Hardening Network Devices

PacNOG15 – Network Security Workshop

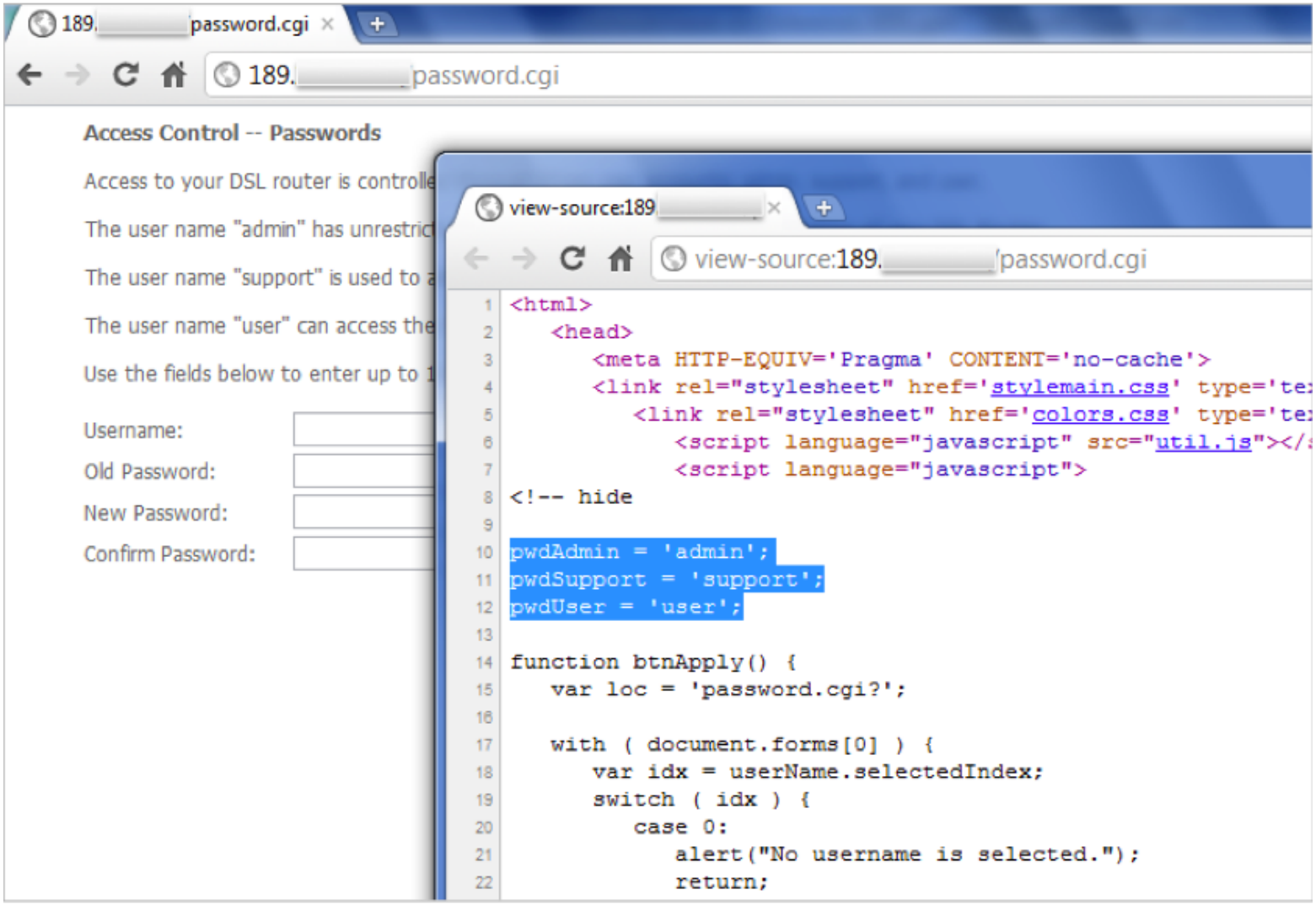
Last updated 29 June 2014

Limiting Device Access

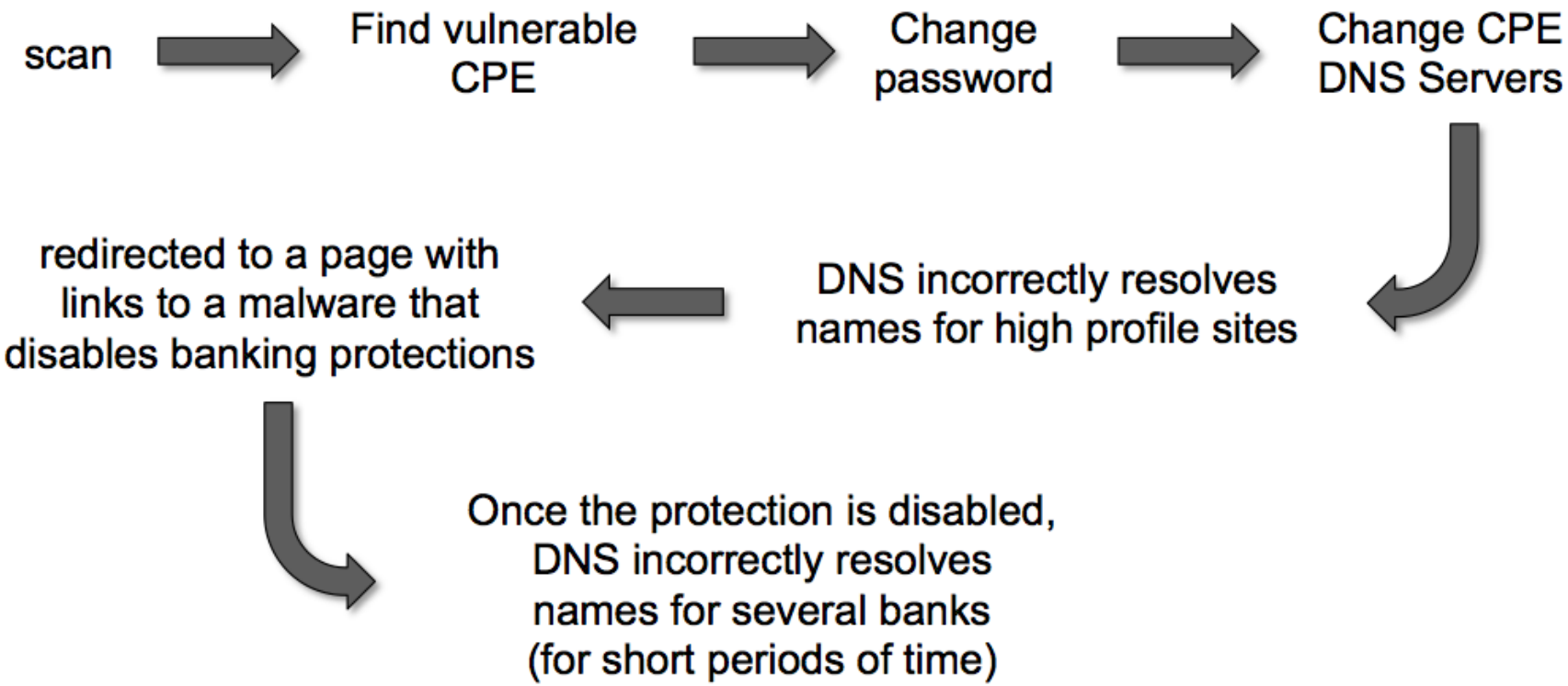
Think of ALL Devices

- The following problem was reported last year 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"

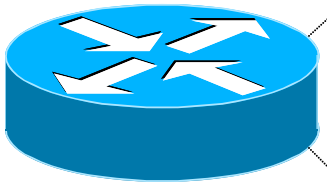
Interface Hardening

- 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 00
!
enable secret enable-secret
username dean secret dean-secret
```

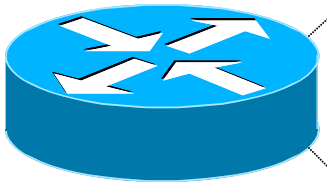
Never Leave Passwords in Clear-Text

- 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
```

