Linux TCG Software Stack
Low Level Design

Version 0.8 r2

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Change Log		
Version	Date	Comments
0	05/13/04	Initial revision
0.1	05/14/04	Added TCS/TSP key management info
0.2	05/16/04	Table of Contents, TCS key management example, TCS misc functions
0.3	05/17/04	Formatting
0.4	05/28/04	Changes based on Tom Lendacky's review
0.5	06/01/04	Changes based on Emily Ratliff's review, typos and formatting
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0.7	06/04/04	Changes based on Emily Ratliff's 2nd Review
0.8	07/20/04	Changes based on review by the Security gurus
0.8 r2	01/14/05	Updates based on code changes. Added TPM Auth manager section.

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1.0 Introduction

The TCG Software Stack (TSS) is the set of software components that supports an application's use of a platform's TPM. The TSS is composed of a set of software modules and components that allow applications to communicate with a TPM in several different ways.

The primary design goals of the TSS are (according to the TSS spec v1.1):

- Supply one entry point for applications to the TPM functionality
  -Provided by the TSS Service Provider Interface
- Provide synchronized access to the TPM
  -Provided by the TPM Request Manager (see section 3.1)
- Hide issues such as byte ordering and alignment from the application
  -Provided internally by the TSS
- Manage TPM resources
  -Provided by the TSS Core Services Daemon

The TSS is divided into modules which are intended to be independent subsystems which communicate through interfaces defined in the TSS specification. Communication between components inside each module is meant to be implementation specific and will not affect callers of an API. The modules and components are represented in the following diagram:

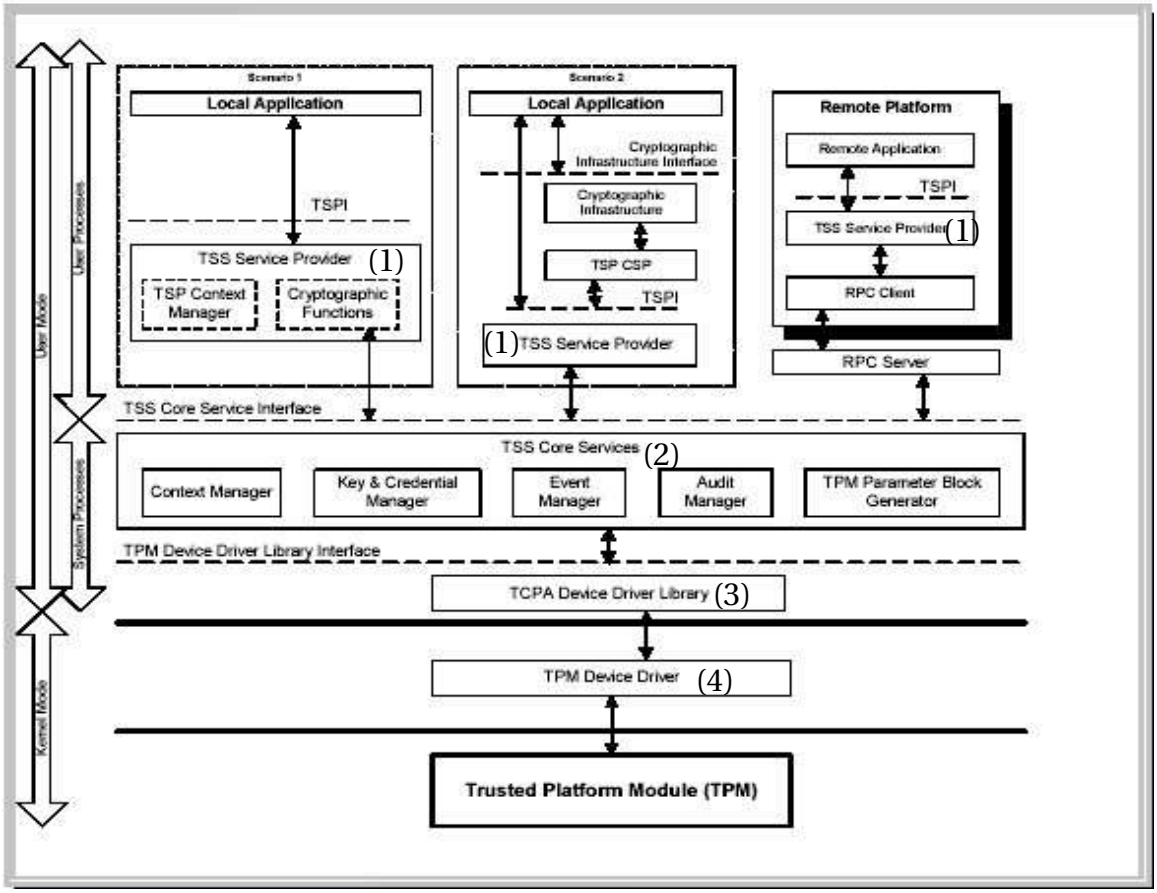


Figure 1.0: Interaction of the pieces of the TSS Software Stack. (1) TSS Service Provider, (2) TSS Core Services, (3) TCPA Device Driver Library, (4) TPM Device Driver

The modules that make up the TSS are the (1) TSS Service Provider (TSP) (see section 2.0), the (2) TSS Core Services (TCS) (see section 3.0), the (3) TCPA Device Driver Library (TDDL) and the (4) TPM Device Driver. The three pieces this low-level design will cover are the TSS Service Provider shared library, the TSS Core Services daemon and the TCPA Device Driver Library. The TCPA Device Driver Library is implemented by this TSS, but contains no additional functions other than those specified in the TSS 1.1 API. The TPM device driver itself will be maintained separately from this TSS and therefore will not be discussed in this low-level design. The following is a diagram of the interaction of the three pieces of the TSS at a high level:

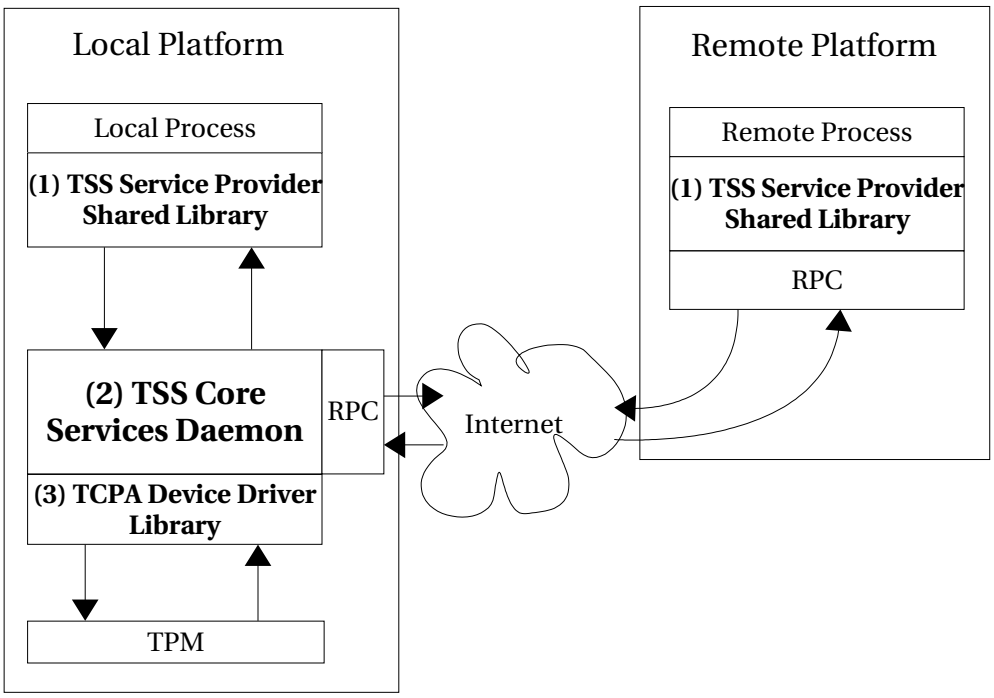


Figure 1.1: Interaction of the pieces of the TSS Software Stack implemented by functions in this document.(1) TSS Service Provider, (2) TSS Core Services, (3) TCPA Device Driver Library.

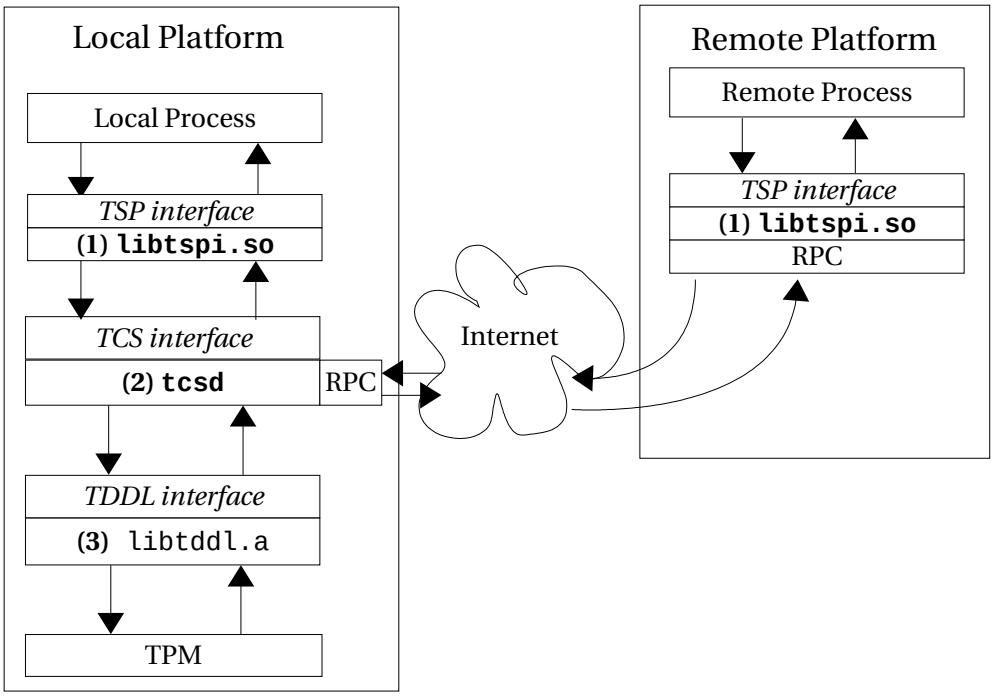


Figure 1.2: Interface interactions between the pieces of the TSS. (1) TSS Service Provider, (2) TSS Core Services, (3) TCPA Device Driver Library.

The current high level design of the Linux TCG Software Stack (HLD-TrustedComputingReferenceImplementationv21.doc) documents the changes that would be made from the original PCD code base in section 4 of that document, so some detail which is not included here can be found there. Also, please refer to the TSS 1.1 specification as a companion document to this low level design.

1.1 Overall Design Considerations

The following sections describe details of the TSS project's overall design.

1.1.0 Threading Model

In keeping with the high level design document mentioned in section 1.0, the threading library used will be the POSIX pthreads library. pthreads will be used in both the TSP shared object and the TCS daemon. In the TSP, pthread mutexes will protect shared data structures from access by multiple threads in the user's application. In the TCS daemon, a new thread will be spawned when a request arrives so that the daemon can continue listening for new requests while the previous one is being processed. pthreads routines will be used to handle these threads and protect any shared data structures.

The maximum number of threads allowed to be running simultaneously in the TCS daemon will be configurable at build time and at run time through a configuration file. The TCS

daemon will re-read its configuration file when sent the SIGHUP signal, allowing the parameter to changed without restarting the TCS daemon.

1.1.1 Globalization / Natural Language Support

NLS support will be enabled through the gettext package. Translation catalogs for languages other than English will not be provided, but will be accepted from the community.

1.1.2 Performance

The LTC-TSS can be optionally configured with `--enable-perf` to link to gprof libraries for profiling. Once test case development is complete, the test suite will be run with profiling of the TSS enabled. At this point, performance related issues will be identified. The performance of all internal routines will be considered at this time and solutions to any performance problems will be made prior to release.

1.1.3 Compatibility

Compatibility with other TSS stacks will be given all possible consideration. Based on proposals by the TSS Working Group, the design/implementation of the LTC-TSS may need to be changed to ensure compatibility. Any revisions of the TSS 1.1 spec by the TSSWG will be integrated into the LTC-TSS and any TSS 1.2 spec design considerations that can be applied to this 1.1 based stack will be implemented. For instance, it is expected that the RPC design accepted by the TSSWG for the TSS 1.2 spec will be widely implemented as the RPC design for most 1.1 TSS's, despite the fact that there is no RPC design specified in the 1.1 spec. For compatibility, the 1.2 RPC design will be implemented in this TSS. If the 1.2 design cannot be approved in time for the release of this TSS, the implementation will be based on the current standing TSS 1.2 draft.

1.1.4 Installation

Installation of the TSP shared library will be to the `/usr/lib` directory, with the `tcsd` executable residing in `/usr/sbin`. Files specific to a distribution will be installed wherever appropriate, for instance the NLS files and `tcsd` startup script locations may vary. These variations will be reflected in the per-distribution RPM's, which will be available for all supported distributions (RedHat Enterprise Linux and SuSE Linux Enterprise Server). Separate RPM's will be available providing the documentation for this package, as is customary with SuSE and RedHat packages.

Although the specific locations of the files to be included in the TSS are listed in this low-level design, alternate locations are certainly acceptable. No design decisions will be made which will necessitate specific locations for any files.

1.1.5 Serviceability

Message logging will be configurable through `syslogd` for all log levels that `syslogd` supports. Separate binary RPM's will be provided with and without debug level messages, so that a configuration error (turning debug level messages on) cannot expose sensitive data. No sensitive data will be logged to any level other than debug.

Once the LTC-TSS is released by IBM externally (presumably on developerWorks or sourceforge.net), support channels will be set up through that particular website. Users will be

able to post bugs, join mailing lists, supply patches and download updates through these channels. Support will be given to anyone through these channels, however support contracts specific to IBM products will also be made available as resources allow.

1.1.6 Build

An automake and autoconf build environment will be provided as part of a CVS or tarball source code release. Full documentation on the build itself will be provided as part of these releases.

1.1.7 Dependencies

The utmost consideration will be given to keeping dependencies for the TSP's shared library and the tcsd to an absolute minimum. Existing dependencies are the libc library, OpenSSL's libcrypto, the pthreads library, a SOAP library and any libraries needed for GUI development. Since the list of libraries needed for the GUI can be quite long, every effort will be taken to minimize it.

It is important to note that these dependencies will not be the same on all platforms. For instance the crypto implementation has been designed so that other crypto interface libraries can be easily plugged in to the TSS at build time. Please see section 2.3 for more information on the pluggable crypto implementations.

1.1.8 Testing Considerations

A complete TSS 1.1 API test suite will be developed concurrently with the TSS. Once completed, the test suite will be integrable with the Linux Test Project's automated test environment. (The tests developed can also be run stand-alone). Once development of the stack is near completion, a daily run of the API test suite will be used to identify bugs. The test suite will be released separately from the TSS stack, available for download as a patch to the LTP tarball, as a tarball itself or from CVS. Included in the test suite package will be the TSS API programming reference and documentation for the LTC-TSS.

The test suite will interface to the TSP, which will then interact with the TCS interface which in turn interacts with the TPM through the TDDL interface. In this way all three interfaces will be tested. No tests specific to the TCS or TDDL interfaces will be written.

