Security Considerations for Intelligent WAN (IWAN)

White Paper

1. Introduction: Intelligent WAN

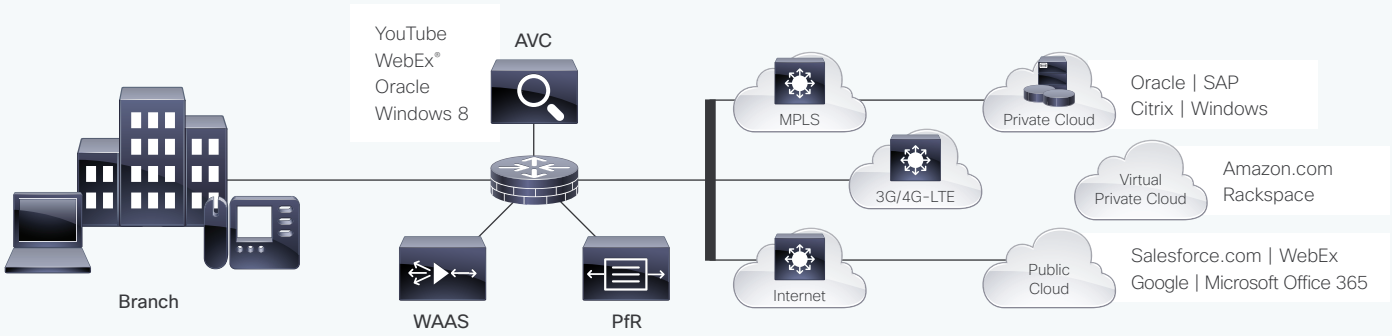
The proliferation of media-rich applications and an increased number of devices connecting to the network are causing a higher demand for bandwidth at branch locations. The bring-your-own-device (BYOD) trend, guest access, and Internet of Things (IoT) are all contributing to the need for more bandwidth.

Lower cost Internet connections have become more reliable and cost less than dedicated links. Cisco® Intelligent WAN (IWAN) solution gives you a way to take advantage of cheaper bandwidth at branch locations, without compromising application performance, availability, or security.

1.1 Cisco IWAN Solution Overview

Figure 1 illustrates some of the main advantages of the Cisco IWAN solution, and how you can benefit from it.

Figure 1. Cisco Intelligent WAN Solution and Benefits



Transport Independence
- Consistent operational model
- Simple provider migrations
- Scalable and modular design
- DMVPN IPsec overlay design

Application Optimization
- Application monitoring with Application Visibility and Control (AVC)
- Application acceleration and bandwidth savings with WAAS

Intelligent Path Control
- Application best path based on delay, loss, jitter, path preference
- Load balancing for full utilization of all bandwidth
- Improved network availability
- Performance Routing (PfR)

Secure Connectivity
- Protected links with strong (FIPS 140-2 Validated) encryption
- Class-leading Cisco Firepower® Threat Defense, including Next-Generation IPS, available on Cisco routers, Firepower Next-Generation Firewalls (NGFWs), and ASA with FirePOWER™ Services
- Cisco Cloud Web Security (CWS) for scalable and secure direct Internet access

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What Is Cisco IOS NetFlow?

Cisco IOS NetFlow is a network protocol for collecting metadata about the traffic flows through a given network device. This data provides actionable information about the sources, destinations, protocols, and volume of data traversing the network, and provides a means to baseline "typical" network traffic patterns. Cisco IOS NetFlow analyzers, like Cisco Stealthwatch, can map network connections and alert administrators to anomalies when traffic patterns change.

Benefits of the Cisco IWAN solution include:

- **Transport Independence Connectivity:** Cisco IWAN provides a Dynamic Multipoint VPN (DMVPN)-based overlay across all available connectivity. This provides one network with a single routing domain, which can be easily multihomed across different types of connections including Multiprotocol Label Switching (MPLS), broadband, and cellular. You gain the flexibility to use any available connectivity and to add or replace network connections without having to modify your network architecture.
- **Intelligent Path Control:** By using Cisco Performance Routing (PfR), Cisco IWAN improves application delivery and WAN efficiency. Cisco PfR dynamically controls data packet forwarding decisions by looking at application type, performance, policies, and path status.
- **Application Optimization:** Cisco Application Visibility and Control (AVC) and Cisco Wide Area Application Services (WAAS) give you visibility of and help you optimize application performance over WAN links.
- **Secure Connectivity and Threat Defense:** To meet common branch office security requirements, including the Payment Card Industry Data Security Standard (PCI-DSS), multiple security measures must be employed. By taking advantage of VPN, firewall, network segmentation, and threat defense capabilities, IWAN helps ensure that the solution provides the security you need.

1.1 Cisco IWAN Solution Overview

The primary focus of the design is to allow active-active usage of WAN transports in the following WAN-aggregation scenarios:

- **Hybrid WAN design:** This model uses Internet VPN as transport in conjunction with traditional WAN to provide more bandwidth for key applications while balancing service-level agreement (SLA) guarantees for the applications.
- **Dual-Internet WAN design:** This model uses two Internet service providers to further reduce cost while maintaining high reliability for network transport.

