T-Kernel Standard Extension Specification

T-Kernel Standard Extension 1.00.02

2009/1

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About this specification, please refer to follows;

Publisher

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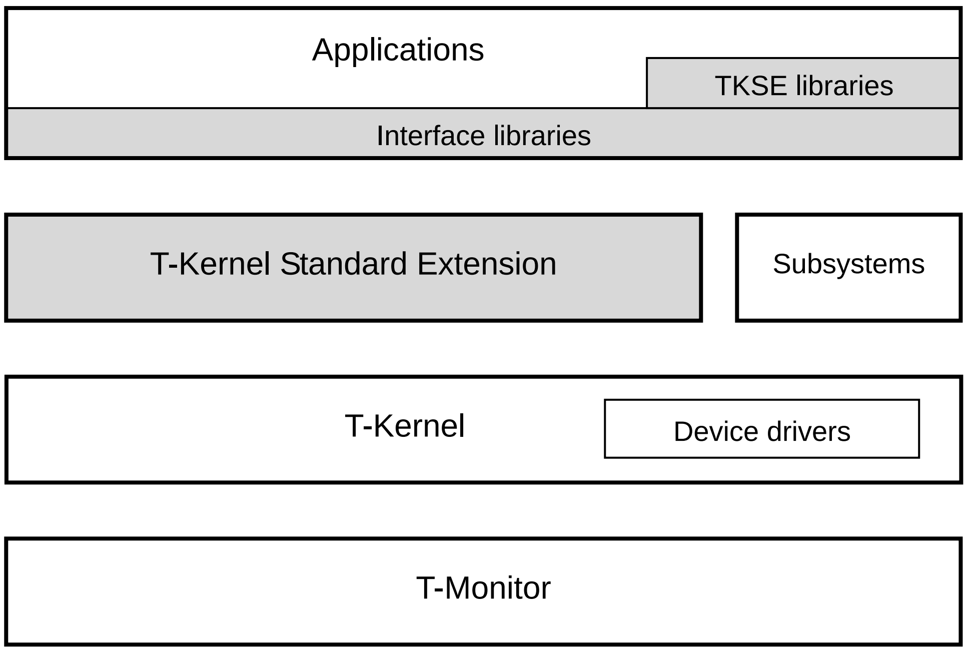
1. T-Kernel Standard Extension Overview

1.1 Position of T-Kernel Standard Extension

T-Kernel Standard Extension (hereinafter called Standard Extension) is a function extension program for T-Kernel. A program that extends the T-Kernel functions to realize more advanced OS functions is called T-Kernel Extension. Standard Extension refers to standard-specification T-Kernel Extension intended to add to T-Kernel those functions generally required for a large system such as file management and process management.
The position of Standard Extension in the entire T-Engine system is shown in Figure 1.



[Figure 1] Position of Standard Extension

T-Kernel is a real-time OS mainly intended for embedded systems and serves as the core of the T-Engine system. Standard Extension is a T-Kernel Extension that runs on T-Kernel, and its main functions are implemented as T-Kernel subsystems. Libraries used to invoke extended SVC of these subsystems in the format of a function in C language are called interface libraries. Part of the Standard Extension functions are provided as TKSE (T-Kernel Standard Extension) libraries that directly link to applications, not subsystems.
A user-made program that runs in Standard Extension is called an application. An application uses various functions using the APIs (Application Programming Interfaces) of Standard Extension. Out of the Standard Extension APIs, functions to be invoked using interface libraries are called system calls, and functions to be invoked using TKSE libraries are called library calls.

1.2 Available Functions

Standard Extension provides the following functions:

- Memory management
- Process/Task management
- Interprocess message
- Global name
- Intertask synchronization and communication
- Standard input/output
- Standard file management
- Event management
- Device management
- Time management
- System management
- Shared library

The details of each function and API specifications are explained in later chapters.

1.3 Target Operating Environment

All the functions of T-Kernel must be available in an environment in which Standard Extension is to run.　Although T-Kernel itself can run in an environment without memory management units (MMUs) of a CPU, Standard Extension requires MMUs.
The operation of Standard Extension requires the following T-Kernel device drivers that meet the T-Engine Standard Device Driver Specifications:

• System disk driver:	Used for memory management, process/task management, and file management, etc.

Standard Extension also uses the following device drivers.　However, these device drivers are not required if the functions are not to be used.

• Clock driver:	Gets and sets the RTC time in time management.
• KB/PD driver:	Receives KB/PD events in event management.
• Console driver:	Handles console input/output in standard input/output.

If either of the device drivers listed above are dependent on other drivers and/or subsystems (such as the PCMCIA card manager), these drivers and/or subsystems are also required.
In Standard Extension, a memory space is used as a logical space using MMUs.　It is required, therefore, that the

device driver can normally access the buffer area of a logical space allocated by a process.　As required, the driver must switch between task spaces, make a space resident, and convert a logical address to a physical address.

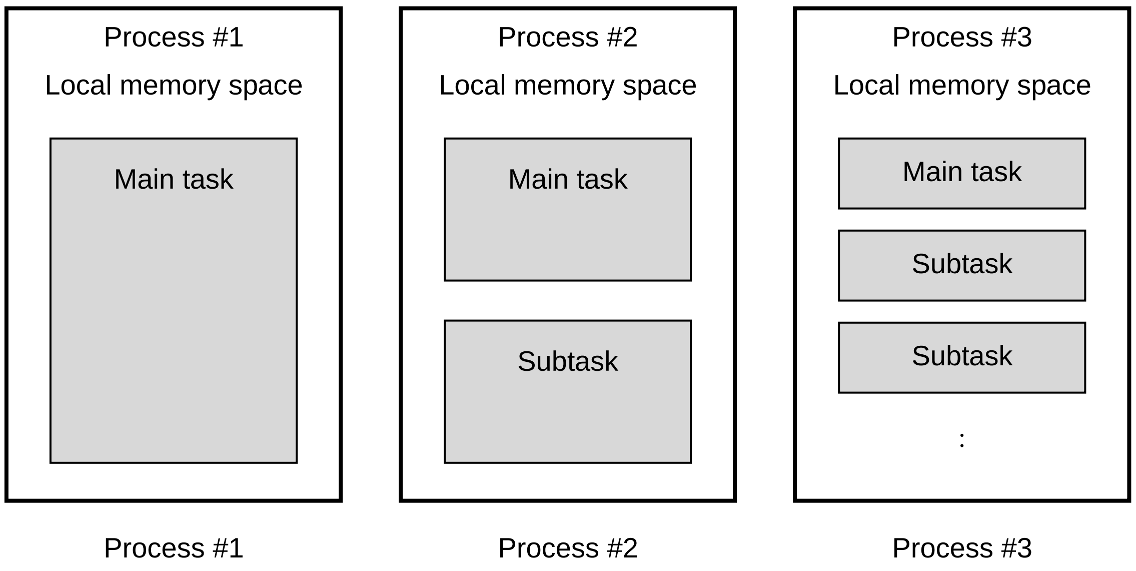
2. Concepts Underlying the T-Kernel Standard Extension

2.1 Process

2.1.1 Definition of Process

A process is a unit used by Standard Extension to manage programs.　Multiple processes can simultaneously exist on a single system.　Each process has an independent local memory space and execution environment, and runs in parallel with other processes.
A process is created when an execution program file on a file system is read using a system call for process creation.　Each process that has been created is given a unique process ID by which it is identified.　A process ID is a positive integer.

A process has one or more tasks.　A task is an execution unit of a program.　Tasks are scheduled for execution according to their task priorities.
A task that becomes ready for running just after process creation is called a main task.　There can be one and only one main task in each process and, when the main task exits, the entire process immediately exits.　Apart from the main task, subtasks can be created by invoking the system call for task creation.　One or more subtasks can be created in one process.　Even when a subtask exits, the process does not exit.　A main task and subtasks are collectively called a task.　A task is given a unique task ID at the time of creation and is identified by this ID. A task ID is a positive integer.
Tasks in the same process share the local memory space.



[Figure 2] Relationship between processes and main task/subtasks

A process that has created a process is called a parent process and the created process is called a child process. All the processes have a parent process, except for the initial process, the first one created at system startup, which does not have a parent process.　The entire system, therefore, consists of processes formed in a tree structure with the initial process defined as the root.
When Process A in a tree structure exits, the child processes of Process A get a new parent process, which is the parent process of Process A.　The general tree structure will be thus maintained.　One exception is the case in which the initial process exits and its child process no longer have a parent process.

2.1.2 Address Space of Process

A space that a program can access using a specified address is called an address space.　A 32-bit address space has addresses from 0x00000000 to 0xFFFFFFFF, which can be used to access memory or I/O device mapped to each of these addresses.
Address spaces consist of physical and logical address spaces.　A physical address space is defined at the time of system hardware design.　A logical address space is virtually managed using functions such as MMUs. Processes of Standard Extension normally use only the logical address space.
Part of the address space mapped to memory is called a memory space.　However, actual physical memory may not be allocated to all the addresses of a memory space because virtual memory is supported by Standard Extension.
To enable access to a memory space by allocating actual memory, use the system call (`tkse_get_mbk`) or the library (`malloc API`) of the Standard Extension memory management functions.　A cluster of memory with contiguous logical addresses thus assigned is called a "memory area."　Processes allocate and releases the memory area as required to enable access to memory.
Standard Extension manages virtual memory using a page file on the file system.　This enables use of a memory area larger than the actual physical memory size.　Since page-in and page-out from the memory area is automatically executed by the memory management of Standard Extension, an application can use the memory area without being aware whether the memory area exists on the physical memory or not.　If realtime memory access is required, page-out of the target area can be prohibited by specifying it (to be) memory-resident.　The specified resident memory area always exists on the physical memory.

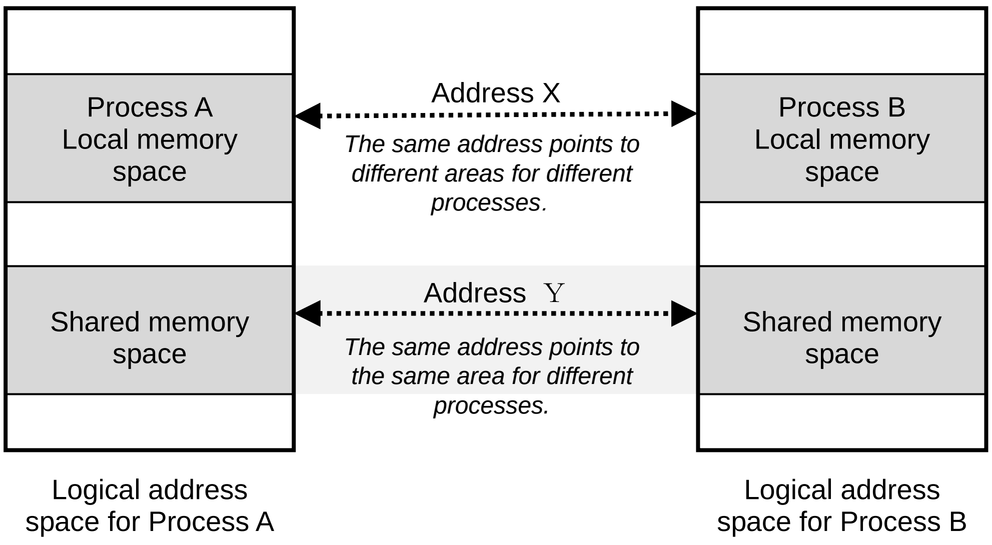
Standard Extension has the following three types of memory spaces:

- Local memory space
- Shared memory space
- System memory space

Local memory space refers to memory space with independent address and content for each process.　The code and data area to be used by the process is normally placed in the local memory space.
The local memory space of one process cannot be accessed by another process.　When a process accesses the local memory space using an address belonging to the local memory space of another process, access to its own process area occurs if the memory area for this process is reserved at this address in its own local memory space. A memory protection exception occurs otherwise.

Addresses of an area reserved in the local memory space are unique to each process. Processes may allocate areas with addresses that have the same values with each other but actually point to different areas. If the local memory space has an area allocated by Process A, therefore, Address X in this area cannot be used by Process B. Address X for Process A and Address X for Process B may have the same value but actually point to different areas.

Shared memory space refers to memory space that can be accessed by any process. This space can be used to pass data between processes.
Addresses of an area allocated in shared memory space are common to all the processes. If Process A allocates an area in the shared memory space which has Address Y, Process B can read the same area by accessing Address Y.


Process A
Local memory space
Address X
The same address points to different areas for different processes.
Process B
Local memory space
Shared memory space
Address Y
The same address points to the same area for different processes.
Shared memory space
Logical address space for Process A
Logical address space for Process B

[Figure 3] Local memory space and shared memory space

System memory space refers to special memory space that Standard Extension uses internally. This space, intended for the use by a system program or driver, must not be used by a general application. If a process accesses an area of the system memory space, a memory protection exception occurs in the same way as when it accesses the local memory of another process.

2.1.3 Process State and Task State

A task has a task state according to its state of operation. A process state refers to the task state of the main task of a process.
A task state is one of the following five basic states. These task states conform to the task state of T-Kernel. However, a task cannot be put in SUSPENDED state. Additionally, only a subtask can be put in DORMANT state. No main task can be put in DORMANT state. No running task can be put in DORMANT state.

(1) RUNNING state

Means that the task is running. At any one time, there can be one task in RUNNING state at most.

(2) READY state

Means that the task, ready for execution, cannot be executed because another task with a higher precedence is being executed.

When a task in RUNNING state goes to READY or WAITING state, one of other tasks in READY state with the highest precedence goes to RUNNING state.

Dispatch refers to an operation in which a CPU resource is allocated to a task in READY state and the task goes to RUNNING state. Preempt refers to an operation in which a task in RUNNING state releases the CPU resources and goes to READY state.

(3) WAITING state

Means that the execution of the task is temporarily suspended because a system call is invoked to suspend the execution of the task itself.

(4) DORMANT state

Means that the task has not yet been started or has completed execution.

While a task is in DORMANT state, information regarding its execution state is not saved. When a task in DORMANT state is started and goes to READY state, execution of the task starts from the task start address.

Only a subtask can go to DORMANT state.

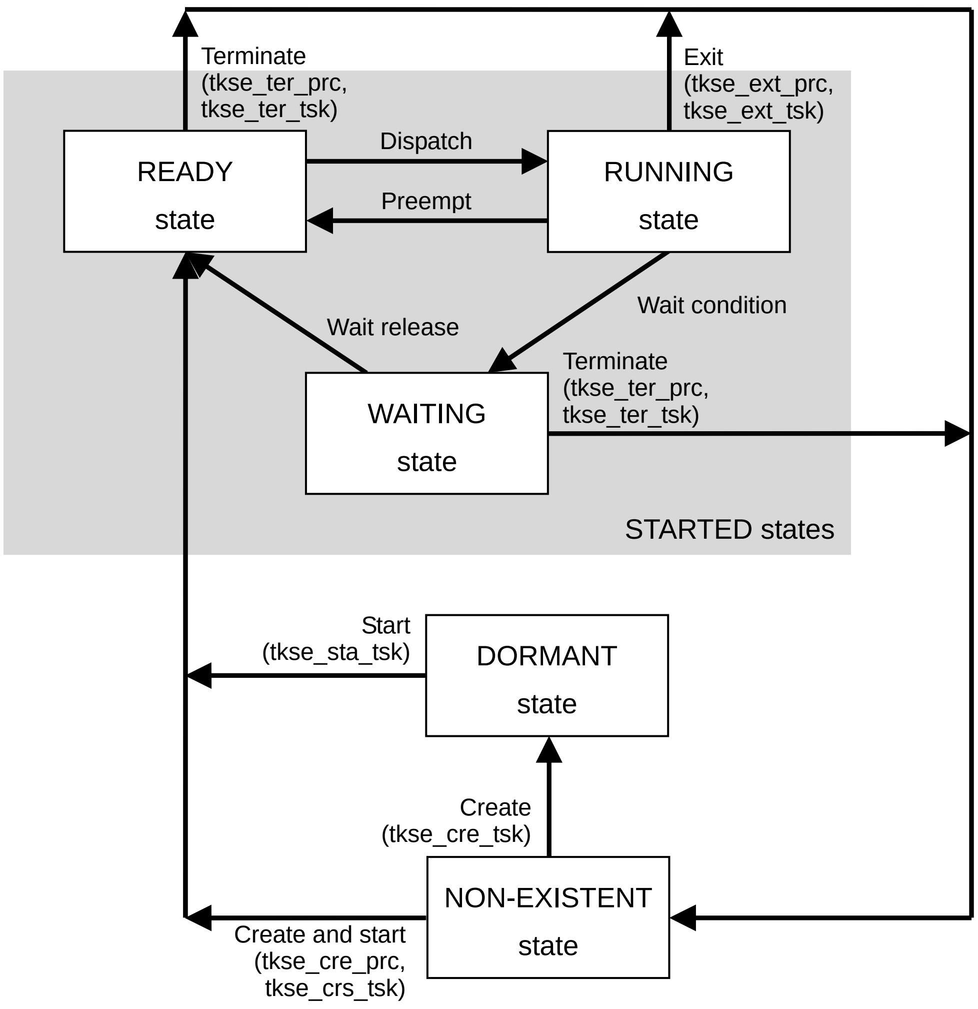
(5) NON-EXISTENT state

Means that the task has not yet been created or has been deleted.

The NON-EXISTENT state is a virtual state. A task in NON-EXISTENT state is actually not registered in the system.

The following shows the task state transition for a general implementation. Depending on the implementation, there can be state transitions not shown in this figure or transient states that do not fall into any of the categories provided.

When a task going to READY state has higher precedence than the currently running task, a dispatch may occur at the same time as the task goes to READY state, and it may make an immediate transition to RUNNING state. In such a case, the task that was in RUNNING state up to this point is said to have been preempted by the new task going to RUNNING state. Note also that, even if the explanation of a system call function describes that a task "goes to READY state," it may immediately go to RUNNING state depending on the task precedence.
“Task start” refers to the transition of a task in DORMANT state into READY state. Therefore, all other states than DORMANT and NON-EXISTENT states may be called "STARTED" state collectively. Task exit refers to the transition of a task in STARTED state into DORMANT state.
“Task wait release” refers to the transition of a task in WAITING state into READY state. A factor that releases WAITING state is called a task wait release factor.



[Figure 4] Task State Transitions

2.1.4 Process/Task Priority and Scheduling

Each task has an independent task priority. The task priority of the main task of a process is called a process priority. Each subtask also has priority; Subtask priority can be set to a different value than process priority . Priority should be set at the time of creating a process or subtask. Priority can be changed dynamically while a task is running.
Priority can be set to a range of values from 0 to 255 (with 0 being the highest). Tasks are classified into three priority groups according to their priority values, each of which is given different scheduling. Standard Extension basically offers two types of scheduling: Absolute priority scheduling and round robin scheduling.
Under absolute priority scheduling, the higher the task priority, the higher the task precedence. Therefore, while a task is in RUNNING state, another task with a lower priority than the former never goes to RUNNING state. This scheduling is basically the same as the scheduling of T-Kernel.
Under round robin scheduling, tasks go to RUNNING state in turn without regard to the task priorities. A task priority means a relative scheduling frequency. More specifically, the higher the priority, the more the run time allocated to a task (time during which a task can stay in RUNNING state). After the allocated run time elapses, the task precedence becomes the lowest, and another task goes to RUNNING state. In other words, a task with a low priority is run without fail.

Depending on the priority values, tasks are classified into the following three priority groups:

A. Absolute priority group (Priority: 0 to 127)
   Tasks in this group are subject to absolute priority scheduling based on task priorities (with 0 being the highest priority).
   However, tasks with the same priority are scheduled equally and periodically in a round-robin fashion.
   If a task with a high priority is in RUNNING or READY state, a task with a low priority never runs.

B. Round robin group 1 (Priority: 128 to 191)
   Tasks in this group are scheduled in a round robin fashion (with 128 being the highest priority).
   This group has a lower precedence than the absolute priority group. If any task in the absolute priority group is in RUNNING or READY state, no task in this group is executed. If no task in the absolute priority group is in RUNNING or READY state, the execution of a task with a low priority in this group is ensured.

C. Round robin group 2 (Priority: 192 to 255)
   Tasks in this group are scheduled in a round robin fashion (with 192 being the highest priority).
   This group has a lower precedence than other groups (the absolute priority group and round robin group 1). If any task in other groups is in RUNNING or READY state, no task in this group is executed. If no task in other groups is in RUNNING or READY state, the execution of a task with a low priority in this group is ensured.

Actual scheduling is executed as follows:

1. If there are tasks in READY state in the absolute priority group, the one with the highest priority goes to RUNNING state and is executed. If not, go to step 2.
   If there are multiple tasks with the highest priority, they are scheduled equally and periodically in a round robin fashion.

2. If there are tasks in READY state in round robin group 1, a task is selected according to the relative precedences of the tasks, and then put into RUNNING state and is executed (not necessarily the highest priority). If not, go to step 3.

3. If there are tasks in READY state in round robin group 2, a task is selected according to the relative precedences of the tasks, and then put into RUNNING state and is executed (not necessarily the highest priority). If not, execute the scheduling procedure from the beginning again.

2.1.5 Execution Environment of Process

A process retains the following information as an execution environment:

- Process IDs of this process, parent process, and child process
- Process/Task priorities

- Current work files (Standard file management)
- Open files (Standard file management, standard I/O)
- Message queue (Interprocess message)

The execution environment just after a process is created is set up as follows:

• Process ID of this process:	ID assigned at the time of creation
• Process ID of parent process:	ID of process that created this process
• Process ID of child process:	None
• Process/Task priority:	Priority specified at the time of creation
• Current work files:	Work file of parent process at the time of creation
• Open files:	None
• Message queue:	Empty

Kernel objects such as semaphore can be associated with a process that created the object by specifying an attribute (`TA_DELEXIT`) at the time of creation.　An object associated with a process is automatically deleted when the process exits.

2.1.6 User Process and System Process

There are two types of processes: User process and system process.　A process can be specified as a user or system process by specifying an attribute when the process is created.
A user process can use all the functions of Standard Extension.　A system process can use the functions available to a user process and directly use a system call (`tk_xxx_yyy`) of T-Kernel.
A system process is intended for a use close to the system core, e.g., in combination with a debugger or upper system.　In principle, a general application shall be specified as a user process.

2.1.7 Creating a Process

A process can be created by invoking a system call, `tkse_cre_prc`, specifying an execution program file of a process and process creation message.
A process creation message is a message passed from a parent process to its child process at process creation.
A process creation message has an ordinary message structure identical to that of an interprocess message.

```
typedef struct {
        W msg_type;             /* Message type */
        W msg_size;             /* Message size (in byes) */
        UB msg_body[n];         /* Message body (msg_size bytes) */
} MESSAGE;
```

When a process has been successfully created, the main task of the process is started. At this time, the main task function receives a process creation message as an argument.
One of the two ways of receiving a message can be selected: Receiving message data directly or receiving individual components into which message data is broken assuming that it consists of character strings delimited with blanks. According to the use by the user, the name definition for the main task function should be selected from those shown in the following. However, only one of the names can be defined at one time.

(1) Format 1

```
W MAIN (MESSAGE *msg)
/* MESSAGE *msg; Pointer to a message */
{
        /* Program execution code */
        return exit-code;
}
```

When the name of a main task function is defined as `MAIN`, a process creation message `msg` is directly received as a function argument. At this time, there is no limit on the value of message type `msg_type`.

(2) Format 2

```
W main (W ac, TC **argv)
/* W ac; Number of string items */
/* TC **argv; Pointer to pointer array of string items */
{
        /* Program execution code */
        return exit-code;
}
```

When the name of a main task function is defined as `main`, message data `msg_body` of a process creation message is regarded as one TRON code string that is delimited with space character `TK_KSP` and ending with `TNULL`. In this case, the number of items delimited with space characters is passed to the `main` task function argument `ac` and pointers to strings in each item are passed to argument `argv` as a pointer array.

If msg_body does not end with TNULL, the termination character of msg_body is replaced with TNULL before argument analysis processing is executed. At this time, the termination character of msg_body is lost.
When Format 2 is used, message type msg_type = 0 must be specified. If msg_type ≠ 0 is specified, ac = 0 and *argv = NULL are always set regardless of the content of msg_body, and therefore no message can be received.
The process exits when processing returns from main task function MAIN or main. This is equivalent to process exit due to tkse_ext_prc.

2.1.8 Combination with T-Kernel Programs

Applications that run in Standard Extension can run in combination with T-Kernel programs. Applications can access mainly the following two types of T-Kernel programs:

- Device drivers
  Device drivers control various devices connected to the system.
  They are accessed using the device management function of Standard Extension.
- Subsystems
  Subsystems are used by various middleware to add functions to the system.
  They are accessed using extended SVC provided by various subsystems.

These T-Kernel programs are collectively called system programs. System programs run in the same system memory space as T-Kernel.
System programs can be placed in the memory space by linking them directly to T-Kernel. They can also be dynamically loaded and unloaded by applications.
An application can load a system program by issuing tk_lod_spg with the system program executable file.
Since the area in which it is loaded is dynamically allocated, the system program must be created in a relocatable format. If the location address of a system program stored in an executable file is a logical address out of the range managed by the operating system, it is loaded at a fixed address according to the location information of the executable fie.

After the system program is loaded, execution starts with the main function written in the following pattern. Unlike process creation, the MAIN function cannot be used.

```
W main (W ac, TC **argv)
/* W ac; Number of string items */
/* TC **argv; Pointer to pointer array of string items */
{
        if (ac >= 0) {
            /* Program load processing */
        } else {
            /* Program unload processing */
        }
        return exit-code;
}
```

Argument `arg` used when `tkse_lod_spg` loads a system program is regarded as one TRON code string delimited with spaces and ending with `TNULL`. The number of items delimited with space characters is passed to the `main` function arguement `ac` and pointers to strings in each item are passed to argument `argv` as a pointer array. At the time of loading, `ac ≥ 0` is always set.
`tkse_unl_spg` unloads a system program that has been loaded. In the same way as for loading, the `main` function is invoked. However, `ac < 0` is set at the time of unloading and therefore either of loading or unloading processing is executed after evaluating the ac value.
The `main` function is executed as the quasi-task portion of a task that invoked `tkse_lod_spg`. Since the T-Kernel API is available for the `main` function, this portion should include the definition or deletion of a subsystem in the case of a subsystem or the registration or deletion of a device in the case of a device driver.
The `main` function must not change the status of any of its tasks such as task exit because it may affect the RUNNING state of the invoking task.

2.2 Synchronization and Communication

2.2.1 Interprocess Synchronization and Communication

Standard Extension provides the following functions to execute interprocess communication:

(1) Interprocess message

The interprocess message function sends a data structure called a message from a sending process to a receiving process to realize one-to-one interprocess communication.　This function can also be used for interprocess synchronization.

A message sent by Send Message (`tkse_snd_msg`) is stored in a message queue by a receiving process.　A message queue is unique to each process, and automatically created and initialized when a process is created.

The receiving process executes Receive Message (`tkse_rcv_msg`) to retrieve a message stored in the message queue of this process.　Asynchronous message reception can also be executed if a message handler is defined for the receiving process.　In this case, when the receiving process receives a message, the message handler is started while interrupting the main task.

Interprocess message is used not only as a means of interprocess communication but also of delivering information from the system to a process.　For example, when a child process exits, a child process exit message is sent from the system to its parent process.　Such a message sent by the system is called a system message.

(2) Global name

The global name function allows multiple processes to share four-byte data to which any name called a global name has been assigned.

Since each process has an independent local memory space, multiple processes cannot share data with each other using, for example, global variables in a local memory space.　Such functions as shared memory and message buffer can be used to share data.　To use these functions, however, it is necessary to first share the addresses of an area of shared memory or the IDs of OS objects such as message buffer.　The global name function is intended to share such addresses and IDs.

Although the use of the global name function is intended for sharing of addresses and IDs, any four-byte data can be shared.

(3) Shared memory

Interprocess communication using shared memory is a method for passing data using the shared memory space described above.

This method is used to allow multiple processes to access large quantities of data.　Instant passing of data is possible because no data copy is executed.　However, considerations must be given to the absence of access security and the necessity of combined use of other functions for synchronization and exclusive control.

Interprocess synchronization can be executed using the interprocess message function.　If more detailed synchronization at the task level is required, the intertask synchronization and communication function can be used.

2.2.2 Intertask Synchronization and Communication

(1) Intertask synchronization and communication functions

Intertask synchronization and communication are achieved using OS objects provided for synchronization and communication. The functions provided by these OS objects are called the intertask synchronization and communication functions.
The following OS objects can be used for the intertask synchronization and communication.

- Semaphore
- Mutex
- Event flag
- Mailbox
- Message buffer
- Rendezvous port

To use any of these intertask synchronization and communication functions, it is necessary, first of all, to create an OS object for the function. Each of the objects that have been created is given a unique object ID. This object ID is used for synchronization and communication among tasks.
Intertask synchronization and communication can be executed not only between tasks in the same process but also between tasks in different processes. However, mailbox can be used only between tasks in the same process.
The specifications of the Standard Extension intertask synchronization and communication functions conform to those of the T-Kernel intertask synchronization and communication functions. However, object IDs of objects created in Standard Extension cannot be used in T-Kernel because object IDs are managed by Standard Extension independently. Conversely, object IDs of objects created in T-Kernel cannot be used in Standard Extension, either. Furthermore, there are some restrictions on the specification of attributes at the time of object creation (for details of the specifications, see the explanation of system calls).
If a message handler of the process interrupts while a task is in WAITING state due to intertask synchronization and communication functions, the WAITING state of the task is released and the system call returns `E_DISWAI`.

(2) Task-dependent synchronization functions

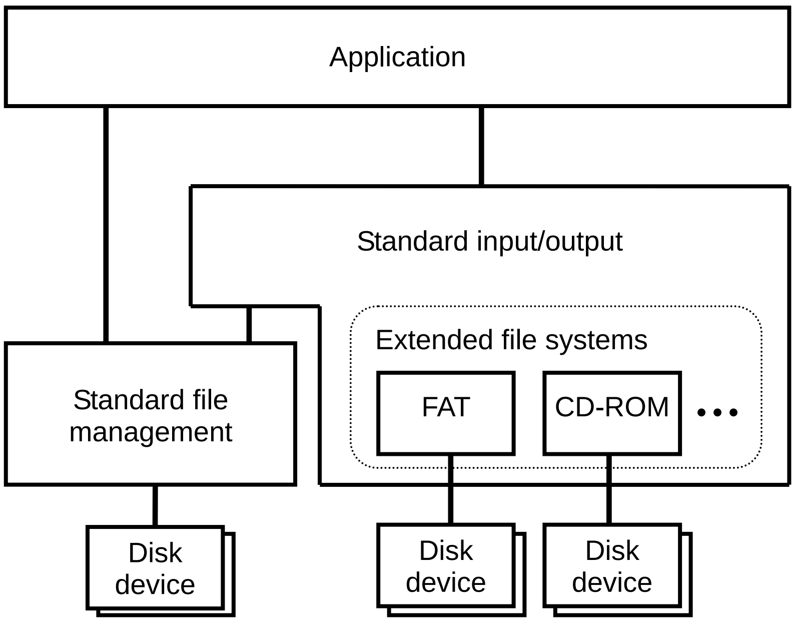
Synchronization among tasks can also be achieved by directly manipulating the states of other tasks instead of using the intertask synchronization and communication functions. The functions used to achieve synchronization through control of the states of other tasks are called the task-dependent synchronization functions.

The task-dependent synchronization functions available in Standard Extension are the task wakeup, task sleep and cancellation of them.

2.3 Standard File Management and Standard Input/Output Functions

2.3.1 File Management of Standard Extension

Standard Extension has the file management functions that permit the use of a disk device registered in T-Kernel as a file system.
The file management functions consist of the standard file management function and the standard input/output function: The former is used to directly manipulate the T-Kernel standard file system (hereinafter called, standard file system), and the latter is used to handle various file systems including the standard file system in an unified way.
The standard input/output function can handle not only the standard file system but also file systems in other formats.　These file systems in other formats are called extended file systems.　The file formats supported in the specifications of the current version are the FAT12, FAT16, and FAT32 file systems and the CD-ROM (ISO9660 Level1) file system.　A different file system than these can also be embedded as an extended file system in the standard input/output.



[Figure 5] Position of File Management

To use a disk device as a file system, it is necessary to connect the file system first.　The connected file system has a unique connection name, which is then used to manipulate a file existing on the file system.　The standard file management and the standard input/output permit simultaneous connection of multiple different file systems.
A file system must be connected before starting a process or system program from an executable file and conducting virtual memory management using a page file.