1.1.9 Documentation

A full API and programming reference as well as build and install documentation will be provided with the LTC-TSS. The API and programming reference will be packaged with the test cases (except where released in RPM form), while build and install information will be released with any source code release of the LTC-TSS.

1.1.10 Design Problems

The TPM spec mandates that RSA encrypted blobs will be padded using an OAEP padding parameter of the NULL terminated string “TCPA”. In the existing OpenSSL implementation of RSA encryption, it is not possible to specify the OAEP padding parameter. In order to set this parameter (and thereby decrypt data form a TPM), a change to OpenSSL will be required. Other cryptographic service providers may have a similar problem.

There are several different callbacks an application can register with the TSS. Unfortunately, the TSS 1.1 spec specifies that the addresses of these callback functions be set by the `Tspi_SetAttribUint32()` function, who's parameter is only 32bits long. This makes setting a callback function impossible on a 64bit platform. In order to fix this problem, a `Tspi_SetAttribUlong64()` will be defined and used solely to set 64 bit attributes of objects. This is still in compliance with the TSS 1.1 spec, which states in section 1.3 that "The addition of any functions do not exclude a TSS implementation form <sic> being considered a valid implementation."

When the TSS specification was created, its use was considered mainly in an environment with a GUI available. This led to the decision that by default, a policy object is set to spawn a popup window to receive authorization data. This becomes a problem on platforms where no GUI is available. To solve this problem, the LTC-TSS will allow an administrator to set the default policy for secret modes to be either popup, plaintext, SHA1 or callback. This option can be set in the TCSD's configuration file.

1.1.11Permissions

The file access permissions will be set as follows:

File	User ID	Group ID	Permissions	Purpose
`tcsd`	`tss`	`tss`	`-rwx------`	TSS Core Services Daemon
`libtspi.so`	`root`	`root`	`-r-xr-xr-x`	TSS Service Provider shared library
`system.data`	`tss`	`tss`	`-rw-------`	TCSD Persistent Storage file
`user.{pid}`	`process_pid`	`process_gid`	`-rw-------`	Per-process User Persistent Storage files
`/var/tpm`	`tss`	`tss`	`drw-rw-rwt`	Directory which will contain all Persistent Storage files

The TSS Core Services Daemon will be set to a unique, non-root UID (here named `tss`), to avoid making the system as susceptible to remote attacks.

Since any application should be able to link to the TSP interface, it is given user, group and other permission to read and execute.

The system persistent storage file, `system.data`, should only be readable by the TCSD, so its mode is restricted to `0600`, and its user and group ID's are set to that of the TCSD.

The user persistent storage files, shown above as `user.{pid}`, should only be readable and writable by the user who's process created them. Therefore its mode is restricted to `0600` and its user and group ID's are set to that of the creating process. Its worthwhile to note that although child processes of a process that creates a persistent store do not inherit their parent's persistent store, there is no reason to restrict their access to the parent's persistent storage file.

The directory where all persistent storage files are written (by default `/var/tpm`) is readable and writable by user, group and others, with the sticky bit on. This will ensure that although all users can write their persistent storage files to this directory, users cannot overwrite or delete other user's files.

2.0 TSS Service Provider

The TSS Service Provider is implemented as a C shared library (and optionally a static library) that links to the user's application. The TSP provides internal object management for keys, data blobs and all other types of objects, as well as a transparent interface to one or more TCS daemons and an interface to user persistent storage. The TSP also provides the user interface component for authentication data, an interface to the generic cryptographic routines (used internally) and a key caching mechanism.

2.1 Object Management

All TSP objects are maintained in one global linked list per process[1]. This list is updated and maintained as the application makes its API calls during its lifetime. When an application makes an API call that requires an object to be created, everything that is known about that object at object creation time is filled out. Subsequent API calls will complete the object's description and perhaps create the actual object at a later time. For example, if an application calls `Tspi_Context_CreateObject()` to create a policy object, the new object will be created internally to the TSP with type `TSS_OBJECT_TYPE_POLICY` and several default attributes. This object is added to the global liked list and is thus added to the TSP's management system. Subsequently the user may call `Tspi_SetAttribUint32()` to set the policy's secret mode or secret lifetime. The default values would then be overwritten in the TSP's object (which contained default values). Finally the user would call `Tspi_Policy_AssignToObject()` to associate the new policy with some object (usually an RSA key). The TSP's internal policy object would then have a pointer to the requested object assigned in the policy object, thereby associating it with the target object.

2.1.0 Data Structures

`AnObject` - *include/spi_internal_types.h*

Each object created through the TSP exists in an entry in a linked list. Each entry in the list is an `AnObject` structure. The `AnObject` structure contains all generic object attributes such as size, type and the TSP and TCS contexts it may tie to. It also contains a pointer to the object itself.

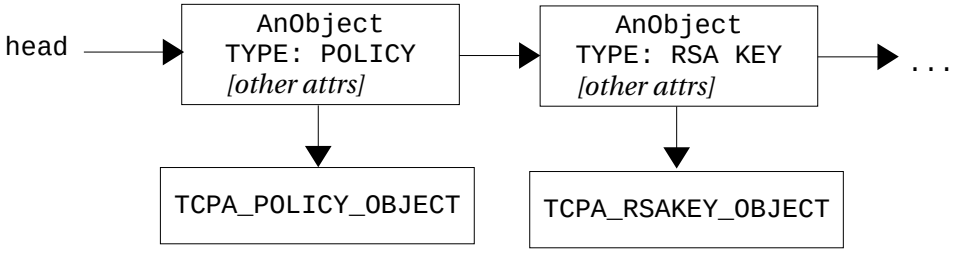


Figure 2.1.0: A sample object list

2.1.1 Object Creation Functions

1 recognized as possible performance bottleneck. Implementations may be changed to work around any performance problems uncovered.

`addObject` – *tspi/obj.c*

Synopsis:

```
TSS_HOBJECT addObject(UINT32 contextHandle, UINT32
objectType)
```

Description:

`addObject` adds a new object to the internal list of objects managed by the TSP. `contextHandle` is a TCS context handle, or 0 if a connection to a TCS does not yet exist. `objectType` is the type of TSP object to be created.

Return Value:

`addNbject` returns the handle to the newly created object.

Synchronization:

The TSP's object lock is held while the new object is added to the list.

Errors:

If an error occurs, `NULL_HOBJECT` is returned to the calling function.

`setObject` – *tspi/obj.c*

Synopsis:

```
TSS_RESULT setObject(TSS_HOBJECT objectHandle, void *buffer,
UINT32 sizeOfBuffer)
```

Description:

`setObject` sets the internal memory pointer of the TSP context `objectHandle`. The TSP context's memory pointer is set to `buffer` and the size of the buffer is set to `sizeOfBuffer`.

Return Value:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The TSP's object lock is held while the new object is modified.

Errors:

If `objectHandle` is an invalid TSP object handle, `setObject` returns `TSS_E_INVALID_HANDLE`.

`createObject` – *tspi/obj.c*

Synopsis:

```
AnObject *createObject()
```

Description:

`createObject` calls `calloc` to create a new `AnObject` structure. The structure is freed either when an application calls `Tspi_Context_CloseObject()`, or `Tspi_Context_Close()`.

Return Value:

On success, a reference to the newly created object is returned.

Synchronization:

None.

Errors:

If `calloc` fails, `NULL` is returned and an error is logged.

2.1.2 Object Support functions

`getNextObjectHandle` – *tspi/obj.c*

Synopsis:

```
TSS_HOBJECT getNextObjectHandle()
```

Description:

`getNextObjectHandle` returns the next available TSP object handle.

Return Values:

The next available TSP object handle is returned.

Synchronization:

None.

Errors:

None.

`internal_GetContextObjectForContext` – *tspi/obj.c*

Synopsis:

```
TSS_RESULT internal_GetContextObjectForContext
(TCS_CONTEXT_HANDLE tcsContext, TSS_HCONTEXT * tspContext)
```

Description:

`internal_GetContextObjectForContext` searches through the list of TSP contexts until it finds one whose TCS context matches `tcsContext`. Once it finds a match, `*tspContext` is set to the value of the matching TSP context.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The TSP's object lock is held while the list is searched.

Errors:

If a matching context is not found, `TSS_E_INVALID_HANDLE` is returned.

`internal_GetContextForContextObject` – *tspi/obj.c*

Synopsis:

```
TSS_RESULT internal_GetContextForContextObject(TSS_HCONTEXT
hContext, TCS_CONTEXT_HANDLE * handleOut)
```

Description:

`internal_GetContextForContextObject` sets the value of *handleOut to the `TCS_CONTEXT_HANDLE` structure which matches the TSP context `hContext`.

Return Values:

On success, `TSS_SUCCESS` is returned and `*handleOut` is set.

Synchronization:

Calls `getAnObjectByHandle()`, which will hold the TSP object lock while searching the list.

Errors:

If `hContext` is not found, `TSS_E_INVALID_HANDLE` is returned.

`obj_getPolicyOfObject` – *tspi/obj.c*

Synopsis:

```
TSS_HOBJECT obj_GetPolicyOfObject(TSS_HOBJECT objectHandle,
UINT32 policyType)
```

Description:

`obj_GetPolicyOfObject` returns the policy object associated with TSP object `objectHandle` and of policy type `policyType`. If `objectHandle` is a handle to an object that has no policy associated with it, 0 is returned.

Return Values:

On success, the policy object that is requested is returned.

Synchronization:

Calls `getAnObjectByHandle()`, which will hold the TSP object lock while searching the list.

Errors:

If `objectHandle` is a handle to an object that has no policy associated with it, 0 is returned

`obj_getContextForObject` – *tspi/obj.c*

Synopsis:

```
TCS_CONTEXT_HANDLE obj_getContextForObject(TSS_HOBJECT
objectHandle)
```

Description:

`obj_getContextForObject` returns the TCS context associated with the TSP context `objectHandle`.

Return Values:

On success, the `TCS_CONTEXT_HANDLE` requested is returned.

Synchronization:

Calls `getAnObjectByHandle()`, which will hold the TSP object lock while searching the list.

Errors:

If `objectHandle` does not exist, `NULL_TCS_HANDLE` is returned.

`obj_getTpmObject` – *tspi/obj.c*

Synopsis:

```
TSS_RESULT obj_getTpmObject(TCS_CONTEXT_HANDLE tcsContext,
TSS_HOBJECT * out)
```

Description:

`obj_getTpmObject` searches the TSP context list for a TPM object that is associated with TCS `tcsContext`. If the search finds an object, the value of `*out` is set to it and `TSS_SUCCESS` is returned.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

Calls `getAnObjectByHandle()`, which will hold the TSP object lock while searching the list.

Errors:

If `tcsContext` is not an existing TCS context handle or there are no objects of type `TSS_OBJECT_TYPE_TPM`, `TSS_E_INVALID_HANDLE` is returned and `*out` is not touched.

`getObjectTypeByHandle` – *tspi/obj.c*

Synopsis:

```
UINT32 getObjectTypeByHandle(TSS_HOBJECT objectHandle)
```

Description:

`getObjectTypeByHandle` searches the TSP's object list for `objectHandle` and returns that object's type.

Return Values:

On success, the type of object `objectHandle` is returned.

Synchronization:

Calls `getAnObjectByHandle()`, which will hold the TSP object lock while searching the list.

Errors:

If `objectHandle` is not a valid TSP object handle, `NULL_HOBJECT` is returned.

`destroyObjectsByContext` – *tspi/obj.c*

Synopsis:

```
void destroyObjectsByContext(TCS_CONTEXT_HANDLE tcsContext)
```

Description:

`destroyObjectsByContext` searches through the TSP's list of objects, removing each one that's bound to the TCS represented by `tcsContext`. If no objects are bound to the TCS represented by `tcsContext`, no action is taken.

Return Values:

None.

Synchronization:

Holds the TSP object lock while searching the list.

Errors:

None.

`removeObject` – *tspi/obj.c*

Synopsis:

```
void removeObject(TSS_HOBJECT objectHandle)
```

Description:

`removeObject` searches the TSP's list of object for objet handle `objectHandle` and removes that object from its list. If no object has the handle `objectHandle`, no action is taken.

Return Values:

None.

Synchronization:

Holds the TSP object lock while searching the list.

Errors:

None.

`destroyObject` – *tspi/obj.c*

Synopsis:

```
void destroyObject(AnObject *object)
```

Description:

`destroyObject` frees memory associated with the `AnObject` structure.

Return Values:

None.

Synchronization:

None.

Errors:

None.

`getObject` – *tspi/obj.c*

Synopsis:

```
TCPA_RESULT getObject(TSS_HOBJECT objectHandle, void
**outBuffer, UINT32 * outSize)
```

Description:

`getObject` searches the TSP's internal list of objects for `objectHandle` and returned references to that object and its size.

Return Values:

On success, `*outSize` is set to the size of the found object, `*outSize` bytes are `malloc`'d for `*outBuffer` and a copy of the requested object is copied into `*outBuffer`. `TSS_SUCCESS` is then returned. The caller is expected to handle freeing of the object returned in `outBuffer`.

Synchronization:

Calls `getAnObjectByHandle()`, which will hold the TSP object lock while searching the list.

Errors:

If `malloc` fails, `TSS_E_OUTOFOMEMORY` is returned. If `objectHandle` does not

exist, `TSS_E_INVALID_HANDLE` is returned.

`concatObjects` – *tspi/obj.c*

Synopsis:

```
AnObject *concatObjects(AnObject ** first, AnObject *second)
```

Description:

`concatObjects` appends the object pointed to by second immediately after the object pointed to by first in the TSP's internal list of objects.

Return Values:

`*first` is always returned.

Synchronization:

The TSP object lock is held while manipulating the list.

Errors:

None.

2.2 Key Cache Management

At the TSP level, the data structure used to keep track of loaded (cached) keys is based on the key's parent. (Here "loaded" is in the TSS sense of the word, meaning ready to use by a TSS application). Since each key loaded by the TSP was loaded in reference to a wrapping key (which ultimately led back to some key resident in the TCS), a list of linked lists is maintained in the TSP where the head of each list contains the wrapping key handle. All TSP keys created which had a certain wrapping key as its parent are then added to the list descending from that wrapping key's list head. A data structure such as the following will be built as keys are created:

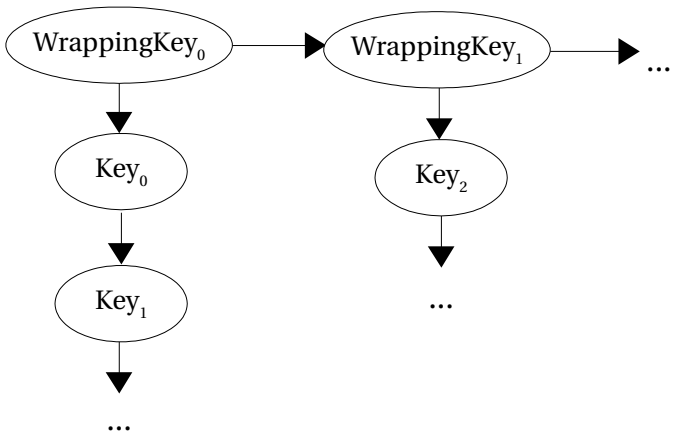


Figure 2.2a: TSP Key Cache objects. $WrappingKey_0$ is an object internal to the TSP that contains the key handle of the key used to wrap Key_0 and Key_1. Likewise, $WrappingKey_1$ was used to wrap Key_2 when it was created. These lists are strictly used for accounting of currently loaded keys, there is no direct link between the object list and this list (see figure 2.2b).

