NEC OpenFlow enabled IP8800/S3640

User's Guide

Revision 1.2

04/30/2009

Empowered by Innovation

NEC

Revision History

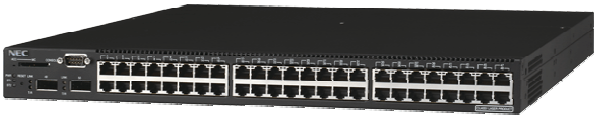
Revision	Date	Author	Description
1.0	04/11/2009	Yasunobu Chiba	Initial release.
1.1	04/11/2009	Yasunobu Chiba	Conditions that a flow entry is registered to the hardware search engine are described.
1.2	04/30/2009	Yasunobu Chiba	Rev159 support.

Contents

1. Basics

There are two types of OpenFlow prototype switches which are based on NEC's product IP8800/S3640-24T2XW and IP8800/S3640-48T2XW (http://www.nec.co.jp/ip88n/ip8800_s3640/index.html).

IP8800/S3640-24T2XW



IP8800/S3640-48T2XW

1.1 Interfaces

Interface	# of ports	
	S3640-24T2XW	S3640-48T2XW
1000BASE-T	24 (*1)	48
1000BASE-X(SFP)	4 (*1)	0
10G BASE-R (XFP)	2	2

*1: Four ports can be configured as SFP ports.

1.2 Supported OpenFlow Spec

There are three releases:

OpenFlow spec.	NEC software revision	Release date
v0.8.1	113	11/09/2008
v0.8.2	113nh	11/09/2008
v0.8.9	159	04/30/2009

Note that both v0.8.1 and v0.8.2 are no longer supported. We suggest you to use the latest version of the software.

1.3 Features

Feature	Description
Wirespeed OpenFlow Switching	Switching capacity: 88Gbps, 65.5Mpps (S3640-24T2XW) 136Gbps, 101.2Mpps (S3640-48T2XW)
Virtual OpenFlow Switch	Multiple OpenFlow switch instances on one box (port-based and VLAN Tag-based). Each switch can be controlled by the different controller.
Flow Table Quota	Number of flow entries can be statically allocated to each virtual OpenFlow switch.

1.4 Flow Tables

There are three types of flow tables, hardware table and two software tables. The hardware table is shared among virtual OpenFlow switches while software tables are dedicated to each virtual switch. If a flow entry satisfies the following four conditions, the entry is set to the hardware flow table. Otherwise, one of the software tables is used.

- Exact match
- IPv4 packet (Ether Type = IPv4)
- Single action
- (Output to a single physical port) or (Output to a single physical port + MAC DA modification)

Note that even if a flow entry is registered on the hardware table, IP fragment is forwarded by software forwarder exceptionally. The hardware table can be configured as "single-wide mode" or "double-wide mode". If "single-wide mode" is selected, hardware forwarding engine will match only the fields in IP, TCP/UDP header and VLAN ID. In the case of "double-wide mode", hardware forwarding engine will match all the header fields specified in OpenFlow Spec but the number of flow entries is limited. The following table shows the maximum number of flow entries in each table.

Hardware	Single-wide mode (Exact match)	[IP8800/S3640-24T2XW] 3046 entries [IP8800/S3640-48T2XW] For port 1-24, 49-50: 3046 entries

		For port 25-48: 3048 entries
	Double-wide mode (Exact match)	[IP8800/S3640-24T2XW] 1510 entries [IP8800/S3640-48T2XW] For port 1-24, 49-50: 1510 entries For port 25-48: 1512 entries
Software	Exact match	131072 entries/virtual switch
	Wildcard match	100 entries/virtual switch

1.5 Performance

Packets which hit hardware flow entry are forwarded in wire speed. Packets which hit software flow entry are forwarded by software. The following table shows the forwarding performance.