In both designs, all branch traffic is brought to your headquarters network, which makes further routing decisions and routes Internet-bound traffic to the Internet. With additional security measures in place, it is possible to forward certain Internet-bound traffic directly from the branch office. This design variation is called direct Internet access (DIA). The primary advantages of DIA are reduced bandwidth requirements at your headquarters, reduced network hops and latency due to direct routing, and better optimization from Internet-based content delivery network (CDN) solutions.

To reap these advantages, security of the solution is crucial. Read on to gain a high-level view of the security architecture for Cisco IWAN solution and how it protects against security challenges.

To understand more about the Cisco IWAN architecture, refer to the Cisco IWAN deployment guide (reference).

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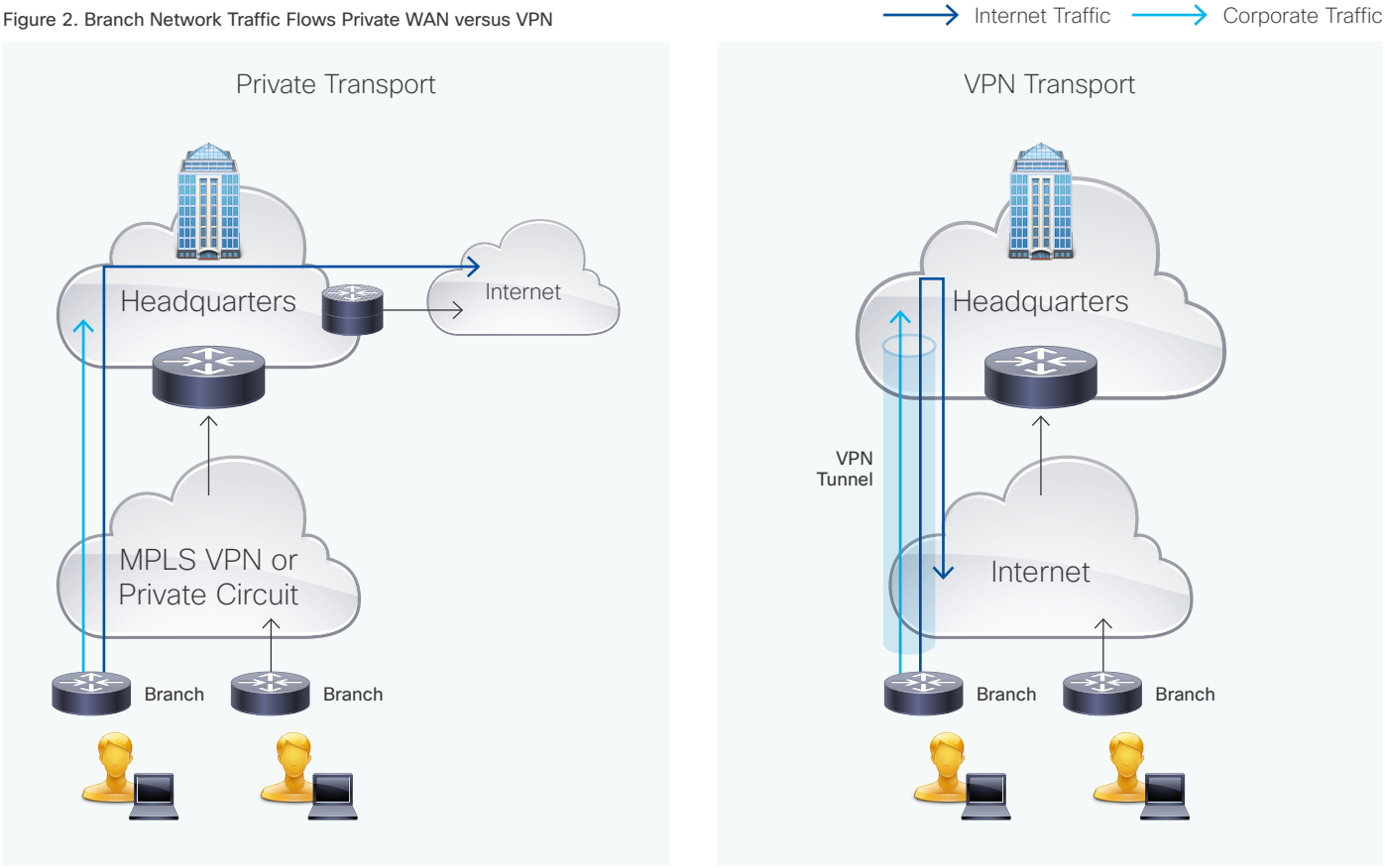
2. Security Architecture for Cisco IWAN

Traditionally, all branch traffic is forwarded to headquarters before being distributed to the rest of the corporate network and Internet using private WAN connectivity. Most of the security enforcements are deployed at the headquarters network. All security, access control, and monitoring policies are enforced there. See Figure 2.

Figure 2. Branch Network Traffic Flows Private WAN versus VPN



When you use the Cisco IWAN solution, the security and policy enforcement model still remains the same as shown in Figure 2. All the traffic is brought into a headquarters or larger regional office before being distributed out to the actual destination. That means you can follow the same security architecture, and benefit from added transport and edge security provided by the IWAN solution.