2.3.2 Standard File Management Function

The standard file management function is used to directly handle the standard file system with a hypertext-based network structure.　The handling of real and virtual objects, which is the unique function of the standard file system, and file records use the standard file management function.

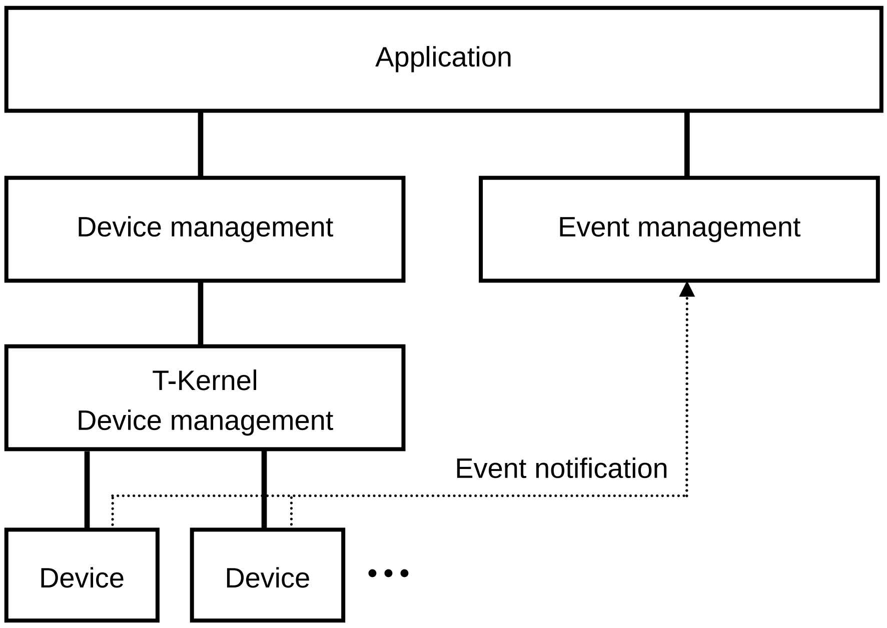
2.3.3 Standard Input/Output Function

The standard input/output function realizes file access from applications using common system calls without regard to differences between specifications of file systems.　However, restrictions on file name lengths, maximum file sizes, and others in the original file systems also apply to the standard input/output.

2.4 Device Management and Event Management Functions

2.4.1 Access to T-Kernel Device and Event Notification

Standard Extension provides the device management function that permits access to devices registered in T-Kernel, and the event management function that allows applications to receive event notifications sent from devices.



[Figure 6] Positions of Device Management and Event Management

2.4.2 Device Management Function

Device management function enables access to the T-Kernel device management function from Standard Extension.　The actual manipulation and management of devices are executed by T-Kernel.
Devices can be registered only from T-Kernel.　Devices cannot be registered or deleted from Standard Extension.

2.4.3 Event Management Function

Event management function allows applications to receive event notifications generated asynchronously by devices.　Event notifications from devices are converted into a data structure called an event, and are stored sequentially in the event queue of event management.　Since there is only one event queue for the entire system, the event management function cannot be used by multiple processes at the same time.
An application can get an event to retrieve an event stored in the event queue.　It can also receive an event as a message.

The main purpose of event management is to realize interactive human interfaces.　Therefore, event management is designed on the assumption that it is used to send event notifications from keyboards, pointing devices, and other such human interface devices to applications as *events*.　However, device events, extended device events, application events, and other events can also be used to send event notifications from other devices to applications.

3. T-Kernel Standard Extension Common Specifications

3.1 Data Types

3.1.1 Basic Data Types

```
typedef    char              B;            /* Signed 8-bit integer */
typedef    short             H;            /* Signed 16-bit integer */
typedef    int               W;            /* Signed 32-bit integer */
typedef    unsigned char     UB;           /* Unsigned 8-bit integer */
typedef    unsigned short    UH;           /* Unsigned 16-bit integer */
typedef    unsigned int      UW;           /* Unsigned 32-bit integer */

typedef    char              VB;           /* 8-bit data without a fixed type */
typedef    short             VH;           /* 16-bit data without a fixed type */
typedef    int               VW;           /* 32-bit data without a fixed type */
typedef    void              *VP;          /* pointer to data without a fixed type */

typedef    volatile B        _B;           /* volatile declaration */
typedef    volatile H        _H;
typedef    volatile W        _W;
typedef    volatile UB       _UB;
typedef    volatile UH       _UH;
typedef    volatile UW       _UW;

typedef    int               INT;          /* Signed integer of processor bit width */
typedef    unsigned int      UINT;         /* Unsigned integer of processor bit width */

typedef    INT               ID;           /* General ID */
typedef    INT               MSEC;         /* General time (milliseconds) */
typedef    void              (*FP)();      /* General function address */
typedef    INT               (*FUNCP)();   /* General function address */

#define    LOCAL             static        /* Local symbol definition */
#define    EXPORT                          /* Global symbol definition */
#define    IMPORT            extern        /* Global symbol reference */

/*
 * Boolean values
 * TRUE = 1 is defined, but any value other than 0 is TRUE.
 * A decision such as bool == TRUE must be avoided for this reason.
 * Instead use bool != FALSE.
 */
typedef     INT             BOOL;
#define     TRUE            1             /* True */
#define     FALSE           0             /* False */
/*
 * TRON code
 */
typedef     UH              TC;           /* TRON code */
#define     TNULL           ((TC)0)       /* TRON code string termination */
```

* The difference between VB, VH, and VW and B, H, and W is that the former mean only the bit width is known, not the contents of the data type, whereas the latter clearly indicate integer type.
* Processor bit width must be 32 bits or above.　INT and UINT must therefore always have a width of 32 bits or more.
* BOOL defines TRUE = 1, but any value other than 0 is also TRUE.　For this reason, a decision such as bool == TRUE must be avoided.　Instead use bool != FALSE.

[Additional Notes]
Parameters that clearly do not take negative values are also in principle signed integer (INT) data type.　This is in keeping with the overall TRON rule that integers should be treated as signed numbers to the extent possible.　As for the timeout (TMO tmout) parameter, its being a signed integer enables the use of TMO_FEVR (= .1) having special meaning.　Parameters with unsigned data type are those treated as bit patterns (object attribute, event flag, etc.).

3.1.2 Other Defined Data Types

The following names are used for other data types that appear frequently or have special meaning, in order to make the parameter meaning clear.

```
typedef     INT             FN;           /* Function code */
typedef     INT             RNO;          /* Rendezvous number */
typedef     UINT            ATR;          /* Object/handler attributes */
typedef     INT             ER;           /* Error code */
typedef     INT             PRI;          /* Priority */
typedef     INT             TMO;          /* Timeout */
typedef     UINT            RELTIM;       /* Relative time */
typedef     struct systim {               /* System time */
                  W         hi;           /* High 32 bits */
                  UW        lo;           /* Low 32 bits */
} SYSTIM;
```

```
/*
 * Common constants
 */
#define     NULL          0          /* Null pointer */
#define     TA_NULL       0          /* No special attributes indicated */
#define     TMO_POL       0          /* Polling */
#define     TMO_FEVR      (-1)       /* Eternal wait */
```

* A data type that combines two or more data types is represented by its main data type. For example, the value returned by tkse_cre_prc can be a process ID or error code, but since it is mainly a process ID, the data type is ID.

3.2 Error Codes

3.2.1 Overview

System call return codes are in principle to be signed integers.　When an error occurs, a negative error code is returned; and if processing is completed normally, E_OK (= 0) or a positive value is returned. The meaning of returned values in the case of normal completion is specified separately for each system call.　An exception to this principle is that there are some system calls that do not return when called.
A system call that does not return is declared in the C language API as having no return code (that is, a void type function).
An error code consists of the main error code and sub error code.　The low 16 bits of the error code are the sub error code, and the remaining high bits are the main error code.　Main error codes are classified into error classes based on the necessity of their detection, the circumstances in which they occur and other factors.

```
#define     MERCD(er)        ( (ER)(er) >> 16 )                  /* Main error code */
#define     SERCD(er)        ( (H)(er) )                         /* Sub error code */
#define     ERCD(mer, ser)   ( (ER)(mer) << 16 | (ER)(UH)(ser) )
```

3.2.2 List of Error Codes

The following shows error codes of Standard Extension.　Main error codes from 0 to -255 are error codes compatible with T-Kernel and have the same meaning as those for T-Kernel.　Error codes from -256 and later are error codes unique for Standard Extension.

Error codes in a range not defined as an error class are reserved for the purpose of future expansions.

——— Normal Completion Error Class (0) ———

E_OK　0　Normal completion

——— Internal Error Class (-5 to -8) ———

E_SYS　ERCD(-5, 0)　System error

An error of unknown cause affecting the system as a whole.

E_NOCOP　ERCD(-6, 0)　The specified co-processor cannot be used

This error code is returned when the specified co-processor is not installed in the currently running hardware, or abnormal co-processor operation was detected.

——— Unsupported Error Class (-9 to -16) ———

E_NOSPT　ERCD(-9, 0)　Unsupported function

When some system call functions are not supported and such a function was specified, error code E_RSATR or E_NOSPT is returned.　If E_RSATR does not apply, error code E_NOSPT is returned.

E_RSFN　ERCD(-10, 0)　Reserved function code number

This error code is returned when it is attempted to execute a system call specifying a reserved function code (undefined function code), and also when it is attempted to execute an undefined extended SVC handler (when the function code is positive).

E_RSATR　ERCD(-11, 0)　Reserved attribute

This error code is returned when an undefined or unsupported object attribute is specified.

Checking for this error may be omitted if system-dependent optimization is implemented.

——— Parameter Error Class (-17 to -24) ———

E_PAR　ERCD(-17, 0)　Parameter error

Checking for this error may be omitted if system-dependent optimization is implemented.

E_ID　ERCD（-18, 0)　Invalid ID number

E_ID is an error that occurs only for objects having an ID number.

Error code E_PAR is returned when a static error is detected because, for example, the specified ID number is a reserved number or out of range of interrupt definition numbers.

—— Call Context Error Class (-25 to -32) ——

E_CTX	ERCD(-25, 0)	Context error

This error indicates that the specified system call cannot be issued in the current context (the context must be the task portion/task-independent portion or handler RUN state).

This error is always returned whenever a system call is issued in a semantically incorrect context, for example, when a system call that sends its own task into WAITING state is issued from a task-independent portion.

This error is returned also for other system calls when, due to implementation limitations, they cannot be issued in a given context (such as an interrupt handler).

E_MACV	ERCD(-26, 0)	Memory cannot be accessed; memory access privilege error

Error detection is implementation-dependent.

E_OACV	ERCD(-27, 0)	Object access privilege error

This error code is returned when a user task tries to manipulate a system object.

The definition of system objects and error detection are implementation-dependent.

E_ILUSE	ERCD(-28, 0)	System call illegal use

—— Resource Constraint Error Class (-33 to -40) ——

E_NOMEM	ERCD(-33, 0)	Insufficient memory

This error code is returned when there is insufficient memory (no memory) for allocating an object control block space, user stack space, memory pool space, message buffer space or the like.

E_LIMIT	ERCD(-34, 0)	System limit exceeded

This error code is returned when it is attempted to create more objects than the system allows.

—— Object State Error Class (-41 to -48) ——

E_OBJ	ERCD(-41, 0)	Invalid object state
E_NOEXS	ERCD(-42, 0)	Object does not exist
E_QOVR	ERCD(-43, 0)	Queuing or nesting overflow

—— Wait Error Class (-49 to -56) ——

E_RLWAI	ERCD(-49, 0)	WAITING state released
E_TMOUT	ERCD(-50, 0)	Polling failed or timeout
E_DLT	ERCD(-51, 0)	The object being waited for was deleted
E_DISWAI	ERCD(-52, 0)	Wait released by wait disabled state

—— Device Error Class (-57 to -64) (T-Kernel/SM) ——

E_IO	ERCD(-57, 0)	IO error

* Error information specific to individual devices may be defined in E_IO sub-codes.

E_NOMDA	ERCD(-58, 0)	No media

—— Status Error Class (-65 to -72) (T-Kernel/SM) ——

E_BUSY	ERCD(-65, 0)	Busy
E_ABORT	ERCD(-66, 0)	Processing was aborted
E_RONLY	ERCD(-67, 0)	Write protected

—— Memory Management Error Class (-257 to -260) (Standard Extension) ——

E_SYSMEM	ERCD(-257, 0)	Insufficient system memory space

This error is returned when there is only insufficient memory space to be used inside Standard Extension.

—— File Management Error Class (-261 to -280) (Standard Extension) ——

E_FNAME	ERCD(-261, 0)	Invalid path name; invalid file name
E_FD	ERCD(-262, 0)	Invalid file descriptor
E_FACV	ERCD(-263, 0)	File access privilege error
E_PERM	ERCD(-264, 0)	Undeletable file
E_PWD	ERCD(-265, 0)	Invalid password

Should not be used by Standard Extension.

E_ENDR	ERCD(-266, 0)	The end record has been reached
E_REC	ERCD(-267, 0)	Invalid record type
E_NOLNK	ERCD(-268, 0)	Not a link file
E_LOCK	ERCD(-269, 0)	The record is locked
E_XFS	ERCD(-270, 0)	Belongs to a different file system
E_NOFS	ERCD(-271, 0)	File system not connected
E_NODSK	ERCD(-272, 0)	Insufficient disk space

E_ILFMT	ERCD(-273, 0)	Invalid disk format
E_SEIO	ERCD(-274, 0)	Standard input/output error

Device Management Error Class (-281 to -290) (Standard Extension)

E_NODEV	ERCD(-281, 0)	The device does not exist
E_ERDEV	ERCD(-282, 0)	Abnormal device status

4. T-Kernel Standard Extension Functions

4.1 Memory Management Function

4.1.1 Overview of the Memory Management Function

The Memory Management Function of the “Standard Extension” manages data memory areas. It manages three types of data memory areas: local memory area, shared memory area, and system memory area. It provides the function of allocating and freeing a specified number of memory blocks for each area.

System calls provide the functions to allocate memory in blocks only. The block size depends on the MMU functions and others, and is set to the optimum value for your system.
To divide and manage the memory area smaller in size than in blocks unit, the library shall be used or the necessary processes shall be executed in your application. Normally, library shall be used instead of using system calls directly; system calls shall be directly used only if library is insufficient.

The allocated memory blocks have successive logical addresses, and the starting logical address is returned to your application. Because the logical address will not change once allocated, you can directly access the memory blocks with the returned address. You are free to write/read data to/from the allocated memory blocks, but as a general rule, programs cannot be run in them.

Because an exclusive memory access control is not provided, it shall be implemented in your application, by using semaphores, etc. if necessary.

4.1.2 System Calls

Get Memory Block

tkse_get_mbk

C Language Interface

```
ER ercd = tkse_get_mbk(VP *adr, INT nblk, UINT atr);
```

Parameter

VP	*adr	area where start address of allocated memory area is returned
INT	nblk	the number of allocated memory blocks (> 0)
UINT	atr	attributes of memory blocks
		[(M_COMMON || M_SYSTEM)] | [M_RESIDENT] | [TA_DELEXIT]
		M_COMMON : specify common memory
		M_SYSTEM : specify system memory
		M_RESIDENT : specify resident
		TA_DELEXIT : specify deletion on process termination

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible access not allowed (adr)
E_NOMEM	insufficient memory area
E_SYSMEM	Insufficient system memory area
E_PAR	illegal parameter

Description

Allocate the contiguous memory area as many as the number of blocks specified by “nblk” and return the start address to “*adr”.
Specify the attribute of memory area for “atr” as follows:

atr := [(M_COMMON || M_SYSTEM)] | [M_RESIDENT] | [TA_DELEXIT]

M_COMMON	: specify common memory
M_SYSTEM	: specify system memory
M_RESIDENT	: specify resident
TA_DELEXIT	: specify deletion on process termination

When “M_COMMON” attribute is specified, the memory areas are accessible as common memory from all processes.
When “M_SYSTEM” attribute is specified, the memory areas are accessible as system memory only from systems (OS, device drivers, etc.). This specification shall not be used from application processes.
When both “M_COMMON” and “M_SYSTEM” are not specified, only local memory is enabled. Local memory is accessible only from the processes to which memory blocks are allocated.

When the “M_RESIDENT” attribute is specified, the memory area constantly exists as resident memory in the main memory without being swapped out to disks. Without the specification, it is set to nonresident memory. In systems without virtual memory, this setting has no particular meaning (equal to resident).

When the “TA_DELEXIT” attribute is specified, memory blocks are automatically released after the process exits which allocated the memory blocks. However, in the case of local memory, the memory blocks are released when the process is terminated with or without this setting.

Release Memory Block

tkse_rel_mbk

C Language Interface

```
ER ercd = tkse_rel_mbk(VP adr);
```

Parameter

VP	adr	address of memory block to be released

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_PAR	illegal memory block address

Description

Release the memory block specified by “adr”. “adr” should be the address obtained by “tkse_get_mbk()”.

Refer to Memory State

tkse_mbk_sts

C Language Interface

```
ER ercd = tkse_mbk_sts(M_STATE *pk_sts);
```

Parameter

M_STATE	pk_sts	area whose memory state is returned

Return Parameter

ER	ercd	error code

content of pk_sts

```
typedef struct    m_state {
        INT        blksz;        /* block size */
        INT        total;        /* total number of blocks */
        INT        free;         /* the number of remaining blocks */
} M_STATE;
```

blksz	memory allocation unit byte number (one block).The number of bytes in memory allocation unit(one block). In general, this is the CPU's page size. 4KB on the standard scale.
total	total number of blocks across the system.
free	The number of unused blocks across the system.

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (sts) not allowed

Description

Get current memory usage, etc.

In systems with virtual memory, the total number of blocks and the number of remaining blocks may not be uniquely determined. Therefore, concrete meanings are implementation-dependent. However, “free/total” shall be set to as a reference value to indicate the remaining memory ratio.
When concrete value cannot be set by implementation, both the total number of blocks and the number of remaining blocks may be set to -1.

4.1.3 Library Calls

Allocate Nonresident Local Memory

malloc

C Language Interface

```
void* adr = malloc(size_t size);
```

Parameter

size_t	size	number of bytes to be allocated (> 0)

Return Parameter

void*	adr	≠ NULL	normal termination (allocated memory address)
		＝ NULL	error

Description

Allocate specified size of memory from nonresident local memory, and return the start address.
The attribute of allocated memory is set to “TA_DELEXIT”.

Allocate Nonresident Local Memory

calloc

C Language Interface

```
void* adr = calloc(size_t nelem, size_t elsize);
```

Parameter

size_t	nelem	the number of elements to be allocated (> 0)
size_t	elsize	the number of one element (> 0)

Return Parameter

void*	adr	≠ NULL	normal termination (allocated memory address)
		＝ NULL	error

Description

Allocate storage area of the elements which are as many as the number of “nelem” and as large as the size of “elsize” from nonresident local memory, and return the start address.
The allocated area is initialized with zero.
The attribute of allocated memory is set to “TA_DELEXIT”.

Reallocate Nonresident Local Memory

realloc

C Language Interface

```
void* adr = realloc(void *ptr, size_t size);
```

Parameter

void	*ptr	address of the area to be resized
		an area is newly allocated when “NULL” is specified
size_t	size	the number of bytes to be allocated (≧ 0)
		the area is released when zero is specified

Return Parameter

void*	adr	≠ NULL	normal termination (allocated memory address)
		＝ NULL	error

Description

Reallocate after changing size of the area specified by “ptr” in nonresident local memory to “size”, and return the start address.
“ptr” should be the address returned by “malloc()”, “calloc()”, or “realloc()”.

Free Nonresident Local Memory

free

C Language Interface

```
void free(void *ptr);
```

Parameter

void	*ptr	address of the area to be freed

Description

Free the area in nonresident local memory specified by “ptr”.
“ptr” should be the address returned by “malloc()”, “calloc()”, or “realloc()”.

Allocate Nonresident Common Memory

Smalloc

C Language Interface

```
void* adr = Smalloc(size_t size);
```

Parameter

size_t	size	the number of bytes to be allocated (> 0)

Return Parameter

void*	adr	≠ NULL	normal termination (allocated memory address)
		＝ NULL	error

Description

Allocate specified size of memory from nonresident common memory, and return the start address.
The attribute of allocated memory is set to “M_COMMON”.

Allocate Nonresident Common Memory

Scalloc

C Language Interface

```
void* adr = Scalloc(size_t nelem, size_t elsize);
```

Parameter

size_t	nelem	the number of elements to be allocated (> 0)
size_t	elsize	the number of one element (> 0)

Return Parameter

void*	adr	≠ NULL	normal termination (allocated memory address)
		＝ NULL	error

Description

Allocate an storage area of the elements which are as many as the number of “nelem” and as large as the size of “elsize” from nonresident common memory, and return the start address.
The attribute of allocated memory is set to “M_COMMON”, and the area is initialized with zero.

Reallocate Nonresident Common Memory

Srealloc

C Language Interface

```
void* adr = Srealloc(void *ptr, size_t size);
```

Parameter

void	*ptr	address of the area to be resized
		an area is newly allocated when NULL is specified
size_t	size	the number of bytes to be reallocated (≧ 0)
		the area is released when zero is specified

Return Parameter

void*	adr	≠ NULL	normal termination (allocated memory address)
		＝ NULL	error

Description

Reallocate after changing the size of the area specified by “ptr” in nonresident common memory to “size”, and return the start address.

The “ptr” should be the address of the memory area allocated in the same process, and the address should be the address returned by “Smalloc()”, “Scalloc()”, or “Srealloc()”.

Free Nonresident Common Memory

Sfree

C Language Interface

```
void    Sfree(void *ptr);
```

Parameter

void	*ptr	address of the area to be released

Description

Free an area in nonresident common memory specified by “ptr”. The “ptr” should be the address of the memory area allocated in the same process and should be the address returned by “Smalloc()”, “Scalloc()”, or “Srealloc()”.

4.2 Process/Task Management Function

4.2.1 Process/Task Management Function Overview

Standard Extension process / task management function offers the function for carrying out parallel operation of many processes.
Process / task management has a function about creation and termination the process or the task, state change, and information acquisition. When performing synchronization/communication between processes and between tasks, the synchronization/communication function between tasks (event flag, message buffer, etc) and the interprocess communication function (message, global name, shared memory, etc) are used.

4.2.2 System Calls

Create/Execute Processes

tkse_cre_prc

C Language Interface

```
ER ercd = tkse_cre_prc(T_CPRC *pk_cprc, MESSAGE* msg);
```

Parameter

```
T_CPRC   *pk_cprc    process creation information
MESSAGE              *msg          initial process message

          typedef    struct {
                     ATR      prcatr;     /* process attribute */
                     VP       prchdr;     /* handler for the source object of a process */
                     PRI      pri;        /* process priority */
                              0 ≦ pri ≦ 255    any priority
                              ＝ -1            the same priority as this process

                     /* other implementation-dependent information */

          } T_CPRC;
```

prcatr indicates process attribute and specifies the following:

prcatr := (TPA_SYS || TPA_USR) | (TPA_SEIO || TPA_LINK || TPA_PTR)

TPA_SYS	creates as a system process
TPA_USR	creates as a user process
TPA_SEIO	a handle for the process is a path name of standard input/output file
TPA_LINK	a handle for the process is a link to the file of the standard file system
TPA_PTR	a handle for the process is a pointer to the codes loaded in memory

```
typedef struct {
          W         msg_type;     /* message type */
          W         msg_size;     /* message size (number of bytes) */
          MSGBODY   msg_body;     /* message body (msg_size bytes) */
} MESSAGE;
```

* For details of the MSGBODY union, refer to "3.2.2 Message Structure"

Return Parameter

ER ercd	≧ 0	normal termination (created process ID)
	＜ 0	error

Error Code

E_FACV	no access privileges (E) for the file (when TPA_SEIO, TPA_LINK is specified)
E_MACV	access to address (msg, hdr(TPA_PTR)) not allowed
E_BUSY	could not open the file because it is already opened exclusively
E_IO	input/output error occurred
E_NOEXS	no file present
E_NOFS	the file system to which the file belongs is not connected
E_NOMEM	insufficient memory area (insufficient memory area to load)
E_REC	no program record present in the file. or the content of the program record is unusual (when TPA_LINK is specified)

Description

Creates a process and allocates a process ID.

prcatr of T_CPRC structure indicates the attribute of a created process.

If TPA_SEIO attribute is specified, a new process is created using the content of the specified file as its program code. Specify the path name of the standard input/output of the target file for prchdr.

IF TPA_LINK the attribute is specified, a new process is created using the content of the first executable program record in the file of the specified standard file system as its program code.　Specify the link (LINK*) to the standard file system file for prchdr.

If TPA_PTR attribute is specified, new process is created using program codes in memory. Specify the pointer of the program codes in memory for prchdr. Note that the format of the program codes in memory and the running methods are implementation-dependent.

The priority of created process will be specified by pri value. At the same time, the main task is created and it starts.

When the process (main task) starts to run, the message specified by msg is passed. This message structure is essentially the same as the structure of the interprocess message.

If msg_type = 0 for a message, msg_body[] should be a string which ends with TNULL.

Supplement

TPA_PTR attribute is assumed to be the romization of program codes. There are several possible ways to run the process's program codes in the ROM, such as to directly run the program in the ROM or to run it after transferring it to the RAM. The optimal method is determined according to the applications being applied and the hardware. Therefore, the format and the running method for the program codes may be determined implementation-dependently.

Exit Process

tkse_ext_prc

C Language Interface

```
void tkse_ext_prc(W code);
```

Parameter

W	code	process exit code

Return Parameter

none

Description

Exit this process normally, and send the process normal termination message with a specified “code” to the parent process.

All the resources such as files used in invoking process are automatically released except certain resources (options such as “tkse_cre_sem” without “TA_DELEXIT” specification).

Terminate Other Process

tkse_ter_prc

C Language Interface

```
ER ercd = tkse_ter_prc(ID pid, W code, W opt);
```

Parameter

ID	pid	target process ID	
		＞ 0	any process
		＝ 0	invoking process (cannot be specified: error)
		＝ -1	parent process
W	code	exit code	
W	opt	specify how to terminate	
		(TERM_NRM || TERM_ALL)	
		TERM_NRM	Terminate the specified process only
		TERM_ALL	Terminate the specified process and all the descendant processes

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_ILUSE	invoking process is specified (pid = 0 or PID of invoking process)
	process with higher user level than that of invoking process is specified
E_NOEXS	no process (pid) existent
E_PAR	illegal parameter (specification other than “opt” = “TERM_NRM” and ”TERM_ALL”)

Description

Terminate the specified process, and send the process termination message with a specified “code” to the parent process of the specified process.

When “TERM_ALL” is specified, specified process and all the descendant processes are killed. In this case, the termination messages of the descendant processes of the specified process are not sent. When the parent process of invoking process or further its own parent process is specified, invoking processed is also killed.

Change Priority of Processes/Tasks

tkse_chg_pri

C Language Interface

```
ER ercd = tkse_chg_pri(ID id, PRI pri, W opt);
```

Parameter

ID	id	target process ID or task ID	
PRI	pri	priority to be changed	
W	opt	specify how to change the priority	
		(P_ABS || P_REL) | [P_TASK]	
		P_ABS	absolute specification (change to specified priority)
		P_REL	relative specification (change to current priority + “pri”)
		P_TASK	Set task as target

Return Parameter

ER	ercd	≧ 0	normal termination (priority after change: 0-255)		
			P_TASK	specified	priority of task with ID id
			P_TASK	unspecified	priority of main task of a process with ID id
		＜ 0	error code		

Error Code

E_NOEXS	no process (id) existent
E_ID	no task (id) existent or, no task in invoking process
E_PAR	priority value is out of range (in relative specification, new priority is out of current priority group) illegal parameter (specification of the parameter other than opt = “P_ABS”,”P_REL”,or “P_TASK”)

Description

Change the priority of the specified process/task.

When “P_TASK” is not specified:

id = 0	Change the priorities of all the tasks in invoking process.
id = -1	Change the priorities of all the tasks in the parent process.

id ＞ 0	Change the priorities of all the tasks in a process with process ID specified by “id”.

When “P_TASK” is specified :

id ＝ 0	Change the priority of invoking task.
id ＞ 0	Change the priority of task with task ID specified by “id”. The tasks which can be specified are only the tasks in invoking process.

When “P_ABS” is specified (absolute specification), the priority after change is set to the value specified by “pri”.
When “P_REL” is specified (relative specification), the priority after change is set to current priority value added by the value specified by “pri”.
In a priority change with relative specification, a priority cannot be changed to the priority other than the priorities in current priority group.

Get Process State

tkse_prc_sts

C Language Interface

```
ER ercd = tkse_prc_sts(ID pid, P_STATE* buff, TC* name);
```

Parameter

ID	pid	target process ID
		＞ 0 any process
		＝ 0 invoking process
		＝ -1 parent process
P_STATE*	buff	storage area in process state
		(not stored in the case of NULL)
TC*	name	storage area of process name (area for process name's maximum length + one character)
		(not stored in the case of NULL)

Return Parameter

ER	ercd	＞ 0	normal termination (specified process ID)
		＜ 0	error code

P_STATE* buff process state

```
typedef struct {
        UW      state;          /* process state */
        PRI     priority;       /* current process priority (0 - 255) */
        ID      parpid;         /* process ID of the parent process */
} P_STATE;
```

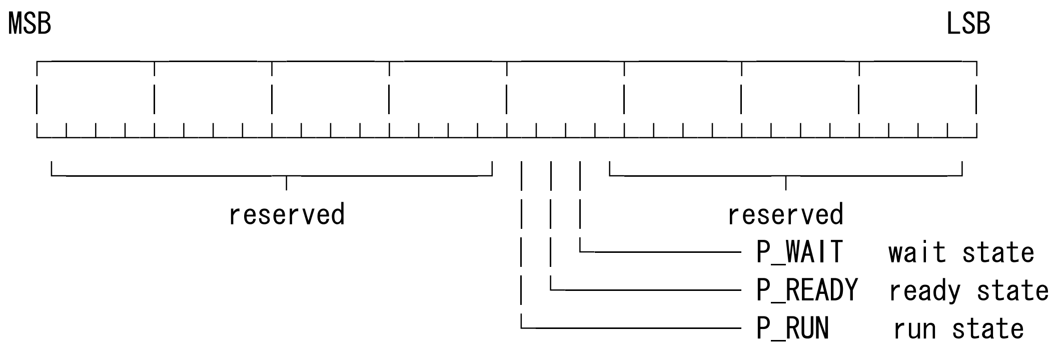
Error Code

E_MACV	access to inaccessible address (buff, path) not allowed
E_NOEXS	no process (pid) existent

Description

Retrieve the process state specified by “pid”, and store it in the area specified by “buff”. Also the process name of the specified process shall be stored in the area specified by “name”. When either “buff” or “name” is set to NULL, no information is stored.

The process state (state) is as follows: Each value "1" indicates that a process is in the state.



[Figure 7] Process state

Get Statistics Information about Processes

tkse_get_inf

C Language Interface

```
ER ercd = tkse_get_inf(ID pid, P_INFO* buff);
```

Parameter

ID	pid	target process ID
	＞ 0	any process
	＝ 0	invoking process
	＝ -1	parent process
P_INFO* buff	storage area of statistical information	

```
typedef struct {
        UW      etime;          /*cumulative elapsed time (in seconds)*/
        UW      utime;          /*cumulative CPU time spent in process*/
        UW      stime;          /*cumulative CPU time spent in system*/
        W       tmem;           /*total memory size required to execute*/
        W       wmem;           /*currently allocated actual memory size*/
        W       resv[11];       /*reserved*/
} P_INFO;
```

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (buff) not allowed
E_NOEXS	no process (pid) existent

Description

Get statistical information on the specified process.
“utime” and “stime” are set to the total time of all tasks existing at the time which are included in the process. Therefore, the time spent by previously terminated tasks is not included. The sum of “utime” and “stime” is the cumulative CPU time spent by the process.

