

CISCO VALIDATED PROFILE

# Access Switching Education Vertical

April 2016

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# Profile Introduction

The Enterprise market segment can be divided into five broader verticals: Education, Financial, Health, Retail, and Government. This document focuses on a typical Education deployment profile, and you can use it as a reference validation document for a University or a K-12 Education profile.

Education network environments combine the technology requirements of large enterprises with a specialized set of demands that includes security needs, enhanced network services, and efficient network management. The following sections describe the challenges specific to these environments.

## SECURITY

Universities need to protect personal, academic, and copyrighted information. Security-rich features such as MAB, dot1x, guest-access (centralized and local web-auth), CISF, IPV6 First-Hop-Security (FHS) are deployed.

## SPECIALIZED SERVICES

Educational infrastructures must enable traditional and specialized resources in order to provide accessibility and speed. Network services such as video delivery, SDG, Plug-n-Play, Auto-Conf, and Quality of Experience with custom QoS and Auto QoS are deployed.

## MIGRATION TO IPV6

Devices increasingly run on IPv6, while network infrastructures are likely to continue on IPv4. Dual Stack deployments with features such as IPv6 access, IPv6 FHS, and IPv6 Multicast are enabled for this Education vertical guide.

## EFFICIENT NETWORK MANAGEMENT

The Education infrastructures cannot afford downtime in their networks. The network administrators should be able to efficiently manage and monitor their networks. The administrators could use Cisco-provided tools such as Cisco Prime Infrastructure and WebUI to quickly deploy, manage, monitor, and troubleshoot the end-to-end network.



## PRICE-PERFORMANCE AND SCALABILITY

Universities and colleges face tight IT budgets and steep technology demands. Various models of Cisco Catalyst 3850/3650/2960X/3750X/C3560CX with high-port density, POE-enabled ports with EnergyWise-capable services are deployed for the Educational vertical.

The following table summarizes the key areas on which this Education profile focuses.

**Table 1** Education profile feature summary

Deployment areas	Features
Security	MAB, dot1x, guest access (CWA, LWA), CISF, IPv6 FHS
Network services	Video content delivery (L2/L3 multicast), SDG (mDNS), Plug-n-Play or Smart Install, Custom QoS, AutoQoS, AutoConf
IPv6 migration	Dual Stack, V6 multicast, IPv6 FHS
Network planning & troubleshooting	NetFlow, SPAN, R-SPAN, Wireshark
Efficient network management	Cisco Prime Infrastructure, WebUI
Price-performance	EnergyWise, PoE, high-port density, mGIG chassis, collapsible core/distribution at smaller sites

# Network Profile

Based on the research, customer feedback, and configuration samples, the Education Vertical Profile is designed with a deployment topology that is generic and can easily be modified to fit any specific deployment scenario. This profile caters both to the smaller K-12 and the larger University Campus deployments.

For K-12 deployments, due to the smaller geographical size, budget restrictions, and smaller scale, the Core is collapsed to the Distribution layer, and Cisco Catalyst 4500 (and in some cases Catalyst 3850) can be used as a combination of Distribution plus Core.

For larger University campus deployments—which cover larger geographical areas, larger scale, and heavier usage of resources—this design uses the classic 3-tier architecture of Access, Distribution, and Core. Please refer to the topology for further details.



