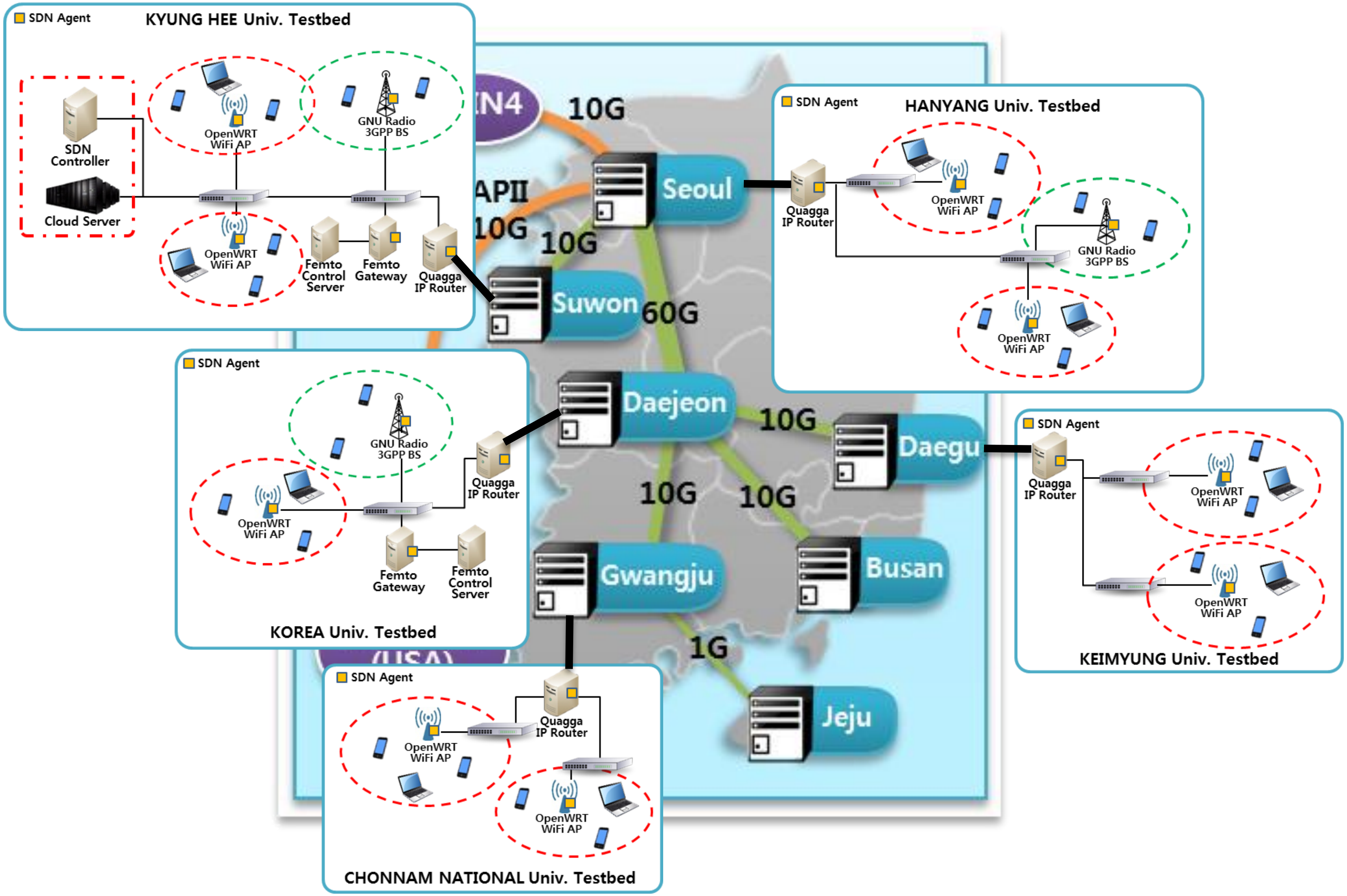
3GPP BS and Core



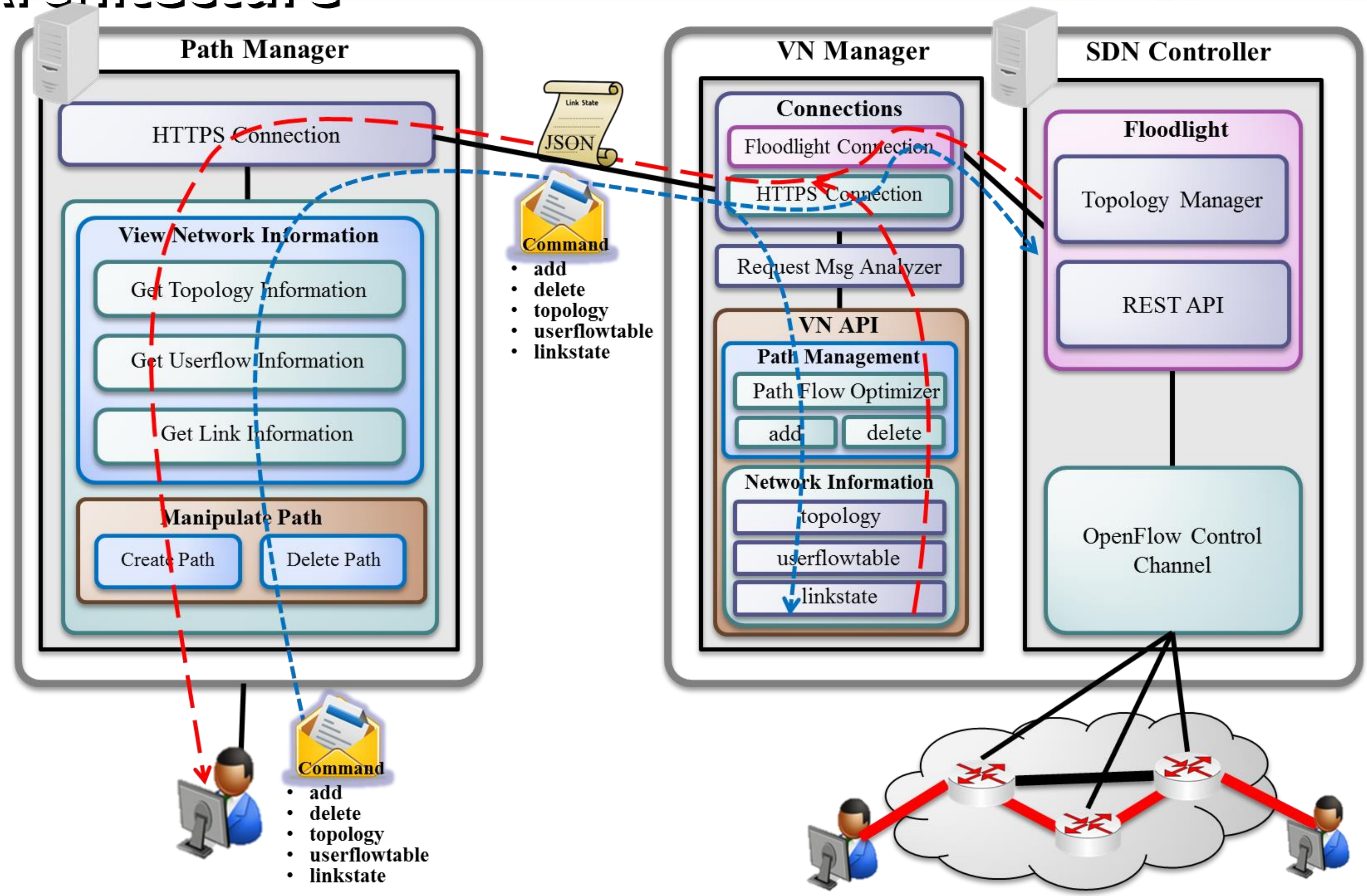
Overall Architecture for OSS based Mobile Networks



Test-bed for Mobile Networks Based on Open Sources



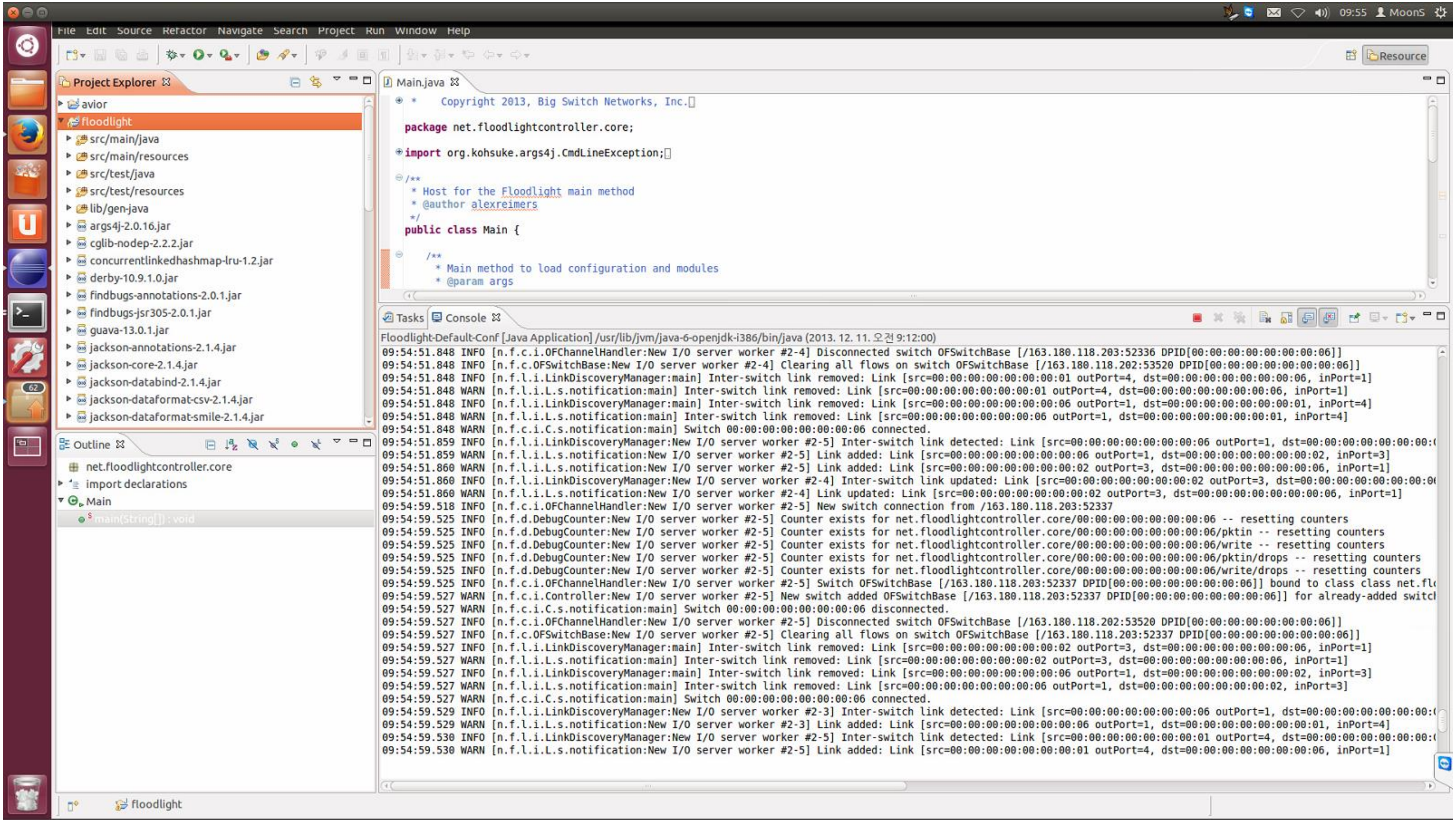
OpendFlow based Network Management Architecture



