# Network Virtualization—Network Admission Control Deployment Guide

This document provides guidance for enterprises that want to deploy the Cisco Network Admission Control (NAC) Appliance for their campus users. Two solutions for Network Admission Control are proposed and analyzed in this document, at both the architectural and functional levels. For related information, see the following documents:

- *Network Virtualization—Access Control Design Guide*— http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/AccContr.html
- *Network Virtualization—Guest and Partner Access Deployment Guide*— http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/GuestAcc.html
- *Network Virtualization—Path Isolation Design Guide*— http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/PathIsol.html
- *Network Virtualization—Services Edge Design Guide*— http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/ServEdge.html

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# Introduction

This document provides network architects with a general understanding of how to leverage network virtualization to make a centralized NAC Appliance deployment easier. This document allows the network architect to select a design and reference the specific implementation details in the associated design guides. The foundation technologies associated with enterprise network virtualization architecture are divided into the following three functional areas:

- Access control
- Path isolation
- Services edge

Several technologies and techniques can be used to provide the functionality required in each area. Rather than attempting to provide detailed information for every available technology option within the scope of this document, a separate set of design guides provide more information on each of these technologies:

- *Network Virtualization—Access Control Design Guide*—
  http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/AccContr.html
- *Network Virtualization—Path Isolation Design Guide*—
  http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/PathIsol.html
- *Network Virtualization—Services Edge Design Guide*—
  http://www.cisco.com/en/US/docs/solutions/Enterprise/Network_Virtualization/ServEdge.html

This modularity provides the flexibility to combine various sections of these design guides to tailor the solution implementation documentation to better serve customer requirements and architect choices.

Most enterprise networks do not perform user validation or security posture checking for systems before allowing a device access to the network. Typically, any network device can be connected to any open wired network port, which exposes the enterprise to insecure devices and potentially infected machines. Devices that do not comply with the enterprise network access policy can greatly affect the availability of network resources to the enterprise by spreading worms and viruses and placing vulnerable machines that can be targeted by attackers inside the corporate environment.

IT departments are tasked with providing reliable secure network services for customers, partners, and guests, and need a way to check devices for compliance with corporate security policy. Cisco NAC provides a mechanism to authenticate a user before being allowed access to the corporate network, and to verify that the device with which they are connecting meets the corporate security policy (anti-virus, up-to-date service packs, and patches are applied). If a device is out-of-policy, NAC provides a mechanism to automate remediation of the system without a call to technical support. Enterprise networks today must accommodate partner and guest access in addition to the traditional corporate employee access. NAC supports this functionality with different access policies for different user types. A NAC policy may grant a guest user Internet access only, a partner may have access to the Internet plus a limited set of internal corporate systems, and internal employees can have full access.

NAC deployments currently consist of two key pieces: a NAC Appliance Manager that is centrally deployed, and several NAC Appliance Servers that are distributed throughout the campus. In many environments, a distributed deployment can be cost-prohibitive because of the large number of NAC Appliance Servers that must be deployed. Virtualization enables an enterprise to centralize all the NAC Appliance Servers into the data center, achieving better economies of scale, and provides an isolated network for remediation. A virtualized deployment can reduce the number of devices needed to cover a campus, providing both capital and operational cost savings.

By implementing a NAC solution, enterprises can control network access, prevent un-patched systems from gaining access to the corporate network, quarantine systems that do not meet policy, and remediate with little or no help from IT.

The main technical requirements for a virtualized NAC solution are as follows:

- Isolation of the device from the internal enterprise until the user is authenticated and the access policy is applied
- Isolated remediation on the virtualized network
- Automated remediation of out-of-compliance asset
- Support for both wired and wireless access
- Provisioning for multiple user types (employee, partner, guest)
- Authentication and authorization for user and device
- Minimize the number of managed devices
- Better utilization of user licenses

# End-to-End Network Virtualization Solution

To provide virtualized NAC, a virtual network is created for authentication and quarantine. This virtual network is logically overlaid onto the existing infrastructure, and allows connectivity only to authentication and remediation resources. After the user is authenticated and the access device meets policy, the NAC manager can place the device into the appropriate VLAN.

