SEC+
Lesson 5:
Maintain Enterprise Campus Network Architecture

Objectives

- Compare and contrast security implications of different on-premises network architecture models
- Apply security principles to secure on-premises network architecture
- Select effective controls to secure on-premises network architecture
- Ensure secure communications for remote access and tunneling

Lesson 5

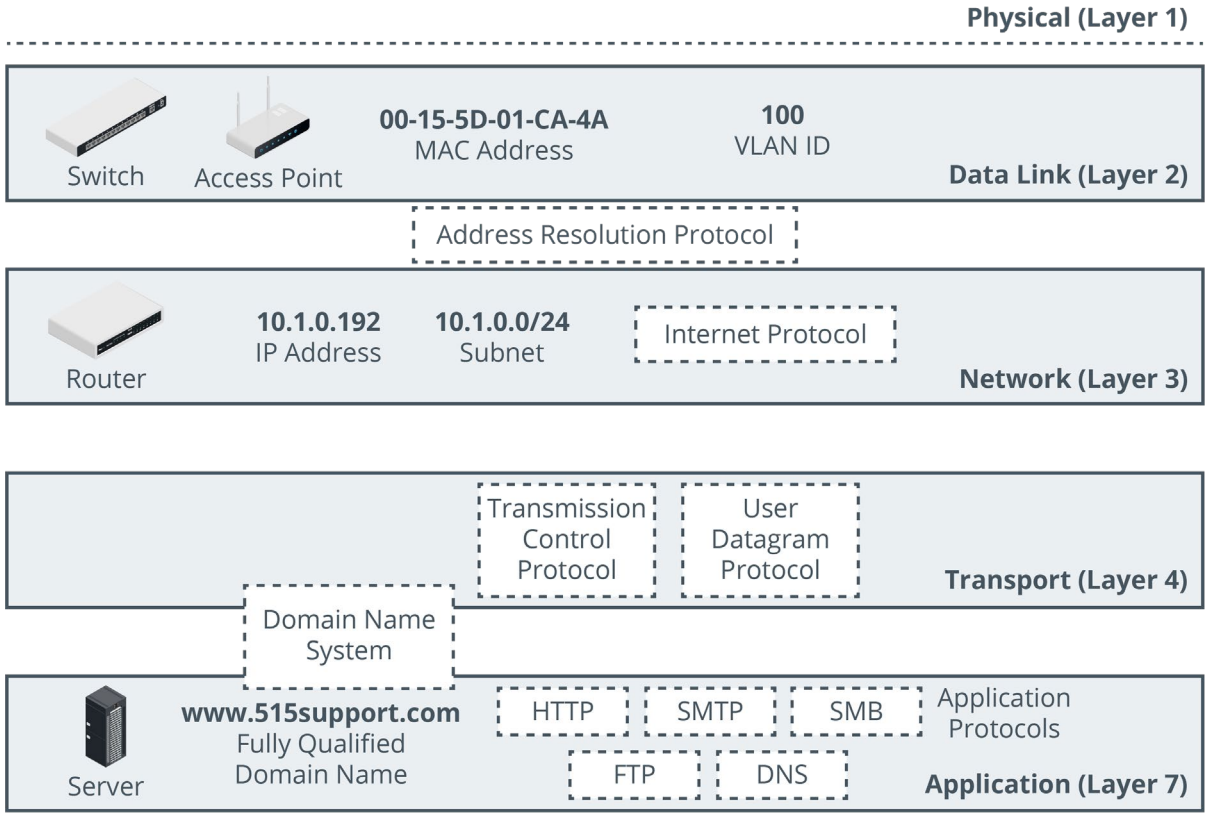
Topic 5A

Enterprise Network Architecture

Architecture and Infrastructure Concepts

- Selection and placement
  - Infrastructure (media, appliances, addressing/forwarding for connectivity)
  - Applications/services
  - Data
- Workflows
  - Access
  - Email mailbox server
  - Mail transfer server

Network Infrastructure



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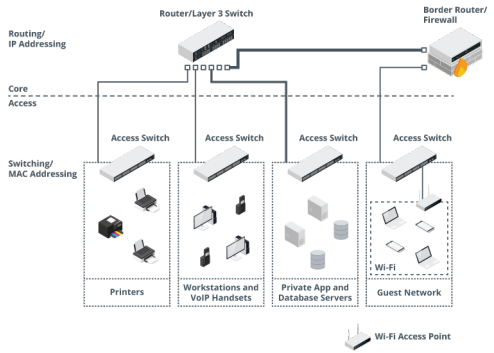
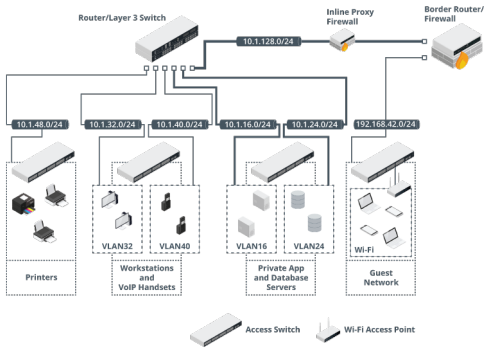
Switching Infrastructure Considerations

- Topology of nodes and links
  - Physical versus logical
- On-premises networks
  - Office/campus
  - Structured cabling
- Hierarchical design
  - Limit size of broadcast domains
  - Enforce segmentation



