An Implementation Model and Solutions for Stepwise Introduction of SDN

-A proposal of AP-GW model-

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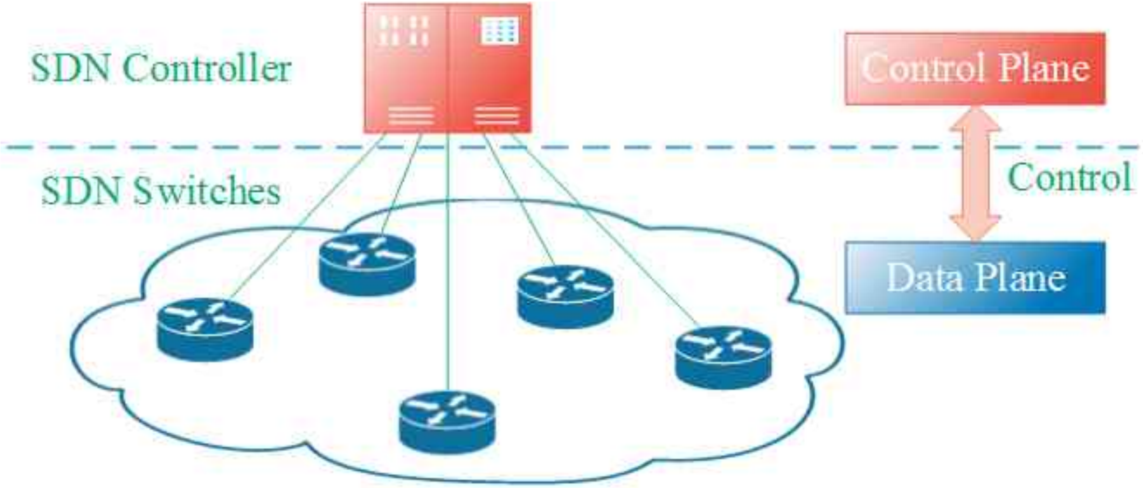
Background

- Software-Defined Network (SDN) has been interested in the field of network management.
  - It enables flexible and uniform management.
  - It has been expected to overcome the issues of network administrations.
    - Reduction of human error by reducing human intervention.
    - Providing high quality network with small cost by integrating network resource.
- Example of actual use case
  - Data Center
    - Using network resource with aggregated control
  - Wide Area Network
    - Rapid control against service dependent network
  - Security
    - Countermeasure against DDoS

Problem on conventional SDN implementation model



- Adaption against conventional network protocols
  - Necessary to handle traditional network routing protocols.
  - Implementing against closed local network
    - Requires to change almost all of the switches in the network
- Issues on the scalability
  - Load against controller increases depending on the scale of controlled network

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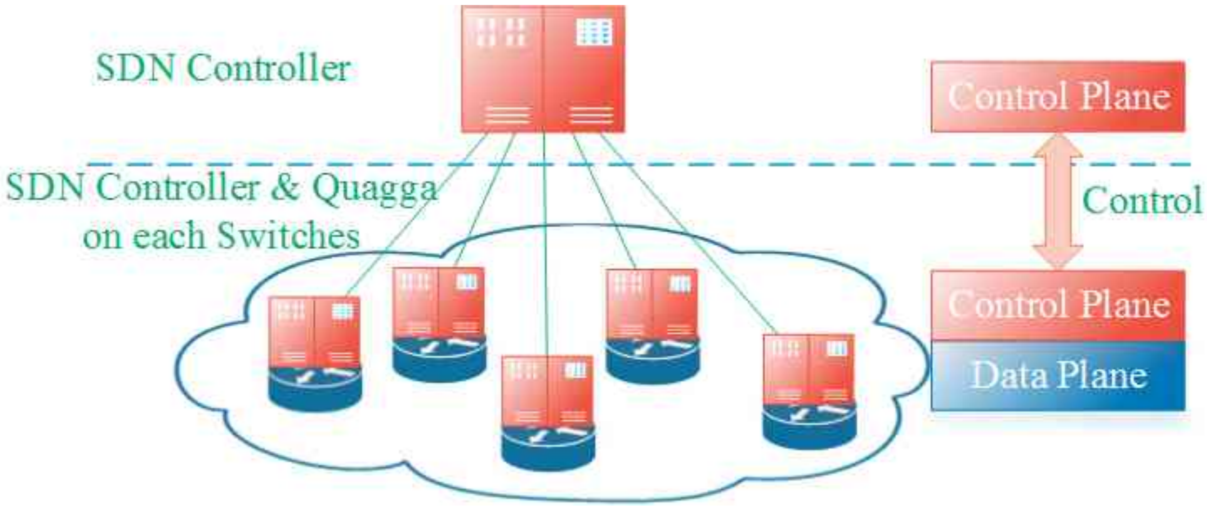
Objective