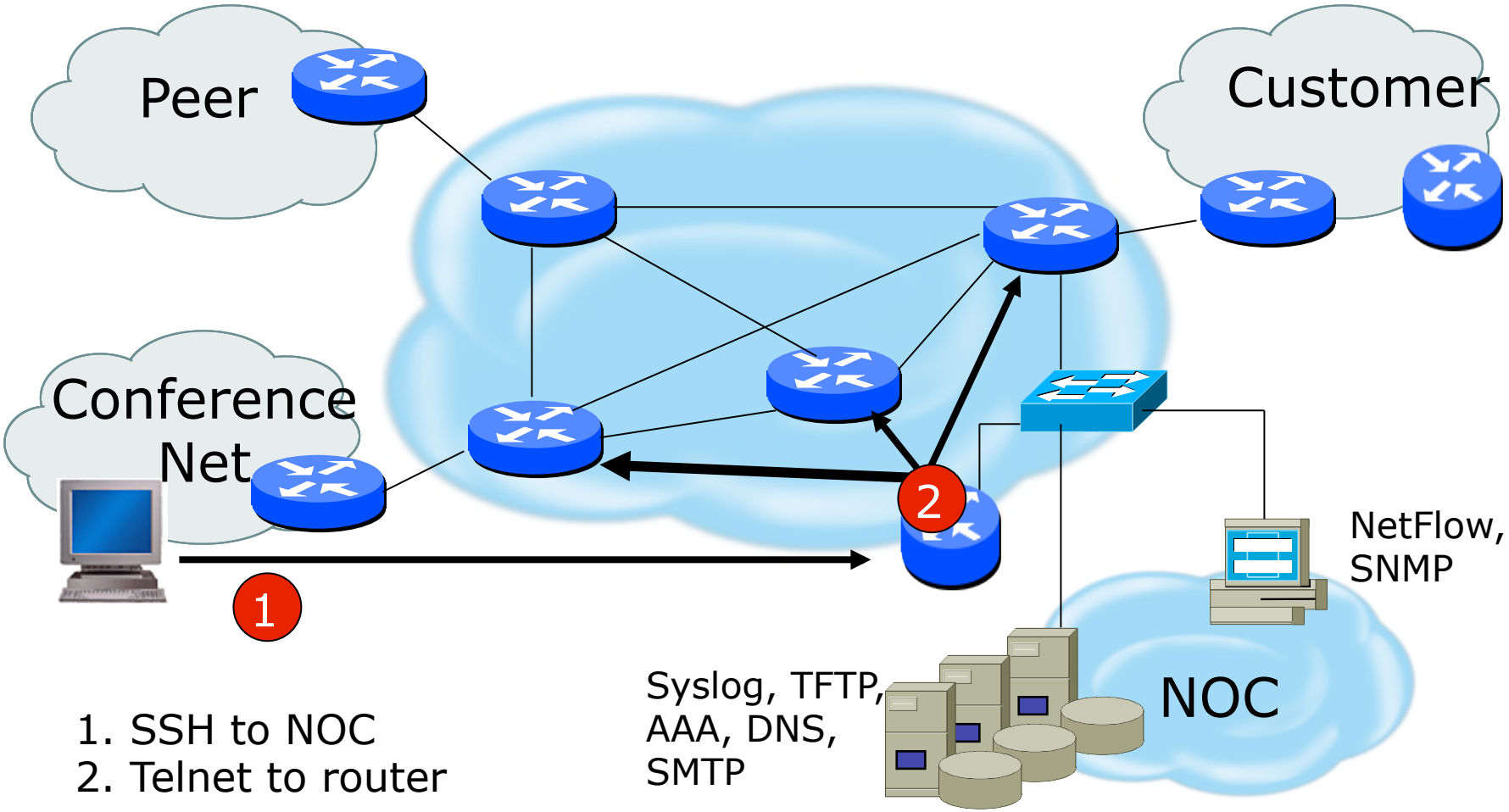
Do NOT have group passwords!

Restrict Access To Trusted Hosts

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

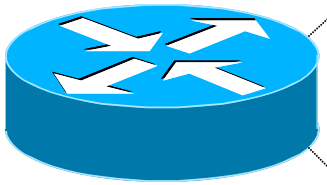
```
access-list 103 permit tcp host 192.168.200.7
192.168.1.0 0.0.0.255 eq 22 log-input
access-list 103 permit tcp host 192.168.200.8
192.168.1.0 0.0.0.255 eq 22 log-input
access-list 103 permit tcp host 192.168.100.6
192.168.1.0 0.0.0.255 eq 23 log-input
access-list 103 deny ip any any log-input
!
line vty 0 4
 access-class 103 in
 transport input ssh telnet
```

Telnet using SSH 'Jumphost'



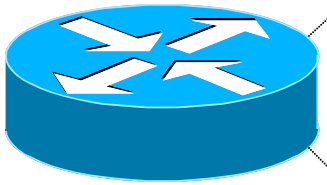
1. SSH to NOC
2. Telnet to router

Banner – What Is Wrong ?