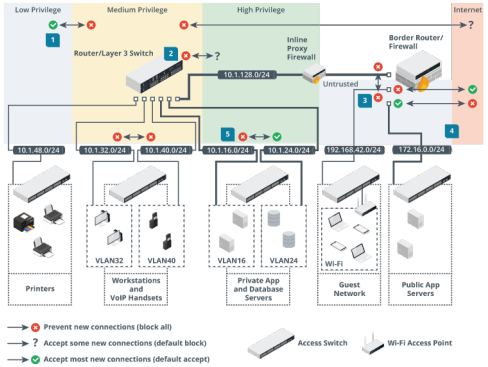
Routing Infrastructure Considerations



- Layer 3 logical segmentation
  - Networks and subnetworks (subnets)
- Internet Protocol (IP)
  - IPv4 and IPv6
  - Network prefix/subnet mask
- Virtual LAN (VLAN)
  - Map layer 2 switch port topology to layer 3 IP subnet topology
  - Makes logical topology independent of port location on physical switches

Security Zones

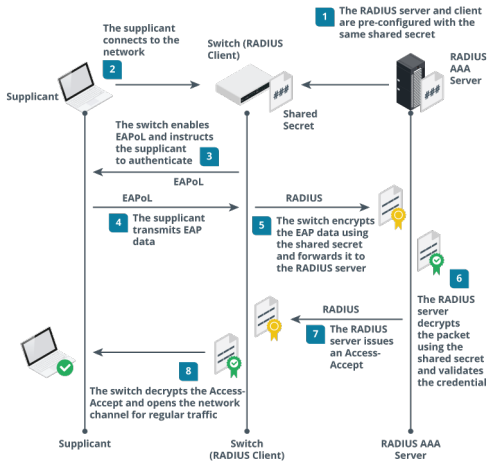
- Segment containing hosts with same access control/security requirements
  - Public versus private
  - Database and file servers
    - Compartmentalize different types of data assets
  - Client devices
  - Public-facing app servers
  - Network infrastructure servers



Attack Surface

- Points at which threat actor can gain access
  - Layer 1/2 versus layer 3 versus layer 4/7
- Defense in depth and layered security controls
- What problems arise from weaknesses in the network design/architecture?
  - Single points of failure
  - Complex dependencies
  - Availability over confidentiality and integrity
  - Lack of documentation and change control
  - Overdependence on perimeter security

Port Security



- Physical port security and administratively disabled ports
- MAC filtering and limiting
- 802.1X, EAP, and RADIUS
  - Supplicant (user's computer)
  - Authenticator/RADIUS client (switch)
  - Authentication/RADIUS server
  - IEEE 802.1X allows switches to implement EAP over LAN (EAPoL)
  - Extensible Authentication Protocol (EAP) provides framework for authentication methods/factors
  - Remote Authentication Dial-in User Service (RADIUS) allows use of a directory of user accounts and credentials

Physical Isolation

- Single host or group of hosts not connected to any other network
  - Air gapped
- Difficult to manage
  - Updates via media devices

Architecture Considerations (1)

- Cost
  - Upfront capital cost and loss of value through depreciation
  - Ongoing maintenance and support
- Compute and responsiveness
  - Reduce workload processing time
- Scalability and ease of deployment
  - Minimize costs associated with increasing (or decreasing) workloads

Architecture Considerations (2)

- Availability
  - Minimize downtime
- Resilience and ease of recovery
  - Reduce time taken to recover from failures
- Power
  - Costs of high compute resources and reliability of infrastructure
- Patch availability
  - Mitigate vulnerabilities
  - Inability patch due to third-party management or lack of vendor support
- Risk transference
  - Contracting infrastructure to third-parties

Enterprise Network Architecture

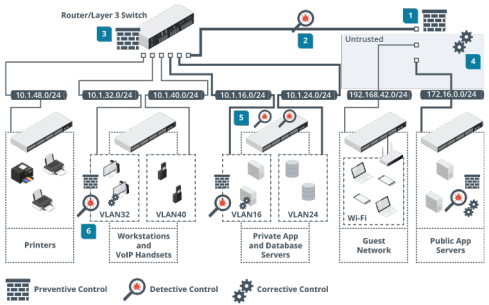
- Architecture and infrastructure concepts
  - Media, applications/services, data supporting workflows
- Network infrastructure
  - OSI layer model
- Switching and routing infrastructure considerations
- Security zones and attack surface
- Port security and physical isolation
  - MAC filtering, 802.1X/EAP/RADIUS
- Architecture considerations
  - Cost, compute/responsiveness, scalability/ease of deployment, availability, resilience/ease of recovery, power, patch availability, risk transference

Lesson 5

Topic 5B

Network Security Appliances

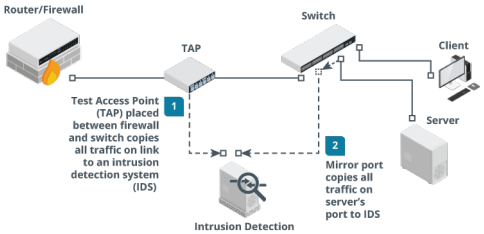
Device Placement



- Selection of effective controls
  - Enforce segmentation, apply access controls, monitor traffic
- Defense in depth
  - Zone border (mostly preventive)
  - Within zone (mostly detective)
  - Endpoint controls (preventive, detective, and corrective)