## End-to-End Overview

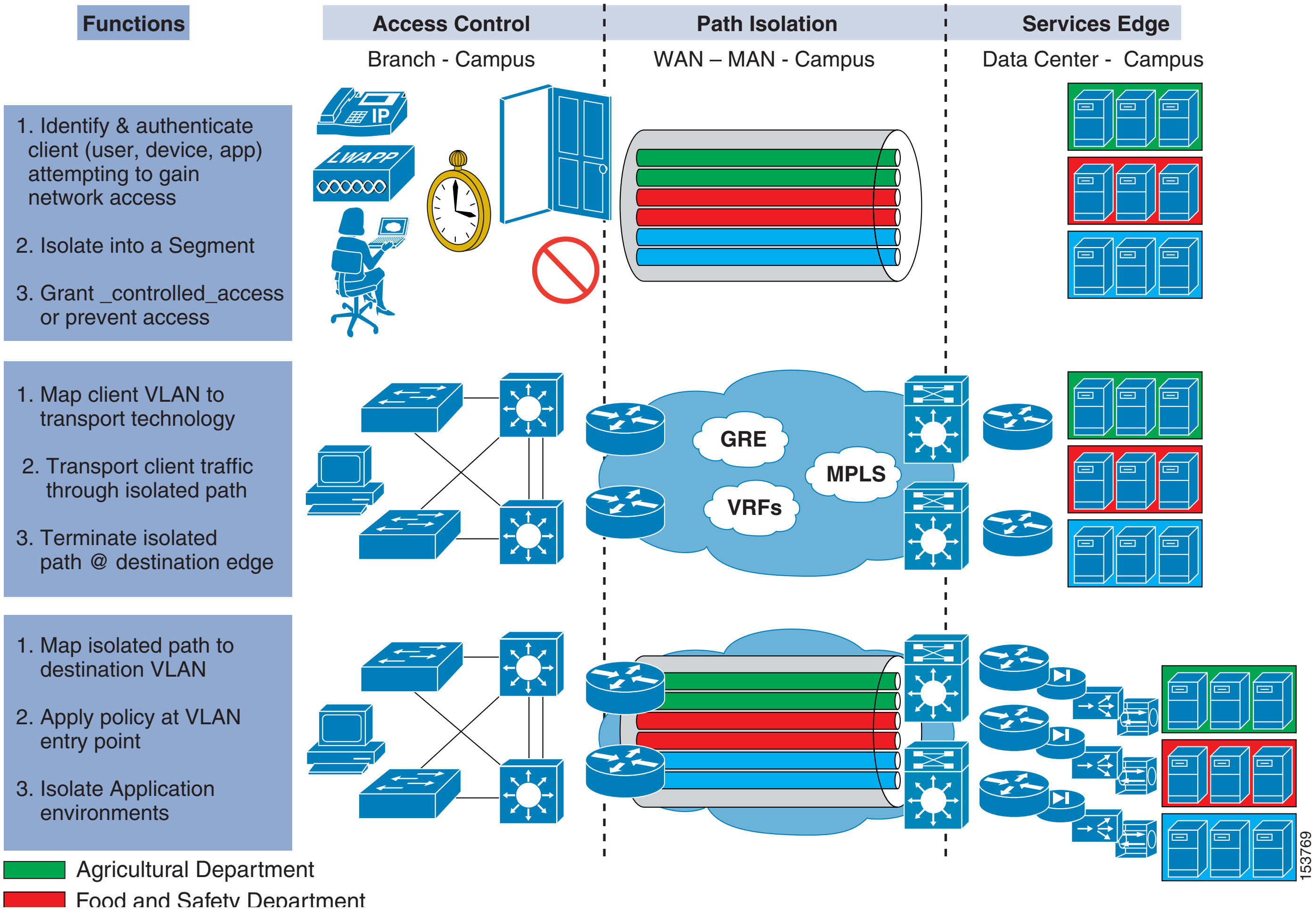
The goal with this solution is threefold:

- Identify, authenticate, and associate the user to the access policy
- Isolate the user device from the production network while checking the device posture, and to remediate if necessary
- Move the device into the appropriate network segment

The solution framework is divided into three functional areas (see Figure 1), each of which maps to one of these objectives:

- User authentication
- Path isolation
- Services edge

*Figure 1 Solution Framework—Three Functional Areas*


Functions
Access Control
Path Isolation
Services Edge
Branch - Campus
WAN – MAN - Campus
Data Center - Campus
1. Identify & authenticate client (user, device, app) attempting to gain network access
2. Isolate into a Segment
3. Grant _controlled_access or prevent access
IP
LWAPP
1. Map client VLAN to transport technology
2. Transport client traffic through isolated path
3. Terminate isolated path @ destination edge
GRE
MPLS
VRFs
1. Map isolated path to destination VLAN
2. Apply policy at VLAN entry point
3. Isolate Application environments
🟩 Agricultural Department
🟥 Food and Safety Department
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The end-to-end solution involves an optimal combination of chosen technologies available in each functional area.

**Note** The main goal of this deployment guide is to provide an end-to-end virtualized NAC solution. This means that the technical elements comprising the path isolation and services edge functional areas are shared and valid for both categories of users.

# User Authentication and Access

When users connect to a NAC-enabled network, they are placed into the authentication and remediation virtual network and challenged for authentication credentials. User authentication can happen via the Cisco NAC client software, web-based authentication, a guest access button, or MAC white listing. Authentication is used to associate a user with an access policy and to put the client in the proper VLAN.