The above objects are very simple linked lists containing only a key handle and a

pointer to the next list. The purpose of this data structure is merely to keep track of which keys are loaded at a given moment in the TSP. When the user calls `Tspi_Key_LoadKey()` or `Tspi_Key_UnloadKey()`, this data structure would be updated.

The object manager and key cache work together in the following way. When an application wants to create a new key, it calls `Tspi_Context_CreateObject()` with arguments to create an object of type `TSS_OBJECT_TYPE_RSAKEY`. `Tspi_Context_CreateObject()` internally calls `addObject()`, which creates the object and sets the TSP context and object type (implicitly, policy objects are also created for the RSA key for both migration and usage). `Tspi_Context_CreateObject()` then allocates and completes as much of a `TCPA_RSAKEY_OBJECT` as it can. (Since the key data is not yet known, it cannot be filled out, but the key's attributes are passed in, and so are already known). When the user then calls `Tspi_Key_CreateKey()`, passing in the handle to the created RSA key object, it does some sanity checking of the handle (and the policies for the key with that handle) and calls the TCS daemon to create the key. Once the call from the TCS daemon returns with the key data, that data is copied into the object's `TCPA_RSAKEY_OBJECT` structure and the key object creation is finished. The key is not yet in the TSP's key cache, however. Once the user calls one of the XX_LoadKey functions, `addKeyHandle()` is called and the key is considered cached.

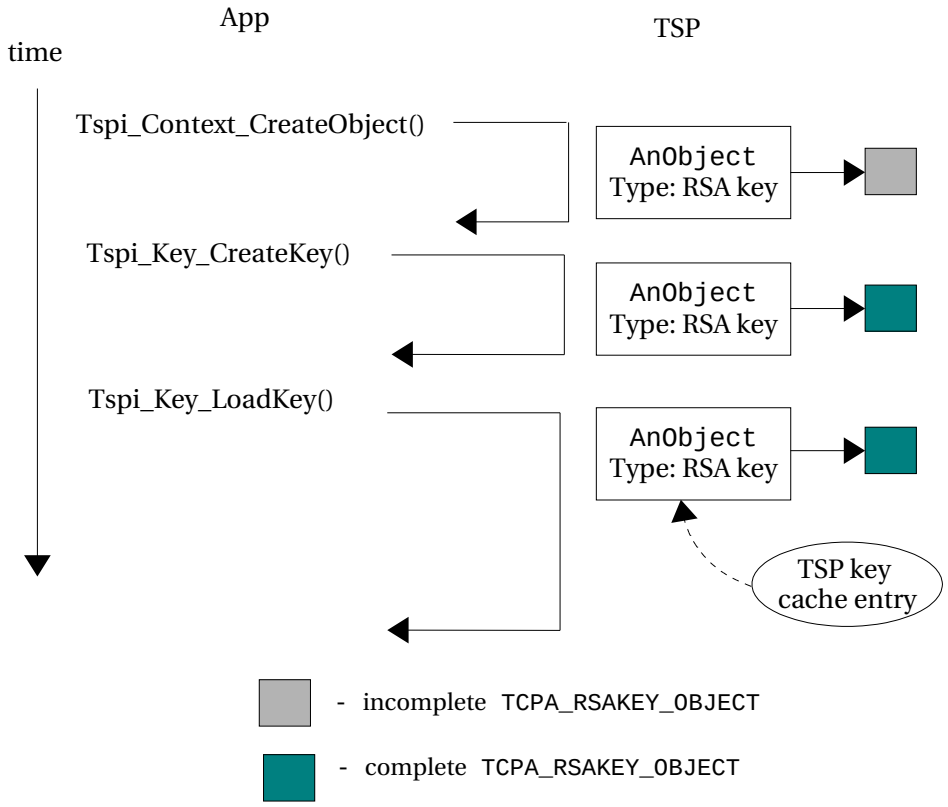


Figure 2.2b: TSP Key creation. The dotted arrow linking the cache entry to the object represents the fact that there is no direct memory reference between the two, but both entities contain a handle to the same key.

2.2.0 Data Structures

`TSPKeyHandleContainer` - *include/spi_internal_types.h*

`TSPKeyHandleContainer` is used to create the linked list of TSP key handles associated with each `TCSKeyHandleContainer`.

`TCSKeyHandleContainer` - *include/spi_internal_types.h*

`TCSKeyHandleContainer` is a list of TCS keys that the TSP has knowledge of. For each key that the TSP creates, a TSPKeyHandleContainer is added to the TCSKeyHandleContainer for that key's parent. (See figure 2.2)

2.2.1 Object Creation Functions

`createTSPKeyHandleContainer` – *tspi/obj.c*

Synopsis:

```
TSPKeyHandleContainer *createTSPKeyHandleContainer()
```

Description:

`createTSPKeyHandleContainer` `calloc`'s space for a new TSP key cache entry. The entry is freed when the corresponding key object is destroyed.

Return Values:

On success, a reference to the key cache entry is returned.

Synchronization:

None.

Errors:

If `calloc` fails, an error is logged and `NULL` is returned.

`createTCSKeyHandleContainer` – *tspi/obj.c*

Synopsis:

```
TCSKeyHandleContainer *createTCSKeyHandleContainer()
```

Description:

`createTCSKeyHandleContainer` `calloc`'s space for a new TCS key cache entry. The entry is freed when the corresponding key object is destroyed.

Return Values:

On success, a reference to the key cache entry is returned.

Synchronization:

None.

Errors:

If `calloc` fails, an error is logged and `NULL` is returned.

2.2.2 Support Functions

`concatTSPKeyHandleContainer` – *tspi/obj.c*

Synopsis:

```
TSPKeyHandleContainer *concatTSPKeyHandleContainer
(TSPKeyHandleContainer ** first, TSPKeyHandleContainer
*second)
```

Description:

`concatTSPKeyHandleContainer` appends the object pointed to by second immediately after the object pointed to by first in the TSP's internal TSP key cache.

Return Values:

`*first` is always returned.

Synchronization:

The TSP key cache lock is held while manipulating the list.

Errors:

None.

`removeTSPKeyHandle` – *tspi/obj.c*

Synopsis:

```
void removeTSPKeyHandle(TSS_HKEY tspHandle)
```

Description:

`removeTSPKeyHandle` removes the TSP key referenced by `tspHandle`. If `tspHandle` does not exist, no action is taken.

Return Values:

None.

Synchronization:

The TSP key cache lock is held while manipulating the list.

Errors:

None.

`concatTCSKeyHandleContainer` – *tspi/obj.c*

Synopsis:

```
TCSKeyHandleContainer *concatTCSKeyHandleContainer
(TCSKeyHandleContainer ** first, TCSKeyHandleContainer
*second)
```

Description:

`concatTCSKeyHandleContainer` appends the object pointed to by second immediately after the object pointed to by first in the TSP's internal TCS key cache.

Return Values:

`*first` is always returned.

Synchronization:

The TSP key cache lock is held while manipulating the list.

Errors:

None.

`getTCSKeyHandleContainerByTCSHandle` – *tspi/obj.c*

Synopsis:

```
TCSKeyHandleContainer *getTCSKeyHandleContainerByTCSHandle
```

```
(TCS_KEY_HANDLE tcsHandle)
```

Description:

getTCSKeyHandleContainerByTCSHandle searches through the TSP's key cache for for the key cache container whose TCS key handle matches tcsHandle.

Return Values:

On success, a reference to the key cache container requested is returned.

Synchronization:

The TSP key cache lock is held while the list is searched.

Errors:

If tcsHandle is not a valid TCS key handle, NULL is returned.

addKeyHandle – *tspi/obj.c*

Synopsis:

```
TSS_RESULT addKeyHandle(TCS_KEY_HANDLE tcsHandle, TSS_HKEY
tspHandle)
```

Description:

addKeyHandle creates a new TSP key cache entry bound to tspHandle. If a key cache container already exists for the TCS tcsHandle, the new TSP key cache entry is added to that, otherwise a new TCS key cache entry is created for tcsHandle. Allocated memory will be freed if the application explicitly calls Tspi_Context_CloseObject(), Tspi_Context_Close() or if the key is evicted.

Return Values:

On success, TSS_SUCCESS is returned.

Synchronization:

The TSP key cache lock is held while the new item is added.

Errors:

If malloc fails, TSS_E_OUTOFMEMORY is returned, and an error is logged.

removeTCSKeyHandle – *tspi/obj.c*

Synopsis:

```
void removeTCSKeyHandle(TCS_KEY_HANDLE tcsHandle)
```

Description:

removeTCSKeyHandle searches for the TCS key cache container that matches tcsHandle and removes it. All TSP key cache handles that were associated with the removed TCS key cache container are removed as well.

Return Values:

None.

Synchronization:

The TSP key cache lock is held while manipulating the list.

Errors:

None.

`getTCSKeyHandle` – *tspi/obj.c*

Synopsis:

```
TCS_KEY_HANDLE getTCSKeyHandle(TSS_HKEY tspHandle)
```

Description:

`getTCSKeyHandle` searches the TSP key cache list `tspHandle` and returns the TCS key handle associated with it.

Return Values:

On success, `getTCSKeyHandle` returns the TCS key handle requested.

Synchronization:

The TSP key cache lock is held while the list is searched.

Errors:

If no key handle matches `tspHandle`, `NULL_TCS_HANDLE` is returned.

2.3 Cryptographic Services

Cryptographic services are provided by a cryptographic library implementing the functions below (section 2.3.0). Crypto implementations will be found in their own directories under `tspi/crypto`, the current implementation being provided by openssl, in `tspi/crypto/openssl`. The decision on which library will be the cryptographic provider will be made at build time, based on which library is available.

Adding a new crypto implementation should be fairly straightforward:
1) Create a new directory, e.g. `src/tspi/crypto/myCrypto`.
2) Inside this directory, add a file named '`crypto.c`' which implements the functions in section 2.3.0
3) Add a check in configure.in for your crypto library and headers (see the openssl section of `configure.in` for an example). Make sure that the build system sets the variable "CRYPTO_PACKAGE" to the name of the directory you created in step 1. At build time, `src/tspi/crypto/$CRYPTO_PACKAGE/crypto.c` will be built.

One hurdle to implementing the cryptographic operations needed to interact with a TPM is the fact that the TPM requires the OAEP padding parameter of RSA encrypt/decrypt operations to be set to the NULL terminated string "TCPA".

2.3.0 Cryptographic functions

`TSS_Hash` – *tspi/crypto/$CRYPTO_PACKAGE/crypto.c*

Synopsis:

```
TCPA_RESULT TSS_Hash(UINT32 HashType, UINT32 BufSize, BYTE
*Buf, BYTE * Digest)
```

Description:

Compute the hash value of the data pointed to by `Buf`. The hash algorithm to be used is specified by `HashType`. The length of the input buffer is specified by `BufSize` and `Digest` is the location where the resulting hash value will be written. It is assumed that `Digest` points to enough bytes to hold the resulting hash.

Return Values:

On success, the hash is written to `Digest` and `TSS_SUCCESS` is returned.

Synchronization:

None.

Synchronization:

None.

Errors:

If `HashType` is not a supported type, `TSS_E_BAD_PARAMETER` is returned. If a call to the underlying crypto library fails, `TSS_E_INTERNAL_ERROR` is returned and the underlying crypto library's error printing functions are invoked.

`TSS_HMAC` – *tspi/crypto/$CRYPTO_PACKAGE/crypto.c*

Synopsis:

```
UINT32 TSS_HMAC(UINT32 HashType, UINT32 SecretSize, BYTE*
Secret, UINT32 BufSize, BYTE* Buf, BYTE* hmacOut)
```

Description:

`TSS_HMAC` computes the HMAC of the data at `Buf` based on the hash algorithm `HashType`. `BufSize` should be the number of bytes pointed to by `Buf`. `SecretSize` should be the size of the secret passed in at location `Secret`. The resulting HMAC will be written to the address pointed to by `hmacOut`. It is assumed that that `hmacOut` points to enough bytes to hold the resulting HMAC.

Return Values:

On success, the HMAC is written to `hmacOut` and `TSS_SUCCESS` is returned.

Synchronization:

None.

Synchronization:

None.

Errors:

If `HashType` is not a supported type, `TSS_E_BAD_PARAMETER` is returned.

`TSS_RSA_Encrypt` – *tspi/crypto/$CRYPTO_PACKAGE/crypto.c*

Synopsis:

```
int TSS_RSA_Encrypt(unsigned char *dataToEncrypt, unsigned
int dataToEncryptLen, unsigned char *encryptedData, unsigned
int *encryptedDataLen, unsigned char *publicKey, unsigned
int keysize)
```

Description:

`TSS_RSA_Encrypt` encrypts `dataToEncryptLen` bytes pointed to by `dataToEncrypt` using the key data `publicKey`. The size of `publicKey` is specified by `keysize`. The resulting encrypted data is written to `encryptedData` and `*encryptedDataLen` is set to the number of encrypted bytes written.

Data passed to `TSS_RSA_Encrypt` will be encrypted using PKCS#1 OAEP padding and a public exponent of 3.

Return Values:

On success, *encryptedDataLen is set to the number of encrypted bytes written to encryptedData and TSS_SUCCESS is returned.

Synchronization:

None.

Errors:

If the RSA key object cannot be created due to a malloc failure, TSS_E_OUTOFMEMORY is returned and none of the input parameters are touched. If calls to the the underlying crypto library fail, TSS_E_INTERNAL_ERROR is returned.

TSS_Verify – *tspi/crypto/$CRYPTO_PACKAGE/crypto.c*

Synopsis:

```
int TSS_Verify(UINT32 HashType, BYTE *pHash, UINT32
iHashLength, unsigned char *pModulus, int iKeyLength, BYTE
*pSignature, UINT32 sig_len)
```

Description:

TSS_Verify decrypts the signature at pSignature using the key pModulus and compares the result to pHash. iHashLength should be the length of the data at pHash and iKeyLength should be the length of the key. Currently the only supported HashType is TSS_HASH_SHA1.

Data passed to TSS_Verify will be decrypted using PKCS#1 OAEP padding and a public exponent of 3.

Return Values:

On success the result of the comparison between pHash and the decryption operation will be returned.

Synchronization:

None.

Errors:

If the RSA key object cannot be created due to a malloc failure, TSS_E_OUTOFMEMORY is returned and none of the input parameters are touched. If calls to the the underlying crypto library fail, TSS_E_INTERNAL_ERROR is returned.

TSS_RSA_PKCS15_Encrypt – *tspi/crypto/$CRYPTO_PACKAGE/crypto.c*

Synopsis:

```
int TSS_RSA_PKCS15_Encrypt(unsigned char *dataToEncrypt,
unsigned int dataToEncryptLen, unsigned char *encryptedData,
unsigned int *encryptedDataLen, unsigned char * publicKey,
unsigned int keysize, BYTE* seed);
```

Description:

TSS_RSA_PKCS15_Encrypt encrypts dataToEncryptLen bytes pointed to by dataToEncrypt using the key data publicKey. The size of publicKey is specified by keysize. The resulting encrypted data is written to encryptedData and *encryptedDataLen is set to the number of encrypted bytes written. seed is

currently unused.

Data passed to `TSS_RSA_Encrypt` will be encrypted using PKCS#1 v1.5 padding and a public exponent of 3.

