

# ACOS Hardening Guide

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# INTRODUCTION

This document contains information and recommendations to help you harden and secure your A10 ACOS systems, which will improve security in your networks and ACOS deployments. This information describes recommended security practices for hardening your ACOS systems that should be considered and applied in accordance with your organization's security policy.

**NOTE:** This document is not intended to be a tutorial on the general use and configuration of ACOS systems or how to best utilize and take advantage of security-related features and services of these systems. For information on features and services, see the [ACOS product documentation](#).

## NETWORKING SYSTEM PLANES

ACOS hardening is addressed for three different planes inherent in contemporary networking systems.

1. Management Plane – Supports functions used to control and administer the ACOS system with applications such as Command Line Interface (CLI), web-based management GUI (Web/GUI), logging, and Authentication/Authorization/Accounting (AAA). These functions use commonly known protocols such as Secure Shell (SSH), SNMP, HTTP/HTTPS, Syslog, RADIUS, TACACS+, LDAPS, and others.
2. Control Plane – Supports functions used between networking devices such as the Border Gateway Protocol (BGP), Open Shortest Path First (OSPF), Routing Information Protocol (RIP), Intermediate System to Intermediate System (IS-IS), Bidirectional Forwarding Protocol (BFD), and others.
3. Data Plane – Supports functions that operate on data passing through the ACOS systems and between the ACOS system and interior managed service systems. These include functions such as
  - Application Delivery services (e.g. load balancing, server health monitoring, packet inspection/transformation, white/black lists, etc.)
  - Application Acceleration services (e.g. HTTP Acceleration/Caching, SSL/TLS Offloading, SSL/TLS Proxy, etc.)
  - Application Security services (e.g. SSL/TLS Intercept (SSLi), Web-Application Firewall (WAF), Application Access Management (AAM), Single Sign-On (SSO), bandwidth limiting, connection/rate limiting, etc.)
  - Distributed Denial of Service (DDOS) services (e.g. Detection, Mitigation, & Cloud Protection)
  - IPv6 Migration/IPv4 Preservation (e.g. Carrier Grade NAT (CGN/CGNAT), NAT64/DNS64, DS-Lite, 6rd, LW4o6, etc.).

Hardening considerations are presented, in turn, for each of the planes in the subsequent chapters of this document.

## SCOPE

This document addresses hardening factors for:

- ACOS ADC+ releases 4.1.4-GR1 and later
- ACOS TPS releases 3.2.3 and later

Configuration examples presented in this document are provided for the ACOS CLI. Corresponding ACOS Web/GUI and aXAPI operations are available and described in the ACOS product documentation.

Configuration examples presented are provided for IPv4 addressing only. For IPv6 equivalents, see the ACOS product documentation.

On occasions where the contents of this document conflict or are inconsistent with the ACOS product documentation, the ACOS documentation should be considered as the defining reference.

## CONVENTIONS

The following conventions are used in the content and prose of discussions for this document.

- Underline indicates emphasis.
- *Italics* indicates references to specific documents in the [ACOS product documentation](#).
- [Blue Italics Underline](#) indicates a clickable link to another location in this document.
- [Blue Normal Underline](#) indicates a clickable hyperlink to an internet accessible web page.
- `Courier font` indicates ACOS CLI commands or parameters

### CLI Examples

ACOS CLI examples presented in this document shown as `single-indented`, `Courier font`, for input commands and parameter, as well as displayed output content. For example:

```
// HTTPS, mgmt. port already enabled
// Create Mgmt I/F ACL 100 for ACOS mgmt. port (incl HTTPS, mgmt. port rules).
//   - ACL 100 will be an overall ACL for the ACOS mgmt. port
//
ACOS-TH####(config)#access-list 100 1 remark "ACL - mgmt port @ HTTPS"
ACOS-TH####(config)#access-list 100 2 permit tcp 10.10.10.0 /24 any eq 443

ACOS-TH####(config)#enable-management service acl-v4 100
ACOS-TH####(config-enable-management acl-v4)#management
```

Additional conventions used in CLI examples include:

- **bold** indicates ACOS CLI commands and their parameters.
- **exit** commands to complete input at a given configuration level are not indicated, for readability.
- Lines starting with `ACOS-TH####` indicate CLI command inputs.
- Lines starting with `//` are comments included in the example for the purpose of this document. If entered at CLI prompt, an ACOS error message will be displayed.
- Command contents between `<<<` and `>>>` indicate references to earlier examples.

## Notes

The following conventions are used for notation callouts in this document.

**NOTE:** Notes are represented like this and contain technical information the reader should take note of, providing important additional information to the prior discussion or example content.

**DOCUMENT NOTE:** Notes are represented like this and contain information the reader should take note of regarding scope and presentation in the remainder of the document.

**SECURITY NOTE:** Even though this document is focused on hardening and security overall, notes like this contain information and perspective that is particularly important for the reader to take note of.

## DOCUMENTATION

ACOS product documentation can be found in the SOFTWARE AND DOCUMENTATION section of the [A10 Support Portal](#).

## DOWNLOAD THE LATEST ACOS SOFTWARE

Visit the [A10 Support Portal](#) to download the latest update images for ACOS software and be up to date with the most recent security vulnerability remediations and corrections.

For information on vulnerability exposures and resolved ACOS releases see the Security Advisories at the [A10 Product Security Incident Response Team \(PSIRT\)](#) webpage at the [A10 Networks website](#).

**SECURITY NOTE:** A majority of vulnerabilities in networked systems are simply due to the underlying software being out of date, when updates are readily available. Exposures to vulnerabilities grow significantly the longer systems are left un-patched or out of date. Updates for ACOS software are no different and regularly contain remediations (fixes) to sources of risk or compromise in A10 systems.

It is strongly recommended that ACOS administrators put programs in place to maintain their ACOS systems up to date, especially for deployed and production configurations. For information on available versions and updates, contact your A10 Sales Engineer or the A10 Technical Assistance Center (TAC).



## HARDENING THE ACOS MANAGEMENT PLANE

This chapter addresses hardening considerations of the ACOS management plane whose functions support management and device administration of the ACOS System. These functions include:

- interactive management and administration of the system,
- connections to management services (e.g. NTP, Syslog, external authentication services),
- support for management data gathering services (e.g. SNMP, NetFlow), and
- programmatic management services (e.g. RESTful aXAPI, External Health Monitor, aFlex).

It is critical that the ACOS management plane is protected and is used within the bounds of acceptable practices by trusted administrators with access from trusted management systems to ensure the availability and stability of the ACOS system.

### PASSWORD AND USER MANAGEMENT

Passwords control administrative access to the ACOS systems as well as configuration resources and key services of ACOS. More secure environments will manage passwords and users through RADIUS, TACACS+, or LDAPS external authentication servers. Certainly, users and their passwords can also be configured locally in ACOS for conditions when external services are not available or have failed.

It is important to consider that when external authentication configurations become unavailable that access to the ACOS device is not ultimately blocked or unavailable. To this end it can be important for availability of the ACOS system to have locally configured users, beyond just the ACOS root admin, that can manage the ACOS system on these occasions.

The following subsections share hardening recommendations for configuring passwords, locally configured administrators, and assigning access privileges.

#### *Change the ACOS Default Admin Password*

By default, ACOS is provisioned with one administrator account named “admin” and one partition named “shared.” This default admin account, also referred to as the [root admin account](#), is the master administrator of the ACOS system and has root access to ACOS. Root access means that “admin” has read-write privileges to all ACOS objects across all partitions.

It is strongly recommended to change the default “a10” (or “a10\$pass” for FIPS-certified ACOS devices) to a strong user-defined password. For example:

```
ACOS-TH#### (config) #admin admin
ACOS-TH#### (config-admin:admin) #password Gtu$B0y7
```

#### *Change the ACOS Default Enable Password*

When users log into the CLI, the initial User EXEC level of access provides a very limited set of management operations. These include showing (viewing) the status or configuration information of the system, initiating SSH or Telnet terminal sessions to remote systems, performing management connectivity operations (e.g. ping, traceroute, test a device’s health status), and entering the Privileged EXEC level.

The Privileged EXEC level of the CLI allows users to change or modify the ACOS system configuration and can be entered via the global password-protected `enable` command. By default, this password that is empty (e.g. just press Enter at the password prompt).

It is strongly recommended to change this default to a strong user-defined password. For example:

```
ACOS-TH#### (config) #enable-password 7y0B$utG
```

## Common Password Security Practices

The following security practices are commonplace in the industry and should be considered for any passwords configured in the ACOS system.

- Contain at least 8 characters and include uppercase, lowercase, numeric, and special characters.
- Are not the same values as passwords included in this document or any other ACOS product document.
- Are not based on words in any language, jargon, slang or dialect and are not words or based on words found in any dictionary.
- Are not based on personal or familiar names, such as the name of a family member, pet, or friend.
- Are not based personal information, such as PINs, telephone numbers, addresses, or birthdays.
- Are not based on predictable patterns, such as '12345678', 'qwerty', 'aaaabbbb', or '123123'.
- Are not based commonly known default passwords for networking or other products, such as 'password', 'admin', 'user', 'sysadm', or 'root'.
- Are not any of the above spelled backwards.
- Are not any of the above prefixed or post fixed by a number, such as ;jambalaya1; or ;1jambalaya;.

Especially for networking devices, the following are additional common practices to consider.

- Periodically change static passwords, though this is recognizably tedious in even modest networks and potentially unmanageable in larger networks without automation capabilities.
- Avoid using passwords commonly known as default passwords in networking products, including Internet of Things (IoT) devices.
- Note that passwords, shared secrets, secret keys, etc. for various networking protocols, their implementation in ACOS, or ACOS implementation features may be limited in the ranges of characters allowed. Typically, these conditions will occur for the range of special characters supported.

**NOTE:** Where applicable, this document will endeavor to note these constraints.

## Local Password Practices

ACOS cannot control or enforce your policy for passwords when they are managed by RADIUS, TACACS+, or LDAPS services external to ACOS. However, A10 can recommend various password practices and can provide some services to enforce policy for passwords locally configured on the ACOS system.

## Password Complexity

The default complexity for local ACOS user passwords is nominal as follows.

- At least 3 characters long (non-FIPS mode)
- At least 8 characters long (FIPS mode)

A10 recommends that ACOS systems enable the strict password policy for complexity which applies the following constraints on ACOS user passwords.

- Is at least 8 characters long
- Contains 2 or more uppercase characters ('A' – 'Z')
- Contains 2 or more lowercase characters ('a' – 'z')
- Contains 2 or more numeric characters ('0' – '1')
- Contains 1 or more special characters (e.g. !@#\$%^&\*()-=+\_{}[]~?:\./)

Strict password complexity can be enabled through the `system password-policy` command. For example:

```
ACOS-TH####(config)# system password-policy strict Aging strict history strict
```

## Password Aging

By default, local ACOS user passwords are not aged. It is a recommended practice that administrators enable the strict password policy for aging which applies the following password constraints.

- Maximum password validity – 60 days
- Warning period prior to age-out – 7 days

Strict password aging can be enabled through the `system password-policy` command. For example:

```
ACOS-TH####(config)# system password-policy strict Aging strict history strict
```

## Password History

By default, up to 3 prior passwords are retained by ACOS to avoid their reuse by local ACOS users. A10 recommends that ACOS systems enable the strict password policy for history which will retain up to 5 prior passwords.

Strict password history can be enabled through the `system password-policy` command. For example:

```
ACOS-TH####(config)# system password-policy strict Aging strict history strict
```

## Failed Authentication Lockout

ACOS cannot control or enforce your policy for handling multiple failed authentications detected through RADIUS, TACACS+, or LDAPS services. ACOS does, however, support an administrator lockout capability for failed authentications on locally configured, ACOS user accounts. The `admin-lockout` feature is enabled by default with the following settings.

- 5 # of failed attempts before the account is locked out
- 10 minutes Duration the account is locked out and any further attempts will be summarily failed
- 10 minutes Duration after which prior failed attempts will be forgotten

A10 recommends that administrators do not disable this feature and update it by using the `admin-lockout` command to settings consistent with the organization's security policy. The following example changes the threshold to 5 failed attempts over a period of 30 minutes with a lockout of the account for 1 hour if the threshold is reached.

```
ACOS-TH####(config)#admin-lockout threshold 5
ACOS-TH####(config)#admin-lockout duration 60
ACOS-TH####(config)#admin-lockout reset-time 30
```

**NOTE:** Setting the `duration` value to zero (0) will permanently lockout an account if the number of failed attempts reach the threshold. On these occasions, the root administrator of the ACOS system will need to manually unlock the account to reenable access for the ACOS user.

## Authentication, Authorization, and Accounting (AAA)

Authentication, Authorization, and Accounting (AAA) is a framework fundamental to securing user access to ACOS systems. ACOS provides a number of methods for authenticating users and preventing unauthorized to management services of the system, ranging from local authentication services on the system to Role-Based Authentication (RBA) using external servers.

The following subsections discuss key aspects of this framework in ACOS, including:

- Authentication methods supported
- Foundation model for User Access and Privileges
- Role-Based Access (RBA) with external servers

## ACOS Authentication Methods

Authentication permits or denies access to the ACOS based on the administrator username and password credentials provided when ACOS is being access from the:

- System's Web/GUI
- Command Language Interface (CLI) via the system console or remotely via SSH
- aXAPI for external management applications.

By default, when an admin user or management application attempts to login to the ACOS system, the device determines whether the username and password exist in a local database. Without additional configuration, the authentication process stops at this point. If the username and password exist in the local database, the user is permitted access; otherwise, access is denied.

Authorized users can configure the ACOS system to also use external RADIUS, TACACS+ or LDAP servers for authentication. ACOS can be configured to use one or more of these methods, along with the local database using the `authentication type` CLI command. Precedence of authentication method is indicated by the order specified and ACOS will query them in order as it attempts to successfully authenticate access.

**NOTE:** The local database method must always be included in this configuration as it is an ever-present fallback in the event that all external authentication servers are not available. Authentication using only remote servers is not supported by ACOS.

For example, to configure the ACOS system to use external RADIUS authentication and the local database, with RADIUS preferred:

```
ACOS-TH#### (config) #authentication type radius local
```

Alternately, to configure the ACOS for multi-tier authentication where TACACS+ is queried first, a RADIUS backup authentication service is tried next, a secondary backup LDAP server after that, and lastly the local database as a last resort.

```
ACOS-TH#### (config) #authentication type tacacs radius ldap local
```

**NOTE:** The local database option (`local`) must be included as one of the authentication sources, regardless of the order is which the sources are used.

---

## ACOS User Access and Privilege Assignment

---

ACOS users (administrators) can be assigned a range of access types and privileges when their accounts are created; either through locally configured accounts or through external authentication services such as RADIUS, TACACS+, or LDAPS. It is important to be diligent when making access and privilege assignments for ACOS users and their relative roles in administering the ACOS system.

See the *ACOS Management Access and Security Guide* for details on configuring users (administrators) for the ACOS system.

### User Access Types

---

ACOS supports three (3) fundamental access methods for administrators.

- `cli` Access to the ACOS CLI via physical console or remote terminal session. This is the most intimate level of access for configuring the ACOS system.
- `web` Access to the ACOS GUI via web browser. This method provides a rich graphical interface to configure the ACOS system, though some granular configuration options may be only available via the CLI.
- `axapi` Real-time access to XML-based programs via HTTP/HTTPS. This method supports programmatic access to ACOS configuration and extended services for external management applications.

When assigning access types for a given user (admin) account, ACOS administration should consider the following:

- Not all ACOS admins need to have CLI access. For many admins, Web/GUI access will be enough.
- In general, more seasoned administrators should be permitted to access the ACOS CLI, given the CLI's notable complexity and extended capabilities compared to the Web/GUI interface.
- Administrators without the need to develop or run applications using the aXAPI web/cli access should not be enabled for aXAPI access.

### Read, Write, Partition Privileges

---

ACOS supports three (3) fundamental privileges for administrators.

- `read` Allows the administrator to view and display ACOS configuration elements.
- `write` Allows the administrator to create, modify, or delete ACOS configuration elements - with the exception of selected External Health Monitor objects.
- `partition` Constrains the administrator other privileges (read, write) to the scope of a given ACOS Layer 3 Virtual (L3V) partition.

These privileges are assigned in combinations to enable a range of abilities for administrators to configure and observe status/statistics in the overall ACOS system or in the scope of a given L3V partition.

When assigning privileges for a given user (admin) account, the ACOS administration should consider the following:

- ACOS admins responsible for monitoring status and notifying others to resolve downed links, excessive CPU use, etc. should only be assigned "read" privilege.
- Only admins trusted to make changes in the ACOS system's configuration should be assigned "write" privilege.
- Partition-based admin accounts should consider the points described above relative to the respective L3V partitions defined for the ACOS system.

- Shared partition admin accounts can affect the overall ACOS system, including any L3V partitions that it supports. Accordingly, this level of privilege should be assigned for more seasoned and trusted members of the organization.
- Always be diligent and cautious when assigning privileges to ACOS admin accounts.

ACOS also supports an optional Role-Based Access (RBA) mechanism, discussed below, which builds on top of this base-set of privileges for finer-grained control of permissions and privileges of ACOS administrator accounts

### HM Privilege

---

There is a fourth privilege for ACOS administrator accounts, the External Health Monitor (hm) privilege, that is noteworthy of separate mention and consideration.