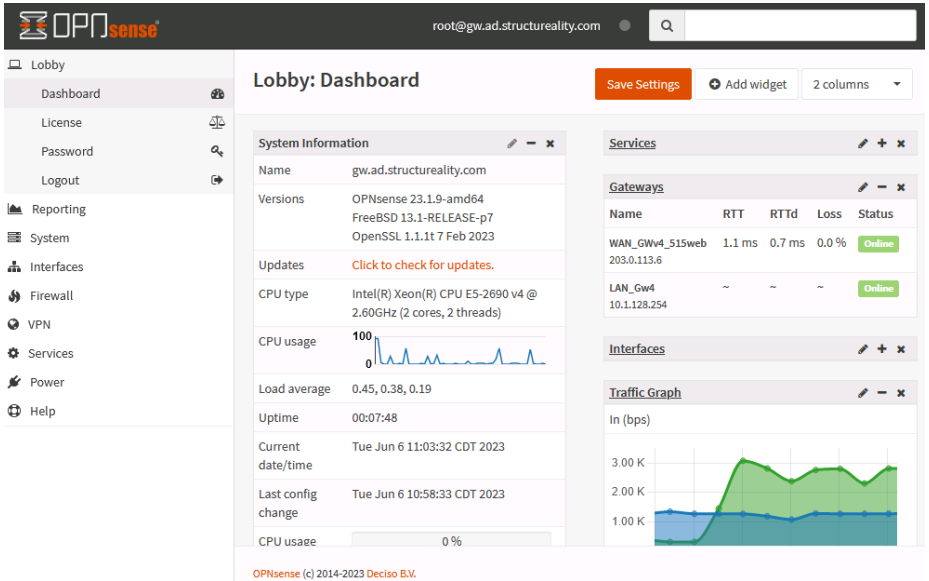
Device Attributes

- Active versus passive
  - Passive controls don’t require hosts to be configured to use them (and might not be detectable by hosts)
  - Active controls require host configuration or software agents
- Inline versus tap/monitor
  - Inline is installed as part of cable path (“bump-in-the-wire”)
  - Switched port analyzer (SPAN) or mirror port
  - Test access point (TAP)
- Fail-open
  - Preserves access on fail to prioritize availability
- Fail-close
  - Prevents access on fail to priorities confidentiality/integrity



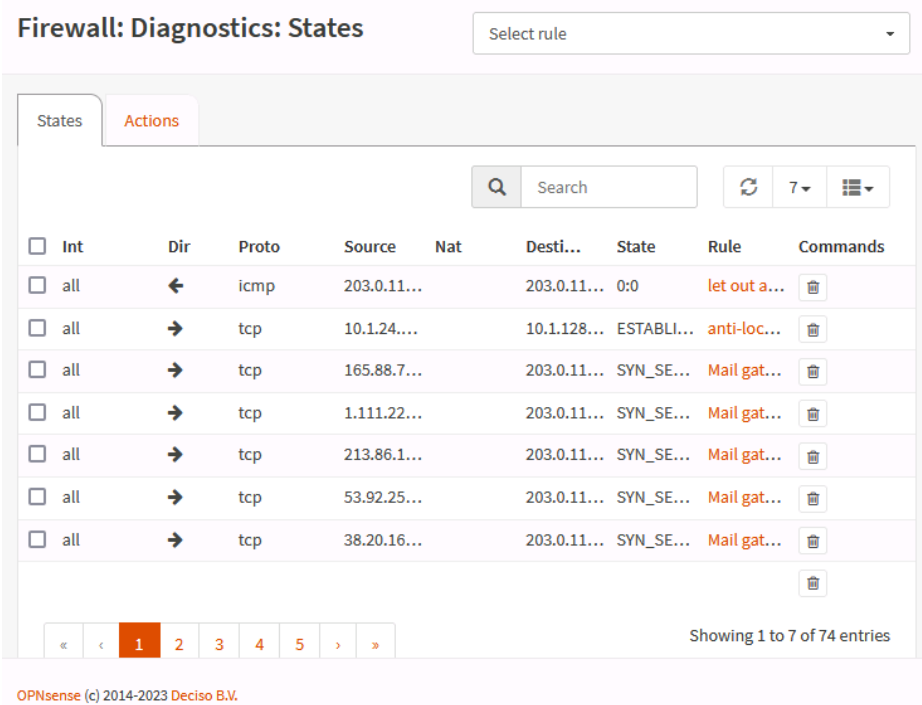
Firewalls

- Enforce a network access control list (ACL)
- Packet filtering inspects headers only
  - Source and destination IP address
  - Protocol ID/type (TCP, UDP, ICMP, routing protocols, and so on)
  - Source and destination port numbers (TCP or UDP application type)
  - Drop/deny/reject or accept/permit a packet (and/or log)
  - Inbound, outbound, or both
- Placement and attributes
  - Routed, bridged, or inline placement
  - Firewall appliance versus router firewall



Layer 4 and Layer 7 Firewalls

- Stateful inspection validates connections
  - State table stores connection information
- Transport layer (layer 4)
  - TCP handshake
  - New versus established and related connections
- Application layer (layer 7)
  - Validate protocol and match threat signatures
  - Application layer gateway, stateful multilayer inspection, or deep packet inspection
  - Application-specific filtering



