Open Source
A Catalyst for Innovation
Next Gen Smart Grid & Prosumer Service Driven Network

AMI
- Advanced Metering Infrastructure

PMU
- Phasor Measurement Unit

openADR
- Automated Demand Response

Real Time Gateway Systems

Generation

Transmission

Distribution

Mobile

Internet

Internet of Things

Producer / Consumer

Regulated Enterprise
Examples of Open Source Platforms & Products
Linux

Popular Mainstream Linux Distributions

- Debian
- Ubuntu
- Linux Mint
- Fedora
- Arch Linux
- Red Hat Enterprise Linux (commercial product)
- SUSE Linux Enterprise Server (commercial product)
- Yocto Project (platform for embedded Linux systems)
Open Source & Service Driven Network

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Open Network Foundation (ONF)

ONF Board Members
- Google
- Facebook
- Yahoo
- Microsoft
- NTT Communication
- Deutsche Telekom
- Verizon
- Goldman Sachs
OpenStack

OPENSTACK

Project Founders:
- RackSpace
- NASA
OpenDaylight

Project Founders:
• Cisco
• IBM
• Microsoft
• Ericsson
• VMware
Open vSwitch

- Security: VLAN isolation, traffic filtering
- Monitoring: Netflow, sFlow, SPAN, RSPAN
- QoS: traffic queuing and traffic shaping
- Automated Control: OpenFlow, OVSDB mgmt. protocol

Physical NIC
Network Functions Virtualisation (NFV)

NFV is an ETSI project with founding members:
- AT&T
- BT
- Deutsche Telekom
- Orange
- Telecom Italia
- Telefonica
- Verizon

Source: Defining NFV: Network Functions Virtualization (NFV) Dr. Prodip Sen Chair, ETSI NFV ISG
Shipping OpenFlow Products

Switches - Commercial
• Arista 7500/7150
• Brocade MLX/NetIron products
• Cisco Nexus 3000
• Dell N3000/N400
• Extreme BlackDiamond
• HP ProCurve
• IBM BNT G8264
• Juniper MX & EX9200 (not GA)
• NEC ProgrammableFlow switches
• Smaller vendors (Mikrotik, ODMs)

Switches - Open Source
• Open vSwitch (Xen, KVM)
• NetFPGA reference implementation
• OpenWRT
• Mininet (emulation)

Controllers - Commercial
• NEC ProgrammableFlow Controller
• VMware NSX
• Big Switch Networks
• Cisco eXtensible Network Controller
• HP VAN SDN Controller

Controllers - Open Source
• Open Daylight (Java)
• NOX (C++/Python)
• Beacon (Java)
• Floodlight (Java)
• Maestro (Java)
• RouteFlow (NOX, Quagga, ...)
• NodeFlow (JavaScript)
• Trema (Ruby)
OpenFlow @ Google

Problem
• Traffic engineering in inter-DC WAN backbone

Solution
• Custom data center edge switches
• Cluster of OpenFlow controllers in each data center data center edge switches behave like a single node
• BGP and IS-IS between OpenFlow controllers; classic routing between data centers
• Centralized traffic engineering application path elements are downloaded into individual controllers
OpenFlow @ NEC

NEC ProgrammableFlow: OpenFlow in Data Center

- Fabric of physical and hypervisor (Hyper-V) switches
- Single control, management and configuration entity
- Virtual bridges, routers, packet filters, traffic redirection and QoS
- Use case: mid-sized virtualized data centers
Network migration from existing virtual environment to ProgrammableFlow

- **Main Site**
  - a) Virtualizes existing business servers
  - b) Network Virtualization
  - c) Migrate VM
  - Controller: ProgrammableFlow Controller
  - Switch: ProgrammableFlow Switch
  - VM: Virtual Machine
  - NW: Network

- **Back up Site**
  - d) Back up
  - Controller: ProgrammableFlow Controller
  - Switch: ProgrammableFlow Switch

- **Main Site**
  - a) Deploy Server Virtualization to achieve private cloud (Challenge is network operation)
  - b) Virtualizes network to achieve more flexible operational environment
  - c) Migrate VM to virtual network environment sequentially
  - d) Back up high priority business systems

Controller: ProgrammableFlow Controller
Switch: ProgrammableFlow Switch
VM: Virtual Machine
NW: Network

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NEC @ NIPPON EXPRESS

Nippon Express benefits from ProgrammableFlow

- Unit Space (core switch rack space):
  - Existing Network: 32
  - PFlow: 10
  - 70% savings

- Power Consumption:
  - Existing Network: 14 kW
  - PFlow: 2.5 kW
  - 80% reduction

- Outsourcing Fee (core switch rack space):
  - Existing Network: $90K
  - PFlow: $0
  - 100% savings

- Failure Recovery Time:
  - Existing Network: 50 seconds
  - PFlow: 1 second
  - 98% improvement
Networking & IT Open Source Convergence

Source: [www.nec.com](http://www.nec.com) modified by Dick Willson
OpenFlow Control of Real-Time Flows
Proof of Concept
SDN (Software-Defined Networking) can switch the traffic flows for real-time packets to different MPLS paths based on the measured jitter and delay.

Choose best path for “real time” traffic

- Both real-time and best-effort packets go through MPLS-1.
- SDN network monitoring periodically checks delay between circuit emulators via MIB polling.

Source: [www.nec.com](http://www.nec.com) modified by Dick Willson
Switching Real-Time Traffic to Avoid Congested Path

SDN (Software-Defined Networking) switches the real-time traffic flows based on the delay over the MPLS cloud.

Congested Traffic Condition

1. Heavy Traffic in MPLS-1
2. Delay Detection by monitoring tool
3. Flow Control by SDN
4. Switching Real-Time Traffic Path to MPLS-2

Source: www.nec.com modified by Dick Willson
Proof of Concept: Experimental Environment

Real-time traffic switching has been achieved by NetInsight's Circuit Emulator 'Nimbra' and NEC's SDN Technology 'ProgrammableFlow.'