This privilege allows the ACOS admin to import, create, edit, and delete scripts intended for the purpose of monitoring health and status of external server applications by the ACOS system. Though a very useful and practical capability, this ACOS feature (by its very nature) represents an avenue for programs/code unsanctioned by A10 to enter the otherwise closed ACOS system.

**SECURITY NOTE:** The `hm` privilege is only supported for configured ACOS admins with both `read` and `write` privileges for the ACOS shared partition. It is not supported for partition ACOS admins since External Health Monitors execute on a system-wide basis in the ACOS device.

The `hm` privilege is disabled by default for provisioned admin users.

With this privilege a malicious or compromised administrator or an administrator whose system is unknowingly compromised could introduce programs/code into the ACOS system that could leverage a variety of vulnerabilities and attacks, negatively impacting the ACOS system or the connected network and systems.

Accordingly, the `hm` privilege should be assigned only to administrators who are significantly trusted in the organization. Only these administrators should be allowed to develop and maintain External Health Monitor scripts on the ACOS system or, more importantly, to establish them on production ACOS system deployments.

For more information on configuring administrative users, refer to the *ACOS Management Access and Security Guide*. See the [External Health Monitor Practices](#) discussion below for additional discussion on securing this feature.

**SECURITY NOTE:** The `hm` privilege could allow an administrator to use the ACOS External Health Monitor feature for potentially malicious purposes. Only assign this privilege to administrators sufficiently trusted in your organization.

### Role-Based Access (RBA)

---

RBA allows finer grained controls of ACOS management privileges, described above, with predefined roles mapped to standardized privilege levels (for RADIUS and TACACS+) and predefined roles with additional parameters (for LDAP). This affords much more efficient scaling of privilege and access management for larger user communities.

To support these roles and additional access factors, ACOS defines extensions to the data model (e.g. schema, dictionary, etc.) for these protocol that can be configured into the external authentication servers, as described in the *ACOS Management Access and Security Guide* of the ACOS product documentation.

### ACOS RBA with TACACS+ or RADIUS

For ACOS systems enabling TACACS+ or RADIUS for external authentication, ACOS supports a number of predefined roles which map to privilege levels of these protocols as shown in the table below.

Access Role	RADIUS Privilege	TACACS+ Privilege	Partition Role
<b>ReadWriteAdmin</b>	2	15	N
<b>SystemAdmin</b>	3	14	N
<b>NetworkAdmin</b>	4	13	N
<b>NetworkOperator</b>	5	12	N
<b>SlbServiceAdmin</b>	6	11	N
<b>SlbServiceOperator</b>	7	10	N
<b>ReadOnlyAdmin</b>	1	0	N
<b>PartitionReadWrite</b>	8	9	Y
<b>PartitionNetworkOperator</b>	9	8	Y
<b>PartitionSlbServiceAdmin</b>	10	7	Y
<b>PartitionSlbServiceOperator</b>	11	6	Y
<b>PartitionReadOnly</b>	12	5	Y

**SECURITY NOTE:** The `ReadWriteAdmin` role includes the ACOS `hm` privilege, allowing access to External Health Monitor files as described in the [HM Privilege](#) discussion above. See the [External Health Monitor Practices](#) discussion for more information on potential security risks involving these monitors.

See the [Securing Other Management Protocols](#) section below for discussions on securely configuring RADIUS and TACACS+ servers in ACOS.

### ACOS RBA with LDAP

For ACOS systems enabling LDAP for external authentication, ACOS supports a number of predefined roles that may be indicated for the `A10AdminRole` parameter of the LDAP schema extensions for ACOS. These roles include:

- `ReadOnlyAdmin`
- `ReadWriteAdmin`
- `PartitionSlbServiceOperator`
- `PartitionReadOnly`
- `PartitionReadWrite`

Another element of the LDAP schema extension is the `A10AccessType` parameter. It consists of a list of access privileges corresponding to the [User Access Types](#) and [HM Privilege](#) discussed earlier; namely:

- `cli`
- `web`
- `axapi`
- `hm`

**SECURITY NOTE:** Including the `hm` attribute for a `ReadWriteAdmin` role will allow access to External Health Monitor files as described in the [HM Privilege](#) discussion above. See the [External Health Monitor Practices](#) discussion for more information on potential security risks involving these monitors.

See the [Securing Other Management Protocols](#) section below for discussions on securely configuring LDAP and servers in ACOS.

## Limit User Network Access

In addition to securing access to an ACOS system by identity and configured privilege (as described above), constraining access to the ACOS system and its services provides a further layer of confidence by ensuring that access is only from trusted network segments or even individually trusted client systems.

Two ways to limit access based on where users are accessing ACOS from include:

- Access relative to user (administrator) identity
- Access relative to ACOS interface and service

## User Identity Access Controls

ACOS cannot control or enforce where RADIUS, TACACS+, or LDAPS configured ACOS users can access ACOS from. In these cases, network administrators are responsible for managing identity-based access to ACOS systems in their authentication service infrastructure.

ACOS does, however, support identity-based access controls for locally configured ACOS user accounts. By default, locally configured ACOS users are permitted to login from any source address, without restriction. The `trusted-host` command allows individual users to be restricted from logging in based on their IP subnet or host address or through an Access Control List (ACL) for more complex criteria.

For example, to restrict logins for “bob” from any DHCP-assigned, address on the 10.10.10.x subnet, though not from when connected in on any other subnet, and “ted” from the hardened and monitored management access server at 10.10.7.42:

```
ACOS-TH#### (config) #admin bob
ACOS-TH#### (config-admin:bob) #trusted-host 10.10.10.0/24

ACOS-TH#### (config) #admin ted
ACOS-TH#### (config-admin:bob) #trusted-host 10.10.7.42/32
```

**NOTE:** IPv6 is not supported for the address information parameter to the `trusted-host` command. However, the IPv6 addresses are supported for the `access-list` variant below.

As an alternate example, an ACL can be used to restrict logins for “carol” from any DHCP-assigned, client address on the 10.10.10.x subnet or the 10.10.7.42 access server:

```
ACOS-TH#### (config) #access-list 7 1 remark "ACL - Net Admin segment + Restricted Server"
ACOS-TH#### (config) #access-list 7 2 permit ip 10.10.10.0/24
ACOS-TH#### (config) #access-list 7 3 permit ip 10.10.7.42/32

ACOS-TH#### (config) #admin carol
ACOS-TH#### (config-admin:bob) #trusted-host access-list 7
```

**NOTE:** User level ACLs are not able to constrain the ACOS devices interfaces being used for permitted client addresses. The services themselves being used for such access (e.g. SSH, HTTPS, etc.) do, however, provide interface level access control.



## Interface and Service Level Controls

Every ACOS system supports interfaces for a management port, real data ports (e.g. `eth1`, `eth2`, etc.), and virtual ethernet ports (e.g. `ve1`, `ve2`, etc.) based on VLAN configuration. By default, as shown in the table below, selected management services are only enabled on the management port, except for “ping” which is also enabled on real and virtual ethernet ports.

Management Service	Management I/F	Data Interfaces
PING	Enabled	Enabled
SSH	Enabled	Disabled
Telnet	Disable	Disabled
HTTP	Enabled, w/ Redirect to HTTPS	Disabled
HTTPS	Enabled	Disabled
SNMP	Enabled	Disabled

ACOS also supports management functions where the ACOS system initiates to trusted servers for various management services; including NTP, TACACS+, Radius, and LDAP/LDAPS. These functions are enabled only when configured into the ACOS system.

By default, these enabled services and functions have no access restrictions. ACOS supports a range of ACLs to support limiting access to management services by users in selected networks segments or from specific network addresses. ACLs can also be used to constrain access by the ACOS system to specific, trusted management servers.

**DOCUMENT NOTE:** For clarity of purpose, this document will use the management interface ACL method for access control examples of management services and functions. This method uses the `enable-management service acl-v4` form of the `enable-management service` command to apply ACL rules on supported interfaces of the ACOS system.

Though certainly viable, other ACL methods are beyond scope for the remainder of this document. Administrators are referred to ACOS product documentation for insights into other ACL methods that may be more convenient for their deployments of like and equivalent access rules.

ACOS supports two basic, underlying forms of ACLs; standard and extended. Standard ACLs (`acl-id` values 1 -99) support source IP address host and segment constraints. Extended ACLs (`acl-id` values 100 – 199) support a variety of additional controls; including IP destination addressing, TCP/UDP source/destination ports, and others.

**NOTE:** For simplicity and to avoid ACOS management-related ACL nuances, this document will use the extended ACL form for access control examples.

It is commonplace for ACOS deployments to seek management access via data ports, in addition to the system’s management port. ACOS allows various management services to be:

- enabled or disabled per interface, and
- configured with per-interface ACLs for finer grained access controls.

The following is an example of using ACLs for broader community access to for selected services for:

- HTTPS access only via management and eth1 data ports from the 10.10.10.0/24 network segment.
- SSH access via data port eth1, though just from the 192.10.7.42 shared access server.

```
// HTTPS, mgmt. port already enabled
// Create Mgmt I/F ACL 100 for ACOS mgmt. port (incl HTTPS, mgmt. port rules).
//   - ACL 100 will be an overall ACL for the ACOS mgmt. port
//
ACOS-TH####(config)#access-list 100 1 remark "ACL - mgmt port @ HTTPS"
ACOS-TH####(config)#access-list 100 2 permit tcp 10.10.10.0 /24 any eq 443

ACOS-TH####(config)#enable-management service acl-v4 100
ACOS-TH####(config-enable-management acl-v4)#management

// Enable HTTPS on ethernet 1
// Create Mgmt I/F ACL 101 for ACOS eth1 port (incl HTTPS, eth1 port rules).
//   - ACL 101 will be an overall ACL for the ACOS eth1 port
//
ACOS-TH####(config)#enable-management service https
ACOS-TH####(config-enable-management https)#ethernet 1

ACOS-TH####(config)#access-list 101 1 remark "ACL - eth1 port @ HTTPS"
ACOS-TH####(config)#access-list 101 2 permit tcp 10.10.10.0 /24 any eq 443

ACOS-TH####(config)#enable-management service acl-v4 101
ACOS-TH####(config-enable-management acl-v4)#ethernet 1

// Enable SSH on ethernet 1
// Add SSH, eth1 port rules to eth1 ACL 101
//
ACOS-TH####(config)#enable-management service ssh
ACOS-TH####(config-enable-management ssh)#ethernet 1

ACOS-TH####(config)#access-list 101 5 remark "ACL - eth1 port @ SSH from hardened server"
ACOS-TH####(config)#access-list 101 6 permit tcp host 192.10.7.42 any eq 22

ACOS-TH####(config)#show management
```

	PING	SSH	Telnet	HTTP	HTTPS	SNMP	ACL
mgmt	ACL 100	ACL 100	ACL 100	ACL 100	ACL 100	ACL 100	100
eth1	ACL 101	ACL 101	ACL 101	ACL 101	ACL 101	ACL 101	101
eth2	on	off	off	off	off	off	-
eth3	on	off	off	off	off	off	-
eth4	on	off	off	off	off	off	-

**DOCUMENT NOTE:** The extended ACLs 100 and 101 created here will be used throughout the remainder of this document in examples of provisioning access controls to harden and secure ACOS management plane protocols. ACL 100 will build up rules for management access on the `mgmt` interface. ACL 101 will do the same for the `eth1` interface.

## UNSECURE MANAGEMENT ACCESS PROTOCOLS

ACOS supports the following general management services and protocols for access from management clients and to external servers.

- CLI/Terminal Access                      SSH, Telnet
- Web-GUI and aXAPI Access              HTTPS, HTTP
- Network Management Access          SNMPv1/v2, SNMPv3
- Remote File Transfer                    HTTPS, HTTP, SFTP, SCP, FTP, TFTP

Of these, the following are considered unsecured as they exchange information in clear text, without encryption.

- Access Protocols                        Telnet, HTTP, SNMPv1/v2
- File Transfer Protocols                FTP, TFTP

Administrators can view which general management services are enabled, on which interfaces, and if there are any interface ACLs enabled with the `show management` command. For example:

```
ACOS-TH#### (config) #show management
      PING      SSH      Telnet      HTTP      HTTPS      SNMP      ACL
-----
mgmt  on        on        off         on         on          on         -
eth1  on        off       off         off        off         off        -
eth2  on        off       off         off        off         off        -
eth3  on        off       off         off        off         off        -
eth4  on        off       off         off        off         off        -
```

### Telnet, HTTP, SNMPv1/v2

By default, Telnet and SNMP are disabled in ACOS, while HTTP is enabled. Secure practices recommend that Telnet and SNMPv1/v2 protocols remain disabled in the ACOS system.

**NOTE:** Secure configuration of SNMPv3 is discussed separately, later in this document.

By default, HTTP access on the ACOS management plane will automatically redirect HTTP (TCP port 80) connections to the HTTPS service (TCP port 443). Though not recommended, full access to the ACOS Web-GUI and aXAPI services via HTTP can be enabled as follows.

```
ACOS-TH#### (config) #web-service auto-redirt disable
```

**NOTE:** Whether automatic redirects are enabled or not, HTTP on TCP port 80 will show up in security and vulnerability scanner results. When automatic redirects remain enabled, the scope of exchanges on HTTP connections will be only that needed to redirect these connections to the HTTPS service. This scope contains no sensitive information or security exposures, even though the scanners will often report potential vulnerabilities.

For organizations with strict security policies that prohibit any HTTP traffic in their device management networks, this method of access to the ACOS system can be fully disabled, while leaving HTTPS access enabled, as follows.

```
ACOS-TH#### (config) #web-service server disable
```

**NOTE:** Attempting to disable HTTP with the `no enable-management service http management` command will not disable HTTP redirects when the `auto-redirt` feature is enabled.

## Avoid Using FTP, TFTP, or HTTP File Transfer Mechanisms

The following management operations support the transfer of files into and from the ACOS system.

- Import, Export commands
- Periodic Import commands
- Backup of Log Files
- Backup of System Configuration
- Periodic Backups
- Backup of System Information
- Copying Running Configuration
- Loading ACOS Web/GUI service certificate or private-key
- Power On Auto Provisioning
- Log Exports
- Restoring Start-up Configuration
- Loading an SSH Key
- Importing an SSH Public Key
- Upgrading ACOS to a new version
- Exporting System Information for troubleshooting
- Periodic Importing of Geo-Location Lists
- Enabling the loopback interface to source such management traffic (ACOS TPS Only)

It is recommended that ACOS administration make and define a common practice for their ACOS admins to not use FTP, TFTP, or HTTP options for these and any other ACOS operations not listed above.

Instead, the following secure transfer protocols options should be used.

- scp: Remote file path of SCP file                      Format: scp://[user@]host/file
- sftp: Remote file path of SFTP file                      Format: sftp://[user@]host/file
- https: Remote file path of HTTP file                      Format: https://[user@]host/file

## SECURING INTERACTIVE MANAGEMENT SESSIONS

Interactive management methods available in of ACOS include:

- CLI via system console of the ACOS device
- CLI via remote terminal connections
- Web/GUI from web browsers
- Programmatic aXAPI from RESTful management applications.

The following subsections share hardening recommendations for configuring these services and their underlying SSH and HTTPS access protocols.

### Session Timeouts

Terminating an idle session within a short time period reduces the window of opportunity for unauthorized personnel to take control of an unattended, management session enabled on the console, a remote terminal, browser, or an aXAPI application that has been left unattended.

ACOS supports management access session timeouts for the following services:

- ACOS CLI via the system console or remote terminal connections (e.g. SSH)
- ACOS Web/GUI
- ACOS aXAPI programmatic API

### CLI Session Timeout

ACOS CLI sessions can be configured to timeout after a period of inactivity resulting in the following behaviors.

- Console port - login session will be terminated, returning terminal session to ACOS login prompt.
- Remote terminal - TCP connection to remote terminal (e.g. SSH) client will be terminated by ACOS.

By default, ACOS CLI sessions will time-out after 15 minutes of inactivity. Use the `terminal idle-timeout` command to change this duration in accordance with the organization's security policy. For example, to set the idle-timeout to 10 minutes:

```
ACOS-TH#### (config) #terminal idle-timeout 10
```

### Web/GUI Session and aXAPI Timeouts

ACOS Web/GUI and aXAPI applications sessions can be configured to timeout after a period of inactivity with ACOS terminating their underlying TCP connections.

By default, these sessions will time-out after 10 minutes of inactivity. Use the `web-service gui-timeout-policy` and `web-service axapi-timeout-policy` commands to change these durations in accordance with the organization's security policy. For example, to set the idle-timeout to 15 and 20 minutes; respectively:

```
ACOS-TH#### (config) #web-service gui-timeout-policy idle 15
```

```
ACOS-TH#### (config) #web-service axapi-timeout-policy idle 20
```

## Login Banners

Legal notification requirements can be very complex and vary by jurisdiction, company policies, department policies, and other guidelines. Failure to display a login banner prior to a logon attempt or displaying a banner with insufficient content can compromise an organizations ability to prosecute malicious users. It may also put the organization at legal risk by monitoring users' activities without consideration in such notifications.

Login banners are recommended on all external, interactive interfaces for the ACOS system. The content of these banners should be consistent with the organization's policies and reviewed by legal counsel, if needed. From a security perspective, they should not contain any of the following information.

- Purpose, location, logical network name, or owner of the device.
- Make, model, or manufacturer of the device.
- Software or version on the device.

It is recommended that login banners should be displayed before access authentication (e.g. username and/or password entry) is completed.