Hardware Forwarding		88Gbps, 65.5Mpps (S3640-24T2XW) 136Gbps, 101.2Mpps (S3640-48T2XW)
Software Forwarding	64 bytes	1674 pps (0.8Mbps)
	256 bytes	1611 pps (3.2Mbps)
	512 bytes	1470 pps (6.0Mbps)
	1024 bytes	1332 pps (10.9Mbps)
	1518 bytes	1223 pps (14.8Mbps)

2. Pre-requirements

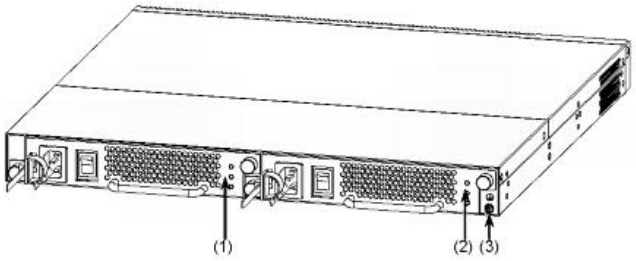
First of all, please make sure that you have all required hardware, OpenFlow enabled firmware and software license file before you start installation/configuration. The required items are shown in the table below.

Item		#
Hardware	Switch: IP8800/S3640-24T2XW or IP8800/S3640-48T2XW	1
	Power Supply Unit (PSU) and Power Cable: PS-A01	1-2
	FAN Unit: FAN-01 (required if you use only one PSU)	0-1
	SD Card: SD128(T)	1
	Serial Cable: Crossover serial cable with DE9F connectors	1
Software	OpenFlow enabled IP8800 firmware (k.img)	1
	Software license for OpenFlow enabled IP8800 (license.dat)	1

Serial console terminal with DE9M serial connector	1

If you do not have the firmware, please consult with us. Also, if you do not have the software license, please send an email with the serial number of your switch (the number can be found in the output of "show version" command).

