INTERLINK NETWORKS

Technical Document

RAD-Series AAA Server Administrator's Guide

Version 7.4 for Linux

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Revision History

Date	Version	Type
07/2008	7.4.0	New product release

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About this Document

Welcome to RAD-Series AAA Server software. This guide provides information about:

- Server components and operation
- Server Manager configuration
- Advanced server configuration, including:
  - EAP authentication
  - External data stores
  - Advanced Policy
- Server and accounting logging and monitoring

See the *RAD-Series Getting Started Guide* for installation and basic configuration instructions.

Audience

This *Administrator's Guide* is for Network and Systems Administrators who must configure and maintain the AAA Server. It's assumed that you:

- Are familiar with basic Unix commands
- Know the hardware and software profiles of the server machines and other devices used throughout the network
- Are familiar with LDAP or Oracle configuration, if implemented
- For wireless networks, know the EAP methods and user name formats used

Notational Conventions

Text in this guide is marked in different styles to denote various things.

Text Marked...	Indicates...
`Fixed-width font`	Code, a command, a file name, or a file parameter. Enter exactly what is shown.
`Fixed-width italic`	A variable. Enter what is correct for your installation, not what is shown.
Normal italic	Title of a book or other publication.
Bold	Something noteworthy, so we emphasize it.
Blue underline	Hypertext link. Click the link to send e-mail to the account or to open the document in your browser.

Introduction

Overview

The Interlink Networks RAD-Series AAA Server software provides Authentication, Authorization, and Accounting services to secure wired or wireless networks. It uses the RADIUS protocol for LAN access control and supports:

- Password Authentication Protocol (PAP)
- Challenge-Handshake Authentication Protocol (CHAP)
- Microsoft® Challenge-Handshake Authentication Protocol (MS-CHAP), v1 and v2
- Extensible Authentication Protocol (EAP)

The AAA Server fully implements the IEEE 802.1X standard for securing wireless LANs using Extensible Authentication Protocol (EAP). EAP authentication may be done using any of several different methods. See page 18 for a list of supported EAP methods.

The server also supports:

- Proxying authentication and accounting messages to another RADIUS server
- Redundant LDAP or Oracle® user data stores, including load balancing and failover functions
- SNMP integration
- DHCP relay from configured IP address pools
- Advanced Policy to implement:
  - DNIS routing
  - Dynamic Access Control
  - Authorization based on logical groups

Software Components

The RAD-Series software delivered to you includes:

- AAA Server RADIUS server application
- Server Manager administration console
- Remote Control

You may have additional components, depending on your license option.

AAA Server

AAA Server application is comprised of:

- Finite State Machine (FSM) and some associated routines
- Software modules
- Configuration files

When the server is started, it loads and initializes the software modules and reads the configuration files.

Finite State Machine

At the core of the server is the Finite State Machine (FSM) and associated state tables that define all processes for handling RADIUS requests. At server startup, the FSM reads instructions from a state table (by default the `radius.fsm` text file). The state table outlines what modules to call in response to certain events and in what order to call them.

The server comes with a default state table capable of handling standard RADIUS and EAP requests with no modification. However, you can extend or customize server function just by modifying the default state table or creating new state tables. For example, you can log interim accounting messages by calling the appropriate predefined module at a certain point in the accounting handling process.

The FSM also provides the flexibility to call custom plug-ins created with the Software Developers Kit (SDK) in lieu of the standard server modules.

Software Modules

AAA software modules define the actions that the server performs in response to FSM events--such as authenticating requests, authorizing service, and logging. Built-in actions support various extensions, such as authenticating users with information retrieved from replicated data stores.

To customize the AAA Server with a proprietary software module, you must build and compile your plug-ins using the Software Developers Kit (SDK), which is purchased separately.

Configuration Files

The configuration files store application-specific information used by the software modules to process requests. Most configuration parameters are modified through the Server Manager, although some AAA Server features can only be configured by using a text editor. The files you'll most commonly work with are:

- **`aaa.config`** - defines all server properties.
- **`authfile`** - defines realm datastores.
- **`decision files –`** contain advanced policy information for user authorization and session control based on any logical group that can be defined with attribute-value (A-V) pairs.
- **`dictionary`** - defines all attributes and values that may be used to build A-V pairs recognized by the server. These A-V pairs convey information in requests and responses. This file also contains definitions for all the authentication types that the server recognizes.
- **`EAP.authfile –`** defines realm authentication actions.
- **`las.conf`** - enables session tracking and specifies some session timing values.
- **`log.config –`** defines accounting message logging behavior.
- **`radius.fsm -`** is the Finite State Machine table. You can edit this to reorder server processing steps or call custom plug-ins.
- **`realm files`** - contain user profile entries, including check, deny, and reply items.
- **users** - defines user profiles which can be used for exceptions to the normal realm based configuration.The default `users` file contains only the test_user entry after an initial installation.
- **`vendors`** contains optional entries for vendor names and numbers.

Server Manager

Server Manager is a browser-based application for configuring and managing AAA Servers on local or remote machines. It can also be used to view or print server and accounting logs. Server Manager has two main components:

- Server Manager program
- Java graphical user interface

The Java interface can be customized for your application by using the UI API, which is part of the Software Developers Kit.

Server Manager requires the Java Run-Time Environment (JRE) installed on each administrator workstation from which you will access it. See the *Getting Started Guide* for more information.

Remote Control

The Remote Control program contains the Java RMI objects that facilitate communication between remote servers and the Server Manager program. You only need to install this component

on server machines that do not have Server Manager installed.

How the AAA Server Works

RADIUS Message Exchange

The server and its clients communicate through an exchange of RADIUS messages (data packets) that contain information related to a user request. Different types of RADIUS messages are exchanged throughout the AAA process.

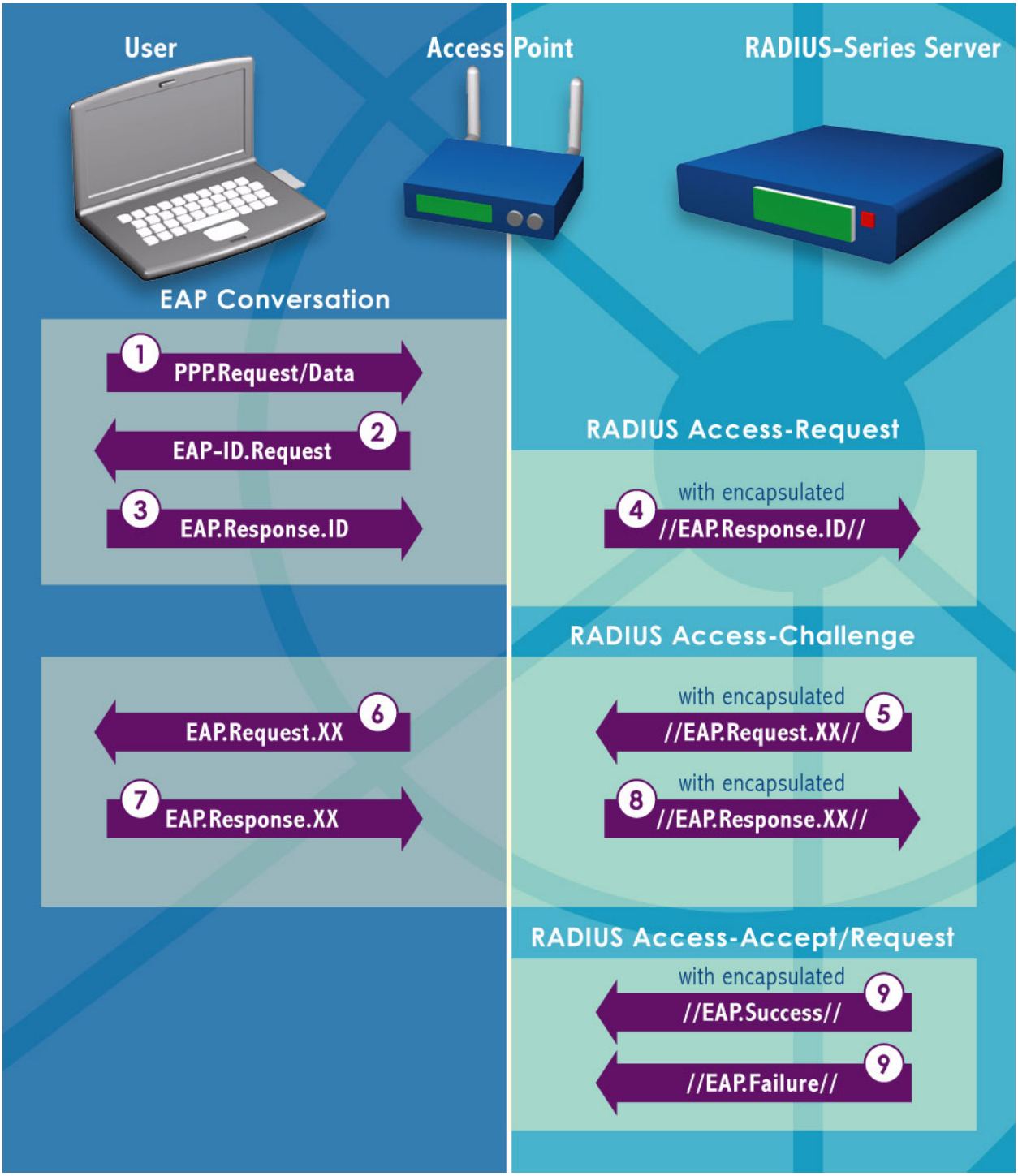
When the server receives a request, it first validates the access device that sent the request, then the user. If the access device is permitted to send requests to the server, the AAA software takes information from the **Access-Request** message and attempts to match the request to a realm user profile store and a user profile. The realm policies and user profiles specify conditions that must be met to successfully authenticate and authorize a user. If an EAP authentication method is used, the server and the client exchange a series of **Access-Challenge** messages to verify the user's credentials.

If authentication is successful, the server goes on to authorization. Authorization may verify other information, such as the port number of the access device. If all conditions are met, the server sends an **Access-Accept** packet to the access device. An Access-Accept data packet includes attribute-value pairs that specify the type of user service and other session information, such as a timeout value that indicates when to disconnect the user.

If at any point conditions are not met, the server will send an **Access-Reject** message and the access device will disconnect the user.

When the access device receives an Access-Accept packet, it may send an **Accounting-Request** message to the server to start logging the session. The Accounting-Request data packet describes the type of service being delivered and the user that will use the service. The server responds with an **Accounting-Response** message.

During the session, the access point and the server may exchange **Accounting-Alive** messages to verify that the session is still active.



RADIUS message exchange with EAP authentication

RADIUS Message Format

RADIUS requests and replies are transported by UDP. By default, the server listens on UDP port 1812 for Access-Requests and port 1813 for Accounting-Requests.

EAP-enabled access devices use the EAPOL (EAP Over LAN) standard format for transporting EAP messages within RADIUS messages. EAP requests and responses are encapsulated in the `RADIUS EAP-Message` attribute of the RADIUS messages. EAPOL also provides control functions such as start, logoff, and key distribution.

Password Encryption

The User-Password attribute within RADIUS messages are hidden using the RADIUS MD5 hashing algorithm.

Shared Secrets

RADIUS servers and their clients maintain a trust relationship through the use of a shared secret. A shared secret is a string up to 1023 characters long, with no spaces. The same secret is configured on both the server and the client device. A server may share a different secret with each of its clients.

Attribute-Value Pairs

RADIUS messages are primarily composed of attribute-value (A-V) pairs. A-V pairs represent a variable and one of the possible values that the variable can hold. A-V pairs are exchanged in RADIUS messages to:

- Match values when authorizing an Access-Request (check and deny items)
- Add provisioning instructions or other messages to an Access-Accept data packet (reply items)

In an AAA configuration file, the A-V pairs usually follow the syntax:

```
AttributeName=Value
```

A-V pairs also appear in server accounting logs where they follow the syntax:

```
AttributeName=:Type:Value
```

Request Processing

When the AAA Server receives any RADIUS message, it calls the FSM and defines a starting event according to the type of message. This first event will determine the first action. The following diagrams show how the default FSM calls actions to process requests for authentication, authorization, and accounting. This process can be modified by editing the FSM table or by creating custom plug-ins to replace the standard actions.

Authentication

The authentication process verifies that the access device and the user are legitimate.

1 The access device sends the server an Access-Request containing the User-Name from which the Server get the user ID and realm.

2 The Server checks for the user's profile in the default users file and if found uses it to authenticate the user.

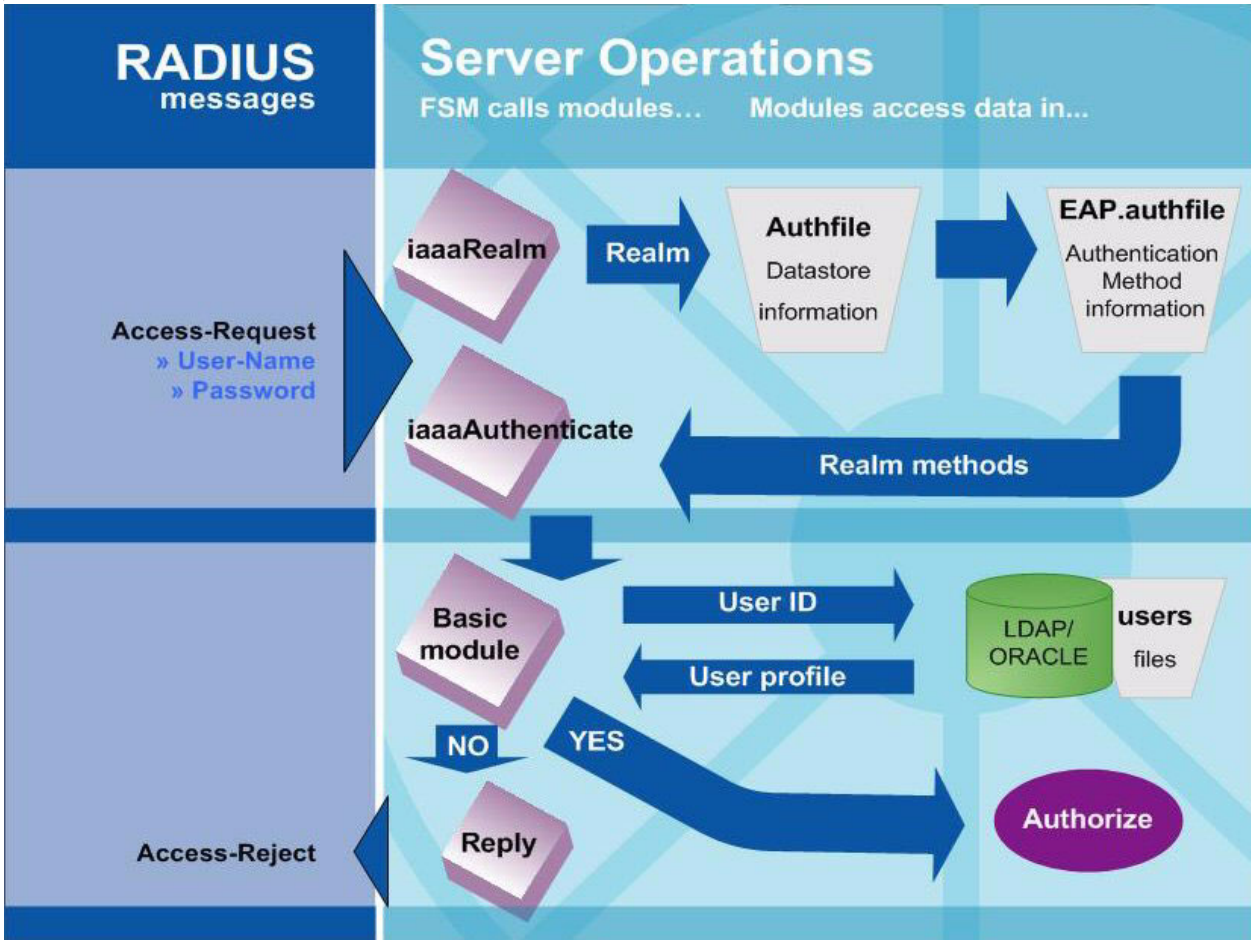
3 If the username is not found in the default users file then the Server finds the realm's user profile storage entry in the `authfile`.

4 The server authenticates the user according to the protocol established by the realm's authenticator entry in the EAP.authfile.

If PAP, CHAP, or MS-CHAP is used, the server searches the user data store for a matching user profile.

If an EAP method is used, authentication will be carried out according to the EAP method (MD5, PEAP, TLS, TTLS, AKA, SIM etc.).

5 If authentication succeeds, the server proceeds to authorization. If authentication fails, the server sends an Access-Reject message to the access device, who disconnects the user.



BASIC (non-EAP) authentication process

Authorization

The authorization process determines what services can be extended to the user. The AAA Server can authorize users through several methods:

- On a user-by-user basis with check and reply items
- Based on realms through its Local Authorization Server (LAS) functions
- Based on other logical groups through stored POLICY decisions (advanced policy) that make use of more sophisticated checks and conditional reply items.

Note: You need the Advanced Policy Engine license to implement advanced policy.

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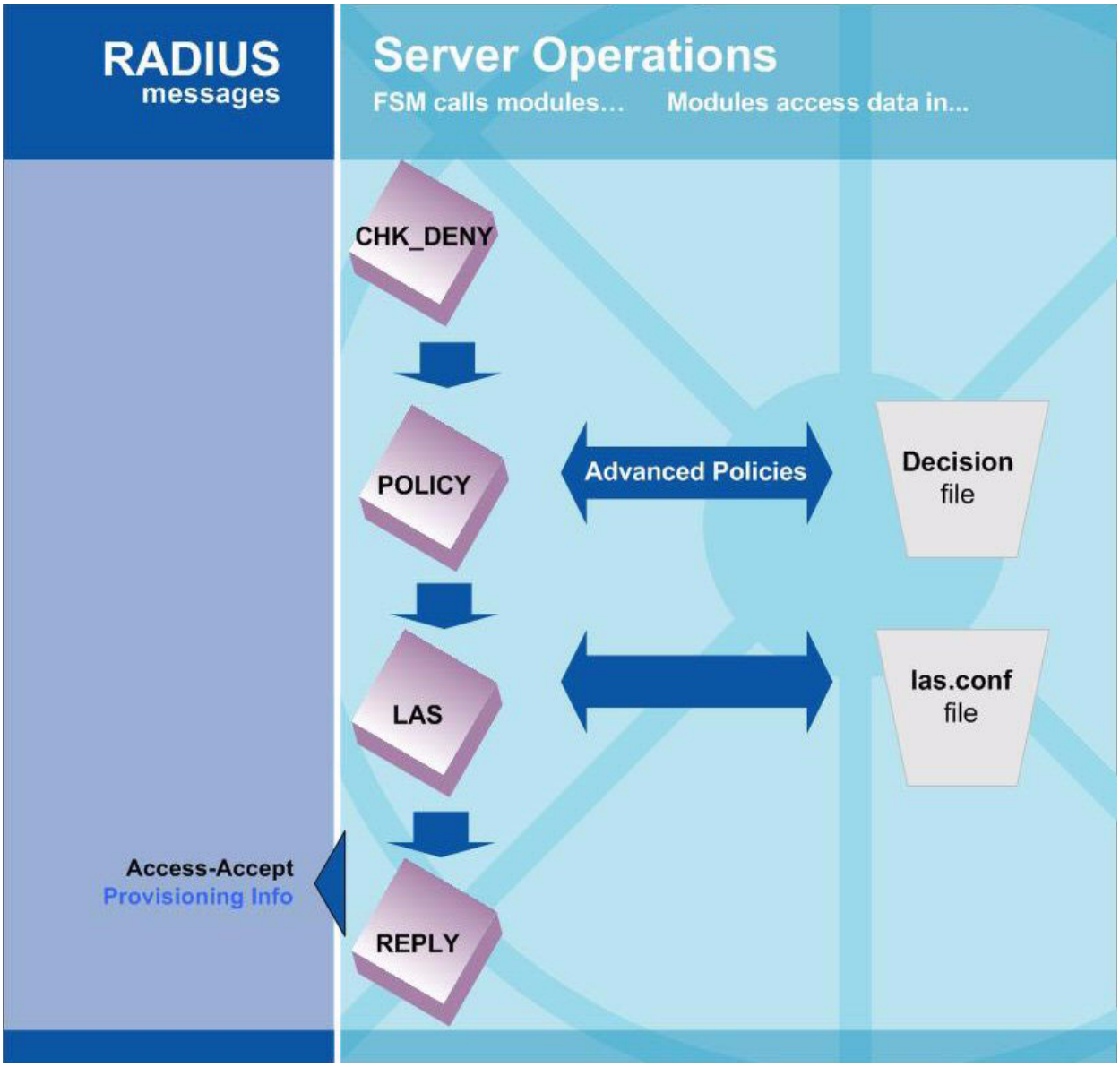
1 The server evaluates the request against any check and deny items stored with the user profile. For example: a check item indicating that the request must be from port 1 on the access device must match a corresponding `NAS-Port=1` A-V pair in the request for the request to be accepted.

2 If the Advanced Policy Engine is licensed and there is a `Policy-Pointer` attribute from the user or realm profiles, the server evaluates the authorization policy specified by the `Policy-Pointer` attribute.

3 The server retrieves realm authorization policies from the `las.conf` file (if LAS is enabled).

4 If all conditions are met, the server sends an Access-Accept message back to the access device.

If any conditions are not met, the server sends an Access-Reject message back to the access device, which disconnects the user.



Authorization flow in default Finite State Machine

Accounting

During operation with session tracking enabled for the realm, the AAA Server tracks information received in Accounting-Requests from the client in an active session table. When the session is stopped, the session record is written to the accounting log file. The predefined accounting logs follow the Interlink-MERIT format. To some degree, you can modify:

- Where and in what format the server generates the logs by editing the `log.config` file.
- When the logging occurs by editing the FSM table.

1 The access device sends an Accounting-Request to the server to start recording the session.

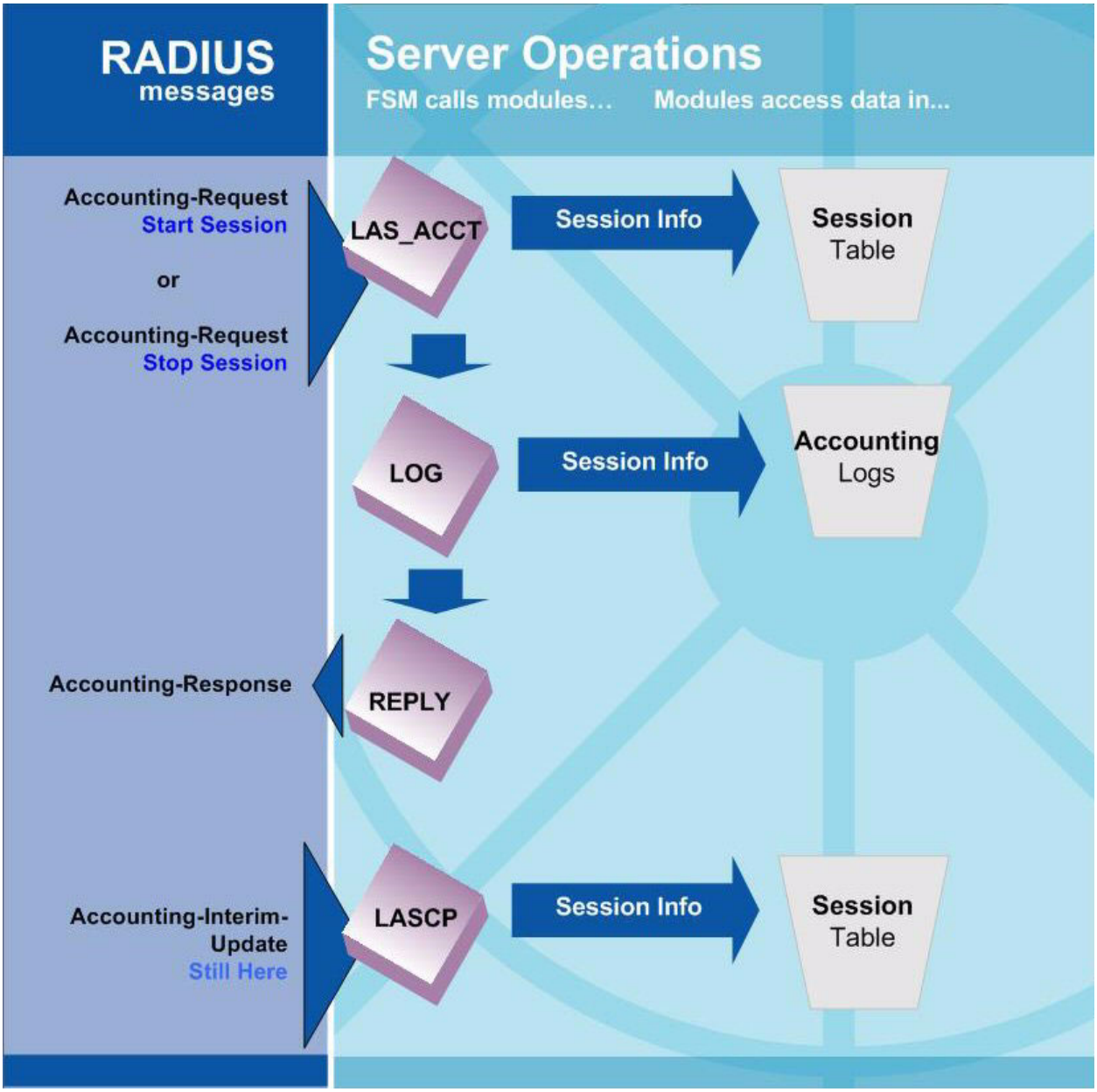
2 The server checks the `log.config` file for the realm's logging format.

3 The server begins tracking the session and sends an Accounting-Response to the access device to confirm this.

4 During the session, the access device and the server may exchange Accounting-Alive (Accounting-Interim-Update) messages to verify that the session is still active.

5 The access device sends an Accounting-Request message to the server to stop recording the session, which the server acknowledges with an Accounting-Response.

6 The server writes the session record to the accounting log.



Accounting Process

WLAN Security

With support for IEEE 802.1x functionality, the AAA Server provides security framework to support EAP authentication mechanisms for Wireless Local Area Network (WLAN) users. The AAA Server:

- Authenticates wireless users with password or non-password based mechanisms
- Supports dynamic key generation for data encryption between the access point and wireless stations

EAP Authentication

If the Access-Request message sent to the AAA Server indicates an EAP authentication method for this user, an EAP conversation is encapsulated within the RADIUS exchange that allows mutual authentication to take place directly between the user and server without intervention by the access device. Mutual authentication may be achieved by challenges and responses or exchanging certificates.

1 The access device sends the server an Access-Request containing the encapsulated EAP Identity Response message.

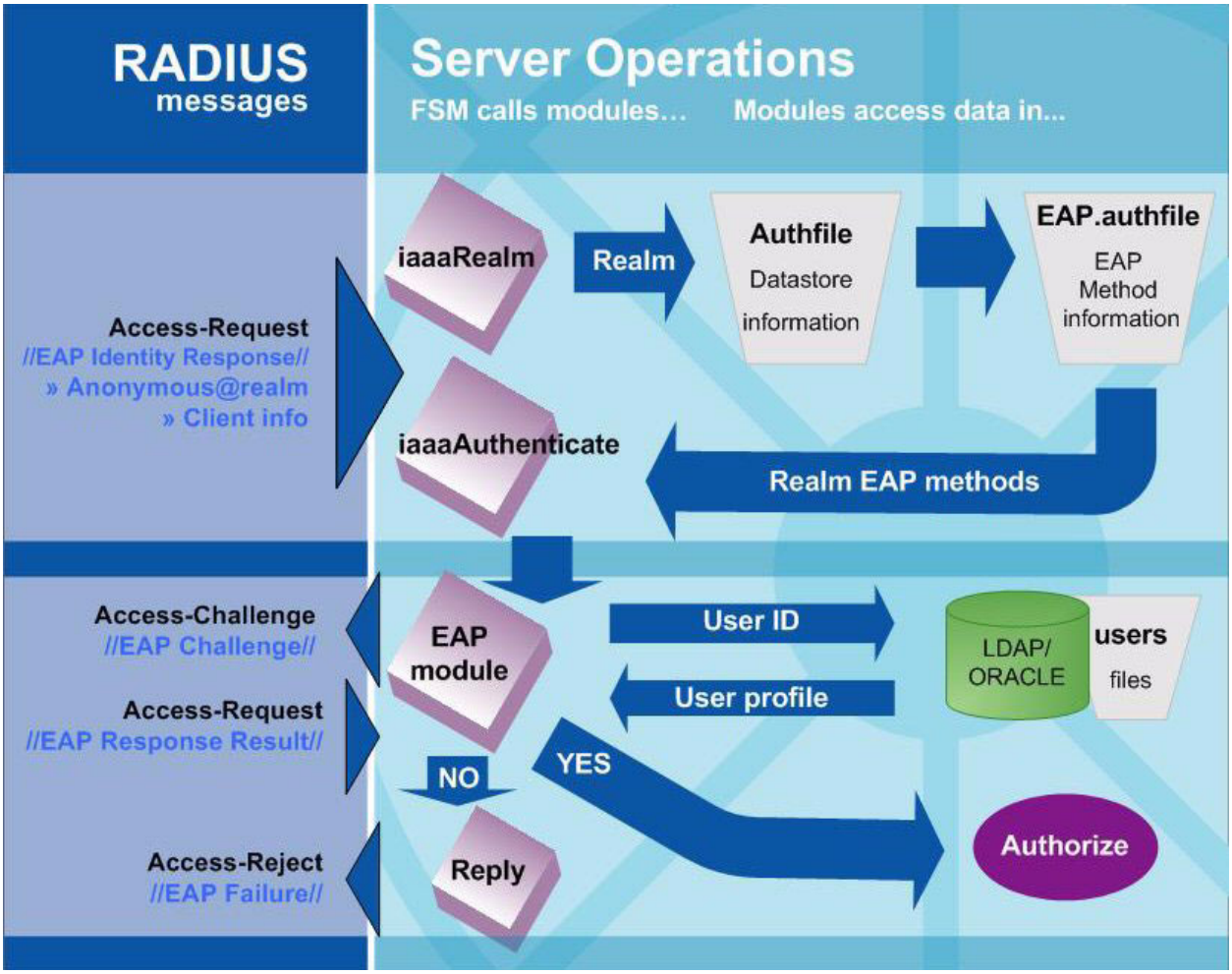
2 The Server checks for the user profile in the default users file and if found uses it for step 4.

3 If the username is not found in the default users file then the server finds the realm's user profile storage entry in the `authfile`.

4 The server issues its EAP challenge to the user and verifies the response.
   - The EAP module searches the user data store for a matching user profile.
   - The server sends an Access-Challenge with an encapsulated EAP message to the user via the access point. There may be several such exchanges.

5 If authentication succeeds, the server proceeds to authorization.

   If authentication fails, the server sends an EAP-Failure to the supplicant and an Access-Reject message to the access device, which disconnects the user.



EAP authentication using a single-phase challenge

Tunneled EAP Authentication

The TTLS and PEAP methods establish a tunnel for secure message exchange. In these methods, the authentication process is divided into two phases:

Phase 1: Secure communication is established between the realm user and the AAA Server.

Phase 2: Actual user authentication is performed.

Separating these operations also provides flexibility. For example, with TTLS you can proxy the authentication requests to a remote RADIUS server. This enables you to provide wireless access to users whose profiles are stored on a legacy RADIUS server that does not support EAP.

In TTLS and PEAP there is a server certificate but there is no client-side certificate to exchange, making it easier to administer a large number of users.

Tunneled methods often have an outer realm user, which is associated with the tunnel itself. This outer realm and "anonymous" user is configured with its own identity separate from the many inner realm users who are authenticated through the tunnel. In some cases (most PEAP implementations), the "outer" tunnel realm and the inner authentication realms bear the same name and there is no "anonymous" user.

1 The access device sends the server an Access-Request containing the encapsulated EAP Identity Response message. This message usually contains information for the outer realm user.

2 The server finds the tunnel realm's authenticator entry in the `EAP.authfile`.

3 The server authenticates the outer realm user.

4 If authentication succeeds, the server establishes a tunnel to the user machine.

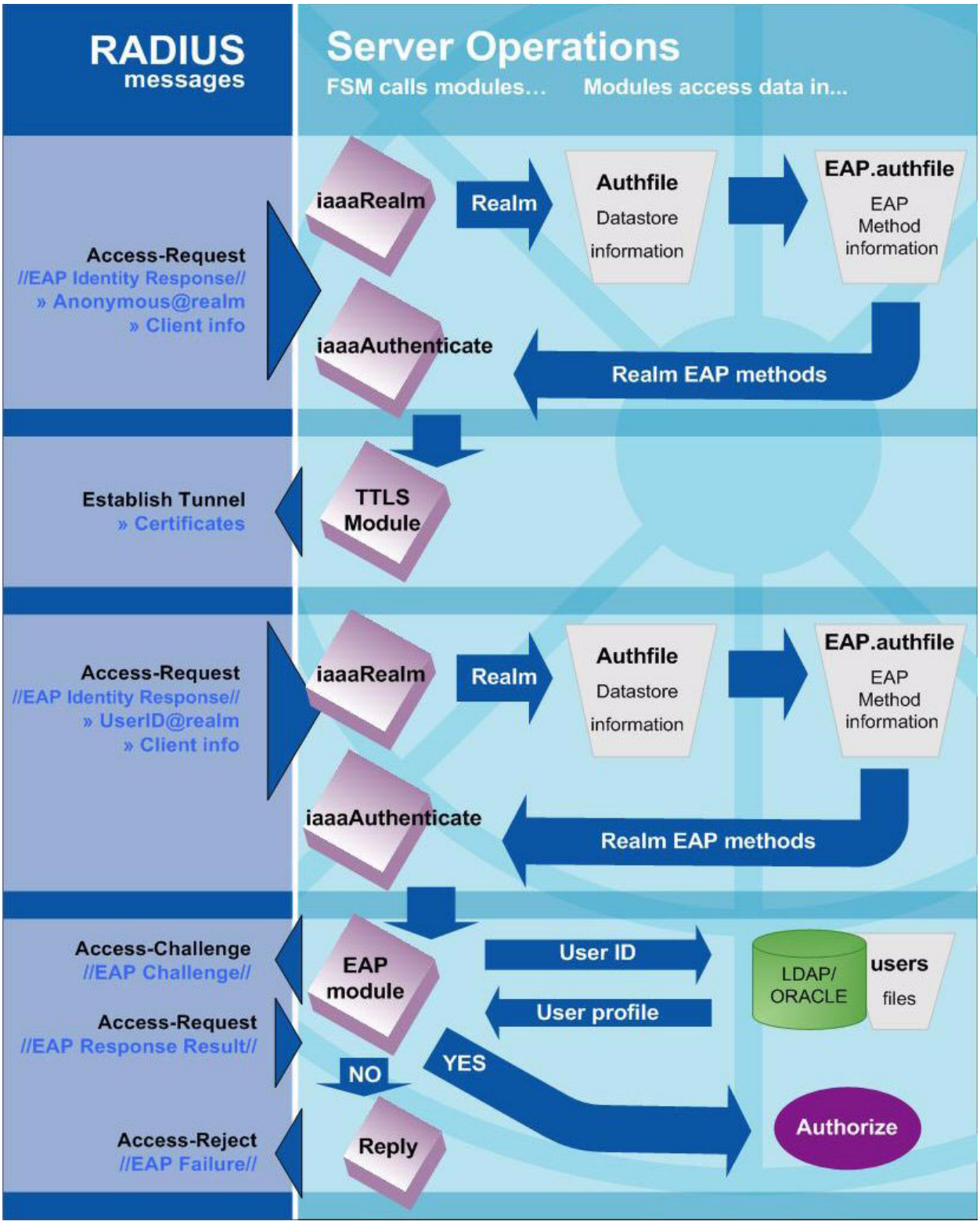
5 The user sends an Access-Request message through the tunnel containing the actual user information.

6 The server finds the inner realm's user profile storage entry in the `authfile`.

7 The server authenticates the actual user. This may utilize a second EAP method, such as EAP-MD5.
   - The EAP module searches the user DataStore for a matching user profile.
   - The server and user exchange Access-Challenges with encapsulated EAP messages through the tunnel.

8 If authentication succeeds, the server proceeds to authorization.

   If authentication fails, the server sends an EAP-Failure to the supplicant and an Access-Reject message to the access point, which disconnects the user.



TTLS authentication

Preparing the WLAN

A WLAN requires you to synchronize items on the supplicant, access point, and the AAA Server. The following table lists the items you need to synchronize on each node.

Item	Nodes	Notes
Shared Secret	Access Device Server	The shared secret configured on the access device and server must match for the two to communicate. Use the Access Devices link to configure this item on the servers.
EAP Support	Access Device	Most access devices require you to enable EAP. You do not need to specify an EAP method, but you must enable support for EAP.
EAP Method	Client Supplicant Server	Verify the supplicants support the EAP methods the server supports. Enable EAP on the supplicants. Configure the same EAP method on the supplicant and the server. Use the Local Realms link to configure this item on servers.
EAP Tunnel Realm	Client Supplicant Server	Required for TTLS. Verify the supplicant has an anonymous user configured on it and configure a tunnel realm for that anonymous user on the server. For example, if supplicant's anonymous user is: anonymous@tunnel.com, you should configure a realm for: tunnel.com. You must configure tunnel realms for TTLS. Configuring tunnel realms for PEAP is optional. Use the Local Realms link to configure this item on the server.
Users	Server	The server must have access to a repository with information for each user. The server supports several different methods for retrieving user information. Server Manager can administer user information stored locally in realm flat files. Use the Users link to administer the default set of users. Use the Local Realms link and select the users icon to administer a specific set of Users associated with a realm.
Client Certificate	Client Supplicant	For TLS only. The digital certificate identifying the client
Client CA Certificate	Server	For TLS only. Used by AAA Server to authenticate client certificates. Use the Server Properties link and select Certificate Path Properties. In the Certificate Authority Path field, configure the location of the client CA certificate on the server.

Item	Nodes	Notes
Server Certificate	Server	For TLS, TTLS, and PEAP only. The digital certificate identifying the server. Use the Server Properties link and select Certificate Path Properties. In the Certificate Path field, configure the location of the client CA certificate on the server.
Server CA Certificate	Client Supplicant	For TLS, TTLS, and PEAP only. Used by clients to authenticate the server certificate.

Choosing an EAP Method

Choose EAP methods based on your security requirements and the clients you support.

First, create an inventory of the wireless clients you support. Wireless clients need specific supplicant software for each EAP method (WLAN access devices must only support EAP). You must use supplicants that support the hardware platforms, operating systems, and WLAN cards in your environment. Ideally, you should try to use client hardware and software that allows you to use one EAP method for all your wireless clients. This may mean avoiding solutions that are proprietary or support only a small variety of clients.

Next, determine which of the following features are important to you:

1 Dynamic Key Exchange—Distributes a user-specific encryption key to the client and access device during the authentication process. Without this feature, all clients must share the same static encryption key.

2 Mutual Authentication—Protects against unauthorized (rogue) access points by allowing clients to authenticate the network they are connecting to.

3 Password-based Authentication—Clients provide a password to authenticate to the network. Typically the password is sent to the server in a hashed (one-way encrypted) form. If you are integrating with an existing password storage format, be sure the EAP method you chose is compatible with the password storage format. For the most flexibility, choose an EAP method that allows the AAA Server to access the password in clear text (for example, the PAP password format). Storing passwords in clear text requires you to use EAP methods that encrypt the channel between the client and the access point (like TTLS or PEAP).

4 Digital Certificate/Token Card-based Authentication—Uses a token card, smart card, or digital certificate assigned to each user for authentication. This feature must be deployed in an environment with supporting infrastructure—for example, an organization with a PKI and user-specific certificates.

5 Encrypted Tunnel—Establishes an encrypted channel to securely deliver authentication messages and encryption keys. The encrypted tunnel encapsulates another EAP method that provides the actual user authentication. Encrypted tunnels are good for securing authentication methods that are vulnerable when not encapsulated in an encrypted tunnel.

Supported EAP Methods

The following table lists the EAP methods the AAA Server supports and which of the above features each method offers. Use the table and your inventory information to help decide which EAP method to use.

EAP Method	Feature	Description
TTLS • PAP • CHAP • MS-CHAP • MS-CHAPv2 • EAP-MD5	1, 2, 3, 5	**Tunneled TLS**: Can carry additional EAP or legacy authentication methods, like PAP and CHAP. Integrates with the widest variety of password storage formats and existing password-based authentication systems. Supplicants available for a large number of clients. May use PAP, CHAP, MS-CHAP, or EAP-MD5 for inner realm authentication.
PEAP, v0 and v1 • EAP-MD5 • MS-CHAPv2 • EAP-GTC	1, 2, 5	**Protected EAP**: Functionally very similar to TTLS, but does not encapsulate legacy authentication methods. May use EAP-MD5, MS-CHAPv2, or EAP-GTC for inner realm authentication.
TLS	1, 2, 4, 5	**Transport Layer Security**: Uses TLS (also known as SSL) to authenticate the client using its digital certificate. Note: some supplicants require specific extensions to support certificates for EAP.
EAP-MD5	3	**Message Digest 5**: Passwords are hashed using the MD5 algorithm. Can be deployed for protecting access to LAN switches where the authentication traffic will not be transmitted over airwaves. Can also be safely deployed for wireless authentication inside EAP tunnel methods (see feature 5 above).
EAP-GTC	4	**Generic Token Card**: Carries user specific token cards for authentication.
EAP-AKA	1, 2, 4	**Authentication and Key Agreement**: Authentication is based on the use of a USIM or (R)UIM cards.
EAP-SIM	1, 2, 4	**Subscriber Identity Module**: Authentication is based on the use of a SIM card.

Note: If you are using TLS, TTLS, or PEAP, be sure you configure the required digital certificates after you configure all your realms.

Process for Securing WLANs

Below is the general process for using the AAA server to secure your WLAN. See the following sections of this guide for procedures explaining each of the steps.

1 Access Server Manager . See "Accessing Server Manager" on page 29.

2 If the server is remote, add the server to the Server Manager's Managed Servers list. See "Adding Servers" on page 30.

3 Load the AAA Server configuration into Server Manger. See "Loading Configurations into Server Manager" on page 38.

4 Identify the access devices that will send access requests to the AAA Server. See "Defining Access Devices" on page 40.

5 Configure tunnel realms if you are using TTLS. See "Defining Realms" on page 48.

6 Configure user authentication realms and user profile data stores. See "Defining Realms" on page 48.

7 Configure user profiles to identify each user accessing services through the AAA Server.

   If you are using local realm files or the default users file, see "Defining Users" on page 63.

   If you are using an LDAP directory, see "Using an LDAP Server" on page 111.

   If you are using an Oracle database, see "Using Oracle® Database" on page 118.

8 Configure digital certificates if you are using TLS, TTLS, or PEAP. See "Administering Digital Certificates" on page 58.

9 Deploy the configuration by:
   - Saving the configuration to one or more AAA Servers. See "Saving Configurations" on page 39.
   - Stopping and starting the AAA Server program. See "Server Administration" on page 32.

Understanding Server Manager

Server Manager is the browser-based application for remotely managing your AAA Servers. It provides administrator access to configuration, administration, and monitoring functions from any networked workstation with an Internet browser.

This section describes the Server Manager graphical user interface. It shows how to:

- Use the Server Manager navigational elements
- Select servers for configuration and administration

There are also instructions for reconfiguring the Server Manager:

- Administrative User Name and Password
- UDP Port Number
- Java Connector type (may use an SSL connection)

Navigating in Server Manager

The Server Manager screen contains four principal work areas

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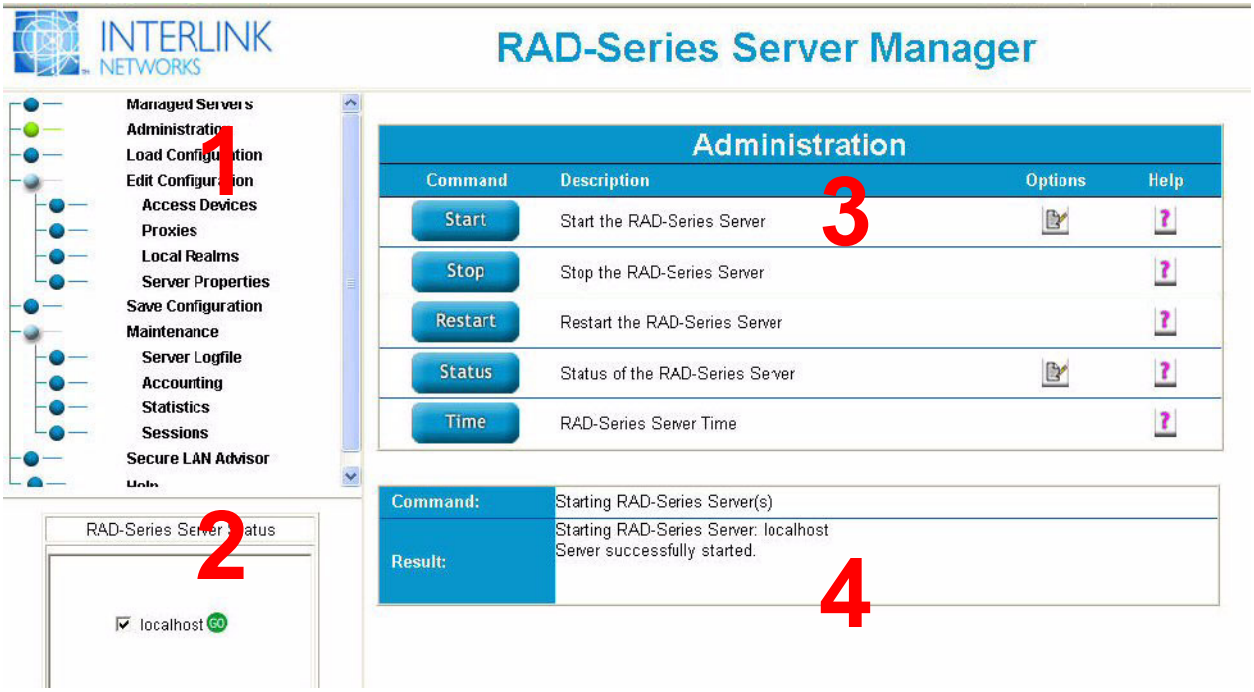

1. Navigation frame

The Navigation frame on the left of the screen lists the tasks you can perform on the selected AAA Servers. Clicking one of the links opens the corresponding page in the Workspace frame.

2. Server Status frame

The Server Status frame, located beneath the Navigation frame, allows you to select the AAA Servers to be managed before executing commands in the Workspace.

The icons next to each server indicate its current status.

- — Server Manager cannot connect to the administrative agent (RMI object) on the AAA Server.
- — the AAA Server is running.
- — the AAA Server is not running.

Note: If you do not see at least the localhost server listed in the Status frame after accessing Server Manager, it may be that the administrator workstation does not have the Java Run-time Environment installed, or that the Java login box is hidden, and you didn't finish authenticating to the run-time environment. See the *Getting Started Guide* for instructions on installing the JRE.

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3. Workspace frame

The Workspace frame is the main work area for the Server Manager. The content of this frame changes depending on the task you've selected from the Navigation frame.

For some tasks, pop-up dialogs appear above the Workspace frame for entering additional configuration parameters, for example, when configuring realm entries and setting LDAP directory attributes.

4. Message frame

The area below the Workspace frame displays the results of administrative operations, such as starting and stopping the server.

The Secure LAN Advisor

The Secure LAN Advisor is an HTML tutorial/help system in the Server Manager GUI that walks you through the tasks for securing WLANs with the AAA Server. The Secure LAN Advisor provides information only—it does not edit configuration files. Follow the Secure LAN Advisor while using Server Manager to create and deploy basic AAA configurations for securing WLANs.