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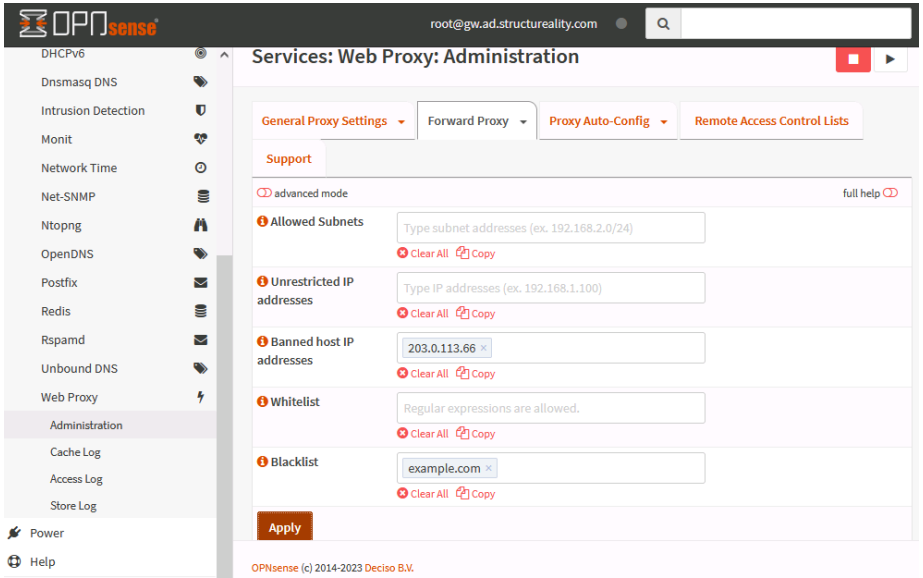
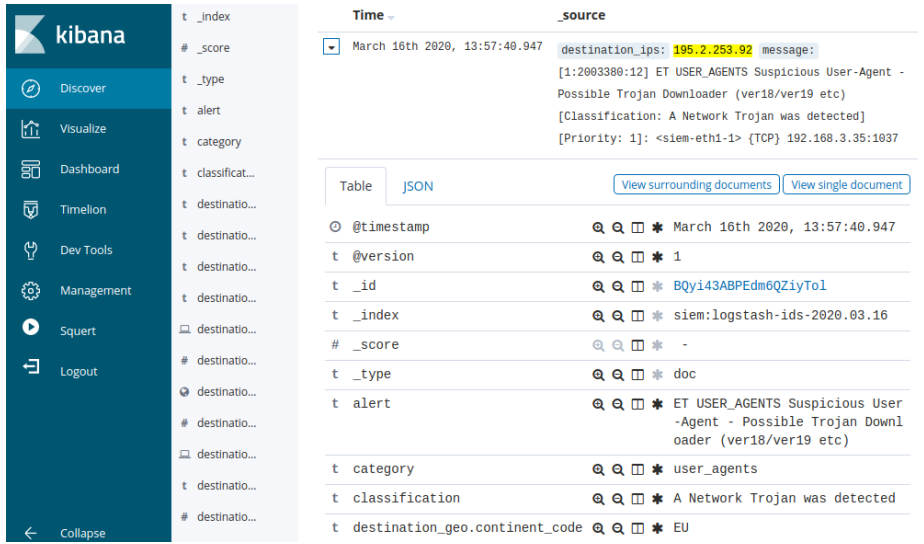
Proxy Servers



- Forward proxy server
  - Proxy opens connections with external servers on behalf of internal clients
  - Application-specific filters
  - Non-transparent and transparent proxies
  - User authentication
- Reverse proxy server
  - Proxy opens connections with internal servers on behalf of external clients

Intrusion Detection Systems

- Sensor captures traffic
  - Placement
  - Inline versus mirror/tap/monitor
- Intrusion Detection System (IDS)
  - Detection engine performs real-time analysis of indicators
  - Passive logging/alerting
- Intrusion Prevention System (IPS)
  - Active response (block, reset, redirect)
  - Inline response versus integration with other security tools



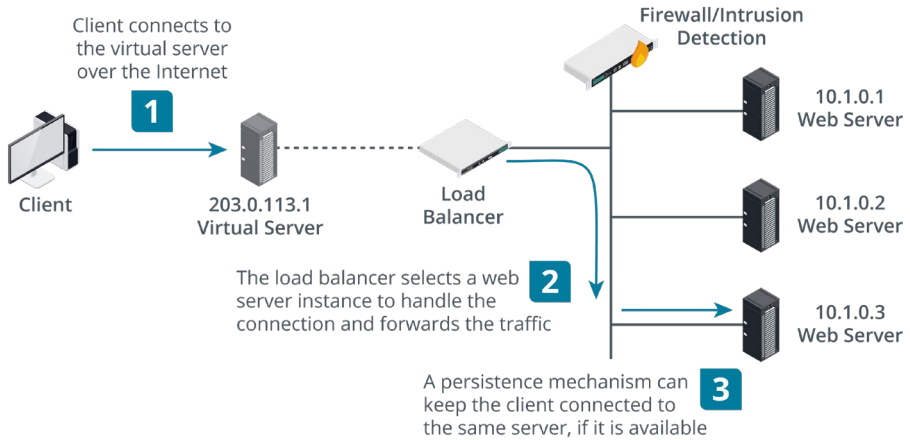
Screenshot Security Onion securityonion.net

Next-generation Firewalls and Unified Threat Management

- Next-generation firewall
  - Application-aware filtering, user account-based filtering, IPS, cloud inspection, …
- Unified threat management (UTM)
  - Combining security controls into single agent and management platforms
  - Firewall, anti-malware, network intrusion prevention, spam filtering, content filtering, data loss prevention, VPN, cloud access gateway, …