Return Values:

On success, `*encryptedDataLen` is set to the number of encrypted bytes written to `encryptedData` and `TSS_SUCCESS` is returned.

Synchronization:

None.

Errors:

If the RSA key object cannot be created due to a `malloc` failure, `TSS_E_OUTOFMEMORY` is returned and none of the input parameters are touched. If calls to the the underlying crypto library fail, `TSS_E_INTERNAL_ERROR` is returned.

2.4 Graphical User Interface

The sole GUI components to the LTC TSS will be the pop up windows used to input authentication data for new and existing keys. Any number of different toolkits can be used to implement the underlying functionality needed by the `popup_GetSecret()` function in section 2.4.0.

In the same way that the cryptographic implementations are pluggable, the GUI components will be as well. `DisplayNewPINWindow` and `DisplayPINWindow` will be the abstraction point here (these are the two functions called by `popup_GetSecret`). In order to add a new type of GUI component to drive the popup messages, do the following:
1) Create a new directory, e.g. `src/tspi/gui/myGui`.
2) Inside this directory, create the files '`main.c`', '`support.c`', '`interface.c`' and '`callbacks.c`' which implement `DisplayNewPINWindow()` and `DisplayPINWindow()`.
3) Add a check in configure.in for your GUI library and headers (see the GTK section of `configure.in` for an example). Make sure that the build system sets the variable "GUI_PATH" to the name of the directory you created in step 1. At build time, `src/tspi/gui/$GUI_PATH/*.c` will be built.

2.4.0 Graphical User Interface Functions

`popup_GetSecret` - *tspi/secrets.c*

Synopsis:

```
TSS_RESULT popup_GetSecret(UINT32 new_pin, BYTE *message,
void *auth_hash)
```

Description:

`popup_GetSecret` invokes an underlying implementation to display a GUI window for accepting authentication data. If `new_pin` is non-zero, `DisplayNewPINWindow` will be invoked, otherwise `DisplayPINWindow` will be invoked. Both `DisplayNewPINWindow` and `DisplayPINWindow` are implented based on which GUI toolkit is available at build time.

`message` will be displayed in the title bar of the window created. The SHA-1 hash of the data collected by the PIN window will be written to `auth_hash`.

`DisplayNewPINWindow` is intended to have entry boxes for a password and confirm

password (to receive a password which has not previously been entered), whereas `DisplayPINWindow` will only have a box to enter one password, where that password has previously been passed into the TSP and is only being verified.

Return Values:

On success, the SHA-1 hash of the data collected by the PIN window will be written to `auth_hash` and `TSS_SUCCESS` is returned.

Synchronization:

None.

Errors:

If message is not set, or if the GUI pop up dialog is canceled by the user, `TSS_E_INTERNAL_ERROR` is returned.

2.5 Memory Management

The memory management functions in the TSP are used when data allocated by the TSS must be returned to the application. At a later time this data will need to be `free`'d due to a call to `Tspi_Context_CloseObject()` or explicitly by a call to `Tspi_Context_FreeMemory()`. Each `malloc`'d area of memory is associated with the TCS that the current TSP context is associated with. This will enable easy cleanup of memory allocated by a TCS for one or more TSP contexts which may close unexpected.

2.5.0 Data Structures

`MemSlot` - *include/memmgr.h*

A `MemSlot` holds a reference to a memory area and pointer to the next `MemSlot`.

`ContextMemSlot` - *include/memmgr.h*

A `ContextMemSlot` holds a `TCS_CONTEXT_HANDLE`, a pointer to a `MemSlot` and a pointer to the next `ContextMemSlot`. For each TCS context handle the TSP gets, a linked list of memory references will be maintained.

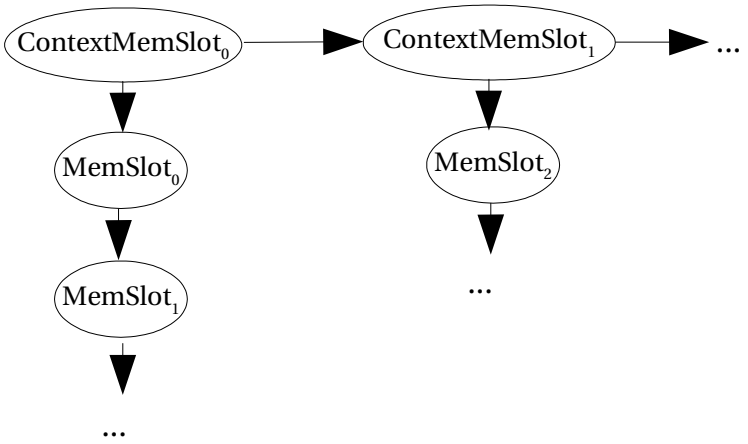


Figure 2.0.5.0: Memory references maintained by the TSP

2.5.1 Functions

`createMemSlot` - *tspi/memmgr.c*

Synopsis:

```
MemSlot *createMemSlot()
```

Description:

`createMemSlot calloc`'s a `MemSlot` structure to be used by the memory management subsystem. The mem slot is freed when either the application closes its TSP context or explicityl calls `Tspi_Context_FreeMemory()`.

Return Values:

On success, a reference to a new, zeroed-out `MemSlot` structure is returned.

Synchronization:

None.

Errors:

If `calloc` fails, `TSS_E_OUTOFOMEMORY` is returned.

`concatMemSlot` - *tspi/memmgr.c*

Synopsis:

```
MemSlot *concatMemSlot(MemSlot **first, MemSlot *second)
```

Description:

`concatMemSlot` appends the `MemSlot` pointed to by `second` immediately after the `MemSlot` pointed to by `first`.

Return Values:

`*first` is always returned.

Synchronization:

The TSP mem cache lock is held while manipulating the list.

Errors:

None.

`removeMemSlotByPointer` - *tspi/memmgr.c*

Synopsis:

```
TSS_RESULT removeMemSlotByPointer(ContextMemSlot * cms, void
*pointer)
```

Description:

`removeMemSlotByPointer` searches through the memory list inside `cms` for `pointer`. If `pointer` is a valid memory pointer in `cms`, it is then removed.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The TSP mem cache lock is held while removing the item from the list.

Errors:

If `pointer` is not found in `cms`'s memory list, `TSS_E_INTERNAL_ERROR` is returned.

`calloc_tspi` - *tspi/memmgr.c*

Synopsis:

```
void *calloc_tspi(TCS_CONTEXT_HANDLE tcsContext, UINT32
howMuch)
```

Description:

`calloc_tspi` attempts to allocate a `MemSlot` of size `howMuch` in the `ContextMemSlot` referenced by `tcsContext`. If a `ContextMemSlot` does not exist for `tcsContext`, a new one is created.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

Holds the mem cache lock while adding the `MemSlot`.

Errors:

If an error occurs, it is passed on to the caller.

`free_tspi` - *tspi/memmgr.c*

Synopsis:

```
TSS_RESULT free_tspi(TCS_CONTEXT_HANDLE tcsContext, void
*memPointer)
```

Description:

`free_tspi` deallocates the memory located at `memPointer` from the `ContextMemSlot` structure associated with `tcsContext`.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

Holds the mem cache lock while removing the `MemSlot`.

Errors:

If an error occurs, it is passed on through to the caller. If `tcsContext` is not a valid TCS context, `TSS_E_INVALID_HANDLE` is returned.

`isThisPointerSPI` - *tspi/memmgr.c*

Synopsis:

```
BOOL isThisPointerSPI(TCS_CONTEXT_HANDLE tcsContext, void
*memPointer)
```

Description:

`isThisPointerSPI` searches for the `ContextMemSlot` referenced by `tcsContext` for a pointer that matches `memPointer`. If it is found, `TRUE` is returned, else `FALSE`.

Return Values:

TRUE if memPointer is an existing reference to memory inside the ContextMemSlot referenced by tcsContext, FALSE otherwise.

Synchronization:

Holds the mem slot pointer while searching the list.

Errors:

If tcsContext is not a valid TCS context, FALSE is returned.

2.6 Persistent Storage

User Persistent Storage (PS) is created to store keys on disk for loading at a later time. Stored in user PS are a key's public and encrypted private areas, the key's properties and the UUID of the key and its parent. The UUID's of keys kept in user PS can be the same as the UUID's of keys in other processes' user PS, since no one entity knows about both keys. If one process's TSP registers a key from its user PS into system PS and another process then tries to register its key into system PS with a duplicate UUID, the TSS will return TSS_E_KEY_ALREADY_REGISTERED.

The term 'persistent storage' can be confusing here, since the term persistent is usually understood to mean “across multiple processes lifetimes.' Persistent storage is a more applicable term to the TCS's storage, since it does exist across processes lifetimes, TCSD restarts and platform restarts. However, the term 'persistent storage' is used here as well in order to match the language in the TSS 1.1 specification.

The user persistent storage maintained by a TSP is a per-process data store. Its lifetime is the same as that of the process that's using it. The user persistent storage will be created as /var/tpm/user.{pid}, where {pid} is the process id of the TSP. On fork(), the child process will not retain any access to the parent's TSP key store.

The user and system PS files will be binary stores of the keys and key attributes listed above. Keys will be stored in a way that makes key searches by UUID, public data and TCPA_KEY structure optimal (these are the 3 search types possible in explicit calls to the TCS). The format used is the following:

```
UINT32   num_keys_on_disk
TSS_UUID UUID_key0
TSS_UUID parent_UUID_key0
UINT16   public_key_size0
UINT16   blob_size0
UINT16   cache_flags0
BYTE[]   public_key0
BYTE[]   blob0
TSS_UUID UUID_key1
TSS_UUID parent_UUID_key1
UINT16   public_key_size1
UINT16   blob_size1
UINT16   cache_flags1
BYTE[]   public_key1
BYTE[]   blob1
[...]
EOF
```

The `cache_flags` variable will record where the key's parent is stored (User or System PS) and whether the key is valid or not. The valid flag is set when the key is written to disk and unset by any operation that unregisters the key.

Performance tests will determine whether its necessary to break out the public data area of each key. This should yield faster search times (since the entire key blob will not have to be read from disk to perform some searches), but will require more disk space, since the public data area is contained in the key's blob.

2.6.0 Persistent Storage Functions

`ps_get_parent_uuid_by_uuid` - *tspi/ps/tspps.c*

Synopsis:

```
TSS_RESULT ps_get_parent_uuid_by_uuid( int fd, TSS_UUID
*uuid, TSS_UUID *ret_uuid )
```

Description:

`ps_get_parent_uuid_by_uuid` checks the persistent data store kept in the file with file descriptor `fd` for the UUID `uuid` and if found, copies the parent UUID of it into the area pointed to by `ret_uuid`.

Return Values:

On success, `*ret_uuid` is filled with the requested UUID and `TSS_SUCCESS` is returned.

Synchronization:

The file itself is locked using `flock()` while the file is searched.

Errors:

If `uuid` is not found or its parent UUID is not found, `TSS_E_PS_KEY_NOTFOUND` is returned. If an error occurs while searching for `uuid`, `TSS_E_INTERNAL_ERROR` is returned.

`ps_get_key_by_uuid` - *tspi/ps/tspps.c*

Synopsis:

```
TSS_RESULT ps_get_key_by_uuid( int fd, TSS_UUID uuid, BYTE*
ret_buffer, UINT16* ret_buffer_size )
```

Description:

`ps_get_key_by_uuid` checks the persistent data store kept in the file with descriptor `fd` for the UUID `uuid` and if found, returns the key data associated with it in `ret_buffer` and the size of the key in `*ret_buffer_size`.

Return Values:

On success, `ret_buffer` will contain the key data of key with UUID `uuid` and the `ret_buffer_size` is set to the size of the returned key and `TSS_SUCCESS` is returned.

Synchronization:

The file itself is locked using `flock()` while the key is being read.

Errors:

If uuid is not found, TSS_E_PS_KEY_NOTFOUND is returned. If the operation of key extraction fails, TCS_E_INTERNAL_ERROR is returned.

ps_is_pub_registered - *tspi/ps/tspps.c*

Synopsis:

```
TSS_RESULT ps_is_pub_registered( int fd, TCPA_STORE_PUBKEY
*pub, BOOL *is_reg )
```

Description:

ps_is_pub_registeredd checks the persistent data store kept in the file with descriptor fd for the public key data *pub and if found, returns TRUE in the variable is_reg.

Return Values:

On success, *is_reg is set and TSS_SUCCESS is returned.

Synchronization:

The file itself is locked using flock() while the file is searched.

Errors:

If an error occurs while searching for *pub, TSS_E_INTERNAL_ERROR is returned.

ps_get_uuid_by_pub - *tspi/ps/tspps.c*

Synopsis:

```
TSS_RESULT ps_get_uuid_by_pub( int fd, TCPA_STORE_PUBKEY
*pub, TSS_UUID **ret_uuid )
```

Description:

ps_get_uuid_by_pub checks the persistent data store kept in the file with descriptor fd for the public key data pub and if found, mallocs new space and copies its UUID into a buffer pointed to by **ret_uuid.

Return Values:

On success, **ret_uuid is set to the requested UUID and TSS_SUCCESS is returned.

Synchronization:

The file itself is locked using flock() while the file is searched.

Errors:

If the public key data does not match any keys in the requested persistent store TSS_E_PS_KEY_NOTFOUND is returned. If the operation of extracting the UUID fails, TCS_E_INTERNAL_ERROR is returned. If memory cannot be malloc'd to return the uuid, TSS_E_OUTOFMEMORY.

ps_write_key - *tspi/ps/tspps.c*

Synopsis:

```
TSS_RESULT ps_write_key( int fd, TSS_UUID *uuid, TSS_UUID
parent_uuid, UINT32* parent_ps, BYTE* key_blob, UINT32
key_blob_size )
```

Description:

ps_write_key writes the key pointed to by key_blob to the persistent store in the file with descriptor fd. uuid is set as the UUID and parent_uuid is set as the key's

parent's UUID. If `parent_ps` is `TSS_PS_TYPE_SYSTEM`, the parent's persistent storage type is recorded as system storage, else user storage.

Return Values:
On success, the key is written to persistent storage and `TSS_SUCCESS` is returned.

Synchronization:
The file itself is locked using `flock()` while the key is being written.

Errors:
If any operation fails, `TCS_E_INTERNAL_ERROR` is returned.

`get_file` - *tspi/ps/tspps.c*

Synopsis:

```
int get_file()
```

Description:
`get_file` is a function used by other functions to obtain a handle to a persistent storage file. On the first call of get_file, the persistent storage file will be created, opened and locked. On subsequent calls, the file lock will be taken and the handle will be returned.

Return Values:
On success, the integer handle to persistent storage is returned.

Synchronization:
The file is locked using `flock()` while the key is being written.

Errors:
If any operation fails, `TCS_E_INTERNAL_ERROR` is returned.

`put_file` - *tspi/ps/tspps.c*

Synopsis:

```
int put_file(int fd)
```

Description:
`put_file` is a function used by other functions to release a handle to a persistent storage file. `put_file` is basically just a wrapper to `flock`(), with the file lock being released.

Return Values:
On success, the integer handle to persistent storage is returned.

Synchronization:
The file's lock is released using `flock()`.

Errors:
If any operation fails, `-1` is returned.

`write_key_init` - *tspi/ps/tspps.c*

Synopsis:

```
int write_key_init(int fd, UINT32 pub_data_size, UINT32
blob_size)
```

Description:

`write_key_init` is used to move the file pointer of the file with descriptor `fd` to the point where the next key can be written.