Process Exit Message

tkse_req_emg

C Language Interface

```
ER ercd = tkse_req_emg(ID pid, W t_mask);
```

Parameter

ID	pid	target process ID	
		＝ -1	parent process
		＞ 0	any process
W	t_mask	specify exit message type (specify with OR)	
		0	clear notification
		MM_ABORT	notify when target process is aborted
		MM_EXIT	notify when target process is terminated normally
		MM_TERM	notify when target process is killed

Return Parameter

ER	ercd	＞ 0	normal termination (original “t_mask”)
		＜ 0	error code

Error Code

E_ILUSE	invoking process is specified (“pid = 0” or “PID” of invoking process)
E_NOEXS	no process (pid) existent
E_PAR	illegal parameter (illegal t_mask)

Description

Sending of the exit message shall be set to invoking process when the process specified by “pid” is terminated. “pid= -1” indicates a parent process. Invoking process cannot be specified (E_ILUSE).

Specify the types of termination to be notifed by “t_mask”.

t_mask = [MM_ABORT] | [MM_EXIT] | [MM_TERM]

MM_ABORT	notify when target process is aborted
MM_EXIT	notify when target process normally exits

MM_TERM	notify when target process is terminated

When “t_mask = 0”, exit message is cleared. When “t_mask < 0”, the setting remains unchanged.

The old setting value of “t_mask” shall be returned as a return value when invoking process is terminated, the setting is automatically cleared.

The exit messages have the following formats:

```
typedef struct {
        W           type;       /* message type (MS_SYS2) */
        W           size;       /* message size */
        W           kind;       /* termination type (MS_ABORT,MS_EXIT,MS_TERM) */
        ID          pid;        /* process ID of the terminated process */
        W           code;       /* exit code */
} EXITMSG;
```

“kind”, “pid”, and “code” have the same content as the termination message to be sent to parent process.

kind	termination message type (any of “MS_ABORT”, “MS_EXIT”, or “MS_TERM”)
pid	process ID of the terminated process
code	system error code or exit code specified by “tkse_ext_prc()” and “tkse_tE_prc()”

“EXITMSG” is set to one of various “MS_SYS2” system messages.

```
typedef union {
        struct {                /* MS_SYS2 basic form*/
        W           type;       /* message type (MS_SYS2) */
        W           size;       /* message size */
        W           kind;       /* kind */
        VW          info[1];    /* various information different per each type */
} base;
        EXITMSG exitmsg;        /* exit message*/
} MSG_SYS2;
```

The exit message is sent differently from normal termination messages notifying the parent process when child process is terminated. Therefore, if exit message is set to a child process, a further termination message may be received after receiving the exit message (MS_SYS2).

Retrieve Various Information about Processes

tkse_prc_inf

C Language Interface

```
ER ercd = tkse_prc_inf(ID pid, W item, VP buf, W len);
```

Parameter

ID	pid	target process ID		
		＝ 0	this process	
		＝ -1	parent process	
		＞ 0	any process	
W	item	type of information		
		PI_LINK	(0x00010000)	retrieves the link to program file
		PI_NTSK	(0x00020000)	retrieves the number of tasks in a process
		PI_TSKSTAT	(0x00030000)	retrieves the states of each task
		PI_CREINF	(0x00040000)	information during process creation
VP	buf	buffer for storing information		
		(If NULL, not stored)		
W	len	byte length of buffer area (buf) for storing information		

Return Parameter

ER	ercd	＞ 0	normal termination (size necessary for buf (number of bytes))
		＜ 0	error code

Error Code

E_MACV	access to address (buff,path) not allowed
E_NOEXS	no process (pid) present
E_PAR	illegal parameter (insufficient len, illegal item)

Description

Retrieves various information about the process specified by pid (process ID) to store in buf.
Specify the type of information as an item. pid = 0 indicates this process and pid = -1 indicates parent process.

len indicates buf size (number of bytes). If len is less than the necessary size, an error (E_PAR) occurs and nothing is stored in buf. Returns the size (number of bytes) necessary for buf. If buf = NULL is specified, information will not be stored, but the size necessary for buf will be returned as a return value. In this case, len will be ignored.

Specify one of the following for the type of information (item):

```
#define PI_LINK          0x00010000      /* link to the program file */
#define PI_NTSK          0x00020000      /* number of tasks in a process */
#define PI_TSKSTAT       0x00030000      /* each task state */
#define PI_CREINF        0x00040000      /* information during process creation */
```

PI_LINK :

item	PI_LINK
buf	LINK

Retrieves the link to program file. Returns the link to the program file specified by tkse_cre_prc().

PI_NTSK :

item	PI_NTSK
buf	W ntsk

Retrieves the number of tasks (total number of main and sub tasks) in the processes.

PI_TSKSTAT :

```
item    PI_TSKSTAT + n
buf     typedef struct {
                ID    tskid;      /* task ID */
                UW    state;      /* task state */
                PRI   priority;   /* task priority */
        } P_TSKSTAT;
state = P_DORMANT || P_WAIT || P_READY || P_RUN
```

Retrieves the state information about the nth task. If n = 0, then main task will be retrieved. If n ≧ 1, then subtask will be retrieved. n is valid only until number of tasks retrieved by PI_NTSK is minus 1.

PI_CREINF :

```
        item        PI_CREINF
        buf         typedef struc {
                            PRI   pri;         /* process priority */
                            ATR   prcatr;      /* process attribute */
                            VB    prchdr[1];   /* handler for the source object of a process */
                    } P_CREINF;
```

Returns information during process creation with tkse_cre_prc().
Note that buf's required size should be retrieved in advance, since prchdr[1] is a variable length field.

Subtask Creation

tkse_cre_tsk

C Language Interface

```
ER ercd = tkse_cre_tsk(FP entry, PRI pri);
```

Parameter

FP	entry	subtask start address
W	pri	subtask priority

Return Parameter

ER	ercd	＞ 0	normal termination (created subtask ID)
		＜ 0	error code

Error Code

E_MACV	illegal address (entry)
E_LIMIT	subtask count limit exceeded
E_NOMEM	insufficient memory area

Description

Creates a subtask in this process.

The subtask is defined as a function in the following format:

```
void subtask(W arg)
{
        /* arg is a parameter specified with tkse_sta_tsk()   etc. */

        < subtask code >

        /* task termination */
        tkse_ext_tsk();
}
```

Subtasks enter into dormant state after creation. To run them, use tkse_sta_tsk() call.

Subtasks cannot end in a return.

Subtask Startup

tkse_sta_tsk

C Language Interface

```
ER tkse_sta_tsk(ID id, W arg)
```

Parameter

ID	id	subtask ID
W	arg	subtask start parameter

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_ID	illegal task ID (id is invalid or cannot be used)
E_NOEXS	object does not exist (the task specified in id does not exist)
E_OBJ	illegal object state (the task is not in DORMANT state)

Description

Runs the subtask created by tkse_cre_tsk().

Subtask Creation and Startup

tkse_crs_tsk

C Language Interface

```
ER ercd = tkse_crs_tsk(FP entry, PRI pri, W arg);
```

Parameter

FP	entry	subtask start address
W	pri	subtask priority
W	arg	subtask start parameter

Return Parameter

ER	ercd	＞ 0	normal termination (created subtask ID)
		＜ 0	error code

Error Code

E_MACV	illegal address (entry)
E_LIMIT	subtask count limit exceeded
E_NOMEM	insufficient memory area

Description

Creates and starts a subtask in this process.
Equivalent to tkse_cre_tsk() call except that it enters into executable state after creation.

Exit invoking task

tkse_ext_tsk

C Language Interface

```
void        tkse_ext_tsk(void);
```

Parameter

none

Return Parameter

none

Description

Exit invoking task.

When exiting the main task, process is exited. Therefore, all tasks in the process will be exited.

Terminate Other Task

tkse_ter_tsk

C Language Interface

```
ER ercd = tkse_ter_tsk(ID tskid);
```

Parameter

ID	tskid	target task ID

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_ID	illegal task ID (tskid)

Description

Terminate the specified task.

Only subtasks in invoking process can be specified. Invoking task and the main task cannot be specified.

Task Sleep

tkse_slp_tsk

C Language Interface

```
ER ercd = tkse_slp_tsk(TMO tmout);
```

Parameter

TMO	tmout	timeout period	
		＞ 0	wait for a specific period of time (milliseconds)
		＝ -1	wait for an infinite period of time

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_TMOUT	not woken up although the timeout period has expired
E_DISWAI	waiting suspended because message handler is invoked
E_PAR	illegal parameter (time)

Description

Put this task into sleep state.

When only timeout period specified by “tmout” expires or the task is woken up by another task, the wait state is released.
When the task is interrupted by the message handler, the wait state is released.

Task Wake up

tkse_wup_tsk

C Language Interface

```
ER ercd = tkse_wup_tsk(ID tskid);
```

Parameter

ID	tskid	target task ID

Return Parameter

ER	ercd	error code

Error Code

E_OK	mormal termination
E_ID	illegal task ID (tskid)
E_LIMIT	exceeded the limit of wake-up request queueing

Description

When the task specified by “tskid” is in the sleep state, the wait state is released. When the specified task is not in the sleep state, the wake-up request is queued.

Only tasks in invoking process can be specified. Tasks of other process cannot be woken up. Besides, invoking task cannot be specified.

Cancel Task Wake-up Request

tkse_can_wup

C Language Interface

```
ER ercd = tkse_can_wup(ID tskid);
```

Parameter

ID	tskid	target task ID	
		＞ 0	any task
		＝ 0	invoking task

Return Parameter

E_OK	normal termination
E_ID	illegal task ID (tskid)

Description

Cancel all the wake-up requests queued in the task specified by “tskid”.

Only tasks in invoking process can be specified.

Delay Task

tkse_dly_tsk

C Language Interface

```
ER ercd = tkse_dly_tsk(RELTIM dlytim);
```

Parameter

RELTIM	dlytim	delay time (milliseconds ≧ 0)

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_DISWAI	waiting suspended because message handler is invoked
E_PAR	illegal parameter (time)

Description

Put invoking task into the wait state for specified time duration.

When “dlytim = 0” is specified, the execution is suspended and the task is rescheduled. That is, this changes the task from the execution state to the executable state.
When the task is interrupted by the message handler, the wait state is released.

Get Invoking Task ID

tkse_get_tid

C Language Interface

```
ER ercd = tkse_get_tid();
```

Parameter

none

Return Parameter

ER	ercd	＞ 0	normal termination (invoking task ID)
		＜ 0	error code

Description

Get task ID of invoking task.

Load Load Module

tkse_lod_mod

C Language Interface

```
ER ercd = tkse_lod_mod(T_LMOD *pk_mod, P_DYNLDINF *info);
```

Parameter

T_LMOD *pk_mod	load module information
P_DYNLDINF* info	information concerning loaded object

```
typedef struct {
        ATR     modatr;     /* load module attribute */
        VP      modhdr;     /* handler for a load module */
} T_LMOD;
```

modatr indicates an attribute of the load module and is specified as follows:

modatr := (TMA_SEIO || TMA_LINK || TMA_PTR)

TMA_SEIO	a handle for the load module is a standard input/output file path
TMA_LINK	a handle for the load module is a link to the file of the standard file system
TMA_PTR	a handle for the load module is a pointer to the codes loaded in memory

```
typedef struct {
        VP      loadaddr;   /* load address */
        UW      loadsize;   /* load size */
        FP      entry;      /* entry address */
        UW      info[3];    /* machine-dependent information */
} P_DYNLDINF;
```

Return Parameter

ER	ercd	＞ 0	normal termination (load ID)
		＜ 0	error code

Error Code

E_FACV	no access privileges (E) for the file (when TMA_SEIO, TMA_LINK is specified)
E_MACV	access to address (info, hdr(TMA_PTR)) not allowed
E_BUSY	could not open the file because it is already opened exclusively
E_IO	input/output error occurred
E_NOEXS	no file present
E_NOFS	the file system to which the file belongs is not connected
E_NOMEM	insufficient memory area (insufficient memory area to load)
E_REC	no program record present in the file. Or the content of program record is unusual (when TMA_LINK is specified).

Description

Loads a load module into the local space of this process, and then allocates a load ID to it.

modatr of T_LMOD structure indicates an attribute of the load module.
If TMA_SEIO attribute is specified, the content of the specified file is loaded as a load module. Specify the path name of the standard input/output of the target file for modhdr.
If TMA_LINK the attribute is specified, the content of the first executable program record in the file of the specified standard file system is loaded as load modules. Specify the link (LINK*) to the standard file system file for modhdr.
If TMA_PTR attribute is specified, object code in memory may be loaded as a load module. Specify the pointer of the object codes in memory for modhdr. Note that the format of the object codes in memory and the running methods are implementation-dependent.

If the load is successful, returns information concerning the loaded load module to info.

The load module is loaded (mapped) in memory, but no processing such as a relocation are done. If the same load module as that has been already loaded is also specified, another new memory space is allocated to load it.

Unload Load Module

tkse_unl_mod

C Language Interface

```
ER ercd = tkse_unl_mod(ID loadid);
```

Parameter

ID	loadid	load ID of load module (ID obtained by “tkse_lod_mod()”)

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination

Description

Unload the load module specified by “loaded”. There is no concern whether the load module is in use or not.

Meanwhile, all load modules are automatically unloaded when the process is terminated.

4.3 Interprocess Message Function

4.3.1 Interprocess Message Function Overview

The interprocess messages function of the “Standard Extension” provides the functions to send and receive messages among any processes.
Each process has a specific message queue, and interprocess message communication is executed through this message queue. The destination of the message is specified by the process ID. The source is also discriminated by the process ID of sending process.
This function is also used for sending exit messages of the child process by the system as well as communicating inter-processes message by application.
The interprocess message can be sent to this process as well as other processes. As an example of this type of message, there are timed-out messages.

The message queue is FIFO and messages are always put in the order of sending. When the message queue on the receiving side is full at sending of messages, you can designate a wait until availability of queue or a return on error.

Normally, received messages are stored in the message queue and picked up by the request to receive message. However, definition of message handler allows an asynchronous processing of message when messages of the specified type are received.

4.3.2 Message Type

Messages are classified into 31 types of messages from 1 to 31 according to the type number.
The message type is defined as follows:

```
#define MS_ABORT     ( 1)     /* abort process */
#define MS_EXIT      ( 2)     /* exit process */
#define MS_TERM      ( 3)     /* terminate process */
#define MS_TMOUT     ( 4)     /* timeout */
#define MS_SYSEVT    ( 5)     /* system event (kill) */

#define MS_SYS1      ( 6)     /* used in system */
#define MS_SYS2      ( 7)     /* used in system */
#define MS_SYS3      ( 8)     /* used in system */
#define MS_SYS4      ( 9)     /* used in system */
#define MS_SYS5      (10)     /* used in system */
#define MS_MNG0      (11)     /* reserved */
#define MS_MNG1      (12)     /* reserved */
#define MS_MNG2      (13)     /* reserved */
#define MS_MNG3      (14)     /* reserved */
#define MS_MNG4      (15)     /* reserved */
#define MS_MNG5      (16)     /* reserved */
#define MS_MNG6      (17)     /* reserved */
#define MS_MNG7      (18)     /* reserved */
#define MS_MNG8      (19)     /* reserved */
#define MS_MNG9      (20)     /* reserved */
#define MS_MNG10     (21)     /* reserved */
#define MS_MNG11     (22)     /* reserved */
#define MS_MNG12     (23)     /* reserved */

#define MS_TYPE0     (24)     /* application definition */
#define MS_TYPE1     (25)     /* application definition */
#define MS_TYPE2     (26)     /* application definition */
#define MS_TYPE3     (27)     /* application definition */
#define MS_TYPE4     (28)     /* application definition */
#define MS_TYPE5     (29)     /* application definition */
#define MS_TYPE6     (30)     /* application definition */
#define MS_TYPE7     (31)     /* application definition */


#define MS_MIN       ( 1)     /* minimal message type */
#define MS_MAX       (31)     /* maximal message type */
```

Each message type is associated with a bit ready type mask, and multiple target message types can be specified by using a union (OR) pattern of type masks.

The message type mask is defined as follows:

```
#define MSGMASK(msgtype)          (1 << ((msgtype) - 1))

#define MM_ABORT       MSGMASK(MS_ABORT)     /* abort process        */
#define MM_EXIT        MSGMASK(MS_EXIT)      /* exit process         */
#define MM_TERM        MSGMASK(MS_TERM)      /* terminate process */
#define MM_TMOUT       MSGMASK(MS_TMOUT)     /* timeout */
#define MM_SYSEVT      MSGMASK(MS_SYSEVT)    /* system event (kill) */
#define MM_SYS1        MSGMASK(MS_SYS1)      /* used in system */
#define MM_SYS2        MSGMASK(MS_SYS2)      /* used in system */
#define MM_SYS3        MSGMASK(MS_SYS3)      /* used in system */
#define MM_SYS4        MSGMASK(MS_SYS4)      /* used in system */
#define MM_SYS5        MSGMASK(MS_SYS5)      /* used in system */
#define MM_MNG0        MSGMASK(MS_MNG0)      /* reserved */
#define MM_MNG1        MSGMASK(MS_MNG1)      /* reserved */
#define MM_MNG2        MSGMASK(MS_MNG2)      /* reserved */
#define MM_MNG3        MSGMASK(MS_MNG3)      /* reserved */
#define MM_MNG4        MSGMASK(MS_MNG4)      /* reserved */
#define MM_MNG5        MSGMASK(MS_MNG5)      /* reserved */
#define MM_MNG6        MSGMASK(MS_MNG6)      /* reserved */
#define MM_MNG7        MSGMASK(MS_MNG7)      /* reserved */
#define MM_MNG8        MSGMASK(MS_MNG8)      /* reserved */
#define MM_MNG9        MSGMASK(MS_MNG9)      /* reserved */
#define MM_MNG10       MSGMASK(MS_MNG10)     /* reserved */
#define MM_MNG11       MSGMASK(MS_MNG11)     /* reserved */
#define MM_MNG12       MSGMASK(MS_MNG12)     /* reserved */

#define MM_TYPE0       MSGMASK(MS_TYPE0)     /* application definition */
#define MM_TYPE1       MSGMASK(MS_TYPE1)     /* application definition */
#define MM_TYPE2       MSGMASK(MS_TYPE2)     /* application definition */
#define MM_TYPE3       MSGMASK(MS_TYPE3)     /* application definition */
#define MM_TYPE4       MSGMASK(MS_TYPE4)     /* application definition */
#define MM_TYPE5       MSGMASK(MS_TYPE5)     /* application definition */
#define MM_TYPE6       MSGMASK(MS_TYPE6)     /* application definition */
#define MM_TYPE7       MSGMASK(MS_TYPE7)     /* application definition */

#define MM_ALL         (0x7fffffff)          /* all masks */
```

```
#define MM_NULL        (0)                         /* blank mask */
```

4.3.3 Message Structure

A message has the following structure:

```
typedef struct message {
        W           msg_type;       /* message type */
        W           msg_size;       /* message body size (bytes) */
        MSGBODY msg_body;           /* message body */
} MESSAGE;
```

The structure of the message body (MESSAGE) is determined by “msg_type”.

4.3.4 System Message

The messages with message type number 1-5 are called system messages, and are automatically generated in system. The system messages are essentially not affected by an overflow of message queueing and would not be discarded. Meanwhile, applications are not particularly prohibited to transfer system messages.
Each system message is described as follows:

(1) MS_ABORT -- abort message of the child process
It is automatically sent from child process to parent process when a process is aborted by a system error.
The structure is as follows:

```
W           msg_type :  1   message type = MS_ABORT
W           msg_size :  8   the number of message body bytes
MSGBODY msg_body :      message body
                        struct {
                              ID   pid;      /* process ID of the terminated child process */
                              W    code;     /* system error code */
                        };
```

Where a code is a generated system error code, and is set to zero for an abort with “MH_TERM” message handler.

(2) MS_EXIT -- normal termination message of the child process
It is automatically sent from child process to parent process when a process is normally terminated by the

system call “tkse_ext_prc()”.

The structure is as follows:

```
W          msg_type :  2   message type = MS_EXIT
W          msg_size :  8   the number of message body bytes
MSGBODY msg_body :        message body
                       struct {
                               ID    pid;      /* process ID of the terminated child process */
                               W     code;     /* exit code specified by “tkse_ext_prc()” */
                       };
```

(3) MS_TERM -- termination message of the child process

It is automatically sent from child process to parent process when a process is terminated by the system call “tkse_ter_prc()”.

The structure is as follows:

```
W          msg_type :  3   message type = MS_EXIT
W          msg_size :  8   the number of message body bytes
MSGBODY msg_body :        message body
                       struct {
                               ID    pid;    /* process ID of the terminated child process */
                               W     code;   * exit code specified by “tkse_ter_prc()” */
                       };
```

(4) MS_TMOUT -- timed-out message of invoking process

A time-out message requested by the system call “tkse_req_tmg()”. It is automatically sent to this process after the specified time period.

The structure is as follows:

```
W          msg_type :  4   message type = MS_TMOUT
W          msg_size :  4   the number of message body bytes
MSGBODY msg_body :        message body
                       struct {
                               W     code;   /* code specified by tkse_req_tmg() */
                       };
```

4.3.5 Message Handler

The message handler is a mechanism to process the reception of interprocess messages asynchronously.
The message handler processes the messages asynchronously to the ongoing process when messages of the specified type are received. Therefore, up to 31 types of message handlers corresponding to the respective message types can be simultaneously defined.
The message handlers are executed as follows:

- When a message with the corresponding type is received, the message handler is executed to interrupt the current process in the main task.

- Also when a message is sent in the wait state by some system call, the message handler is invoked, and the main task of the process goes into an execution state. In this case, a system call whose main task is in a long wait state is unconditionally interrupted, and is led to an uncertain result. That is, when message handler is terminated, the interrupted system call returns as “E_DISWAI” error.

- The message handler works as a part of the normal process codes, there is no limit on the executable system calls, etc.

- When the message handler is terminated, the main task is usually resumed from the interrupted point; but, it is possible to move the execution point to any position of the main task (position specified by “setjmp”) using “longjmp ()” directly from the message handler.

- The message handler is not nested. More specifically, a start-up of new message handler (including other message types) waits until the currently processing message handler exits.

- When the message handler is invoked, the message which invoked the message handler is picked up from the message queue, and the pointer is passed as the parameter of a handler.

- The message handler must always exits by “tkse_ret_msg()” system call.

The message handlers are defined as functions with the following form:

```
void msg_hdr(W pid, MESSAGE *r_msg)
{
/*          where “pid” is a sending process ID. (zero for this process) */
/*          “r_msg” is a pointer to the received message. */

            Process of Received Messages
```

```
                    tkse_ret_msg (0);    /* exit (when returning to the interrupted point) */

                    or

                    tkse_ret_msg (1);    /* exit (when moving to any point) */
                    longjmp (reent, code);    /* jump to reent */
        }
```

You can use the following message handlers defined as special message handlers by system:

(1) MH_NONE : Messages are ignored without any processing. In this case, system calls with a wait are exceptionally not interrupted. This is used to simply ignore the specific types of messages entirely without queueing.

(2) MH_BREAK : Messages are ignored without any processing. In this case, system calls with a wait are not interrupted, and “E_DISWAI” error is returned. This is used to process time-outs, etc.

(3) MH_TERM : invoking process are aborted and “MS_ABORT” message (error code = 0) are sent to parent process.

4.3.6 System Calls

Send Message

tkse_snd_msg

C Language Interface

```
ER ercd = tkse_snd_msg(ID pid, MESSAGE* msg, W opt);
```

Parameter

ID	pid	destination process ID	
		＞ 0	any process
		＝ 0	invoking process
		＝-1	parent process
MESSAGE*		msg	sending message
W	opt	specify how to wait for sending (NOWAIT || WAIT || CONFM)	

NOWAIT: not wait for message queue to be free
WAIT　: wait for message queue to be free
CONFM: wait to receive messages

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (msg) not allowed
E_DISWAI	wait processing interrupted because message handler is invoked
E_NOEXS	no process (pid) existent
E_SYSMEM	insufficient system memory area (destination message queue is full (when “NOWAIT” is specified))
E_PAR	illegal parameter (illegal option and illegal message type)
E_ILUSE	invoking process is specified (“pid = 0” or “PID of invoking process”)(when “CONFM” is specified)
E_LIMIT	size of message body exceeded the system limit, or is zero or less

Description

Send messages to the process specified by “pid”.
In the case “NOWAIT” is specified, the task is normally terminated when messages are put in the message queue of the destination process. When the destination message queue is full, an exit by error occurs.
In the case “WAIT” is specified, the task is normally terminated when messages are put in the message queue of the destination process. When the message queue is full, it waits for it to be free. When the destination process is terminated during a waiting, an exit by error occurs.
A message is put in the message queue of the destination process in the case “CONFM” is specified, and then the task is normally terminated when the message sent by the destination process is received or when it is cleared from the message queue. Wait until then. When only header section is obtained by “tkse_rcv_msg()” with the “CHECK” option, the message is not considered to be received. When a message is received with an “NOCLR” option, it is considered to be received even if it remains in the queue. When the destination process is terminated during a waiting, an error exit occurs. When this process is the destination, the “CONFM” option causes an error.

Receive Message

tkse_rcv_msg

C Language Interface

ER ercd = tkse_rcv_msg(W t_mask, MESSAGE* msg, W msgsz, W opt);

Parameter

W	t_mask	message type mask targeted to be received
MESSAGE*	msg	storage area of received message
W	msgsz	byte size of total storage area of received message. "msgsz ≧ 8" is required since message header section is included,.
W	opt	specify the action to receive (WAIT || NOWAIT || WAIEVT) | (CLR || NOCLR) | (CHECK)

WAIT	: wait to receive messages of the specified type
NOWAIT	: not wait for messages of the specified type
WAIEVT	: wait for the messages of the specified type to be received and the event to occur
CLR	: after receiving message, the message is eliminated from the queue
NOCLR	: after receiving message, the message is left in the queue
CHECK	: check whether there are messages or not

Return Parameter

ER	ercd	＞ 0	normal termination (source process ID of received message)
		＝ 0	normal termination (invoking process is the source of received message)
		＜ 0	error code

Error Code

E_MACV	access to inaccessible address (msg) not allowed
E_DISWAI	wait processing interrupted because message handler is invoked
E_TMOUT	no messages of the specified type are existent (t_mask) (When NOWAIT is specified)
E_PAR	illegal parameter ("msgsz" is too small. "t_mask≦0" When non- "WAIEVT" is specified, "t_mask<0" When "WAIEVT" is specified)

Description

Receive the messages of the specified type to invoking process.

When received messages cannot be put in specified area, they are stored in the area of “msg” only within the range of “msgsz” and an error exit occurs. In this case, messages are left in the buffer regardless of the CLR option. However, nothing is stored in the area of “msg” When “msgsz < 8”. When the entire message cannot be stored, the actual message size is determined from the header section of the stored messages. Therefore, this system call will be executed again after preparing sufficient size of area to store the message.

In the case “WAIT” is specified, wait until the arrival of message when the messages of the specified type have not been received.

In the case “NOWAIT” is specified, execute an error exit when the messages of the specified type have not been received.

In the case “WAIEVT” is specified, the basic behavior of the “WAIEVT” is the same as the “WAIT”, but the notification of event occurrence by “tkse_brk_msg()” clears the wait state even if messages have not been received. In this case, an error (E_NOME) exit occurs.
In the case “WAIEVT” is specified, “t_mask = 0” can also be specified. In this case, no message will be received and the task waits until the notification of event occurrence.
Only one “WAIEVT” can be simultaneously specified for tasks over the entire system, When multiple tasks invoke “tkse_rcv_msg()” with the “WAIEVT” option, only the “WAIEVT” of last invoked task is available. Other tasks are processed in the same manner as the “WAIT” option.
“WAIEVT” is premised on using in the upper system (T-Shell, etc). “WAIEVT” usually shall not be specified by applications.

In the case “CLR” is specified, eliminate the messages from the queue after the messages are received.

In the case “NOCLR” is specified, leave the messages in the queue even after the messages are received.

In the case “CHECK” is specified, the behavior is as follows:

1. When no message exists, the “WAIT” or “WAIEVT” puts the task in a wait state, and the “NOWAIT” causes error exit.

2. When messages of the specified type exist, the task is normally terminated after the messages are stored in “msg”. The “CLR” eliminates messages from the queue while the “NOCLR” leaves messages in the queue.

3. When messages of the specified type do not exist and the other types of messages exist, only the top 8 bytes of the messages (msg_type and msg_size) are stored in “msg” and the task is normally terminated. In this case, messages are left in the queue regardless of the “CLR”.

When “CHECK” is specified, since the messages other than the specified typed ones may be obtained, the type of received message should be always checked.

Clear Message

tkse_clr_msg

C Language Interface

ER ercd = tkse_clr_msg (W t_mask, W last_mask);

Parameter

W	t_mask	~~target~~ message type mask targetd to clear
		(all message types in the case “MM_ALL” is specified)
W	last_mask	message type mask for clear exit
		(cleared to the end of the message queue in the case “MM_NULL” is specified)
		(only one message is cleared when “MM_ALL” is specified）

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_PAR	illegal parameter (t_mask≦0, last_mask<0)

Description

Clear the received messages of the specified type to invoking process.

Out of the messages received in the message queue of invoking process, messages of the type specified by "t_mask” shall be cleared to the right before of the message of the type specified by “last_mask”. The messages of the type specified by “last_mask” are not cleared. However, only one message of the “last_mask “type is cleared in the case “last_mask = MM_ALL”. However, only one message of the “last_mask” type is cleared when “last_mask = MM_ALL”.
Examples of specifying “t_mask” and the “last_mask” are shown as follows:

t_mask	last_mask	behavior
MM_ALL	MM_NULL	clear all the received messages
-	MM_ALL	clear only one message specified by “t_mask”
MM_ALL	MM_ALL	clear only the top one message

Request Time-out Message

tkse_req_tmg

C Language Interface

```
ER ercd = tkse_req_tmg (TMO tmout, W code);
```

Parameter

TMO	tmout	time for sending message (milliseconds)
W	code	time-out message code

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_SYSMEM	insufficient system memory area
E_PAR	illegal parameter (time ≦ 0)

Description

Request to send the time-out message (MS_TMOUT) to invoking process after specified time period is passed.

This function is used to monitor the time-out of specific processings in combination with message handler.

Cancel Time-out Message

tkse_can_tmg

C Language Interface

```
ER ercd = tkse_can_tmg();
```

Parameter

none

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination

Description

Cancel all the time-out message requests of invoking process. When there is no timeout message request, nothing shall be done.

The time-out messages that have been already sent and put in the message queue are not cleared.

Notify The Occurrence of Event

tkse_brk_msg

C Language Interface

```
ER ercd = tkse_brk_msg();
```

Parameter

none

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination

Description

Release the wait on “tkse_rcv_msg()” by the “WAIEVT” attribute specification.

In the case “tkse_brk_msg()” is invoked, if no task is put in the wait state by the“WAIEVT” specification, the request to release waiting is recorded. However, the request count to release waiting is not recorded.

Define Message Handler

tkse_def_msg

C Language Interface

```
ER ercd = tkse_def_msg (W t_mask, FUNCP msg_hdr);
```

Parameter

W	t_mask	target message type mask
FUNCP	msg_hdr	message handler start address
	＝ NULL	release message handler definition
	＝ MH_NONE	system definition handler (ignored)
	＝ MH_BREAK	system definition handler (suspended)
	＝ MH_TERM	system definition handler (process exit)

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (msg_hdr) not allowed
E_PAR	illegal parameter (t_mask≦0)

Description

Define a message handler corresponding to the message of a specified type.

When the message handler for a message of the same type is already defined, the last defined message handler is enabled.

Exit Message Handler

tkse_ret_msg

C Language Interface

ER ercd = tkse_ret_msg (W ret)

Parameter

W	ret	return specification
	＝ 0:	resume the execution from the point interrupted by message handler
	≠ 0 :	return from this system call to directly continue executing

Return Parameter

ER	ercd	error code
		(When “ret ＝ 0”) no return
		(When “ret ≠ 0”) =0 succeeded(normal)

Error Code

E_OK	normal termination

Description

Terminate the execution of message handler.
When “ret = 0” is specified, the execution is resumed from the position interrupted by message handler instead of being returned from this system call. When an interruption occurs while executing a system call including a wait, an error code which indicates the invoking (start-up) of message handler is returned from the system call, in stead of ensuring the execution of the system call.
When “ret ≠ 0” is specified, instead of being resumed at the position interrupted by the message handler, the task shall continue the execution after returning from this system. In this case, the control will usually be moved elsewhere by ”longjmp()” at the end of the handler.

This system call must surely be executed at the end of the message handler.
In addition, this system call can be issued only at the message handler. A system error occurs when it is issued at the other area.

When multiple start-up requests are issued by message handlers, the message handler that was requested after the execution of this system call shall be invoked.