- Propose the stepwise implementation AP-GW model for SDN.
  - Adaption against traditional network routing protocols.
  - Improvement of scalability by distributing controllers.

- Cooperation with traditional IP networks and implementation of network resource management faculty.
  - Run Quagga on each SDN switches to exploit management function of traditional IP network resources.
  - Run SDN controller on each SDN switches to construct a hierarchical and de-centeralized structure.
- Implementation of prototype of proposed model.
  - Demonstrate that our proposal can be useful.

Proposal of AP-GW



- Improvement of scalability
  - Hierarchical structure enables to distribute the load of controller.
  - Processing load derived by adapting against traditional routing protocol can be reduced.
- Possibility of stepwise implementation
  - SDN can be implemented with small implementation costs.
  - Synchronizing between flow-table and FIB for internet routing

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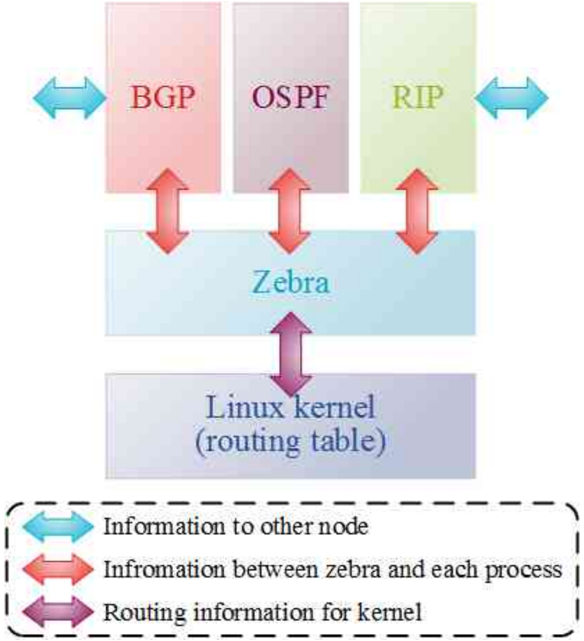
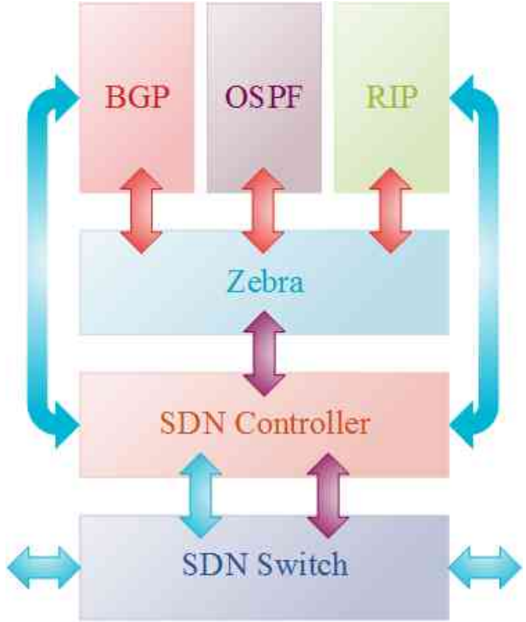
Implementing each module on SDN switch