3. Hardware Installation



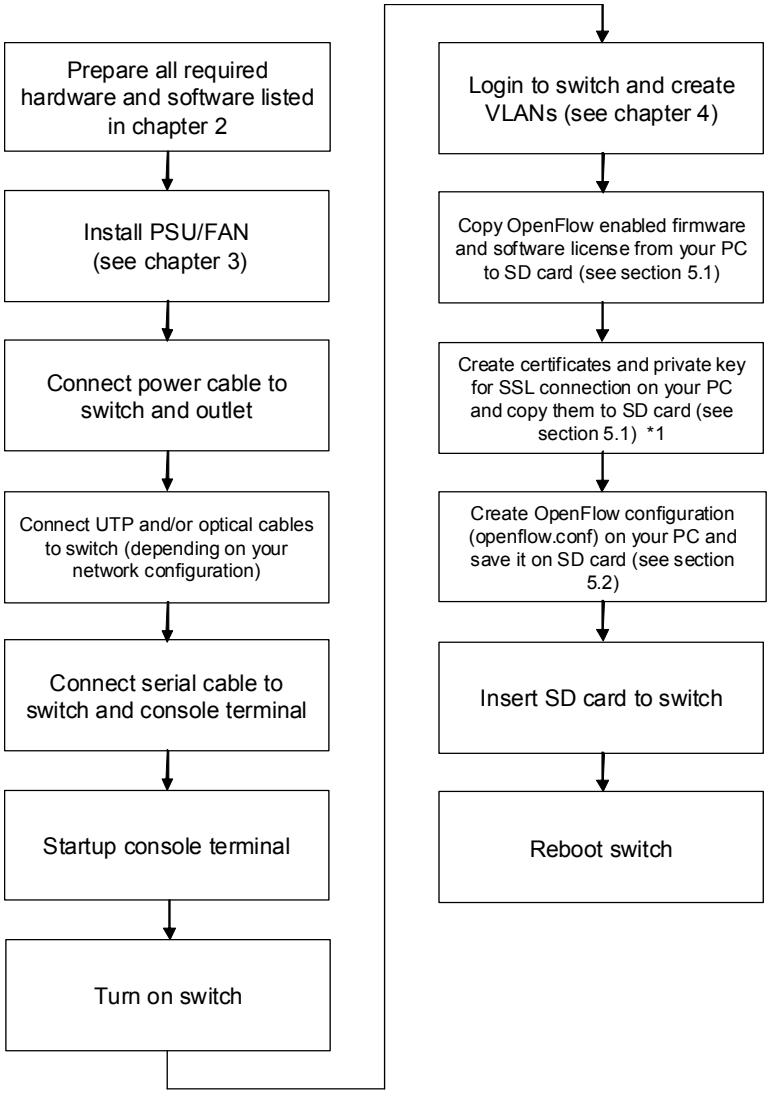
(1) PSU Slot #1
(2) PSU Slot #2
(3) GND

Power Supply Unit Installation

Please look the figure above. If you have two PSUs (PS-A01), insert them to the slot #1 and #2. If you have only one PSU, insert PSU to the slot #1 and insert FAN unit (FAN-01) to the slot #2.

4. How to configure?

Follow the flow chart below to setup the OpenFlow enabled switch.



*1: Only required if you use SSL connection as Secure Channel.

Here we explain how to configure the switch from CLI. You can create a configuration file containing the commands we explain here, store it in SD card, and copy the configuration to the startup configuration file.

4.1 Step1: Login to the switch

4.1.1 Via network

Telnet to the switch's IP address (if you've already configure the switch's IP address)

4.1.2 Serial Port

Use normal null-modem cable (crossover serial cable). Here is the configuration of serial connection:

Baud rate	9600
Data	8bit
Parity	none
Stop	1bit
Flow Control	none

First, you need to login to the switch. Default username is "operator". Password is not set.

```
login: operator

Copyright (c) 2005-2008 ALAXALA Networks Corporation. All rights
reserved.
```

Then you need to run "enable" command and "configure" command.

```
> enable
# configure
(config)#
```

Now you can start putting the following command.

4.2 Step2: Creating vlan for OpenFlow switch

First, you need to disable STP because it does not work in OpenFlow enabled mode.

```
spanning-tree disable
```

Then create a vlan for OpenFlow switch. Here is an example:

```
vlan 1
name "OpenFlow Project A"
```

Then associate ports to the created vlan. Specify "switchport mode dot1q-tunnel" to those interfaces.

```
interface gigabitethernet 0/1
 switchport mode dot1q-tunnel
 switchport access vlan 1
interface gigabitethernet 0/2
 switchport mode dot1q-tunnel
 switchport access vlan 1
interface gigabitethernet 0/3
 switchport mode dot1q-tunnel
 switchport access vlan 1
interface gigabitethernet 0/4
 switchport mode dot1q-tunnel
 switchport access vlan 1
```

As we see later, we can have multiple OpenFlow switches on one physical switch. You need to create different vlans and associate ports exclusively to each vlan.

```
vlan 2
  name "OpenFlow Project B"
interface gigabitethernet 0/5
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/6
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/7
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/8
 switchport mode dot1q-tunnel
 switchport access vlan 2
```

The switch also allows us to assign a tagged VLAN on a single interface to OpenFlow switch (as a logical port of OpenFlow switch). In such cases, specify "switchport mode trunk" and "switchport trunk allowed vlan *VLANIDs*" to receive tagged frames on the

interface. Here is an example.

```
interface gigabitethernet 0/9
 switchport mode trunk
 switchport trunk allowed vlan 1,2
```

In this case, frames received on the interface 0/9 can be forwarded to vlan 1 or vlan 2 based on VLAN tag.

4.3 Step3: Setup Control Interface

You need to have at least one interface through which OpenFlow switch can talk to the controller. To do so, create another vlan and associate at least one interface to the vlan, and then give the IP address to the vlan. You probably need to specify the default gateway (or routing table) to reach the controller. Here is an example.

```
vlan 3
  name "OpenFlow Control Vlan"
interface gigabitethernet 0/22
 switchport mode access
 switchport access vlan 3
interface vlan 3
  ip address 171.67.74.60 255.255.255.240
ip route 0.0.0.0 0.0.0.0 171.67.74.49
```

4.4 Step4: Save Configuration

Finally, you need to save current configuration as follows. "save" command copies current configuration to startup configuration.

```
(config)# save
```

4.5 Step5: Configure OpenFlow Switch

Please refer to the next chapter.