Where the branch is connected to the Internet directly, it is subject to the full range of Internet-based attacks and vulnerabilities. Thus, you need to incorporate additional security technologies into the architecture to protect the branch, and visitors, from security challenges arising from direct Internet connectivity. The main security objectives associated with direct connectivity to the public Internet are:

- Network isolation
- Data confidentiality and integrity
- Intrusion and advanced threat prevention
- Content inspection and malware detection

These challenges are explained in detail next, along with how Cisco IWAN architecture helps resolve them.

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2.1 Network Isolation

By separating networks so no traffic is passed between them helps to ensure that traffic is not leaked between the networks. In the Cisco IWAN solution, WAN-to-LAN separation is achieved using Virtual Route Forwarding (VRF), and network segmentation is done using the Cisco IOS® Software Zone-Based Firewall (ZBFW).

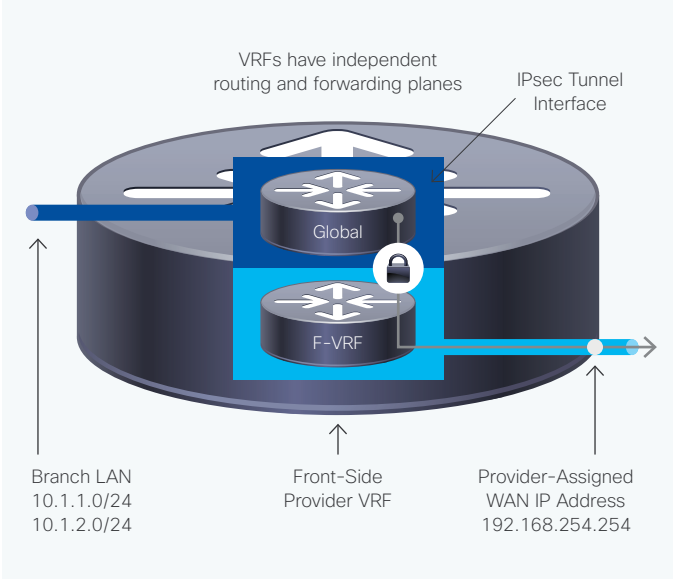
2.1.1 WAN-to-LAN Separation Using Front-Side VRF

Separating your internal network from the Internet is essential in protecting the branch network from unauthorized access and accidental traffic leakage.

Internet service providers (ISPs) and enterprise networks use their own IP routing and IP addressing schemes. Mixing up these schemes in the branch router can create inadvertent packet traffic forwarding to the wrong network, causing routing failures and data leakage. Also, rogue routing updates can cause disruptions. Virtual Route Forwarding gives you the ability to define virtual independent routing domains. Think of these as virtual routers with their own routing protocols and forwarding rules. This separation eliminates the possibility of routing attacks, inadvertent forwarding of corporate traffic to ISP networks, and IP address and subnet collisions between ISP and corporate networks.

Cisco IWAN uses a VRF configuration called front-side VRF (FVRF). See Figure 3. In this configuration, the DMVPN and branch network are parts of the global (inside) VRF while the WAN interface belongs to a separate (outside) VRF. Traffic from the branch network is routed only into the DMVPN tunnel network, using learnt routes via Border Gateway Protocol (BGP), Enhanced Interior Gateway Routing Protocol (EIGRP), or to a designated default route in the global VRF. The WAN interface is part of a different VRF. Only the DMVPN tunnel traffic, and certain control and management traffic, is routed through this interface.

Figure 3. Isolation of External Networks Using Front-Side VRF



2.1.2 Intra-LAN Separation Using Zone-Based Firewall

The Cisco IOS Software ZBFW feature gives you the ability to define different network security zones within the branch network and restrict access between the zones using granular access policies.

The configuration involves defining security zones based on the security requirements of the branch. After the zones are defined, each network interface is made a member of one security zone. One interface can only belong to one zone, but a zone can have multiple interfaces as part of it. Interfaces belonging to the same zone have unrestricted traffic flow between them. Traffic flows between zones are blocked by default. Policies need to be defined and applied between each zone pairs so that traffic can flow between those zones.

Use this reference for more details about Cisco IOS Software ZBFW.

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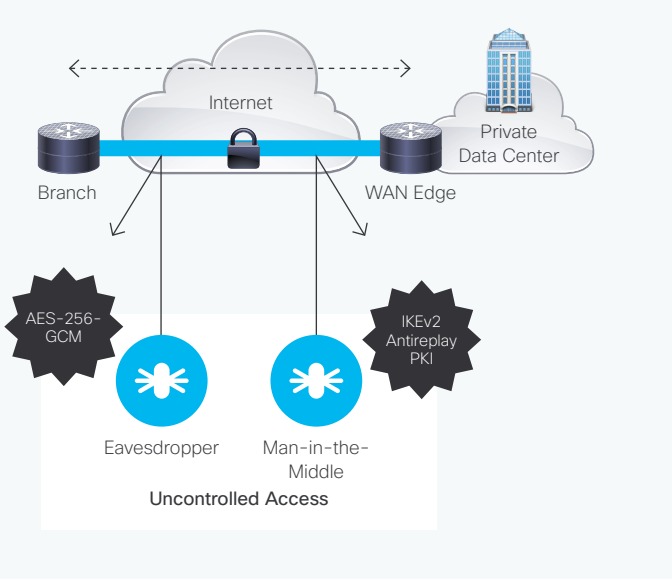
2.2 Data Confidentiality and Integrity

Unprotected Internet communication is open to eavesdropping, traffic injection, session hijacking, etc. See Figure 4. Public Internet connections are more vulnerable to these attacks compared with MPLS connections, but these attacks are still possible in MPLS networks. To protect your network, implement safeguards over all WAN connections.