Development Environment

- Ubuntu 12.04 (Basic OS)
- Floodlight version 0.90 (providing REST API)
- Eclipse IDE v.3.7.2 (Java development Env.)
  - Java v.1.7
- Apache tomcat v.7.0(supporting HTTP/HTTPS)

Floodlight based SDN controller Development Environment

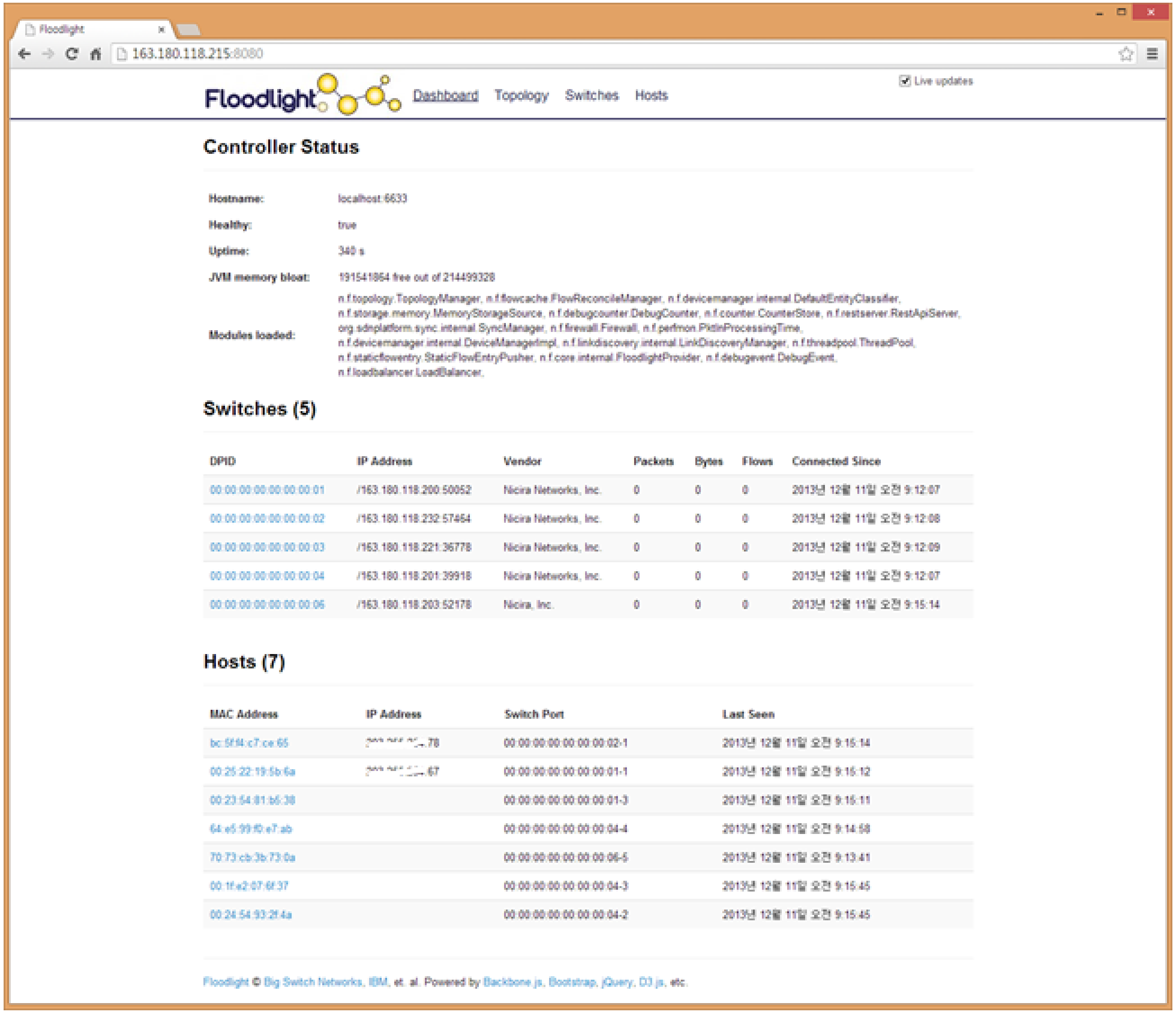

File Edit Source Refactor Navigate Search Project Run Window Help
09:55 MoonS
Resource
Project Explorer
avior
floodlight
src/main/java
src/main/resources
src/test/java
src/test/resources
lib/gen-java
args4j-2.0.16.jar
cglib-nodep-2.2.2.jar
concurrentlinkedhashmap-lru-1.2.jar
derby-10.9.1.0.jar
findbugs-annotations-2.0.1.jar
findbugs-jsr305-2.0.1.jar
guava-13.0.1.jar
jackson-annotations-2.1.4.jar
jackson-core-2.1.4.jar
jackson-databind-2.1.4.jar
jackson-dataformat-csv-2.1.4.jar
jackson-dataformat-smile-2.1.4.jar
Outline
net.floodlightcontroller.core
import declarations
Main
main(String[]) : void
floodlight
Main.java
Tasks
Console

```
 *   Copyright 2013, Big Switch Networks, Inc.

package net.floodlightcontroller.core;

import org.kohsuke.args4j.CmdLineException;

/**
 * Host for the Floodlight main method
 * @author alexreimers
 */
public class Main {

    /**
     * Main method to load configuration and modules
     * @param args
```

Floodlight-Default-Conf [Java Application] /usr/lib/jvm/java-6-openjdk-i386/bin/java (2013. 12. 11. 오전 9:12:00)

```
09:54:51.848 INFO [n.f.c.i.OFChannelHandler:New I/O server worker #2-4] Disconnected switch OFSwitchBase [/163.180.118.203:52336 DPID[00:00:00:00:00:00:00:06]]
09:54:51.848 INFO [n.f.c.OFSwitchBase:New I/O server worker #2-4] Clearing all flows on switch OFSwitchBase [/163.180.118.202:53520 DPID[00:00:00:00:00:00:00:06]]
09:54:51.848 INFO [n.f.l.i.LinkDiscoveryManager:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:01 outPort=4, dst=00:00:00:00:00:00:00:06, inPort=1]
09:54:51.848 WARN [n.f.l.i.L.s.notification:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:01 outPort=4, dst=00:00:00:00:00:00:00:06, inPort=1]
09:54:51.848 INFO [n.f.l.i.LinkDiscoveryManager:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:01, inPort=4]
09:54:51.848 WARN [n.f.l.i.L.s.notification:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:01, inPort=4]
09:54:51.848 WARN [n.f.c.i.C.s.notification:main] Switch 00:00:00:00:00:00:00:06 connected.
09:54:51.859 INFO [n.f.l.i.LinkDiscoveryManager:New I/O server worker #2-5] Inter-switch link detected: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:
09:54:51.859 WARN [n.f.l.i.L.s.notification:New I/O server worker #2-5] Link added: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:02, inPort=3]
09:54:51.860 WARN [n.f.l.i.L.s.notification:New I/O server worker #2-5] Link added: Link [src=00:00:00:00:00:00:00:02 outPort=3, dst=00:00:00:00:00:00:00:06, inPort=1]
09:54:51.860 INFO [n.f.l.i.LinkDiscoveryManager:New I/O server worker #2-4] Inter-switch link updated: Link [src=00:00:00:00:00:00:00:02 outPort=3, dst=00:00:00:00:00:00:00:0
09:54:51.860 WARN [n.f.l.i.L.s.notification:New I/O server worker #2-4] Link updated: Link [src=00:00:00:00:00:00:00:02 outPort=3, dst=00:00:00:00:00:00:00:06, inPort=1]
09:54:59.518 INFO [n.f.c.i.OFChannelHandler:New I/O server worker #2-5] New switch connection from /163.180.118.203:52337
09:54:59.525 INFO [n.f.d.DebugCounter:New I/O server worker #2-5] Counter exists for net.floodlightcontroller.core/00:00:00:00:00:00:00:06 -- resetting counters
09:54:59.525 INFO [n.f.d.DebugCounter:New I/O server worker #2-5] Counter exists for net.floodlightcontroller.core/00:00:00:00:00:00:00:06/pktin -- resetting counters
09:54:59.525 INFO [n.f.d.DebugCounter:New I/O server worker #2-5] Counter exists for net.floodlightcontroller.core/00:00:00:00:00:00:00:06/write -- resetting counters
09:54:59.525 INFO [n.f.d.DebugCounter:New I/O server worker #2-5] Counter exists for net.floodlightcontroller.core/00:00:00:00:00:00:00:06/pktin/drops -- resetting counters
09:54:59.525 INFO [n.f.d.DebugCounter:New I/O server worker #2-5] Counter exists for net.floodlightcontroller.core/00:00:00:00:00:00:00:06/write/drops -- resetting counters
09:54:59.525 INFO [n.f.c.i.OFChannelHandler:New I/O server worker #2-5] Switch OFSwitchBase [/163.180.118.203:52337 DPID[00:00:00:00:00:00:00:06]] bound to class class net.fl
09:54:59.527 WARN [n.f.c.i.Controller:New I/O server worker #2-5] New switch added OFSwitchBase [/163.180.118.203:52337 DPID[00:00:00:00:00:00:00:06]] for already-added switc
09:54:59.527 WARN [n.f.c.i.C.s.notification:main] Switch 00:00:00:00:00:00:00:06 disconnected.
09:54:59.527 INFO [n.f.c.i.OFChannelHandler:New I/O server worker #2-5] Disconnected switch OFSwitchBase [/163.180.118.202:53520 DPID[00:00:00:00:00:00:00:06]]
09:54:59.527 INFO [n.f.c.OFSwitchBase:New I/O server worker #2-5] Clearing all flows on switch OFSwitchBase [/163.180.118.203:52337 DPID[00:00:00:00:00:00:00:06]]
09:54:59.527 INFO [n.f.l.i.LinkDiscoveryManager:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:02 outPort=3, dst=00:00:00:00:00:00:00:06, inPort=1]
09:54:59.527 WARN [n.f.l.i.L.s.notification:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:02 outPort=3, dst=00:00:00:00:00:00:00:06, inPort=1]
09:54:59.527 INFO [n.f.l.i.LinkDiscoveryManager:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:02, inPort=3]
09:54:59.527 WARN [n.f.l.i.L.s.notification:main] Inter-switch link removed: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:02, inPort=3]
09:54:59.527 WARN [n.f.c.i.C.s.notification:main] Switch 00:00:00:00:00:00:00:06 connected.
09:54:59.529 INFO [n.f.l.i.LinkDiscoveryManager:New I/O server worker #2-3] Inter-switch link detected: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:
09:54:59.529 WARN [n.f.l.i.L.s.notification:New I/O server worker #2-3] Link added: Link [src=00:00:00:00:00:00:00:06 outPort=1, dst=00:00:00:00:00:00:00:01, inPort=4]
09:54:59.530 INFO [n.f.l.i.LinkDiscoveryManager:New I/O server worker #2-5] Inter-switch link detected: Link [src=00:00:00:00:00:00:00:01 outPort=4, dst=00:00:00:00:00:00:00:
09:54:59.530 WARN [n.f.l.i.L.s.notification:New I/O server worker #2-5] Link added: Link [src=00:00:00:00:00:00:00:01 outPort=4, dst=00:00:00:00:00:00:00:06, inPort=1]
```