## CLI Login Banner

A login banner can be configured for the ACOS CLI using the `banner login` command. This will display the banner's content after the ACOS admin user name is entered and before the password is prompted. For example:

```
ACOS-TH####(config)#banner login multi-line
Input a string to mark the end of banner text, up to 2 characters:
bb
Enter text message, end with string 'bb'.
*** WARNING ***
```

```
This system is private and may be accessed only by authorized users for official purposes. The system owner reserves the right to monitor any and all activity taking place on this system and any attempts to connect to it. Individuals using this computer system are subject to having all of their activities monitored and recorded by system personnel. Use of this system evidences an express consent to such monitoring and agreement that if such monitoring reveals evidence of possible abuse or criminal activity, system personnel may provide the results of such monitoring to appropriate officials. Unauthorized users or users who exceed (or attempt to exceed) their authorized level of access are subject to prosecution under any local or international laws that apply as well as Company initiated proceedings.
```

```
bb
ACOS-TH####(config)#
```

**NOTE:** Be careful not to confuse this with the `banner exec` command which configures a banner to be displayed after successful logins.

**NOTE:** The above banner is only provided as an example. You should consult the organization's policies and/or legal counsel for the actual content.

## Web/GUI Login Banner

A login banner can be configured for the ACOS Web/GUI's login page using the `web-service login-message` command, with the message in double-quotes (""). For example:

```
ACOS-TH#### (config) #web-service login-message "                               *** WARNING
***\n\nThis system is private and may be accessed only by authorized users for official purposes. The system
owner reserves the right to monitor any and all activity taking place on this system and any attempts to connect to
it. Individuals using this computer system are subject to having all of their activities monitored and recorded by
system personnel. Use of this system evidences an express consent to such monitoring and agreement that if such
monitoring reveals evidence of possible abuse or criminal activity, system personnel may provide the results of
such monitoring to appropriate officials. Unauthorized users or users who exceed (or attempt to exceed) their
authorized level of access are subject to prosecution under any local or international laws that apply as well as
Company initiated proceedings.\n\n"
ACOS-TH#### (config) #
```

**NOTE:** This banner is displayed after a successful login via the ACOS Web/GUI. The ACOS Web/GUI does not presently support a pre-login banner.

**NOTE:** The `web-service` command above supports a single string, terminated by entering the CLI command. Line breaks and blank lines can be included using `'\n'` and `'\n\n'` characters; respectively.

**NOTE:** The above banner is only provided as an example. You should consult the organization's policies and/or legal counsel for the actual content.

## Securing SSH and HTTPS Services

Updating cryptographic keys and certificates is a common requirement of an organizations security policy, both when installing a new networking device and periodically. The following describe procedures to update keys and certificates in ACOS for SSH and HTTPS.

### Update SSHD Keys

A common security practice is to update the network device's SSH Server key to ensure appropriate key size and uniqueness, thus avoiding potentially duplicate or undersized keys instantiated by the manufacturer. Though this should not be necessary with new installations of contemporary ACOS devices and releases, ACOS devices with a history of upgrades from legacy releases could still have issues on this front.

Accordingly, it is recommended to re-generate or replace the SSH Server key by using the `sshd key regenerate` or `sshd key load` ACOS commands, followed by a restart of the SSH server with the `sshd restart` command. Note that the `sshd restart` command will cause existing SSH sessions to be terminated.

**NOTE:** Replacement of the key is the preferred approach as it consistent with the FIPS-compatible mode of operation for ACOS.

The following example shows how to regenerate the SSH server's RSA key with a new 2048-bit RSA key and SHA-256 signature.

```
ACOS-TH#### (config) #sshd key regenerate size 2048
```

```
ACOS-TH#### (config) #sshd restart
```

**NOTE:** A 4096-bit key size would be even stronger and is also supported.

### Update HTTPS Cert-Key Pair

A common security practice is to update the network device's HTTPS certificate and key (cert-key) pair to ensure appropriate key size and cert-key pair uniqueness, thus avoiding potentially duplicate or undersized cert-keys instantiated by the manufacturer. Though this should not be necessary with new installations of contemporary ACOS devices and releases, ACOS devices with a history of upgrades from legacy releases could still have issues on this front.

Accordingly, it is recommended to re-generate or replace the using HTTPS cert-key pair by using the `web-service secure regenerate` or `web-service secure load` ACOS commands, followed by a restart of the HTTPS server with the `web-service restart` command. Note that the `web-service restart` command will cause existing HTTPS sessions to be terminated.

**NOTE:** Replacement of the key-pair is the preferred approach as it consistent with the FIPS-compatible mode of operation for ACOS.

The following example shows how to regenerate the HTTPS cert-key pair with a self-signed certificate, based on a 2048-bit RSA key with SHA-2 signature and valid for 2 years.

```
ACOS-TH#### (config) #web-service secure regenerate domain my-domain country my-country-code
state my-state-code
```

```
ACOS-TH#### (config) #web-service restart
```

**NOTE:** HTTPS certificates used with ACOS systems are often self-signed since device management networks are commonly isolated within an organization's internal, private network environment, are not permitted access to the Internet, and/or have no otherwise available Certificate Authority (CA).



Administrators seeking to generate their own HTTPS cert-key pair for the ACOS system should ensure the following:

- For RSA pair: Public Key  $\geq$  1024-bit, Private Key  $\geq$  2048-bit, Signature Alg = SHA-2
- For ECDSA pair: Public Key  $\geq$  224-bit, Private Key  $\geq$  224-bit, Signature Alg = SHA-2

Once generated, the cert-key pair can be loaded for use by the ACOS HTTPS service. For example, to load a newly generated cert-key pair (new) from a local administration system (10.1.2.20):

```
ACOS-TH#### (config) #web-service secure wipe
ACOS-TH#### (config) #web-service secure certificate load scp://u1@10.1.2.20/home/u1/new-key.pem
ACOS-TH#### (config) #web-service secure private-key load scp://u1@10.1.2.20/home/u1/new-cert.pem

ACOS-TH#### (config) #web-service restart
```

## EXTERNAL HEALTH MONITOR PRACTICES

The External Health Monitors (Ext-HMs) feature of ACOS is meant to allow the monitoring of server and service availability for custom server applications and applications outside the set of those known or knowable to ACOS. This feature allows ACOS deployments to import scripts and code into the ACOS system to be written in shell, python, and other languages and to be scheduled to be periodically executed to determine health and availability of the underlying servers and their services.

Though Ext-HMs can provide a tremendously valuable service and capability, they also represent an avenue for programs/code, not sanctioned or warranted by A10, into the ACOS system. Inherent in the Ext-HM feature is the addition of programmatic code, in the form of scripts, by administrators into the closed, system-level, run-time environment within ACOS. Running at elevated processing privilege, this code will have intimate access throughout the ACOS system and broad connectivity to its deployed networking environment.

Well behaved scripts contain trusted code solely for performing functions to monitor the health of real servers and applications in the organization's network. It is the organization's responsibility to ensure the integrity and content of these scripts; namely, that the code is trusted and that the scripts are free of code that can compromise the security of the ACOS system or systems in connected networks.

Malicious code in External Health Monitor scripts, whether intentional by disaffected ACOS admins or unintentional by compromised ACOS admins or their systems, can expose the ACOS system and connected environment to a range of exploits, such as, but not limited to, the following:

- Denial of Service (DoS),
- Distributed Denial of Service (DDoS)
- Remote Code Execution (RCE)
- Buffer Overflow
- Trojan Horses
- Network Worms
- Exfiltration of Sensitive Information
- Side-Channel Vulnerabilities
- Brute Force Attacks
- Man-in-the-Middle Attacks
- Spyware
- Ransomware

To secure Ext-HMs and keep them secure, ACOS administration can restrict access to these services, monitor access activity, and review the content of these scripts.

### *Restricting Extended Health Monitor Access*

All ACOS admins, except for the ACOS root admin, are not permitted to import, create, edit/modify, or delete Ext-HM scripts as a default. Selected ACOS admins sufficiently trusted to access these scripts can be allowed to perform these operations by provisioning them with the health monitor (`hm`) privilege. For more information on configuring administrative users, refer the [User Access and Privilege Assignment](#) discussion above.

Only ACOS, system-level admins with Read-Write (R/W) privilege and specifically assigned this new privilege will be permitted to perform these operations for External Health Monitor scripts. As these monitoring scripts have access throughout the ACOS system, this privilege is not available to partition constrained ACOS admins.

**SECURITY NOTE:** To minimize the threat surface of this feature, provision this privilege for the fewest users necessary.

## Monitor External Health Monitor Activities

Administrator and aXAPI application activities to configure external health monitors in the ACOS system can be monitored through the ACOS Audit Log (see [Audit Logging Practices](#) below). These configuration operations can be monitored more effectively when audit logging to an external Syslog server is configured and enabled. As such, real-time filters and alerts can be configured to detect the following CLI commands, as well as their aXAPI and Web/GUI equivalent operations.

- import health-monitor
- create health-monitor
- edit health-monitor
- no audit enable
- no audit enable privilege
- no logging auditlog host

These operations can be detected by matching rules on the Syslog server for the following strings in ACOS log records.

- import health-monitor
- health external create
- health external edit
- no audit enable
- no logging auditlog host

Import, create, and edit operations on external health monitor scripts represent potential threat events when administrators are establishing or are trying to instantiate programs (code) on the ACOS system which could contain malicious content. The audit log operations can be indicators that someone may be disabling logging in the system to avoid its recording or reporting their subsequent activities, which could include external health monitor script access operations.

Especially for ACOS production deployments, it is strongly recommended that these events raise alerts in the organization which promote their inspection and review, in accordance with the organization's security policy.

## Review Extended Health Monitor Scripts

External health monitor scripts should be reviewed and audited, especially when alerts described above are raised, to ensure the scripts' integrity and intended use in the ACOS system. Instantiated scripts can be:

- Listed with the `show health external` command.
- Inspected individually using the `show health external <script-name.ext>` command, where `<script-name.ext>` is the filename of a listed script.
- Exported for offline inspection and review with the `export health external <script-name.ext>` command, where `<script-name.ext>` is the filename of a listed script.

## SECURING OTHER MANAGEMENT PROTOCOLS

ACOS supports a variety of other protocols for various management services when they are configured and enabled. These protocols typically have two aspects for security; namely, enabling security features of the protocols and using ACOS ACLs to limit external access to these protocols. These protocols include:

- NTP
- Radius
- SNMP
- TACACS+
- LDAP/LDAPS

The following subsections share hardening recommendations when configuring these services and their underlying protocols.

### NTP

Maintaining accurate time is a critical function in providing accurate and secure network services. The Network Time Protocol (NTP) is a UDP-based protocol which accurately maintains and synchronizes time across devices in the network. For instance, NTP ensures that timestamps in network device log messages are coherently recorded by logging servers shared among the devices.

The NTP client service in ACOS is disabled by default.

### NTP Authentication

It is important to enable NTP authentication for any NTP time source configured in an ACOS system. This will ensure that the contents of NTP messages are not modified and are only exchanged with trusted NTP peers. Administrators can configure NTP authentication with the `ntp auth-key ACOS` command.

This command is used to specify the key ID, algorithm, and shared secret password for authentication to be used with one or more NTP servers. These authentication values must match corresponding values configured on the remote NTP servers. Alternatives for the choice of algorithm include:

- `md5` Uses Message Digest Algorithm 5 (MD5) encryption, 128-bits
- `sha` Uses Security Hash Algorithm (SHA-0) encryption, 160 bits
- `sha1` Uses Security Hash Algorithm (SHA-1) encryption, 160 bits (**recommended, most secure**)

**NOTE:** SHA-0 was the original version of the SHA. It was found to be flawed due ease of producing hash collisions and was revised as the SHA-1 to strengthen its cryptographic strength.

It is a good practice to include multiple NTP peers on different interfaces to maximize time continuity if one of the NTP peers goes offline or the interface's link goes down.

The following example configures two NTP local network peers with authentication and where the first peer is set as preferred.

```
// Create two authentication keys (29748, 13579) w/ SHA-1.
// Add them to ACOS's list of trusted keys.
ACOS-TH####(config)#ntp auth-key 29748 SHA1 ascii Zn17yf37x
ACOS-TH####(config)#ntp auth-key 13579 SHA1 ascii XxEnc192

ACOS-TH####(config)#ntp trusted-key 29748
ACOS-TH####(config)#ntp trusted-key 13579

// Configure two NTP servers with their corresponding trusted keys and enable time
// synchronization with them.
ACOS-TH####(config)#ntp server 10.171.124.36
```

```
ACOS-TH#### (config-ntpsvr:10.171.124.36) #prefer  
ACOS-TH#### (config-ntpsvr:10.171.124.36) #key 29748  
ACOS-TH#### (config-ntpsvr:10.171.124.36) #enable  
  
ACOS-TH#### (config) #ntp server 192.69.131.204  
ACOS-TH#### (config-ntpsvr:192.69.131.204) #key 13579  
ACOS-TH#### (config-ntpsvr:192.69.131.204) # enable
```

Alternatively, for vThunder/Cloud or SOHO environments where there is no local NTP peer available, a remote NTP peer from NIST can be configured as follows.

```
// Create two authentication keys (12345, 54321) w/ SHA-1.
// Add them to ACOS's list of trusted keys.
ACOS-TH####(config)#ntp auth-key 12345 SHA1 ascii Ugx17hF9yF
ACOS-TH####(config)#ntp auth-key 54321 SHA1 ascii Wny9y6fZX7

ACOS-TH####(config)#ntp trusted-key 12345
ACOS-TH####(config)#ntp trusted-key 54321

// Configure two NTP servers with their corresponding trusted keys and enable time
// synchronization with them.
ACOS-TH####(config)#ntp server time-a-g.nist.gov
ACOS-TH####(config-ntpsvr:time-a-g.nist.gov)#prefer
ACOS-TH####(config-ntpsvr:time-a-g.nist.gov)#key 12345
ACOS-TH####(config-ntpsvr:time-a-g.nist.gov)#enable

ACOS-TH####(config)#ntp server time-a-b.nist.gov
ACOS-TH####(config-ntpsvr:time-b-g.nist.gov)#key 54321
ACOS-TH####(config-ntpsvr:time-b-g.nist.gov)#enable
```

**NOTE:** Authentication keys are assigned at the time of registration with the NIST service, as described in <https://www.nist.gov/pml/time-and-frequency-division/time-services/nist-authenticated-ntp-service>.

**NOTE:** For a list of NIST NTP time servers, see <https://tf.nist.gov/tf-cgi/servers.cgi>.

## NTP Interfaces and ACLs

To limit NTP exchanges with selected, trusted servers on their desired ACOS interfaces, ACLs can be applied. The following example builds on those with ACLs above in order to enable NTP exchanges with the 10.171.124.36 server on the `mgmt` port and the 192.69.131.204 server on the `eth1` data port using the standard NTP port 123.

```
// Add NTP 10.171.124.36:123, mgmt port rule to mgmt ACL 100
ACOS-TH####(config)#access-list 100 10 remark "ACL - NTP mgmt. port, UDP Src Port 123"
ACOS-TH####(config)#access-list 100 11 permit udp host 10.171.124.36 eq 123 any

// Add NTP 192.69.131.204:123, eth1 port rule to eth1 ACL 101
ACOS-TH####(config)#access-list 101 10 remark "ACL - NTP eth1 port, UDP Src Port 123"
ACOS-TH####(config)#access-list 101 11 permit udp host 192.69.131.204 eq 123 any
```

## SNMP

Simple Network Management Protocol (SNMP) is an Internet Standard protocol widely used in network management for network monitoring with three versions of significance. SNMPv1 is the original version of the protocol. SNMPv2c and SNMPv3 bring feature improvements in performance, flexibility and security.

SNMPv2c uses community names for read and write access, much like passwords are used for authentication, to distinguish privilege. SNMPv2c passes these community names in clear-text on the wire, so it is still considered weak from a security perspective. Malicious users could capture these community names and use them in SNMP SET commands to perform unauthorized and damaging changes to the ACOS system or use SNMP GET commands to access unauthorized or sensitive information from the system.

SNMPv3 adds a higher degree of security to SNMPv2c by authenticating and encrypting packets over the network.

The following subsections share recommendations for securely configuring SNMP in ACOS systems.

### For Security Policies that Prohibit SNMP

SNMP support in ACOS is disabled by default and is accordingly compliant with organization security policies that mandate SNMP be summarily disabled in all networking systems. If an ACOS system's configuration has enabled SNMP, this service can be summarily disabled with the `no` form of the `snmp-server enable service ACOS` command. For example:

```
ACOS-TH#### (config)#no snmp-server enable service
```

Alternatively, for device management networks that allow and require SNMP, review and consider the following subsections.

### SNMPv3 Configuration

For organizations allowing SNMP in their security policy, SNMPv3 should be used and configured in the ACOS system using the following steps.

- Enabling SNMP and Configuring the Engine ID
- Configuring the View
- Configuring the Group
- Configuring the User
- Configuring Traps
- Configuring SNMP I/Fs and ACLs

#### Enabling SNMP and Configure SNMPv3 Engine ID

In SNMPv3, SNMP user authentication and privacy digests are derived from an engine ID and user passwords. As such, this identifier must be configured before adding SNMPv3 user accounts.