Load Balancers

- Distributes requests across farm or pool of servers (nodes)
  - Layer 4 load balancer
  - Layer 7 load balancer (content switch)
- Scheduling
  - Round robin
  - Fewest existing connections / best response time
  - Weighting
  - Heartbeat and health checks
- Source IP affinity
- Session persistence



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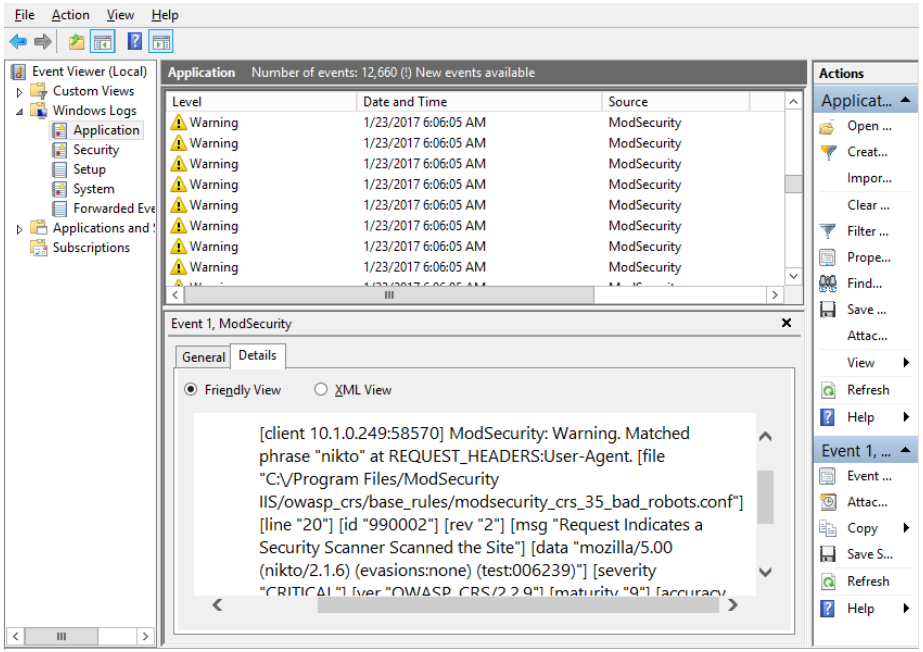
Web Application Firewalls



- Able to inspect code in HTTP packets
- Matches suspicious code to vulnerability database
- Can be implemented as software
  on host or as appliance

Screenshot used with permission from Microsoft.

Network Security Appliances

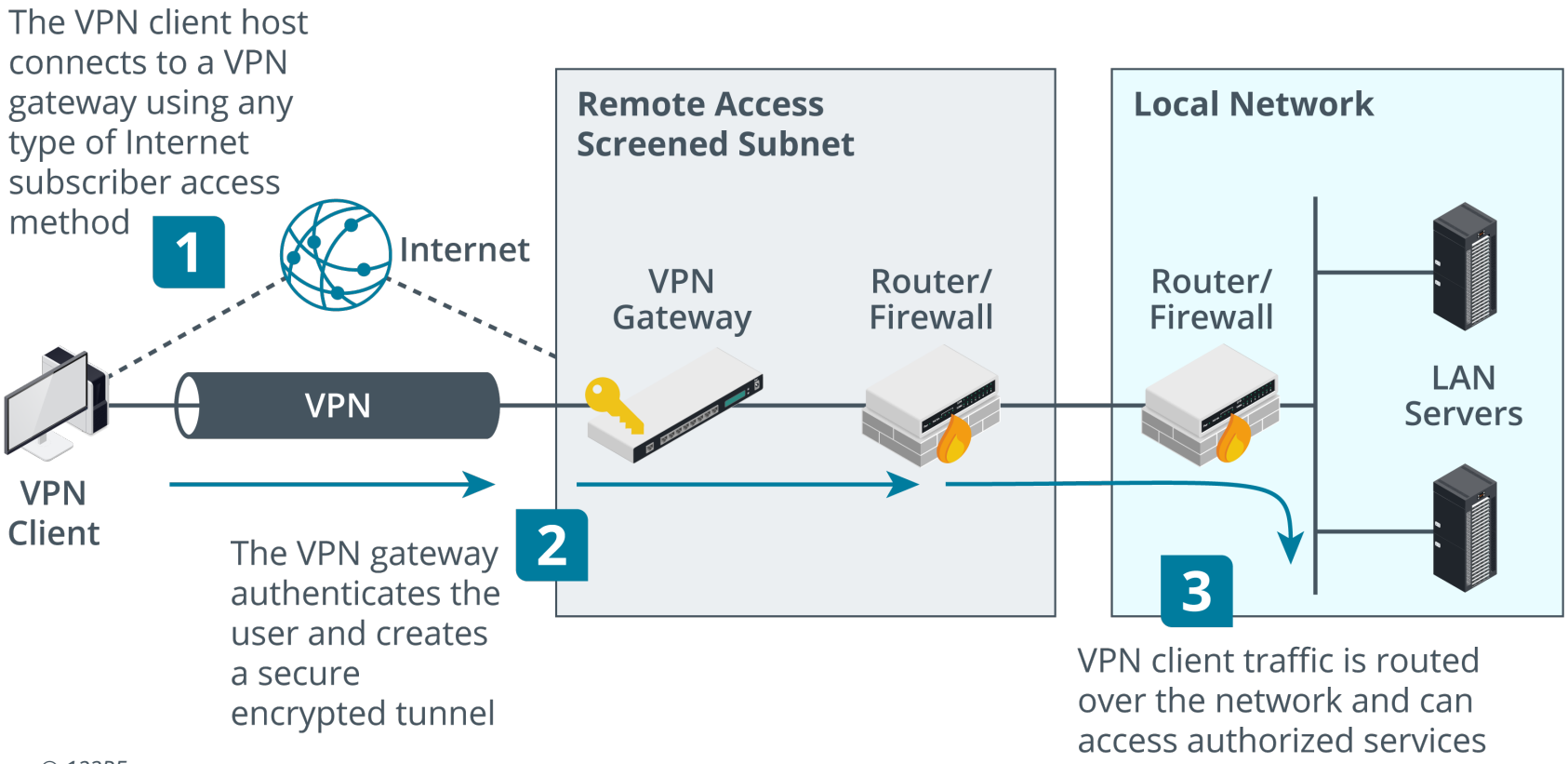
- Device placement
  - Defense in depth plus use of preventive, detective, and corrective controls
- Device attributes
  - Active versus passive, inline versus TAP/monitor, fail-open versus fail-closed
- Firewalls (layer 4/7)
- Proxy servers
- Intrusion detection systems
- Next-generation firewalls and unified threat management
- Load balancers
- Web application firewalls

