Hardening IPv6 Network Devices

ITU/APNIC IPv6 Workshop

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Acknowledgements

- This material originated from the Cisco ISP/IXP Workshop Programme developed by Philip Smith & Barry Greene
  - These slides were developed by Dean Pemberton

- Bug fixes and improvements are welcomed
  - Please email *workshop (at) bgp4all.com*

Philip Smith

Agenda

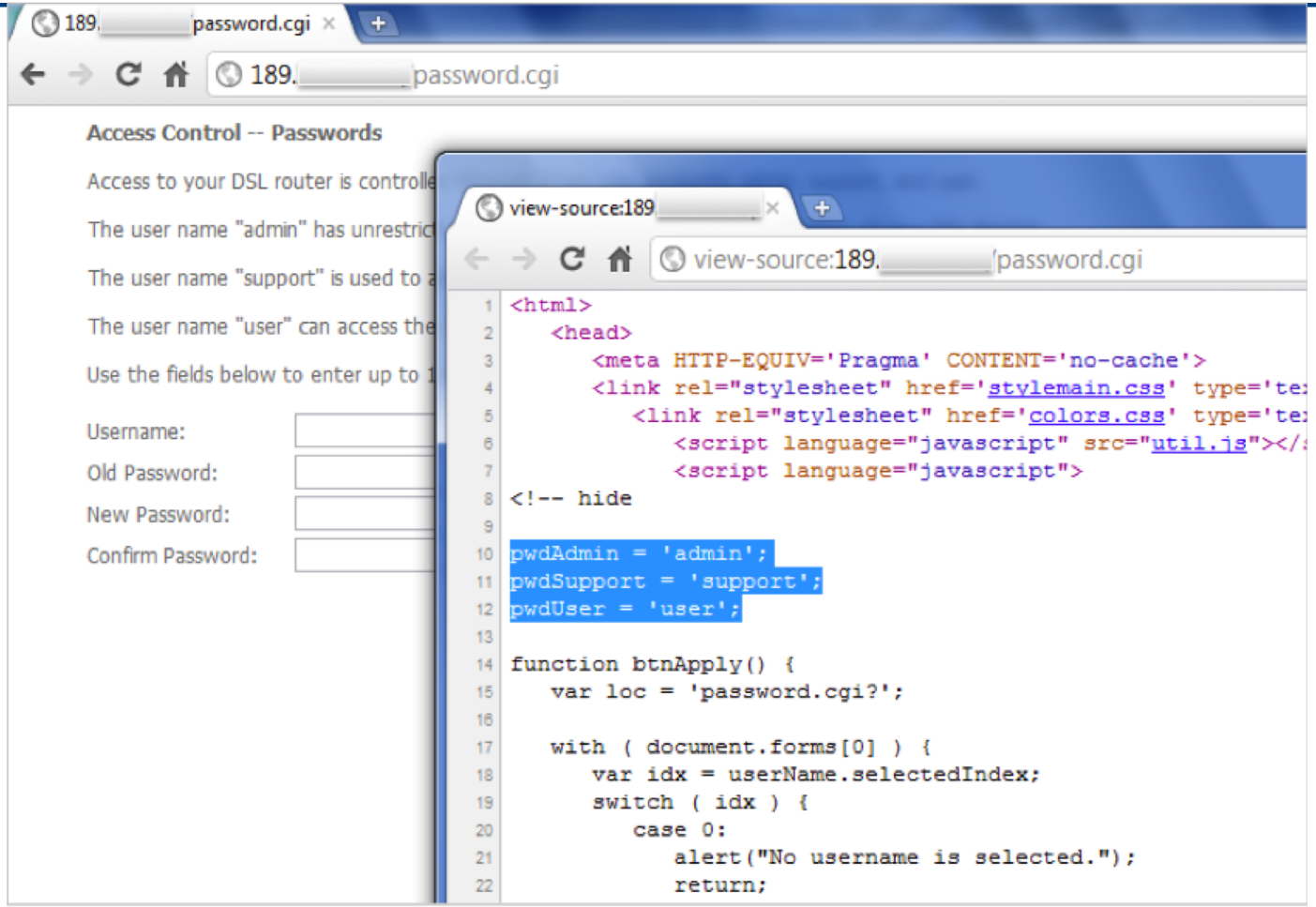
- Limiting Device Access
- Secure SNMP Access
- Securing the Data Path
- Configuration and Archiving

