

Kerberos V5 System Administrator's Guide

Release: 1.10

Document Edition: 1.0

Last updated: June 14, 2007

MIT

1 Introduction

1.1 Why Should I use Kerberos?

Since Kerberos negotiates authenticated, and optionally encrypted, communications between two points anywhere on the internet, it provides a layer of security that is not dependent on which side of a firewall either client is on. Since studies have shown that half of the computer security breaches in industry happen from *inside* firewalls, Kerberos V5 from MIT will play a vital role in the security of your network.

1.2 Documentation for Kerberos V5

This document is one piece of the document set for Kerberos V5. The documents, and their intended audiences, are:

- **Kerberos V5 Installation Guide:** a concise guide for installing Kerberos V5. Kerberos administrators (particularly whoever will be making site-wide decisions about the installation) and the system administrators who will be installing the software should read this guide.
- **Kerberos V5 System Administrator's Guide:** a sysadmin's guide to administering a Kerberos installation. The System Administrator's Guide describes the administration software and suggests policies and procedures for administering a Kerberos installation. Anyone who will have administrative access to your Kerberos database should read this guide.
- **Kerberos V5 UNIX User's Guide:** a guide to using the Kerberos UNIX client programs. All users on UNIX systems should read this guide, particularly the "Tutorial" section.

1.3 Overview of This Guide

The next chapter describes how Kerberos works.

Chapter three describes administration of the principals in the Kerberos database.

Chapter four describes how you can use DNS in configuring your Kerberos realm.

Chapter five describes administrative programs for manipulating the Kerberos database as a whole.

Chapter six describes OpenLDAP Configuration steps.

Chapter seven describes issues to consider when adding an application server to the database.

Chapter eight describes our problem reporting system.

The appendices include the list of Kerberos error messages, and a complete list of the time zones understood by `kadmin`.

2 How Kerberos Works

This section provides a simplified description of a general user's interaction with the Kerberos system. This interaction happens transparently—users don't need to know and probably don't care about what's going on—but Kerberos administrators might find a schematic description of the process useful. This description glosses over a lot of details; for more information, see *Kerberos: An Authentication Service for Open Network Systems*, a paper presented at Winter USENIX 1988, in Dallas, Texas. This paper can be retrieved by FTP from `athena-dist.mit.edu`, in the location: `/pub/ATHENA/kerberos/doc/usenix.PS`.

2.1 Network Services and Their Client Programs

In an environment that provides network services, you use *client* programs to request *services* from *server* programs that are somewhere on the network. Suppose you have logged in to a workstation and you want to 'rlogin' to a typical UNIX host. You use the local 'rlogin' client program to contact the remote machine's 'rlogind' daemon.

2.2 Kerberos Tickets

Under Kerberos, the 'klogind' daemon allows you to login to a remote machine if you can provide 'klogind' a Kerberos ticket which proves your identity. In addition to the ticket, you must also have possession of the corresponding ticket session key. The combination of a ticket and the ticket's session key is known as a credential.

Typically, a client program automatically obtains credentials identifying the person using the client program. The credentials are obtained from a Kerberos server that resides somewhere on the network. A Kerberos server maintains a database of user, server, and password information.

2.3 The Kerberos Database

Kerberos will give you credentials only if you have an entry in the Kerberos server's *Kerberos database*. Your database entry includes your Kerberos *principal* (an identifying string, which is often just your username), and your Kerberos password. Every Kerberos user must have an entry in this database.

2.4 Kerberos Realms

Each administrative domain will have its own Kerberos database, which contains information about the users and services for that particular site or administrative domain. This administrative domain is the *Kerberos realm*.

Each Kerberos realm will have at least one Kerberos server, where the master Kerberos database for that site or administrative domain is stored. A Kerberos realm may also have one or more *slave servers*, which have read-only copies of the Kerberos database that are periodically propagated from the master server. For more details on how this is done, see the "Set Up the Slave KDCs for Database Propagation" and "Propagate the Database to Each Slave KDC" sections of the Kerberos V5 Installation Guide.

2.5 The Ticket-Granting Ticket

The `kinit` command prompts for your password. If you enter it successfully, you will obtain a *ticket-granting ticket* and a *ticket session key* which gives you the right to use the ticket. This combination of the ticket and its associated key is known as your *credentials*. As illustrated below, client programs use your ticket-granting ticket credentials in order to obtain client-specific credentials as needed.

Your credentials are stored in a *credentials cache*, which is often just a file in `/tmp`. The credentials cache is also called the *ticket file*, especially in Kerberos V4 documentation. Note, however, that a credentials cache does not have to be stored in a file.

2.6 Network Services and the Master Database

The master database also contains entries for all network services that require Kerberos authentication. Suppose that your site has a machine, `'laughte.r.mit.edu'`, that requires Kerberos authentication from anyone who wants to `'rlogin'` to it. The host's Kerberos realm is `'ATHENA.MIT.EDU'`.

This service must be registered in the Kerberos database, using the proper service name, which in this case is the *principal*:

```
host/laughte.r.mit.edu@ATHENA.MIT.EDU
```

The `'/'` character separates the Kerberos *primary* (in this case, `'host'`) from the *instance* (in this case, `'laughte.r.mit.edu'`); the `'@'` character separates the realm name (in this case, `'ATHENA.MIT.EDU'`) from the rest of the principal. The primary, `'host'`, denotes the name or type of the service that is being offered: generic host-level access to the machine. The instance, `'laughte.r.mit.edu'`, names the specific machine that is offering this service. There will generally be many different machines, each offering one particular type of service, and the instance serves to give each one of these servers a different Kerberos principal.

2.6.1 The Keytab File

For each service, there must also be a *service key* known only by Kerberos and the service. On the Kerberos server, the service key is stored in the Kerberos database.

On the server host, these service keys are stored in *key tables*, which are files known as *keytabs*.¹ For example, the service keys used by services that run as root are usually stored in the keytab file `/etc/krb5.keytab`. **N.B.:** This service key is the equivalent of the service's password, and must be kept secure. Data which is meant to be read only by the service is encrypted using this key.

2.7 The User/Kerberos Interaction

Suppose that you walk up to a host intending to login to it, and then `'rlogin'` to the machine `'laughte.r'`. Here's what happens:

1. You login to the workstation and use the `'kinit'` command to get a ticket-granting ticket. This command prompts you for your Kerberos password. (On systems running

¹ Keytabs were called *svt tabs* in Kerberos V4.

the Kerberos V5 ‘login’ program, this may be done as part of the login process, not requiring the user to run a separate program.)

- A. The ‘kinit’ command sends your request to the Kerberos master server machine. The server software looks for your principal name’s entry in the Kerberos database.
 - B. If this entry exists, the Kerberos server creates and returns a ticket-granting ticket and the key which allows you to use it, encrypted by your password. If ‘kinit’ can decrypt the Kerberos reply using the password you provide, it stores this ticket in a credentials cache on your local machine for later use. The name of the credentials cache can be specified in the ‘KRB5CCNAME’ environment variable. If this variable is not set, the name of the file will be ‘/tmp/krb5cc_<uid>’, where <uid> is your UNIX user-id, represented in decimal format.
2. Now you use the ‘rlogin’ client to access the machine ‘laugther’.

host% rlogin laugther

- A. The ‘rlogin’ client checks your ticket file to see if you have a ticket for the ‘host’ service for ‘laugther’. You don’t, so ‘rlogin’ uses the credential cache’s ticket-granting ticket to make a request to the master server’s ticket-granting service.
- B. This ticket-granting service receives the request for a ticket for ‘host/laugther.mit.edu’, and looks in the master database for an entry for ‘host/laugther.mit.edu’. If the entry exists, the ticket-granting service issues you a ticket for that service. That ticket is also cached in your credentials cache.
- C. The ‘rlogin’ client now sends that ticket to the ‘laugther’ ‘klogind’ service program. The service program checks the ticket by using its own service key. If the ticket is valid, it now knows your identity. If you are allowed to login to ‘laugther’ (because your username matches one in /etc/passwd, or your Kerberos principal is in the appropriate ‘.k5login’ file), klogind will let you login.

2.8 Definitions

Following are definitions of some of the Kerberos terminology.

| | | | |
|------------------|--|----------------|---|
| client | an entity that can obtain a ticket. This entity is usually either a user or a host. | | |
| host | a computer that can be accessed over a network. | | |
| Kerberos | in Greek mythology, the three-headed dog that guards the entrance to the underworld. In the computing world, Kerberos is a network security package that was developed at MIT. | | |
| KDC | Key Distribution Center. A machine that issues Kerberos tickets. | | |
| keytab | a key table file containing one or more keys. A host or service uses a <i>keytab</i> file in much the same way as a user uses his/her password. | | |
| principal | a string that names a specific entity to which a set of credentials may be assigned. It can have an arbitrary number of components, but generally has three: <table border="0" data-bbox="383 1825 1409 1899"> <tr> <td style="padding-left: 20px;">primary</td><td>the first part of a Kerberos <i>principal</i>. In the case of a user, it is the username. In the case of a service, it is the name of the service.</td></tr> </table> | primary | the first part of a Kerberos <i>principal</i> . In the case of a user, it is the username. In the case of a service, it is the name of the service. |
| primary | the first part of a Kerberos <i>principal</i> . In the case of a user, it is the username. In the case of a service, it is the name of the service. | | |

- instance** the second part of a Kerberos *principal*. It gives information that qualifies the primary. The instance may be null. In the case of a user, the instance is often used to describe the intended use of the corresponding credentials. In the case of a host, the instance is the fully qualified hostname.
- realm** the logical network served by a single Kerberos database and a set of Key Distribution Centers. By convention, realm names are generally all uppercase letters, to differentiate the realm from the internet domain.

The typical format of a typical Kerberos principal is primary/instance@REALM.

- service** any program or computer you access over a network. Examples of services include “host” (a host, *e.g.*, when you use `telnet` and `rsh`), “ftp” (FTP), “krbtgt” (authentication; cf. *ticket-granting ticket*), and “pop” (email).
- ticket** a temporary set of electronic credentials that verify the identity of a client for a particular service.
- TGT** Ticket-Granting Ticket. A special Kerberos ticket that permits the client to obtain additional Kerberos tickets within the same Kerberos realm.

3 Configuration Files

3.1 Supported Encryption Types

Any tag in the configuration files which requires a list of encryption types can be set to some combination of the following strings. Encryption types marked as “weak” are available for compatibility but not recommended for use.

| | |
|--------------------------------------|---|
| <code>des-cbc-crc</code> | DES cbc mode with CRC-32 (weak) |
| <code>des-cbc-md4</code> | DES cbc mode with RSA-MD4 (weak) |
| <code>des-cbc-md5</code> | DES cbc mode with RSA-MD5 (weak) |
| <code>des-cbc-raw</code> | DES cbc mode raw (weak) |
| <code>des3-cbc-raw</code> | Triple DES cbc mode raw (weak) |
| <code>des3-cbc-sha1</code> | |
| <code>des3-hmac-sha1</code> | |
| <code>des3-cbc-sha1-kd</code> | Triple DES cbc mode with HMAC/sha1 |
| <code>des-hmac-sha1</code> | DES with HMAC/sha1 (weak) |
| <code>aes256-cts-hmac-sha1-96</code> | |
| <code>aes256-cts</code> | AES-256 CTS mode with 96-bit SHA-1 HMAC |
| <code>aes128-cts-hmac-sha1-96</code> | |
| <code>aes128-cts</code> | AES-128 CTS mode with 96-bit SHA-1 HMAC |
| <code>arcfour-hmac</code> | |
| <code>rc4-hmac</code> | |
| <code>arcfour-hmac-md5</code> | RC4 with HMAC/MD5 |
| <code>arcfour-hmac-exp</code> | |
| <code>rc4-hmac-exp</code> | |
| <code>arcfour-hmac-md5-exp</code> | Exportable RC4 with HMAC/MD5 (weak) |
| <code>des</code> | The DES family: <code>des-cbc-crc</code> , <code>des-cbc-md5</code> , and <code>des-cbc-md4</code> (weak) |
| <code>des3</code> | The triple DES family: <code>des3-cbc-sha1</code> |
| <code>aes</code> | The AES family: <code>aes256-cts-hmac-sha1-96</code> and <code>aes128-cts-hmac-sha1-96</code> |

rc4 The RC4 family: arcfour-hmac

The string **DEFAULT** can be used to refer to the default set of types for the variable in question. Types or families can be removed from the current list by prefixing them with a minus sign (“-”). Types or families can be prefixed with a plus sign (“+”) for symmetry; it has the same meaning as just listing the type or family. For example, “**DEFAULT -des**” would be the default set of encryption types with DES types removed, and “**des3 DEFAULT**” would be the default set of encryption types with triple DES types moved to the front.

While **aes128-cts** and **aes256-cts** are supported for all Kerberos operations, they are not supported by older versions of our GSSAPI implementation (krb5-1.3.1 and earlier).

By default, AES is enabled in this release. Sites wishing to use AES encryption types on their KDCs need to be careful not to give GSSAPI services AES keys if the servers have not been updated. If older GSSAPI services are given AES keys, then services may fail when clients supporting AES for GSSAPI are used. Sites may wish to use AES for user keys and for the ticket granting ticket key, although doing so requires specifying what encryption types are used as each principal is created.

If all GSSAPI-based services have been updated before or with the KDC, this is not an issue.

3.2 Salts

Your Kerberos key is derived from your password. To ensure that people who happen to pick the same password do not have the same key, Kerberos 5 incorporates more information into the key using something called a salt. The supported values for salts are as follows.

| | |
|------------------|---|
| normal | default for Kerberos Version 5 |
| v4 | the only type used by Kerberos Version 4, no salt |
| norealm | same as the default, without using realm information |
| onlyrealm | uses only realm information as the salt |
| afs3 | AFS version 3, only used for compatibility with Kerberos 4 in AFS |
| special | only used in very special cases; not fully supported |

3.3 krb5.conf

The **krb5.conf** file contains Kerberos configuration information, including the locations of KDCs and admin servers for the Kerberos realms of interest, defaults for the current realm and for Kerberos applications, and mappings of hostnames onto Kerberos realms. Normally, you should install your **krb5.conf** file in the directory **/etc**. You can override the default location by setting the environment variable ‘**KRB5_CONFIG**’.

The **krb5.conf** file is set up in the style of a Windows INI file. Sections are headed by the section name, in square brackets. Each section may contain zero or more relations, of the form:

```
foo = bar
```

or

```
fubar = {
    foo = bar
    baz = quux
}
```

Placing a ‘*’ at the end of a line indicates that this is the *final* value for the tag. This means that neither the remainder of this configuration file nor any other configuration file will be checked for any other values for this tag.

For example, if you have the following lines:

```
foo = bar*
foo = baz
```

then the second value of foo (baz) would never be read.

The `krb5.conf` file can include other files using either of the following directives at the beginning of a line:

```
include FILENAME
includedir DIRNAME
```

FILENAME or *DIRNAME* should be an absolute path. The named file or directory must exist and be readable. Including a directory includes all files within the directory whose names consist solely of alphanumeric characters, dashes, or underscores. Included profile files are syntactically independent of their parents, so each included file must begin with a section header.

The `krb5.conf` file may contain any or all of the following sections:

- libdefaults** Contains default values used by the Kerberos V5 library.
- login** Contains default values used by the Kerberos V5 login program.
- appdefaults** Contains default values that can be used by Kerberos V5 applications.
- realms** Contains subsections keyed by Kerberos realm names. Each subsection describes realm-specific information, including where to find the Kerberos servers for that realm.
- domain_realm** Contains relations which map domain names and subdomains onto Kerberos realm names. This is used by programs to determine what realm a host should be in, given its fully qualified domain name.
- logging** Contains relations which determine how Kerberos programs are to perform logging.
- capaths** Contains the authentication paths used with direct (nonhierarchical) cross-realm authentication. Entries in this section are used by the client to determine the intermediate realms which may be used in cross-realm authentication. It is also used by the end-service when checking the transited field for trusted intermediate realms.
- plugins** Contains tags to register dynamic plugin modules and to turn modules on and off.

3.3.1 [libdefaults]

The `libdefaults` section may contain any of the following relations:

default_keytab_name

This relation specifies the default keytab name to be used by application servers such as `telnetd` and `rlogind`. The default is `/etc/krb5.keytab`.

default_realm

Identifies the default Kerberos realm for the client. Set its value to your Kerberos realm. If this is not specified and the TXT record lookup is enabled (see Chapter 4 [Using DNS], page 35), then that information will be used to determine the default realm. If this tag is not set in this configuration file and there is no DNS information found, then an error will be returned.

default_tgs_enctypes

Identifies the supported list of session key encryption types that should be returned by the KDC. The list may be delimited with commas or whitespace. Kerberos supports many different encryption types, and support for more is planned in the future. (see Section 3.1 [Supported Encryption Types], page 7 for a list of the accepted values for this tag). The default value is `aes256-cts-hmac-sha1-96 aes128-cts-hmac-sha1-96 des3-cbc-sha1 arcfour-hmac-md5 des-cbc-crc des-cbc-md5 des-cbc-md4`.

default_tkt_enctypes

Identifies the supported list of session key encryption types that should be requested by the client. The format is the same as for *default_tgs_enctypes*. The default value for this tag is `aes256-cts-hmac-sha1-96 aes128-cts-hmac-sha1-96 des3-cbc-sha1 arcfour-hmac-md5 des-cbc-crc des-cbc-md5 des-cbc-md4`.

permitted_enctypes

Identifies all encryption types that are permitted for use in session key encryption. The default value for this tag is `aes256-cts-hmac-sha1-96 aes128-cts-hmac-sha1-96 des3-cbc-sha1 arcfour-hmac-md5 des-cbc-crc des-cbc-md5 des-cbc-md4`.

allow_weak_crypto

If this is set to 0 (for false), then weak encryption types will be filtered out of the previous three lists (as noted in Section 3.1 [Supported Encryption Types], page 7). The default value for this tag is false, which may cause authentication failures in existing Kerberos infrastructures that do not support strong crypto. Users in affected environments should set this tag to true until their infrastructure adopts stronger ciphers.

clockskew Sets the maximum allowable amount of clockskew in seconds that the library will tolerate before assuming that a Kerberos message is invalid. The default value is 300 seconds, or five minutes.

ignore_acceptor_hostname

When accepting GSSAPI or `krb5` security contexts for host-based service principals, ignore any hostname passed by the calling application and allow any service principal present in the keytab which matches the service name and realm name (if given). This option can improve the administrative flexibility

of server applications multi-homed hosts, but can compromise the security of virtual hosting environments. The default value is false.

k5login_authoritative

If the value of this relation is true (the default), principals must be listed in a local user's k5login file to be granted login access, if a k5login file exists. If the value of this relation is false, a principal may still be granted login access through other mechanisms even if a k5login file exists but does not list the principal.

k5login_directory

If set, the library will look for a local user's k5login file within the named directory, with a filename corresponding to the local username. If not set, the library will look for k5login files in the user's home directory, with the filename .k5login. For security reasons, k5login files must be owned by the local user or by root.

kdc_timesync

If this is set to 1 (for true), then client machines will compute the difference between their time and the time returned by the KDC in the timestamps in the tickets and use this value to correct for an inaccurate system clock. This corrective factor is only used by the Kerberos library. The default is 1.

kdc_req_checksum_type

ap_req_checksum_type

safe_checksum_type

An integer which specifies the type of checksum to use. Used for compatibility with DCE security servers which do not support the default RSA MD5 used by this version of Kerberos. The kdc_req_checksum_type is only used for DES keys. The ap_req_checksum_type defaults to the preferred checksum for the encryption type being used if unset. If set, then the selected checksum is used regardless of the type of key being used. The possible values and their meanings are as follows.

| | |
|-------------|----------------------------------|
| 1 | CRC32 |
| 2 | RSA MD4 |
| 3 | RSA MD4 DES |
| 4 | DES CBC |
| 7 | RSA MD5 |
| 8 | RSA MD5 DES |
| 9 | NIST SHA |
| 12 | HMAC SHA1 DES3 |
| -138 | Microsoft MD5 HMAC checksum type |

preferred_preauth_types

This allows you to set the preferred preauthentication types which the client will attempt before others which may be advertised by a KDC. The default

value for this setting is "17, 16, 15, 14", which forces libkrb5 to attempt to use PKINIT if it is supported.

ccache_type

Use this parameter on systems which are DCE clients, to specify the type of cache to be created by kinit, or when forwarded tickets are received. DCE and Kerberos can share the cache, but some versions of DCE do not support the default cache as created by this version of Kerberos. Use a value of 1 on DCE 1.0.3a systems, and a value of 2 on DCE 1.1 systems. The default value is 4.

dns_lookup_kdc

Indicate whether DNS SRV records should be used to locate the KDCs and other servers for a realm, if they are not listed in the information for the realm. (Note that the 'admin_server' entry must be in the file, because the DNS implementation for it is incomplete.)

Enabling this option does open up a type of denial-of-service attack, if someone spoofs the DNS records and redirects you to another server. However, it's no worse than a denial of service, because that fake KDC will be unable to decode anything you send it (besides the initial ticket request, which has no encrypted data), and anything the fake KDC sends will not be trusted without verification using some secret that it won't know.

If this option is not specified but 'dns_fallback' is, that value will be used instead. If neither option is specified, the behavior depends on configure-time options; if none were given, the default is to enable this option. If the DNS support is not compiled in, this entry has no effect.

dns_lookup_realm

Indicate whether DNS TXT records should be used to determine the Kerberos realm of a host.

Enabling this option may permit a redirection attack, where spoofed DNS replies persuade a client to authenticate to the wrong realm, when talking to the wrong host (either by spoofing yet more DNS records or by intercepting the net traffic). Depending on how the client software manages hostnames, however, it could already be vulnerable to such attacks. We are looking at possible ways to minimize or eliminate this exposure. For now, we encourage more adventurous sites to try using Secure DNS.

If this option is not specified but 'dns_fallback' is, that value will be used instead. If neither option is specified, the behavior depends on configure-time options; if none were given, the default is to disable this option. If the DNS support is not compiled in, this entry has no effect.

dns_fallback

General flag controlling the use of DNS for Kerberos information. If both of the preceding options are specified, this option has no effect.

realm_try_domains

Indicate whether a host's domain components should be used to determine the Kerberos realm of the host. The value of this variable is an integer: -1 means not to search, 0 means to try the host's domain itself, 1 means to also try the domain's immediate parent, and so forth. The library's usual mechanism

for locating Kerberos realms is used to determine whether a domain is a valid realm—which may involve consulting DNS if `dns.lookup_kdc` is set. The default is not to search domain components.

extra_addresses

This allows a computer to use multiple local addresses, in order to allow Kerberos to work in a network that uses NATs. The addresses should be in a comma-separated list.

udp_preference_limit

When sending a message to the KDC, the library will try using TCP before UDP if the size of the message is above `udp_preference_list`. If the message is smaller than `udp_preference_list`, then UDP will be tried before TCP. Regardless of the size, both protocols will be tried if the first attempt fails.

verify_ap_req_nofail

If this flag is set, then an attempt to get initial credentials will fail if the client machine does not have a keytab. The default for the flag is not set.

ticket_lifetime

The value of this tag is the default lifetime for initial tickets. The default value for the tag is 1 day.

renew_lifetime

The value of this tag is the default renewable lifetime for initial tickets. The default value for the tag is 0.

noaddresses

Setting this flag causes the initial Kerberos ticket to be addressless. The default for the flag is set.

forwardable

If this flag is set, initial tickets by default will be forwardable. The default value for this flag is not set.

proxiable If this flag is set, initial tickets by default will be proxiable. The default value for this flag is not set.

rdns If set to false, prevent the use of reverse DNS resolution when translating host-names into service principal names. Defaults to true. Setting this flag to false is more secure, but may force users to exclusively use fully qualified domain names when authenticating to services.

3.3.2 [appdefaults]

Each tag in the [appdefaults] section names a Kerberos V5 application or an option that is used by some Kerberos V5 application[s]. The value of the tag defines the default behaviors for that application.

For example:

```
[appdefaults]
  telnet = {
    ATHENA.MIT.EDU = {
      option1 = false
    }
  }
  telnet = {
    option1 = true
    option2 = true
  }
  ATHENA.MIT.EDU = {
    option2 = false
  }
  option2 = true
```

The above four ways of specifying the value of an option are shown in order of decreasing precedence. In this example, if telnet is running in the realm EXAMPLE.COM, it should, by default, have option1 and option2 set to true. However, a telnet program in the realm ATHENA.MIT.EDU should have option1 set to false and option2 set to true. Any other programs in ATHENA.MIT.EDU should have option2 set to false by default. Any programs running in other realms should have option2 set to true.

The list of specifiable options for each application may be found in that application's man pages. The application defaults specified here are overridden by those specified in the [realms] section.

3.3.3 [login]

Each tag in the [login] section of the file is an option for login.krb5. This section may contain any of the following relations:

krb5_get_tickets

Indicate whether or not to use a user's password to get V5 tickets. The default value is true.

krb_run_aklog

Indicate whether or not to run aklog. The default value is false.

aklog_path

Indicate where to find aklog. The default value is \$(prefix)/bin/aklog.

accept_passwd

A true value will cause login not to accept plaintext passwords. The default value is false. This is not yet implemented.

3.3.4 [realms]

Each tag in the [realms] section of the file is the name of a Kerberos realm. The value of the tag is a subsection with relations that define the properties of that particular realm. For each realm, the following tags may be specified in the realm's subsection:

kdc

The name or address of a host running a KDC for that realm. An optional port number, separated from the hostname by a colon, may be included. If the name or address contains colons (for example, if it is an IPv6 address), enclose

it in square brackets to distinguish the colon from a port separator. For your computer to be able to communicate with the KDC for each realm, this tag must be given a value in each realm subsection in the configuration file, or there must be DNS SRV records specifying the KDCs (see Chapter 4 [Using DNS], page 35).

master_kdc

Identifies the master KDC(s). Currently, this tag is used in only one case: If an attempt to get credentials fails because of an invalid password, the client software will attempt to contact the master KDC, in case the user's password has just been changed, and the updated database has not been propagated to the slave servers yet.

database_module

This relation indicates the name of the configuration section under [dbmodules] for database specific parameters used by the loadable database library.

admin_server

Identifies the host where the administration server is running. Typically, this is the master Kerberos server. This tag must be given a value in order to communicate with the kadmin server for the realm.

default_domain

This tag is used for Kerberos 4 compatibility. Kerberos 4 does not require the entire hostname of a server to be in its principal like Kerberos 5 does. This tag provides the domain name needed to produce a full hostname when translating V4 principal names into V5 principal names. All servers in this realm are assumed to be in the domain given as the value of this tag

v4_instance_convert

This subsection allows the administrator to configure exceptions to the default_domain mapping rule. It contains V4 instances (the tag name) which should be translated to some specific hostname (the tag value) as the second component in a Kerberos V5 principal name.

v4_realm This relation is used by the krb524 library routines when converting a V5 principal name to a V4 principal name. It is used when the V4 realm name and the V5 realm name are not the same, but still share the same principal names and passwords. The tag value is the Kerberos V4 realm name.

auth_to_local_names

This subsection allows you to set explicit mappings from principal names to local user names. The tag is the mapping name, and the value is the corresponding local user name.

auth_to_local

This tag allows you to set a general rule for mapping principal names to local user names. It will be used if there is not an explicit mapping for the principal name that is being translated. The possible values are:

DB:*filename*

The principal will be looked up in the database *filename*. Support for this is not currently compiled in by default.