Configuring Servers through Server Manager

Server Manager provides a temporary workspace for editing configurations. As you work, changes are stored in local temporary files before being saved to the actual server configuration files. There is only one set of temporary files in Server Manager, reflecting the server configuration that was last downloaded.

To configure your AAA Servers in Server Manager, you'll:

1 Select managed AAA Server(s).

2 Load the configuration files from a single AAA Server.

3 Edit the configuration as necessary.

4 Save the new configuration to the selected AAA Server(s).

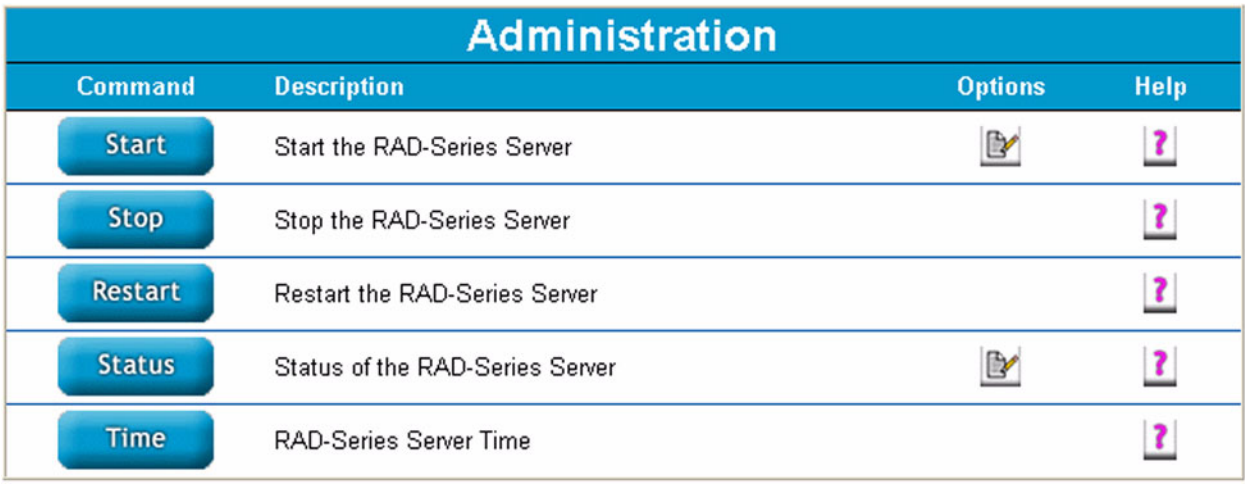
5 Stop and start the AAA Server(s) to activate the new configuration.

Managing Multiple Servers

The AAA Server Status frame in the lower left corner of the Server Manager screen shows a list of managed servers. This list enables you to see the current status of the servers, as well as to select them for administration.

Check the server in the Status frame to select it before executing commands in the Workspace.

Use the Server Manager Administration page to execute basic server commands. You can also use this page to change the server startup settings or reset the log files.



Server Manager can be used to view active session data, read server and accounting logs, and view server statistics. See "Maintenance" on page 87 for more information.

Configuring Server Manager

Certain features of the Server Manager program can be reconfigured in a text editor.

Changing the UDP Port Number

Server Manager uses two UDP port numbers to listen for information from the workstation browsers:

- Port 8080 for non-SSL (http) connections
- Port 8443 for SSL (https) connections

Port 8080 is enabled by default. To switch ports or to change either port number:

1 In a text editor, open the file `server.xml` (in `/opt/tomcat/conf` by default).

2 Locate the lines:

```
<Connector className="org.apache.coyote.tomcat4.CoyoteConnector"
      port="8080" minProcessors="5" maxProcessors="75"
      enableLookups="true" redirectPort="8443"
      acceptCount="100" debug="0" connectionTimeout="20000"
      useURIValidationHack="false" disableUploadTimeout="true" />
```

and:

```
<Connector className="org.apache.coyote.tomcat4.CoyoteConnector"
      port="8443" minProcessors="5" maxProcessors="75"
      enableLookups="true"
      acceptCount="100" debug="0" scheme="https" secure="true"
      useURIValidationHack="false" disableUploadTimeout="true" >
```

3 To switch from port 8080 to port 8443 (for SSL), remove the **<!--** and **-->** brackets surrounding the 8443 Connector tag and comment out the 8080 Connector tag by placing the brackets around it.

4 To change port numbers, change each instance of "8080" or "8443" to the port number you wish to use.

5 Save and close `server.xml`.

6 Stop and restart Server Manager.

Changing the Shared Secret

Information exchanged between AAA Servers and the Server Manager program is validated by a shared secret. This secret **must** be the same for all AAA Servers connected to the Server Manager.

1 In a text editor, open the file `gui.properties` (in `/opt/tomcat/webapps/aaa/WEB-INF` by default).

2 Find the line:

`rmi.config.secret = !!config.secret!!`

Replace `config.secret` with the shared secret you wish to use.

Note: In gui.properties, the slash character must be used as an escape for any special characters in your secret. rmiserver.properties does not require an escape character.

---

3 Save and close `gui.properties`.

4 For each server you have installed, repeat steps 2 and 3 for the file `rmiserver.properties` (in `/opt/aaa/remotecontrol` by default).

5 Stop Server Manager and Remote Control.

6 Start Server Manager and Remote Control.

Changing the User Name and Password

To change the Server Manager administrative user name or password:

1 In a text editor, open the file `aaa-users.xml` (in `/opt/tomcat/conf/` by default).

2 Find the line:

`<user name="`*`New-UserName`*`" password="`*`New-Password`*`" roles="tomcat" />`

Replace *`New-UserName`* or *`New-Password`* with the values you wish to use.

3 Save and close `aaa-users.xml`.

4 Stop and restart Server Manager.

Configuring Server Manager for SSL

To secure data passed between the AAA Server Manager program and your administrator workstations, we strongly recommend that you implement a Secure Socket Layer connection (https). Using SSL requires that, on the Server Manager host machine, you:

- Install Java Secure Socket Extension (JSSE) 1.0.2 or higher
- Create a keystore containing a new certificate
- Configure Server Manager for SSL

Install JSSE

1 Download the JSSE and unpack the JSSE distribution package.

2 Copy `jcert.jar`, `jnet.jar` and `jsse.jar` into the `/lib/ext` directory found in your Java home directory (`/opt/aaa/java` by default).

If this directory doesn't already exist in your Java home directory, create it.

3 If it does not exist, create the file `/lib/security/java.security` in your Java home directory.

4 Add the following to the `java.security` file:

```
security.provider.2=com.sun.net.ssl.internal.ssl.Provider
```

Create a Keystore and Certificate

The keystore is a repository file that contains keys and certificates. If you do not have an existing keystore, you'll need to create one and add a certificate for SSL to it.

You can create a certificate with the `keytool` utility included with the JDK. Refer to the JDK documentation for more information.

1 Change directory to the Java `bin` directory (`/opt/aaa/java/bin` by default).

2 Run `keytool`.

```
keytool -genkey -alias tomcat -keyalg RSA -keystore Keystore-path
```

For *`Keystore-path`* enter the full path of an existing keystore or specify a new one.

3 Follow the prompts to provide information about the keystore and certificate.

The final prompt asks for the certificate password. Make up a password and note it for use in `server.xml`. You can press Enter at this prompt.

The keystore will be created in the location you specified.

Edit Server.XML

1 In a text editor, open the file `server.xml` (in `/opt/tomcat/conf/` by default).

2 Locate and uncomment the following lines by deleting <!-- and -->:

```
<!--
<Connector className="org.apache.coyote.tomcat4.CoyoteConnector"
      port="8443" minProcessors="5" maxProcessors="75" enableLookups="true"
      acceptCount="100" debug="0" scheme="https" secure="true"
      useURIValidationHack="false" disableUploadTimeout="true" >
<Factory className="org.apache.coyote.tomcat4.CoyoteServerSocketFactory"
      keystoreFile="<<the keystore path specified when you ran keytool>>"
      keystorePass="<<the password specified when you ran keytool>>"
      clientAuth="false" protocol="TLS" />
</Connector>
-->
```

3 Edit the `keystoreFile` and `keystorePass` parameters. For example:

```
<Factory className="org.apache.coyote.tomcat4.CoyoteServerSocketFactory"
      keystoreFile="/opt/aaa/java/lib/security/mykeystore"
      keystorePass="topsecret"
      clientAuth="false" protocol="TLS" />
```

You can optionally change the UDP port number by replacing 8443 with the number you wish to use.

4 Comment out the Connector block for port 8080 by inserting <!-- and --> before and after it.

5 Add the JSSE `.jar` files to your `CLASSPATH` by adding these lines to the Server Manager `startup.sh` file (in `/opt/tomcat/bin` by default):

```
CLASSPATH=${CLASSPATH}:${JAVA_HOME}/lib/ext/jsse.jar
CLASSPATH=${CLASSPATH}:${JAVA_HOME}/lib/ext/jnet.jar
CLASSPATH=${CLASSPATH}:${JAVA_HOME}/lib/ext/jcert.jar
export CLASSPATH
```

6 Run `shutdown.sh` (in `/opt/tomcat/bin` by default) to stop Server Manager.

7 Run `startup.sh` (in `/opt/tomcat/bin` by default) to restart Server Manager.

Starting Server Manager

On the machine where you've installed Server Manager:

1 Open your terminal window.

2 Change directory to `/Server Manager directory/bin` (`/opt/tomcat/bin` by default).

3 Run `startup.sh`.

If the process fails to start:

4 Check the log file `catalina.out` (in `/opt/tomcat/logs` by default).

If you see the message "Root cause - Address already in use," the default port 8080 is already being used by another process.

5 At your shell prompt, enter `lsof -i :8080` to identify the process currently using port 8080.

6 Either change the Server Manager port or kill the process using the port.

Stopping Server Manager

To stop the Server Manager program:

1 Open your terminal window.

2 Change directory to `/Server Manager directory/bin`.

3 Run `shutdown.sh`.

Starting Remote Control

Remote Control is installed on remote servers to connect them to the Server Manager interface. This program must be started on the host machine before you can use Server Manager to connect to the server. On each remote machine where you've installed Remote Control:

1 Open a terminal window.

2 Change directory to the `/remotecontrol` directory (default is `/opt/aaa/remotecontrol`).

3 Run `rmistart.sh`.

Accessing Server Manager

Once the Server Manager program is started, to access the graphical user interface:

1 Open your browser and enter the URL `http://IP-address:Port/aaa` where:

- *IP-address* is the IP for the machine that hosts the Server Manager program.
- *Port* is the port number assigned to Server Manager. Default is 8080.

2 Enter the Server Manager username and password you choose at installation.

You'll see the Server Manager Administration page.

3 If this is the first time you're accessing Server Manager, enter the user name and password again to authenticate to the Java Run-Time Environment.

You'll see the Server Manager Administration page, with localhost listed in the Status frame.

Tip: Bookmark this page in your browser for ease of access later on.

If you see a Java run-time error in the Status frame, the workstation may not have the Java Run-Time Environment installed or the second Java logon box may be hiding behind some window, awaiting your entry.

Managed Servers

Server Manager utilizes the Remote Control program installed on the AAA Servers in your network to form a Java RMI connection to them. Once Server Manager connects to an AAA Server, it is listed among the Managed Servers. You can download and upload configuration and log file data or issue server commands.

This section shows how to:

- Add AAA Servers to the list to be managed through Server Manager
- Change managed AAA Server profiles
- Delete AAA Servers from the Managed Servers list

Adding Servers

All AAA Servers managed by the Server Manager are shown in the Server Status frame in the lower left corner of the screen. Follow these steps to add a server to the list.

Note: The server installed on the same machine as the Server Manager is automatically added as **localhost**. It uses the loopback (local) address 127.0.0.1.

1 In the Navigation frame, click Managed Servers.

2 Click the Manage New Server link.

3 On the Add Server page, enter the server's:
   - Name — label to identify the server in Server Manager
   - Fully-qualified Domain Name or IP address

4 Click the Create button.

   The AAA Server's name appears in the Status frame, along with its status.

Modifying Server Profiles

You can change the name, domain name or IP address for any AAA Server currently listed in the Server Manager Server Status frame. You can also modify AAA Server start options for those servers already in the connected state.

After a server has been connected, the Managed Server:Modify Server page shows a list of installation directories under Server Properties. These paths must match the server's actual file directories.

1 In the Navigation frame, click the Managed Servers link.

2 On the Managed Servers page, click the server name link.

3 Modify the fields as necessary.

4 Click the Modify button.

Deleting Servers

To remove an AAA Server from the Managed Servers list:

1 In the Navigation frame, click the Managed Servers link.

2 Click the  button next to the server name.

3 Click Delete to confirm the deletion.

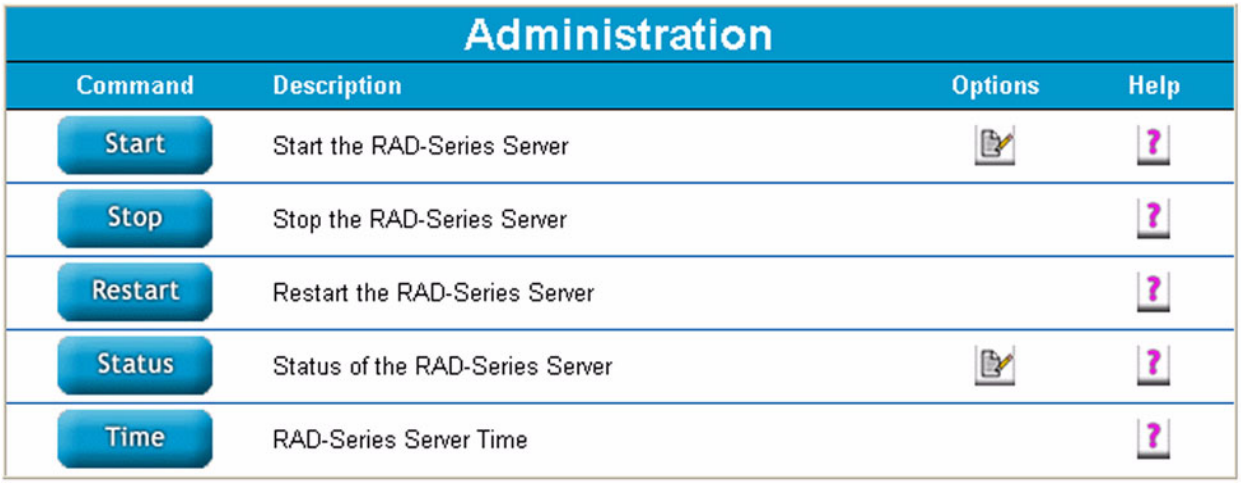
The server name should disappear from the Managed Servers page and the Server Status frame.

Server Administration

This section shows how to issue commands to:

- Start and stop the server
- Change the server's startup options
- Restart the server after changing configurations, without stopping the service
- Report on server status
- Change the options for the status check program
- Report on server time

The Server Manager Administration page provides controls for executing server commands.



The Message frame below the Administration page displays the most recently executed command and its result (server messages). Initially, this frame is empty.

Starting the Server

To start one or more AAA Servers:

1 In the Server Status frame, select the server(s) to start. Be sure only these servers are selected.

2 In the Navigation frame, click Administration.

3 Click Start.

You'll see the result of each server start in the Message frame. There should be a GO next to the server(s) in the Server Status frame.

Setting Server Start Options

Use the Server Start Options page to assign non-default arguments for AAA Server startup.

Note: These startup arguments are not part of the AAA Server configuration files. They are stored locally on the Server Manager and apply to all AAA Servers started by the Server Manager.

UDP Ports

You can change the port the server uses to listen for authentication or accounting requests from the UDP standard 1812 and 1813.

The authentication and accounting relay ports are used when forwarding requests to machines using different port numbers than the standard 1812 and 1813.

Debug Level

The debug level specifies the amount of detail written to the `radius.debug` file. You can set the debug level to a value between 0 and 4. Each level includes the information in the levels before it. Higher levels write more information to the debug file, slowing performance. Debugging is intended for limited time use for testing purposes.

Level	Description
0	No debugging (default)
1	Brief trace
2	High-level FSM output, some function tracing, A-V pairs, etc.
3	Full function tracing
4	Low-level FSM and configuration file output

Reset Logs

You can set the server's log file and session table to back up to a file with the extension `.old and` to restart each time the server is started. Clearing the log file also clears the debug file.

Note: Resetting the session table is only recommended for testing environments.

To Change Server Start Options

1 In the Navigation frame, click Administration.

2 Click the  button next to the Start button to display the Start Options page.

3 Make the desired changes.

4 Click OK.

Stopping the Server

To stop one or more AAA Servers:

1 In the Server Status frame, select the server(s) to stop. Be sure only these servers are selected.

2 In the Navigation frame, click Administration.

3 Click Stop.

You'll see the results of each server stop in the Message frame. There should be a 

next to the server(s) name.

Restarting the Server

The Restart function causes selected AAA Server(s) to reload a new configuration without first being stopped and restarted.

1 In the Server Status frame, select the server(s) to restart. Be sure only the desired servers are selected.

2 In the Navigation frame, click Administration.

3 Click Restart.

You'll see the results of each server restart in the Message frame.

You must stop and start the AAA Server to apply all server startup options and the following server properties:

- Server Certificate Path
- Certificate Revocation List Path
- Server Private Key Path
- Client Certificate Authority Path
- Random Seed Path
- Hold Replies

Reporting Server Status

Use the Status function to check the operational status of the selected AAA Server(s).

Note: To see extended output, a localhost entry in the server's Access Devices or Proxies list is required.

1 In the Navigation frame, click Administration.

2 In the Status frame, select the AAA Server(s) for which to report status.

3 Click Status.

You'll see the results of each status check in the Message frame.

Extended Server Status Output

The extended status message contains this additional information

Message Lines	Description
MF: vp=44/18 auth=1/0 waldo=0/0 redo=0/0 DNS-MF: client=4/0 addr=3/0 name=3/0 CLIENT-MF: vendor=20/0 vendor_list=6/0 (found=6) LAS-MF: sess=1/0 str=0/0 abs=0/0 db=0/0	Memory allocation information in the format of ***=allocated/freed*** for A-V pairs, authreqs, clients, IP addresses, DNS names, vendors, vendor lists and sessions.
Status: 0 authen, 0 unconfirmed, 0 connected, 0 suspended, 0 unknown Status: 0 disconn, 0 reject, 0 no-token, 0 cancel, 0 collision	Local Authorization Service statistics. Will report 0 for all statuses unless Session Tracking is enabled for some realm.
auth queue: Qmax(40000) hwm(1) Qcur(1) rReq(1) xAcc(0) xRej(0) rDup(0) rBad(0)	RADIUS authentication request statistics: queue maximum, high water mark, current number, received requests, transmitted accepts, transmitted rejects, duplicate requests, bad requests.
acct queue: Qmax(40000) hwm(0) Qcur(0) rReq(0) xResp(0) rDup(0) rBad(0)	RADIUS accounting request statistics: queue maximum, high water mark, current number, received requests, transmitted responses, duplicate requests, bad requests.
authfile (x) clients(x) users(x) Start time(x.x)	The number of: defined realms (in authfile), clients, users (in default users file) and the server's last start time.

Message Lines	Description
fsmid(default-4.01) dictid(1.29), vendid(1.9)	Version information for the finite state table, dictionary and vendors files. You can modify this information by changing the lines like: *%FileID Version-String* Where *FileID* is: • **FSMID** in a state table (.fsm) • **DICTID** in the dictionary file • **VENDORSID** in the vendors file *Version-String* is the version identifier you wish to assign to that file.
Version 7.4.0 AAA_POLL BINARY_AATV CHK_SHELLS CHK_TOKEN EMAIL LAS = 1.7.1 (NO-HGAS) Y2K	Server version and build information.
"t25(2026)" is responding	A success message. If radcheck fails, one of the following messages will appear: • No reply from server *Name (UDP-port)* • Received non-matching id in server response • Received invalid reply digest from server • No such server: *Name*
Number of retries(x)	Only appears when greater than 0.
Exit Codes	0 - Successful completion -2 or 254 - Remote server had errors -1 or 255 - Local errors 1 - Timeout errors

Changing Status Command Options

To change the values used in the Status command:

1 In the Status frame, select the server.

2 In the Navigation frame, click Administration.

3 Click the  button next to the Status button to display the Status Options page.

4 Change the:
- Timeout (Seconds)
- Number Retries

5 Click OK.

Reporting Server Time

To check the system time on servers:

1 In the Status frame, select the server(s).

2 In the Navigation frame, click Administration.

3 Click Time.
You'll see the results in the Message frame.

Load Configuration

This section shows how to load server configurations into Server Manager for editing.

Loading copies configuration files from a source AAA Server installation into the Server Manager workspace. You can download a configuration from any one server, edit it and save it to many servers.

Loading overwrites the temporary files in Server Manager's workspace with the selected server's active configuration files. If you do not save the previous set of configurations back to one of the connected servers, any work done in Server Manager is lost when you reload the configuration. Do not reload between sessions if you are still configuring the same server, unless you wish to revert to the active server configuration.

The Server Manager only shows configurations for the last server loaded. When you wish to work with a different server, save the current configuration (if you wish to preserve it), then load the new server.

Loading does not copy any server security certificates or other security files. Manually copy these files between servers if they are to be shared.

Loading Configurations into Server Manager

To copy an AAA Server configuration into the Server Manager temporary workspace:

1 In the Navigation frame, click Load Configurations.

2 In the Workspace frame, select the source server from which to copy.

3 Click the Load button. Wait until the transfer is confirmed.

Save Configuration

This section shows you how to:

- Save configurations after editing them in Server Manager
- Push configurations from one AAA Server to another

Server Manager preserves changes to the temporary files between sessions, but you must save to copy these changes to the server's actual configuration files. The changes will not take effect until you restart the server, so you can save changes any number of times without affecting the server operation.

You can save a configuration to any (or all) servers that have an active connection with the Server Manager program. This way, you can reconfigure several servers at once or push configurations from a test machine to a production machine. The Save page always shows from which server the configuration originated and lets you select to which it should be saved.

Note: Server Manager saves the entire workspace configuration (access devices, proxies, local realms, users and server properties) to the servers you select. It does not save server security certificates and other security files. You must manually copy these files between servers if they are to be shared.

Saving Configurations

1 In the Navigation frame, click Save Configurations.

2 In the Workspace frame, select the destination server(s). You can select as many as you wish.

3 Click the Save button. Wait until the transfer is confirmed.

Edit Configuration

This section contains instructions to configure the AAA Server's:

- Access devices — client devices sending Access-Requests to the server
- Proxies — other servers to or from which requests are forwarded
- Authentication realms — user realms authenticated by this server
- User data stores — files, directories, and databases from which the server will retrieve user profiles

There are also procedures for setting up:

- DHCP
- SNMP
- Server Properties

See "Using External Data Stores" on page 111 to configure the server for use with an LDAP directory or other external data store.

Defining Access Devices

In Server Manager, an access device is any other network device—Network Access Server (NAS) or wireless Access Point (AP)— from which the AAA Server will receive RADIUS service requests (aka its clients). It does not include proxy servers, which are configured separately under Proxies. The server configuration must include an entry for all the access devices that will communicate with the server.

These procedures modify the server's `clients` file.

See "Defining Proxies" on page 43 for instructions on defining proxy servers.

Using Wildcards

When specifying a client device name, you can use the * wild card to replace any portion of the IP address. For example, if the device name `15.*` is entered, then all clients in the "15." subnet can access the AAA Server. Similarly, if the device name * is entered, then any client can access the AAA Server.

The following wildcard patterns are allowed, where a, b, or c are numbers less than or equal to 255:

```
*, *.*, *.*.*, *.*.*.*
a.*, a.*.*, a.*.*.*
a.b.*, a.b.*.*
a.b.c.*
```

The wildcard patterns listed on the same line above are considered to be duplicates, since they will match the same set of IP addresses.

The more specific entries are given more precedence. For example: 15.12.* will have more precedence than 15.*. The entries are internally arranged to make this precedence effective.

Adding an Access Device

1 In the Navigation frame, click Access Devices.

2 Click the New Access Device link or  .

3 In Name, enter the device's IP address or fully-qualified domain name.

4 Enter and confirm the Shared Secret to be used between this device and the server.

The secret must be less than 1023 characters and cannot contain spaces.

5 The Vendors field determines which vendor-specific attributes are returned to the client in RADIUS messages. Use CTRL + Click to select all that apply.

Usually, it is sufficient to select the hardware vendor. If you don't want to send any VSAs, choose Generic.

6 To define additional instructions for handling Access-Requests, check the Option boxes. These are advanced features that are not required normally.

Option	Description
Debug	Dump packets into the server's debug output file. To use this option, you must set the server's debug level to > 0 in Server Start Options.
No Check	Do not check all attributes to determine if the request is a duplicate. This can be set to increase server performance if you know that the client sends standard messages that can easily be detected as duplicates.
No Encaps	Do not encapsulate vendor response.This option is useful if the client requires nonencapsulated A-V pairs.
Old CHAP	Use pre-RFC CHAP with this client.

7 Click Create.

Modifying a Device Definition

To change settings for an existing device:

1 In the Navigation frame, click Access Devices.

2 Click the device name link on the Access Devices page.

3 Change the settings.

4 Click Modify.

Deleting a Device

To completely remove a device from the server's list of clients:

1 In the Navigation frame, click Access Devices.

2 Click the  next to the device name on the Access Devices page.

3 Click Delete.

Defining Proxies

To proxy authentication or accounting requests with the AAA Server, identify both:

- Proxy servers that this server may receive requests from
- Remote servers that this server may proxy requests to

Self-referring Client Entry (localhost)

If the server has a self-referring client entry named **localhost**, the server Status command program (`radcheck`) will return extended information, such as authentication and accounting request statistics. This entry is automatically made in the Proxies list when the server is installed. Deleting it will change the Status command output to a single line, "*host* is|is not responding," but won't seriously alter server functioning. See "Reporting Server Status" on page 35 for a description of the extended output.

Note: The localhost entry shown in the Proxies list should not be confused with the loopback localhost that appears in the Server Status frame and corresponds to an AAA Server installed on the same host machine as the Server Manager.

Using Wildcards

When specifying a proxy realm name, you can use the wild card syntax, *`*.realm`*.

This syntax provides a shorthand for handling several realms the same way. For example, a company may have several branches, eastern.company.com, western.company.com, and central.company.com. Using the wildcard `*.company.com`, all three realms would be forwarded to the same server.

It does not matter in what order you enter regular or wildcard realm names in the Server Manager. When the server reads the realms it sorts the entries so that:

- Non-wildcard entries come first
- Wildcard entries of length *n* come before wildcard entries of < *n*.

This ensures that wildcard entries are used only when there is no exact match among the regular entries and that when there are several wildcards that may apply, the "best-fit" entry is selected.

Receiving Requests from a Proxy Server

To define proxy servers from which the AAA Server will receive authentication requests:

1 In the Navigation frame, click Proxies.

2 Click the New Proxy link.

3 In Name, enter the IP address or fully-qualified domain name of the proxy server.

4 In Shared Secret, enter the string used to establish trust between the proxy server and the AAA Server.

The shared secret cannot be more than 1023 characters long or contain spaces.

5 The Vendors field determines which vendor-specific attributes are forwarded to the server in RADIUS messages. Use CTRL + Click to select all that apply.

Usually, it is sufficient to select the hardware vendor. If you don't want to send any VSAs, choose Generic.

6 Check the Response options to define any additional instructions for handling Access-Request messages. Unless you have special requirements, you probably do not need any options.

Options are:

Option	Description
Check All	Check all attributes to determine if the response is a duplicate. This may be necessary if the remote server sends non-standard messages that can't easily be detected as duplicates.
Debug	Dump packets into the server's debug output file. To use this option, you must set the server's debug level > 0 in Server Start Options.
Prune	Forces pruning as if the response were being returned by an access device. Using Prune with the Generic vendor option prunes all vendor-specific attributes before a message is returned to the proxy server.

7 Click Create.

Proxying Requests to a Remote Server

To configure the AAA Server as a proxy to a remote server:

1 In the Navigation frame, click Proxies.

2 Click the New Proxy link.

3 In Name, enter the IP address or fully-qualified domain name of the remote server.

4 In Shared Secret, enter the string used to establish trust between the remote server and the AAA Server.

The shared secret cannot be more than 1023 characters long or contain spaces.

5 The Vendors field determines which vendor-specific attributes are to be forwarded to the remote server in reply messages. Choose all that apply; if there are no special requirements, choose Generic.

Use CTRL + Click to select more than one.

6 Enter all the Realms to forward to the remote server:

- Choose Add New Realm from the drop-down menu.
- On the Proxy Realm dialog, enter the realm Name.
- To Forward Accounting as well as authentication requests, click the Yes option button.
- Click Save.

Repeat this step for each realm to be proxied.

7 To send authentication requests to a port other than the default 1812, enter the port number in Authentication Relay Port.

This number overrides any relay port you set up under the server's start options.

Note: The current RADIUS default ports are 1812 and 1813. Older RADIUS servers may listen for requests on ports 1645 and 1646.

---

8 To send accounting requests to a port other than the default 1813, enter the port number in Accounting Relay Port.

This number overrides any relay port you set up under the server's start options.

9 To send all A-V pairs when returning messages to the authentication server, turn on (Yes) Append Attributes.

10 Click Create.

Modifying a Proxy Configuration

To change the settings for any proxy relationship between the AAA Server and another server:

1 In the Navigation frame, click Proxies.

2 Select the other server from the Proxies list.

3 Change the settings as necessary.

To stop proxying a realm:

- Select the realm from the Realms to Forward drop-down menu.
- Click Delete.

To change ports: enter the new Authentication Relay Port or Accounting Relay Port number.

To stop forwarding accounting messages:

- Select the realm from the Realms to Forward drop-down menu.
- Change the Forward Accounting selection to Yes or No.

4 Click Modify.

Deleting a Proxy Configuration

To completely stop receiving requests from or forwarding requests to a remote server:

1 In the Navigation frame, click Proxies.

2 Click the  button next to the server name the Proxies list.

3 Click Delete.

Proxying Accounting Requests to a Central Server

By modifying the Finite State Machine table (.fsm), you can forward all received accounting messages to a central server. This configuration will disable all local accounting for all realms normally handled by the AAA Server.

To forward accounting for a single realm, follow the steps in "Proxying Requests to a Remote Server" on page 45.

To proxy all accounting:

1 Complete the steps to add the server to your Proxies list.

2 In a text editor, open `radius.fsm` (by default in `etc/opt/aaa/`)and locate the lines:

```
AcctWait:
      *.*.ACK          ACCT_SWITCH    AcctLog
      *.*.ACCT_DUP     ACK            ReplyHold
```

Replace them with:

```
ACCTwait:
      *.*.ACK          RAD2RAD        ReplyHold    Xstring="central.server"
      *.*.ACCT_DUP     RAD2RAD        ReplyHold    Xstring="central.server"
```

where "*central.server*" is the fully-qualified domain name or IP address of the central accounting server which must be found in the `clients` file.

3 To forward the accounting to a port other than 1813, modify the `clients` file for that port, see "Proxying Requests to a Remote Server" on page 45.

4 Save and close `radius.fsm`.

5 Stop and start the server.

Defining Realms

Generally, a realm is a group of users who share a common characteristic, such as being employees of the same company, division, department, or subscribers to the same internet service. All users of a given realm are:

- Stored in the same location
- Authenticated by the same protocol
- Identified by their User-Name attribute value (e.g.: userid@realm)

Define a **separate** realm for each group of users who:

- Use different authentication protocols
- Use different domain names
- Are stored in different locations (different directories or files)

You may also need multiple realms if using two-phase EAP methods, such as TTLS. For more information on configuring AAA Servers for WLAN and 802.1X environments, use the Secure LAN Advisor from the Server Manager Navigation frame.

These procedures modify the server's `authfile` and `EAP.authfile`.

About Realms

Realm vs. Domain

A domain refers to a fully-qualified domain name registered with DNS. The realm name may or may not be a domain name. For example, the NULL realm exists to accommodate users who are not associated with any domain name, but who still require authentication.

In general, we recommend that if users in a realm are required to supply a domain name upon login, the domain name be used as the realm name—for example, yourcompany.com. Similarly, any flat file used to store user profiles for this realm should also bear the realm name.

NULL Realm

The NULL realm is defined in the default server configuration. This is beneficial to those people who manually edit the las.conf file to add the NULL realm and store the users in the default users file.

The NULL realm can be reconfigured to handle authentication requests where the user doesn't supply a domain name, such as for Windows domains. Any time a user name does not contain the realm portion of the NAI format *userid@realm*, the server automatically considers the user part of the NULL realm and applies the authentication method defined for NULL.

The default users file, found in fresh installations of the server, is used for testing the server installation and is set to perform password authentication on the default test_user. Remove this user from the file when you are done testing the initial installation.

There can be only one NULL realm per server. However it can exist once with each of the possible protocol options.

Wildcards

The wildcard * can be used in authentication realm names, as well as for proxy realms. See "Using Wildcards" on page 43 for more information.

Configuring TTLS Authentication

If you are using TTLS to authenticate users, you will need to define at least two realms for the group:

- One realm to establish the tunnel to the outer realm user (e.g.: anonymous@tunnelrealm.com)
- Inner authentication realms that indicate where user profiles are stored and the authentication method that will be used to authenticate actual users

When defining a TTLS tunnel realm, the name must match what has been configured on the client device as the anonymous user's realm name. Usually, this is the primary domain for the organization. When defining the inner authentication realms, the name should be the group's own logon domain name or else use the NULL realm.

TTLS can be used to authenticate users on legacy RADIUS servers, once the tunnel has been established to secure the connection between the user and the AAA Server.

The process for configuring TTLS realms is:

1 Configure your TTLS clients, so you know the realm of the anonymous user.

2 Add a tunnel realm.

3 Either:

Add authentication realm(s) for the inner users.

or

Configure the AAA Server as a proxy to the legacy server where users will be authenticated. See "Proxying Requests to a Remote Server" on page 45.

4 Generate and install server-side certificates and keys. See "Administering Digital Certificates" on page 58.

Add a Tunnel Realm

To add a TTLS tunnel realm:

1 In the Navigation frame, click Local Realms.

2 Click the New Local Realm link or  .

3 In Name, enter the anonymous user's realm name as set up on the user machines.

4 In Realm Type, choose TTLS Tunnel.

5 Click Create.

Add Authentication Realms

Follow the steps in "Defining Authentication Realms" on page 52 to add the authentication realm.

- In Realm Type, choose Authentication.
- For TTLS with PAP or CHAP, select Password Authentication for the Security Method.
- For TTLS with EAP, select EAP Authentication for the Security Method, then choose all the methods set up on your clients from the drop-down list. Use CTRL + Click to select more than one.

Configuring PEAP Authentication

PEAP implementations use the same realm name for the outer and inner user, even though it is a two-phase authentication method. You need only one authentication realm for each domain name.

You cannot authenticate users on a legacy RADIUS server with PEAP.

The process for configuring PEAP realms is:

1 Configure your PEAP clients.

Note: PEAP client software is installed with Windows® XP Service Pack 1 and 2 and third-party supplicants.

---

2 Add authentication realm(s) for the inner users.

3 Generate and install server-side certificates and keys. See "Administering Digital Certificates" on page 58.

Add Authentication Realm

Follow the steps in "Defining Authentication Realms" on page 52 to add the authentication realm.

- In Realm Type, choose Authentication.
- For the Security Method, choose EAP Authentication, then select the all the PEAP methods set up on your clients from the drop-down list. If you are using any third party supplicants that do not support PEAP version 1, you will need to select "PEAP Version 1 Disabled".

Configuring TLS Authentication

TLS does not access a data store for user profiles. Instead, this method requires certificates to be installed on both the AAA Server and on each user workstation.

The process for configuring TLS realms is:

1 Add authentication realm(s).

2 Generate and install server- and client-side certificates. See "Administering Digital Certificates" on page 58.
   - For the server, you will need two certificates: a CA (certificate authority) certificate and a server-specific certificate.
   - For each user workstation, you will need the same CA certificate and a client-specific certificate. Client certificates must have the User-Name in the field that was selected in Server Properties -> Certificate Properties -> Client User Name Attribute. See "Client User Name Attribute" on page 71.

Add Authentication Realm(s)

Follow the steps in "Defining Authentication Realms" on page 52 to add the authentication realm.

- In Realm Type, choose Authentication.
- In User Profile Storage, choose No Store - EAP TLS Certificates.

Defining Authentication Realms

Follow these steps to define each user realm to be authenticated by the AAA Server.

See the Secure LAN Advisor (found in the Navigation frame) for more detailed information on configuring AAA Servers for WLAN and 802.1X environments.

1 In the Navigation frame, click Local Realms.

2 Click the New Local Realm link or  .

3 In Name, enter the domain name users enter at login.

4 In Realm Type, choose Authentication.

5 In User Profile Storage, choose the type of data store you're using for this realm.
- LDAP — LDAP directory
- Local Storage — flat file identified by name in User Storage Parameters
- No Store - TLS — authenticate using client and server security certificates, rather than user profiles
- No Store - Allow — no authentication, allow all users in this realm
- No Store - Deny — no authentication, deny all users in this realm
- Oracle — Oracle database. Requires special licensing option.
- OS Security Database — UNIX password storage
- SecurID/ACE server — RSA SecurID identification and authentication. Requires special licensing option.
- KTH Kerberos IV — authenticate against a KTH Kerberos version IV server. Requires special licensing option.
- CNS Kerberos IV — authenticate against a CNS Kerberos version IV server. Requires special licensing option.

6 Enter any additional User Storage Parameters that appear:
- LDAP — complete steps in "Identifying LDAP Directories" on page 53
- Local Storage — enter unique realm file name or select the default users file
- Oracle — complete steps in "Identifying Oracle Servers" on page 56

7 Select the Security Method:
- For PAP, CHAP, or MS-CHAP, choose Password Authentication.
- For all other 802.1X methods, select EAP Authentication, then choose all the methods set up on your clients from the drop-down list.

Use CTRL + Click to select more than one option.

You can use the `authfile` to manually define custom authentication types. See "Authfile Entry Syntax" on page 186 for instructions.

8 To define a packet filter for the realm, enter the filter name in Filter ID.

This will override any explicit filters defined in user profiles.

9 To limit concurrent sessions, click Yes to enable Session Tracking.

Note: Enabling Session Tracking sets the number of concurrent sessions to the global Simultaneous Use value set in Session Table Properties under the Server Properties page. You can override this number by defining a Simultaneous-Use value for an individual user in the user profile.

10 Click Create.

Identifying LDAP Directories

When you choose LDAP from the User Profile Storage drop-down list on the Add a Realm page, a set of additional parameters appears under User Storage Parameters. These fields let you identify the LDAP directories from which the AAA Server will retrieve user profiles.

1 To treat *`userid`* as binary, case-sensitive, choose `BIN` for the `Filter-Type`. To treat *`userid`* as case-insensitive, choose `CIS` for the `Filter-Type`.

2 To search the LDAP Directory based on an attribute from the request other than the default one, User-Id, change the `Request-Attribute-For-Search` field to the desired attribute name.

3 From the drop-down list that appears in User Profile Storage Parameters, choose New LDAP Directory.

4 On the LDAP Directory dialog, enter the following fields:

Field	Description
Directory Name	Name of the directory that appears in the Server Manager drop-down list. This does not have to be the actual directory name, just an identifier.
Host	IP address or fully-qualified domain name of the host the LDAP directory runs on.
Port	TCP port number the LDAP directory runs on. If no value is given, defaults to either 389 for non-SSL or 636 for SSL ports.
Use SSL	Enable (Yes) or disable (No) SSL between the AAA Server and this LDAP directory. If using SSL, also specify the server's CA certificate path and file in the Server Properties:ProLDAP group.
Administrator	*Distinguished Name (dn)* of the administrative user permitted to search the LDAP directory. This ID should match the ID you set up on your directory for the AAA Server. This user must have read access to all the users to be authenticated by the AAA Server and their passwords. If this field is omitted, the server will perform a bind to the directory using the user credentials from the Access-Request if it is necessary to validate the user's password.

Field	Description
Password / Confirm Password	Password used by the Administrator to bind to the LDAP directory server. Enter it twice to confirm it.
Search Base	Pointer into the directory where the AAA Server will begin to search for users in this realm. Enter a comma-delimited list of A-V pairs that represent the directory levels, no spaces.
Filter	LDAP filter attribute.
Access Mode	Determines the mode to be used to access this LDAP server for this LDAP directory. The default Access Mode is Auto. • Bind When binding as the user for authentication is desired. No Policy-Pointers, check items, or reply items will be returned to the RAD-Series server when Bind is specified. • Search When a LDAP search as the configured administrator is desired. The RAD-Series server expects the user's password in the search result. The RAD-Series server must perform an administrator search on the LDAP server when Policy-Pointers, check items, or reply items must be returned. • Auto When a LDAP search as the configured administrator (search anonymously if no configured administrator) is desired. After the search the RAD-Series server expects the password to be returned in the search results. The RAD-Series server binds as the user if the password is not available. Policy-Pointers, check items, and deny items will not be returned by the LDAP server if the RAD-Series server reverts to bind. This mode can affect performance, since two LDAP operations may occur for one authentication. IMPORTANT: You must use Auto with a Microsoft Active Directory.

5 Click Save.

6 To associate other LDAP directories with this realm, repeat Steps 3 through 5.

Each realm may be configured with up-to-four redundant LDAP directories, which are used by the server when it performs load balancing and failover.

7 Complete the procedure to add or modify the realm.

Modify a Directory Configuration

To change the information entered for any of the defined LDAP directories:

1 Click Local Realms, then click the  button next to the realm name to display the Modify Realm page.

2 Select the directory from the User Storage Parameters drop-down list.

3 On the LDAP Directory dialog, make the necessary changes.

4 Click Save.

5 Click Modify.

Delete a Directory

1 Click Local Realms, then click the  button next to the realm name to display the Modify Realm page.

2 Select the directory from the User Storage Parameters drop-down list.

3 On the LDAP Directory dialog, click Delete.

4 Click Modify.

Identifying Oracle Servers

When you choose Oracle from the User Profile Storage drop-down list on the Server Manager Add a Realm page, a set of additional parameters appears under User Storage Parameters. These fields let you identify the Oracle daemon (`db_srv`) that will retrieve user profiles for the AAA Server.

1 From the drop-down list that appears in User Profile Storage Parameters, choose New Oracle Server.

2 On the Oracle Server dialog, enter the following fields. All are required:

Field	Description
Database Name	Name for this Oracle database to appear in the User Storage list. Does not have to be the database name in Oracle.
Host	IP address or fully-qualified domain name of the db_srv daemon host machine.
Port	TCP port number the db_srv daemon uses for authentication messages.

Each listed server must have a unique host name and port (you cannot have two servers running on the same machine and listening to the same port number).

3 Click Save.

4 To associate other Oracle servers with this realm, repeat Steps 2 through 4.

Each realm may be configured with up-to-32 redundant Oracle servers, which are used by the server when it performs load balancing and failover.

5 Complete the procedure to add or modify the realm.

Modify an Oracle Server Configuration

To change the information entered for any of the defined Oracle servers:

1 Click Local Realms, then click the  button next to the realm name to display the Modify Realm page.

2 Select the server from the User Storage Parameters drop-down list.

3 On the Oracle Server dialog, make the necessary changes.

4 Click Save.

5 Click Modify.

Delete an Oracle Server

1 Click Local Realms, then click the  button next to the realm name to display the Modify Realm page.

2 Select the server from the User Storage Parameters drop-down list.

3 On the Oracle Server dialog, click Delete.

4 Click Modify.

Modifying a Realm Definition

To change settings for an existing authentication realm:

1 In the Navigation frame, click Local Realms.

2 Click the realm name link on the Local Realms page.

3 Change the settings.

4 Click Modify.

Deleting a Realm

To completely remove an authentication realm:

1 In the Navigation frame, click Local Realms.

2 Click the  next to the device name on the Local Realms page.

3 Click Delete.

Administering Digital Certificates

TLS, TTLS, and PEAP use certificates for authentication. To configure realms using these methods you must:

- Generate certificates and the corresponding private keys for the RADIUS server.
- Install signed certificates and private keys in the server's directories.
- For TLS, you must also generate certificates and private keys for each user workstation that will access the network.

If you are supporting multiple realms, configure digital certificates after you've added all of your realms.

You can deploy digital certificates in an environment with supporting infrastructure—for example, an organization with a PKI and user-specific certificates.

Using the "Self-Signed" Digital Certificates

The AAA Server creates a unique set of "self-signed" digital certificates during installation that are based on its DNS name. Server Manager uses these certificates by default. You can use the self-signed certificates in production environments for TTLS and PEAP and in testing environments for TLS.

The self-signed server certificates are in `/etc/opt/aaa/security/`. They are:

- `rsa_cert.pem` — server certificate
- `rsa_key.pem` — server key
- `ca_list.pem` — list of client CA certificates
- `sampleclientcert.p12` — sample client certificate
- `root.cer` — CA for server certificate

For TTLS and PEAP

If you are using TTLS or PEAP, the default certificates are safe to deploy in your production environment. The AAA Server is its own Certificate Authority. If you are managing multiple AAA Servers, you must have the same set of digital certificates on each server in your configuration. Pick one of your AAA Servers and copy the set of self-signed digital certificates to every AAA Server in the configuration. You should save each AAA Server's original self-signed certificates for future use.

Copy /etc/opt/aaa/security/root.cer to the CA storage on supplicants that enable server certificate checking.

For TLS

If you are using TLS, use the default certificates to simulate and troubleshoot TLS certificate administration before you deploy your own enterprise certificates.

1 Copy /etc/opt/aaa/security/root.cer to the CA storage on the supplicant.

2 Copy /etc/opt/aaa/security/demouser.p12 to user the certificate storage on the supplicant:
   - The pass phrase for sampleclientcert.p12 is: 1234
   - The user name for sampleclientcert.p12 is: demouser@eap.realm

3 Configure a TLS realm for eap.realm on the AAA Server

Using Your Own Digital Certificates and Keys

If you don't use the default self-signed AAA Server certificates, you must generate certificates and the corresponding private keys for the RADIUS server and (when using TLS) each workstation that will access your network services. To acquire a server- or client-specific certificate, submit a certificate signature request (CSR) to a certificate authority (CA), such as Verisign or Microsoft.

Note: For TLS, the same Certificate Authority must be used to sign certificates for both the AAA Server and the user workstation.

Obtaining Certificates and Creating Keys

Follow these steps to create a CSR and corresponding key:

1 Start the AAA Server that will be authenticating access requests.

2 Create or choose a directory for the certificates and your private key. Because the private key is stored unencrypted, it is very important to restrict access to the directory.

3 Use the OpenSSL Certificate Request Generator or another utility to create two files:
- the key, `rsa_key.pem`
- the CSR, `rsa_cert.pem`

To create these files with openssl, enter the following at the command line prompt:

```
openssl req -new -nodes -out req.pem -keyout Key-location
```

For Key-location specify the `rsa_key.pem` file, including the path of the directory you have chosen to store the server- or client-specific key. For example: `/etc/opt/aaa/security/sa_key.pem`.

Note: Do not protect the key with a passphrase.

4 You will be prompted to enter information that will be used to generate the private key file and CSR file. Complete the information according to the following table:

Field	Enter
Country code	Two-letter ISO code for your country. The code for the United States is US.
Organizational unit name	Name of the division, department, or other organizational unit that will be authenticated using this certificate.
Organization name	Name of your organization. Verisign may require any host names to belong to a domain registered to this organization.
E-mail address	The e-mail address that should be used to receive the certificate.

Field	Enter
Locality name (city)	Name of your city or town. If you operate with a license granted by a city, this field is required; enter the name of the city that granted your license.
State name	Name of the state or province in which your organization operates. Do not abbreviate.
Common name	Fully-qualified domain name of the server or client that will use this certificate.

