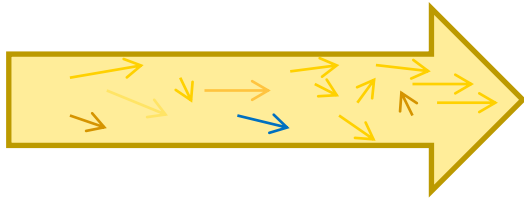


NEC and OpenFlow: Building Programmable Networks

**Information Technologies Group (ITG)
Enterprise Technologies Unit
NEC Corporation of America**

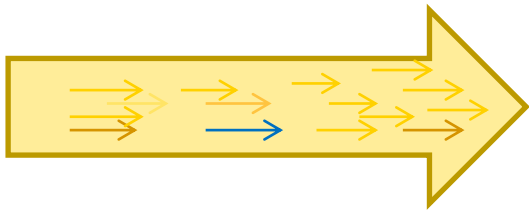
Building Programmable Networks

Before OpenFlow



Firms' Business Logic unaligned to network flows

After OpenFlow



Firms' Business Logic aligned to network flows

Cloud

Innovations now integrated with the network

- Software as a service

Business Logic

In harmony with network operating system

- Network orchestration

Network Services

Run as an application on top of the controller

- Develop custom features

Results = Higher Agility

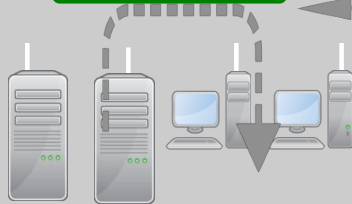
OpenFlow Switch

NEC PF820

Secure Channel



Flow Table



Packet

Packet

- 10G/40G ports
- Pluggable optics
- 120-240V AC
- Redundant fans/power
- Mount 19-inch rack, 1 RU
- OpenFlow spec 1.0.0

Rule

Action

Stats

OpenFlow Protocol

Packet

NEC OpenFlow Controller

NEC ProgrammableFlow Controller



NEC 6800

- Multi-tenant networks
- Location Free Networking
- OpenFlow Network Control
 - Topology Discovery
 - Fault Detection
 - Self repair
- Policy based security and compliance

Empowered by Innovation



OpenFlow's evolution

Origins in Research and Education



- Experiments to scale
- Network innovation
- Run on production network
- Discover new protocols
- Researchers controlling their campus networks

Open Ecosystem Open Networking Foundation



Enterprise Adoption Championed by Vendors

- IT business alignment and agility
- Predictable performance
- Virtualized programmable networks
- Built-in security
- Dynamic innovation

NEC and Openflow

History

- Founded CleanSlate Lab at Stanford University leading to OpenFlow Innovations
- NEC and HP first to develop OpenFlow prototype switch
- NEC switches deployed in more than 20 universities and labs
- 5 years of NEC research and development on OpenFlow
- **NEC first to commercialize OpenFlow 1G switch and controller**

Commercialization

- ProgrammableFlow: First Network Virtualization solution leveraging OpenFlow
- NEC first to make commercial deployment of ProgrammableFlow
- **NEC wins Best of Interop under Infrastructure Category**

Standard Participation

- Member of Open Network Foundation (Members – 90% top switch vendors)
- **Leading the North-bound API standards connecting DC management plane**

Deployment and Showcases

- NEC providing switch for nationwide production backbone (Internet2)
- **NEC is working with Verizon Labs (Waltham) on edge content serving DC**
- NEC participating in Supercomputing SC2011
- NEC has showcased the first Multi-DC RDMA transfer using openflow
- **NEC showcasing Openflow support in Windows 8 at Build 2011**

Introducing ProgrammableFlow

Simple, Scalable, Secure, Open Networking

- First OpenFlow Enabled Fabric
- Secure, Barrier Free Network Virtualization
- Variety of applications: Cloud services, network aggregation, monitoring, DDOS, appliance pooling, and many others