RULE:*exp* The local name will be formulated from *exp*.

The format for *exp* is `[n:string](regex)s/pattern/replacement/g`. The integer *n* indicates how many components the target principal should have. If this matches, then a string will be formed from *string*, substituting the realm of the principal for `$0` and the *n*'th component of the principal for `$n` (e.g. if the principal was `johndoe/admin` then `[2:$2$1foo]` would result in the string `"adminjohndoefoo"`). If this string matches *regex*, then the `s//[g]` substitution command will be run over the string. The optional *g* will cause the substitution to be global over the string, instead of replacing only the first match in the string.

DEFAULT

The principal name will be used as the local user name. If the principal has more than one component or is not in the default realm, this rule is not applicable and the conversion will fail.

For example:

```
[realms]
  ATHENA.MIT.EDU = {
    auth_to_local = RULE:[2:$1](johndoe)s/^.*$/guest/
    auth_to_local = RULE:[2:$1;$2](^.*;admin$)s/;admin$/
    auth_to_local = RULE:[2:$2](^.*;root)s/^.*$/root/
    auto_to_local = DEFAULT
  }
```

would result in any principal without `root` or `admin` as the second component to be translated with the default rule. A principal with a second component of `admin` will become its first component. `root` will be used as the local name for any principal with a second component of `root`. The exception to these two rules are any principals `johndoe/*`, which will always get the local name `guest`.

3.3.5 [domain_realm]

The `[domain_realm]` section provides a translation from a domain name or hostname to a Kerberos realm name. The tag name can be a host name, or a domain name, where domain names are indicated by a prefix of a period (`'.'`). The value of the relation is the Kerberos realm name for that particular host or domain. Host names and domain names should be in lower case.

If no translation entry applies, the host's realm is considered to be the hostname's domain portion converted to upper case. For example, the following `[domain_realm]` section:

```
[domain_realm]
  .mit.edu = ATHENA.MIT.EDU
  mit.edu = ATHENA.MIT.EDU
  crash.mit.edu = TEST.ATHENA.MIT.EDU
  example.com = EXAMPLE.COM
```

maps `crash.mit.edu` into the `TEST.ATHENA.MIT.EDU` realm. All other hosts in the `mit.edu` domain will map by default to the `ATHENA.MIT.EDU` realm, and all hosts in the `example.com` domain will map by default into the `EXAMPLE.COM` realm. Note the entries for the hosts `mit.edu` and `example.com`. Without these entries, these hosts would be mapped into the Kerberos realms `'EDU'` and `'ORG'`, respectively.

3.3.6 [logging]

The [logging] section indicates how a particular entity is to perform its logging. The relations in this section assign one or more values to the entity name. Currently, the following entities are used:

| | |
|---------------------|---|
| kdc | These entries specify how the KDC is to perform its logging. |
| admin_server | These entries specify how the administrative server is to perform its logging. |
| default | These entries specify how to perform logging in the absence of explicit specifications otherwise. |

Values are of the following forms:

FILE=<filename>

FILE:<filename>

This value causes the entity's logging messages to go to the specified file. If the '=' form is used, the file is overwritten. If the ':' form is used, the file is appended to.

STDERR This value causes the entity's logging messages to go to its standard error stream.

CONSOLE

This value causes the entity's logging messages to go to the console, if the system supports it.

DEVICE=<devicename>

This causes the entity's logging messages to go to the specified device.

SYSLOG[:<severity>[:<facility>]]

This causes the entity's logging messages to go to the system log.

The *severity* argument specifies the default severity of system log messages. This may be any of the following severities supported by the `syslog(3)` call, minus the `LOG_` prefix: `LOG_EMERG`, `LOG_ALERT`, `LOG_CRIT`, `LOG_ERR`, `LOG_WARNING`, `LOG_NOTICE`, `LOG_INFO`, and `LOG_DEBUG`. For example, a value of 'CRIT' would specify `LOG_CRIT` severity.

The *facility* argument specifies the facility under which the messages are logged. This may be any of the following facilities supported by the `syslog(3)` call minus the `LOG_` prefix: `LOG_KERN`, `LOG_USER`, `LOG_MAIL`, `LOG_DAEMON`, `LOG_AUTH`, `LOG_LPR`, `LOG_NEWS`, `LOG_UUCP`, `LOG_CRON`, and `LOG_LOCAL0` through `LOG_LOCAL7`.

If no severity is specified, the default is `ERR`. If no facility is specified, the default is `AUTH`.

In the following example, the logging messages from the KDC will go to the console and to the system log under the facility `LOG_DAEMON` with default severity of `LOG_INFO`; and the logging messages from the administrative server will be appended to the file `/var/adm/kadmin.log` and sent to the device `/dev/tty04`.

```
[logging]
kdc = CONSOLE
kdc = SYSLOG:INFO:DAEMON
admin_server = FILE:/var/adm/kadmin.log
admin_server = DEVICE=/dev/tty04
```

3.3.7 [capaths]

In order to perform direct (non-hierarchical) cross-realm authentication, a database is needed to construct the authentication paths between the realms. This section defines that database.

A client will use this section to find the authentication path between its realm and the realm of the server. The server will use this section to verify the authentication path used by the client, by checking the transited field of the received ticket.

There is a tag for each participating realm, and each tag has subtags for each of the realms. The value of the subtags is an intermediate realm which may participate in the cross-realm authentication. The subtags may be repeated if there is more than one intermediate realm. A value of "." means that the two realms share keys directly, and no intermediate realms should be allowed to participate.

There are n^2 possible entries in this table, but only those entries which will be needed on the client or the server need to be present. The client needs a tag for its local realm, with subtags for all the realms of servers it will need to authenticate with. A server needs a tag for each realm of the clients it will serve.

For example, ANL.GOV, PNL.GOV, and NERSC.GOV all wish to use the ES.NET realm as an intermediate realm. ANL has a sub realm of TEST.ANL.GOV which will authenticate with NERSC.GOV but not PNL.GOV. The [capaths] section for ANL.GOV systems would look like this:

```
[capaths]
ANL.GOV = {
    TEST.ANL.GOV = .
    PNL.GOV = ES.NET
    NERSC.GOV = ES.NET
    ES.NET = .
}
TEST.ANL.GOV = {
    ANL.GOV = .
}
PNL.GOV = {
    ANL.GOV = ES.NET
}
NERSC.GOV = {
    ANL.GOV = ES.NET
}
ES.NET = {
    ANL.GOV = .
}
```

The [capaths] section of the configuration file used on NERSC.GOV systems would look like this:

```
[capaths]
  NERSC.GOV = {
    ANL.GOV = ES.NET
    TEST.ANL.GOV = ES.NET
    TEST.ANL.GOV = ANL.GOV
    PNL.GOV = ES.NET
    ES.NET = .
  }
  ANL.GOV = {
    NERSC.GOV = ES.NET
  }
  PNL.GOV = {
    NERSC.GOV = ES.NET
  }
  ES.NET = {
    NERSC.GOV = .
  }
  TEST.ANL.GOV = {
    NERSC.GOV = ANL.GOV
    NERSC.GOV = ES.NET
  }
}
```

In the above examples, the ordering is not important, except when the same subtag name is used more than once. The client will use this to determine the path. (It is not important to the server, since the transited field is not sorted.)

This feature is not currently supported by DCE. DCE security servers can be used with Kerberized clients and servers, but versions prior to DCE 1.1 did not fill in the transited field, and should be used with caution.

3.3.8 [dbdefaults]

The [dbdefaults] section provides default values for the database specific parameters. It can also specify the configuration section under [dbmodules] section for database specific parameters used by the database library.(see Section 3.3.9 [dbmodules], page 20).

The following tags are used in this section:

database_module

This relation indicates the name of the configuration section under the [dbmodules] for database specific parameters used by the loadable database library.

ldap_kerberos_container_dn

This LDAP specific tag indicates the DN of the container object where the realm objects will be located. This value is used if the container object is not mentioned in the configuration section under [dbmodules].

ldap_kdc_dn

This LDAP specific tag indicates the default bind DN for the KDC server. The KDC server does a login to the directory as this object. This object should have the rights to read the Kerberos data in the LDAP database. This value is

used if the bind DN for the KDC is not mentioned in the configuration section under [dbmodules].

ldap_kadmin_dn

This LDAP specific tag indicates the default bind DN for the Administration server. The administration server does a login to the directory as this object. This object should have the rights to read and write the Kerberos data in the LDAP database. This value is used if the bind DN for the Administration server is not mentioned in the configuration section under [dbmodules].

ldap_service_password_file

This LDAP specific tag indicates the file containing the stashed passwords (created by `kdb5_ldap_util stashsrvpw`) for the objects used by the Kerberos servers to bind to the LDAP server. This file must be kept secure. This value is used if no service password file is mentioned in the configuration section under [dbmodules].

ldap_servers

This LDAP specific tag indicates the list of LDAP servers that the Kerberos servers can connect to. The list of LDAP servers is whitespace-separated. The LDAP server is specified by a LDAP URI. This value is used if no LDAP servers are mentioned in the configuration section under [dbmodules]. It is recommended to use the `ldapi://` or `ldaps://` interface and not to use `ldap://` interface.

ldap_conns_per_server

This LDAP specific tag indicates the number of connections to be maintained per LDAP server. This value is used if the number of connections per LDAP server are not mentioned in the configuration section under [dbmodules]. The default value is 5.

3.3.9 [dbmodules]

Contains database specific parameters used by the database library. Each tag in the [dbmodules] section of the file names a configuration section for database specific parameters that can be referred to by a realm. The value of the tag is a subsection where the relations in that subsection define the database specific parameters.

For each section, the following tags may be specified in the subsection:

db_library This tag indicates the name of the loadable database library. The value should be 'db2' for DB2 database and 'kldap' for LDAP database.

database_name

This DB2-specific tag indicates the location of the database in the filesystem. The default is
`/usr/local/var/krb5kdc/principal.`

disable_last_success

If set to `true`, suppresses KDC updates to the "Last successful authentication" field of principal entries requiring preauthentication. Setting this flag may im-

prove performance. (Principal entries which do not require preauthentication never update the “Last successful authentication” field.)

disable_lockout

If set to **true**, suppresses KDC updates to the “Last failed authentication” and “Failed password attempts” fields of principal entries requiring preauthentication. Setting this flag may improve performance, but also disables account lockout.

ldap_kerberos_container_dn

This LDAP specific tag indicates the DN of the container object where the realm objects will be located.

ldap_kdc_dn

This LDAP specific tag indicates the default bind DN for the KDC server. The KDC server does a login to the directory as this object. This object should have the rights to read the Kerberos data in the LDAP database.

ldap_kadmin_dn

This LDAP specific tag indicates the default bind DN for the Administration server. The administration server does a login to the directory as this object. This object should have the rights to read and write the Kerberos data in the LDAP database.

ldap_service_password_file

This LDAP specific tag indicates the file containing the stashed passwords (created by `kdb5_ldap_util stashsrvpw`) for the objects used by the Kerberos servers to bind to the LDAP server. This file must be kept secure.

ldap_servers

This LDAP specific tag indicates the list of LDAP servers that the Kerberos servers can connect to. The list of LDAP servers is whitespace-separated. The LDAP server is specified by a LDAP URI. It is recommended to use `ldapi://` or `ldaps://` interface to connect to the LDAP server.

ldap_conns_per_server

This LDAP specific tags indicates the number of connections to be maintained per LDAP server.

3.3.10 Plugins

Tags in the `[plugins]` section can be used to register dynamic plugin modules and to turn modules on and off. Not every `krb5` pluggable interface uses the `[plugins]` section; the ones that do are documented here.

Each pluggable interface corresponds to a subsection of `[plugins]`. All subsections support the same tags:

module This tag may have multiple values. Each value is a string of the form `"module:pathname"`, which causes the shared object located at `pathname` to be registered as a dynamic module named `module` for the pluggable inter-

face. If pathname is not an absolute path, it will be treated as relative to the "krb5/plugins" subdirectory of the krb5 library directory.

enable_only

This tag may have multiple values. If there are values for this tag, then only the named modules will be enabled for the pluggable interface.

disable

This tag may have multiple values. If there are values for this tag, then the named modules will be disabled for the pluggable interface.

The following subsections are currently supported within the [plugins] section:

3.3.10.1 pwqual interface

The pwqual subsection controls modules for the password quality interface, which is used to reject weak passwords when passwords are changed. In addition to any registered dynamic modules, the following built-in modules exist (and may be disabled with the disable tag):

| | |
|---------------|---|
| dict | Checks against the realm dictionary file |
| empty | Rejects empty passwords |
| hesiod | Checks against user information stored in Hesiod (only if Kerberos was built with Hesiod support) |
| princ | Checks against components of the principal name |

3.3.10.2 kadm5_hook interface

The kadm5_hook interface provides plugins with information on principal creation, modification, password changes and deletion. This interface can be used to write a plugin to synchronize MIT Kerberos with another database such as Active Directory. No plugins are built in for this interface.

3.3.10.3 clpreauth interface

The clpreauth and kdcpreauth interfaces allow plugin modules to provide client and KDC preauthentication mechanisms. The following built-in modules exist:

pkinit This module implements the PKINIT preauthentication mechanism.

encrypted_challenge

This module implements the encrypted challenge FAST factor.

encrypted_timestamp

This module implements the encrypted timestamp mechanism.

3.3.11 pkinit options

The following are **pkinit-specific** options. Note that these values may be specified in [libdefaults] as global defaults, or within a realm-specific subsection of [libdefaults], or may be specified as realm-specific values in the [realms] section. Also note that a realm-specific value over-rides, does not add to, a generic [libdefaults] specification. The search order is:

1. realm-specific subsection of [libdefaults]

```
[libdefaults]
    EXAMPLE.COM = {
        pkinit_anchors = FILE:/usr/local/example.com.crt
    }
```


2. realm-specific value in the `[realms]` section,

```
[realms]
  OTHERREALM.ORG = {
    pkinit_anchors = FILE:/usr/local/otherrealm.org.crt
  }
```

3. generic value in the `[libdefaults]` section.

```
[libdefaults]
  pkinit_anchors = DIR:/usr/local/generic_trusted_cas/
```

3.3.11.1 Specifying pkinit identity information

The syntax for specifying Public Key identity, trust, and revocation information for pkinit is as follows:

FILE:*file-name*[,*key-file-name*]

This option has context-specific behavior.

pkinit_identity

pkinit_identities

file-name specifies the name of a PEM-format file containing the user's certificate. If *key-file-name* is not specified, the user's private key is expected to be in *file-name* as well. Otherwise, *key-file-name* is the name of the file containing the private key.

pkinit_anchors

pkinit_pool

file-name is assumed to be the name of an OpenSSL-style ca-bundle file.

DIR:*directory-name*

This option has context-specific behavior.

pkinit_identity

pkinit_identities

directory-name specifies a directory with files named **.crt* and **.key*, where the first part of the file name is the same for matching pairs of certificate and private key files. When a file with a name ending with *.crt* is found, a matching file ending with *.key* is assumed to contain the private key. If no such file is found, then the certificate in the *.crt* is not used.

pkinit_anchors

pkinit_pool

directory-name is assumed to be an OpenSSL-style hashed CA directory where each CA cert is stored in a file named *hash-of-ca-cert.#*. This infrastructure is encouraged, but all files in the directory will be examined and if they contain certificates (in PEM format), they will be used.

pkinit_revoke

directory-name is assumed to be an OpenSSL-style hashed CA directory where each revocation list is stored in a file named *hash-*

of-ca-cert.r#. This infrastructure is encouraged, but all files in the directory will be examined and if they contain a revocation list (in PEM format), they will be used.

PKCS12:*pkcs12-file-name*

pkcs12-file-name is the name of a PKCS #12 format file, containing the user's certificate and private key.

PKCS11:*[module_name=]module-name[:slotid=slot-id][:token=token-label][:certid=cert-id][:certlabel=cert-label]*

All keyword/values are optional. *module-name* specifies the location of a library implementing PKCS #11. If a value is encountered with no keyword, it is assumed to be the *module-name*. If no *module-name* is specified, the default is **opensc-pkcs11.so**. **slotid=** and/or **token=** may be specified to force the use of a particular smart card reader or token if there is more than one available. **certid=** and/or **certlabel=** may be specified to force the selection of a particular certificate on the device. See the **pkinit_cert_match** configuration option for more ways to select a particular certificate to use for pkinit.

ENV:*environment-variable-name*

environment-variable-name specifies the name of an environment variable which has been set to a value conforming to one of the previous values. For example, **ENV:X509_PROXY**, where environment variable **X509_PROXY** has been set to **FILE:/tmp/my_proxy.pem**.

3.3.11.2 pkinit krb5.conf options

pkinit_identities

Specifies the location(s) to be used to find the user's X.509 identity information. This option may be specified multiple times. Each value is attempted in order until identity information is found and authentication is attempted. Note that these values are **not** used if the user specifies **X509_user_identity** on the command line.

pkinit_anchors

Specifies the location of trusted anchor (root) certificates which the client trusts to sign KDC certificates. This option may be specified multiple times. These values from the config file are **not** used if the user specifies **X509_anchors** on the command line.

pkinit_pool

Specifies the location of intermediate certificates which may be used by the client to complete the trust chain between a KDC certificate and a trusted anchor. This option may be specified multiple times.

pkinit_revoke

Specifies the location of Certificate Revocation List (CRL) information to be used by the client when verifying the validity of the KDC certificate presented. This option may be specified multiple times.

pkinit_require_crl_checking

The default certificate verification process will always check the available revocation information to see if a certificate has been revoked. If a match is found

for the certificate in a CRL, verification fails. If the certificate being verified is not listed in a CRL, or there is no CRL present for its issuing CA, and `pkinit_require_crl_checking` is `false`, then verification succeeds.

However, if `pkinit_require_crl_checking` is `true` and there is no CRL information available for the issuing CA, then verification fails.

`pkinit_require_crl_checking` should be set to `true` if the policy is such that up-to-date CRLs **must** be present for every CA.

pkinit_dh_min_bits

Specifies the size of the Diffie-Hellman key the client will attempt to use. The acceptable values are currently 1024, 2048, and 4096. The default is 2048.

pkinit_win2k

This flag specifies whether the target realm is assumed to support only the *old*, pre-RFC version of the protocol. The default is `false`.

pkinit_win2k_require_binding

If this flag is set to `true`, it expects that the target KDC is patched to return a reply with a checksum rather than a nonce. The default is `false`.

pkinit_eku_checking

This option specifies what Extended Key Usage value the KDC certificate presented to the client must contain. (**Note** that if the KDC certificate has the `pkinit_SubjectAlternativeName` encoded as the Kerberos TGS name, ECU checking is not necessary since the issuing CA has certified this as a KDC certificate.) The values recognized in the `krb5.conf` file are:

kpKDC This is the default value and specifies that the KDC must have the `id-pkinit-KPKdc` ECU as defined in RFC4556.

kpServerAuth

If `kpServerAuth` is specified, a KDC certificate with the `id-kp-serverAuth` ECU as used by Microsoft will be accepted.

none If `none` is specified, then the KDC certificate will not be checked to verify it has an acceptable ECU. The use of this option is **not recommended**.

pkinit_kdc_hostname

The presense of this option indicates that the client is willing to accept a KDC certificate with a `dNSName SAN` (Subject Alternative Name) rather than requiring the `id-pkinit-san` as defined in RFC4556. This option may be specified multiple times. Its value should contain the acceptable hostname for the KDC (as contained in its certificate).

pkinit_cert_match

Specifies matching rules that the client certificate must match before it is used to attempt `pkinit` authentication. If a user has multiple certificates available (on a smart card, or via other media), there must be exactly one certificate chosen before attempting `pkinit` authentication. This option may be specified multiple times. All the available certificates are checked against each rule in order until there is a match of exactly one certificate.

The Subject and Issuer comparison strings are the RFC2253 string representations from the certificate Subject DN and Issuer DN values.

The syntax of the matching rules is:

```
[relation-operator]component-rule ...
```

where

relation-operator

can be either **&&**, meaning all component rules must match, or **||**, meaning only one component rule must match. The default is **&&** if not specified.

component-rule

can be one of the following. Note that there is no punctuation or whitespace between component rules.

<SUBJECT>*regular-expression*

<ISSUER>*regular-expression*

<SAN>*regular-expression*

<EKU>*extended-key-usage-list*

where *extended-key-usage-list* is a comma-separated list of required Extended Key Usage values. All values in the list must be present in the certificate.

```
pkinit
msScLogin
clientAuth
emailProtection
```

<KU>*key-usage-list*

where *key-usage-list* is a comma-separated list of required Key Usage values. All values in the list must be present in the certificate.

```
digitalSignature
keyEncipherment
```

Examples:

```
pkinit_cert_match = ||<SUBJECT>.*DoE.*<SAN>.*@EXAMPLE.COM
pkinit_cert_match = &&<EKU>msScLogin,clientAuth<ISSUER>.*DoE.*
pkinit_cert_match = <EKU>msScLogin,clientAuth<KU>digitalSignature
```

3.3.12 Sample krb5.conf File

Here is an example of a generic `krb5.conf` file:

```

[libdefaults]
    default_realm = ATHENA.MIT.EDU
    default_tkt_enctypes = des3-hmac-sha1 des-cbc-crc
    default_tgs_enctypes = des3-hmac-sha1 des-cbc-crc
    dns_lookup_kdc = true
    dns_lookup_realm = false

[realms]
    ATHENA.MIT.EDU = {
        kdc = kerberos.mit.edu
        kdc = kerberos-1.mit.edu
        kdc = kerberos-2.mit.edu:750
        admin_server = kerberos.mit.edu
        master_kdc = kerberos.mit.edu
        default_domain = mit.edu
    }
    EXAMPLE.COM = {
        kdc = kerberos.example.com
        kdc = kerberos-1.example.com
        admin_server = kerberos.example.com
    }
    OPENLDAP.MIT.EDU = {
        kdc = kerberos.mit.edu
        admin_server = kerberos.mit.edu
        database_module = openldap_ldapconf
    }

[domain_realm]
    .mit.edu = ATHENA.MIT.EDU
    mit.edu = ATHENA.MIT.EDU

[capaths]
    ATHENA.MIT.EDU = {
        EXAMPLE.COM = .
    }
    EXAMPLE.COM = {
        ATHENA.MIT.EDU = .
    }

[logging]
    kdc = SYSLOG:INFO
    admin_server = FILE=/var/kadm5.log

[dbdefaults]
    ldap_kerberos_container_dn = cn=krbcontainer,dc=example,dc=com

[dbmodules]
    openldap_ldapconf = {
        db_library = kldap
        ldap_kerberos_container_dn = cn=krbcontainer,dc=example,dc=com
        ldap_kdc_dn = "cn=krbadmin,dc=example,dc=com"
        # this object needs to have read rights on
        # the realm container and principal subtrees
        ldap_kadmind_dn = "cn=krbadmin,dc=example,dc=com"
        # this object needs to have read and write rights on
        # the realm container and principal subtrees
        ldap_service_password_file = /etc/kerberos/service.keyfile
        ldap_servers = ldaps://kerberos.mit.edu
        ldap_conns_per_server = 5
    }

```

3.4 kdc.conf

The `kdc.conf` file contains KDC configuration information, including defaults used when issuing Kerberos tickets. Normally, you should install your `kdc.conf` file in the directory `/usr/local/var/krb5kdc`. You can override the default location by setting the environment variable `'KRB5_KDC_PROFILE'`.

The `kdc.conf` file is set up in the same format as the `krb5.conf` file. (See Section 3.3 [krb5.conf], page 8.) The `kdc.conf` file may contain any or all of the following three sections:

kdcdefaults

Contains default values for overall behavior of the KDC.

realms Contains subsections keyed by Kerberos realm names. Each subsection describes realm-specific information, including where to find the Kerberos servers for that realm.

logging Contains relations which determine how Kerberos programs are to perform logging.

3.4.1 [kdcdefaults]

The following relation is defined in the [kdcdefaults] section:

kdc_ports This relation lists the ports on which the Kerberos server should listen for UDP requests by default. This list is a comma separated list of integers. If this relation is not specified, the compiled-in default is 88,750, the first being the assigned Kerberos port and the second which was used by Kerberos V4.

kdc_tcp_ports

This relation lists the ports on which the Kerberos server should listen for TCP connections by default. This list is a comma separated list of integers. If this relation is not specified, the compiled-in default is not to listen for TCP connections at all.

If you wish to change this (which we do not recommend, because the current implementation has little protection against denial-of-service attacks), the standard port number assigned for Kerberos TCP traffic is port 88.

restrict_anonymous_to_tgt

This flag determines the default value of `restrict_anonymous_to_tgt` for realms. The default value is `false`.

3.4.2 [realms]

Each tag in the [realms] section of the file names a Kerberos realm. The value of the tag is a subsection where the relations in that subsection define KDC parameters for that particular realm.