5 Submit the CSR to VeriSign or another certificate authority. Request the certificate in Base-64 format.

You will receive the server- or client-specific certificate through the e-mail address you specified when you used openssl to generate the CSR or the certificate may be downloaded from a web page.

How the certificate is submitted and delivered varies according to the certificate authority that you use. For example, a CSR is submitted to Microsoft and the certificate is downloaded from a web page.

Installing Server Certificates and Keys

1 Add the CA certificate to the `ca_list.pem` file (found in `/etc/opt/aaa/security/` by default) by copying and pasting the contents of the certificate.

2 Copy the files for the server-specific certificate and key contents into the AAA Server security directory (`/etc/opt/aaa/security/` by default).

Installing Client Certificates and Keys

For each user workstation where you will make a TLS connection:

1 Install the CA certificate in the Trusted Root Certification Authorities store.

2 Install its user-specific (or computer-specific) key and certificate:
- Install computer-specific certificates in the Local Computer certificate store. Set the Subject Alternative Name property to match the FQDN of the wireless client computer account, which should be the same as the User-Name (userid@realm).
- Install user-specific certificates in the Current User certificate store. Set the Subject Alternative Name property to match the universal principal name (UPN) or common name of the user account, which should be the same as the User-Name (userid@realm).

Defining Digital Certificate Locations

The AAA Server uses the default self-signed certificates by default. If you want to use your own certificates, you must define where the required certificates reside on the server.

1 Click Server Properties in the Navigation Tree.

2 Click Certificate Path Properties in the Main Screen.

3 Click each of the following links in the Workspace area, then enter the full path and click Create:

- Certificate Path: For TLS, TTLS, and PEAP. Full path to the AAA Server certificate in `.pem` or `.cer` format.
- Private Key Path: Full path to the file in `.pem` or `.cer` format that contains the private key used to generate the AAA Server certificate. This file cannot be encrypted.
- Certificate Authority Path: For TLS, TTLS, and PEAP. Full path to the CA certificate for the client certificate. Used by the AAA Server to authenticate client certificates. The CA certificate for the client certificate must be in `.pem` format.
- Random Seed Path: For TLS, TTLS, and PEAP. Full path to the random seed used to generate keys.

Defining Users

User profiles may be stored locally (in realm flat files or the default users file) or in an external source, like an LDAP directory. Use the procedures in this topic to add users to realm files for local storage. Otherwise, use the interface to your data repository to add user profiles. If you have a small number of users from different realms, you can store all of their profiles in the default users file.

The following procedures modify the realm file you specified when configuring the realm.

For information on using LDAP storage, see "Using External Data Stores" on page 111.

User A-V Pairs

User profile information is stored as a set of A-V pairs. These A-V pairs mostly fall into two primary groups:

- Check/deny items--for authorization (simple policy). This includes checking for Service Type, NAS/Login ID, Caller/Calling Station ID, etc.
- Reply items--for provisioning. This includes any session data returned to the access device, such as session control limits, filters, callback numbers, IP addresses, port limits, and reply messages.

The Server Manager creates standard RADIUS A-V pairs based on your selections and writes them in the realm file user entry. Some information, such as vendor-specific attributes, are entered on the Add User page Free tab using A-V pair syntax. All user A-V pairs, whether entered through the Server Manager GUI or directly into the file, represent a **one-to-one match** between the attribute and a specified value. You cannot specify lists of values for any single user attribute.

Note: Wireless access points that adhere to the 802.1X standard should support the reply item attributes utilized by Server Manager. Verify the capabilities of your access points with the access point vendor.

See "Configuration Files" on page 176 for user A-V pair syntax and a description of Interlink-specific user attributes. Standard RADIUS attributes are defined in the server's dictionary file, by default in `/etc/opt/aaa`.

User Name Formats

A user name in Network Access Identifier (NAI) format should look like *userid@realm*, for example: "you@yourcompany.com." When adding users to local realm files, supply only the *`userid`* part of their NAI format login string.

Adding User Profiles

To add new users to a realm file:

1 In the Navigation frame, click Local Realms for users stored in a realm file or click Users for users stored in the default users file.

2 If you clicked Local Realms then click the  button next to the realm name.

3 Enter the User Name and click Create.

Note: User Name must be less than 64 characters and cannot contain &, ", ~, \, /, %, $, ', or spaces. Include only the *userid* portion of the NAI format user name except in the default users file which needs the full NAI.

---

4 Complete the authentication information on the General tab:

- Enter a Password and Confirm Password. The password cannot contain the \ character.
- To store passwords in hashed form, choose a Password Hashing Mechanism compatible with the user's authentication method.

Note: For PEAP, and TTLS, choose a password hashing mechanism compatible with the inner realm authentication method.

Authentication Method	Hashing Mechanisms
PAP	Any
MS-CHAP	Plain Text or NT Hash
EAP-GTC	Any
EAP-MD5	Plain Text or MD5 Hash
EAP-TLS	none

5 If you do not need to specify any other information for this user, click Create again.

Otherwise, follow the procedures in "Controlling and Provisioning Sessions" on page 65 to complete the user profile form, then click Create.

Controlling and Provisioning Sessions

Complete the Server Manager Users page tabs to enter provisioning information, such as:

- Filters
- Session limits
- Point of access

Session control attributes appear as check, deny, or reply items in the realm file.

Specify Login Service Type

To configure users for login service types (such as dumb-terminal access):

1 Complete the steps to add a new user.

2 On the General tab, choose Login from Service Type drop-down menu.

3 Click the NAS/Login tab and complete the relevant Login fields.

Specify Framed Service Type

To configure dial-up users for framed service types:

1 Complete the steps to add a new user.

2 On the General tab, choose Framed from Service Type drop-down menu.

3 Click the Framed tab and select the Framed Protocol to use.

4 Optionally, complete any of the other Framed fields.

Set Timeout Values

1 Complete the steps to add a new user.

2 On the General tab, enter:
   - Session Timeout — how many consecutive seconds user can access the service.
   - Idle Timeout — how many consecutive seconds of idle connection time can pass before the session is terminated.

Establish Filters

If you've defined filters on your access devices, you can specify which filter to apply to the user. You can only associate one filter with the user.

1 Complete the steps to add a new user.

2 On the General tab, enter the filter name exactly as set up on your device in Filter ID.

Establish Callback Number

If you're setting up a callback service type.

1 Complete the steps to add a new user.

2 On the General tab, choose one of the Callback Service Type(s) from the drop-down menu.

2 Enter **either**:

Callback Number to dial exactly this string of numbers

or

Callback ID name of a place and number to be interpreted by the access device.

Control Access by Device

To limit users to access only through specific devices:

1 Complete the steps to add a new user.

2 Click the NAS/Login tab and enter the NAS IP address.

3 Optionally, enter:

- NAS Port — port number that must appear in an Access-Request for authorization to succeed
- NAS ID — NAS identifier that must appear in an Access-Request for authorization to succeed
- NAS Port Type — if NAS differentiates among its ports

Assign a Static IP Address

1 Complete the steps to add a new user.

2 Click the Framed tab and enter the IP address in Framed IP Address.

3 If the user is a router to a network, also enter the Framed IP Netmask.

Define DHCP Address Pool

Use this to associate an address pool with the user if you're using the AAA Server as a DHCP relay. Be sure to also enable DHCP in Server Properties. See "Using DHCP" on page 78.

1 Complete the steps to add a new user.

2 Click the Free tab and enter the A-V pair: `Address-Pool=`*`name-of-pool`*.

Control Access by Dial-Up Number/MAC Address

This configuration limits the user to calling from or to the specified dial-up number or, in the case of a wireless network, to the station's MAC address.

To deny access to specific numbers/addresses, such as 800 numbers, see "Deny Access" on page 68.

1 Complete the steps to add a new user.

2 Click the Others tab.

3 To allow the user to only call **from** a specific phone number or machine, enter the number or MAC address in the Calling ID field.

To allow the user to only call **to** a specific phone number or access point, enter the number or MAC address in the Called ID field.

Set Reauthentication Session Timeout

For wireless users, you can set how often (in seconds) the access point will attempt to reauthenticate the user. If authentication fails, the access point terminates the session.

To do this procedure you must enable Session Tracking for the user's realm. See "Defining Authentication Realms" on page 52.

Note: Some access points do not properly support session tracking with RADIUS accounting messages.

---

1 Complete the steps to add a new user.

2 Click the Free tab and in Reply text enter:

```
Terminate = 1
```

3 In Check text, enter:

```
Session-Timeout = Number of seconds
```

Override Concurrent Session Limit

To do this procedure you must enable Session Tracking for the user's realm. See "Defining Authentication Realms" on page 52.

Note: Enabling Session Tracking sets the number of concurrent sessions to the global Simultaneous Use value set in Session Table Properties under the Server Properties page. You can override this number by defining a Simultaneous-Use value for an individual user in the user profile.

---

1 Complete the steps to add a new user.

2 Click the Free tab and in Check text enter:

```
Simultaneous-Use = Max-number-sessions
```

Set Port Limit

If you're using Multilink PPP, you can set the maximum number of ports that may be assigned to the user for a single session.

1 Complete the steps to add a new user.

2 Click the Others tab and in Port Limit enter the maximum number of ports.

Deny Access

To deny a user access through a specific connection point:

1 Complete the steps to add a new user.

2 Click the Free tab and in Check text enter any or all of the following:
- `NAS-Port != Port-number`
- `NAS-ID != value`
- `Calling-Station-ID != AP-MAC-address`
- `Called-Station-ID != dial-up number`

Policy-Pointer

Advanced policy can be used apply special criteria for deciding if the user should be allowed in or which reply items to return. It can be invoked by defining the `policy-pointer` attribute with the decision file name as its value. See "User/Realm policy" on page 127 for information on using this attribute.

1 Complete the steps to add a new user.

2 Click the Free tab and in Check text enter the following:
- `Policy-Pointer = file.name`

NOTE: You need the Advanced Policy Engine license to implement an advanced policy.

Modifying a User Profile

1 In the Navigation frame, click Local Realms for users stored in a realm file or click Users for users stored in the default users file.

2 If you clicked Local Realms then click the  button next to the realm name.

3 Click the  button next to the User Name.

If you don't see the user listed, enter the User Name at the top of the page and click Search.

4 Change the entries on any of the five User tabs.

Note: To change the password hashing mechanism, first reenter and confirm the password.

---

5 Click Modify.

Deleting Users from Realm Files

To remove a user profile from the realm file:

1 In the Navigation frame, click Local Realms for users stored in a realm file or click Users for users stored in the default users file.

2 If you clicked Local Realms then click the  button next to the realm name.

3 Click the  button next to the user name on the User page.

4 Click Delete.

Defining Server Properties

Use the Server Properties page to change the default AAA Server settings.

These procedures modify the server's `aaa.config` and/or `las.conf` files.

Modifying Server Properties

1 In the Navigation frame, click Server Properties.

2 Click the link to the group of properties you wish to modify.

3 Change the values.

4 Click Modify.

See the topics below for a list of configurable properties.

Certificate Properties

These properties specify the location of certificates used in TLS, TTLS, and PEAP authentication. Any security files that were not installed with the server must be manually installed in these directories.

Server Certificate Path (optional)

Used in EAP-TLS, TTLS, and PEAP message processing. Full path to the server certificate in `.pem` or `.cer` format. The default is `/etc/opt/aaa/security/rsa_cert.pem`, which is a self-signed certificate created at installation time.

Server Private Key Path

The full path to the private key file associated with the server certificate for EAP-TLS, TTLS, and PEAP. This file cannot be encrypted. The default is `etc/opt/aaa/security/rsa_key.pem`.

Client Certificate Authority Path (optional)

Used in EAP-TLS, EAP-TTLS, and EAP-PEAP message processing. Full path to the CA certificate used to sign the server certificate. The default is `etc/opt/aaa/security/ca_list.pem`, which is created with the self-signed server certificate at installation time.

Certificate Revocation List Path (optional)

Used in EAP-TLS message processing. Full path to a list of prohibited client certificates in `.pem` or `.cer` format. No default is set. If this path is specified but no CRL file is found, the server will not authenticate.

Random Seed Path (optional)

Used in EAP-TLS, EAP-TTLS, and EAP-PEAP message processing. Full path to the random seed file. This file may contain any type of random data. The default is `etc/opt/aaa/security/random.rnd`, which was created during server installation.

Client User Name Attribute

Used only for TLS authentication. The name in the client certificate used to validate the User Name from the TLS Access-Request. Choose which field and attribute to match:

- **Subject:CommonName** (default) — Use the CommonName (CN) from the Subject field.
- **Subject:EmailAddress** — Use the Email Address (E) from the Subject field.
- **SubjectAltName:RFC822Name** — Use the RFC822Name from the SubjectAltName field of the certificate's subject alternative name extension.
- **Check all attributes** — Search all of the above three fields.

DHCP Relay Properties

These properties are used to configure the AAA server as a DHCP relay agent. For more information, see "Using DHCP" on page 78.

DNS Update Properties

These properties determine how the AAA server resolves IP addresses with DNS.

DNS Refresh Interval

Interval in seconds at which to refresh the IP addresses for Access Devices and Proxies that have been configured by host name. Default is 3600.

DNS Refresh Time Frame

When a DNS entry for a configured client expires (needs refreshing), all other clients that would normally be refreshed within this number of seconds are refreshed immediately. Default is 60.

Message Handling Properties

These properties determine how the AAA server performs RADIUS message handling.

Hold Replies

Number of seconds the AAA server holds a request after replying to it in case a retransmission is necessary. Default is 6. The value should be twice the default retransmission period of the access devices involved. This does not apply to packets that are forwarded to another server. If set to 0, a special behavior is invoked where the AAA server does not change the hold time for a request.

Note: Using the special value of 0 or a hold time greatly in excess of the retransmission policy of an access device may cause the authentication and accounting queues to grow too large.Tailor this value by the *total* and *holding* values reported on a per-request basis.

Global Retry Limit

Maximum number of retransmissions allowed before a RETRY event occurs (a RETRY event is similar to a TIMEOUT event and should be caught by the default FSM). The purpose of this is to catch an authentication request and perform some action when a certain number of retransmissions from an access device occur. The default is 0 and no limits are imposed.

Max. Accounting Requests

The maximum number of active accounting requests to be handled by the AAA server. The default is 40000. When this limit is exceeded, the server drops the request and logs the event.

Hold Accounting Requests

The number of seconds the AAA server holds an accounting request after replying to it. This hold time allows the server to capture duplicate requests. Default is 0. Specify a value that is twice the retransmission interval configured on the access devices. This value overrides the global value set with the Hold Replies parameter.

Max. Authentication Requests

The maximum number of active authentication requests to be handled by the AAA server. Default is 40000. When this limit is exceeded, the server sends an Access-Reject message and logs the event.

Hold Authentication Requests

The number of seconds the AAA server holds an authentication request after replying to it. This hold time allows the server to capture duplicate requests. Default is 0. Specify a value that is twice the retransmission interval configured on the access devices. This value overrides the global value set with the Hold Replies parameter.

Max. Send Message Size

The maximum size in bytes for an outbound RADIUS packet. Default is 16536.

This property is primarily intended for debugging a customized server configuration that might transmit very large packets. Limiting it to be the UDP MTU for the network will prevent excessively large packets from being forwarded (or replied to) in certain circumstances. The minimum value is 4096.

Max. Receive Message Size

The maximum size in bytes for an inbound RADIUS packet. Default is 16536.

This property is primarily intended for debugging a customized server configuration that might transmit very large packets. Limiting it to be the UDP MTU for the network will prevent excessively large packets from being forwarded (or replied to) in certain circumstances. The minimum value is 4096.

Miscellaneous Properties

These properties are used for performance tuning and other server behavior.

Microsoft Host-Based Authentication

If enabled (Yes), the server will strip "host/" from the EAP-Identity sent by Microsoft clients configured to authenticate as computer on a wireless connection. When using TLS authentication, the remaining string is compared to the selected Client User Name Attribute field in the client certificate. When using PEAP/MSCHAPv2 authentication, the remaining string is used as the inner-realm userid. Enabled (Yes) is the default.

Maximum Log File Size

The maximum size in bytes of the server log file and accounting log file. The minimum value for this parameter is 65536; the maximum is 2147483647 (default).

ProLDAP Properties

These properties specify how the server interacts with LDAP servers. They are global properties used for all LDAP servers.

TLS CA certificate directory

Used if SSL is enabled for the connection to the LDAP servers. The path to a directory containing individual Certificate Authority files. This is used if there is no single TLS CA certificate file specified. No default is set.

TLS CA certificate file

Used if SSL is enabled for the connection to the LDAP servers. The full path of a single file containing certificates for all the Certificate Authorities that clients will recognize. Always used before TLS CA certificate directory. No default is set.

TLS certificate file

The TLS RAD-Series server certificate file specifies the file that contains the certificate that the RAD-Series server will use. This parameter is necessary if any of the LDAP directories are configured to use SSL and require validation of the LDAP client certificate. There is no default value.

TLS private key file

The TLS RAD-Series server private key file specifies the file that contains the private that the RAD-Series server will use. This parameter is necessary if any of the LDAP directories are configured to use SSL and require validation of the LDAP client certificate. There is no default value.

OpenLDAP Debug

Enables or disables OpenLDAP debugging. Output is written to the `radius.debug` file. The default is 0, disabled. A value of -1 maximizes LDAP debugging. See the OpenLDAP documentation for additional debug levels.

LDAP version

The version of the LDAP protocol to employ. The default value is 3. If your LDAP server requires version 2 of the protocol, enter that number here.

Timeout for TCP connect

Time in 1/10 seconds after which the AAA server stops waiting for a TCP connection to an LDAP server to complete. Default is 30 (3 seconds).

LDAP timeout

Time in seconds after which the AAA server stops sending a request to an LDAP server if it has not replied to the request. Default is 60.

Minimum wait before retry

Time in seconds the AAA server waits between requests to an LDAP server when there is no current connection for the data store. Default is 1.

Retry interval

In the event multiple LDAP servers are configured for a data store and at least one is connected, the interval in seconds at which the AAA server tries to connect to the remaining LDAP servers. Default is 60 seconds.

Session Table Properties

These properties determine how the AAA server records active session table information.

Session Hold Time

Time in seconds the AAA server waits before removing a session in the Stop state. Default is 300 (5 minutes).

NOTE: This is **NOT** the time the AAA server waits for an Accounting-Start message. That time is 15 seconds plus the value of Token-Hold-Adjustment. After that time elapses without an Accounting-Start message, a session is moved into the Not-Confirmed state and does not count against a Simultaneous Use limit.

Session Kill Time

Time in seconds AAA server waits before completely removing a session in the Not-Confirmed, Disconnected, Rejected, or Collided state. Default is 300 (5 minutes).

Session Clear Time

Time in seconds the AAA server waits before removing a session in the Suspended state. Default is 1815 (30 minutes 15 seconds).

Session Check Time

Interval in seconds at which the AAA server checks for changes to the session table and writes them to the `session.las` file. Default is 300 (5 minutes).

Session Idle Time

Time in seconds the AAA server waits for a check point message before suspending a session. Default is 915 (15 minutes 15 seconds).

Session Update Time

Time in seconds between updates to the status of sessions. Default is 5.

Token Hold Adjustment

The time in seconds a token may be held after a session is accepted yet no confirmation is received after the request is released by the engine. A token may be held up to 15 seconds plus Token-Hold-Adjustment. Default is 5.

Auto Save Interval

Time in seconds between saving of the sessions to the session.las file by the AAA server. Default is 300 (5 minutes).

Simultaneous Use

The maximum number of active sessions users may have, unless a user-specific value is configured that overrides this number. The default value is 1. The value -1 sets no limit. The value 0 prevents access to any user that does not have a specific value configured.

Session Table Limit

The maximum number of sessions that can be held in the Session Table. When this number is met, authentication requests that would normally result in a new session are ignored. Default is 2147483647 (maximum allowed).

SNMP Properties

This property, Enable SNMP Support, turns on (Yes) or off (No) SNMP monitoring. The default is No.

For more information, see "Using SNMP" on page 77.

Tunneling Properties

This property, Tunneling Reply Items, specifies what the server should do with VPN tunneling attributes configured as reply items for a user entry if the Access-Request contains no tunneling hints. Make a selection from the drop-down list.

For more information, see "Tunneling" on page 82.

Using SNMP

The AAA Server can exchange information with any Simple Network Management Protocol (SNMP) master agent software that supports the AgentX protocol (see RFC 2741 for more technical information about this protocol).

At startup the server automatically activates its SNMP subagent if SNMP is enabled and the subagent registers the application with the SNMP master agent.

Enabling and Disabling SNMP

1 In the Navigation frame, click Server Properties.

2 Click the SNMP Properties link.

3 Click Yes to Enable SNMP or No to Disable SNMP.

4 Click Modify.

MIB Objects

Information exchanged through SNMP is represented by objects in the Managed Information Base (MIB). The MIB includes extensions for RADIUS authentication and accounting servers that are supported by the AAA Server. The MIB objects that the AAA Server will interpret to the SNMP master agent are defined in the files:

- RADIUS_ACC_SERVER_MIB.txt
- RADIUS_AUTH_SERVER_MIB.txt

These files can be found in the server's configuration directory, by default `/etc/opt/aaa/`.

Since the AAA Server performs both authentication and accounting functions, some of the MIB objects return duplicated information.

All of the MIB objects that are sent to the management workstation by the server in response to SNMP requests are read-only, except for radiusAuthServConfigReset and radiusAcctServConfigReset, which allow a write operation.

Note: When you check the AAA Server status, the server will increase the radiusAuthServTotalAccessRequests count but will not increase radiusAuthServAccessRequests for any client. This behavior will result in a total authentication request count that will not equal the sum of requests received by individual clients.

See RFCs 2619 and 2621 for a description of the MIB objects for RADIUS authentication and accounting servers.

Using DHCP

The AAA Server can be configured to act as a DHCP relay to request IP address assignments from a DCHP server and pass them to an access device. You can associate DHCP address pools with either individual users or realms.

The AAA Server does **not** support:

- DHCP server failover
- Relay agent information option
- Dynamic DNS updates

See RFC 2131 for more technical information about the DHCP protocol.

Required DHCP Server Features

Required Features	Recommended Features
Assign addresses from its IP address pools based on the User Class or Vendor Class Identification attribute.	Assign IP addresses outside the network it resides in. Many RADIUS/DHCP deployments will require this capability. Send to ports above the well-known port range (0-1023).Without this capability the AAA Server will not be able to run as a non-root process.

Process for Using DHCP

To use the AAA Server as a DHCP relay, you'll need to:

1 Configure the AAA Server for DHCP.

2 Set up realms for DHCP.

3 Define DHCP address pools for realms or specific users.

4 Configure the DHCP server to synchronize with the AAA Server's DHCP properties.

5 Stop and start the AAA Server. See "Server Administration" on page 32 for instructions.

Configuring the AAA Server for DHCP

1 In the Navigation frame, click Server Properties.

2 Click the DHCP Relay Properties link.

3 On the DHCP Relay screen, select Yes to Enable DHCP Support.

4 Enter either the:

DHCP Server Name — fully qualified domain name of the DHCP server

or

DHCP IP Address — IP address of the DHCP server

5 If necessary, change any of the following defaulted values:

Property	Description
DHCP Server Port	The UDP port on the DHCP server to which DHCP requests are sent. Default is 67.
DHCP Relay Port	The UDP port on the AAA server at which DHCP responses are received. Default is 67.
Client Hardware Type	Value passed to the DHCP server to indicate hardware type. Options are: 0 (NONE) or 1 (ETHER). Default is 1.
Initial Retransmission Interval	Interval in seconds before the initial retransmission of a request to the DHCP server. Default is 4. The AAA Server will double the retransmission interval for each subsequent retransmission.
Maximum Retransmission Interval	The maximum interval in seconds at which the AAA server retransmits DHCP requests. Default is 60.
Maximum Discover Retransmissions	The maximum number of retransmissions AAA server makes when acknowledging IP address assignments from the DHCP Server. No default is set.
Maximum Request Retransmissions	The maximum number of retransmissions AAA server makes when requesting IP address assignments from the DHCP Server. No default is set.
Maximum DHCP Message Length	The maximum size in bytes of messages that can be received from the DHCP server. No default is set.

Property	Description
Send Maximum DHCP Message Size	If Yes, always send the maximum DHCP message size to the DHCP server (required by some DHCP servers). If No, send the minimum DHCP message size. Default is No.
Send User Class	Specifies which attribute in the DHCP message will carry the IP address pool name. If Yes, the pool name will be sent in the User-Class option. If No, the pool name will be sent in the Vendor-Class-Identifier option. Default is No.

6 Click Modify.

Setting Up Realms for DHCP

For each realm that will get IP address assignments via DHCP:

1 In the Navigation frame, click Local Realms.

2 Click the realm name link.

3 Click Yes to turn on Session Tracking.

Note: Enabling Session Tracking sets the number of concurrent sessions to the global Simultaneous Use value set in Session Table Properties under the Server Properties page. You can override this number by defining a Simultaneous-Use value for an individual user in the user profile.

4 Click Modify.

Defining Address Pools for Specific Users

If the user profile is stored in local storage:

1 In the Navigation frame, click Local Realms for users stored in a realm file or click Users for users stored in the default users file.

2 If you clicked Local Realms then click the  button next to the realm name.

3 Click the  button next to the User Name.

4 Click the Free tab on the Modify User page.

5 Enter the A-V pair: `Address-Pool=`*`name-of-pool`*

6 Click Modify.

If the user profile is stored in an LDAP directory, add the reply-item attribute to your LDIF file:

`aaaReply: Interlink:Address-Pool=`*`name-of-pool`*

Configuring the DHCP Server

Be sure the following properties on the DHCP server do not conflict with the AAA Server's DHCP properties:

- The DHCP server's DHCP Lease value must be greater than the AAA Server's Session-Kill and Session-Clear values.
- The DHCP server must be configured to match the DHCP Send User Class setting configured on the AAA Server.

Tunneling

The AAA Server establishes tunnels, such as compulsory VPN tunnels, by returning standard RADIUS tunneling attributes to the client device.

Tunneling Hints

The server resolves tunneling hints in an Access-Request message in this way:

- If all hints match configured attributes, the configured values are returned to the client.
- If some of the hints match configured attributes, both configured values and hints are returned to the client.
- If none of the hints match configured attributes, the hints are returned to the client.

To specify how the server should handle requests that do **not** contain any tunneling hints:

1 In the Navigation frame, click Server Properties.

2 In the Workspace frame, click the link for Tunneling Properties.

3 Make a selection from the Tunneling Reply Items drop-down list:
   - Return-Configured-Tunnel-Attributes: Allow the return of tunnel attributes in the authentication reply.
   - Return-No-Tunnel-Attributes: Do not return any tunnel attributes in the authentication reply.
   - Reject-Access-Request: Fail the authentication by silently discarding the Access-Request.

4 Click Modify.

Or, you could manually configure the `NO_HINTS` attribute in the `aaa.config` file.

Establishing a Tunnel for a User

If the user profile is stored in local storage, you can add tunneling attributes in Server Manager.

1 In the Navigation frame, click Local Realms for users stored in a realm file or click Users for users stored in the default users file.

2 If you clicked Local Realms then click the  button next to the realm name.

3 Click the  button next to the User Name to display the User Profile page.

4 Click the Free tab and enter the tunneling attributes one per line in the Reply list box using standard A-V pair syntax:

attribute = value

5 Click Create or Modify:

You can also configure user tunnel attributes by adding them as reply items to the realm file, default users file or LDAP user profile. For example:

```
user Password = "topsecret",
   session-timeout =43200,
   idle-timeout =3600,
   Tunnel-Type =PPTP,
   Tunnel-Medium-Type =IPv4,
   Tunnel-Client-Endpoint =192.168.127.1,
   . . .
```

If the user profile is stored in an LDAP directory, you can use an LDIF file to add the tunnel definition to the profile as reply item attributes. Use the syntax:

aaaReply: *Tunneling-Attribute = Value*

For example:

```
aaaReply: Tunnel-Password = Michigan
```

Tunneling Attributes

Tunneling attributes are returned as reply items in a RADIUS Access-Accept message. These tunneling attributes are supported by the AAA Server:

Attribute	Description
Tunnel-Medium-Type	Indicates the transport medium to use when establishing the tunnel. Values are: • IPv4 • IPv6 • NSAP • HDLC (8-bit multidrop) • BBN-1822 (1822) • IEEE-802 (all 802 media plus Ethernet, "canonical format") • E-163 (POTS) • E-164 (SMDS, Frame Relay, ATM) • F-69 (Telex) • X-121 (X.25, Frame Relay) • IPX • Appletalk • DecnetIV • Banyan-Vines • E-164-NSAP
Tunnel-Type	Indicates the tunneling protocol to use when establishing the tunnel. Values are: • PPTP • L2F • L2TP • ATMP • VTP • AH • IP-IP-Encap • MIN-IP-IP • ESP • GRE • DVS • IP-IP • VLAN
Tunnel-Client-Endpoint	Address of the client that initiated the tunnel.
Tunnel-Server-Endpoint	Address of the server that provides the tunnel to the user.
Tunnel-Password	Password for access to the machine specified by Tunnel-Server-Endpoint. This is not the password used for authentication.

Attribute	Description
Tunnel-Private-Group-ID	Group identifier for a private session. Private groups may be used to associate a tunnel with a particular group of users, for example, to route unregistered IP addresses through a particular interface.
Tunnel-Assignment-ID	Indicates what tunnel to use to provide the appropriate level of service. Data transfer for users that share the same assignment are multiplexed over a shared tunnel.
Tunnel-Preference	When using tagged tunnel attributes, indicates each tunnel's relative level of preference. Specified as an ordinal number: first, second, etc.
Tunnel-Client-Auth-ID	Name used by the client during the authentication that occurs between Tunnel-Client-Endpoint and Tunnel-Client-Server.
Tunnel-Server-Auth-ID	Name used by the server during the authentication that occurs between Tunnel-Client-Endpoint and Tunnel-Client-Server.

Tagged Tunneling Attributes

The AAA software supports tagged attributes that can be used to specify tunneling alternatives, in the event that the access device cannot establish the preferred tunnel configuration.

To specify a tagged attribute, use the syntax:

Tunneling-Attribute =:Tag-no:Value,

The order in which the access device should consider the tunnel alternatives is specified with the `Tunnel-Preference` attribute. For example, if Tag set 2 is actually the preferred tunnel, the entry would be:

`Tunnel-Preference =:2:1,`

Some access devices do not support tagged attributes. We recommend that when you return multiple tunnel definitions to a client, you should have at least one set of attributes that is untagged or tagged with a 0 value, so that there is a tunnel definition available to a client that does not support tags.

This example shows two sets of tagged values for the same tunneling attributes.

```
Tunnel-Type =:1:PPTP,
Tunnel-Medium-Type =:1:IPv4,
Tunnel-Client-Endpoint =:1:192.168.127.1,
Tunnel-Server-Endpoint =:1:192.155.111.1,
Tunnel-Password =:1:Michigan,
Tunnel-Private-Group-ID =:1:engineering,
Tunnel-Assignment-ID =:1:management,
Tunnel-Preference =:1:1,
Tunnel-Client-Auth-ID =:1:NET,
Tunnel-Server-Auth-ID =:1:Michigan,
Tunnel-Type =:2:L2TP,
Tunnel-Medium-Type =:2:IPv4,
Tunnel-Client-Endpoint =:2:192.168.127.1,
Tunnel-Server-Endpoint =:2:192.170.130.1,
Tunnel-Password =:2:California,
Tunnel-Private-Group-ID =:2:engineering,
Tunnel-Assignment-ID =:2:management,
Tunnel-Preference =:2:2,
Tunnel-Client-Auth-ID =:2:NET,
Tunnel-Server-Auth-ID =:2:California
```

Reversing Configuration Changes

If you do not wish to keep changes you made to the temporary configuration files in Server Manager, you can revert to a previous copy by reloading the original configuration from the server, provided you haven't yet saved since loading.

Maintenance

This sections explains the AAA Server functions for:

- Reading the server log file
- Reading accounting logs
- Reporting on server authentication and accounting request statistics
- Reporting on active sessions
- Debugging the server

Reporting Server Log File

The AAA Server log file contains a history of server messages generated in response to:

- Server starts/stops
- Internal errors
- Access-Requests and Accounting-Requests

Server logs are automatically compressed and stored each day in a different file in the server's log file directory (`var/opt/aaa/logs` by default). Logs follow the file naming convention `logfile.`*`yyyymmdd`*`.`

To view server log file messages through the Server Manager:

1 In the Server Status frame, select the server.

2 In the Navigation frame, click Server Logfile.

3 Under Search Parameters, enter any filters to limit the messages displayed.
   - Begin/End — date and time range during which event occurred
   - Number of Records — the maximum number of records to show; may be any number from 1 to 999
   - User — user name in request; may be just userid (e.g.: fred) or full NAI format name (e.g.: fred@abc.com)

4 Under Message Type, select (Yes) all the types you want displayed and deselect (No) any you do not want.

Message Type	Description
Server failure	Messages indicating a server internal error or a problem with the configuration files.

Message Type	Description
Warning message	Messages indicating a problem with the server, but the server is still able to process RADIUS requests.
Information message	All messages that are not one of the other types. By default, they are not displayed.
Server start	Messages generated during each server startup or restart.
Server stop	Messages generated when the administrator shuts down the server.
Authentication request (grey)	Access-Request message received.
Authentication failure (red)	Access-Reject message sent.
Authentication success (green)	Access-Accept message sent.
Accounting response (blue)	Accounting-Request response message sent.

5 Click Search to display the log file results.

You'll see the Type, Time, and Description for each message displayed in the Message frame.

Reporting User Accounting Records

The AAA Server records session information in an active session table record. When the server receives an Accounting-Request to stop the session, this information is written to the server's accounting log file.

By default, accounting log files are written in MERIT standard format in `/var/opt/aaa/acct/session.yyyy-mm-dd.log`. See "Accounting Record Format" on page 90 for a description of log file information.

You can control the session logging behavior by changing when the server's Finite State Machine (FSM) calls the LOG action. See "Modifying Accounting Logging Behavior" on page 94.

Note: Not all wireless access points support RADIUS account logging. You should verify support with the access point vendor.

Viewing the Accounting Log

To view accounting log records in Server Manager:

1 In the Server Status frame, select the server.

2 In the Navigation frame, click Accounting.

3 Under Search Parameters, enter any filters to limit the records displayed:

- Begin/End — date and time range during which session occurred
- Number of Records — the maximum number of records to show; may be any number from 1 to 999
- User — user name; may be just userid (e.g.: fred) or full NAI format name (e.g.: fred@abc.com)
- Realm — realm name; if no User specified, pulls all records from this realm that match the other criteria

---

Note: Enter NULL to display NULL realm records. Don't leave the field blank.

- NAS — network access server from which session originated; may use NAS-Identifier or NAS-IP-Address

---

Note: This parameter will find a leading substring or an exact match. For example, a value of t14 would match records with NAS/Port field t14.interlinknetworks.com/1234)

---

4 Click Search. The selected accounting records appear in the Workspace frame.

Accounting Record Format

In the default MERIT format, the first line of an accounting record contains 14 tab delimited fields that represent the user session information. If a value does not exist, NA appears as the value's placeholder.

The first line of an accounting record contains:

LAS-Start LAS-Code LCL-Time LAS-Duration LCL-Duration User-Name Authenticated-User-Name Session-ID Timelimit NAS/Port Service-Class Filter-ID Service-Type

After the first line, each A-V pair in the Accounting-Request-Stop message is listed, preceded by the characters "##."

Note: The default format is specified by the "log_v2_0" setting for the `AATV` parameter in the log.config file. Alternate formats, including Livingston Call Detail Records, may be specified.

Accounting Attributes

These attributes appear on the first line of the MERIT accounting record:

Attribute	Description
LAS-Start (epoch)	Time when session started (in seconds), relative to 1/1/1970.
LAS-Code (keyword)	Reason why record was logged. Codes are: • LAS-Normal 0 • LAS-Reject 1 • LAS-Cancel 2 • LAS-Noconfirm 3 • LAS-Overtime 4 • LAS-Unknown 5 • LAS-Notlocal 7 • LAS-Suspend 8 • LAS-Failed 9 • LAS-Authorized 10 • LAS-NASreboot 11 • LAS-Remote 12 • LAS-Duplicate 13 • LAS-Collision 14 • LAS-Stop 15
LCL-Time (r-epoch)	Time when record was logged, relative to LAS-Start.
LAS-Duration (integer)	Duration of session (in seconds) according to the LAS.

Attribute	Description
LCL-Duration (integer)	Duration of session (in seconds) according to RADIUS huntgroup server for NAS.
User-Name (special)	User-Id "@" User-Realm from RADIUS User-Name attribute. If realm uses a tunneled authentication method, this field will show the outer user identity.
Authenticated-User-Name (special)	If realm uses a tunneled authentication method, this field will show the authenticated Inner-Identity value. Otherwise, always shows the RADIUS User-Name value. You must enable session tracking for the outer realm to see this value. Doing so will also set the number of concurrent sessions for the realm to whatever value you have defined for the Simultaneous-Use parameter of las.conf.
Session-Id (q-string)	Session ID (should be unique).
NA	Empty field. Always NA.
Timelimit (integer)	Session Time limit.
NAS/Port (special)	NAS-Identifier "/" NAS-Port-Number.
Service-Class (string)	Merit charging/access-ctl service class.
Filter-Id (string)	Filter name associated with session.
Service-Type (special)	May be: • FRAMED/PPP • FRAMED/PPP/ip-addr • FRAMED/SLIP • FRAMED/SLIP/ip-addr • LOGIN • LOGIN/TELNET • LOGIN/TELNET/PROMPT • LOGIN/TELNET/PROMPT • LOGIN/TELNET/ip-addr • LOGIN/TELNET/ip-addr/tcp-port

Accounting Record Extensions

Standard Accounting RFC extensions may appear in a RAD-Series accounting record in addition to the basic session information. These extensions are the A-V pairs sent from the client in the Accounting-Request-Stop message. See the Accounting Extensions section of the `dictionary` file for a list of valid A-V pairs.

Access Device Values

Vendor-specific attributes (VSAs) related to the access device may appear among the accounting record extensions. These represent attribute values that describe the access device used for authentication and authorization. Valid attributes are defined in the `dictionary` file. You may extend the VSA list by adding the vendor to the `vendors` file and the attributes and their values to the `dictionary` file.

Example Accounting Record

```
1079387320 LAS-Stop 7 7 NA t2001l@iln.com t2001l@iln.com '4054b8.1.t15'
NA NA t25.iln.com/2001 NA NA NA
##      User-Name:0='t2001l@iln.com'
##      NAS-IP-Address:2=192.168.3.25
##      Acct-Authentic:1=RADIUS
##      Acct-Session-Id:0='4054b8.1.t15'
##      Acct-Status-Type:1=Stop
##      Vendor-Specific:6=v251658249-1415060708090a0b0c0d0e0f
##      Vendor-Specific:6=vCisco-1415060708090a0b0c0d0e0f
##      Vendor-Specific:6=v101058054-0606
##      Acct-Delay-Time:1=0
```

Modifying the Accounting Log

Certain features of the standard RAD-Series accounting log format can be reconfigured through the `log.config` file.

Writing CDR Accounting Records

You can configure the server to write Accounting log records in the Livingston Call Detail Record (CDR) format, rather than the default MERIT format.

If you change radius.fsm to call ACCT rather than LOG for each logged message event, logs will be stored in an alternate directory (`/var/opt/aaa/radacct`).

1 In a text editor, open the `log.config` file found in the server's configuration file directory. Locate the following line, which should be found near the beginning of the file:

   `aatv log_v2_0`

2 Change `aatv log_v2_0` to `aatv log_acct`

3 Save and close the file.

4 Stop and start the server.

Changing the Accounting Log Filename

1 In a text editor, open the `log.config` file found in the server's configuration file directory. Locate the following line, which should be found near the beginning of the file:

```
filename session.%Y-%m-%d.log
```

2 Change `session.%Y-%m-%d.log` to the filename syntax you wish to use.

3 Save and close the file.

4 Stop and start the server.

Changing the Accounting Log Rollover Interval

The log rollover interval specifies how often a new log file is created to store accounting records. The interval is determined by the finest unit of time in the timestamp portion of the filename.

If `gzip` is in your UNIX path, log files are automatically compressed when they rollover.

1 In a text editor, open the log.config file found in the server's configuration file directory. Locate the following line, which should be found near the beginning of the file:

```
filename session.%Y-%m-%d.log
```

2 Rename the file to reflect the rollover interval. For example, for hourly rollover:

```
%Y-%m-%d-%H
```

3 Save and close the file.

4 Stop and start the server.

Modifying Accounting Logging Behavior

You can change server logging behavior by modifying the server's `radius.fsm` file.

All RADIUS accounting message types marked LOG are logged by the server. To log any type of accounting messages, simply change the action to LOG for the event handler that corresponds to the message. These should always take the next action ReplyHold.

Interim Accounting Logging

To indicate that a session is still active, a client may send an Accounting-Alive (Accounting-Interim-Update) message at regular intervals during the session. To generate logs when the server receives this message, rather than wait for Accounting-Stop:

1 In a text editor, open the file `radius.fsm` (found in `/etc/opt/aaa` by default).

2 Find the lines:

```
AcctLog:
     *.*.ACCT_START          ReplyPrep         ReplyPolicyHold
     *.*.ACCT_STOP           LOG               ReplyHold
     *.*.ACCT_ALIVE          ReplyPrep         ReplyPolicyHold
```

3 Change:

```
     *.*.ACCT_ALIVE          ReplyPrep         ReplyPolicyHold
```

To:

```
     *.*.ACCT_ALIVE          LOG               ReplyHold
```

4 To turn **on** logging for any other message types:

- Change `ReplyPrep` to `LOG`
- Change `ReplyPolicyHold` to `ReplyHold`.

To turn **off** logging, reverse the settings.

5 Save and exit `radius.fsm`.

6 Stop and start the server.

Proxy Accounting Messages

Normally, the server logs all accounting messages locally. To log messages on a central server, follow the steps in "Proxying Accounting Requests to a Central Server" on page 47 to change the .fsm settings.

Reporting Server Statistics

Use the Server Manager Statistics page to retrieve a count of selected events that occurred on the AAA Server within a given time period. Statistics are displayed using a bar graph. You'll see the total number of:

- Server starts
- Server stops
- Accounting-Requests
- Authentication-Requests
- Authentication-Successes
- Authentication-Failures

1 In the Server Status frame, select the server.

2 Navigation frame, click Statistics.

3 Under Search Parameters, enter the Begin and End date and time of the period for which to retrieve statistics.

4 Click Search.

Reporting Active Server Sessions

Once the server receives an Accounting-Request-Start message, it begins to store session information in an active session table record. Only after the server receives the Accounting-Request-Stop message from the access device, indicating the user's session is terminated, does it clear its active session table record and write the session information to the accounting log file.

Note: Not all wireless access points support RADIUS session-based account logging. Verify support with the access point vendor.

Viewing Active Sessions

1 In the Server Status frame, select the server.

2 In Navigation frame, click Sessions.

3 Enter the Session Filtering parameters.

You can enter either or both values. Only sessions matching these values will be retrieved.

4 Click Display.

The Workspace display changes to show a list of active sessions.

5 Click a user session link to display the session attributes.

6 Click OK to return to the active session list.

Stopping Active Sessions

To clear sessions that were terminated on the access device but are maintained as active by the AAA Server:

1 Follow the procedure Viewing Active Sessions.

2 Click Stop.

The AAA Server will clear the record from its active session table, but no action is taken by the access device.

Note: You can only stop a session on a server that contains a self-referring client entry. When you install an AAA Server, it automatically adds this entry (localhost) to the server's Proxies configuration.

Server Programs

radiusd

`radiusd` is the main server program, used to handle Access-Requests and Accounting-Requests from RADIUS clients. Authentication and accounting requests come to `radiusd` in the form of UDP packets conforming to the RADIUS protocol.

Message processing is based upon a finite state machine that `radiusd` loads into memory when the server is first started. You can configure which finite state machine the server loads upon startup with the `-f FSM-file` option, but it is static after server startup.

`radiusd` runs as a daemon that you can start from the Server Manager console, the command line or through an inetd service.

Synopsis

```
radiusd  -c <Working-directory> -p <Authentication-port>
-pp <Authentication-relay-port> -q <Accounting-port>
-qq <Accounting-relay-port> -da <AATV-directory>
-d <Config-directory> -dl Logfile-directory> -l <Log-format>
-di <IPC-directory> -dm <Accounting-directory> -a <Livingston-
directory> -dd <Data-directory> -dr <Run-directory> -f <FSM>
-g {syslog|logfile|stderr} -h -n -s -x -v -z
```

Options

You can start radiusd with any of the following options to override built-in defaults. Server startup options can also be changed in the Server Manager.

Option	Description
-c <*Working-directory*>	New current working directory. If you specify this directory, you can use paths relative to the working directory for subsequent radiusd directory options.
-p <*Authentication-port*>	Port number to listen for authentication requests on.
-pp <*Authentication-relay-port*>	Port number to relay authentication requests to, if the remote server uses a port other than UDP standard 1812 for authentication requests.
-q <*Accounting-port*>	Port number to listen for accounting requests on.
-qq <*Accounting-relay-port*>	Port number to relay accounting requests to.

Option	Description
-t <*Timeout*>	This switch has been disabled and is only allowed for backwards compatibility. Minutes to timeout if server is inactive. Overrides default of 15 if server is running under inetd service. If set to 0, server is put into blocking mode and will never timeout or terminate.
-da <*AATV-directory*>	Location of binary AATVs, if other than installation default.
-d <*Config-directory*>	Location of configuration files.
-dl <*Logfile-directory*>	Server log file directory. Default is var/opt/aaa/logs.
-l <*Logfile-name*>	Server log file name. Default is logfile.%Y%m%d.
-di <*IPC-directory*>	Location of shared memory operation files.
-dm <*Accounting-directory*>	Location of accounting session records.
-a <*Livingston-directory*>	Location of Livingston Call Detail Records (when used as an alternative to the default MERIT format).
-dd <*Data-directory*>	Location of active session information stored in the session.las file. The sesstab utility requires that this option be defined if the server has been installed in a nondefault location.
-dr <*Run-directory*>	Location of the file where the server's process ID is stored.
-f <*FSM*>	Alternate FSM file to load upon startup, instead of the default radius.fsm file.
-g {logfile|syslog|stderr}	Where server events are logged. Enter option plus logfile (server logfile), syslog (system logfile), or stderr.
-h	Display the help syntax.
-n	Start new session table for LAS upon server startup.
-s	Run in single process (non-spawning) mode.
-v	Display RADIUS version.
-x	Add to debug flag value.
-z	Empty (zap) the log file & debug file.

radcheck

`radcheck` determines whether a given AAA Server is operational. `radcheck` may be invoked from any host, not just those with a self-referring clients entry, although more information is returned for those so registered.

Synopsis

`radcheck` `-d <Directory> -o -p <UDP-port> -r <Retries> -t <Timeout> -v -x` ***`<Name>`***

Arguments

<*Name*> IP address or fully-qualified domain name of a machine running a AAA Server.

Options

Option	Description
-d <*Directory*>	An alternate directory containing clients and dictionary files, instead of the default /etc/opt/aaa/ directory. If no -d option is given, radcheck will look in the default location. An error is displayed if the configuration files cannot be found.
-h	Display the help syntax.
-o	Do not use the Status-Server RADIUS packet code.
-p <*UDP-port*>	Alternate UDP port number, instead of the default 1812.
-r <*Retries*>	Maximum number of retries instead of the default of 10.
-t <*Timeout*>	Alternate timeout value (in seconds) instead of the default of 3.
-v	Display radcheck version information.
-x	Add to debug flag value.