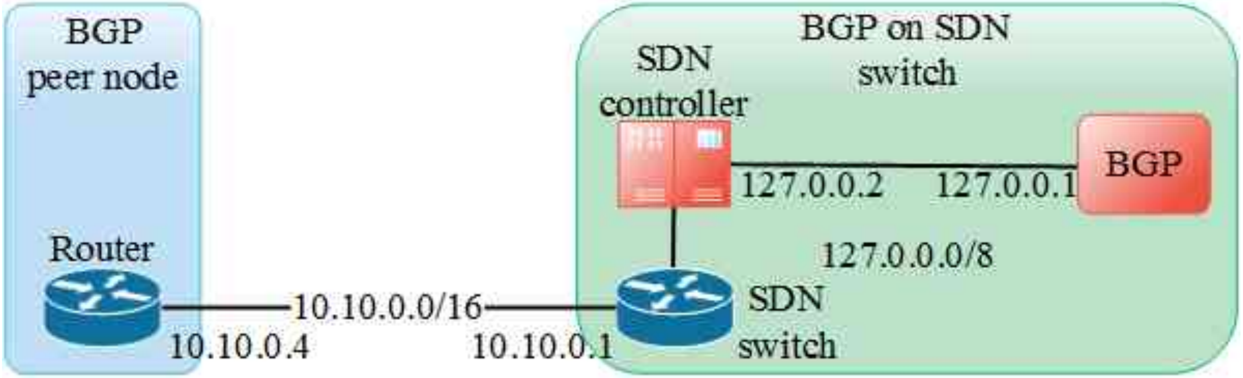
Quagga on Linux machine



Quagga on SDN switch

- OF ports cannot send out packets without OF functions.
  - Enable daemon program to communicate with others via OF ports.
  - Functions to packet out local transferred packets (SDN-NAPT).
- Packet transfers are based on flow information.
  - Translation function between routing information and flow entry.

Outline of SDN-NAPT



Global		Local (Loopback)	
dst	src	src	dst
10.10.0.4:179	10.10.0.1:37348	127.0.0.2:8179	127.0.0.1:44156

- RAW socket for internal packet translation and OF function for external packet translation are used for communication.
  - RAW socket is adopted to support the equivalence of translation.
  - Not only BGP but also any service can be provided.

