

# Software Defined Networks

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# INTRODUCTION TO SDN

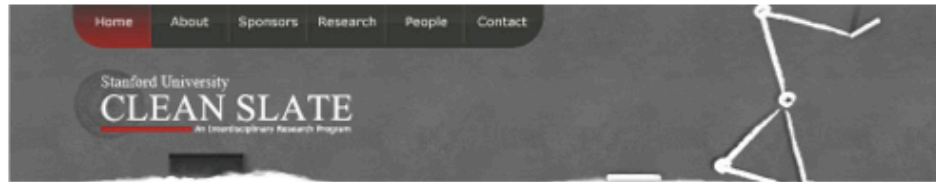
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# Where Did SDN Come From?



# Where Did SDN Come From?

2008



## Clean Slate Program

We created Clean Slate Program more than five years ago with Stanford's depth and breadth of expertise to explore what kind of Internet we would design if we were to start with a clean slate and 20-30 years of hindsight. Though the mission was well defined, the potential approach was not. We began with a number of small exploratory projects that led to a few flagship projects that show lot of promise.

We are pleased to report that Clean Slate Program led to many small projects and the following four on-going flagship projects that have the potential to transform different parts of the Internet.

- Internet Infrastructure: [OpenFlow and Software Defined Networking](#)
- Mobile Internet: [POMI 2020](#)
- Mobile Social Networking: [MobiSocial](#)
- Data Center: [Stanford Experimental Data Center Lab](#)

Clean Slate Program has ceased to exist as of January 2012 and has successfully transformed into these four large projects. We invite you to visit the website of these projects, become familiar and get involved.



docomo  
DOCOMO USA LAB

Deutsche  
Telekom

NEC



XILINX

ERICSSON

# What is Software Defined Network (SDN)?

- An approach and architecture in networking where **control and data planes are DECOUPLED** and **intelligence and state are logically CENTRALIZED**
- Enablement where **underlying network infrastructure is abstracted** from the applications [network **VIRTUALIZATION**](overlay)
- A concept that **leverages programmatic interfaces (API)** to enable external systems to influence network provisioning, control and operations