4.4 Memory Management Function

4.4.1 Overview of the Memory Management Function

The global name function of the “Standard Extension” provides the functions to create data shared among processes by giving any name and to refer to the data by using the created name.

The global name data is a single 32 bit data (W), and the data can be named with up to 256 characters. Meaningful character codes are usually used as a name without any special restriction, and any data with up to 256 letters (512 bytes) until “TNULL(0)” can be used.

4.4.2 System Calls

Create Global Name Data

tkse_cre_nam

C Language Interface

```
ER ercd = tkse_cre_nam(TC* name, W data, W opt);
```

Parameter

TC*	name	target global name (only top 256 characters (512 bytes) valid)
W	data	data to register
W	opt	specify data creation

(N_CREATE || N_MODIFY || N_FORCE)
| [NA_PROTECT] | [TA_DELEXIT]

N_CREATE	: create new
N_MODIFY	: modification
N_FORCE	: creation and modification
NA_PROTECT	: protect specification against modification and removal
TA_DELEXIT	: auto removal specification

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to address (name) not allowed
E_OBJ	name already present (for N_CREATE)
	name is protected (for N_MODIFY, N_FORCE)
E_NOEXS	no name present (for N_MODIFY)
E_SYSMEM	insufficient system memory area
E_PAR	illegal parameter (illegal opt, blank name)

Description

Creates or modifies global name data specified by the name.

If N_CREATE is specified and the global name data with specified name is not present, then it is created. If the data is already present, an error occurs.
If N_MODIFY is specified and the global name data with specified name is present, then the data is modified. If the data is not present, an error occurs.
If N_FORCE is specified and the global name data with specified name is present, then the data is modified. If the data is already present, an error occurs.

NA_PROTECT as well as N_CREATE may be specified. If NA_PROTECT is specified, processes other than those that created the global name data are prohibited from modifying and removing it. If this or tkse_del_nam() calls is issued from processes other than those that created the global name data to which NA_PROTECT is specified, E_OBJ error occurs. NA_PROTECT specification is valid until the object is removed.

TA_DELEXIT as well as other options can be specified. If TA_DELEXIT is specified, global name data will be removed automatically when the process which created or last modified the data exits. Even if TA_DELEXIT is already specified by other process, the last process which executed this system call by specifying TA_DELEXIT is processed.

Remove Global Name Data

tkse_del_nam

C Language Interface

```
ER ercd = tkse_del_nam(TC* name);
```

Parameter

TC*	name	target global name (only top 256 characters (512 bytes) valid)

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to address (name) not allowed
E_OBJ	name is protected
E_NOEXS	no name present
E_PAR	illegal parameter (blank name)

Description

Removes global name data specified by the name.
If NA_PROTECT is specified during global name data creation and processes other than those that created the global name data try to remove it, E_OBJ error occurs.

Get Global Name Data

tkse_get_nam

C Language Interface

```
ER ercd = tkse_get_nam (TC* name, W* data);
```

Parameter

TC*	name	target global name (only up to the top 256 characters (512 bytes) valid)
W*	data	get data storage area

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (name,data) not allowed
E_NOEXS	no name existent
E_PAR	illegal parameter (blank name)

Description

Get global name data specified by the name.

4.5 Synchronous Intertask Communication Function

4.5.1 Synchronous Intertask Communication Function Overview

The synchronous intertask communication function of the “Standard Extension” provides the followings as a mechanism for synchronization and communication among tasks.

- · semaphore
- · mutex
- Eventflag
- mailbox
- Messagebuffer
- rendezvous

The synchronous intertask communication function is nearly equivalent to the corresponding function in T-Kernel. However, its function is partly limited and not full compatible. In addition, the ID of each object such as semaphore is the one managed in the “Standard Extension”. So the ID is not the same as those used in T-Kernel system calls. However, only for task ID, task ID's of the Standard Extension are the same as those of the T-Kernel.

The following section describes only the differences (restrictions) with T-Kernel system calls. Refer to T-Kernel specifications for details of each system call.

4.5.2 System Calls (Semaphore)

Create Semaphore

tkse_cre_sem

C Language Interface

```
ID semid = tkse_cre_sem ( T_CSEM *pk_csem );
```

Parameter

T_CSEM	*pk_csem	semaphore creation information

```
typedef struct t_csem {
        VP      exinf;      /* extended information */
        ATR     sematr;     /* semaphore attribute */
        INT     isemcnt;    /* semaphore's initial count value */
        INT     maxsem;     /* semaphore's maximum count value */
} T_CSEM;
```

semaphore attribute sematr

sematr:= (TA_TFIFO || TA_TPRI) | (TA_FIRST || TA_CNT) | TA_DELEXIT

TA_TFIFO	manage wait tasks with “FIFO”
TA_TPRI	manage wait tasks with priority order
TA_FIRST	prioritize a task at the top of the queue
TA_DELEXIT	specify auto deletion

Return Parameter

ID	semid	＞ 0	semaphore ID (normal termination)
		＜ 0	error code

Description

Create a semaphore according to “pk_csem”. However, “exinf” is ignored.
In the case the “TA_DELEXIT” attribute is specified, the semaphore is automatically deleted when the process which created the semaphore exits.
Although the other attributes are equivalent to the T-Kernel semaphore, the “TA_NODISWAI” attribute cannot be specified.
The semaphore ID is managed by the T-Kernel Extension and different from the ID used in the T-Kernel native system call.

The created semaphore is available from every process.

Delete Semaphore

tkse_del_sem

C Language Interface

```
ER ercd = tkse_del_sem( ID semid);
```

Parameter

ID	semid	semaphore ID

Return Parameter

ER	ercd	error code

Description

Delete the semaphore specified by “semid”.

Return Semaphore Resource

tkse_sig_sem

C Language Interface

```
ER ercd = tkse_sig_sem ( ID semid, INT cnt );
```

Parameter

ID	semid	semaphore ID
INT	cnt	the number of returned resources

Return Parameter

ER	ercd	error code

Description

Return as many resources as the number of “cnt” to semaphore specified by “semid”.

Get Semaphore Resource

tkse_wai_sem

C Language Interface

```
ER ercd = tkse_wai_sem ( ID semid, INT cnt, TMO tmout );
```

Parameter

ID	semid	semaphore ID
INT	cnt	the number of returned resources
TMO	tmout	time-out period

Return Parameter

ER	ercd	error code

Description

Get as many resources as the number of “cnt” from semaphore specified by “semid”.
When the task is interrupted by the message handler, the wait state is released and “E_DISWAI” is returned.

Refer to Semaphore State

tkse_ref_sem

C Language Interface

```
ER ercd = tkse_ref_sem ( ID semid, T_RSEM *pk_rsem );
```

Parameter

T_RSEM	*pk_rsem	address to which the semaphore state is returned

```
typedef struct t_rsem {
        VP      exinf;      /* extended information */
        ID      wtsk;       /* waiting task ID */
        INT     semcnt;     /* current semaphore count value */
} T_RSEM;
```

Return Parameter

ER	ercd	error code

Description

Refer to the semaphore state specified by “semid”, and return its content to the address indicated by “pk_rsem”. However, “exinf” always returns NULL. NULL is always returned to “exinf”.

4.5.3 System Calls (Mutex)

Create Mutex

tkse_cre_mtx

C Language Interface

```
ID mtxid = tkse_cre_mtx ( T_CMTX *pk_cmtx );
```

Parameter

```
T_CMTX   *pk_cmtx    mutex creation information

         typedef struct t_cmtx {
                 VP        exinf;        /* extended information */
                 ATR       mtxatr;       /* mutex attribute */
                 PRI       ceilpri;      /* mutex's ceiling on priority level*/
         } T_CMTX;

         mutex attribute mtxatr
                 mtxatr := (TA_TFIFO || TA_TPRI) | TA_DELEXIT
                           TA_TFIFO      manage wait tasks with “FIFO”
                           TA_TPRI       manage wait tasks with priority order
                           TA_DELEXIT    specify auto deletion
```

Return Parameter

ID	mtxid	＝ 0	mutex ID (normal termination)
		＜ 0	error code

Description

Create the mutex according to “pk_cmtx”. However, “exinf” and “ceilpri” are ignored.
When the “TA_DELEXIT” attribute is specified, the mutex is automatically deleted when the process which created the mutex exits.
Although other attributes are equivalent to the T-Kernel mutex, the “TA_NODISWAI” attribute, “TA_INHERIT” attribute, and the “TA_CEILING” attribute cannot be specified.
The mutex ID is managed by the “T-Kernel Extension” and different from the ID used in the T-Kernel native system call.
The created mutex is available from every process.

Delete Mutex

tkse_del_mtx

C Language Interface

```
ER ercd = tkse_del_mtx (ID mtxid)
```

Parameter

ID	mtxid	mutex ID

Return Parameter

ER	ercd	error code

Description

Delete the mutex specified by “mtxid”.

Lock Mutex

tkse_loc_mtx

C Language Interface

```
ER ercd = tkse_loc_mtx ( ID mtxid, TMO tmout );
```

Parameter

ID	mtxid	mutex ID
TMO	tmout	time-out period

Return Parameter

ER	ercd	error code

Description

Lock the mutex specified by “mtxid”.
When the task is interrupted by the message handler, the wait state is released and “E_DISWAI” is returned.

Unlock Mutex

tkse_unl_mtx

C Language Interface

```
ER ercd = tkse_unl_mtx ( ID mtxid );
```

Parameter

ID	mtxid	mutex ID

Return Parameter

ER	ercd	error code

Description

Unlock the mutex specified by “mtxid”.

Refer to Mutex State

tkse_ref_mtx

C Language Interface

```
ER ercd = tkse_ref_mtx ( ID mtxid, T_RMTX *pk_rmtx );
```

Parameter

ID	mtxid	mutex ID
T_RMTX	*pk_rmtx	the address to which the mutex state is returned

```
typedef struct t_rmtx {
        VP      exinf;      /* extended information */
        ID      htsk;       /* locked task ID */
        ID      wtsk;       /* lock wait task ID */
} T_RMTX;
```

Return Parameter

ER	ercd	error code

Description

Refer to the mutex state specified by “mtxid”, and return its content to the address indicated by “pk_rmtx”. However, NULL is always returned to “exinf”.

4.5.4 System Calls (Eventflag)

Create Eventflag

tkse_cre_flg

C Language Interface

```
ID flgid = tkse_cre_flg ( T_CFLG *pk_cflg )
```

Parameter

T_CFLG	*pk_cflg	eventflag create information

```
typedef struct t_cflg {
        VP      exinf;      /* extended information */
        ATR     flgatr;     /* eventflag attribute */
        UINT    iflgptn;    /* eventflag initial value */
} T_CFLG;
```

eventflag attribute flgatr

flgatr:= (TA_TFIFO || TA_TPRI) | (TA_WMUL || TA_WSGL) | TA_DELEXIT

TA_TFIFO	manage wait tasks with “FIFO”
TA_TPRI	manage wait tasks with priority order
TA_WSGL	disallow a wait on multiple tasks
TA_WMUL	allow a wait on multiple tasks
TA_DELEXIT	specify auto deletion

Return Parameter

ID	flgid	＞ 0	eventflag ID (normal termination)
		＜ 0	error code

Description

Create an eventflag according to “pk_cflg”. However, “exinf” is ignored.
In the case the “TA_DELEXIT” attribute is specified, the eventflag is automatically deleted when the process which created the eventflag exits.
Although the other attributes are equivalent to the T-Kernel eventflag, the “TA_NODISWAI” attribute cannot be specified.
The event flag ID is managed by the “T-Kernel Extension” and different from the ID used in the T-Kernel native system call.
The created eventflag is available from every process.

Delete Eventflag

tkse_del_flg

C Language Interface

```
ER ercd = tkse_del_flg ( ID flgid );
```

Parameter

ID	flgid	eventflag ID

Return Parameter

ER	ercd	error code

Description

Delete the eventflag specified by “flgid”.

Set Eventflag

tkse_set_flg

C Language Interface

```
ER ercd = tkse_set_flg ( ID flgid, UINT setptn );
```

Parameter

ID	flgid	eventflag ID
UINT	setptn	bit pattern to be set

Return Parameter

ER	ercd	error code

Description

Set the pattern of “setptn” to the eventflag specified by “flgid”.

Clear Eventflag

tkse_clr_flg

C Language Interface

```
ER ercd = tkse_clr_flg ( ID flgid, UINT clrptn );
```

Parameter

ID	flgid	eventflag ID
UINT	clrptn	bit pattern to be cleared

Return Parameter

ER	ercd	error code

Description

The eventflag specified by “flgid” shall be cleared with the pattern of “clrptn”.

Wait Eventflag

tkse_wai_flg

C Language Interface

```
ER ercd = tkse_wai_flg ( ID flgid, UINT waiptn, UINT wfmode, UINT *p_flgptn, TMO tmout );
```

Parameter

ID	flgid	eventflag ID
UINT	waiptn	wait bit pattern
UINT	wfmode	wait mode
	TWF_ANDW	AND wait
	TWF_ORW	OR wait
	TWF_CLR	specify to clear all
	TWF_BITCLR	specify to clear conditional bit only
UINT	*p_flgptn	the address to which bit pattern is returned when a wait is cleared
TMO	tmout	time-out period

Return Parameter

ER	ercd	error code

Description

Wait until the bit specified by “waiptn” is set to the eventflag specified by “flgid” in the wait condition specified by “wfmode”.
When the task is interrupted by the message handler, the wait state is released and “E_DISWAI” is returned.

Refer to Eventflag State

tkse_ref_flg

C Language Interface

```
ER ercd = tkse_ref_flg ( ID flgid, T_RFLG *pk_rflg );
```

Parameter

T_RFLG	*pk_rflg	the address to which the eventflag state is returned

```
typedef struct t_rflg {
        VP      exinf;      /* extended information */
        ID      wtsk;       /* waiting task ID */
        UINT    flgptn;     /* current eventflag pattern */
} T_RFLG;
```

Return Parameter

ER	ercd	error code

Description

Refer to the semaphore state specified by “flgid” and return its content to the address indicated by “pk_rflg”. However, NULL is always returned to “exinf”.

4.5.5 System Calls (Mailbox)

Create Mailbox

tkse_cre_mbx

C Language Interface

```
ID mbxid = tkse_cre_mbx( T_CMBX *pk_cmbx );
```

Parameter

T_CMBX* pk_cmbx   mailbox creation information

```
typedef struct t_cmbx {
        VP          exinf;          /* extended information */
        ATR         mbxatr;         /* mailbox attribute */
} T_CMBX;
```

mailbox attribute mbxatr

mbxatr:= (TA_TFIFO || TA_TPRI) | (TA_MFIFO || TA_MPRI)

TA_TFIFO	queueing of waiting tasks is in FIFO
TA_TPRI	queueing of waiting tasks is in priority order
TA_MFIFO	queueing of messages is in FIFO
TA_MPRI	queueing of messages is in priority order

Return Parameter

ID	mbxid	＞ 0	mailbox ID (normal termination)
		＜ 0	error code

Description

Creates the mailbox according to pk_cmbx. However, exinf is ignored.
The attribute specification is equivalent to T-Kernel mailbox, but TA_NODISWAI attribute cannot be specified. Also, if TA_DELEXIT attribute is specified, it will be ignored.
The mailbox ID is managed by the T-Kernel Extension and is different from the ID used in the T-Kernel native system call.

Since the pointer to the data is passed, the mailbox is only available within the process which created the mailbox. It is not available in communications between different processes.

Therefore, if the process which created the mailbox exits, the mailbox will be automatically removed with or without TA_DELEXIT attribute specification.

Remove Mailbox

tkse_del_mbx

C Language Interface

```
ER ercd = tkse_del_mbx ( ID mbxid ) ;
```

Parameter

ID	mbxid	mailbox ID

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error code

Description

Removes the mailbox denoted by mbxid.
If processes other than the process which created the mailbox try to remove the mailbox, an error occurs.

Send to Mailbox

tkse_snd_mbx

C Language Interface

```
ER ercd = tkse_snd_mbx ( ID mbxid, T_MSG *pk_msg );
```

Parameter

ID	mbxid	mailbox ID
T_MSG*	pk_msg	start address of message packet

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error code

Description

Sends the message packet whose start address is pk_msg to the target mailbox denoted by mbxid.
The content of message packet is not copied and only start address (pk_msg value) is passed on receiving.

If processes other than the process which created the mailbox try to send to the mailbox, an error occurs.

Receive from Mailbox

tkse_rcv_mbx

C Language Interface

```
ER ercd = tkse_rcv_mbx ( ID mbxid, T_MSG **ppk_msg, TMO tmout ) ;
```

Parameter

ID	mbxid	mailbox ID
TMO	tmout	timeout specification

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error code
T_MSG*	pk_msg	start address of message packet	

Description

Receives a message from the mailbox denoted by mbxid.

If processes other than the process which created the mailbox try to receive from the mailbox, an error occurs.

Refer to Mailbox State

tkse_ref_mbx

C Language Interface

```
ER tkse_ref_mbx ( ID mbxid, T_RMBX *pk_rmbx ) ;
```

Parameter

ID mbxid	mailbox ID
T_RMBX* pk_rmbx	packet address to which the mailbox state is returned

```
typedef struct t_rmbx {
        VP exinf;            /* extended information */
        ID wtsk;             /* presence of waiting task */
        T_MSG* pk_msg;       /* start address of the next message packet to be received */
} T_RMBX;
```

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error code

Description

Refers to the mailbox state specified by semid and returns its content to the address denoted by pk_rmbx. However, exinf always returns NULL.

4.5.6 System Calls (Messagebuffer)

Create Messagebuffer

tkse_cre_mbf

C Language Interface

```
ID mbfid = tkse_cre_mbf ( T_CMBF *pk_cmbf );
```

Parameter

```
T_CMBF  *pk_cmbf                messagebuffer create information
        typedef struct t_cmbf {
                VP          exinf;      /* extended information */
                ATR         mbfatr;     /* messagebuffer attribute */
                INT         bufsz;      /* message buffer size (bytes) */
                INT         maxmsz;     /* maximum length of message (bytes) */
        } T_CMBF;

        message buffer attribute mbfatr
                mbfatr := (TA_TFIFO || TA_TPRI) | TA_DELEXIT
                            TA_TFIFO    manage wait tasks with "FIFO"
                            TA_TPRI     manage wait tasks with priority order
                            TA_DELEXIT  specify auto deletion
```

Return Parameter

ID	mbfid	＞ 0	messagebuffer ID (normal termination)
		＜ 0	error code

Description

Create message buffer according to “pk_cmbf”. However, “exinf” is ignored.
When the “TA_DELEXIT” attribute is specified, the message buffer is automatically deleted when the process which created the message buffer exits.
Although the other attributes are equivalent to the T-Kernel message buffer, the “TA_NODISWAI” attribute cannot be specified.
The message buffer ID is managed by the “T-Kernel Extension” and different from the ID used in the T-Kernel native system call.
The created message buffer is available from every process.

Delete Messagebuffer

tkse_del_mbf

C Language Interface

```
ER ercd = tkse_del_mbf ( ID mbfid );
```

Parameter

ID	mbfid	message buffer ID

Return Parameter

ER	ercd	error code

Description

Delete the message buffer specified by “mbfid”.

Send to Messagebuffer

tkse_snd_mbf

C Language Interface

```
ER ercd = tkse_snd_mbf ( ID mbfid, VP msg, INT msgsz, TMO tmout );
```

Parameter

ID	mbfid	message buffer
VP	msg	start address of a sending data
INT	msgsz	size of a sending data (bytes)
TMO	tmout	timeout period

Return Parameter

ER	ercd	error code

Description

Send data specified by “msg” and “msgsz” to the message buffer specified by “mbfid”.
When the task is interrupted by the message handler, the wait state is released and “E_DISWAI” is returned.

Receive from Messagebuffer

tkse_rcv_mbf

C Language Interface

```
INT msgsz = tkse_rcv_mbf ( ID mbfid, VP msg, TMO tmout );
```

Parameter

ID	mbfid	message buffer
VP	msg	start address to store received data
TMO	tmout	time-out period

Return Parameter

INT	msgsz	＞ 0	size of receiving data (bytes)
		＜ 0	error code

Description

Receive data from the message buffer specified by “mbfid” to store in “msg”.
When the task is interrupted by the message handler, the wait state is released and “E_DISWAI” is returned.

Refer to Message Buffer State

tkse_ref_mbf

C Language Interface

```
ER ercd = tkse_ref_mbf ( ID mbfid, T_RMBF *pk_rmbf );
```

Parameter

ID	mbfid	message buffer
T_RMBF	*pk_rmbf	message buffer state information

```
typedef struct t_rmbf {
        VP      exinf;      /* extended information */
        ID      wtsk;       /* receive wait task ID ID of the task waiting to be received*/
        ID      stsk;       /* send wait task ID ID of the task waiting to be sent*/
        INT     msgsz;      /* size of the next message to be received (bytes) */
        INT     frbufsz;    /* free buffer size (bytes) */
        INT     maxmsz;     /* maximum length of message (bytes) */
} T_RMBF;
```

Return Parameter

ER	ercd	error code

Description

Refer to the message buffer state specified by “mbfid” and return its content to the address indicated by “pk_rmbf”. However, NULL is always returned to “exinf”.

4.5.7 System Calls (Rendezvous Port)

Create Rendezvous Port

tkse_cre_por

C Language Interface

```
ID porid = tkse_cre_por ( T_CPOR *pk_cpor );
```

Parameter

```
T_CPOR  *pk_cpor    rendezvous port create information

        typedef struct t_cpor {
                VP          exinf;          /* extended information */
                ATR         poratr;         /* port attribute */
                INT         maxcmsz;        /* maximum length of call out message (bytes) */
                INT         maxrmsz;        /* maximum length of response message (bytes) */
        } T_CPOR;

        rendezvous port attribute poratr
                poratr:= (TA_TFIFO || TA_TPRI) | TA_DELEXIT
                            TA_TFIFO      manage wait tasks with FIFO
                            TA_TPRI       manage wait tasks with priority order
                            TA_DELEXIT    auto removal specification
```

Return Parameter

ID	porid	＞ 0	rendezvous ID (normal termination)
		＜ 0	error code

Description

Create rendezvous port according to “pk_cpor”. However, “exinf” is ignored.
When the “TA_DELEXIT” attribute is specified, the rendezvous port is automatically deleted when the process which created the rendezvous port exits.
Although the other attributes are equivalent to the T-Kernel eventflag, the “TA_NODISWAI” attribute cannot be specified.
The rendezvous port ID is the one managed by the T-Kernel Extension and different from the ID used in the T-Kernel native system call.
The created rendezvous port is available from every process.

Delete Rendezvous Port

tkse_del_por

C Language Interface

```
ER ercd = tkse_del_por ( ID porid );
```

Parameter

ID	porid	rendezvous port ID

Return Parameter

ER	ercd	error code

Description

Delete the rendezvous port specified by “porid”

Call Rendezvous

tkse_cal_por

C Language Interface

```
INT rmsgsz = tkse_cal_por ( ID porid, UINT calptn, VP msg, INT cmsgsz, TMO tmout );
```

Parameter

ID	porid	rendezvous port ID
UINT	calptn	bit pattern to designate selection condition
VP	msg	start address of message
INT	cmsgsz	size of calling message (bytes)
TMO	tmout	time-out period

Return Parameter

INT	rmsgsz	＞ 0	size of response message (the number of bytes)
		＜ 0	error code

Description

Call the rendezvous for the rendezvous port specified by “porid”.
When the task is interrupted by the message handler, the wait state is released and “E_DISWAI” is returned.

Accept Rendezvous

tkse_acp_por

C Language Interface

INT cmsgsz = tkse_acp_por (ID porid, UINT acpptn, RNO *p_rdvno, VP msg, TMO tmout);

Parameter

ID	porid	rendezvous port ID
UINT	acpptn	bit pattern to designate selection condition
INT	*p_rdvno	the address to which the rendezvous number is returned
VP	msg	start address of message
TMO	tmout	time-out period

Return Parameter

INT	cmsgsz	＞ 0	size of calling message (bytes)
		＜ 0	error code

Description

Accept the rendezvous for the rendezvous port specified by “porid”.
When the task is interrupted by the message handler, the wait state is released and “E_DISWAI” is returned.

Forward Rendezvous

tkse_fwd_por

C Language Interface

```
ER ercd = tkse_fwd_por ( ID porid, UINT calptn, RNO rdvno, VP msg, INT cmsgsz );
```

Parameter

ID	porid	rendezvous port ID
UINT	calptn	bit pattern to designate selection condition
INT	rdvno	rendezvous number before forwarding
VP	msg	start address of message
INT	cmsgsz	calling message size (bytes)

Return Parameter

ER	ercd	error code

Description

Forward the accepted rendezvous to another rendezvous port.

Reply to Rendezvous

tkse_rpl_rdv

C Language Interface

```
ER ercd = tkse_rpl_rdv ( RNO rdvno, VP msg, INT rmsgsz );
```

Parameter

INT	rdvno	rendezvous number
VP	msg	start address of response reply message
INT	rmsgsz	size of reply message size (the number of bytes)

Return Parameter

ER	ercd	error code

Description

Return rendezvous response reply to exit rendezvous.

Refer to Rendezvous Port State

tkse_ref_por

C Language Interface

```
ER ercd = tkse_ref_por ( ID porid, T_RPOR *pk_rpor );
```

Parameter

ID	porid	rendezvous port ID
T_RPOR	*pk_rpor	rendezvous port state information

```
typedef struct t_rpor {
        VP      exinf;      /* extended information */
        ID      wtsk;       /* call wait task ID */
        ID      atsk;       /* accept wait task ID */
        INT     maxcmsz;    /* maximum length of call out message (bytes) */
        INT     maxrmsz;    /* maximum length of response message (bytes) */
} T_RPOR;
```

Return Parameter

ER	ercd	error code

Description

Refer to the message buffer state specified by “porid” and returns its content to the address indicated by “pk_rpor”. However, NULL is always returned to “exinf”.

4.6 Standard Input/Output Function

4.6.1 Standard Input/Output Function Overview

Standard input/output mainly provides functions related to file input/output. It also enables you to operate files, preferably without being aware of the differences of different file systems.

Currently, supported system calls are as follows (see "6.6 System Calls" for details):

ER tkse_attach(const TC *devnm, const char *connm, int mode)	file system connection
ER tkse_detach(const TC *devnm, int eject)	file system disconnection
ER tkse_open(const char *path, int oflag, mode_t mode)	open file system
ER tkse_close(int fildes)	close file system
ER tkse_lseek(int fildes, off_t offset, int whence)	move the current position of a file/directory
ER tkse_read(int fildes, void *buf, size_t nbyte)	read file
ER tkse_write(int fildes, const void *buf, size_t nbyte)	write file
ER tkse_getdents(int fildes, struct dirent *buf, size_t nbyte)	fetch directory entry
ER tkse_stat(const char *path, struct stat *sb)	retrieval of file information 1
ER tkse_lstat(const char *path, struct stat *sb)	retrieval of file information 2
ER tkse_fstat(inf fildes, struct stat *sb)	retrieval of file information 3
ER tkse_rename(const char *from, const char *to)	rename file
ER tkse_unlink(const char *path)	remove directory entry
ER tkse_mkdir(const char *path, mode_t mode)	directory creation
ER tkse_rmdir(const char *path)	directory removal
ER tkse_dup(int oldd)	file descriptor replication 1
ER　tkse_dup2(int oldd, int newd)	file descriptor replication 2
ER tkse_fsync(int fildes)	file's disk cache content and disk synchronization
ER tkse_chdir(const char *path)	modify current directory 1
ER tkse_fchdir(int fildes)	modify current directory 2
ER tkse_chmod(const char *path, mode_t mode)	modify file mode 1
ER tkse_fchmod(int fildes, mode_t mode)	modify file mode 2
ER tkse_creat(const char *path, mode_t mode)	file creation
ER tkse_utimes(const char *path, const struct timeval times[2])	modify access time, modification time
ER tkse_umask(mode_t cmask)	set file creation mask
ER tkse_truncate(const char *path, off_t length)	set file size to the specified length 1
ER tkse_ftruncate(int fildes, off_t length)	set file size to the specified length 2
ER tkse_sync(void)	disk cache content and disk synchronization
ER tkse_getfsstat(struct statfs *buf, W bufsize, int flags)	retrieve a list of file systems
ER tkse_getlink(const char *path, char *buf)	retrieve a LINK to standard file

4.6.2 Target File System

The following file systems are targeted:

(1) T-Kernel Standard File System

Files and directories are not distinguished in the standard file system. On the standard input/output, they are classified as either a file or a directory according to the following conditions:

- directory
  Files which include link records.
  Indicates this directory and parent directories whose file type (file's application type) are 6 (cabinet pictogram)

- file
  Files other than directory.
  The file's destination is one leading record only whose record type is 31. The target record is fixed when tkse_open or tkse_write is called first time after file creation, and remains the same until tkse_close is called.

(2) FAT File System

Accommodates FAT12, FAT16, FAT32 file system. Accommodates VFAT long file name.
Accommodates disks without partition information such as floppy disks.
For disks with partition information such as hard disks, only primary partitions are accommodated.

(3) CD-ROM File System

Accommodates ISO 9660 Level 1 file system. Read only and unable to write.

4.6.3 File Access

(1) attach/detach file system
First, in order to access the file system on the device using STDIO, it is necessary to attach the file system(tkse_attach). The name of the file system specified at this time is called the "connection name".
To cancel connection, it is necessary to detach the file system(tkse_detach).

(2) open/close file
Writing and reading of the file become possible by opening of the file after file system connection. Success of opening of the file will assign a new file descriptor. File descriptor is the identifier with zero or more integral values, and performs the file operation using this identifier. By closing of the file, the file descriptor becomes invalid.
The file descriptor is effective only within the process which opened the applicable file. File operation cannot be

performed using the file descriptor which other processes opened. All the files that the process opened are closed by the process termination.
A directory can also obtain the file descriptor by opening/closing.

4.6.4 Initial State of File Discriptor

The following file descriptors will be automatically opened at process startup:

STDIN_FILENO	0	standard Input
STDOUT_FILENO	1	standard output
STDERR_FILENO	2	standard error output

These are all console I/Os assigned to the invoked process.
There are the following restrictions:

- File descriptors cannot be copied from the parent process.
- The above file descriptors 0, 1, 2 cannot be closed.

4.6.5 Disk Cache

y using the disk cache, writing and reading can be performed efficiently.
The data of the disk cache can be made to reflect in the file on a device by performing Close of the file, or the synchronization (tkse_sync, tkse_fsync) of the disk cache.

4.6.6 File Name

Directories and files cannot have the names which Japanese EUC cannot describe. Note that directories and files with such names cannot be created.
If there exist directories and files which have the names which Japanese EUC cannot describe, the results of retrieving the names are uncertain.

The maximum length of each file name may differ according to target file systems, any portion that exceeds the maximum length in each file system will be ignored.

- When referring a file:
  The matching file name is found after any part greater than the maximum length is ignored.

- When creating a file:
  The file is created with the name after any part greater than the maximum length is truncated.

• retrieval of file name
The file name is retrieved after any part greater than the maximum length is truncated.

[Unique specification of T-Kernel Standard File System]

(1) Conversion to TRON code
In conversion from Japanese EUC to TRON code, single-byte characters are converted to corresponding double-byte characters (JIS level-1).
The conversion from TRON code to Japanese EUC is the reverse, and if there exist corresponding single-byte characters, they are converted to single-byte characters. However, two characters "/" and ":" are not converted to single-byte characters to distinguish path name and a delimiter representing the order in which it appears.
For example, file name string "Example1" is retrieved from
the file called "Example1". When specifying this file, since either "Example1" or "Example1" is converted to "Example1", the same file will be specified.
In file names such as "Manuscript paper/E1", "/" is treated as a delimiter of path names, so the file called "Manuscript paper/E1" may not be specified. In this cases, the file may be specified by specifying "Manuscript paper/E1".

(2) Maximum filename length
File names up to 20 characters are allowed in the T-Kernel standard file system, but the maximum number of file names consisting of ASCII characters only will be extended to 34 characters by employing special encoding of file names.
Only if a file name is greater than 20 characters and it consists of ASCII characters (but characters only in the range 0x20-0x7e), the following special encoding will apply.
Besides this, a file name is only converted from Japanese EUC to TRON code.

• Special encoding
Each character used in file names in the T-Kernel standard file system is encoded with two bytes (TC type = TRON code). Leading three characters of this file name consisting of two bytes/character are assumed to be a start mark of special encoding, 34 bytes of the remaining 17 characters make up a file name encoded with one byte/character.