Operation of SDN Controller : Floodlight



Controller Status

Hostname:	localhost:6633
Healthy:	true
Uptime:	340 s
JVM memory bloat:	191541864 free out of 214499328
Modules loaded:	n.f.topology.TopologyManager, n.f.flowcache.FlowReconcileManager, n.f.devicemanager.internal.DefaultEntityClassifier, n.f.storage.memory.MemoryStorageSource, n.f.debugcounter.DebugCounter, n.f.counter.CounterStore, n.f.restserver.RestApiServer, org.sdnplatform.sync.internal.SyncManager, n.f.firewall.Firewall, n.f.perfmon.PktInProcessingTime, n.f.devicemanager.internal.DeviceManagerImpl, n.f.linkdiscovery.internal.LinkDiscoveryManager, n.f.threadpool.ThreadPool, n.f.staticflowentry.StaticFlowEntryPusher, n.f.core.internal.FloodlightProvider, n.f.debugevent.DebugEvent, n.f.loadbalancer.LoadBalancer,

Switches (5)

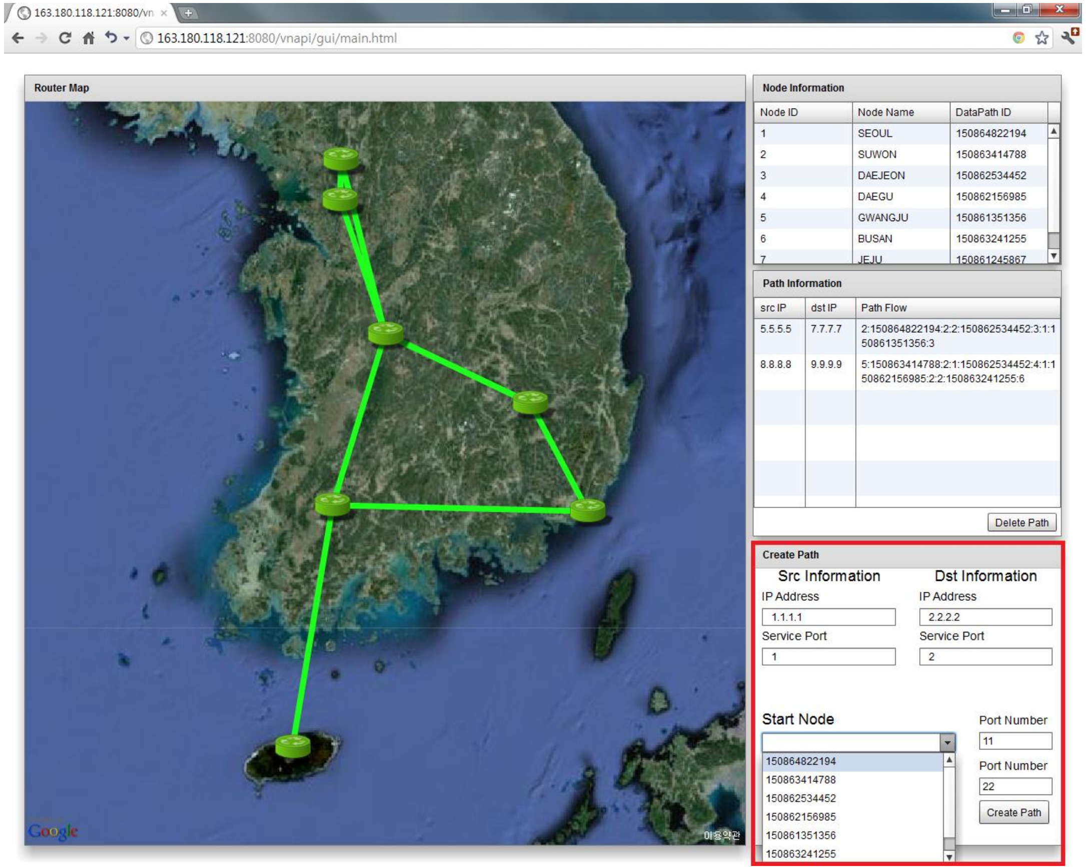
DPID	IP Address	Vendor	Packets	Bytes	Flows	Connected Since
00:00:00:00:00:00:00:01	/163.180.118.200:50052	Nicira Networks, Inc.	0	0	0	2013년 12월 11일 오전 9:12:07
00:00:00:00:00:00:00:02	/163.180.118.232:57464	Nicira Networks, Inc.	0	0	0	2013년 12월 11일 오전 9:12:08
00:00:00:00:00:00:00:03	/163.180.118.221:36778	Nicira Networks, Inc.	0	0	0	2013년 12월 11일 오전 9:12:09
00:00:00:00:00:00:00:04	/163.180.118.201:39918	Nicira Networks, Inc.	0	0	0	2013년 12월 11일 오전 9:12:07
00:00:00:00:00:00:00:06	/163.180.118.203:52178	Nicira, Inc.	0	0	0	2013년 12월 11일 오전 9:15:14

Hosts (7)

MAC Address	IP Address	Switch Port	Last Seen
bc:5f:f4:c7:ce:65	[redacted].78	00:00:00:00:00:00:00:02-1	2013년 12월 11일 오전 9:15:14
00:25:22:19:5b:6a	[redacted].67	00:00:00:00:00:00:00:01-1	2013년 12월 11일 오전 9:15:12
00:23:54:81:b6:38		00:00:00:00:00:00:00:01-3	2013년 12월 11일 오전 9:15:11
64:e5:99:f0:e7:ab		00:00:00:00:00:00:00:04-4	2013년 12월 11일 오전 9:14:58
70:73:cb:3b:73:0a		00:00:00:00:00:00:00:06-5	2013년 12월 11일 오전 9:13:41
00:1f:e2:07:6f:37		00:00:00:00:00:00:00:04-3	2013년 12월 11일 오전 9:15:45
00:24:54:93:2f:4a		00:00:00:00:00:00:00:04-2	2013년 12월 11일 오전 9:15:45

Floodlight © Big Switch Networks, IBM, et. al. Powered by Backbone.js, Bootstrap, jQuery, D3.js, etc.