Switch port state for users connecting to an Ethernet port include the following:

- Static port configuration—A port is statically assigned to a VLAN and not managed by NAC; the port is in turn statically associated with a virtual network or segment. This may be done to accommodate a specific type of network device but care must be taken to protect the physical port because an attacker could disconnect the device and gain network access via this port. Cisco recommends that these ports be placed into a VLAN with application-specific filters to restrict the ability of an attacker to use this port to gain general network access.

- Authentication VLAN—This is the VLAN into which all users are placed when connecting to the network. The authentication VLAN is mapped to the authentication virtual network isolating all traffic from the corporate network. If any remediation is necessary, the user is quarantined in this VLAN until the system passes all checks and then the device is moved to the access VLAN.
- Access VLAN—The access VLAN into which the user is placed can vary by user type. One access VLAN can be used for all users once authenticated, or different VLANs can be used for different user types. These user VLANs can be further isolated with distributed access control lists (ACLs) or by being mapped to virtual networks.
- MAC White Listing—This feature can be enabled on the NAC Manager to allow the switch to use the MAC address as the client identity. In this case, NAC Manager has a database of client MAC addresses that are allowed network access. This is useful for devices such as printers and other network-enabled devices that are unmanned.

## Path Isolation

Before a device has been allowed access to the corporate network, it must be authenticated and potentially remediated. While the device is being checked, it needs to be isolated from the corporate network. To achieve this, you can keep traffic logically isolated by using separate Layer 2 domains for authentication and access. To preserve end-to-end separation, these Layer 2 domains must be extended across the entire network. Extending Layer 2 domains end-to-end negates all the scalability and modularity benefits achieved by a hierarchical network design. IP routing is at the heart of the hierarchical design because of its ability to limit the size of broadcast domains and to lessen the impact of failures and changes by providing a modular structure that can prevent problems from propagating and affecting the entire network. A mechanism to provide network virtualization while preserving the scalability and modularity of the routed network is necessary.

When the Layer 2 domains at the edge are connected to the routed core of the hierarchical network, the logical isolation achieved at the edge by the Layer 2 domains is lost. Virtualized NAC requires that the initial authentication and remediation traffic to be routed to the NAC Appliance Servers located in the data center. A mechanism to give continuity to those segments over the routed core is needed.

The following alternatives are available to maintain this logical traffic separation in the Layer 3 domain of the enterprise network:

- Distributed ACLs and Policy-Based Routing (PBR)—ACLs can be configured at the frontier points between the edge Layer 2 domains and the routed core. These ACLs should ensure that hosts in the authentication VLAN can reach only the NAC Appliance Servers and any systems needed for remediation. PBR is then used to forward all authentication VLAN traffic to the NAC Appliance Servers in the data center. PBR must be configured hop by hop, it complicates device configurations, and can make troubleshooting difficult. Because of this, distributed ACLs and PBR is not recommended for campus NAC deployments.
- Overlay of Generic Routing Encapsulation (GRE) tunnels interconnecting VRFs—Another mechanism to provide continuity over the routed network to the logical separation provided by VLANs at the edge is to use IP tunnel overlays. A tunnel overlay (either in a full or partial mesh) is created for the authentication network. In this design, the access VLANs are placed into the global table. The tunnel overlay is mapped to the authentication VLAN at the first Layer 3 gateway (typically the distribution layer but it can be the access layer if a routed access design is used). This both isolates the authentication and remediation traffic and removes the need for PBR because all traffic is routed up to the data center and handed off to the NAC appliances.

By associating the VLAN interfaces and the tunnel interfaces in a group to a VPN Routing and Forwarding (VRF) instance, VLANs can be mapped to the required tunnel overlay. VRFs are considered as virtual routers (although they are not strictly that) to which different interfaces can be assigned. Assigning VLAN interfaces and tunnel interfaces to these virtual routers, or VRFs, effectively creates a virtual network that has its own links and routed hops. Thus, a virtual network built this way consists of VLANs, VRFs, and GRE tunnels, all working together to form a separate overlay topology. A routing protocol must run between the VRFs and over the tunnel mesh to provide the necessary reachability information. The underlying infrastructure is designed according to well-known hierarchical and high resiliency principles. Therefore, the tunnel overlay enjoys these benefits. See "Network Virtualization Deployment Scenarios, page 7" for a high-level deployment model. More information is provided in the *Network Virtualization—Path Isolation Design Guide*.