Lesson 5

Topic 5C

Virtual Private Networks

Remote Access Architecture (1)



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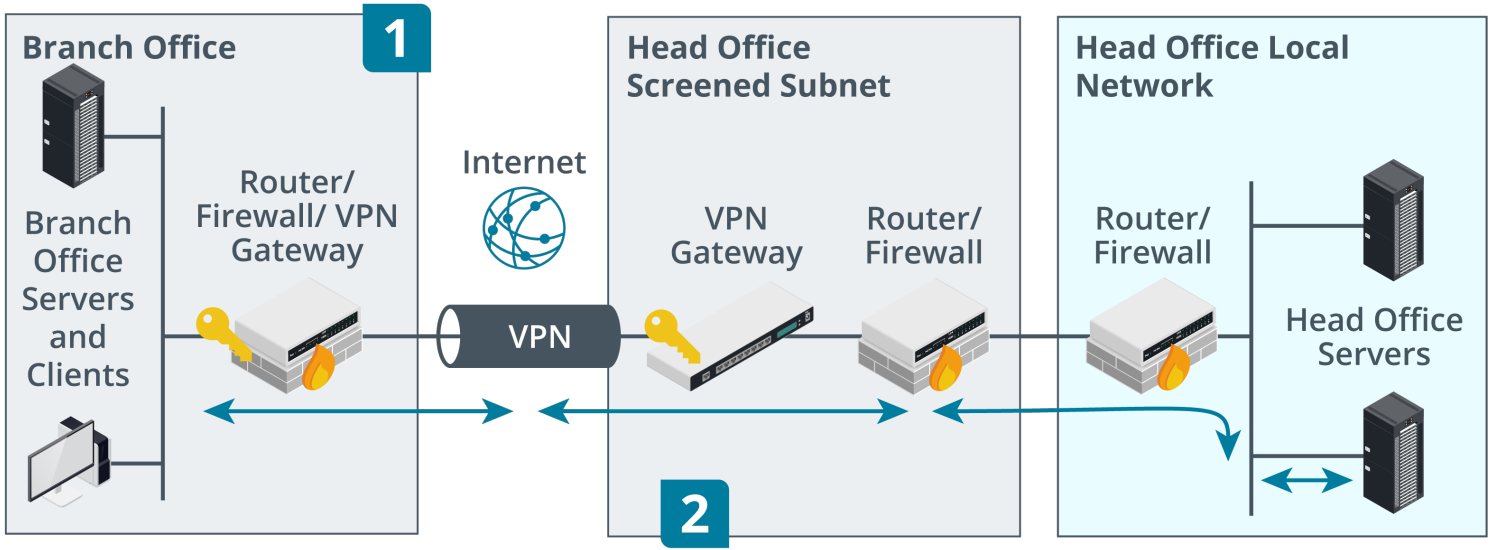
Remote Access Architecture (2)

The VPN gateway at a branch office establishes a VPN connection with the head office site



Traffic for a host at a remote site is automatically routed and tunneled over the VPN link

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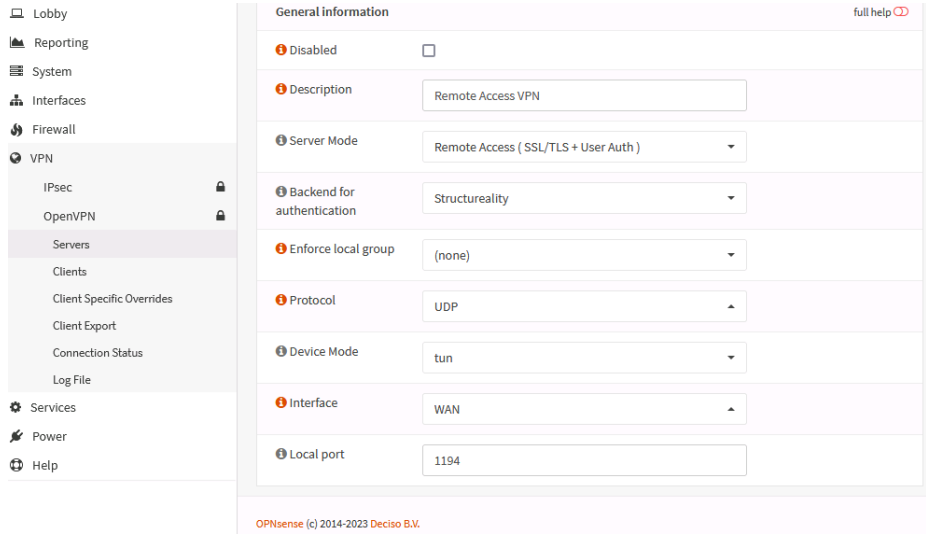
Transport Layer Security Tunneling