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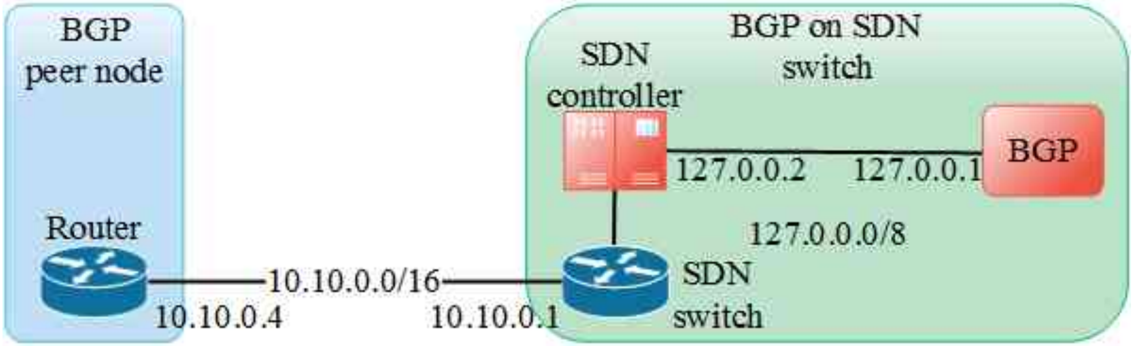
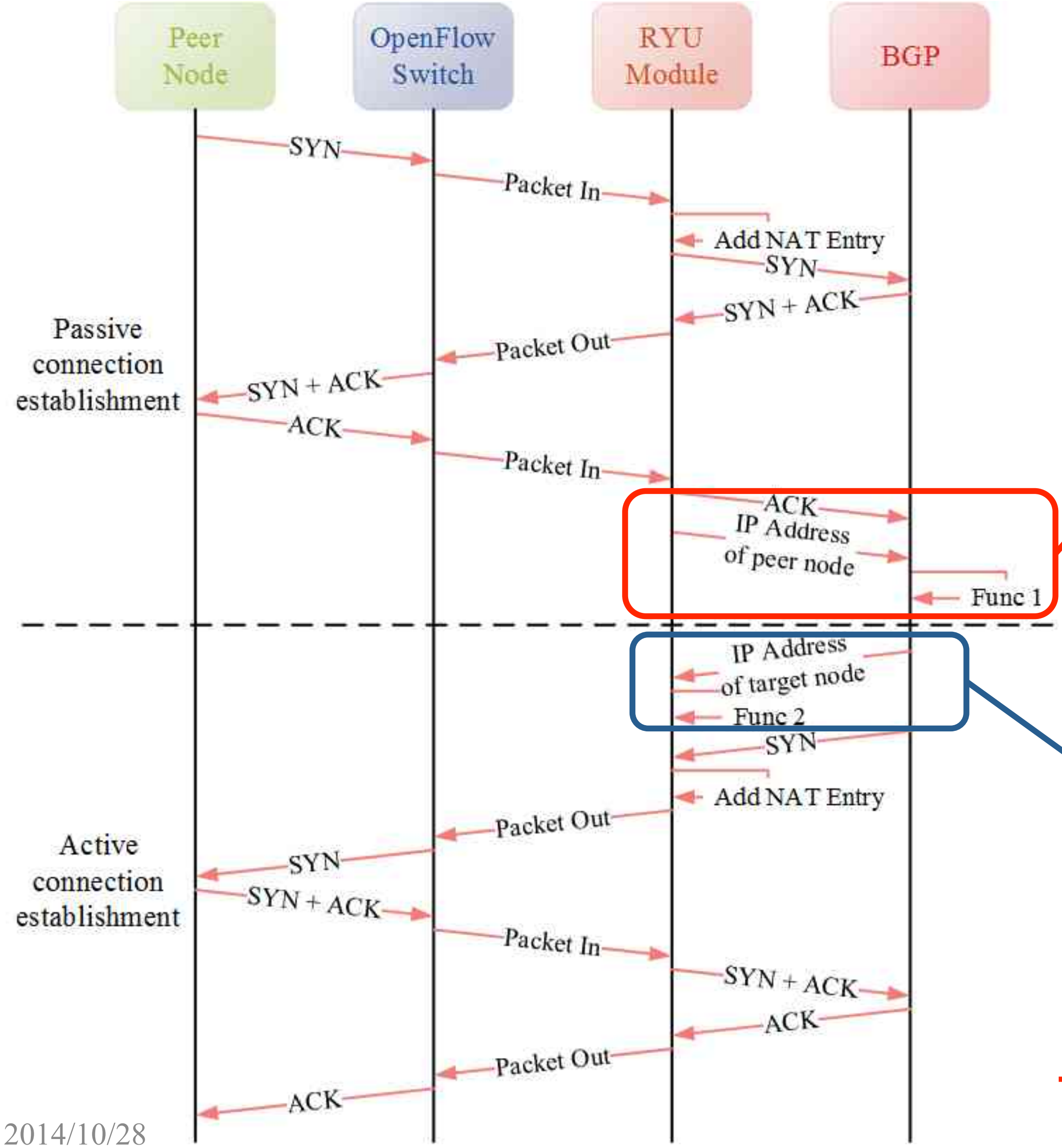
Implementation of SDN-NAPT

- Loop back address will be default gateway from the local service.
  - IP address of it self cannot be set as default gateway.
  - IP address of SDN controller have to be set as destination address.



- BGP makes a connection only against BGP peer node.
  - Spoofing function against BGP process is required.
- BGP establishes peer connection.
  - It is necessary to notice the information of destination node to controller for an active connection from BGP process.

Sequence of session initiation of SDN-NAPT



Override the IP address of destination peer after establishment of BGP session.