**NOTE:** If the SNMPv3 engine ID is changed, all SNMPv3 user accounts will need to be reconfigured.

If the SNMP service is enabled in ACOS, the engine ID can be configured using the `snmp-server engineID` command. For example, to do both operations:

```
ACOS-TH#### (config)#snmp-server enable service
ACOS-TH#### (config)#snmp-server engineID 1234567890
```

```
ACOS-TH#### (config)#show snmp-server engineID
EngineID: 80001f880431323334353637383930
```

## Configure SNMP Views

Beyond overall access to SNMP services in ACOS, SNMP views grant or restrict user groups access to specific portions of the MIB. As such, they can be used to allow certain SNMP users access to sensitive information in the MIB, while denying access for the same information to less trusted users. In ACOS, SNMPv3 group definitions include specific views to control MIB access for their SNMP users.

For example, to define a view called “mibs-wo-ifs-access” that permits access to all of MIB-2 (1.3.6.1.2.1) and A10 MIB (1.3.6.1.4.1.22610), while excluding access to the `Interfaces` branch (1.3.6.1.2.1.2) under MIB-2 and the `axInterfaces` branch (1.3.6.1.4.1.22610.2.1.7.1) under the A10 MIB:

```
ACOS-TH#### (config)#snmp-server view mibs-wo-ifs-access 1.3.6.1.2.1 included
ACOS-TH#### (config)#snmp-server view mibs-wo-ifs-access 1.3.6.1.4.1.22610 included

ACOS-TH#### (config)#snmp-server view mibs-wo-ifs-access 1.3.6.1.2.1.2 excluded
ACOS-TH#### (config)#snmp-server view mibs-wo-ifs-access 1.3.6.1.4.1.22610.2.4.1.7.1 excluded
```

## Configure SNMPv3 Groups

SNMPv3 supports three basic security methods which can be specified for various SNMPv3 user groups along with the respective SNMP views they will have read access to.

- `noauth` - Does not use any authentication of packets, aka `authNoPriv`.
- `auth` - Uses packet authentication but does not encrypt the packets, aka `noAuthNoPriv`.
- `priv` - Uses packet authentication and encryption, aka `authPriv`. **(recommended)**

Users added to these groups will include the appropriate and corresponding selections for security algorithms. For example, to define a group called “users-group1” that enables both packet authentication and encryption for read access to the view in the example above:

```
ACOS-TH#### (config)#snmp-server group users-group1 v3 priv read mibs-wo-ifs-access
```

## Configure SNMPv3 Users

Having completed the previous steps, SNMPv3 user accounts can now be defined. ACOS administrators will be able to select the authentication and encryption algorithms to be used on an individual user basis, including the following options.

- `auth` Specifies the encryption method for user authentication.
  - `md5` Use Message Digest Algorithm 5 (MD5) encryption, 128-bits
  - `sha` Use Security Hash Algorithm (SHA) encryption, 160 bits **(recommended, most secure)**
- `priv` Specifies the encryption method to use for user privacy.
  - `aes` Use Advanced Encryption Standard (AES) algorithm. This uses a fixed block size of 128 bits, and has a key size of 128, 192, or 256 bits. **(recommended, most secure)**
  - `sha` Use Data Encryption Standard (DES) algorithm to apply a 56-bit key to each 64-bit block of data. This is considered strong encryption.



For example, to add an SNMPv3 user called “user-5” for the group in the example above and passwords for both authentication and encryption using the stronger of SNMPv3 cryptographic algorithms:

```
ACOS-TH#### (config)#snmp-server SNMPv3 user user-5 group users-group1 v3      auth aes
(XYnC2MQD_
                                                    priv aes .6_(cWBN9a
```

**NOTE:** SNMPv3 passwords in ACOS can be 8-31 printable ASCII characters long and may only contain - . ( ) special characters.

### Configure SNMPv3 Traps

SNMP traps are alert messages sent from a monitored SNMP-enabled device to a central collector, colloquially referred to as an SNMP trap receiver, SNMP Manager, or a Network Management System (NMS) device. In SNMPv3 managed networks, the identity and security settings need to be configured for this class of messages, as they do not have the benefit of a user or manager application to enter or select them.

For this purpose, ACOS supports a modest SNMPv3-related extension to the `snmp-server host` command normally used to configure SNMPv1/2c for a given trap receiver. This command extension, `user <name>`, identifies a configured SNMP user account and associated security setting to use when generating SNMPv3-compatible traps. Furthermore, since these messages will only involve SNMP notifications rather than read/write accessible objects, it is a good practice to limit the associated view-scope to NOTIFICATION-TYPE MIB items or the related MIB branches.

The following example first defines an SNMP view that includes all ACOS-specific SNMP traps (`axNotification-1.3.6.1.4.1.22610.2.4.3.12`) and then defines an SNMPv3 group for the view, along with recommended security method. Next, an SNMPv3 user account is defined using this groups. Lastly, SNMPv3 hosts are defined to be the receivers of traps (10.10.10.12 and 192.10.10.12) generated within the scope of the view; including the associated cryptographic selections and passwords.

```
ACOS-TH#### (config)#snmp-server view acos-mib-trap 1.3.6.1.4.1.22610.2.4.3.12 included

ACOS-TH#### (config)#snmp-server group users-acos-traps v3 priv read acos-mib-traps
ACOS-TH#### (config)#snmp-server SNMPv3 user user-acos-traps group users-group1 v3
                                                    auth aes
*XYnC2MQD<
                                                    priv aes
^6"}{WBN9]

ACOS-TH#### (config)#snmp-server host 10.10.10.12 version 3 user user-acos-traps
ACOS-TH#### (config)#snmp-server host 192.10.10.12 version 3 user user-acos-traps

ACOS-TH#### (config)#snmp-server enable traps all
```

## SNMP Interfaces and ACLs

With the ACOS SNMP service configured, the next step is to provision it for access with external SNMP clients. This includes enabling the service for access from selected interfaces of the ACOS device and optionally restricting access to selected, secured SNMP Networks Management Systems (NMSs) via ACLs.

**NOTE:** There are a couple of different ways to do ACL for ACOS management services as indicated in the examples that follow.

SNMP is enabled for access using the `enable management ACOS` command. For example, to enable SNMP access on the `management` and `eth1` interfaces of the ACOS device:

```
ACOS-TH####(config)#enable-management service snmp
ACOS-TH####(config-enable-management snmp)#management
ACOS-TH####(config-enable-management snmp)#ethernet 1
```

Additionally, to generally restrict access on clients allowed to access these SNMP services on 10.10.10.120 and 192.10.10.120 to clients from specific management and eth1 subnetworks; respectively:

```
// SNMP, mgmt. port already enabled
// Allow SNMP access from 10.10.10.0/24 subnet, SNMP port rule to mgmt ACL 100
ACOS-TH####(config)#access-list 100 15 remark "ACL - mgmt port @ SNMP"
ACOS-TH####(config)#access-list 100 16 permit udp 10.10.10.0 /24 any eq 161

// SNMP, eth1 port already enabled
// Allow SNMP access from 192.10.10.0/24 subnet, SNMP port rule to eth1 ACL 101
ACOS-TH####(config)#access-list 101 15 remark "ACL - eth1 port @ SNMP"
ACOS-TH####(config)#access-list 101 16 permit udp 192.10.10.0 /24 any eq 161
```

Alternately, to restrict access from specific client, SNMP NMS systems at 10.10.10.12 for access to ACOS via the system's management interface only:

```
// SNMP, mgmt. port already enabled
// Allow SNMP access from 10.10.10.12 host, SNMP port rule to mgmt ACL 100
ACOS-TH####(config)#access-list 100 15 remark "ACL - mgmt port @ SNMP, from 10.10.10.12"
ACOS-TH####(config)#access-list 100 16 permit udp 10.10.10.12 any eq 161

// SNMP, eth1 port already enabled
// Leave blocked SNMP access on eth1 - ACL 101 comment to document
ACOS-TH####(config)#access-list 101 15 remark "ACL - eth1 port @ SNMP, no rule to permit"
```

## When SNMPv3 Is Not an Option

Real-world deployments can still encounter environments with legacy SNMP management resources where SNMPv3 is not a viable option. When this is the case, review the following considerations to better secure SNMP services.

- At least seek to support SNMPv2c.
  - Modest security is still better than no security.
- Never (never, ever) use “public” for a community string.
  - This is the 1st community string in even most simple-minded hacker's playbook

- Treat community strings like device/system passwords. Namely, with strong password strength.
  - This may be more cumbersome to manage, but it will be much more secure.
- If possible, do not define or configure a read-write (rw) community
  - Write-access via this community to SNMP objects can allow potentially malicious users (and hackers) to modify the state of the SNMP-enabled device and adversely impact the normal operation of the system to affect a Denial-Of-Service (DOS) of the system and/or its connected network environment.  
  
**NOTE:** SNMPv1/v2c in ACOS does not support read-write (rw) communities or SNMP SET operations, to avoid such potential security exposures.
- Apply strict access controls (ACLs) for Read-only (ro) community SNMP managers as a best means to control access to sensitive information that could be exposed from the device's MIB.
  - There are few, if any, alternatives to contain sensitive information leakage for this access vector.

## RADIUS

Remote Access Dial-In User Service (RADIUS) is an IETF standard for Authentication, Authorization and Accounting (AAA). Like TACACS+ and LDAP the RADIUS protocol can be used to externally authenticate users (administrators) of the ACOS system in addition to its use authorization and accounting services as discussed separately and later in this chapter. Compared to TACACS+ the Radius protocol is faster yet less reliable, owing to its use of UDP rather than TCP. RADIUS is also the less secure of the two as it only encrypts the password fields rather than the entire message payloads.

The following subsections share recommendations for securely configuring RADIUS in ACOS systems.

### RADIUS Authentication

RADIUS servers configured in an ACOS system must specify the common, shared secret values used to encrypt the message password during session initialization. These shared secret values should be strong passwords and consistent with the organization's security policies.

**NOTE:** ACOS only supports RADIUS servers that include a secret key or secret server value in their installed configurations.

It is a good practice to configure multiple RADIUS servers on different interfaces, for redundancy and improved availability. ACOS supports a maximum of two (2) configured RADIUS servers with preference being in the order they are configured.

The following example configures two RADIUS servers, with authentication preference to the first server (10.171.124.37). It then shows how to enable both RADIUS and local user authentication methods for the system, with preference to the RADIUS mechanism.

```
ACOS-TH#### (config) #radius-server host 10.171.124.37 secret Zn17yf37x
ACOS-TH#### (config) #radius-server host 192.69.131.205 secret Vke1324as

ACOS-TH#### (config) #authentication type radius local
```

**NOTE:** Radius secret values in ACOS can be up to 128 printable ASCII characters long and may only contain - . () special characters.

### RADIUS Interfaces and ACLs

To limit RADIUS connections with selected, trusted servers on their desired ACOS interfaces, ACLs can be applied. The following example builds on those with ACLs above in order to enable RADIUS authentication and accounting exchanges with the 10.171.124.37 server on the `mgmt` port and the 192.69.131.205 server on the `eth1` data port.

```
// Add RADIUS 10.171.124.37:1812/1813, mgmt port rule to mgmt ACL 100
ACOS-TH#### (config) #access-list 100 25 remark "ACL - RADIUS mgmt. port, UDP Src Port 1812/13"
ACOS-TH#### (config) #access-list 100 26 permit udp host 10.171.124.37 eq 1812 any
ACOS-TH#### (config) #access-list 100 27 permit udp host 10.171.124.37 eq 1813 any

// Add RADIUS 192.69.131.205:1812/1813, eth1 port rule to eth1 ACL 101
ACOS-TH#### (config) #access-list 101 25 remark "ACL - RADIUS eth1 port, UDP Src Port 1812/13"
ACOS-TH#### (config) #access-list 101 26 permit udp host 192.69.131.205 eq 1812 any
ACOS-TH#### (config) #access-list 101 27 permit udp host 192.69.131.205 eq 1813 any
```

**NOTE:** Prior to IANA's assignment of ports 1812 and 1813, ports 1645 and 1646 (authentication and accounting, respectively) were the de facto standard ports used for RADIUS. The use of ports 1645 and 1646 continues to be common practice for many RADIUS server configurations.

## TACACS+

TACACS+ is a Cisco protocol that can be used to externally authenticate users (administrators) of the ACOS system, as well as provide authorization and accounting services discussed later in this chapter. Compared to Radius the TACACS+ protocol is more reliable yet slower, owing to its use of TCP rather than UDP. TACACS+ is also the more secure of the two as it encrypts its message payloads rather than just the password field.

The following subsections share recommendations for securely configuring TACACS+ in ACOS systems.

### TACACS+ Authentication

TACACS+ servers configured in an ACOS system must specify the common, shared secret values used to encrypt message payloads. These shared secret values should be strong passwords and consistent with the organization's security policies.

**NOTE:** ACOS only supports TACACS+ servers that include a secret key or secret server value in their installed configurations.

It is a good practice to configure multiple TACACS+ servers on different interfaces for redundancy and improved availability. ACOS supports a maximum of two (2) configured TACACS+ servers with preference being in the order they are configured.

The following example configures two TACACS+ servers, with authentication preference to the first server (10.171.124.37). It then enables both TACACS+ and local user authentication methods for the system, with preference to the TACACS+ mechanism.

```
ACOS-TH#### (config) #tacacs-server host 10.171.124.37 secret Zn17yf37x
ACOS-TH#### (config) #tacacs-server host 192.69.131.205 secret Vke1324as
```

```
ACOS-TH#### (config) #authentication type tacplus local
```

**NOTE:** TACACS+ secret values in ACOS can be up to 127 printable ASCII characters long and may only contain - . ( ) special characters.

### TACACS+ Interfaces and ACLs

To limit TACACS+ connections with selected, trusted servers on their desired ACOS interfaces, ACLs can be applied. The following example builds on those with ACLs above in order to enable TACACS+ connections with the 10.171.124.37 server on the `mgmt` port and the 192.69.131.205 server on the `eth1` data port using the standard TACACS+ port 49.

```
// Add TACACS+ 10.171.124.37:49, mgmt port rule to mgmt ACL 100
ACOS-TH#### (config) #access-list 100 20 remark "ACL - TACACS+ mgmt. port, TCP Src Port 49"
ACOS-TH#### (config) #access-list 100 21 permit tcp host 10.171.124.37 eq 49 any
```

```
// Add TACACS+ 192.69.131.205:49, eth1 port rule to eth1 ACL 101
ACOS-TH#### (config) #access-list 101 20 remark "ACL - TACACS+ eth1 port, TCP Src Port 49"
ACOS-TH#### (config) #access-list 101 21 permit tcp host 192.69.131.205 eq 49 any
```

## LDAP/LDAPS

Lightweight Directory Access Protocol (LDAP) is an open, vendor-neutral, industry standard commonly used in network infrastructures for administrative user identity and capabilities management. LDAP's scope focuses singularly on user identification, hierarchy, capabilities, and authentication. LDAP has no provisions for authorization or accounting services.

LDAP has no inherent security considerations for secure communications and messaging. For security, LDAP relies upon encapsulating exchanges under SSL/TLS called LDAPS (LDAP over SSL). Compared to TACACS+ and RADIUS, LDAPS is the most secure approach for external authentication services access. It is commonplace to combine LDAP with TACACS+ and/or RADIUS for authorization and accounting AAA services.

The following subsections share recommendations for securely configuring LDAPS in ACOS systems.

### LDAP Security

LDAP servers configured in an ACOS system should enable operation over SSL/TLS by including the `ssl` parameter to ensure the secure exchange of LDAP protocol messages.

It is a good practice to configure multiple LDAPS servers on different interfaces, for redundancy and improved availability. ACOS supports a maximum of two (2) configured LDAPS servers with preference being in the order they are configured.

The following example configures two LDAPS servers, with preference to the first server (10.171.124.37). It then enables both LDAP and local user authentication methods for the system, with preference to the LDAP mechanism.

```
ACOS-TH#### (config) #ldap-server host 10.171.124.37 cn LDAPServer-1 dn
ou=StaffAccounts,ou=ServiceAccounts,dc=ad,dc=example,dc=org ssl
```

```
ACOS-TH#### (config) #ldap-server host 192.69.131.205 cn LDAPServer-2 dn
ou=StaffAccounts,ou=ServiceAccounts,dc=ad,dc=example,dc=edu ssl
```

```
ACOS-TH#### (config) #authentication type ldap local
```

### LDAPS Interfaces and ACLs

To limit LDAPS connections with selected, trusted servers on their desired ACOS interfaces, ACLs can be applied. The following example builds on those with ACLs above in order to enable LDAPS connections with the 10.171.124.37 server on the `mgmt` port and the 192.69.131.205 server on the `eth1` data port using the standard LDAPS port 636.

```
// Add LDAPS 10.171.124.37:636, mgmt port rule to mgmt ACL 100
ACOS-TH#### (config) #access-list 100 30 remark "ACL - LDAPS mgmt. port, TCP Src Port 636"
ACOS-TH#### (config) #access-list 100 31 permit tcp host 10.171.124.37 eq 636 any
```

```
// Add LDAPS 192.69.131.205:636, eth1 port rule to eth1 ACL 101
ACOS-TH#### (config) #access-list 101 30 remark "ACL - LDAPS eth1 port, TCP Src Port 636"
ACOS-TH#### (config) #access-list 101 31 permit tcp host 192.69.131.205 eq 636 any
```

## LOGGING PRACTICES

Event logging provides visibility into the operation of an ACOS system as well as the underlying networks connected to the system. Logging is critical to the security of ACOS systems as it provides an ability to review and audit the history of activities on the system. This knowledge gained from logging can be used:

- To alert the organization on occasions of activities warranting timely review.
- In forensic investigations of security events – such as breaches, intrusions, service denials, scan attempts, probes, etc.
- To troubleshoot network and service issues impacting service availability.
- ... and more

Logs can be stored locally on the ACOS system or in more secure configurations can be sent to remote, centralized servers via the industry-standard Syslog protocol. Typically, severity levels of the reported events are used to determine the volume, extent, and targets of reported events

The following subsections share recommendations for securely configuring event logging in ACOS systems.