- Use TLS to negotiate a secure connection
  - Machines authenticated by PKI certificates
    - Mutual authentication allows VPN gateway to authenticate client certificates
  - User account authentication via RADIUS
- Tunnel network traffic over TLS
- Can use TCP or UDP



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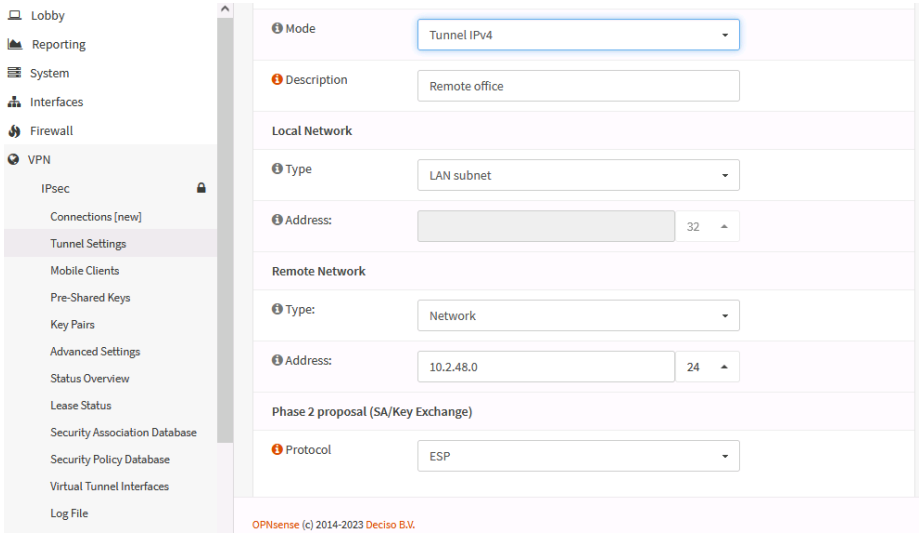
Internet Protocol Security Tunneling

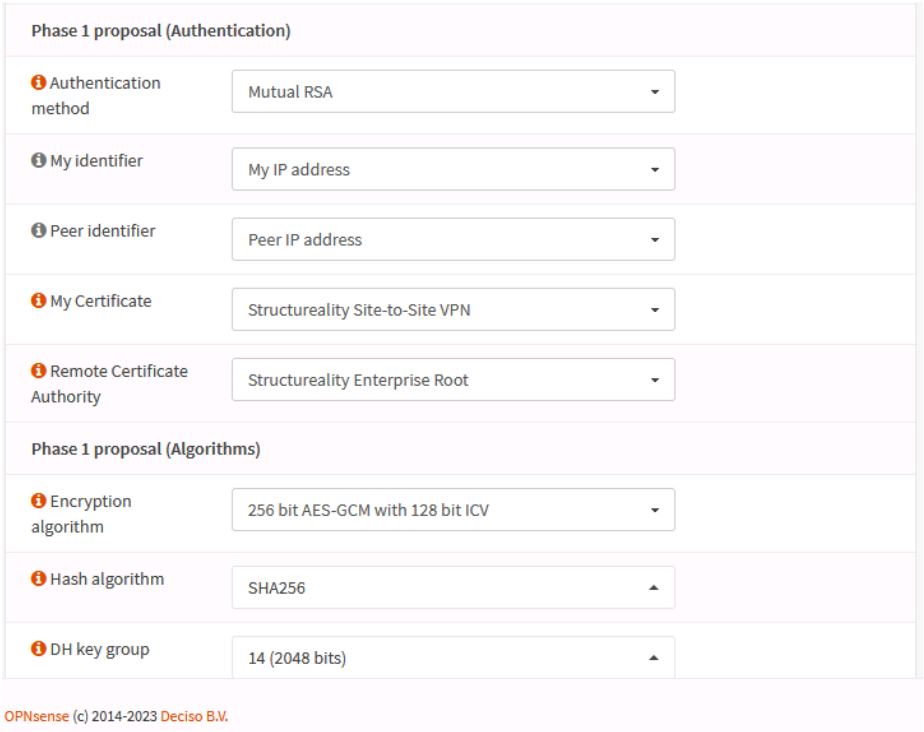


- Provides confidentiality and/or integrity
  - Authentication Header (AH)
    - Signs packet but does not encrypt payload
    - Provides authentication/integrity only
  - Encapsulation Security Payload (ESP)
    - Provides confidentiality and/or authentication/integrity
- Modes
  - Transport mode for host-to-host connections on a private network
  - Tunnel mode between gateways across an unsecure network

Screenshot used with permission from Rubicon Communications, LLC.