**D**ECOUPLED

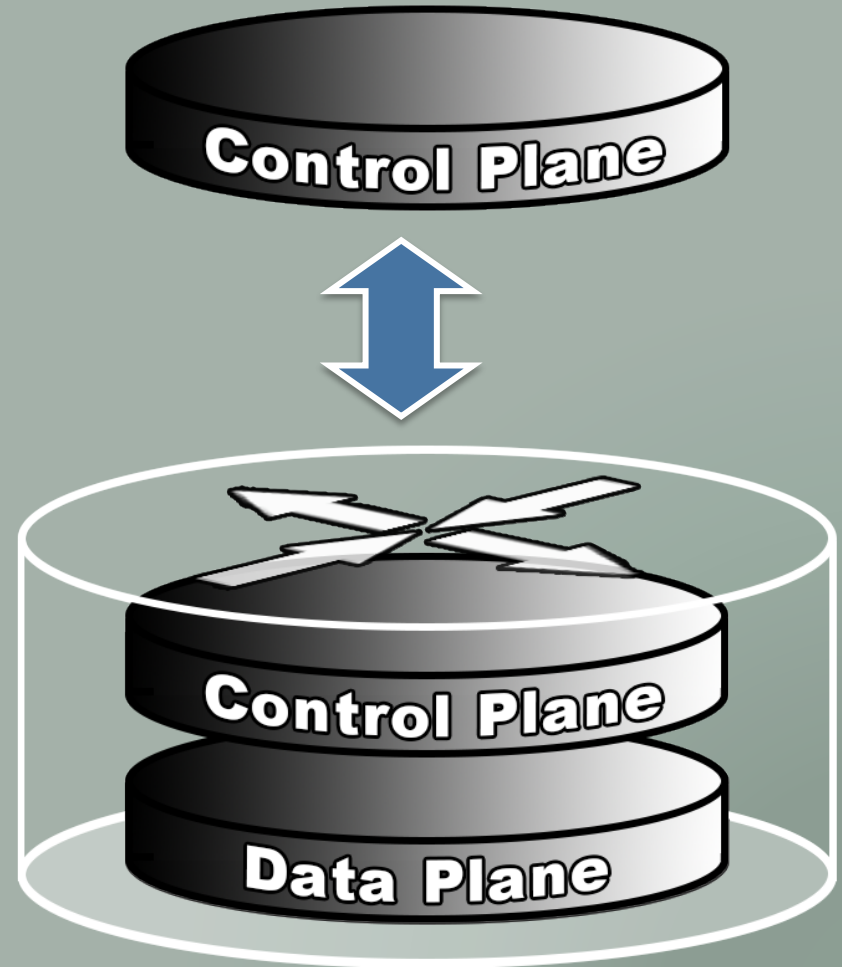
**C**ENTRALIZED

**V**IRTUALIZATION

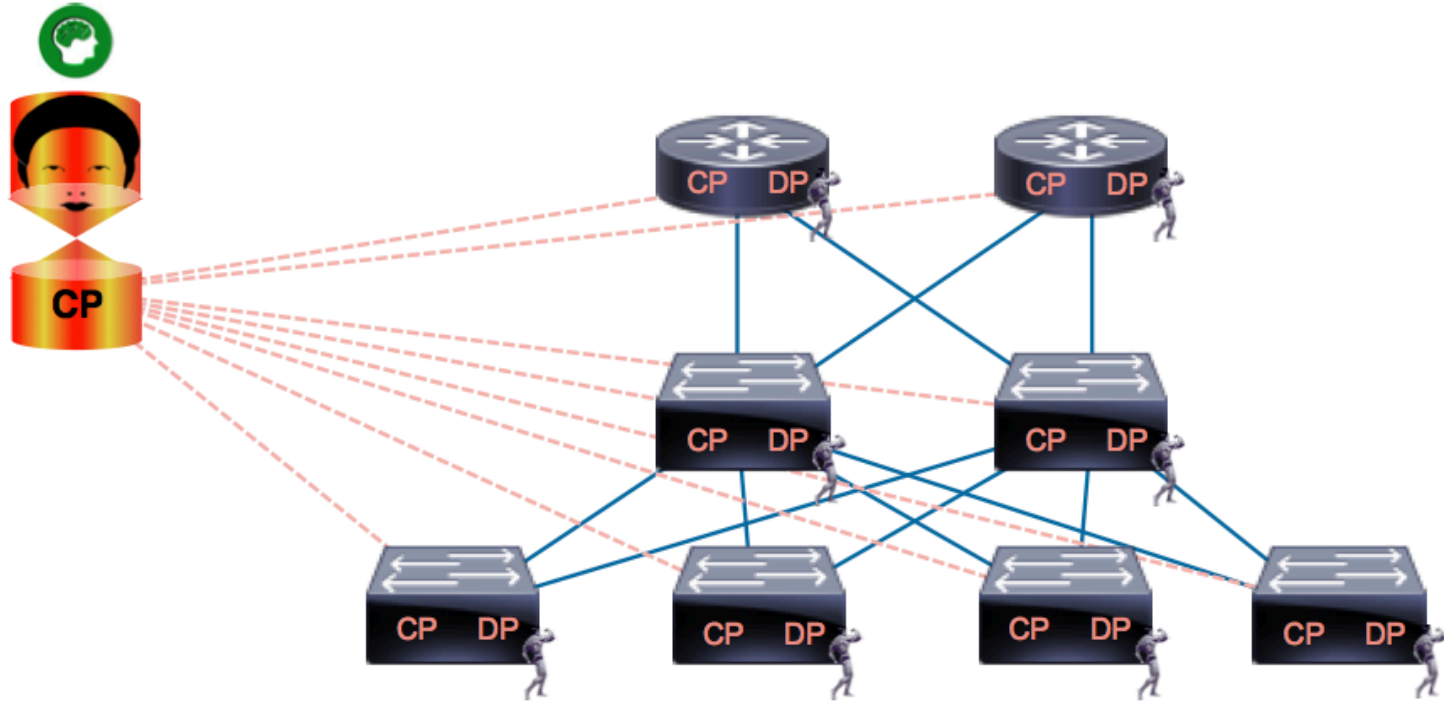
**A**PI

# Decoupled

- Determine best path, management
  - Control plane
  - Hop count, cost, bandwidth
- Switching Packets
  - Data plane
- Communication Protocols