Limiting Device Access

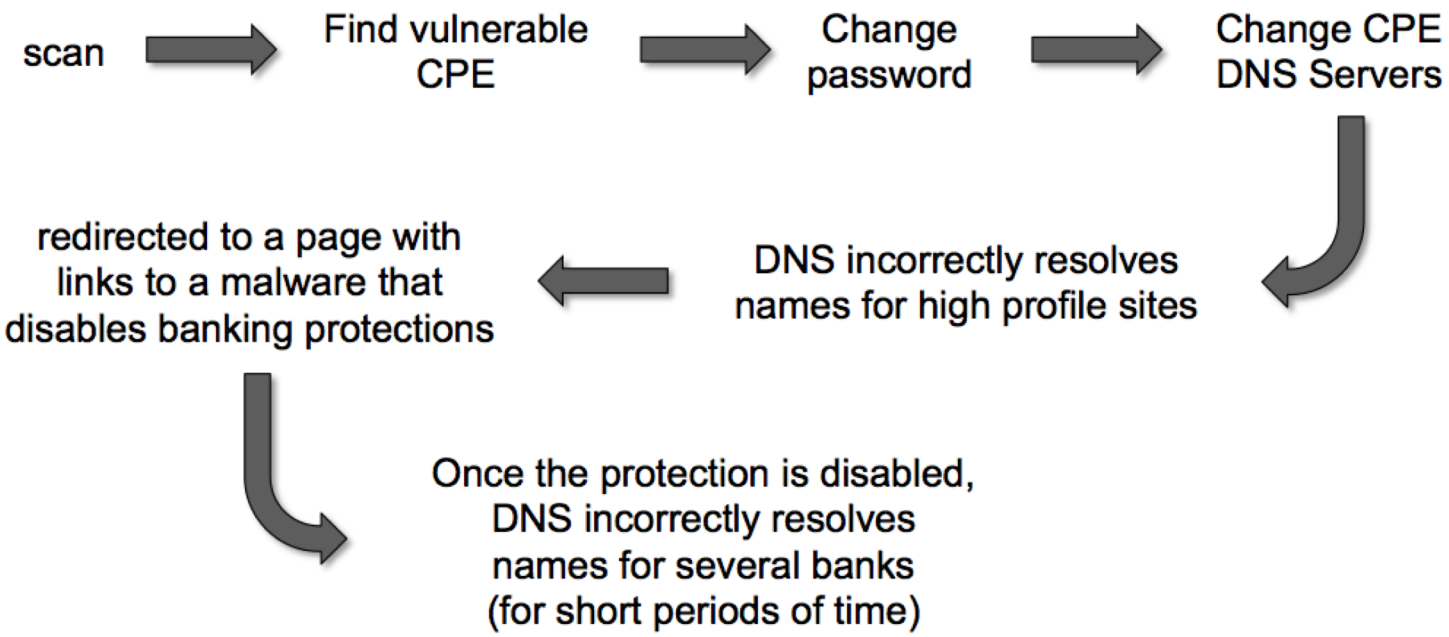
Think of ALL Devices

- The following problem was reported in 2013 and affects low-end CPEs (ADSL connections only)
  - Admin password exposed via web interface
  - Allow WAN management (this means anyone on Internet)
  - Bug fixed and reintroduced depending on the firmware version
- The bug is quite a number of years old

Password Visible via Web Interface



How CPE are Exploited



Magnitude of Problem

- 4.5 Million CPEs (ADSL Modems) using a unique malicious DNS
- In early 2012 more than 300,000 CPEs still infected
- 40 malicious DNS servers found

- Could device hardening have made a difference?

Device Physical Access

- Equipment kept in highly restrictive environments
- Console access
  - password protected
  - access via OOB management
  - configure timeouts
- Individual users authenticated
- Social engineering training and awareness

- "If you can touch it… the device now belongs to you"

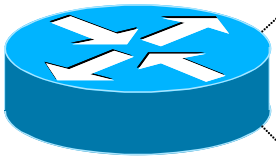
Interface Hardening

- IPv4
  - no ip proxy-arp
  - no ip unreachables
  - no ip redirects
  - no ip directed-broadcast
  - no ip mask-reply
- IPv6
  - no ipv6 unreachables
  - no ipv6 redirects

Device Access Control

- Set passwords to something not easily guessed
- Use single-user passwords (avoid group passwords)
- Encrypt the passwords in the configuration files
- Use different passwords for different privilege levels
- Use different passwords for different modes of access
- IF AVAILABLE – use digital certificate based authentication mechanisms instead of passwords