Internet Key Exchange

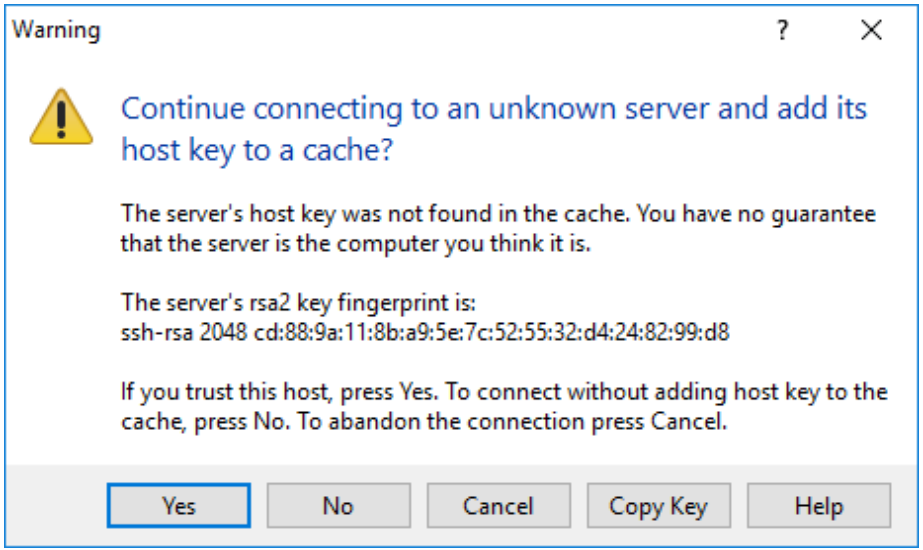
- Establishes Security Association (SA) between peers
- Phase I provides authentication
  - PKI/certificates
  - Pre-shared key
- Phase II establishes cipher suites and key sizes and use of AH or ESP
- IKE v1 supports host-to-host and site-to-site tunneling
- IKE v2 adds better support for client-to-site remote access VPN



Remote Desktop

- GUI-based remote terminal software
- Remote Desktop Protocol (RDP)
  - Connect to physical machines
  - RDP gateway to virtual desktops and apps
- HTML5/clientless
  - Access desktops and web applications from Internet via gateway to internal network
  - Browser support for canvas element plus WebSockets

Secure Shell

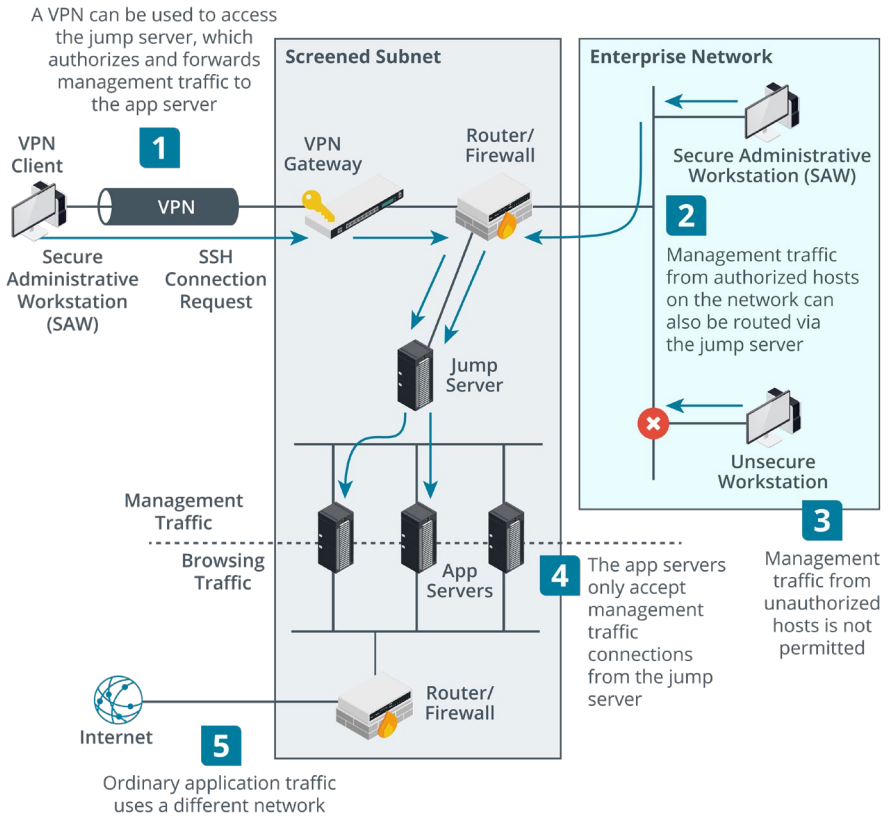


- Remote administration with public key cryptography security
- Host key identifies server
- Client authentication
  - Username/password
  - Public key authentication
  - Kerberos
- Key management
- SSH commands
  - ssh versus scp (Secure Copy)

Screenshot used with permission from PuTTY.

Out-of-band Management and Jump Servers

- Secure admin workstations (SAWs)
- Out-of-band (OOB) management
  - Serial/modem/console port
  - Virtual terminal
  - Separate cabling or VLAN isolation
- Jump servers
  - Single host accepts SSH or RDP connections from SAWs
  - Forwards connections to app servers
  - App servers only accept connections from jump server



Virtual Private Networks

- Remote access architecture
  - Tunneling, client-to-site remote access VPN, site-to-site VPN
- Transport Layer Security (TLS) tunneling
- Internet Protocol Security (IPSec) tunneling
- Internet Key Exchange
- Remote Desktop
- Secure Shell
- Out-of-band management and jump servers

Lesson 5

Summary