• Start mark of special encoding
TK_U(0x2355), TK_X(0x2358), 0xA121

• File name encoding
ASCII codes (0x20-0x7e) are converted to 0x80-0xde and two characters each are packed and converted to TC type (two bytes/character format).

```
((c1 + 0x60) << 8) | (c2 + 0x60) -> TC type
```

c1: odd number character
c2: even number character

If the number of characters of a file name is odd, last one character will not be packed and be assumed to be a normal TRON code (TC type).

* 0xA121 corresponds to 1-1 code of JIS X 0212 (supplemental kanji set). This is undefined in JIS code and is usually not used.
* After packing, they are either undefined characters in D zone of TRON code or characters corresponding to KSC5601 (Korean).

4.6.7 Path Name

The path names which indicate files are in the following format:

/connection name/directory name/file name

Example: "/CD/DIR_1/FILE.EXT"

The character code is Japanese EUC. The delimiter codes "/", "." may be single-byte characters (ASCII).
In T-Kernel standard file system, specification in the order it appears such as ":1" is available.

Example: "/SYS/DIR:1/FILE.EXT:2"
":" and numerals may be single-byte characters (ASCII).

* If all characters after ":" are numerals, the order they appear is specified. And, to find a file which already exists, use the file name with the order in which it appears, and to create a new file, use the file name without the order it appears.
For example, to create a file called "NEW_FILE:3", find NEW_FILE with the order in which it appears as "3". If it does not exist, create a file called "NEW_FILE".

* Since current directory function is not implemented, full path name should always be specified.

4.6.8 Root Directory

Root directory is a virtual read-only directory, and its subdirectories may include all the connected file systems. For root directory, you can open and close the directory, fetch the directory entry, and retrieve directory information. You can also move current directory to root directory.
If root directory is specified in other system calls, an error occurs.

4.6.9 Current Directory

A process retains each current directory and enables you to use relative path name.
Initial process's initial state of the current directory is root directory "/", and a child process inherits parent's current directory.

4.6.10 This Directory "." and Parent Directory ".."

This directory "." and parent directory ".." are allowed to use as a path name in all directories of all file systems.
There exists neither "." nor ".." in standard file system, but they are allowed to use as virtual files.
In addition, ".." in the root directory of each file system points the system's root directory, and "." and ".." in the system's root directory point the root directory itself.

4.6.11 Error Code

In libraries which the leverage standard input/output system calls, the following error codes are set to a variable errno when an error occurs:

```
#include <errno.h>
```

EFAULT	illegal address
EINVAL	illegal parameter
ENOMEM	insufficient memory
EEXIST	already present
EMFILE	maximum open files exceeded
ESRCH	no process
EINTR	interrupted by a system call
EBADF	illegal file descriptor
EACCES	no access privileges
EPERM	processing not allowed
EROFS	unwritable file system
EXDEV	not the same file system
ENOENT	no file or directory
ENOSPC	insufficient disk space
ENODEV	processing on device not allowed
EIO	input/output error
EDEADLK	abnormal lock
EBUSY	busy
＜ 0	other error

4.6.12 System Calls

Attach file system

tkse_attach

C Language Interface

```
ER ercd = tkse_attach( const TC *devnm, const char *connm, int mode );
```

Parameter

const TC	*devnm	device name
const char	*connm	device connection name
int	mode	connection mode

mode := (SF_STDFS || SF_FATFS || SF_CDROM) | [SF_RONLY]

SF_RONLY	0x0001	read only
SF_STDFS	0x0000	T-Kernel Standard File system
SF_FATFS	0x0100	FAT File system
SF_CDROM	0x0200	CD-ROM File system

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Connect the device qualified with the device name “devnm” with the connection name “connm” and the connected mode “mode”.

The connection name is up to 16 bytes (except character-string terminal '¥0'). However, it is up to 8 characters (up to 8 bytes for single-byte characters only, up to 16 bytes for double-byte characters only) for the T-Kernel standard file system.

Detach file system

tkse_detach

C Language Interface

```
ER tkse_detach( const TC *devnm, int eject );
```

Parameter

const TC	*devnm		device name
int	eject		media eject setting
	eject =	0	eject no media
		1	eject media
		others	undefined (cannot be designated)

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Detach the device with device name “devnm”.

Open File/Directory

tkse_open

C Language Interface

ER ercd = tkse_open(const char *path, int oflag, mode_t mode);

Parameter

const char	*path	file path to open
int	oflag	open mode of file/directory
mode_t	mode	mode when “O_CREAT” is specified

Return Parameter

ER	ercd	≧ 0	file descriptor
		＜ 0	error

Description

Open the file/directory specified by the path name “path” in the open mode “oflag”.
If successful, file descriptor (≧0) is returned as a return parameter.
The file descriptor is the minimum among the all unused numbers.

oflag := (O_RDONLY || O_WRONLY || O_RDWR) | [O_CREAT | [O_EXCL]] | [O_TRUNC] | [O_APPEND]

“oflag” can be one of the following:

O_RDONLY	0x0000	ead only
O_WRONLY	0x0001	write only
O_RDWR	0x0002	read/write

Optionally, “oflag” can also be OR of the above and the following:

O_CREAT	0x0200	Create the file if there is not a file
O_TRUNC	0x0400	Delete file content
O_EXCL	0x0800	An error occurs if there is a file
O_APPEND	0x0008	Constantly appended at the end

O_CREAT	Create the file if there is not a file. If the file already exists, the flag has no effect. Create a file in the mode specified by “mode”.
O_EXCL	Specify this along with “O_CREAT”. If the file already exists, an error occurs. Ignore if O_CREAT is not specified.
O_TRUNC	Discard file content and set file size to zero. Ignored if set to directory. Ignored in the case of read-only open (“O_RDONLY” specification).
O_APPEND	Constantly appended at the end of file when writing to the file. At this point, the current position is moved to the end. Same as moving to the end of file by using “tkse_lseek” just before “tkse_write”.

“mode” should be specified only when “O_CREAT” is specified.
Specify the “mode” by taking the union of the followings with OR:

S_IRWXU 00700	owner RWX mask
S_IRUSR 00400	owner R read permission
S_IWUSR 00200	owner W write permission
S_IXUSR 00100	owner X execute permission
S_IRWXG 00070	group RWX mask
S_IRGRP 00040	group R read permission
S_IWGRP 00020	group W write permission
S_IXGRP 00010	group X execute permission
S_IRWXO 00007	other RWX mask
S_IROTH 00004	other R read permission
S_IWOTH 00002	other W write permission
S_IXOTH 00001	other X execute permission
S_ISUID 04000	run time user ID setting
S_ISGID 02000	run time group ID setting
S_ISVTX 01000	sticky bit

These “mode” specifications have different scopes according to the target file systems. Invalid specifications will be ignored in the target file system.
In addition, the mask with “umask” will not be executed since the “umask” function is not currently implemented.

• T-Kernel Standard File system

The file type determined at “tkse_open()” time remains unchanged until the execution of “tkse_close()”. For example, when the file including link record is opened at “tkse_open()” as a directory, its file type is held as a directory even if link record is entirely deleted by other processes until the execution of “tkse_close()”

Set the file access attributes to read-only when read-only permission is given to its owner, group, and the others. In other cases, write permission is given.

The file access mode is always set to default.

• FAT File system

The read-only attribute is set when read-only permission is given to the owner, group, and others. In other cases, write permission is given.

Close file / directory

tkse_close

C Language Interface

```
ER ercd = tkse_close( int fildes );
```

Parameter

int	fildes	file descriptor

Return Parameter

ER	ercd	＝ 0	normal termination
		＜ 0	

Description

Close the file/directory specified by the file descriptor “fildes”.

When “fd” is the last simultaneous write open file descriptors, the disk cache is synchronized with the disk for the file to close.

Move the current position of a file/directory

tkse_lseek

C Language Interface

```
ER ercd = tkse_lseek( int fildes, off_t offset, int whence );
```

Parameter

int	fildes	file descriptor
off_t	offset	offset from the specified position
int		specify to start whence

whence := (SEEK_SET || SEEK_CUR || SEEK_END)

SEEK_SET 0	move to the “offset” position
SEEK_CUR 1	move to the current position + offset
SEEK_END 2	move to the end + offset

Return Parameter

ER	ercd	＝ 0	normal termination
		＜ 0	error

Description

Move the current position (position in bytes) of the file/directory specified by the file descriptor “fildes”.
When “fildes” designates a directory, “tkse_lseek” should not be used for purposes other than those of setting the current position to zero.

Read file

tkse_read

C Language Interface

```
ER ercd = tkse_read ( int fildes, void *buf, size_t nbyte );
```

Parameter

int	fildes	file descriptor
void	*buf	read buffer
size_t	nbyte	read size (in bytes)

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Read “nbyte” bytes from the current position of the file specified by the file descriptor “fildes” to “buf”. Advance the file's current position for the number of read bytes.
The return parameter zero designates the end of file. When an error occurred during reading, the file's current position is unchanged.

Write file

tkse_write

C Language Interface

ER ercd = tkse_write(int fildes, const void *buf, size_t nbyte);

Parameter

const int	fildes	file descriptor
void	*buf	write-buffer
size_t	nbyte	write size (bytes)

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Write “buf” from the current position of the file specified by the file descriptor “fildes” to “nbyte” bytes. Advance the file's current position for the number of written bytes.

The return parameter zero indicates the end of file.

When an error occurres during writing, it is indeterminate how much data is written, but the file's current position is unchanged.

When the file's current position exceeds the actual file size:

- T-Kernel Standard File system

  An error occurs.

- FAT File system

  The byte sequence of zero is written from the end of the file to the current position. The number of bytes of the return parameter is not included in this area.

Get directory entry

tkse_getdents

C Language Interface

```
ER ercd = tkse_getdents( int fildes, struct dirent *buf, size_t nbyte );
```

Parameter

int	fildes	file descriptor
struct dirent	*buf	read buffer of directory entry
size_t	nbyte	read size (bytes)

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Read directory entry (record) from the current position of the directory specified by the file descriptor “fildes”, and convert it into a “struct dirent” format to write to “buf”.
Specify the size of “buf” in “nbyte” (bytes). Read contiguous directory entries to be entered into this size. Move the directory's current position so that the directory entry next to the the directory entry that is lastly read can be indicated.

```
struct dirent {
        unsigned int      d_fileno;          /* file number */
        unsigned short    d_reclen;          /* record length (the number of bytes) */
        unsigned char     d_type;            /* file type */
        unsigned char     d_namlen;          /* string length of “d_name” */
        char              d_name[255+1];     /* file name */
};
```

file type:

DT_UNKNOWN	0 unknown
DT_FIFO	1 named pipe (FIFO)
DT_CHR	2 character type special file
DT_DIR	4 directory
DT_BLK	6 block type special file

DT_REG	8 normal file
DT_LNK	10 symbolic link
DT_SOCK	12 socket

“struct dirent” is a variable length data, and its size can be determined from “d_reclen”. When multiple directory entries are read, the position in “buf” where the next directory entry was stored can be determined by “d_reclen”. The return parameter zero indicates the end of directory.

- T-Kernel Standard File system
  The file name including the order of appearance is stored in “d_name”.
  When directory entries are obtained by “tkse_getdents” multiple times, the order in which they appear may become incorrect by the accesses from other processes.

Get file information

tkse_stat

C Language Interface

```
ER ercd = tkse_stat ( const char *path, struct stat *sb );
```

Parameter

const char	*path	file path name
struct stat	*sb	buffer to get file information

※**Return Parameter** and **Description** are in common with “tkse_fstat()” to be described

Get file information

tkse_lstat

C Language Interface

```
ER ercd = tkse_lstat( const char *path, struct stat *sb );
```

Parameter

const char	*path	file path name
struct stat	*sb	buffer to get file information

※**Return Parameter** and **Description** are in common with “tkse_fstat()” to be described

Get file information

tkse_fstat

C Language Interface

```
ER ercd = tkse_fstat( int fildes, struct stat *sb );
```

Parameter

int	fildes	file descriptor
struct stat	*sb	buffer to get file information

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Get the information of the file specified by the path name “path” to store in “sb”.
“lstat()” returns link information when the specified file is a symbolic link.
“stat()” returns the information of the file which the link refers to. Other than that, “stat()” and “lstat()” return the same result. (However, “lstat()” and “stat()” are substantially the same since the link file is not currently supported.)
“tkse_fstat()” returns the information concerning the opened file indicated by “fildes”.

```
struct stat {
    dev_t               st_dev;          /* device ID */
    ino_t               st_ino;          /* file serial number */
    mode_t              st_mode;         /* modify file mode */
    nlink_t             st_nlink;        /* the number of links */
    uid_t               st_uid;          /* owner ID */
    gid_t               st_gid;          /* group ID */
    dev_t               st_rdev;         /* device type */
    struct timespec     st_atimespec;    /* latest access time */
    struct timespec     st_mtimespec;    /* latest update time */
    struct timespec     st_ctimespec;    /* latest file state update time */
    off_t               st_size;         /* file size (bytes) * /
    int64_t             st_blocks;       /* the number of assigned blocks of file */
    u_int32_t           st_blksize;      /* block size (the number of bytes) */
    u_int32_t           st_flags;        /* user-defined flag */
```

```
        u_int32_t           st_gen;             /* file generate number */
        int32_t             st_lspare;          /* (reserved) */
        int64_t             st_qspare[2];       /* (reserved) */
    };

    #define st_atime st_atimespec.tv_sec
    #define st_mtime st_mtimespec.tv_sec
    #define st_ctime st_ctimespec.tv_sec
```

S_BLKSIZE 512 block size (bytes) as an unit of “st_blocks”

The union (OR) value of the following values is returned to the file mode “st_mode”.

S_IRWXU	0000700	owner RWX mask
S_IRUSR	0000400	owner R read permission
S_IWUSR	0000200	owner W write permission
S_IXUSR	0000100	owner X execute permission
S_IRWXG	0000070	group RWX mask
S_IRGRP	0000040	group R read permission
S_IWGRP	0000020	group W write permission
S_IXGRP	0000010	group X execute permission
S_IRWXO	0000007	other RWX mask
S_IROTH	0000004	other R read permission
S_IWOTH	0000002	other W write permission
S_IXOTH	0000001	other X execute permission
S_ISUID	0004000	run time user ID setting
S_ISGID	0002000	run time group ID setting
S_ISVTX	0001000	sticky bit
S_IFMT	0170000	file type mask
S_IFIFO	0010000	named pipe (FIFO)
S_IFCHR	0020000	character type special file
S_IFDIR	0040000	directory
S_IFBLK	0060000	block type special file
S_IFREG	0100000	normal file
S_IFLNK	0120000	symbolic link
S_IFSOCK	0140000	socket

The union (OR) value of the following values is returned to the user-defined flag st_mode.

SF_ARCHIVED	0x00010000	archive file
SF_SYSTEM	0x40000000	system file
SF_HIDDEN	0x80000000	hidden file

```
struct timespec {
                time_t      tv_sec;         /* second */
                long        tv_nsec;        /* nano-second */
};
```

The number of seconds starting from the date and time at 00:00:00 GMT, Jan 1, 1985 shall be set to “time_t”. (It is based on TRON specifications, and is different from UNIX.)
When the time recorded in a file is prior to the standard date and time, zero (tv_sec=0, tv_nsec=0) is returned.
When the time recorded in a file is beyond the time range designated by “time_t”, 0x7fffffff (tv_sec=0x7fffffff, tv_nsec=0) is returned.
The time recorded in a file is updated at the timing specified in the File system.
The information to be obtained may differ according to target File systems.

- T-Kernel Standard File system

  st_dev device ID

  Since device IDs are dynamically assigned when devices are registered, they are not fixed values.

  “st_ino” file ID
  “st_mode”, “S_IRUSR”, “S_IRGRP” and “S_IROTH” are constantly set.
  “S_IXUSR”, “S_IXGRP”, and “S_IXOTH” are constantly set.
  “S_IWUSR”, “S_IWGRP”, and “S_IWOTH” are set only when the read-only attribute is not set.

Owner, group, and other independent attributes are not set. It is always the same.
For the file type, either “S_IFDIR” or “S_IFREG” is set.
The file type at opening is set by “tkse_fstat”, and other attributes are determined according to the current file type or with or without a link record.
Other attributes are never set.

st_nlink	the number of file references
st_uid	(always 0)
st_gid	(always 0)
st_rdev	(always 0)
st_atimespec	latest access time
st_mtimespec	latest update time
st_ctimespec	file create time
st_size	target record size

Only the size of record targeted for access is taken into account. Therefore, it will be smaller than the actual file size when multiple data records are included.
When the file type of the target file is a directory, the number of link records is set.

st_blocks	total number of used blocks the number of used blocks including total records and management information.
st_blksize	logical block size
st_flags	“SF_HIDDEN” is set for hidden virtual object.
st_gen	(always 0)

• FAT File system

st_dev device ID

Since device IDs are dynamically assigned when devices are registered, they are not fixed values.

st_ino	value based on the position of directory entry in the disk not always a fixed value.
st_mode	“S_IRUSR”, “S_IRGRP”, and “S_IROTH” are constantly set. “S_IXUSR”, “S_IXGRP”, and “S_IXOTH” are constantly set. “S_IWUSR”, “S_IWGRP”, and “S_IWOTH” are set only when the read-only attribute is not set. Owner, group, and other independent attributes are not set. It is always the same. For the file type, either “S_IFDIR” or “S_IFREG” is set. Other attributes are never set.
st_nlink	(always 1)
st_uid	(always 0)
st_gid	(always 0)
st_rdev	(always 0)
st_atimespec	latest access date (time is constantly 00:00:00)
st_mtimespec	latest update time
st_ctimespec	file create time access time and creation time are only set to VFAT. In other cases, update time is set to every attribute.
st_size	file size
st_blocks	the number of used blocks
st_blksize	cluster size
st_flags	“SF_ARCHIVED”, “SF_SYSTEM”, and “SF_HIDDEN” are set according to FAT file types.
st_gen	(always 0)

- CD-ROM File system

st_dev	device ID Since device IDs are dynamically assigned when devices are registered, they are not fixed values.
st_ino	value based on the position of directory record in the disk
st_mode	"S_IRUSR", "S_IRGRP", and "S_IROTH" are constantly set. "S_IXUSR", "S_IXGRP", and "S_IXOTH" are constantly set. For the file type, either "S_IFDIR" or "S_IFREG" is set. Other attributes are never set.
st_nlink	(always 1)
st_uid	(always 0)
st_gid	(always 0)
st_rdev	(always 0)
st_atimespec	date and time for recording
st_mtimespec	date and time for recording
st_ctimespec	date and time for recording
st_size	file size
st_blocks	the number of blocks to be used
st_blksize	logical block size
st_flags	"SF_HIDDEN" is set for a hidden file.
st_gen	(always 1)

- Console I/O (standard input/output)

※ valid only for "tkse_fstat()"

st_dev	(always 0)
st_ino	(always 0)
st_mode	"S_IRUSR|S_IWUSR|S_IFCHR" are set. (Fixed value)
st_nlink	(always 1)
st_uid	(always 0)
st_gid	(always 0)
st_rdev	(always 0)
st_atimespec	(always 0)
st_mtimespec	(always 0)
st_ctimespec	(always 0)
st_size	(always 0)
st_blocks	(always 0)
st_blksize	(always 0)
st_flags	(always 0)
st_gen	(always 0)

Rename file

tkse_rename

C Language Interface

```
ER ercd = tkse_rename ( const char *from, const char *to );
```

Parameter

const char	*from	file name before changing(renaming)
const char	*to	file name after changing(renaming)

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Rename the file name 'from' to the file name 'to'.
When 'to' already exists, 'to' is deleted. In this case, 'from' and 'to' should be the same type (both are files or directories).
When 'from' and 'to' are in different directories, the files are moved between directories.
'from' and 'to' must be in the same file system.

- T-Kernel Standard file system
  When the read-only attribute is set to the file indicated by 'to', an error occurs.
  The file path name indicated by 'to' must be in the unopen state.
  In the case 'from' is included in the path name 'to' or 'to' is a subdirectory of 'from' when renaming a directory, the directory is renamed.
  ※If 'from' is included in the path name 'to', files may not be accessed by using the path name hereafter.

- FAT File system
  'to' must be in the unopen state.
  In the case 'from' is included in the path name 'to' when renaming a directory, an error occurs.

Unlink directory entry

tkse_unlink

C Language Interface

```
ER ercd = tkse_unlink( const char *path );
```

Parameter

const char	*path	directory path to be deleted

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Delete the file specified by the path name “path”.
A directory or an open file cannot be deleted.

- T-Kernel Standard File system
  In the case file type is other than six, discriminate file type depending on whether a link record exists at the invoked time or not.
  Therefore, an error occurs if the file type is six or the file includes a link record.

Make directory

tkse_mkdir

C Language Interface

```
ER ercd = tkse_mkdir( const char *path, mode_t mode );
```

Parameter

const char	*path	directory name to create
mode_t	mode	directory create mode
		※ same as the “mode” of “tkse_open()”.

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Make the directory specified by the path name “path”.
The directory name "." and ".." cannot be made.

Remove directory

tkse_rmdir

C Language Interface

```
ER ercd = tkse_rmdir( const char *path );
```

Parameter

const char	*path	directory name to remove

Return Parameter

ER	ercd	≧ 0	normal termination
		＜ 0	error

Description

Remove the directory specified by the path name “path”.
The directory to be removed (except "." and "..") must be blank.
The directory "." and ".." cannot be removed.
The directory must be in the unopen state.

- T-Kernel Standard File system
  Discriminate file type depending on with or without a link record at the invoked time.
  Therefore, files without link records are targeted for deletion regardless of the file type.

Replicate File Descriptor

tkse_dup

C Language Interface

```
ER ercd = tkse_dup( int oldd );
```

Parameter

int oldd	file descriptor to replicate

* Similar to tkse_dup2() for descriptions after [**Return Parameter**].

Replicate File Descriptor

tkse_dup2

C Language Interface

ER ercd = tkse_dup2(int oldd, int newd);

Parameter

int oldd	file descriptor to replicate
int newd	any new file descriptor

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Replicates file descriptor oldd.

In dup2, newd will be set to a new file descriptor. In dup, the unused minimum number will be set to a new file descriptor.

After replication, oldd and newd are treated as the same, and share current position pointer.

If file descriptor newd is already used, the file is closed and then replicated.

File's Disk Cache Content and Disk Synchronization

tkse_fsync

C Language Interface

```
ER ercd = tkse_fsync( int fildes );
```

Parameter

int	fildes	file descriptor

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Writes the not yet written data of the file specified by the file descriptor fildes to disk.
Returns after writing to disk is complete.

Modify Current Directory

tkse_chdir

C Language Interface

```
ER ercd = tkse_chdir( const B *path );
```

Parameter

const B	*path	working directory path

* Similar to tkse_fchdir() for descriptions after [Return Parameter].

Modify Current Directory

tkse_fchdir

C Language Interface

```
ER ercd = tkse_fchdir( int fildes );
```

Parameter

int fildes	file descriptor

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Changes the working directory to the directory to which path name path points or to the directory opened by the file descriptor fildes.

Change File Mode

tkse_chmod

C Language Interface

```
#include <extension/seio.h>

ER tkse_chmod( const B *path, mode_t mode );
```

Parameter

const B	*path	file and directory path
mode_t	mode	mode specification

* Similar to tkse_fchmod() for descriptions after [**Return Parameter**]

Change File Mode

tkse_fchmod

C Language Interface

```
ER ercd = tkse_fchmod( int fildes, mode_t mode );
```

Parameter

int	fildes	file descriptor
mode_t	mode	mode specification

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Changes the mode of a file/directory to which path name path points or the mode of a file/directory opened by fildes.

Specify the mode by taking the union of the followings with OR:

S_IRWXU 00700	owner	RWX	mask
S_IRUSR 00400	owner	R	read permission
S_IWUSR 00200	owner	W	write permission
S_IXUSR 00100	owner	X	execute permission
S_IRWXG 00070	group	RWX	mask
S_IRGRP 00040	group	R	read permission
S_IWGRP 00020	group	W	write permission
S_IXGRP 00010	group	X	execute permission
S_IRWXO 00007	other	RWX	mask
S_IROTH 00004	other	R	read permission
S_IWOTH 00002	other	W	write permission
S_IXOTH 00001	other	X	execute permission
S_ISUID 04000	run time user	ID	setting
S_ISGID 02000	run time group	ID	setting
S_ISVTX 01000	sticky bit		

These mode settings have different scopes according to the target file systems. Invalid settings will be ignored in the target file system.

If the file modes of already opened files are changed, the changes here will not affect them until they are closed.

Create File

tkse_creat

C Language Interface

```
ER ercd = tkse_creat( const B *path, mode_t mode );
```

Parameter

const B	*path	file and directory path
mode_t	mode	mode specification

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Performs a processing equivalent to the setting (O_CREAT | O_WRONLY | O_TRUNC) to open's oflag.

The file descriptor as a return value is the minimum of all unused numbers.

Modify Access Time, Modification Time

tkse_utimes

C Language Interface

```
ER ercd = tkse_utimes( const B *path, const struct timeval times[2] );
```

Parameter

const B	*path	file and directory path
const struct timeval	times[2]	modify access time, modification time

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Changes the access time, the modification time of a file/directory to which the path name path points.

utimes sets times[0].tv_sec to access time, times[1].tv_sec to modification time.

Sets seconds since the date and time at 00:00:00 GMT, Jan 1, 1985 to time_t, timeval.tv_sec. (It is based on TRON specifications, and is different from UNIX.)

If NULL is set to times, file's access time and modification time are set to current time.

• Standard File system

If zero is set to access time and modification time, these times are unchanged.

```
struct timeval {
        long tv_sec;        /* second */
        long tv_usec;       /* microsecond */
};
```

Set File Creation Mask

tkse_umask

C Language Interface

```
mode_t tkse_umask( mode_t cmask );
```

Parameter

mode_t cmask	mask value

Return Parameter

previous umask value

error code (errno)

none

Description

Used to set mode when files are created.
cmask is cancelled by mode which is set when a process creates a file.
Specify by taking the union of cmask and the following with OR:

S_IRWXU 00700	owner RWX mask
S_IRUSR 00400	owner R read permission
S_IWUSR 00200	owner W write permission
S_IXUSR 00100	owner X execute permission
S_IRWXG 00070	group RWX mask
S_IRGRP 00040	group R read permission
S_IWGRP 00020	group W write permission
S_IXGRP 00010	group X execute permission
S_IRWXO 00007	other RWX mask
S_IROTH 00004	other R read permission
S_IWOTH 00002	other W write permission
S_IXOTH 00001	other X execute permission
S_ISUID 04000	run time user ID setting
S_ISGID 02000	run time group ID setting
S_ISVTX 01000	sticky bit

These umask settings have different scopes according to the target file systems.

Invalid settings will be ignored in the target file system.

The initial value of system's cmask is set to zero, and the process inherits parent process's cmask.

Set File Size to the Specified Length

tkse_truncate

C Language Interface

```
ER ercd = tkse_truncate( const B *path, off_t length );
```

Parameter

const B	*path	file and directory path
off_t	length	file size to specify

* See tkse_ftruncate() for descriptions after [Return Parameter].

Set File Size to the Specified Length

tkse_ftruncate

C Language Interface

```
ER ercd = tkse_ftruncate( int fildes, off_t length );
```

Parameter

int	fildes	file descriptor
off_t	length	file size to specify

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Extends or truncates the file size of a file to which path name path points or the file size of a file opened by fildes to the specified size length bytes.

If length is less than the file size, the file size will be truncated to length bytes, and truncated portion will be lost.

If length is greater than the file size, the file size will be extended to length bytes, and zero is written in the extended portion.

If length is equal to the file size, nothing is done.

Disk Cache Content and Disk Synchronization

tkse_sync

C Language Interface

```
void tkse_sync( void );
```

Parameter

none

Return Parameter

none

Error Code

none

Description

Writes all the not yet written data in memory to disk.
Returns after writing to disk is complete.

Retrieve a List of File systems

tkse_getfsstat

C Language Interface

```
ER ercd = tkse_getfsstat( struct statfs *buf, W bufsize, int flags );
```

Parameter

struct statfs	*buf	retrieval information storage area
W	bufsize	storing area size
int	flags	

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Retrieves information about all the connected file systems to store it in buf.

bufsize is the size (number of bytes) of buf's area, all the information that can be stored in buf concerning file system.

For example, if bufsize = sizeof(struct statfs) * 10, information concerning up to ten file systems will be stored.

If NULL is set to buf, bufsize will be ignored and the number of connected file systems will be returned as a return value.

Set MNT_WAIT or MNT_NOWAIT to flags. But flags will be ignored and be meaningless in the current implementation. Normally, set MNT_WAIT.

```
#define MNT_WAIT       1
#define MNT_NOWAIT  2

typedef struct fsid {
                W val[2];
} fsid_t;                       /* file system ID */

#define MNAMELEN 90 /* maximum length of connection name/device name */

struct statfs {
		W	f_spare2;		/* (blank) */
		W	f_bsize;		/* logical block size (B: number of bytes) */
		W	f_iosize;		/* optimal block size to transfer (B) */
		W	f_blocks;		/* file system space (LB: number of logical blocks) */
		W	f_bfree;		/* file system free space (LB) */
		W	f_bavail;		/* free space available to general users (LB) */
		W	f_files;		/* * maximum number of files */
		W	f_ffree;		/* * number of blank files */
		fsid_t	f_fsid;			/* file system ID (always 0) */
		uid_t	f_owner;		/* connected user (always zero) */
		int	f_type;			/* file system type */
		int	f_flags;		/* connect flag */
		W	f_spare[6];		/* (blank) */
		B	f_mntonname[MNAMELEN];		/* connection name */
		B	f_mntfromname[MNAMELEN];	/* device name */
	};
```

The value of items marked with * may be undefined according to file systems. In such cases, the items will be set to -1.

In the current implementation, free space f_bavail available to general users is equal to file system free space f_bfree.

The file system type f_type is one of the following:

```
	#define MOUNT_FATDS	 4	/* FAT	File system */
	#define MOUNT_CDFS	14	/* CD-ROM File system */
	#define MOUNT_STDFS	20	/* Standard File system */
```

The value of connect flag f_flags is set to the result of taking the union of the following information:

```
	#define MNT_RDONLY	0x00000001  /* read-only */
```

The connection name f_mntonname is a path name from root.

```
	Example: "/SYS"
```

The device name f_mntfromname is set to the device name prepended by "/dev/".

```
	Example: "/dev/pca0"
```

In the current implementation, information concerning root file system is not returned.

Retrieve a LINK to Standard File

tkse_getlink

C Language Interface

```
ER ercd = tkse_getlink( const B *path, B *buf );
```

Parameter

const B	*path	file path of standard input/output
B	*buf	LINK information storage area

Return Parameter

ER	ercd	≧ 0	normal termination (file descriptor of created file)
		＜ 0	error exit

Description

Returns LINK information based on standard file system specifications of a file or directory denoted by the path name path to buf.

buf should be an area with the size greater than or equal to sizeof(LINK).

LINK information is stored to buf and zero is returned as a return value, only if the file or directory specified by path is a file in standard file system.

If the file or directory specified by path is not a file in standard file system, the content of buf is indefinite and -1 is returned as a return value and errno is set to -1 as well.

LINK information is retrievable without access privileges to the file or directory specified by path. However, access privileges to the routing directories to the target file or directory which is included in path is needed as access privileges to directories would be required when opening a file with open().

4.7 Standard File Management Function

4.7.1 Standard File Management Function Overview

The standard file management function provides the standard file system of “Standard Extension” and the functions to manipulate its files.
“Standard Extension” recommends that normal file manipulation should be executed by using the standard input/output functions. If you wish to use the functions specific to standard file system, the standard file management functions shall be used.

The standard file system has a structure based on real/virtual object models, with following features:

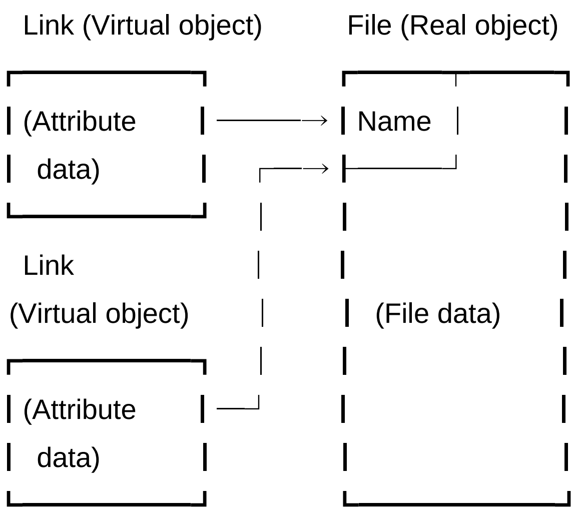
・File organization consisting of ordered record sequence with variable length (record stream)
・Any network-like reference relationships via links (virtual object) included in files
　(A directory in the traditional file system does not exist.)
・Direct access to files via links (virtual object)

Since files are used by multiple users in chronological order and furthermore used simultaneously by multiple users in network environment, detailed file access management and high-level protection mechanism are provided.
However, the current version of “Standard Extension” does not support multiple users.