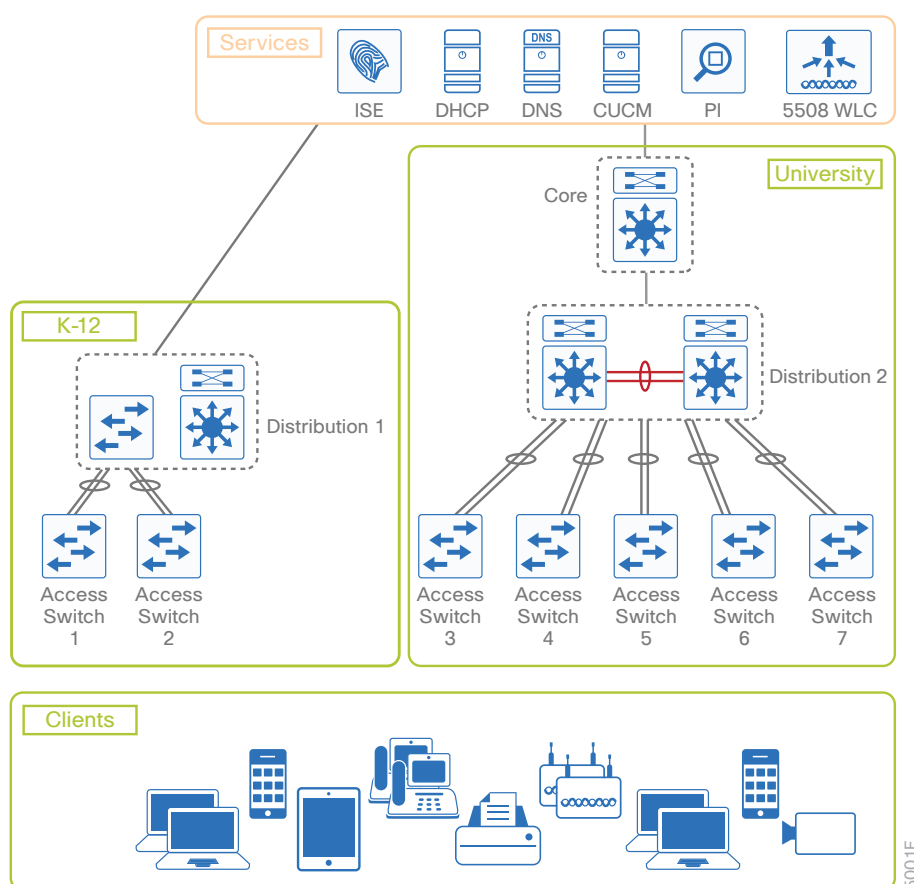
## TOPOLOGY DIAGRAM

Figure 1 shows the “converged” K-12 and the University Campus that is used for the validation of the Education Vertical Profile.

### Disclaimer

The links between the different network layers in the topology are mainly to facilitate this profile validation across different platform combinations, and the actual deployment could vary based on specific requirement

Figure 1 Education Profile: vertical topology



Site-1 (the left-portion of the topology) represents the K-12 deployment where a Catalyst 3K is used as a distribution switch along with Catalyst 4500s that are used as collapsed core/distribution.

Site-2 (the right portion of the topology) represents a typical University Campus deployment with a Catalyst 4500 in the distribution layer and a Catalyst 6500 in the core layer. Based on the size of the campus (both its geographical location and user-scale), there might be more distribution switches connecting to the core layer.

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**Disclaimer**

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The links between the different network layers in the topology are mainly to facilitate this profile validation across different platform combinations and the actual deployment could vary based on specific requirement

## HARDWARE & FEATURE SPECIFICATIONS

This section describes the 3-D feature matrix where the hardware platforms are listed along with their place-in-network (PIN) and the relevant vertical features.

### Key Vertical Features

Table 2 defines the 3-D hardware, PIN, and the features deployed. The scale of these configured features, the test environment, and the list of end-points and hardware/software versions of the network topology are defined later in this document.

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**Disclaimer**

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Refer to appropriate CCO documentation for release/feature support across different platforms.

**Table 2** 3-D feature summary with hardware and PIN

Deployment layer (PIN)	Platforms	Critical vertical features
Access	Switch1: C3850 5-M stack Switch2: C3650 5-M stack Switch3: C3850 9-M stack Switch4: C3650 5-M stack Switch 5: C3560CX 3-M stack Switch 6: 3750X 6-M stack Switch 7: 2960X 4-M stack or 2960XR 2-M stack	V4/V6- Dual Stack Web Auth, 802.1x, MAB, AAA, Radius Custom QoS Ingress/Egress, AutoQoS DHCP snooping, DAI, Port Security, Storm Control, IPSG IPv6 FHS ACL (IPv4/IPv6) L2-EtherChannel EnergyWise, POE (endpoints) SNMP Multicast-IPv4/v6, IGMP/MLD Snooping SDG SPAN, R-SPAN, Wireshark, FNF
Distribution	Dist1: WS-3850-12XS 2-M stack, Cat4K(SUP7E) Dist2: Cat4K-VSS (SUP8E) or Cat4K-VSS (SUP7E)	VSS OSPF Multicast-IPv4/v6 PIM SSM/SM EtherChannel SNMP SDG Custom QoS Ingress/Egress FNF, NetFlow-lite
Core	Core1: Cat6K	BGP, OSPF Multicast EtherChannel



## Hardware Profile

Table 3 defines the set of relevant hardware, servers, test equipment, and endpoints that are used to complete the end-to-end Education Vertical Profile deployment.