### Logging Levels

ACOS supports following severities:

- |                         |         |  |
|-------------------------|---------|--|
| • emergency             | Level 0 | emergency events - system unusable     |
| • alert                 | Level 1 | alert events - take action immediately |
| • critical              | Level 2 | system is in critical condition        |
| • error                 | Level 3 | system has an error condition          |
| • warning events        | Level 4 | system has warning conditions          |
| • warning notifications | Level 5 | normal but significant conditions      |
| • information           | Level 6 | informational messages                 |
| • debugging             | Level 7 | debug level messages                   |

As a general guideline, it is a good practice to enable level 6 (information) and level 7 (debugging) messages for local file logging only as these events are typically used for troubleshooting. With these levels, remote logs can be easily overrun or the bandwidth of the management ACOS CPU(s) may be outstripped, resulting in dropped or missed events.

Logging higher level events (emergency (0) - warning notifications (5)) to remote servers for alerts, forensic, and monitoring purposes is recommended. These levels should include the information needed for these activities, consistent with the organization's security policy.

**NOTE:** On some ACOS systems, notably CGN-based systems, warning event volume at these levels may overrun the capacity of the ACOS management plane, the logging servers, or both.

When configuring the logging level in ACOS, the indicated level will be the lowest logging level and will enable all higher level. For example, to enable remote logging to Syslog for only error, critical, alert and emergency events:

```
ACOS-TH#### (config) #logging syslog error
```

## Console and Monitor Logging

By default, ACOS will not display logging events as they occur to the ACOS system's console or to remote CLI sessions in the EXEC mode (entered via the `enable` ACOS CLI command). For organizations with security policies that seek higher agility and real-time awareness for their administrator community, ACOS allows these logging events to be configured for these displays at the discretion of the organization via the `logging console` and `logging monitor` CLI commands.

For example, to configure ACOS to only display only emergency and alert events on the ACOS system's console and display only emergency on the remote, CLI sessions in EXEC mode:

```
ACOS-TH#### (config) #logging console alert
ACOS-TH#### (config) #logging monitor emergency
```

## Configuring Remote Syslog Servers

It is a good practice to configure multiple Syslog servers on different interfaces for redundancy and improved availability. When multiple Syslog servers are configured, ACOS will replicate logging event messages to all the servers indicated. ACOS supports a maximum of ten (10) configured Syslog servers.

Syslog servers can be configured in ACOS using the `logging host` command. By default, the ACOS device can reach remote log servers only if they are reachable through the ACOS device's data ports, not the management port. To enable the ACOS device to reach remote log servers through the management port, include the `use-mgmt` parameter.

The following example configures two Syslog servers, with one constrained for access on the `mgmt` port.

```
ACOS-TH#### (config) #logging host 10.171.124.37 use-mgmt
ACOS-TH#### (config) #logging host 192.69.131.205
```

**NOTE:** For Syslog logging configured using the `logging host` command, log events from the ACOS management and control planes will be replicated across the configured servers. Log events from the ACOS data plane, however, will not be replicated. To support data plane logging replication, see the [Advance Logging Services](#) discussion below.

## Syslog Interfaces and ACLs

To limit Syslog connections with selected, trusted servers on their desired ACOS interfaces, ACLs can be applied. The following example builds on those with ACLs above in order to enable Syslog connections with the 10.171.124.37 server on the `mgmt` port and the 192.69.131.205 server on the `eth1` data port using the standard Syslog port 514.

```
// Add Syslog 10.171.124.37:514, mgmt port rule to mgmt ACL 100
//
ACOS-TH#### (config) #access-list 100 35 remark "ACL - Syslog mgmt. port, TCP Src Port 514"
ACOS-TH#### (config) #access-list 100 36 permit tcp host 10.171.124.37 eq 514 any

// Add Syslog 192.69.131.205:514, eth1 port rule to eth1 ACL 101
//
ACOS-TH#### (config) #access-list 101 35 remark "ACL - Syslog eth1 port, TCP Src Port 514"
ACOS-TH#### (config) #access-list 101 36 permit tcp host 192.69.131.205 eq 514 any
```



## *Advanced Logging Service*

ACOS supports an event logging service, called ACOS Events, that can be used as an alternative to the traditional `logging hosts` service. The ACOS Events service is configurable through the `acos-events` CLI command and supports advanced logging features available for groups of log servers; such as:

- Replication Across Servers
- Data Plane Event Replication
- Round-Robin Event Reporting
- Rate Limiting
- Syslog, CEF, and LEEF log formats
- Integrated Logging Server Health Check
- Major Module Events Include/Exclude
- Rules to Include/Exclude Event Groups

The same principles described above can be applied to ACOS Events. For more information on this service, see the ACOS product documentation.

## AUDIT LOGGING PRACTICES

The ability to monitor and review a history of activities performed on the ACOS system by administrators and administrative applications is essential to an organizations security awareness. It also provides agility in detecting intentioned or mis-intentioned mal-behavior. Auditing logging in ACOS provides this capability by logging the following types of system management events.

- Administrator logins and log outs for CLI, GUI, and aXAPI sessions
- Unsuccessful administrator login attempts
- Configuration changes. All attempts to change the configuration are logged, even if they are unsuccessful.
- CLI commands at the Privileged EXEC level (if audit logging is enabled for this level)

Audit logging is configured and administered separately from general Syslog logging, described earlier. The following subsections share hardening recommendations and practices for this service.

### *Audit Logging Enabled by Default*

In ACOS, audit logging is enabled by default. Moreover, and very importantly, configuration activities to disable audit logging are not saved in the running configuration which means that turning off this service, with the `no audit enable` command, will not persist across ACOS system reload and reboot operations.

### *Configuring Audit Logging*

ACOS systems, especially in production deployments, should configure this service to log privileged mode CLI commands, in addition to EXEC mode commands supported by default. Privileged mode command logging can be enabled as follows.

```
ACOS-TH#### (config) #audit enable privilege
```

Typically, the number of entries recorded in the audit log would be considered next, especially for logs maintained on the ACOS system. Since it is a bad practice to rely on logs not centrally stored, this is a moot point.

### *Audit Logging to Remote Syslog*

Audit logging should always be done to centralized remote syslog servers where they are free from manipulation by malicious activities in the network device. This service can be configured and restricted to selected ACOS system interfaces, as described below.

### *Audit Logging to Syslog*

ACOS audit logging can and should be configured to report log events to Syslog, rather than a local log file, with the `logging auditlog host` command. For example:

```
ACOS-TH#### (config) # logging auditlog host 10.171.124.38
```

**NOTE:** ACOS currently supports only one (1) configured Syslog server for audit logging.

## Audit Logging Interfaces and ACLs

To limit Syslog connections for audit logging with the selected, trusted servers on the desired ACOS interfaces, ACLs can be applied. The following example builds on those with ACLs above in order to enable this service with the 10.171.124.38 server on the `mgmt` port using the standard Syslog port 514.

```
// Add Syslog of Audit Log for 10.171.124.38:514, mgmt port rule to mgmt ACL 100
//
ACOS-TH####(config)#access-list 100 40 remark "ACL - Syslog of Audit Log, TCP Src Port 514"
ACOS-TH####(config)#access-list 100 41 permit tcp host 10.171.124.38 eq 514 any
```

**NOTE:** Audit logging activity to the Syslog server will be very modest in both transaction rate and bandwidth, so using the limited bandwidth `mgmt` port should not pose performance impact to the ACOS system.

## Monitoring Audit Logging Activities

Administrator and aXAPI application activities to configure audit logs in the ACOS system can be monitored and trigger alerts. Very importantly, activities to disable this logging, especially in a deployed production system, can be an indicator of mal-intent and attempts to compromise the integrity of the ACOS system.

As such, real-time filters and alerts can be configured to detect the following CLI commands, as well as their aXAPI and Web/GUI equivalent operations.

- no audit enable
- no logging auditlog host
- no audit enable privilege

These audit log operations can be indicators that someone may be disabling logging in the system to avoid its recording or reporting their subsequent activities, potentially with malicious intent. It is strongly recommended that these events raise alerts in the organization which promote their inspection and review, in accordance with the organization's security policy.

## OTHER MANAGEMENT PLANE PROTOCOLS

Hardening consideration for other ACOS management plane protocols will be addressed in future revisions of this document.

## HARDENING THE ACOS CONTROL PLANE

This chapter addresses hardening considerations for the ACOS control plane consisting of protocols supporting routing, link-state, neighbor-discovery, signaling and other protocols that define and maintain the topology and state of the network. Namely, protocols that support and coordinate the movement of data through the ACOS data plane.

Hardening of the ACOS control plane is critical to ensure that the services of the ACOS data plane are available and uncompromised. This includes the following protocols.

- Internet Control Message Protocol (ICMP)
- Dynamic Host Configuration Protocol (DHCP)
- Border Gateway Protocol (BGP)
- Open Shortest Path First (OSPF)
- Intermediate System – Intermediate System (IS-IS)
- Routing Information Protocol (RIP)
- Bi-Directional Forwarding Detection (BFD)

Other control plane protocols supported by ACOS are limited in their ability and scope to be secured. These include the following.

- ACOS High Availability Protocol (VRRP-A)
- Link Aggregation Control Protocol (LACP)
- Link Layer Discovery Protocol (LLDP)

## GENERAL CP HARDENING

### *ICMP Redirects and Destination Unreachables*

A malicious user can adversely impact the CPU usage, and hence performance, of routing services in ACOS by continually sending packets to an ACOS device which forces it to respond with ICMP redirect or ICMP unreachable messages. To avoid such exploits, configure ACOS to not send ICMP redirect or ICMP unreachable messages for both IPv4. For example:

```
ACOS-TH#### (config) #ip icmp disable redirect
ACOS-TH#### (config) #ip icmp disable unreachable
```

### *DHCP Relay*

A DHCP relay is an agent that forwards DHCP packets between clients and servers. ACOS systems can be configured for this service to relay DHCP traffic between DHCP clients and DHCP servers located in different VLANs or subnets. When enabled, the ACOS device intercepts broadcast DHCP packets sent by clients on interfaces configured with the helper address. It then places the receiving interface's IP address (not the helper address) in the relay gateway address field and forwards the DHCP packet to the server. When the DHCP server replies, the ACOS device forwards the response to the client.

The DHCP relay service in ACOS is disabled by default. If this service is not needed in the target network topology, it is recommended to leave the service disabled.

## ROUTING PROTOCOL HARDENING

There are many advised and recommended practices for routing in the industry. From a security point of view, it is important to consider practices that ensure the integrity of routing updates exchanged with trusted neighbors. Malicious individuals or groups that can instantiate unauthorized routers in the network can send phony route advertisements that may alter or disrupt the intended flow of traffic, allowing them to observe sensitive information, exfiltrate data, or deny service in the network.

To avoid these compromises, enable authentication features supported by the underlying routing protocols to ensure that only trusted routers are participating in routing exchanges for the deployed network.

### BGP

Border Gateway Protocol (BGP) is often called the routing protocol of the Internet. It is the protocol that manages how packets are routed across the internet by exchanging routing and reachability information between edge routers. BGP is a popular target of attackers. To increase security of the BGP configuration for ACOS consider enabling security factors for BGP, as described below.

**NOTE:** In addition to the following discussions, the [ANSSI BGP Configuration Best Practices](#) is a good resource for general and security best practice recommendations for BGP.

### EBGP-Multihop

When external BGP (EBGP) peers are not directly connected to each other, they must cross one or more non-BGP routers to reach each other. Configuring EBGP multihop enables the peers to pass through the other routers to form peer relationships and exchange update messages. EBGP multihop uses the 1-byte Time-To-Live (TTL) packet value to limit the number intermediate devices the BGP packets can traverse.

Starting values for the TTL are commonly 64 to 255. However, for more restricted topologies the TTL can be initiated with a smaller value. The following example sets a maximum of two intermediate devices that can be traversed by setting the `ebgp-multihop` parameter to 2.

```
ACOS-TH####(config)#router bgp 123
ACOS-TH####(config-bgp:123)# bgp router-id 10.10.10.1

ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 remote-as 123
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 ebgp-multihop 2
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 enforce-multihop
```

### BGP MD5 Authentication

BGP supports a Message Digest 5 (MD5) authentication mechanism. When enabled for BGP peers, any Transmission Control Protocol (TCP) segment belonging to BGP exchanged between the peers is verified and accepted only if authentication is successful. To enable and configure this mechanism use the `password` setting, as follows.

```
ACOS-TH####(config)#router bgp 123
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 password MNQHsKkg4oC70A2D
```

**NOTE:** BGP passwords in ACOS can be up to 80 printable ASCII characters long and cannot contain ' "<>&\/? special characters.

## BGP Prefix Limits

---

To avoid memory exhaustion and the ACOS BGP service from being interrupted, especially in configurations where portions of all Internet prefixes may need to be stored, configure a maximum number of prefixes for each BGP peer using the `maximum-prefix` setting. The following example configures 2 BGP peers with 256 and 2048 prefix maximums. The second will generate a warning when 85% of the limit is reached, rather than the default 75%:

```
ACOS-TH####(config)#router bgp 123
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 maximum-prefix 256

ACOS-TH####(config)#router bgp 321
ACOS-TH####(config-bgp:321)#neighbor 10.10.10.220 maximum-prefix 2048 85
```

## BGP Prefix Filters

ACOS prefix lists can be used to permit or deny specific prefixes that are sent or received by the ACOS BGP service. They should be used to ensure network traffic is sent over intended paths and should be applied to BGP peers for both inbound and outbound prefixes. ACOS supports prefix filtering by BGP autonomous system (AS) path access lists where by the ACOS device can filter incoming received and outgoing advertised prefixes based on the AS-path attribute of a prefix.

In the example below, inbound prefixes are restricted to those originated by the indicated remote AS and outbound prefixes advertised to those originated by the local AS (e.g. the ACOS device).

```
ACOS-TH####(config)#ip as-path AS-PLIST-IN ^321$ permit
ACOS-TH####(config)#ip as-path AS-PLIST-OUT ^

ACOS-TH####(config)#router bgp 123
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 remote-as 321
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 filter-list AS-PLIST-IN in
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 filter-list AS-PLIST-OUT out
```

For the example below, prefix lists are defined such that 192.168.1.0/24 and 192.168.9.0/24 are the only prefixes accepted inbound from the BGP peer and the prefix 172.122.1.0/24 is the only route allowed to be advertised to the BGP peer

```
ACOS-TH####(config)#ip prefix-list LIST-IN seq 5 permit 192.168.1.0/24
ACOS-TH####(config)#ip prefix-list LIST-IN seq 10 permit 192.168.9.0/24
ACOS-TH####(config)#ip prefix-list LIST-IN seq 15 deny 0.0.0.0/0 le 32

ACOS-TH####(config)#ip prefix-list LIST-OUT seq 5 permit 172.122.1.0/24

ACOS-TH####(config)#router bgp 123
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 remote-as 321
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 filter-list LIST-IN in
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 filter-list LIST-OUT out
```



## OSPF

Open Shortest Path First (OSPF) is a routing protocol for IP networks and falls into the group of interior gateway protocols (IGPs), operating within a single autonomous system (AS). As an IGP, OSPF is also a popular target of interior attackers to disrupt or compromise network integrity. ACOS supports OSPFv2 for IPv4 and OSPFv3 for IPv6.

To increase security of the OSPF configuration for ACOS consider enabling the OSPF security features described below.

### OSPF MD5 Authentication

OSPFv3 uses IPsec to secure communications between neighbors and does not require separate hardening considerations.

OSPFv2 supports an MD5 authentication mechanism which should be enabled along with a password for configured OSPF instances. The following IPv4 example defines an OSPF instance and shows how to enable it for MD5 password authentication.

```
ACOS-TH####(config)#router ospf 1
ACOS-TH####(config-ospf:1)#router-id 10.10.10.1
ACOS-TH####(config-ospf:1)#area 0 authentication message-digest

ACOS-TH####(config)# interface ethernet 3
ACOS-TH####(config-if:ethernet:3)#ip address 10.10.10.1 255.255.255.0
ACOS-TH####(config-if:ethernet:3)#ip ospf authentication message-digest
ACOS-TH####(config-if:ethernet:3)#ip ospf message-digest-key 42 md5 Bh^grZz3mT&iPw6M
```

**NOTE:** OSPF passwords in ACOS can be up to 16 printable ASCII characters long and cannot contain ' "<>\/? special characters.

### OSPF Passive Interfaces

Sending or processing OSPF Link-State Advertisements (LSAs) can be disabled to avoid advertising information on networks outside the OSPF router's administrative control. This practice mitigates information leaks and potential false information into the OSPF IGP.

The `passive-interface` command is available for this purpose for both OSPFv2 and OSPFv3. The following example shows how to configure a passive interface under OSPFv2 on the Virtual Ethernet (VE) interface on the `eth2` data port and OSPFv3 on `eth3`:

```
ACOS-TH####(config)#router ospf 1
ACOS-TH####(config-ospf:1)#passive-interface ethernet 2

ACOS-TH####(config)#router ipv6 ospf 2
ACOS-TH####(config-ospf:2)#passive-interface ethernet 3
```

### OSPF Route Filters

When the `passive-interface` configuration can't be used, filtering summary routes advertised or processed by a configured OSPF router for the network helps to reduce the probability of introducing false routes. In this configuration, routing occurs when route filtering is enabled for an interface with information advertised (out) or processed (in), limited by the filters.