Path Manager



Node Information

Node ID	Node Name	DataPath ID
1	SEOUL	150864822194
2	SUWON	150863414788
3	DAEJEON	150862534452
4	DAEGU	150862156985
5	GWANGJU	150861351356
6	BUSAN	150863241255
7	JEJU	150861245867

Path Information

src IP	dst IP	Path Flow
5.5.5.5	7.7.7.7	2:150864822194:2:2:150862534452:3:1:150861351356:3
8.8.8.8	9.9.9.9	5:150863414788:2:1:150862534452:4:1:150862156985:2:2:150863241255:6

Delete Path

Create Path

Src Information

IP Address: 1.1.1.1

Service Port: 1

Dst Information

IP Address: 2.2.2.2

Service Port: 2

Start Node

150864822194
150863414788
150862534452
150862156985
150861351356
150863241255

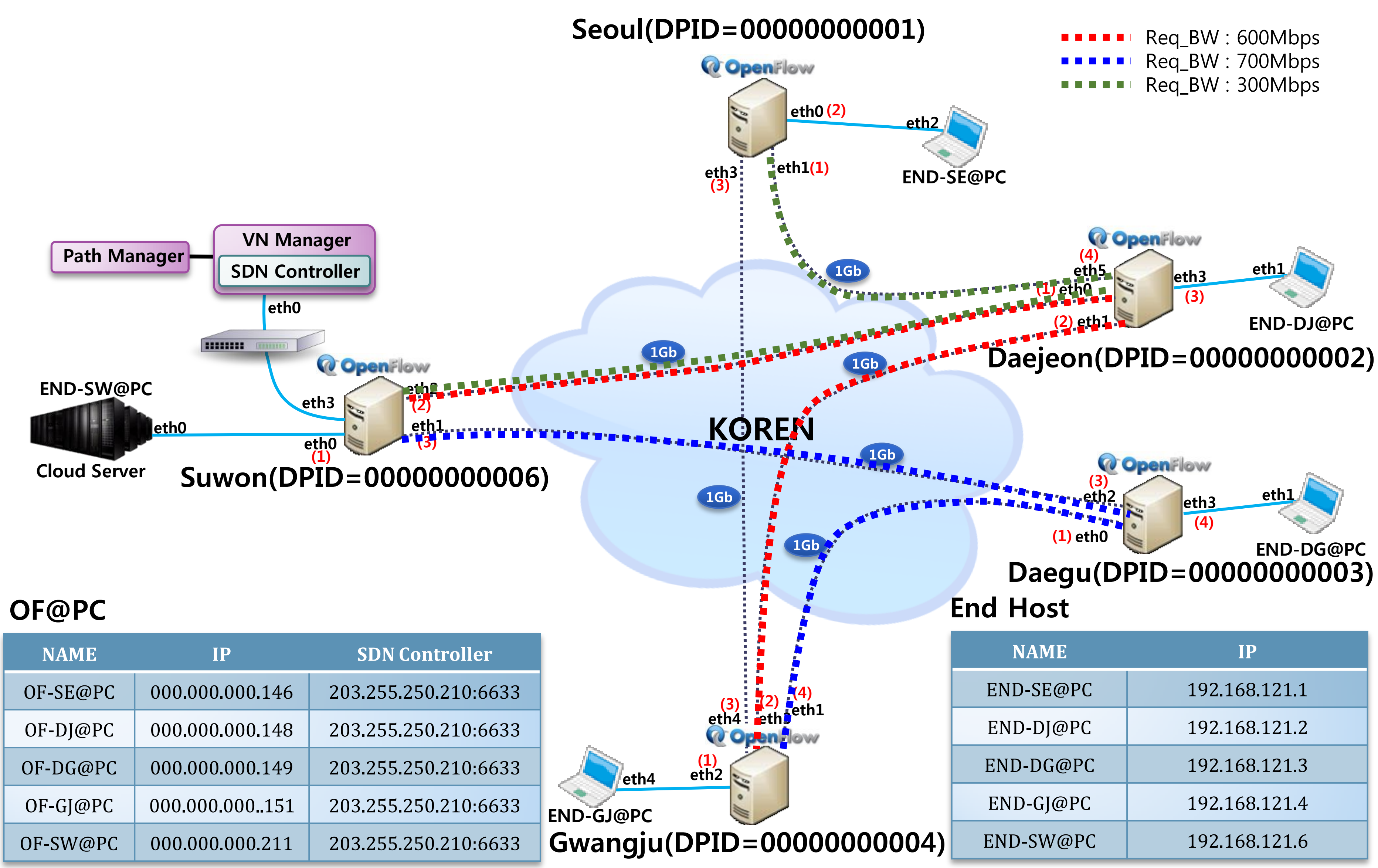
Port Number: 11

Port Number: 22

Create Path

No.	Components name	Description
1	Router Map	Shows the information related to the Topology information
2	Node Information	Shows the information related to the Node information
3	Path Information	Shows the information related to the path flow information, And can delete registered path flow.
4	Create Path	Can generate path flow

Scenario for Flow Creation



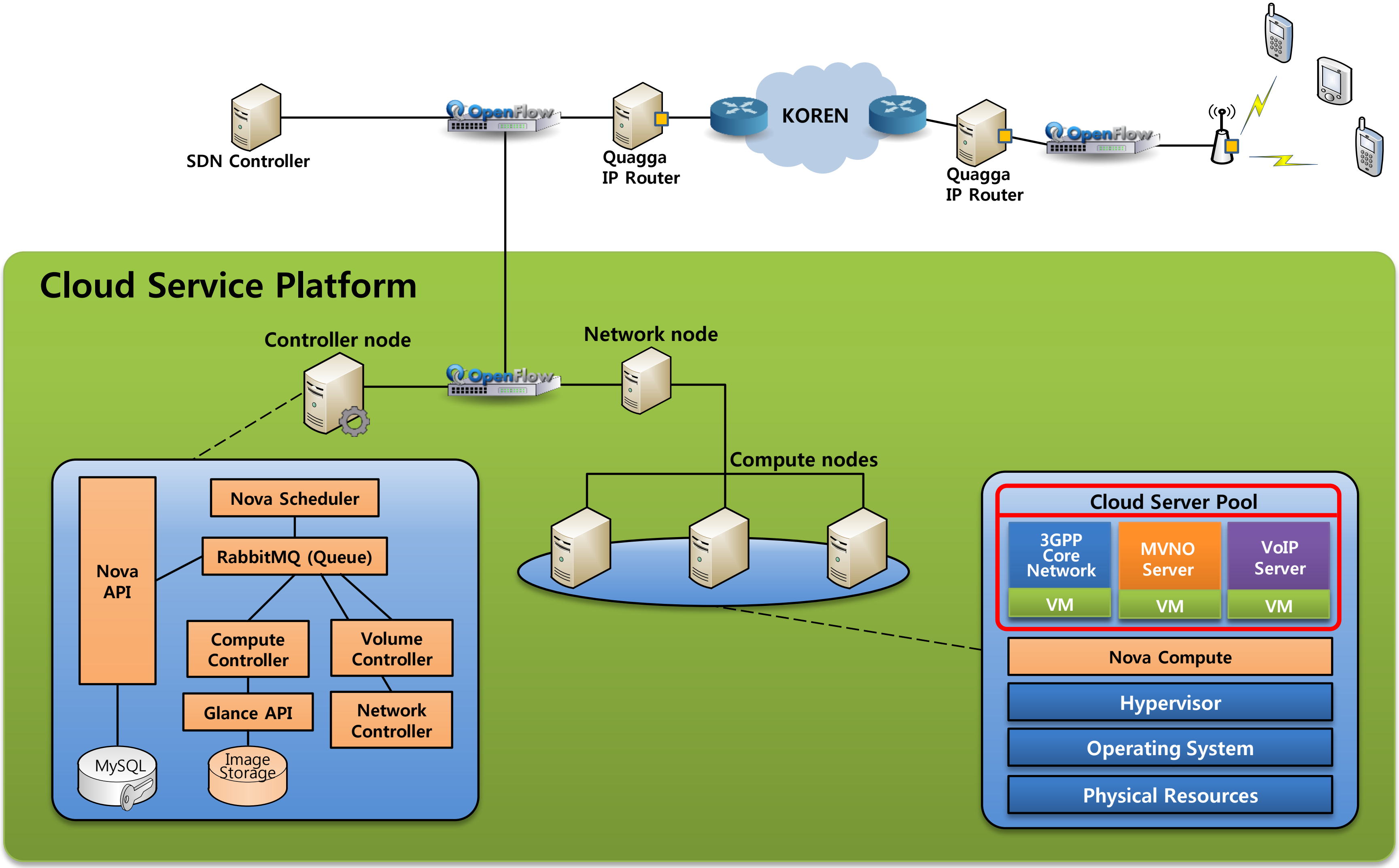
OF@PC

NAME	IP	SDN Controller
OF-SE@PC	000.000.000.146	203.255.250.210:6633
OF-DJ@PC	000.000.000.148	203.255.250.210:6633
OF-DG@PC	000.000.000.149	203.255.250.210:6633
OF-GJ@PC	000.000.000..151	203.255.250.210:6633
OF-SW@PC	000.000.000.211	203.255.250.210:6633

End Host

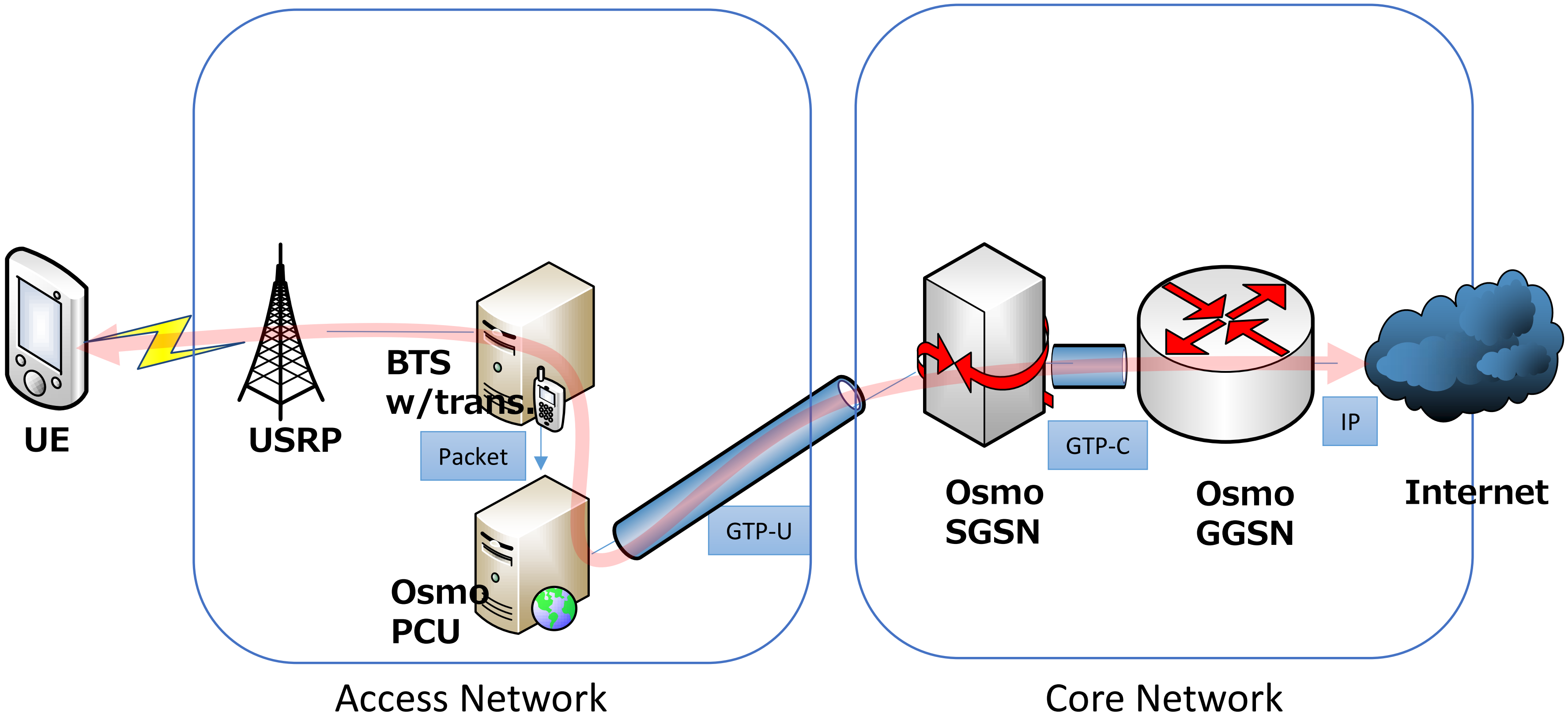
NAME	IP
END-SE@PC	192.168.121.1
END-DJ@PC	192.168.121.2
END-DG@PC	192.168.121.3
END-GJ@PC	192.168.121.4
END-SW@PC	192.168.121.6