For each realm, the following tags may be specified in the [realms] subsection:

acl_file (String.) Location of the access control list (acl) file that kadmin uses to determine which principals are allowed which permissions on the database. The default is `/usr/local/var/krb5kdc/kadm5.acl`.

admin_keytab (String.) Location of the keytab file that the legacy administration daemons `kadmin4` and `v5passwd` use to authenticate to the database. The default is `/usr/local/var/krb5kdc/kadm5.keytab`.

default_principal_expiration

(Absolute time string.) Specifies the default expiration date of principals created in this realm. The default value for this tag is 0.

default_principal_flags

(Flag string.) Specifies the default attributes of principals created in this realm. The format for this string is a comma-separated list of flags, with '+' before each flag that should be enabled and '-' before each flag that should be disabled. The default is `postdateable, forwardable, tgt-based, renewable, proxiability, dup-skey, allow-tickets, and service enabled..`

There are a number of possible flags:

postdateable

Enabling this flag allows the principal to obtain postdateable tickets.

forwardable

Enabling this flag allows the principal to obtain forwardable tickets.

tgt-based Enabling this flag allows a principal to obtain tickets based on a ticket-granting-ticket, rather than repeating the authentication process that was used to obtain the TGT.

renewable Enabling this flag allows the principal to obtain renewable tickets.

proxiability Enabling this flag allows the principal to obtain proxy tickets.

dup-skey Enabling this flag allows the principal to obtain a session key for another user, permitting user-to-user authentication for this principal.

allow-tickets

Enabling this flag means that the KDC will issue tickets for this principal. Disabling this flag essentially deactivates the principal within this realm.

preauth

If this flag is enabled on a client principal, then that principal is required to preauthenticate to the KDC before receiving any tickets. On a service principal, enabling this flag means that service tickets

| | |
|------------------|---|
| | for this principal will only be issued to clients with a TGT that has the preauthenticated ticket set. |
| hwauth | If this flag is enabled, then the principal is required to preauthenticate using a hardware device before receiving any tickets. |
| pwchange | Enabling this flag forces a password change for this principal. |
| service | Enabling this flag allows the the KDC to issue service tickets for this principal. |
| pwservice | If this flag is enabled, it marks this principal as a password change service. This should only be used in special cases, for example, if a user's password has expired, then the user has to get tickets for that principal without going through the normal password authentication in order to be able to change the password. |

- dict_file** (String.) Location of the dictionary file containing strings that are not allowed as passwords. If none is specified or if there is no policy assigned to the principal, no dictionary checks of passwords will be performed.
- kadmin_port** (Port number.) Specifies the port on which the kadmin daemon is to listen for this realm. The assigned port for kadmin is 749.
- kpasswd_port** (Port number.) Specifies the port on which the kpasswd daemon is to listen for this realm. The default is 464.
- key_stash_file** (String.) Specifies the location where the master key has been stored (via `kdb5_util stash`). The default is `/usr/local/var/krb5kdc/.k5.REALM`, where *REALM* is the Kerberos realm.
- kdc_ports** (String.) Specifies the list of ports that the KDC is to listen to for UDP requests for this realm. By default, the value of `kdc_ports` as specified in the `[kdcdefaults]` section is used.
- kdc_tcp_ports** (String.) Specifies the list of ports that the KDC is to listen to for TCP requests for this realm. By default, the value of `kdc_tcp_ports` as specified in the `[kdcdefaults]` section is used.
- master_key_name** (String.) Specifies the name of the principal associated with the master key. The default is K/M.
- master_key_type** (Key type string.) Specifies the master key's key type. The default value for this is `des3-cbc-sha1`. For a list of all possible values, see Section 3.1 [Supported Encryption Types], page 7.
- max_life** (Delta time string.) Specifies the maximum time period for which a ticket may be valid in this realm. The default value is 24 hours.
- max_renewable_life** (Delta time string.) Specifies the maximum time period during which a valid ticket may be renewed in this realm. The default value is 0.
- supported_encetypes** List of key:salt strings. Specifies the default key/salt combinations of principals for this realm. Any principals created through `kadmin` will have keys of these types. The default value for this tag is `aes256-cts-hmac-sha1-96:normal aes128-cts-hmac-sha1-96:normal des3-cbc-sha1:normal arcfour-hmac-md5:normal`. For lists of possible values, see Section 3.1 [Supported Encryption Types], page 7 and Section 3.2 [Salts], page 8.
- reject_bad_transit** A boolean value (`true`, `false`). If set to `true`, the KDC will check the list of transited realms for cross-realm tickets against the transit path computed from the realm names and the `capaths` section of its `krb5.conf` file; if the path in the ticket to be issued contains any realms not in the computed path, the ticket will not be issued, and an error will be returned to the client instead. If this

value is set to **false**, such tickets will be issued anyways, and it will be left up to the application server to validate the realm transit path.

If the **disable-transited-check** flag is set in the incoming request, this check is not performed at all. Having the **reject_bad_transit** option will cause such ticket requests to be rejected always.

This transit path checking and config file option currently apply only to TGS requests.

Earlier versions of the MIT release (before 1.2.3) had bugs in the application server support such that the server-side checks may not be performed correctly. We recommend turning this option on, unless you know that all application servers in this realm have been updated to fixed versions of the software, and for whatever reason, you don't want the KDC to do the validation.

This is a per-realm option so that multiple-realm KDCs may control it separately for each realm, in case (for example) one realm has had the software on its application servers updated but another has not.

This option defaults to **true**.

restrict_anonymous_to_tgt

A boolean value (**true**, **false**). If set to **true**, the KDC will reject ticket requests from anonymous principals to service principals other than the realm's ticket-granting service. This option allows anonymous PKINIT to be enabled for use as FAST armor tickets without allowing anonymous authentication to services. By default, the value of **restrict_anonymous_to_tgt** as specified in the **[kdcdefaults]** section is used.

3.4.3 pkinit options

The following are **pkinit-specific** options. Note that these values may be specified in **[kdcdefaults]** as global defaults, or within a realm-specific subsection of **[realms]**. Also note that a realm-specific value over-rides, does not add to, a generic **[kdcdefaults]** specification. The search order is:

1. realm-specific subsection of **[realms]**

```
[realms]
  EXAMPLE.COM = {
    pkinit_anchors = FILE:/usr/local/example.com.crt
  }
```

2. generic value in the **[kdcdefaults]** section.

```
[kdcdefaults]
  pkinit_anchors = DIR:/usr/local/generic_trusted_cas/
```

3.4.3.1 pkinit kdc.conf options

For information about the syntax of some of these options, see See Section 3.3.11.1 [pkinit identity syntax], page 23.

pkinit_identity

Specifies the location of the KDC's X.509 identity information. This option is **required** if pkinit is to be supported by the KDC.

pkinit_anchors

Specifies the location of trusted anchor (root) certificates which the KDC trusts to sign client certificates. This option is **required** if pkinit is to be supported by the KDC. This option may be specified multiple times.

pkinit_pool

Specifies the location of intermediate certificates which may be used by the KDC to complete the trust chain between a client's certificate and a trusted anchor. This option may be specified multiple times.

pkinit_revoke

Specifies the location of Certificate Revocation List (CRL) information to be used by the KDC when verifying the validity of client certificates. This option may be specified multiple times.

pkinit_require_crl_checking

The default certificate verification process will always check the available revocation information to see if a certificate has been revoked. If a match is found for the certificate in a CRL, verification fails. If the certificate being verified is not listed in a CRL, or there is no CRL present for its issuing CA, and **pkinit_require_crl_checking** is **false**, then verification succeeds.

However, if **pkinit_require_crl_checking** is **true** and there is no CRL information available for the issuing CA, then verification fails.

pkinit_require_crl_checking should be set to **true** if the policy is such that up-to-date CRLs **must** be present for every CA.

pkinit_dh_min_bits

Specifies the minimum number of bits the KDC is willing to accept for a client's Diffie-Hellman key. The default is 2048.

pkinit_allow_upn

Specifies that the KDC is willing to accept client certificates with the Microsoft UserPrincipalName (UPN) Subject Alternative Name (SAN). This means the KDC accepts the binding of the UPN in the certificate to the Kerberos principal name.

The default is false.

Without this option, the KDC will only accept certificates with the id-pkinit-san as defined in RFC4556. There is currently no option to disable SAN checking in the KDC.

pkinit_eku_checking

This option specifies what Extended Key Usage (EKU) values the KDC is willing to accept in client certificates. The values recognized in the **kdc.conf** file are:

kpClientAuth

This is the default value and specifies that client certificates must have the id-pkinit-KPClientAuth EKU as defined in RFC4556.

scLogin

If **scLogin** is specified, client certificates with the Microsoft Smart Card Login EKU (id-ms-kp-sc-logon) will be accepted.

none If **none** is specified, then client certificates will not be checked to verify they have an acceptable EKU. The use of this option is **not recommended**.

3.4.4 Sample kdc.conf File

Here's an example of a `kdc.conf` file:

```
[kdcdefaults]
    kdc_ports = 88

[realms]
    ATHENA.MIT.EDU = {
        kadmind_port = 749
        max_life = 12h 0m 0s
        max_renewable_life = 7d 0h 0m 0s
        master_key_type = des3-hmac-sha1
        supported_encetypes = des3-hmac-sha1:normal des-cbc-crc:normal des-cbc-crc:v4
    }

[logging]
    kdc = FILE:/usr/local/var/krb5kdc/kdc.log
    admin_server = FILE:/usr/local/var/krb5kdc/kadmin.log
```

4 Using DNS

4.1 Mapping Hostnames onto Kerberos Realms

Mapping hostnames onto Kerberos realms is done in one of two ways.

The first mechanism, which has been in use for years in MIT-based Kerberos distributions, works through a set of rules in the `krb5.conf` configuration file. (See Section 3.3 [krb5.conf], page 8.) You can specify mappings for an entire domain or subdomain, and/or on a hostname-by-hostname basis. Since greater specificity takes precedence, you would do this by specifying the mappings for a given domain or subdomain and listing the exceptions.

The second mechanism works by looking up the information in special `TXT` records in the Domain Name Service. This is currently not used by default because security holes could result if the DNS `TXT` records were spoofed. If this mechanism is enabled on the client, it will try to look up a `TXT` record for the DNS name formed by putting the prefix `_kerberos` in front of the hostname in question. If that record is not found, it will try using `_kerberos` and the host's domain name, then its parent domain, and so forth. So for the hostname `BOSTON.ENGINEERING.FOOBAR.COM`, the names looked up would be:

```
_kerberos.boston.engineering.foobar.com
_kerberos.engineering.foobar.com
_kerberos.foobar.com
_kerberos.com
```

The value of the first `TXT` record found is taken as the realm name. (Obviously, this doesn't work all that well if a host and a subdomain have the same name, and different realms. For example, if all the hosts in the `ENGINEERING.FOOBAR.COM` domain are in the `ENGINEERING.FOOBAR.COM` realm, but a host named `ENGINEERING.FOOBAR.COM` is for some reason in another realm. In that case, you would set up `TXT` records for all hosts, rather than relying on the fallback to the domain name.)

Even if you do not choose to use this mechanism within your site, you may wish to set it up anyway, for use when interacting with other sites.

4.2 Hostnames for KDCs

MIT recommends that your KDCs have a predefined set of `CNAME` records (DNS hostname aliases), such as `kerberos` for the master KDC and `kerberos-1`, `kerberos-2`, . . . for the slave KDCs. This way, if you need to swap a machine, you only need to change a DNS entry, rather than having to change hostnames.

A new mechanism for locating KDCs of a realm through DNS has been added to the MIT Kerberos V5 distribution. A relatively new record type called `SRV` has been added to DNS. Looked up by a service name and a domain name, these records indicate the hostname and port number to contact for that service, optionally with weighting and prioritization. (See RFC 2782 if you want more information. You can follow the example below for straightforward cases.)

The use with Kerberos is fairly straightforward. The domain name used in the `SRV` record name is the domain-style Kerberos realm name. (It is possible to have Kerberos realm

names that are not DNS-style names, but we don't recommend it for Internet use, and our code does not support it well.) Several different Kerberos-related service names are used:

_kerberos._udp

This is for contacting any KDC by UDP. This entry will be used the most often. Normally you should list port 88 on each of your KDCs.

_kerberos._tcp

This is for contacting any KDC by TCP. The MIT KDC by default will not listen on any TCP ports, so unless you've changed the configuration or you're running another KDC implementation, you should leave this unspecified. If you do enable TCP support, normally you should use port 88.

_kerberos-master._udp

This entry should refer to those KDCs, if any, that will immediately see password changes to the Kerberos database. This entry is used only in one case, when the user is logging in and the password appears to be incorrect; the master KDC is then contacted, and the same password used to try to decrypt the response, in case the user's password had recently been changed and the first KDC contacted hadn't been updated. Only if that fails is an "incorrect password" error given.

If you have only one KDC, or for whatever reason there is no accessible KDC that would get database changes faster than the others, you do not need to define this entry.

_kerberos-adm._tcp

This should list port 749 on your master KDC. Support for it is not complete at this time, but it will eventually be used by the `kadmin` program and related utilities. For now, you will also need the `admin_server` entry in `krb5.conf`. (See Section 3.3 [krb5.conf], page 8.)

_kpasswd._udp

This should list port 464 on your master KDC. It is used when a user changes her password.

Be aware, however, that the DNS SRV specification requires that the hostnames listed be the canonical names, not aliases. So, for example, you might include the following records in your (BIND-style) zone file:

```
$ORIGIN foobar.com.
_kerberos          TXT      "FOOBAR.COM"
kerberos           CNAME    daisy
kerberos-1         CNAME    use-the-force-luke
kerberos-2         CNAME    bunny-rabbit
_kerberos._udp     SRV      0 0 88 daisy
                  SRV      0 0 88 use-the-force-luke
                  SRV      0 0 88 bunny-rabbit
_kerberos-master._udp SRV    0 0 88 daisy
_kerberos-adm._tcp SRV      0 0 749 daisy
_kpasswd._udp      SRV      0 0 464 daisy
```

As with the DNS-based mechanism for determining the Kerberos realm of a host, we recommend distributing the information this way for use by other sites that may want to interact

with yours using Kerberos, even if you don't immediately make use of it within your own site. If you anticipate installing a very large number of machines on which it will be hard to update the Kerberos configuration files, you may wish to do all of your Kerberos service lookups via DNS and not put the information (except for **admin_server** as noted above) in future versions of your **krb5.conf** files at all. Eventually, we hope to phase out the listing of server hostnames in the client-side configuration files; making preparations now will make the transition easier in the future.

5 Administrating the Kerberos Database

Your Kerberos database contains all of your realm's Kerberos principals, their passwords, and other administrative information about each principal. For the most part, you will use the `kdb5_util` program to manipulate the Kerberos database as a whole, and the `kadmin` program to make changes to the entries in the database. (One notable exception is that users will use the `kpasswd` program to change their own passwords.) The `kadmin` program has its own command-line interface, to which you type the database administrating commands.

`Kdb5_util` provides a means to create, delete, load, or dump a Kerberos database. It also includes a command to stash a copy of the master database key in a file on a KDC, so that the KDC can authenticate itself to the `kadmind` and `krb5kdc` daemons at boot time.

`Kadmin` provides for the maintenance of Kerberos principals, KADM5 policies, and service key tables (keytabs). It exists as both a Kerberos client, `kadmin`, using Kerberos authentication and an RPC, to operate securely from anywhere on the network, and as a local client, `kadmin.local`, intended to run directly on the KDC without Kerberos authentication. `kadmin.local` need not run on the kdc if the database is LDAP. Other than the fact that the remote client uses Kerberos to authenticate the person using it, the functionalities of the two versions are identical. The local version is necessary to enable you to set up enough of the database to be able to use the remote version. It replaces the now obsolete `kdb5_edit` (except for database dump and load, which are provided by `kdb5_util`).

The remote version authenticates to the KADM5 server using the service principal `kadmin/admin`. If the credentials cache contains a ticket for the `kadmin/admin` principal, and the `-c ccache` option is specified, that ticket is used to authenticate to KADM5. Otherwise, the `-p` and `-k` options are used to specify the client Kerberos principal name used to authenticate. Once `kadmin` has determined the principal name, it requests a `kadmin/admin` Kerberos service ticket from the KDC, and uses that service ticket to authenticate to KADM5.

5.1 Kadmin Options

You can invoke `kadmin` or `kadmin.local` with any of the following options:

-r *REALM*

Use *REALM* as the default Kerberos realm for the database.

-p *principal*

Use the Kerberos principal *principal* to authenticate to Kerberos. If this option is not given, `kadmin` will append `admin` to either the primary principal name, the environment variable `USER`, or to the username obtained from `getpwuid`, in order of preference.

-q *query*

Pass *query* directly to `kadmin`. This is useful for writing scripts that pass specific queries to `kadmin`.

You can invoke `kadmin` with any of the following options:

-k [-t *keytab*]

Use the keytab *keytab* to decrypt the KDC response instead of prompting for a password on the TTY. In this case, the principal will be '*host/hostname*'. If **-t** is not used to specify a keytab, then the default keytab will be used.

-c *credentials cache*

Use *credentials_cache* as the credentials cache. The credentials cache should contain a service ticket for the **kadmin/admin** service, which can be acquired with the **kinit** program. If this option is not specified, **kadmin** requests a new service ticket from the KDC, and stores it in its own temporary ccache.

-w *password*

Use *password* as the password instead of prompting for one on the TTY. Note: placing the password for a Kerberos principal with administration access into a shell script can be dangerous if unauthorized users gain read access to the script.

-x *db_args* Specifies the database specific arguments.

-x *host=<hostname>*

Specifies the LDAP server to connect to by a LDAP URI. It is recommend to use `ldapi://` or `ldaps://` interface to connect to the LDAP server.

-x *binddn=<bind_dn>*

Specifies the Distinguished Name (DN) of the object used by the administration server to bind to the LDAP server. This object should have the read and write rights on the realm container, principal container and realm subtree.

-x *bindpwd=<bind_password>*

Specifies the password for the above mentioned binddn. It is recommended not to use this option. Instead, the password can be stashed using the `stashsrpvw` command of `kdb5_ldap-util`.

Note: This database specific argument is applicable only to **kadmin.local** and the KADM5 server.

-s *admin_server[:port]*

Specifies the admin server that **kadmin** should contact.

You can invoke **kadmin.local** with an of the follwing options:

-d *dbname*

Specifies the name of the Kerberos database.

-e "*etypes ...*"

Sets the list of cryptosystem and salt types to be used for any new keys created. See Section 3.1 [Supported Encryption Types], page 7 and Section 3.2 [Salts], page 8 for available types.

-m

Do not authenticate using a keytab. This option will cause **kadmin** to prompt for the master database password.

5.2 Date Format

Many of the `kadmin` commands take a duration or time as an argument. The date can appear in a wide variety of formats, such as:

```
"15 minutes"
"7 days"
"1 month"
"2 hours"
"400000 seconds"
"next year"
"this Monday"
"next Monday"
yesterday
tomorrow
now
"second Monday"
fortnight
"3/31/1992 10:00:07 PST"
"January 23, 2007 10:05pm"
"22:00 GMT"
```

Note that if the date specification contains spaces, you must enclose it in double quotes. Note also that you cannot use a number without a unit. (I.e., `"60 seconds"` is correct, but `"60"` is incorrect.) All keywords are case-insensitive. The following is a list of all of the allowable keywords.

| | |
|--------------------------------|--|
| Months | january, jan, february, feb, march, mar, april, apr, may, june, jun, july, jul, august, aug, september, sep, sept, october, oct, november, nov, december, dec |
| Days | sunday, sun, monday, mon, tuesday, tues, tue, wednesday, wednes, wed, thursday, thurs, thur, thu, friday, fri, saturday, sat |
| Units | year, month, fortnight, week, day, hour, minute, min, second, sec |
| Relative | tomorrow, yesterday, today, now, last, this, next, first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth, ago |
| Time Zones | <code>kadmin</code> recognizes abbreviations for most of the world's time zones. A complete listing appears in Section A.2 [<code>kadmin</code> Time Zones], page 97. |
| 12-hour Time Delimiters | am, pm |

5.3 Principals

Each entry in the Kerberos database contains a Kerberos principal (see Section 2.8 [Definitions], page 5) and the attributes and policies associated with that principal.

5.3.1 Retrieving Information About a Principal

5.3.1.1 Attributes

To retrieve a listing of the attributes and/or policies associated with a principal, use the `kadmin get_principal` command, which requires the "inquire" administrative privilege. The syntax is:

```
get_principal principal
```

The `get_principal` command has the alias `getprinc`.

For example, suppose you wanted to view the attributes of the principal `jennifer/root@ATHENA.MIT.EDU`. You would type:

```
shell% kadmin
kadmin: getprinc jennifer/root
Principal: jennifer/root@ATHENA.MIT.EDU
Expiration date: [never]
Last password change: Mon Jan 31 02:06:40 EDT 2002
Password Expiration date: [none]
Maximum ticket life: 0 days 10:00:00
Maximum renewable life: 7 days 00:00:00
Last modified: Wed Jul 24 14:46:25 EDT 2002 (joeadmin/admin@ATHENA.MIT.EDU)
Last successful authentication: Mon Jul 29 18:20:17 EDT 2002
Last failed authentication: Mon Jul 29 18:18:54 EDT 2002
Failed password attempts: 3
Number of keys: 2
Key: vno 2, Triple DES cbc mode with HMAC/sha1, no salt
Key: vno 2, DES cbc mode with CRC-32, no salt
Attributes: DISALLOW_FORWARDABLE, DISALLOW_PROXIABLE
Policy: [none]
kadmin:
```

The `get_principal` command has a `-terse` option, which lists the fields as a quoted, tab-separated string. For example:

```
kadmin: getprinc -terse jennifer/root
jennifer/root@ATHENA.MIT.EDU 0 1027458564
0 36000 (joeadmin/admin@ATHENA.MIT.EDU
1027536385 18 2 0 [none] 604800 1027980137
1027980054 3 2 1 2 16 0 1
2 1 0
kadmin:
```

5.3.1.2 Retrieving a List of Principals

To generate a listing of principals, use the `kadmin list_principals` command, which requires the “list” privilege. The syntax is:

```
list_principals [expression]
```

where *expression* is a shell-style glob expression that can contain the characters ‘*’, ‘?’, ‘[’, and ‘]’. All policy names matching the expression are displayed. The `list_principals` command has the aliases `listprincs`, `get_principals`, and `getprincs`. For example:

```
kadmin: listprincs test*
test3@ATHENA.MIT.EDU
test2@ATHENA.MIT.EDU
test1@ATHENA.MIT.EDU
testuser@ATHENA.MIT.EDU
kadmin:
```

If no expression is provided, all principals are printed.

5.3.2 Privileges

Administrative privileges for the Kerberos database are stored in the file `kadm5.acl`.

The format of the file is:

```
Kerberos_principal      permissions      [target_principal] [restrictions]
```

The Kerberos principal (and optional target principal) can include the “*” wildcard, so if you want any principal with the instance “admin” to have full permissions on the database, you could use the principal “*/admin@REALM” where “REALM” is your Kerberos realm. `target_principal` can also include backreferences to `Kerberos_principal`, in which “**number*” matches the component *number* in the `Kerberos_principal`.

Note: a common use of an *admin* instance is so you can grant separate permissions (such as administrator access to the Kerberos database) to a separate Kerberos principal. For example, the user `joeadmin` might have a principal for his administrative use, called `joeadmin/admin`. This way, `joeadmin` would obtain `joeadmin/admin` tickets only when he actually needs to use those permissions.

The permissions are represented by single letters; UPPER-CASE letters represent negative permissions. The permissions are:

| | |
|----------|---|
| a | allows the addition of principals or policies in the database. |
| A | disallows the addition of principals or policies in the database. |
| d | allows the deletion of principals or policies in the database. |
| D | disallows the deletion of principals or policies in the database. |
| m | allows the modification of principals or policies in the database. |
| M | disallows the modification of principals or policies in the database. |
| c | allows the changing of passwords for principals in the database. |
| C | disallows the changing of passwords for principals in the database. |
| i | allows inquiries to the database. |
| I | disallows inquiries to the database. |
| l | allows the listing of principals or policies in the database. |
| L | disallows the listing of principals or policies in the database. |
| s | allows the explicit setting of the key for a principal |
| S | disallows the explicit setting of the key for a principal |
| * | All privileges (admcil). |
| x | All privileges (admcil); identical to “*”. |

The restrictions are a string of flags. Allowed restrictions are:

[+ -]*flagname*

flag is forced to indicated value. The permissible flags are the same as the + and - flags for the `kadmin addprinc` and `modprinc` commands.

-clearpolicy

policy is forced to clear

-policy *pol* policy is forced to be *pol*

expire *time*

pwexpire *time*

maxlife *time*

maxrenewlife *time*

associated value will be forced to MIN(*time*, requested value)

The above flags act as restrictions on any add or modify operation which is allowed due to that ACL line.

Here is an example of a `kadm5.acl` file. Note that order is important; permissions are determined by the first matching entry.

```
*/admin@ATHENA.MIT.EDU *
joeadmin@ATHENA.MIT.EDU  ADMCIL
joeadmin/*@ATHENA.MIT.EDU il */root@ATHENA.MIT.EDU
*@ATHENA.MIT.EDU cil */admin@ATHENA.MIT.EDU
*/*@ATHENA.MIT.EDU i
*/admin@EXAMPLE.COM * -maxlife 9h -postdateable
```

In the above file, any principal in the ATHENA.MIT.EDU realm with an `admin` instance has all administrative privileges. The user `joeadmin` has all permissions with his `admin` instance, `joeadmin/admin@ATHENA.MIT.EDU` (matches the first line). He has no permissions at all with his null instance, `joeadmin@ATHENA.MIT.EDU` (matches the second line). His root instance has *inquire* and *list* permissions with any other principal that has the instance `root`. Any principal in ATHENA.MIT.EDU can inquire, list, or change the password of their `admin` instance, but not any other `admin` instance. Any principal in the realm ATHENA.MIT.EDU (except for `joeadmin@ATHENA.MIT.EDU`, as mentioned above) has *inquire* privileges. Finally, any principal with an `admin` instance in EXAMPLE.COM has all permissions, but any principal that they create or modify will not be able to get postdateable tickets or tickets with a life of longer than 9 hours.

5.3.3 Adding or Modifying Principals

To add a principal to the database, use the `kadmin add_principal` command, which requires the “add” administrative privilege. This function creates the new principal, prompting twice for a password, and, if neither the `-policy` nor `-clearpolicy` options are specified and the policy “default” exists, assigns it that policy. The syntax is:

```
kadmin: add_principal [options] principal
```

To modify attributes of a principal, use the `kadmin modify_principal` command, which requires the “modify” administrative privilege. The syntax is:

```
kadmin: modify_principal [options] principal
```

`add_principal` has the aliases `addprinc` and `ank`¹. `modify_principal` has the alias `modprinc`.

The `add_principal` and `modify_principal` commands take the following switches:

-x *db_princ_args*

Denotes the database specific options. The options for LDAP database are:

-x *dn=<dn>*

Specifies the LDAP object that will contain the Kerberos principal being created.

-x *linkdn=<dn>*

Specifies the LDAP object to which the newly created Kerberos principal object will point to.

-x *containerdn=<container_dn>*

Specifies the container object under which the Kerberos principal is to be created.

-x *tktpolicy=<policy>*

Associates a ticket policy to the Kerberos principal. Specifying an empty string value clears the ticket policy associated with the principal. Note: * `dn` and `containerdn` options are not valid while modifying the principal. * `containerdn` and `linkdn` options cannot be specified with `dn` option. * If `dn` or `containerdn` options are not specified while adding the principal, the principals are created under the principal container configured in the realm or the realm container. * `dn` and `containerdn` should be within the subtrees or principal container configured in the realm.