Secure Access with Passwords and Logout Timers



```
line console 0
 login
 password console-pw
 exec-timeout 1 30
line vty 0 4
 login
 password vty-pw
 exec-timeout 5 0
!
enable secret enable-secret
username dean secret dean-secret
```

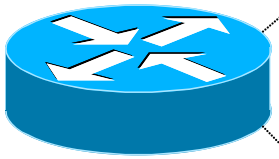
Never Leave Passwords in Clear-Text

- service password-encryption command
- password command
  - Will encrypt all passwords on the Cisco IOS
  - with Cisco-defined encryption type “7”
  - Use “command password 7 <password>” for cut/paste operations
  - Cisco proprietary encryption method
- secret command
  - Uses MD5 to produce a one-way hash
  - Cannot be decrypted
  - Use “command secret 5 <password>”
  - to cut/paste another “enable secret” password

Management Plane Filters

- Authenticate Access
- Define Explicit Access To/From Management Stations
  - SNMP
  - Syslog
  - TFTP
  - NTP
  - AAA Protocols
  - DNS
  - SSH, Telnet, etc.

Authenticate Individual Users



```
username dean secret dean-secret
username miwa secret miwa-secret
username pfs secret pfs-secret
username staff secret group-secret
```

Do NOT have group passwords!

User Authentication: Good

- From Cisco IOS 12.3, MD5 encryption was added for user passwords
  - **Do NOT use type 7 encryption**
    - (it is easy to reverse)

```
aaa new-model
aaa authentication login neteng local
username pfs secret 5 $1$j6Ac$3KarJszBV3VMaL/2Nio3E.
username dean secret 5 $1$LPV2$Q04NwAudy0/4AHHHQHvWj0
line vty 0 4
 login neteng
 access-class 3 in
```

User Authentication: Better

- Use centralised authentication system
  - RADIUS (not recommended for system security)
  - TACACS+

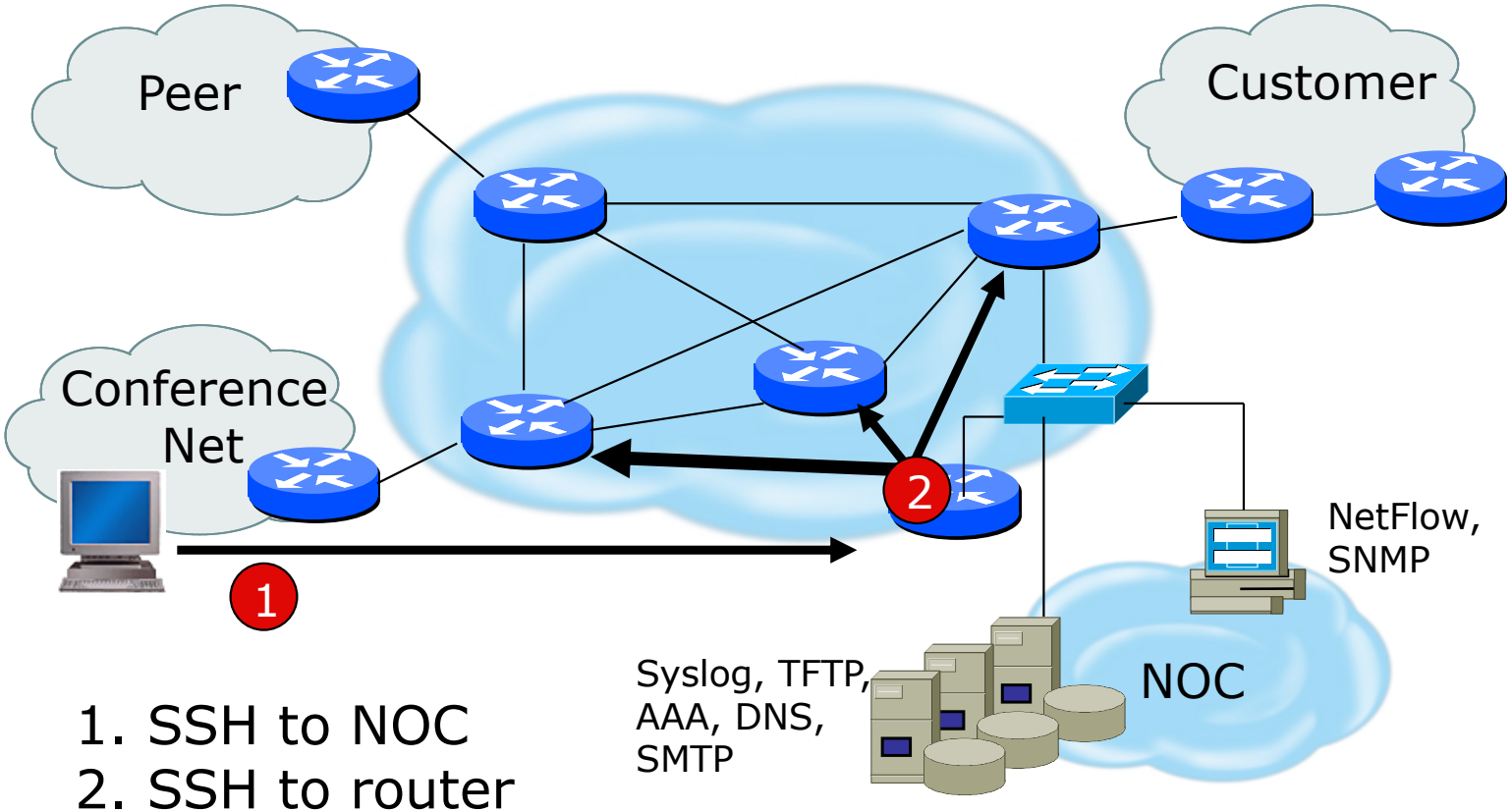
```
aaa new-model
aaa authentication login default group tacacs+ enable
aaa authentication enable default group tacacs+ enable
aaa accounting exec start-stop group tacacs+
!
ip tacacs source-interface Loopback0
tacacs server IPv6-TP
 address ipv6 2001:DB8::1
 key CKr3t#
tacacs server IPv4-TP
 address ipv4 192.168.1.1
 key CKr3t#
line vty 0 4
 access-class 3 in
```