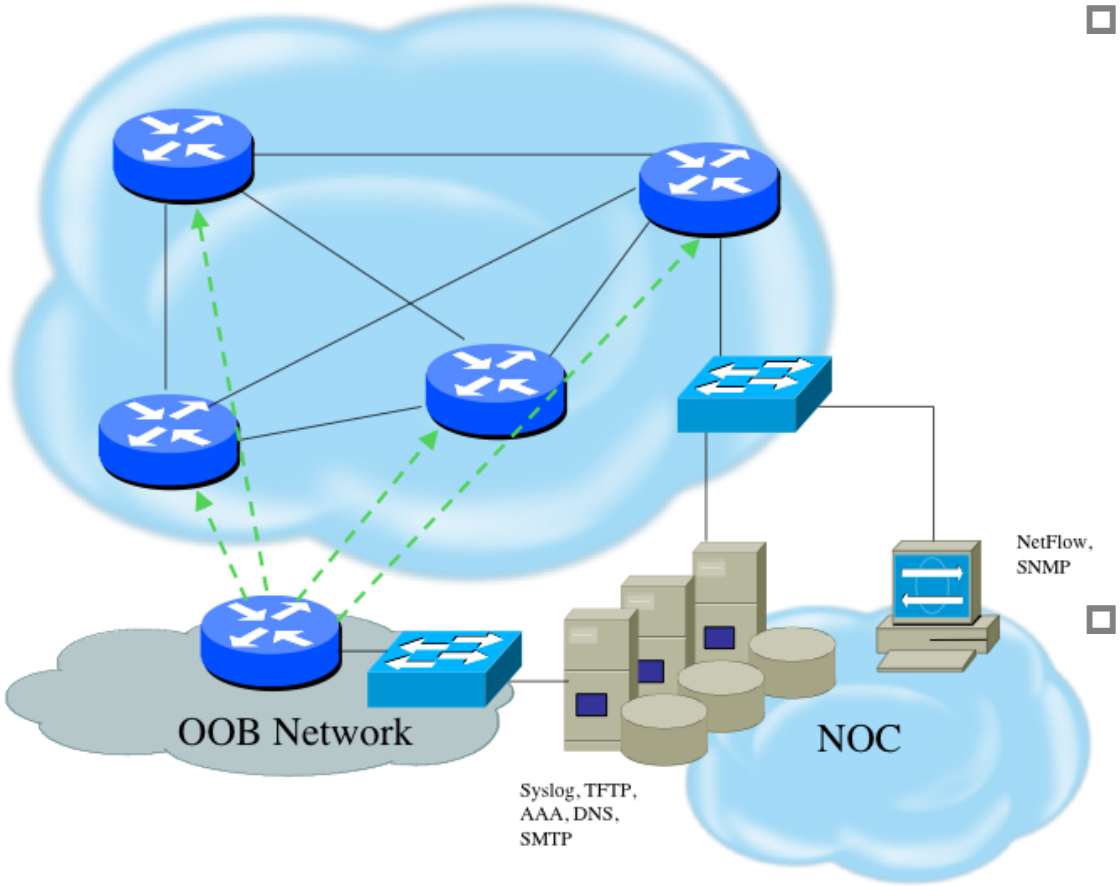
```
banner login ^C

      You should not be on this device.

      Please Get Off My Router!!
^C
```

More Appropriate Banner



```
!!!!  WARNING  !!!!
You have accessed a restricted device.
All access is being logged and any
unauthorized access will be prosecuted
to the full extent of the law.
```

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 primarily used
  - Telnet only from jumphosts
- HTTP 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
```

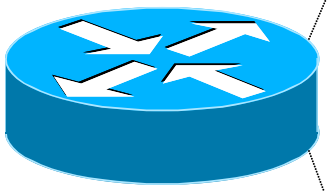
- If the router has SNMP, protect it!