5. How to run OpenFlow switch?

To boot as an OpenFlow enabled switch, insert SD card (Secure Digital card) which

contains the OpenFlow-enabled boot image, a special license file for the OpenFlow enabled switch, and OpenFlow configuration file. The switch will boot as a normal IP8800/S3640 switch if the boot image is missing. The switch will not boot if the license file is missing or invalid but the boot image is provided.

5.1 SD Card

SD card has to contain the following files:

k.img	Binary file (executable image) for OpenFlow enabled IP8800/S3640.
license.dat	License file for OpenFlow enabled switch.
openflow.conf	Configuration file for (only) OpenFlow related features.

In addition, if you want to use SSL for secure channel, following files need to exist in SD card as well.

ca_cert.pem	Certification of CA (will be used for validating contoller's certification).
sw_cert.pem	Certification of this switch (with CA's signature).
sw_key.pem	Secret key of this switch.

Note that we suggest you to use NEC certified SD card. Otherwise, you may encounter a problem. A license file is associated with a specific physical switch. You cannot copy it to non-authorized switches. If you do not have the license file, please contact us with the output of the "show version" command.

5.2 openflow.conf

The file has to be Unix-style LF line-endings (not CR+LF). Be careful if you edit ofconf.txt with Windows. The line beginning with "#" will be ignored. There are three commands defined.

no-save	If specified, configuration changes won't be saved to the SD card (useful if using non-official SD card)

double-wide-mode	If specified, hardware forwarding engine will match all the header fields specified in OpenFlow Spec. If not specified, hardware forwarding engine will match only the fields in IP, TCP/UDP header and VLAN ID.
setvsi	Start OpenFlow switch. You can start multiple OpenFlow Switch on different vlans. This command has several parameters as shown in the table below.

setvsi <vlan id> <list of ports> <tcp|ssl> <controller ip address[:port]> [<ca cert> <my cert> <my private key>] [dpid <datapath id>] [hwlimit <max entry num>] [max-backoff <backoff time>] [echo-interval <interval time>]	
vlan id	OpenFlow vlan id, i.e., vlan id for OpenFlow switch.
list of ports	Port numbers belongs to OpenFlow vlan. Ports should be separated by ",". The range of ports can be specified by "-". "." is used to specify VLAN on a tagged port (e.g. 1.2 means vlan 2 on port 1).
tcp|ssl	Transport protocol of secure channel.
controller ip	IP address of the controller.
port	TCP port number of the controller.
ca cert	File name for the certification of CA.
my cert	File name for the certification of this switch.
my private key	File name for the secrate key of this switch.
datapath id	OpenFlow switch id (12 hex digits).
max entry num	Number of hardware flow entries will be allocated.
backoff time	Maximum interval between controller connection attempts in seconds.
Interval time	Interval between echo requests in seconds. If 0 is specified, echo is never sent.

Here is an example of the configuration file.

```
no-save
double-wide-mode
setvsi 1 1,2,3,4,9.1 tcp 172.16.4.180 dpid 0x0123456789ab
setvsi 2 5-8,9.2 tcp 172.16.4.64 dpid 0x01234567abcd
```

5.3 Boot

Insert SD card, and turn on the switch. OpenFlow switch will start automatically based on openflow.conf in SD card.

5.4 To run openflow switch manually

5.4.1 To stop

To stop a running openflow switch on vlan <vlan id>, use deletevsi command.

deletevsi <vlan id>	
vlan id	OpenFlow vlan id, i.e., vlan id for OpenFlow switch.

```
# deletevsi 1
```

5.4.2 To start

Use setvsi command. Please refer to openflow.conf section.

6. Useful command

6.1 Unix commands

Please take a look at /usr/bin, /usr/local/bin, /usr/sbin/, /usr/local/sbin.

