O3 Project
Network Business Innovation by SDN WAN Technologies

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O3 project (NEC, NTT, NTT Communications, Fujitsu, Hitachi)
Agenda

- Trend on Future Information Networking
- Innovation through O3 User-oriented SDN
- O3 Technologies for SDN WAN
- SDN Use Cases in O3 Project
- SDN Ready Open Source Software
- Conclusion & Future Work
Innovation through O3 User-oriented SDN
Toward open User-oriented SDN

3 Contributions for User-oriented SDN
(1) Open development with OSS
(2) Standardization of architecture and interface
(3) Commercialization of new technologies
O3 Project Concept, Approach, & Goal

- **Open, Organic, Optima**
  - Anyone, Anything, Anywhere
  - Neutrality & Efficiency for Resource, Performance, Reliability, ...
  - Multi-Layer, Multi-Provider, Multi-Service

- **User-oriented SDN for WAN**
  - Softwarization: Unified Tools and Libraries
  - On-demand, Dynamic, Scalable, High-performance

- **Features**
  - Object-defined Network Framework
  - SDN WAN Open Source Software
  - SDN Design & Operations Guideline

- **Accelerates**
  - Service Innovation, Re-engineering, Business Eco-System
O3 Deliverables: User-oriented SDN

- Provides **Orchestration** for different user requirements

**Management for AP providers** (ex. Skype, Lync, Facebook)

**Management for service providers** (ex. IaaS, PaaS, SaaS)

**Management for carrier network** (ex. Design, Deploy, Operate)

I'd like to automate service management including IT systems.

I'd like to control and operate n/w in fine-grained manner.

Flexible n/w platform for various requests from users.

I'd like to change AP performance dynamically.

Northbound API (Innovation for users)

Open Network Platform

Southbound API (Innovation among vendors)

Packet | Optical | Mobile

Physical network
O3 Object-defined Network Platform

- Network is abstracted as graph of base Objects
- Control functions are the operators for the Objects
- Different types of NW are defined through extension of Objects

**AP provider**

**Service provider**

**Carrier**

**Extended Operator function (for AP provider)**

**Basic Operator function**

**Extended Operator function (for Service provider)**

**Extended Operator function (for Carrier)**

Specify only the bandwidth, delay, SLA on the abstraction layer.

Find-grained control of routing, traffic, fault monitoring, and operation management.

Open Network Platform (ODENOS)

Driver (Protocol-object convertor)

- OpenFlow
- Overlay
- Optical/packet transport
- Mobile

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SDN & OpenFlow World Congress 2014 @ Dusseldorf
O3 Technologies for SDN WAN
Established the SDN guideline for carrier networks which is required to design, deploy and operate the large scale of SDN in the following steps:

**Drafting guideline**
- Draft includes
  - Criteria to select SDN equipment
    - Capacity
    - Capability
    - Reliability etc.
  - Criteria for evaluation
    - Flexibility
    - Time to deploy SDN etc.
  - Evaluation techniques
    - Design parameters identification
    - Testing and reporting templates

**Testing & analyzing**
- Evaluation techniques
  - Test bed setup
  - HW/SW SDN feature evaluation
  - Design parameters certification
  - Test results analysis

**Completed Doc.**
- Final document
  - Test results
  - Analysis reports
**SDN Software Switch: Lagopus**

- **SDN 10Gbps S/W forwarding node with 1M flows**

![Diagram of SDN Software Switch: Lagopus]

- Large scale flow detection and flow search

- **fff**: Flexible parallel Flow processing Framework

- Control plane and management plane

- Fast software-based data plane

- A prototype of SDN software switch

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Signal Interwork between Optical & Packet

- Enables ....
  a wide variety of service quality & rapid service tune-up

Conventional configuration

Configuration at this study
Virtual Wireless Networks

- Support multiple virtual networks over wireless networks while avoiding degradation of high priority traffic even when traffic demand and data rate of wireless link changes over time
SDN Framework: ODENOS

- **Network Abstraction Model:** Hierarchical
  - Node, Port, Link, Flow, Packet
- **Enables easy Extension & Customization**
Abstract Network Operators in ODENOS

- Slicer, Federator, Aggregator, Link-Layerizer
**NW Operator: Slicer**

- **Slicer**: creates copies of the network object based on the given policy: Edge ports, TCP/UDP port number (i.e., application)
- **Enables multi-tenancy, multiple applications**
NW Operator: Aggregator & Federator

- **Aggregator:** Creates single big-switch abstraction
- **Federator:** Connects multiple networks
- **Use Case:** Multi-domain controller (with controller hierarchy)
NW Operator: Link-Layerizer

- **Link-Layerizer**: Creates a network from the upper-layer nodes and lower-layer “paths” (flows)
- **Use Case**: Unified Control of Multi-layer Networks