```
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
- Choose community strings that are difficult to guess
- Limit SNMP access to specific IP addresses
- Limit SNMP output with views

Secure Logging Infrastructure

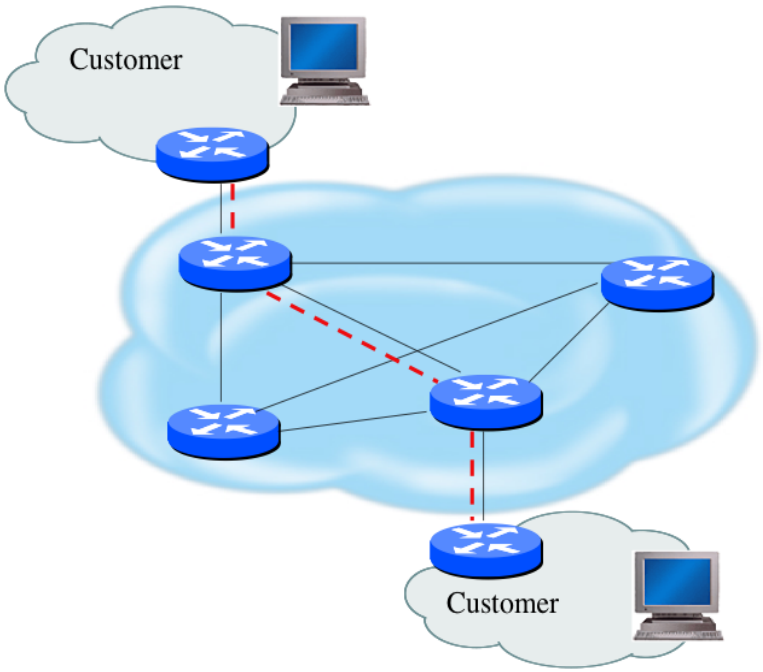
- Log enough information to be useful but not overwhelming.
- Create backup plan for keeping track of logging information should the syslog server be unavailable
- Remove private information from logs
- How accurate are your timestamps?

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

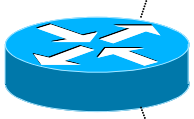
Filtering Deployment Considerations

- 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



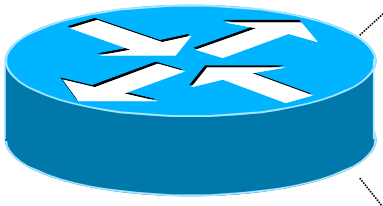
```
ipv6 access-list INBOUND-iACL
 remark Permit the legitimate signaling traffic (BGP, EIGRP, PIM)
 permit tcp host 2001:db8:20::1 host 2001:db8:20::2 eq bgp
 permit tcp host 2001:db8:20::1 eq bgp host 2001:db8:20::2
 permit 88 any any
 permit 103 any any
 remark Permit NDP packets
 permit icmp any 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)



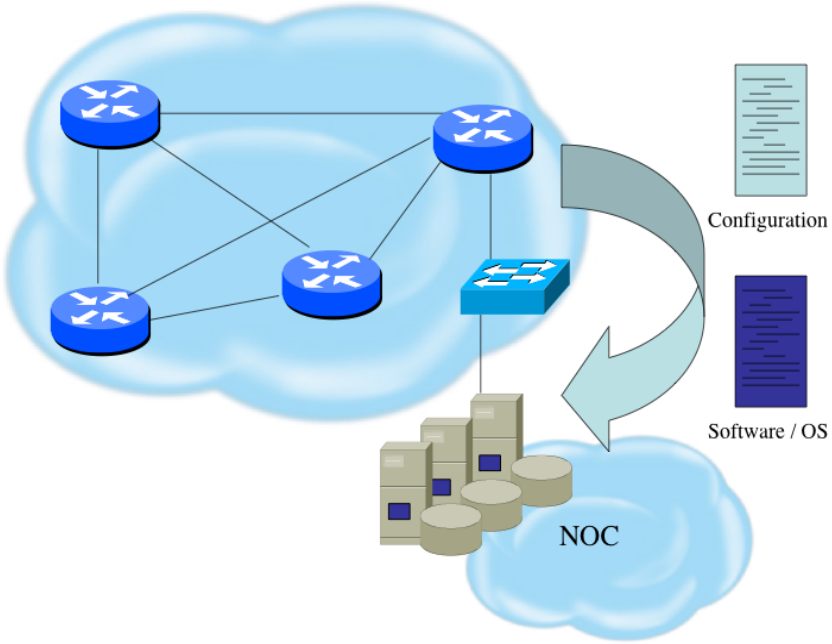
```
ipv6 access-list extended DSL-ipv6-Outbound
 permit ipv6 2001:DB8:AA65::/48  any
 deny   ipv6 any any log

