PIX-IE
An SDN-based Programmable Internet eXchange

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Our Background

- Operating an academic IX (DIX-IE) in Japan
  - a common layer 2 IX
  - an experimental and academic IX in Japan

- Challenge making an SDN-based IX since 2014
  - improving IX functionalities with SDN technologies
SDN IX = SDN + IX

SDN IX

IX

- Interconnection
- Stability
- Prefix-based control

SDN

- Programability
- Flexibility

Flexible Route Control
Flexible Path Exchange
Security
PIX-IE

- Programmable Internet Exchange in Edo
  - enhancing IX functionality by using SDN technologies (e.g. OpenFlow)
  - implementing and testing the IX with actual customers
Remarkable Features of the PIX-IE

- BUM traffic localization and reduction
- L2 Path Exchange
- DDoS Mitigation

- Low Cost
  - using merchant chip-based switches and original controller based on open source tools
  - software-based switch (Lagopus)
Current Implementation of the PIX-IE

- Control Plane
  - Ryu (a python-based OpenFlow controller framework)
    - we do not use huge SDN controllers

- Data Plane
  - NEC PF5240, DELL s6000, lagopus (on a commercial X86 server)

- Management Interface
  - Flask (python-based Web Application Framework)

- Protocol
  - OpenFlow 1.3
Operation Model

- AS operators directly configure the PIX-IE through the controller interface
  - e.g. add new peering, packet filtering,...
PIX-IE Features

- BUM traffic localization and reduction
- L2 Path Exchange
- DDoS Mitigation
BUM traffic localization and reduction

- proxy ARP and ND
- reduce undesired broadcast packets on IX networks
  - avoid network troubles such as broadcast storm on the IX
  - only allow traffic for exchanging route information and forwarding
BUM traffic localization (cont’d)

- PIX-IE Controller
- ARP/ND Probe
- AS X ASBR
- OpenFlow Switch
- AS Y ASBR

9/29/16
BUM traffic localization (cont’d)

AS – IP List (known)

\{
  "AS X" : <ASBR IP X>,
  "AS Y" : <ASBR IP Y>
\}
Send ARP requests and ND neighbor solicitation packets to the listed IP addresses and record the replied info
When make a peering between AS X and AS Y

Forward the ARP request packet to only the controller by the flow entry

<arp request>
dst mac : ff:ff:ff:ff:ff:ff
src mac : AS X’s MAC
sender IP : AS X’s IP
target IP : AS Y’s IP

<flow entry (pre-installed)>
match :
  eth type == ARP, arp opcode == 1
action :
  packet-in
When make a peering between AS X and AS Y

Get the destination MAC address of the request on the controller
When make a peering between AS X and AS Y

Compose an ARP reply and send the reply to AS X’s ASBR through the OpenFlow switch
PIX-IE Features

- BUM traffic localization and reduction
- L2 Path Exchange
- DDoS Mitigation
Deployment in INTEROP Tokyo 2014/2015

- INTEROP Tokyo
  - the largest ICT exhibition in Japan
  - over 140,000 people participated every year

- ShowNet
  - the largest interoperability testing and demonstrating network since 1994
  - still driving by volunteer members from academic and industry in Japan
  - deployed our prototype of the PIX-IE with NTT lab team (lagopus team)
2014: Path Exchange

- connecting 70 layer-2 paths among external and ShowNet

Traffic Volume

AS-VLAN mapping list

VLAN mapping topology
2015: DDoS Mitigation on the PIX-IE

- mitigating DDoS traffic on IX switches in realtime
  - current IXs cannot mitigate attack traffic on their fabric
External (IX/Transit/REN)

PIX-1F
2015: DDoS Mitigation on the PIX-IE

① generate DDoS traffic (SYN Flood, DNS Amp)

② collect sFlow data

③ flow analyzer

④ share detection result on our sharing platform

⑤ Apply traffic filters on the SDN IX

TestCenter

Internet2
We faced many problems...

- Undesired loops and storms...
  - the troubles cannot accept on IXs
  - solid mechanisms for rule validation is required
- Data Plane implementation
  - each switches has different implementation of OpenFlow data plane
- Lost controller
  - when a controller session is lost, many OF switches flush their OpenFlow table....
  - hybrid switches work as L2 switches and make undesired loops and storms...
Expectations for Software Switches

- **Strong stability**
  - IX facilities need strong stability for providing stable connections

- **Fine grained network monitoring**
  - sFlow, netFlow

- **More programabilities**
  - RESTful APIs, YANG-model
Next Steps

- We are ready for connecting ASes on the PIX-IE!
  - start with academic ASes for testing the IX
- More Use-Cases
- Our source codes will be available on GitHub
- Sharing our experiences with operators’ groups
Thank you!
Any suggestions and comments are welcome!

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