Notice information of destination node before connection establishment

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Translation of routing information to flow entry

- Correspondence between routing information and flow entry

Kernel routing table	Flow entry
Destination	match : nw_dst
Gateway	actions : setfield
Metric	priority
Iface	actions : output

  - MAC address is required to be handled by flow entry, where kernel routing table does not.
- Example of translation
  - Kernel routing table

```
# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
20.10.0.0       10.10.0.2       255.255.0.0     UG    0      0        0 eth1
```

  - Flow entry

```
# ovs-ofctl dump-flows br0 --protocol=OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=2.976s, table=0, n_packets=0, n_bytes=0,priority=1000,
ip,nw_dst=20.10.0.0/16 actions=set_field:08:00:27:e0:db:bf->eth_dst,
set_field:08:00:27:bf:22:e9->eth_src,output:2
```


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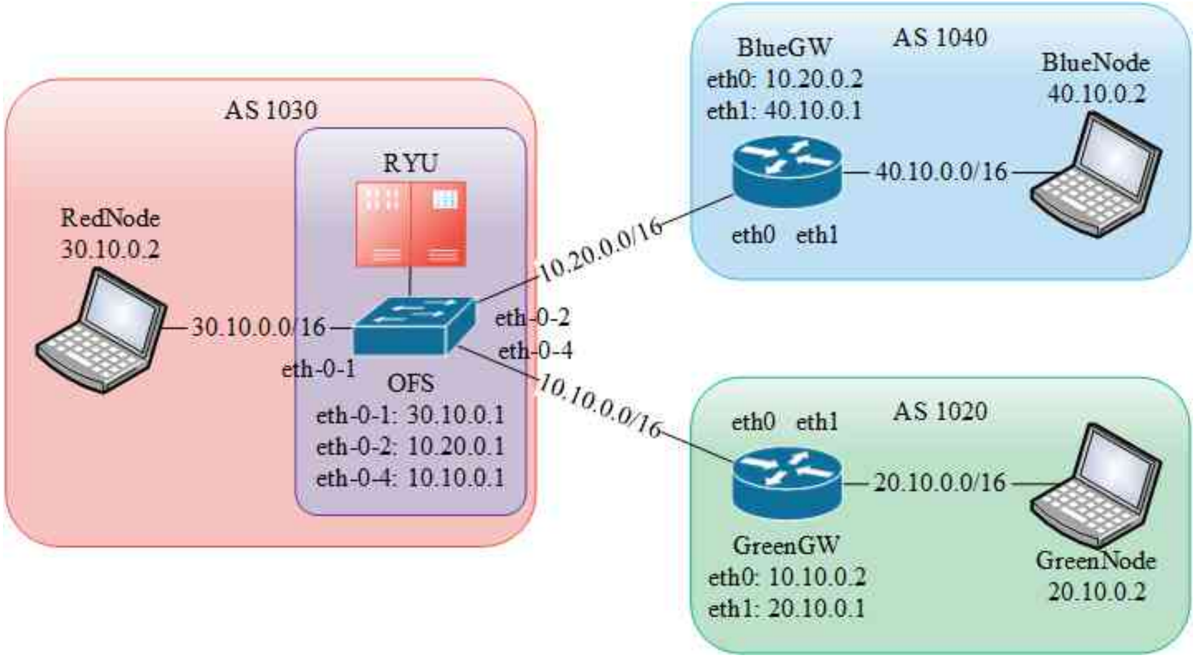
Evaluation environment



- Conducted an operational verification
  - Correct BGP communication between OFS and each GWs
  - Routing information and flow entry of each switches

Evaluation result

- Dump of packets between GreenGW and OFS

dumpEth0_1.pcap [Wireshark 1.10.5 (SVN Rev Unknown from unknown)]