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



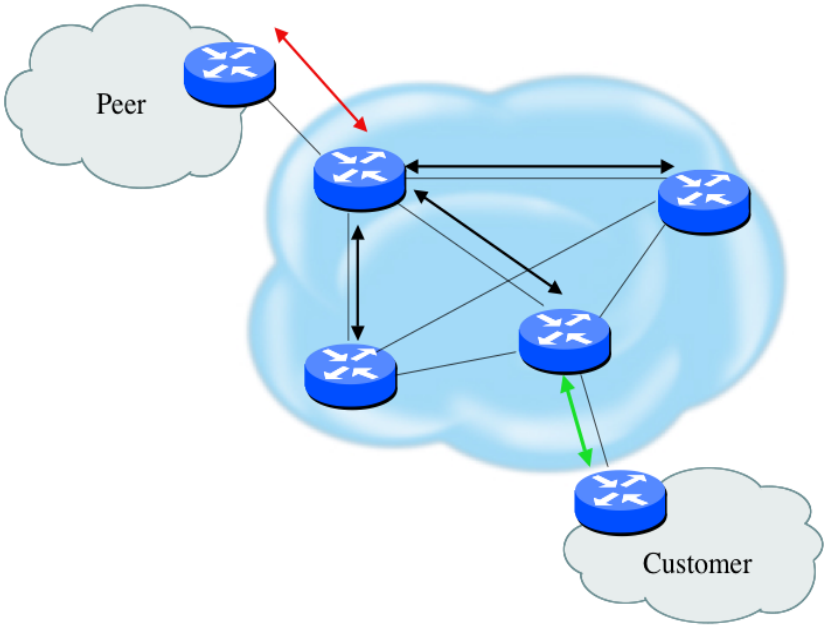
- Files stored on specific systems with limited access
- All access to these systems are authenticated and audited
- SCP is used where possible; FTP is NEVER used; TFTP still used
- Configuration files are polled and compared on an hourly basis (RANCID)
- Filters limit uploading / downloading of files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

Threats Against Routing Protocols

Router Security Considerations

- Segment areas for route redistribution and ensure limited access to routers in critical backbone areas
- Design networks so outages don’t affect entire network but only portions of it
- Control router access
  - Watch for internal attacks on these systems
  - Use different passwords for router enable and monitoring system root access.
- Scanning craze for all kinds of ports – this will be never ending battle

Routing Control Plane

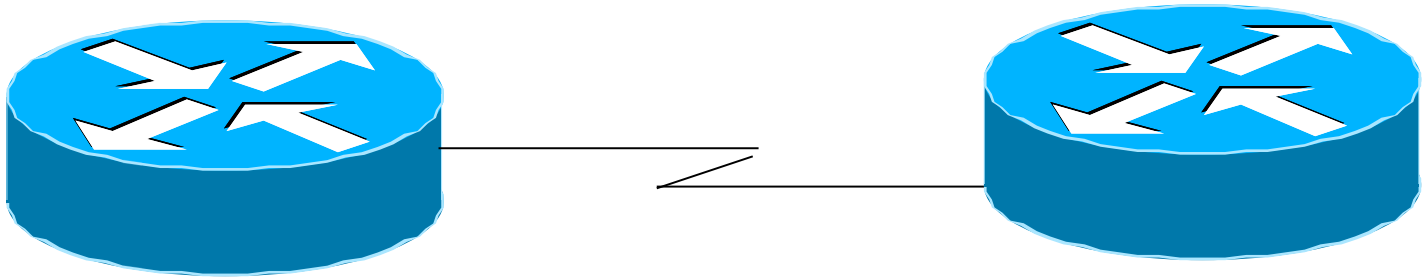


- MD-5 authentication
  - Some deploy at customer's request
- Route filters limit what routes are believed from a valid peer
- Packet filters limit which systems can appear as a valid peer
- Limiting propagation of invalid routing information
  - Prefix filters
  - AS-PATH filters (trend is leaning towards this)
  - Route damping (latest consensus is that it causes more harm than good)
- Not yet possible to validate whether legitimate peer has authority to send routing update

Why Use Route Authentication

- Route Authentication equates to data origin authentication and data integrity
- In BGP, requires TCP resets to be authenticated so malicious person can't randomly send TCP resets
- In cases where routing information traverses shared networks, someone might be able to alter a packet or send a duplicate packet
- Routing protocols were not initially created with security in mind…..this needs to change….