# Centralized



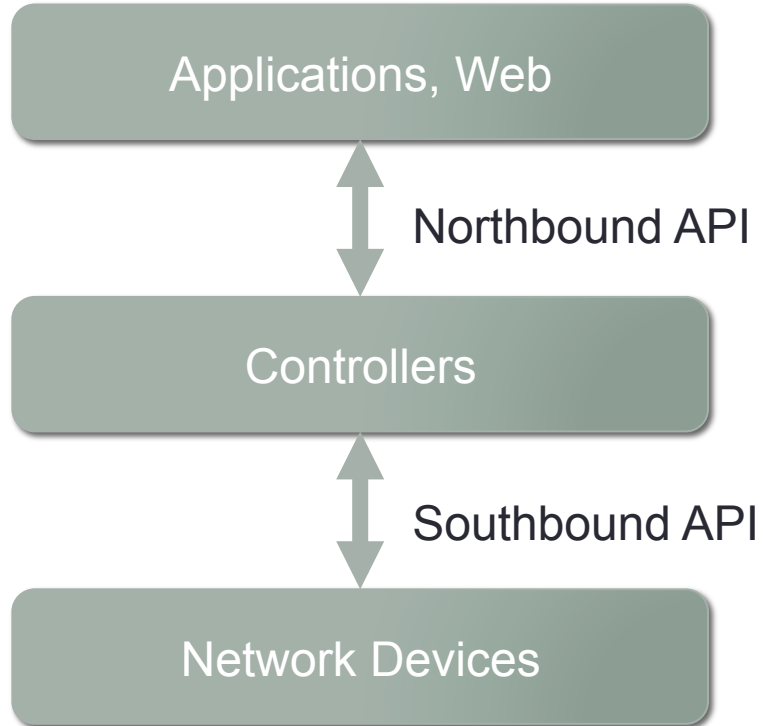
**Control plane becomes centralized**  
**Physical device retains Data plane functions only**