Open Stack Based Mobile Core Environment



OS : Ubuntu 14.04 LTS Server
OpenStack : Icehouse version

Implementation in 3GPP Cellular Network

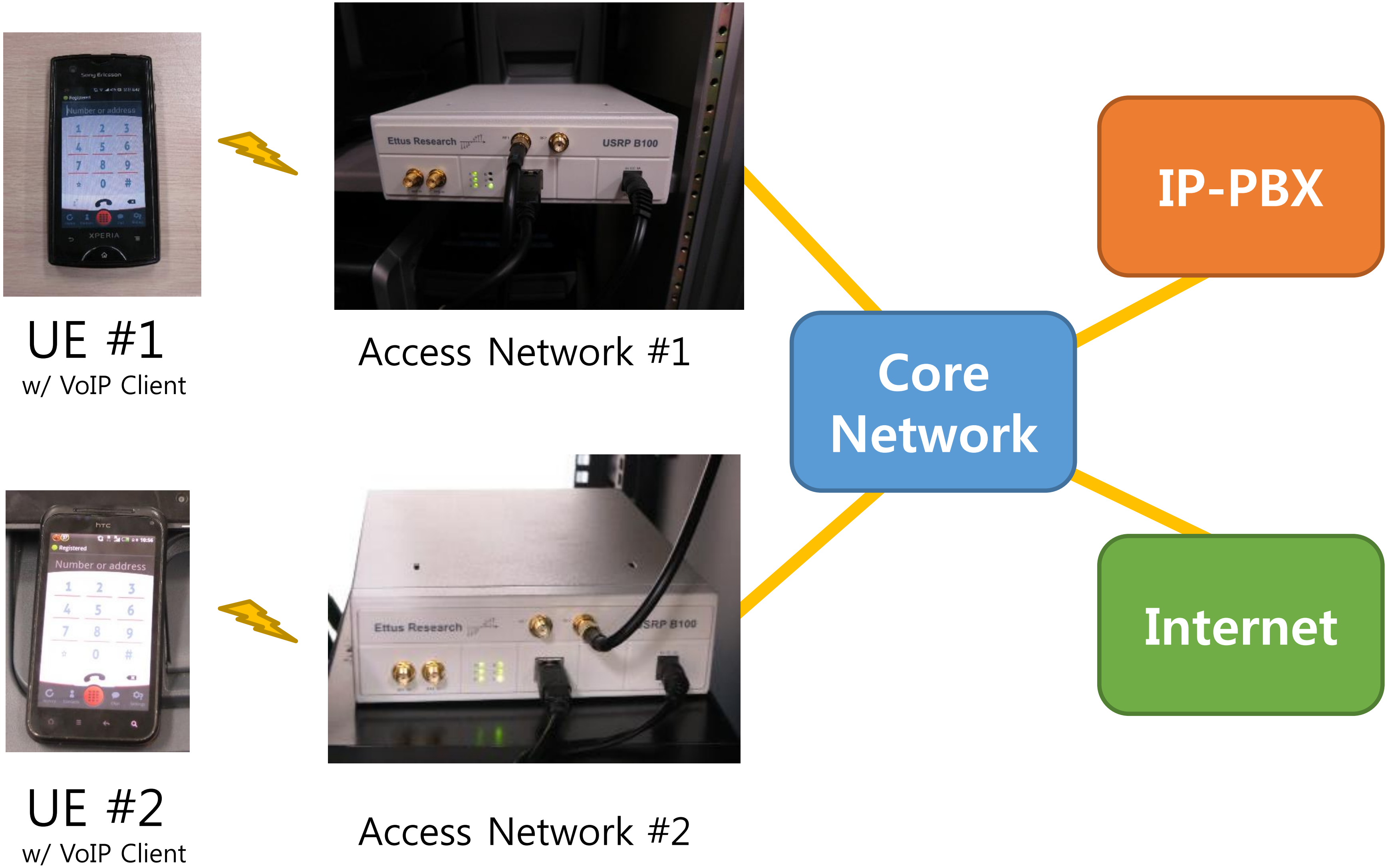


UE: User Equipment
USRP: Universal Software Radio Peripheral
BTS: Base Transceiver Station
PCU: Packet Control Unit

GTP: GPRS Tunneling Protocol
SGSN: Serving GPRS Support Node
GGSN: Gateway GPRS Support Node

***Osmocom** Project: **O**pen **S**ource **Mo**bile **Com**munications by GSM and DECT

Constructing 3GPP Cellular Network Test-bed



UE #1

w/ VoIP Client

Access Network #1

UE #2

w/ VoIP Client

Access Network #2

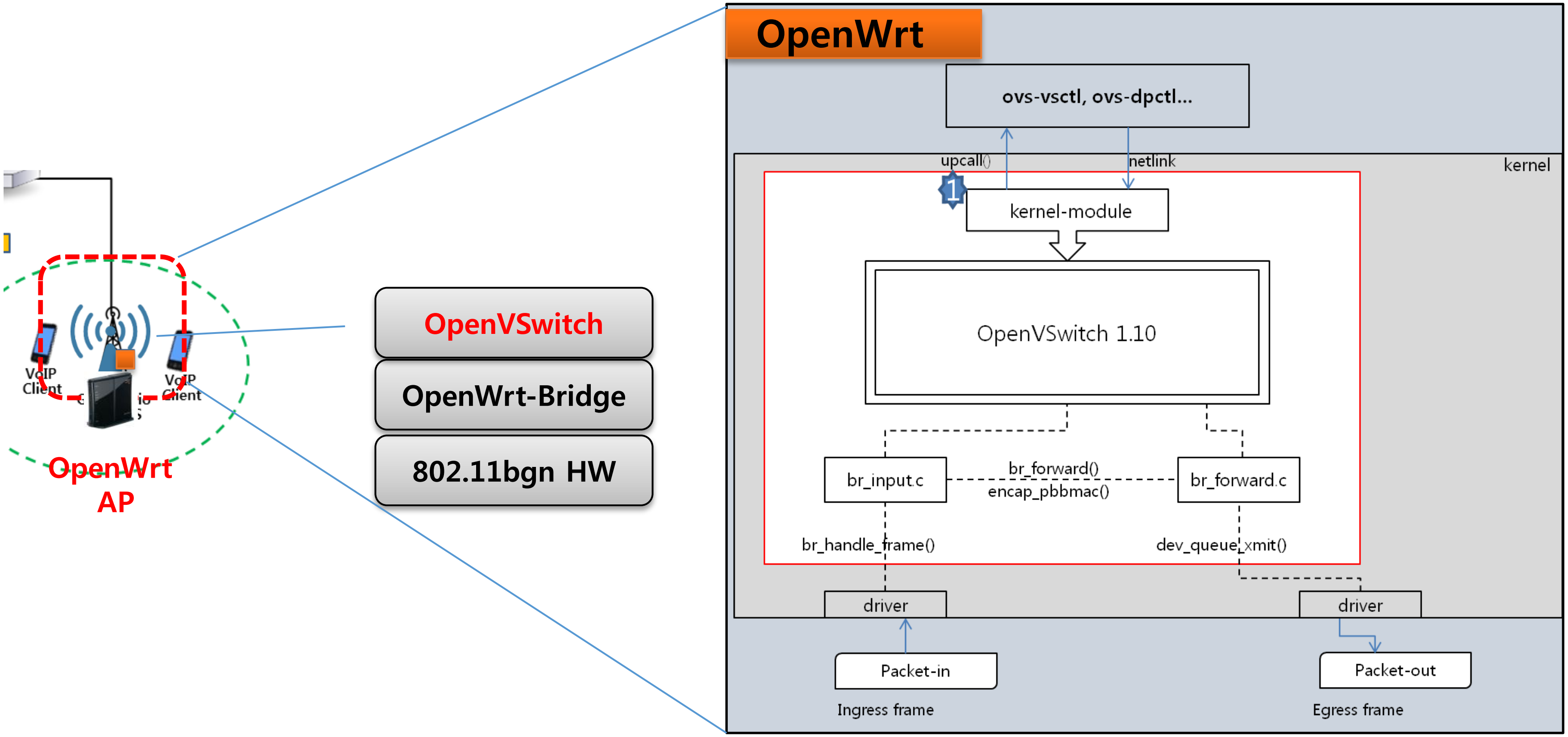
Core Network

IP-PBX

Internet

Constructing OpenWrt based WLAN environment

- OpenWrt AP software architecture
  - OpenWrt AP inernal



VoIP Client

VoIP Client

OpenWrt AP

OpenVSwitch

OpenWrt-Bridge

802.11bgn HW

OpenWrt

ovs-vsctl, ovs-dpctl...