Return Values:

On success, the value of the offset into the persistent storage file (in bytes) where the new key should be written is returned. It calls find_write_offset to check if there are any "holes" in the file and if so, returns the offset of the hole. If not, the file pointer is seeked to the end of the file and that offset is returned.

Synchronization:

None.

Errors:

If an error occurs in seeking, `-1` is returned.

`find_write_offset` - *tspi/ps/tspps.c*

Synopsis:

```
int find_write_offset(UINT32 pub_data_size, UINT32
blob_size)
```

Description:

`find_write_offset` is used by `write_key_init()` to find any "holes" in the persistent storage file to write a new key to. Based on the size of the public key data and blob, `find_write_offset` moves through the key disk cache and tries to find an invalid cache entry (an entry that has been flagged as invalid in the PS) that matches these two fields. If found, the offset into the file of this "hole" is returned.

Return Values:

On success, the value of the offset into the persistent storage file (in bytes) where the new key should be written is returned.

Synchronization:

The key disk cache lock is held while searching for the invalid key.

Errors:

If no "empty" space in the PS file is found, `-1` is returned.

2.6.1 Key Registration Functions

The following key registration functions sit on top of the persistent storage functions in section 2.6.0. They act as wrappers, first creating the persistent store file name based on their process ID and then returning a `TSS_RESULT` based on whether the underlying persistent store function succeeds or fails.

`keyreg_IsKeyAlreadyRegistered` - *tspi/keyreg.c*

Synopsis:

```
BOOL keyreg_IsKeyAlreadyRegistered(UINT32 keyBlobSize, BYTE
*keyBlob)
```

Description:

`keyreg_IsKeyAlreadyRegistered` checks the persistent store for the public key data contained in `keyBlob`. `keyBlobSize` is currently unused.

Return Values:

If the key exists, `TRUE` is returned, else `FALSE`.

Synchronization:

The file lock is held by the layer below (see functions in section 2.6.0).

Errors:

If an error occurs, `FALSE` is returned and the error is logged.

`keyreg_WriteKeyToFile` - *tspi/keyreg.c*

Synopsis:

```
TSS_RESULT keyreg_WriteKeyToFile(TSS_UUID myUUID, TSS_UUID
parentUUID, UINT32 parentPSType, UINT32 blobSize, BYTE
*blob)
```

Description:

`keyreg_WriteKeyToFile` generates the persistent storage file based on the current process ID and calls the underlying persistent storage function to write the key blob into it.

Return Values:

On success `TSS_SUCCESS` is returned.

Synchronization:

The file lock is held by the layer below (see functions in section 2.6.0).

Errors:

If an error occurs while generating the persistent storage filename, `TSS_E_INTERNAL_ERROR` is returned.

`keyreg_RemoveKey` - *tspi/keyreg.c*

Synopsis:

```
TSS_RESULT keyreg_RemoveKey(TCS_CONTEXT_HANDLE tcsContext,
TSS_UUID *uuid)
```

Description:

`keyreg_RemoveKey` searches the key disk cache for an entry with UUID equal to `uuid`. If its found, the cache entry is marked invalid. In the future, if a new key needs to be written to disk, the invalidated entry will be overwritten.

Return Values:

If a disk cache entry is found with a UUID matching `uuid`, the entry is marked invalid and TSS_SUCCESS is returned.

Synchronization:

The key disk cache lock is held while searching through the cache. The file lock is never taken, since no changes to the file are made.

Errors:

If a key with UUID `uuid` is not found in the disk cache, `TSS_E_PS_KEY_NOTFOUND`

is returned.

`keyreg_GetKeyByUUID` - *tspi/keyreg.c*

Synopsis:

```
TSS_RESULT keyreg_GetKeyByUUID(TCS_CONTEXT_HANDLE
tcsContext, TSS_UUID *uuid, UINT32 *blobSizeOut, BYTE
**blob)
```

Description:

`keyreg_GetKeyByUUID` takes the file lock for the persistent storage file and calls the underlying persistent storage function (`ps_get_key_by_uuid`) to retreive the key `*blob` from it. `*blobSizeOut` is also set to the size of the retreived key blob. `malloc` is called to create space for the returned blob.

Return Values:

On success `TSS_SUCCESS` is returned.

Synchronization:

The file lock is held by the layer below (see functions in section 2.6.0).

Errors:

If an error occurs while getting the persistent storage file's lock, `TSS_E_INTERNAL_ERROR` is returned. If the underlying persistent storage function fails, its return code is passed through to the caller.

`keyreg_GetParentUUIDByUUID` - *tspi/keyreg.c*

Synopsis:

```
TSS_RESULT keyreg_GetParentUUIDByUUID(TSS_UUID *uuid,
TSS_UUID * parent_uuid)
```

Description:

`keyreg_GetParentUUIDByUUID` generates the persistent storage file based on the current process ID and calls the underlying persistent storage function to retreive the parent's UUID of the key with UUID `uuid`.

Return Values:

On success `TSS_SUCCESS` is returned and `*parent_uuid` is set.

Synchronization:

The file lock is held by the layer below (see functions in section 2.6.0).

Errors:

If an error occurs while generating the persistent storage filename, `TSS_E_INTERNAL_ERROR` is returned. If the underlying persistent storage function fails, `TSS_E_PS_KEY_NOTFOUND` is returned.

`keyreg_GetParentPSTypeByUUID` - *tspi/keyreg.c*

Synopsis:

```
TSS_RESULT keyreg_GetParentPSTypeByUUID(TSS_UUID *uuid,
UINT32 * psTypeOut)
```

Description:

`keyreg_GetParentPSTypeByUUID` checks the key disk cache for a key with UUID

`uuid` and returns its PS type in `*psTypeOut`.

Return Values:

On success, `*psTypeOut` is set to the persistent storage type of the parent UUID of the key matching `uuid` and `TSS_SUCCESS` is returned.

Synchronization:

The key disk cache lock is held while searching the list.

Errors:

If the UUID `uuid` is not found, `TSS_E_PS_KEY_NOTFOUND` is returned.

`keyreg_replaceEncData_PS` - *tspi/keyreg.c*

Synopsis:

```
TSS_RESULT keyreg_replaceEncData_PS(BYTE * encData, BYTE
*newEncData)
```

Description:

`keyreg_replaceEncData_PS` generates the persistent storage file based on the current process ID and calls the underlying persistent storage function to replace `encData` with `newEncData`.

Return Values:

On success `TSS_SUCCESS` is returned.

Synchronization:

The file lock is held by the layer below (see functions in section 2.6.0).

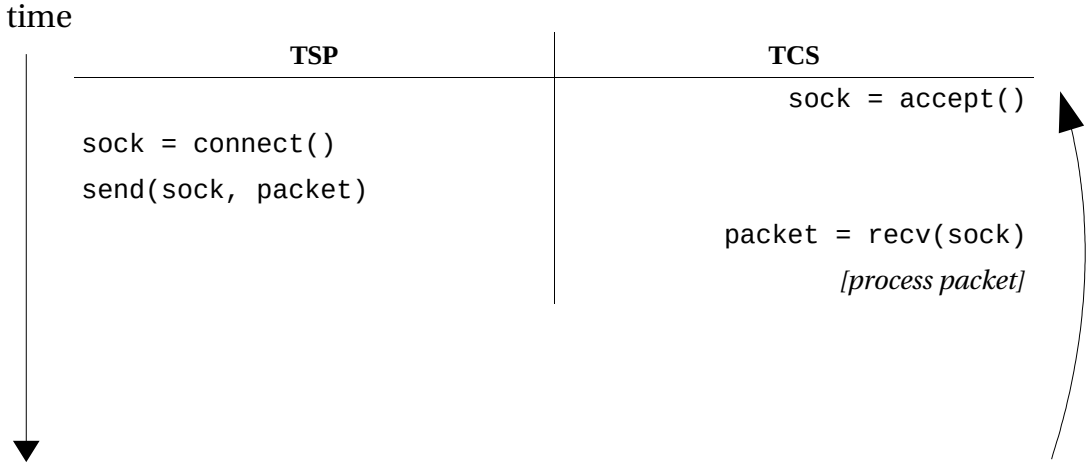
Errors:

If an error occurs while generating the persistent storage filename, `TSS_E_INTERNAL_ERROR` is returned.

2.7 TCS Calling Interface

The format of the packets transferred between the TSP and the TCS layers are set to be defined by a proposal to the TSS Working Group (TSSWG) as of the writing of this document. The LTC-TSS will conform to this packet format once it is approved by the TSSWG. The format is expected to be SOAP based.

From the TSP's view, a transaction between the TCS and TSP would look like a standard client-server interaction:



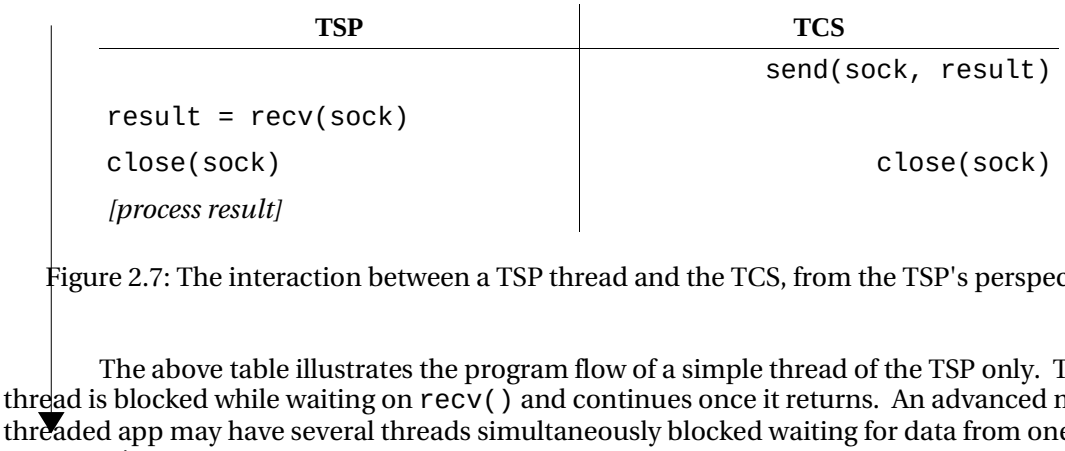


Figure 2.7: The interaction between a TSP thread and the TCS, from the TSP's perspective

The above table illustrates the program flow of a simple thread of the TSP only. The thread is blocked while waiting on `recv()` and continues once it returns. An advanced multi-threaded app may have several threads simultaneously blocked waiting for data from one or more TCS's.

Please refer to section 3.1 for information on the TCS's processing of packets.

2.8 Utilities

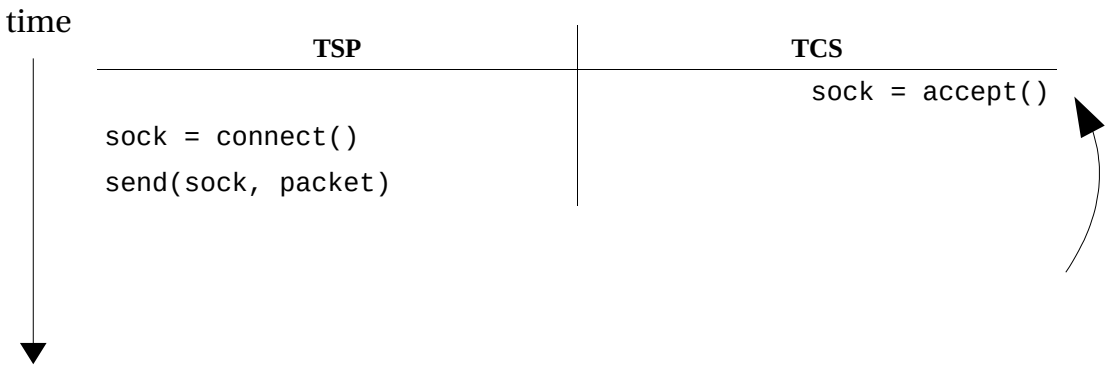
Some functions included in the LTC-TSS are not enumerated in this low level design . The use and purpose of these functions should be obvious to anyone reading the code and so are not included here. These are functions for things such as sanity checking whether a context exists or is the right type, utilities to manipulate blobs of data, routines to convert from one data type to another and so on. All functions not enumerated here are internal to the TSS only.

3.0 TCG Core Service

3.1 TCS Calling Interface

The TCG Core Services daemon is required to be implemented as a system service, being the sole access to the TPM hardware (through the TCG device driver layer). The TCS provides serialized TPM access to multiple TSP's, manages the system persistent key storage, manages requests made to the TPM as well as providing the API services specified in the TSS 1.1 specification. The TCS also manages the log of PCR events.

The TCS is multi-threaded, but the view of a transaction from the TCS side is slightly less complex:



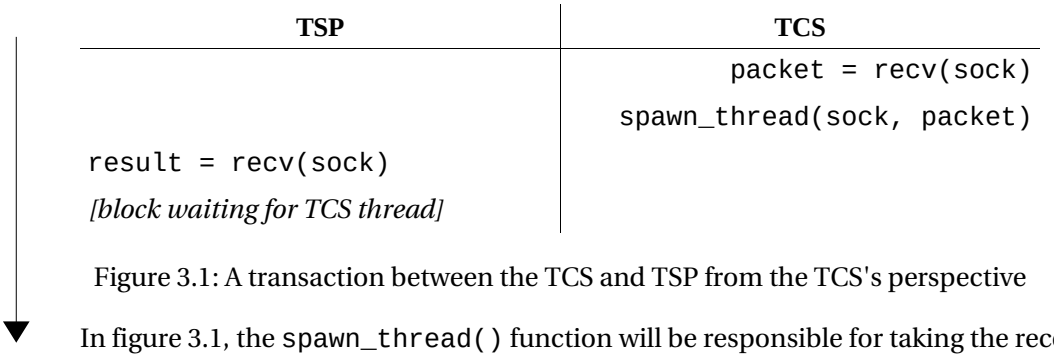


Figure 3.1: A transaction between the TCS and TSP from the TCS's perspective

In figure 3.1, the `spawn_thread()` function will be responsible for taking the received packet, decoding it, calling the correct function based on the TCS ordinal and calling `send()` to return the result of the operation to the TSP. This operation may block if the thread requires access to the TPM. Since a TPM request can take on the order of seconds to complete, a TPM Request Manager (TRM), residing inside the TCS, will block more than one thread from accessing the TPM at a time. The TRM will be responsible for maintaining the queue of current TPM requests, while the TCSKCM will dispatch threads to the TRM based on which key and auth contexts each request requires and which contexts are cached in the TPM. A simple scheduler algorithm such as round-robin would not be appropriate for the , since the TPM's resources are limited and swapping out contexts for requests from multiple threads has high overhead. Performance data from test cases will be used to identify an optimal algorithm.