See "Reporting Server Status" on page 35 for a description of radcheck output.

radpwtst

`radpwtst` is a test client program. It generates RADIUS packets to perform a password authentication on a specified user using the current server configuration.

If the authentication succeeds, `radpwtst` displays "`authentication OK`" on standard output. Otherwise, `radpwtst` displays "*`User-Name`* `authentication failed`."

radpwtst can also send accounting requests. When a response is received, radpwtst displays "`Accounting Response received.`"

Synopsis

```
radpwtst -a <ACKs> -c <Code> -d <Directory> -f <File> -h
-i <NAS-IP-address> -l <Async-Port> -n -p <UDP-port> -r <Retries>
-s <Servername> -t <Timeout> -u <Type> -v -w <Password> -X -x
-z <Challenge-password> -:<attribute=value> -0 <User-Name>
```

Arguments

<*`User-Name`*> User-Name to send with the test request. If no realm is specified, the server looks for the user in the NULL realm data store. By default, the NULL realm data store is the `NULL.users` file distributed with the server.

Options

Option	Description
-a <*ACKS*>	Number of responses to ignore. Used to test possible retransmission problems.
-c <*Code*>	RADIUS packet type codes from the following list: 1: Access-Request 4: Accounting-Request 12: Status-Server (the message sent by the radcheck utility)
-d <*Directory*>	An alternate directory containing the server's clients, dictionary, and vendors files, instead of the default /etc/opt/aaa directory. If no -d option is given, radpwtst will look for the default location. An error will be displayed if the configuration files cannot be found.
-f <*File*>	Input file of A-V pairs to send with radpwtst.
-h	Displays the radpwtst help syntax.
-i <*NAS-IP-address*>	An alternate NAS-IP-address instead of the originating machine's IP address.
-l <*Async-Port*>	The NAS port with an alternate asynchronous port number instead of default asynchronous port 1.
-n	Forces the Authentication-Only value to be used in the Service-Type A-V pair.
-p <*UDP-port*>	An alternate UDP port number. For an Access-Request the default UDP port number is 1812 or the number specified in the /etc/services file for radiusd. For an Accounting-Request the default port number is 1813 or the number specified in the /etc/services file for radacct.
-r <*Retries*>	Maximum number of retries instead of the default of 10.
-s <*Servername*>	An alternate server instead of the built-in default.
-t <*Timeout*>	An alternate timeout value (in seconds) instead of the default of 3.

Option	Description
-u <*Service-Type*>	One of several Service-Type values instead of the default auth value. Note, that the default auth value will fail if no password (or an empty password) is included in the Access-Request (default or -c 1) produced by radpwtst. RADIUS server requires a valid (nonempty) password be provided in Access-Request packets where the Service-Type is Authenticate-Only. Valid Service-Type values are: • admin • auth • dumb • exec • outbound • ppp • slip • dbadmin • dbdumb • dbppp • dbslip **Note:** db stands for dial back in the last four types.
-v	Displays the radpwtst version.
-w <*Password*>	Password to use, instead of being prompted for one.
-X	Same as -x.
-x	Increases the debug level which displays additional debug output and account logging on the screen.
-z <Challenge-p*assword*>	Challenge password to use in response t Access-Challenge, instead of being prompted for one.
-:<*attribute=value*>	One or more A-V pairs to add to the test request.
-0	Suppress copyright message.

Stopping Sessions

You can clear sessions with radpwtst. To clear a session, you must know its `Acct-Session-ID`, which you can determine by running `sesstab`. The following command line will manually stop a session by sending an Accounting-Request stop message:

radpwtst `-c 4 -s [<Server FQDN>|<Server IP-Address>] -i <NAS-IP-address> -l <Async-Port>` **-:Acct-Status-Type=Stop -:Acct-Session-Id="<Session-Id>"**

radsignal

The `radsignal` utility performs 3 functions:

- turns debugging on and off or sets the level of debug output, while the server is running. This function replaces raddbginc.
- Initiate server logfile rollover.
- Initiate accounting stream file rollover.

Synopsis

```
radsignal -h -v
radsignal -di <IPC-directory> <pid> debug <delta>
radsignal -di <IPC-directory> <pid> roll logfile
radsignal -di <IPC-directory> <pid> roll stream <stream-name>
```

Arguments

<***pid***> The process ID of `radiusd` (the AAA Server program). You can determine this by running:

```
ps -eaf | grep radiusd
```

<*delta*> The number of debug levels to **increment** from the current level (not the number of the level you want). The debug level will not increase past level 4. 0 turns debugging off. All debug output is sent to the `radius.debug` file in `/var/opt/aaa/logs` or in an alternate location specified by the `radiusd -dl` option.

<*stream-name*> The name of the accounting stream to roll. If one is not specified then the default stream (`*default*`) is used.

`debug, roll logfile, and roll stream` are keywords that identify the invocation desired and are described below after the options.

Options

Option	Description
-di <*IPC-directory*>	IPC directory path; required if radiusd installed in a nondefault location. <*IPC-directory*> must match the path given by the radiusd -di option.
-h	Displays the radsignal syntax and can not be combined with other options.
-v	Displays the radsignal version and can not be combined with other options.

Description `debug`

This form of invocation specifies that you wish to change the level of debug output generated by radiusd. You can use the radsignal command to turn debugging on and off or set the level of output while the server is running using radsignal. Debugging output by the server can also be turned on when starting the server at a specified level of output. All of the debug output is sent to the radius.debug file, in the default directory or in an alternate location specified by the radiusd `-dl` option.

Debug Levels

When starting radiusd, you can turn on debug output and set the level of output with the `-x` option. Each instance of the `-x` option at the command line will increase the debug level by one up to level 4. After the server is started, you continue to control the level of debugging output with the radsignal command. Each debug level provides the information from the previous levels, plus its own. The higher the number, the more detail.

Level	Description
0	No debugging (default)
1	Brief trace
2	High-level FSM output, some function tracing, A-V pairs, etc.
3	Full function tracing
4	Low-level FSM and configuration file output

DESCRIPTION `roll logfile`

This form of invocation specifies that you wish `radiusd` to immediately roll the logfile. "rolling" the logfile consists of closing the current logfile and opening a new logfile. If, for example, the current logfile is named '`logfile.20060304`' then it will be renamed to '`logfile_part01.20060304`' and the current logfile will be called '`logfile_part02.20060304`'. This is the same as what is done if the logfile reaches the maximum configured file size. Each subsequent request to roll the logfile will increment the 2-

digit "part number" up to a maximum of 99 and will grow to 3-digit or larger "part numbers" as required.

The file name modification algorithm is to insert "`_part`**`NN`**" into the filename preceding the last dot of the file name. The intent is to preserve the filename extension, in case the filename extension is used by the server administrator.

DESCRIPTION `roll stream`

This form of invocation specifies that you wish `radiusd` to immediately roll the accounting stream specified by <*`stream-name`*>. "rolling" the accounting stream consists of closing the current file used for that stream and opening a new file for the stream. If, for example, the current accounting logfile for the stream is named '`session.2006-03-04.log`' then it will be renamed to '`session.2006-03-04_part01.log`' and the current accounting logfile will be called '`session.2006-03-04_part02.log`'. This is the same as what is done if the accounting logfile reaches the maximum configured file size. Each subsequent request to roll the accounting stream will increment the 2-digit "part number" up to a maximum of 99 and will grow to 3-digit or larger "part numbers" as required.

The file name modification algorithm is the same as roll logfile above.

radrecord

The `radrecord` utility reads Interlink (MERIT-style) accounting log files and prints out specific session information to standard output. This utility will not read Livingston Call Detail Records. Using various command line options, it is possible to create flexible and powerful search criteria to obtain information from the logs.

Note: If any session log file is compressed with either gzip (1) or compress (1), radrecord will try to use the corresponding decompression program to read the file.

You can also read the accounting logs through the Server Manager Accounting page.

Synopsis

```
radrecord -a <After> -b <Before> -c -d <Directory> -f <Filter> -h
-i <Session-ID> -l <Log-config> -n <NAS/port> -o <Time> -p <Protocol>
-r <Reason>:<Reason> -s <Service-Class> -u <User-ID>
-x -:<attribute=value> -1 <filename> <Accounting-logfile> <...>
```

Arguments

<*`Accounting-logfile`*> One or more accounting log files to search.

Options

-d <*Directory*>	Alternate directory name containing the AAA Server authfile, clients, and .users files, instead of the default /etc/opt/aaa directory. If no -d option is given, radrecord will look for the default location. An error will be displayed if the configuration files cannot be found.
-h	Displays the help syntax.
-a <*After*>	The date and time of the session to begin retrieving data from. Takes a string in the format: %Y-%m-%d/%H:%M:%S. For example, 1997-12-01/15:01:30 means 3:01:30pm, December 1, 1997. Hour, minute, and second may be omitted and each default to 0. Day and month may be omitted and each default to 1.
-b <*Before*>	The date and time of the last session to retrieve data from. Takes a string in the format: %Y-%m-%d/%H:%M:%S. For example, 1997-12-01/15:01:30 means 3:01:30pm, December 1, 1997. Hour, minute, and second may be omitted and each default to 0. Day and month may be omitted and each default to 1.
-e <*NA-equ*>	Assign a value for output to replace N/A values in record.
-f <*Filter*>	Only searches for sessions with a Filter-ID matching the given regular expression.
-h	Displays the radrecord syntax.
-i <*Session-ID*>	Only searches for sessions with the given session ID.
-l <*Log-config*>	Outputs any session log in the format and to the file configured in the specified configuration file for the LOG AATV (defaults to log.config).
-n <*NAS/port*>	Only searches for sessions with the given NAS ID and (optionally) port.
-o <*Time*>	Specify a time in '%Y-%m-%d/%H:%M:%S' format, i.e., 2003-01-17/12:49:03.
-p <*Protocol*>	Only searches for sessions that used the specified protocol.
-r <*Reason*>:<*Reason*>	Only searches for sessions with a reason code within the specified range. A reason code may either be a integer or a text name as listed in the LAS-Code value section of the dictionary file.
-s <*Service-Class*>	Only searches for sessions with a service class name matching the specified service class regular expression.

-u <*User-ID*>	Only searches for sessions that used the given user ID.
-x	Add to debug flag value.
-:<*attribute=value*>	Specify an A-V pairs to match with each session record. This may be used multiple times if needed.
-1 <*filename*>	Find only first session of each user listed in the specified file. You must create and save the file with a list of users.

Troubleshooting

Debugging

The server can be set to print out debugging information that may be useful for troubleshooting. The debug level and directory is set when the server is started. See "Setting Server Start Options" on page 33 and "radsignal" on page 103 to change the debug level.

All debug output is sent to the `radius.debug` file in the server log file directory.

Error Messages

Below are error messages that may be helpful for troubleshooting.

Server Log File Messages

These messages appear in the server's log file.

Message	Probable Cause	Possible Solution
Request from unknown client.	Using DNS names, rather than IP addresses, to specify clients. Upon startup, entries in your clients file are not yet in the server's buffer, so this message may appear at the beginning of the server log file. It only indicates a problem if the server continues to fail to resolve DNS names.	Enter correct DNS name in clients file entry. Add both backward and forward entries for client in DNS database.
LAS_ACCT: user realm '*xxx.xxx*' not configured	Realm is not configured in the las.conf file and you're using the LAS feature for authorization policies.	Add the realm to the las.conf file.
read_clients: Missing required client '*xxx*' : line *y*	Entry on line *y* of the clients file is missing the required parameter '*xxx*'.	Add the omitted parameter to the clients file entry.
Couldn't get our own IP address(es)	No entry for the AAA Server in your DNS database.	Add both backward and forward entries for AAA Server in DNS database.

Message	Probable Cause	Possible Solution
doconfig: init_fsm() failed init_fsm: FSM defined with *-x* states from radius.fsm	Finite state machine failed to initialize.	Verify that radius.fsm exists in the server configuration file directory. If you modified the .fsm, be sure all entries follow the correct syntax.
file_pass: password failure for 'xxx'	User provided an incorrect password	Verify password with user. Add correct password to .users file or user profile database.
Vendor *x* attribute *y* unknown	Server received an attribute that is not defined in the dictionary.	Add vendor-specific attributes to the dictionary file.

radiusd Error Messages

These messages are returned by the server if `radiusd` fails to start. They appear in the Message frame at the bottom of the Server Manager Administration page or on your Terminal screen.

Message	Probable Cause	Solution
Invalid port number	Port number is a non-numerical value	Specify a numerical value in Start Options.
Invalid timeout value	Port number is a non-numerical value	Specify a numerical value in Start Options.
Invalid option *option*	The named option is invalid.	Review the options in your configuration file entries. See Chapter 5 for a list of valid options.
setup_logfile: Couldn't open *path*/logfile.yyyymmdd for logging, error 13 Permission denied	radiusd does not have write permission for the directory.	Change permissions of directory or specify an alternate server log file directory in Server Connections.
bind: Address already in use	Another process is already using the port.	Kill the process or change the port number used by radiusd. The port is specified in Start Options.
gethostname() returned no or incorrect DNS	NAS server's DNS entry is configured incorrectly.	Check DNS configurations for both forward and reverse entries.
Received invalid reply digest from server	Server and client do not agree on shared secret.	Verify that the shared secret in the clients file agrees with the secret configured on the client.

Server Reply Messages

These messages may be sent to users when access has been rejected.

Message	Probable Cause	Possible Solution
Access controlled	Host name user wants to access requires authentication.	
Access not allowed	The user's request matched some configured Deny item	
Authentication failure	The user's authentication has failed.	
xyz access is prohibited	Users are prohibited from using protocol *xyz* (PPP or SLIP) by their service provider.	
Can't process request now, try again later	The server has too many pending requests at the moment.	
Error creating file	The server has a file system problem.	Check file permissions for the file and directory.
Improper 'userid@realm' specification	User access ID should be in the format of userid@realm. Most probably, a user has omitted @realm from their logon name and the server has not been configured to handle a NULL realm.	
Invalid authentication realm	The realm identified in the user access ID has not been configured for the server.	Verify that the authfile has an entry for the realm and that radiusd is loading configuration files from the correct location.

Using External Data Stores

The AAA Server allows you to store user profiles in a local realm file or to retrieve them from external data stores. This section shows how to configure the server to access user profiles from:

- LDAP directory servers
- Oracle databases

Using an LDAP Server

If you only need to retrieve user IDs and passwords from the LDAP server, just follow the procedure "Identifying LDAP Directories" on page 53.

However, if you wish to implement simple authorization policies with check or reply items, we recommend that you review this entire topic. It will familiarize you with:

- Interlink-specific attributes and object classes
- Extending the standard LDAP schema

About ProLDAP™

ProLDAP™ is Interlink Networks' proprietary LDAP schema, based on the OpenLDAP 2.x release. It interfaces with any LDAP server using protocol version 3. Previous OpenLDAP releases are version 2 and are not supported by the Interlink Networks schema.

To determine the version of the LDAP standard used by a commercially released LDAP server, consult the product documentation or contact the vendor. If your LDAP vendor has extended or otherwise modified the version 3 LDAP standard, you may need to modify the ProLDAP schema.

The standard schema file is `iaaa-radius.ldif`. We also include the `55iaaa-radius.ldif` file to extend the schema for iPlanet 5.0.

Note: There may be several schema files installed with an LDAP server. Modifying schema files can result in problems. Never delete unused schema elements from the standard schema. They require no additional operational or administrative overhead and deleting them could cause problems.

Securing LDAP Communications

To use Secure Socket Layer (SSL) when communicating with LDAP directories:

Note: SSL secures the connection to a specific host and logical port, so repeat this procedure for each directory separately.

1 Follow the steps in Modifying a Directory Configuration to display the LDAP Directory dialog.

2 Click Yes to Use SSL, then click Save.

3 Click Modify.

4 Click Server Properties > ProLDAP Properties.

5 Enter the path to the AAA Server TLS CA certificate directory.

or

Enter the name of the AAA Server TLS CA certificate file.

6 Enter the TLS certificate file if required by the LDAP server.

7 Enter the TLS private key file if required by the LDAP server.

8 Click Modify.

9 If the AAA Server is already running:
- Click Save Configuration and select the server.
- Stop and restart the server.

The AAA server uses OpenSSL, which requires a random number generator that has been seeded with at least 128 bits of randomness. If there is no default seeding file or if the file is too short, the "PRNG not seeded" error message may occur. To avoid this, use an operating system with the randomness devices:

- `/dev/urandom`
- `/dev/random`

On systems without `/dev/urandom` or `/dev/random`, it's a good idea to use the Entropy Gathering Demon (EGD). OpenSSL will automatically look for an EGD socket at `/var/run/egd-pool`, `/dev/egd-pool`, `/etc/egd-pool` and `/etc/entropy`.

Failing that, set the environmental variable RANDFILE to point to the default random seed file:

`/etc/opt/aaa/security/random.rnd`

Password Encryption

The AAA Server can receive passwords from the LDAP server in clear text format or encrypted by SSHAMD5, SHA1, x-NT hash, x-lm hash and UNIX-crypt. If passwords are encrypted by other methods, configure the AAA Server to bind to the LDAP server for authentication.

Extending the ProLDAP Schema

Do the following if you are storing check and reply items with user profiles in the LDAP directory.

If you are only storing user profiles based on the core LDAP schema (to retrieve the uid and password), this procedure is not necessary.

1 Copy the `iaaa-radius.schema` file to the LDAP server.

2 Modify `slapd.conf` by adding the following line:

`include` *`Path-to-radiusschemafile`*

Where *`Path-to-radiusschemafile`* is the full path to location of the `iaaa-radius.schema` file.

3 Add the Interlink-specific attributes to your LDAP user profiles. (See `aaasample.ldif` file for examples.)

If your LDAP server vendor has modified or extended the standard version 3 schema, the `iaaa-radius.schema` file may not work. In this case you will have to modify iaaa-radius.schema. The server includes the `55iaaa-radius.ldif` file as an example of a file that has been modified for the iPlanet 5.0 LDAP server.

Interlink Object Classes

The extended schema files contain the Interlink object class:

Object Class	Description
aaaPerson	Represents the set of attributes a user entry must or may contain.

Interlink-specific Attribute Types

The following Interlink attributes are used to store check/reply items.

Attribute Type	Description
aaaCheck	An A-V pair that must be present in the user entry for the entry to evaluate to True
aaaDeny	An A-V pair that must **not** be present in the user entry for the entry to evaluate to True
aaaReply	An A-V pair sent back to the access device to authorize the session (e.g. to set a session time limit)

LDIF User Entry Syntax

User entries must contain any attribute-value pairs required by the `aaaPerson` object class or whichever alternate object class you specify for the `ObjectClass` parameter.

In an LDIF file, a user entry is represented as follows:

```
dn: attr = value, attr = value,...
ObjectClass: aaaPerson
uid: value
userPassword: value
User-ID: value
User-Password: value
aaaCheck: attr = value
aaaDeny: attr = value
aaaReply: attr = value
```

Parameter	Description
dn	Distinguished Name. Identifies a directory entry in the LDAP schema by using a series of comma-separated attributes and values, where the left-most value specifies the actual directory object and the right-most value specifies the directory root point. For example, ou=people, o=interlink.com points to the organizational unit, people, located on the directory branch below the organization, interlink.com.
uid	User identifier. Normally, uid or cn is part of dn. This is the default filter for a realm. If you specify another attribute as the filter, this parameter is optional.
userPassword	LDAP attribute that identifies the password for the user.
ObjectClass	Indicates what A-V pairs must or may be used in the user entry. This attribute is not required for user authentication, but it is required if you wish to add User-ID, User-Password, Check/Deny, or Reply Items to the user profile. In addition to or instead of aaaPerson, other object classes (e.g., the standard LDAP schema Person class) may be specified.
User-ID	RADIUS attribute that may be used to identify a user (instead of uid).
User-Password	RADIUS attribute, defined in the aaaPerson object class.
aaaCheck, aaaDeny, aaaReply	Specify any A-V pair(s) defined in the AAA Server's dictionary file that you wish to use as a check, deny, or reply item for the user.

Check and Reply Items

The ProLDAP implementation lets you store check and reply items with user profiles.

If your AAA implementation includes user check or reply items, configure these items to be returnable in a search of the LDAP directory. Binding as the user will not return check items.

To Override Simultaneous Session Limit

This A-V pair overrides the global simultaneous session limit set in Server Properties.

```
aaaCheck: Simultaneous-Use = Max-number-sessions
```

To Control Access Points

These A-V pairs specify the NAS port or machine through which the user is permitted to access the network.

```
aaaCheck: NAS-Port = Port-number
aaaCheck: NAS-ID = ID-string
aaaCheck: Calling-Station-ID = User-MAC-address
```

To Deny Access

These A-V pairs deny the user access from the port or machine specified.

```
aaaDeny: NAS-Port = Port-number
aaaDeny: NAS-ID = value
aaaDeny: Called-Station-ID = AP-MAC-Address
```

To Set Reauthentication Session Timeout

```
aaaReply: Session-Timeout = Number-seconds
aaaReply: Termination-Action = 1
```

To Set Idle Timeout

```
aaaReply: Idle-Timeout = Number-seconds
```

To Assign Static IP Address

This A-V pair cannot be used with an 802.1X framework.

```
aaaReply: Framed-IP-Address = value
```

To Apply Filters

```
aaaReply: Filter-ID = value
```

Known Issues with ProLDAP™

These are a few issues to be aware of when configuring the server to use ProLDAP.

Failover not operating properly

If the LDAP server process terminates in such a way that the TCP connection remains active, the AAA Server will not recognize that the LDAP server is not accessible. Instead of rotating to the next LDAP server, the AAA Server will retransmit the request until it times out.

Authentications time out on LDAP restart

If the LDAP server is started (or restarted) while the AAA Server is running, one or two authentication requests may timeout during the LDAP restart. Starting the LDAP server before starting the AAA Server will prevent this issue from occurring.

Case-sensitive Filter IDs

A feature of LDAP servers is that they match Distinguished Names in a case-insensitive manner. Using case-sensitive filter IDs could cause Distinguished Names to be mismatched or not found.

Clear-text passwords stored in LDAP

The regular expression `^{.+}.*$` indicates that the password is hashed using the scheme named between the { and } characters. There is no specification for handling clear-text (unhashed) passwords that contain a leading prefix of `{.+}`. This leads to confusions, such as:

`{md5}` looks like hasher '`md5`' produced a zero-length hash

`{nothing}interesting` looks like hasher '`nothing`' produced a hash of '`interesting`'

Any clear-text password that appears to be hashed will be rejected as invalid by the Interlink server. Most likely, the apparent hasher will be rejected as invalid. Even if the apparent hasher is valid, the apparent hash will be invalid. Therefore, a user could supply the correct password, only to have the server reject it as invalid. It should be noted that the LDAP standard already recommends against storing clear-text passwords in an LDAP directory.

Lost LDAP-Response Messages

If the LDAP server is installed on the same host as the AAA Server or if it is an especially fast LDAP server, some of the LDAP-response messages may be lost by the AAA Server and authentication requests will timeout.

Using Oracle® Database

The AAA Oracle module allows you to retrieve user profiles from an Oracle8*i* database. When dealing with a large number of users, an Oracle data store delivers much higher server performance than File or Unix-PW storage. It also supports the server's load balancing feature.

Oracle can be configured to store:

- User name and password
- A limited set of reply item attributes

Its current limitations are:

- No check or deny item attributes
- No logging of Accounting-Requests to database, only to text file

You can store users in an Oracle database on one platform and authenticate those users with an AAA Server installed on another platform, such as the Red Hat Linux operating system.

To set up realms to use an Oracle data store, follow the procedure "Identifying Oracle Servers" on page 56.

Requirements

To implement an Oracle data store, you must first purchase and install:

- Red Hat Enterprise Linux, HP-UX, or Sun Solaris operating systems. Only these platforms support the `db_srv` daemon required to communicate with Oracle.
- Oracle8*i* development package. This includes the libraries required by the `db_srv` daemon.

Set up your environment to enable the Oracle database and `db_srv` daemon.

Oracle Data Store Processing

When the AAA Server receives a request from a user in a realm that has been configured for Oracle storage, the Finite State Machine (FSM) calls the iaaaRealm action, which in turn calls the Oracle action to retrieve user profiles from the Oracle database.

When the Oracle action receives a request from iaaaRealm. it uses the `AUTH_NET_REQ` data structure to send the request to the `db_srv` daemon. The daemon acts as an Oracle listener, waiting to receive requests from the Oracle action. `db_srv` daemon sends a SQL query to the Oracle database and uses the `AUTH_NET_USERSAUTH_NET_USER` data structure to return the appropriate replies to the Oracle action. The Oracle action returns the results to the FSM.

Multiple `db_srv` daemons can communicate with a single database or a set of replicated databases. Each daemon must be on a different machine or listening to a different port.

The Oracle module also provides round-robin load balancing and failover of Oracle `db_srv` daemons.

Storing User Profiles in Oracle

The AAA Server authenticates users against the values stored in the `network_auth_name` and `network_auth_password` columns of the `AUTH_NET_USERS` table. The rest of the table stores RADIUS reply items returned to the server through the `db_srv` daemon.

Users Table Structure

Define a users table with the following SQL statements:

```
create table AUTH_NET_USERS
(
network_auth_name VARCHAR2(63),
network_auth_password VARCHAR2(128),
session_timeout number (10),
idle_timeout number(10),
port_limit number(10),
tunnel_type number(10),
tunnel_medium_type number(10),
tunnel_client_end VARCHAR2(64),
tunnel_server_end VARCHAR2(64),
acct_tunnel_connection VARCHAR2(64),
service_type number(10),
framed_protocol number(10),
framed_ip_addr number(10),
framed_ip_netmask number(10),
framed_routing number(10),
filter_id VARCHAR(128),
framed_compression number(10)
);

COMMIT;
```

The columns in the AUTH_NET_USERS table correspond to the following RADIUS attributes. Store the A-V pair value in the corresponding column.

Column	RADIUS Attribute
network_auth_name	User-Name
network_auth_password	Password
network_timeout	Session-Timeout
idle_timeout	Idle-Timeout
port_limit	Port-Limit
tunnel_type	Tunnel-Type
tunnel_medium_type	Tunnel-Medium-Type
tunnel_client_end	Tunnel-Client-End
tunnel_server_end	Tunnel-Server-End
connection_id	Connection-Id
service_type	Service-Type
framed_protocol	Framed-Protocol
framed_ip_address	Framed-IP-Address
framed_ip_netmask	Framed-IP-Netmask
framed_routing	Framed-Routing
filter_id	Filter-Id
framed_compression	Framed-Compression

Create the Users Table

To execute the table statement:

1 Start an instance of the database where user profiles will be stored.

2 Start SQL*Plus and connect to the database.

3 At the SQL prompt, enter `START create.sql` to create the users table.

4 Add user records to the table with the following SQL command:

```
insert into AUTH_NET_USERS values ('User-Name', 'Password', Session-
Timeout, Idle-Timeout, Idle-Timeout, Port-Limit, Tunnel-Type,
'Tunnel-Client-End', 'Tunnel-Server-End', 'Acct-Tunnel-Connection',
Service-Type, Framed-Protocol, Framed-IP-Address, Framed-IP-Netmask,
Framed-Routing,'Filter-Id', Framed-Compression);

commit;
```

Replace the variables in the example above with the attribute values for this user. Enclose string type values in quotes. You can write a NULL value to any attribute, except for `User-Name` and `Password`.

Note: You can add all users at once by modifying the fill.sql command file included with db_srv, then running START fill.sql from the SQL prompt.

Always create the table:

- In the database's default SYSTEM table space
- In the default database or a database that has been assigned an SID

Modify the Users Table

To remove users from the table, at the SQL prompt, enter:

```
delete * from AUTH_NET_USERS where network_auth_name = 'User-Name';

commit;
```

Substitute the `network_auth_name` column value for the *'User-Name'* placeholder.

Note: You can use the clear.sql command file included with db_srv to clear all users from the table. Run START clear.sql from the SQL prompt.

Whenever modifying the SQL statement or `create.sql` script that creates the users table:

- Always name the table `AUTH_NET_USERS`
- Do not add, remove, modify, or change the order of the predefined columns

Configuring db_srv Daemon

The `db_srv` daemon is the client that interfaces with the Oracle database and AAA Server. Run a daemon on each Oracle database host machine you wish to access (one `db_srv` per AAA connection).

Install db_srv Daemon

The db_srv Daemon is installed with the AAA Server. If the Oracle database is also hosted on this machine, you can choose Oracle server as a component when you install the AAA Server software. If not, run the installer on the machine that hosts the Oracle database and choose to install only the Oracle server component.

To install the daemon:

1 Copy the AAA installer from the download directory to the Oracle host machine.

2 Log on as the user permitted to communicate with the Oracle database.

3 Run the installer:

```
# sh /local directory path/RAD-Series.7.3.0.linux.i686.bin
```

4 Enter option number 4 for Oracle:

```
ENTER A COMMA-SEPARATED LIST OF NUMBERS REPRESENTING THE COMPONENTS
TO BE INSTALLED: 4
```

5 Follow the prompts to choose the directories where you want the files installed.

Edit db_srv.opt

Before executing the daemon, edit the configuration file, `db_srv.opt` (in `/etc/opt/aaa` by default):

1 Locate the lines:

```
DB_SRV_PORT=Port
DB_SRV_ORA_UID=User-Name
DB_SRV_ORA_PWD=Password
DB_SRV_ORA_SID=Oracle-SID
export DB_SRV_PORT DB_SRV_ORA_UID DB_SRV_ORA_PWD DB_SRV_ORA_SID
```

2 Enter values for:

Parameter	Description
DB_SRV_PORT	Port number used by db_srv for incoming authentication requests from the AAA Server. Should match port you configure on the AAA Server. Any available port number may be used. Typically, port numbers greater than 4000 are used, since port numbers for standard services are usually less than 4000. If multiple db_srv daemons are running on the same machine, each daemon must be listening to a different port.
DB_SRV_ORA_UID	Oracle user name used to access the database.
DB_SRV_ORA_PWD	Oracle password used to access the database.
DB_SRV_ORA_SID	Oracle ID for the database to connect to when more than one database exists on the machine. If the parameter is omitted, the daemon connects to the default database, which is defined during database installation.

Start db_srv Daemon

To execute the daemon, at the command line, run:

```
run_db_srv.sh
```

If `db_srv.opt` is not installed in the default location, use the `-f` *`Directory`* option where *`Directory`* is the full path to the configuration file.

Using Advanced Policy

The RAD-Series Advanced Policy module lets you define advanced policies to control the processing of requests. Advanced policies are logical expressions that result in a true or false answer when evaluated against a request. Depending on the outcome, A-V pairs may be added to the request as reply items and event codes may be returned to the FSM to control progress to the next state.

Unlike the user check and deny items, advanced policies can include a wide range of criteria and comparisons using:

- Boolean operators and relative operators
- Complex expressions
- Nested statements

Advanced policies are specifically used to implement:

- Dialed Number Identification Service (DNIS) routing
- Dynamic Access Control (DAC) time-based provisioning
- Control access according to NAS addresses or ports
- Logical user groups (other than realm)

Decision Files

Advanced policies are defined in decision files. There is a new additional format for Decision files now. The old format contains policy group entries which are still supported but it is not documented here. If you are using the group format you can to refer to your old documentation. The new format is more of a scripting language and should be easier to use. The Decision file must be all the same format, the formats can not be intermixed.

Decision files make policy decisions by matching requests to a sequence of conditions. The Decision file is evaluated against the request removing, modifying and/or adding A-V pairs as directed until an **`exit`** command is encountered. Any remaining lines are not evaluated. The **`exit`** command specifies the state machine event to give the state machine. The event is used to control the flow through the state machine. For instance, the NAK event will cause the state machine to send a NAK to the request. See "Finite State Machine (FSM)" on page 206 for more information on FSMs.

Implementing Advanced Policies

The default FSM file distributed with the RAD-Series server provides several places to implement advanced policies:

1. Request pre-processing policy
2. User/Realm policy
3. Reply post-processing policy
4. Proxy send request policy
5. Proxy receive response policy

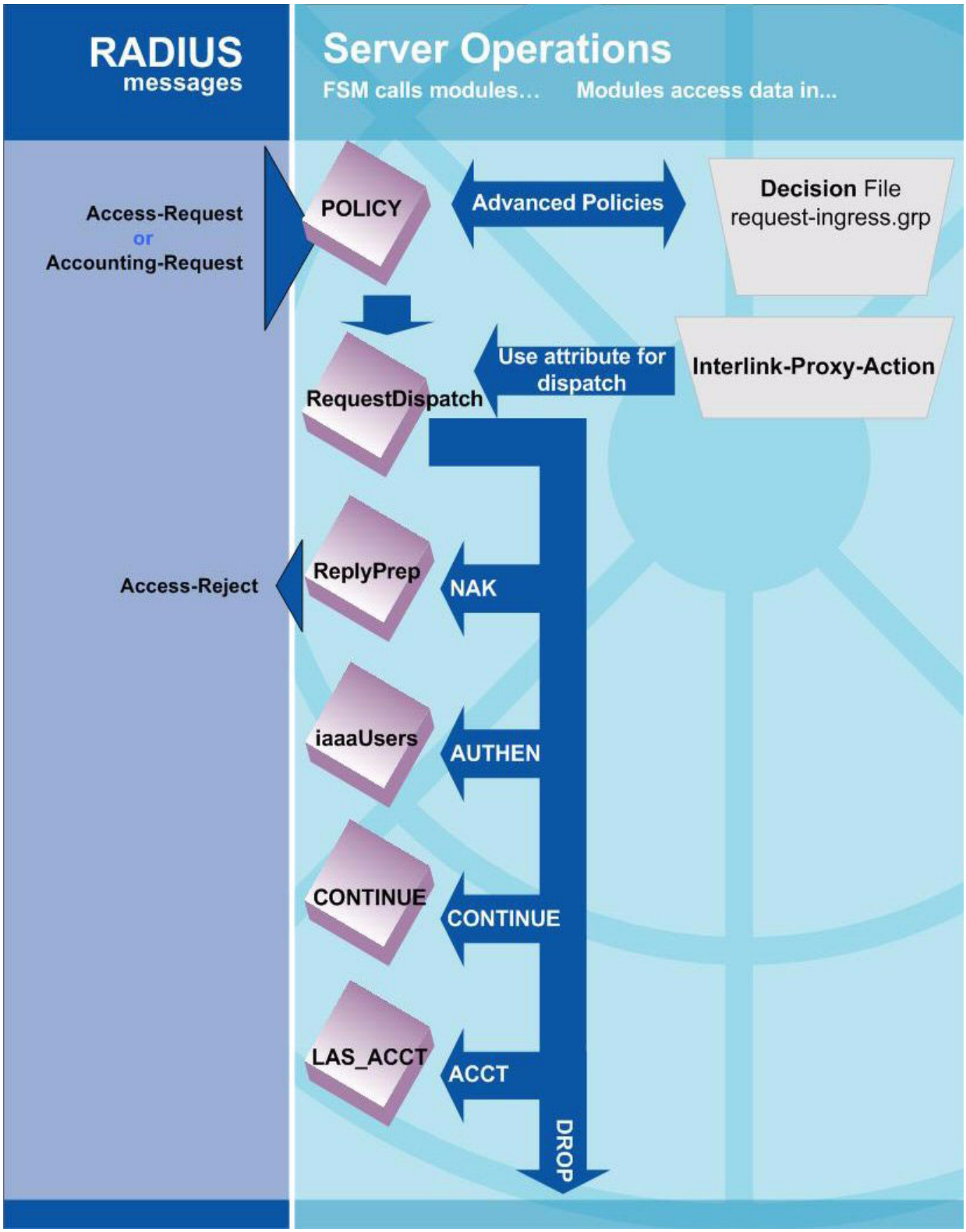
The `radius.fsm` file can also be modified to implement advanced policies in decision files at additional points in the FSM file. See "Calling Decision Files" on page 171 for further details on modifying the FSM file to implement advanced policies

Request pre-processing policy

All requests are subjected to the request pre-processing policy that is defined in the `request-ingress.grp` decision file. The request pre-processing policy is applied as the very first step in the FSM, before the request is dispatched for processing.

The request pre-processing policy may alter the request arbitrarily:

- A-V pairs may be added, changed, or removed
- The request classification may be altered
- The request may be rejected immediately
- The request may be dropped entirely, there will be no reply sent



Flow of Request Pre-Processing Policy

User/Realm policy

All requests are subjected to user/realm policy after authentication. User/realm policy is applied only after a successful authentication.

A user policy is specified in a `Policy-Pointer` attribute on the request as either a check item or a reply item, see "Policy-Pointer" on page 68 for information on configuring it. If the `Policy-Pointer` attribute is found in the check items then the Server will not look for one in the reply items. The value of the `Policy-Pointer` attribute is treated just like the `Xstring` value from the FSM file; it specifies the URL for the decision file to be evaluated.

A realm policy is specified in a `Policy-Pointer` parameter in a `ProLDAP` realm entry in an authfile. The value of the `Policy-Pointer` parameter is treated just like the `Xstring` value from the FSM file; it specifies the URL for the decision file to be evaluated.

If a request contains a `Policy-Pointer` attribute, as either a check item or a reply item, the named advanced policy will be applied. If a request contains no `Policy-Pointer` attribute and the realm entry has a `Policy-Pointer` parameter, the named advanced policy will be evaluated. If neither the request, nor the realm entry, contain a `Policy-Pointer`, then no user or realm policy is applied; in this case the `POLICY` action returns an `ACK` event to the FSM.

See the "Authorization flow in default Finite State Machine" on page 9 for the flow of user/realm policy.

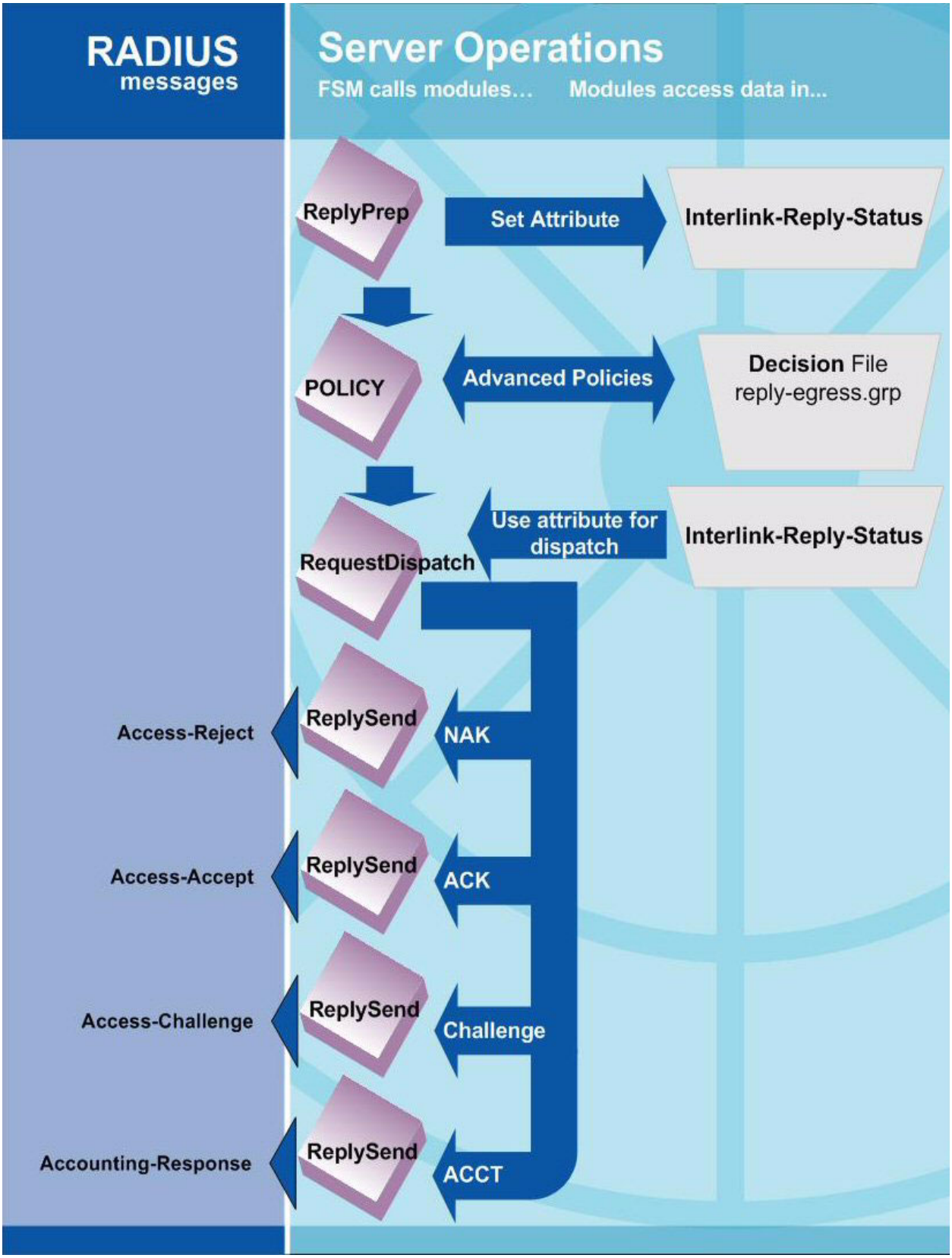
Reply post-processing policy

All replies are subjected to the reply post-processing policy that is defined in the `reply-egress.grp` decision file. The reply post-processing policy is applied as the very last step in the FSM, just before the RADIUS reply message is created and sent.

The reply post-processing policy may alter the request arbitrarily:

- A-V pairs may be added, modified, or removed
- The reply type may be changed
- The request may be dropped entirely, there will be no reply sent

If the client is defined as `type=NAS` or `type=PROXY+PRUNE` (possibly including vendors), the pruning rules specified in the dictionary will have been applied according to the reply type that was in effect before the post-processing policy is evaluated.



Flow of Reply Post-Processing Policy

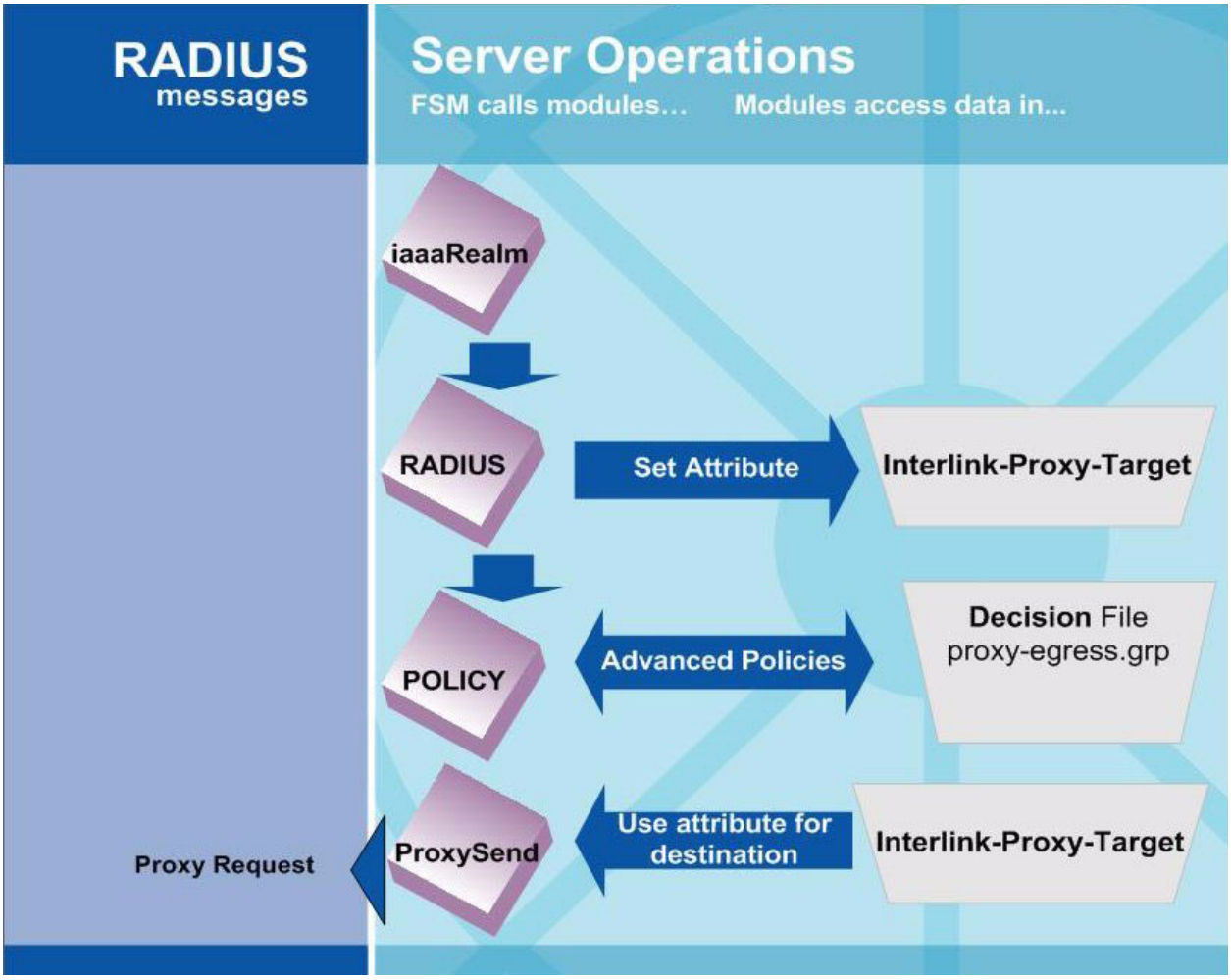
Proxy send request policy

All requests that need to be proxied are subjected to the proxy send request policy defined in the proxy-egress.grp decision file. The proxy send request policy is applied as the very last step in the FSM before the RADIUS proxy request message is created and sent.

The proxy send request policy may alter the request arbitrarily except as noted below:

- A-V pairs may be added, modified, or removed
- The request may be rejected immediately
- The request may be dropped entirely, there will be no reply sent
- The proxy target host may be changed

Note: Do NOT modify or remove, any Proxy-State or Proxy-Action A-V pairs. Doing so will interfere with proxy functionality.