upcall()

netlink

kernel

1

kernel-module

OpenVSwitch 1.10

br_input.c

br_forward()

encap_pbbmac()

br_forward.c

br_handle_frame()

dev_queue_xmit()

driver

driver

Packet-in

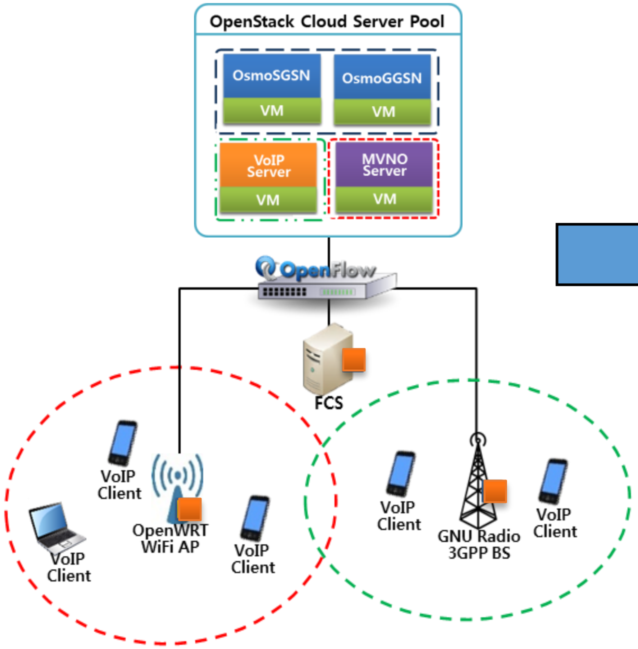
Ingress frame

Packet-out

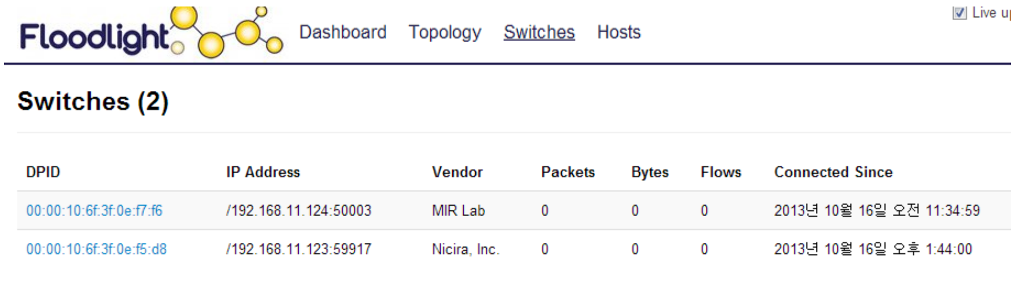
Egress frame

🟧 SDN Agent

Constructing OpenWrt based WLAN environment – testing with SDN Controller

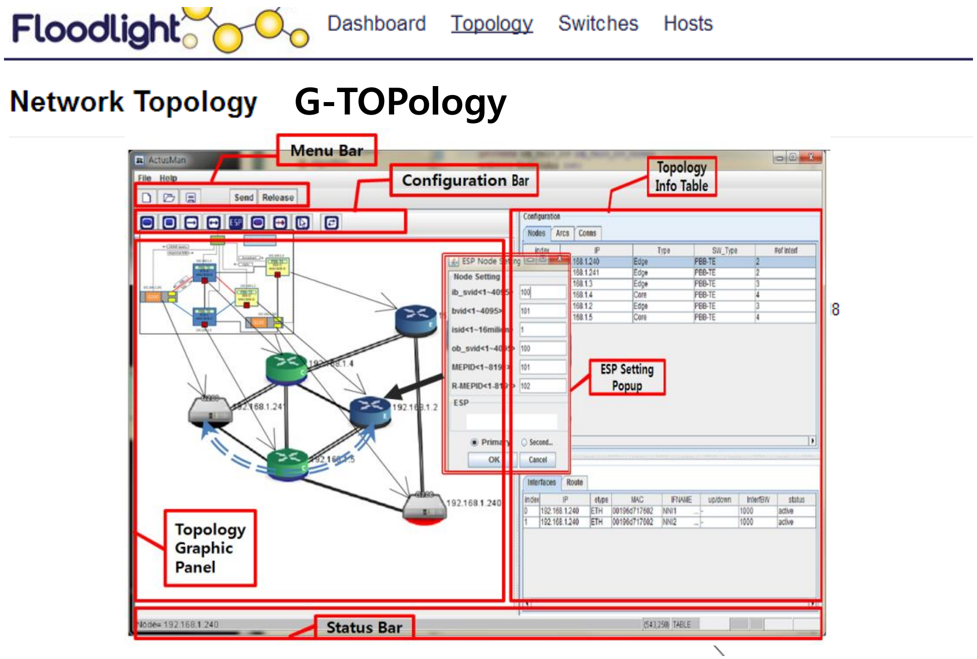


HYU testbed



Switches (2)

DPID	IP Address	Vendor	Packets	Bytes	Flows	Connected Since
00:00:10:6f:3f:0e:f7:f6	/192.168.11.124:50003	MIR Lab	0	0	0	2013년 10월 16일 오전 11:34:59
00:00:10:6f:3f:0e:f5:d8	/192.168.11.123:59917	Nicira, Inc.	0	0	0	2013년 10월 16일 오후 1:44:00