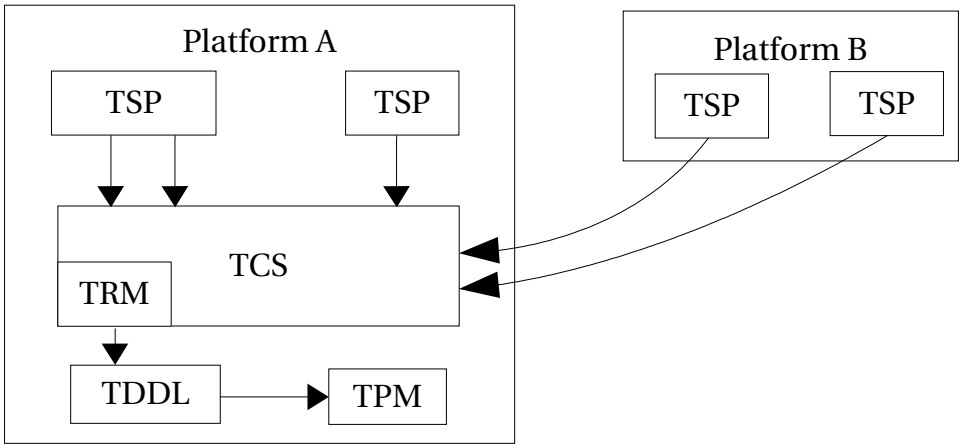


Figure 3.2: Multi-threaded access to a TPM. Each arrow represents a thread of execution.

3.1.0 Data Structures

`TCSRequest`

The TCSRequest structure will hold a decoded request from the TSP. After receiving the encoded data from the TSP, `packetDecode` will be called to convert it into a TCSRequest structure. The TCSRequest will then be handled by the TCS.

3.1.1 Functions [FIXME]

`packetDecode` – tcs/main.c

Synopsis:

```
struct TCSRequest *packetDecode(void *data)
```

Description:

`packetDecode` takes data received from a TSP and decodes it into a valid TCS request. The structure of `TCSRequest` will be described in an upcoming TSSWG proposal.

Return Values:

On success, `packetDecode` returns a newly allocated `TCSRequest` structure, filled out with data from `*data`.

Synchronization:

None.

Errors:

If a valid TCS request cannot be created from `data`, `NULL` is returned.

`packetEncode` – tcs/main.c

Synopsis:

```
int packetEncode(struct TCSRequest *req, char *dest)
```

Description:

`packetEncode` takes a `TCSRequest` to be returned to a TSP and encodes it into a format that the TSP will understand. The structure of `TCSRequest` will be described in an upcoming TSSWG proposal. `req` is encoded into the correct format and written to `dest`. The number of bytes written to `dest` is then returned.

Return Values:

On success, `packetEncode` returns the number of bytes written to `dest`.

Synchronization:

None.

Errors:

If a valid encoded packet cannot be created from req, `-TSS_E_INTERNAL_ERROR` is returned.

3.2 System Persistent Storage

Once a TCS daemon is started and it begins the task of managing a platform's TPM, the system PS begins to be populated with keys. Initially, only the TPM's Storage Root Key (SRK) is read from the chip and written to system persistent storage, but eventually TSP's will begin requesting that their keys be registered in system PS. Keys registered in system PS will be available until the application calls `Tspi_Context_UnregisterKey()`. The keys registered in system PS will remain on disk after the application exits and will survive system reboots/halts and TCS restarts. The amount of system PS is limited only by available disk space.

System persistent storage is kept in the file `/var/tpm/system.data`. The system persistent storage file will have the same format as the user persistent storage files. The TCS daemon will create `/var/tpm/system.data` (including the directory) if it does not exist. The `/var/tpm` directory will be set with its sticky bit on, so that applications cannot modify or

delete the system persistent storage file.

The system persistent storage file format will be the following:

```
UINT32   num_keys_on_disk
TSS_UUID UUID_key0
TSS_UUID parent_UUID_key0
UINT16   public_key_size0
UINT16   blob_size0
UINT16   cache_flags0
BYTE[]   public_key0
BYTE[]   blob0
TSS_UUID UUID_key1
TSS_UUID parent_UUID_key1
UINT16   public_key_size1
UINT16   blob_size1
UINT16   cache_flags1
BYTE[]   public_key1
BYTE[]   blob1
[...]
EOF
```

The `cache_flags` variable will record where the key's parent is stored (User or System PS) and whether the key is valid or not. The valid flag is set when the key is written to disk and unset by any operation that unregisters the key. At TCSd shutdown time, the `disk_cache` array in memory is scanned and any invalid keys are zeroized on disk. `num_keys_on_disk` keeps count of the total number of spaces on disk that keys occupy. The `num_keys_on_disk` variable is not affected by whether a key is valid or not.

3.2.0Functions

`getNextTcsKeyHandle` - *tcs/cache.c*

Synopsis:

```
TCS_KEY_HANDLE getNextTcsKeyHandle()
```

Description:

`getNextTcsKeyHandle` generates the next unique TCS key handle and returns it.

Return Values:

On success, the next available TCS key handle is returned.

Synchronization:

The TCS key handle lock is held while generating the next handle. This is the only function where this lock is held. Its used only to ensure key handles are unique.

Errors:

None.

`getNextTimeStamp` - *tcs/cache.c*

Synopsis:

```
UINT32 getNextTimeStamp()
```

Description:

`getNextTimeStamp` generates the next time stamp and returns it.

Return Values:

On success, the next available time stamp is returned.

Synchronization:

The time stamp lock is held while generating the next handle. This is the only function where this lock is held. Its used only to ensure time stamps are unique.

Errors:

None.

`initDiskCache` - *tcs/cache.c*

Synopsis:

```
TSS_RESULT initDiskCache()
```

Description:

`initDiskCache` initializes the disk cache lock, takes the persistent storage file's lock and calls the underlying function (`init_disk_cache`) to initialize the disk cache.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The file lock on the persistent storage file is held while calling `init_disk_cache`.

Errors:

If we fail to get the file lock, `TSS_E_INTERNAL_ERROR` is returned. If `init_disk_cache` fails, its error is passed through to the caller.

`closeDiskCache` - *tcs/cache.c*

Synopsis:

```
TSS_RESULT closeDiskCache()
```

Description:

`closeDiskCache` takes the persistent storage file's lock and calls the underlying function (`close_disk_cache`) to close the disk cache.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The file lock on the persistent storage file is held while calling `close_disk_cache`.

Errors:

If we fail to get the file lock, `TSS_E_INTERNAL_ERROR` is returned. If `close_disk_cache` fails, its error is passed through to the caller.

`getParentUUIDByUUID` - *tcs/cache.c*

Synopsis:

```
TSS_RESULT getParentUUIDByUUID(TSS_UUID *uuid, TSS_UUID
```

```
**ret_uuid)
```

Description:

`getParentUUIDByUUID` checks the key disk cache for the UUID `uuid` and if found, returns the parent UUID of it in `*ret_uuid`.

Return Values:

On success, `*ret_uuid` is set to the requested UUID and `TSS_SUCCESS` is returned.

Synchronization:

The key disk cache lock is held while the cache is searched.

Errors:

If `uuid` is not found, `TCS_E_FAIL` is returned.

`removeRegisteredKey` - *tcs/cache.c*

Synopsis:

```
TSS_RESULT removeRegisteredKey(TSS_UUID *uuid)
```

Description:

`removeRegisteredKey` searches the key disk cache for the UUID `uuid` and if found, marks the key associated with it as being invalid in the cache.

Return Values:

On success, the requested key is marked invalid in the cache and `TSS_SUCCESS` is returned.

Synchronization:

The key disk cache is held while the cache is searched.

Errors:

If `uuid` is not found, `TCS_E_KEY_NOT_REGISTERED` is returned.

`getRegisteredKeyByUUID` - *tcs/ps/tcsps.c*

Synopsis:

```
TSS_RESULT getRegisteredKeyByUUID(TSS_UUID *uuid, BYTE*
blob, UINT16* blob_size)
```

Description:

`getRegisteredKeyByUUID` gets the file handle for the current persistent storage file and calls `ps_get_key_by_uuid` to retrieve the key's blob. The persistent store is searched for the UUID `uuid` and if found, returns the key data associated with it in `blob` and the size of the key in `*blob_size`.

Return Values:

On success, `blob` will contain the key data of key with UUID `uuid` and the `blob_size` is set to the size of the returned key and `TSS_SUCCESS` is returned.

Synchronization:

None.

Errors:

If `ps_get_key_by_uuid` fails, its error is returned to the caller. If the PS file handle

cannot be obtained, TSS_E_INTERNAL_ERROR is returned.

get_parent_ps_type_by_uuid - *tcs/ps/tcsps.c*

Synopsis:

```
TSS_RESULT get_parent_ps_type_by_uuid( int fd, TSS_UUID
*uuid, UINT32* ret_ps_type )
```

Description:

get_parent_ps_type_by_uuid checks the persistent data store kept in the file with handle fd for the UUID uuid and if found, returns the parent's persistent storage type in *ret_ps_type.

Return Values:

On success, *ret_ps_type is set to the requested persistent storage type and TSS_SUCCESS is returned.

Synchronization:

The key disk cache lock is held while the cache is searched.

Errors:

If uuid is not found, TSS_E_PS_KEY_NOTFOUND is returned.

ps_is_pub_registered - *tcs/ps/tcsps.c*

Synopsis:

```
TSS_RESULT ps_is_pub_registered( int fd, TCPA_STORE_PUBKEY
*pub, BOOL* is_reg )
```

Description:

ps_is_pub_registered checks the persistent data store kept in the file with handle fd for the public key data pub and if found, returns TRUE in the variable is_reg.

Return Values:

On success, *is_reg is set and TSS_SUCCESS is returned.

Synchronization:

The key disk cache lock is held while the cache is searched. The file lock is held by the caller.

Errors:

If no key matches pub, TSS_SUCCESS is returned and *is_reg is set to FALSE. If an error occurs while searching for the key, TSS_E_INTERNAL_ERROR is returned.

ps_get_uuid_by_pub - *tcs/ps/tcsps.c*

Synopsis:

```
TSS_RESULT ps_get_uuid_by_pub( int fd, TCPA_STORE_PUBKEY
*pub, TSS_UUID **ret_uuid )
```

Description:

ps_get_uuid_by_pub checks the persistent data store kept in the file with handle fd for the public key data pub and if found, returns the UUID of it in *ret_uuid.

Return Values:

On success malloc is called to allocate space for *ret_uuid, which is set to the requested UUID and TSS_SUCCESS is returned.

Synchronization:

The file itself is locked using `flock()` by the caller. The key disk cache lock is held while the cache is searched.

Errors:

If the public key data does not match any keys in the requested persistent store, `TSS_E_PS_KEY_NOTFOUND` is returned. If the operation of extracting the UUID fails, `TSS_E_INTERNAL_ERROR` is returned. If the call to malloc fails, `TSS_E_OUTOFMEMORY` is returned.

`ps_write_key` - *tcs/ps/tcsps.c*

Synopsis:

```
TSS_RESULT ps_write_key( int fd, TSS_UUID *uuid, TSS_UUID
*parent_uuid, UINT32* parent_ps, BYTE* key_blob, UINT32
key_blob_size )
```

Description:

`ps_write_key` writes the key pointed to by `key_blob` to the persistent store in the file with descriptor `fd`. `uuid` is set as the UUID and `parent_uuid` is set as the key's parent's UUID. If `parent_ps` is `TSS_PS_TYPE_SYSTEM`, the parent's persistent storage type is recorded as system storage, else user storage.

Return Values:

On success, the key is written to persistent storage and `TSS_SUCCESS` is returned.

Synchronization:

The file itself is locked using `flock()` while the key is being written.

Errors:

If any operation fails, `TCS_E_INTERNAL_ERROR` is returned.

3.3 TCS Context Handling

TCS contexts are generated by the TCS daemon (not the TPM!) and are used by a TSP to tie objects and data that it creates to a specific TCS. The list of TCS contexts which have been created by the TCS and returned to some TSP is maintained internally to the TCS. When a TSP terminates its connection to the TCS, the TCS handle is destroyed.

3.3.0 Data Structures

`tcsContext`- *include/tcs_internal_types.h*

The `tcsContext` structure contains a `TCS_CONTEXT_HANDLE` and a pointer to the next `tcsContext`. `tcsContext` structures are used to maintain a linked list of all existing `TCS_CONTEXT_HANDLE`'s.

3.3.1 Functions

`create_tcs_context` - *tcs/cxt.c*

Synopsis:

```
struct tcs_context *create_tcs_context()
```

Description:

`create_tcs_context` calls `calloc` to create a `struct tcs_context` and returns it. The TCS context is freed when the application closes its connection with the TCS.

Return Values:

On success, a reference to the newly created `struct tcs_context` is returned.

Synchronization:

None.

Errors:

If `calloc` fails, `NULL` is returned.

`get_context` - *tcs/cxt.c*

Synopsis:

```
struct tcs_context *get_context(TCS_CONTEXT_HANDLE handle)
```

Description:

`get_context` searches the TCS's internal list of `TCS_CONTEXT_HANDLE`'s for one that matches `handle` and returns a reference to it.

Return Values:

On success, the `struct tcs_context` structure that holds `TCS_CONTEXT_HANDLE tcsContext` is returned.

Synchronization:

The TCS context lock must be held by the caller while the list is being searched.

Errors:

If `handle` is not found, `NULL` is returned.

`destroy_context` - *tcs/cxt.c*

Synopsis:

```
void destroy_context(TCS_CONTEXT_HANDLE handle)
```

Description:

`destroy_context` removes the internal data structures used to maintain a reference to `handle`.

Return Values:

None.

Synchronization:

The TCS context lock is held while the list is being searched.

Errors:

None.

`make_context` - *tcs/cxt.c*

Synopsis:

```
TCS_CONTEXT_HANDLE makeTcsContext()
```

Description:

`make_context` creates a `struct tcs_context` and adds its to the TCS's internal list. In the process, a new `TCS_CONTEXT_HANDLE` is created and returned.

Return Values:

On success, the newly created `TCS_CONTEXT_HANDLE` is returned.

Synchronization:

The TCS context lock is held while the list is being manipulated.

Errors:

If `malloc` fails, an error is logged and `NULL_TCS_HANDLE` is returned.

3.4 Event Handling

A PCR event is recorded when the TSPi passes in a `TSS_PCR_EVENT` structure to `Tspi_TPM_PcrExtend()`. The event type and internals of the TSS_PCR_EVENT structure are all application defined, the TSS only has to append the event to the event log for the PCR being manipulated. The event log is maintained by the TCS in order to return to the application on a call to `Tspi_TPM_GetEvent()`, `Tspi_TPM_GetEvents()` or `Tspi_TPM_GetEventLog()`.

PCR Events are logged using a linked list of `TSS_PCR_EVENT` structures per PCR. Each time an event occurs on a PCR, a new event structure is added to the linked list that corresponds to that PCR.

Due to the fact that some PCR events are logged for PCR extends in kernel space, the TCSD can be configured to read those kernel maintained event logs from the /proc (or in upcoming Linux kernel versions, /sysfs). In order to allow TCSD implementors to write an interface for any external event source, an abstraction has been added. Please see *tcs/imaem.c* and *include/imaem.h* for an example of an external log source implementation. An overview is provided in the Portability section (4.0) of this document.

3.4.0 Data Structures

`event_log` – *include/tcsem.h*

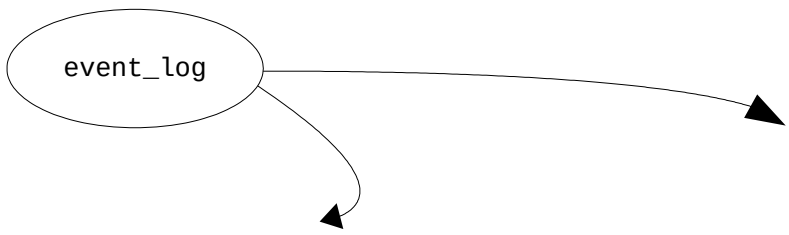
`event_log` structures are used to keep pointers to the arrays of `event_wrapper` structures that are maintained per PCR.