Sample MD-5 Auth Configuration (OSPFv2)



```
interface Loopback0
 ip address 70.70.70.70 255.255.255.255
 ip ospf 10 area 0
!
interface Serial2
 ip address 192.16.64.2 255.255.255.0
 ip ospf 10 area 0
 ip ospf message-digest-key 1 md5 mk6
!
router ospf 10
 area 0 authentication message-digest
```

```
interface Loopback0
 ip address 172.16.10.36 255.255.255.240
 ip ospf 10 area 0
!
interface Serial1/0
 ip address 192.16.64.1 255.255.255.0
 ip ospf 10 area 0
 ip ospf message-digest-key 1 md5 mk6
!
router ospf 10
 area 0 authentication message-digest
```

Sample OSPFv3 IPSec Configuration

```
interface Loopback0
 ipv6 address 2001:DB8::10:10:10:10/128
 ipv6 ospf 100 area 0

interface FastEthernet0/0
 description Area 0 backbone interface
 ipv6 address 2001:DB8:2000::1/64
 ipv6 ospf network broadcast
 ipv6 ospf 100 area 0

interface FastEthernet0/1
 description Area 1 interface
 ipv6 address 2001:DB8:1000::2/64
 ipv6 ospf network broadcast
 ipv6 ospf 100 area 1
 ipv6 ospf authentication ipsec spi 257 sha1 20a43b29a07a27dcf58a57 09bf210ccbf972917d

ipv6 router ospf 100
 router-id 10.10.10.10
 log-adjacency-changes detail
 passive-interface Loopback0
 timers spf 0 1
 timers pacing flood 15
 area 0 range 2001:DB8::/64
 area 0 range 2001:DB8:2000::/64
 area 1 range 2001:DB8:1000::/64
 area 0 encryption ipsec spi 256 esp aes-cbc 256 0 c79bc443b2c09b3 208d49eb19168ca5…b191 68ca5
```

Control Plane (Routing) Filters

- Filter traffic destined TO your core routers
- Develop list of required protocols that are sourced from outside your AS and access core routers
  - Example: eBGP peering, GRE, IPSec, etc.
  - Use classification filters as required
- Identify core address block(s)
  - This is the protected address space
  - Summarization is critical for simpler and shorter filter lists

BGP Security Techniques

- BGP Community Filtering
- MD5 Keys on the eBGP and iBGP Peers
- Max Prefix Limits
- Prefer Customer Routes over Peer Routes (RFC 1998)
- GTSM (i.e. TTL Hack)

Audit and Validate Your Routing Infrastructures

- Are appropriate paths used?
  - Check routing tables
  - Verify configurations
- Is router compromised?
  - Check access logs

Routing Security Conclusions

- Current routing protocols do not have adequate security controls
- Mitigate risks by using a combination of techniques to limit access and authenticate data
- Be vigilant in auditing and monitoring your network infrastructure
- Consider MD5 authentication
- Always filter routing updates….especially be careful of redistribution

But Wait…There's More…

- RPKI – Resource Public Key Infrastructure, the Certificate Infrastructure to Support the other Pieces
  - We need to be able to authoritatively prove who owns an IP prefix and what AS(s) may announce it
  - Prefix ownership follows the allocation hierarchy (IANA, RIRs, ISPs, etc)
  - Origin Validation
    - Using the RPKI to detect and prevent mis-originations of someone else's prefixes (early 2012)
  - AS-Path Validation AKA BGPsec
    - Prevent Attacks on BGP (future work)

BGP – Why Origin Validation?

- Prevent YouTube accident & Far Worse
- Prevents most accidental announcements
- Does not prevent malicious path attacks
- That requires 'Path Validation' and locking the data plane to the control plane, the third step, BGPsec

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
- Filtering help everyone – PLEASE deploy anti-spoofing filters
- 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

Hardening Network Devices