Figure 4. Assure Confidentiality by Using Strong Cryptography



Cisco IWAN confidentiality and integrity is achieved by deploying IP Security (IPsec)-based DMVPN to communicate between branch and data center sites. DMVPN is transport independent and can be deployed on both private and public WAN links.

The Cisco DMVPN is based on IPsec industry standards, which provides a choice of advanced cryptographic algorithms including 256-bit Advanced Encryption Standard Elliptic Curve Cryptography (AES-256-GCM, or "Suite B") coupled with Internet Key Exchange version 2 (IKEv2).

IKEv2 provides the ability to authenticate each peer before establishing the VPN session. Public key infrastructure (PKI) with digital certificates provides a highly secure controlled mechanism for authenticating VPN peers. This mitigates the possibility of man-in-the middle attacks and identity spoofing by unauthorized devices presenting themselves as legitimate VPN peers. We recommend that each enterprise maintain its own certificate server, or Hardware Security Module, and issue certificates to branch routers following a strict issuance policy. This helps ensure strong certificate management. Care should be taken that these certificates are not inadvertently issued to non-router assets, as certificates could be misused.

Cisco IWAN management solution provides a mechanism for automatically installing digital certificates and periodically renewing the certificates automatically. This makes deploying a PKI solution effortless.

Refer to section 8 for more details about PKI deployment.

2.3 Intrusion and Attack Prevention

After the router is connected to the Internet, it will be subjected to attacks and intrusion attempts. These attacks are designed to cripple or take down the router or attack or infect the devices connected behind the router. To mitigate these risks, class-leading Cisco Firepower Next-Generation Intrusion Prevention (NGIPS) and Cisco Advanced Malware Protection (AMP) are available on Cisco Routers and on dedicated threat appliances that can sit behind the router, where required.

2.3.1 Control Plane Protection

These features protect the router itself from external or internal attacks intended to cripple router performance or to take control of the router. Some of the solutions used help:

- Turn off unwanted listening ports like HTTP, so that these ports are not used to gain access or overwhelm router control plane
- Enable control plane policing
- Turn off plaintext access modes like Telnet
- Enable authenticated access
- Limit router access only from a limited management subnet

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2.3.1.1 Control Plane Policing

Control plane packets are those destined for the router and are processed by the router's CPU. Large amounts of such traffic can overwhelm the router's CPU and affect overall router performance.

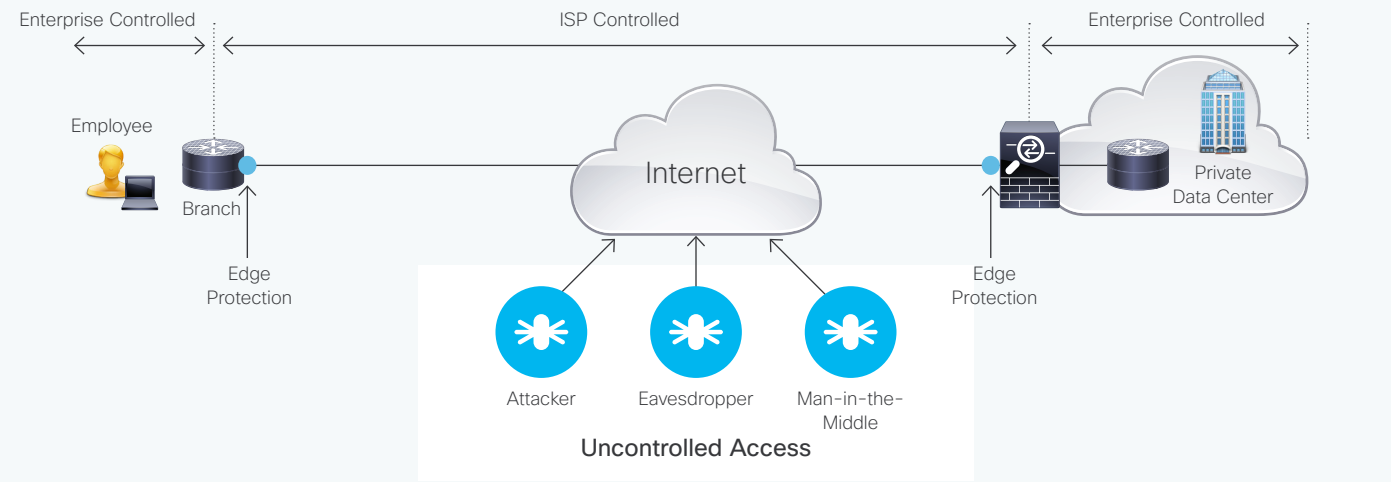
The Cisco IOS Control Plane Policing (CoPP) feature helps to protect the router from excessive or malicious control plane packets. Typical control plane packets are routing updates, such as Simple Network Management Protocol (SNMP), Internet Control Message Protocol (ICMP), IKE, Secure Shell (SSH) Protocol, and Telnet. Cisco IOS CoPP can help define priorities for each type of control packet and define a rate limit for control packets. Beyond the configured rate limit threshold, packets can be either dropped or allowed. The feature uses Cisco Modular QoS CLI (MQC).