This list of hardware, along with the relevant software versions and the role of these devices, complement the actual physical topology defined in Figure 1.

**Table 3** *Hardware profile of servers and endpoints*

VM and HW	Software versions	Description
Cisco Prime	Version 3.0 TP2	For network management
Cisco ISE	Version 1.2/1.3/1.4	Radius server used for authentication, authorization
CUCM	Version 10.1	CUCM server for managing IP phones
DNS/AD server	Windows 8 Enterprise Server	Windows external server for DNS and Active Directory management
APIC-EM Plug-n-Play	APIC-EM 1.0	For Day0 config and image management
Cisco UCS Server	ESXI 5.5.0	To manage and host the virtual machines
Ixia	IxNetwork 7.51.1014.17 EA-Patch1	Generate traffic streams and to emulate dot1x clients
Cisco Unified IP Phones 7960, 7945, 9971	Cisco IP phones	Endpoints
Windows laptops	Windows 7/8	Endpoints
MacBook Pro laptops	OSX 10.10.x	Endpoints for SDG
Apple TV	3rd Gen 2013, 7.0	SDG server
IP camera	NA	Endpoints
Printer	N/A	Endpoints

## TEST ENVIRONMENT

This section describes the features and the relevant scales at which the features are deployed across the physical topology. Table 4 lists the scale for each feature.

### **Disclaimer**

The table below captures a sample set of scale values used in one of the use cases. Refer to appropriate CCO documentation/datasheets for comprehensive scale data.

**Table 4** Education Profile: feature scale

Feature	Scale
EtherChannels	6-8
VLANs	1k
STP	64
MAC Learning	2k MAC addresses
Storm Control (bcast)	128 interfaces
IPv4 ACLs/ACEs(RACL/PACL)	20 ACLs (10 Cisco ACEs per ACL), 10K ACE
IPv6 ACLs/ACEs	10 ACLs (10 ACEs per ACL), 10K ACE
Static routes	16 IPv4/IPv6
SSH server	All switches
NTP client	All switches
SPAN/RSPAN	2/2
Stacking	3 up to 9 members
802.1Q VLAN trunking	6 trunks
SVI	80
IGMP/MLD Snooping	300 groups
NetFlow	6 monitors+10k flows
QoS	40 classes+11 policy-maps+38 policers
SNMP	Cisco PI/MIB walks
DHCP snooping	600 clients
IP phones (MAB clients)	50
IPDT	Enabled on interface and vlan
Dot1x clients	500 (real+emulation)
WebAuth clients	20 PCs (real+emulation)
EnergyWise clients	50 (phones+cameras+PCs+printers)
Port-security	128 Interfaces
SDG	20 ATVs (K12), 100ATVs+50 Printers (Univ) (real+emulation)
V6 clients	50 (real+emulation)

# Use Case Scenarios

## TEST METHODOLOGY

The use-cases listed in Table 5 are executed using the topology defined in Figure 1, along with the test environment already shown in Table 4.

Images are loaded on the devices under test via the tftp server using the Management interface.

To validate a new release, the network topology is upgraded with the new software while loading the complete configuration that comprises the use cases and relevant traffic profiles. Addition of new use cases acquired from the field or customer deployments are added on top of the existing configuration.

During each use-case execution, syslog is monitored closely across the devices for any relevant system events, errors, or alarms. With respect to longevity for this profile setup, CPU and memory usage are monitored during overnight runs as well as during the weekends, paying special attention systems memory usage and any memory leaks. Furthermore, to test the robustness of the software release and platform under test, specific negative events are triggered during the use-case execution process.

## USE-CASES

Table 5 describes the use cases that were executed on the Educational Vertical Profile. These use cases are divided into buckets of technology areas to show the complete coverage of the deployment scenarios. Use cases continuously evolve based on the feedback from the field.

These technology buckets are composed of system upgrade, security, network services, monitoring & troubleshooting, simplified management, and system health monitoring, along with system and network resiliency.

