



# Software-Defined Networking Matrix Switching

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## **Abstract**

This whitepaper describes a Software-Defined Networking use case, using an OpenFlow controller and white box switches to implement Open Systems Interconnection model (OSI) Layer-1 matrix switch functionality for World Wide Technology's Advanced Technology Center (ATC).

## Overview

The WWT Advanced Technology Center (ATC) is a significant investment in technology infrastructure with more than 100 racks of networking, compute and storage products used to demonstrate and deploy integrated architectural solutions for World Wide Technology customers, partners and employees.

The ATC is organized into four groups of labs for research and development, testing, training and integration. Each lab addresses different phases for the introduction, evolution and lifecycle of technology products. Because of the dynamic nature of this environment, automating the deployment and re-deployment of the resources into varying topologies increases use of the hardware and reduces costs, providing both CAPEX and OPEX savings.

Additionally, a primary function of the ATC is customer demonstrations and proofs of concept (PoCs). The ability to instantiate, validate and document a topology and then save the configuration is an important benefit to WWT customers and internal users.

## Orchestration

WWT has implemented QualiSystems ([www.qualisystems.com](http://www.qualisystems.com)) CloudShell, a DevOps self-service orchestration and automation platform for IT infrastructures and networks.

One benefit of CloudShell is the increase in efficiency and ROI of test infrastructure by better resource sharing. Commonly requested topologies can be defined as a service catalog, which increases the quality of the documentation. These cataloged topologies can be automatically provisioned to a baseline configuration and the network interfaces dynamically provisioned through the control libraries for NetScout / ONPATH ([www.netscout.com](http://www.netscout.com)).

## Layer-1 Switching

The NetScout / ONPATH Technologies offers a solution that automates moves, adds and changes of network connectivity by implementing true Layer-1 switching using a software interface.

This eliminates moving cables using potentially error-prone manual methods. While this increases the efficient use of lab equipment, using a purpose built appliance for all ports in the data center can be a costly solution. To mitigate the costs, this deployment uses a nGenius 3900 Series Packet Flow Switch with 48 port (S-Blade) modules as an aggregation (spine) providing a backbone to the Top of Rack (ToR) OpenFlow switches. Infrastructure services like impairment generators are connected to this aggregation switch as well.

## Software-Defined Networking

WWT invests in the development of solutions around emerging technologies like Software-Defined Networking (SDN). OpenFlow is one implementation of SDN concepts. OpenFlow is a forwarding table management protocol used by a central controller to manage one or more switches. OpenFlow agents on the switches follow an imperative model; the controller provides specific instructions to the switch, for example, to forward all traffic between two ports.

While an OpenFlow switch can be instructed to match on IP packet headers of OSI Layers 2 thru 4, the most primitive construct is to match on an input port and forward all packets to an output port. This capability provides similar functionality to the NetScout / ONPATH Packet Flow (Layer-1) switch at a lower cost per port. By using the NetScout / ONPATH switch as a spine (backbone) switch and deploying white box OpenFlow switches as Top of Rack (ToR) switches, the cost per port of the solution can be reduced by approximately 50 percent.

The Capital Expenditure (CAPEX) savings of the solution for a deployment of 100 racks of equipment and a target of 32 host ports per rack is more than three times the cost of software development and testing.

## White Box Switches

White box switches are low-cost, bare-metal switches based on Broadcom (or other merchant silicon) and a network operating system supplied by vendors such as Pica8, Cumulus or Big Switch. These switches are not expected to have a complex feature set like a brand name switch, because the SDN controller is programming the control plane of the switch and making the forwarding decision.

The list price of white box switches is significantly less than the equivalent-speed, brand-name switches, or dedicated special purpose appliances. However, there are costs to design, develop, test and maintain software to program the forwarding plane through the northbound interface of the SDN controller.

The use of white box switches and a central SDN controller is the main driver to affect the CAPEX cost savings of this solution.

## Solution Goals

The primary goals of this solution include:

- Demonstrate a practical use case of SDN technology
- Reduce the CAPEX in the ATC by limiting the use of dedicated Layer-1 switches
- Reduce OPEX costs by eliminating most manual cabling in the ATC

An additional less tangible but important benefit of developing this solution is to gain insight into the process of joint software development efforts between WWT and QualiSystems network and software engineers.

## Solution Development

WWT, working with the Quali engineering team, created a Layer- 1 SDN driver to invoke software developed by WWT to manage the Cisco ([www.cisco.com](http://www.cisco.com)) distributed SDN controller with northbound REST API calls. This provides a functional SDN equivalent to the CloudShell driver managing a NetScout/ONPATH Layer- 1 switch.

The SDN driver provides port-to-port mapping on OpenFlow switches, emulating a Layer-1 matrix switch. Device interfaces, routers, switches, servers and test tools in the ATC are permanently

connected to ports on the OpenFlow switches. CloudShell manages these resources and the ports on the OpenFlow switches to establish logical connectivity between devices for the duration of the equipment reservation.

## Performance Validation

Two levels of performance validation were conducted as part of the implementation phase of this solution, port-to-port switching latency of the white box switches and scalability of the SDN controller.

### Switching Latency

Latency of the white box switches compared to both a back-to-back physical cable and the NetScout / ONPATH were conducted using an IXIA appliance. All tests used the same 10Gigabit Cisco SFP-10G-SR optics and IXIA configured with the 'Cut-Through Latency' test, line rate, in a bi-directional mode. The tests were run for five minutes and no frame loss was encountered in any of the tests.

**Table 1 Latency Test Results**

	Device under Test (DUT) MTU Setting	Latency in nanoseconds MIN   AVE   MAX
Baseline	64	0   3   10 ns
NetScout ONPATH	64	120   131   140 ns
White Box	64	1,130   1,180   1,290 ns
Baseline	9200	0   3   10 ns
NetScout ONPATH	9200	120   131   140 ns
White Box	9200	8,430   8,475   8,580 ns

The worst-case latency for the OpenFlow switch is 8.58 microseconds or 0.0085 milliseconds. This is an acceptable performance level for the training, demo and POC network deployments.

### Controller Scalability

The scalability of the SDN controller was validated by developing a test program to inject flows to the northbound REST interface of the SDN controller using the same code base being called by CloudShell. This effort was undertaken to validate that the controller would scale to at least 9,600 flows, sufficient to provide any-to-any connectivity for the 100 racks of equipment in the data center.

## Business Outcomes

Implementing this use case in the ATC further allows WWT to show case the reality of SDN to our customers and partners.

A solution based on merchant silicon is an example of a key tenant of SDN, a measurable CAPEX cost reduction. The operational efficiency of provisioning topologies using software and a lab scheduling and automation system provides both tangible OPEX savings as well as intangible benefits of operational efficiencies and improved end-user satisfaction.

## Getting Started

WWT can help bring the competitive advantages and benefits of SDN to your organization in a way that supports your business goals. We can help you de-risk new technology investments and facilitate experimentation through the ATC, bring our proven integration fulfillment capability to cost-effectively deploy technology in an accelerated lifecycle and deliver the advantages of our strong relationships with partners leading the industry in SDN solutions.

We are here to talk about next steps and answer any questions.

**Contact us at:** 800.432.7008

**Learn more at:** [www.wwt.com](http://www.wwt.com)