-expire *date*

Sets the expiration date of the principal to *date*.

-pwexpire *date*

Sets the expiration date of the password to *date*.

-maxlife *maxlife*

Sets the maximum ticket life of the principal to *maxlife*.

-maxrenewlife *maxrenewlife*

Sets the maximum renewable life of tickets for the principal to *maxrenewlife*.

-kvno *number*

Explicitly sets the key version number to *number*. MIT does not recommend doing this unless there is a specific reason.

-policy *policy*

Sets the policy used by this principal. (See Section 5.4 [Policies], page 50.) With `modify_principal`, the current policy assigned to the principal is set or changed. With `add_principal`, if this option is not supplied, the `-clearpolicy`

¹ `ank` was the short form of the equivalent command using the deprecated `kadmin5` database administrative tool. It has been kept

is not specified, and the policy “default” exists, that policy is assigned. If a principal is created with no policy, `kadmin` will print a warning message.

-clearpolicy

For `modify_principal`, removes the current policy from a principal. For `add_principal`, suppresses the automatic assignment of the policy “default”.

{-|+}allow_postdated

The “-allow_postdated” option prohibits this principal from obtaining post-dated tickets. “+allow_postdated” clears this flag. In effect, “-allow_postdated” sets the `KRB5_KDB_DISALLOW_POSTDATED` flag on the principal in the database.

{-|+}allow_forwardable

The “-allow_forwardable” option prohibits this principal from obtaining forwardable tickets. “+allow_forwardable” clears this flag. In effect, “-allow_forwardable” sets the `KRB5_KDB_DISALLOW_FORWARDABLE` flag on the principal in the database.

{-|+}allow_renewable

The “-allow_renewable” option prohibits this principal from obtaining renewable tickets. “+allow_renewable” clears this flag. In effect, “-allow_renewable” sets the `KRB5_KDB_DISALLOW_RENEWABLE` flag on the principal in the database.

{-|+}allow_proxiable

The “-allow_proxiable” option prohibits this principal from obtaining proxiable tickets. “+allow_proxiable” clears this flag. In effect, “-allow_proxiable” sets the `KRB5_KDB_DISALLOW_PROXIABLE` flag on the principal in the database.

{-|+}allow_dup_skey

The “-allow_dup_skey” option disables user-to-user authentication for this principal by prohibiting this principal from obtaining a session key for another user. “+allow_dup_skey” clears this flag. In effect, “-allow_dup_skey” sets the `KRB5_KDB_DISALLOW_DUP_SKEY` flag on the principal in the database.

{-|+}requires_preauth

The “+requires_preauth” option requires this principal to preauthenticate before being allowed to kinit. -requires_preauth clears this flag. In effect, +requires_preauth sets the `KRB5_KDB_REQUIRES_PRE_AUTH` flag on the principal in the database.

{-|+}requires_hwauth

The “+requires_hwauth” flag requires the principal to preauthenticate using a hardware device before being allowed to kinit. “-requires_hwauth” clears this flag. In effect, “+requires_hwauth” sets the `KRB5_KDB_REQUIRES_HW_AUTH` flag on the principal in the database.

{-|+}allow_svr

The “-allow_svr” flag prohibits the issuance of service tickets for this principal. “+allow_svr” clears this flag. In effect, “-allow_svr” sets the `KRB5_KDB_DISALLOW_SVR` flag on the principal in the database.

{-|+}allow_tgs_req

The “-allow_tgs_req” option specifies that a Ticket-Granting Service (TGS) request for a service ticket for this principal is not permitted. You will probably never need to use this option. “+allow_tgs_req” clears this flag. The default is “+allow_tgs_req”. In effect, “-allow_tgs_req” sets the KRB5_KDB_DISALLOW_TGT_BASED flag on the principal in the database.

{-|+}allow_tix

The “-allow_tix” option forbids the issuance of any tickets for this principal. “+allow_tix” clears this flag. The default is “+allow_tix”. In effect, “-allow_tix” sets the KRB5_KDB_DISALLOW_ALL_TIX flag on the principal in the database.

{-|+}needchange

The “+needchange” option sets a flag in attributes field to force a password change; “-needchange” clears it. The default is “-needchange”. In effect, “+needchange” sets the KRB5_KDB_REQUIRES_PWCHANGE flag on the principal in the database.

{-|+}password_changing_service

The “+password_changing_service” option sets a flag in the attributes field marking this principal as a password change service. (Again, you will probably never need to use this option.) “-password_changing_service” clears the flag. The default is “-password_changing_service”. In effect, the “+password_changing_service” option sets the KRB5_KDB_PWCHANGE_SERVICE flag on the principal in the database.

{-|+}ok_as_delegate

The “+ok_as_delegate” option sets a flag in tickets issued for the service principal. Some client programs may recognize this flag as indicating that it is okay to delegate credentials to the service. If ok_as_delegate is set on a cross-realm TGT, it indicates that the foreign realm’s ok_as_delegate flags should be honored by clients in the local realm. The default is “-ok_as_delegate”.

-randkey Sets the key for the principal to a random value (**add_principal** only). MIT recommends using this option for host keys.

-pw *password*

Sets the key of the principal to the specified string and does not prompt for a password (**add_principal** only). MIT does not recommend using this option.

-e *enc:salt...*

Uses the specified list of enctype-salttype pairs for setting the key of the principal. The quotes are necessary if there are multiple enctype-salttype pairs. This will not function against kadmin daemons earlier than krb5-1.2. See Section 3.1 [Supported Encryption Types], page 7 and Section 3.2 [Salts], page 8 for available types.

-unlock Unlocks a locked principal (one which has received too many failed authentication attempts without enough time between them according to its password policy) so that it can successfully authenticate.

If you want to just use the default values, all you need to do is:

```
kadmin: addprinc jennifer
WARNING: no policy specified for "jennifer@ATHENA.MIT.EDU";
defaulting to no policy.

Enter password for principal jennifer@ATHENA.MIT.EDU: ⇐ Type the password.
Re-enter password for principal jennifer@ATHENA.MIT.EDU: ⇐ Type it again.
Principal "jennifer@ATHENA.MIT.EDU" created.
kadmin:
```

If you want to create a principal which is contained by a LDAP object, all you need to do is:

```
kadmin: addprinc -x dn=cn=jennifer,dc=example,dc=com jennifer
WARNING: no policy specified for "jennifer@ATHENA.MIT.EDU";
defaulting to no policy.

Enter password for principal jennifer@ATHENA.MIT.EDU: ⇐ Type the password.
Re-enter password for principal jennifer@ATHENA.MIT.EDU: ⇐ Type it again.
Principal "jennifer@ATHENA.MIT.EDU" created.
kadmin:
```

If you want to create a principal under a specific LDAP container and link to an existing LDAP object, all you need to do is:

```
kadmin: addprinc -x containerdn=dc=example,dc=com -x linkdn=cn=david,dc=example,dc=com david
WARNING: no policy specified for "david@ATHENA.MIT.EDU";
defaulting to no policy.

Enter password for principal david@ATHENA.MIT.EDU: ⇐ Type the password.
Re-enter password for principal david@ATHENA.MIT.EDU: ⇐ Type it again.
Principal "david@ATHENA.MIT.EDU" created.
kadmin:
```

If you want to associate a ticket policy to a principal, all you need to do is:

```
kadmin: modprinc -x tktpolicy=userpolicy david
Principal "david@ATHENA.MIT.EDU" modified.
kadmin:
```

If, on the other hand, you want to set up an account that expires on January 1, 2000, that uses a policy called “stduser”, with a temporary password (which you want the user to change immediately), you would type the following. (Note: each line beginning with ⇒ is a continuation of the previous line.)

```
kadmin: addprinc david -expire "1/1/2000 12:01am EST" -policy stduser
⇒ +needchange

Enter password for principal david@ATHENA.MIT.EDU: ⇐ Type the password.
Re-enter password for principal
david@ATHENA.MIT.EDU: ⇐ Type it again.
Principal "david@ATHENA.MIT.EDU" created.
kadmin:
```

If you will need cross-realm authentication, you need to add principals for the other realm's TGT to each realm. For example, if you need to do cross-realm authentication between the realms ATHENA.MIT.EDU and EXAMPLE.COM, you would need to add the principals

‘krbtgt/EXAMPLE.COM@ATHENA.MIT.EDU’ and ‘krbtgt/ATHENA.MIT.EDU@EXAMPLE.COM’ to both databases. You need to be sure the passwords and the key version numbers (kvno) are the same in both databases. This may require explicitly setting the kvno with the ‘-kvno’ option. See Section 5.7 [Cross-realm Authentication], page 71 for more details.

5.3.4 Deleting Principals

To delete a principal, use the `kadmin delete_principal` command, which requires the “delete” administrative privilege. The syntax is:

```
delete_principal [-force] principal
```

`delete_principal` has the alias `delprinc`. The `-force` option causes `delete_principal` not to ask if you’re sure. For example:

```
kadmin: delprinc jennifer
Are you sure you want to delete the principal
"jennifer@ATHENA.MIT.EDU"? (yes/no): yes
Principal "jennifer@ATHENA.MIT.EDU" deleted.
Make sure that you have removed this principal from
all ACLs before reusing.
kadmin:
```

5.3.5 Changing Passwords

To change a principal’s password use the `kadmin change_password` command, which requires the “modify” administrative privilege (unless the principal is changing his/her own password). The syntax is:

```
change_password [options] principal
```

The `change_password` option has the alias `cpw`. `change_password` takes the following options:

- randkey** Sets the key of the principal to a random value.
- pw *password*** Sets the password to the string *password*. MIT does not recommend using this option.
- e "*enc:salt...*"** Uses the specified list of enctype-salttype pairs for setting the key of the principal. The quotes are necessary if there are multiple enctype-salttype pairs. This will not function against `kadmin` daemons earlier than `krb5-1.2`. See Section 3.1 [Supported Encryption Types], page 7 and Section 3.2 [Salts], page 8 for possible values.
- keepold** Keeps the previous kvno’s keys around. This flag is usually not necessary except perhaps for TGS keys. Don’t use this flag unless you know what you’re doing. This option is not supported for the LDAP database

For example:

```
kadmin: cpw david
```

```
Enter password for principal david@ATHENA.MIT.EDU: ⇐ Type the new password.
```

```
Re-enter password for principal david@ATHENA.MIT.EDU: ⇐ Type it again.
```

```
Password for david@ATHENA.MIT.EDU changed.
```

```
kadmin:
```

Note that `change_password` will not let you change the password to one that is in the principal's password history.

5.4 Policies

A policy is a set of rules governing passwords. Policies can dictate minimum and maximum password lifetimes, minimum number of characters and character classes a password must contain, and the number of old passwords kept in the database.

5.4.1 Retrieving Policies

To retrieve a policy, use the `kadmin get_policy` command, which requires the “inquire” administrative privilege. The syntax is:

```
get_policy [-terse] policy
```

The `get_policy` command has the alias `getpol`. For example:

```
kadmin: get_policy admin
Policy: admin
Maximum password life: 180 days 00:00:00
Minimum password life: 00:00:00
Minimum password length: 6
Minimum number of password character classes: 2
Number of old keys kept: 5
Reference count: 17
kadmin:
```

The *reference count* is the number of principals using that policy.

The `get_policy` command has a `-terse` option, which lists each field as a quoted, tab-separated string. For example:

```
kadmin: get_policy -terse admin
admin 15552000    0    6    2    5    17
kadmin:
```

5.4.2 Retrieving the List of Policies

You can retrieve the list of policies with the `kadmin list_policies` command, which requires the “list” privilege. The syntax is:

```
list_policies [expression]
```

where *expression* is a shell-style glob expression that can contain the characters `*`, `?`, and `[]`. All policy names matching the expression are displayed. The `list_policies` command has the aliases `listpols`, `get_policies`, and `getpols`. For example:

```

kadmin: listpols
test-pol
dict-only
once-a-min
test-pol-nopw

kadmin: listpols t*
test-pol
test-pol-nopw
kadmin:

```

5.4.3 Adding or Modifying Policies

To add a new policy, use the `kadmin add_policy` command, which requires the “add” administrative privilege. The syntax is:

```
add_policy [options] policy_name
```

To modify attributes of a principal, use the `kadmin modify_policy` command, which requires the “modify” administrative privilege. The syntax is:

```
modify_policy [options] policy_name
```

`add_policy` has the alias `addpol`. `modify_policy` has the alias `modpol`.

The `add_policy` and `modify_policy` commands take the following switches:

-maxlife *time*

Sets the maximum lifetime of a password to *time*.

-minlife *time*

Sets the minimum lifetime of a password to *time*.

-minlength *length*

Sets the minimum length of a password to *length* characters.

-minclasses *number*

Requires at least *number* of character classes in a password.

-history *number*

Sets the number of past keys kept for a principal to *number*. This option is not supported for LDAP database.

-maxfailure *maxnumber*

Sets the maximum number of authentication failures before the principal is locked. Authentication failures are only tracked for principals which require preauthentication.

-failurecountinterval *failuretime*

Sets the allowable time between authentication failures. If an authentication failure happens after *failuretime* has elapsed since the previous failure, the number of authentication failures is reset to 1.

-lockoutduration *lockouttime*

Sets the duration for which the principal is locked from authenticating if too many authentication failures occur without the specified failure count interval elapsing.

Note: The policies are created under realm container in the LDAP database.

5.4.4 Deleting Policies

To delete a policy, use the `kadmin delete_policy` command, which requires the “delete” administrative privilege. The syntax is:

```
delete_policy [-force] policy_name
```

The `delete_policy` command has the alias `delpol`. It prompts for confirmation before deletion. For example:

```
kadmin: delete_policy guests
Are you sure you want to delete the policy "guests"?
(yes/no): yes
kadmin:
```

Note that you must cancel the policy from all principals before deleting it. The `delete_policy` command will fail if it is in use by any principals.

5.4.5 Updating the History Key

If a policy specifies a number of old keys kept of two or more, the stored old keys are encrypted in a history key, which is found in the key data of the `kadmin/history` principal.

Currently there is no support for proper rollover of the history key, but you can change the history key (for example, to use a better encryption type) at the cost of invalidating currently stored old keys. To change the history key, run:

```
kadmin: change_password -randkey kadmin/history
```

This command will fail if you specify the **-keepold** flag. Only one new history key will be created, even if you specify multiple key/salt combinations.

In the future, we plan to migrate towards encrypting old keys in the master key instead of the history key, and implementing proper rollover support for stored old keys.

5.5 Global Operations on the Kerberos Database

The `kdb5_util` command is the primary tool for administrating the Kerberos database. The syntax is:

```
kdb5_util command [kdb5_util_options] [command_options]
```

The `kdb5_util` command takes the following options, which override the defaults specified in the configuration files:

- r** *realm* specifies the the Kerberos realm of the database.
- d** *database_name*
specifies the name under which the principal database is stored.
- k** *master_key_type*
specifies the key type of the master key in the database.
- M** *master_key_name*
specifies the principal name of the master key in the database.
- m** indicates that the master database password should be read from the TTY rather than fetched from a file on disk.
- sf** *stash_file*
specifies the stash file of the master database password
- P** *password*
specifies the master database password. MIT does not recommend using this option.

5.5.1 Dumping a Kerberos Database to a File

To dump a Kerberos database into a file, use the `kdb5_util dump` command on one of the KDCs. The syntax is:

```
kdb5_util dump [-old] [-b6] [-b7] [-ov]
                [-verbose] [-mkey_convert] [-new_mkey_file] [filename
                [principals...]]
```

The `kdb5_util dump` command takes the following options:

- old** causes the dump to be in the Kerberos 5 Beta 5 and earlier dump format (“`kdb5_edit load_dump version 2.0`”).
- b6** causes the dump to be in the Kerberos 5 Beta 6 format (“`kdb5_edit load_dump version 3.0`”).
- b7** causes the dump to be in the Kerberos 5 Beta 7 format (“`kdbt_edit load_dump version 4`”).
- ov** causes the dump to be in `ovsec_adm_export` format. Currently, the only way to preserve per-principal policy information is to use this in conjunction with a normal dump.
- verbose** causes the name of each principal and policy to be printed as it is dumped.
- mkey_convert**
prompts for a new master password, and then dumps the database with all keys reencrypted in this new master key
- new_mkey_file**
reads a new key from the default keytab and then dumps the database with all keys reencrypted in this new master key

For example:

```
shell% kdb5_util dump dumpfile
shell%
```

```

shell% kdb5_util dump -verbose dumpfile
kadmin/admin@ATHENA.MIT.EDU
krbtgt/ATHENA.MIT.EDU@ATHENA.MIT.EDU
kadmin/history@ATHENA.MIT.EDU
K/M@ATHENA.MIT.EDU
kadmin/changepw@ATHENA.MIT.EDU
shell%

```

If you specify which principals to dump, you must use the full principal, as in the following example. (The line beginning with \Rightarrow is a continuation of the previous line.):

```

shell% kdb5_util dump -verbose dumpfile K/M@ATHENA.MIT.EDU
 $\Rightarrow$  kadmin/admin@ATHENA.MIT.EDU
kadmin/admin@ATHENA.MIT.EDU
K/M@ATHENA.MIT.EDU
shell%

```

Otherwise, the principals will not match those in the database and will not be dumped:

```

shell% kdb5_util dump -verbose dumpfile K/M kadmin/admin
shell%

```

If you do not specify a dump file, `kdb5_util` will dump the database to the standard output.

There is currently a bug where the default dump format omits the per-principal policy information. In order to dump all the data contained in the Kerberos database, you must perform a normal dump (with no option flags) and an additional dump using the “-ov” flag to a different file.

5.5.2 Restoring a Kerberos Database from a Dump File

To restore a Kerberos database dump from a file, use the `kdb5_util load` command on one of the KDCs. The syntax is:

```

kdb5_util load [-old] [-b6] [-b7] [-ov] [-verbose]
               [-update] [-hash] dumpfilename dbname [admin_dbname]

```

The `kdb5_util load` command takes the following options:

- old** requires the dump to be in the Kerberos 5 Beta 5 and earlier dump format (“kdb5_edit load_dump version 2.0”).
- b6** requires the dump to be in the Kerberos 5 Beta 6 format (“kdb5_edit load_dump version 3.0”).
- b7** requires the dump to be in the Kerberos 5 Beta 7 format (“kdb5_edit load_dump version 4”).
- ov** requires the dump to be in `ovsec_adm_export` format.
- verbose** causes the name of each principal and policy to be printed as it is loaded.
- update** causes records from the dump file to be updated in or added to the existing database. This is useful in conjunction with an `ovsec_adm_export` format dump if you want to preserve per-principal policy information, since the current default format does not contain this data.
- hash** causes the database to be stored as a hash rather than a binary tree.

For example:

```

shell% kdb5_util load dumpfile principal
shell%

```



```
shell% kdb5_util load -update dumpfile principal
shell%
```

If the database file exists, and the **-update** flag was not given, `kdb5_util` will overwrite the existing database.

5.5.3 Creating a Stash File

A stash file allows a KDC to authenticate itself to the database utilities, such as `kadmin`, `kadmind`, `krb5kdc`, and `kdb5_util`.

To create a stash file, use the `kdb5_util stash` command. The syntax is:

```
kdb5_util stash [-f keyfile]
```

For example:

```
shell% kdb5_util stash
kdb5_util: Cannot find/read stored master key while reading master key
kdb5_util: Warning: proceeding without master key

Enter KDC database master key:  ⇐ Type the KDC database master password.
shell%
```

If you do not specify a stash file, `kdb5_util` will stash the key in the file specified in your `kdc.conf` file.

5.5.4 Creating and Destroying a Kerberos Database

If you need to create a new Kerberos database, use the `kdb5_util create` command. The syntax is:

```
kdb5_util create [-s]
```

If you specify the **-s** option, `kdb5_util` will stash a copy of the master key in a stash file. (See Section 5.5.3 [Creating a Stash File], page 55.) For example:

```
shell% /usr/local/sbin/kdb5_util -r ATHENA.MIT.EDU create -s
kdb5_util: No such file or directory while setting active database to
⇒ '/usr/local/var/krb5kdc/principal'
Initializing database '/usr/local/var/krb5kdc/principal' for
⇒ realm 'ATHENA.MIT.EDU',
master key name 'K/M@ATHENA.MIT.EDU'
You will be prompted for the database Master Password.
It is important that you NOT FORGET this password.

Enter KDC database master key:  ⇐ Type the master password.
Re-enter KDC database master key to verify:  ⇐ Type it again.
shell%
```

If you need to destroy the current Kerberos database, use the `kdb5_util destroy` command. The syntax is:

```
kdb5_util destroy [-f]
```

The **destroy** command destroys the database, first overwriting the disk sectors and then unlinking the files. If you specify the **-f** option, `kdb5_util` will not prompt you for a confirmation before destroying the database.

```

shell% /usr/local/sbin/kdb5_util -r ATHENA.MIT.EDU destroy

kdb5_util: Deleting KDC database stored in /usr/local/var/krb5kdc/principal, are you sure
(type yes to confirm)? <=yes
OK, deleting database '/usr/local/var/krb5kdc/principal'...

shell%

```

5.6 Global Operations on the Kerberos LDAP Database

The `kdb5_ldap_util` is the primary tool for administrating the Kerberos LDAP database. It allows an administrator to manage realms, Kerberos services (KDC and Admin Server) and ticket policies. The syntax is:

```

kdb5_ldap_util [-D user_dn [-w passwd]] [-H ldap_uri] command [command_options]

```

-D *user_dn*

Specifies the Distinguished Name (DN) of the user who has sufficient rights to perform the operation on the LDAP server.

-w *passwd* Specifies the password of *user_dn*. This option is not recommended.

-H *ldap_uri*

Specifies the URI of the LDAP server. It is recommended to use `ldapi://` or `ldaps://` to connect to the LDAP server.

5.6.1 Creating a Kerberos Realm

If you need to create a new realm, use the command as follows:

```

create [-r realm] [-subtrees subtree_dn_list] [-sscope search_scope] [-containerref container_reference_dn]
[-k mkeytype] [-m|-P password] [-sf stashlename] [-s] [-maxtktlife max_ticket_life]
[-maxrenewlife max_renewable_ticket_life] [ticket_flags]

```

Options to create realm in directory are as follows:

- r** *realm* Specifies the Kerberos realm of the database; by default the realm returned by 'krb5_default_local_realm' (3) is used.
- subtrees** *subtree_dn_list* Specifies the list of subtrees containing principals of a realm. The list contains the DN of the subtree objects separated by colon(:).
- sscope** *search_scope* Specifies the scope for searching the principals under the subtree. The possible values are 1 or one (one level), 2 or sub (subtree).
- containerref** *container_reference_dn* Specifies the DN of the container object in which the principals of a realm will be created. If the container reference is not configured for a realm, the principals will be created in the realm container.
- k** *mkeytype* Specifies the key type of the master key in the database; the default is that given in 'kdc.conf'.
- m** Specifies that the master database password should be read from the TTY rather than fetched from a file on disk.
- p** *password* Specifies the master database password. This option is not recommended.
- sf** *stashfilename* Specifies the stash file of the master database password.
- s** Specifies that the stash file is to be created.
- maxtktlife** *max_ticket_life* Specifies maximum ticket life for principals in this realm. This value is used, if it is not set on the principal.
- maxrenewlife** *max_renewable_ticket_life* Specifies maximum renewable life of tickets for principals in this realm. This value is used, if it is not set on the principal.
- ticket_flags** Specifies the ticket flags. If this option is not specified, by default, none of the flags are set. This means all the ticket options will be allowed and no restriction will be set. This value is used, if it is not set on the principal.

The various flags are:

{-|+}allow_postdated

-allow_postdated prohibits principals from obtaining postdated tickets. (Sets the 'KRB5_KDB_DISALLOW_POSTDATED' flag.) **+allow_postdated** clears this flag.

{-|+}allow_forwardable

-allow_forwardable prohibits principals from obtaining forwardable tickets. (Sets the 'KRB5_KDB_DISALLOW_FORWARDABLE' flag.) **+allow_forwardable** clears this flag.

{-|+}allow_renewable

-allow_renewable prohibits principals from obtaining renewable tickets. (Sets the 'KRB5_KDB_DISALLOW_RENEWABLE' flag.) **+allow_renewable** clears this flag.

{-|+}allow_proxiability

-allow_proxiability prohibits principals from obtaining proxiability tickets. (Sets the 'KRB5_KDB_DISALLOW_PROXABLE' flag.) **+allow_proxiability** clears this flag.

{-|+}allow_dup_skey

-allow_dup_skey disables user-to-user authentication for principals by prohibiting principals from obtaining a sessions key for another user. (Sets the 'KRB5_KDB_DISALLOW_DUP_SKEY' flag.) **+allow_dup_skey** clears this flag.

{-|+}requires_preauth

+requires_preauth requires principals to preauthenticate before being allowed to kinit. (Sets the 'KRB5_KDB_REQUIRES_PRE_AUTH' flag.) **-requires_preauth** clears this flag.

{-|+}requires_hwauth

+requires_hwauth requires principals to preauthenticate using a hardware device before being allowed to kinit. (Sets the 'KRB5_KDB_REQUIRES_HW_AUTH' flag.) **-requires_hwauth** clears this flag.

{-|+}ok_as_delegate

+ok_as_delegate sets the OK-AS-DELEGATE flag on tickets issued for use with this principal as the service, which clients may use as a hint that credentials can and should be delegated when authenticating to the service. (Sets the 'KRB5_KDB_OK_AS_DELEGATE' flag.) **-ok_as_delegate** clears this flag.

{-|+}allow_svr

-allow_svr prohibits the issuance of service tickets for principals. (Sets the 'KRB5_KDB_DISALLOW_SVR' flag.) **+allow_svr** clears this flag.

{-|+}allow_tgs_req

-allow_tgs_req specifies that a *Ticket-Granting Service (TGS)* request for a service ticket for principals is not permitted. This option is useless for most things. **+allow_tgs_req** clears this flag. The default is **+allow_tgs_req**. In effect, **-allow_tgs_req** sets

the 'KRB5_KDB_DISALLOW_TGT_BASED' flag on principals in the database.

{-|+}allow_tix

-allow_tix forbids the issuance of any tickets for principals. **+allow_tix** clears this flag. The default is **+allow_tix**. In effect, **-allow_tix** sets the 'KRB5_KDB_DISALLOW_ALL_TIX' flag on principals in the database.

{-|+}needchange

+needchange sets a flag in attributes field to force a password change; **-needchange** clears it. The default is **-needchange**. In effect, **+needchange** sets the 'KRB5_KDB_REQUIRES_PWCHANGE' flag on principals in the database.