# Virtualization (Overlay)



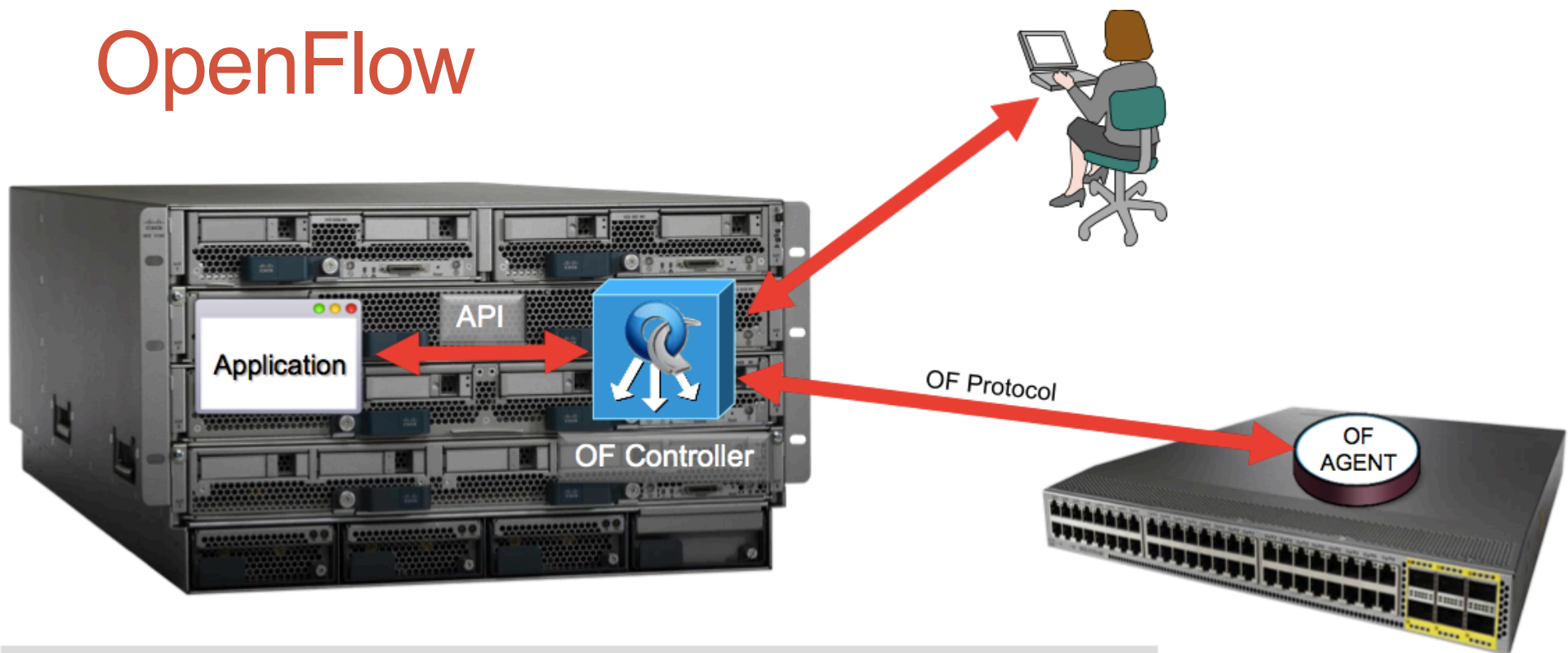
# API



# SDN Related Protocols/Standards

Decoupled	OpenFlow, OpFlex
Centralized	OpenDayLight, APIC
Virtualization	VxLAN, LISP, OTV
API	REST, onePK