- MPLS/BGP VPNs (RFC 2547)—This technique uses Multiprotocol Label Switching (MPLS) to dynamically create a tunnel mesh similar to the tunnel overlay Cisco created for the GRE-based solution. These dynamic tunnels are better known as label-switched paths (LSPs), which handle traffic forwarding, while Border Gateway Protocol (BGP) is used to carry routing information between the VRFs. The separation of the control plane and the data plane is the key to being able to create the LSPs dynamically. This is the most scalable technique of all of the techniques described, but it is also the most demanding in terms of platform capabilities.

Although all the techniques listed can be used, some are better suited for a campus NAC deployment than others. Distributed ACLs and PBR can be very difficult to manage and troubleshoot in a large environment, and is not recommended unless it is the only option that the infrastructure supports. VRF and GRE is a good solution if the network has no other requirement for virtualization. This approach is straightforward to configure, and management and troubleshooting can be done by anyone that has a routing and switching background. Full campus MPLS VPN is the best choice if the enterprise requires multiple virtual overlay networks; for instance, if NAC, guest, and partner networks are required.

Whichever technique is used, it can be overlaid onto the existing infrastructure. This means that the network continues to function as usual, and only traffic that is steered into the created virtual network is isolated or segmented. When adding support for NAC, the requirement for isolation is the authentication and remediation traffic only. This is achieved by creating a virtual network for NAC authentication traffic using one of the methods listed above. Regular traffic continues to be forwarded as normal without having to create a dedicated segment for any other category of users. Isolating the initial connection of a user without altering the existing network traffic flow is the main benefit to this type of deployment for NAC.

## Services Edge

Users attaching to the NAC authentication virtual network are isolated from the main corporate environment. Several services are needed from this isolated environment to enable a user to login and do any necessary remediation. Services such as DHCP/DNS, access to authentication services such as AD/LDAP (proxied through the NAC Appliance Server but perhaps requiring direct access), access to remediation servers, and Internet access for remediation need to be pinholed through so that normal user login can happen. The services edge also provides access to services that are shared between the NAC and corporate networks. To achieve this, the services edge provides logical connectivity and security mechanisms over shared facilities, such as firewalls, load balancers, and even intrusion detection systems. For the purposes of the NAC connectivity scenario, connectivity is limited to the sharing and virtualization of firewalls to provide screening for traffic from the quarantined environment and for Internet connectivity, DHCP and DNS services for users on the NAC virtual network, and access to authentication services.

# Network Virtualization Deployment Scenarios

This section covers the following network virtualization deployment scenarios:

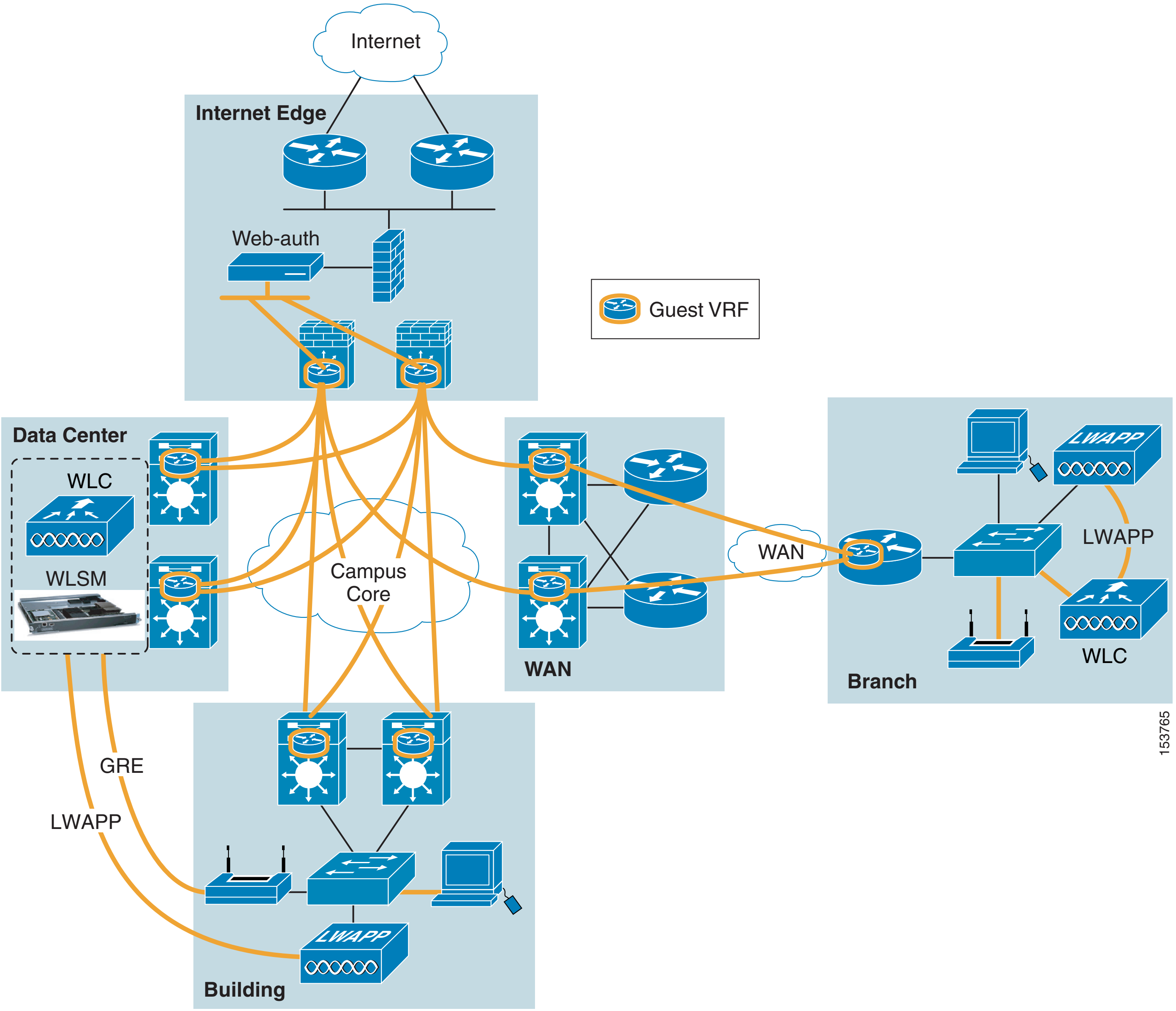
- Network Admission Control—Option A
- Network Admission Control—Option B