{-|+}password_changing_service

+password_changing_service sets a flag in the attributes field marking principal as a password change service principal (useless for most things). **-password_changing_service** clears the flag. This flag intentionally has a long name. The default is **-password_changing_service**. In effect, **+password_changing_service** sets the 'KRB5_KDB_PWCHANGE_SERVICE' flag on principals in the database.

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu create -sscope 2
-subtree ou=users,dc=example,dc=com -r ATHENA.MIT.EDU
Password for "cn=admin,dc=example,dc=com":
Initializing database for realm 'ATHENA.MIT.EDU'
You will be prompted for the database Master Password.
It is important that you NOT FORGET this password.
Enter KDC database master key:
Re-enter KDC database master key to verify:
shell%
```

5.6.1.1 eDirectory Options

-kdcdn *kdc_service_list*

Specifies the list of KDC service objects serving the realm. The list contains the DNs of the KDC service objects separated by colon(:).

-admindn *admin_service_list*

Specifies the list of Administration service objects serving the realm. The list contains the DNs of the Administration service objects separated by colon(:).

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu create -sscope 2
-subtree ou=users,dc=example,dc=com -kdcdn cn=krbkdc,dc=example,dc=com -admindn cn=krbadmin,dc=example,dc=com
Password for "cn=admin,dc=example,dc=com":
Initializing database for realm 'ATHENA.MIT.EDU'
You will be prompted for the database Master Password.
It is important that you NOT FORGET this password.
Enter KDC database master key:
Re-enter KDC database master key to verify:
shell%
```

5.6.2 Modifying a Kerberos Realm

If you need to modify a realm, use the command as follows:

```
modify [-r realm] [-subtrees subtree_dn] [-sscope search_scope] [-containerref container_reference_dn]
[-maxtktlife max_ticket_life] [-maxrenewlife max_renewable_ticket_life] [-ticket_flags]
```

Options to modify realm in directory are as follows:

- r** *realm* Specifies the Kerberos realm of the database; by default the realm returned by `krb5_default_local_realm` (3) is used.
- subtrees** *subtree_dn_list*
Specifies the list of subtrees containing principal objects in the realm. The list contains the DN of the subtree objects separated by colon(:). This list replaces the existing list.
- sscope** *search_scope*
Specifies the scope for searching the principals under the subtrees. The possible values are 1 or one (one level), 2 or sub (subtrees).
- containerref** *container_reference_dn*
Specifies the Distinguished Name (DN) of the container object in which the principals of a realm will be created.
- maxtktlife** *max_ticket_life*
Specifies maximum ticket life for principals in this realm. This value is used, if it is not set on the principal.
- maxrenewlife** *max_renewable_ticket_life*
Specifies maximum renewable life of tickets for principals in this realm. This value is used, if it is not set on the principal.
- ticket_flags**
Specifies the ticket flags. If this option is not specified, by default, none of the flags are set. This means all the ticket options will be allowed and no restriction will be set. This value is used, if it is not set on the principal.

The various flags are:

{-|+}allow_postdated

-allow_postdated prohibits principals from obtaining postdated tickets. (Sets the 'KRB5_KDB_DISALLOW_POSTDATED' flag.) **+allow_postdated** clears this flag.

{-|+}allow_forwardable

-allow_forwardable prohibits principals from obtaining forwardable tickets. (Sets the 'KRB5_KDB_DISALLOW_FORWARDABLE' flag.) **+allow_forwardable** clears this flag.

{-|+}allow_renewable

-allow_renewable prohibits principals from obtaining renewable tickets. (Sets the 'KRB5_KDB_DISALLOW_RENEWABLE' flag.) **+allow_renewable** clears this flag.

{-|+}allow_proxiability

-allow_proxiability prohibits principals from obtaining proxiability tickets. (Sets the 'KRB5_KDB_DISALLOW_PROXABLE' flag.) **+allow_proxiability** clears this flag.

{-|+}allow_dup_skey

-allow_dup_skey Disables user-to-user authentication for principals by prohibiting principals from obtaining a sessions key for another user. (Sets the 'KRB5_KDB_DISALLOW_DUP_SKEY' flag.) **+allow_dup_skey** clears This flag.

{-|+}requires_preauth

+requires_preauth requires principals to preauthenticate before being allowed to kinit. Sets the 'KRB5_KDB_REQUIRES_PRE_AUTH' flag. **-requires_preauth** clears this flag.

{-|+}requires_hwauth

+requires_hwauth requires principals to preauthenticate using a hardware device before being allowed to kinit. (Sets the 'KRB5_KDB_REQUIRES_HW_AUTH' flag.) **-requires_hwauth** clears this flag.

{-|+}allow_svr

-allow_svr prohibits the issuance of service tickets for principals. (Sets the 'KRB5_KDB_DISALLOW_SVR' flag.) **+allow_svr** clears This flag.

{-|+}allow_tgs_req

-allow_tgs_req specifies that a *Ticket-Granting Service (TGS)* request for a service ticket for principals is not permitted. This option is useless for most things. **+allow_tgs_req** clears this flag. The default is. **+allow_tgs_req**. In effect, **-allow_tgs_req** sets the 'KRB5_KDB_DISALLOW_TGT_BASED' flag on principals in the database.

{-|+}allow_tix

-allow_tix forbids the issuance of any tickets for principals. **+allow_tix** clears this flag. The default is **+allow_tix**. In

effect, `-allow_tix` sets the 'KRB5_KDB_DISALLOW_ALL_TIX' flag on principals in the database.

{-|+}needchange

`+needchange` sets a flag in attributes field to force a password change; `-needchange` clears it. The default is `-needchange`. In effect, `+needchange` sets the 'KRB5_KDB_REQUIRES_PWCHANGE' flag on principals in the database.

{-|+}password_changing_service

`+password_changing_service` sets a flag in the attributes field marking principal as a password change service principal (useless for most things). `-password_changing_service` clears the flag. This flag intentionally has a long name. The default is `-password_changing_service`. In effect, `+password_changing_service` sets the 'KRB5_KDB_PWCHANGE_SERVICE' flag on principals in the database.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu
modify -r ATHENA.MIT.EDU +requires_preauth
Password for "cn=admin,dc=example,dc=com":
shell%
```

5.6.2.1 eDirectory Options

-kdcdn *kdc_service_list*

Specifies the list of KDC service objects serving the realm. The list contains the DNs of the KDC service objects separated by a colon (:). This list replaces the existing list.

-clearkdcdn *kdc_service_list*

Specifies the list of KDC service objects that need to be removed from the existing list. The list contains the DNs of the KDC service objects separated by a colon (:).

-addkdcdn *kdc_service_list*

Specifies the list of KDC service objects that need to be added to the existing list. The list contains the DNs of the KDC service objects separated by a colon (:).

-admin dn *admin_service_list*

Specifies the list of Administration service objects serving the realm. The list contains the DNs of the Administration service objects separated by a colon (:). This list replaces the existing list.

-clearadmin dn *admin_service_list*

Specifies the list of Administration service objects that need to be removed from the existing list. The list contains the DNs of the Administration service objects separated by a colon (:).

-addadmin dn *admin_service_list*

Specifies the list of Administration service objects that need to be added to the existing list. The list contains the DNs of the Administration service objects separated by a colon (:).

5.6.3 Retrieving Information about a Kerberos Realm

view [-r *realm*]

Displays the attributes of a realm. Option is as follows:

-r *realm* specifies the Kerberos realm of the database; by default the realm returned by `krb5_default_local_realm` (3) is used.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu view -r ATHENA.MIT.EDU
Password for "cn=admin,dc=example,dc=com":
Realm Name: ATHENA.MIT.EDU
Subtree: ou=users,dc=example,dc=com
Subtree: ou=servers,dc=example,dc=com
SearchScope: ONE
Maximum ticket life: 0 days 01:00:00
Maximum renewable life: 0 days 10:00:00
Ticket flags: DISALLOW_FORWARDABLE
shell%
```

5.6.4 Destroying a Kerberos Realm

destroy [-f] [-r *realm*]

Destroys an existing realm. Options are as follows:

-f If specified, will not prompt the user for confirmation.
-r *realm* specifies the Kerberos realm of the database; by default the realm returned by `'krb5_default_local_realm'` (3) is used.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldap-server1.mit.edu destroy -r ATHENA.MIT.EDU
Password for "cn=admin,dc=example,dc=com":
Deleting KDC database of 'ATHENA.MIT.EDU', are you sure?
type 'yes' to confirm)? Yes
OK, deleting database of 'ATHENA.MIT.EDU'...
shell%
```

5.6.5 Listing available Kerberos Realms

list This option lists the name of the realms.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu list
Password for "cn=admin,dc=example,dc=com":
ATHENA.MIT.EDU
OPENLDAP.MIT.EDU
MEDIA-LAB.MIT.EDU
shell%
```

5.6.6 Stashing Service Object's Password

stashsrvpw [-f *filename*] **servicedn**

This command allows an administrator to store the password of service object in a file. The KDC and Administration server uses this password to authenticate to the LDAP server. Options are as follows:

- f *filename*** Specifies the complete path of the service password file. By default, `/usr/local/var/service_passwd` is used.
- servicedn** Specifies the Distinguished Name (DN) of the service object whose password is to be stored in file.

For example:

```
shell% kdb5_ldap_util stashsrvpw -f /home/andrew/conf_keyle cn=service-kdc,dc=example,dc=com
Password for "cn=service-kdc,dc=example,dc=com":
Re-enter password for "cn=service-kdc,dc=example,dc=com":
shell%
```

5.6.7 Creating and Modifying a Ticket Policy

This command creates a ticket policy in directory.

```
create_policy [-r realm] [-maxrenewlife max_renewable_ticket_life] [ticket_flags] policy_name
```

Ticket policy objects are created under the realm container.

This command modifies a ticket policy in directory.

```
modify_policy [-r realm] [-maxrenewlife max_renewable_ticket_life] [ticket_flags] policy_name
```

Options are as follows:

- r *realm*** Specifies the Kerberos realm of the database; by default the realm returned by `krb5_default_local_realm(3)` is used.
- maxtktlife *max_ticket_life*** specifies maximum ticket life for principals.
- maxrenewlife *max_renewable_ticket_life*** specifies maximum renewable life of tickets for principals.
- ticket_flags** Specifies the ticket flags. If this option is not specified, by default, none of the flags are set. This means all the ticket options will be allowed and no restriction will be set.

The various flags are:

{-|+}allow_postdated

-allow_postdated prohibits principals from obtaining postdated tickets. (Sets the 'KRB5_KDB_DISALLOW_POSTDATED' flag.) **+allow_postdated** clears this flag.

{-|+}allow_forwardable

-allow_forwardable prohibits principals from obtaining forwardable tickets. (Sets the 'KRB5_KDB_DISALLOW_FORWARDABLE' flag.) **+allow_forwardable** clears this flag.

{-|+}allow_renewable

-allow_renewable prohibits principals from obtaining renewable tickets. (Sets the 'KRB5_KDB_DISALLOW_RENEWABLE' flag.) **+allow_renewable** clears this flag.

{-|+}allow_proxiability

-allow_proxiability prohibits principals from obtaining proxiability tickets. (Sets the 'KRB5_KDB_DISALLOW_PROXABLE' flag.) **+allow_proxiability** clears this flag.

{-|+}allow_dup_skey

-allow_dup_skey Disables user-to-user authentication for principals by prohibiting principals from obtaining a sessions key for another user. (Sets the 'KRB5_KDB_DISALLOW_DUP_SKEY' flag.) **+allow_dup_skey** clears This flag.

{-|+}requires_preauth

+requires_preauth requires principals to preauthenticate before being allowed to kinit. (Sets the 'KRB5_KDB_REQUIRES_PRE_AUTH' flag.) **-requires_preauth** clears this flag.

{-|+}requires_hwauth

+requires_hwauth requires principals to preauthenticate using a hardware device before being allowed to kinit. (Sets the 'KRB5_KDB_REQUIRES_HW_AUTH' flag.) **-requires_hwauth** clears this flag.

{-|+}allow_svr

-allow_svr prohibits the issuance of service tickets for principals. (Sets the 'KRB5_KDB_DISALLOW_SVR' flag.) **+allow_svr** clears This flag.

{-|+}allow_tgs_req

-allow_tgs_req specifies that a *Ticket-Granting Service (TGS)* request for a service ticket for principals is not permitted. This option is useless for most things. **+allow_tgs_req** clears this flag. The default is **+allow_tgs_req**. In effect, **-allow_tgs_req** sets the 'KRB5_KDB_DISALLOW_TGT_BASED' flag on principals in the database.

{-|+}allow_tix

-allow_tix forbids the issuance of any tickets for principals. **+allow_tix** clears this flag. The default is **+allow_tix**. In

effect, `-allow_tix` sets the 'KRB5_KDB_DISALLOW_ALL_TIX' flag on principals in the database.

{-|+}needchange

`+needchange` sets a flag in attributes field to force a password change; `-needchange` clears it. The default is `-needchange`. In effect, `+needchange` sets the 'KRB5_KDB_REQUIRES_PWCHANGE' flag on principals in the database.

{-|+}password_changing_service

`+password_changing_service` sets a flag in the attributes field marking principal as a password change service principal (useless for most things). `-password_changing_service` clears the flag. This flag intentionally has a long name. The default is `-password_changing_service`. In effect, `+password_changing_service` sets the 'KRB5_KDB_PWCHANGE_SERVICE' flag on principals in the database.

policy_name

Specifies the name of the ticket policy.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu create_policy
-r ATHENA.MIT.EDU -maxtktlife "1 day" -maxrenewlife "1 week" -allow_forwardable usertktpolicy
Password for "cn=admin,dc=example,dc=com":
shell%
```

5.6.8 Retrieving Information About a Ticket Policy

view_policy [-r *realm*] policy_name

view_policy

This option displays the attributes of a ticket policy. Option is as follows:

-r *realm* Specifies the Kerberos realm of the database; by default the realm returned by `krb5_default_local_realm(3)` is used.

policy_name

Specifies the name of the ticket policy.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu view_policy
-r ATHENA.MIT.EDU usertktpolicy
Password for "cn=admin,dc=example,dc=com":
Ticket policy: usertktpolicy
Maximum ticket life: 0 days 01:00:00
Maximum renewable life: 0 days 10:00:00
Ticket flags: DISALLOW_FORWARDABLE REQUIRES_PWCHANGE
shell%
```

5.6.9 Destroying a Ticket Policy

destroy_policy [-force] [-r *realm*] policy_name

Destroys an existing ticket policy. Options are as follows:

- force** Forces the deletion of the policy object. If not specified, will be prompted for confirmation while deleting the policy. Enter yes to confirm the deletion.
- r realm** Specifies the Kerberos realm of the database; by default the realm returned by `krb5_default_local_realm(3)` is used.
- policy_name** Specifies the name of the ticket policy.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu
destroy_policy -r ATHENA.MIT.EDU usertktpolicy
Password for "cn=admin,dc=example,dc=com":
This will delete the policy object 'usertktpolicy', are you sure?
(type 'yes' to confirm)? Yes
** policy object 'usertktpolicy' deleted.
shell%
```

5.6.10 Listing available Ticket Policies

list_policy [-r *realm*]

Lists the name of ticket policies in a realm.

Options are as follows:

- r realm** Specifies the Kerberos realm of the database; by default the realm returned by `krb5_default_local_realm(3)` is used.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu list_policy -r ATHENA.MIT.EDU
Password for "cn=admin,dc=example,dc=com":
usertktpolicy
tempusertktpolicy
krbtktpolicy
shell%
```

5.6.11 Creating a Service Object (eDirectory)

```
create_service -kdc|-admin|-pwd [-servicehost service_host_list] [-realm realm_list] [-randpw|
-fileonly] [-filename] service_dn
```

Creates a service object in directory and assigns appropriate rights on the container holding kerberos data.

Options are as follows:

- kdc** Specifies the KDC service
- admin** Specifies the Administration service
- pwd** Specifies the Password service
- servicehost** *service_host_list*
Specifies the list of entries separated by a colon (:). Each entry consists of the hostname or IP address of the server hosting the service, transport protocol and the port number of the service separated by a pound sign (#). For example,

```
server1#tcp#88:server2#udp#89.
```

-realm *realm_list*

Specifies the list of realms that are to be associated with this service. The list contains the name of the realms separated by a colon (:).

-randpw Generates and sets a random password. This option is used to set the random password for the service object in directory and also to store it in the file. **-fileonly** option cannot be used with **-randpw** option.

-fileonly Stores the password only in a file and not in directory. The **-randpw** option can not be used when **-fileonly** option is specified.

-f *filename*

Specifies the complete path of the file where the service object password is stashed. If this option is not specified, the default file will be `/usr/local/var/service_passwd`

service_dn Specifies the Distinguished Name (DN) of the Kerberos service to be created.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu
create_service -kdc -randpw -f /home/andrew/service_passwd cn=service-kdc,dc=example,dc=com
Password for "cn=admin,dc=example,dc=com":
File does not exist. Creating the file /home/andrew/service_passwd...
shell%
```

5.6.12 Modifying a Service Object (eDirectory)

```
modify_service [-servicehost service_host_list | [-clearservicehost service_host_list] [-addservicehost service_host_list]] [-realm realm_list | [-clearrealm realm_list] [-addrealm realm_list]] service_dn
```

Modifies the attributes of a service and assigns appropriate rights, if realm associations are changed.

Options are as follows:

-servicehost *service_host_list*

List of entries separated by a colon (:) where each entry consists of host name or IP address of the server hosting the service, transport protocol, and port number of the service separated by a pound sign (#). This list replaces the existing list. For example,

```
server1#tcp#88:server2#udp#89
```

-clearservicehost *service_host_list*

Specifies the list of servicehost entries to be removed from the existing list. This is a colon separated list.

-addservicehost *service_host_list*

Specifies the list of servicehost entries to be added to the existing list. This is a colon separated list.

-realm *realm_list*

Specifies the list of realms that are to be associated with this service. The list contains the name of the realms separated by a colon (:). This list replaces the existing list.

-clearrealm *realm_list*

Specifies the list of realms to be removed from the existing list. The list contains the name of the realms separated by a colon (:).

-addrealm *realm_list*

Specifies the list of realms to be added to the existing list. The list contains the name of the realms separated by a colon (:).

service_dn Specifies the Distinguished Name (DN) of the Kerberos service to be modified.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu
modify_service -realm ATHENA.MIT.EDU cn=service-kdc,dc=example,dc=com
Password for "cn=admin,dc=example,dc=com":
Changing rights for the service object. Please wait ... done
shell%
```

5.6.13 Retrieving Service Object Information (eDirectory)

view_service *service_dn*

Displays the attributes of a service. Options are as follows:

service_dn Specifies the Distinguished name (DN) of the Kerberos service to be viewed.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu
view_service cn=service-kdc,dc=example,dc=com
Password for "cn=admin,dc=example,dc=com":
Service dn: cn=service-kdc,dc=example,dc=com
Service type: kdc
Service host list:
Realm DN list: cn=ATHENA.MIT.EDU,cn=Kerberos,dc=example,dc=com
shell%
```

5.6.14 Destroying a Service Object (eDirectory)

destroy_service [-force] [-f *stashfilename*] *service_dn*

Destroys an existing service. Options are as follows :

- force** If specified, will not prompt for user's confirmation, instead will force destruction of service.
- f *stashfilename*** Complete path of the service password file from where the entry corresponding to the `service_dn` needs to be removed.
- service_dn** Distinguished Name (DN) of the Kerberos service to be destroyed.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu
destroy_service cn=service-kdc,dc=example,dc=com
Password for "cn=admin,dc=example,dc=com":
This will delete the service object 'cn=service-kdc,dc=example,dc=com', are you sure?
(type 'yes' to confirm)? Yes
** service object 'cn=service-kdc,dc=example,dc=com' deleted.
shell%
```

5.6.15 Listing Available Service Objects (eDirectory)

list_service [-basedn *base_dn*]

Lists the name of services under a given base in directory. Options is as follows:

-basedn *base_dn*

Specifies the base DN for searching the policies, limiting the search to a particular subtree. If this option is not provided, LDAP Server specific search base will be used. For e.g., in the case of OpenLDAP, value of `defaultsearchbase` from '`slapd.conf`' file will be used, where as in the case of eDirectory, the default value for the base DN is Root.

For example:

```
shell% kdb5_ldap_util -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu list_service
Password for "cn=admin,dc=example,dc=com":
cn=service-kdc,dc=example,dc=com
cn=service-adm,dc=example,dc=com
cn=service-pwd,dc=example,dc=com
shell%
```

5.6.16 Passwords for Service Objects (eDirectory)

setsrvpw [-randpw|-fileonly][-f *filename*] service_dn

Allows an administrator to set password for service objects such as KDC and Administration server in eDirectory and store them in a file. The `-fileonly` command stores the password in a file and not in the eDirectory object. Options are as follows:

- randpw** Generates and sets a random password on the directory object and stores it in the file. The **-fileonly** option can not be used if **-randpw** option is already specified.
- fileonly** Stores the password only in a file and not in eDirectory. The **-randpw** option can not be used when **-fileonly** option is specified.
- f *filename*** Specifies the complete path of the file where the service object password is stashed. If this option is not specified, the default file will be `/usr/local/var/service_passwd`.
- service_dn** Specifies the Distinguished Name (DN) of the service object whose password is to be set.

For example:

```
shell% kdb5_ldap_util setsrvpw -D cn=admin,dc=example,dc=com -H ldaps://ldap-server1.mit.edu
setsrvpw -f /home/andrew/conf_keyfile cn=service-kdc,dc=example,dc=com
Password for "cn=admin,dc=example,dc=com":
Password for "cn=service-kdc,dc=example,dc=com":
Re-enter password for "cn=service-kdc,dc=example,dc=com":
shell%
```

5.7 Cross-realm Authentication

In order for a KDC in one realm to authenticate Kerberos users in a different realm, it must share a key with the KDC in the other realm. In both databases, there must be `krbtgt` service principals for realms. These principals should all have the same passwords, key version numbers, and encryption types. For example, if the administrators of `ATHENA.MIT.EDU` and `EXAMPLE.COM` wanted to authenticate across the realms, they would run the following commands on the KDCs in *both* realms:

```
shell%: kadmind.local -e "des3-hmac-sha1:normal des-cbc-crc:v4"
kadmind: addprinc -requires_preauth krbtgt/ATHENA.MIT.EDU@EXAMPLE.COM
Enter password for principal krbtgt/ATHENA.MIT.EDU@EXAMPLE.COM:
Re-enter password for principal krbtgt/ATHENA.MIT.EDU@EXAMPLE.COM:
kadmind: addprinc -requires_preauth krbtgt/EXAMPLE.COM@ATHENA.MIT.EDU
Enter password for principal krbtgt/EXAMPLE.COM@ATHENA.MIT.EDU:
Enter password for principal krbtgt/EXAMPLE.COM@ATHENA.MIT.EDU:
kadmind:
```

Even if most principals in a realm are generally created with the `requires_preauth` flag enabled, this flag is not desirable on cross-realm authentication keys because doing so makes it impossible to disable preauthentication on a service-by-service basis. Disabling it as in the example above is recommended.

It is also very important that these principals have good passwords. MIT recommends that TGT principal passwords be at least 26 characters of random ASCII text.

5.8 Changing the `krbtgt` Key

A Kerberos Ticket Granting Ticket (TGT) is a service ticket for the principal `krbtgt/REALM`. The key for this principal is created when the Kerberos database is initialized and need not be changed. However, it will only have the encryption types

supported by the KDC at the time of the initial database creation. To allow use of newer encryption types for the TGT, this key has to be changed.

Changing this key using the normal `kadmin change_password` command would invalidate any previously issued TGTs. Therefore, when changing this key, normally one should use the **-keepold** flag to `change_password` to retain the previous key in the database as well as the new key. For example:

```
kadmin: change_password -randkey -keepold krbtgt/ATHENA.MIT.EDU@ATHENA.MIT.EDU
```

After issuing this command, the old key is still valid and is still vulnerable to (for instance) brute force attacks. To completely retire an old key or encryption type, run the `purgekeys` command to delete keys with older kvnos, ideally first making sure that all tickets issued with the old keys have expired.

6 Configuring Kerberos with OpenLDAP back-end

1. Set up SSL on the OpenLDAP server and client to ensure secure communication when the KDC service and LDAP server are on different machines. `ldapi://` can be used if the LDAP server and KDC service are running on the same machine.
 - A. Setting up SSL on the OpenLDAP server:
 - a. Get a CA certificate using OpenSSL tools
 - b. Configure OpenLDAP server for using SSL/TLS

For the latter, you need to specify the location of CA certificate location in `slapd.conf` file.

Refer to the following link for more information:
<http://www.openldap.org/doc/admin23/tls.html>
 - B. Setting up SSL on OpenLDAP Client:
 - a. For the KDC and Admin Server, you need to do the client-side configuration in `ldap.conf`.
 For example,


```
TLS_CACERT /etc/openldap/certs/cacert.pem
```
2. Include the Kerberos schema file (`kerberos.schema`) in the configuration file (`slapd.conf`) on the LDAP Server, by providing the location where it is stored.


```
include /etc/openldap/schema/kerberos.schema
```
3. Choose DNs for the KDC and kadmin servers to bind to the LDAP server, and create them if necessary. These DNs will be specified with the `ldap_kdc_dn` and `ldap_kadmind_dn` directives in `krb5.conf`; their passwords can be stashed with `kdb5_ldap_util stashsrvpw` and the resulting file specified with the `ldap_service_password_file` directive.
4. Choose a DN for the global Kerberos container entry (but do not create the entry at this time). This DN will be specified with the `ldap_kerberos_container_dn` directive in `krb5.conf`. Realm container entries will be created underneath this DN. Principal entries may exist either underneath the realm container (the default) or in separate trees referenced from the realm container.
5. Configure the LDAP server ACLs to enable the KDC and kadmin server DNs to read and write the Kerberos data.

Sample access control information

```
access to dn.base=""
  by * read

access to dn.base="cn=Subschema"
  by * read

access to attrs=userPassword,userPKCS12
  by self write
  by * auth

access to attrs=shadowLastChange
```

```

        by self write
        by * read

# Providing access to realm container
access to dn.subtree= "cn=EXAMPLE.COM,cn=krbcontainer,dc=example,dc=com"
        by dn.exact="cn=kdc-service,dc=example,dc=com" read
        by dn.exact="cn=adm-service,dc=example,dc=com" write
        by * none

# Providing access to principals, if not underneath realm container
access to dn.subtree= "ou=users,dc=example,dc=com"
        by dn.exact="cn=kdc-service,dc=example,dc=com" read
        by dn.exact="cn=adm-service,dc=example,dc=com" write
        by * none

access to *
        by * read

```

If the locations of the container and principals or the DNs of the service objects for a realm are changed then this information should be updated.