`event_wrapper` – *include/tcsem.h*

`event_wrapper` structures each hold one `TSS_PCR_EVENT` and a pointer to the next `event_wrapper`.

`ext_log_source` -- *include/tcsem.h*

`ext_log_source` structures hold pointers to functions that will open, close, and retrieve log entries from an externally defined source.



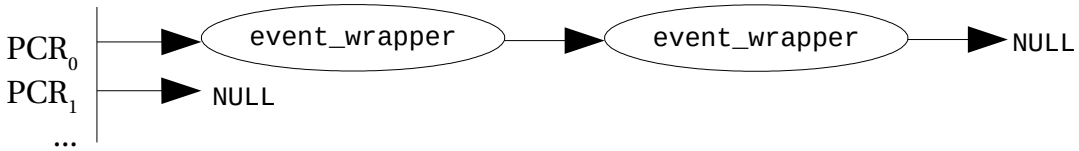


Figure 3.5.0: A PCR Event Log structure. At this point, 2 events have occurred on PCR_0, no events have occurred on PCR_1 and PCR's 2+ are not shown.

3.4.1 Functions

`event_log_init` - *tcs/tcsem.c*

Synopsis:

```
TSS_RESULT event_log_init()
```

Description:

`event_log_init` `calloc`'s a new event_log struct, initializes its mutexes and sets up its kernel and firmware log sources based on the TCSD's compile time flags.

Return Values:

On success, the TCS event log is created and `TSS_SUCCESS` is returned.

Synchronization:

None.

Errors:

If `calloc` fails, `TSS_E_OUTOFMEMORY` is returned.

`event_log_final` - *tcs/tcsem.c*

Synopsis:

```
TSS_RESULT event_log_final()
```

Description:

`event_log_final` `free`'s all event log structures and returns `TSS_SUCCESS`.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The event log lock is held while the event log structures are being deallocated.

Errors:

None.

`event_log_add`- *tcs/tcsem.c*

Synopsis:

```
TSS_RESULT event_log_add(TSS_PCR_EVENT *event, UINT32
*pNumber)
```

Description:

`event_log_add` adds a new PCR event to the TCS's internal PCR event log. `event-`

>ulPcrIndex should contain the PCR number that the even occurred on. PCR events are not deallocated until a TCS shutdown. The number of the event is returned in *pNumber.

Return Values:
On success, the event is added and TSS_SUCCESS is returned.

Synchronization:
The TCS event log lock is held while the event is being added.

Errors:
If malloc fails in creating the new PCREvent structure, TSS_E_OUTOFMEMORY is returned.

get_pcr_event- *tcs/tcsem.c*

Synopsis:
```
TSS_PCR_EVENT *get_pcr_event(UINT32 pcrIndex, UINT32
eventNumber)
```

Description:
getPCREventByNumber retreives the TSS_PCR_EVENT structure with event number eventNumber from the event log of the PCR with index pcrIndex.

Return Values:
On success, a reference to the requested TSS_PCR_EVENT structure is returned.

Synchronization:
The TCS event log lock is held while the event list is being searched.

Errors:
If pcrIndex is out of range or the event number DNE, NULL is returned.

get_num_events- *tcs/tcsem.c*

Synopsis:
```
UINT32 get_num_events(UINT32 pcrIndex)
```

Description:
getPCREventByNumber retrurns the number of events that have occurred on PCR number pcrIndex.

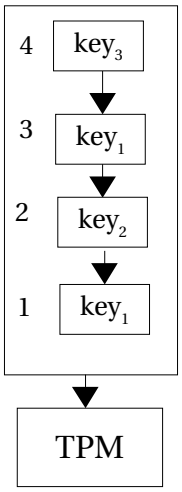
Return Values:
On success, the number of events that have occurred on PCR pcrIndex is returned.

Synchronization:
The TCS event log lock is held while the event list is being searched.

Errors:
None.

3.5 Key Cache Management

TCS key cache operations are initiated by a TSP. It is the TCS's job to juggle the requests of multiple TSP's at once, making the necessary TPM calls to swap key contexts. In order to facilitate access by multiple TSP's, a v1.1 TPM optionally provides the ability to swap out key and auth session contexts. This frees up the TPM's limited internal resources and allows the TCS to more easily context switch between the resources needed by multiple TSP processes. The following example has been simplified from an implementation perspective to illustrate key caching. Please see section 3.1 for information on how the TCSKCM and TRM work together.



In the figure at left, each numbered box represents a pending TPM request that requires the key represented by its number. This example assumes that the TPM in use has the ability to load up to 2 keys at a time and that keys #2 and #3 are already loaded. Since request 1 needs to be submitted to the TPM which requires key #1, the TCS Key and Credential Manager (TCSKCM) will make a TPM_SaveKeyContext request to the TPM. This will export key #3 from the TPM and free its internal TPM resources. The TCSKCM will then call TPM_LoadKey for key #1 and submit request number 1 to the TPM. Once request 1 has finished, the TCSKCM will see that key #2 is already present in the TPM and request 2 can be issued. Likewise, request 3 can be issued because key #1 is still resident in the TPM. Once request 3 has completed, the TCSKCM must either issue a TPM_SaveKeyContext command to the TPM for key #1 or #2, or issue a TPM_EvictKey command to evict key #1 or #2. Then, the TCSKCM issues a TPM_LoadKeyContext command to have the TPM load key #3 back into the TPM before request 4 can be submitted.

Figure 3.6: Key contention within the TCS

If the TPM does not support the TPM_SaveKeyContext / TPM_LoadKeyContext interface (optional for a v1.1 TPM), TPM_LoadKey and TPM_EvictKey will be used. The TCSKCM will attempt to be optimal in its calls to the TPM, ordering them as appropriate to minimize the total number of TPM requests .

3.5.0 Data Structures

`key_mem_cache`- *include/tcs_utils.h*

The `key_mem_cache` structure contains information about the key being kept in the TCS's cache. `key_mem_cache` entries contain info such as the key's UUID, its parent's UUID, its public data, the key blob itself, whether the key is actually resident in the TPM and so on.

3.5.1 Functions

`getParentPubBySlot` – *tcs/cache.c*

Synopsis:

```
TCPA_STORE_PUBKEY *getParentPubBySlot(TCPA_KEY_HANDLE
tpm_handle)
```

Description:

`getParentPubBySlot` searches through the TCS key cache for an entry matching

`tpm_handle`. When its found, a reference to that key's parent's public key is returned.

Return Values:
On success, a reference to the requested key's parent's public key is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If the `slot` is not found, `NULL` is returned.

`getPubBySlot` – *tcs/cache.c*

Synopsis:
```
TCPA_STORE_PUBKEY *getPubBySlot(TCPA_KEY_HANDLE tpm_handle)
```

Description:
`getPubBySlot` searches through the TCS key cache for an entry matching `tpm_handle`. When its found, a reference to that key's public key is returned.

Return Values:
On success, a reference to the requested key's public key is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If the slot is not found, `NULL` is returned.

`getPubByHandle` – *tcs/cache.c*

Synopsis:
```
TCPA_STORE_PUBKEY *getPubByHandle(TCS_KEY_HANDLE tcs_handle)
```

Description:
`getPubByHandle` searches through the TCS key cache for an entry matching `TCS_KEY_HANDLE tcs_handle`. When its found, a reference to that key's public key is returned.

Return Values:
On success, a reference to the requested key's public key is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If the TCS context is not found, `NULL` is returned.

`setParentByHandle` – *tcs/cache.c*

Synopsis:
```
TSS_RESULT setParentByHandle(TCS_KEY_HANDLE tcs_handle,
TCS_KEY_HANDLE p_tcs_handle)
```

Description:
`setParentByHandle` searches through the TCS key cache for an entry matching

`TCS_KEY_HANDLE tcs_handle`. If its found, a key with a handle matching `p_tcs_handle` is searched for. If they're both found, a pointer from child to parent is set internally in the TCS `key_disk_cache` structure of the child.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If the TCS context is not found, `TCS_E_FAIL` is returned.

`getUuidByPub` – *tcs/cache.c*

Synopsis:

```
TSS_UUID *getUuidByPub(TCPA_STORE_PUBKEY *pub)
```

Description:

`getUuidByPub` searches through the TCS key cache for an entry who's public key matches `pub`. When its found, a reference to that key's UUID is returned.

Return Values:

On success, a reference to the requested key's UUID is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If the cache cannot be initialized, or no cached key matches `pub`, `NULL` is returned.

`getUUIDByEncData` – *tcs/cache.c*

Synopsis:

```
TSS_UUID *getUUIDByEncData(BYTE * encData)
```

Description:

`getUUIDByEncData` searches through the TCS key cache for an entry who's encrypted data area matches `encData`. When its found, a reference to that key's UUID is returned.

Return Values:

On success, a reference to the requested key's UUID is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If the cache cannot be initialized, or no cached key matches `encData`, `NULL` is returned.

`getTCSKeyHandleByEncData` – *tcs/cache.c*

Synopsis:

```
TCS_KEY_HANDLE getTCSKeyHandleByEncData(BYTE * encData)
```

Description:

`getTCSKeyHandleByEncData` searches through the TCS key cache for an entry who's encrypted data area matches `encData`. When its found, that key's `TCS_KEY_HANDLE` is returned.

Return Values:

On success, the requested key's `TCS_KEY_HANDLE` is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If the cache cannot be initialized, or no cached key matches `encData`, `NULL_TCS_HANDLE` is returned.

`replaceEncData_knowledge` – *tcs/cache.c*

Synopsis:

```
void replaceEncData_knowledge(BYTE * encData, BYTE
*newEncData)
```

Description:

`replaceEncData_knowledge` searches through the TCS key cache for an entry with encrypted data matching `encData` and replaces that encrypted data with `newEncData`.

Return Values:

On success, the requested `encData` is replaced.

Synchronization:

The TCS key cache lock is held while the list is being manipulated.

Errors:

If the cache cannot be initialized, or if a key matching `encData` cannot be found, no action is taken.

`add_mem_cache_entry` – *tcs/cache.c*

Synopsis:

```
TSS_RESULT add_mem_cache_entry(TCS_KEY_HANDLE tcs_handle,
TCPA_KEY_HANDLE tpm_handle, TCPA_KEY *blob)
```

Description:

`add_mem_cache_entry` creates a new TCS key cache entry for the key with handle `tcs_handle` if no entry exists with the same TCS key handle. `tpm_handle` and `tcs_handle` are set in the new cache object and its time stamp is set. New memory is also allocated for a `TCPA_KEY` and `blob` is copied into the object of the new key cache entry. Memory allocated is freed if the key is explicitly evicted by a call to `Tspi_Key_EvictKey()`.

Return Values:

On success, or if a cache entry with the same TCS handle exists, `TSS_SUCCESS` is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If `malloc` fails, `TSS_E_OUTOFMEMORY` is returned.

`setSlotBySlot` – *tcs/cache.c*

Synopsis:

```
TSS_RESULT setSlotBySlot(UINT32 old_handle, UINT32
new_handle)
```

Description:

`setSlotBySlot` searches the TCS's key cache for an entry with a `TCPA_KEY_HANDLE` matching `old_handle`. If found, it replaces the `TCPA_KEY_HANDLE` in the cache entry with `new_handle` and updates the slot's time stamp. `setSlotBySlot` is used by the TCSKCM to update a cache entry when a key is loaded into the TPM that has been previously loaded.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The TCS key cache lock is held while the list is being manipulated.

Errors:

If no cache entry has a `TCPA_KEY_HANDLE` matching `old_handle`, `TCS_E_FAIL` is returned.

`setSlotByHandle` – *tcs/cache.c*

Synopsis:

```
TSS_RESULT setSlotByHandle(TCS_KEY_HANDLE tcs_handle,
TCPA_KEY_HANDLE tpm_handle)
```

Description:

`setSlotByHandle` searches the TCS's key cache for an entry who's TCS key handle matches `tcs_handle`. If found, the entry's `TCPA_KEY_HANDLE` is set to `tpm_handle` and its time stamp is updated.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The TCS key cache lock is held while the list is being manipulated.

Errors:

If no key cache entry has a `TCS_KEY_HANDLE` matching `tcs_handle`, `TCS_E_FAIL` is returned.

`remove_mem_cache_entry` – *tcs/cache.c*

Synopsis:

```
TSS_RESULT remove_mem_cache_entry(TCS_KEY_HANDLE tcs_handle)
```

Description:

`remove_mem_cache_entry` searches through the TCS key cache for an entry with a

TCS key handle matching `tcs_handle`. If found, the entry is removed from the cache.

Return Values:
None.

Synchronization:
The TCS key cache lock is held while the list is being manipulated.

Errors:
If no cache entry matches `tcs_handle`, `TCS_E_FAIL` is returned.

`setUuidsByPub` – *tcs/cache.c*

Synopsis:

```
TSS_RESULT setUuidsByPub(TCPA_STORE_PUBKEY *pub, TSS_UUID
*uuid, TSS_UUID *p_uuid)
```

Description:
`setUuidsByPub` searches through the TCS key cache for an entry with a public key matching `pub`. If found, the cache entry's UUID and parent UUID are set to `uuid` and `p_uuid` respectively.

Return Values:
On success, `setUuidsByPub` returns `TSS_SUCCESS.`

Synchronization:
The TCS key cache lock is held while the list is being manipulated.

Errors:
If no key's public data matches `pub`, `TCS_E_FAIL` is returned.

`getSlotByHandle` – *tcs/cache.c*

Synopsis:

```
TCPA_KEY_HANDLE getSlotByHandle(TCS_KEY_HANDLE tcs_handle)
```

Description:
`getSlotByHandle` searches through the TCS key cache for an entry with a TCS handle matching `tcs_handle`. If found, the entry's `TCPA_KEY_HANDLE` is returned.

Return Values:
On success, the entry's `TCPA_KEY_HANDLE` is returned.

Synchronization:
The TCS key cache lock is held while the list is being manipulated.

Errors:
If no cache entry's TCS handle matches `tcsHandle`, `NULL_TPM_HANDLE` is returned.

`getSlotByPub` – *tcs/cache.c*

Synopsis:

```
TCPA_KEY_HANDLE getSlotByPub(TCPA_STORE_PUBKEY *pub)
```

Description:
`getSlotByPub` searches through the TCS key cache for an entry with a public key matching `pub`. If found, the entry's `TCPA_KEY_HANDLE` is returned.

Return Values:

On success, the entry's TCPA_KEY_HANDLE is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If no cache entry's public key matchespub, NULL_TPM_HANDLE is returned.

getTCSKeyHandleByPub – *tcs/cache.c*

Synopsis:

```
TCS_KEY_HANDLE getTCSKeyHandleByPub(TCPA_STORE_PUBKEY *pub)
```

Description:

getTCSKeyHandleByPub searches through the TCS key cache for an entry with a public key matching pub. If found, the entry's TCS key handle is returned.

Return Values:

On success, the requested TCS key handle is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If no cache entry's public key matches pub, NULL_TCS_HANDLE is returned.

getParentPubByPub – *tcs/cache.c*

Synopsis:

```
TCPA_STORE_PUBKEY *getParentPubByPub(TCPA_STORE_PUBKEY *pub)
```

Description:

getParentPubByPub searches through the TCS key cache for an entry with a public key matching pub. If found, a reference to the entry's parent's public key is returned.