UNIVERGE PF series

ProgrammableFlow Controller (PFC)



ProgrammableFlow Switch Family (PFS)



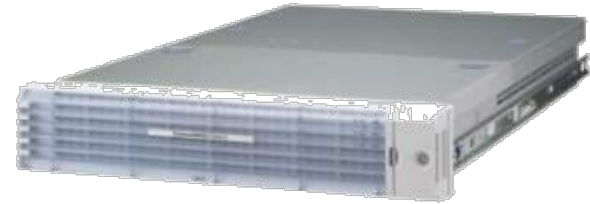
Grand Prix



Special Prize

NEC ProgrammableFlow Controller overview

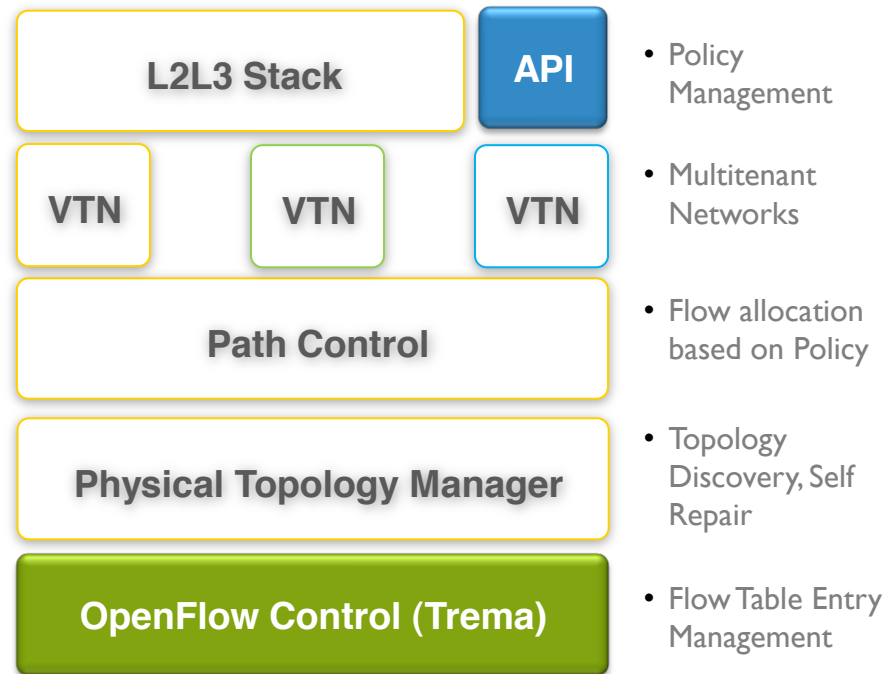
- First generally-available OpenFlow controller
- OpenFlow 1.0.0
- Linux appliance



PF6800
ProgrammableFlow Controller Appliance

Benefits

- Dramatically reduces network operation costs through simplified network management
- Increases service agility by providing network control through a single pain of glass
- Improves return on investment by Increasing network and server utilization
- Reduces power and space requirements verses chassis deployments
- Achieves greater resiliency to network equipment failures
- Foundation for multi-vendor network hardware environment



Univerge PF5240 – ProgrammableFlow Switch

Features

- 48 10/100/1000 ports + 4 1000/10000 ports 176Gbps fully non blocking switching in 1U form factor
- OpenFlow Support - Flow Entries capabilities of 64,000-160,000
- Hybrid OpenFlow
 - Connects OpenFlow Networks to L2/L3 Networks
 - Virtual switch instance for running OpenFlow and distributed protocols on the same equipment
- L2/L3
 - OSPF,BGP, RIP,VRRP, PIM, MLD
 - STP, RSTP, MSTP, PVST, IGMP, Rate limiting, bandwidth control
- Data Center Ready
 - Modular design with internal redundant hot-swappable power supplies and fan
 - 4 sfp+ ports supporting cost effective SFP+ SR
 - Front to Back/Back to Front Airflow