6. Start the LDAP server as follows:

```
slapd -h "ldapi:/// ldaps://"
```

7. Modify the `krb5.conf` file to include LDAP specific items listed below:

```

'realms'
'database_module'

'dbmodules'
'db_library'
'db_module_dir'
'ldap_kdc_dn'
'ldap_kadmin_dn'
'ldap_service_password_file'
'ldap_servers'
'ldap_conns_per_server'

```

For the sample '`krb5.conf`' file, refer to Section 3.3.12 [Sample `krb5.conf` File], page 26. For more details, refer to the section '`krb5.conf`'

8. Create the realm using '`kdb5_ldap_util`'.

```
kdb5_ldap_util -D cn=admin,dc=example,dc=com create -subtrees ou=users,dc=example,dc=com -
r EXAMPLE.COM -s
```

Use the `-subtrees` option if the principals are to exist in a separate subtree from the realm container. Before executing the command, make sure that the subtree mentioned above '`(ou=users,dc=example,dc=com)`' exists. If the principals will exist underneath the realm container, omit the `-subtrees` option and do not worry about creating the principal subtree.

For more information, refer to the section *Global Operations on the Kerberos LDAP Database*.

The realm object is created under the `ldap.kerberos.container.dn` specified in the configuration file. This operation will also create the Kerberos container, if not present already. This will be used to store information related to all realms.

9. Stash the password of the service object used by the KDC and Administration service to bind to the LDAP server using the `stashrvpw` command of `kdb5_ldap_util`. The

object DN should be the same as `ldap_kdc_dn` and `ldap_kadmind_dn` values specified in the `krb5.conf` file.

```
kdb5_ldap_util -D cn=admin,dc=example,dc=com stashsrvpw -f /etc/kerberos/service.keyfile cn=krbadm
```

10. Add `krb5principalname` to the indexes in `slapd.conf` to speed up the access.

With the LDAP back end it is possible to provide aliases for principal entries. Currently we provide no mechanism provided for creating aliases, so it must be done by direct manipulation of the LDAP entries.

An entry with aliases contains multiple values of the `krbPrincipalName` attribute. Since LDAP attribute values are not ordered, it is necessary to specify which principal name is canonical, by using the `krbCanonicalName` attribute. Therefore, to create aliases for an entry, first set the `krbCanonicalName` attribute of the entry to the canonical principal name (which should be identical to the pre-existing `krbPrincipalName` value), and then add additional `krbPrincipalName` attributes for the aliases.

Principal aliases are only returned by the KDC when the client requests canonicalization. Canonicalization is normally requested for service principals; for client principals, an explicit flag is often required (e.g. `kinit -C`) and canonicalization is only performed for initial ticket requests.

7 Application Servers

If you need to install the Kerberos V5 programs on an application server, please refer to the Kerberos V5 Installation Guide. Once you have installed the software, you need to add that host to the Kerberos database (see Section 5.3.3 [Adding or Modifying Principals], page 44), and generate a *keytab* for that host, that contains the host's key. You also need to make sure the host's clock is within your maximum clock skew of the KDCs.

7.1 Keytabs

A *keytab* is a host's copy of its own keylist, which is analogous to a user's password. An application server that needs to authenticate itself to the KDC has to have a keytab that contains its own principal and key. Just as it is important for users to protect their passwords, it is equally important for hosts to protect their keytabs. You should always store keytab files on local disk, and make them readable only by root, and you should never send a keytab file over a network in the clear. Ideally, you should run the **kadmin** command to extract a keytab on the host on which the keytab is to reside.

7.1.1 Adding Principals to Keytabs

To generate a keytab, or to add a principal to an existing keytab, use the **ktadd** command from **kadmin**, which requires the “inquire” administrative privilege. (If you use the **-glob princ_exp** option, it also requires the “list” administrative privilege.) The syntax is:

```
ktadd [-k[eytab] keytab] [-q] [-e
key:salt_list] [principal | -glob princ_exp]
...]
```

The **ktadd** command takes the following switches:

- k[eytab] keytab**
use *keytab* as the keytab file. Otherwise, **ktadd** will use the default keytab file (**/etc/krb5.keytab**).
- e "enc:salt..."**
Uses the specified list of enctype-salttype pairs for setting the key of the principal. The quotes are necessary if there are multiple enctype-salttype pairs. This will not function against **kadmin** daemons earlier than **krb5-1.2**. See Section 3.1 [Supported Encryption Types], page 7 and Section 3.2 [Salts], page 8 for all possible values.
- q**
run in quiet mode. This causes **ktadd** to display less verbose information.
- principal | -glob principal expression**
add *principal*, or all principals matching *principal expression* to the keytab. The rules for *principal expression* are the same as for the **kadmin list_principals** (see Section 5.3.1.2 [Retrieving a List of Principals], page 42) command.

Here is a sample session, using configuration files that enable only ‘**des-cbc-crc**’ encryption. (The line beginning with \Rightarrow is a continuation of the previous line.)

```

kadmin: ktadd host/daffodil.mit.edu@ATHENA.MIT.EDU
kadmin: Entry for principal host/daffodil.mit.edu@ATHENA.MIT.EDU with
       kvno 2, encryption type DES-CBC-CRC added to keytab
       WRFILE:/etc/krb5.keytab.
kadmin:

kadmin: ktadd -k /usr/local/var/krb5kdc/kadmind.keytab
       => kadmin/admin kadmin/changepw
kadmin: Entry for principal kadmin/admin@ATHENA.MIT.EDU with
       kvno 3, encryption type DES-CBC-CRC added to keytab
       WRFILE:/usr/local/var/krb5kdc/kadmind.keytab.
kadmin:

```

7.1.2 Removing Principals from Keytabs

To remove a principal from an existing keytab, use the kadmin `ktremove` command. The syntax is:

```
ktremove [-k[eytab] keytab] [-q] principal [kvno | all | old]
```

The `ktremove` command takes the following switches:

- k[eytab]** *keytab*
use *keytab* as the keytab file. Otherwise, `ktremove` will use the default keytab file (`/etc/krb5.keytab`).
- q**
run in quiet mode. This causes `ktremove` to display less verbose information.
- principal*
the principal to remove from the keytab. (Required.)
- kvno*
remove all entries for the specified principal whose Key Version Numbers match *kvno*.
- all**
remove all entries for the specified principal
- old**
remove all entries for the specified principal except those with the highest kvno.

For example:

```

kadmin: ktremove -k /usr/local/var/krb5kdc/kadmind.keytab kadmin/admin
kadmin: Entry for principal kadmin/admin with kvno 3 removed
       from keytab WRFILE:/usr/local/var/krb5kdc/kadmind.keytab.
kadmin:

```

7.2 Clock Skew

In order to prevent intruders from resetting their system clocks in order to continue to use expired tickets, Kerberos V5 is set up to reject ticket requests from any host whose clock is not within the specified maximum clock skew of the KDC (as specified in the `kdc.conf` file). Similarly, hosts are configured to reject responses from any KDC whose clock is not within the specified maximum clock skew of the host (as specified in the `krb5.conf` file). The default value for maximum clock skew is 300 seconds, or five minutes.

MIT suggests that you add a line to client machines' `/etc/rc` files to synchronize the machine's clock to your KDC at boot time. On UNIX hosts, assuming you had a kdc called `kerberos` in your realm, this would be:


```
gettime -s kerberos
```

If the host is not likely to be rebooted frequently, you may also want to set up a cron job that adjusts the time on a regular basis.

7.3 Getting DNS Information Correct

Several aspects of Kerberos rely on name service. In order for Kerberos to provide its high level of security, it is less forgiving of name service problems than some other parts of your network. It is important that your Domain Name System (DNS) entries and your hosts have the correct information.

Each host's canonical name must be the fully-qualified host name (including the domain), and each host's IP address must reverse-resolve to the canonical name.

Other than the `localhost` entry, make all entries in each machine's `/etc/hosts` file in the following form:

| IP address | fully-qualified hostname | aliases |
|------------|--------------------------|---------|
|------------|--------------------------|---------|

Here is a sample `/etc/hosts` file:

```
# this is a comment
127.0.0.1      localhost localhost@mit.edu
10.0.0.6      daffodil.mit.edu trillium wake-robin
```

Additionally, on Solaris machines, you need to be sure the “hosts” entry in the file `/etc/nsswitch.conf` includes the source “dns” as well as “file”.

Finally, each host's keytab file must include a host/key pair for the host's canonical name. You can list the keys in a keytab file by issuing the command `klist -k`. For example:

```
viola# klist -k
Keytab name: /etc/krb5.keytab
KVNO Principal
-----
1 host/daffodil.mit.edu@ATHENA.MIT.EDU
```

If you telnet to the host with a fresh credentials cache (ticket file), and then `klist`, the host's service principal should be `host/fully-qualified-hostname@REALM_NAME`.

7.4 Configuring Your Firewall to Work With Kerberos V5

If you need off-site users to be able to get Kerberos tickets in your realm, they must be able to get to your KDC. This requires either that you have a slave KDC outside your firewall, or you configure your firewall to allow UDP requests into at least one of your KDCs, on whichever port the KDC is running. (The default is port 88; other ports may be specified in the KDC's `kdc.conf` file.) Similarly, if you need off-site users to be able to change their passwords in your realm, they must be able to get to your Kerberos admin server. The default port for the admin server is 749.

If your on-site users inside your firewall will need to get to KDCs in other realms, you will also need to configure your firewall to allow outgoing TCP and UDP requests to port 88. Additionally, if they will need to get to any Kerberos V4 KDCs, you may also need to allow TCP and UDP requests to port 750. If your on-site users inside your firewall will need to

get to Kerberos admin servers in other realms, you will also need to allow outgoing TCP and UDP requests to port 749.

If any of your KDCs are outside your firewall, you will need to allow **kprop** requests to get through to the remote KDC. **kprop** uses the **krb5_prop** service on port 754 (tcp).

If you need your off-site users to have access to machines inside your firewall, you need to allow TCP connections from their off-site hosts on the appropriate ports for the programs they will be using. The following lines from **/etc/services** show the default port numbers for the Kerberos V5 programs:

| | | | |
|---------------------|----------|------------|-------------------------------------|
| ftp | 21/tcp | | # Kerberos ftp and telnet use the |
| telnet | 23/tcp | | # default ports |
| kerberos | 88/udp | kdc | # Kerberos V5 KDC |
| kerberos | 88/tcp | kdc | # Kerberos V5 KDC |
| klogin | 543/tcp | | # Kerberos authenticated rlogin |
| kshell | 544/tcp | cmd | # and remote shell |
| kerberos-adm | 749/tcp | | # Kerberos 5 admin/changepw |
| kerberos-adm | 749/udp | | # Kerberos 5 admin/changepw |
| krb5_prop | 754/tcp | | # Kerberos slave propagation |
| eklogin | 2105/tcp | | # Kerberos auth. & encrypted rlogin |

By default, Kerberos V5 **telnet** and **ftp** use the same ports as the standard **telnet** and **ftp** programs, so if you already allow telnet and ftp connections through your firewall, the Kerberos V5 versions will get through as well. If you do not already allow telnet and ftp connections through your firewall, but need your users to be able to use Kerberos V5 telnet and ftp, you can either allow ftp and telnet connections on the standard ports, or switch these programs to non-default port numbers and allow ftp and telnet connections on those ports to get through.

Kerberos V5 **rlogin** uses the **klogin** service, which by default uses port 543. Encrypted Kerberos V5 rlogin uses the **eklogin** service, which by default uses port 2105.

Kerberos V5 **rsh** uses the **kshell** service, which by default uses port 544. However, the server must be able to make a TCP connection from the kshell port to an arbitrary port on the client, so if your users are to be able to use **rsh** from outside your firewall, the server they connect to must be able to send outgoing packets to arbitrary port numbers. Similarly, if your users need to run **rsh** from inside your firewall to hosts outside your firewall, the outside server needs to be able to connect to an arbitrary port on the machine inside your firewall. Because Kerberos V5 **rcp** uses **rsh**, the same issues apply. If you need to use **rsh** (or **rcp**) through your firewall and are concerned with the security implications of allowing connections to arbitrary ports, MIT suggests that you have rules that specifically name these applications and, if possible, list the allowed hosts.

The book *UNIX System Security*, by David Curry, is a good starting point for learning to configure firewalls.

8 Backups of Secure Hosts

When you back up a secure host, you should exclude the host's keytab file from the backup. If someone obtained a copy of the keytab from a backup, that person could make any host masquerade as the host whose keytab was compromised. This could be particularly dangerous if the compromised keytab was from one of your KDCs. If the machine has a disk crash and the keytab file is lost, it is easy to generate another keytab file. (See Section 7.1.1 [Adding Principals to Keytabs], page 77.) If you are unable to exclude particular files from backups, you should ensure that the backups are kept as secure as the host's root password.

8.1 Backing Up the Kerberos Database

As with any file, it is possible that your Kerberos database could become corrupted. If this happens on one of the slave KDCs, you might never notice, since the next automatic propagation of the database would install a fresh copy. However, if it happens to the master KDC, the corrupted database would be propagated to all of the slaves during the next propagation. For this reason, MIT recommends that you back up your Kerberos database regularly. Because the master KDC is continuously dumping the database to a file in order to propagate it to the slave KDCs, it is a simple matter to have a cron job periodically copy the dump file to a secure machine elsewhere on your network. (Of course, it is important to make the host where these backups are stored as secure as your KDCs, and to encrypt its transmission across your network.) Then if your database becomes corrupted, you can load the most recent dump onto the master KDC. (See Section 5.5.2 [Restoring a Kerberos Database from a Dump File], page 54.)

9 Bug Reporting

In any complex software, there will be bugs. If you have successfully built and installed Kerberos V5, please use the `krb5-send-pr` program to fill out a Problem Report should you encounter any errors in our software.

Bug reports that include proposed fixes are especially welcome. If you do include fixes, please send them using either context diffs or unified diffs (using `'diff -c'` or `'diff -u'`, respectively). Please be careful when using “cut and paste” or other such means to copy a patch into a bug report; depending on the system being used, that can result in converting TAB characters into spaces, which makes applying the patches more difficult.

The `krb5-send-pr` program is installed in the directory `/usr/local/sbin`.

The `krb5-send-pr` program enters the problem report into our Problem Report Management System (PRMS), which automatically assigns it to the engineer best able to help you with problems in the assigned category.

The `krb5-send-pr` program will try to intelligently fill in as many fields as it can. You need to choose the *category*, *class*, *severity*, and *priority* of the problem, as well as giving us as much information as you can about its exact nature.

The PR **category** will be one of:

| | | | |
|-------------------------|------------------------|-------------------------|---------------------------|
| <code>krb5-admin</code> | <code>krb5-appl</code> | <code>krb5-build</code> | <code>krb5-clients</code> |
| <code>krb5-doc</code> | <code>krb5-kdc</code> | <code>krb5-libs</code> | <code>krb5-misc</code> |
| <code>pty</code> | <code>telnet</code> | <code>test</code> | |

Choose the category that best describes the area under which your problem falls.

The **class** can be *sw-bug*, *doc-bug*, *change-request*, or *support*. The first two are exactly as their names imply. Use *change-request* when the software is behaving according to specifications, but you want to request changes in some feature or behavior. The *support* class is intended for more general questions about building or using Kerberos V5.

The **severity** of the problem indicates the problem’s impact on the usability of Kerberos V5. If a problem is *critical*, that means the product, component or concept is completely non-operational, or some essential functionality is missing, and no workaround is known. A *serious* problem is one in which the product, component or concept is not working properly or significant functionality is missing. Problems that would otherwise be considered *critical* are rated *serious* when a workaround is known. A *non-critical* problem is one that is indeed a problem, but one that is having a minimal effect on your ability to use Kerberos V5. *E.g.*, The product, component or concept is working in general, but lacks features, has irritating behavior, does something wrong, or doesn’t match its documentation. The default severity is *serious*.

The **priority** indicates how urgent this particular problem is in relation to your work. Note that low priority does not imply low importance. A priority of *high* means a solution is needed as soon as possible. A priority of *medium* means the problem should be solved no later than the next release. A priority of *low* means the problem should be solved in a future release, but it is not important to your work how soon this happens. The default priority is *medium*.

Note that a given severity does not necessarily imply a given priority. For example, a non-critical problem might still have a high priority if you are faced with a hard deadline. Conversely, a serious problem might have a low priority if the feature it is disabling is one that you do not need.

It is important that you fill in the *release* field and tell us what changes you have made, if any.

A sample filled-out form from a company named “Toasters, Inc.” might look like this:

```
To: krb5-bugs@mit.edu
Subject: misspelled "Kerberos" in title of installation guide
From: jcb
Reply-To: jcb
Cc:
X-send-pr-version: 3.99

>Submitter-Id: mit
>Originator: Jeffrey C. Gilman Bigler
>Organization:
mit
>Confidential: no
>Synopsis: Misspelled "Kerberos" in title of installation guide
>Severity: non-critical
>Priority: low
>Category: krb5-doc
>Class: doc-bug
>Release: 1.0-development
>Environment:
<machine, os, target, libraries (multiple lines)>
System: ULTRIX imbrium 4.2 0 RISC
Machine: mips
>Description:
    Misspelled "Kerberos" in title of "Kerboros V5 Installation Guide"
>How-To-Repeat:
    N/A
>Fix:
    Correct the spelling.
```

If the `krb5-send-pr` program does not work for you, or if you did not get far enough in the process to have an installed and working `krb5-send-pr`, you can generate your own form, using the above as an example.

Appendix A Appendix

A.1 Kerberos Error Messages

A.1.1 Kerberos V5 Library Error Codes

This is the Kerberos v5 library error code table. Protocol error codes are `ERROR_TABLE_BASE_krb5` + the protocol error code number; other error codes start at `ERROR_TABLE_BASE_krb5 + 128`.

0. `KRB5KDC_ERR_NONE`: No error
1. `KRB5KDC_ERR_NAME_EXP`: Client's entry in database has expired
2. `KRB5KDC_ERR_SERVICE_EXP`: Server's entry in database has expired
3. `KRB5KDC_ERR_BAD_PVNO`: Requested protocol version not supported
4. `KRB5KDC_ERR_C_OLD_MAST_KVNO`: Client's key is encrypted in an old master key
5. `KRB5KDC_ERR_S_OLD_MAST_KVNO`: Server's key is encrypted in an old master key
6. `KRB5KDC_ERR_C_PRINCIPAL_UNKNOWN`: Client not found in Kerberos database
7. `KRB5KDC_ERR_S_PRINCIPAL_UNKNOWN`: Server not found in Kerberos database
8. `KRB5KDC_ERR_PRINCIPAL_NOT_UNIQUE`: Principal has multiple entries in Kerberos database
9. `KRB5KDC_ERR_NULL_KEY`: Client or server has a null key
10. `KRB5KDC_ERR_CANNOT_POSTDATE`: Ticket is ineligible for postdating
11. `KRB5KDC_ERR_NEVER_VALID`: Requested effective lifetime is negative or too short
12. `KRB5KDC_ERR_POLICY`: KDC policy rejects request
13. `KRB5KDC_ERR_BADOPTION`: KDC can't fulfill requested option
14. `KRB5KDC_ERR_ETYPE_NOSUPP`: KDC has no support for encryption type
15. `KRB5KDC_ERR_SUMTYPE_NOSUPP`: KDC has no support for checksum type
16. `KRB5KDC_ERR_PADATA_TYPE_NOSUPP`: KDC has no support for padata type
17. `KRB5KDC_ERR_TRTYPE_NOSUPP`: KDC has no support for transited type
18. `KRB5KDC_ERR_CLIENT_REVOKED`: Clients credentials have been revoked
19. `KRB5KDC_ERR_SERVICE_REVOKED`: Credentials for server have been revoked
20. `KRB5KDC_ERR_TGT_REVOKED`: TGT has been revoked
21. `KRB5KDC_ERR_CLIENT_NOTYET`: Client not yet valid - try again later
22. `KRB5KDC_ERR_SERVICE_NOTYET`: Server not yet valid - try again later
23. `KRB5KDC_ERR_KEY_EXP`: Password has expired
24. `KRB5KDC_ERR_PREAUTH_FAILED`: Preauthentication failed
25. `KRB5KDC_ERR_PREAUTH_REQUIRED`: Additional pre-authentication required
26. `KRB5KDC_ERR_SERVER_NOMATCH`: Requested server and ticket don't match
27. `KRB5PLACEHOLD_27`: KRB5 error code 27

- 28. KRB5PLACEHOLD_28: KRB5 error code 28
- 29. KRB5PLACEHOLD_29: KRB5 error code 29
- 30. KRB5PLACEHOLD_30: KRB5 error code 30
- 31. KRB5KRB_AP_ERR_BAD_INTEGRITY: Decrypt integrity check failed
- 32. KRB5KRB_AP_ERR_TKT_EXPIRED: Ticket expired
- 33. KRB5KRB_AP_ERR_TKT_NYV: Ticket not yet valid
- 34. KRB5KRB_AP_ERR_REPEAT: Request is a replay
- 35. KRB5KRB_AP_ERR_NOT_US: The ticket isn't for us
- 36. KRB5KRB_AP_ERR_BADMATCH: Ticket/authenticator don't match
- 37. KRB5KRB_AP_ERR_SKEW: Clock skew too great
- 38. KRB5KRB_AP_ERR_BADADDR: Incorrect net address
- 39. KRB5KRB_AP_ERR_BADVERSION: Protocol version mismatch
- 40. KRB5KRB_AP_ERR_MSG_TYPE: Invalid message type
- 41. KRB5KRB_AP_ERR_MODIFIED: Message stream modified
- 42. KRB5KRB_AP_ERR_BADORDER: Message out of order
- 43. KRB5KRB_AP_ERR_ILL_CR_TKT: Illegal cross-realm ticket
- 44. KRB5KRB_AP_ERR_BADKEYVER: Key version is not available
- 45. KRB5KRB_AP_ERR_NOKEY: Service key not available
- 46. KRB5KRB_AP_ERR_MUT_FAIL: Mutual authentication failed
- 47. KRB5KRB_AP_ERR_BADDIRECTION: Incorrect message direction
- 48. KRB5KRB_AP_ERR_METHOD: Alternative authentication method required
- 49. KRB5KRB_AP_ERR_BADSEQ: Incorrect sequence number in message
- 50. KRB5KRB_AP_ERR_INAPP_CKSUM: Inappropriate type of checksum in message
- 51. KRB5KRB_AP_PATH_NOT_ACCEPTED: Policy rejects transited path
- 52. KRB5KRB_ERR_RESPONSE_TOO_BIG: Response too big for UDP, retry with TCP
- 53. KRB5PLACEHOLD_53: KRB5 error code 53
- 54. KRB5PLACEHOLD_54: KRB5 error code 54
- 55. KRB5PLACEHOLD_55: KRB5 error code 55
- 56. KRB5PLACEHOLD_56: KRB5 error code 56
- 57. KRB5PLACEHOLD_57: KRB5 error code 57
- 58. KRB5PLACEHOLD_58: KRB5 error code 58
- 59. KRB5PLACEHOLD_59: KRB5 error code 59
- 60. KRB5KRB_ERR_GENERIC: Generic error (see e-text)
- 61. KRB5KRB_ERR_FIELD_TOOLONG: Field is too long for this implementation
- 62. KRB5PLACEHOLD_62: KRB5 error code 62
- 63. KRB5PLACEHOLD_63: KRB5 error code 63
- 64. KRB5PLACEHOLD_64: KRB5 error code 64
- 65. KRB5PLACEHOLD_65: KRB5 error code 65
- 66. KRB5PLACEHOLD_66: KRB5 error code 66

- 67. KRB5PLACEHOLD_67: KRB5 error code 67
- 68. KRB5PLACEHOLD_68: KRB5 error code 68
- 69. KRB5PLACEHOLD_69: KRB5 error code 69
- 70. KRB5PLACEHOLD_70: KRB5 error code 70
- 71. KRB5PLACEHOLD_71: KRB5 error code 71
- 72. KRB5PLACEHOLD_72: KRB5 error code 72
- 73. KRB5PLACEHOLD_73: KRB5 error code 73
- 74. KRB5PLACEHOLD_74: KRB5 error code 74
- 75. KRB5PLACEHOLD_75: KRB5 error code 75
- 76. KRB5PLACEHOLD_76: KRB5 error code 76
- 77. KRB5PLACEHOLD_77: KRB5 error code 77
- 78. KRB5PLACEHOLD_78: KRB5 error code 78
- 79. KRB5PLACEHOLD_79: KRB5 error code 79
- 80. KRB5PLACEHOLD_80: KRB5 error code 80
- 81. KRB5PLACEHOLD_81: KRB5 error code 81
- 82. KRB5PLACEHOLD_82: KRB5 error code 82
- 83. KRB5PLACEHOLD_83: KRB5 error code 83
- 84. KRB5PLACEHOLD_84: KRB5 error code 84
- 85. KRB5PLACEHOLD_85: KRB5 error code 85
- 86. KRB5PLACEHOLD_86: KRB5 error code 86
- 87. KRB5PLACEHOLD_87: KRB5 error code 87
- 88. KRB5PLACEHOLD_88: KRB5 error code 88
- 89. KRB5PLACEHOLD_89: KRB5 error code 89
- 90. KRB5PLACEHOLD_90: KRB5 error code 90
- 91. KRB5PLACEHOLD_91: KRB5 error code 91
- 92. KRB5PLACEHOLD_92: KRB5 error code 92
- 93. KRB5PLACEHOLD_93: KRB5 error code 93
- 94. KRB5PLACEHOLD_94: KRB5 error code 94
- 95. KRB5PLACEHOLD_95: KRB5 error code 95
- 96. KRB5PLACEHOLD_96: KRB5 error code 96
- 97. KRB5PLACEHOLD_97: KRB5 error code 97
- 98. KRB5PLACEHOLD_98: KRB5 error code 98
- 99. KRB5PLACEHOLD_99: KRB5 error code 99
- 100. KRB5PLACEHOLD_100: KRB5 error code 100
- 101. KRB5PLACEHOLD_101: KRB5 error code 101
- 102. KRB5PLACEHOLD_102: KRB5 error code 102
- 103. KRB5PLACEHOLD_103: KRB5 error code 103
- 104. KRB5PLACEHOLD_104: KRB5 error code 104
- 105. KRB5PLACEHOLD_105: KRB5 error code 105