4.7.2 File and Link

A file consists of ordered record sequence with variable length.
A link is a kind of key pointer for referring to a file, and it has a data structure composed of data which indicates referred file and several attribute data specific to the link.
The link can exist as a record with being embedded in any files. Multiple links indicating a file can exist, and consequently network-like reference relationships among any files can be defined as a whole.
In the correspondence to real/virtual object model, a file has one-on-one correspondence to a real object and a link has one-on-one correspondence to a virtual object.

In general, a file is directly referred via the link. Therefore, a file name does not have absolute meaning and is used as a search key. A file can have any file name of up to 20 characters, and it doesn’t matter if multiple files with the identical file name exist.



[Figure 8] Relation of file and links

4.7.3 File System

A file system is a physical unit for managing files, is built in storage media, and has ahas a ceiling on physical size.
The file system certainly has a root file, and all files in the file system are reachable by sequentially following the links included in the root file.
In the correspondence to real/virtual object model, a root file corresponds to a device real object.

In general, reference relationships between files via links are defined and integrated in a single file system, but a indirect link for referring to files in other file system is available and particularly called a indirect link. Because a reference via the indirect link is not integrated with changes in other destination file system, be aware that the existence of destination file is not assured.

The file system name and the device location name are set when the file system is generated.

A file system name is a name of up to 20 characters that is also set as a root file name and used by the system and users to absolutely discriminate file systems. A file system name must be unique, because file systems with identical file system name are regarded as the identical.

The device location name consists of up to 20 characters that indicate a physical device where a file system is stored. And it used to access other machines via the network or to ask the installation of floppy, etc.

4.7.4 Connect File System

There is no file system available at system startup, a file system will become available just after the connection operation. Therefore, minimum connection of file system is normally required as system initialization.

A file system is connected by specifying the logical device name where destination file system exists and the connection name. The connection name is a name of up to 8 characters for discriminating a connected file system, and is used as an absolute path name that indicates a root file of connected file system. When connected, a link to the root file of the connected file system is also obtained.
Therefore, use of link or connection name obtained at connection enables the access to a root file of the connected file system the access to a root file of the connected file system is enabled by using link or connection name obtained at connection, and sequential tracing of the following links from a root file allows you to access any file in the connected file system the access to any file in the connected file system is enabled by following links from a root file.

A file system is disconnected by specifying the logical device name of the file system targeted to be disconnected. Consequently, a file access via the link which indicates a file in disconnected file system is unavailable. This state is called a disconnected state.
In the correspondence to real/virtual object model, a link in disconnected state corresponds to a virtual object.

The connection of file system is a function simply to register the existence of file system dynamically with the file management function, and is a flat connection without any structure. Therefore, network-like static file reference structure across multiple file systems is built by using indirect links which refer to files in the different file systems.

4.7.5 File ID

At file generation, a unique number called file ID is attached to every file in the file system to be internally discriminated. A file ID is a value in the range from 0 (maximum file ID), and the maximum file ID (namely, maximum file count) is defined at file system generation. Since the file ID is represented by 16 bit numeric value, the maximum file ID can not exceed 65535.

A root file in the file system constantly has the file ID 0.

4.7.6 Link

A link is a kind of key pointer for accessing a file, and it has a data structure which holds file system name where destination file exists, file ID, and several attribute data as links.
The link is simply a dynamic data as a pointer, but it becomes a fixed existence by being stored as a record in a file. Thus, the stored link is particularly called a fixed link. Since the fixed link does not have file system name, only the reference to the file in the same file system is possible. And when fixed link is taken out from the file, the file system name to which the file belongs is set as a data structure of the link.

Thus, to store a link which refers to different file system in a file as a fixed link, a special file called a link file shall be generated in the file system to be stored in advance, and a link in it which indicates the link file shall be stored as a fixed file.

A link file is a special file which holds file system name where the file to be referred exists, file ID, file name, and generation time and date. And the access to the link file is automatically interpreted as an access to a file in the different destination file system. A link which indicates a link file is particularly called an indirect link, and a link which indicates a normal file is called a direct link.
Since a multiple indirect link, namely reference to file via more than two link files, is not supported, an error indicating that the file does not exist occurs when accessed.

A file reference via the link file by an indirect link is as follows:

・Identify a file system by its file system name. An access is disabled when unconnected. In addition, a connection name is irrelevant to the access via a link file.

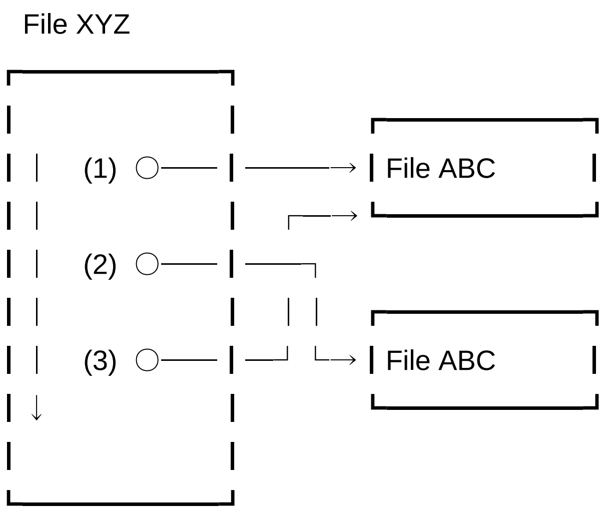
・Check the file in the file system identified by file ID. And when both or either of file name and generation time matches and the file is not a link file, accesses the file as a target. In other cases, the file to be referred is regarded as nonexistent and the access is disabled.

4.7.7 Working File

The file currently targeted for processing by certain process is called a working file of the process. A process enables any file to be a working file by using system call.
A working file is held as an execution environment in a process, and is inherited to generated child processes.
The working file can be undefined, and the working file of a process first generated in a system is in undefined state.

4.7.8 Path Name

In general, a file is directly referred by a link. However, a link cannot be interactively traced in a batch-style application, etc, so a file can be referred by specifying link sequence to be directly traced.
As a link sequence for this purpose, a list in order of file names referred by each link is called a path name. In this case, only a file name does not assure the uniqueness. So, a file name shall be used by appending it with the order of appearance.
The order it appears is a serial number assigned from 0 to (n-1) when there are “n” number of links referring to files with the identical file name in a file. When the order it appears is omitted, it is assumed to be zero, namely the first time.



The reference to link (1) is ABC or ABC:0
The reference to link (2) is ABC:1
The reference to link (3) is ABC:2

[Figure 9] Example of the order of appearance in pathname

The path name has the following syntax and is treated as one character-string of up to 256 characters:

[Path name]	::= [Special reference]|[Special reference] / [Simple path name]|[Simple path name]
[Simple path name]	::= [Simple path name] / [Reference specification]| [Reference specification]
[Reference specification]	::= [File name] |[File name]:[Order it appears]
[Special reference]	::= / [Connection name]| ≡
[Order it appears]	::= Numeric value
[File name]	::= String (up to 20 characters)
[Connection name]	::= String (up to 8 characters)

A special reference has the following meaning:

/ [Connection name]	--	indicating the root file of the file system connected by the specified connection name.
≡	--	indicating a working file.

/ ≡ : As the symbols “/, ≡, :” are special codes as follows, displayable all characters including blank(space) is enabled as the file name. If "/" is existent at the end of path name character-string, it will be ignored.

/	TC_FDLM 0xff21
:	TC_FSEP 0xff22
≡	TC_FOWN 0xff23

The path name beginning with "/ [Connection name]" is a path name from the root file of a file system, and is called an absolute path name. In other cases, a path name is a relative path name from the current working file, and is called a relative path name.

A path name can be indicated as follows:

/latest/project/software specifications/core specification/file management

external specification/chapter 10/example:1

≡

4.7.9 File Type

There are mainly two types of files as follows, and a file simply means a normal file.

Normal file: a file in a usual sense in terms of the place where data is stored.
Link file : a special file used to indirectly refer to files in another file system, and an indirect link is the link indicating this type of file.

4.7.10 Normal File Composition

A normal file is composed of an ordered sequence of any byte-length records, namely record streams, and each record is composed of the following elements:

・Record type
・Record subtype
・Record size
・Record body

The record type is a value in the range of 0 to 31 which indicates the type of a record.

0 Link record
A record which stores a link to the other file. Since the content is directly treated by file management function, direct manipulation of it from applications is restricted.

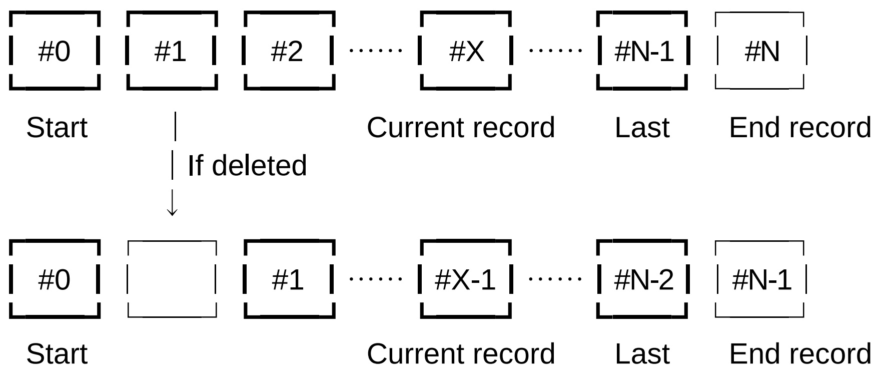
1-31 Data record
A record type defined as a system. File management function, however, has no concern with its content and treats it as just a byte sequence.

The record subtype is an auxiliary type specification used according to the record type and a16 bit unsigned numeric value used for a keyword.
The record size is 32 bit data that indicates the number of bytes of a record body. Although the link record does not have record size information, the size (52 bytes) of LINK structure, which indicates the size of an area required for input/output of records, is set to the record size. However, the size of this link record is not counted in the total number of bytes as file management information.
The record body is a data sequence of the number of bytes specified by the record size, and its content is determined depending on the record type. The record body of the link record is specially treated.

4.7.11 Record Number / Current Record

Each record of a file is numbered in sequence according to the order of record defining the first record as “0”, and

this number is called a record number. As the record number indicates the order of records, it dynamically changes by record insertion/deletion.
A record next to the last record is deemed to virtually exist, and this record is called the end record. If there are "N" pieces of records, the end record will have record number "N".
A current record is defined as a target record to be currently accessed in the opened files, and a data access is executed to the record of the current record. A current record can be moved by specifying the record number, and a search based on the record type, etc.
The current record is not changed even by record insertion/deletion, and only the record number corresponding to the current record is changed.



[Figure 10] Change of the record number by record deletion

4.7.12 Link File Composition

A link file is a file which is generated and used to indirectly refer to a file in the different file systems. In the link file, there is not any application data, but only the following management data is stored:

・File ID of the file to be referred
・Application type of the file to be referred
・File name of the file to be referred
・Generation date and time of the file to be referred
・File system name where the file to be referred exists
・Device location name of the file system where the file to be referred exists

4.7.13 File Control

A file is accessed by processes. A positive integer called file descriptor (fd > 0) defined by each process is assigned to the open file, and the actual file is accessed using this file descriptor.
On process termination, all the opened files are automatically closed. A current record is also defined as a target record to be accessed for the opened file.

The file descriptor and the current record location are defined as specific to the process, and are not especially passed on to child processes.
A working file is passed on to child processes as a process environment.

4.7.14 Reference Count of File

In a file, a reference count which indicates the number of fixed links referring to the file in the same file system exists. The reference count is zero at file generation, and is incremented by one when a fixed link to the file is generated, namely a link is stored in the file. Conversely, the reference count is decremented by one when fixed link is deleted.
As the reference count indicates references in the same file system, file references via link file are not reflected in the reference count. In addition, the reference count is applied to the link file itself, too.
A file deletion is enabled only for a file with reference count zero. If a fixed link is included in the deleted file, the reference count of the file to which the fixed link refers is decremented by one. And even if it results in zero, the file will not be deleted. Meanwhile, a file deletion which includes a fixed link is enabled only when forced deletion is specified at deletion.
The same holds for link file deletion, and it is enabled when the reference count of the link file itself is zero. Note that the destination file of the link file cannot be deleted via link file.
The reference count of the root file in the file system is exceptionally one from the beginning, so the way it works that it cannot be deleted at all.
A file with reference count zero does not have a fixed link which refers to it. Therefore, when dynamic link is lost, it cannot be accessed in the usual way. However, it can be accessed by retrieving links to all files in the file system.

4.7.15 File Access

A file is to be opened by specifying any of “READ”/”WRITE”/”UPDATE”, and the following mode specification is enabled in order to restrict the simultaneous open of the same file from others at opening: The mode setting defaults to share mode, but usually an exclusive write mode is a safe option.

Exclusive mode :	prohibit any simultaneous open from others
Exclusive write mode :	prohibit simultaneous open for writing/updating from others.
Share mode :	not prohibit any simultaneous open from others.

T combination of the mode that enables a new simultaneous open to the mode that has been already opened is as shown below. : If newly simultaneous open is not enabled, an error occurs at opening.

		Newly simultaneous open mode								
		Exclusive			Exclusive write			Share		
Existing open mode		R	W	U	R	W	U	R	W	U
Exclusive mode	R	×	×	×	×	×	×	×	×	×
	W	×	×	×	×	×	×	×	×	×
	U	×	×	×	×	×	×	×	×	×
Exclusive write mode	R	×	×	×	○	×	×	○	×	×
	W	×	×	×	×	×	×	○	×	×
	U	×	×	×	×	×	×	○	×	×
Share mode	R	×	×	×	○	○	○	○	○	○
	W	×	×	×	×	×	×	○	○	○
	U	×	×	×	×	×	×	○	○	○

A record lock function to prohibit others from executing access to each record of the opened file is also prepared.

The accesses to the locked record from others are as follows:

・To read, write, replace, reduce size, and delete the record result in an error.
・To make the record search target or the current record is enabled.

When you try to lock an already locked record, an error occurs or you are forced to wait until it is unlocked.

4.7.16 File System Management Information

The following management information for each file system can be read:

```
typedef struct {
        UH      fs_bsize;           /* the number of bytes of logical block */
        UH      fs_nfile;           /* maximum number of files */
        H       fs_lang;            /* language used in the file system */
        H       fs_level;           /* access management level of the file system */
        W       fs_nblk;            /* total number of blocks */
        W       fs_nfree;           /* total number of unused blocks */
        STIME   fs_mtime;           /* last updated time of the system block */
        STIME   fs_ctime;           /* creation time of a file system */
        TC      fs_name[L_FSNM];    /* file system name */
        TC      fs_locat[L_DLNM];   /* device location name */
} FS_STATE;
```

・”fs_bsize” is the number of bytes of one logical block, and shall be the power of 2.

・”fs_nfile” indicates the maximum number of file registrable in the file system. This value equals to the maximum file ID + 1.

・”fs_lang” indicates the language used in the file system, and represents the character code system used in this file system.

・”fs_level” represents an access management level in the file system, and can be the following values:

0: Level 0	-- no access management
1: Level 1	-- access management (no hidden name)
2: Level 2	-- access management (hidden name)

・”fs_nblk” indicates total number of logical blocks in the file system, and this value equals to maximum value of logical block number +1.

・”fs_nfree” is a current total number of unused logical blocks, and this data fluctuates dynamically.

・”fs_mtime” and ”fs_ctime” are respectively the last updated time and the generated time of the file system represented by seconds since the reference date and time at starting from 00:00:00 GMT, Jan 1, 1985.

・”fs_name” and ”fs_locat” are respectively the names set at generation time (at the time of format)of the file system, and it is padded with trailing zeros if the name is less than 20 characters in length.

The management information of the file system is set at generation time (format time) of the file system, and thereafter unchanged except total number of unused logical blocks (fs_nfree), last updated time of the system blocks (fs_mtime), file system name and device location name.

4.7.17 File Management Information

The following management information for each file can be read: However in case of the link file, the information of a file to which the link file refers will be read, and the management information of the link file itself can not be read.

File name:
A file name of 20 characters and may be modified.

Reference count:
Indicate the number of fixed links referring to the file in the same file system.

File management information:
Various management information is as shown below:

```
typedef struct {
        UH      f_type;             /* file type/owner access mode */
        UH      f_atype;            /* application type */
        TC      f_owner[L_USRNM];  /* file owner name (in the case of hidden name, it is
                                        constantly zero) */
        TC      f_group[L_USRNM];  /* owner group name (in the case of hidden name, it is
                                        constantly zero) */
        UH      f_grpacc;           /* group access level */
        UH      f_pubacc;           /* general access level */
        H       f_nlink;            /* the number of included links */
        H       f_index;            /* index level */
        W       f_size;             /* total number of bytes of the file */
        W       f_nblk;             /* total number of used logical blocks */
        W       f_nrec;             /* total number of records */
        STIME   f_ltime;            /* shelf life of the file (date and time) */
        STIME   f_atime;            /* latest access time */
        STIME   f_mtime;            /* last updated time */
        STIME   f_ctime;            /* file create time */
} F_STATE;
```

・”f_type” indicates file type, access attribute, and owner access mode, as follows:

TTTT xxxx BAPO xRWE
T: file type

0	link file
1	normal file
2-	reserved

P: permanent attribute

The value one indicates that this file is prohibited from removal.

0: read-only attribute

The value one indicates that this file is read-only.

A: application attribute 1

B: application attribute 2

The attribute specified and used by an application. The file management has no concern with its meaning.

RWE:	file owner access mode (Respecitively enabled in the case of 1)
x :	reserved (zero)

・Application type (f_atype) is the data set and used by an application, and this data is not used by the file management.

・Owner name (f_owner) and owner group name (f_group) consist of 12 characters each; if it consists of less than 12 characters, it is padded with trailing zeros. The subsequent hidden name of two characters is always obtained as zeros.

・The group access level (f_grpacc) and the general access level (f_pubacc) have the following compositions:

xxxx RRRR WWWW EEEE

RRRR : lowest readable user level (0-15)

WWWW : lowest writable user level (0-15)

EEEE : lowest executable user level (0-15)

xxxx : unused (0)

・The number of included links (f_nlink) indicates the number of link records which the file includes.

・The index level indicates the indirect multiplicity of 0-based record index.

・The total number of bytes of the file (f_size) is the total number of bytes of data actually written in the file, and is the total amount of the record size of each record. In this case, the record size of the link record is counted as zero.

・The total number of logical blocks in use indicates the total number of logical blocks used in the file.

・The total number of records indicates the total number of records existent in the file.

・The date and time is set to the number of seconds starting from the date and time at 00:00:00 GMT (Greenwich Mean Time), Jan 1, 1985. This data is indicated to be invalid in the case the value is -1.

Latest access time (f_atime)

Time when the file data is last read or the index is last updated. At file generation, -1 (if not supported) or generation time of the file is set.

Last updated time (f_mtime)

The time when the file data is last updated. At file generation, the generation time is set.

File creation time (f_ctime)

The time when the file is generated for the first time.

Shelf life (f_ltime)

Shelf life of the file.　-1 is set when file is generated. This data is set and used by an application. It is not used in the file management.

File location information :

The file system information to which each file belongs. This content is a part of the management information of the file system.

```
typedef struct {
        STIME   fs_ctime;               /* creation time of a file system */
        TC      fs_name[L_FSNM];        /* file system name */
        TC      fs_locat[L_DLNM];       /* device location name */
        TC      fs_dev[L_DEVNM];        /* logical device name */
} F_LOCATE;
```

・The logical device name is the name of the block type device where the file system exists at the point.

Link file information :

For the link file, the following destination information held in the link file itself can be obtained: This information can be retrieved even when the destination file system is not connected.

4.7.18 Link Structure

Used to access files. The link has following data structure:

```
typedef struct {
        TC      fs_name[L_FSNM]; /* file system name */
        UH      f_id;    /* file ID */
        UH      atr1;    /* Attribute data 1 */
        UH      atr2;    /* Attribute data 2 */
```

```
                UH          atr3;     /* Attribute data 3 */
                UH          atr4;     /* Attribute data 4 */
                UH          atr5;     /* Attribute data 5 */
        } LINK;
```

・The file system name is the connected file system name itself and used to absolutely discriminate the file system. When it is set to fixed link, this information will not be stored in the file.

・The file ID is a file ID in the file system identified by the file system name.

・Attribute data 1-5 are attribute data held as link itself and their usage, and determined by upper level applications since the file management has no concern with their contents in general. All the default values of a newly generated link shall be zero. This data is stored in the file when it is set to fixed link, and the content stored in the file is retrieved when the fixed link is read.

In the file management, actual file access is executed only by using the file system name and the file ID.
In general, a link obtained from the file management function is used, but an application can create the link by directly setting the file system name and the file ID.
For example, as the file ID of a root file is zero, a direct link to the root file in the file system can be created by an application if the file system name is available.

4.7.19 System Calls

Get Link to File

tkse_get_lnk

C Language Interface

```
ER ercd = tkse_get_lnk(TC *path, LINK *lnk, W mode);
```

Parameter

TC	*path	target path name		
		NULL	target is a working file	
LINK	*lnk	storage area of obtained link (output)		
		specify working file (input: when “F_BASED” is set)		
W	mode	mode to get link		
		(F_NORM || F_BASED) | [F_DIRECT]		
		F_NORM	specify normal file	
		F_BASED	specify working file	
		F_DIRECT	specify to get direct link	

Return Parameter

ER	ercd	＜ 0	error code
		0	normal termination (a link to a normal file)
		1	normal termination (a link to a link file: F_DIRECT not specified)
		2	normal termination (a link to a normal file to which the link file refers: When “F_DIRECT” is set)

Description

Get a link to the file specified by the path name. When NULL is specified by the path name, get a link to the current working file.

When the path name is relative path name, with F_NORM specification, the link shall be based on the current working file, and with “F_BASED” specification, the link shall be based on the file specified by “lnk” as a working file.

When the specified file is a link file, without “F_DIRECT” specification, a link to the link file itself shall be obtained. In this case, the existence of the normal file to which obtained link file refers is not assured.

In the case of “F_DIRECT” specification, a direct link to the normal file to which the link file refers is obtained.

To retrieve the link to a file, an access privileges to execute/search (E) each file included in the path name is needed, but an access privileges to execute/search (E) the destination file itself is not needed.

Change Working File

tkse_chg_wrk

C Language Interface

```
ER ercd = tkse_chg_wrk(LINK *lnk);
```

Parameter

LINK	*lnk	working file to be changed
	NULL	set working file as undefined

Return Parameter

ER	ercd	error code

Description

Set the specified file to a working file of invoking process.

To set a working file, an access privileges to execute/search (E) the file is required.

Create File

tkse_cre_fil

C Language Interface

ER ercd = tkse_cre_fil(LINK *lnk, TC *name, A_MODE *mode, UH atype, W opt);

Parameter

LINK	*lnk	storage area of the link to created file (output)
		specify file system (input: when “F_FLOAT” is set)
		specify parent file (input: when “F_FIX” is set)
		specify file to be created (input: when “F_FILEID” is set)
TC	*name	file name (valid for 0 or up to maximum number of file name characters)
A_MODE	*mode	access mode
		NULL apply default access mode
UH	atype	file application type
W	opt	attribute of creation
		(FLOAT || F_FIX || F_FILEID)
		F_FLOAT floating link specification
		F_FIX fixed link specification
		F_FILEID file ID specification

Return Parameter

ER	ercd	＜ 0 error code
		＞ 0 normal termination (file descriptor)

Description

Create normal new file and open it to update in the file system where the file (in the case of link file, a normal file to which the link file refers) specified by “lnk” exists.

All the attribute data of the link to the generated file are set to zero, and are stored in the area specified by “lnk”.

In the case of “F_FLOAT” specification, a file shall be simply created . The reference count of the created file is set to 0.
In this case, since only the file system name specified by “lnk” is valid and file ID is ignored, the file specified by “lnk” doesn’t need to exist.

In the case of “F_FIX” specification, a link to the created file is appended to the last record position of the file specified by”lnk” as a link record (subtype = 0) at the last record position of the file specified by “lnk”. The reference count of the created file shall be set to 1. In this case, the file specified by “lnk” shall exist and be able to be write opened.

In the case of “F_FILEID” specification, create a file with the same file ID as the file ID specified by “lnk”.
The reference count of the created file is set to 0. In this case, the file specified by “lnk” shall not exist.

“A_MODE” specifies the access mode of created file.

Even when owner access mode of the created file is read-only, the file is opened to update, and the record number is set to zero.

Create Link File

tkse_cre_lnk

C Language Interface

```
ER ercd = tkse_cre_lnk(LINK *lnk, F_LINK *ref, W opt);
```

Parameter

LINK	*lnk	storage area of the link to created file (output)	
		specify file system	(input: when “F_FLOAT” is specified)
		specify parent file	(input: when “F_FIX” is specified)
		specify file to be created	(input: when “F_FILEID” is specified)
F_LINK	*ref	link file content to be created	
W	opt	content of link file to be created	
		(F_FLOAT || F_FIX || F_FILEID)	
		F_FLOAT	floating link specification
		F_FIX	fixed link specification
		F_FILEID	file ID specification

Return Parameter

ER	ercd	error code

Description

Create a link file with the content specified by “ref” in the file system where the file (In the case of link file, a normal file to which the link file refers) specified by “lnk” exists.

All the link attribute data of the link to the created file are set to zero, and are stored in the area specified by “lnk”.

The meaning of “F_FLOAT”, “F_FIX”, and “F_FILEID” is identical with “tkse_cre_fil()”.

The content of the created link file is the one specified by “ref”, but the creation time is set to the time when this system call is executed instead of “ref->f_ctime”.

The actual existence of the file specified by “ref” is not checked.

When “ref->fs_name” is identical with the file system name specified by “lnk”, a link file cannot be created. That results in an error.

Generate File Directly

tkse_gen_fil

C Language Interface

```
ER ercd = tkse_gen_fil(LINK *lnk, TC *name, F_STATE *stat, F_LINK *ref, W opt);
```

Parameter

LINK	*lnk	storage area of generated file link (output)
		specify file system (input: when “F_FLOAT” is specified)
		specify parent file (input: when “F_FIX” is specified)
		specify file to be generated (input: when “F_FILEID” is specified)
TC	*name	file name (valid for 0 or up to maximum number of file name characters)
		(valid only at normal file generation; when name is NULL at this time, an error occurs)
		(Not referred at all when generating a link to file)
F_STATE	*stat	file content to be generated
F_LINK	*ref	link file content to be generated
		(valid only at link file generation)
W	opt	attribute of generation
		(F_FLOAT || F_FIX || F_FILEID)
		F_FLOAT floating link specification
		F_FIX fixed link specification
		F_FILEID file ID specification

Return Parameter

ER	ercd	＜ 0	error code
		＝ 0	normal termination (at link file generation)
		＞ 0	normal termination (file descriptor: at normal file generation)

Description

Newly generate a normal file or a link file in the file system where the file (In the case of link file, normal file to which the link file refers) specified by “lnk” exists, and open it for updating if a normal file is generated

All the attribute data of the link to the generated link file is set to zero, and is stored in an area specified by “lnk”.

The meaning of “F_FLOAT”, “F_FIX”, and “F_FILEID” is identical with “tkse_cre_fil()”.

The generated file content is specified by “stat”, and whether it is a normal file or a link file is distinguished by “stat->f_type”.

At normal file generation, a normal file with the name specified by “name” shall be generated and the generated file management information shall be set to the content specified by “stat”. However, the values of “f_nlink”, “f_index”, “f_size”, “f_nblk”, and “f_nrec” are ignored and initialized at file generation.

All other contents of “stat” are ignored and link file of “ref” content is generated. It is same as the behavior of “tkse_cre_lnk()”, and “ref->f_ctime” is valid as well.

Since this system call is used for special purpose of restoring a file system, etc., it can be executed only in a process at user level 0.

At normal file generation, the file is opened for updating. Since there is no record in this state, the current record indicates the end record and the record number is zero.

Open File

tkse_opn_fil

C Language Interface

```
ER ercd = tkse_opn_fil(LINK *lnk, W o_mode, TC *pwd);
```

Parameter

LINK	*lnk	target file	
W	o_mode	open mode	
		(F_READ || F_WRITE || F_UPDATE) | [F_EXCL || F_WEXCL]	
		F_READ	open for reading
		F_WRITE	open for writing
		F_UPDATE	open for updating (reading/writing)
		F_EXCL	exclusive mode
		F_WEXCL	exclusive write mode
TC	*pwd	password	
		NULL	no password specification

Return Parameter

ER	ercd	error code

Description

Open the file specified by “lnk” in the specified mode. To open a file, an access privileges corresponding to the open mode is required.

Since password function is currently unsupported, “pwd” is set to NULL.

The current record is set to the start record of the opened file. When there is no record in the file, the current record is set to the end record.

Close File

tkse_cls_fil

C Language Interface

```
ER ercd = tkse_cls_fil(W fd);
```

Parameter

W	fd	file descriptor

Return Parameter

ER	ercd	error code

Description

Close the opened file.

When the process which opened the file exits, the file will be automatically closed.

Delete File

tkse_del_fil

C Language Interface

```
ER ercd = tkse_del_fil(LINK *org, LINK *lnk, W force);
```

Parameter

LINK	*org	parent file of the file targeted to be deleted
		NULL no parent file specification
LINK	*lnk	file targeted to be deleted
W	force	forcible deletion specification
		＝ 0 : not delete when the destination file includes a link record.
		≠ 0 : delete when the destination file includes a link record.

Return Parameter

ER	ercd	＜ 0 error code
		≧ 0 normal termination (the number of link records when reference count results in zero after deletion)

Description

Delete the link record which indicates the file specified by “lnk” in the parent file specified by “org”, and decrement the reference count of the file by one. When reference count results in zero, the file itself specified by “lnk” shall be deleted. In this case, an access privileges to write (W) parent file is required.

In the case of no parent file setting (org = NULL), if the reference count of the file specified by “lnk” is zero, the file shall be deleted. An error is caused by the reference count other than zero.

When the file targeted for deletion is a link file, the link file itself is the target for deletion; the destination file for reference of the link file will not be deleted.

In the case of no forced deletion (force = 0), if the file to be deleted include a link record, the file will not be deleted as an error. In the case of forced deletion (force ≠ 0), if the file to be deleted includes a link record, the file shall be deleted and the reference count of the file shall be decremented by one which the included link record indicates. And as the result, the number of link records whose reference count results in zero is set to return value.

When the file to be deleted is in any of the following, an error occurs without the deletion of the file :

・Permanent attribute is set
・open process is existent
・process which is used as a working file is existent

The file can be deleted even when read-only attribute is set.

Move Current Record

tkse_see_rec

C Language Interface

```
ER ercd = tkse_see_rec(W fd, W offset, W mode, W *recnum);
```

Parameter

W	fd	file descriptor	
W	offset	offset to move	
W	mode	move mode	
		＝ 0	move to the record number for current record number + offset
		＞ 0	move to the position for “offset” record number
			It should be offset≧ 0
		＜ 0	move to the record number position for the end of record number + “offset”
			It should be be offset≦0
W	*recnum	storage area of the current record number after move	
		NULL	not stored

Return Parameter

ER	ercd	error code

Description

Move the current record position for the opened file to the specified location.

When specified destination exceeds the existing range of record, an error occurs and the current record will not be changed.

Find Record

tkse_fnd_rec

C Language Interface

```
ER ercd = tkse_fnd_rec(W fd, W mode, UW typemask, UH subtype, W *recnum);
```

Parameter

W	fd	file descriptor	
W	mode	search mode (specify start position/direction to search)	
		(F_FWD || F_NFWD || F_BWD || F_NBWD || F_TOPEND || F_ENDTOP)	
		F_FWD	from the current record to the end record
		F_NFWD	from the record next to the current one to the end of record
		F_BWD	from the current record to the top record
		F_NBWD	from the record previous to the current one to top record
		F_TOPEND	from the top record to the end of record
		F_ENDTOP	from the end of record to the top record
UW	typemask	"bitmask" of the record type targeted for search	
		support for LSB type 0	
		support for MSB type 31	
UH	subtype	record subtype targeted for search	
		0	applied to all subtypes (without subtype check)
W	*recnum	storage area of the current record number as a result of search	
		NULL	not stored

Return Parameter

ER	ercd	＜ 0	error code
		≧ 0	normal termination (searched record type)

Description

Search the specified record in the opened file, and set the found record as the current record.