**Table 5** List of use case scenarios

No.	Focus area	Use cases
System upgrade		
1	Upgrade (Distribution/Access)	<p>Network administrator should be able to perform switch upgrade and downgrade between releases seamlessly.</p> <ul style="list-style-type: none"> <li>All of the configuration should be migrated seamlessly during the upgrade/downgrade operation</li> <li>SW Install, Clean, Expand</li> </ul>
Security		
2	CISF (Access)	<p>Network admin to secure the L2 access against MITM, DOS attacks using the CISF (Cisco Integrated Security Features)</p> <ul style="list-style-type: none"> <li>PortSecurity, IPSG, DAI, DHCP snooping</li> </ul>

Table 5 continued

3	IPv6 FHS (Distribution/Access)	Network admin to secure the IPv6 network against MITM, DOS attacks by providing control-plane and data-plane filtering using IPv6 FHS (First-Hop-Security) <ul style="list-style-type: none"> <li>IPv6 Snooping, ND Inspection, RA guard, Source &amp; Destination Guard, DHCPv6 Guard</li> </ul>
4	IBNS 2.0 Mode (eEdge/new-style) (Access)	Network admin wants to deploy endpoint/end-user security using MAB/ Dot1x with IBNS 2.0 mode (eEdge/new-style). <ul style="list-style-type: none"> <li>PC behind the Phone: AuthC &gt; Dot1x for the PC and MAB for the Phone, Host Mode : Multi-Domain</li> <li>Dot1x, MAB : PCs, phones. Host mode: Single Host, Multi-Auth</li> <li>AuthZ &gt; dACL, Dynamic VLAN</li> </ul>
5	Auth-Manager Mode (legacy) (Access)	Network admin wants to deploy endpoint/end-users security using MAB/ Dot1x with Auth-Manager Mode (legacy). <ul style="list-style-type: none"> <li>PC behind the Phone: AuthC &gt; Dot1x for the PC and MAB for the phone, HostMode : Multi-Domain</li> <li>Dot1x, MAB : PCs, phones. Hostmode: Single Host, Multi-Auth</li> <li>AuthZ--&gt; dACL, Dynamic VLAN</li> </ul>
6	Guest-Access (Access)	Network admin wants to provide temporary guest access using the LWA and CWA. <ul style="list-style-type: none"> <li>LWA—Custom/Default Pages</li> <li>CWA—Self Register Guest Portal</li> </ul>
Network services		
7	Multicast Video (Distribution/Access)	Network admin wants to enable and deploy multicast services. <ul style="list-style-type: none"> <li>V4 &amp; V6 Multicast</li> <li>L3/L2 Multicast video delivery using PIM-SM, SSM, IGMP/MLD Snooping</li> </ul>
8	EnergyWise (Distribution/Access)	Enable network admins to measure and manage energy usage in the network by implementing energy saving policies for various endpoints (phones, cameras, PCs) and scenarios (shutdown/sleep/hibernate, wake-on-LAN)
9	SDG (Distribution/Access)	Network admin enables the SDG services on wired networks so that teachers can access IT-maintained Apple TV and printers, and students can access only the printers.
10	Auto QoS (Access)	Network admin needs to enhance user experience by ensuring traffic and application delivery. <ul style="list-style-type: none"> <li>AutoQoS for Cisco devices such as IP phones, IP cameras, etc.</li> </ul>

Table 5 continued

11	Custom QoS (Distribution/Access)	Network admin needs to enhance user experience by ensuring traffic and application delivery using custom QoS policies for trusted/untrusted interfaces. <ul style="list-style-type: none"> <li>Traffic types: VOIP, Video, Call Control, Transactional Data, Bulk Data, Scavenger</li> <li>Policing Ingress and Priority &amp; BW Management in Egress</li> </ul>
12	Plug-n-Play (Distribution/Access)	Simplify network provisioning of new switches by Zero-Touch-Deployment for Day0 using NG-PNP app via APIC-EM for image and config management
13	Smart Install (Distribution/Access)	Simplify network provisioning of new switches by Zero-Touch-Deployment for Day0 using Smart Install
14	AutoConf (Access)	Simplified network deployment of IP phones, cameras, telepresence, access points, and other end units connected to a Catalyst switch for a network administrator
15	ASP (Access)	Enable ease-of-use feature (for example, ASP that enables admin to automatically detect the devices that are connected to configure the port using macros)
Monitoring & troubleshooting		
16	SPAN, Wireshark (Distribution/Access)	Network admin should be able to troubleshoot the network by capturing and analyzing the traffic. <ul style="list-style-type: none"> <li>SPAN, Remote-SPAN</li> <li>Wireshark-Dataplane &amp; Control Plane Capturing</li> </ul>
17	NetFlow (Distribution/Access)	Enable IT admins to determine network resource usage and capacity planning by monitoring IP traffic flows using Flexible NetFlow <ul style="list-style-type: none"> <li>Traffic types: L2, IPv4, IPv6</li> <li>FNFv9, IPFIX-v10</li> <li>Prime Collector/LiveAction</li> </ul>
Simplified management		
18	Prime-Manage-Monitor (Distribution/Access)	Network admin wants to manage and monitor all the devices in the network using Cisco Prime Infrastructure.