The `area filter-list OSPFv2` command is available for this purpose when the router is acting as an Area Border Router (ABR). For example:

```
ACOS-TH####(config)#ip prefix-list LIST-IN seq 5 permit 192.168.1.0/24
ACOS-TH####(config)#ip prefix-list LIST-IN seq 10 permit 192.168.9.0/24
ACOS-TH####(config)#ip prefix-list LIST-IN seq 15 deny 0.0.0.0/0 le 32

ACOS-TH####(config)#router ospf 1
ACOS-TH####(config-ospf:1)#area 0 filter-list prefix-list LIST-IN in
```

**NOTE:** Filter lists are not available for OSPFv3 configurations.

## OSPF Prefix Limits

To avoid memory exhaustion and the ACOS OSPF service from being interrupted, configure OSPF to limit resource consumption using the `overflow database` command for OSPFv2. Limits may be defined for LSA or AS-external-LSA volumes.

For example:

```
ACOS-TH####(config)#router ospf 1
ACOS-TH####(config-ospf:1)#overflow database 4194304

ACOS-TH####(config)#router ospf 2
ACOS-TH####(config-ospf:1)#overflow database external 2097152
```

**NOTE:** OSPF database limits are not available for OSPFv3 configurations.

## IS-IS

Integrated Intermediate System-to-Intermediate System (IS-IS) is a link-state Interior Gateway Protocol (IGP) developed in the late 1980s and standardized by the International Standards Organization (ISO) in ISO/IEC 10589 for the ISO protocol suite. RFC 1195 defined IS-IS support for IPv4, and additional IETF extensions have defined IS-IS support for IPv6 (RFC 2373). As an IGP, IS-IS is also another target of interior attackers to disrupt or compromise network integrity.

To increase security of the IS-IS configuration for ACOS consider enabling IS-IS security features described below.

### IS-IS MD5 Authentication

By default, IS-IS supports a plaintext authentication mechanism which provides nominal security, if any, against unauthorized parties. IS-IS can, however, be configured to support an HMAC-MD5 mechanism where the password is never sent on the wire. Instead, it is used to calculate a data-integrity checksum for subsequent exchanges on the connection.

When an HMAC-MD5 password is configured the password is never sent on the wire. Rather it is used to calculate a checksum used to ensure the data-integrity exchanges on the connection. Enabling MD5 authentication is recommended, if the stronger IS-IS keychain authentication is not supported in the target network.

For example, for level 1 IS-IS:

```
ACOS-TH#### (config) #router isis
ACOS-TH#### (config-isis) #net 47.0000.0000.0000.0001.00
ACOS-TH#### (config-isis) #is-type level-1
ACOS-TH#### (config-isis) #authentication mode md5 level-1

ACOS-TH#### (config) #interface ethernet 3
ACOS-TH#### (config-if:ethernet:3) #ip address 10.10.10.1 255.255.255.0
ACOS-TH#### (config-if:ethernet:3) #ip router isis
ACOS-TH#### (config-if:ethernet:3) #isis password Zz!%hHt7aR$!@95@ level-1
```

**NOTE:** ISIS passwords in ACOS can be up to 16 printable ASCII characters long and cannot contain ' "<>& \ / ? special characters.

### IS-IS MD5 Keychain Authentication

The more secure form of authentication is available for IS-IS which extends the MD5 authentication mechanism to operate over a group of keys, called a “key chain”. For example, first set up a key chain of three (3) MD5 passwords/key-strings:

```
ACOS-TH#### (config) #key chain my-isis-key-chain-#1
ACOS-TH#### (config-keychain) #key 1
ACOS-TH#### (config-keychain-key) #key-string y*OckB!Yi%BKo6gv

ACOS-TH#### (config-keychain) #key 2
ACOS-TH#### (config-keychain-key) #key-string m*x!q!@ac!YhVjmK

ACOS-TH#### (config-keychain) #key 3
ACOS-TH#### (config-keychain-key) #key-string %CA4T%OptNW3HfNJ
```

**NOTE:** Keychain authentication strings in ACOS can be up to 16 printable ASCII characters long and cannot contain ' "<>& \ / ? special characters.

Next, enable both MD5 and key chain authentication.

```
ACOS-TH####(config)#router isis
ACOS-TH####(config-isis)#net 47.0000.0000.0000.0001.00
ACOS-TH####(config-isis)#is-type level-1
ACOS-TH####(config-isis)#isis authentication mode md5
ACOS-TH####(config-isis)#isis authentication mode key-chain my-isis-key-chain-#1 level-1
```

## IS-IS Passive Interfaces

Sending or processing IS-IS routing updates can be disabled to avoid advertising information on networks outside the IS-IS router's administrative control. This practice mitigates information leaks and potentially false information into the IS-IS IGP.

The `passive-interface` command is available for this purpose for IS-IS. For example, to configure a passive interface under IS-IS on Ethernet port 7:

```
ACOS-TH####(config)#router isis
ACOS-TH####(config-isis)#passive-interface ethernet 7
```

## Routing Information Protocol

The Routing Information Protocol (RIP) is a historic distance-vector routing protocols that uses hop count as a routing metric. It prevents routing loops by limiting the number of hops allowed from source to destination and support various mechanisms to prevent incorrect routing information from being propagated. ACOS supports RIP Version 1 (RIPv1) and Version 2 (RIPv2).

To increase security of the RIP configuration for ACOS consider enabling RIP security features described below.

### Do Not Enable RIPv1

RIPv1 has no support for router authentication. RIPv2 made up for this shortcoming by including MD5 and key chain authentication mechanisms. As such, use of RIPv1 should be avoided for network environments requiring RIP services.

ACOS supports RIPv2, by default, for configured RIP routers.

### RIP MD5 Authentication

By default, RIPv2 supports a plaintext authentication mechanism which provides nominal, if any security against unauthorized parties. RIPv2 can, however, be configured to support an MD5 mechanism for improved security.

Enabling MD5 authentication is recommended, if the stronger MD5 keychain authentication is not supported in the target network.

The following example defines a RIPv2 instance on eth3 and shows how to enable it for MD5 password authentication.

```
ACOS-TH#### (config) #router rip
ACOS-TH#### (config-rip) #network 10.10.10.0/24
ACOS-TH#### (config-rip) #network ethernet 3

ACOS-TH#### (config) #interface ethernet 3
ACOS-TH#### (config-if:ethernet:3) #ip address 10.10.10.1 255.255.255.0
ACOS-TH#### (config-if:ethernet:3) #ip rip authentication mode md5
ACOS-TH#### (config-if:ethernet:3) #ip rip authentication string DgUwTtzc34F8rEO2
```

**NOTE:** RIPv2 passwords in ACOS can be up to 16 printable ASCII characters long and cannot contain ' "<>&\/? special characters.

### RIPv2 MD5 Keychain Authentication

A more secure form of authentication is available for RIPv2 which extends the MD5 authentication mechanism to operate over a group of keys called a “key chain”. For example, first set up a key chain of three (3) MD5 passwords/key-strings:

```
ACOS-TH#### (config) #key chain my-ripv2-key-chain-#1
ACOS-TH#### (config-keychain) #key 1
ACOS-TH#### (config-keychain-key) #key-string HIz2%2ovr1j*dT%d

ACOS-TH#### (config-keychain) #key 2
ACOS-TH#### (config-keychain-key) #key-string jx^#dpQ!j63VDeE*

ACOS-TH#### (config-keychain) #key 3
ACOS-TH#### (config-keychain-key) #key-string !tpkTWHHg^YD&x@d
```

**NOTE:** Keychain authentication strings can be up to 16 printable ASCII characters long and cannot contain ' "<>&\/? special characters.

Next, enable both MD5 and key chain authentication, as follows.

```
ACOS-TH####(config)#interface ethernet 3
ACOS-TH####(config-if:ethernet:3)#ip address 10.10.10.1 255.255.255.0
ACOS-TH####(config-if:ethernet:3)#ip rip authentication mode md5
ACOS-TH####(config-if:ethernet:3)#ip rip authentication key-chain my-ripv2-key-chain-#1
```

## Bidirectional Forwarding Detection (BFD)

Bidirectional Forwarding Detection (BFD) is a network protocol used to detect faults between forwarding engines. BFD does not have its own discovery mechanism and relies on sessions explicitly configured between endpoints or use of other protocols to determine adjacency (e.g. BGP, OSPF, IS-IS) and bootstrap BFD sessions.

Bidirectional Forwarding Detection (BFD) provides very fast failure detection for routing protocols. When BFD is enabled, the ACOS device periodically sends BFD control packets to the neighboring devices that are also running BFD. If a neighbor stops sending BFD control packets, the ACOS device quickly brings down the BFD session(s) with the neighbor and recalculates paths for routes affected by the down neighbor.

BFD does not have its own discovery mechanism and relies on sessions explicitly configured between endpoints or use of other protocols to determine adjacency (e.g. BGP, OSPF, IS-IS) and bootstrap BFD sessions.

To increase security of the BFD configuration for ACOS consider enabling the BFD security features described below

### BFD Authentication

BFD can be configured for individual ACOS interfaces or specific neighbors, in conjunction with other routing protocols (OSPF, IS-IS, BGP) enabled. It is a good practice to enable BFD authentication when instantiating this service with the routing configuration using one of the following schemes for shared secret values configured on BFD endpoints.

- Simple password
- Keyed MD5
- Meticulous Keyed MD5
- Keyed SHA1 **(recommended)**
- Meticulous Keyed SHA1 **(recommended)**

The simple password and MD5 schemes provide nominal to weak security protection from attacks. Use of these schemes for BFD authentication is strongly discouraged and should be applied only when compatibility with legacy implementations not supporting SHA1 is needed.

**NOTE:** Though meticulous keyed BFD authentication schemes are more secure than their keyed alternatives, they may not be available in commercial routers when proprietary high-availability features are enabled and may take additional time to authenticate.

The following configuration examples apply BFD for ISIS configured routers in ACOS. Like and similar configuration operations are supported for BGP, OSPF, and RIP. See the ACOS product documentation for information on configuring BFD with these other routing protocols.

#### Per Instance BFD Authentication

The following example sets up an ISIS router, configures the interface for BFD authentication with meticulous keyed SHA1 (with the `bfd authentication` command), and enables BFD on the ISIS router (with the `isis bfd` command).

```
// Set-up ISIS Router on eth3
ACOS-TH####(config)#interface ethernet 3
ACOS-TH####(config-if:ethernet:3)#ip address 10.10.10.1 255.255.255.0
ACOS-TH####(config-if:ethernet:3)#ip router isis
ACOS-TH####(config-if:ethernet:3)#isis password Zz!%hHt7aR$L@95@ level-1

// Enable BFD with authentication for all peers on eth3
// Enable BFD for ISIS router on eth3 port
ACOS-TH####(config-if:ethernet:3)#bfd authentication 1 meticulous-sha1 T@ZqIkA4*16FN#9p
ACOS-TH####(config-if:ethernet:3)#isis bfd
```

**NOTE:** BFD shared, secret keys in ACOS can be up to 16 printable ASCII characters long and cannot contain ' ">&\/? special characters.

**NOTE:** Per interface configuration for BFD shared secret key values is supported in this fashion for the BGP, OSPF, ISIS, and RIP routing protocols

### BFD Authentication – Per BGP Neighbor

Alternatively, BFD authentication can be configured for individual neighbors using the `fall-over bfd` variant of the `neighbor ACOS` command, as shown in the following example.

```
ACOS-TH####(config)#router bgp 123
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 remote-as 123
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 password MNQHsKkg4oC70A2D
ACOS-TH####(config-bgp:123)#neighbor 10.10.10.197 fall-over bfd authentication 1 meticulous-sha1 0oSZB%QV5FHSI@W
```

**NOTE:** BFD shared, secret keys in ACOS can be up to 16 printable ASCII characters long and cannot contain ' ">&\/? special characters.

**NOTE:** Per neighbor configuration for BFD shared secret key values is supported in ACOS only for the BGP routing protocols.



## OTHER CONTROL PLANE PROTOCOL HARDENING

ACOS supports other control plane protocols, notably for Link-Layer and High Availability functions. The scope of these protocols, which include the following, does not include provisions for authentication or encryption.

- Link Aggregation Control Protocol (LACP)
- Link Layer Discovery Protocol (LLDP)
- ACOS High Availability Protocol (VRRP-A)

The following sub-sections discuss approaches to containing potential exposures for these otherwise unsecure-able protocols.

### *Link Aggregation Control Protocol (LACP)*

Link Aggregation Control Protocol (LACP) is a standard link-layer protocol that supports the bundling of several physical (virtual) ports together to form a single logical channel. It allows a network device to negotiate the bundling of links by sending LACP packets to directly-connected peers that also support LACP.

LACP is disabled by default in ACOS. If LACP is not supported for devices on networks directly connected to the ACOS system, it is recommended to leave the service disabled. Otherwise, a good practice is to ensure LACP is only configured and enabled for ACOS system interfaces connected to immediate networks supporting LACP-enabled devices.

For example, to create an LACP trunk and assign the `eth3` data port, with a system priority of 32768:

```
// Assign eth3 to the LACP trunk
ACOS-TH####(config)#interface ethernet 3
ACOS-TH####(config-if:ethernet:3)#trunk-group 4 lacp

ACOS-TH####(config)#lacp system-priority 32768
```

Permitting the following for only ACOS systems and other LACP-enabled devices on interconnecting switches can constrain most, if not all, exposures to compromises or attacks on LACP.

- EtherType := 0x8809
- Ethernet Slow Protocols Subtype := 0x01
- LACP Version := 0x01

### *Link Layer Discovery Protocol (LLDP)*

The Link Layer Discovery Protocol (LLDP) is a standard link-layer protocol for advertising their identity, capabilities, and neighbors on IEEE 802 networks. It allows ACOS systems to discover directly-connected LAN neighbors and these neighbors to discover the ACOS system devices.

LLDP is disabled by default in ACOS. If LLDP is not supported for devices on networks directly connected to the ACOS system, it is recommended to leave the service disabled. Otherwise, a good practice is to ensure LLDP is only configured and enabled for ACOS system interfaces connected to immediate networks supporting LLDP-enabled devices.

For example, to enable LLDP on `eth2` data port for both discovery (`rx`) and announcement (`tx`):

```
// Enable LLDP on eth3
ACOS-TH####(config)#interface ethernet 2
ACOS-TH####(config-if:ethernet:2)#lldp enable rx tx
```

Permitting the following for only ACOS systems and other LLDP-enabled devices on interconnecting switches can constrain most, if not all, exposures to compromises or attacks on LLDP.

- EtherType := 0x88cc

## ACOS High Availability Protocol (VRRP-A)

VRRP-A is an A10 proprietary protocol that provides the High Availability (HA) feature for ACOS systems. Though it does borrow concepts from the Virtual Router Redundancy Protocol (VRRP), this A10 HA protocol is completely different from the industry standard, specified in IETF RFC-5798.

Whereas the standard VRRP is meant for redundancy amongst routers, VRRP-A supports HA for ACOS ADC and CGN systems; providing redundancy for:

- Virtual server IP addresses (VIPs)
- Floating IP addresses used as default gateways by downstream devices
- IPv6 NAT pools
- IPv4 NAT pools
- IPv4 static range lists and individual mappings for inside source NAT

The VRRP-A service in ACOS is disabled by default. If the ACOS system is not deployed in a HA configuration, it is recommended to leave the service disabled. Alternatively, and as is very commonly the case when deployments seek high availability, it is a good practice to ensure that VRRP-A is carefully configured and only enabled for interfaces connecting ACOS systems.

Permitting the following for only ACOS systems on interconnecting switches can constrain most, if not all, exposures to compromises or attacks on VRRP-A.

- Multicast IPv4 := 224.0.0.210
- Multicast IPv6 := FF02::D2

**NOTE:** VRRP-A also has a dependency on availability of the SSH protocol for exchanges among ACOS systems. It is important to ensure that the SSH management is enabled for dedicated interfaces (real or virtual) connecting ACOS devices, using the `enable-management service ssh` CLI command.

## HARDENING THE ACOS DATA PLANE

Data planes are often viewed as the least important of the three planes to harden, as it is often thought that secure practices for the management and control planes will ensure security of the data planes. While this can be true for the strength and integrity of the overall ACOS system, there are still many features and configuration options that promote secure data plane traffic.

ACOS seeks to provide a highly-secured and massively performant data plane service. It also has the notable challenge of still providing support for legacy servers that use secure services considered insecure and antiquated by contemporary standards and industry expectations. This is true most notably for cryptographic ACOS features like SSL/TLS, IPsec, OpenSSH, offloading, proxy, and inspection.

Another aspect of ACOS hardening involves strengthening various services accessed via the ACOS data plane, such as a Web/GUI resource sitting behind an ACOS system. Web/GUI vulnerabilities are now at about 50% of all industry published matters. To help protect legacy, under-provisioned, or misconfigured web servers a number of considerations are suggested below.

## GENERAL DP HARDENING

There are some areas to consider in hardened ACOS deployments that don't fit into another category, such as ICMP Redirects (anti-DoS) and Anomalous Packet Handling (anti-DoS).