Restrict Access To Trusted Hosts

- Use filters to specifically permit hosts to access an infrastructure device
- Example:

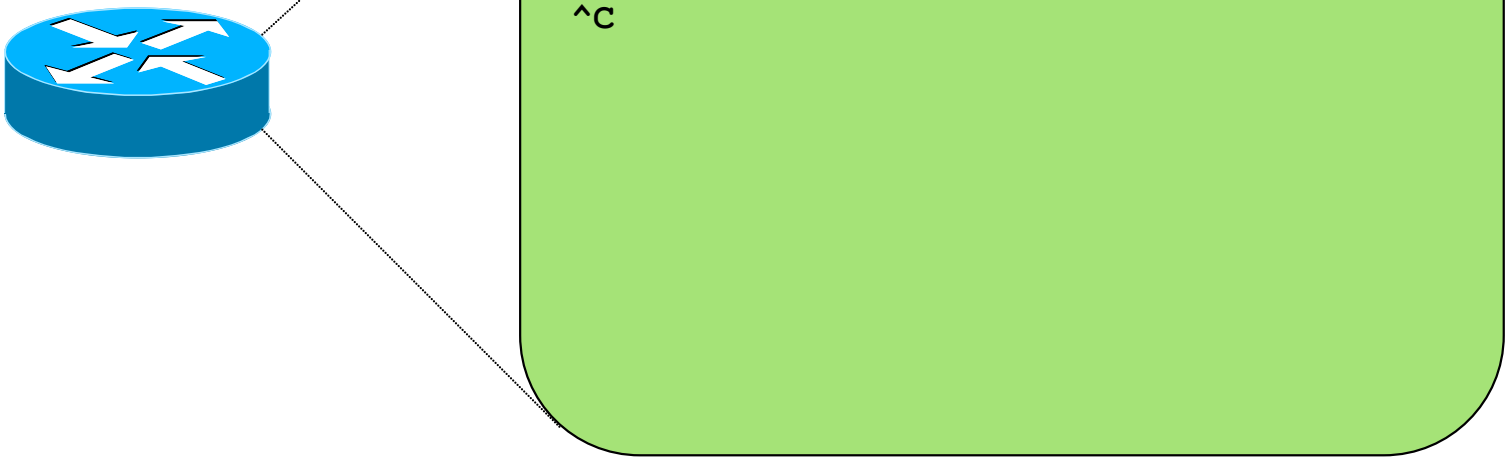
```
ip access-list extended VTY
 permit tcp host 192.168.200.7 192.168.1.0 0.0.0.255 eq 22 log-input
 permit tcp host 192.168.200.8 192.168.1.0 0.0.0.255 eq 22 log-input
 permit tcp host 192.168.100.6 192.168.1.0 0.0.0.255 eq 23 log-input
 deny   ip any any log-input
!
line vty 0 4
 access-class VTY in
 transport input ssh telnet
```