6.2 showswitch

You can see the OpenFlow tables.

showswitch [<vlan id>] [detail]	
vlan id	OpenFlow vlan id.
detail	Show detailed switch information.

Example:

```
# showswitch
vlan    ports                                        secure channel
----    -----                                        --------------
1       1, 2, 3, 4, 9.1                               connected
2       5, 6, 7, 8, 9.2                               disconnected
```

```
# showswitch 1 detail
Virtual switch 1
  Datapath ID : 1250999896491(0x123456789ab)
  Port       : gigabitethernet 0/1 (link up, 1G full)
               gigabitethernet 0/2 (link up, 1G full)
               gigabitethernet 0/3 (link up, 1G full)
               gigabitethernet 0/4 (link up, 1G full)
               gigabitethernet 0/9.1 (link down)
  Conn mode   : tcp
  Controller  : 172.16.4.180:6633 (connected)
  Exact match : hw 0 / hw max 1510
  Exact match : sw 0 / sw max 131072
  Wildcard    : sw 0 / sw max 100
  Packet buff : 256 packets / 4294967295 MB
  Miss sendlen: 128 bytes
```

6.3 showflow

You can see the OpenFlow tables.

showflow [<vlan id>] [detail]	
vlan id	OpenFlow vlan id.
detail	Show detailed flow information.

Example:

```
# showflow
  duration=87s,table_id=0,priority=65535,n_packets=17,n_bytes=14
2,idle_timeout=60,hard_timeout=0,in_port=1,dl_vlan=ffff,dl_src=0
0:00:00:00:00:01,dl_dst=00:00:00:00:00:03,dl_type=0800,nw_src=19
2.168.1.1/32,nw_dst=192.168.1.3/32,nw_proto=17,tp_src=1024,tp_ds
t=1024,action=output:3
  duration=8s,table_id=0,priority=65535,n_packets=1,n_bytes=142,
idle_timeout=60,hard_timeout=0,in_port=2,dl_vlan=ffff,dl_src=00:
00:00:00:00:02,dl_dst=00:00:00:00:00:01,dl_type=0800,nw_src=192.
168.1.2/32,nw_dst=192.168.1.1/32,nw_proto=17,tp_src=1024,tp_dst=
1024,action=output:1
```

```
# showflow 1 detail
------------------------------------------------------------------------------
Matching key
  Input port  : 1                 VLAN ID    : 65535(0xffff)
  MAC SA      : 00:00:00:00:00:01    MAC DA     : 00:00:00:00:00:03
  TYPE        : 0x800[IP]           IP protocol : 17[UDP]
  IP SA       : 192.168.1.1/32       IP DA      : 192.168.1.3/32
  Source port : 1024(0x400)          Dest port   : 1024(0x400)
Information
  Idle timeout: 60 sec              Hard timeout: 0 sec
  Priority    : 65535
  IFP slice no: 15                IFP entry no: 0
  Packet count: 17                Byte count  : 142
  Created     : Wed Mar  4 15:34:41 2009
  Expires     : Wed Mar  4 15:36:23 2009
  Action type : 0[OUTPUT]           Max length  : 0
                                Output port : 3(0x3)
------------------------------------------------------------------------------
Matching key
  Input port  : 2                 VLAN ID    : 65535(0xffff)
  MAC SA      : 00:00:00:00:00:02    MAC DA     : 00:00:00:00:00:01
  TYPE        : 0x800[IP]           IP protocol : 17[UDP]
  IP SA       : 192.168.1.2/32       IP DA      : 192.168.1.1/32
  Source port : 1024(0x400)          Dest port   : 1024(0x400)
Information
  Idle timeout: 60 sec              Hard timeout: 0 sec
  Priority    : 65535
  IFP slice no: 15                IFP entry no: 1
  Packet count: 1                 Byte count  : 142
  Created     : Wed Mar  4 15:36:00 2009
  Expires     : Wed Mar  4 15:37:00 2009
  Action type : 0[OUTPUT]           Max length  : 0
                                Output port : 1(0x1)
```