When target record is not found, an error occurs and the current record will not be changed.

Find Link Record

tkse_fnd_lnk

C Language Interface

```
ER ercd = tkse_fnd_lnk(W fd, W mode, LINK *lnk, UH subtype, W *recnum);
```

Parameter

W	fd	file descriptor
W	mode	search mode (specification of start position/direction/content to search)
		(F_FWD || F_NFWD || F_BWD || F_NBWD || F_TOPEND || F_ENDTOP)

| [F_SFILE] | [F_SNAME]

	| [F_SATR1] | [F_SATR2] | [F_SATR3] |
	[F_SATR4] | [F_SATR5]
	same as F_FWD-F_ENDTOP tkse_fnd_rec()
F_SFILE	link record which indicates the same file as “lnk”
F_SNAME	link record which indicates the file with the same file name as “lnk”
F_SATR1	link record with the same attribute data 1 as “lnk”
F_SATR2	link record with the same attribute data 2 as “lnk”
F_SATR3	link record with the same attribute data 3 as “lnk”
F_SATR4	link record with the same attribute data 4 as “lnk”
F_SATR5	link record with the same attribute data 5 as “lnk”

LINK	*lnk	targeted link for search
		enabled only when F_SFILE-F_SATR5 is specified
UH	subtype	targeted record subtype for search
		0 applied to all subtypes (without subtype check)
W	*recnum	storage area of the current record number as a result
		NULL not stored

Return Parameter

ER	ercd	error code

Description

Search the specified link record in the opened file, and set the found link record as the current record.
When destination record is not found, an error occurs and the current record will not be changed.

Read Record

tkse_rea_rec

C Language Interface

```
ER ercd = tkse_rea_rec(W fd, W offset, B *buf, W size, W *r_size, UH *subtype);
```

Parameter

W	fd	file descriptor	
W	offset	byte position to start reading (≧0)	
B	*buf	storage area of read data	
		NULL	not stored
W	size	byte size of read data storage area (≧0)	
W	*r_size	remaining byte size from the starting byte position	
		storage area with the size (record size - offset)	
		NULL	not stored
UH	*subtype	storage area of record type	
		NULL	not stored

Return Parameter

ER	ercd	＜ 0	error code
		≧0	normal termination (the record type of the current record)

Description

Read the current record of the opened file.

When record size < offset + size, only the (record size - offset) bytes data is read and stored in “buf”.

When “offset ≧ record size”, “buf = NULL”, or “size = 0”, nothing is stored in “buf” but values corresponding to “*r_size” and “*subtype” are stored. This is used when retrieving record type or subtype only.

When the current record is a link record, the content of the entire “LINK” structure is read to “buf”, and the size of “LINK” structure is stored in “*r_size”. In this case, the condition must be met that “offset = 0”, “size ≧size of “LINK” structure” (or size = 0).

When the current record is the end record, or is locked by other process, an error occurs.

Write Record

tkse_wri_rec

C Language Interface

```
ER ercd = tkse_wri_rec(W fd, W offset, B *buf, W size, W *r_size, UH *subtype, UW units);
```

Parameter

W	fd	file descriptor
W	offset	byte position to start writing (-1≦ offset < record size)
		-1: write to the end of record (addition)
B	*buf	pointer to the write data
		NULL not written
W	size	byte size of write data (≧0)
W	*r_size	remaining byte size from the starting byte position
		storage area of the size (record size after writing - offset)
		NULL not stored
UH	*subtype	pointer to the record type to be modified
		NULL No change
UW	units	unit to get block (K bytes)
		0 any

Return Parameter

ER	ercd	error code

Description

Write to the current record of the opened file.

When record size < offset + size, the record size increases after writing.

"Units" specifies the unit of getting additional blocks in K bytes necessary for record size increase, and specifies to allocate consecutive block area of greater than or equal to “units” size (less than or equal to “size”).

“units = 0” means that any way to allocate blocks is allowed.

When “size = 0” or “buf = NULL”, data is not written. When “subtype ≠ NULL”, record subtype is changed.
When “buf = NULL” and “record size < offset + size”, record size is increased. The data for(of) increased portion is

indeterminate. This is used when reserving record's additional block area in combination with “units” setting.

When offset = -1, data is constantly written to the end of record at this point, and the value of “size” is stored in “*r_size”. Even when the same record is opened by multiple processes and simultaneously opened, this setting assures that written data is not overwritten by another data.

When the current record is a link record, the content of “buf” is “LINK” structure. However, only portion of attribute data is written, the file itself to be referred cannot be changed. In this case, the condition must be met that “offset = 0”, “size ≧ size” of LINK structure (or “size = 0”).

When the current record is the end record or the current record is locked by other process, an error occurs.

Insert Record

tkse_ins_rec

C Language Interface

```
ER ercd = tkse_ins_rec(W fd, B *buf, W size, W type, UH subtype, UW units);
```

Parameter

W	fd	file descriptor
B	*buf	pointer to the inserted record data
		NULL data is not written
W	size	byte size of the inserted record (≧0)
W	type	record type of inserted record
UH	subtype	subtype of the inserted record
UW	units	unit to get block (K bytes)
		0 any

Return Parameter

ER	ercd	error code

Description

Insert new record just before current record of the opened file.

"Units" specifies the unit to get blocks in K bytes necessary in inserted record, and specifies to allocate consecutive block area of greater than or equal to “units” size (less than or equal to size). The “units = 0 “means that any way to allocate blocks is allowed.

When “buf” = “NULL”, the size of inserted record becomes “size”, but the data is indeterminate. This is used to get record's block area beforehand in combination with “units” specification.

When “type = 0”, a link record is inserted and the content of “buf” is set to the “LINK” structure. By inserting a link record, the reference count of the file which the link indicates is incremented by one. In this case, the condition must be met that ”buf ≠ NULL”, “size = size of “LINK” structure”, and the file which the link indicates must exist in the same file system.

Append Record

tkse_apd_rec

C Language Interface

ER ercd = tkse_apd_rec(W fd, B *buf, W size, W type, UH subtype, UW units);

Parameter

W	fd	file descriptor	
B	*buf	pointer to the additional record data	
		NULL	data is not written
W	size	byte size of the additional record (≧0)	
W	type	record type of additional record	
U	subtype	record subtype of the additional record	
UW	units	unit to get block (K bytes)	
		0	any

Return Parameter

ER	ercd	error code

Description

Insert new record into the end of the opened file.

This system call is identical with “tkse_ins_rec()” except that a record is constantly inserted into the last record (before the end of record) regardless of the position of current record.

Delete Record
tkse_del_rec

C Language Interface

```
ER ercd = tkse_del_rec(W fd);
```

Parameter

W	fd	file descriptor

Return Parameter

ER	ercd	＜ 0	error code
		＝ 1	normal termination (deletion of link record results in reference count = 0)
		＝ 0	normal termination (other than the mentioned above)

Description

Delete the current record of the opened file and move the current record to the next record of the deleted one.

When the deleted record is a link record, the reference count of the file which the link record indicates is decremented by one. When reference count then results in zero, return value one is returned.

An error occurs when the current record is the end record, is locked by other process, or is the current record of other open process.

Truncate Record Size

tkse_trc_rec

C Language Interface

```
ER ercd = tkse_trc_rec(W fd, W size);
```

Parameter

W	fd	file descriptor
W	size	record byte size to be reduced (≧0)

Return Parameter

ER	ercd	error code

Description

Truncate record size of the current record of the opened file to “size” bytes. Nothing shall be executed when record size≦”size”.

An Error occurs when current record is the end record, link record, or locked by other processes

Exchange File Content

tkse_xch_fil

C Language Interface

```
ER ercd = tkse_xch_fil(W fd_1, W fd_2);
```

Parameter

W	fd_1	file descriptor 1
W	fd_2	file descriptor 2

Return Parameter

ER	ercd	error code

Description

Exchange the contents of the opened two files.

Only data part of file are exchanged; the file management information remains unchanged except access date and update time.

The two files to be exchanged must exist in the same file system and must be opened for update in the exclusive mode.

The current records after exchange are respectively the top record.

Record lock

tkse_loc_rec

C Language Interface

```
ER ercd = tkse_loc_rec(W fd, W mode);
```

Parameter

W	fd	file descriptor
W	mode	lock mode
		(F_UNLOCK || F_LOCK || F_TSLOCK || F_CKLOCK)

F_LOCK	lock setting (waiting)
F_UNLOCK	unlock
F_TSLOCK	lock setting (no waiting)
F_CKLOCK	check lock state

Return Parameter

ER	ercd	error code

Description

Lock the current record of the opened file.

When “F_LOCK” (lock (waiting)) is set and locked by other process, waits until it will be unlocked (waiting shall be in the priority order of process while the waiting with same priority shall be in the order of entering into waiting state). Normal termination shall be executed without any processing when locked by the same file descriptor of invoking process. An error occurs when locked by the other file descriptor of invoking process.

In the case “F_UNLOCK” (unlock) is set, normal termination shall be executed without any processing when the record is unlocked. Unlock is enabled only when locked by the same file descriptor of this process, otherwise an error occurs.

In the case “F_TSLOCK” (lock (no waiting)) is set, an error occurs when the record was locked by other process or other file descriptor.

In the case “F_CKLOCK” (check lock state) is set, when the record was locked by other process or other file descriptor, an error occurs, and otherwise normal termination shall be executed without any processing.

The file descriptor other than the locked file descriptor is prohibited from reading, writing, resizing, modifying and deleting the locked record.
The lock set by the opened process is released at file close.

Check File Access Privileges

tkse_chk_fil

C Language Interface

```
ER ercd = tkse_chk_fil(LINK *lnk, W mode, TC *pwd);
```

Parameter

LINK	*lnk	target file	
W	mode	check mode	
		([F_READ] | [F_WRITE] | [F_EXCUTE]) || [F_EXIST]	
		F_READ	check access privileges to read (R)
		F_WRITE	check access privileges to write (W)
		F_EXCUTE	check access privileges to execute/search (E)
		F_EXIST	check existence of file
TC	*pwd	password (valid only when “F_READ” or “F_WRITE” is specified)	
		NULL	no password specification

Return Parameter

ER	ercd	＜ 0	error code
		＝ 0	normal termination (when non-“F_EXIST” is specified)
		≧ 0	normal termination (file access information: when “F_EXIST” is specified)

Description

Check whether the access specified by specified file is enabled or not.

An error occurs when the access specified in combination with “F_READ”, “F_WRITE”, and “F_EXCUTE” is disabled.

Since password function is currently unsupported, “pwd” is set to NULL.

In the case of “F_EXIST” specification, an error occurs when the file does not exist; when the file exists, the following access information is returned as return value:

0.....0 BAPO SRWE

B: application attribute 2 (1:ON, 0:OFF)

A: application attribute 1	(1:ON, 0:OFF)
P: permanent attribute	(1:ON, 0:OFF)
O: Read-only attribute	(1:ON, 0:OFF)
S: with or without password	(1: with password, 0: without password)
R: access privileges to read (R)	(1: with password, 0: without password)
W: access privileges to write (W)	(1: with password, 0: without password)
E: access privileges to execute/search (E)	(1: with password, 0: without password)

Change File Access Mode

tkse_chg_fmd

C Language Interface

```
ER ercd = tkse_chg_fmd(LINK *lnk, A_MODE *mode);
```

Parameter

LINK	*lnk	target file
A_MODE	*mode	access mode to be changed

Return Parameter

ER	ercd	error code

Description

Change access mode of the specified file.

“F_NOCHG” specification to the each of following data of access mode means that the item should not be changed.

・owner access mode (f_ownac)
・group access level (f_grpacc)
・public access level (f_pubacc)
・owner group number (f_grpno)

Regarding the change of access mode, when access level in the file system is zero, anyone can change the access mode, However when access level is not zero, it can be changed by the process of the file owner only.

When the access modes of the files that have been already opened are changed, the changes will not affect the files that have been already opened.

Change File Access Attribute

tkse_chg_fat

C Language Interface

```
ER ercd = tkse_chg_fat(LINK *lnk, W attr);
```

Parameter

LINK	*lnk	target file
W	attr	access attribute to be changed

(F_SETRONLY || F_RSTRONLY || F_SETPERM || F_RSTPERM ||
F_SETA1 || F_RSTA1 || F_SETA2 || F_RSTA2)

F_SETRONLY	set read-only attribute
F_RSTRONLY	reset read-only attribute
F_SETPERM	set permanent attribute
F_RSTPERM	reset permanent attribute
F_SETA1	set application attribute 1
F_RSTA1	reset application attribute 1
F_SETA2	set application attribute 2
F_RSTA2	reset application attribute 2

Return Parameter

ER	ercd	error code

Description

Change the access attribute to the specified file.

Regarding the change of access mode, when access level in the file system is zero, only the access mode can be changed by anyone. However when access level is not zero, it can be changed by the process of the file owner.

When the access modes of the files that have been already opened are changed, the changes will not affect the files that have been already opened.

Change File name

tkse_chg_fnm

C Language Interface

```
ER ercd = tkse_chg_fnm(LINK *lnk, TC *name);
```

Parameter

LINK	*lnk	target file
TC	*name	file name to be changed (valid to TNULL or the maximum number of file name characters)

Return Parameter

ER	ercd	error code

Description

Change the file name of the specified file.

Regarding the change of file name, when access level in the file system is zero, the file name can be changed by anyone. However when access level is not zero, it can be changed by the process of the file owner only.

The name of the file whose unwritable or unremovable attribute is set cannot be changed. The name of the file with which read-only attribute or permanent attribute is set cannot be changed.

When the specified file is a link file, both the name of destination file for reference and reference file held in the link file are changed.

Change File Date and Time

tkse_chg_ftm

C Language Interface

```
ER ercd = tkse_chg_ftm(LINK *lnk, F_TIME *times);
```

Parameter

LINK	*lnk	target file	
F_TIME	*times	date and time to be changed	
		NULL	set to the current date and time

Return Parameter

ER	ercd	error code

Description

Change the shelf life, the latest access time, and the last updated time of the specified file.

When each value of “F_TIME” is less than or equal to zero, the item is not changed.

When access level in the file system is zero, the file date and time can be changed. However when access level is not zero, it can be change by the process of the file owner only.

Get file information

tkse_fil_sts

C Language Interface

```
ER ercd = tkse_fil_sts(LINK *lnk, TC *name, F_STATE *stat, F_LOCATE *locat);
```

Parameter

LINK	*lnk	target file	
TC	*name	storage area of file name (area for maximum file name + one character)	
		NULL	not stored
F_STATE	*stat	storage area of the file management information	
		NULL	not stored
F_LOCATE	*locat	storing area of the file location information	
		NULL	not stored

Return Parameter

ER	ercd	＜ 0	error code
		≧ 0	normal termination (reference count of the file)

Description

Retrieve the specified file information.

Get file information

tkse_ofl_sts

C Language Interface

```
ER ercd = tkse_ofl_sts(W fd, TC *name, F_STATE *stat, F_LOCATE *locat);
```

Parameter

W	fd	file descriptor
TC	*name	storage area of file name (area for maximum file name + one character)
		NULL not stored
F_STATE	*stat	storage area of the file management information
		NULL not stored
F_LOCATE	*locat	storage area of the file location information
		NULL not stored

Return Parameter

ER	ercd	＜ 0 error code
		≧ 0normal termination (reference count of the file)

Description

Retrieve the opened file information.

Get Link File Information

tkse_lnk_sts

C Language Interface

```
ER ercd = tkse_lnk_sts(LINK *lnk, F_LINK *stat);
```

Parameter

LINK	*lnk	target link file	
F_LINK	*stat	storage area of the link file information	
		NULL	not stored

Return Parameter

ER	ercd	＜ 0	error code
		≧ 0	normal termination (reference count of the link file)

Description

Retrieve the link file information of the specified link file.

When the specified file is not a link file, an error occurs.

Synchronize Link File

tkse_syn_lnk

C Language Interface

```
ER ercd = tkse_syn_lnk(LINK *lnk, W opt);
```

Parameter

LINK	*lnk	target link file
W	opt	synchronization attribute
		＝0 check only
		≠ 0 check and update

Return Parameter

ER	ercd	＜ 0 error code
		≧ 0 normal termination (synchronization state)

Description

Check whether the file name, the generation time held by the specified link file are matched with the actual file name and generation time of the destination file for reference.

Only check shall be executed when “opt=0”. When “opt ≠ 0” and the data does not match, updating shall be executed so that the information held by specified link file can be matched with the actual file name and generation time of the destination file for reference.

The return value indicates the following synchronization state:

F_SYNC	matching
F_DNAME	different file name
F_DDATE	different generation time
F_DBOTH	different in both file name and generation time

When the specified file is not a link file, an error occurs.

Get default access mode

tkse_get_dfm

C Language Interface

```
ER ercd = tkse_get_dfm(DA_MODE *mode);
```

Parameter

```
DA_MODE *mode     storage area of default access mode
        typedef struct {
                UH      f_ownacc;           /* owner access mode */
                UH      f_grpacc;           /* group access level */
                UH      f_pubacc;           /* public access level */
                H       f_grpno;            /* group number (0-4) */
                UH      f_gacc[N_GRP];      /* group access level */
        } DA_MODE;
```

Return Parameter

```
ER          ercd          error code
```

Description

Get default access mode.

The default access mode is applied when the access mode is not specified at file generation.

While “f_gacc[4]” as a data just for reference indicates a group access level set to each user group, “f_grpacc” as an actual group access level is actually applied.

Set default access mode

tkse_set_dfm

C Language Interface

```
ER ercd = tkse_set_dfm(DA_MODE *mode);
```

Parameter

DA_MODE *mode	default access mode to be set

Return Parameter

ER	ercd	error code

Description

Set default access mode.

The changed default access mode is valid for all processes.

Attach File system

tkse_att_fls

C Language Interface

```
ER ercd = tkse_att_fls(TC *dev, TC *name, LINK *lnk, UW mode);
```

Parameter

TC	*dev	device name
TC	*name	connection name (valid to TNULL or maximum number of characters for connection name)
LINK	*lnk	storage area of the link to root file of the attached file system
		NULL not stored
UW	mode	connection mode
		(FS_SYNC || FS_ASYN || FS_RONLY)
		FS_SYNC : synchronous write
		FS_ASYN : asynchronous write
		FS_RONLY : read-only

Return Parameter

ER	ercd	error code

Description

Connect up the file system in the specified device to the system by the specified connection name.

The connection name is used to specify the root file in the connected file system by absolute path name. It should not be the same as the connection names that have been already connected.

In the case “FS_SYNC” (synchronous write) is specified, writing into file is necessarily executed at the time of executing a write system call.
In the case “FS_ASYN” (asynchronous write) is specified, writing into file is not necessarily executed at the time of executing a write system call.
In the case “FS_RONLY” (read-only) is specified, every file write is prohibited.

An error occurs when reconnection of the connected file system is attempted or file system with the same file system name as the name of file system to which connecting is attempted is already connected. To connect the file system, connection access privileges to the device is needed.

Detach File system

tkse_det_fls

C Language Interface

```
ER ercd = tkse_det_fls(TC *dev, W eject);
```

Parameter

TC	*dev	device name	
W	eject	specify to eject	
		＝ 0	not eject
		≠ 0	eject (ignored, when device is unable to be ejected)

Return Parameter

ER	ercd	error code

Description

Detach the connected file system in the specified device from the system. At this time, when the content, etc. temporarily held in the memory exists, they shall be all written to the file system.

Detach is unavailable when a file in the file system targeted for detach is opened, or a process used as a working file exists.

To detach the file system, connection access privileges to the device is needed.

Synchronize File system

tkse_syn_fls

C Language Interface

```
ER ercd = tkse_syn_fls(void);
```

Parameter

none

Return Parameter

ER	ercd	error code

Description

The content, etc. temporarily held in the memory shall be all written to the file system, and the entire file system is updated to be existent for eliminating inconsistency. It shall be executed to all the connected file systems.

Get File system Management Information

tkse_fls_sts

C Language Interface

```
ER ercd = tkse_fls_sts(TC *dev, FS_STATE *buff);
```

Parameter

TC	*dev	device name
FS_STATE	*buff	storage area of the file system management information

Return Parameter

ER	ercd	＜ 0	error code
		＝ 0	normal termination (file system writable)
		＝ 1	normal termination (file system read-only)

Description

Retrieve the management information of the connected file system in the specified device.

To retrieve the management information of the file system, connection access privileges to the device is needed.

Change File system Information

tkse_chg_fls

C Language Interface

```
ER ercd = tkse_chg_fls(TC *dev, TC *fs_name, TC *fs_locate);
```

Parameter

TC	*dev	device name	
		An error occurs in the case of NULL.	
TC	*fs_name		file system name to be changed
		NULL	No change
TC	*fs_locate	device location name to be changed	
		NULL	No change

Return Parameter

ER	ercd	error code

Description

Change the names of both file system and the device location of the connected file system in the specified device.

To change file system information, connection access privileges and write access privileges to the device are needed.

Get Links Sequentially

tkse_get_nlk

C Language Interface

```
ER ercd = tkse_get_nlk(LINK *lnk);
```

Parameter

LINK	*lnk	link to the start file (input)
		storage area of link to next file (output)

Return Parameter

ER	ercd	＜ 0 error code
		≧ 0 normal termination (reference count of the retrieved file)

Description

Retrieve the link to a file with a minimum file ID among (out of) files with the file ID greater than the file ID of the specified start file.

The file ID of the start file can be that of of nonexistent file in practice. All the attribute data to the link to the retrieved file is set to zero.

This system call allows you to retrieve links to all files (including files with reference count = 0) in the file system.

Get File system

tkse_lst_fls

C Language Interface

```
ER ercd = tkse_lst_fls(F_ATTACH *buff, W cnt);
```

Parameter

```
F_ATTACH *buff     storage area of the file system connection information (array)
                   typedef struct {
                           TC      a_name[L_CONNM];/* connection name */
                           TC      dev[L_DEVNM];   /* logical device name */
                    } F_ATTACH;

W        cnt        ＞ 0            Indicate the element number of “buff”.
                    ＝ F_GETDEV     Get device name.
                    ＝ F_GETNAM     Get connection name.
```

Return Parameter

```
ER        ercd        ＜ 0  error code
                      ≧ 0  normal termination (the number of the connected file systems)
                      ＝ 1  normal termination (when “F_GETDEV” and “F_FETNAM” is specified)
```

Description

Retrieve the connection name and the device name of the file systems that have been already connected.

When “cnt > 0”, retrieve connection information of all the connected file systems to store in “buff”.
When the number of the connected file systems is greater than the number of specified element (cnt), retrieve only the first pieces as many information as the number of element (cnt).

When “cnt” is set to “F_GETDEV”, the device name corresponding to the connection name set to “buff->a_name[] “ shall be stored into in “buff->dev[]”.
When “cnt” is set to “F_GETNAM”, the connection name corresponding to the device name set to “buff->dev[]” shall be stored into in “buff->a_name[]”.

Map Record

tkse_map_rec

C Language Interface

```
ER ercd = tkse_map_rec(W fd, W offset, B **addr, W size, W mode);
```

Parameter

W	fd	file descriptor
W	offset	byte offset to start map
B	**addr	storage area of the mapped memory address
W	size	byte size to be mapped
W	mode	map mode
		([F_READ] | [F_WRITE] | [F_EXCUTE]) | [F_COMMON || F_SYSTEM]

F_READ	map to read
F_WRITE	map to write
F_EXECUTE	map to execute
F_COMMON	mapped to the shared memory space
F_SYSTEM	mapped to the system memory space

Return Parameter

ER	ercd	＜ 0	error code
		＞ 0	normal termination (map ID)

Description

Map the “size” bytes from “offset” of the current record of the opened file to memory space. The content of the mapped record can be accessed as a memory.

When “F_COMMON” is specified, it is mapped to the shared memory space. In this case, the access from all processes is enabled. When “F_SYSTEM” is specified, it is mapped to the system memory space. In this case, accessed from all system processes is enabled. The general application process, even if it is the mapped process itself, cannot access from the public application process. Consequently, this setting shall not be used by an application process.

When neither “F_COMMON” nor “F_SYSTEM” is specified, it is mapped on the local memory space of the mapping process. In this case, access from the non-mapping process is not enabled.

The address to be mapped is determined by the system, and cannot be specified by the application.
The map mode specification shall be consistent with the opened mode.(E_FD)

・”F_READ” open does not allow the mapping in “F_WRITE” mode.
・”F_WRITE” open does not allow the mapping in “F_READ” and “F_EXCUTE” mode.

A link record cannot be mapped.(E_REC)

During mapping, the following manipulations are prohibited, and an E_BUSY error occurs.

・del_rec　when the mapped record is targeted.
・wri_rec　when the mapped record is targeted.
・trc_rec　when the mapped record is targeted.
・xch_fil　when the file including the mapped record is targeted.

Mapping is restricted in the following cases:
・file system in the removable media
・file system with logical block size less than 4KB

Unmap Record

tkse_ump_rec

C Language Interface

```
ER ercd = tkse_ump_rec(W fd, W mapid);
```

Parameter

W	fd	file descriptor
W	mapid	map ID

Return Parameter

ER	ercd	error code

Description

Release the map specified by map ID of the opened file. The map set by the opened process is released at file close.

Change File system Connection Mode

tkse_chg_fsm

C Language Interface

```
ER ercd = tkse_chg_fsm(TC *dev, UW mode);
```

Parameter

TC	*dev	logical device name
UW	mode	connection mode (same as the mode of att_fls)
		(FS_SYNC || FS_ASYN || FS_RONLY)

FS_SYNC	synchronization
FS_ASYN	asynchronization
FS_RONLY	read-only

Return Parameter

ER	ercd	＜ 0	error code
		≧ 0	normal termination (connection mode before change)

Description

Change the connection state of the device “dev” to the connection mode specified by “mode”. “dev” must be an device that has been already connected. The connection mode before change is returned as a return value.

To change the connection mode, connection access privileges to the device “dev” is required.

When writable attribute is set before the connection mode change, even if the attribute is changed to unwritable, the write mode record map mapped by “tkse_map_rec()” is valid and writing is enabled. In the case a file is “F_WRITE” or “F_UPDATE” open, when connection mode is changed to read-only, writing to the file by “tkse_wri_rec()”, etc. causes an “E_RONLY” error.

Synchronize on File Basis

tkse_syn_fil

C Language Interface

```
ER ercd = tkse_syn_fil(W fd);
```

Parameter

fd	file descriptor

Return Parameter

ER	ercd	error code

Description

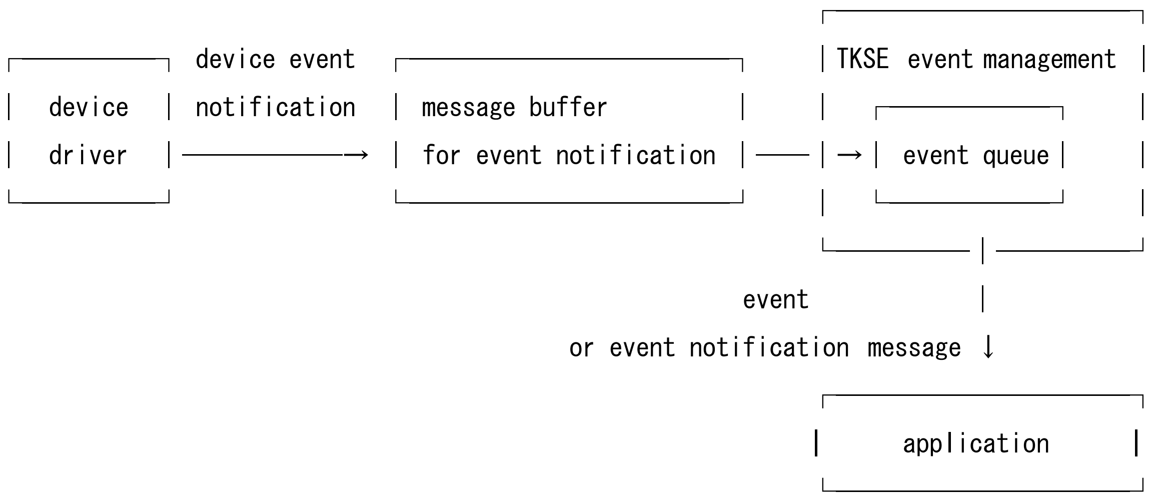
Regarding the file in specified open, the content, etc. temporarily held in memory of specified open file shall be written to the disk. Also the content written on the record map (tkse_rec_map) shall be written to the disk

4.8 Event Management Function

4.8.1 Event Management Function Overview

The event management function of Standard Extension uniformly treats notifications of phenomena from various devices as "events". The main purpose of event management function is to achieve interactive human interfaces. Therefore, keyboard and pointing devices are mainly assumed as the target devices of event management, but other devices can be supported.

The following figure describes the overview of event management scheme:


device driver
device event notification
message buffer for event notification
TKSE event management
event queue
event or event notification message
application

[Figure 11] Position of Event Management

The event notification from various devices is conveyed to the event management using the T-Kernel device event notification function. The event management creates events based on event notification from devices to sequentially store in the event queue.

The interface between the event management and devices essentially shall be device event notifications only. The function to control devices directly from the event management is not provided. In addition, the event management does not depend upon specific devices.

An application sequentially fetches an event from the event queue to execute an action corresponding to it.

The application also can get the notification of event occurrence by using the interprocess message function. Then, the notification (“tkse_brk_msg” call) of event occurrence in the interprocess message function is invoked from the event management when an event occurs.

At a certain point, it is premised on the rule that specific processes only fetch events by using the event management function. Applications should work according to the rule. The event management function itself does not provide a specific mechanism to ensure this rule.

4.8.2 Event Type

Events are distinguished by type number of 0-15 and, events of the following types are defined:

- type number 0 null event (EV_NULL):
  the pseudo event indicating that a target event has not occurred.

- type number 1 button down event (EV_BUTDWN):
  It occurs when the device button is pressed.

- type number 2 button up event (EV_BUTUP):
  It occurs when the device button is released.

- type number 3 key down event (EV_KEYDWN):
  It occurs when a key on the keyboard is pressed.

- type number 4 key up event (EV_KEYUP):
  It occurs when a key on the keyboard is released.

- type number 5 auto repeat key event (EV_AUTKEY):
  It periodically repeats when the target key of auto repeat is kept held down. The time (offset) taken until the first auto repeat key event from when the target key of auto repeat is pressed, and the recurrence interval (interval) can be set to any values.

- type number 6 device event (EV_DEVICE):
  It is a generic event which occurs according to device's certain operation, and the content depends on the device. This event occurs when removable media such as a disk are installed.

- type number 7 extended device event (EV_EXDEV):
  It is the device event (EV_DEVICE) appended by extended information.
  Used for the device events which have extended information such as ucode (ubiquitous ID).

- type number 8-15 application event (EV_APPL1 - EV_APPL8):
  Defined and used by applications and used as a communication function among applications.

A type mask corresponding to each event type is also defined and the target event type can be specified by this mask. The type mask is bit ready and the events of the type corresponding to "1" are targeted. However, a mask is not defined for a null event in the nature.

Event	type number	type mask
EV_NULL	0	------
EV_BUTDWN	1	EM_BUTDWN (0x0001)
EV_BUTUP	2	EM_BUTUP (0x0002)
EV_KEYDWN	3	EM_KEYDWN (0x0004)
EV_KEYUP	4	EM_KEYUP (0x0008)
EV_AUTKEY	5	EM_AUTKEY (0x0010)
EV_DEVICE	6	EM_DEVICE (0x0020)
EV_EXDEV	7	EM_EXDEV (0x0040)
EV_APPL1	8	EM_APPL1 (0x0080)
:	:	: :
EV_APPL8	15	APPL8 (0x4000)

Meanwhile, the following special masks are prepared as type masks:

EM_NULL	0x0000
EM_ALL	0x7fff

4.8.3 Event Creation from Device Event Notifications

The event management creates the event (Chapter 8.5 : EVENT Structure) from the event types (TDEvtTyp) for the device event notifications to be stored in the event queue. There are four event types, and each of them determines an event type as follows:

(1) Basic Event (TDEvtTyp = 0x0001 - 0x002F)

(A) Basic events other than keyboard / pointing device:

defined events:

TDE_unknown	0x00	undefined
TDE_MOUNT	0x01	media insert
TDE_EJECT	0x02	media eject
TDE_ILLMOUNT	0x03	illegal media insert
TDE_ILLEJECT	0x04	illegal media eject
TDE_REMOUNT	0x05	media reinsert
TDE_CARDBATLOW	0x06	card battery remaining alarm
TDE_CARDBATFAIL	0x07	card battery failure
TDE_REQEJECT	0x08	media eject request

→ These events are stored in the event queue as device event (EV_DEVICE).