## Network Admission Control—Option A

This end-to-end proposition includes the following components (see Figure 2):

- Access control—NAC client authentication or web-based authentication
- Path isolation—GRE tunnel overlay and VRF
- Services edge—Application Control Engine (ACE), Firewall Services Module (FWSM), and NAC Appliance

*Figure 2 End-to-End Network Virtualization*



## Access Control

When a user connects to the network, they are placed into an authentication VLAN by the NAC Appliance Manager. The authentication VLAN has very limited access to the rest of the network; typically, from this VLAN a user can access services that are needed for user authentication and OS and application updates. Users can authenticate in one of two ways: if attaching to the network with a corporate PC, the user is authenticated with the NAC client; if the system attaching to the network is uncontrolled, the user is prompted to authenticate after opening a web browser. The NAC client can support single signon so the user does not see a secondary authentication after logging onto their PC. The NAC web authentication can support both username/password or guest access. After the user is authenticated and the PC has passed all policy checks, the system is moved from the authentication

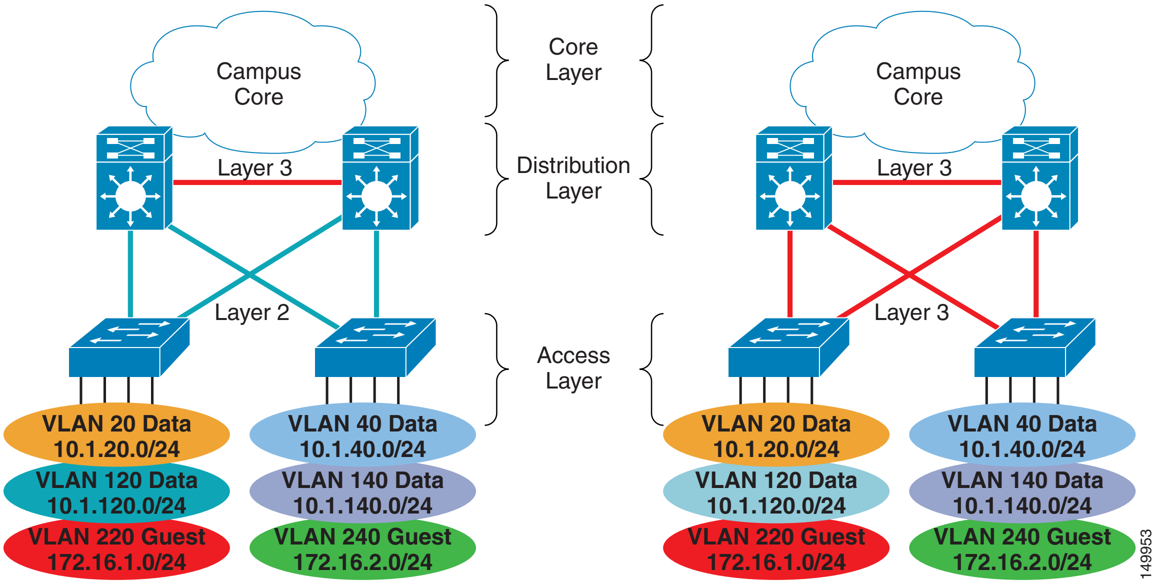
VLAN to an access VLAN based on the user profile. The access VLAN can be identified by name or number. Using the VLAN name, an enterprise can for example create a VLAN “Guest” on all switches in the network and not have to match VLAN numbers from each switch to a profile on the NAC Manager, simplifying management and reducing configuration errors.