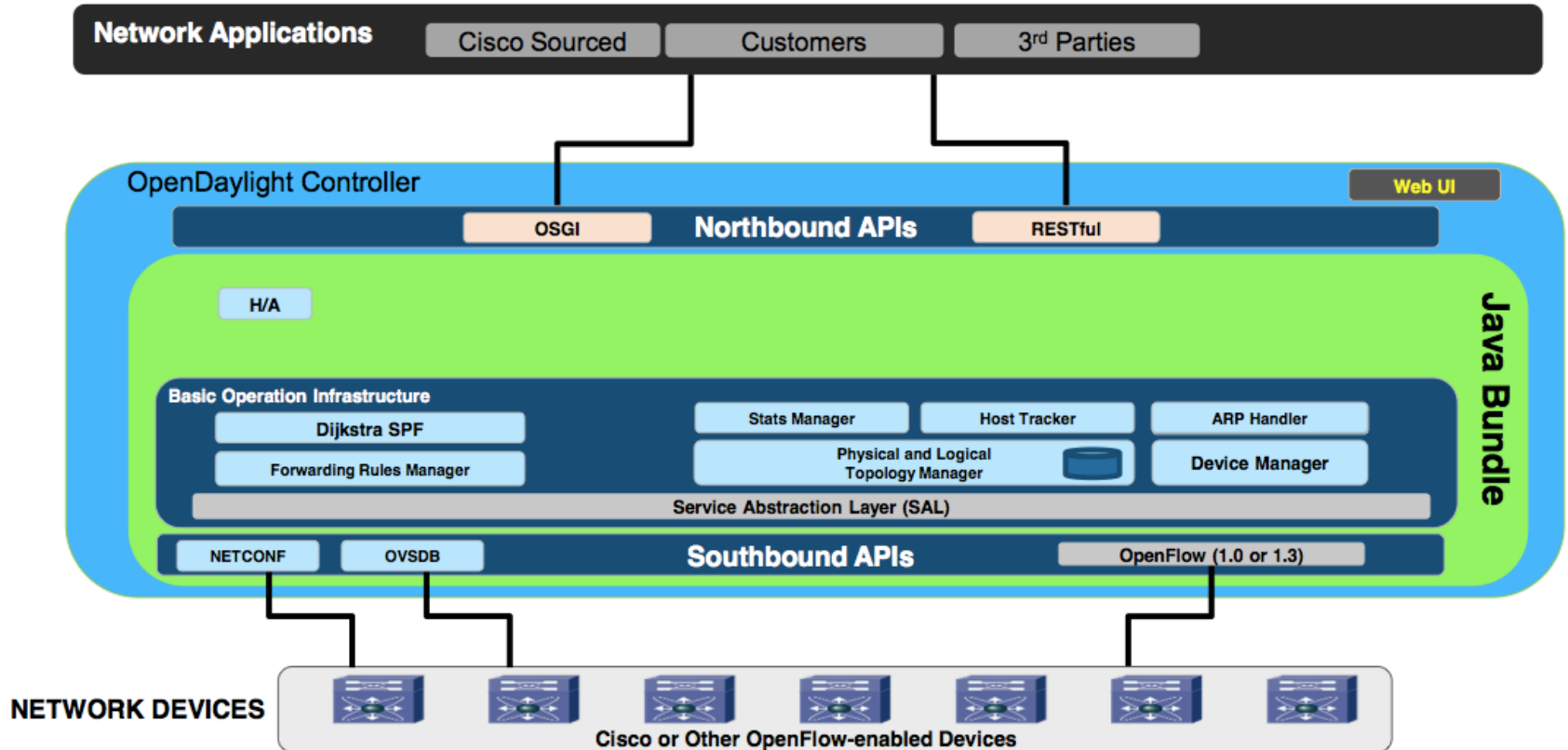
# OpenFlow



...a Layer 2 communications protocol that gives access to the **forwarding plane** of a network device,

...a **specification** for building switches conforming to the protocol

# OpenDayLight Project



# OpenDayLight

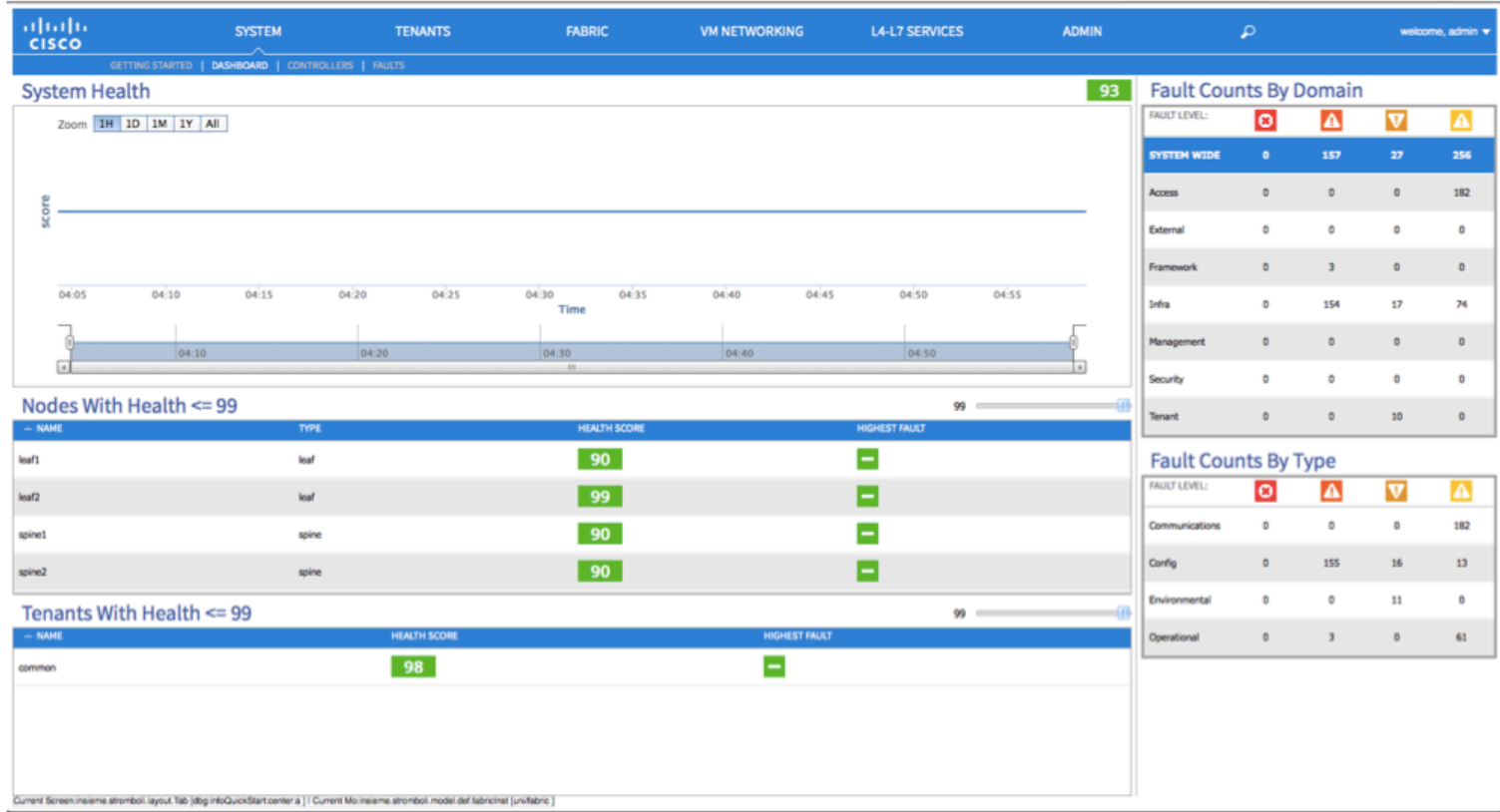
The screenshot displays the OpenDayLight web interface. At the top, there are navigation tabs for "Devices", "Flows", and "Troubleshoot", along with a user profile for "admin". The main area is divided into several sections:

- Existing Nodes:** A table listing nodes s1 through s7 with their Node IDs and a link to "Flows Ports".
- Network Topology:** A diagram showing a network structure with nodes s2, s3, s4, s5, s6, and s7. Node s3 is connected to two hosts with IP addresses 10.0.0.1 and 10.0.0.2.
- Uptime:** A table showing the connection status for nodes s6 and s7.
- Flow Details:** A table showing flow statistics for nodes s1, including In Port, DL Src, DL Dst, DL Type, DL Vlan, NW Src, NW Dst, NW Proto, TP Src, TP Dst, Actions, Bytes, Packets, Time (s), Timeout (s), Out Port(s), Out Vlan, and Priorit.

Hosts can be added or learned

Flow-specifications can be defined

# APIC-DC



# APIC-EM

The screenshot displays the Cisco APIC-EM Enterprise Module interface. On the left is a navigation menu with options: Home, Discovery, Device Inventory, Host Inventory, Topology, Policies, Quality of Service, ACL Analysis (highlighted), and Zero Touch Deployment. The main area shows a network topology with various devices like switches (md-sw1, 3845-1, 3925-1, 3925-2, 3925-3, 3845-2, md-sw2) and servers (TRMSRV\_10.87.105.218, TRMSRV\_10.87.105.219). A green path is highlighted from source to destination. On the right, the 'Settings' panel is active, showing Source IP 10.87.93.152 and Destination IP 10.87.93.165, with App/Service set to HTTPS. Below this are 'Show path' and 'Clear' buttons. The 'ACL' panel on the far right lists the path nodes and their ACL status:

- 10.87.93.152: No relevant ACL.
- md-sw2: No relevant ACL.
- 3845-2: No relevant ACL.
- isr3925-3: No relevant ACL.
- isr3925-2: No relevant ACL.
- isr3925-1: No relevant ACL.

At the bottom, there are links for Tutorials, Cisco Forums, and Cisco Marketplace, along with a 'Make a Wish' button.



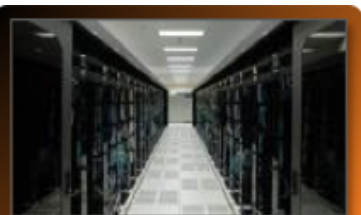
# Customer Needs: Network Programmability



## Research/ Academia

- Experimental OpenFlow/SDN components for production networks

Network  
“Slicing”