- 106. KRB5PLACEHOLD_106: KRB5 error code 106
- 107. KRB5PLACEHOLD_107: KRB5 error code 107
- 108. KRB5PLACEHOLD_108: KRB5 error code 108
- 109. KRB5PLACEHOLD_109: KRB5 error code 109
- 110. KRB5PLACEHOLD_110: KRB5 error code 110
- 111. KRB5PLACEHOLD_111: KRB5 error code 111
- 112. KRB5PLACEHOLD_112: KRB5 error code 112
- 113. KRB5PLACEHOLD_113: KRB5 error code 113
- 114. KRB5PLACEHOLD_114: KRB5 error code 114
- 115. KRB5PLACEHOLD_115: KRB5 error code 115
- 116. KRB5PLACEHOLD_116: KRB5 error code 116
- 117. KRB5PLACEHOLD_117: KRB5 error code 117
- 118. KRB5PLACEHOLD_118: KRB5 error code 118
- 119. KRB5PLACEHOLD_119: KRB5 error code 119
- 120. KRB5PLACEHOLD_120: KRB5 error code 120
- 121. KRB5PLACEHOLD_121: KRB5 error code 121
- 122. KRB5PLACEHOLD_122: KRB5 error code 122
- 123. KRB5PLACEHOLD_123: KRB5 error code 123
- 124. KRB5PLACEHOLD_124: KRB5 error code 124
- 125. KRB5PLACEHOLD_125: KRB5 error code 125
- 126. KRB5PLACEHOLD_126: KRB5 error code 126
- 127. KRB5PLACEHOLD_127: KRB5 error code 127
- 128. KRB5_ERR_RCSID: (RCS Id string for the krb5 error table)
- 129. KRB5_LIBOS_BADLOCKFLAG: Invalid flag for file lock mode
- 130. KRB5_LIBOS_CANTREADPWD: Cannot read password
- 131. KRB5_LIBOS_BADPWDMATCH: Password mismatch
- 132. KRB5_LIBOS_PWDINTR: Password read interrupted
- 133. KRB5_PARSE_ILLCHAR: Illegal character in component name
- 134. KRB5_PARSE_MALFORMED: Malformed representation of principal
- 135. KRB5_CONFIG_CANTOPEN: Can't open/find Kerberos configuration file
- 136. KRB5_CONFIG_BADFORMAT: Improper format of Kerberos configuration file
- 137. KRB5_CONFIG_NOTENUFSPACE: Insufficient space to return complete information
- 138. KRB5_BADMSGTYPE: Invalid message type specified for encoding
- 139. KRB5_CC_BADNAME: Credential cache name malformed
- 140. KRB5_CC_UNKNOWN_TYPE: Unknown credential cache type
- 141. KRB5_CC_NOTFOUND: Matching credential not found
- 142. KRB5_CC_END: End of credential cache reached
- 143. KRB5_NO_TKT_SUPPLIED: Request did not supply a ticket
- 144. KRB5KRB_AP_WRONG_PRINC: Wrong principal in request

- 145. KRB5KRB_AP_ERR_TKT_INVALID: Ticket has invalid flag set
- 146. KRB5_PRINC_NOMATCH: Requested principal and ticket don't match
- 147. KRB5_KDCREP_MODIFIED: KDC reply did not match expectations
- 148. KRB5_KDCREP_SKEW: Clock skew too great in KDC reply
- 149. KRB5_IN_TKT_REALM_MISMATCH: Client/server realm mismatch in initial ticket request
- 150. KRB5_PROG_ETYPE_NOSUPP: Program lacks support for encryption type
- 151. KRB5_PROG_KEYTYPE_NOSUPP: Program lacks support for key type
- 152. KRB5_WRONG_ETYPE: Requested encryption type not used in message
- 153. KRB5_PROG_SUMTYPE_NOSUPP: Program lacks support for checksum type
- 154. KRB5_REALM_UNKNOWN: Cannot find KDC for requested realm
- 155. KRB5_SERVICE_UNKNOWN: Kerberos service unknown
- 156. KRB5_KDC_UNREACH: Cannot contact any KDC for requested realm
- 157. KRB5_NO_LOCALNAME: No local name found for principal name
- 158. KRB5_MUTUAL_FAILED: Mutual authentication failed
- 159. KRB5_RC_TYPE_EXISTS: Replay cache type is already registered
- 160. KRB5_RC_MALLOC: No more memory to allocate (in replay cache code)
- 161. KRB5_RC_TYPE_NOTFOUND: Replay cache type is unknown
- 162. KRB5_RC_UNKNOWN: Generic unknown RC error
- 163. KRB5_RC_REPLAY: Message is a replay
- 164. KRB5_RC_IO: Replay I/O operation failed XXX
- 165. KRB5_RC_NOIO: Replay cache type does not support non-volatile storage
- 166. KRB5_RC_PARSE: Replay cache name parse/format error
- 167. KRB5_RC_IO_EOF: End-of-file on replay cache I/O
- 168. KRB5_RC_IO_MALLOC: No more memory to allocate (in replay cache I/O code)
- 169. KRB5_RC_IO_PERM: Permission denied in replay cache code
- 170. KRB5_RC_IO_IO: I/O error in replay cache i/o code
- 171. KRB5_RC_IO_UNKNOWN: Generic unknown RC/IO error
- 172. KRB5_RC_IO_SPACE: Insufficient system space to store replay information
- 173. KRB5_TRANS_CANTOPEN: Can't open/find realm translation file
- 174. KRB5_TRANS_BADFORMAT: Improper format of realm translation file
- 175. KRB5_LNAME_CANTOPEN: Can't open/find lname translation database
- 176. KRB5_LNAME_NOTRANS: No translation available for requested principal
- 177. KRB5_LNAME_BADFORMAT: Improper format of translation database entry
- 178. KRB5_CRYPTO_INTERNAL: Cryptosystem internal error
- 179. KRB5_KT_BADNAME: Key table name malformed
- 180. KRB5_KT_UNKNOWN_TYPE: Unknown Key table type
- 181. KRB5_KT_NOTFOUND: Key table entry not found
- 182. KRB5_KT_END: End of key table reached

- 183. KRB5_KT_NOWRITE: Cannot write to specified key table
- 184. KRB5_KT_IOERR: Error writing to key table
- 185. KRB5_NO_TKT_IN_RLM: Cannot find ticket for requested realm
- 186. KRB5DES_BAD_KEYPAR: DES key has bad parity
- 187. KRB5DES_WEAK_KEY: DES key is a weak key
- 188. KRB5_BAD_ENCTYPE: Bad encryption type
- 189. KRB5_BAD_KEYSIZE: Key size is incompatible with encryption type
- 190. KRB5_BAD_MSIZ: Message size is incompatible with encryption type
- 191. KRB5_CC_TYPE_EXISTS: Credentials cache type is already registered.
- 192. KRB5_KT_TYPE_EXISTS: Key table type is already registered.
- 193. KRB5_CC_IO: Credentials cache I/O operation failed XXX
- 194. KRB5_FCC_PERM: Credentials cache file permissions incorrect
- 195. KRB5_FCC_NOFILE: No credentials cache found
- 196. KRB5_FCC_INTERNAL: Internal credentials cache error
- 197. KRB5_CC_WRITE: Error writing to credentials cache
- 198. KRB5_CC_NOMEM: No more memory to allocate (in credentials cache code)
- 199. KRB5_CC_FORMAT: Bad format in credentials cache
- 200. KRB5_INVALID_FLAGS: Invalid KDC option combination (library internal error) [for dual tgt library calls]
- 201. KRB5_NO_2ND_TKT: Request missing second ticket [for dual tgt library calls]
- 202. KRB5_NOCREDS_SUPPLIED: No credentials supplied to library routine
- 203. KRB5_SENDAUTH_BADAUTHVERS: Bad sendauth version was sent
- 204. KRB5_SENDAUTH_BADAPPLVERS: Bad application version was sent (via sendauth)
- 205. KRB5_SENDAUTH_BADRESPONSE: Bad response (during sendauth exchange)
- 206. KRB5_SENDAUTH_REJECTED: Server rejected authentication (during sendauth exchange)
- 207. KRB5_PREAUTH_BAD_TYPE: Unsupported preauthentication type
- 208. KRB5_PREAUTH_NO_KEY: Required preauthentication key not supplied
- 209. KRB5_PREAUTH_FAILED: Generic preauthentication failure
- 210. KRB5_RCACHE_BADVNO: Unsupported replay cache format version number
- 211. KRB5_CCACHE_BADVNO: Unsupported credentials cache format version number
- 212. KRB5_KEYTAB_BADVNO: Unsupported key table format version number
- 213. KRB5_PROG_ATYPE_NOSUPP: Program lacks support for address type
- 214. KRB5_RC_REQUIRED: Message replay detection requires rcache parameter
- 215. KRB5_ERR_BAD_HOSTNAME: Hostname cannot be canonicalized
- 216. KRB5_ERR_HOST_REALM_UNKNOWN: Cannot determine realm for host
- 217. KRB5_SNAME_UNSUPP_NAME_TYPE: Conversion to service principal undefined for name type

- 218. KRB5KRB_AP_ERR_V4_REPLY: Initial Ticket response appears to be Version 4 error
- 219. KRB5_REALM_CANT_RESOLVE: Cannot resolve KDC for requested realm
- 220. KRB5_TKT_NOT_FORWARDABLE: Requesting ticket can't get forwardable tickets
- 221. KRB5_FWD_BAD_PRINCIPAL: Bad principal name while trying to forward credentials
- 222. KRB5_GET_IN_TKT_LOOP: Looping detected inside krb5_get_in_tkt
- 223. KRB5_CONFIG_NODEFREALM: Configuration file does not specify default realm
- 224. KRB5_SAM_UNSUPPORTED: Bad SAM flags in obtain_sam_padata
- 225. KRB5_KT_NAME_TOOLONG: Keytab name too long
- 226. KRB5_KT_KVNONOTFOUND: Key version number for principal in key table is incorrect
- 227. KRB5_APPL_EXPIRED: This application has expired
- 228. KRB5_LIB_EXPIRED: This Krb5 library has expired
- 229. KRB5_CHPW_PWDNULL: New password cannot be zero length
- 230. KRB5_CHPW_FAIL: Password change failed
- 231. KRB5_KT_FORMAT: Bad format in keytab
- 232. KRB5_NOPERM_ETYPE: Encryption type not permitted
- 233. KRB5_CONFIG_ETYPE_NOSUPP: No supported encryption types (config file error?)
- 234. KRB5_OBSOLETE_FN: Program called an obsolete, deleted function
- 235. KRB5_EAL_FAIL: unknown getaddrinfo failure
- 236. KRB5_EAL_NODATA: no data available for host/domain name
- 237. KRB5_EAL_NONAME: host/domain name not found
- 238. KRB5_EAL_SERVICE: service name unknown
- 239. KRB5_ERR_NUMERIC_REALM: Cannot determine realm for numeric host address

A.1.2 Kerberos V5 Database Library Error Codes

This is the Kerberos v5 database library error code table.

- 0. KRB5_KDB_RCSID: (RCS Id string for the kdb error table)
- 1. KRB5_KDB_INUSE: Entry already exists in database
- 2. KRB5_KDB_UK_ERROR: Database store error
- 3. KRB5_KDB_UK_RERROR: Database read error
- 4. KRB5_KDB_UNAUTH: Insufficient access to perform requested operation
- 5. KRB5_KDB_NOENTRY: No such entry in the database
- 6. KRB5_KDB_ILL_WILDCARD: Illegal use of wildcard
- 7. KRB5_KDB_DB_INUSE: Database is locked or in use—try again later
- 8. KRB5_KDB_DB_CHANGED: Database was modified during read
- 9. KRB5_KDB_TRUNCATED_RECORD: Database record is incomplete or corrupted
- 10. KRB5_KDB_RECURSIVELOCK: Attempt to lock database twice
- 11. KRB5_KDB_NOTLOCKED: Attempt to unlock database when not locked

12. KRB5_KDB_BADLOCKMODE: Invalid kdb lock mode
13. KRB5_KDB_DBNOTINITED: Database has not been initialized
14. KRB5_KDB_DBINITED: Database has already been initialized
15. KRB5_KDB_ILLDIRECTION: Bad direction for converting keys
16. KRB5_KDB_NOMASTERKEY: Cannot find master key record in database
17. KRB5_KDB_BADMASTERKEY: Master key does not match database
18. KRB5_KDB_INVALIDKEYSIZE: Key size in database is invalid
19. KRB5_KDB_CANTREAD_STORED: Cannot find/read stored master key
20. KRB5_KDB_BADSTORED_MKEY: Stored master key is corrupted
21. KRB5_KDB_CANTLOCK_DB: Insufficient access to lock database
22. KRB5_KDB_DB_CORRUPT: Database format error
23. KRB5_KDB_BAD_VERSION: Unsupported version in database entry
24. KRB5_KDB_BAD_SALTTYPE: Unsupported salt type
25. KRB5_KDB_BAD_ENCTYPE: Unsupported encryption type
26. KRB5_KDB_BAD_CREATEFLAGS: Bad database creation flags
27. KRB5_KDB_NO_PERMITTED_KEY: No matching key in entry having a permitted enc type
28. KRB5_KDB_NO_MATCHING_KEY: No matching key in entry
29. KRB5_KDB_SERVER_INTERNAL_ERR: Server error
30. KRB5_KDB_ACCESS_ERROR: Unable to access Kerberos database
31. KRB5_KDB_INTERNAL_ERROR: Kerberos database internal error
32. KRB5_KDB_CONSTRAINT_VIOLATION: Kerberos database constraints violated

A.1.3 Kerberos V5 Magic Numbers Error Codes

This is the Kerberos v5 magic numbers error code table.

0. KV5M_NONE: Kerberos V5 magic number table
1. KV5M_PRINCIPAL: Bad magic number for krb5_principal structure
2. KV5M_DATA: Bad magic number for krb5_data structure
3. KV5M_KEYBLOCK: Bad magic number for krb5_keyblock structure
4. KV5M_CHECKSUM: Bad magic number for krb5_checksum structure
5. KV5M_ENCRYPT_BLOCK: Bad magic number for krb5_encrypt_block structure
6. KV5M_ENC_DATA: Bad magic number for krb5_enc_data structure
7. KV5M_CRYPTOSYSTEM_ENTRY: Bad magic number for krb5_cryptosystem_entry structure
8. KV5M_CS_TABLE_ENTRY: Bad magic number for krb5_cs_table_entry structure
9. KV5M_CHECKSUM_ENTRY: Bad magic number for krb5_checksum_entry structure
10. KV5M_AUTHDATA: Bad magic number for krb5_authdata structure
11. KV5M_TRANSITED: Bad magic number for krb5_transited structure
12. KV5M_ENC_TKT_PART: Bad magic number for krb5_enc_tkt_part structure

13. KV5M_TICKET: Bad magic number for krb5_ticket structure
14. KV5M_AUTHENTICATOR: Bad magic number for krb5_authenticator structure
15. KV5M_TKT_AUTHENT: Bad magic number for krb5_tkt_authent structure
16. KV5M_CREDS: Bad magic number for krb5_creds structure
17. KV5M_LAST_REQ_ENTRY: Bad magic number for krb5_last_req_entry structure
18. KV5M_PA_DATA: Bad magic number for krb5_pa_data structure
19. KV5M_KDC_REQ: Bad magic number for krb5_kdc_req structure
20. KV5M_ENC_KDC_REP_PART: Bad magic number for krb5_enc_kdc_rep_part structure
21. KV5M_KDC_REP: Bad magic number for krb5_kdc_rep structure
22. KV5M_ERROR: Bad magic number for krb5_error structure
23. KV5M_AP_REQ: Bad magic number for krb5_ap_req structure
24. KV5M_AP_REP: Bad magic number for krb5_ap_rep structure
25. KV5M_AP_REP_ENC_PART: Bad magic number for krb5_ap_rep_enc_part structure
26. KV5M_RESPONSE: Bad magic number for krb5_response structure
27. KV5M_SAFE: Bad magic number for krb5_safe structure
28. KV5M_PRIV: Bad magic number for krb5_priv structure
29. KV5M_PRIV_ENC_PART: Bad magic number for krb5_priv_enc_part structure
30. KV5M_CRED: Bad magic number for krb5_cred structure
31. KV5M_CRED_INFO: Bad magic number for krb5_cred_info structure
32. KV5M_CRED_ENC_PART: Bad magic number for krb5_cred_enc_part structure
33. KV5M_PWD_DATA: Bad magic number for krb5_pwd_data structure
34. KV5M_ADDRESS: Bad magic number for krb5_address structure
35. KV5M_KEYTAB_ENTRY: Bad magic number for krb5_keytab_entry structure
36. KV5M_CONTEXT: Bad magic number for krb5_context structure
37. KV5M_OS_CONTEXT: Bad magic number for krb5_os_context structure
38. KV5M_ALT_METHOD: Bad magic number for krb5_alt_method structure
39. KV5M_ETYPE_INFO_ENTRY: Bad magic number for krb5_etype_info_entry structure
40. KV5M_DB_CONTEXT: Bad magic number for krb5_db_context structure
41. KV5M_AUTH_CONTEXT: Bad magic number for krb5_auth_context structure
42. KV5M_KEYTAB: Bad magic number for krb5_keytab structure
43. KV5M_RCACHE: Bad magic number for krb5_rcache structure
44. KV5M_CCACHE: Bad magic number for krb5_ccache structure
45. KV5M_PREAUTH_OPS: Bad magic number for krb5_preauth_ops
46. KV5M_SAM_CHALLENGE: Bad magic number for krb5_sam_challenge
47. KV5M_SAM_KEY: Bad magic number for krb5_sam_key
48. KV5M_ENC_SAM_RESPONSE_ENC: Bad magic number for krb5_enc_sam_response_enc

- 49. KV5M_SAM_RESPONSE: Bad magic number for krb5_sam_response
- 50. KV5M_PREDICTED_SAM_RESPONSE: Bad magic number for krb5_predicted_sam_response
- 51. KV5M_PASSWD_PHRASE_ELEMENT: Bad magic number for passwd_phrase_element
- 52. KV5M_GSS_OID: Bad magic number for GSSAPI OID
- 53. KV5M_GSS_QUEUE: Bad magic number for GSSAPI QUEUE

A.1.4 ASN.1 Error Codes

- 0. ASN1_BAD_TIMEFORMAT: ASN.1 failed call to system time library
- 1. ASN1_MISSING_FIELD: ASN.1 structure is missing a required field
- 2. ASN1_MISPLACED_FIELD: ASN.1 unexpected field number
- 3. ASN1_TYPE_MISMATCH: ASN.1 type numbers are inconsistent
- 4. ASN1_OVERFLOW: ASN.1 value too large
- 5. ASN1_OVERRUN: ASN.1 encoding ended unexpectedly
- 6. ASN1_BAD_ID: ASN.1 identifier doesn't match expected value
- 7. ASN1_BAD_LENGTH: ASN.1 length doesn't match expected value
- 8. ASN1_BAD_FORMAT: ASN.1 badly-formatted encoding
- 9. ASN1_PARSE_ERROR: ASN.1 parse error
- 10. ASN1_BAD_GMTIME: ASN.1 bad return from gmtime
- 11. ASN1_MISMATCH_INDEF: ASN.1 non-constructed indefinite encoding
- 12. ASN1_MISSING_EOC: ASN.1 missing expected EOC

A.1.5 GSSAPI Error Codes

Generic GSSAPI Errors:

- 0. G_BAD_SERVICE_NAME: No in SERVICE-NAME name string
- 1. G_BAD_STRING_UID: STRING-UID-NAME contains nondigits
- 2. G_NOUSER: UID does not resolve to username
- 3. G_VALIDATE_FAILED: Validation error
- 4. G_BUFFER_ALLOC: Couldn't allocate gss_buffer_t data
- 5. G_BAD_MSG_CTX: Message context invalid
- 6. G_WRONG_SIZE: Buffer is the wrong size
- 7. G_BAD_USAGE: Credential usage type is unknown
- 8. G_UNKNOWN_QOP: Unknown quality of protection specified
- 9. G_BAD_HOSTNAME: Hostname in SERVICE-NAME string could not be canonicalized
- 10. G_WRONG_MECH: Mechanism is incorrect
- 11. G_BAD_TOK_HEADER: Token header is malformed or corrupt
- 12. G_BAD_DIRECTION: Packet was replayed in wrong direction
- 13. G_TOK_TRUNC: Token is missing data
- 14. G_REFLECT: Token was reflected

15. G_WRONG_TOKID: Received token ID does not match expected token ID

Kerberos 5 GSSAPI Errors:

0. KG_CCACHE_NOMATCH: Principal in credential cache does not match desired name
1. KG_KEYTAB_NOMATCH: No principal in keytab matches desired name
2. KG_TGT_MISSING: Credential cache has no TGT
3. KG_NO_SUBKEY: Authenticator has no subkey
4. KG_CONTEXT_ESTABLISHED: Context is already fully established
5. KG_BAD_SIGN_TYPE: Unknown signature type in token
6. KG_BAD_LENGTH: Invalid field length in token
7. KG_CTX_INCOMPLETE: Attempt to use incomplete security context
8. KG_CONTEXT: Bad magic number for krb5_gss_ctx_id_t
9. KG_CRED: Bad magic number for krb5_gss_cred_id_t
10. KG_ENC_DESC: Bad magic number for krb5_gss_enc_desc
11. KG_BAD_SEQ: Sequence number in token is corrupt
12. KG_EMPTY_CCACHE: Credential cache is empty
13. KG_NO_CTYPES: Acceptor and Initiator share no checksum types

A.2 kadmin Time Zones

This is a complete listing of the time zones recognized by the **kadmin** command.

| | |
|----------------|--|
| gmt | Greenwich Mean Time |
| ut, utc | Universal Time (Coordinated). |
| wet | Western European Time. (Same as GMT.) |
| bst | British Summer Time. (1 hour ahead of GMT.) |
| wat | West Africa Time. (1 hour behind GMT.) |
| at | Azores Time. (2 hours behind GMT.) |
| bst | Brazil Standard Time. (3 hours behind GMT.) Note that the abbreviation BST also stands for British Summer Time. |
| gst | Greenland Standard Time. (3 hours behind GMT.) Note that the abbreviation GST also stands for Guam Standard Time. |
| nft | Newfoundland Time. (3.5 hours behind GMT.) |
| nst | Newfoundland Standard Time. (3.5 hours behind GMT.) |
| ndt | Newfoundland Daylight Time. (2.5 hours behind GMT.) |
| ast | Atlantic Standard Time. (4 hours behind GMT.) |
| adt | Atlantic Daylight Time. (3 hours behind GMT.) |
| est | Eastern Standard Time. (5 hours behind GMT.) |
| edt | Eastern Daylight Time. (4 hours behind GMT.) |
| cst | Central Standard Time. (6 hours behind GMT.) |
| cdt | Central Daylight Time. (5 hours behind GMT.) |
| mst | Mountain Standard Time. (7 hours behind GMT.) |
| mdt | Mountain Daylight Time. (6 hours behind GMT.) |
| pst | Pacific Standard Time. (8 hours behind GMT.) |
| pdtd | Pacific Daylight Time. (7 hours behind GMT.) |
| yst | Yukon Standard Time. (9 hours behind GMT.) |
| ydt | Yukon Daylight Time. (8 hours behind GMT.) |
| hst | Hawaii Standard Time. (10 hours behind GMT.) |
| hdt | Hawaii Daylight Time. (9 hours behind GMT.) |
| cat | Central Alaska Time. (10 hours behind GMT.) |
| ahst | Alaska-Hawaii Standard Time. (10 hours behind GMT.) |
| nt | Nome Time. (11 hours behind GMT.) |
| idlw | International Date Line West Time. (12 hours behind GMT.) |
| cet | Central European Time. (1 hour ahead of GMT.) |
| met | Middle European Time. (1 hour ahead of GMT.) |
| mewt | Middle European Winter Time. (1 hour ahead of GMT.) |
| mest | Middle European Summer Time. (2 hours ahead of GMT.) |
| swt | Swedish Winter Time. (1 hour ahead of GMT.) |
| sst | Swedish Summer Time. (1 hours ahead of GMT.) |
| fwtd | French Winter Time. (1 hour ahead of GMT.) |
| fst | French Summer Time. (2 hours ahead of GMT.) |
| eet | Eastern Europe Time; Russia Zone 1. (2 hours ahead of GMT.) |
| bt | Baghdad Time; Russia Zone 2. (3 hours ahead of GMT.) |
| it | Iran Time. (3.5 hours ahead of GMT.) |
| zp4 | Russia Zone 3. (4 hours ahead of GMT.) |
| zp5 | Russia Zone 4. (5 hours ahead of GMT.) |
| ist | Indian Standard Time. (5.5 hours ahead of GMT.) |
| zp6 | Russia Zone 5. (6 hours ahead of GMT.) |
| nst | North Sumatra Time. (6.5 hours ahead of GMT.) Note that the abbreviation NST is also used for Newfoundland Stanard Time. |
| sst | South Sumatra Time; Russia Zone 6. (7 hours ahead of GMT.) Note that SST is also Swedish Summer Time. |
| wast | West Australian Standard Time. (7 hours ahead of GMT.) |
| wadt | West Australian Daylight Time. (8 hours ahead of GMT.) |
| jt | Java Time. (7.5 hours ahead of GMT.) |
| cct | China Coast Time; Russia Zone 7. (8 hours ahead of GMT.) |
| jst | Japan Standard time; Russia Zone 8. (9 hours ahead of GMT.) |
| kst | Korean Standard Time. (9 hours ahead of GMT.) |
| cast | Central Australian Standard Time. (9.5 hours ahead of GMT.) |

Appendix B Copyright

Copyright © 1985-2012 by the Massachusetts Institute of Technology.

All rights reserved.

Export of software employing encryption from the United States of America may require a specific license from the United States Government. It is the responsibility of any person or organization contemplating export to obtain such a license before exporting.

WITHIN THAT CONSTRAINT, permission to use, copy, modify, and distribute this software for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of M.I.T. not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. Furthermore if you modify this software you must label your software as modified software and not distribute it in such a fashion that it might be confused with the original MIT software. M.I.T. makes no representations about the suitability of this software for any purpose. It is provided “as is” without express or implied warranty.

Documentation components of this software distribution are licensed under a Creative Commons Attribution-ShareAlike 3.0 Unported License. (<http://creativecommons.org/licenses/by-sa/3.0/>)

Individual source code files are copyright MIT, Cygnus Support, Novell, OpenVision Technologies, Oracle, Red Hat, Sun Microsystems, FundsXpress, and others.

Project Athena, Athena, Athena MUSE, Discuss, Hesiod, Kerberos, Moira, and Zephyr are trademarks of the Massachusetts Institute of Technology (MIT). No commercial use of these trademarks may be made without prior written permission of MIT.