Benefits

- ProgrammableFlow OpenFlow technology delivers chassis like capabilities with fixed ports economics
- NEC OpenFlow capability delivers enterprise class performance with dramatic reductions in network complexity and configuration
- High-availability location free networks with hitless fail-over and hot insertion/removal of units

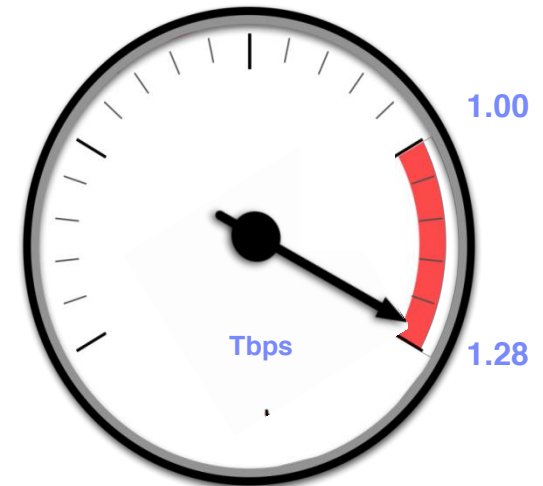


PF5240-48T4XW

Empowered by Innovation **NEC**

Univerge PF5820 - ProgrammableFlow Switch

- **10GbE(SFP/SFP+) x 48 ports +**
- **40GbE(QSFP+) x 4 ports**
 - Up to 64 x 1Gb/10 Gb SFP+ ports with optional breakout cables
- **OpenFlow based flow handling with hardware at full wire rate(1.28Tbps)**
 - Support Layer 2 (MAC) forwarding table manipulated through OpenFlow
 - Layer 2 (MAC) Table max 96K entries
 - 12-tuple flow table max 750 entries
- **Redundant hot swappable power supplies**
- **Rack-mountable in standard 19" racks. Dimensions 17.3" wide, 19.0" deep, 1U high**



NEC PF5820 Deployment in NDDI OS3E

Background

Network Development and Deployment Initiative (NDDI) is a Partnership between Internet2, Indiana University (IU) and the Clean Slate Program at Stanford University

Goal is to create a new network platform and complementary software to support global scientific research
Internet2 Network service called the Open Science, Scholarship and Services Exchange (OS3E).



Internet2's success in deploying NEC OpenFlow switches for research networks made NEC a natural candidate for the OS3E production network. The NEC PF5820 met all of our evaluation objectives and the initial deployment with ProgrammableFlow has gone well – completely as expected.”

- Matt Davy, co-director of the Internet2 NDDI program and Chief Architect for Indiana University

Initial Deployment 5 NEC PF5820s

- McLean, VA
- Chicago, IL
- New York City, NY
- Seattle, WA
- Los Angeles, CA

Production Deployment of ProgrammableFlow

What Customers are Saying:



Public Cloud

*“Network complexity has grown to a point beyond reasonable. ProgrammableFlow provides an **automated** means of network self-repair, and gives us the **single pane of management** and control we have long sought.”*

Eric Miller, CEO of Genesis Hosting Solutions



Enterprise Data Center

“By adopting ProgrammableFlow, we have significantly **reduced our network operational costs.**”

Yuji Noguchi, General Manager, Information Technology

The New Era of Open Networks



ProgrammableFlow

Simple

- Deploy Multi-Tenant Virtual Networks as easily as deploying VMs
- Integrate network and application policy
- Centralized network management and control
- Eliminates need for spanning tree or other distributed protocols

Scalable

- Scales from single switch to entire data center fabric
- Policy based appliance integration

Secure

- Integrated Multitenant Access Control

Open

- Create multivendor OpenFlow enabled switches, virtual switches and NICs

necam.com/pflow