Note: Transit packets through the router do not pose a problem for the router CPU, so the Cisco IOS CoPP feature is not necessary.

2.3.2 Edge Protection

In addition to safeguarding your router control plane, you also need to apply security protections at your network edge to protect the corporate network from external access. See Figure 5.

Figure 5. Protect Your Network with Network Edge Safeguards



When the branch router is connected to the Internet, it is exposed to access attempts and Internet-based attacks. Both the router and the branch network behind the router need to be protected. One way to achieve this protection is to restrict inbound traffic at the WAN interface to only VPN and designated management traffic. This is essentially IKE and IPsec traffic. Along with this, some essential management traffic like ICMP echo, Dynamic Host Configuration Protocol (DHCP), and Network Time Protocol (NTP) may also need to be permitted from specific networks or devices. Beyond this, no external traffic is permitted to enter the network, thereby preventing any external access attempts.

By allowing only DMVPN and management traffic from designated IP addresses, all other traffic (including bad traffic) is blocked from entering the branch router or the branch network. Perform this using the ZBFW feature in the router. The traffic policies between the WAN zone and the "self" zone of the router define the permitted traffic from the Internet. No traffic is allowed to the branch network behind the router.

IP-based distributed-denial-of-service (DDoS) attacks are still possible. But it cannot compromise the router as the traffic is blocked by the access control. A DoS attack can possibly congest the WAN link. In that case, Cisco IOS PfR can detect this congestion and redirect the traffic to an alternate path. DDoS attempts are highly unlikely in IWAN designs because in most deployments, provider IP addresses are used on the WAN interfaces making it very difficult for an attacker to know what device this is. Provider IP addresses can also be dynamically assigned to the router, which further obscures this attack point.

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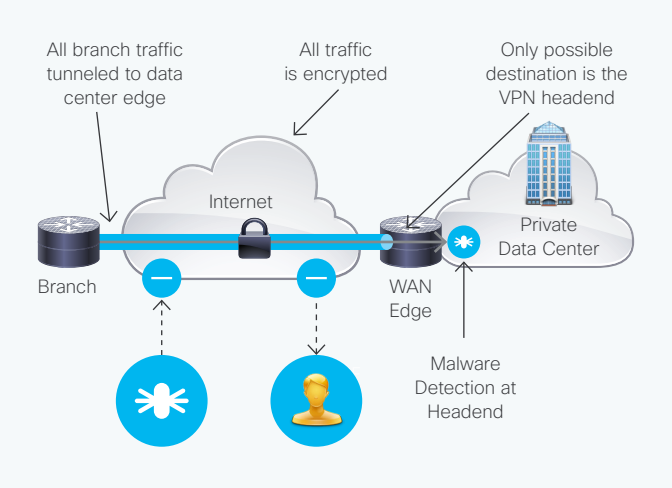
2.4 Content Scanning and Malware Detection

In the Cisco IWAN solution all the traffic exchange between the branch and the rest of the world is routed via the central site though the secure tunnel. Traffic flow is essentially the same as in the private WAN architecture, so the Cisco IWAN architecture does not add any additional security and content scanning requirements. See Figure 6. If the original security model did content scanning at the central site, the same model can be continued. The branch router forwards all traffic over highly secure DMVPN tunnels. Content can be inspected at the central site or at the demilitarized zone (DMZ) for security compliance. The Cisco IWAN DMVPN design does not change how or where content security scanning is needed in an organization's network.

Figure 6. Content Scanning of Branch Traffic at the Headend



2.4.1 Intrusion Prevention

The only way for traffic from the Internet to reach the branch is through the headquarters' Internet link. The branch router blocks any direct traffic to or from the Internet. Because no traffic from the Internet is allowed directly at the branch network, no additional intrusion prevention requirements exist at the branch. Any tools deployed at the central DMZ and branch will suffice without any additional policy changes because of Cisco IWAN.

Cisco Firepower NGIPS and AMP: One advantage of having a Cisco router at the branch is the ability to deploy it with the Firepower Virtual Appliance, featuring Firepower NGIPS and Advanced Malware Protection (AMP) capability. A typical deployment of Cisco Network AMP includes centralized management with Firepower Management Center. Firepower Management Center manages Firepower Sensors (physical and virtual) installed at different parts of the network. Firepower Management Center centrally manages threat defense policies and configurations, and also correlates threat indicators across sensors and endpoints with AMP for Endpoints.

The Firepower Sensor virtual appliance can be deployed on a Cisco Unified Computing System™ (Cisco UCS®) Express blade installed on a Cisco IWAN branch router. It runs on a VMware ESXi virtual environment running on the Cisco UCS Express blade. This enables distributed malware detection across branch offices.