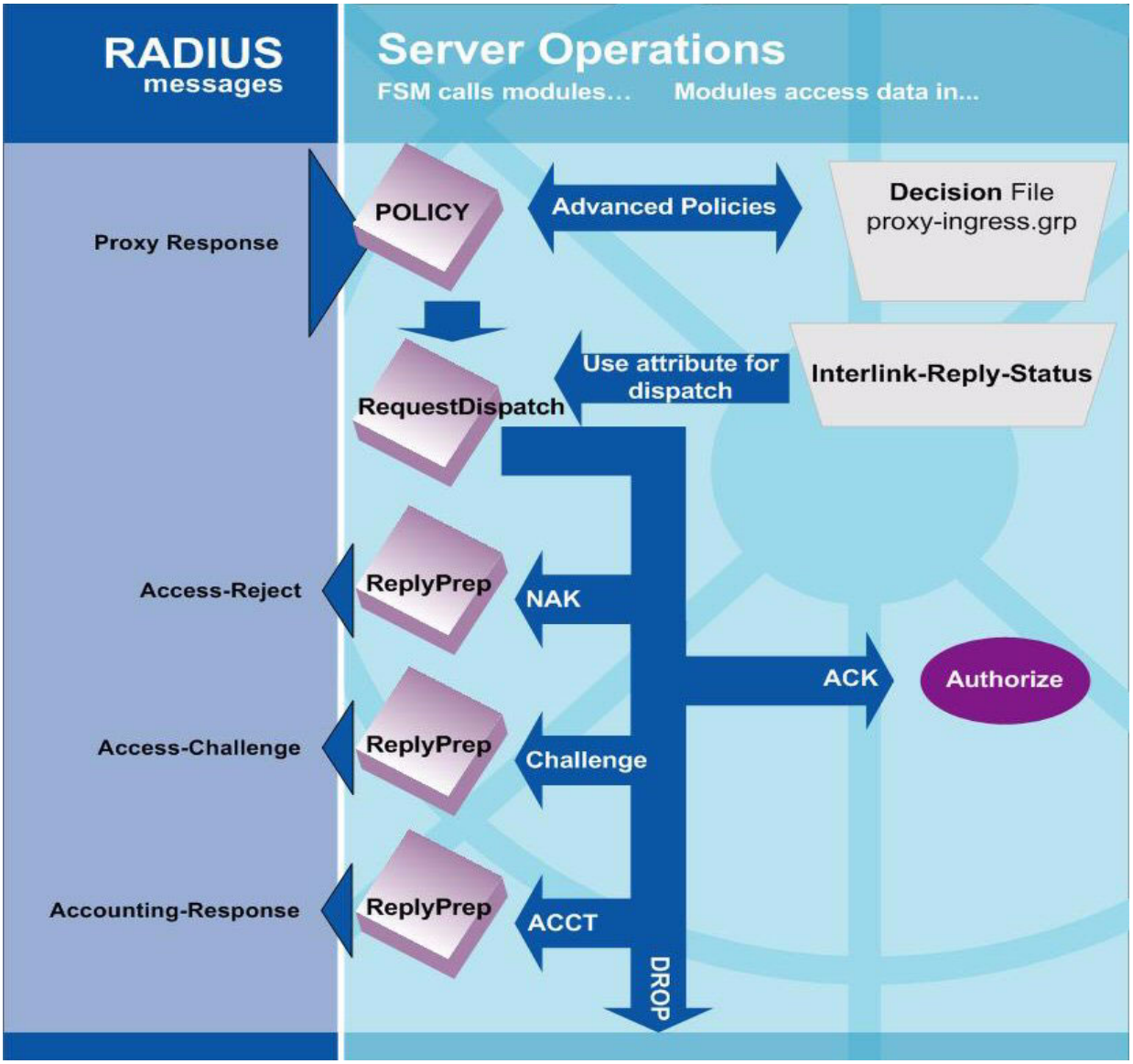
Flow of Proxy Send Request Policy

Proxy receive response policy

All proxy replies are subjected to the proxy receive response policy defined in the proxy-ingress.grp decision file. The proxy receive response policy is applied as the very first step in the FSM after the reply is received.

The proxy receive response policy may alter the request arbitrarily:

- A-V pairs may be added, modified, or removed
- The reply type may be altered
- The request may be rejected immediately
- The request may be dropped entirely, there will be no reply sent



Flow of Proxy Receive Response Policy

Policy Syntax

There are several action command keywords:

- **if (*<bool-expr>*) { *<action-list1>* } else { *<action-list2>* }**
- **delete *<attr-spec>***
- **insert *<attr-spec>* = *<value-expr>***
- **modify *<attr-spec>* = *<value-spec>***
- **exit "*<event-name>*"**
- **log "*<log-level>*" "*<log-message>*", *<attr-spec>*, ... *<attr-spec>***

Keywords and function names are case-sensitive.

Command	Parameter Description
if	***<bool-expr>*** is a boolean expression. See "Boolean Expressions" on page 149 for a description. ***<action-list1>*** and ***<action-list2>*** are sequences of action commands that may include additional if commands, nested to an arbitrary depth. When the **else** clause is omitted, ***<action-list2>*** may be considered an empty sequence of action commands.
delete	***<attr-spec>*** is an attribute specification. The use of instance specification, including "last" and "*", is allowed. The use of attribute functions is not permitted
insert	***<attr-spec>*** is an attribute specification. The use of instance specification, including "begin" and "last" is allowed. The use of attribute functions is not allowed. The default instance for ***<attr-spec>*** is "last". ***<value-expr>*** is a value expression. ***<value-expr>*** may use an attribute specification. The use of instance specification, including "last", is allowed. The use of attribute functions is allowed. If ***<value-expr>*** refers to an attribute, the default instance is "last". If ***<value-expr>*** refers to an instance that is not present, a no-such-instance run-time error occurs. See "Error Handling" on page 168 for details. The types of ***<attr-spec>*** and ***<value-spec>*** must be compatible. See "Type Compatibility" on page 152 for details.

Command	Parameter Description
modify	***<attr-spec>*** is an attribute specification. The use of instance specification, including "last", is allowed. The use of attribute functions is not allowed. The default instance for ***<attr-spec>*** is "last". If ***<attr-spec>*** refers to an instance that is not present, a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details. ***<value-spec>*** is a value specification. ***<value-spec>*** may use attribute-specifications. The use of instance specification, including "last", is allowed. The use of attribute functions is allowed. If ***<value-spec>*** refers to an attribute, the default instance for ***<value-spec>*** is "last". If ***<value-spec>*** refers to an instance that is not present, a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details. The value types for ***<attr-spec>*** and ***<value-spec>*** must be compatible. See "Type Compatibility" on page 152 for details.
exit	***<event-name>*** must be a quoted string. ***<event-name>*** must specify an event that is defined. There are a number of predefined events. Additional events may be defined in the FSM file using "`%event <name>`" syntax. See "Events" on page 208 for more detailed information on finite state machine events. Event names are case-insensitive (MyEvent is the same as MYEVENT)
log	***<log-level>*** must be a quoted string. ***<log-level>*** must be a log-level type: NOTICE, ERROR, CRITICAL, ALERT, WARNING, INFO ***<log-level>*** is case-insensitive ("ERROR" same as "Error"). ***<log-message>*** must be a quoted string. Multiple instances for ***<attr-spec>*** are allowed and cause all named instances to be reported in the logfile. The use of instance specification, including "last" and '*', is allowed. The default instance specification for the attributes in the **log** command is "last". If ***<attr-spec>*** refers to an instance that is not present, this will be indicated in the logfile output. A no-such-instance run-time error will NOT be generated in this case.

There are several Attribute Functions:

- **count(*<attr-spec>*)**
- **length(*<attr-spec>*)**
- **substr(*<attr-spec>* ...)**
- **tolower(*<attr-spec>*)**
- **toupper(*<attr-spec>*)**

Keywords and function names are case-sensitive.

Function	Parameter Description
count	***<attr-spec>*** is an attribute specification. The use of instance specification, including "last" and "*", is allowed. The use of an attribute function is not allowed. The default instance for ***<attr-spec>*** is "last".
length	***<attr-spec>*** is an attribute specification. The use of instance specification, including "last", is allowed. The use of an attribute function is not allowed. The default instance for ***<attr-spec>*** is "last".
substr	***<attr-spec>*** is an attribute specification. The use of instance specification, including "last", is allowed. The use of an attribute function is not allowed. The default instance for ***<attr-spec>*** is "last". Keywords of "offset", "before", "before last", "after" and "after last" define the rest of the command format. See "substr function" on page 165 for a detailed description
tolower	***<attr-spec>*** is an attribute specification. The use of instance specification, including "last", is allowed. The use of an attribute function is not allowed. The default instance for ***<attr-spec>*** is "last".
toupper	***<attr-spec>*** is an attribute specification. The use of instance specification, including "last", is allowed. The use of an attribute function is not allowed. The default instance for ***<attr-spec>*** is "last".

Decision files are evaluated from beginning to end. The Decision file is evaluated against the request removing, modifying and/or adding A-V pairs as directed until an **exit** command is encountered. Any remaining lines are not evaluated. The **exit** command specifies the state machine event to give the state machine. The event is used to control the flow through the state machine. For instance, the NAK event will cause the state machine to send a NAK to the request. If the end of the file is reached without executing an **exit** command then the ACK event will be returned to the state machine. See "Finite State Machine (FSM)" on page 206 for more information on FSMs.

Use a pound sign (#) to comment out any lines you do not want applied.

Decision files must be stored in the same directory that contains the server's other configuration files. There are no required naming conventions for a decision file, but the file name must match its reference in `radius.fsm`, `authfile`, realm files, or the default users file.

Attribute Specifications

Attribute specifications have several pieces:

- Vendor Name
- Attribute Name
- Tag Value
- Value
- Instance
- Functions

Vendor Names

When more than one vendor has defined an attribute with the same name, it is necessary to distinguish between them. This is accomplished by prefixing the attribute name with the vendor name, offset by a `':'` (colon) character.

For example:

```
RADIUS:Reply-Message
Cisco:Cisco-AvPair
MERIT:Xvalue
```

No white space is allowed around the `':'` character.

For example:

```
RADIUS : Reply-Message
RADIUS: Reply-Message
RADIUS :Reply-Message
```

Are NOT valid. Using these forms will result in a syntax-error load-time error. See "Error Handling" on page 168 for more details.

Vendor names are defined in the server's vendors file.
Vendor names are case-insensitive (`MERIT` is the same as `Merit`).

Attribute Names

Attribute names are specified by simply writing the name of the attribute.

For example:

```
Reply-Message
Cisco-AvPair
Xvalue
```

Attribute names are defined in the server's dictionary file.
Attribute names are case-insensitive (`Reply-Message` is the same as `REPLY-MESSAGE`).

Tag Value

If the attribute is a tagged attribute then the reference to the attribute may optionally include a tag value using :<tag>: format. See "Value Specifications" on page 138 for more information.

Value

See "Value Specifications" on page 138 for a description of the value syntax.

Attribute Instance Specifications

There can be more than one instance of a given attribute on the request. It is sometimes necessary to specify which instance is of interest. It is sometimes necessary to specify the absolute location of an attribute instance (when inserting, for example).

Attribute instance specifications are provided using **[]** syntax following the attribute name. The instance of interest is indicated inside the **[]**'s. The instance can be specified numerically using a positive integer constant, using a keyword or using the special symbol '*****'.

For example:

```
Reply-Message
Reply-Message[2]
Reply-Message[last]
Reply-Message[*]
```

White space is allowed around and between the **[]**'s.

For example:

```
Reply-Message [ 3 ]
Reply-Message[ last]
```

No instance specification

When the specific instance is of no consequence, it may be left unspecified. This is equivalent to specifying "last" (see "last keyword" on page 136). See the individual action-command, attribute function and comparison operator descriptions for details.

Numeric instance specification

When a specific instance is desired, it may be specified numerically. Instances are numbered from 0 (the first instance).
Negative instance numbers are not allowed.

Suppose that:

```
Reply-Message = "abc"
Reply-Message = "def"
Reply-Message = "ghi"
```

Then:

```
Reply-Message[0] = "abc"
Reply-Message[1] = "def"
Reply-Message[2] = "ghi"
```

Keyword instance specification

When a specific instance is desired, it may be specified using one of the following keywords which are case sensitive or the special symbol '**`*`**':

- **`begin`** keyword

  When the beginning of the list is desired (when inserting), use the "begin" keyword. This keyword is only supported by the **`insert`** command, on the left side of the '**`=`**'.

  For example:

  ```
  insert Reply-Message[begin] = "This is first"
  ```

  See "insert" on page 131 for details and examples.

  Using this keyword in other places results in an invalid-instance-specification load-time error. See "Error Handling" on page 168 for more details.

- **`last`** keyword

  When the last instance (the one located closest to the end of the list) of a particular attribute is desired, use the "last" keyword.

  For example:

  ```
  Reply-Message[last]
  ```

  This is the default in all situations. See the individual action command, attribute function and comparison operator descriptions for details.

  Suppose that:

  ```
  Reply-Message = "abc"
  Reply-Message = "def"
  ```

  Then:

  ```
  Reply-Message[last] = "def"
  ```

- **`*`** keyword

  When all instances are desired, use the '**`*`**' symbol.

  For example:

  ```
  Reply-Message[*]
  ```

  This form is only supported by the **`delete`** and **`log`** commands and the **`count()`** attribute function. Using this form in unsupported contexts results in an invalid-instance-specification

load-time error. See "Error Handling" on page 168 for more details.

Attribute Functions

Attribute functions are provided using ***keyword(<attr-spec>)*** syntax.

For example:

```
count( Reply-Message )
count( Reply-Message[0] )
count( Reply-Message[*] )
```

White space is allowed around and between the '**()**' characters.

For example:

```
count( Reply-Message )
count( Reply-Message)
count (Reply-Message)
count (Reply-Message )
```

Are all valid.

There are many possible attribute functions. See description in "Attribute Functions" on page 163 for details.

Value Specifications

Constant values may be specified in various ways depending on the value type. See "Type Compatibility" on page 152 for more details.

1. Integer values

Integer values may be specified as decimal integers, including a leading '-' sign. Integer values can not have any leading zeros. A tag may also be specified by using :tag: syntax prefixed to the value. The tag value must be in the range of 0 to 31.

For example these are legal:

```
10
0
-37
:3:10
:0:37
```

These are NOT legal:

```
0123
:32:92
:0:-37
```

Integer values may also be specified as hexadecimal integers.
Hexadecimal values are always unsigned.

For example:

```
0x3
0x6F32e5
0x00AB34
:1:0x3
:9:0xf3AB
```

Integer values can be used with integer, short, octet and tag-int type attributes.

Integer values used with an integer attribute can have a value range of 0 to 4294967295.
Integer values used with a short attribute can have a value range of 0 to 65535.
Integer values used with an octet attribute can have a value range of 0 to 255.
Integer values used with a tagged integer attribute can have a value range of 0 to 16777215.

Violating the value range results in an invalid integer value load-time error. See "Error Handling" on page 168 for more details.

An integer value can be entered as a negative number but the attributes and values will be treated as unsigned numbers when comparisons are performed.

2. Named integer values

Named integer values are enclosed in double quotes '"'. A tag may be provided by using :tag:

syntax prefixed to the named value.

For example:

```
Service-Type = "FRAMED"
Tunnel-Type = :12:"PPTP"
```

Named integer values are defined in the server's dictionary file.
Named integer values are case-insensitive (`FRAMED` is the same as `Framed`).
Named integer values can only be used with integer and tag-int type attributes that have defined named values.
Named integer values can only be used with the attribute for which they are defined.
Using an undefined named value results in an unknown named value load-time error. See "Error Handling" on page 168 for more details.

3. String values

String values are enclosed in double quotes '"'. There are escape sequences to allow for the inclusion of non-printable characters in a string value. Tags may be specified by using :tag: syntax prefixed to the value.

```
The defined escape sequences and meanings are:
   Sequence   Meaning
      \0      Null
      \"      Double Quote
      \\      Backslash
      \b      Bell
      \n      Line Feed
      \r      Carriage Return
      \t      Tab
      \h      Backspace
      \f      Form Feed
      \xHH    The octet whose value is the specified 2 digit hex number
```

For example:

```
"a string value"
"and\x20some\x20\"escapes\"\x20\n"
:21:"a string value"
```

String values can be used with string, tag-str and octets type attributes.

The length of a string attribute and/or string value is not limited except by memory. However, if a string attribute ultimately is inserted into a RADIUS packet then the server will enforce the following maximums and if violated will result in logging the error in the logfile and dropping the request:

string and octets	253 characters
tag-str	252 characters
vendor specific string and octets	247 characters
vendor specific tag-str	246 characters

4. IP Address values

IP Address values are enclosed in double quotes '"'.
IP address values must be specified in standard dotted-quad notation.

For example:

```
"1.2.3.4"
```

The use of an invalid IP address results in a syntax-error load-time error. See "Error Handling" on page 168 for more details.

5. Date values

There is no provision for specifying date value constants at this time. The value of date type attributes may be compared and copied. It is only date value constants that are not supported.

The use of a constant value in conjunction with a date type attribute results in a syntax-error load-time error. See "Error Handling" on page 168 for more details.

6. Tag-Str values

Attributes of type Tag-Str use string values. See String values (item 3 above) for details.

7. Tag-Int values

Attributes of type Tag-Int use integer and named integer values. See Integer values (item 1 above) and Named integer values (item 2 above) for details.

8. Octets values

Attributes of type octets use string values. See String values (item 3 above) for details.

9. Octet values

Attributes of type octet use integer values. See Integer values (item 1 above) for details.

10. Short values

Attributes of type short use integer values. See Integer values (item 1 above) for details.

Attribute Value Handling

Attributes in RADIUS Messages

Each attribute in a RADIUS message has several fields: attribute code, attribute length, tag and value. For tagged-string attributes, the tag field is optionally present. For vendor-specific attributes, the value field has several sub-fields: vendor code, attribute code, attribute length (details vary by vendor and/or attribute code). See the RADIUS RFCs for additional details.

Attributes in the RAD-Series Server

In the RAD-Series RADIUS server, attributes have several fields: vendor code, attribute code, tag and value. For all attributes, the tag field and the vendor code field are always present.

Tagged Attributes and the Advanced Policy Language

In the RAD-Series RADIUS server advanced policy language, the tag field of tagged attributes and the value field of tagged attributes are treated separately.

For conditional expressions in the If command, comparisons consider only the value field of attributes and constants. The tag field is ignored.

For the **`insert`** command, the tag field from the value on the right hand side of the '=' is preserved in the inserted attribute.

For the **`modify`** command, the tag field from the value on the right hand side of the '=' is ignored. The tag field of the modified (target) attribute is left unchanged.

For attribute functions that operate on string values (length, substr, tolower, toupper), only the value field is considered. The tag field is ignored. For attribute functions that return the same type of attribute as their parameter (substr, tolower, toupper), the tag field of the source attribute is preserved in the function return value.

Operators

The following operators may be used:

Operator	Description
=	Equal to, see "= Operator" on page 143
!=	Not equal to, see "!= Operator" on page 144
>	Greater than, see "> Operator" on page 147
<	Less than, see "< Operator" on page 145
>=	Greater than or equal to, see ">= Operator" on page 148
<=	Less than or equal to, see "<= Operator" on page 146
&&	Logical AND, see "&& Operator" on page 149
||	Logical OR, see "|| Operator" on page 150
!	Logical NOT, see "! Operator" on page 150
()	Parentheses, see "() Operator" on page 151

Comparison operators

General comparison operator

1. Syntax

   <value1> <operator> <value2>

2. Parameters

   <value1> and ***<value2>*** are value expressions.

   <value1> and ***<value2>*** may use attribute-specifications. The use of instance specification, including "last", is allowed. The use of attribute functions is allowed.

   Either ***<value1>*** or ***<value2>*** (or both) must refer to an attribute.

   This determines the type for the comparison.

   The types of ***<value1>*** and ***<value2>*** must be compatible. See "Type Compatibility" on page 152 for details.

   If ***<value1>*** or ***<value2>*** refers to an attribute, the default instance is "last".

3. Operation

   Returns a boolean value that indicates the result of the comparison.

   If ***<value1>*** or ***<value2>*** refers to an attribute that is a tagged type (tag-int or tag-str), only the value portion is used for comparison purposes. See "Tagged Attributes and the Advanced Policy Language" on page 141.

   For string and octets type values the comparison is performed using the native collation sequence of the system (ASCII), in a case-sensitive fashion. Extended characters (those outside the 7-bit ASCII range) are considered as positive values; in other words, characters are considered to be unsigned.

   For integer type values the comparison is performed in a signed fashion, using native system byte ordering.

   For IP Address type values the comparison is performed in an unsigned fashion, using big-endian (network/MSB-first) byte ordering.

   For date type values the comparison is performed in an unsigned fashion, using native system byte ordering.

4. Examples

   Some equivalent specifications (NAS-Port is an example):

   ```
   NAS-Port
   NAS-Port[last]
   ```

   Instance specifications that are allowed:

   ```
   NAS-Port
   NAS-Port[0]
   NAS-Port[302]
   NAS-Port[last]
   ```

   Instance specifications that are **NOT** allowed:

```
NAS-Port[begin]
NAS-Port[*]
```

Using any of these specifications results in an invalid-instance-specification load-time error. See "Error Handling" on page 168 for more details.

See the individual comparison operator descriptions below for more complete examples.

= Operator

1. Syntax

   <value1> = <value2>

2. Parameters

   See Parameters in "General comparison operator" on page 142 for details.

3. Operation

   Compares two values for equality:

   false: ***<value1>*** not equal to ***<value2>***
   true: ***<value1>*** equal to ***<value2>***

   See Operation in "General comparison operator" on page 142 for more details.

   If ***<value1>*** or ***<value2>*** refers to an attribute for which there are no instances on the request, the comparison yields false.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   NAS-Port = 2 is true
   NAS-Port = 3 is false
   2 = NAS-Port is true (same as 2 = NAS-Port[last])
   3 = NAS-Port is false (same as 3 = NAS-Port[last])
   ```

   Suppose that:

   ```
   NAS-Port = 2
   NAS-Port = 3
   ```

   Then:

   ```
   NAS-Port = 2 is false
   NAS-Port = 3 is true
   NAS-Port[0] = 2 is true
   NAS-Port[1] = 2 is false
   NAS-Port[0] = 3 is false
   NAS-Port[1] = 3 is true
   NAS-Port = NAS-Port is true
   NAS-Port[last] = NAS-Port is true
   2 = NAS-Port is false (same as 2 = NAS-Port[last])
   3 = NAS-Port is true (same as 3 = NAS-Port[last])
   NAS-Port[2] = 2 is false (NAS-Port[2] is not present)
   ```

Suppose that:

```
Reply-Message = "abc"
Tunnel-Password = :2:"abc"
Tunnel-Password = :1:"abc"
```

Then:

```
Tunnel-Password[0] = Tunnel-Password[1] is true
Tunnel-Password[0] = Reply-Message is true
Tunnel-Password[0] = "abc" is true
Reply-Message = Tunnel-Password is true
"abc" = Tunnel-Password[0] is true
:21:"abc" = Tunnel-Password is true
:21:"abc" = Reply-Message is true
```

!= Operator

1. Syntax

   <value1> != <value2>

2. Parameters

   See Parameters in "General comparison operator" on page 142 for details.

3. Operation

   Compares two values for inequality:

   false: ***<value1>*** equal to ***<value2>***
   true: ***<value1>*** not equal to ***<value2>***

   See Operation in "General comparison operator" on page 142 for more details.

   If ***<value1>*** or ***<value2>*** refers to an attribute for which there are no instances on the request, the comparison yields true.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   NAS-Port != 2 is false
   NAS-Port != 3 is true
   2 != NAS-Port is false
   3 != NAS-Port is true
   NAS-Port[2] != 2 is true (NAS-Port[2] is not present)
   ```

   Suppose that:

   ```
   NAS-Port = 2
   NAS-Port = 3
   ```

   Then:

   ```
   NAS-Port != 2 is true
   NAS-Port[0] != 2 is false
   NAS-Port[1] != 2 is true
   ```

```
NAS-Port != 3 is false
NAS-Port != 4 is true
2 != NAS-Port is true (same as 2 != NAS-Port[last])
3 != NAS-Port is false (same as 3 != NAS-Port[last])
4 != NAS-Port is true (same as 4 != NAS-Port[last])
NAS-Port[2] != 7 is true (NAS-Port[2] is not present)
```

Suppose that:

```
Tunnel-Password = :2:"abc"
Tunnel-Password = :1:"abc"
```

Then:

```
Tunnel-Password[0] != Tunnel-Password[1] is false
```

< Operator

1. Syntax

   <attr1> < <attr2>

2. Parameters

   See Parameters in "General comparison operator" on page 142 for details.

3. Operation

   Compares two values for less than:

   false: ***<value1>*** not less than
   true: ***<value1>*** less than ***<value2>***

   See Operation in "General comparison operator" on page 142 for more details.

   If ***<value1>*** or ***<value2>*** refers to an attribute for which there are no instances on the request, the comparison yields false.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   NAS-Port < 2 is false
   NAS-Port < 3 is true
   2 < NAS-Port is false
   37 < NAS-Port[2] is false (NAS-Port[2] is not present)
   ```

   Suppose that:

   ```
   NAS-Port = 2
   NAS-Port = 3
   ```

   Then:

   ```
   NAS-Port < 2 is false
   NAS-Port < 3 is false
   NAS-Port < 4 is true
   2 < NAS-Port is true (same as 2 < NAS-Port[last])
   ```

Suppose that:

```
Tunnel-Type = :2:"PPTP" (this has the value 1)
Tunnel-Type = :1:"VLAN" (this has the value 13)
```

Then:

```
Tunnel-Type[0] < Tunnel-Type[1] is true (same as 1 < 13)
Tunnel-Type < 7 is false (same as 13 < 7)
```

Suppose that:

```
Tunnel-Password = :2:"abc"
Tunnel-Password = :1:"def"
```

Then:

```
Tunnel-Password[0] < Tunnel-Password[1] is true
```

<= Operator

1. Syntax

   <attr1> <= <attr2>

2. Parameters

   See Parameters in "General comparison operator" on page 142 for details.

3. Operation

   Compares two values for less than or equal to:

   false: ***<value1>*** not less than or equal to ***<value2>***
   true: ***<value1>*** less than or equal to ***<value2>***

   See Operation in "General comparison operator" on page 142 for more details.

   If ***<value1>*** or ***<value2>*** refers to an attribute for which there are no instances on the request, the comparison yields false.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   NAS-Port <= 2 is true
   NAS-Port <= 3 is true
   2 <= NAS-Port is true
   3 <= NAS-Port is false
   NAS-Port[2] <= 55 is false (NAS-Port[2] is not present)
   ```

   Suppose that:

   ```
   NAS-Port = 2
   NAS-Port = 3
   ```

   Then:

   ```
   NAS-Port <= 2 is false
   NAS-Port <= 3 is true
   ```

```
2 <= NAS-Port is true (same as 2 <= NAS-Port[last])
3 <= NAS-Port is true (same as 3 <= NAS-Port[last])
```

Suppose that:

```
Tunnel-Password = :2:"abc"
Tunnel-Password = :1:"abc"
Tunnel-Password = :3:"def"
```

Then:

```
Tunnel-Password[0] <= Tunnel-Password[1] is true
Tunnel-Password[0] <= Tunnel-Password[2] is true
```

> Operator

1. Syntax

   <attr1> > <attr2>

2. Parameters

   See Parameters in "General comparison operator" on page 142 for details.

3. Operation

   Compares two values for greater than:

   false: ***<value1>*** not greater than ***<value2>***
   true: ***<value1>*** greater than ***<value2>***

   See Operation in "General comparison operator" on page 142 for more details.

   If ***<value1>*** or ***<value2>*** refers to an attribute for which there are no instances on the request, the comparison yields false.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   NAS-Port > 1 is true
   NAS-Port > 2 is false
   NAS-Port > 3 is false
   NAS-Port > 4 is false
   1 > NAS-Port is false
   2 > NAS-Port is false
   3 > NAS-Port is true
   4 > NAS-Port is true
   NAS-Port[2] > 1 is false (NAS-Port[2] is not present)
   ```

   Suppose that:

   ```
   NAS-Port = 2
   NAS-Port = 3
   ```

   Then:

```
NAS-Port > 1 is true
NAS-Port > 2 is true
NAS-Port > 3 is false
NAS-Port > 4 is false
1 > NAS-Port is false
2 > NAS-Port is false
3 > NAS-Port is false
4 > NAS-Port is true
```

Suppose that:

```
Tunnel-Password = :2:"def"
Tunnel-Password = :1:"abc"
```

Then:

```
Tunnel-Password[0] > Tunnel-Password[1] is true
```

>= Operator

1. Syntax

   <attr1> >= <attr2>

2. Parameters

   See Parameters in "General comparison operator" on page 142 for details.

3. Operation

   Compares two values for greater than or equal to:

   false: ***<value1>*** not greater than or equal to ***<value2>***
   true: ***<value1>*** greater than or equal to ***<value2>***

   See Operation in "General comparison operator" on page 142 for more details.

   If ***<value1>*** or ***<value2>*** refers to an attribute for which there are no instances on the request, the comparison yields false.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   NAS-Port >= 1 is true
   NAS-Port >= 2 is true
   NAS-Port >= 3 is false
   NAS-Port >= 4 is false
   1 >= NAS-Port is false
   2 >= NAS-Port is true
   3 >= NAS-Port is true
   4 >= NAS-Port is true
   NAS-Port[2] >= 2 is false (NAS-Port[2] is not present)
   ```

   Suppose that:

```
NAS-Port = 2
NAS-Port = 3
```

Then:

```
NAS-Port >= 1 is true
NAS-Port >= 2 is true
NAS-Port >= 3 is true
NAS-Port >= 4 is false
1 >= NAS-Port is false
2 >= NAS-Port is false
3 >= NAS-Port is true
4 >= NAS-Port is true
```

Suppose that:

```
Tunnel-Password = :2:"abc"
Tunnel-Password = :1:"abc"
Tunnel-Password = :3:"def"
```

Then:

```
Tunnel-Password[0] >= Tunnel-Password[1] is true
Tunnel-Password[2] >= Tunnel-Password[1] is true
```

Boolean Expressions

&& Operator

1. Syntax

   <left-expr> && <right-expr>

2. Parameters

   <left-expr> and ***<right-expr>*** are boolean expressions.

3. Operation

   The **&&** operator evaluates the ***<left-expr>*** always. The ***<right-expr>*** is evaluated only when the <left-expr> evaluates to a true value.

   This is the traditional short-circuit evaluation most people expect.

   The value is true if both the ***<left-expr>*** and ***<right-expr>*** evaluate to true values. Otherwise the value is false.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   Reply-Message = "hello"
   ```

   Then:

   ```
   NAS-Port = 2 && Reply-Message = "hello" is true
   ```

|| Operator

1. Syntax

   <left-expr> **||** ***<right-expr>***

2. Parameters

   <left-expr> and <right-expr> are boolean expressions.

3. Operation

   The **||** operator evaluates the ***<left-expr>*** always. The ***<right-expr>*** is evaluated only when the ***<left-expr>*** evaluates to a false value.

   This is the traditional short-circuit evaluation most people expect.

   The value is true if either the ***<left-expr>*** or the ***<right-expr>*** evaluates to a true value. Otherwise the value is false.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   Reply-Message = "hello"
   ```

   Then:

   ```
   NAS-Port = 2 || Reply-Message = "xyz" is true
   NAS-Port = 7 || Reply-Message = "hello" is true
   ```

! Operator

1. Syntax

   ! ***<expr>***

2. Parameters

   <expr> is a Boolean expression.

3. Operation

   The **!** operator evaluates the ***<expr>***. The value is the boolean complement of the <expr> value.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   ! NAS-Port = 3 is true
   ! NAS-Port > 1 is true
   ! NAS-Port = 2 is false
   ```

() Operator

1. Syntax

   (*<expr>*)

2. Parameters

   <expr> is a boolean expression.

3. Operation

   The ***<expr>*** is evaluated. The value is the result of the evaluation.

4. Examples

   Suppose that:

   ```
   NAS-Port = 2
   ```

   Then:

   ```
   (NAS-Port = 2) is true
   ((NAS-Port = 2)) is true
   (NAS-Port = 3) is false
   ((NAS-Port = 3)) is false
   ```

Operator precedence and association

When multiple operators appear in a boolean expression, the following precedence and association rules are applied.

1. Precedence rules

   The precedence rules in decreasing order are:

   ()
   !
   && ||

2. Association rules

   The association rules are:

   && left-to-right
   || left-to-right
   ! right

3. Examples:

   The boolean expression:

   ```
   Reply-Message = "hello" && NAS-Port > 7 ||
   Reply-Message = "goodbye" || Reply-Message = "nothing"
   ```

   Is fully parenthesized as:

```
( ( (Reply-Message = "hello") && (NAS-Port > 7) ) ||
  (Reply-Message = "goodbye") ) ||
(Reply-Message = "nothing")
```

And is evaluated:

```
if ( Reply-Message = "hello" )
    if ( NAS-Port > 7 )
        return true
if ( Reply-Message = "goodbye" )
    return true
if ( Reply-Message = "nothing" )
    return true
return false
```

The boolean expression:

```
Reply-Message = "goodbye" ||
! Reply-Message = "hello" && NAS-Port > 7
```

Is fully parenthesized as:

```
( (Reply-Message = "goodbye") ||
  ( ! (Reply-Message = "hello") ) &&
  (NAS-Port > 7)
```

And is evaluated:

```
if ( Reply-Message = "goodbye" )
    if ( NAS-Port > 7 )
        return true
    else
        return false
else
    if ( Reply-Message = "hello" )
        return false
    else
        if ( NAS-Port > 7 )
            return true
        else
             return false
```

Type Compatibility

Attribute types are compatible if the value-types are the same.

Integer-value attribute types:
- integer
- tag-int
- short
- octet

String-value attribute types:
- string
- tag-str

octets

Date-value attribute types:
date

IP-address-value attribute types:
ipaddr

It is not permissible to mix attributes from different value-type groups. Doing so results in a type-mismatch load-time error. See "Error Handling" on page 168 for more details.

Since an integer attribute can be copied into any of the other three integer type attributes, it is possible to end up with a value that does not fit into that attribute when placed into a RADIUS packet. When the server encounters excess bits while putting an attribute into the packet it will log the issue in the logfile and ignore the excess high order bits.

Action Commands

if Command

1. Syntax

   if (<bool-expr>) { <action-list1> } else { <action-list2> }
   if (<bool-expr>) { <action-list1> }

2. Parameters

   <bool-expr> is a boolean expression. See "Boolean Expressions" on page 149.

   <action-list1> and ***<action-list2>*** are sequences of action commands that may include additional if commands, nested to an arbitrary depth.

   When the else clause is omitted, ***<action-list2>*** may be considered an empty sequence of action commands.

3. Operation

   Conditionally evaluates policy actions.

   Evaluates the ***<bool-expr>***. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

   If the result of evaluating ***<bool-expr>*** is true, evaluates ***<action-list1>***.

   If the result of evaluating ***<bool-expr>*** is false (and an else clause is present), evaluates ***<action-list2>***.

4. Examples

- Suppose that:

```
Session-Limit[0] = 10
Session-Limit[1] = 300
```

The commands:

```
if ( Session-Limit[1] < 30 )
{
    modify Session-Limit[1] = 30
}
else
{
    if ( Session-Limit[1] > 240 )
    {
        modify Session-Limit[1] = 240
    }
}
```

Results in:

```
Session-Limit[0] = 10
Session-Limit[1] = 240
```

- Suppose that:

```
NAS-IP-Address = "192.168.1.2
NAS-Identifier = "fred"
Port-Limit = 23
```

The commands:

```
if ( (NAS-IP-Address = "192.168.1.2") &&
     ((NAS-Identifier = "jack") || (Port-Limit > 20))
   )
{
    exit "NAK"
}
```

Results in:

```
Request being rejected.
```

delete Command

1. Syntax

   delete *<attr-spec>*

2. Parameters

   <attr-spec> is an attribute specification, see"Attribute Specifications" on page 134. The use of instance specification, including '*****' is allowed. The use of attribute functions is **not** permitted.

   The default instance for ***<attr-spec>*** is "last".

3. Operation

   Deletes the named instance from the request. All instances may be deleted by using the '*****' instance specifier.

If ***<attr-spec>*** refers to an instance that is not present, no instances will be deleted. A no-such-instance run-time error is NOT generated in this case.

4. Examples

- Suppose that:

```
NAS-Port = 2
Reply-Message = "Hello, world!"
Reply-Message = "So long"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
delete Reply-Message[*]
```

Results in:

```
NAS-Port = 2
NAS-IP-Address = "2.3.4.5"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "Hello, world!"
Reply-Message = "So long"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
delete Reply-Message
```

Results in:

```
NAS-Port = 2
Reply-Message = "Hello, world!"
NAS-IP-Address = "2.3.4.5"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "Hello, world!"
Reply-Message = "So long"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
delete Reply-Message[0]
```

Results in:

```
NAS-Port = 2
Reply-Message = "So long"
NAS-IP-Address = "2.3.4.5"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "Hello, world!"
```

The command:

```
delete NAS-IP-Address[*]
```

Results in:

```
NAS-Port = 2
Reply-Message = " Hello, world!"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "Hello, world!"
```

The command:

```
delete NAS-IP-Address[0]
```

Results in:

```
NAS-Port = 2
Reply-Message = " Hello, world!"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "Hello, world!"
```

The command:

```
delete NAS-IP-Address[last]
```

Results in:

```
NAS-Port = 2
Reply-Message = " Hello, world!"
```

insert Command

1. Syntax

   insert *<attr-spec> = <value-expr>*

2. Parameters

   <attr-spec> is an attribute specification, see"Attribute Specifications" on page 134. The use of instance specification, including "begin" and "last", is allowed. The use of attribute functions is **not** allowed.
   The default instance for <attr-spec> is "last".

   <value-expr> is a value expression.
   <value-expr> may use attribute specification. The use of instance specification, including "last", is allowed. The use of attribute functions is allowed.
   If <value-expr> refers to an attribute, the default instance is "last".
   If <value-expr> refers to an instance that is not present, a no-such-instance run-time error occurs. See "Error Handling" on page 168 for details.

   The types of <attr-spec> and <value-spec> must be compatible. See "Type Compatibility" on page 152 for details.

3. Operation

   Insert ***<attr-spec>*** into the request, having the value of ***<value-expr>***. See "Tagged

Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

If ***<attr-spec>*** refers to an instance that is not present, the location will be the end the list.

If ***<attr-spec>*** refers to a tagged attribute (tag-int or tag-str) and ***<value-spec>*** is not a tagged value, the tag for the inserted attribute will be set to 0.

If ***<attr-spec>*** refers to an attribute that is not tagged and ***<value-spec>*** is a tagged value, the tag is ignored.

The instance location specified by ***<attr-spec>*** indicates the desired target location for the inserted instance. The algorithm used is "final opportunity", as opposed to "earliest opportunity". This means inserting "last" is the same as inserting at the end and inserting instance n occurs just before the already-present instance n (or the end if instance n is not already present).

4. Examples

- Suppose that:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
insert Reply-Message = Reply-Message
```

Results in:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
Reply-Message = "message#2"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
insert Reply-Message[0] = "a new message"
```

Results in:

```
NAS-Port = 2
Reply-Message = "a new message"
Reply-Message = "message#1"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "message#1"
```

```
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
insert Reply-Message[1] = "a new message"
```

Results in:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "a new message"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
insert Reply-Message[2] = "a new message"
```

Results in:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "message#2"
Reply-Message = "a new message"
NAS-IP-Address = "2.3.4.5"
```

- Suppose that:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
```

The command:

```
insert Reply-Message[last] = "a new message"
```

Results in:

```
NAS-Port = 2
Reply-Message = "message#1"
Reply-Message = "message#2"
NAS-IP-Address = "2.3.4.5"
Reply-Message = "a new message"
```

- Suppose that:

```
NAS-Port = 2
NAS-IP-Address = "2.3.4.5"
```

The command:

```
insert Reply-Message[begin] = "Hello, world!"
```

Results in:

```
Reply-Message = "Hello, world!"
NAS-Port = 2
NAS-IP-Address = "2.3.4.5"
```

- Suppose that:

  ```
  Reply-Message = "hello"
  ```

  The command:

  ```
  insert Tunnel-Password = Reply-Message
  ```

  Results in:

  ```
  Reply-Message = "hello"
  Tunnel-Password = :0:"hello"
  ```

- Suppose that:

  ```
  Tunnel-Password = :2:"abc"
  ```

  The command:

  ```
  insert Reply-Message = Tunnel-Password
  ```

  Results in:

  ```
  Tunnel-Password = :2:"abc"
  Reply-Message = "abc"
  ```

- Suppose that:

  ```
  Tunnel-Password = :2:"abc"
  ```

  The command:

  ```
  insert Tunnel-Password = :3:"def"
  ```

  Results in:

  ```
  Tunnel-Password = :2:"abc"
  Tunnel-Password = :3:"def"
  ```

- Suppose that:

  ```
  Reply-Message = "hello"
  ```

  The command:

  ```
  insert Reply-Message = :3:"def"
  ```

  Results in:

  ```
  Reply-Message = "hello"
  Reply-Message = "def"
  ```

- Suppose that:

  ```
  Reply-Message = "abc"
  ```

  The command:

  ```
  insert NAS-Port = count( Reply-Message[*] )
  ```

  Results in:

  ```
  Reply-Message = "abc"
  NAS-Port = 1
  ```

modify Command

1. Syntax

   modify *<attr-spec>* = *<value-spec>*

2. Parameters

   <attr-spec> is an attribute specification, see"Attribute Specifications" on page 134. The use of instance specification, including "last", is allowed. The use of attribute functions is **not** allowed.
   The default instance for ***<attr-spec>*** is "last".
   If ***<attr-spec>*** refers to an instance that is not present, a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

   <value-spec> is a value specification.
   <value-spec> may use attribute-specifications. The use of instance specification, including "last", is allowed. The use of attribute functions is allowed.
   If ***<value-spec>*** refers to an attribute, the default instance for <value-spec> is "last".
   If ***<value-spec>*** refers to an instance that is not present, a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

   The value types for ***<attr-spec>*** and ***<value-spec>*** must be compatible. See "Type Compatibility" on page 152 for details.

3. Operation

   Modifies ***<attr-spec>*** to have the value of ***<value-spec>***. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

   If ***<attr-spec>*** refers to a tagged attribute (tag-int or tag-str) and ***<value-spec>*** is a tagged value, the tag of ***<attr-spec>*** is not modified. Only the value of ***<attr-spec>*** is modified.

4. Examples

- Suppose that:

  ```
  Reply-Message = "123"
  Reply-Message = "456"
  ```

  The command:

  ```
  modify Reply-Message = "abc"
  ```

  Results in:

  ```
  Reply-Message = "123"
  Reply-Message = "abc"
  ```

- Suppose that:

  ```
  Reply-Message = "123"
  Reply-Message = "456"
  ```

  The command:

  ```
  modify Reply-Message = Reply-Message[0]
  ```

Results in:

```
Reply-Message = "123"
Reply-Message = "123"
```

- Suppose that:

  ```
  NAS-Identifier = "abc.def.ghi"
  ```

  The command:

  ```
  modify NAS-Identifier = "wxyz"
  ```

  Results in:

  ```
  NAS-Identifier = "wxyz"
  ```

- Suppose that:

  ```
  Tunnel-Password = :2:"abc"
  ```

  The command:

  ```
  modify Tunnel-Password = "def"
  ```

  Results in:

  ```
  Tunnel-Password = :2:"def"
  ```

- Suppose that:

  ```
  Tunnel-Password = :2:"abc"
  ```

  The command:

  ```
  modify Tunnel-Password = :4:"ghi"
  ```

  Results in:

  ```
  Tunnel-Password = :2:"ghi"
  ```

- Suppose that:

  ```
  Reply-Message = "hello"
  Tunnel-Password = :17:"abc"
  ```

  The command:

  ```
  modify Reply-Message = Tunnel-Password
  ```

  Results in:

  ```
  Reply-Message = "abc"
  Tunnel-Password = :17:"abc"
  ```

- Suppose that:

  ```
  Reply-Message = "hello"
  Tunnel-Password = :17:"abc"
  ```

  The command:

  ```
  modify Tunnel-Password = Reply-Message
  ```

  Results in:

  ```
  Reply-Message = "hello"
  Tunnel-Password = :17:"hello"
  ```

- Suppose that:

```
NAS-Port = 7
Reply-Message = "abc"
Reply-Message = "def"
```

  The command:

```
modify NAS-Port = count( Reply-Message[*] )
```

  Results in:

```
NAS-Port = 2
Reply-Message = "abc"
Reply-Message = "def"
```

- Suppose that:

```
Reply-Message = "abc"
Reply-Message = "def"
```

  The command:

```
modify Reply-Message[0] = Reply-Message[1]
```

  Results in:

```
Reply-Message = "def"
Reply-Message = "def"
```

exit Command

1. Syntax

   exit "*<event-name>*"

2. Parameters

   <event-name> must be a quoted string.

   <event-name> must specify an event that is defined. There are a number of predefined events. Additional events may be defined in the FSM file using **"%event *<name>*"** syntax. See "Events" on page 208 for more detailed information on finite state machine events.

   Event names are case-insensitive (MyEvent is the same as MYEVENT).

3. Operation

   Terminates evaluation of the policy and returns the named event to the finite state machine. See "FSM Interaction" on page 168 for more details.

   The use of an undefined event name results in an undefined-event load-time error. See "Error Handling" on page 168 for more details.

4. Examples

```
exit "ACK"
```

log Command

1. Syntax

   log "*<log-level>*" "*<log-message>*"
   log "*<log-level>*" "*<log-message>*", *<attr-spec>*
   log "*<log-level>*" "*<log-message>*", *<attr-spec>*, ... *<attr-spec>*

2. Parameters

   <log-level> must be a quoted string.
   <log-level> must be a log-level type:
   FATAL, ERROR, CRITICAL, ALERT, WARNING, INFO
   <log-level> is case-insensitive ("ERROR" same as "Error").

   <log-message> must be a quoted string.

   Multiple instances for ***<attr-spec>*** are allowed and cause all named instances to be reported in the logfile, see"Attribute Specifications" on page 134. The use of instance specification, including "last" and "*", is allowed. The default instance specification for the attributes in the **log** command is "last".

   If ***<attr-spec>*** refers to an instance that is not present, this will be indicated in the logfile output. A no-such-instance run-time error will NOT be generated in this case.

3. Operation

   Causes a message to be written to the logfile.

   When attributes are specified, they are reported one value per line in the logfile. Multiple instances are reported one value per line as well.

   All **log** output lines will include the file/line location of the **log** command that generated the message.

   All **log** output will be generated using the standard logging functions which puts a timestamp on the output line.

4. Example

```
log "Warning" "This user should not come in through this NAS",
   User-Name, NAS-IP-Address
```

Attribute Functions

- **count** function
  1. Syntax

     count (*<attr-spec>*)

  2. Parameters

     <attr-spec> specifies an attribute (possibly including vendor or instance), see"Attribute Specifications" on page 134.
     The default instance for ***<attr-spec>*** is '**last**'.

3. Operation

   Returns an integer value that indicates the number of instances.

   If ***<attr-spec>*** refers to instance '*****', then **count()** yields the total number of instances of ***<attr-spec>*** that are present.
   If ***<attr-spec>*** refers to a specific instance that is present, then **count()** yields the value 1.
   If ***<attr-spec>*** refers to an instance that is not present, then **count()** yields the value 0. A no-such-instance run-time error is NOT generated in this case.

- **length** function

  1. Syntax

     length (*<attr-spec>*)

  2. Parameters

     <attr-spec> specifies an attribute (possibly including vendor or instance) which must be of type String, Tag-Str, or Octets, see"Attribute Specifications" on page 134.
     The default instance for ***<attr-spec>*** is '**last**'.

  3. Operation

     Returns an integer value that indicates the number characters in the string attribute. For a Tag-Str attribute it does not include the tag octet. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

     If ***<attr-spec>*** refers to an instance that is not present, then a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

- **substr** function

  Using 'offset' keyword

  1. Syntax

     substr (<attr-spec> offset <start>)
     substr (<attr-spec> offset <start> length <number>)

  2. Parameters

     <attr-spec> specifies an attribute (possibly including vendor or instance) which must be of type String, Tag-Str, or Octets, see"Attribute Specifications" on page 134.
     The default instance for ***<attr-spec>*** is '**last**'.
     <start> is the offset from the beginning of the string to the first character of the desired substring. It must be a non-negative integer constant.
     <number> is the optional length of the desired substring. It must be a non-negative integer constant.
     If "length <number>" is not present then the length defaults to the remainder of the string.

  3. Operation

     Returns the requested substring, with same type as the source. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

     When the length is not specified the remainder of the string value is used.

     If the offset is off the end of the string then substr returns an empty string.

     For example:

     ```
     insert Reply-Message = "a string of characters"
     substr( Reply-Message offset 0 length 8 )
     ```

     Returns the string: "a string".

     ```
     insert Reply-Message = "a string of characters"
     substr( Reply-Message offset 16 length 82 )
     ```

     Returns the string: "acters".

     ```
     insert Reply-Message = "a string of characters"
     substr( Reply-Message offset 12 )
     ```

     Returns the string: "characters".

     ```
     insert Reply-Message = "a string of characters"
     substr( Reply-Message offset 32 )
     ```

     Returns the empty string: "".