## Path Isolation

The first stage of the path isolation solution is the creation of a VLAN to use for network authorization. This is very straightforward and all you have to do is add a new VLAN for authentication, following the same guidelines used for the deployment of other VLANs in the network access layer. In the campus, there is a separate authentication VLAN for each access layer switch.

Alternatively, a routed access layer can be used in which the VLANs are created at the access layer and do not impact the configuration of the distribution layer switches. Typically, it is best to stay with the current design in this model. Figure 3 shows both the traditional and routed access campus deployments.

***Figure 3 Traditional and Routed Access Campus Deployments***


Campus Core
Layer 3
Layer 2
Core Layer
Distribution Layer
Access Layer
Campus Core
Layer 3
Layer 3
VLAN 20 Data 10.1.20.0/24
VLAN 40 Data 10.1.40.0/24
VLAN 120 Data 10.1.120.0/24
VLAN 140 Data 10.1.140.0/24
VLAN 220 Guest 172.16.1.0/24
VLAN 240 Guest 172.16.2.0/24
VLAN 20 Data 10.1.20.0/24
VLAN 40 Data 10.1.40.0/24
VLAN 120 Data 10.1.120.0/24
VLAN 140 Data 10.1.140.0/24
VLAN 220 Guest 172.16.1.0/24
VLAN 240 Guest 172.16.2.0/24
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Next, the authentication VLAN is terminated into a Layer 3 VPN. In the associated design, the VLANs are terminated at the distribution in the campus. This can be generalized to include the devices at the border between the switched and routed portions of the network. In a routed access design, the authentication VLAN is connected to the Layer 3 VPN in the access layer switches.

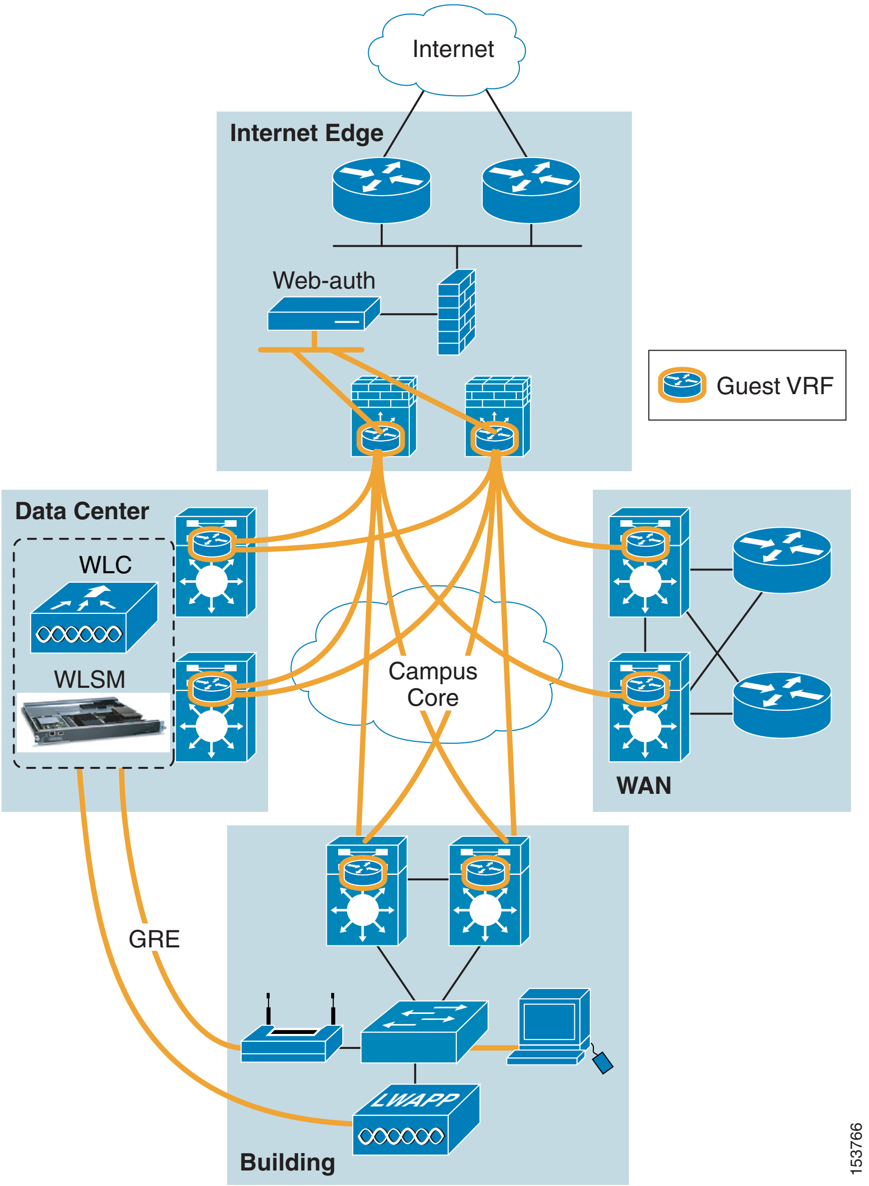
The authentication VLAN is kept separate from the rest of the network by mapping the VLAN to a VRF at the first Layer 3 hop. The IP default gateway for all devices in the authentication VLAN is an address in the VRF. By making the VLAN part of the VRF, the hosts in the authentication VLAN are removed from the original global network and isolated from the rest of the network because the VRF is a separate routing table. The result is similar to having connected the authentication VLAN to a separate physical network that is not connected to the original global network. Traffic in the authentication VLAN does not have a route or connection to the original network, and the original network does not know how to get to the isolated authentication VLAN.