### Anomalous Packets Handling

Anomalous packet encodings can be used by malicious parties attempting to disrupt or surveil the ACOS system, or to subvert the data-stream it is processing. Traffic of this nature is generally more commonplace on ACOS interfaces at the network edge where DoS and precursor surveillance are seen more and more often in the industry. Internal networks will typically see significantly less malformed traffic but are still not immune to activities of bad actors.

ACOS supports the detection of a variety of packet anomalies, with no impact to performance in ACOS systems that include A10 Flexible Traffic Accelerators (FTAs) and nominal impact in other ACOS hardware-based and virtual platforms. Since ACOS passes such packets without event by default, it is a good practice to configure ACOS to drop them.

### Drop Anomalous L3/L4 Packets

ACOS is configured to drop anomalous packets through the `ip anomaly-drop` command with several anomaly groups to choose from as shown in the example below. Additional options are supported for compatibility with legacy anomaly controls in ACOS.

```
ACOS-TH#### (config) #ip anomaly-drop packet-deformity layer-3
ACOS-TH#### (config) #ip anomaly-drop packet-deformity layer-4
ACOS-TH#### (config) #ip anomaly-drop security-attack layer-3
ACOS-TH#### (config) #ip anomaly-drop security-attack layer-4
```

The complete list of anomalies and their statistics can be seen with the `show ip anomaly-drop statistics` command. They are associated with the anomaly groups above as follows.

#### Deformities – Layer 3

- Runt IP Header
- Bad IP Header Length
- Bad IP Flags
- Bad IP TTL
- Bad IP Checksum
- Bad IP Payload Length
- Oversize IP Payload
- Bad IP Fragment Offset
- IP-over-IP Tunnel Mismatch
- IP-over-IP Tunnel Error
- VXLAN Tunnel Error
- GRE Tunnel Error
- GRE PPTP Error

#### Attacks – Layer 3

- Land Attack <sup>(2)</sup>
- ICMP Ping of Death <sup>(2)</sup>
- No IP Payload
- Empty Fragment
- Micro Fragment

#### Deformities – Layer 4

- Runt TCP/UDP Header
- TCP Short Header
- TCP Bad IP Length
- TCP Fragmented Header <sup>(1)</sup>
- TCP Bad Checksum
- TCP Option Error
- TCP Bad Urgent Offset
- TCP SYN and FIN <sup>(1) (2)</sup>
- TCP SYN Fragment <sup>(1) (2)</sup>
- TCP Null Flags <sup>(1) (2)</sup>
- TCP Null Scan <sup>(1)</sup>
- TCP XMAS Flags <sup>(1)</sup>
- TCP XMAS Scan <sup>(1)</sup>
- UDP Short Header
- UDP Bad Length
- UDP Bad Checksum
- UDP Port Loopback <sup>(1)</sup>

#### Attacks – Layer 4

- \*\*\* Incl. Layer 4 Deformities above with note <sup>(1)</sup>
- UDP Kerberos Fragment

<sup>(1)</sup> Anomaly is included in both deformities and attacks.

<sup>(2)</sup> Anomaly also has a separate, legacy control under the `ip anomaly-drop` command.

---

## Drop IP Option Packets

---

IP options in packets are generally considered to be a security risk as they can be used to leak address and topology information about interior networks to the outside world or bypass network security controls. It is a common practice to filter out (drop) packets with IP Options, especially for networked devices deployed at the network edge.

ACOS systems are often deployed at or near the network edge. For such ACOS systems it is recommended that packets with IP Options be summarily dropped. This behavior is enabled with the `ip anomaly-drop` command. For example:

```
ACOS-TH#### (config) #ip anomaly-drop ip-option
```

---

## Drop IPv4 Source Routing

---

IPv4 source routing options were originally intended to aid in network diagnostics and troubleshooting, allowing the sender of a packet to specify an exact path or sequence of gateways that the packet must traverse on its way to the destination. Malicious users long ago figured out how to use these options to target network segments while bypassing configured and learned routing topology information, allowing them to determine the path packets take; potentially subverting security policies and management of the target network. Accordingly, it has become a common practice to drop IPv4 packets attempting to specify routing paths within interior networks.

ACOS does not support configurations to selectively drop source routing options, while allowing other options to pass. To drop IPv4 packets with source routing options, ACOS deployments will need to enable dropping of packets with any IPv4 options, as described above.

---

## Monitor Anomalous L3/L4 Packets Statistics

---

Anomalous packets can be a bellwether of malicious activity, more so for some malformed packets than others. For example, bad checksums can happen from time to time. However, spikes or elevations in these events can be good indicators of DoS attacks and surveillance attempts.

Administrative users are advised to monitor ACOS anomaly volume through the `acosIpAnomalyDropS` statistics array (1.3.6.1.4.1.22610.2.4.10.55.5.1) via SNMP and take appropriate actions on occasions of increased anomalous activity.

---

## Disable ICMP Redirects

---

ICMP redirects let one network device inform another of a better path to a given IP destination. By default, ACOS sends an ICMP redirect if it receives a packet that needs to be routed through the interface it was received. Attackers can leverage this common default behavior, using the CPU overhead it entails to deny service (DoS) in the ACOS system's data plane.

To avoid such exploits in the ACOS data, control, and management planes it is recommended to configure ACOS to not send ICMP redirects. For example:

```
ACOS-TH#### (config) #ip icmp disable redirect
```

## SSL/TLS CONFIGURATION HARDENING

The ACOS data plane in A10 ADC and SSL Insight (SSLi) products supports a robust set of SSL/TLS-based features; such as cryptographic acceleration/off-loading, forward/reverse proxies, and interception/inspection. Underlying these features is the SSL/TLS data plane that provides common cryptographic services.

The SSL/TLS data plane can be a challenging area for many organizations that need to support legacy environments with old browser or web servers, historic applications that still need to function, and the like. To support these environments, SSL/TLS in the ACOS data plane continues to make older SSL/TLS protocol versions and ciphers available. For example, ACOS continues to support the SSL Version 3 (SSLv3) protocol since some ACOS deployments still need to talk to antiquated production servers and applications that only support SSLv3.

**NOTE:** Transport Layer Security (TLS) is the successor to the Secure Socket Layer (SSL) protocols. The reader will see that ACOS ubiquitously use the term SSL (or ssl) for ACOS SSL/TLS object names and configuration keywords. These references should be effectively considered to refer to TLS, the successor protocol to SSL, unless otherwise noted.

ACOS abstracts two basic configuration objects for provisioning the SSL/TLS service instances. One is the [client SSL \(client-ssl\) template](#) used to configure ACOS for SSL/TLS connections initiated by external clients, such as browsers and RESTful client applications. The other is the [server SSL \(server-ssl\) template](#) used to configure ACOS for SSL/TLS connections to external servers or resources being requested, such as HTTPS web servers and SMTPS mail servers. These templates can be further provisioned with additional options and settings before associating the them with ACOS Virtual IPs (VIPs). They are created and configured using the `slb template client-ssl` and `slb template server-ssl` commands.

In the subsections below, we share common practices and alternatives for securely configuring ACOS's SSL/TLS underlying services.

## SSL/TLS Ciphers

When an SSL client or server template is created a default set of ciphers are enabled which includes many of the ciphers that ACOS supports. This default set of ciphers can be overridden by creating an SSL cipher template with the `slb template cipher` ACOS command, specifically enabling select ciphers in the template. The cipher template can then be bound to the client or server SSL template using the `template cipher` command. For example:

```
ACOS-TH#### (config) #slb template cipher sample-cipher-templ-1
ACOS-TH#### (config-cipher) #TLS1_ECDHE_ECDSA_AES_128_GCM_SHA256 priority 82
ACOS-TH#### (config-cipher) #TLS1_ECDHE_RSA_AES_128_GCM_SHA256 priority 80
ACOS-TH#### (config-cipher) #TLS1_RSA_AES_256_SHA256 priority 24
ACOS-TH#### (config-cipher) #TLS1_RSA_AES_128_SHA256 priority 22
ACOS-TH#### (config-cipher) #TLS1_RSA_AES_128_SHA
ACOS-TH#### (config-cipher) #TLS1_RSA_AES_256_SHA

ACOS-TH#### (config) #slb template client-ssl sample-client-ssl-template
ACOS-TH#### (config-client ssl) #template cipher sample-cipher-templ-1

ACOS-TH#### (config) #slb template server-ssl sample-server-ssl-template
ACOS-TH#### (config-server ssl) #template cipher sample-cipher-templ-1
```

Cipher priority values can be 1 - 100 with the highest (most favored) priority being 100. When ciphers are assigned the same priority the strongest (most secure) ciphers will be more favored for incoming SSL/TLS connections processed against the client SSL template. If the optional priority value is not indicated, a default value of 1 (least favored) will be applied.

**NOTE:** Priority values are ignored by ACOS for server SSL templates since it is the external SSL/TLS responder that chooses the cipher for a session from the preferred cipher list configured on the server SSL template. Cipher templates for server SSL templates serve only to control which ciphers are proposed in connections to SSL/TLS responders.

The following section discusses SSL cipher templates for various common use-cases, along with a cipher template equivalent to the default settings for newly created client and server SSL templates.

### Maximum Compatibility

For maximum compatibility with the broadest range of browsers and SSL/TLS applications the following [SSL cipher template enables all ciphers supported in ACOS](#), including several ciphers that are considered unsecure, or even deprecated by contemporary standards. Ciphers are indicted in order of their security strength with corresponding priority values.

The ciphers in this template are often a starting point when a deployment requires support for legacy SSL/TLS servers and applications. This is especially true when it is not clear what specific SSL/TLS ciphers these legacy systems need. As ACOS administrators determine which of the weaker or very weakest ciphers are not needed, those ciphers can be removed to refine the template.

```

ACOS-TH####(config)#slb template cipher MaxCompatability-Ciphers
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_CHACHA20_POLY1305_SHA256 priority 96
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_CHACHA20_POLY1305_SHA256 priority 94
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_CHACHA20_POLY1305_SHA256 priority 92
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_256_GCM_SHA384 priority 88
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_256_GCM_SHA384 priority 86
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_256_GCM_SHA384 priority 84
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_128_GCM_SHA256 priority 82
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_128_GCM_SHA256 priority 80
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_128_GCM_SHA256 priority 78
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_256_SHA384 priority 68
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_256_SHA384 priority 66
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_256_SHA256 priority 64
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_128_SHA256 priority 62
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_128_SHA256 priority 60
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_128_SHA256 priority 58
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_256_SHA priority 48
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_256_SHA priority 46
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_256_SHA priority 44
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_128_SHA priority 42
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_128_SHA priority 40
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_128_SHA priority 38
ACOS-TH####(config-cipher)#TLS1_RSA_AES_256_GCM_SHA384 priority 28
ACOS-TH####(config-cipher)#TLS1_RSA_AES_128_GCM_SHA256 priority 26
ACOS-TH####(config-cipher)#TLS1_RSA_AES_256_SHA256 priority 24
ACOS-TH####(config-cipher)#TLS1_RSA_AES_128_SHA256 priority 22
ACOS-TH####(config-cipher)#TLS1_RSA_AES_256_SHA priority 20
ACOS-TH####(config-cipher)#TLS1_RSA_AES_128_SHA priority 18
ACOS-TH####(config-cipher)#SSL3_RSA_DES_192_CBC3_SHA priority 10
ACOS-TH####(config-cipher)#SSL3_RSA_RC4_128_SHA priority 6
ACOS-TH####(config-cipher)#SSL3_RSA_RC4_128_MD5 priority 4

```

Even though the objective for this template is interoperability with dated, legacy systems, a number of these ciphers are considered less than strong, in varying degrees, and will be reported as potential exposures by contemporary vulnerabilities scanners. Particularly noteworthy in this regard are the following ciphers, which should be the 1<sup>st</sup> to be excluded if not fundamentally necessary for interoperability.

- RC4 ciphers – extremely weak, will be flagged as highly vulnerable (prio 4 - 6 ciphers)
- 3DES cipher – very weak, will be flagged as highly vulnerable (prio 10 cipher)

Also, ciphers potentially exposed to various vulnerabilities should be considered, especially as the industry continues to shift to sanctioning only Perfect Forward Secrecy (PFS) ciphers. These should be the 2<sup>nd</sup> focus for exclusion if not required for interoperability.

- AES CBC ciphers – medium strength, flagged as low or informational severity (prio 18 - 24 and 38 - 68 ciphers)
- RSA AES ciphers – varying strengths, flagged informational severity (prio 18 - 28 ciphers)
- Non-PFS ciphers – varying strengths, flagged as informational severity (prio 4 - 68 ciphers)

At this time, there are certain ciphers only supported on select A10 Thunder platforms. These include:

- CHACHA-POLY ciphers - only for A10 vThunder (prio 92 – 96 ciphers)
- ECDHE AES-256 w/ SHA-384 ciphers - only for A10 vThunder and A10 Thunder with 3rd generation SSL card(s) (prio 66 – 68 ciphers)



## ACOS Default Compatibility

As described above, when client and server SSL templates are created, they have a default set of ciphers enabled which is a subset of the complete set of ciphers supported by ACOS. This would be the equivalent to creating a template like the `MaxCompatability-Ciphers` one above and excluding selected ciphers not included in the default.

The following template example shows which the ciphers are not included by default for client and server SSL templates without an SSL cipher template configured to otherwise specify their supported cipher suites.

```
ACOS-TH####(config)#slb template cipher ACOS_Default-Ciphers

ACOS-TH####(config-cipher)#    <<< Include the ciphers from the MaxCompatability-Ciphers
                                example above >>>

ACOS-TH####(config-cipher)#no TLS1_DHE_RSA_CHACHA20_POLY1305_SHA256
ACOS-TH####(config-cipher)#no TLS1_DHE_RSA_AES_256_GCM_SHA384
ACOS-TH####(config-cipher)#no TLS1_DHE_RSA_AES_128_GCM_SHA256
ACOS-TH####(config-cipher)#no TLS1_DHE_RSA_AES_256_SHA256
ACOS-TH####(config-cipher)#no TLS1_DHE_RSA_AES_128_SHA256
ACOS-TH####(config-cipher)#no TLS1_DHE_RSA_AES_256_SHA
ACOS-TH####(config-cipher)#no TLS1_DHE_RSA_AES_128_SHA
ACOS-TH####(config-cipher)#no SSL3_RSA_RC4_128_MD5
```

This template is shared here for informational purposes only and to surface ciphers enabled/disabled by default, with no other configuration considerations in client and server SSL templates. The underlying default ciphers enabled by default in client and server SSL templates is otherwise not readily apparent in ACOS.

In general, A10 recommends that ACOS administrators always define SSL cipher templates for their deployments instead of simply relying on ACOS defaults.

## Maximum Security, HTTP2 Compatibility

Deployments that seek to maximize security will enable only PFS ciphers that use ChaCha20-Poly1305 or AES-GCM encryption algorithms. These ciphers are generally considered some of the strongest, commonly supported ciphers in the industry today. They are also fully compatible with cipher requirements for the HTTP/2 (aka HTTP/2.0) protocol.

An SSL cipher template supporting this most secure scope would look like the following.

```
ACOS-TH####(config)#slb template cipher MaxSec_HTTP2_0-Ciphers
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_CHACHA20_POLY1305_SHA256 priority 96
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_CHACHA20_POLY1305_SHA256 priority 94
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_CHACHA20_POLY1305_SHA256 priority 92
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_256_GCM_SHA384 priority 88
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_256_GCM_SHA384 priority 86
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_256_GCM_SHA384 priority 84
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_128_GCM_SHA256 priority 82
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_128_GCM_SHA256 priority 80
ACOS-TH####(config-cipher)#TLS1_DHE_RSA_AES_128_GCM_SHA256 priority 78
```

## SSL Labs A+ Ciphers

Though SSL Labs (by Qualys, Inc) is not an industry standard, many companies use it as a guideline or reference test to assess their web services' security and browser compatibility. The following SSL cipher template will support efforts to achieve A+ score from SSL Labs.

**NOTE:** Many other factors are involved in SSL Labs' scoring methodology, beyond supported ciphers.

```
ACOS-TH####(config)#slb template cipher APlus_SSSLabs-Ciphers
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_CHACHA20_POLY1305_SHA256 priority 96
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_CHACHA20_POLY1305_SHA256 priority 94
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_256_GCM_SHA384 priority 88
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_256_GCM_SHA384 priority 86
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_128_GCM_SHA256 priority 82
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_128_GCM_SHA256 priority 80
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_256_SHA384 priority 68
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_256_SHA384 priority 66
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_128_SHA256 priority 62
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_128_SHA256 priority 60
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_256_SHA priority 48
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_256_SHA priority 46
ACOS-TH####(config-cipher)#TLS1_ECDHE_ECDSA_AES_128_SHA priority 42
ACOS-TH####(config-cipher)#TLS1_ECDHE_RSA_AES_128_SHA priority 40
```

DHE ciphers are commonly excluded from this list as they are much slower than ECDHE. Additionally, modern TLS clients have supported elliptical curve key exchanges for quite some time.

## SSL/TLS Protocol Versions

ACOS supports the following SSL/TLS protocol versions with controls in the client and server SSL templates to override the enabled or disabled defaults.

- TLS Version 1.2 (TLSv1.2) - default enabled
- TLS Version 1.1 (TLSv1.1) - default enabled
- TLS Version 1.0 (TLSv1.0) - default enabled
- SSL Version 3 (SSLv3) - enabled (non-FIPS mode), disabled (FIPS mode)

TLSv1.2 is broadly supported throughout the industry today and is supported by ACOS.