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No.	Time	Source	Destination	Protocol	Length	Info
3	0.113349	10.10.0.2	10.10.0.1	TCP	74	59110 > bgp [SYN] Seq=0 Win=146
4	0.158063	10.10.0.1	10.10.0.2	TCP	74	bgp > 59110 [SYN, ACK] Seq=
5	0.158145	10.10.0.2	10.10.0.1	TCP	66	59110 > bgp [ACK] Seq=1 Ack
6	0.158430	10.10.0.2	10.10.0.1	BGP	119	OPEN Message
7	0.226337	10.10.0.1	10.10.0.2	TCP	66	bgp > 59110 [ACK] Seq=42949
8	1.115588	10.10.0.1	10.10.0.2	BGP	138	OPEN Message, KEEPALIVE Mes
9	1.115648	10.10.0.2	10.10.0.1	TCP	66	59110 > bgp [ACK] Seq=54 Ac
10	1.116089	10.10.0.2	10.10.0.1	BGP	104	KEEPALIVE Message, KEEPALIV
11	1.192189	10.10.0.1	10.10.0.2	TCP	66	bgp > 59110 [ACK] Seq=1 Ack
12	1.228733	10.10.0.1	10.10.0.2	TCP	66	bgp > 59110 [ACK] Seq=1 Ack=92
13	1.229402	10.10.0.1	10.10.0.2	BGP	85	KEEPALIVE Message
14	1.259803	10.10.0.2	10.10.0.1	TCP	66	59110 > bgp [ACK] Seq=92 Ac
15	1.360882	10.10.0.1	10.10.0.2	TCP	66	bgp > 59110 [ACK] Seq=20 Ac
16	2.130025	10.10.0.2	10.10.0.1	BGP	177	UPDATE Message, UPDATE Mess
17	2.193100	10.10.0.1	10.10.0.2	BGP	172	UPDATE Message, UPDATE Message
18	2.193150	10.10.0.2	10.10.0.1	TCP	66	59110 > bgp [ACK] Seq=203 Ack=1

OPEN Message

KEEPALIVE Message

UPDATE Message

BGP messages are transferred as expected

Evaluation result cont.

- Dump of flows in each node
  - GreenGW

```
# route -n
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
0.0.0.0         10.10.0.1       0.0.0.0         UG    0      0        0 eth0
10.10.0.0       0.0.0.0         255.255.0.0     U     0      0        0 eth0
10.20.0.0       10.10.0.1       255.255.0.0     UG    1      0        0 eth0
20.10.0.0       0.0.0.0         255.255.0.0     U     0      0        0 eth1
30.10.0.0       10.10.0.1       255.255.0.0     UG    0      0        0 eth0
40.10.0.0       10.10.0.1       255.255.0.0     UG    0      0        0 eth0
```

Routing information of AS1030 (OFS)

  - OFS

```
Switch# ovs-ofctl dump-flows br0 --protocol=OpenFlow13
OFPST_FLOW reply (OF1.3) (xid=0x2):
 cookie=0x0, duration=216.25s, table=0, n_packets=0, n_bytes=0,
priority=1000,ip,nw_dst=40.10.0.0/16 actions=set_field:00:0a:85:07:0c:34-
>eth_dst,set_field:00:1e:08:08:93:38->eth_src,output:4
 cookie=0x0, duration=200.05s, table=0, n_packets=0, n_bytes=0,
priority=1000,ip,nw_dst=20.10.0.0/16 actions=set_field:00:0a:85:07:0c:38-
>eth_dst,set_field:00:1e:08:08:93:36->eth_src,output:2
 cookie=0x0, duration=218.471s, table=0, n_packets=31, n_bytes=2692,
priority=10 actions=CONTROLLER:65535
```

Routing information of AS1020 (Green)

Routing information are transferred as expected

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Conclusion and future work

- Conclusion
  - We proposed the implementation model of AP-GW which can overcome the problems of current SDN implementation model.
  - We introduced the specific design and implementation of our prototype and demonstrated that our implementation can handle conventional network protocols.
- Future work
  - Implementation of distributed controller for the wide area network.
  - Evaluation using real monitored data in the service network.
  - Overcome the problem of small flow entry size of current OpenFlow switch.

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