“Commercial use” means use of a name in a product or other for-profit manner. It does NOT prevent a commercial firm from referring to the MIT trademarks in order to convey information (although in doing so, recognition of their trademark status should be given).

The following copyright and permission notice applies to the OpenVision Kerberos Administration system located in `kadmin/create`, `kadmin/dbutil`, `kadmin/passwd`, `kadmin/server`, `lib/kadm5`, and portions of `lib/rpc`:

Copyright, OpenVision Technologies, Inc., 1993-1996, All Rights Reserved

WARNING: Retrieving the OpenVision Kerberos Administration system source code, as described below, indicates your acceptance of the following terms. If you do not agree to the following terms, do not retrieve the OpenVision Kerberos administration system.

You may freely use and distribute the Source Code and Object Code compiled from it, with or without modification, but this Source Code is provided to you “AS IS” EXCLUSIVE OF ANY WARRANTY, INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY OTHER WARRANTY, WHETHER EXPRESS OR IMPLIED. IN NO EVENT WILL OPENVISION HAVE ANY LIABILITY FOR ANY LOST PROFITS, LOSS OF DATA OR COSTS OF PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, OR FOR ANY SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES ARISING OUT OF THIS AGREEMENT, INCLUDING, WITHOUT LIMITATION, THOSE RESULTING FROM THE USE OF THE SOURCE CODE, OR THE FAILURE OF THE SOURCE CODE TO PERFORM, OR FOR ANY OTHER REASON.

OpenVision retains all copyrights in the donated Source Code. OpenVision also retains copyright to derivative works of the Source Code, whether created by OpenVision or by a third party. The OpenVision copyright notice must be preserved if derivative works are made based on the donated Source Code.

OpenVision Technologies, Inc. has donated this Kerberos Administration system to MIT for inclusion in the standard Kerberos 5 distribution. This donation underscores our commitment to continuing Kerberos technology development and our gratitude for the valuable work which has been performed by MIT and the Kerberos community.

Portions contributed by Matt Crawford <crawdad@fnal.gov> were work performed at Fermi National Accelerator Laboratory, which is operated by Universities Research Association, Inc., under contract DE-AC02-76CHO3000 with the U.S. Department of Energy.

Portions of `src/lib/crypto` have the following copyright:

Copyright © 1998 by the FundsXpress, INC.

All rights reserved.

Export of this software from the United States of America may require a specific license from the United States Government. It is the responsibility of any person or organization contemplating export to obtain such a license before exporting.

WITHIN THAT CONSTRAINT, permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of FundsXpress. not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. FundsXpress makes no representations about the suitability of this software for any purpose. It is provided "as is" without express or implied warranty.

THIS SOFTWARE IS PROVIDED "AS IS" AND WITHOUT ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

The implementation of the AES encryption algorithm in `src/lib/crypto/builtin/aes` has the following copyright:

Copyright © 2001, Dr Brian Gladman <brg@gladman.uk.net>, Worcester, UK.

All rights reserved.

LICENSE TERMS

The free distribution and use of this software in both source and binary form is allowed (with or without changes) provided that:

1. distributions of this source code include the above copyright notice, this list of conditions and the following disclaimer;
2. distributions in binary form include the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other associated materials;
3. the copyright holder's name is not used to endorse products built using this software without specific written permission.

DISCLAIMER

This software is provided 'as is' with no explicit or implied warranties in respect of any properties, including, but not limited to, correctness and fitness for purpose.

Portions contributed by Red Hat, including the pre-authentication plug-in framework and the NSS crypto implementation, contain the following copyright:

Copyright © 2006 Red Hat, Inc.
Portions copyright © 2006 Massachusetts Institute of Technology
All Rights Reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- Neither the name of Red Hat, Inc., nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

The bundled verto source code is subject to the following license:

Copyright 2011 Red Hat, Inc.

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

The implementations of GSSAPI mechglue in GSSAPI-SPNEGO in `src/lib/gssapi`, including the following files:

```

lib/gssapi/generic/gssapi_err_generic.et
lib/gssapi/mechglue/g_accept_sec_context.c
lib/gssapi/mechglue/g_acquire_cred.c
lib/gssapi/mechglue/g_canon_name.c
lib/gssapi/mechglue/g_compare_name.c
lib/gssapi/mechglue/g_context_time.c
lib/gssapi/mechglue/g_delete_sec_context.c
lib/gssapi/mechglue/g_dsp_name.c
lib/gssapi/mechglue/g_dsp_status.c
lib/gssapi/mechglue/g_dup_name.c
lib/gssapi/mechglue/g_exp_sec_context.c
lib/gssapi/mechglue/g_export_name.c
lib/gssapi/mechglue/g_glue.c
lib/gssapi/mechglue/g_imp_name.c
lib/gssapi/mechglue/g_imp_sec_context.c
lib/gssapi/mechglue/g_init_sec_context.c
lib/gssapi/mechglue/g_initialize.c
lib/gssapi/mechglue/g_inquire_context.c
lib/gssapi/mechglue/g_inquire_cred.c
lib/gssapi/mechglue/g_inquire_names.c
lib/gssapi/mechglue/g_process_context.c
lib/gssapi/mechglue/g_rel_buffer.c
lib/gssapi/mechglue/g_rel_cred.c
lib/gssapi/mechglue/g_rel_name.c
lib/gssapi/mechglue/g_rel_oid_set.c
lib/gssapi/mechglue/g_seal.c
lib/gssapi/mechglue/g_sign.c
lib/gssapi/mechglue/g_store_cred.c
lib/gssapi/mechglue/g_unseal.c
lib/gssapi/mechglue/g_userok.c
lib/gssapi/mechglue/g_utils.c
lib/gssapi/mechglue/g_verify.c
lib/gssapi/mechglue/gssd_pname_to_uid.c
lib/gssapi/mechglue/mglueP.h
lib/gssapi/mechglue/oid_ops.c
lib/gssapi/spnego/gssapiP_spnego.h
lib/gssapi/spnego/spnego_mech.c

```

and the initial implementation of incremental propagation, including the following new or changed files:

```

include/iprop_hdr.h
kadmind/server/ipropd_svc.c
lib/kdb/iprop.x
lib/kdb/kdb_convert.c
lib/kdb/kdb_log.c
lib/kdb/kdb_log.h
lib/krb5/error_tables/kdb5_err.et
slave/kpropd_rpc.c
slave/kproplog.c

```

are subject to the following license:

Copyright © 2004 Sun Microsystems, Inc.

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED “AS IS”, WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

Kerberos V5 includes documentation and software developed at the University of California at Berkeley, which includes this copyright notice:

Copyright © 1983 Regents of the University of California.
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of the University nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE REGENTS AND CONTRIBUTORS “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Portions contributed by Novell, Inc., including the LDAP database backend, are subject to the following license:

Copyright © 2004-2005, Novell, Inc.
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

- The copyright holder's name is not used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Portions funded by Sandia National Laboratory and developed by the University of Michigan's Center for Information Technology Integration, including the PKINIT implementation, are subject to the following license:

COPYRIGHT © 2006-2007
THE REGENTS OF THE UNIVERSITY OF MICHIGAN
ALL RIGHTS RESERVED

Permission is granted to use, copy, create derivative works and redistribute this software and such derivative works for any purpose, so long as the name of The University of Michigan is not used in any advertising or publicity pertaining to the use of distribution of this software without specific, written prior authorization. If the above copyright notice or any other identification of the University of Michigan is included in any copy of any portion of this software, then the disclaimer below must also be included.

THIS SOFTWARE IS PROVIDED AS IS, WITHOUT REPRESENTATION FROM THE UNIVERSITY OF MICHIGAN AS TO ITS FITNESS FOR ANY PURPOSE, AND WITHOUT WARRANTY BY THE UNIVERSITY OF MICHIGAN OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE REGENTS OF THE UNIVERSITY OF MICHIGAN SHALL NOT BE LIABLE FOR ANY DAMAGES, INCLUDING SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WITH RESPECT TO ANY CLAIM ARISING OUT OF OR IN CONNECTION WITH THE USE OF THE SOFTWARE, EVEN IF IT HAS BEEN OR IS HEREAFTER ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

The pkcs11.h file included in the PKINIT code has the following license:

Copyright 2006 g10 Code GmbH
Copyright 2006 Andreas Jellinghaus

This file is free software; as a special exception the author gives unlimited permission to copy and/or distribute it, with or without modifications, as long as this notice is preserved.

This file is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY, to the extent permitted by law; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

Portions contributed by Apple Inc. are subject to the following license:

Copyright 2004-2008 Apple Inc. All Rights Reserved.

Export of this software from the United States of America may require a specific license from the United States Government. It is the responsibility of any person or organization contemplating export to obtain such a license before exporting.

WITHIN THAT CONSTRAINT, permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Apple Inc. not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. Apple Inc. makes no representations about the suitability of this software for any purpose. It is provided “as is” without express or implied warranty.

THIS SOFTWARE IS PROVIDED “AS IS” AND WITHOUT ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

The implementations of UTF-8 string handling in `src/util/support` and `src/lib/krb5/unicode` are subject to the following copyright and permission notice:

The OpenLDAP Public License
Version 2.8, 17 August 2003

Redistribution and use of this software and associated documentation (“Software”), with or without modification, are permitted provided that the following conditions are met:

1. Redistributions in source form must retain copyright statements and notices,
2. Redistributions in binary form must reproduce applicable copyright statements and notices, this list of conditions, and the following disclaimer in the documentation and/or other materials provided with the distribution, and
3. Redistributions must contain a verbatim copy of this document.

The OpenLDAP Foundation may revise this license from time to time. Each revision is distinguished by a version number. You may use this Software under terms of this license revision or under the terms of any subsequent revision of the license.

THIS SOFTWARE IS PROVIDED BY THE OPENLDAP FOUNDATION AND ITS CONTRIBUTORS “AS IS” AND ANY EXPRESSED OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE OPENLDAP FOUNDATION, ITS CONTRIBUTORS, OR THE AUTHOR(S) OR OWNER(S) OF THE SOFTWARE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

The names of the authors and copyright holders must not be used in advertising or otherwise to promote the sale, use or other dealing in this Software without specific, written prior permission. Title to copyright in this Software shall at all times remain with copyright holders.

OpenLDAP is a registered trademark of the OpenLDAP Foundation.

Copyright 1999-2003 The OpenLDAP Foundation, Redwood City, California, USA. All Rights Reserved. Permission to copy and distribute verbatim copies of this document is granted.

Marked test programs in `src/lib/krb5/krb` have the following copyright:

Copyright © 2006 Kungliga Tekniska Högskolan
(Royal Institute of Technology, Stockholm, Sweden).
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of KTH nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY KTH AND ITS CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL KTH OR ITS CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Portions of the RPC implementation in `src/lib/rpc` and `src/include/gssrpc` have the following copyright and permission notice:

Copyright © 2010, Oracle America, Inc.

All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of the "Oracle America, Inc." nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Copyright © 2006,2007,2009 NTT (Nippon Telegraph and Telephone Corporation). All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer as the first lines of this file unmodified.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY NTT “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL NTT BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Copyright 2000 by Carnegie Mellon University

All Rights Reserved

Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Carnegie Mellon University not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission.

CARNEGIE MELLON UNIVERSITY DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO EVENT SHALL CARNEGIE MELLON UNIVERSITY BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

Copyright © 2002 Naval Research Laboratory (NRL/CCS)

Permission to use, copy, modify and distribute this software and its documentation is hereby granted, provided that both the copyright notice and this permission notice appear in all copies of the software, derivative works or modified versions, and any portions thereof.

NRL ALLOWS FREE USE OF THIS SOFTWARE IN ITS “AS IS” CONDITION AND DISCLAIMS ANY LIABILITY OF ANY KIND FOR ANY DAMAGES WHATSOEVER RESULTING FROM THE USE OF THIS SOFTWARE.

Portions extracted from Internet RFCs have the following copyright notice:

Copyright © The Internet Society (2006).

This document is subject to the rights, licenses and restrictions contained in BCP 78, and except as set forth therein, the authors retain all their rights.

This document and the information contained herein are provided on an “AS IS” basis and THE CONTRIBUTOR, THE ORGANIZATION HE/SHE REPRESENTS OR IS SPONSORED BY (IF ANY), THE INTERNET SOCIETY AND THE INTERNET ENGINEERING TASK FORCE DISCLAIM ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION HEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Copyright © 1991, 1992, 1994 by Cygnus Support.

Permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation. Cygnus Support makes no representations about the suitability of this software for any purpose. It is provided “as is” without express or implied warranty.

Copyright © 2006 Secure Endpoints Inc.

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the “Software”), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED “AS IS”, WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

Portions of the implementation of the Fortuna-like PRNG are subject to the following notice:

Copyright © 2005 Marko Kreen
All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR AND CONTRIBUTORS “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Copyright © 1994 by the University of Southern California

EXPORT OF THIS SOFTWARE from the United States of America may require a specific license from the United States Government. It is the responsibility of any person or organization contemplating export to obtain such a license before exporting.

WITHIN THAT CONSTRAINT, permission to copy, modify, and distribute this software and its documentation in source and binary forms is hereby granted, provided that any documentation or other materials related to such distribution or use acknowledge that the software was developed by the University of Southern California.

DISCLAIMER OF WARRANTY. THIS SOFTWARE IS PROVIDED “AS IS”. The University of Southern California MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED. By way of example, but not limitation, the University of Southern California MAKES NO REPRESENTATIONS OR WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. The University of Southern California shall not be held liable for any liability nor for any direct, indirect, or consequential damages with respect to any claim by the user or distributor of the ksu software.

Copyright © 1995

The President and Fellows of Harvard University

This code is derived from software contributed to Harvard by Jeremy Rassen.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. All advertising materials mentioning features or use of this software must display the following acknowledgement:

This product includes software developed by the University of California, Berkeley and its contributors.
4. Neither the name of the University nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE REGENTS AND CONTRIBUTORS “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS

OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Copyright © 2008 by the Massachusetts Institute of Technology.
 Copyright 1995 by Richard P. Basch. All Rights Reserved.
 Copyright 1995 by Lehman Brothers, Inc. All Rights Reserved.

Export of this software from the United States of America may require a specific license from the United States Government. It is the responsibility of any person or organization contemplating export to obtain such a license before exporting.

WITHIN THAT CONSTRAINT, permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of Richard P. Basch, Lehman Brothers and M.I.T. not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. Richard P. Basch, Lehman Brothers and M.I.T. make no representations about the suitability of this software for any purpose. It is provided "as is" without express or implied warranty.

The following notice applies to `src/lib/krb5/krb/strptime.c`:

Copyright © 1997, 1998 The NetBSD Foundation, Inc.
 All rights reserved.

This code was contributed to The NetBSD Foundation by Klaus Klein.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. All advertising materials mentioning features or use of this software must display the following acknowledgement:
 This product includes software developed by the NetBSD Foundation, Inc.
 and its contributors.
4. Neither the name of The NetBSD Foundation nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE NETBSD FOUNDATION, INC. AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE FOUNDATION OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT,

INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

The following notice applies to Unicode library files in `src/lib/krb5/unicode`:

Copyright 1997, 1998, 1999 Computing Research Labs,
New Mexico State University

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE COMPUTING RESEARCH LAB OR NEW MEXICO STATE UNIVERSITY BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

The following notice applies to `src/util/support/strncpy.c`:

Copyright © 1998 Todd C. Miller <Todd.Miller@courtesan.com>

Permission to use, copy, modify, and distribute this software for any purpose with or without fee is hereby granted, provided that the above copyright notice and this permission notice appear in all copies.

THE SOFTWARE IS PROVIDED "AS IS" AND THE AUTHOR DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS. IN NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY SPECIAL, DIRECT, INDIRECT, OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

The following notice applies to `src/util/profile/argv_parse.c` and `src/util/profile/argv_parse.h`:

Copyright 1999 by Theodore Ts'o.

Permission to use, copy, modify, and distribute this software for any purpose with or without fee is hereby granted, provided that the above copyright notice and this permission notice appear in all copies. THE SOFTWARE IS PROVIDED "AS IS" AND THEODORE TS'O (THE AUTHOR) DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE, INCLUDING ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS. IN

NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY SPECIAL, DIRECT, INDIRECT, OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE. (Isn't it sick that the U.S. culture of lawsuit-happy lawyers requires this kind of disclaimer?)

The following notice applies to SWIG-generated code in `src/util/profile/profile_tcl.c`:

Copyright © 1999-2000, The University of Chicago

This file may be freely redistributed without license or fee provided this copyright message remains intact.

The following notice applies to portions of `src/lib/rpc` and `src/include/gssrpc`:

Copyright © 2000 The Regents of the University of Michigan. All rights reserved.

Copyright © 2000 Dug Song <dugsong@UMICH.EDU>. All rights reserved, all wrongs reversed.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of the University nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Implementations of the MD4 algorithm are subject to the following notice:

Copyright © 1990, RSA Data Security, Inc. All rights reserved.

License to copy and use this software is granted provided that it is identified as the "RSA Data Security, Inc. MD4 Message Digest Algorithm" in all material mentioning or referencing this software or this function.

License is also granted to make and use derivative works provided that such works are identified as "derived from the RSA Data Security, Inc. MD4 Message Digest Algorithm" in all material mentioning or referencing the derived work.

RSA Data Security, Inc. makes no representations concerning either the merchantability of this software or the suitability of this software for any particular purpose. It is provided “as is” without express or implied warranty of any kind.

These notices must be retained in any copies of any part of this documentation and/or software.

Implementations of the MD5 algorithm are subject to the following notice:

Copyright © 1990, RSA Data Security, Inc. All rights reserved.

License to copy and use this software is granted provided that it is identified as the “RSA Data Security, Inc. MD5 Message-Digest Algorithm” in all material mentioning or referencing this software or this function.

License is also granted to make and use derivative works provided that such works are identified as “derived from the RSA Data Security, Inc. MD5 Message-Digest Algorithm” in all material mentioning or referencing the derived work.

RSA Data Security, Inc. makes no representations concerning either the merchantability of this software or the suitability of this software for any particular purpose. It is provided “as is” without express or implied warranty of any kind.

These notices must be retained in any copies of any part of this documentation and/or software.

The following notice applies to `src/lib/crypto/crypto_tests/t_mddriver.c`:

Copyright © 1990-2, RSA Data Security, Inc. Created 1990. All rights reserved.

RSA Data Security, Inc. makes no representations concerning either the merchantability of this software or the suitability of this software for any particular purpose. It is provided “as is” without express or implied warranty of any kind.

These notices must be retained in any copies of any part of this documentation and/or software.

Portions of `src/lib/krb5` are subject to the following notice:

Copyright © 1994 CyberSAFE Corporation.

Copyright 1990,1991,2007,2008 by the Massachusetts Institute of Technology.

All Rights Reserved.

Export of this software from the United States of America may require a specific license from the United States Government. It is the responsibility of any person or organization contemplating export to obtain such a license before exporting.

WITHIN THAT CONSTRAINT, permission to use, copy, modify, and distribute this software and its documentation for any purpose and without fee is hereby granted, provided that the above copyright notice appear in all copies and that both that copyright notice and this permission notice appear in supporting documentation, and that the name of M.I.T. not be used in advertising or publicity pertaining to distribution of the software without specific, written prior permission. Furthermore if you modify this software you must label your software as modified software and not distribute it in such a fashion that it might be confused with the original M.I.T. software. Neither M.I.T., the Open Computing Security Group, nor CyberSAFE Corporation make any representations about the suitability of this software for any purpose. It is provided “as is” without express or implied warranty.

Portions contributed by PADL Software are subject to the following license:

Copyright (c) 2011, PADL Software Pty Ltd. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. Neither the name of PADL Software nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY PADL SOFTWARE AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL PADL SOFTWARE OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

The bundled libev source code is subject to the following license:

All files in libev are Copyright (C)2007,2008,2009 Marc Alexander Lehmann.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Alternatively, the contents of this package may be used under the terms of the GNU General Public License ("GPL") version 2 or any later version, in which case the provisions of the GPL are applicable instead of the above. If you wish to allow the use of your version of this package only under the terms of the GPL and not to allow others to use your version of this

file under the BSD license, indicate your decision by deleting the provisions above and replace them with the notice and other provisions required by the GPL in this and the other files of this package. If you do not delete the provisions above, a recipient may use your version of this file under either the BSD or the GPL.

Table of Contents

| | | |
|----------|--|----------|
| 1 | Introduction | 1 |
| 1.1 | Why Should I use Kerberos? | 1 |
| 1.2 | Documentation for Kerberos V5 | 1 |
| 1.3 | Overview of This Guide | 1 |
| 2 | How Kerberos Works | 3 |
| 2.1 | Network Services and Their Client Programs | 3 |
| 2.2 | Kerberos Tickets | 3 |
| 2.3 | The Kerberos Database | 3 |
| 2.4 | Kerberos Realms | 3 |
| 2.5 | The Ticket-Granting Ticket | 4 |
| 2.6 | Network Services and the Master Database | 4 |
| 2.6.1 | The Keytab File | 4 |
| 2.7 | The User/Kerberos Interaction | 4 |
| 2.8 | Definitions | 5 |
| 3 | Configuration Files | 7 |
| 3.1 | Supported Encryption Types | 7 |
| 3.2 | Salts | 8 |
| 3.3 | krb5.conf | 8 |
| 3.3.1 | [libdefaults] | 10 |
| 3.3.2 | [appdefaults] | 13 |
| 3.3.3 | [login] | 14 |
| 3.3.4 | [realms] | 14 |
| 3.3.5 | [domain_realm] | 16 |
| 3.3.6 | [logging] | 17 |
| 3.3.7 | [capaths] | 18 |
| 3.3.8 | [dbdefaults] | 19 |
| 3.3.9 | [dbmodules] | 20 |
| 3.3.10 | Plugins | 21 |
| 3.3.10.1 | pwqual interface | 22 |
| 3.3.10.2 | kadm5_hook interface | 22 |
| 3.3.10.3 | clpreauth interface | 22 |
| 3.3.11 | pkinit options | 22 |
| 3.3.11.1 | Specifying pkinit identity information | 23 |
| 3.3.11.2 | pkinit krb5.conf options | 24 |
| 3.3.12 | Sample krb5.conf File | 26 |
| 3.4 | kdc.conf | 28 |
| 3.4.1 | [kdcdefaults] | 28 |
| 3.4.2 | [realms] | 28 |
| 3.4.3 | pkinit options | 32 |
| 3.4.3.1 | pkinit kdc.conf options | 32 |
| 3.4.4 | Sample kdc.conf File | 34 |

| | | |
|----------|--|-----------|
| 4 | Using DNS | 35 |
| 4.1 | Mapping Hostnames onto Kerberos Realms | 35 |
| 4.2 | Hostnames for KDCs | 35 |
| 5 | Adminstrating the Kerberos Database | 39 |
| 5.1 | Kadmin Options | 39 |
| 5.2 | Date Format | 41 |
| 5.3 | Principals | 41 |
| 5.3.1 | Retrieving Information About a Principal | 41 |
| 5.3.1.1 | Attributes | 41 |
| 5.3.1.2 | Retrieving a List of Principals | 42 |
| 5.3.2 | Privileges | 43 |
| 5.3.3 | Adding or Modifying Principals | 44 |
| 5.3.4 | Deleting Principals | 49 |
| 5.3.5 | Changing Passwords | 49 |
| 5.4 | Policies | 50 |
| 5.4.1 | Retrieving Policies | 50 |
| 5.4.2 | Retrieving the List of Policies | 50 |
| 5.4.3 | Adding or Modifying Policies | 51 |
| 5.4.4 | Deleting Policies | 52 |
| 5.4.5 | Updating the History Key | 52 |
| 5.5 | Global Operations on the Kerberos Database | 52 |
| 5.5.1 | Dumping a Kerberos Database to a File | 53 |
| 5.5.2 | Restoring a Kerberos Database from a Dump File | 54 |
| 5.5.3 | Creating a Stash File | 55 |
| 5.5.4 | Creating and Destroying a Kerberos Database | 55 |
| 5.6 | Global Operations on the Kerberos LDAP Database | 56 |
| 5.6.1 | Creating a Kerberos Realm | 56 |
| 5.6.1.1 | eDirectory Options | 59 |
| 5.6.2 | Modifying a Kerberos Realm | 60 |
| 5.6.2.1 | eDirectory Options | 62 |
| 5.6.3 | Retrieving Information about a Kerberos Realm | 63 |
| 5.6.4 | Destroying a Kerberos Realm | 63 |
| 5.6.5 | Listing available Kerberos Realms | 63 |
| 5.6.6 | Stashing Service Object's Password | 63 |
| 5.6.7 | Creating and Modifying a Ticket Policy | 64 |
| 5.6.8 | Retrieving Information About a Ticket Policy | 66 |
| 5.6.9 | Destroying a Ticket Policy | 66 |
| 5.6.10 | Listing available Ticket Policies | 67 |
| 5.6.11 | Creating a Service Object (eDirectory) | 67 |
| 5.6.12 | Modifying a Service Object (eDirectory) | 68 |
| 5.6.13 | Retrieving Service Object Information (eDirectory) | 69 |
| 5.6.14 | Destroying a Service Object (eDirectory) | 69 |
| 5.6.15 | Listing Available Service Objects (eDirectory) | 70 |
| 5.6.16 | Passwords for Service Objects (eDirectory) | 70 |
| 5.7 | Cross-realm Authentication | 71 |
| 5.8 | Changing the krbtgt Key | 71 |

| | | |
|-------------------|--|-----------|
| 6 | Configuring Kerberos with OpenLDAP back-end | 73 |
| 7 | Application Servers | 77 |
| 7.1 | Keytabs | 77 |
| 7.1.1 | Adding Principals to Keytabs | 77 |
| 7.1.2 | Removing Principals from Keytabs | 78 |
| 7.2 | Clock Skew | 78 |
| 7.3 | Getting DNS Information Correct | 79 |
| 7.4 | Configuring Your Firewall to Work With Kerberos V5..... | 79 |
| 8 | Backups of Secure Hosts | 81 |
| 8.1 | Backing Up the Kerberos Database | 81 |
| 9 | Bug Reporting | 83 |
| Appendix A | Appendix | 87 |
| A.1 | Kerberos Error Messages | 87 |
| A.1.1 | Kerberos V5 Library Error Codes | 87 |
| A.1.2 | Kerberos V5 Database Library Error Codes | 93 |
| A.1.3 | Kerberos V5 Magic Numbers Error Codes | 94 |
| A.1.4 | ASN.1 Error Codes | 96 |
| A.1.5 | GSSAPI Error Codes | 96 |
| A.2 | kadmin Time Zones | 97 |
| Appendix B | Copyright | 99 |