## Massively Scalable Data Center

- Customize with Programmatic APIs to provide deep insight into network traffic

Network Flow  
Management



## Cloud

- Automated provisioning and programmable overlay, OpenStack

Scalable  
Multi-Tenancy



## Service Providers

- Policy-based control and analytics to optimize and monetize service delivery

Agile Service Delivery



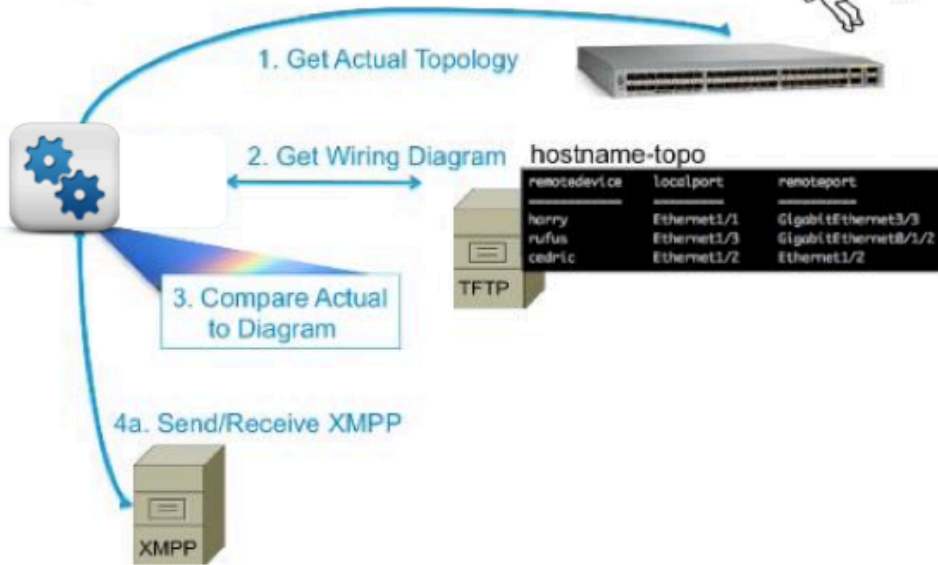
## Enterprise

- Virtual workloads, VDI, Orchestration of security profiles

Private Cloud  
Automation

# Get IMs From Routers/Switches

Wiring Verification: Could It Be True?



```
version 5.0(3)U5(1)
interface Ethernet1/2
  description configured via vwap python script

cho# show run int Ethernet 1/3

[Command: show running-config interface Ethernet1/3
!Time: Wed Oct 17 22:12:53 2012

version 5.0(3)U5(1)

interface Ethernet1/3

cho#
```

cho Ethernet1/2 is correctly wired to cedric(FOC1550R03Z) Ethernet1/2. Downloading interface config.

cho connected 4:25

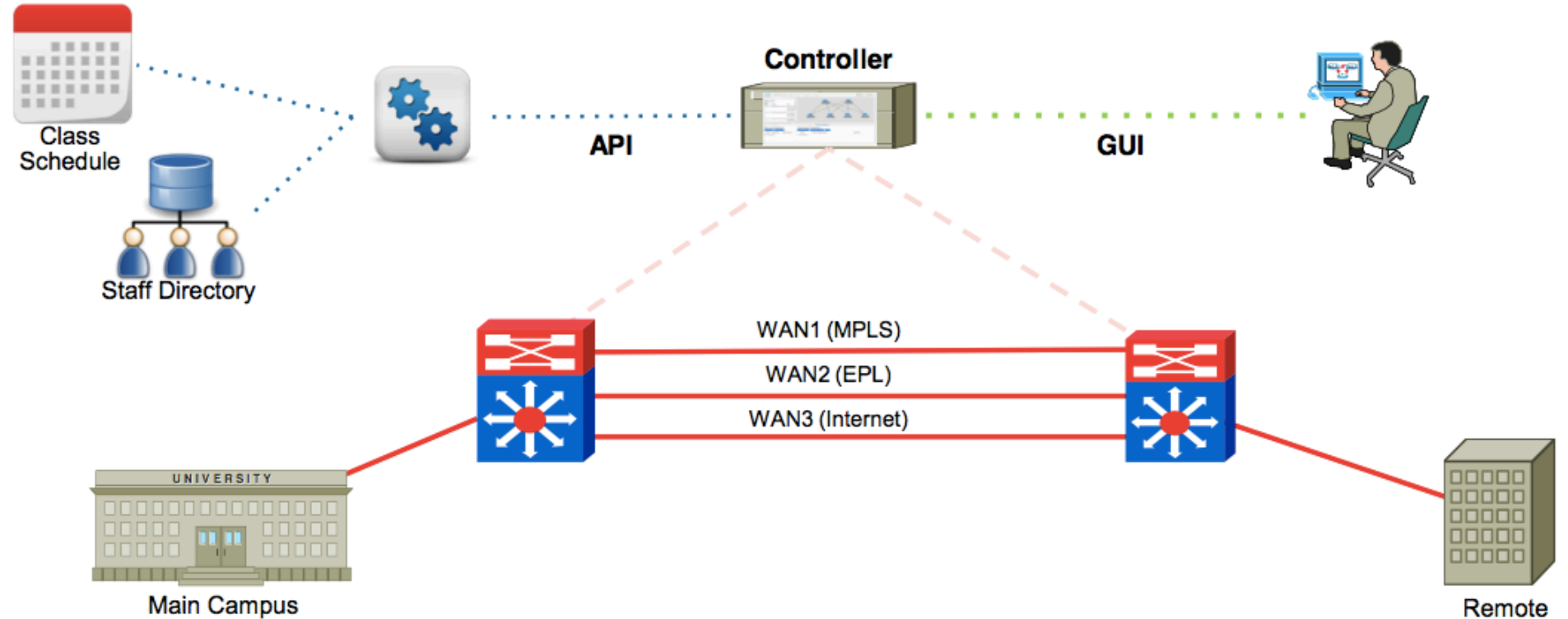
cho Ethernet1/3 **\*\*WRONG PORT ERROR\*\***: is wired to rufus GigabitEthernet0/0/2, should be rufus GigabitEthernet0/1/2