Using an SSH 'Jumphost'

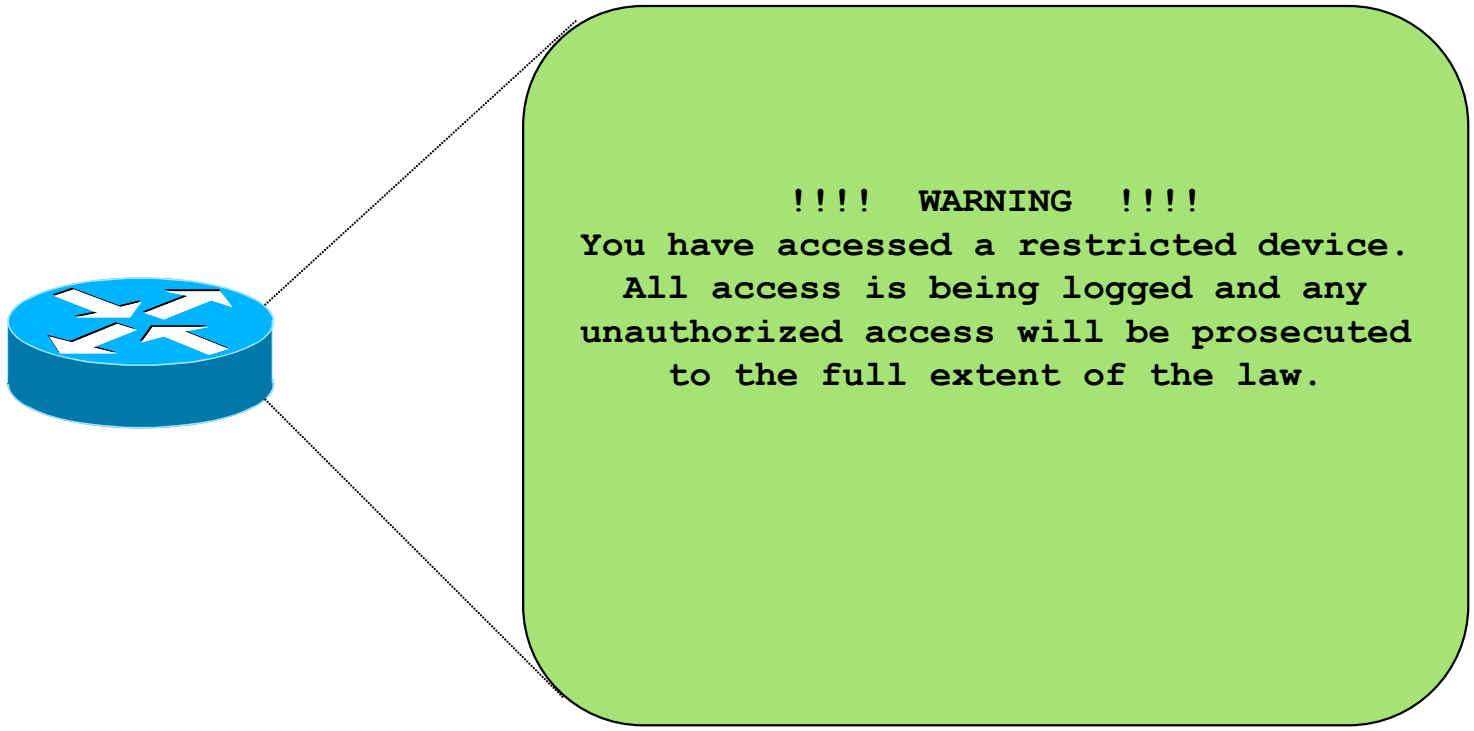


1. SSH to NOC
2. SSH to router

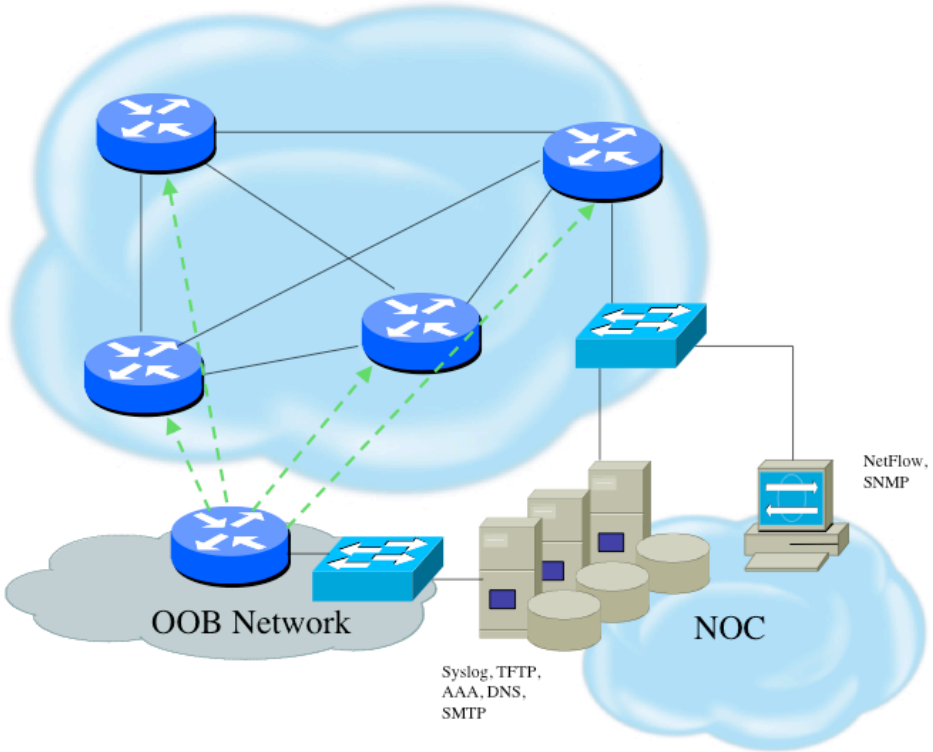
Banner – What Is Wrong ?



More Appropriate Banner



Device OOB Management



- Out-of-band device management should be used to ensure DoS attacks do not hinder getting access to critical infrastructure devices
- Dial-back encrypted modems are sometimes still used as backup

Device Management Common Practice (1)

- SSH used exclusively
  - Do NOT use Telnet, not even from Jumphosts
- HTTP and HTTPS access explicitly disabled
- All access authenticated
  - Varying password mechanisms
  - AAA usually used
    - Different servers for in-band vs OOB
    - Different servers for device authentication vs other
    - Static username pw or one-time pw
  - Single local database entry for backup

Device Management Common Practice (2)

- Each individual has specific authorization
- Strict access control via filtering
- Access is audited with triggered pager/email notifications
- SNMP is read-only
  - Restricted to specific hosts
  - View restricted if capability exists
  - Community strings updated every 30-90 days

Turn Off Unused Services

- Global Services
  - no service finger (before Cisco IOS 12.0)
  - no ip finger
  - no service pad
  - no service udp-small-servers