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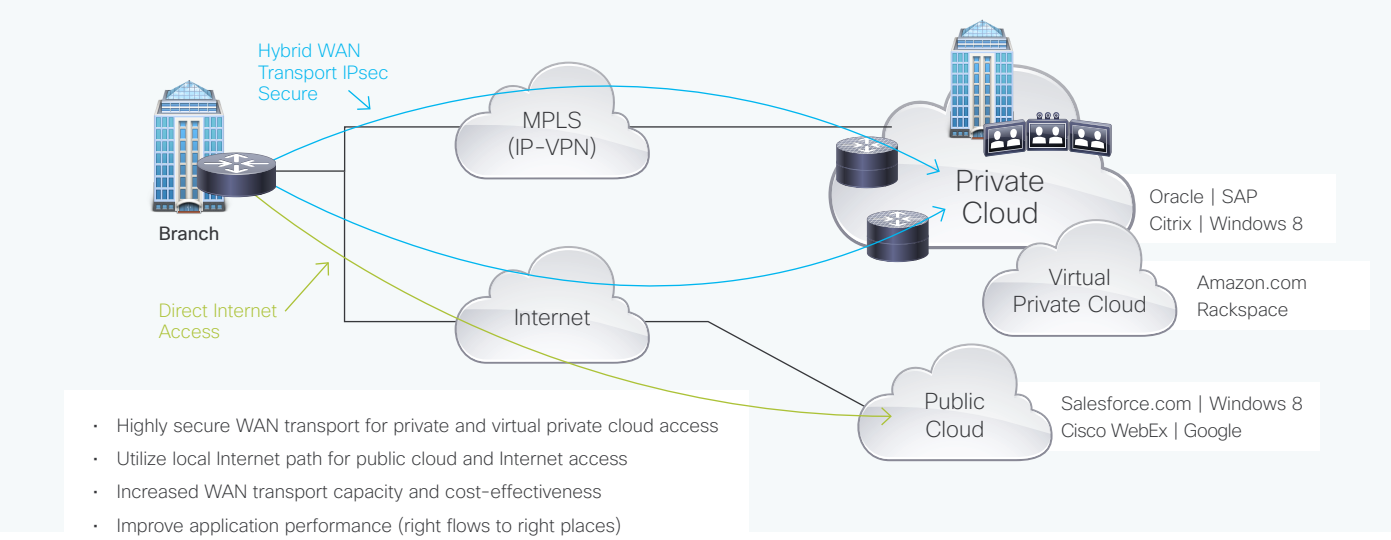
Security Considerations for Intelligent WAN (IWAN)

3. Security Requirements of Direct Internet Access

DIA is a variation of the Cisco IWAN solution in which certain Internet-bound traffic or public cloud traffic from the branch can be routed directly to the Internet via the broadband connection. In traditional architecture all the traffic is routed to headquarters. The primary advantages of DIA are reduced bandwidth requirements at headquarters, reduced network hops and latency because of direct routing, and better optimization from Internet-based CDN solutions. This makes DIA desirable in some deployments.

Figure 7. Internet-Based Secure WAN Transport and DIA at the Branch



Sending traffic directly from the branch to the Internet creates additional security challenges because the traffic bypasses the security tools deployed at headquarters. Therefore, you need to deploy security features at the branch. This paper next describes branch security requirements and how the Cisco IWAN solution can help meet them.

3.1 Guest Network Traffic

It's becoming more common for branch deployments to offer guest network access for visitors and partners. Guest devices are not controlled by corporate IT policies and may not be compliant with IT and InfoSec standards. In addition, it may not be your company's responsibility to protect the brought-in device and the data stored in it. Therefore, it makes sense, to route traffic from guest devices directly to the Internet.

Protecting Enterprise Networks: When allowing guest access, it is possible for a compromised device to spread malware to the rest of your branch network. Even worse, an attacker could use their brought-in device to compromise the branch network. The easiest way to protect the branch is to add guest devices to a separate wireless LAN (WLAN)/virtual LAN (VLAN) and make that network part of a separate guest zone of ZBFW. Guest zones should not have any access to the branch network zone. Directly route any traffic from this VLAN to the Internet. Guest devices can be forced into this WLAN by using an exclusive guest Secure Set Identifier (SSID). Your Ethernet ports can be protected with 802.1x-based authentication with guest VLAN fallback, where unauthenticated devices are automatically added to the guest VLAN, restricting their access to branch network.

Enforcing Access and Content Restrictions: Some IT administrators may want to enforce certain access and content restrictions on the guest access network. They may also want to set up malware protection on the guest network. You can achieve access restrictions by activating guest zone-to-Internet zone policies on the Cisco IOS ZBFW configuration.

Web content restriction and malware filtering can be achieved by using the Cisco Cloud Web Security (CWS) Connector feature on Cisco IOS Software. Cisco CWS Connector forwards all Internet traffic to Cisco CWS infrastructure where access control, content filtering, and malware filtering are enforced. Your security administrator can define these policies on the customer portal. (More details about Cisco CWS are provided in the following sections).

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3.2 Branch Network Traffic

In this deployment, the Internet-bound traffic from the devices on the branch network is directly routed to the Internet. This traffic bypasses the security tools at headquarters. Therefore, you need to enable additional security features at the branch.

Internet traffic primarily consists of HTTP and HTTPS. A significant advantage of DIA can be achieved by forwarding just HTTP/HTTPS directly. This paper describes two deployment models for DIA, depending on the company's security model and the desired degree of bandwidth saving. Forwarding only web traffic saves bandwidth at headquarters and reduces direct traffic exposure. Directing all traffic to the Internet saves much more bandwidth but exposes more traffic types.