At this point, you have created a new VLAN for authentication and connected it to a Layer 3 VPN, a virtual router instance, but communication is not enabled past this point in the network.

The next step is to connect the authentication VRF at the distribution switch back to the services edge so that clients can communicate to the NAC Appliance servers and manager. A GRE tunnel from the VRF in the distribution back to the VRF at the services edge switch can be used to accomplish this. The overlay GRE tunnels create a logical network across the existing network. This overlay network is used to carry traffic from clients while they are authenticated and their security posture is checked. Because the VRFs are isolated and have only tunnel and VLAN interfaces associated with them, this network is isolated from the rest of the infrastructure.

Figure 4 shows the original global network and the overlaid virtual network sharing the same infrastructure.

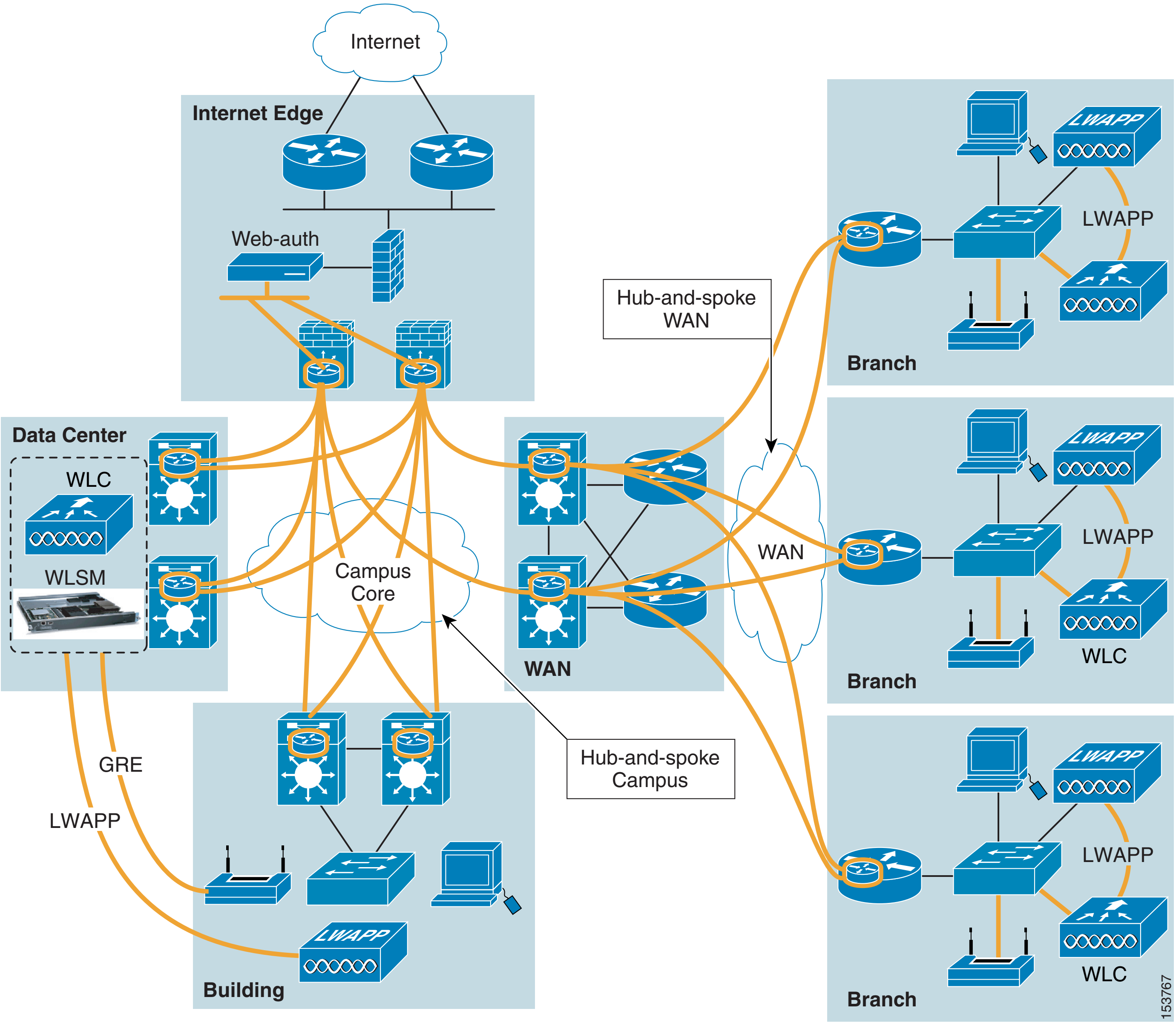
***Figure 4 VRF Overlay Network in the Campus***