![Diagram of Link-Layerizer](image)
SDN Use Cases in O3 Project
Proof-of-Concept: Physical Configuration

- WAN experiments with Multi-vendor Equipment

Data center 1

- VM
- NEC VTEP
- NEC OFS
- NTT vSW

Data center 2

- NEC VTEP
- VM
- JGN-X

Data center 3

- NEC VTEP
- VM
- JGN-X

Inter-DC network (emulated)

- Hitachi PTN
- Fujitsu OTN
- Fujitsu OTN
- Hitachi PTN

VTEP: VXLAN Tunnel End Point
OFS: OpenFlow Switch
vSW: Virtual OpenFlow Switch
PTN: Packet Transport Node
OTN: Optical Transport Node
PoC on Multi-Layer & Domain Control

Overlay Control

Transport Control

OpenFlow Control
PoC on Network Visualization

- Multi-layer topology visualization from logical network instances
- Inter-layer correlation mapping through operators
- Trouble shooting, failure analysis, etc.
PoC on Packet & Optical Integrated Mgmt

- Control of transport network based on simple requirements from users such as transmission speed and response time
- Flexible multilayer resource utilization to meet user requirements

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SDN Ready Open Source Software
SDN Software Switch: Lagopus

“Lagopus” features and targets

- High-performance packet processing
  - Support for 1M flow control rules
  - Forwarding performance over 10 Gbps

- Support for various protocols
  - Extensive support for latest stable specification OpenFlow 1.3.4 (including MPLS, PBB, and QinQ in wide area networks)
  - Top score in “Ryu certification tests”
    http://osrg.github.io/ryu/certification.html

- Support for various config/mgmt interfaces
  - OF-CONFIG, OVSDB, CLI, SNMP, and Ethernet OAM (including features under development)

- Modular architecture
  - New protocol modules or management interface modules easily deployed on “unified configuration data store” basis.

- Support for multiple data planes
  - General-purpose servers (IA servers)
    - Parallelized and multi-threaded packet processing
    - I/O acceleration by leveraging Intel DPDK
  - Bare metal switches (under development)
    - For general-purpose hardware switches

- Open source
  - Released as open source software at http://lagopus.github.io/
SDN Framework: ODENOS

**Network abstraction model**

**Base class**
- Inheritance

**OpenFlow**
- Graph of “flow” networks

**Overlay**
- Graph of tunnels

**VTN**
- Graph of vBridges and vRouters

**Packet/transport**
- Graph of transport paths

**Network Abstraction Model**
- Network Abstraction Model
  - Topology
  - Flow
  - Packet

**Topological representation**
- graph-based representation of network structure and statistics

**Flow**
- point/multipoint-to-point/multipoint communications (OpenFlow path, MPLS / optical paths, and overlay tunnels)

**Packet**
- OpenFlow packet_in/out.

**Network control structure model**

**LinkLayerizer**
- Combination of network layers

**Slicer**
- Creation of virtual networks

**Aggregator**
- aggregation of topology

**Federator**
- Federation of topology

**Instance of various logical network**

**Operators for network instances**

**Design a SDN controller as an arbitral combination of logical network and operators**
Conclusion & Future Work
Conclusion & Future Work

- O3 project provides SDN ready environment
  - SDN Design, Deployment & Operations Guideline
  - SDN Framework: Object-defined Network Platform
    - Network Abstractions and Programming Model
  - SDN-enabled WAN nodes
    - SDN Software Forwarding and Control
    - Optical, Packet and Wireless Network Control

Jump-start with O3 Open Source Software!!

Future plan

<table>
<thead>
<tr>
<th>Achievement</th>
<th>2014</th>
<th>2015</th>
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<tr>
<td>O3 Website</td>
<td>Released</td>
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<tr>
<td>SDN guideline</td>
<td>Plan to release by 3/E</td>
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<tr>
<td>Common control FW (OSS)</td>
<td>Plan to release Dec/E</td>
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<tr>
<td>SDN-enabled WAN nodes (OSS)</td>
<td>Lagopus: Released</td>
<td>Others: by 3/E</td>
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This research is executed under a part of a “Research and Development of Network Virtualization Technology” program commissioned by the Ministry of Internal Affairs and Communications.
Trend on
Future Information Networking
Software-Defined Networking (SDN)

- SDN is a technology to innovate new services and to accelerate businesses
- Network will be designed, deployed and operated by business application and orchestration system

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Commercial SDN technologies are mainly applied to "closed domain networks", such as enterprise, datacenter, and mobile core.

- **Enterprise**
  - Secure virtual network infra.

- **Data center**
  - Global multiple distributed DCs

- **Mobile core**
  - Load-based flexible resource allocation

**Open & Agile end-to-end service deployments and operations to satisfy service SLA/QoS for various users**