7. Support

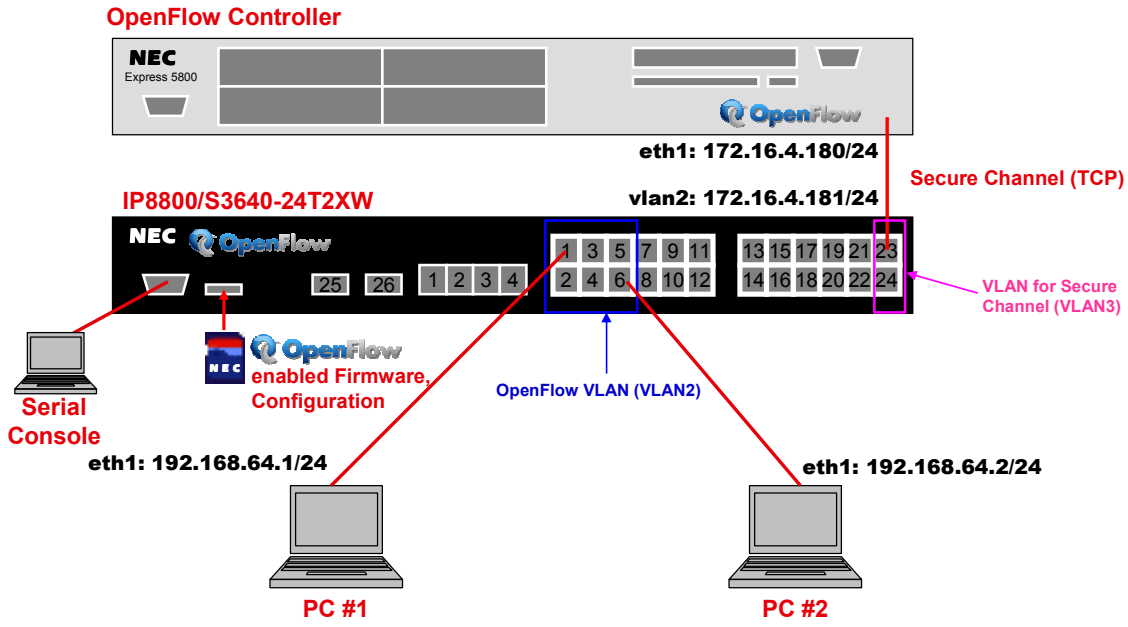
If you have any question, problem, or enhancement request regarding the switch, please feel free to contact us, ofs-support@spf.jp.nec.com. Please provide us with your network configuration and the output of the following commands when you send a problem report or question.

```
# cat /build_info
# cat /mnt/openflow.conf
# ls -l /mnt/k.img
# showswitch detail
# showflow detail
# show tech-support
```

We are on your side.

Appendix – Example

Here we provide a configuration example of the switch shown in the figure below.



In this example, port #1 to #6 are associated with VLAN2. VLAN2 is configured as an OpenFlow switch instance. The switch instance works in "double-wide" mode. Port #23 and #24 are associated with VLAN3 and port #23 is used to connect with OpenFlow controller. Remaining ports (#7-#22) are associated with default vlan (VLAN1) and work as a legacy L2 switch. VLAN and interface configuration might be:

```
spanning-tree disable
vlan 2
  name "OpenFlow VLAN"
vlan 3
  name "OpenFlow Control VLAN"
interface vlan 3
  ip address 172.16.4.181 255.255.255.0
interface gigabitethernet 0/1
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/2
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/3
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/4
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/5
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/6
 switchport mode dot1q-tunnel
 switchport access vlan 2
interface gigabitethernet 0/23
 switchport mode access
 switchport access vlan 3
interface gigabitethernet 0/24
 switchport mode access
 switchport access vlan 3
```

SD card contains three files; OpenFlow enabled firmware (k.img), software license (license.dat), and OpenFlow configuration (openflow.conf). openflow.conf might contain:

```
double-wide-mode
setvsi 2 1-6 tcp 172.16.4.180 dpid 0x0123456789ab
```