This concept can be implemented with point-to-point GRE tunnels as well as multipoint GRE tunnels. The details on how to do this are provided in the *Network Virtualization—Path Isolation Design Guide*. For the specific NAC application, keep in mind that the requirement is for many-to-one connectivity, in which many users are accessing a central NAC Appliance farm that provides authentication, remediation, and network assignment.

GRE termination hubs are required for a termination point for the GRE tunnels from the distribution layer in the campus. Typically, this termination point is in the services edge switches in the data center. All GRE tunnels are terminated here and allow client traffic only to route to the services edge environment for processing.

***Figure 5 LAN and WAN GRE Tunnel Overlay (Private WAN)***



## Services Edge

In the services edge functional area, users access the following services:

- ACE modules
- DNS servers
- FWSM
- Internet
- NAC Appliance Servers and Manager
- Remediation servers

At the services edge, the clients are connected to the NAC Appliance servers. The appliances are fronted by the ACE module that is used to load balance the inbound connections across a bank of NAC appliances. The appliances authenticate the users and check the devices against the enterprise policy. For this to be possible, the NAC Appliance must have access to backend authentication servers, typically AD or LDAP, and the clients need to be able to access basic services such as HTTP, HTTPS, and DNS, as well as any protocol that a corporate remediation or patching system might use.

If the clients successfully authenticate and pass the policy checks, they can be placed into a VLAN. The client VLAN can be selected by name or number, but the best deployment method is to use VLAN names. This allows the user to be placed into the same VLAN regardless of the access layer switch to which they connect. For example, all the corporate access VLANs can be named “Employee” on the access layer switches regardless of what the VLAN numbers are today. This way the configuration on the NAC Appliance is greatly simplified (all corporate users can be sent to VLAN “Employee” regardless of where they connect.)

If the clients lack authentication credentials but are guest users, a guest option can be displayed to the user from the web login page. A guest user is not typically checked against any policy because they are uncontrolled systems. Guests can be placed in a separate guest-only VRF or into a VLAN with limited network access via ACLs. Common services used for guest and employee access can be shared. In many cases, the same DNS, DHCP, and Internet systems are shared between the two user groups so that system duplication is not necessary.

If the clients authenticate successfully but do not pass the policy check, they are placed into a quarantine state. They stay in the authentication virtual network to isolate them from the corporate network. They are given just enough access to remediate their system so that they are compliant (access to AV server, SMS/SUS, windowsupdate.microsoft.com, and so on), and then placed into the appropriate VLAN after they pass the checks.

# Network Admission Control—Option B

This end-to-end solution involves the following:

- Access control—NAC client authentication or web-based authentication
- Path isolation—MPLS
- Services edge—ACE and NAC Appliance Server

## Access Control

Access control for Option B is handled in the same way as for Option A. An additional VLAN is added to each access layer, typically following the design in place for existing VLANs. This VLAN is named "Auth-VLAN" and is the VLAN into which new users are placed when they connect to the network. When authenticated and checked for policy compliance, the user is placed into the proper VLAN by the NAC Appliance. The client VLAN can be mapped to any MPLS virtual network.

## Path Isolation

Deploying with enterprise MPLS VPN is similar to the setup in Option A. The VRF with GRE tunnels are replaced with the MPLS virtual networks. In an existing MPLS VPN design, an additional virtual network is added to the existing networks and used for client authentication and remediation as they joined the network. The "Auth-VLAN" is connected to the authentication virtual network and all traffic follows a default route back to the services edge, where it is handed off to the NAC Appliance for processing.

## Services Edge

The services edge is handled identically in Option B as it was in Option A.