Return Values:

On success, a reference to the requested key's parent's public key is returned.

Synchronization:

The TCS key cache lock is held while the list is being searched.

Errors:

If no cache entry's public key matches pub, NULL is returned.

isKeyInMemCache – *tcs/cache.c*

Synopsis:

```
BOOL isKeyInMemCache(TCS_KEY_HANDLE tcs_handle)
```

Description:

isKeyInMemCache searches through the TCS key cache for an entry with aTCS key handle matching tcs_Handle. If found, TRUE is returned. If the key is not found, FALSE is returned.

Return Values:

The existence of the key in the TCS key cache is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
None.

`getBlobByPub` – *tcs/cache.c*

Synopsis:
```
TSS_RESULT getBlobByPub(TCPA_STORE_PUBKEY *pub, TCPA_KEY
**ret_key)
```

Description:
`getBlobByPub` searches through the TCS key cache for an entry with a public key matching `pub`. If found, a reference to the key's blob is copied into `*ret_key`.

Return Values:
On success, `*ret_key` is set and `TSS_SUCCESS` is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If the requested key cannot be found, `TCS_E_FAIL` is returned.

`getBlobBySlot` – *tcs/cache.c*

Synopsis:
```
TSS_RESULT getBlobBySlot(TCPA_KEY_HANDLE tpm_handle,
TCPA_KEY **ret_key)
```

Description:
`getBlobByPub` searches through the TCS key cache for an entry with a `TCPA_KEY_HANDLE` matching `tpm_handle`. If found, a reference to the key's blob is copied into `*ret_key`.

Return Values:
On success, `*ret_key` is set and `TSS_SUCCESS` is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If the requested `TCPA_KEY_HANDLE` cannot be found, `TCS_E_FAIL` is returned.

`getAnyHandleBySlot` – *tcs/cache.c*

Synopsis:
```
TCS_KEY_HANDLE getAnyHandleBySlot(TCPA_KEY_HANDLE
tpm_handle)
```

Description:
`getAnyHandleBySlot` searches through the TCS key cache for an entry with a `TCPA_KEY_HANDLE` matching `tpm_handle`. If found, the entry's TCS key handle is

returned.

Return Values:
On success, the requested entry's TCS key handle is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If no cached key matches `tpm_handle`, `NULL_TCS_HANDLE` is returned.

`getKeyHandleByUuid` – *tcs/cache.c*

Synopsis:
```
TCS_KEY_HANDLE getKeyHandleByUuid(TSS_UUID *uuid)
```

Description:
`getKeyHandleByUuid` searches through the TCS key cache for an entry with a UUID matching `uuid`. If found, the entry's TCS key handle is returned.

Return Values:
On success, the requested entry's TCS key handle is returned.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If no cached key matches `uuid`, `NULL_TCS_HANDLE` is returned.

`refreshTimeStampBySlot` – *tcs/cache.c*

Synopsis:
```
TSS_RESULT refreshTimeStampBySlot(TCPA_KEY_HANDLE
tpm_handle)
```

Description:
`refreshTimeStampBySlot` searches through the TCS key cache for an entry with a key slot of `tpm_handle`. If found, the entry's time stamp is updated.

Return Values:
On success, the requested entry's time stamp is updated.

Synchronization:
The TCS key cache lock is held while the list is being searched.

Errors:
If no cached key has a key slot matching `tpm_handle`, `TCS_E_FAIL` is returned.

3.6 TPM Auth Manager

The TPM Auth Manager keeps track of the maximum number of auth sessions available from the TPM, the number of currently open auth sessions and who holds them, putting threads to sleep and waking them up when auth sessions are and aren't available, and so on. A table is maintained which keeps track of how many auth sessions are opened and which TCS/TPM handles are mapped to each other. Whenever a thread requests a new auth handle through TCSP_OIAP and TCSP_OSAP, the auth manager coordinates all

the resources required to make sure the thread gets its auth handle.

3.6.0 Data Structures

`struct auth_mgr` – *include/tcsem.h*

The `auth_mgr` structure is used to hold the attributes and variables needed to keep track of current and outstanding auth handle requests made to the TPM. Included in the structure is a pointer to a table of mappings which track the current open auth handles between the TCSD and the TPM.

`struct auth_map` – *include/tcsem.h*

`auth_map` is used to hold one element of the auth manager's auth mapping table. The table records the mapping from a TCS handle to a TPM handle.

3.6.1 Functions

`auth_mgr_init` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_init()
```

Description:

`auth_mgr_init` sets the max number of auth sessions in the `auth_mgr` structure, allocates space for the auth mappings table and initializes the auth manager lock.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

None.

Errors:

None.

`auth_mgr_final` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_final()
```

Description:

`auth_mgr_final` sends a wakeup signal to all threads with pending auth requests on the overflow queue, then free's the overflow structure.

Return Values:

On success, `TSS_SUCCESS` is returned.

Synchronization:

The auth manager lock is held while the overflow list is being touched.

Errors:

None.

`auth_mgr_swap_in` – *tcs/auth_mgr.c*

Synopsis:

```
void auth_mgr_swap_in()
```

Description:

`auth_mgr_swap_in` handles the case when a new auth context can be obtained from the TPM. If we're interacting with a TPM that supports auth context swapping, the next available thread is allowed to swap in its context [ed. not implemented]. If we're interacting with a TPM that doesn't support auth context swapping and there is a thread sleeping on the overflow queue, it is awakened.

Return Values:

None.

Synchronization:

The caller must hold the auth manager lock.

Errors:

`None.`

`auth_mgr_swap_out` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_swap_out(TCS_CONTEXT_HANDLE hContext)
```

Description:

`auth_mgr_swap_out` handles the case when a new auth context is requested from the TPM, but the TPM doesn't have the resources to deliver it. If we're interacting with a TPM that supports auth context swapping, an inactive thread must have its auth context swapped out of the TPM [ed. not yet implemented]. If we're interacting with a TPM that doesn't support auth context swapping, the current thread is put on the overflow queue, to be awakened when resources become available. If this thread is the last available running thread, it cannot be put to sleep (since no other thread would be available to service new requests), so `TCPA_RESOURCES` is returned, signalling the TSP to retry at a later time.

Return Values:

On success, the current thread's auth context is swapped out and `TSS_SUCCESS` is returned.

Synchronization:

The caller must hold the auth manager lock.

Errors:

If the condition variable cannot be obtained from the context when the thread is required to sleep, `TSS_E_INTERNAL_ERROR` is returned. If the requesting thread is last available thread and it must be put to sleep, `TCPA_RESOURCES` is returned.

`auth_mgr_close_context` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_close_context(TCS_CONTEXT_HANDLE
tcs_handle)
```

Description:

`auth_mgr_close_context` runs through the auth mappings table and terminates any auth mappings associated with `tcs_handle` with the TPM. If any auth mappings are terminated, `auth_mgr_swap_in` is then called.

Return Values:

On success, all auth mappings associated with `tcs_handle` are closed with the TPM and `TCS_SUCCESS` is returned.

Synchronization:

The auth manager lock is held while the auth mappings table is traversed.

Errors:

None. If the call to terminate the auth handle fails, an error is logged.

`auth_mgr_release_auth` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_release_auth(TCS_AUTHHANDLE
tpm_auth_handle)
```

Description:

`auth_mgr_release_auth` searches the auth mappings table for a TPM auth handle matching `tpm_auth_handle` and if found, terminates that handle. `auth_mgr_swap_in` is then called.

Return Values:

On success, the auth mapping associated with `tpm_auth_handle` are closed with the TPM and `TCS_SUCCESS` is returned.

Synchronization:

The auth manager lock is held while the auth mappings table is traversed.

Errors:

None. If the call to terminate the auth handle fails, an error is logged.

`auth_mgr_check` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_check(TCS_CONTEXT_HANDLE tcsContext,
TCS_AUTHHANDLE tpm_auth_handle)
```

Description:

`auth_mgr_check` runs through the auth mappings table and if it finds an entry with `tcsContext` mapping to `tpm_auth_handle`, returns `TSS_SUCCESS`.

Return Values:

On success, `TCS_SUCCESS` is returned.

Synchronization:

The auth manager lock is held while the auth mappings table is traversed.

Errors:

If no mapping is found, `TSS_E_INTERNAL_ERROR` is returned.

`auth_mgr_add` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_add(TCS_CONTEXT_HANDLE tcsContext,
TCS_AUTHHANDLE tpm_auth_handle)
```

Description:

`auth_mgr_add` looks for an empty slot in the auth mappings table and if found, adds an entry, filling it with `tcsContext` mapping to `tpm_auth_handle`.

Return Values:

On success, `TCS_SUCCESS` is returned.

Synchronization:

The auth manager lock must be held by the caller.

Errors:

If no empty mapping space is found, `TSS_E_INTERNAL_ERROR` is returned.

`auth_mgr_req_new` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_BOOL auth_mgr_req_new(TCS_CONTEXT_HANDLE tcsContext)
```

Description:

`auth_mgr_req_new` checks the auth mappings table to see how many mappings are currently opened for TCS context `tcsContext`. If resources are available to allow the context to open another context, `TRUE` is returned, else `FALSE`.

Return Values:

If another auth context can be opened for context `tcsContext`, `TRUE` is returned, else `FALSE`.

Synchronization:

None.

Errors:

None.

`auth_mgr_oiap` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_oiap(TCS_CONTEXT_HANDLE hContext,
TCS_AUTHHANDLE *authHandle, TCPA_NONCE *nonce0)
```

Description:

`auth_mgr_oiap` is a wrapper for `TCSP_OIAP_Internal` which determines if there are enough resources available for another auth context to be opened. Once resources are available, the parameters are passed through.

Return Values:

On success, the return value of `auth_mgr_add` is returned.

Synchronization:

The auth manager lock is held.

Errors:

None.

```
TSS_RESULT
auth_mgr_osap(TCS_CONTEXT_HANDLE hContext,
                TCPA_ENTITY_TYPE entityType,
                UINT32 entityValue,
                TCPA_NONCE nonceOddOSAP,
                TCS_AUTHHANDLE *authHandle,
                TCPA_NONCE *nonceEven,
                TCPA_NONCE *nonceEvenOSAP)
```

`auth_mgr_osap` – *tcs/auth_mgr.c*

Synopsis:

```
TSS_RESULT auth_mgr_osap(TCS_CONTEXT_HANDLE hContext,
TCPA_ENTITY_TYPE entityType, UINT32 entityValue, TCPA_NONCE
nonceOddOSAP, TCS_AUTHHANDLE *authHandle, TCPA_NONCE
*nonceEven,     TCPA_NONCE *nonceEvenOSAP)
```

Description:

`auth_mgr_osap` is a wrapper for `TCSP_OSAP_Internal` which determines if there are enough resources available for another auth context to be opened. Once resources are available, the parameters are passed through.

Return Values:

On success, the return value of `auth_mgr_add` is returned.

Synchronization:

The auth manager lock is held.

Errors:

None.

3.7 Miscellaneous

The miscellaneous functions and data structures listed below do not fall into any of the categories above, but are worth mentioning.

3.7.0 Functions

`getTPMMetrics()` - *tcs/cxt.c*

Synopsis:

```
TSS_RESULT getTPMMetrics()
```

Description:

`getTPMMetrics` queries the TPM on TCS startup to find out information about it. The TPM_GetCapability command is issued to the TPM to get values for the number of PCR's it contains, whether it supports the Save/LoadKeyContext and Save/Load AuthContext ordinals, etc. These values are then used to create the necessary data structures managed by the TCS.

Return Values:

On success, `getTPMMetrics` returns `TSS_SUCCESS`.

Synchronization:

None.

Errors:

If a particular query to the TPM fails, a default value is used in its place if possible. If the TPM cannot be queried, the error value is passed back to the caller.

3.8 TCSD Configuration File

The TCSD will read a configuration file at startup time and again when it receives the SIGHUP signal. The configuration file will contain the following parameters:

1. The port that the TCSD will listen on for remote connections
2. The maximum number of threads allowed to be running in the TCSD simultaneously.
3. The location and name of the system persistent storage file
4. The paths to any external PCR log sources
5. The PCR's which will be controlled by external agents (firmware and kernel)

4.0 Portability

In order to make this document easier to navigate, all portability related items will be echoed in this section.

As stated in the TSS High Level Design document, the LTC TSS will make every attempt to use only POSIX header files and interfaces in order to be as portable as possible.

Crypto:

Adding a new crypto implementation should be fairly straightforward:

1) Create a new directory, e.g. `src/tspi/crypto/myCrypto`.

2) Inside this directory, add a file named '`crypto.c`' which implements the functions in section 2.3.0

3) Add a check in configure.in for your crypto library and headers (see the openssl section of `configure.in` for an example). Make sure that the build system sets the variable "CRYPTO_PACKAGE" to the name of the directory you created in step 1. At build time, `src/tspi/crypto/$CRYPTO_PACKAGE/crypto.c` will be built.

One hurdle to implementing the cryptographic operations needed to interact with a TPM is the fact that the TPM requires the OAEP padding parameter of RSA encrypt/decrypt operations to be set to the NULL terminated string "TCPA".

GUI:

In the same way that the cryptographic implementations are pluggable, the GUI components will be as well. `DisplayNewPINWindow` and `DisplayPINWindow` will be the abstraction point here (these are the two functions called by `popup_GetSecret`). In order to add a new type of GUI component to drive the popup messages, do the following:

1) Create a new directory, e.g. `src/tspi/gui/myGui`.

2) Inside this directory, create the files '`main.c`', '`support.c`', '`interface.c`' and '`callbacks.c`' which implement `DisplayNewPINWindow()` and `DisplayPINWindow()`.

3) Add a check in configure.in for your GUI library and headers (see the GTK section of `configure.in` for an example). Make sure that the build system sets the variable "GUI_PATH" to the name of the directory you created in step 1. At build time, `src/tspi/gui/$GUI_PATH/*.c` will be built.

Memory Pinning:

The TSS 1.1 API specification states that secrets should be pinned in memory and zeroed out prior to being freed. Since memory pinning is an OS specific operation, the `pin_memory()` function will need to be reimplemented.

Internationalization:

NLS support will be enabled through the gettext package. Since gettext may not be available for all OS's, all gettext calls will be made part of the logging macros, found in `src/include/log.h`. This should make changing the library used for internationalization easier. Also, visit `configure.in` and `src/tspi/Makefile.am` for examples of adding new internationalization library support at build time.

External Event Log Sources:

To define a new external event logging source, a new `ext_log_source` structure must be defined and the functions in this structure must be also be created. The structure has function pointers for opening the log source, closing the log source, getting a single log entry from the source and getting multiple entries from the source. Using these 4 functions, the TCSD functions can be implemented. For an example of an external log source implementation, see *include/imaem.h* and *tcs/imaem.c*.

5.0 References

1. *TCG Software Stack (TSS) Specification, Version 1.1.* Trusted Computing Group, Incorporated. August 20, 2003. (C) 2003.
http://www.trustedcomputinggroup.org/downloads/TSS_Version__1.1.pdf

2. *Trusted Computing Platform Alliance (TCPA) Main Specification Version 1.1b.* Trusted Computing Group, Incorporated. (C) 2003
http://www.trustedcomputinggroup.org/downloads/Main_TCG_Arcitecture_v1_1b.zip