  - no service tcp-small-servers
  - no ip bootp server
  - no cdp run
- Interface Services
  - no ip redirects
  - no ip directed-broadcast
  - no ip proxy arp
  - no cdp enable

Secure SNMP Access

Secure SNMP Access

- SNMP is primary source of intelligence on a target network!
- Block SNMP from the outside

```
access-list 101 deny udp any any eq snmp
```

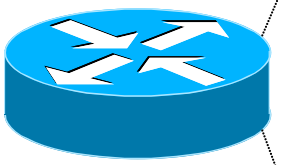
- If the router has SNMP, protect it!

```
snmp-server community fO0bAr RO 8
access-list 8 permit 127.1.3.5
```

- Explicitly direct SNMP traffic to an authorized management station.

```
snmp-server host fO0bAr 127.1.3.5
```

Secure SNMP Access



```
ipv6 access-list SNMP-PERMIT
 permit ipv6 2001:DB8:22::/64 any
 permit ipv6 any 2001:DB8:22::/64
!
no snmp community public
no snmp community private
!
snmp-server enable traps
snmp-server enable traps snmp authentication
snmp-server enable traps snmp coldstart
snmp-server trap-source Loopback0
snmp-server community v6comm RO ipv6 SNMP-PERMIT
```

SNMP Best Practices

- Do not enable read/write access unless really necessary
  - Read – for access by Networking Monitoring System (eg LibreNMS)
  - Write – never!
- Choose community strings that are difficult to guess
  - Use same algorithm as for passwords
- Limit SNMP access to specific IP addresses
- Limit SNMP output with views