     If ***<attr-spec>*** refers to an instance that is not present, then a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

  Using 'before' keyword

  1. Syntax

     substr (<attr-spec> before "<before-string>")
     substr (<attr-spec> before last "<before-string>")

2. Parameters

   <attr-spec> specifies an attribute (possibly including vendor or instance) which must be of type String, Tag-Str, or Octets, see"Attribute Specifications" on page 134.
   The default instance for ***<attr-spec>*** is '**last**'.
   <before-string> must be a quoted string constant.

3. Operation

   Returns the requested substring with same type as the source. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

   The substring will start from the beginning of the string up to but not including the first occurrence of ***<before-string>*** for '**before**'.

   The substring will start from the beginning of the string up to but not including the last occurrence of ***<before-string>*** for '**before last**'.

   When ***<before-string>*** is not found the entire string is returned.

   For example:

   ```
   insert Reply-Message = "a string of characters"
   substr( Reply-Message before " of" )
   ```

   Returns the string: `"a string"`.

   ```
   insert Reply-Message = "a string of characters"
   substr( Reply-Message before last " " )
   ```

   Returns the string: `"a string of"`.

   ```
   insert Reply-Message = "a string of characters"
   substr( Reply-Message before "not-there" )
   ```

   Returns the entire string: `"a string of characters"`.

   If ***<attr-spec>*** refers to an instance that is not present, then a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

Using 'after' keyword

1. Syntax

   ```
   substr ( <attr-spec> after "<after-string>" )
   substr ( <attr-spec> after last "<after-string>" )
   ```

2. Parameters

   <attr-spec> specifies an attribute (possibly including vendor or instance) which must be of type String, Tag-Str, or Octets, see"Attribute Specifications" on page 134.
   The default instance for ***<attr-spec>*** is '**last**'.
   <after-string> must be a quoted string constant.

3. Operation

   Returns the requested substring with same type as the source. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

   The substring will start following the first occurrence of ***<after-string>*** for '**after**'.

   The substring will start following the last occurrence of ***<after-string>*** for '**after**

last'.

When ***<after-string>*** is not found the empty string is returned.

For example:

```
insert Reply-Message = "a string of characters"
substr( Reply-Message after " of" )
```

Returns the string: `" characters"`.

```
insert Reply-Message = "a string of characters"
substr( Reply-Message after last " " )
```

Returns the string: `"characters"`.

```
insert Reply-Message = "a string of characters"
substr( Reply-Message after "not-there" )
```

Returns the empty string: `""`.

If ***<attr-spec>*** refers to an instance that is not present, then a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

- **tolower** function

  1. Syntax

     tolower (*<attr-spec>*)

  2. Parameters

     <attr-spec> specifies an attribute (possibly including vendor or instance) which must be of type String, Tag-Str, or Octets, see"Attribute Specifications" on page 134.
     The default instance for ***<attr-spec>*** is '**last**'.

  3. Operation

     Returns the string value converted to lowercase with same type as the source. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

     If ***<attr-spec>*** refers to an instance that is not present, then a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

- **toupper** function

  1. Syntax

     toupper (*<attr-spec>*)

  2. Parameters

     <attr-spec> specifies an attribute (possibly including vendor or instance) which must be of type String, Tag-Str, or Octets, see"Attribute Specifications" on page 134.
     The default instance for ***<attr-spec>*** is '**last**'.

  3. Operation

     Returns the string value converted to uppercase with same type as the source. See "Tagged Attributes and the Advanced Policy Language" on page 141 for how tags are handled.

     If ***<attr-spec>*** refers to an instance that is not present, then a no-such-instance run-time error is generated. See "Error Handling" on page 168 for more details.

Error Handling

This section describes how error conditions are handled by the advanced policy engine.

There are two types of errors: load-time errors and run-time errors.

1. Load-time Errors

The following load-time errors are defined:
syntax error
type mismatch
invalid instance specification
invalid integer value
invalid IP address constant
invalid tag value
unknown named value
undefined event
undefined value

When a load-time error occurs, the decision file is considered invalid; it is not loaded. A message in the logfile will indicate the location of the problem by file and line number. An ERROR event is returned to the state machine. See "FSM Interaction" on page 168 for more details.

2. Run-time Errors

The following run-time errors are defined:
no such instance

When a run-time error occurs, the policy evaluation is terminated. A message in the logfile will indicate the location of the problem by file and line number. An ERROR event is returned to the state machine. See "FSM Interaction" on page 168 for more details.

FSM Interaction

This section describes how the advanced policy engine interacts with the finite state machine.

1. Invoking Policies

   Policies are invoked using the POLICY action in the FSM. The Xstring parameter uses a URL-like syntax to specify the policy to be invoked.

   Example:

   decisionfile://MyPolicy.policy

   See "Calling Decision Files" on page 171 for more details on invoking policies.

   When a policy is invoked, it is evaluated.

   When a policy is evaluated, it may return an event to the state machine to direct the

subsequent processing of a request.

2. Returning Events

   There are several ways to return an event to the state machine:

   `exit` Command
   Default Event
   Error Condition

   - **`exit`** Command

     Using the **`exit`** command causes the evaluation of the policy to be terminated. The specified event is returned to the state machine.
   - Default Event

     If evaluation of a decision file reaches the end without encountering an **`exit`** command, the default event is returned to the state machine.

     The default event is ACK.
   - Error Conditions

     When an error occurs, an ERROR event is returned to the state machine.

Internal Attributes

The following Interlink-specific attributes are useful in policy conditions or replies.

Attribute	Description
Interlink-Packet-Code	An integer that indicates what type of RADIUS message has been received: either 1 (Access-Request) or 4 (Accounting-Request).
Interlink-Proxy-Action	A string (normally determined by information in the Access-Request or Accounting-Request) that indicates the name of the starting event in the FSM when the AAA Server receives a RADIUS message. You can preempt this value by modifying the `request-ingress.grp` decision file to determine the start event.
Interlink-Proxy-Target	A string that identifies the proxy target host system. The proxy target host system must be listed in the AAA server's clients file.
Interlink-Reply-Status	An integer that contains an FSM code representing the reply status: • `ACK` -- Access-Accept or Accounting-Response • `NAK` -- Access-Reject • `ACC_CHAL` -- Access-Challenge This attribute is used to preserve the reply status of a request while applying reply post-processing policy. This attribute is used to preserve the reply status of a proxy response while applying proxy receive response policy.
Interlink-Request-Type	A string that identifies the request type: • "REQUEST" -- a normal request • "CONTINUATION" -- a continuation of an in-progress EAP conversation
User-Id	After the server parses the NAI (userid@realm), it assigns the userid value to this attribute.
User-Realm	After the server parses the NAI (userid@realm), it assigns the realm value to this attribute.
Time-of-Day	A string containing the time of day the request was received. It uses a 24 hour clock in *hh:mm* format.
Day-Of-Week	An integer representing the day of the week the request was received, where 0 represents Sunday and 6 represents Saturday.
Date-Time	A string containing the date and time the request was received. It uses a 24 hour clock in *yyyy:mm:dd:hh:mm* format.

Calling Decision Files

Once policies are stored in decision files, call the decision files at the appropriate points in the `radius.fsm` file, `authfile, or user profiles`.

From radius.fsm

The `POLICY` action should be called in the FSM whenever you wish to use Advanced Policy functions, such as Dynamic Access Control. Use the `Xstring` parameter to pass a decision file name to the `POLICY` action. The `Xstring` value must be no more than 63 characters long.

Event* POLICY *Next-state* Xstring=decisionfile://*Filename

You must specify the decision file to use each time the `POLICY` action is called. If necessary, your group entries should also contain a `Decision` reply item to return the next event to the FSM.

Note: If the `POLICY` action occurs before the user's profile is retrieved, reply items from the decision file are superseded by any duplicate attributes in a user profile. Conversely, if `POLICY` occurs after the user's profile is retrieved, the user's reply items will be superseded by the policy group reply items.

The DAC.fsm and DNIS.fsm files distributed with the AAA Server already call the corresponding decision file at the appropriate point in the server process. You need only make implementation-specific changes. See "Modifying the FSM for DNIS" on page 174 and "Modifying the FSM for DAC" on page 173 for details.

From authfile

Place a `Policy-Pointer` in a LDAP realm data store naming the full path to the decision file containing the group authorization policies. Enclose the pointer in double or single quotes. The `Policy-Pointer` string cannot be more than 63 characters long.

```
realm ProLDAP "comment"
{
   Policy-Pointer = "decisionfile://path-to-file"
   Directory . . .
}
```

The `POLICY` action will look for the first group entry in the decision file that matches the A-V pairs in a user request and reply accordingly.

From user profiles

In the default users file or realm files, place a `Policy-Pointer` as a check or reply item naming the full path to the decision file containing the group authorization policies. Enclose the pointer in double or single quotes. The `Policy-Pointer` string cannot be more than 63 characters long.

```
carl Password = carl, Policy-Pointer = "decisionfile://path-to-file"
or
```

```
fred Password = fred
   Policy-Pointer = "decisionfile://path-to-file"
```

The POLICY action will look for the first group entry in the decision file that matches the A-V pairs in a user request and reply accordingly. See "User/Realm policy" on page 127 for more details.

Dynamic Access Control

Dynamic Access Control (DAC) enables you to provide different levels of network access to the same users depending on:

- Access periods
- Account and password expiration date and time

Dynamic Access Control utilizes three Interlink-specific attributes to check values in user requests:

Attribute	Description
Time-of-Day	A string containing the time of day the request was received. It uses a 24 hour clock in *hh:mm* format.
Day-Of-Week	An integer representing the day of the week the request was received, where 0 represents Sunday and 6 represents Saturday.
Date-Time	A string containing the date and time the request was received. It uses a 24 hour clock in *yyyy:mm:dd:hh:mm* format.

Modifying the FSM for DAC

Do the following to modify `radius.fsm` to support Dynamic Access Control.

1 In a text editor, copy the contents of `DAC.fsm`, by default found in `/etc/opt/aaa`.

2 Open `radius.fsm` (in the same directory) and paste the contents of `DAC.fsm` over `radius.fsm`. Replace the complete text.

3 If you're using a different decision file than the supplied `DAC.grp` decision file, change the `CheckDAC` state so that the `POLICY` action calls your DAC decision file. For example:

```
CheckDAC:
    *.*.ACK     POLICY     AuthWait    Xstring=decisionfile://DAC.grp
```

4 Save and close `radius.fsm`.

DAC Decision File

Edit the `DAC.grp` decision file to define your DAC policies. There are sample entries for most groups you will need. Modify each group to reflect your time-based policies. For example:

```
# Daytime Access Check
if ( (Access-Group[0] = "daytime") &&
     ((Time-Of-Day[0] >= "06:00") && (Time-Of-Day[0] <= "20:00")) )
{
    insert Reply-Message = "Daytime access allowed"
    exit "ACK"
}
```

Note: The Reply-Message reply item attribute may not be returned if the user is authenticated with a tunneled EAP method.

Comment out any condition you don't need by placing a pound sign (#) before each line.

The last line should remain so any user that does not match one of the conditions will get rejected.

If you rename this file, edit `radius.fsm` so that the `CheckDAC` state `Xstring` parameter points to the correct filename.

Keep this file in the server's configuration directory, by default `/etc/opt/aaa`.

DNIS Routing

In a typical DNIS routing scheme, requests are handled according to the `Calling Station-Id` and `Called-Station-Id` attributes. The `POLICY` action matches the `Calling-Station-Id` and `Called-Station-Id` attribute values in the Access-Request to the conditions defined in the DNIS decision file and returns the matching policy group reply items and the FSM events `Forward` and `Abandon`.

The required events and states are defined in the DNIS.fsm file delivered with the server.

Modifying the FSM for DNIS

Do the following to modify `radius.fsm` to support DNIS routing.

1 In a text editor, copy the contents of `DNIS.fsm`, by default found in `/etc/opt/aaa`.

2 Open `radius.fsm` (in the same directory) and paste the contents of `DNIS.fsm` over `radius.fsm`. Replace the complete text.

3 If you're using a different decision file than the supplied `DNIS.grp` decision file, change the `Start3` state so that the `POLICY` action calls your DNIS decision file. For example:

```
Start3:
   *.*.AUTHEN         POLICY   Start4   Xstring=decisionfile://DNIS.grp
   *.*.AUTH_ONLY      POLICY   Start4   Xstring=decisionfile://DNIS.grp
   *.*.AUTHENTICATE   POLICY   Start4   Xstring=decisionfile://DNIS.grp
   *.*.ACCT           POLICY   Start4   Xstring=decisionfile://DNIS.grp
   *.*.LAS_ACCT       POLICY   Start4   Xstring=decisionfile://DNIS.grp
```

4 Modify the `Start4` state so that `Xstring` points to the fully qualified domain name or IP address of the server to which you are forwarding requests and must be listed in the AAA server's clients file. The clients file entry is needed to get the shared secret to use.

```
Start4:
   *.*.Forward    RAD2RAD    Start4a    Xstring=192.168.0.0
```

5 Save and close `radius.fsm`.

DNIS Decision File

Edit the `DNIS.policy` decision file to reflect your station-based access policies. For example, change the Calling-Station and Called-Station numbers in the `Controlled Access` condition:

```
# Controlled Access
if ( ( count(Calling-Station-Id[0]) > 0 ) &&
     ( Calling-Station-Id[0] = "7341234567" ) )
    {
        exit "Forward"
    }
}
if ( ( count(Called-Station-Id[0]) > 0 ) &&
     ( Called-Station-Id[0] = "7341236543" ) )
    {
        exit "Forward"
    }
}
```

You can enter additional conditions and attributes to this policy if your policies require that other conditions be met.

Comment out any condition you don't need by placing a pound sign (#) before each line.

The last line should remain unchanged so it can authenticate any user that does not match one of the other conditions.

If you rename this file, edit `radius.fsm` so that the `Start3` state `Xstring` parameter points to the correct filename.

Keep this file in the server's configuration directory, by default `/etc/opt/aaa`.

Configuration Files

About Configuration Files

Some advanced features of the AAA Server cannot be configured through the Server Manager console. For example, if you want to define Advanced Policy, vendor-specific attributes, or logging behavior, you will need to manually edit the AAA Server configuration files.

This section provides reference information for all the files that you may need to edit to maintain the AAA Server configuration. You can also find this information in the MAN pages distributed with the server. By default the man pages are located in `/opt/share/aaa/man`.

Throughout this section, required parameters are marked in bold face type and optional ones in a normal face. In addition, when a variable should be replaced with a specific value by the administrator, the variable will appear in an italic face. For example:

```
realm ProLDAP "comment"
{
   Directory "directory comment"
   {
         URL "ldap://192.168.3.8:389"
         SearchBase "ou=devision,dc=com"
   }
}
```

File Format

Entries

All configuration files consist of one or more entries. These entries include parameters that define a configuration item for the server—a client, a user profile, a realm, and others.

A parameter (field) may contain one or more A-V pairs. See page 179 for a description of A-V pair syntax.

Entries that define newer configuration objects use a block format:

```
Object object-name
{
   Parameter value
   Parameter "value string"
}
```

Enclose string values within single or double quotes if the value contains spaces or special characters other than underscore (_) and dash (-). There is no difference between using single or double quotes.

All configuration files have a maximum input line length of 1023 characters. Anything exceeding

the limit is processed as another line.

Delimiters

Fields within entries are delimited by whitespace (one or more spaces or tabs).

You may also use comma-space to delimit A-V pair lists in users files and .fsm files.

Comment Lines

Comment lines begin with a pound (#) character. The server ignores these lines when loading them into memory at startup.

File Location

By default, configuration files are located in:

```
/etc/opt/aaa
```

MAN pages are located in:

```
/opt/share/aaa/man
```

Commonly Used Files

The configuration files you'll most commonly work with are:

- **`aaa.config`** defines all server properties.
- **`authfile`** defines realm datastores.
- **`clients`** defines client attributes and shared secret.
- **`decision files`** contain advanced policy information for user authorization and session control based on any logical group that can be defined with attribute-value (A-V) pairs. See "Using Advanced Policy" on page 124 for information about creating decision files.
- **`dictionary`** defines all attributes and values that may be used to build A-V pairs recognized by the server. These A-V pairs convey information in requests and responses. This file also contains definitions for all the authentication types that the server recognizes.
- **`EAP.authfile`** defines realm authentication actions.
- **`las.conf`** defines Local Authorization Service behavior. It enables session tracking and specifies some session timing values.
- **`log.config`** defines accounting message logging behavior.
- **`radius.fsm`** is the Finite State Machine table. You can edit this to reorder server processing steps or call custom plug-ins.
- **`realm (.users)`** files contain user profile entries, including check/deny and reply items. Realm files are sometimes referred to as `.users` files, because they contain profiles for users in a single realm and may be given any descriptive name, such as the realm name. All realm files **must** have the extension `.users`.
- **users** defines user profiles which can be used for exceptions to the normal realm based configuration.The default `users` file contains only the test_user entry after an initial installation.
- **`vendors`** contains optional entries for vendor names and numbers and it maps external attributes to and from vendor-specific attributes.

Attribute-Value Pairs

The AAA Server sends information in terms of attributes. When a message is exchanged among access devices and servers, one or more attributes and values are sent pairwise as an attribute-value pair (A-V pair).

attribute = value

Attributes are defined to be one of the following value types: IP address, string, vendor, tag string, tag integer, date, integer, string, octet, and short values. The attribute may take any of the supported, legal values defined for it in the `dictionary` file.

The AAA Server supports most standard RADIUS attributes for session control and provisioning. Attribute names and their enumerated values are defined in the `dictionary` file. See the RADIUS RFC documents (2865, 2866, 2867, 2868, 2869) for a description of the attributes.

Note: The Reply-Message attribute is not supported as a reply item for users in EAP PEAP and EAP TTLS realms.

This section describes Interlink-specific configuration and session attributes with the files where they are most likely to be used.

Attribute-Value Pair Syntax (realm, users and .fsm)

When specifying A-V pairs in a realm file, `users` file or `.fsm` file entry, you should put a space before and after the equals (=) or not equal (!=) operator. Some other formats will work but are not guaranteed to be supported in future versions. An example is:

```
Simultaneous-Use = 3
```

Within a list of A-V pairs they are delimited by commas.

```
User-Name = msmith, Password = nopass, NAS-IP-Address = 192.168.6.59
```

Reply item A-V pairs in a `.users` file are listed on separate, indented lines. Put a comma after each line, except for the last in the list:

```
User-Name = msmith, Password =pass, NAS-IP-Address = 192.168.6.59
   Session-Timeout = 60,
   Idle-Timeout = 15
```

String values **must** be enclosed by single quote (' ') or double quote (" ") characters if they contain spaces or special characters other than underscore (_) and dash (-). There is no difference between using single or double quotes. Otherwise, the quotation marks are optional:

```
Deny-Message = "Access Denied"

Deny-Message = Access_Denied
```

IP address values may use the common dotted-quad notation, DNS name present in the clients file or the decimal value.

```
NAS-IP-Address = 10.11.0.9
NAS-IP-Address = nas.domain.com
NAS-IP-Address = 168493065
```

Date values follow the format:

- mmm-dd-yyyy — three character month abbreviation (Jan, Feb, Mar, etc.), followed by the day (1 to 31), followed the year expressed as four digits (1998).
- Each field **must** be delimited by a space or a hyphen

```
Event-Timestamp = Jan 8 2002
Event-Timestamp = Jan-8-2002
```

The following example is a syntactically valid A-V pair list:

```
Password = "rock", Service-Type = "Framed", Comment = "This is OK"
```

The following examples are **not** syntactically valid A-V pair lists since the attributes are not separated by both a comma and a space:

```
Password="rock"Service-Type="Framed"Comment="This is not OK"
Password = rock Service-Type = Framed Comment = This is not OK
```

Tagged Attributes

An AAA message may include multiple attributes that are tagged to organize them into defined groups. Depending on its capabilities, a client or server will selectively use one set of tagged attributes. Tagged attributes may be used as check or reply items.

Tagged attributes follow the syntax:

Attribute = :Tag:Value

Attribute is the attribute.

Tag is a unique integer (less than 32) that identifies the attribute set.

Value is the attribute value (in that set). A string value must be enclosed by double or single quotes:

```
Reply-Message = :2:”Hello World”
```

For example, an Access-Accept may contain several different tunnel definitions as tagged attribute sets. `Tunnel-Type = :1:PPTP` indicates that PPTP is the Tunnel-Type in attribute set 1, which defines one type of tunnel that might be established for a user. If it supports tagged attributes, the client can selectively define the tunnel by using only the values belonging to one attribute set.

aaa.config

The `aaa.config` file contains user-defined entries for server properties. These entries override the server's compiled-in defaults.

Note: aaa.config combines the tunneling.hint and engine.config files of previous server versions.

All entries are delimited by whitespace (tabs or spaces).

If a value contains spaces, use single or double-quote characters to enclose the value.

Including Files

You can include configuration data in multiple text files and load them at server startup. For each text file, add a one line entry to the `aaa.config` file that follows the format:

include *filename*

If ***filename*** specifies a relative path, the server will look for the file in the configuration directory.

Server Variable Syntax

Server variables override the server's built-in defaults. Most can be reconfigured on the Server Properties pages in the Server Manager. Only those variables that must be manually added to the `aaa.config` file are described here.

To add a server variable, enter a line in aaa.config for:

variable = value

Server variables are loaded into memory when the server starts. Restart the server if you change server variables in the `aaa.config` file.

Any space or tab characters before the variable or surrounding the equal sign character are ignored.

General Server Properties

Variable	Description
avpair_checking (boolean)	Whether or not the server should perform sanity checks of A-V pairs in messages by checking to see if the flags indicate a valid A-V pair, and if it's a string type A-V pair, whether the string's use count is valid and print the diagnostic information. Values are on or off. This is for diagnostic purposes only and should not be used in production. Defaults to off.
cwd (string)	Changes the current working directory of the AAA server to the specified path. This will be the location of any core files if the server aborts. This allows for overriding the radiusd –c option. The default value is -c option value. If no -c option was used, then the default is the current working directory of the shell that started radiusd.
dns_max_aliases (integer)	Maximum number of aliases per client. The default value is 3.
list_copy_limit (integer)	For customized server configurations that accumulate A-V pairs or generate large responses. Defaults to 512.
ourhostname (string)	By default, the AAA server determines hostname by calling the gethostname command. For multihomed hosts this command may not return the correct name for the interface that the AAA server should use to send and listen for messages. The ourhostname variable sets the interface (DNS name or IP address) that a multihomed server should use. For example: `ourhostname=interface1.radius.server.net`
radius_log_fmt	This variable overrides the radiusd -l option to specify the logfile name format string to be used. The default value is "logfile.%Y%m%d"
send_proxy_action (boolean)	Controls the sending of the MERIT Proxy-Action A-V pair in RADIUS replies or packets forwarded through the server to another RADIUS server. Valid values are on or off. The default value is off

Server Tracking Properties

Variable	Description
log_forwarding	Turns on or off logging of packets forwarded through the server to another RADIUS server. This allows finer detail when tracking problems, at the expense of increased log file size. The variable can occur multiple times to select the set of options desired. Valid options are: • on - Turns on the logging of forwarded packets • off - Turns off all logging of forwarded packets • +digest - log sent forwarding digest turned on • –digest - log sent forwarding digest turned off • +dump - printing of packet contents in hexadecimal is turned on • –dump - printing of packet contents in hexadecimal is turned off • +vector - log initial forwarding digest turned on • –vector - log initial forwarding digest turned off • clear - is equivalent to –digest plus –dump The default value is off.
log_generated_request	Turns on or off the logging of internally generated packets when they are created and when they reach their end-state. It is useful for a customized server configuration that produces accounting requests based on internal state transitions rather than on externally delivered requests. Valid values are on or off. The default value is on.
packet_log	This variable matches a current request with an original request, which may occur when logging certain attributes in a request log. It is useful for tracking situations where a remote server is responding with incorrect values and to investigate if an AATV is corrupting the current request. The variable can occur multiple times to select the set of options desired. Valid options are: • default - sets +current and +original • clear (or none) - removes all options • +abort - Turn on abort and core-dump if there is a mismatch • –abort - Turn off abort and core-dump if there is a mismatch • +both (or +comp) - Turn on comparison of A-V pairs if +current and +original are set • –both (or –comp) - Turn off comparison of A-V pairs • +current (or +cur) - Turn on report only from the modified request • –current (or +cur) - Turn off report only from the modified request • +original (or +orig) - Turn on report only from original request • –original (or –orig) - Turn off report only from original request The default value is +current and +original

Variable	Description
radcheck	This variable enables (or disables) certain reports produced by the radcheck command. The variable can occur multiple times to select the set of options desired. Valid options are: • default - Turns on +queues and +mf. • clear - Turns off all the radcheck options and clears the authentication queue counters. • none - Turns off all the radcheck options. • reset - Clears the authentication queue counters. • +mf - Show malloc and free statistics. • –mf - Do no show malloc and free statistics. • +packets - Show statistics about the number of octets/packets received, replied, forwarded, replies received, and redone. • –packets - Do not show statistics about the number of octets/ packets received, replied, forwarded, replies received, and redone. • +queues - Show authentication and accounting queue information such as: number of unique requests, number of queue overflows, number of duplicate requests. If the number of accounting requests greatly exceeds the number of authentication requests, then a NAS/ network configuration error is possible. • –queues - Do not show authentication and accounting queue information. • +timeouts - Show various timeout counters. • –timeouts - Do not show various timeout counters. The default value is +queues and +mf.

Variable	Description
reply_check	This variable specifies which attributes to check in a reply to ensure they are the same as in the forwarded request. Options allow you to specify the action to take when a mismatch occurs. The variable can occur multiple times to select the set of options desired. Valid options are: • first - Turn on check only the first match, turns off all • all - Turn on check all attributes for matches, turns off first • default - Clears all options, sets first and clears the list of attributes to check • none - Clears the list of attributes to check • clear - Clears all options and sets first • +abort - Turn on abort and core-dump if a check fails • –abort - Turn off abort and core-dump if a check fails • +dump - Turn on logging of the offending packet (in hex) • –dump - Turn off logging of the offending packet • +ignore - Turn on ignoring of responses which have a mismatch • –ignore - Turn off ignoring of responses which have a mismatch • +verbose - Turn on logging of good and bad values of each attribute • –verbose - Turn off logging of good and bad values of each attribute <Attribute-name> - Add this specific attribute to list of checks The default value is none.

authfile and EAP.authfile

The authfile can be used to configure per-realm actions, but the actions in the authfile should be user data retrieval instead of authentication. For example, if a realm retrieves its user data from an LDAP directory with an LDAP Search operation to do EAP authentication, that realm must be configured in the authfile with the ProLDAP AATV and then again in the EAP.authfile with the EAP AATV.

The EAP.authfile is used to configure per-realm authentication actions. The distributed copy of this file contains a DEFAULT entry such as:

```
DEFAULT iaaaAuthenticate "default"
```

That provides the conventional authentication logic for any realm not explicitly configured to authenticate their users in a particular way, for example, Kerberos. Realms that do need some particular method for user authentication must be configured here explicitly.

The entries in these files correspond to the Local Realms page in Server Manager.

Authfile Entry Syntax

realm-name -flags auth-type auth-parameter

or

realm-name -flags auth-type auth-parameter
{
extended-auth-parameters
}

realm-name - portion of the NAI format login following the @ sign (e.g.: yourcompany.com).

flags - the optional flags are used to specify additional information about this realm entry. See Protocol and Case-sensitivity Flags below.

auth-type - name of the `Authentication-Type`, as defined in the dictionary.

auth-parameter - meaning varies by `Authentication-Type`.

extended-auth-parameters - a sequence of parameters and values which vary by `Authentication-Type`.

Some `Authentication-Types` have an extended authentication parameter block as shown in the second example above. The content varies by `Authentication-Type`.

Examples

```
bigearth.net              iaaaFile    flatearth
```

```
satellite.com              iaaaFile    flatearth
flatland.com     -DEFAULT iaaaFile    flatland
flatland.com     -EAP     iaaaFile    flatland
flatland.com   -AKA     localFile  flatland-aka
{
   Request-Attribute-For-Search   "real-username"
}
flatland.com   -SIM     localFile  flatland-sim
{
   Request-Attribute-For-Search   "real-username"
}
ldap.com ProLDAP "This is a comment"
{
   Directory "LDAP directory comment"
   {
      Request-Attribute-For-Search    Real-Username
      Filter-Type                     CIS
      Directory   "Directory 1"
      {
         URL             "ldap://ldap1.ispx.com:389
         Administrator   "cn=admin,ou=devision,dc=com"
         Password        password
         SearchBase      "ou=devision,dc=com"
         Authenticate    Search
   }
}
```

Protocol Flags

If users in the same realm require different authentication methods, you may be able to specify which realm entry to use by putting a flag in the authfile mapping. The flags match one of five mutually exclusive protocol identifiers that may be present in the Access-Request, plus a fourth "default" flag for users who do not explicitly match one of the other attributes. See "Configuring EAP-AKA" on page 214 for information on configuring EAP-AKA. See "Configuring EAP-SIM" on page 234 for information on configuring EAP-SIM.

Flag	Matches Access-Request Attribute
-PW	User-Password
-CHAP	CHAP-Password
-EAP	EAP-Message
-AKA	EAP-Message Data Store lookup for EAP-AKA

Flag	Matches Access-Request Attribute
-SIM	EAP-Message Data Store lookup for EAP-SIM
-DEFAULT	None. Authentication type to use for all users who do not match one of the other flags.

Case-sensitivity Flags

The server can treat user names in a case-sensitive or a case-insensitive manner. These mutually-exclusive flags allow you to control that. The default is `-BIN` (case-sensitive). These flags are ignored for an `Authentication-Type` that uses an extended authentication parameter block and has filter-type capabilities.

Flag	Behavior
-BIN	Username is not modified before authentication.
-CIS	Username is converted to uppercase before authentication. Therefore the data store needs to store the username in uppercase unless the datastore is case-insensitive.

Prefixed users and authfiles

In the `clients` file, you may optionally specify a prefix for a client device. For any users connecting through this client, the server will search for the user's profile in a file called *`prefix`*`.users`. If the user's profile is not found there the server will use the files *`prefix`*`.authfile` and *`prefix`*`.EAP.authfile` to authenticate the user. This allows you to specify different authentication methods for users in the same domain who may connect via different clients under different circumstances, for example: password authentication when connecting through a wired NAS server, vs. EAP authentication when connecting through a wireless AP.

If a prefixed file does not exist or no prefix is specified then the regular non-prefixed file will be used. The `"EAP."` prefixed `authfile` and any other FSM specified prefixed files are mandatory files.

In versions prior to 7.1.1 of the server there was only one `EAP.authfile` that was applied to all clients. Starting with version 7.1.1, the client prefix is applied to the `EAP.authfile`.

clients

The `clients` file defines the access devices that communicate with the server and proxies that the server communicates with. The entries in this file correspond to your entries on the Server Manager Access Devices page and Proxies page. Only `Prefix` must be added directly to the device entry in the `clients` file.

Clients Entry Syntax

Name: Secret **type=*Vendor*:*NAS***`Options` **v1** *Prefix*

or

Name:*Auth-Port:Acct-Port* ***Secret*** **type=*Vendor*:*PROXY***`Options` **v1** *Prefix*

Examples

```
flatland.org f52tl type=Ascend:NAS
216.27.61.137 secret type=Ascend+USR:NAS v1 aaa.
flatlink.com f25lt type=Merit:Proxy
proxy.some.com:1666:1667 real-secret type=none:proxy v1
192.168.1.* secret type=Cisco:NAS v1
```

Parameter	Description
Name	Device fully qualified domain name, IP address or a wildcard pattern.
Auth-Port	Optional authentication relay port to use when proxying authentication requests to this PROXY.
Acct-Port	Optional accounting relay port to use when proxying accounting requests to this PROXY.
Secret	Shared secret between this device and the server. No spaces.
Vendor	Vendors whose attributes should be returned in reply messages. Can enter a list with + prefixed to each name, e.g.: Type=Microsoft+Interlink. Enter NONE to prune all VSAs. See vendors file for a list of defined vendors.
{NAS|PROXY}	Device type: NAS or Proxy server. Use NAS for wireless access points. If a NAS fails the RFC conformance checks then you may wish to configure it as a PROXY which will cause the server to skip the conformance tests. This may require that you add prune, see below.
Options	Additional criteria for messages. Can enter a list with + prefixed to each name. The set of options for a NAS are: • noencaps - Do not encapsulate vendor response (if the access device requires non-encapsulated A-V pairs). • oldchap - For access devices that perform pre-RFC CHAP. • debug - Dump packet traces for this client into the server's debug output file if the server is running at debug level 1 or greater. The set of options for a PROXY are: • prune - Force pruning as if the response were being returned to an NAS. With this option the generic vendor prunes all vendor-specific attributes before a message is returned to the proxy server. This may be used to help prevent problems that might occur if unencapsulated vendor attributes are not correctly mapped in the vendors file. • debug - Dump packet traces for this client into the server's debug output file if the server is running at debug level 1 or greater.
V1	Normally created by Server Manager, it only needs to be added to a clients entry when using prefixed authfile.
Prefix	Prefix to identify the users and/or authfile to use for this client in a request. This parameter can only be configured by manually adding it to a device entry in the clients file.

Realm files (.users) and default users file

Realm files provide local storage of user profiles. Create a separate file for each defined realm to store user profiles for authentication. All realm file names **must** end with the extension `.users`. If you create them through the Server Manager, they will be named whatever you specified when configuring the realm, followed by the extension `.users`.

User Entry Syntax

For the default users file the first line of each user entry consists of User-Name, optionally followed by configuration item and check item fields. Subsequent lines may contain an indented list of reply item A-V pairs. All reply item lines except for the last are followed by a comma:

```
User-Name check-items
   reply-item,
   reply-item,
   ...
```

Example

```
guest@library.org Password = "public", Simultaneous-Use = 20
   session-timeout = 3600,
   idle-timeout = 300
```

Note: For realm files the one difference is that the User-name is replaced with the User-Id. The realm name is omitted

Parameter	Description
User-Name	In default users file this is the user's NAI format login string. In realm files this is the *userid* portion of user's NAI format login string. Omit the realm name.
check-items	Any check or deny items to be matched by the Access-Requests before authorizing a user. See the dictionary for a list of valid attributes. Configuration attributes used for Interlink-specific functions may also appear here. See Configuration Attributes below for a list of valid attributes.
reply-items	Any reply items to be returned to the access device to provision the user session. Each line, except for the last, should be followed by a comma. See the dictionary for a list of valid attributes. Configuration attributes used for Interlink-specific functions may also appear here and will not be returned to the access device. See the dictionary for a list of valid configuration attributes.

General Configuration Attributes Used as Check Items

Configuration attributes provide user-level information for Interlink-specific functions. Only the User-Name attribute is required in a user entry. All other configuration attributes are optional.

Most of these attributes are configurable through the Server Manager Users:Add User page tabs. Any attribute that doesn't have a corresponding field can be entered as an A-V pair on the Free tab or manually added to the user entry in the realm file.

See the `dictionary` file for a list of valid values for each attribute.

Attribute	Description
Comment	Allows you to provide any necessary explanation for the entry.
Deny-Message	Specifies a string that would be returned to the user in the Access-Reject if any deny item for this user caused a rejection. The Deny-Message is only sent when a deny item comparison fails, not when a check item comparison fails. You may use an asterisk wildcard: Deny-Message = "*" This wildcard sends the message "Access denied" and the deny item that triggered the rejection. For example: Access denied, NAS-Port != 3160
Expiration	In date format, specifies when an entry expires. For example: Expiration = "Dec 01 2004" When the specified date has been reached, the user will receive an Access-Reject with the message, "Password has expired," in response to all Access-Requests.
Xvalue	Provides a means to pass an integer value to a module on a per user basis. Usually used in Advanced Policy and custom applications.
Xstring	Provides a means to pass a string value to a module on a per user basis. Usually used in Advanced Policy and custom applications.

Attribute	Description
Password	Specifies the value to compare to the RADIUS User-Password or the user's input in response to an Access-Challenge. Do not use the \ character. To store hashed passwords in the realm file, add the Encryption-type to the password value by using the syntax: Password = {*Encryption-type*}*password* where *Encryption-type* is the hashing algorithm and *password* is the user password. For example: Password = "{md5}CY9rzUYh03PK3k6DJie09g==" Encryption-type can be: • clear • crypt • md5 • sha • ssha • x-nthash • x-lmhash Choose the Encryption-type based on the inner realm authentication method used. The list of Encryption-types can be extended through the Software Developers Kit (SDK).

LAS Configuration Attributes Used as Check Items

These attributes provide information for the server's Local Authorization Service (LAS) function. To activate this feature, you must enable Session Tracking for the user's realm. The following attribute may be added to a user entry to override the global default.

Attribute	Description
Simultaneous-Use	The maximum number of active sessions the user may have. If Session Tracking is enabled for the user's realm, then the global value set in Server Properties is the default value. Any user specific configuration of Simultaneous-Use will be used instead of the default value. A value of -1 will disable the feature—providing an unlimited number of simultaneous sessions for the user. The value 0 will deny access to the user.

Check and Reply Items

A user entry may include check and reply items to control access and provision service.

Check items are A-V pairs that are compared to pairs in a RADIUS Access-Request data packet. There are two types of check items: **regular check items** and **deny items**. Regular check items are compared to the attribute value in the Access-Request message. If the values match, the user is authorized. A deny item is identical to a check item, except the attribute value must not be present in the Access-Request for the user to be authorized. Deny items use the operator != (not equal to) instead of = (equal to).

Note: The server compares a check/deny item in the user profile with the first value that appears for that attribute in an Access-Request. The server will disregard any additional instances of the same attribute in the request. This limitation also applies to tagged attributes, like those used to establish VPN tunnels.

A **reply item** is an A-V pair that is returned in an Access-Accept, Access-Challenge, or Access-Reject message to provide instruction to the access device for provisioning the user. Some of these attributes, such as Session-Timeout, can be used to enforce some simple authorization policies.

Note: The server handles multiple instances of a reply item in the user profile based on the clients file entry for the recipient. The server will consult the pruning rules in the `dictionary` to determine which instances to send based on the NAS type. See "clients" on page 189 for details

---

Some attributes may be used as either check or reply items. In these instances, the attribute may appear in an Access-Request as a hint from the client for a value to assign to the attribute. With the exception of Service-Type and the tunneling attributes, this product does not resolve hints, but you can use a check item to control access based on hints. For example, if you only wish to authenticate users requesting a Telnet service, you could add Service-Type = Telnet as a check item for those users.

Most check and reply item attributes are defined in the standard RADIUS RFC documentation and the `dictionary` file. They can be configured through the Server Manager User:Add User page tabs.

Interlink-specific Attributes

Interlink-specific attributes that may be used as check or reply items are:

Attribute	Description
Day-Of-Week	An integer representing the day of the week, where 0 is Sunday and 6 is Saturday. This attribute is derived from to the current system clock of the machine hosting the authentication server.
Reply-If-Ack-Message	Allows you to specify a message to return to the user if authentication succeeds. Similar to Reply-Message, but only sent in an Access-Accept packet. The normal pruning operation consolidates all Reply-Messages and Reply-If-Ack-Messages into as few Reply-Messages as possible.

las.conf

The `las.conf` file contains a list of configuration items for the server's Local Authorization Service function. There are configuration sections for realms and LAS session items. These sections do not have to be maintained in a particular order; however, an object (a realm, for example) must be defined before it may be referenced.

Most parameters can be configured on the Server Manager's Server Properties:Session Table Properties page. The parameters described here can be manually edited in `las.conf`.

LAS Session Configuration

These parameters let you override the server's default values related to session timing and session limits. Timing parameters are specified in seconds.

Syntax

attribute value

Session Attributes

Attribute	Description
Auto-Save	Interval for LAS to save the session table if there's any change. Default is 300 seconds (5 minutes).
Session-Check-Time	Interval in seconds at which the AAA server checks for Session-Idle-Time timeouts. Default is 300 (5 minutes).

Attribute	Description
Session-Clear-Time	Time in seconds the AAA server waits before removing a session in the Suspended state. Default is 1815 (30 minutes and 15 seconds).
Session-Hold-Time	Time in seconds the AAA server waits before removing a session in the Stop state. Default is 300 (5 minutes).
Session-Idle-Time	Time in seconds the AAA server waits for an accounting Interim Update message before suspending a session. Default is 915 (15 minutes and 15 seconds).
Session-Kill-Time	Time in seconds AAA server waits before removing sessions from the session table that are in the Not-Confirmed, Disconnected, Rejected, or Collided state. Default is 300 (5 minutes).
Session-Table-Limit	The maximum number of sessions that can be held in the Session Table. When this number is met, authentication requests that would normally result in a new session are ignored. Default is 2147483647 (maximum allowed).
Session-Update-Time	Time in seconds between updates to the status of sessions. Default is 5 seconds.
Simultaneous-Use	The maximum number of active sessions users may have, unless a user-specific value is configured that overrides this number. The default value is 1. The value -1 sets no limit. The value 0 prevents access to any user that does not have a specific value configured.
Token-Hold-Adjustment	The additional time the AAA server waits for an Accounting-Start message. The base time is a fixed 15 seconds. After the combined time elapses without an Accounting-Start message, a session is moved into the Not-Confirmed state and does not count against a Simultaneous Use limit. Default is 5 seconds.

LAS Realm Configuration

This section lists realms by name and, optionally, any custom AATV support for the realm. Turning on Session Tracking through the Server Manager automatically adds a realm entry to `las.conf`.

Note: If you make a realm entry by editing las.conf directly and then disable Session Tracking through the Server Manager, the entry will be deleted.

Syntax

```
Realm realm-name
   Authorization LAS-Authorization-AATV
```

```
   Accounting LAS-Accounting-AATV
End-Realm
```

Realm Attributes

Attribute	Description
Realm-Name	Realm name.
LAS-Authorization-AATV	AATV used for realm authorization. Default is LASGEN.
LAS-Accounting-AATV	AATV used for realm accounting. Default is GENACCT.

Logging LAS Realms

The default server behavior is to log accounting messages locally, whether the server processes Access-Request messages locally or sends them to a remote server. If a realm entry exists in `las.conf`, the server will NOT send accounting messages to the server that processed the authentication for the corresponding user.

vendors

The `vendors` file contains a list of entries defining vendors whose attributes are recognized by the server. Each vendor entry contains a vendor name and vendor number. The vendor numbers are SMI Network Management Private Enterprise Code numbers, as managed by IANA.

Entries may optionally contain an interim way of mapping external (with respect to the RADIUS server) attribute numbers to internal vendor-specific attributes. This optional mapping is used in RADIUS requests and responses.This is used primarily to support very old NAS implementations. It should not be necessary when adding new vendors.

Version Tracking

You can track different versions of the vendors file by changing the following line in the file:

`%VENDORSID` ***`Version-String`***

`Version-String` is the version identifier. This string will appear in `radcheck` output.

Vendor Entry Syntax

```
Attribute-String    Value-String     Vendor-Code    Vendor-Name
      {
            Standard-Value Vendor-Specific-Value
            . . .
      }
```

Parameter	Description
Attribute-String	An optional string that defaults to ATTRIBUTE when not specified. When adding vendor-specific attributes to the dictionary file, enter the string that will be used to identify the attributes. You must also specify Value-String.
Value-String	An optional string that defaults to VALUE when not specified. When adding vendor-specific values to the dictionary file, enter the string that will be used to identify the values.
Vendor-Code	The private enterprise number assigned by IANA.
Vendor-Name	Vendor identifier that will appear in the clients file as a type=vendor:nas entry or in the dictionary and .users files in vendor-specific attributes.
Standard-Value	The external or common attribute number as seen in RADIUS requests on the network. Must be mapped to Vendor-Specific-Value.
Vendor-Specific-Value	The internal attribute number.

Standard-Value and Vendor-Specific-Value are used to map attributes from the common attribute space defined in the RADIUS RFC to internal nonconflicting vendor-specific attributes. They address backward compatibility issues for very old NASs. You should not have to use these parameters for new VSA definitions.

Example

```
Merit.Attribute     Merit.Value    61   Merit
       (
              144        144
              145        145
              . . .
       )
```

dictionary

The `dictionary` file contains a list of dictionary translations that the AAA Server uses to parse incoming requests and to generate outgoing responses. It includes definitions of all attributes and their permitted values.

Version Tracking

You can track different versions of the dictionary by changing the following line in the file:

`%DICTID` *`Version-String`*

`Version-String` is the version information. This string will appear in `radcheck` output.

Attribute Entry Syntax

**`{ATTRIBUTE|`*`Attribute-String`*`} `*`Attribute-name Integer-encoding Type`*
`(pruning) # comment`

Parameter	Description
Attribute-String	Vendor-specific attribute identifier defined in the vendors file. If no Attribute-String is defined, use ATTRIBUTE.
Attribute-name	Unique name of an attribute.
Integer-Encoding	Actual attribute number code.
Type	The attribute type. May be: • octet: 8-bit unsigned integer value • short: 16-bit unsigned integer value • integer: 32-bit value in big endian order (high byte first) • date: 32-bit value in big endian order (seconds since 00:00:00 GMT, Jan. 1, 1970) • octets: 0-253 undistinguished octets • abinary: 0-253 Ascend binary filter octets • string: 0-253 octets • vendor: 0-253 octets with octets 0-3 representing the IANA number • ipaddr: 4 octets in network byte order • tag-int: single octet followed by three octets of integer value (used for tunneling attribute) • tag-str: single octet followed by 0-252 octets (used for tunneling attribute)

Parameter	Description
Pruning	Optional pruning expression that controls: • Sending A-V -pair to NAS • Logging the attribute • Encapsulation • Internal attribute identification
Comment	Optional comment about the entry.

Pruning Expressions

Pruning is a feature that allows the server to remove A-V pairs from an Access-Accept, Access-Reject, or Access-Challenge message before sending the message to a client (generally a NAS) that has been configured for pruning in the `clients` file (Type=NAS or Type=proxy+prune). The pruning is defined by optional pruning expressions in the `dictionary` attribute entries.

Pruning is expressed in an attribute entry as follows:

(ack, nak, chall, NOLOG, ENCAPS|NOENCAPS, INTERNAL*)*

If the *ack*, *nak*, or *chall* value is omitted, but the comma is present for that expression, the default value of 0 is used. If no pruning expressions are specified, all defaults are used.

ack, nak, chall: How many instances of the dictionary attribute to add to an Access-Accept, Access-Reject, or Access-Challenge, respectively. May be one of the following values:

- 0—No attributes of this kind (default value)
- 1—One attribute of this kind (last occurrence on the reply list)
- *—any number of attributes of this kind

NOLOG: Do not add the attribute to server log file or session logs.

ENCAPS: Encapsulate the value in the vendor-specific attribute, regardless of the vendor (default value).

NOENCAPS: Do not encapsulate the value within the vendor-specific attribute.

ENCAPS and NOENCAPS keywords are mutually exclusive. If you specify both, only the last one will apply.

INTERNAL: This attribute is for internal use only and will not be sent or received.

Note: Always specify pruning expressions for vendor-specific attributes or they will not be returned to the client in any replies.

Example

```
ATTRIBUTE     Framed-Protocol  7     integer     (1, 0, 0)
ATTRIBUTE     User-Realm       223   string      (*, 0, 0, NOENCAPS)
Interlink.Attr Address-Pool    1     string      (0, 0, 0)
```

Value Entry Syntax

Valid values for integer-type attributes may be defined in the `dictionary` file. Define each value on a separate line.

{*Value-String*|VALUE} *Attribute-Name Value-Name Integer-Encoding*

Parameter	Description
Value-String	Vendor-specific value identifier string defined in the vendors file. If no value-string is defined, use VALUE.
Attribute-Name	The name of the attribute associated with this value.
Value-Name	The name/descriptor of the value.
Integer-Encoding	The actual value used in the A-V pair data format.