Table 5 continued

19	Prime-SWIM (Distribution/Access)	Network admin should be able to manage images on network devices using Cisco Prime Infrastructure for upgrade/downgrade.
20	Prime-Template (Distribution/Access)	Network admin wants to configure deployment using Cisco Prime Infrastructure. <ul style="list-style-type: none"> <li>▪ Import and deploy customer specific configuration templates</li> <li>▪ Schedule configuration for immediate or later deployment</li> <li>▪ Simplify configuration using config-templates</li> </ul>
21	Prime-Troubleshooting (Distribution/Access)	Simplify network troubleshooting and debugging for IT admins <ul style="list-style-type: none"> <li>▪ Monitor &amp; troubleshoot end-end deployment via maps &amp; topologies</li> <li>▪ Monitor network for alarms, syslog, and traps</li> <li>▪ Troubleshoot network performance using traffic flow monitoring</li> </ul>
22	WebUI-Day0 Wizard (Distribution/Access)	Network admin deploys 3850 in the access layer site (Day 0). <ul style="list-style-type: none"> <li>▪ Able to do basic settings in an Access deployment scenario where the switch is deployed in the access layer with a single uplink to peer with the distribution/gateway switch</li> <li>▪ Goal is to configure the switch with necessary management configuration along with relevant switch and port level configurations that can provide connectivity to the end devices</li> </ul>
23	WebUI-Configuration (Distribution/Access)	Network admin to be able to configure the system (Day N) <ul style="list-style-type: none"> <li>▪ Switch uplink/downlink interface configs and provisioning of spanning tree protocol</li> <li>▪ Most commonly used system level services (DHCP, NTP, DNS, Time/Date, Telnet/SSH)</li> <li>▪ Security features-ACL, Access-Session, Port-Security, IPv6 FHS</li> <li>▪ Implement Quality-of-Service using Cisco-recommended Auto-QoS</li> </ul>
24	WebUI-Monitoring (Distribution/Access)	Network admin should be able to monitor the health of the system. <ul style="list-style-type: none"> <li>▪ Monitor the health of the system in terms of the CPU utilization and memory consumption of the switch</li> <li>▪ Have the flexibility to look for the system health during a particular time range</li> <li>▪ Flexible enough to look for the system health during a particular time range</li> </ul>

Table 5 continued

25	WebUI-System Management (Distribution/Access)	Network admin routinely performs the task of Asset Management. <ul style="list-style-type: none"> <li>Includes the detailed hardware inventory information down to serial numbers, software versions, stack information, power usage, licensing information, etc.</li> </ul> <p>Furthermore, it is a common practice to generate system reports based on this for audit purposes.</p>
System health monitoring		
26	System Health (Distribution/Access)	Monitor system health for CPU usage, memory consumption, and memory leaks during longevity
System & network resiliency, robustness		
27	System Resiliency (Distribution/Access)	Verify system level resiliency during the following events: <ul style="list-style-type: none"> <li>Active switch failure</li> <li>Active SUP failure</li> <li>Standby/Member switch failure</li> <li>EtherChannel member link flaps</li> </ul>
28	Network Resiliency (Distribution/Access)	High availability of the network during system failures using: <ul style="list-style-type: none"> <li>VSS</li> </ul>
29	Typical Deployment Events, Triggers (Distribution/Access)	Verify that the system holds well and recovers to working condition after the following events are triggered: <ul style="list-style-type: none"> <li>Config Changes—Add/Remove config snippets, Default-Interface configs</li> <li>Link Flaps, SVI Flaps</li> <li>Clear Counters, Clear ARP, Clear Routes, Clear access-sessions, Clear multicast routes</li> <li>IGMP/MLD Join, Leaves</li> </ul>

# Appendix A

You can find example configurations at the following location:

<http://cvddocs.com/fw/cvpconfig>







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