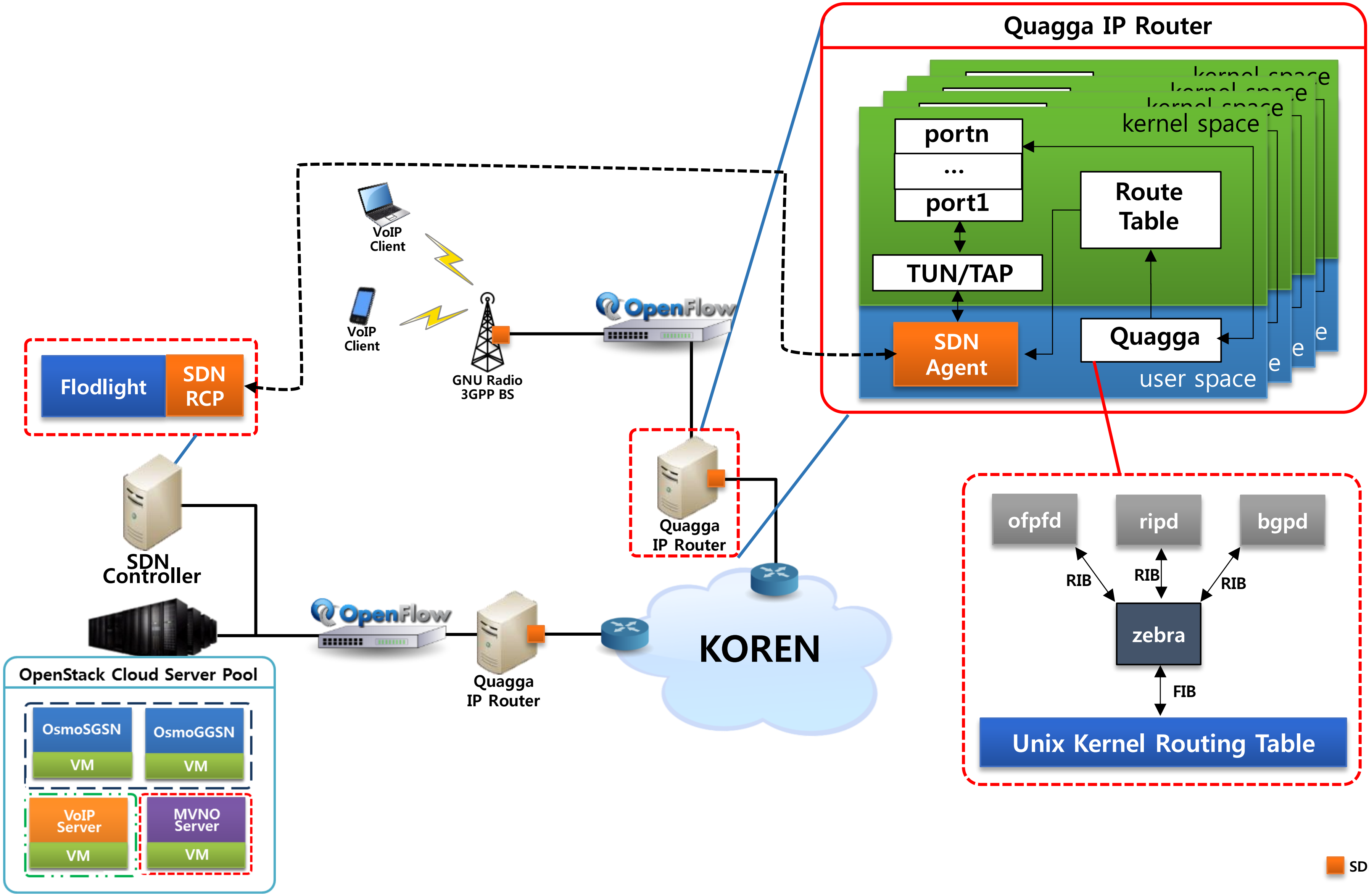


Network Topology G-TOPology

OpenWrt Test

🟧 SDN Agent

Constructing IP Router using Quagga – Router internal



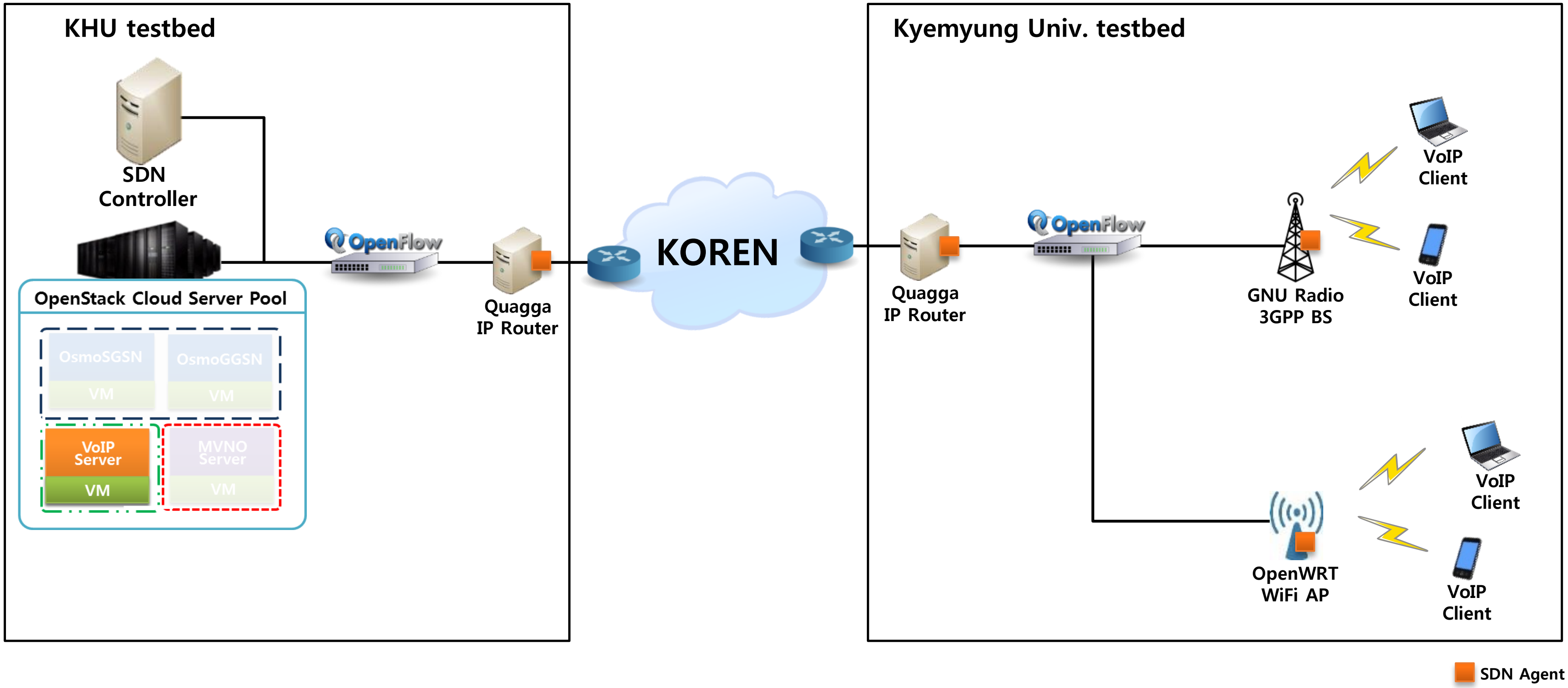
🟧 SDN Agent

VoIP Service Environment using Asterisk IP PBX

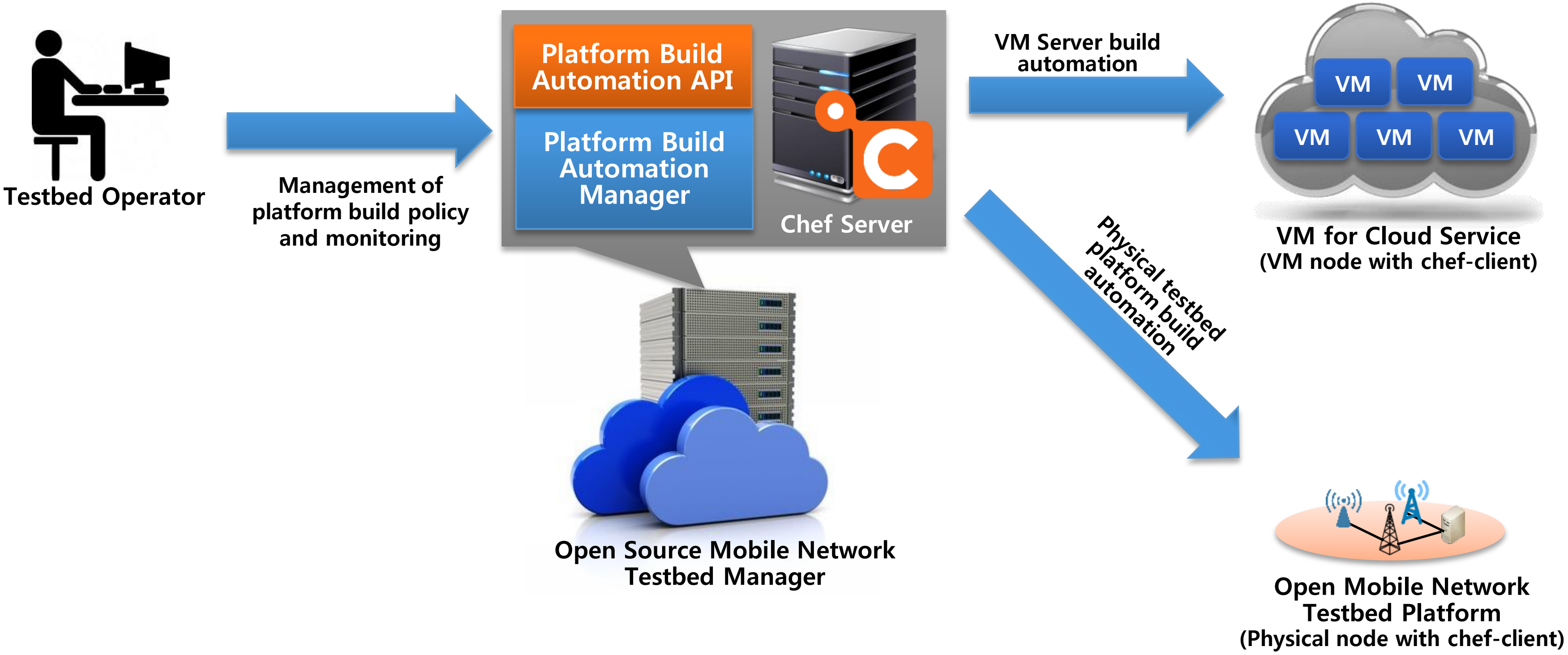
- Asterisk IP PBX (Private Branch eXchange) which is open source.
- Mobile VoIP Client
  - ✓ determine the CODEC according to quality state of access network by mobile terminal such as bandwidth, signal strength and delay.
  - ✓ LinPhone: installing VoIP client on various OS based smart device and laptop
    - Android / iOS / Ubuntu
- Test for VoIP service under GNU Radio 3GPP and OpenWRT Wi-Fi environment
  - ✓ SIP Messaging service
- Digium Web UI
  - ✓ Digium Asterisk Web UI 2.0-r5220 (Open source)
  - ✓ http://163.180.141.237:8088/static/config/index.html

VoIP Service Environment using Asterisk IP PBX (ctd.)

- VoIP service environment on Openstack
  - IP PBX: Asterisk 11.5.1
  - VoIP Client: Linphone
    - ✓ Android based Galaxy Note 10.1 / Galaxy Tab 1 / XPERIA Ray
    - ✓ Ubuntu based Laptop



Development of Platform Build Automation System


Testbed Operator
Management of platform build policy and monitoring
Platform Build Automation API
Platform Build Automation Manager
Chef Server
Open Source Mobile Network Testbed Manager
VM Server build automation
VM
VM
VM
VM
VM
VM for Cloud Service
(VM node with chef-client)
Physical testbed platform build automation
Open Mobile Network Testbed Platform
(Physical node with chef-client)