Secure Logging Infrastructure

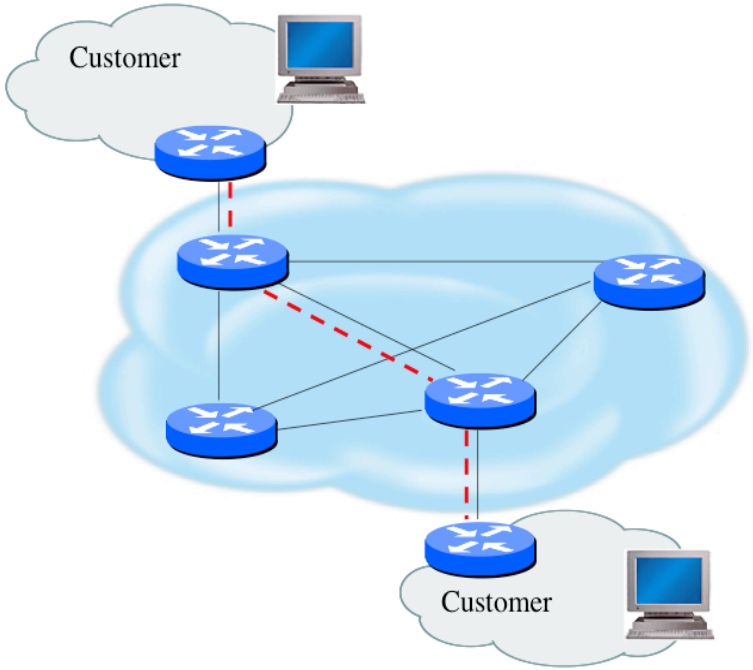
- Log enough information to be useful but not overwhelming.
- Create backup plan for keeping track of logging information should the syslog server be unavailable
- Remove private information from logs
- How accurate are your timestamps?
  - NTP needs to be configured
  - Synchronise with trusted time sources, eg pool.ntp.org or GPS receivers

Fundamental Device Protection Summary

- Secure logical access to routers with passwords and timeouts
- Never leave passwords in clear-text
- Authenticate individual users
- Restrict logical access to specified trusted hosts
- Allow remote vty access only through ssh
- Disable device access methods that are not used
- Protect SNMP if used
- Shut down unused interfaces
- Shut down unneeded services
- Ensure accurate timestamps for all logging
- Create appropriate banners
- Test device integrity on a regular basis

Securing the Data Path

Securing The Data Path



- Filtering and rate limiting are primary mitigation techniques
- Edge filter guidelines for ingress filtering (BCP38/BCP84)
- Null-route and black-hole any detected malicious traffic
- Netflow is primary method used for tracking traffic flows
- Logging of Exceptions

Data Plane (Packet) Filters

- Most common problems
  - Poorly-constructed filters
  - Ordering matters in some devices
- Scaling and maintainability issues with filters are commonplace
- Make your filters as modular and simple as possible
- Take into consideration alternate routes
  - Backdoor paths due to network failures

Filtering Deployment Considerations

- How does the filter load into the router?
- Does it interrupt packet flow?
- How many filters can be supported in hardware?
- How many filters can be supported in software?
- How does filter depth impact performance?
- How do multiple concurrent features affect performance?
- Do I need a standalone firewall?

General Filtering Best Practices

- Explicitly deny all traffic and only allow what you need
- The default policy should be that if the firewall doesn't know what to do with the packet, deny/drop it
- Don't rely only on your firewall for all protection of your network
- Implement multiple layers of network protection
- Make sure all of the network traffic passes through the firewall
- Log all firewall exceptions (if possible)