Example

```
VALUE         Framed-Protocol  PPP             1
VALUE         Framed-Protocol  SLIP            2
Merit.VALUE   LAS-Code         LAS-Normal      0
Merit.VALUE   LAS-Code         LAS-Reject      1
```

log.config

The `log.config` file specifies how accounting logs are generated in the server. It allows you to configure multiple logging streams, which can be used with sophisticated Finite State Machine (FSM) tables. For most applications, configuration of the default stream will suffice.

For any stream, you can configure log file format, location, name, and how often streams are switched between files.There are four possible entry types that control special logging features and options for a stream.

Default Entry

The `default` entry specifies the name of the stream to use as the default and follows the syntax:

default *stream-name*

Default Path Entry

The `default-path` entry specifies the default path for session log files. The `default-path` does not apply to the `*default*` stream. The `default-path` follows the syntax:

default-path *pathname*

Nodefault Entry

The one-keyword **nodefault** entry turns off the defaulting feature. When this entry is used, the default stream name must be identified by the `STRVALUE=keyword` in the finite state machine. Don't use this unless you have some idea of how to manipulate the finite state machine.

Stream Entry

```
stream name {
   aatv AATV_NAME
   aatv-value integer
   filename string
   buffer integer
   chmod octal-value
   close {on|off}
   debug integer
   dont attribute attribute . . .
   gmt|local
   join joined_stream
   header {none|type|full}
   on-endfile shell-command
   path pathname
   update seconds
   wrap integer
```

```
}
end
```

Parameter	Description
stream	Identifies the stream.
aatv	The AATV to use for logging the stream. • LOG_ACCT (Livingston/Lucent/RABU style call detail format) • LOG_ALL (logs all streams defined in log.config) • LOG_BRIEF (simple session format) • LOG_BY_ATTRIBUTE • LOG_BY_NAS • LOG_BY_REALM • LOG_TACACS+ (Cisco TACACS+ accounting record format) • LOG_V1_1 (previous version of Merit logging) • LOG_V2_0 (default Merit style logging)
aatv-value	The Xinteger value to pass to the AATV. The default is 7.
buffer	The number of records to buffer before flushing the buffers to disk. The default is 1.
chmod	The value is an octal UNIX permission value; must have a leading 0. The default is 0640.
close	The value of `on` causes the server to open/close file for each flush. The value of `off` causes the server to not open/close file for each flush The default is off.
debug	The value specifies the logging debug level for accounting messages. If the server is running at least at debug level 1, then if the logging debug level is > the current debug level, raise the debug level to the logging debug level while we are logging the accounting message. Valid values are 0 to 4. The default is 0.
dont	The value is a list of one or more RADIUS accounting attributes that should not be included in the session logfile. The default is none.
filename	The file name format to use for this stream. The default is "session.%Y-%m-%d.log".
gmt|local	Determines whether to evaluate the session filename format string using UTC (GMT) time or local time. The default is local.
header	Specifies the amount of header information to be written to the session logfile. `none` adds no header lines, `type` adds just the first 3 lines of header information and `full` adds all the header lines. The default is full.

Parameter	Description
join	Specifies the stream name of another stream to join to this stream. The joined stream must already be defined. This will allow logging the same accounting message to multiple streams (i.e.: produce multiple outputs.) There is no default.
on-endfile	This specifies a shell command to run when the session logfile is rolled to a new filename. Do not enclose the command in quotes. If the command has a "!" in it, then, before executing the command, the "!" will be replaced by the file name in use before the rollover occurred. There is no default.
path	The value specifies the path to be used for session log files. Do not enclose the path in quotes. The default is the -a option used when starting radiusd or /var/opt/aaa/acct if no -a option was used.
update	The value is the interval in seconds between flushes of the buffer to the session logfile. The default is 900 seconds (15 minutes).
wrap	The number of A-V pairs to put on a line before wrapping to a new line. The default is 3.
end	Keyword that tells the server to stop reading the configuration file, allowing subsequent text to be ignored.

Logging Multiple Streams

To log multiple streams, define a stream named `*default*` with the `aatv` subcommand set to `LOG_ALL`. All other streams defined in `log.config` will also generate accounting logs.

```
stream *default* {
   aatv log_all
}
stream old {
   aatv log_v1_1
   buffer 1
   close on
   filename record.%y%m%d.las
}
stream new {
   aatv log_v2_0
   aatv-value 7
   buffer 1
   close on
   filename recordv2.%y%m%d.las
}
end
```

iaaaAgent.conf

The `iaaaAgent.conf` file contains one parameter, `agentxPingInterval`, which is set to 30 seconds by default. This setting specifies how often the server's SNMP subagent will check to see if a master agent is active. If one is detected and the subagent has not already registered with the master agent, the subagent will register with the master agent and begin processing SNMP requests.

Finite State Machine (FSM)

The main component of the AAA Server's software engine is the Finite State Machine and a few associated routines. At server startup the finite state machine loads state table instructions from an `.fsm` file. It will load the `radius.fsm` file, unless it is missing or another .fsm file is specified by the `radiusd -f` option.

The `.fsm` file defines a state table that includes the states, events, and actions that determine how a request is processed.

Version Tracking

You can track different versions of state tables by adding the following line to the file:

`%FSMID` *`Version-String`*

- The `%` **must** be in the first column.
- *`Version-String`* is the version information. This string will appear in `radcheck` output.

States

Each state defined in a finite state table starts with a line containing just the name of the state, followed by a colon character. Each subsequent line is an event handler with three required and two optional fields. The fields on the line can be separated by spaces and/or tabs:

```
State-name:
    Event-1    Action-1    Next-state-1    intattr=value   stringattr=value
    ... ... ...
    Event-n    Action-n    Next-state-n    intattr=value   stringattr=value
```

- Every *`State-name`* **must** start in column 1.
- Every *`Event-n`* **must not** start in column 1.
- Every *`State-name`* referenced in an event handler must be defined only once in the state table.
- Every *`State-name`*, except for the `End`, must have at least one associated event handler.
- Every *`State-name`*, except for `Start`, must be referenced by at least one event handler in another state as its next state.

The parameters for any event are:

Parameter	Description
State-name	An arbitrary string which represents a state in the FSM. It may be composed of any printable ASCII character except space, new line, carriage return, tab, and colon (:) characters. • Every *State-name* must start in column 1. • Every *State-name*, except for Start, must be referenced by at least one event handler in any state as its next state. • Every *State-name*, except for End, must have at least one associated event handler. • Every *State-name* referenced in an event handler must be defined only once in the finite state machine.
Event	Three-tuple with each part separated by a period in the form: *Last-state.Last-action.Event-name* • Last-state must not start in column 1. • Last-state is the name of the state that generated the event or an asterisk character (*)—that will match any state—if there is no last state for the event or if the last state does not matter. • Last-action is the name of the AATV that generated the event or an arbitrary string (found in the code or arrived in a packet), prefixed with a plus character. This may be an asterisk character (*)—that will match any action—if there is no last action or if the last action does not matter. • Event-name is the name of the event-code returned from Last-action.
Action	Name of the module to call in this event. The called module will return a value that will be used as the next event. For reference, you may refer to a list of "Predefined Actions" in the SDK documentation. Typically, the Interlink Networks AAA server invokes iaaaRealm upon receipt of an authentication request. iaaaRealm in turn invokes the proper authentication module (PROLDAP, ORACLE, etc.), depending on the configuration of the request in question. This process is specific to the server's default state table.
Next-state	Name of next state in the AAA transaction. The current State-name, Action, and the value returned from the Action (an event) determine which event listed under Next-state should be processed next.

Parameter	Description
intattr=value	An optional integer attribute A-V pair that may be passed to an Action as an argument. Value may be either the integer or the symbolic value defined for the attribute in the dictionary. Only one integer argument may be specified for each event.
stringattr=value	An optional string attribute A-V pair that may be passed to an Action as an argument. Value may be any string. Only one string argument may be specified for each event. With the POLICY module you can use the Xstring attribute to specify an URL that identifies where the policy definitions are stored. The pointer string must be less than 64 characters long. See "Using Advanced Policy" on page 124 for instructions.

Events

After an action completes its task, it returns an event code name to the FSM. The previous state and action and the event code name determine the current event, which in turn determines the next action of the FSM. The event code names returned by the standard AAA actions are predefined, but you can create your own names by modifying the .fsm file.

Predefined Event Names

An action may return one of the following predefined events:

Event	Description
ACC_CHAL	The incoming proxy reply is an Access-Challenge or an Access-Challenge should be sent in response to an Access-Request.
ACCT	The incoming request is an Accounting-Request.
ACCT_ALIVE	The incoming Accounting-Request is an interim accounting message.
ACCT_CANCEL	The incoming Accounting-Request is a message to cancel the session.
ACCT_DUP	The incoming Accounting-Request is a duplicate.
ACCT_MSTART	The originating NAS has just rebooted.
ACCT_MSTOP	The originating NAS is about to reboot.
ACCT_OFF	Received accounting message has a Status-Type of Accounting-Off.

Event	Description
ACCT_ON	Received accounting message has a Status-Type of Accounting-On.
ACCT_START	Received accounting message has a Status-Type of Start.
ACCT_STOP	Received accounting message has a Status-Type of Stop.
ACCT_TUNNEL_LINK_REJECT	The incoming Accounting-Request is a message that the user has been denied access to an established tunnel.
ACCT_TUNNEL_LINK_START	The incoming Accounting-Request is a message to start a session through an established tunnel.
ACCT_TUNNEL_LINK_STOP	The incoming Accounting-Request is a message to end a session through an established tunnel.
ACCT_TUNNEL_REJECT	The incoming Accounting-Request indicates that a requested tunnel could not be established.
ACCT_TUNNEL_START	The incoming Accounting-Request is a message to establish a tunnel.
ACCT_TUNNEL_STOP	The incoming Accounting-Request is a message to eliminate a tunnel.
ACK	Acknowledgment of the previous action.
AUTHEN	The incoming request is an Access-Request.
AUTHENTICATE	The incoming request is a proxied Access-Request.
AUTH_ONLY	Received Access-Request has a Service-Type of Authenticate-Only.
CONTINUE	The incoming Access-Request is a continuation of an in-progress EAP conversation. Generally, you should allow the server to handle these events without modification. This event is not pre-defined, it must be defined in the FSM file.
DROP	The request should be dropped, no further processing will occur. This event is not pre-defined, it must be defined in the FSM file with a value that matches the value of DROP for the Interlink-Reply-Status attribute in the dictionary.
DUP	The incoming Access-Request is a duplicate. Generally, you should allow the server to handle these events without modification.
ERROR	The previous action generated an error. Generally, you should allow the server to handle these events without modification.

Event	Description
LASCP	The incoming Accounting-Request is an accounting-interim-update. Generally, you should allow the server to handle these events without modification. This event is not pre-defined, it must be defined in the FSM file.
LAS_ACCT	The incoming request is a LAS proxied Accounting-Request.
NAK	Negative acknowledgment of the previous action.
NO_SUCH_REALM	This value may be returned by the iaaaRealm action when a user's realm cannot be found in the file that iaaaRealm checked (authfile by default).
PROXY_EGRESS	This value may be returned by the RAD2RAD AATV (RADIUS proxy) module to indicate that a request is about to be forwarded. In the default FSM this invokes the proxy post-processing policy. This event is not pre-defined, it must be defined in the FSM file.
PW_EXPIRED	This value may be returned by the iaaaAuthenticate AATV module if the user profile includes an out-of-date value for the Expiration configuration attribute.
RETRIEVE_ERROR	This value may be returned by the user profile retrieval (iaaaRealm, iaaaUsers) when a user's profile cannot be found. Also returned when the "DEFAULT" entry is "found".
RETRIEVE_SUCCESS	This value may be returned by the iaaaRealm or iaaaUsers action when the search for a user's profile is successful.
RETRY_LIMIT	The number of received duplicate requests has exceeded the retry limit.
SEND	Typically used after a post-processing policy to cause the request to be forwarded or the reply to be sent. This event is not pre-defined, it must be defined in the FSM file.
TIMEOUT	The request has timed out due to inactivity.
TIMER	The timer value has expired.
WAIT	The previous action generated a pending event. Generally, you should allow the server to handle these events without modification.

Creating New Event Names

To create custom event names, add to the .fsm file:

`%event name value`

- The `%` must be in column 1.

- ***name*** can be any alphanumeric string and may include underscores (_).
- *value* is an optional integer value for the event which allows your custom plugin to use a specific value for an event.
- You may define a new event anywhere in the .fsm file, but it must be defined before it is referenced.

Actions

The actions in the state table correspond to the server's AATV actions. These actions perform discrete functions, such as initiating an authentication request, replying to an authentication request, or logging an accounting record. For any action used in the .fsm file, there must be a corresponding AATV of the same name.

The following table lists some of the available actions.

Action	Description
ACCT	Writes Livingston call detail records
ACCT_SWITCH	Direct FSM to next state based on reason code of the Accounting-Request
ACC_CHAL	Returns an ACC_CHAL event
ACK	Signifies success
CHK_DENY	Verifies check items in user profile.
CONTINUE	Resume processing of an in-progress EAP conversation
iaaaAuthenticate	Performs authentication (following profile retrieval)
iaaaFile	Attempts to retrieve a user profiles from realm users files
iaaaRealm	Attempts a realm-based dispatch using the specified authfile to locate where a user profile is stored or the authentication type for the realm extracted from a user request
iaaaUsers	Retrieves user profiles from the default users file
LAS	Evaluates realm-based authorization for L.A.S.
LAS_ACCT	Initial action to handle an Accounting-Request for L.A.S.
localFile	Retrieves user profiles from realm files based on the Request-Attribute-For-Search option which defaults to User-ID
LOG	Writes accounting logs as defined in log.config
NAK	Returns an NAK event

Action	Description
NULL	No action placeholder.
PASSWD	Verifies password against Unix password system
POLICY	Evaluates advanced policies
POSTLAS	Allocates tokens for L.A.S.
PROLDAP	Retrieves user profile from an LDAP server
ProxySend	Forwards proxy requests
RAD2RAD	Prepares to send RADIUS proxy requests
ReplyDispatch	Translates the Interlink-Reply-Status attribute to an FSM event
ReplyPrep	Prepares to generate reply messages prior to post-processing policy
ReplySend	Generates reply messages after post-processing policy
RequestDispatch	Translates the Interlink-Proxy-Action attribute to an FSM event
SECURID	Performs authentication with a SecurID server
SIM-TripletFile	Retrieves user profiles from realm files based on the Request-Attribute-For-Search option which defaults to Real-Username. If the reply items contain a set of GSM-Triplet attributes then starting randomly in the list only the required number of GSM triplets will be returned.
SRV_STATUS	For Status-Server (Management-Poll) requests
TIMEOUT	Performs timeout logging and provides feedback to other actions that have pending events
TUNNELING	Encrypts Tunnel-Password and resolves hints from client

Predefined .fsm Files

The following FSM tables can be read by the `radiusd` program at server startup:

.FSM	Description
radius.fsm	Basic functions. This is the default read by the server at startup, unless another .fsm is specified.
logall.fsm	Logs all accounting messages in the format specified in the log.config file.

The default `radius.fsm` file is created from the predefined `/etc/opt/aaa/default.fsm` during server installation. Unless you choose to use an alternate state table, always edit `radius.fsm` and have the `radiusd` program read `radius.fsm`.

Configuring EAP-AKA

The configuration files must be edited manually as EAP-AKA cannot currently be configured using the Server Manager.

Configuration information for EAP-AKA is placed in several files, with some default values built into the server. There is a precedence for the values that can be found in multiple places. The server starts with the built-in default values and overrides them with values in `aaa.config` (global values). The resulting values can be overridden by values in the `EAP.authfile` on a per realm basis. Finally the results of the user credential lookup may override some of these values.

Which file to configure a particular piece of information in is best made on the basis of where it will appear the least number of times. Based on this, the choice is first to use the `aaa.config` file, then `EAP.authfile,` and finally in the user credential datastore.

Some items would not be reasonable to configure on a global basis since they are user-specific, like the user password. These need to be unique, so the user credential datastore is the correct place for them. However some items, such as the `AKA-Algorithm`, may be common to all the users in a given realm so they could be configured in the `EAP.authfile` in just one place instead of each user's entry in the datastore for that realm. If all the realms used the same `AKA-Algorithm` then putting the `AKA-Algorithm` in the `aaa.config` file would be the best option. These are just some basic guidelines for grouping the common values in the best place.

EAP-AKA Features

The Interlink EAP-AKA server is fully compliant with RFC4187, 2006. The RFC's "MUSTs" "SHOULDs", and "RECOMMENDEDs" are implemented. It supports the following features:

- IMSI permanent identities, supportable on a per realm basis
- Non-IMSI permanent identities, supportable on a per realm basis
- Protected success indications, supportable on a per realm basis
- Fast re-authentication, supportable on a per realm basis
- Protected Identity Exchanges using `AT_CHECKCODE`, supportable on a per realm basis
- Authentication Management Field (**`AMF`**) supportable on a per realm basis
- Pseudonym support via algorithmically generated or random pseudonyms, supportable on a per realm basis
- To ensure that permanent usernames, pseudonym usernames, and fast re-authentication usernames are separate and recognizable from each other, the server generates pseudonyms with a leading "4" character and fast re-authentication usernames with a leading "5" character. Per the RFC, permanent usernames derived from the IMSI are prefixed with a leading "0" character.
- Many EAP-AKA parameters are configurable on a per realm basis
- A user's subscriber key (Ki), sequence number, mode, and the name of the appropriate AKA algorithms, may be stored in an external database or local file. If so, the server will automatically generate the authentication vector from this information.

- An authentication vector may be stored in a local file. This is intended for use in a lab environment, and requires no additional user-written plug-ins.
- The user credentials may be retrieved from an AuC if the customer implements an AATV which communicates with the AuC.
- AKA 3GPP Milenage algorithms are provided with configurable parameters.
- The Milenage AKA algorithm can be customized with a simple plug-in.
- Additional customer supplied AKA algorithms may be plugged into the server.
- Occurrences and values of received AKA attributes are validated.
- Support for pseudonym and fast reauthentication identity mapping is built-in, without the need of an external database.

EAP-AKA User Credential Lookup Configuration

The server inherently supports configuration of EAP-AKA user credentials as Reply Items in two forms:

One form is the configuration of the user's `Subscriber-Key` (**`Ki`**), `AKA-Sequence-Number` (**`SQN`**), `AKA-Mode` (Authentication Management Field, **`AMF`**), and `AKA-Algorithm`. See "A3, A8 and AKA Algorithms" on page 251 for a description of the algorithm. The server uses these AVPs as input to generate an authentication vector.

- `Subscriber-Key` is a string attribute containing the binary encoded 128-bit user secret key often referred to as **`Ki`**. The encoding should be in network byte order (big-endian).
- `AKA-Sequence-Number` is a string attribute containing the binary encoded 48-bit user sequence number often referred to as **`SQN`**. The encoding should be in network byte order (big-endian).
- `AKA-Mode` is a string attribute containing the binary encoded 16-bit user authentication management field often referred to as **`AMF`**. The encoding should be in network byte order (big-endian).
- `AKA-Algorithm` is a string attribute indicating the name of the AKA algorithm to be applied in AKA vector generation. Most lines in the configuration files are limited to 1023 characters which places a limit on the length of this string. The value is case-sensitive.

The second form is the configuration of an AKA vector. An `AKA-Vector` is a fixed length binary string (octets) attribute which holds an EAP-AKA authentication vector. The attribute value is a 576-bit binary string (72 bytes) partitioned as follows:

- `RAND` = The first 128 bits (16 bytes) of value
- `XRES` = The next 64 bits (8 bytes) of value
- `CK` = The next 128 bits (16 bytes) of value
- `IK` = The next 128 bits (16 bytes) of value
- `AUTN` = The last 128 bits (16 bytes) of value

Configuration of an AKA-Vector is intended for a test lab environment, when the user's

Subscriber-Key, AKA-Sequence-Number, AKA-Mode, and AKA-Algorithm are not known but AKA vectors have been retrieved from the device to be used in the testing.

The user credentials can be stored in any supported data repository: a local realm users file, a LDAP database, or a customer supplied database.

Additionally, a customer-specific plug-in may provide EAP-AKA user credentials. This plug-in may access a customer supplied database or may contact an authentication center. The plug-in's Authentication-Type needs to be defined in the dictionary and may be configured with an Xstring parameter in the authfile.

Example realm file content

The following is an example of a local realm users file. See "User Entry Syntax" on page 191 for the a description of the format and allowable content. What follows are two EAP-AKA users with reply items used to authenticate the user:

```
# IMSI configured with 128 bit Subscriber-Key, 16 bit AKA-Mode,
#                       48 bit AKA-Sequence-Number, and AKA-Algorithm
801448005551000
  Subscriber-Key ="\x6d\x37\x71\x8a\xcc\xec\x37\x01\x4e\xdb\xf0\xf0\x3b\xe5\x77\xda",
  AKA-Mode = "\xa1\xb2",
  AKA-Sequence-Number = "\x01\x02\x03\x04\x05\x06",
  AKA-Algorithm = "3GPP-Milenage"

# Generic (i.e. non-IMSI permanent identity) user
# configured with a 576 bit AKA vector
fred
  AKA-Vector="\x11\x11\x11\x11\x11\x11\x11\x11\x11\x11\x11\x11\x11\x12\x22\x22\x22\x22
\x22\x22\x22\x22\x22\x22\x22\x22\x33\x33\x33\x33\x33\x33\x33\x33\x33\x33\x33\x33\x
33\x34\x44\x44\x44\x44\x44\x44\x44\x44\x44\x44\x44\x44\x44\x55\x55\x55\x55\x55\x55\x55
\x55\x55\x55\x55\x55\x55\x55\x55\x55\x55\x55"
```

Note - Subscriber-Key, AKA-Mode, AKA-Sequence-Number and AKA-Vector values are binary strings and are configured as quoted strings of hex escaped octets.

Note - If a user's Subscriber-Key is configured, but the AKA-Algorithm is not configured, the default AKA-Algorithm specified in the realm's configuration or the globally configured value will be used.

EAP-AKA Realm-Based Configurations

Many EAP-AKA parameters can be configured on a per realm basis. These parameters are configured in realm entries stored in the authfile and EAP.authfile (these files are possibly prefixed). The realm names may be wild carded.

Realm-Based EAP-AKA Configuration Information in authfile

The user's AKA credentials lookup information is configured in the authfile on a realm by realm basis

The EAP-AKA realm must be configured with the -AKA switch (the -AKA switch is new as of

version 7.4), which shields this realm entry from undesired `iaaaRealm` actions.

If the realm utilizes a local users file, then the `localFile` AATV will be used.

localFile Authentication Type

The `localFile` AATV is an enhanced version of `iaaaFile`. Whereas `iaaaFile` always looks up the user record specified by the `User-Id` attribute value, `localFile` can search based on a specified attribute value. The configuration of a realm which employs `localFile` is followed by a required `{}` block. The `{}` block allows any or all of these three parameters: `Request-Attribute-For-Search, Filter-Type`, and `Policy-Pointer`. Another difference from iaaaFile is that the `Filter-Type` is not controlled by the `-BIN` and `-CIS` flags but by the `Filter-Type` specification in the `{}` block.

Parameter	Description
Request-Attribute-For-Search	This indicates the search attribute to use for a user lookup. The attribute must be a string-type (string, tag-str, octets). The `localFile` AATV is not restricted to use by EAP-AKA, it may be used generically. When `localFile` is used for EAP-AKA, the `Request-Attribute-For-Search` attribute must be configured with a value of `Real-Username`. The default value, if not present, is `User-Id`.
Filter-Type	This is used to specify case-sensitive or case-insensitive treatment of the value of the `Request-Attribute-For-Search` attribute. A value of "`BIN`" causes a case-sensitive lookup. A value of "`CIS`" causes a case-insensitive lookup performed by taking the contents of the attribute specified for searching and converting it to uppercase before the datastore lookup. Therefore the local realm file needs to store the identity in uppercase. The default value, if `Filter-Type` is not present, is `BIN`.
Policy-Pointer	For information on `Policy-Pointer`, see "Authorization" on page 8.

Example localFile authfile configuration for credentials lookup

```
# This realm uses a local realm users file "realm1.users"
eapakarealm1.com     -AKA     localFile     realm1
{
    Request-Attribute-For-Search    Real-Username
}

# This set of wild carded realms use realm users file "ispx.users"
*.ispx.com           -AKA     localFile                ispx
{
    Request-Attribute-For-Search    Real-Username
}
```

PROLDAP Authentication Type

The PROLDAP AATV has, as of version 7.3, been enhanced to support the Request-Attribute-For-Search configuration parameter.

Parameter	Description
Request-Attribute-For-Search	This indicates the search attribute to use for a user lookup. The attribute must be a string-type (string, tag-str, octets). The default value, if not present, is User-Id. When PROLDAP is used for EAP-AKA, the Request-Attribute-For-Search attribute must be configured with a value of Real-Username.

Example PROLDAP authfile configuration for credentials lookup

```
# This realm uses an LDAP database
eapakarealm3.com     -AKA     PROLDAP     "LDAP lookup"
{
    Request-Attribute-For-Search    Real-Username
    Filter-Type                     CIS
    Directory   "Directory 1"
    {
        Host            ldap1.ispx.com
        Port            389
        Administrator   "cn=...,ou=...,ou=...,o=radius"
        Password        password
        SearchBase      "...,ou=...,o=radius"
        Authenticate    Search
    }
}
```

Realm-Based EAP-AKA Configuration Information in EAP.authfile

The EAP.authfile entry for a realm which supports EAP-AKA can contain an optional {} configuration block following the "EAP-Type AKA" specification. This block contains realm specific EAP-AKA configuration information. Some of these configuration lines are EAP-AKA parameters and the AATVs for lookup and update of pseudonym and fast reauthentication identity mappings. See "Pseudonym and Fast Re-Authentication Data Base AATVs" on page 256 for a description of the provided implementation.

Some of the parameters, if not specified in the EAP-Type AKA{} configuration block, will be assigned default values from the aatv.EAP-AKA{} configuration block in aaa.config. Other parameters do not have a default and must be specified if the capability is to be supported.

The following rules apply to the EAP-Type AKA{} configuration block parameters

- The parameter names are case insensitive.
- For parameters with on/off binary values, the values "enabled", "yes", "on", and "true" are synonyms and the values "disabled", "no", "off", and "false" are synonyms.
- String parameter values should be enclosed in single or double quotes.

- When configuring a lookup or update for a fast reauthentication identity or pseudonym, the configuration parsing requires that a string parameter must be specified. It may be an empty string, i.e. "". This string is used as the `Xstring` value for the lookup and update AATV calls. The Interlink provided AATVs do not require an `Xstring` and so the "" should be used. If a custom AATV is written for lookup or update then that AATV may require a string parameter. See the Software Developers Kit for more details on AATVs and `Xstring`.
- If there is no AATV for the lookup or update for a fast reauthentication identity or pseudonym, then the parameter (e.g. `Fast-Reauth-Lookup`) may be simply not configured at all. Alternatively, the configuration may be explicitly configured with an AATV value of "`NULL`" or "`NONE`".
- Pseudonym lookup is disabled if the realm's configuration specifies that pseudonyms should be algorithmically generated (i.e. "Generate-Random-Character-Pseudonyms No"), but NO pseudonym encryption keys are configured in the `aatv.SIMAKA{}` section of the `aaa.config` file.
- Generation of new pseudonyms is disabled if the realm's configuration specifies that pseudonyms should be generated but NO `Pseudonym-Algorithm-Current-Key` is configured in the `aatv.SIMAKA{}` section of the `aaa.config` file.

The `EAP-Type AKA{}` configuration block can contain any subset, including the empty subset, of the following named parameters:

Parameter	Description
AKA-Algorithm	This parameter specifies the default AKA Algorithm for the realm. If the profile for a user in this realm does not specify an AKA Algorithm and if an AKA Algorithm is needed to produce the AKA vector for this user's authentication, then the AKA Algorithm specified by this parameter is used. See "A3, A8 and AKA Algorithms" on page 251 for details on available algorithms. If not explicitly configured, the default value is specified in the `AKA-Algorithm` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.
AKA-Mode	`AKA-Mode` is the user authentication management field often referred to as **`AMF`**. It is an input to the functions f1 and f1*, See 3GPP documents for details. The value is a 16-bit binary string (2 bytes) entered as "`0x`" followed by 2 two digit hex values. "dots" are optional and are just for readability. The encoding should be in network byte order (big-endian). See examples below. If not explicitly configured, the default value is specified in the AKA-Mode parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.

Parameter	Description
Prefixed-IMSI-Permanent-IDs	This parameter indicates whether or not the server should, for this realm, accept permanent identities of the form '0' + IMSI. The EAP-AKA RFC 4187 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The server supports both options. The valid values are "`Enabled`" and "`Disabled`". If not explicitly configured, the default value is specified in the `Prefixed-IMSI-Permanent-IDs` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.
Generic-Permanent-IDs	This parameter indicates whether or not the server should, for this realm, accept generic permanent identities not based on an IMSI, e.g. "fred". The EAP-AKA RFC 4187 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The server supports both options. The valid values are "`Enabled`" and "`Disabled`". If not explicitly configured, the default value is specified in the `Generic-Permanent-IDs` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.
Minimum-Length-IMSI and Maximum-Length-IMSI	These parameters specify the minimum and maximum length of IMSIs that the server will accept. The server performs sanity checks on a permanent identity that is offered as an IMSI to ensure that the identity is neither too short nor too long to be an IMSI. The EAP-AKA RFC 4187 explicitly states that 15 is the maximum. The minimum length is 6 based on a 3 digit MCC plus a 2 digit MNC plus a 1 digit MSIN. This is a theoretical absolute minimum length for an IMSI. Therefore the check made is: `6 <= Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15` If not explicitly configured, the default values are specified in the `Minimum-Length-IMSI` and `Maximum-Length-IMSI` parameters in the `aatv.EAP-AKA{}` section of the `aaa.config` file.

Parameter	Description
Protected-Success-Indications	Protected success indications are an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter indicates whether the server will offer protected success indications to the peer. The valid values are "Enabled" and "Disabled". If not explicitly configured, the default value is specified in the Protected-Success-Indications parameter in the aatv.EAP-AKA{} section of the aaa.config file.
Protected-Identity-Exchanges	The use of the AT_CHECKCODE attribute is an optional feature in EAP-AKA. This parameter determines if the server should use the AT_CHECKCODE attribute. The attribute is used in order to allow protection of the EAP/AKA-Identity messages and any future extensions to them. The implementation of AT_CHECKCODE is RECOMMENDED. The valid values are "Yes" and "No". If not explicitly configured, the default value is specified in the Protected-Identity-Exchanges parameter in the aatv.EAP-AKA{} section of the aaa.config file.
Resync-Update	The EAP-AKA protocol requires support for two features related to the management of sequence numbers (SQN). This parameter specifies an AATV which provides one of the features and an Xstring parameter for this AATV. This AATV is invoked to inform the authentication center (AuC) about synchronization failures. The reception of an EAP-Response/AKA/Synchronization-Failure message from the client will trigger the call to this AATV. This parameter does not need to be configured if your implementation does not require this feature. There is no default.
Auth-Result-Update	The EAP-AKA protocol requires support for two features related to the management of sequence numbers (SQN). This parameter specifies an AATV which provides one of the features and an Xstring parameter for this AATV. This AATV is invoked to inform the authentication center (AuC) about the results of an authentication attempt. The completion of an EAP-AKA authentication sequence (successful or not) will trigger the call to this AATV. This parameter does not need to be configured if your implementation does not require this feature. There is no default.

Parameter	Description
Fast-Reauth-Lookup	Fast re-authentication is an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to map a fast reauthentication identity to the user's real identity and full authentication context. If this parameter is not configured, then fast re-authentication support is disabled for the realm. The Interlink server provides an AATV, `SIMAKA-ReauthCacheLookup`, for this function. See "Fast Re-Authentication" on page 258 for details. There is no default.
Fast-Reauth-Update	Fast re-authentication is an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to update the mapping of a fast reauthentication identity to a user's real identity. If this parameter is not configured, then fast re-authentication support is disabled for the realm. The Interlink server provides an AATV, `SIMAKA-ReauthCacheUpdate`, for this function. See "Fast Re-Authentication" on page 258 for details. There is no default.
Pseudonym-Lookup	Pseudonyms are an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to map a pseudonym to the user's real identity. If this parameter is not configured, then pseudonym support is disabled for the realm. If this parameter specifies the Interlink-provided AATV `SIMAKA-PseudonymDecrypt`, see "Pseudonym" on page 256, then: • The server forces non-random pseudonym generation for this realm. • If no `Pseudonym-Algorithm-Key-*` parameters are defined in the `aatv.SIMAKA{}` section of the `aaa.config` file, then pseudonym support is disabled. • If at least one of the above mentioned keys is defined and the `Pseudonym-Algorithm-Current-Key` is not defined in the `aatv.SIMAKA{}` section of the `aaa.config` file or does not refer to a defined key, then generation of new pseudonyms is disabled but existing pseudonyms can be looked up. There is no default.

Parameter	Description
Pseudonym-Update	Pseudonyms are an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to update the mapping of a pseudonym to a user's real identity. The Interlink provided pseudonym support using an algorithm, does not require an `Pseudonym-Update` AATV. See "Pseudonym" on page 256. There is no default.
Max-Number-Of-Reauths-Before-Full-Auth-Is-Required	Fast re-authentication is an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter specifies an upper limit for the number of subsequent fast re-authentications allowed before a full authentication needs to be performed. The valid range is 1 to 65,535. If not explicitly configured, the default value is specified in the `Max-Number-Of-Reauths-Before-Full-Auth-Is-Required` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.
Fast-Reauth-Realm	When providing a fast reauthentication identity, the server also includes a realm to help ensure that the subsequent fast re-authentication be targeted to this server, the only server which holds the full authentication context if internal caching, rather than an external database, is used to save the fast re-authentication context. This parameter specifies such a realm. Since the maximum length of a fast reauth NAI cannot exceed 253 characters and since the length of the fast reauth user name is 10 characters, the Fast Reauth Realm value must not exceed 242 characters. If the fast reauthentication identity should be generated with NO realm name then this would be configured as "`NULL`". The empty string entry, using just two quotes, indicates that the server should generate a fast reauthentication identity with the same realm name as the permanent identity. If not explicitly configured, the default value is specified in the `Fast-Reauth-Realm` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.

Parameter	Description
Fast-Reauth-Id-Lifetime	Fast re-authentication is a mechanism for a AKA user to freshen his keys periodically. A fast re-authentication, if it is going to take place, will happen in a "short" time after a full authentication or a previous fast re-authentication. This parameter specifies a lifetime for a fast reauthentication identity, in seconds. If the fast reauthentication identity is assigned and isn't used within this period of time, the fast reauthentication identity and the associated full authentication context is purged. The valid range is 1 to 14400 (1 second to 4 hours). If not explicitly configured, the default value is specified in the `Fast-Reauth-Id-Lifetime` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.
Pseudonym-Lifetime	A random character pseudonym, when generated for a user, is placed in an external database. This parameter specifies the lifetime of such a generated random character pseudonym. After the specified length of time has elapsed since the pseudonym was first assigned, the pseudonym is invalidated, independent of how many times the pseudonym was used, if ever. The valid range is 1 to 31,622,400 (1 second to 366 days). If not explicitly configured, the default value is specified in the `Pseudonym-Lifetime` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.
Generate-Random-Character-Pseudonyms	The Interlink server provides a mechanism, using configured encryption keys, by which pseudonyms can be generated as an encrypted form of the permanent identity, which can be subsequently decrypted to reproduce the permanent identity. Alternatively, the server can generate pseudonyms as a string of random characters, similar to the fast reauthentication identity. In this latter case, an external database is required to store the pseudonym to permanent identity mappings. This parameter indicates whether the server generates pseudonyms by algorithm (value=no) or if the server generates random character pseudonyms (value=yes). The valid values are "`Yes`" and "`No`". If not explicitly configured, the default value is specified in the `Generate-Random-Character-Pseudonyms` parameter in the `aatv.EAP-AKA{}` section of the `aaa.config` file.

Example EAP.authfile configuration file

The following `EAP.authfile` configures the EAP-AKA protocol for an AKA realm:

```
eapaka.com    -EAP   EAP     "comment"
```

```
{
  EAP-Type AKA
  {
    AKA-Algorithm                          "3GPP-Milenage"
    Prefixed-IMSI-Permanent-IDs            "Enabled"
    Generic-Permanent-IDs                  "Enabled"
    Minimum-Length-IMSI                    6
    Maximum-Length-IMSI                    15
    Protected-Success-Indications          "Disabled"
    Protected-Identity-Exchanges           No
    AKA-Mode                               0x12ab
    Resync-Update           null           "null"
    Auth-Result-Update      NULL           "none"

    #           Temporary identity datastores
    Fast-Reauth-Lookup   SIMAKA-ReauthCacheLookup   ""
    Fast-Reauth-Update   SIMAKA-ReauthCacheUpdate   ""
    Pseudonym-Lookup     SIMAKA-PseudonymDecrypt    ""
    Pseudonym-Update     NULL                       ""

    #           Fast Reauth configuration:
    Max-Number-Of-Reauths-Before-Full-Auth-Is-Required  2
    Fast-Reauth-Realm                      "this.server.com"
    Fast-Reauth-Id-Lifetime                3600

    #           Pseudonym configuration:
    Pseudonym-Lifetime                     1209600
    Generate-Random-Character-Pseudonyms   "No"
  }
}
```

Global EAP-AKA Configuration in aaa.config

The `aatv.EAP-AKA{}` configuration block, located within the `aaa.config` file, contains global EAP-AKA configuration information. Some of the parameters represent realm default values for those not specified in the realm configuration. Other parameters represent global defaults which do not correspond to any realm based parameter. For the global parameters common to EAP-SIM and EAP-AKA, see "EAP-AKA and EAP-SIM Common Global Configurations" on page 231.

The following rules apply to the `aatv.EAP-AKA{}` configuration block parameters

- The parameter names are case insensitive.
- For parameters with on/off binary values, the values "`enabled`", "`yes`", "`on`", and "`true`" are synonyms and the values "`disabled`", "`no`", "`off`", and "`false`" are synonyms.
- String parameter values should be enclosed in single or double quotes.

The `aatv.EAP-AKA{}` configuration block, in `aaa.config` file, can contain any subset, including the empty subset, of the following named parameters:

The following parameters are global. No realm configuration overrides.

Parameter	Description
Statistics	This parameter enables/disables the output of EAP-AKA statistics to the logfile when the server shuts down. The valid values are "Enabled" and "Disabled". If not explicitly configured, the default value is "Enabled"

The following parameters specify server-wide realm defaults.
These are overridable by the realm configuration.

Parameter	Description
AKA-Algorithm	This parameter specifies the global default AKA Algorithm. If the profile for a user does not specify an AKA Algorithm and if the realm configuration does not specify an AKA Algorithm and if an AKA Algorithm is needed to produce the AKA Vector for this user's authentication, then the AKA Algorithm specified by this parameter is used. See "A3, A8 and AKA Algorithms" on page 251 for details on available algorithms. If not explicitly configured, there is NO default value.
AKA-Mode	AKA-Mode is the user authentication management field often referred to as **AMF**. It is an input to the functions f1 and f1*, See 3GPP documents for details. The value is a 16-bit binary string (2 bytes) entered as "0x" followed by 2 two digit hex values. "dots" are optional and are just for readability. The encoding should be in network byte order (big-endian). See examples below. If not explicitly configured, there is NO default value.
Prefixed-IMSI-Permanent-IDs	This parameter indicates whether or not the server should accept permanent identities of the form '0' + IMSI for a realm, if the realm configuration does not specify this parameter. The EAP-AKA RFC 4187 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The valid values are "Enabled" and "Disabled". If not explicitly configured, the default value is "Enabled".

Parameter	Description
Generic-Permanent-IDs	This parameter indicates whether or not the server should accept generic permanent identities not based on an IMSI, e.g. "fred", for a realm where the realm configuration does not specify this parameter. The EAP-AKA RFC 4187 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The valid values are `"Enabled"` and `"Disabled"`. If not explicitly configured, the default value is `"Disabled"`.
Minimum-Length-IMSI and Maximum-Length-IMSI	These parameters specify the minimum and maximum length of IMSIs that the server will accept. The server performs sanity checks on a permanent identity that is offered as an IMSI to ensure that the identity is neither too short nor too long to be an IMSI. The EAP-AKA RFC 4187 explicitly states that 15 is the maximum. The minimum length is 6, based on a 3 digit MCC plus a 2 digit MNC plus a 1 digit MSIN. This is a theoretical absolute minimum length for an IMSI. Therefore the check made is: `6 <= Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15` If not explicitly configured, the default values are 6 and 15.
Protected-Success-Indications	Protected success indications are an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter indicates whether the server will offer protected success indications to the peer. The valid values are `"Enabled"` and `"Disabled"`. If not explicitly configured, the default value is `"Enabled"`.
Protected-Identity-Exchanges	The use of the AT_CHECKCODE attribute is an optional feature in EAP-AKA. This parameter determines if the server should use the AT_CHECKCODE attribute. The attribute is used in order to allow protection of the EAP/AKA-Identity messages and any future extensions to them. The implementation of AT_CHECKCODE is RECOMMENDED. The valid values are "`Yes`" and "`No`". If not explicitly configured, the default value is Yes
Max-Number-Of-Reauths-Before-Full-Auth-Is-Required	Fast re-authentication is an optional EAP-AKA feature which the Interlink EAP-AKA server supports. This parameter specifies an upper limit for the number of subsequent fast re-authentications allowed before a full authentication needs to be performed. The valid range is 1 to 65,535. If not explicitly configured, the default value is 4.

Parameter	Description
Fast-Reauth-Realm	When providing a fast reauthentication identity, the server also includes a realm to ensure that the subsequent fast re-authentication be targeted to this server, the only server which holds the full authentication context if internal caching, rather than an external database, is used to save the fast re-authentication context. This parameter specifies such a realm. Since the maximum length of a fast reauth NAI cannot exceed 253 characters and since the length of the fast reauthentication identity is 10 characters, the Fast Reauth Realm value must not exceed 242 characters. If the fast reauthentication identity should be generated with NO realm name then this would be configured as "NULL". The empty string entry, using just two quotes, indicates that the server should generate a fast reauthentication identity with the same realm name as the permanent identity. If not explicitly configured, the default value is the empty string entry which indicates the server should generate a fast reauthentication identity with the same realm name as the permanent identity.
Fast-Reauth-Id-Lifetime	Fast re-authentication is a mechanism for an EAP-AKA user to freshen his keys periodically. A fast re-authentication, if it is going to take place, will happen in a "short" time after a full authentication or a previous fast re-authentication. This parameter specifies a lifetime for a fast reauthentication identity, in seconds. If the fast reauthentication identity is assigned and isn't used for this period of time, the fast reauthentication identity and the associated full auth context is purged. The valid range is 1 to 14400 (1 second to 4 hours). If not explicitly configured, the default value is 3600 (one hour),

Parameter	Description
Generate-Random-Character-Pseudonyms	Pseudonyms can be generated as an encrypted form of the permanent identity, which can be subsequently decrypted to reproduce the permanent identity. Alternatively, pseudonyms can be generated as a string of random characters, similar to the fast reauthentication identity. In this case, an external database is required to store the pseudonym to permanent identity mappings. This parameter indicates whether the server generates pseudonyms by algorithm (value="no") or if the server generates random character pseudonyms (value="yes"). The valid values are `"Yes"` and `"No"`. If not explicitly configured, the default value is `"No"`.
Pseudonym-Lifetime	A random character pseudonym, when generated for a user, is placed in an external database. This parameter specifies the lifetime of such a generated random character pseudonym. After the specified length of time has elapsed since the pseudonym was first assigned, the pseudonym is invalidated, independent of how may times the pseudonym was used, if ever used. The valid range is 1 to 31,622,400 (1 second to 366 days). If not explicitly configured, the default value is 1,209,600 (14 days).

Example aaa.config configuration file

```
aatv.EAP-AKA
{
  #   ====================================================================
  #   The following parameters are global. No realm configuration overrides.
  #   ====================================================================

  Statistics                              "Enabled"  # Enabled or Disabled

  #   ====================================================================
  #   All parameters that follow specify server-wide realm defaults.
  #   These are overridable by the realm configuration.
  #   ====================================================================

  Protected-Success-Indications           "Enabled"  # Enabled or Disabled

  Protected-Identity-Exchanges            "Yes"      # Yes or No

  Prefixed-IMSI-Permanent-IDs             "Enabled"  # Enabled or Disabled

  Generic-Permanent-IDs                   "Disabled" # Enabled or Disabled

  Minimum-Length-IMSI 6  # 6<=Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15
  Maximum-Length-IMSI 15 # 6<=Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15

  AKA-Algorithm                           "3GPP-Milenage"
```

```
  #   ========================================================================
  #   The following group of parameters configure the PSEUDONYM support
  #   ========================================================================

  Generate-Random-Character-Pseudonyms    "No"       # yes or no

  Pseudonym-Lifetime                      1209600    # 14 days, in seconds

  #   ========================================================================
  #   The following group of parameters configure FAST RE-AUTHENTICATION
  #   ========================================================================

  Max-Number-Of-Reauths-Before-Full-Auth-Is-Required  4  # range [1 to 65535]

  Fast-Reauth-Realm                       ""         # use perm ID's realm

  Fast-Reauth-Id-Lifetime                 3600       # range [1 to 14400]
}
```

EAP-AKA and EAP-SIM Common Global Configurations

Some parameters common to EAP-AKA and EAP-SIM can ONLY be configured on a global basis. These parameters are configured in the `aatv.SIMAKA{}` configuration block, located within the `aaa.config` file. These parameters represent global defaults which do not correspond to any realm based parameter.

The following rules apply to the `aatv.SIMAKA{}` configuration block parameters

- The parameter names are case insensitive.
- For parameters with on/off binary values, the values "`enabled`", "`yes`", "`on`", and "`true`" are synonyms and the values "`disabled`", "`no`", "`off`", and "`false`" are synonyms.
- String parameter values should be enclosed in single or double quotes.

The `aatv.SIMAKA{}` configuration block, in `aaa.config` file, can contain any subset, including the empty subset, of the following named parameters:

The following parameters are global. There are no realm based configuration overrides.

Parameter	Description
Maximum-Fast-Reauth-Cache-Size	This parameter specifies the maximum size of the in-memory Fast Re-authentication table, in terms of the number of entries. For a given user, the server needs to save the full authentication context for subsequent fast re-authentications. A bound must be placed on the number of entries in this table to protect the server's memory. The valid range is 0 to 1,000,000. A value of zero means that no new fast reauth identities should be added to the cache, but existing non-expired entries will be honored. This value is intended to phase out fast reauth support following a HUP. If not explicitly configured, the default value is the number of licensed users up to a maximum of 1,000,000.
Pseudonym-Algorithm-Key-*n*	Pseudonyms can be generated as an encrypted form of the permanent identity, which can be subsequently decrypted to reproduce the permanent identity. This set of parameters (n = 1 to 16) can used to specify up to 16 encryption keys that can be used for this encryption/decryption. The key value is a 128-bit binary string (16 bytes) entered as "`0x`" followed by 16 two digit hex values. "dots" are optional and are just for readability. See examples below. Pseudonym generation will be disabled for a realm if no keys have been defined and the generation of random character pseudonyms is disabled (`Generate-Random-Character-Pseudonyms "no"`). If not explicitly configured, there are NO default values.
Pseudonym-Algorithm-Current-Key	The key number specified by this parameter is used to select the `Pseudonym-Algorithm-Key` to use to encrypt the permanent identity when generating a new pseudonym. The other keys are used for decryption of pseudonyms previously generated with the other keys, but are not used for generation of new pseudonyms. The valid range is 1 to 16. If not explicitly configured, there is NO default value.
Statistics	This parameter enables/disables the output of common SIM and AKA statistics (`SIMAKA statistics:`) to the logfile when the server shuts down. The valid values are `"Enabled"` and `"Disabled"`. If not explicitly configured, the default value is `"Enabled"`

Example aaa.config configuration file

```
aatv.SIMAKA
{
  #   ====================================================================
  #   The following parameters are global.
  #   They apply to the shared features of EAP-SIM and EAP-AKA.
  #   There are no realm configuration overrides.
  #   ====================================================================

  Maximum-Fast-Reauth-Cache-Size   4096       # range [0 to 1,000,000]

  Pseudonym-Algorithm-Key-1    0x00010203.04050607.08090a0b.0c0d0e0f
  Pseudonym-Algorithm-Key-11   0xa0a1a2a3.a4a5a6a7.a8a9aaab.acadaeaf
  Pseudonym-Algorithm-Key-16   0xf0f1f2f3.f4f5f6f7.f8f9fafb.fcfdfeff

  Pseudonym-Algorithm-Current-Key  11

  Statistics                       "Enabled"  # Enabled or Disabled
}
```

Configuring EAP-SIM

The configuration files must be edited manually as EAP-SIM cannot currently be configured using the Server Manager.