Even though systems supporting only TLSv1.1 and/or TLSv1.0 have been phasing out over the last number of years, it is still not uncommon to encounter them both in legacy SSL/TLS applications, client browsers, and servers. SSLv3-based systems continue to become more and more of a rarity, but still are encountered. Accordingly, the ACOS SSL/TLS data-plane continues to support them.

The following discusses common practices for configuring SSL/TLS protocol versions in SSL templates.

### Disable SSLv3

Notably due to the POODLE (Padding Oracle On Downgraded Legacy Encryption) vulnerability, SSLv3 is considered unsafe to use and can allow plaintext of secure connections to be retrieved an attacker. Furthermore, several other security issues affect SSLv3 and many contemporary ciphers supporting strong security cannot be used with SSLv3. It follows that ensuring SSLv3 is disabled is an important consideration for securing ACOS system deployments, as described below.

#### Disable SSLv3 – Non-FIPS Mode

Most ACOS systems are not FIPS-certified models where SSLv3 is disabled by default. It is highly recommended for security of these systems that ACOS administrators disable SSLv3, unless there is specific need to support it.

Requirements in ACOS deployments to provide services for legacy client/server applications, web servers, and web applications that only work with old browsers (e.g. such as Internet Explorer 6) can be motivating needs to leave SSLv3 support enabled. In these circumstances, seek to isolate the legacy systems through their own ACOS VIPs and client/server SSL templates where SSLv3 can be selectively left enabled without security impacts to other VIPs and services.

SSLv3 is disabled for a client SSL template with the `disable-ssl3` command and for a server SSL template by excluding `30` in the `version` command.

Non-FIPS mode models can be configured to operate in FIPS mode with the `system fips enable` CLI command. For ACOS systems configured in this fashion, see the discussion below.

#### Keep SSLv3 Disabled – FIPS-Mode

SSLv3 is disabled by default in client and server SSL templates when FIPS-mode is enabled. It is highly recommended for security that ACOS administrators avoid enabling SSLv3 without specific need.

Requirements in ACOS deployments as described above can be motivating needs to enable support for SSLv3. In these circumstances, seek to isolate the legacy systems through their own ACOS VIPs and client/server SSL templates where SSLv3 can be selectively enabled without security impacts to other VIPs and services.

SSLv3 is enabled for a client SSL template with the `no disable-ssl3` command and for a server SSL template by including `30` in the `version` command.

## Disable TLSv1.0

TLSv1.0 is also considered unsafe to use, especially with the 2012 advent of the CRIME (Compression Ratio Info-leak Made Easy) security exploit against secret web cookies over HTTPS and SPDY connections. Additionally, TLSv1.0 does not support contemporary ciphers with strong security and will no longer pass compliance testing for PCI (Payment Card Industry) DSS (Data Security Standard) certifications.

TLSv1.0 is enabled by default in client and server SSL templates. It is a good security practice to disable TLSv1.0 using the `version` command in SSL templates, unless there is a specific need to support this version. For example, to configure two client SSL templates with one supporting TLSv1.2 only and the other supporting TLSv1.2 and TLSv1.1:

```
ACOS-TH####(config)#slb template client-ssl client-ssl-template-1
ACOS-TH####(config-client ssl)#version 33 33

ACOS-TH####(config)#slb template client-ssl client-ssl-template-2
ACOS-TH####(config-client ssl)#version 33 32

ACOS-TH####(config-client ssl)#version ?
<30-33> TLS/SSL version: 30-SSLv3.0, 31-TLSv1.0, 32-TLSv1.1 and 33-TLSv1.2
```

For reasons like and akin SSLv3, described above, organizations may need to enable TLSv1.0 to support legacy TLS clients and servers. Similarly, it is a good practice to isolate the legacy systems through their own ACOS VIPs and client/server SSL templates where TLSv1.0 can be selectively enabled, using the `version` command, without security impacts to other VIPs and services.

## 2K dh-param

ACOS client SSL templates support a default size for the DH Parameter of 2048-bits. Though 2048-bits is commonly supported throughout the industry for this setting, legacy SSL/TLS clients require a lesser size.

In these circumstances, it is recommended to isolate legacy systems by dedicating ACOS VIPs and SSL client templates just for these systems where a smaller DH Parameter can be selectively configured without security impacts to other VIPs and services. The DH Parameter can be set for an SSL client template with the `dh-param` command.

## WEB VIP CONFIGURATION HARDENING

With almost 50% of today's vulnerabilities being web-related, secure practices for ACOS Web VIPs is clearly an important area to consider in hardening ACOS system deployments. Notable practices in this pursuit include configuring Web VIPs to reduce exposure to Denial-of-Service (DoS) attacks, ensure web content transferred is encrypted, and supporting HTTP security headers.

Several HTTP security headers have been introduced in recent years that help protect against exploits from various attacks; such as cross-site scripting (XSS), man-in-the-middle (MitM) attacks, clickjacking, cross-site request forgery and other threat vectors. It is important to make sure HTTP security headers are present in outgoing HTTP responses from the Web VIP, even if the underlying HTTP servers are misconfigured or simply do not support them.

These practices are also helpful in reducing warnings and alerts from web application and vulnerability scanners that are becoming more available and used to test security and compliance for web services.

### *Enable TCP Syn-Cookies*

A TCP SYN-flooding attack is a type of Denial-of-Service (DoS) attack and is all too commonly used to target web-based services. The TCP SYN-Cookie is a mechanism that helps protect the ACOS system as well as the services it provides. Enabling SYN-Cookies is always a recommended practice; especially for services facing the network edge.

The following example begins with a basic Web VIP configuration in ACOS with TCP SYN-Cookies enabled. This configuration, which will be further built upon in later discussions, defines a Web VIP for a web-site with the following characteristics.

- Outside IP: 1.1.1.1
- Outside Services: HTTP (80), HTTPS (443)
- Inside IPs: 192.168.1.11, 192.168.1.12
- Inside Services: HTTP (80), HTTPS (443), load balanced

We start by configuring ACOS for two internal web servers and two service groups to load balance across the servers, one group to serve HTTP and the other HTTPS.

```
ACOS-TH####(config)#slb server Inside-Server-1 192.168.1.11
ACOS-TH####(config-real server)# port 80 tcp
ACOS-TH####(config-real server)# port 443 tcp

ACOS-TH####(config)#slb server Inside-Server-2 192.168.1.12
ACOS-TH####(config-real server)# port 80 tcp
ACOS-TH####(config-real server)# port 443 tcp

ACOS-TH####(config)#slb service-group Inside-Group-HTTP tcp
ACOS-TH####(config-slb svc group)# member Inside-Server-1 80
ACOS-TH####(config-slb svc group)# member Inside-Server-2 80

ACOS-TH####(config)#slb service-group Inside-Group-HTTPS tcp
ACOS-TH####(config-slb svc group)# member Inside-Server-1 443
ACOS-TH####(config-slb svc group)# member Inside-Server-2 443
```

Next, we create a client and server SSL templates. For the internet facing client SSL template we choose a set of strong ciphers compatible with getting an A+ rating from Qualys's SSL Labs server test (see [SSL Labs A+ Ciphers](#) discussion above) and bind a suitable SSL/TLS certificate and key. For internal facing server SSL template, we can use the default ciphers.

```
ACOS-TH####(config)#slb template client-ssl HTTPS_Client_Template
ACOS-TH####(config-client ssl)#cert My-Webs-VIP-certificate
ACOS-TH####(config-client ssl)#key My-Webs-VIP-key
ACOS-TH####(config-client ssl)#template cipher APlus_SSLLabs-Ciphers

ACOS-TH####(config)#slb template server-ssl HTTPS_Server_Template
ACOS-TH####(config-server ssl)#template cipher ACOS_Default-Ciphers
```

**NOTE:** Instead of the default ciphers for connections to the internal HTTPS servers, ACOS administrators can define a cipher template consistent with the organization's security policy for communications with these servers.

Next, we create a Web VIP that serves both HTTP and HTTPS to outside users. SYN-cookies are enabled with the `syn-cookie` command.

```
ACOS-TH####(config)#slb virtual-server My-Webs-VIP-1 1.1.1.1
ACOS-TH####(config-slb vserver)#port 80 http
ACOS-TH####(config-slb vserver-vport)#syn-cookie
ACOS-TH####(config-slb vserver-vport)#service-group Inside-Group-HTTP

ACOS-TH####(config-slb vserver)#port 443 https
ACOS-TH####(config-slb vserver-vport)#syn-cookie
ACOS-TH####(config-slb vserver-vport)#service-group Inside-Group-HTTPS
ACOS-TH####(config-slb vserver-vport)#template client-ssl HTTPS_Client_Template
ACOS-TH####(config-slb vserver-vport)#template server-ssl HTTPS_Server_Template
```

**NOTE:** If hardware-based SYN-cookies are configured and enabled for the ACOS system, the software based SYN-cookie mechanism for virtual ports is not used, even if it is configured for the virtual port as described above. Hardware based SYN-cookies are only supported on ACOS systems with FTA hardware and are enabled globally for the ACOS system using the `syn-cookie enable` command. See the ACOS product documentation for more information on this hardware-based feature and its configuration.

## Redirect unencrypted traffic to HTTPS

Unencrypted HTTP connections expose web services to man-in-the-middle (MITM) attacks and risks the interception of user data, passwords, and other sensitive information. It is highly recommended to provide the content of services via HTTPS, redirecting any HTTP request to the HTTPS service.

ACOS can be configured to immediately redirect new HTTP connections to the HTTPS port of the VIP, rather than relying on internal web servers to perform this operation. This method eliminates the possibility of misconfigured servers that could unintentionally leave HTTP access available.

To continue the example above we restrict the Web VIP for HTTPS by doing the following.

- Create an ACOS HTTP template for use in redirecting traffic to HTTPS (443)
- Remove the HTTP service group from the VIP
- Add the redirection HTTP template to the VIP's HTTP service to redirect connections to HTTPS by adding the redirect HTTP template for the service.

```
ACOS-TH#### (config) #slb template http Redirect-to-HTTPS
ACOS-TH#### (config-http) #redirect secure port 443

ACOS-TH#### (config) #slb virtual-server My-Webs-VIP-1 1.1.1.1
ACOS-TH#### (config-slb vserver) #port 80 http
ACOS-TH#### (config-slb vserver-vport) #no service-group Inside-Group-HTTP
ACOS-TH#### (config-slb vserver-vport) #template http Redirect-to-HTTPS
```

When allowed by the organization's security policy, ACOS can be configured to serve HTTPS and redirected HTTP connections using just the internal HTTP servers. This is called SSL offloading and is often used to reduce CPU load on web servers by not having them decrypt SSL/TLS traffic.

To continue the example, we restrict the Web VIP to just the internal HTTP servers as follows.

- Replace the HTTPS service group with the HTTP service group under the HTTPS (443) virtual port (simply declaring it replaces the existing service-group).
- Remove the server SSL template since there will no longer be any SSL/TLS connections to servers on the internal network.

```
ACOS-TH#### (config) #slb virtual-server My-Webs-VIP-1 1.1.1.1
ACOS-TH#### (config-slb vserver) #port 443 https
ACOS-TH#### (config-slb vserver-vport) #service-group Inside-Group-HTTP
ACOS-TH#### (config-slb vserver-vport) #no template server-ssl MaxSec_HTTP2
```

## HTTP Strict Transport Security (HSTS)

The `Strict-Transport-Security` header is a security enhancement that restricts web browsers to access web servers solely over HTTPS. It ensures the connection cannot be established through an insecure HTTP connection which could be susceptible to attacks. Web servers are commonly under-configured by not enabling support for this security header. In more rare circumstances the servers support legacy web implementations that don't support HSTS.

For deployments where administrators are not fully confident of their server settings (present or on-going) or know that legacy servers are in play, ACOS Web VIPs can be configured to include this HTTP header if it does not exist in HTTP responses from the internal servers.

Continuing the example, we define an HTTP template to insert an HSTS header if the real server did not include one in its HTTP responses and then enable this capability for both services on the VIP.

**NOTE:** Of the considered security headers, HSTS is one that **MUST** also be included in the 301/302 redirects from HTTP. Accordingly, it is enabled for the VIP's HTTP port as well.

```
ACOS-TH#### (config) #slb template http add-HSTS
ACOS-TH#### (config-http) #response-header-insert "Strict-Transport-Security: max-age=31536000;
includeSubDomains; preload" insert-if-not-exist

ACOS-TH#### (config) #slb virtual-server My-Webs-VIP-1 1.1.1.1
ACOS-TH#### (config-slb vserver) #port 80 http
ACOS-TH#### (config-slb vserver-vport) #template http add-HSTS

ACOS-TH#### (config-slb vserver) # port 443 https
ACOS-TH#### (config-slb vserver-vport) #template http add-HSTS
```

Administrators should review the parameter selections for this HSTS header and update values for it according to their security policy. Also, see the ACOS product documentation for alternately replacing or adding HSTS headers when the real servers do indeed include them.

## X-XSS-Protection

The `X-XSS-Protection` header is a security enhancement designed to enable the cross-site scripting (XSS) filter built into modern web browsers that prevents them from loading pages when cross-site scripting (XSS) attacks are detected. Valid settings for the header will do one of the following:

- disable protection
- enable protection and attempt to sanitize the response to stop a detected attack
- enable protection and block the response for a detected attack (most secure)

For deployments where administrators are not fully confident of their server settings (present or on-going), or know that legacy servers are in play, ACOS Web VIPs can be configured to include this HTTP header if it does not exist in HTTP responses from the internal servers.

Continuing the example, we define an HTTP template to insert an X-XSS-Protection header if the real server did not include one in its HTTP responses and enable this capability for the HTTPS service on the VIP.

```
ACOS-TH#### (config) #slb template http add-X-XSS-Protection
ACOS-TH#### (config-http) #response-header-insert "X-XSS-Protection: 1; mode=block" insert-if-
not-exist

ACOS-TH#### (config) #slb virtual-server My-Webs-VIP-1 1.1.1.1
ACOS-TH#### (config-slb vserver) #port 443 https
ACOS-TH#### (config-slb vserver-vport) #template http add-X-XSS-Protection
```



The enable and block option is considered the optimal and most secure setting for this header. See the ACOS product documentation for alternately replacing or adding X-XSS-Protection headers when the real servers do indeed include them.

## X-Frame-Options

The X-Frame-Options header indicates whether a browser can render a page in an HTML frame, iframe or object tag. Web sites and applications find this header useful to avoid clickjacking attacks as it helps ensure that their content cannot be embedded in other sites. For hardening, it is a common practice to set this header for one of the following:

- only allow resources that are part of the same origin policy to frame the resource of the HTTP response (SAMEORIGIN)
- deny any resource (local or remote) attempting to frame the resource of the HTTP response (DENY)

For deployments where administrators are not fully confident of their server settings (present or on-going), or know that legacy servers are in play, ACOS Web VIPs can be configured to include this HTTP header if it does not exist in HTTP responses from the internal servers.

Continuing the example, we define an HTTP template to insert an X-Frame-Options header if the real server did not include one in its HTTP responses and enable this capability for the HTTPS service on VIP.

```
ACOS-TH#### (config) #slb template http add-X-Frame-Options
ACOS-TH#### (config-http) #response-header-insert "X-Frame-Options: SAMEORIGIN" insert-if-not-exist

ACOS-TH#### (config) #slb virtual-server My-Webs-VIP-1 1.1.1.1
ACOS-TH#### (config-slb vserver) #port 443 https
ACOS-TH#### (config-slb vserver-vport) #template http add-X-Frame-Options
```

Administrators should review the parameter selections for this X-Frame-Options header and update values for it according to their security policy. See the ACOS product documentation for alternately replacing or adding X-Frame-Options headers when the real servers do indeed include them.

## X-Content-Type-Options

The X-Content-Type-Options header indicates that the MIME types listed in the Content-Type headers should not be changed and must be followed, effectively disabling MIME type sniffing in the browsers. With MIME sniffing, browsers guess what content type is, rather than trusting Content-Type header's value. Based on that guess, browsers can mistakenly interpret the response content (e.g. thinking text content is Javascript) or tricked into executing malicious code. There is only one valid setting for this header.

For deployments where administrators are not fully confident of their server settings (present or on-going), or know that legacy servers are in play, ACOS Web VIPs can be configured to include this HTTP header if it does not exist in HTTP responses from the internal servers.

Continuing the example above, we define an HTTP template to insert an X-XSS-Protection header if the real server did not include one in its HTTP responses and enable this capability for the HTTPS service on the VIP.

```
ACOS-TH####(config)#slb template http add-X-Content-Type-Options
ACOS-TH####(config-http)# response-header-insert "X-Content-Type-Options: nosniff" insert-if-
not-exist

ACOS-TH####(config)#slb virtual-server My-Webs-VIP-1 1.1.1.1
ACOS-TH####(config-slb vserver)# port 443 https
ACOS-TH####(config-slb vserver-vport)# template http add-X-Content-Type-Options
```

With only one real encoding, there is no real need to consider replacing or adding this header when the real servers include them.



## ABOUT A10 NETWORKS

A10 Networks (NYSE: ATEN) provides Reliable Security Always™ through a range of high-performance solutions that enable intelligent automation with deep machine learning to ensure business critical applications are protected, reliable and always available. Founded in 2004, A10 Networks is based in San Jose, Calif., and serves customers globally with offices worldwide.

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