3.2.1 Intrusion Prevention

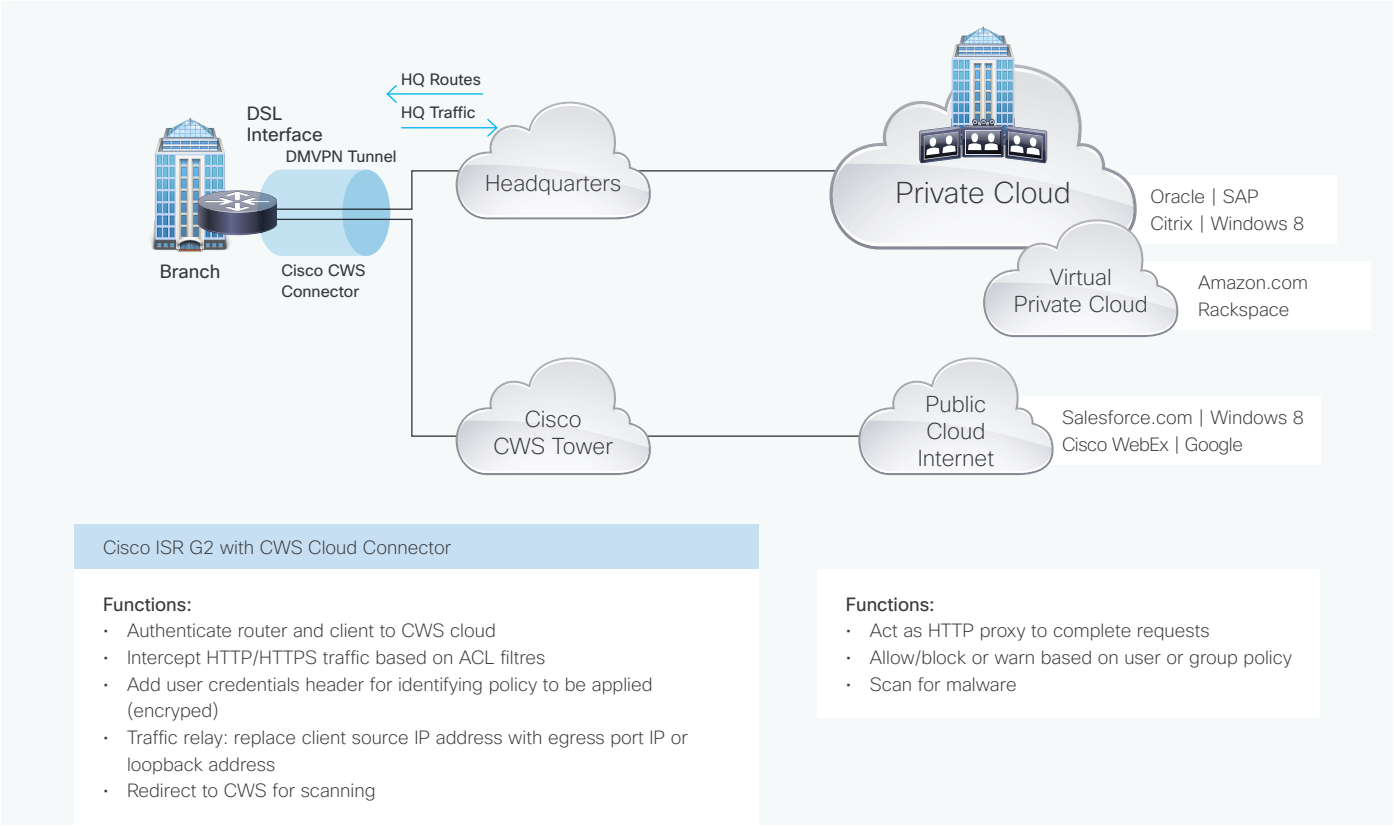
Cisco IOS Intrusion Prevention System (IPS) is a signature-based malware and network attack prevention tool. Use it to prevent known signature-based attacks. The signature set is periodically updated and categorized into different groups. Depending on the router platform type, an appropriate bundle of signatures can be activated.

3.2.2 Malware Protection and Access Control

Two products from Cisco provide malware detection capability for Cisco IWAN: Cisco CWS, which runs on a Cisco Integrated Services Router Generation 2 (ISR G2), and the Cisco Firepower virtual appliance, which is installed on a Cisco UCS Express blade on the Cisco IWAN branch router. Either solution provides the capability. Deploying both provide added security.

Cisco CWS

Figure 8. How Cisco CWS Connector Works



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Cisco CWS is a cloud-based malware detection and content filtering service, which works primarily on web traffic (HTTP and HTTPS). The web traffic needs to be delivered to Cisco CWS cloud servers through a proxy session. On Cisco IOS Software, this feature is called Cisco CWS Connector. After it is deployed on the branch router, Cisco CWS Connector forwards all web traffic to Cisco CWS cloud infrastructure. You use a management portal to define access policies and content filtering rules. Policies can be as granular as needed, and can be defined based on user ID, group, and IP address. Malware filtering is enabled automatically. You have an option to turn on Cisco Firepower NGIPS and AMP on the same portal, which provides added threat defense capabilities.