Ingress Filtering

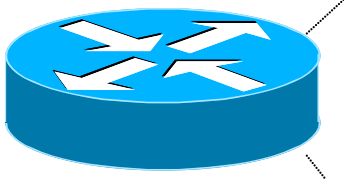
```
ipv6 access-list INBOUND-iACL
 remark Permit the legitimate signaling traffic (BGP, EIGRP, PIM)
 permit tcp host 2001:db8:20::1 host 2001:db8:20::2 eq bgp
 permit tcp host 2001:db8:20::1 eq bgp host 2001:db8:20::2
 permit 88 any any
 permit 103 any any
 remark Permit NDP packets
 permit icmp any any nd-na
 permit icmp any any nd-ns
 permit icmp any any router-advertisement
 permit icmp any any router-solicitation
 remark Deny RH0 and other unknown extension headers
 deny ipv6 any any routing-type 0 log
 deny ipv6 any any log undetermined-transport
 remark Permit the legitimate management traffic
 permit tcp 2001:db8:11::/48 any eq 22
 permit tcp 2001:db8:11::/48 any eq www
 permit udp 2001:db8:11::/48 any eq snmp
 remark Deny any packets to the infrastructure address space
 deny ipv6 any 2001:db8:2222::/48
 deny ipv6 any 2001:db8:20::/48
 permit ipv6 any any
!
interface FastEthernet 0/0
 description Connection to outside network
 ipv6 address 2001:db8:20::2/64
 ipv6 traffic-filter INBOUND-iACL in
```

RFC2827 (BCP38) – Ingress Filtering

- If an ISP is aggregating routing announcements for multiple downstream networks, strict traffic filtering should be used to prohibit traffic which claims to have originated from outside of these aggregated announcements.
- The ONLY valid source IP address for packets originating from a customer network is the one assigned by the ISP (whether statically or dynamically assigned).
- An edge router could check every packet on ingress to ensure the user is not spoofing the source address on the packets which he is originating.

But What About Egress Filtering?

- In theory, certain addresses should not be seen on the global Internet
- In practice they are, and filters aren't being deployed (even when capability available)



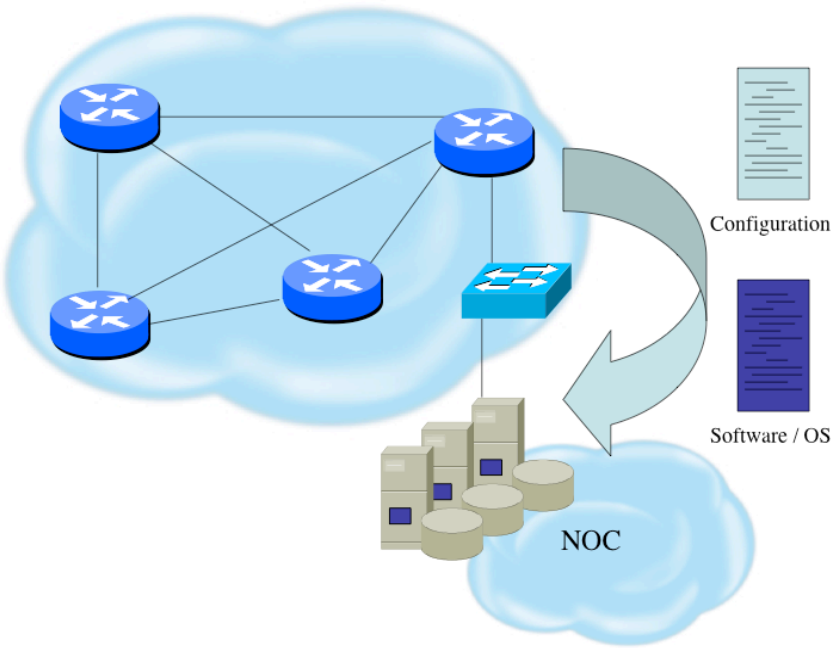
```
ipv6 access-list DSL-ipv6-Outbound
 permit ipv6 2001:DB8:AA65::/48   any
 deny   ipv6 any any log

interface atm 0/0
  ipv6 traffic-filter DSL-ipv6-Outbound out
```

Configuration and archiving

System Images and Configuration Files

- Careful of sending configurations where people can snoop the wire
  - CRC or MD5 validation
  - Sanitize configuration files
- SCP should be used to copy files
  - TFTP and FTP should be avoided
- Use tools like ‘RANCID’ to periodically check against modified configuration files

Software and Configuration Upgrade / Integrity



- Files stored on specific systems with limited access
- All access to these systems are authenticated and audited
- SCP is used where possible; FTP is NEVER used; TFTP still used
- Configuration files are polled and compared on an hourly basis (RANCID)
- Filters limit uploading / downloading of files to specific systems
- Many system binaries use MD-5 checks for integrity
- Configuration files are stored with obfuscated passwords

Infrastructure Security Summary

- Every device in your network could be exploited so make sure to harden them all (especially change default username/passwords)
  - Printers, tablets, CPE's, etc
- Understand what you are sending in the clear from sending device to recipient and protect where needed
- Log and audit for trends since sometimes an abnormality can show the start of reconnaissance for a later attack

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