Configuration information for EAP-SIM is placed in several files, with some default values built into the server. There is a precedence for the values that can be found in multiple places. The server starts with the built-in default values and overrides them with values in `aaa.config` (global values). The resulting values can be overridden by values in the `EAP.authfile` on a per realm basis. Finally the results of the user credential lookup may override some of these values.

Which file to configure a particular piece of information in is best made on the basis of where it will appear the least number of times. Based on this, the choice is first to use the `aaa.config` file, then `EAP.authfile,` and finally in the user credential datastore.

Some items would not be reasonable to configure on a global basis since they are user-specific, like the user password. These need to be unique, so the user credential datastore is the correct place for them. However some items, such as the `A8-Algorithm`, may be common to all the users in a given realm so they could be configured in the `EAP.authfile` in just one place instead of each user's entry in the datastore for that realm. If all the realms used the same `A8-Algorithm` then putting the `A8-Algorithm` in the `aaa.config` file would be the best option. These are just some basic guidelines for grouping the common values in the best place.

EAP-SIM Features

The Interlink EAP-SIM server is fully compliant with RFC4186, 2006. The RFC's "MUSTs" "SHOULDs", and "RECOMMENDEDs" are implemented. It supports the following features:

- IMSI permanent identities, supportable on a per realm basis
- Non-IMSI permanent identities, supportable on a per realm basis
- Protected success indications, supportable on a per realm basis
- Fast re-authentication, supportable on a per realm basis
- Pseudonym support via algorithmically generated or random pseudonyms, supportable on a per realm basis
- To ensure that permanent usernames, pseudonym usernames, and fast re-authentication usernames are separate and recognizable from each other, the server generates pseudonyms with a leading "2" character and fast re-authentication usernames with a leading "3" character. Per the RFC, permanent usernames derived from the IMSI are prefixed with a leading "1" character.
- Many EAP-SIM parameters are configurable on a per realm basis
- A user's subscriber key (Ki), along with the names of the appropriate A3 and A8 algorithms, may be stored in an external database or local file. If so, the server will automatically generate GSM authentication triplets from this information.
- A set of GSM authentication triplets may be stored in a local file. This is intended for use in a lab environment, and requires no additional user-written plug-ins.

- The user credentials may be retrieved from an AuC if the customer implements an AATV which communicates with the AuC.
- A3/A8 3GPP Milenage algorithms are provided with configurable parameters.
- The Milenage A3/A8 algorithm can be customized with a simple plug-in.
- Additional customer supplied A3/A8 algorithms may be plugged into the server.
- Occurrences and values of received SIM attributes are validated.
- Support for pseudonym and fast reauthentication identity mapping is built-in, without the need of an external database.

EAP-SIM User Credential Lookup Configuration

The server inherently supports configuration of EAP-SIM user credentials as Reply Items in two forms:

One form is the configuration of the user's `Subscriber-Key` (**`Ki`**), `A3-Algorithm` and `A8-Algorithm`. See "A3, A8 and AKA Algorithms" on page 251 for a description. The server uses these AVPs as input to generate authentication vectors.

- `Subscriber-Key` is a string attribute containing the binary encoded 128-bit user secret key often referred to as **`Ki`**. The encoding should be in network byte order (big-endian).
- `A3-Algorithm` is a string attribute indicating the name of the A3 algorithm to be applied in GSM triplet generation. Most lines in the configuration files are limited to 1023 characters which places a limit on the length of this string. The value is case-sensitive.
- `A8-Algorithm` is a string attribute indicating the name of the A8 algorithm to be applied in GSM triplet generation. Most lines in the configuration files are limited to 1023 characters which places a limit on the length of this string. The value is case-sensitive.

The second form is the configuration of a collection of GSM triplets. A `GSM-Triplet` is a fixed length binary string (octets) attribute which holds an EAP-SIM authentication vector. The attribute value is a 224-bit binary string (28 bytes) partitioned as follows:

- `RAND` = The first 128 bits (16 bytes) of value
- `Kc` = The next 64 bits (8 bytes) of value
- `SRES` = The last 32 bits (4 bytes) of value

Configuration of GSM triplets is intended for a test lab environment, when the user's `Subscriber-Key`, `A3-Algorithm`, and `A8-Algorithm` are not known but GSM triplets have been retrieved from the device to be used in the testing.

The user credentials can be stored in any supported data repository: a local realm users file, an LDAP database, or a customer supplied database.

Additionally, a customer-specific plug-in may provide EAP-SIM user credentials. This plug-in may access a customer supplied database or may contact an authentication center. The plug-in's `Authentication-Type` needs to be defined in the `dictionary` and may be configured with an `Xstring` parameter in the `authfile`.

Example realm file content

The following is an example of a local realm users file. See "User Entry Syntax" on page 191 for the a description of the format allowable content. What follows are two EAP-SIM users with reply items used to authenticate the user:

```
# IMSI configured with 128 bit Subscriber-Key, A3-Algorithm, and A8-Algorithm
801448005551000
  Subscriber-Key ="\x6d\x37\x71\x8a\xcc\xec\x37\x01\x4e\xdb\xf0\xf0\x3b\xe5\x77\xda",
  A3-Algorithm = "3GPP-Milenage",
  A8-Algorithm = "3GPP-Milenage"

# Generic (i.e. non-IMSI permanent identity) user
# configured with a collection of 224 bit triplets
fred
  GSM-Triplet="\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1
a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a\x1a",
  GSM-Triplet="\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2
b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b\x2b",
  GSM-Triplet="\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3
c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c\x3c",
  GSM-Triplet="\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4
c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c\x4c",
  GSM-Triplet="\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5
c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c\x5c",
  GSM-Triplet="\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6
c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c\x6c",
  GSM-Triplet="\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7
c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c\x7c",
  GSM-Triplet="\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8
c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c\x8c",
  GSM-Triplet="\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9
c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c\x9c"
```

Note - `Subscriber-Key` and `GSM-Triplet` values are binary strings and are configured as quoted strings of hex escaped octets.

Note - If a user's `Subscriber-Key` is configured, but the `A3-Algorithm` and/or `A8-Algorithm` is not configured, the default `A3-Algorithm` and/or `A8-Algorithm` specified in the realm's configuration or the globally configured value will be used.

Note - Under some conditions more GSM triplets may be configured than are necessary for a user's authentication and the server will select the necessary number of GSM triplets from the collection in a manner described in "Realm-Based EAP-SIM Configuration Information in authfile" on page 237.

EAP-SIM Realm-Based Configurations

Many EAP-SIM parameters can be configured on a per realm basis. These parameters are configured in realm entries stored in the `authfile` and `EAP.authfile` (these files are possibly prefixed). The realm names may be wild carded.

Realm-Based EAP-SIM Configuration Information in authfile

The user's SIM credentials lookup information is configured in the `authfile` on a realm by realm basis

The EAP-SIM realm must be configured with the `-SIM` switch (the `-SIM` switch is new as of version 7.3), which shields the realm from undesired `iaaaRealm` actions.

If the realm utilizes a local users file, then one of the two new (as of version 7.3) AATVs should be used: `localFile` or `SIM-TripletFile`.

localFile Authentication Type

The `localFile` AATV is an enhanced version of `iaaaFile`. Whereas `iaaaFile` always looks up the user record specified by the `User-Id` attribute value, `localFile` can search based on a specified attribute value. The configuration of a realm which employs `localFile` is followed by a required `{}` block. The `{}` block allows any or all of these three parameters: `Request-Attribute-For-Search, Filter-Type`, and `Policy-Pointer`.

Parameter	Description
Request-Attribute-For-Search	This indicates the search attribute to use for a user lookup. The attribute must be a string-type (string, tag-str, octets). The `localFile` AATV is not restricted to use by EAP-SIM, it may be used generically. When `localFile` is used for EAP-SIM, the `Request-Attribute-For-Search` attribute must be configured with a value of `Real-Username`. The default value, if not present, is `User-Id`.
Filter-Type	This is used to specify case-sensitive or case-insensitive treatment of the value of the `Request-Attribute-For-Search` attribute. A value of "`BIN`" causes a case-sensitive lookup. A value of "`CIS`" causes a case-insensitive lookup performed by taking the contents of the attribute specified for searching and converting it to uppercase before the datastore lookup. Therefore the local realm file needs to store the identity in uppercase. The default value, if `Filter-Type` is not present, is `BIN`.
Policy-Pointer	For information on `Policy-Pointer`, see "Authorization" on page 8.

When `localFile` retrieves GSM triplets, there may be more configured triplets than are necessary for the user authentication. The EAP-SIM AATV will use the first *N* retrieved triplets, where *N* is the number of triplets this realm requires for a EAP-SIM authentication (i.e. either 2 or 3).

Example localFile authfile configuration for credentials lookup

```
# This realm uses a local realm users file "realm1.users"
eapsimrealm1.com     -SIM     localFile     realm1
{
    Request-Attribute-For-Search    Real-Username
}

# This set of wild carded realms use realm users file "ispx.users"
*.ispx.com           -SIM     localFile                ispx
{
    Request-Attribute-For-Search    Real-Username
}
```

SIM-TripletFile Authentication Type

The `SIM-TripletFile` AATV is very similar to `localFile` with an identical {} block, but is specialized for the retrieval of `GSM-Triplet` credentials.

Parameter	Description
Request-Attribute-For-Search	This indicates the search attribute to use for a user lookup. The attribute must be a string-type (string, tag-str, octets). The default value, if not present, is `Real-Username`.
Filter-Type	This is used to specify case-sensitive or case-insensitive treatment of the value of the `Request-Attribute-For-Search` attribute. A value of "`BIN`" causes a case-sensitive lookup. A value of "`CIS`" causes a case-insensitive lookup performed by taking the contents of the attribute specified for searching and converting it to uppercase before the datastore lookup. Therefore the local realm file needs to store the identity in uppercase. The default value, if `Filter-Type` is not present, is `BIN`.
Policy-Pointer	For information on `Policy-Pointer`, see "Authorization" on page 8.

If `SIM-TripletFile` retrieves `GSM-Triplets` and if there are more configured triplets than are necessary for the user authentication, then `SIM-TripletFile` will return ***N*** configured triplets, where ***N*** is the number of triplets this realm requires for a SIM authentication. Rather than returning the first ***N*** triplets, `SIM-TripletFile` will pick a random starting point in the list of configured triplets and return the next ***N*** triplets, starting at the random starting point and wrapping to the beginning of the list if necessary.

If the datastore will be returning `GSM-Triplets`, then the use `SIM-TripletFile` would be the first choice. If you need a predicable set of `GSM-Triplets`, then use `localFile`.

Example SIM-TripletFile authfile configuration for credentials lookup

```
# This realm uses a local realm users file "realm2.users"
eapsimrealm2.com   -SIM   SIM-TripletFile   realm2
{
    Filter-Type                     CIS
    Request-Attribute-For-Search    Real-Username
    Policy-Pointer                  "decisionfile://policy-1.policy"
}
```

PROLDAP Authentication Type

The `PROLDAP` AATV has, as of version 7.3, been enhanced to support the `Request-Attribute-For-Search` configuration parameter.

Parameter	Description
Request-Attribute-For-Search	This indicates the search attribute to use for a user lookup. The attribute must be a string-type (string, tag-str, octets). The default value, if not present, is `User-Id`. When PROLDAP is used for EAP-SIM, the `Request-Attribute-For-Search` attribute must be configured with a value of `Real-Username`.

Example PROLDAP authfile configuration for credentials lookup

```
# This realm uses an LDAP database
eapsimrealm3.com            -SIM    PROLDAP    "LDAP lookup"
{
    Request-Attribute-For-Search    Real-Username
    Filter-Type                     CIS
    Directory   "Directory 1"
    {
        Host            ldap1.ispx.com
        Port            389
        Administrator   "cn=...,ou=...,ou=...,o=radius"
        Password        password
        SearchBase      "...,ou=...,o=radius"
        Authenticate    Search
    }
}
```

Realm-Based EAP-SIM Configuration Information in EAP.authfile

The `EAP.authfile` entry for a realm which supports EAP-SIM can contain an optional {} configuration block following the "`EAP-Type SIM`" specification. This block contains realm specific EAP-SIM configuration information: EAP-SIM parameters and the AATVs for lookup and update of pseudonym and fast reauthentication identity mappings. See "Pseudonym and Fast Re-Authentication Data Base AATVs" on page 256 for a description of the provided implementation.

Some of the parameters, if not specified in the `EAP-Type SIM{}` configuration block, will be

assigned default values from the `aatv.EAP-SIM{}` configuration block in `aaa.config`. Other parameters do not have a default and must be specified if the capability is to be supported.

The following rules apply to the `EAP-Type SIM{}` configuration block parameters

- The parameter names are case insensitive.
- For parameters with on/off binary values, the values "`enabled`", "`yes`", "`on`", and "`true`" are synonyms and the values "`disabled`", "`no`", "`off`", and "`false`" are synonyms.
- String parameter values should be enclosed in single or double quotes.
- When configuring a lookup or update for a fast reauthentication identity or pseudonym, the configuration parsing requires that a string parameter must be specified. It may be an empty string, i.e. "". This string is used as the `Xstring` value for the lookup and update AATV calls. The Interlink provided AATVs do not require an `Xstring` and so the "" should be used. If a custom AATV is written for lookup or update then that AATV may require a string parameter. See the Software Developers Kit for more details on AATVs and `Xstring`.
- If there is no AATV for the lookup or update for a fast reauthentication identity or pseudonym, then the parameter (e.g. `Fast-Reauth-Lookup`) may be simply not configured at all. Alternatively, the configuration may be explicitly configured with an AATV value of "`NULL`" or "`NONE`".
- Pseudonym lookup is disabled if the realm's configuration specifies that pseudonyms should be algorithmically generated (i.e. "Generate-Random-Character-Pseudonyms No"), but NO pseudonym encryption keys are configured in the `aatv.SIMAKA{}` section of the `aaa.config` file.
- Generation of new pseudonyms is disabled if the realm's configuration specifies that pseudonyms should be generated but no `Pseudonym-Algorithm-Current-Key` is configured in the `aatv.SIMAKA{}` section of the `aaa.config` file.

The `EAP-Type SIM{}` configuration block can contain any subset, including the empty subset, of

the following named parameters:

Parameter	Description
A3-Algorithm	This parameter specifies the default A3 Algorithm for the realm. If the profile for a user in this realm does not specify an A3 Algorithm and if an A3 Algorithm is needed to produce the GSM triplets for this user's authentication, then the A3 Algorithm specified by this parameter is used. See "A3, A8 and AKA Algorithms" on page 251 for details on available algorithms. If not explicitly configured, the default value is specified in the `A3-Algorithm` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
A8-Algorithm	This parameter specifies the default A8 Algorithm for the realm. If the profile for a user in this realm does not specify an A8 Algorithm and if an A8 Algorithm is needed to produce the GSM triplets for this user's authentication, then the A8 Algorithm specified by this parameter is used. See "A3, A8 and AKA Algorithms" on page 251 for details on available algorithms. If not explicitly configured, the default value is specified in the `A8-Algorithm` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Prefixed-IMSI-Permanent-IDs	This parameter indicates whether or not the server should, for this realm, accept permanent identities of the form '1' + IMSI. The EAP-SIM RFC 4186 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The server supports both options. The valid values are "`Enabled`" and "`Disabled`". If not explicitly configured, the default value is specified in the `Prefixed-IMSI-Permanent-IDs` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Generic-Permanent-IDs	This parameter indicates whether or not the server should, for this realm, accept generic permanent identities not based on an IMSI, e.g. "fred". The EAP-SIM RFC 4186 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The server supports both options. The valid values are "`Enabled`" and "`Disabled`". If not explicitly configured, the default value is specified in the `Generic-Permanent-IDs` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.

Parameter	Description
Minimum-Length-IMSI and Maximum-Length-IMSI	These parameters specify the minimum and maximum length of IMSIs that the server will accept. The server performs sanity checks on a permanent identity that is offered as an IMSI to ensure that the identity is neither too short nor too long to be an IMSI. The EAP-SIM RFC 4186 explicitly states that 15 is the maximum. The minimum length is 6 based on a 3 digit MCC plus a 2 digit MNC plus a 1 digit MSIN. This is a theoretical absolute minimum length for an IMSI. Therefore the check made is: `6 <= Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15` If not explicitly configured, the default values are specified in the `Minimum-Length-IMSI` and `Maximum-Length-IMSI` parameters in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Number-Of-Triplets-For-Authentication	This parameter indicates how many GSM triplets are needed for authentication. The EAP-SIM RFC 4186 indicates this value MUST be 2 or 3. If not explicitly configured, the default value is specified in the `Number-Of-Triplets-For-Authentication` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Protected-Success-Indications	Protected success indications are an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter indicates whether the server will offer protected success indications to the peer. The valid values are `"Enabled"` and `"Disabled"`. If not explicitly configured, the default value is specified in the `Protected-Success-Indications` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Fast-Reauth-Lookup	Fast re-authentication is an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to map a fast reauthentication identity to the user's real identity and full authentication context. If this parameter is not configured, then fast re-authentication support is disabled for the realm. The Interlink server provides an AATV, `SIMAKA-ReauthCacheLookup`, for this function. See "Fast Re-Authentication" on page 258 for details. There is no default.

Parameter	Description
Fast-Reauth-Update	Fast re-authentication is an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to update the mapping of a fast reauthentication identity to a user's real identity. If this parameter is not configured, then fast re-authentication support is disabled for the realm. The Interlink server provides an AATV, `SIMAKA-ReauthCacheUpdate`, for this function. See "Fast Re-Authentication" on page 258 for details. There is no default.
Pseudonym-Lookup	Pseudonyms are an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to map a pseudonym to the user's real identity. If this parameter is not configured, then pseudonym support is disabled for the realm. If this parameter specifies the Interlink-provided AATV `SIMAKA-PseudonymDecrypt`, see "Pseudonym" on page 256, then: • The server forces non-random pseudonym generation for this realm. • If no `Pseudonym-Algorithm-Key-*` parameters are defined in the `aatv.SIMAKA{}` section of the `aaa.config` file, then pseudonym support is disabled. • If at least one of the above mentioned keys is defined and the `Pseudonym-Algorithm-Current-Key` is not defined in the `aatv.SIMAKA{}` section of the `aaa.config` file or does not refer to a defined key, then generation of new pseudonyms is disabled but existing pseudonyms can be looked up. There is no default.
Pseudonym-Update	Pseudonyms are an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter specifies an AATV and an Xstring parameter for this AATV. This AATV is invoked to update the mapping of a pseudonym to a user's real identity. The Interlink provided pseudonym support using an algorithm, does not require an `Pseudonym-Update` AATV. See "Pseudonym" on page 256. There is no default.

Parameter	Description
Max-Number-Of-Reauths-Before-Full-Auth-Is-Required	Fast re-authentication is an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter specifies an upper limit for the number of subsequent fast re-authentications allowed before a full authentication needs to be performed. The valid range is 1 to 65,535. If not explicitly configured, the default value is specified in the `Max-Number-Of-Reauths-Before-Full-Auth-Is-Required` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Fast-Reauth-Realm	When providing a fast reauthentication identity, the server also includes a realm to help ensure that the subsequent fast re-authentication be targeted to this server, the only server which holds the full authentication context if internal caching, rather than an external database, is used to save the fast re-authentication context. This parameter specifies such a realm. Since the maximum length of a fast reauth NAI cannot exceed 253 characters and since the length of the fast reauth user name is 10 characters, the Fast Reauth Realm value must not exceed 242 characters. If the fast reauthentication identity should be generated with NO realm name then this would be configured as "`NULL`". The empty string entry, using just two quotes, indicates that the server should generate a fast reauthentication identity with the same realm name as the permanent identity. If not explicitly configured, the default value is specified in the `Fast-Reauth-Realm` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Fast-Reauth-Id-Lifetime	Fast re-authentication is a mechanism for an EAP-SIM user to freshen his keys periodically. A fast re-authentication, if it is going to take place, will happen in a "short" time after a full authentication or a previous fast re-authentication. This parameter specifies a lifetime for a fast reauthentication identity, in seconds. If the fast reauthentication identity is assigned and isn't used within this period of time, the fast reauthentication identity and the associated full authentication context is purged. The valid range is 1 to 14400 (1 second to 4 hours). If not explicitly configured, the default value is specified in the `Fast-Reauth-Id-Lifetime` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.

Parameter	Description
Generate-Random-Character-Pseudonyms	The Interlink server provides a mechanism, using configured encryption keys, by which pseudonyms can be generated as an encrypted form of the permanent identity, which can be subsequently decrypted to reproduce the permanent identity. Alternatively, the server can generate pseudonyms as a string of random characters, similar to the fast reauthentication identity. In this latter case, an external database is required to store the pseudonym to permanent identity mappings. This parameter indicates whether the server generates pseudonyms by algorithm (value=no) or if the server generates random character pseudonyms (value=yes). The valid values are "`Yes`" and "`No`". If not explicitly configured, the default value is specified in the `Generate-Random-Character-Pseudonyms` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.
Pseudonym-Lifetime	A random character pseudonym, when generated for a user, is placed in an external database. This parameter specifies the lifetime of such a generated random character pseudonym. After the specified length of time has elapsed since the pseudonym was first assigned, the pseudonym is invalidated, independent of how many times the pseudonym was used, if ever. The valid range is 1 to 31,622,400 (1 second to 366 days). If not explicitly configured, the default value is specified in the `Pseudonym-Lifetime` parameter in the `aatv.EAP-SIM{}` section of the `aaa.config` file.

Example EAP.authfile configuration file

The following `EAP.authfile` configures the EAP-SIM protocol for a SIM realm:

```
eapsim.com    -EAP   EAP     "comment"
{
  EAP-Type SIM
  {
    A3-Algorithm                            "3GPP-Milenage"
    A8-Algorithm                            "3GPP-Milenage"
    Prefixed-IMSI-Permanent-IDs             "Enabled"
    Generic-Permanent-IDs                   "Enabled"
    Minimum-Length-IMSI                     6
    Maximum-Length-IMSI                     15
    Number-Of-Triplets-For-Authentication  2
    Protected-Success-Indications           "Disabled"

    #           Temporary identity datastores
    Fast-Reauth-Lookup   SIMAKA-ReauthCacheLookup   ""
    Fast-Reauth-Update   SIMAKA-ReauthCacheUpdate   ""
    Pseudonym-Lookup     SIMAKA-PseudonymDecrypt    ""
    Pseudonym-Update     NULL                       ""

    #           Fast Reauth configuration:
    Max-Number-Of-Reauths-Before-Full-Auth-Is-Required  2
    Fast-Reauth-Realm                       "this.server.com"
    Fast-Reauth-Id-Lifetime                 3600

    #           Pseudonym configuration:
    Pseudonym-Lifetime                      1209600
    Generate-Random-Character-Pseudonyms   "No"
  }
}
```

Global EAP-SIM Configuration in aaa.config

The `aatv.EAP-SIM{}` configuration block, located within the `aaa.config` file, contains global EAP-SIM configuration information. Some of the parameters represent realm default values for those not specified in the realm configuration. Other parameters represent global defaults which do not correspond to any realm based parameter. For the global parameters common to EAP-SIM and EAP-AKA, see "EAP-AKA and EAP-SIM Common Global Configurations" on page 231.

The following rules apply to the `aatv.EAP-SIM{}` configuration block parameters

- The parameter names are case insensitive.
- For parameters with on/off binary values, the values "`enabled`", "`yes`", "`on`", and "`true`" are synonyms and the values "`disabled`", "`no`", "`off`", and "`false`" are synonyms.
- String parameter values should be enclosed in single or double quotes.

The `aatv.EAP-SIM{}` configuration block, in `aaa.config` file, can contain any subset, including the empty subset, of the following named parameters:

The following parameters are global. No realm configuration overrides.

Parameter	Description
Statistics	This parameter enables/disables the output of EAP-SIM statistics to the logfile when the server shuts down. The valid values are "Enabled" and "Disabled". If not explicitly configured, the default value is "Enabled"

The following parameters specify server-wide realm defaults.
These are overridable by the realm configuration.

Parameter	Description
A3-Algorithm	This parameter specifies the global default A3 Algorithm. If the profile for a user does not specify an A3 Algorithm and if the realm configuration does not specify an A3 Algorithm and if an A3 Algorithm is needed to produce the GSM triplets for this user's authentication, then the A3 Algorithm specified by this parameter is used. See "A3, A8 and AKA Algorithms" on page 251 for details on available algorithms. If not explicitly configured, there is NO default value.
A8-Algorithm	This parameter specifies the global default A8 Algorithm. If the profile for a user does not specify an A8 Algorithm and if the realm configuration does not specify an A8 Algorithm and if an A8 Algorithm is needed to produce the GSM triplets for this user's authentication, then the A8 Algorithm specified by this parameter is used. See "A3, A8 and AKA Algorithms" on page 251 for details on available algorithms. If not explicitly configured, there is NO default value.
Prefixed-IMSI-Permanent-IDs	This parameter indicates whether or not the server should accept permanent identities of the form '1' + IMSI for a realm, if the realm configuration does not specify this parameter. The EAP-SIM RFC 4186 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The valid values are "Enabled" and "Disabled". If not explicitly configured, the default value is "Enabled".

Parameter	Description
Generic-Permanent-IDs	This parameter indicates whether or not the server should accept generic permanent identities not based on an IMSI, e.g. "fred", for a realm where the realm configuration does not specify this parameter. The EAP-SIM RFC 4186 indicates that the permanent identity SHOULD be derived from the IMSI, but alternatively, an implementation MAY choose a permanent identity that is not based on the IMSI. The valid values are `"Enabled"` and `"Disabled"`. If not explicitly configured, the default value is `"Disabled"`.
Minimum-Length-IMSI and Maximum-Length-IMSI	These parameters specify the minimum and maximum length of IMSIs that the server will accept. The server performs sanity checks on a permanent identity that is offered as an IMSI to ensure that the identity is neither too short nor too long to be an IMSI. The EAP-SIM RFC 4186 explicitly states that 15 is the maximum. The minimum length is 6, based on a 3 digit MCC plus a 2 digit MNC plus a 1 digit MSIN. This is a theoretical absolute minimum length for an IMSI. Therefore the check made is: `6 <= Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15` If not explicitly configured, the default values are 6 and 15.
Number-Of-Triplets-For-Authentication	This parameter indicates how many GSM triplets are needed for authentication. The EAP-SIM RFC 4186 indicates this value MUST be 2 or 3. If not explicitly configured, the default value is 2.
Protected-Success-Indications	Protected success indications are an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter indicates whether the server will offer protected success indications to the peer. The valid values are `"Enabled"` and `"Disabled"`. If not explicitly configured, the default value is `"Enabled"`.
Max-Number-Of-Reauths-Before-Full-Auth-Is-Required	Fast re-authentication is an optional EAP-SIM feature which the Interlink EAP-SIM server supports. This parameter specifies an upper limit for the number of subsequent fast re-authentications allowed before a full authentication needs to be performed. The valid range is 1 to 65,535. If not explicitly configured, the default value is 4.

Parameter	Description
Fast-Reauth-Realm	When providing a fast reauthentication identity, the server also includes a realm to ensure that the subsequent fast re-authentication be targeted to this server, the only server which holds the full authentication context if internal caching, rather than an external database, is used to save the fast re-authentication context. This parameter specifies such a realm. Since the maximum length of a fast reauth NAI cannot exceed 253 characters and since the length of the fast reauthentication identity is 10 characters, the Fast Reauth Realm value must not exceed 242 characters. If the fast reauthentication identity should be generated with NO realm name then this would be configured as "NULL". The empty string entry, using just two quotes, indicates that the server should generate a fast reauthentication identity with the same realm name as the permanent identity. If not explicitly configured, the default value is the empty string entry which indicates the server should generate a fast reauthentication identity with the same realm name as the permanent identity.
Fast-Reauth-Id-Lifetime	Fast re-authentication is a mechanism for a SIM user to freshen his keys periodically. A fast re-authentication, if it is going to take place, will happen in a "short" time after a full authentication or a previous fast re-authentication. This parameter specifies a lifetime for a fast reauthentication identity, in seconds. If the fast reauthentication identity is assigned and isn't used for this period of time, the fast reauthentication identity and the associated full auth context is purged. The valid range is 1 to 14400 (1 second to 4 hours). If not explicitly configured, the default value is 3600 (one hour),

Parameter	Description
Generate-Random-Character-Pseudonyms	Pseudonyms can be generated as an encrypted form of the permanent identity, which can be subsequently decrypted to reproduce the permanent identity. Alternatively, pseudonyms can be generated as a string of random characters, similar to the fast reauthentication identity. In this case, an external database is required to store the pseudonym to permanent identity mappings. This parameter indicates whether the server generates pseudonyms by algorithm (value="no") or if the server generates random character pseudonyms (value="yes"). The valid values are "Yes" and "No". If not explicitly configured, the default value is "No".
Pseudonym-Lifetime	A random character pseudonym, when generated for a user, is placed in an external database. This parameter specifies the lifetime of such a generated random character pseudonym. After the specified length of time has elapsed since the pseudonym was first assigned, the pseudonym is invalidated, independent of how may times the pseudonym was used, if ever used. The valid range is 1 to 31,622,400 (1 second to 366 days). If not explicitly configured, the default value is 1,209,600 (14 days).

Example aaa.config configuration file

```
aatv.EAP-SIM
{
  #   ========================================================================
  #   The following parameters are global. No realm configuration overrides.
  #   ========================================================================

  Statistics                                "Enabled"  # Enabled or Disabled

  #   ========================================================================
  #   All parameters that follow specify server-wide realm defaults.
  #   These are overridable by the realm configuration.
  #   ========================================================================

  Number-Of-Triplets-For-Authentication   2          # range [2 to 3]

  Protected-Success-Indications           "Enabled"  # Enabled or Disabled

  Prefixed-IMSI-Permanent-IDs             "Enabled"  # Enabled or Disabled

  Generic-Permanent-IDs                   "Disabled" # Enabled or Disabled

  Minimum-Length-IMSI 6  # 6<=Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15
  Maximum-Length-IMSI 15 # 6<=Minimum-Length-IMSI <= Maximum-Length-IMSI <= 15

  A3-Algorithm                            "3GPP-Milenage"

  A8-Algorithm                            "3GPP-Milenage"

  #   ========================================================================
  #   The following group of parameters configure the PSEUDONYM support
  #   ========================================================================

  Generate-Random-Character-Pseudonyms    "No"       # yes or no

  Pseudonym-Lifetime                      1209600    # 14 days, in seconds

  #   ========================================================================
  #   The following group of parameters configure FAST RE-AUTHENTICATION
  #   ========================================================================

  Max-Number-Of-Reauths-Before-Full-Auth-Is-Required  4  # range [1 to 65535]

  Fast-Reauth-Realm                        ""        # use perm ID's realm

  Fast-Reauth-Id-Lifetime                  3600      # range [1 to 14400]
}
```

A3, A8 and AKA Algorithms

If authentication vectors are not retrieved from a datastore or supplied by an external AuC, then they must be generated using A3 and A8 algorithms for EAP-SIM or the AKA algorithm for EAP-AKA.

GSM A3 and A8 algorithms can be used in EAP-SIM. [GSM-03.20] specifies the general GSM authentication procedure and the external interface (inputs and outputs) of the A3 and A8

algorithms. The operation of these functions falls completely within the domain of an individual network operator, and therefore, the functions are specified by each operator rather than being fully standardized. The GSM-MILENAGE algorithm, specified publicly in [3GPP-TS-55.205], is an example algorithm set for A3 and A8 algorithms.

The AKA algorithm can also use the GSM functions that are used to implement A3 and A8 algorithms mentioned above.

The A3/A8/AKA algorithm plug-ins are located in the AATV directory (`/opt/aaa/aatv` by default). There may be multiple named A3/A8/AKA algorithms used by the server. They can be specified in the global configuration file, `aaa.config`, in the realm-based configurations, or in an users' profile. See the SDK documentation for information on how to modify the examples or create your own A3/A8/AKA algorithm plug-ins.

3GPP Milenage A3/A8/AKA Algorithm

An implementation of the 3GPP Milenage A3/A8 algorithm functions for EAP-SIM authentication and the AKA algorithm for EAP-AKA are included with the server. The 3GPP Milenage A3/A8/AKA algorithm plug-in module has configuration parameters which allows it to be customized for a specific operator. The A3, A8 and AKA algorithm names, in this plugin, are `3GPP-Milenage`.

See the relevant 3GPP documents for complete details on 3GPP Milenage f1, f1*, f2, f3, f4, f5, f5* algorithms:

- 3GPP TS 35.205 v6.0.0 - General Information
- 3GPP TS 35.206 v6.0.0 - Algorithm Specification
- 3GPP TS 35.207 v6.0.0 - Implementors' Test Data
- 3GPP TS.35.208 v6.0.0 - Design Conformance Test Data
- 3GPP TS.35.909 v6.0.0 - Summary and results of design and evaluation
- 3GPP TS.55.205 v6.2.0 - Authentication and Key Generation functions for A3 and A8

The 3GPP Milenage A3/A8/AKA algorithms are based on the 3GPP Milenage functions:
`f1(), f1*(), f2(), f3(), f4(), f5(), f5*()`

A total of 12 parameters are required to fully specify the function set:
- **`Ek`** 128-bit kernel function
- **`OP`** 128-bit operator specific value
- **`C1-C5`** 128-bit values used to compute f1, f1*, f2, f3, f4, f5, f5*
- **`R1-R5`** integer rotation constants used to compute f1, f1*, f2, f3, f4, f5, f5*

The **`Ek`** kernel function specified by 3GPP Milenage is 128-bit AES (Rijndeal). This plug-in module does not allow the **`Ek`** kernel function to be changed. The underlying implementation provides support for replacing **`Ek`**. If replacing the **`Ek`** kernel function is required, see the SDK documentation for further details.

The 3GPP Milenage A3 algorithm has two variants, corresponding to recommended SRES derivation function #1 and recommended SRES derivation function #2. The A3 function is

affected by the choice, while the A8 function is unaffected. The selection of A3 variant #1 or #2 constitutes another parameter, **`A3-Variant`**. The AKA algorithm is unaffected by this parameter.

The selection of parameter values must match the characteristics of the client devices to be authenticated.

Configuration parameters available in `aatv.3GPP-Milenage{} block in aaa.config file`:

Parameter	Description
`OP`	This is a 128-bit operator-specific constant. The OP value MUST be specified by each operator. Milenage specifies no default for this value. If not explicitly configured, the default value is 0x00000000.00000000.00000000.00000000. Use of this value will generate a warning message in the logfile.
`C1`	This is a 128-bit computation constant. C1 SHOULD have even parity. Use of a value with odd parity will generate a warning message in the logfile. Milenage specifies the default for this value. If not explicitly configured, the default value is 0x00000000.00000000.00000000.00000000.
C2	This is a 128-bit computation constant. C2 SHOULD have odd parity. Use of a value with even parity will generate a warning message in the logfile. Milenage specifies the default for this value. If not explicitly configured, the default value is 0x00000000.00000000.00000000.00000001.
C3	This is a 128-bit computation constant. C3 SHOULD have odd parity. Use of a value with even parity will generate a warning message in the logfile. Milenage specifies the default for this value. If not explicitly configured, the default value is 0x00000000.00000000.00000000.00000002.
C4	This is a 128-bit computation constant. C4 SHOULD have odd parity. Use of a value with even parity will generate a warning message in the logfile. Milenage specifies the default for this value. If not explicitly configured, the default value is 0x00000000.00000000.00000000.00000004.

Parameter	Description
C5	This is a 128-bit computation constant. C5 SHOULD have odd parity. Use of a value with even parity will generate a warning message in the logfile. Milenage specifies the default for this value. If not explicitly configured, the default value is 0x00000000.00000000.00000000.00000008.
R1	This is a rotation constant. The valid range is 0 to 127. Milenage specifies the default for this value. If not explicitly configured, the default value is 64.
R2	This is a rotation constant. The valid range is 0 to 127. Milenage specifies the default for this value. If not explicitly configured, the default value is 0.
R3	This is a rotation constant. The valid range is 0 to 127. Milenage specifies the default for this value. If not explicitly configured, the default value is 32.
R4	This is a rotation constant. The valid range is 0 to 127. Milenage specifies the default for this value. If not explicitly configured, the default value is 64.
R5	This is a rotation constant. The valid range is 0 to 127. Milenage specifies the default for this value. If not explicitly configured, the default value is 96.
A3-Variant	This plug-in module supports the selection of Milenage variant #1 or #2. A3-Variant MUST be 1 or 2. If an alternative SRES derivation function is required, see the SDK documentation for further details. The AKA algorithm is unaffected by this parameter. If not explicitly configured, the default value is 1.

NOTE: The **Ci,Ri** pairs **MUST** be unique.
It must **NOT** be the case that both **Ci** = **Cj** and **Ri** = **Rj** for $i \neq j$.
For instance, it must not be the case that both **C2=C4** and **R2=R4**.

Example aatv.3GPP-Milenage block in aaa.config File

```
aatv.3GPP-Milenage
{
    # OP   128-bit operator-specific constant: CONFIGURATION RECOMMENDED
    OP 0x00000000.00000000.00000000.00000000
    # C1   128-bit computation constant: CONFIGURATION OPTIONAL.
    C1 0x00000000.00000000.00000000.00000000
    # C2   128-bit computation constant: CONFIGURATION OPTIONAL.
    C2 0x00000000.00000000.00000000.00000001
    # C3   128-bit computation constant: CONFIGURATION OPTIONAL.
    C3 0x00000000.00000000.00000000.00000002
    # C4   128-bit computation constant: CONFIGURATION OPTIONAL.
    C4 0x00000000.00000000.00000000.00000004
    # C5   128-bit computation constant: CONFIGURATION OPTIONAL.
    C5 0x00000000.00000000.00000000.00000008
    # R1   rotation constant: CONFIGURATION OPTIONAL.
    R1   64
    # R2   rotation constant: CONFIGURATION OPTIONAL.
    R2   0
    # R3   rotation constant: CONFIGURATION OPTIONAL.
    R3   32
    # R4   rotation constant: CONFIGURATION OPTIONAL.
    R4   64
    # R5   rotation constant: CONFIGURATION OPTIONAL.
    R5   96
    # A3-Variant   algorithm variant: CONFIGURATION OPTIONAL.
    A3-Variant   1
}
```

Pseudonym and Fast Re-Authentication Data Base AATVs

Pseudonym

The Interlink server provides a mechanism for EAP-AKA and EAP-SIM, using configured encryption keys, by which pseudonyms can be generated as an encrypted form of the permanent identity, which can be subsequently decrypted to reproduce the permanent identity. Alternatively, the server can generate pseudonyms as a string of random characters, similar to the fast reauthentication identity. In this latter case, an external database is required to store the pseudonym to permanent identity mappings. For many customers, the algorithm based pseudonyms will be the easiest and most efficient choice. The use of random pseudonyms would only be required if the network operator felt the algorithm did not provide adequate hiding of the permanent identity.

In order for pseudonyms to be used, the realm configuration in `EAP-Type AKA{}` and `EAP-Type SIM{}` must specify the PseudonymLookup parameter with its value being the name of an AATV which maps the Pseudonym to the permanent identity. The configured AATV may be the Interlink provided one, `SIMAKA-PseudonymDecrypt,` which does local decryption of a pseudonym using the pseudonym encryption key that was used to encrypt the pseudonym. The configured AATV may also be a customer provided AATV which accesses an external database to map the Pseudonym to the real identity. The requirements of a customer implementation are defined in the Software Developers Kit.

Random Pseudonyms

The server, when operating in an environment where a central database is used for saving the pseudonym to permanent identity mappings, may be configured to generate a pseudonym as a string of random characters, and store the last-used and last-assigned pseudonyms in this database. The EAP-AKA RFC 4187 and EAP-SIM RFC 4186 recommends saving at least two pseudonyms, the last used and the last assigned. In order for random pseudonyms to work, the realm configuration in `EAP-Type AKA{}` block and the `EAP-Type SIM{}` block in the `EAP.authfile` must specify the `Pseudonym-Lookup` and `Pseudonym-Update` parameters with their values being the names of the AATV which maps the pseudonym to the permanent identity and the AATV which stores the random pseudonym in the database. In this case, the pseudonym algorithm would not be employed and the pseudonym would look just like the fast reauthentication identity, with a different prefix. That is: the random pseudonym identity is 10 characters long, consisting of the pseudonym prefix '2' or '4', followed by 9 random characters from the character set {BCDFGHJKLMNPQRSTVWXYZ0123456789}. The random pseudonym has the benefit that there is no way to reverse engineer the permanent identity. It also has the drawback that there must be a database implemented to store and retrieve the mapping of pseudonym to permanent identity.

Algorithm Based Pseudonyms

Interlink has provided an option in the server that generates a pseudonym by encrypting the real username using an algorithm and an AATV, `SIMAKA-PseudonymDecrypt,` that decrypts a pseudonym to reproduce the real username. The algorithmic approach has these features/benefits, as specified by Ericsson[1] and submitted to the 3GPP TSG SA WG3 working group:

- No external database is needed to store all the assigned pseudonyms.

- A pseudonym generated on one RADIUS server can be processed by a second RADIUS server.
- No user state is kept in the RADIUS server between WLAN sessions.
- Pseudonyms are not stored in the HSS/HLR.
- Any secret keys used in RADIUS server for the generation of pseudonyms are infeasible to recover (even for an attacker that has available a number of matching permanent identities and pseudonyms).
- Given a pseudonym (or even a number of correlated pseudonyms), it is infeasible for an attacker to recover the corresponding permanent identity.
- It is infeasible for an attacker to determine whether or not two pseudonyms correspond to the same permanent identity.
- No random forgery: It is infeasible for an attacker to generate a valid pseudonym (irrespective of the underlying permanent identity).
- No targeted forgery: It is infeasible for an attacker to generate a valid pseudonym corresponding to a given permanent identity.

In order for the Interlink provided algorithm to be used, the global configuration in `aatv.SIMAKA{}` must specify one or more `Pseudonym-Algorithm-Key-`*n* parameters. The key number specified by "`Pseudonym-Algorithm-Current-Key`" is used to encrypt new pseudonyms. The other keys are used for decryption of pseudonyms previously generated with these other keys, but are not used for generation of new pseudonyms. With the algorithm based pseudonyms there is no lifetime applied to the pseudonym. A lifetime can be approximated by defining a new key and making the new key the current key, then after the desired lifetime the old key can be removed and the pseudonyms generated with it will be disabled.

When generating a pseudonym based on a permanent identity which is an IMSI, the server uses a minor modification of an algorithm developed by Ericsson[2] and submitted to the 3GPP TSG SA WG3 working group. In this case, the pseudonym user name is 24 characters long.

When generating a pseudonym based on a permanent identity which is a generic username, e.g. "fred", the server uses an algorithm derived from the same Ericsson algorithm. In this case, the length of the pseudonym varies, depending on the length of the permanent identity:

- `  24 characters if the permanent user name is    1-8 characters.`
- `  45 characters if the permanent user name is   9-24 characters.`
- `  66 characters if the permanent user name is  25-40 characters.`
- `  88 characters if the permanent user name is  41-56 characters.`
- `109 characters if the permanent user name is  57-72 characters.`
- `130 characters if the permanent user name is  73-88 characters.`
- `152 characters if the permanent user name is 89-104 characters.`
- `173 characters if the permanent user name is 104-120 characters.`

1. WLAN – Pseudonym Generation for EAP-SIM/AKA, 3GPP, Ericsson, S3-020654.pdf
2. WLAN – Pseudonym Generation for EAP-SIM/AKA, 3GPP, Ericsson, S3-020654.pdf

- 194 characters if the permanent user name is 121-136 characters.
- 216 characters if the permanent user name is 137-152 characters.
- 237 characters if the permanent user name is 153-168 characters.
- The pseudonym is not generated if the permanent user name is > 168 characters, as the pseudonym identity would exceed 253 characters.

The server will generate a pseudonym identity only if the length of the "pseudonym@realrealm" string will not exceed 253 characters.

For a given IMSI permanent identity, there are 56 random user bits involved in the pseudonym generation, resulting in over 7 million trillion ($7 * 10^{18}$) different pseudonyms for a given IMSI. The probability that a random forgery decrypts back into anything that looks like an IMSI is less than 1 in 4 million.

For a given non-IMSI permanent identity, there are 32 random user bits involved in the pseudonym generation, resulting in over 4 billion different pseudonyms for a given user. The probability that a random forgery decrypts back into anything that looks like generic username is less than 1 in 50 million.

Fast Re-Authentication

Fast re-authentication is a mechanism for a SIM user to freshen his keys periodically. A fast re-authentication, if it is going to take place, will happen in a "short" time after a full authentication or a previous fast re-authentication. If the fast reauthentication identity is assigned and isn't used within this period of time, the fast reauthentication identity and the associated full authentication context is expired.

In order for fast re-authentications to be used, the realm configuration in `EAP-Type AKA{}` and `EAP-Type SIM{}` must specify:

- The Fast-Reauth-Update parameter with its value being the name of an AATV which saves the fast reauthentication identity to permanent identity mapping as well as the other fast re-authentication context (the Master Key from the user's last full authentication, the fast re-authentication counter, and the fast reauthentication identity expiration time).
- The Fast-Reauth-Lookup parameter with its value being the name of an AATV which maps the fast reauthentication identity to the permanent identity and returns the saved context.

The configured AATVs may be the Interlink provided set, `SIMAKA-ReauthCacheUpdate and SIMAKA-ReauthCacheLookup`, which do local caching of the fast reauthentication identity to the permanent identity mapping and the necessary attributes. The configured AATVs may also be a customer provided set of AATVs which access an external database to map the fast reauthentication identity to the permanent identity and returns the saved attributes. The requirements of a customer implementation are defined in the Software Developers Kit (SDK).

The Interlink EAP-AKA/SIM server generates a fast reauthentication identity which is 10 characters long, consisting of the fast reauthentication identity prefix '3' or '5', followed by 9 random characters from the 31 character set consisting of the upper-case characters minus the vowels, plus the 10 digits 0-9, i.e. {BCDFGHJKLMNPQRSTVWXYZ0123456789}.

Since there are 31 choices for each of the 9 random characters, there are then 31^9 different, i.e. more than 26 trillion, fast reauth identities over the universe of all permanent identities.

Selecting only uppercase characters for the server-generated reauth identities allows for case-insensitive databases lookups.

The server sends a fast reauthentication identity to the client, which includes a realm. Before generating a fast reauthentication identity, the server first checks that the total length of the "name@realm" string does not exceed 253 characters, the maximum length of a User-Name attribute value. If it is too long, the server does not generate a reauth identity. Since the name portion of the fast reauthentication identity is 10 characters, this problem only occurs if the realm is greater than 242 characters. The realm is either the configured fast reauth realm or the realm from the permanent identity. Recall that a fast reauth realm can be configured for the purpose of targeting a fast reauth authentication request to the specific server which generated the fast reauthentication identity.

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