cho connected 4:25

scadora shutdown interface ether1/3 4:28

cho Completed.shutdown interface ether1/3 4:28

# Business Metrics Influencing Routing



# OpenFlow Platform Support

Function	Available Now	Q2 CY14	Q3 CY14	Q4 CY14	1H CY15
OpenFlow Feature Level 1	Nexus 3K Nexus 5K Nexus 6K Nexus 7K (PoC) Catalyst 6K (PoC) Catalyst 3K (PoC) Catalyst 4K (PoC) ASR9K(CA)				
OpenFlow Feature Level 2		Catalyst 3K (EFT) Catalyst 4K (EFT) ASR9K	Nexus 7K	Catalyst 6K Catalyst 3K Catalyst 4K Nexus 3K (planning)	
OpenFlow Feature Level 3				Nexus 9K (planning)	Catalyst 3K (planning) ASR9K (planning)

Feature Level 1 – OF Line protocol v1.0; subset of OF1.0 features (Basic matches/Actions, IPv4)

Feature Level 2 – OF Line protocol v1.3; subset of OF1.0/1.3 features (IPv6, Multiple tables, Capabilities)

Feature Level 3 – OF Line protocol v1.3; subset of OF1.0/1.3 features (QoS, MPLS, Group Tables, Meters), Performance & Scale focus, Serviceability and Usability Improvements

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# SDN vs. ACI

## IMPERATIVE CONTROL



Baggage handlers follow sequences of simple, basic instructions

## DECLARATIVE CONTROL



Air traffic control tells where to take off from, but not *how* to fly the plane

# How OpFlex Works

A policy authority such as the APIC manages a logical model of desired state



**POLICY**



**POLICY RESOLUTION**

2



3

**POLICY UPDATE**

1

The policy endpoint interprets the policy and maps it to its hardware capabilities



4



Rendering can leverage any low level programming API including OVSDDB, OpenFlow or device-specific API

USER



IT Services

Apps

IoT

IaaS, PaaS, SaaS

Service Catalog & Portal

Cisco CIAC

VMware vCAC

RLC CloudEntry

Resource Management

OpenStack

UCS Director

vCloud Director

SDN Controller

OpenDayLight  
OpenFlow OpFlex

APIC  
OpenFlow OpFlex onePK

Infrastructure

Network  
FabricPath OTV LISP VxLAN

Storage

Server



DATA CENTER



# Remember This?

## Telephony in 1998



- IP Telephony struggled until we got 'hybrid engineers' to translate between the Circuit Switch 'Tip & Ring' and Packet Switch 'Bits & Bytes' camps
- Likewise, now, we need the next generation of 'hybrid engineers' to translate between traditional network domain engineers and software/application developers

Thank you

# Acronym

- REST – Representational State Transfer
- OSGI – Open Service Gateway Initiative
- ACI – Application Centric Infrastructure
- APIC – Application Policy Infrastructure Controller