Future Research Plan for the Second-half

Constructing eNodeB for providing 4G LTE

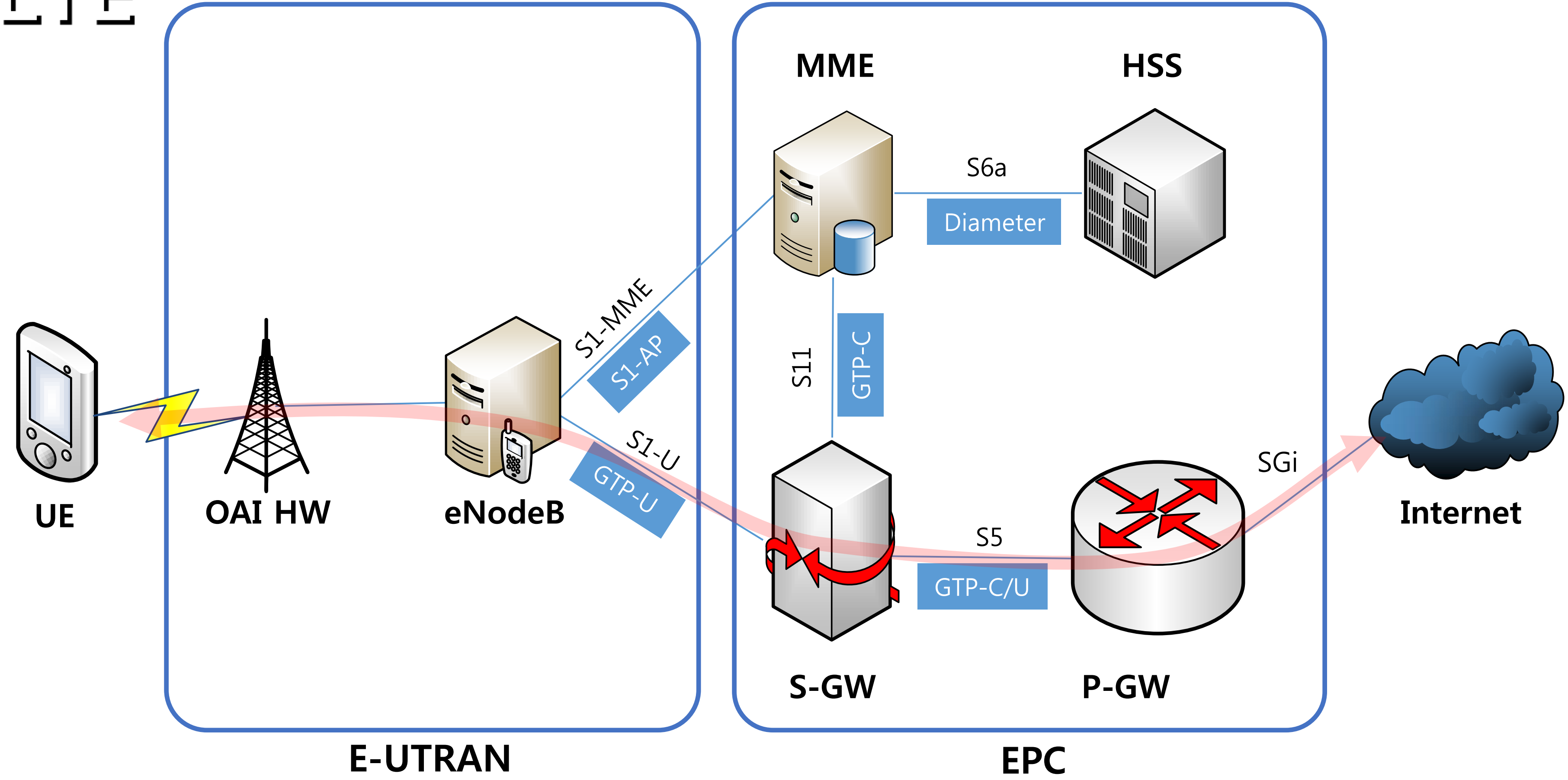
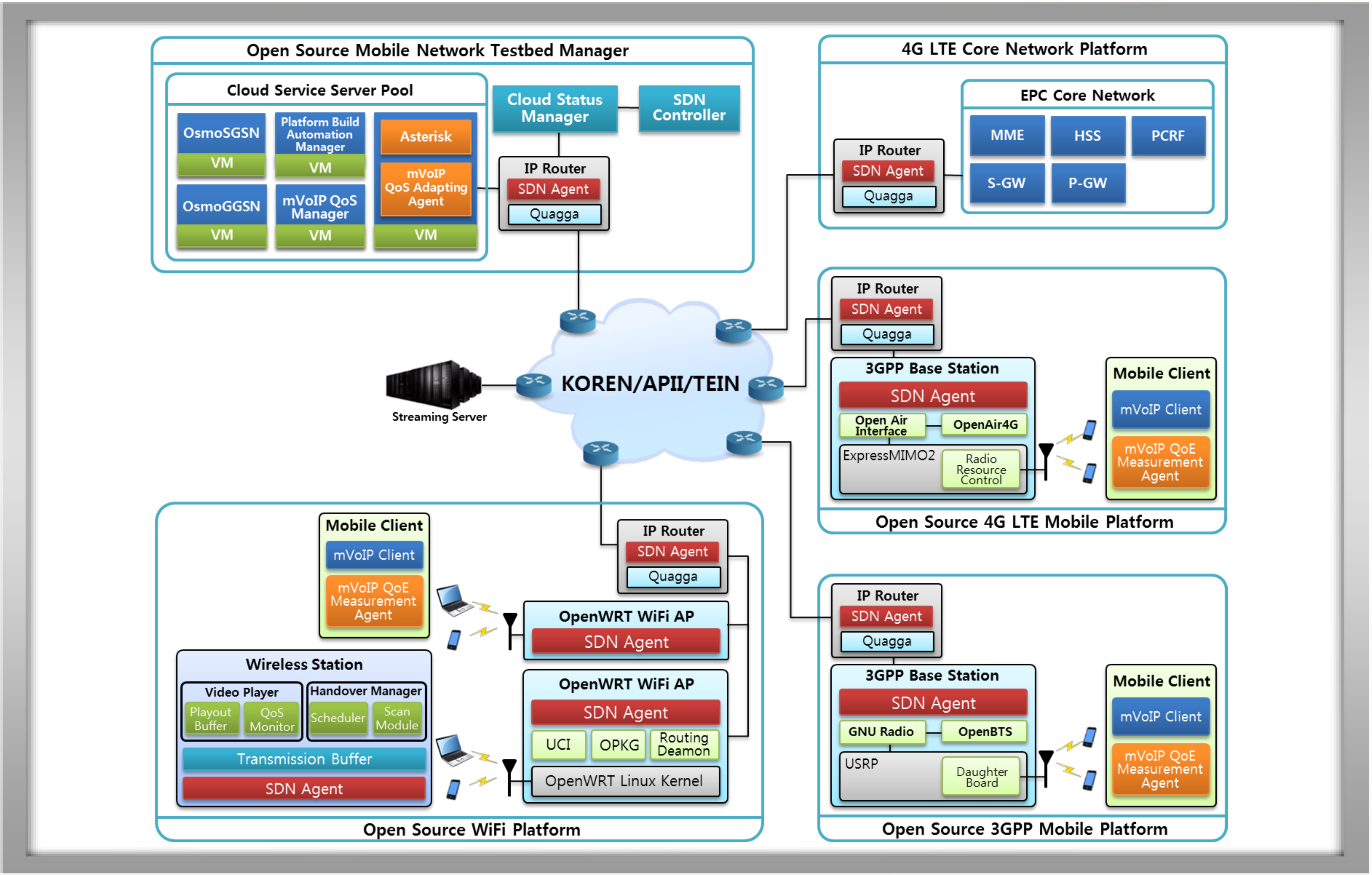


Fig. Cellular Network architecture based on Open Air Interface

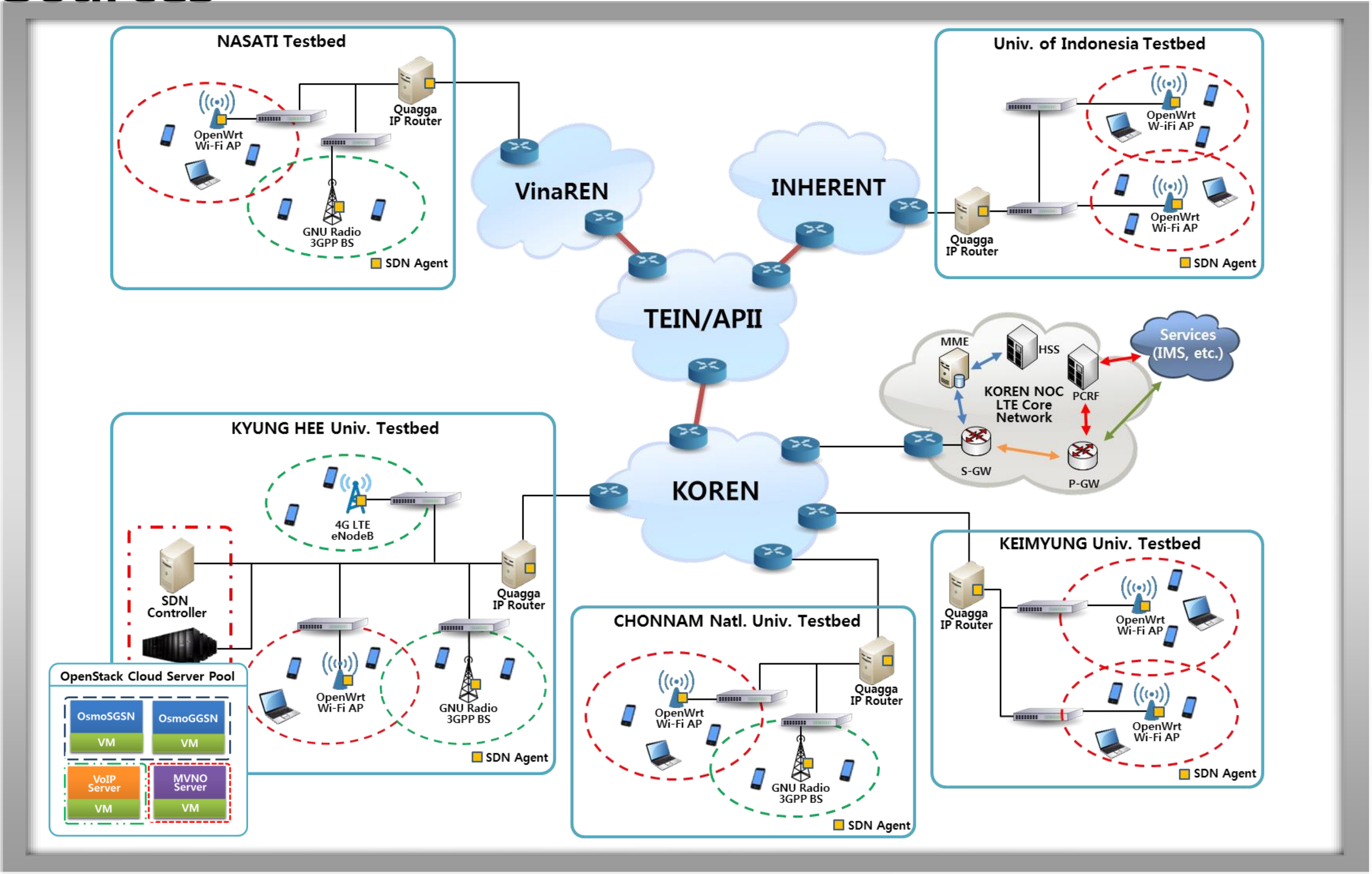
UE: User Equipment
E-UTRAN: Evolved Terrestrial Radio Access Network
eNodeB: Evolved Node B
GTP: GPRS Tunneling Protocol
OAI: Open Air Interface

MME: Mobility Management Entity
HSS: Home Subscriber Server
S-GW: Serving Gateway
P-GW: PDN Gateway

Overall Architecture for OSS based Mobile Networks



Testbed for Mobile Networks Based on Open Sources



Verification Test with International Research Network

- Verification test for platform build automation system
  - Check whether the required Open Mobile Network platform can perform remote auto-configuration
  - Check whether availability of Monitoring for status of building platform
- Open Mobile Network platform connection test
  - Test for Internet connection using Wi-Fi AP based on OpenWrt
  - Test for Internet connection using 3GPP mobile network platform
  - Test for Internet connection using 4G LTE mobile network platform
- mVoIP service verification test considering QoS/SLA
  - Check whether the improve call quality according to monitoring result from Agent
  - Call Quality measurement according to Call Quality MOS-CQE
- Verification test for Fast Handover between APs based on Wi-Fi which provide real-time streaming traffic
  - Measurement of Handoff delay in inter domain
  - Measurement of Handoff delay between other domain

Q&A

Thank you!