Cisco CWS Connector establishes an authenticated session with the Cisco CWS tower and forwards all web traffic to the tower. The tower acts like a web proxy and applies all the access policies and URL filtering on the forward direction. Content filtering and malware filtering is done in the reverse direction. The Cisco CWS tower acts as proxy and establishes a web session with the actual destination. This means the web servers only see the IP address of the Cisco CWS tower. In other words, the branch router's IP address is hidden.

Cisco CWS Connector can be enabled on the WAN interface or DMVPN tunnel interface. It is enabled on the tunnel interface if only web traffic is directly sent to the Internet and the rest of the traffic is routed to headquarters. If the routing is defined in such a way that only corporate traffic is sent to headquarters and the remaining (Internet) traffic is routed directly to the WAN interface, you need to enable Cisco CWS Connector on the WAN interface.

The branch router platform and the Cisco CWS license should be selected based on the number of concurrent users in each branch.

Cisco Firepower on Cisco UCS Express

The Firepower virtual appliance, with Next Generation IPS and AMP capability, can be deployed in the branch router, as explained in section 2.4.3. It inspects traffic between the branch router and the Internet and headquarters and threat intelligence and potential indicators of compromise are reported centrally to Cisco Firepower Management Center where threat correlation and automated reporting occur.

3.2.3 Firewall

When traffic is routed to the Internet directly, the internal IP addresses assigned to the branch devices need to be translated to externally routable IP addresses assigned by the ISP. This is needed so that the ISP can route the packets properly. Similarly, the ZBFW policies need to be modified to permit the return traffic coming from the Internet.

Network Address Translation (NAT): Most broadband providers will only give one or a limited number of IP addresses for each connection. This means NAT needs to be enabled on the outbound Interface if all protocols need to be routed to the Internet. If only web traffic is sent to the Internet, NAT can be avoided by taking advantage of the proxy-like capability of Cisco CWS Connector.

Zone-Based Firewall: Zone policies between the branch network and broadband interface need to be modified to support IP inspection. This is needed to allow return traffic corresponding to the connections initiated from the devices inside the branch. This configuration is not needed if Cisco CWS Connector traffic is the only direct outbound traffic permitted. It will work without IP inspection.

If additional firewalling, including Application (Layer 7) Firewalling are required, Cisco recommends its Next-Generation Firewalls, Firepower NGFW and ASA with FirePOWER Services.

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4. Cisco IWAN Solution Management

- Cisco Prime™ next-generation management is the recommended management tool for Cisco IWAN. Cisco IWAN is also supported by third-party tools. Refer to the Cisco IWAN deployment guide for more details.
- Cisco CWS provides its own cloud-based management portal.
- Cisco Firepower is managed by the Cisco Firepower Management Center.
- Cisco IWAN solution also provides a plug-and-play style configuration bootstrap mechanism for installing brand new branch routers.

5. Cisco Router Security Certifications

Cisco router platforms are validated by third-party labs to help ensure that they meet the requirements of major security certification programs. This helps to ensure that Cisco platforms can meet the security requirements of enterprise customers.

Cisco router platforms are validated against these major certification programs:

- **Federal Information Processing Standard (FIPS) 140-2:** U.S. and Canadian government computer security standard used to accredit cryptographic modules.
- **The Common Criteria (CC) for Information Technology Security Evaluation:** An international standard for computer security certification that defines different Evaluation Assurance Level (EAL) for evaluating security equipment. CC product certifications are recognized by 26 nations.
- Suite B Cryptographic Algorithms specified by the National Institute of Standards and Technology (NIST): Used by NSA's Information Assurance Directorate in solutions approved for protecting National Security Systems (NSS). Suite B includes cryptographic algorithms for encryption, key exchange, digital signature, and hashing.

Table 1 explains the certification levels of each Cisco router platform. Refer to cisco.com/go/securitycert for more details about security certifications.

Table 1. Cisco Router Platform Security Certifications

	FIPS 140-2, Level 2	Common Criteria EAL4	Suite B (RFC6379) Hardware Assist
Cisco ISR 890 Series	✓	✓	✓
Cisco ISR 1900 Series	✓	✓	✓
Cisco ISR 2900 Series	✓	✓	✓
Cisco ISR 3900 Series	✓	✓	✓
Cisco ISR 3900E Series	✓	✓	✓
Cisco ISR 4000 Series	✓	✓	✓
Cisco ASR 1000 Series	✓	✓	✓

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Security Considerations for Intelligent WAN (IWAN)

6. Conclusion

In summary, the Cisco IWAN architecture, coupled with its security and IPsec VPN features, provides the same level of security, privacy, and data integrity as in private WANs, giving confidence to enterprise and government organizations to use the public Internet as a highly secure WAN transport for their branch communication needs.

7. References

- Cisco Intelligent WAN Deployment Guide
- Cisco Intelligent WAN resources
- Cisco IOS Control Plane Policing (CoPP)
- Cisco Data Loss Prevention solution
- Cisco IOS Zone-Based Firewall (ZBFW)
- Cisco Validated Designs
- DMVPN Design Guide
- Global Government Certifications
- Digital Certificates/PKI for IPsec VPNs
- Deploying Cisco IOS Security with a Public-Key Infrastructure
- Cisco Cloud Web Security (CWS)
- Cisco Firepower Threat Defense
- Cisco Advanced Malware Protection

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