Also, basic events other than the following keyboard and pointing device are device events (EV_DEVICE):

(B) Basic events such as keyboard / pointing device:

defined events:

TDE_PDBUT	0x11	PD button state change
TDE_PDMOVE	0x12	PD position move
TDE_PDSTATE	0x13	PD state change
TDE_PDEXT	0x14	PD extended event
TDE_KEYDOWN	0x21	key down
TDE_KEYUP	0x22	key up
TDE_KEYMETA	0x23	meta key state change

→ These events are stored in the event queue as button down (EV_BUTDWN), button up (EV_BUTUP), key down (EV_KEYDWN), and key up (EV_KEYUP).

(2) System Event (TDEvtTyp = 0x0030 - 0x007F)

defined events

TDE_POWEROFF	0x31	power switch off
TDE_POWERLOW	0x32	power remaining alarm
TDE_POWERFAIL	0x33	power failure
TDE_POWERSUS	0x34	auto power suspend
TDE_POWERUPTM	0x35	time update
TDE_CKPWON	0x41	autopower on notification

- The system events are not stored in the event queue.

(3) Event with Extended Information (TDEvtTyp = 0x0080 - 0x00FF)

defined events

→ nothing special.

- Events with extended information are stored in the event queue as an extended device event (EV_EXDEV).

(4) User-defined Event (TDEvtTyp = 0x0100 - 0xFFFF)

defined events

→ nothing special.

- The user-defined events are not stored in the event queue. Also, it is not used in event management as a general rule.

4.8.4 Priority of Event Queue and Event

The event queue is the queue exclusively prepared in the system for storing events, and the events are stored in the order they occur. If there is no space in the queue, newly occurring events, namely the newest event is not put in the queue to be discarded.
The events to be stored in the event queue are restricted by system event masks. That is, only the events of the type corresponding to the bit of system event mask "1" are put in the event queue. The events of the type corresponding to the bit of system event mask "0" are ignored by the entire system to be discarded.
At system startup, the event queue is blank while the system event mask is zero. And because the event management function does not work practically, the system event mask necessarily must be set to an appropriate value.

The following priorities are applied to the events according to each event type, and the event with the higher priority is fetched from the event queue. The events with same priority are fetched in the order they occur.

(1: highest priority - 6: lowest priority)
1. EV_APPL1-4
2. EV_BUTDWN, EV_BUTUP, EV_KEYDWN, EV_KEYUP
3. EV_AUTKEY
4. EV_DEVICE, EV_EXDEV
5. EV_APPL5-8
6. EV_NULL

The null event (EV_NULL) and the auto repeat event (EV_AUTKEY) are not actually put in the event queue, they are automatically created when condition is realized at an event fetch request.

4.8.5 Keyboard Events

(1) Regular Key and Meta Key

The keys are classified into regular keys which generate events when pressed or released and a meta key which does not generate events. The meta keys are keys which are used in combination with other regular keys, such as the shift key.

The following events are generated by pressing or releasing regular keys:

- Key down event (EV_KEYDWN): generated when a keyboard key is pressed.
- Key up event (EV_KEYUP): generated when a keyboard key is released.

• an auto repeat event (EV_AUTKEY): generated periodically when the target key is kept held down.

(2) Auto Repeat Key

Auto repeat key events (EV_AUTKEY) generated when the target auto repeat key is kept held down.
When one key is held down and while holding down another key, only the auto repeat key event of the last pressed key generated.
The key targeted for auto repeat can be set to any keys except meta keys which generate no event key, and every key except meta keys can be the target of auto repeat at system startup.
System calls for setting/fetching the time (offset time) taken to the first occurrence from pressing and the subsequent recurrence interval (interval time) are provided. This time is in milliseconds. However, the recurrence interval of auto repeat key events depends on the implementation. The offset time and the interval time are rounded to the unit of event occurrence time.

4.8.6 Character Code

At key events, the key top code designating a key's physical location, and the encoded character code are returned.
The key top code is a fixed 8 bit code (0-255) according to key's physical location.
The character code is a code encoded by the state of key top code and the meta key. The encode is executed by drivers or hardware, etc. below event management, and has no concern in event management.

4.8.7 Pointing Device Event

The pointing device is used to select objects shown on the screen, and has absolute coordinate values as current position corresponding to the screen resolution. The absolute coordinate values are the coordinate values which have the origin (0, 0) in the upper-left corner of the screen and employ one pixel on the screen as a unit.
The following events are generated by pressing or releasing buttons of the pointing device:

• button down event (EV_BUTDWN): generated when device button is pressed.
• button up event (EV_BUTUP): generated when device button is released.

4.8.8 Designates the Operation Type of the Pointing Device

The pointing devices are classified into the following two types from their behaviors as a whole:

(1) Absolute operation type
Those tablet typed pointing devices such as a digital pen, etc. and their coordinate values are absolutely

determined by the physical position of the pointing device.

(2) Relative operation type (differential type):
Those pointing devices with coordinate values that are relatively determined by the physical movement of the position of a pointing device such as mouse.

The calculation of absolute coordinate values in relative operation type is executed by drivers or hardware, etc. below event management and has no concern in event management.

4.8.9 Wheel Support

The wheel rotation of a wheel mouse is treated as an auto repeat key (EV_AUTKEY). However, the priority of an “EV_AUTKEY” event with the wheel is unlike those of the original “EV_AUTKEY” with key repeat, and is set to the lowest priority (higher than “EV_NULL”).
“EV_KEYDWN” and “EV_KEYUP” events by wheel rotation are not generated.
Wheel's events will automatically disappear from the event queue when either of the following conditions is realized:

(1) An application did not fetch the wheel event within 300 ms after the wheel is turned.

(2) An application fetched the events (except “EV_NULL”) other than the wheel event.

In addition, when the wheel was turned multiple times until an application fetches the event, the total amount is treated as one event. However, once the rotation direction is reversed, the previous rotation amount is discarded.

4.8.10 Event Structure

An Event is defined by the following structure:

```
        typedef struct {
                W           type;          /* event type */
                UW          time;          /* event occurrence time */
                PNT         pos;           /* the position of pointing device when an event occurs */
                EVDATA      data;          /* event specific data */
                UW          stat;          /* meta key, button state */
                UB          exdat[16];     /* extended information */
        } EVENT;
```

(1) type
The event type is indicated by a value in the range of 0-15.

(2) time
Indicate relative time in milliseconds, which shows the order and the interval of event occurrence and is meaningless as absolute time.
The event occurrence time is measured by an event timer. The event timer is implemented by using the system time management function in T-kernel. The event timer resolution depends on the implementation.

(3) pos
Indicate the coordinate values of the pointing device at an event occurrence in the value of absolute coordinates which have the origin (0, 0) in the upper-left corner of the screen. And it is the value of following "PNT" type.

```
        typedef struct point {
                H           x;             /* horizontal coordinate value */
                H           y;             /* vertical coordinate value */
        } PNT;
```

Meanwhile, the meaning of "pos" in the application events depends on the event definition.

(4) data
Indicate event-specific data and has event type-dependent content.

```
        typedef union {
                struct {    /* EV_KEYUP,EV_KEYDWN,EV_AUTKEY */
                    UH      keytop;        /* key top code */
                    TC      code;          /* character code */
        } key;
```

```
struct {        /* EV_DEVICE,EV_EXDEV */
                        H       kind;           /* device event type */
                        H       devno;          /* device number */
} dev;
W               info;           /* other data for event */
} EVDATA;
```

In the case of “EV_KEYDWN”, “EV_KEYUP”, or “EV_AUTKEY”, keys are applied, with consisting of key top code, which indicates the key's physical position, and the encoded character code.
The content of “EV_AUTKEY” event generated by wheel rotation is as follows:

data.key.keytop :	0x8000 + rotation amount	
	rotation amount ＞ 0	rotate the wheel forward
	rotation amount ＜ 0	rotate the wheel backward
data.key.code :	KC_SS_D	rotate the wheel forward
	KC_SS_U	rotate the wheel backward

In the case of “EV_DEVICE”,”dev” is applied. And the type (kind) of device event and the device number (devno) which indicates the device generated by event are set. The event types are defined as follows:

kind =	DE_unknown	0	-- undefined unknown
	DE_MOUNT	0x01	-- media insert
	DE_EJECT	0x02	-- media eject
	DE_ILLMOUNT	0x03	-- illegal media insert
	DE_ILLEJECT	0x04	-- illegal media eject
	DE_REMOUNT	0x05	-- media reinsert
	DE_BATLOW	0x06	-- battery remaining alarm
	DE_BATFAIL	0x07	-- battery failure
	DE_REQEJECT	0x08	-- media eject request
		0x09-0x7F	-- reserved

Also in the case of “EV_EXDEV”,”dev” is applied. And the type (kind) of device event and the device number (devno) which indicates the device generated by event are set. Usually, the event type of the device event notification is set only for the device event type (kind).

kind = XXXXXXXXXXX	0x80-0xFF	-- extended device event type (= device event type)

In the case of “EV_NULL”, “EV_BUTDWN”, or “EV_BUTUP”, this “data” is not used, and “info” is always zero.

In the case of application event (EV_APPL1-8), an event definition-dependent content is set.

(5) stat

Indicate bit ready for the state of the key or the button which does not generate events alone, such as a meta key at an event occurence. For each bit, "0" means released (OFF) state and "1" means pressed (ON) state. The meaning of each bit is defined as follows:

- bit 0- 1 (2bit) PD basic button:
  It indicates the state of main button and subbutton on the pointing device.

- bit 2-20 (19bit) meta key :
  It indicates the state of meta keys on the keyboard.
  The correspondence between each meta key and bit is undefined in the event management.

- bit 21 (1bit) PDtype :
  It indicates the type of the pointing device.

- bit 22-23 (2bit) PD state :
  It indicates the state of the pointing device.

- bit 24-31 (8bit) PD extended button:
  It indicates the state of extended button on the pointing device.
  The correspondence between each button and bit is not defined in the event management.

(6) exdat

Valid when the event type (type) is an extended device event (EV_EXDEV).

Used to store the extended information (16 bytes) mainly passed from the device event notification, such as ucode.

4.8.11 System Calls

Get Event

tkse_get_evt

C Language Interface

ER ercd = tkse_get_evt(W t_mask, EVENT* evt, W opt);

Parameter

W	t_mask	mask of target event type
EVENT*	evt	storage area of obtained event
W	opt	attribute of obtainment
		(CLR || NOCLR)
		CLR　　eliminated from the event queue
		NOCLR　　not eliminated from the event queue

Return Parameter

ER	ercd	≧ 0	normal termination (obtained event type)
		＜ 0	error code

Error Code

E_MACV	access to inaccessible address (evt) not allowed
E_IO	input/output error occurred (some device error occurred)
E_PAR	illegal parameter (t_mask ≦ 0, illegal “opt”)
E_SYSMEM	insufficient system memory area

Description

Fetch the event of the type specified by “t_mask” from the event queue to be stored in the area specified by “evt”.
Without the event of specified type, “EV_NULL” is fetched.
The process when fetching an event from the event queue is specified by “opt”.

Event Occurrence

tkse_put_evt

C Language Interface

```
ER ercd = tkse_put_evt(EVENT* evt, W opt);
```

Parameter

EVENT*	evt	event to occur
W	opt	occurrence attribute
		(EP_NONE || EP_ALL || ([EP_POS] | [EP_STAT] | [EP_TIME]))

EP_NONE	“time”, “pos”, and “stat” are set to the content of “evt” as-is.
EP_ALL	all of “time”, “pos”, and “stat” are set.
EP_POS	position of the current pointing device is set to “pos”.
EP_STAT	state of the current meta key/PD button is set to “stat”.
EP_TIME	value of the current event timer is set to “time”.

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (evt) not allowed
E_IO	input/output error occurred (some device error occurred)
E_SYSMEM	insufficient system memory area
E_PAR	illegal parameter (illegal event type, illegal “opt”)

Description

Generate the event specified by “evt” and put in the event queue. An error occurs when the event queue is full or “EV_NULL” and “EV_AUTKEY” are specified. Also, events out of target in the system event mask are actually not generated and ignored.
The generated events are considered to be generated when this system call is executed, regardless of the “time” value, and are always put in the end of the event queue.

Clear Event

tkse_clr_evt

C Language Interface

ER ercd = tkse_clr_evt(W t_mask, W last_mask);

Parameter

W	t_mask	event type mask targeted to clear	
		＝ EM_ALL	all event types
W	last_mask	last event type mask to clear	
		＝ EM_ALL	clear only one event
		＝ EM_NULL	target is to the end of the event queue

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_PAR	illegal parameter (“t_mask≦0”, “last_mask＜0”)

Description

Clear generated events.
Out of the events in the event queue, events of the type specified by “t_mask” shall be cleared to the right before of the events of the type specified by the “last_mask”. The events of the type of specified by the “last_mask” are not cleared. However, when “last_mask” = “EM_ALL”, it means that only one event of the “last_mask” type is specifically cleared. Also, When “last_mask” = “EM_NULL”, the target is set to the end of the event queue.

Examples to combine “t_mask” and the “last_mask” are shown as follows:

t_mask	last_mask	behavior
EM_ALL	EM_NULL	clear all events
--	EM_ALL	clear only one event specified by “t_mask”
EM_ALL	EM_ALL	clear only the one start event

Get Event Timer Value

tkse_get_etm

C Language Interface

```
RR ercd = tkse_get_etm(UW* time);
```

Parameter

UW	*time	storage area of event timer value

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (time) not allowed

Description

Fetch the current value of the event timer.
The event timer is a relative time in milliseconds, but its actual resolution depends on the implementation.
This system call is generally used to fetch a relative time in milliseconds.

Change System Event Mask

tkse_chg_emk

C Language Interface

```
ER o_mask = tkse_chg_emk(W mask);
```

Parameter

W	mask	system event mask to set	
		＜ 0	not change (obtain current system event mask)

Return Parameter

ER	o_mask	original system event mask

Description

Change the system event mask to the value specified by the “mask”, and return the value of the original system event mask as a return value.
When “mask <0”, the value of current system event mask shall be returned as a return value without any changes.

Request Event Message

tkse_req_evt

C Language Interface

```
ER ercd = tkse_req_evt(W t_mask);
```

Parameter

W	t_mask	target event type mask

Return Parameter

ER	ercd	error code

Error Code

The messages are as follows:

E_OK	normal termination
E_PAR	illegal parameter
E_LIMIT	the system limit is exceeded by the number of registration of event message requests

Description

When an event of the type specified by the “t_mask” is generated, sending of the event as a message to this process is requested. However, “EV_NULL” and “EV_AUTKEY” cannot be sent as messages.
In addition, the event is not eliminated from the event queue even if it is sent as message.

The event message request is cleared by specifying “EM_NULL” to the “t_mask”. Also, it shall be automatically cleared after the process is completed.

```
struct {
        W         msg_type;    /* message type = MS_SYS5 */
        W         msg_size;    /* message size */
        EVENT     evt;         /* event */
        VB        info[];      /* additional information */
}
```

“msg_type” shall be fixed to “MS_SYS5”.
The generated events are stored in “evt”. Meanwhile, additional information may be stored in info according to event types. Therefore, “msg_size” is at least equivalent to “sizeof”(EVENT) and its size increases by the size of additional information. The size varies according to the content of additional information.

Additional information is appended in the case of device event (EV_DEVICE). Additional information is the content of the event notification itself from the device driver.

The sending process ID when receiving messages from “tkse_rcv_msg()” is the process ID when invoking “tkse_put_evt()”. In the case the event was generated by “tkse_put_evt()”. Otherwise, ID = 1 (initial process).

When sending is unsuccessful because the process message queue is full, the event message is simply discarded. The maximum number of processes to simultaneously execute the requests of process event message is limited by the system.

Get Elapsed Time from the Last Event Occurrence

tkse_las_evt

C Language Interface

```
ER ercd = tkse_las_evt(W t_mask);
```

Parameter

W	t_mask	target event type mask

Return Parameter

ER	ercd	≧ 0	normal termination (elapsed time from the last event occurrence)
		＜ 0	error code

Error Code

E_PAR	illegal parameter

Description

Out of events of the type specified by “t_mask”, elapsed time shall be retuned in milliseconds from the last generated event to the current time.
When “EM_BUTDWN” or “EM_BUTUP” is specified to “t_mask”, the pointer movement and the menu button operation are treated as an event occurrenceas well. Also when “EM_KEYDWN” or “EM_KEYUP” is specified, the change of the meta key state is treated as an event occurrence.
The current time is set to the last occurrence time of events of all types by specifying “EM_NULL” to “t_mask”.

Set Auto Repeat Target Key

tkse_set_krm

C Language Interface

ER ercd = tkse_set_krm(KeyMap keymap);

Parameter

KeyMap	keymap	meymap targetd for auto repeat

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (keymap) not allowed

Description

Set the key targetd for auto repeat to the value specified by the “keymap”.
The “keymap” is an array which associates a single key (key top code) with one bit, and is defined as follows:

```
typedef UB          KeyMap[KEYMAX/8];
```

“KEYMAX” is a maximum value of key top codes. The “keymap” structure is as follows:

```
      MSB                                              LSB
      ┌──────┬──────┬──────┬──────┬──────┬──────┬──────┬──────┐
   0  │  00  │  01  │  02  │  03  │  04  │  05  │  06  │  07  │
      │      │      │      │      │      │      │      │      │
     ~                                                        ~
      ├──────┼──────┼──────┼──────┼──────┼──────┼──────┼──────┤
  31  │  F8  │  F9  │  FA  │  FB  │  FC  │  FD  │  FE  │  FF  │
      └──────┴──────┴──────┴──────┴──────┴──────┴──────┴──────┘
```

number is key top code in hexadecimals

[Figure 12] KeyMap structure

The key corresponding to the bit of the specified keymap "1" is set to the target of the auto repeat, the key corresponding to the bit of keymap "0" is not set to the target of the auto repeat.
Meta keys which do not generate events are ignored even if they are set to the auto repeat target.

Get Auto Repeat Target Key

tkse_get_krm

C Language Interface

```
ER ercd = tkse_get_krm(KeyMap keymap);
```

Parameter

KeyMap	keymap	storage area of key map targeted for auto repeat

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (keymap) not allowed

Description

Fetch the key targeted for auto repeat to be stored in the area specified by the “keymap”.
The key corresponding to the bit of the fetched keymap "1" is the target of the auto repeat while the key corresponding to the bit of keymap "0" is not the target of the auto repeat.

Set Auto Repeat Interval

tkse_set_krp

C Language Interface

```
ER ercd = tkse_set_krp(W offset, W interval);
```

Parameter

W	offset	time taken to the occurrence of first auto repeat (in milliseconds)
W	interval	auto repeat recurrence interval (in milliseconds)

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_PAR	illegal parameter (offset≦0, interval≦0)

Description

The time and interval until the occurrence of auto repeat key event (EV_AUTKEY) shall be to the value specified by “offset” and “interval”.
The time is set in milliseconds, however its actual resolution depends on the implementation.

Get Auto Repeat Interval

tkse_get_krp

C Language Interface

```
ER ercd = tkse_get_krp(W* offset, W* interval);
```

Parameter

W	*offset	storage area of the elapsed time until the first occurrence of auto repeat (in milliseconds)
W	*interval	storage of the interval of the occurrence of auto repeat (in milliseconds)

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (“offset”,”interval”) not allowed

Description

Fetch the time and interval until the occurrence of auto repeat event (EV_AUTKEY), to be stored in the area specified by the “offset” and “interval”.

Get PD Position

tkse_get_pdp

C Language Interface

```
ER ercd = tkse_get_pdp(PNT* pos);
```

Parameter

PNT*	pos	storage area of PD position

```
typedef struct point {
        H       x;      /* horizontal coordinate value */
        H       y;      /* vertical coordinate value */
} PNT;
```

Return Parameter

ER	ercd	≧ 0	type of occurred event (normal termination)
		＜ 0	error code

Error Code

E_MACV	access to inaccessible address (pos) not allowed

Description

The position of the current pointing device is fetched in absolute coordinate values.
the type of simultaneously occurring event shall be returned. “EV_NULL “shall be returned when no event occurs.
The content of the event queue shall be unchanged.

4.9 Device Management Function

4.9.1 Device Management Function Overview

The device management function of Standard Extension provides functions to operate devices. The devices are registered devices to the system by T-Kernel device management function. Standard Extension does not have the function to register devices. Besides this, device management function of Standard Extension is essentially equivalent to T-Kernel device management function. See T-Kernel specifications for details.

4.9.2 Basic Concepts

(1) Device Name (UB* type)
A device name is a string of up to 8 characters consisting of the following elements.

```
#define    L_DEVNM    8        /* Device name length */
```

Type:
    Name indicating the device type
    Characters a to z and A to Z can be used.
Unit:
    One letter indicating a physical device
    Each unit is assigned a letter from a to z in order starting from a.
Subunit:
    One to three digits indicating a logical device
    Each subunit is assigned a number from 0 to 254 in order starting from 0.

Device names take the format type + unit + subunit. Some devices may not have a unit or subunit, in which case the corresponding .eld is omitted.
A name consisting of type + unit is called a physical device name. A name consisting of type + unit + subunit may be called a logical device name to distinguish it from a physical device name. If there is no subunit, the physical device name and logical device name arE_IDentical. The term "device name" by itself means the logical device name.
A subunit generally refers to a partition on a hard disk, but can be used to mean other logical devices as well.

Examples:

hda	Hard disk (entire disk)hda
hda0	Hard disk (1st partition)
fda	Floppy disk
rsa	Serial port
kbpd	Keyboard/pointing device

(2) Device ID (ID type)

By registering a device (device driver) with T-Kernel/SM, a device ID (> 0) is assigned to the device (physical device name). Device IDs are assigned to each physical device. The device ID of a logical device consists of the device ID assigned to the physical device to which is appended the subunit number + 1 (1 to 255).

devid:
The device ID assigned at device registration

devid	Physical device
devid + n + 1	The nth subunit (logical device)

Examples:

hda	devid	Entire hard disk
hda0	devid + 1	1st partition of hard disk
hda1	devid + 2	2nd partition of hard disk

(3) Device Attribute (ATR type)

Device attributes are defined as follows, in order to classify devices by their properties.

```
IIII IIII IIII IIII PRxx xxxx KKKK KKKK
```

The high 16 bits are device-dependent attributes defined for each device.
The low 16 bits are standard attributes defined as follows.

```
#define     TD_PROTECT          0x8000      /* P: write protection */
#define TD_REMOVABLE            0x4000      /* R: removable media*/
#define     TD_DEVKIND          0x00ff      /* K: device/media kind */
#define     TD_DEVTYPE          0x00f0      /* device type */

                                            /* device type */
#define     TDK_UNDEF           0x0000      /* undefined/unknown */
#define     TDK_DISK            0x0010      /* disk device*/

                                            /* disk kind*/
#define     TDK_DISK_UNDEF      0x0010      /* miscellaneous disk */
#define     TDK_DISK_RAM        0x0011      /* RAM disk (used as main memory) */
#define     TDK_DISK_ROM        0x0012      /* ROM disk (used as main memory) */
#define     TDK_DISK_FLA        0x0013      /* Flash ROM or other silicon disk*/
#define     TDK_DISK_FD         0x0014      /* floppy disk*/
#define     TDK_DISK_HD         0x0015      /* hard disk*/
#define     TDK_DISK_CDROM      0x0016      /* CD-ROM*/
```

Currently no device types other than disks are defined. Other devices are assigned to undefined type (TDK UNDEF). Note that device types are defined for the sake of distinguishing devices from the standpoint of the user as necessary, such as when applications must change their processing based on the type of device or media. Devices for which no such distinctions are necessary do not have to have a device type assigned. See the individual device driver specifications regarding device-dependent attributes.

(4) Device Descriptor (ID type)

A device descriptor (> 0) is an identifier used for accessing a device, assigned by T-Kernel/SM when a device is opened.

A device descriptor belongs to a resource group. Operations using a device descriptor can be performed only by tasks belonging to the same resource group as the device descriptor. Error code (E_OACV) is returned for requests from tasks belonging to a di.erent resource group.

(5) Request ID (ID type)

When an IO request is made to a device, a request ID (> 0) is assigned identifying the request. This ID can be used to wait for IO completion.

(6) Data Number (INT type)

Device data is specified by a data number. Data is classi.ed into device-specific data and attribute data as follows.

Device-specific data: Data number　> 0

As device-specific data, the data numbers are defined separately for each device.

Examples:

Disk	Data number = physical block number
Serial port	Data number = 0 only

Attribute data: Data number < 0

Attribute data specifies driver or device state acquisition and setting modes, and special functions, etc. Data numbers common to devices are defined, but device-dependent attribute data can also be defined. Details are given later.

4.9.3 System Calls

Open Device

tkse_opn_dev

C Language Interface

ID dd = tkse_opn_dev(UB *devnm, UINT omode) ;

Parameter

UB*	devnm	device name
UNIT	o_mode	open mode

omode := (TD_READ || TD_WRITE || TD_UPDATE) |
[TD_EXCL || TD_WEXCL || TD_REXCL] | [TD_NOLOCK]

TD_READ	open for reading
TD_WRITE	open for writing
TD_UPDATE	open for updating (reading/writing)
TD_EXCL	exclusive
TD_WEXCL	exclusive write
TD_REXCL	exclusive read
TD_NOLOCK	unnecessary lock (resident)

Return Parameter

ID	dd	＞ 0	device descriptor (normal termination)
		＜ 0	error code

Error Code

E_MACV	access to address (dev,error) not allowed
E_BUSY	the device (dev) is already opened exclusively.
E_OACV	the read or write processing to the device (dev) is not allowed.
E_NOEXS	no device (dev) present (not registered)
E_LIMIT	maximum open device number exceeded
Others	errors returned from device drivers

Description

Opens the device specified by dev in the mode specified by o_mode, and returns a device descriptor if successful. The exclusive mode and exclusive write mode limit the opening of one device at the same time.

When the process which opened a device exits, the device will be automatically closed.

Close Device

tkse_cls_dev

C Language Interface

```
ER ercd = tkse_cls_dev( ID dd, UINT option );
```

Parameter

ID	dd	device descriptor
UINT	option	close option

option:= [TD_EJECT]

TD_EJECT	media eject (ignored for unejectable devices)

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_ID	no device descriptor present
Others	errors returned from device drivers

Description

Closes the device specified by dd.

Read Device Data (Asynchronus)

tkse_rea_dev

C Language Interface

```
ID reqid = tkse_rea_dev( ID dd, INT start, VP buf, INT size, TMO tmout );
```

Parameter

ID	dd	device descriptor
INT	start	start position for reading (≧ 0: specific data, ＜ 0: attribute data)
VP	buf	storing area of read data
INT	size	read data size
TMO	tmout	timed-out for request accept (millisecond)

Return Parameter

ID	reqid	＞ 0	request ID (normal termination)
		＜ 0	error code

Error Code

E_MACV	not allowed to access address
E_ID	there exists no device descriptor, or it is D_WRITE opened.
E_OACV	the read processing to the device (dd) is not allowed.
E_NOMDA	no device (dd) media present
E_LIMIT	maximum request number exceeded
E_TMOUT	timeout
E_ABORT	abort
Others	errors returned from device drivers

Description

Starts to read the data of the device specified by dd from the start position specified by start by the size specified by size to the area specified by buf. Returns to its caller without waiting for completion of reading.

If size = 0, actual reading is not performed, but current readable data size is checked.

Read Device Data (Synchronus)

tkse_srea_dev

C Language Interface

```
ER ercd = tkse_srea_dev( ID dd, INT start, VP buf, INT size, INT *asize );
```

Parameter

ID	dd	device descriptor
INT	start	start position for reading (≧ 0: specific data, ＜ 0: attribute data)
VP	buf	storing area of read data
INT	size	read data size
INT*	asize	read data size

Return Parameter

ER	ercd	error code

Error Code

E_MACV	not allowed to access address
E_ID	there exists no device descriptor, or it is D_WRITE opened.
E_OACV	the read processing to the device (dd) is not allowed.
E_NOMDA	no device (dd) media present
E_LIMIT	maximum request number exceeded
E_ABORT	abort
Others	errors returned from device drivers

Description

Read the data of the device specified by dd from the start position specified by start by the size specified by size to the area specified by buf. If reading is complete, actual read size is set to asize, returning its caller.

If size = 0, actual reading is not performed, but current readable data size is returned to asize.

Write Data to Device (Asynchronus)

tkse_wri_dev

C Language Interface

```
ID reqid = tkse_wri_dev( ID dd, INT start, VP buf, INT size, TMO tmout );
```

Parameter

ID	dd	device descriptor
INT	start	start position for writing (≧ 0: specific data, ＜ 0: attribute data)
VP	buf	storing area of write data
INT	size	read data size
TMO	tmout	timed-out for request accept (millisecond)

Return Parameter

ID	reqid	＞ 0	request ID (normal termination)
		＜ 0	error code

Error Code

E_MACV	access to address (buf,a_size,error) not allowed
E_ID	there exists no device descriptor, or it is D_READ opened.
E_OACV	the write processing to the device (dev) is not allowed.
E_NOMDA	no device (dd) media present
E_RONLY	unwritable device (dev)
E_LIMIT	maximum request number exceeded
E_TMOUT	timeout
E_ABORT	abort
Others	errors returned from device drivers

Description

Starts to write data to the device specified by dd from the start position specified by start by the size specified by size from the area specified by buf. Returns to its caller without waiting for completion of writing.

If size = 0, actual writing is not performed, but current writable data size is checked.

Write Data to Device (Synchronus)

tkse_swri_dev

C Language Interface

```
ER ercd = tkse_swri_dev( ID dd, INT start, VP buf, INT size, INT *asize );
```

Parameter

ID	dd	device descriptor
INT	start	start position for writing (≧ 0: specific data, ＜ 0: attribute data)
VP	buf	storing area of write data
INT	size	read data size
INT	asize	read data size

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to address (buf,a_size,error) not allowed
E_ID	there exists no device descriptor, or it is D_READ opened.
E_OACV	the write processing to the device (dev) is not allowed.
E_NOMDA	no device (dd) media present
E_RONLY	unwritable device (dev)
E_LIMIT	maximum request number exceeded
E_ABORT	abort
Others	errors returned from device drivers

Description

Write data to the device specified by dd from the start position specified by start by the size specified by size from the area specified by buf. If writing is complete, actual written size is set to asize, returning its caller.

If size = 0, actual writing is not performed, but current writable data size is returned to asize.

Wait for Request Completion for Device

tkse_wai_dev

C Language Interface

```
ID reqid = tkse_wai_dev( ID dd, ID reqid, INT *asize, ER *ioer, TMO tmout );
```

Parameter

ID	dd	device descriptor
ID	reqid	request ID
INT*	asize	read/write size
ER*	ioer	input/output error
TMO	tmout	timed-out (millisecond)

Return Parameter

ER	ercd	error code

Error Code

E_ID	illegal dd or reqid
E_OBJ	reqid request is waiting for other task's completion
E_NOEXS	no processing request (when reqid = 0)
E_TMOUT	timeout
E_ABORT	abort
Others	errors returned from device drivers

Description

Waits for reqid request's completion for the device specified by dd. If reqid = 0, the completion of one of the requests for dd is waited.

Request to Suspend Device

tkse_sus_dev

C Language Interface

```
ER ercd = tkse_sus_dev(UINT mode);
```

Parameter

UINT	mode	mode specification	
		mode ::= D_EMRGSUS || D_SUSPEND | [D_FORCE]	
		|| D_DISSUS || D_ENASUS || D_CHECK	
		|| D_NOTIFY | [D_NOTSUS] | [D_NOTRES]	
		D_SUSPEND	suspend
		D_DISSUS	prohibit suspend
		D_ENASUS	permit suspend
		D_CHECK	check suspend prohibit count
		D_EMRGSUS	emergency suspend
		D_FORCE	forced suspend specification
		D_NOTIFY	notification request
		D_NOTSUS	notification to suspend
		D_NOTRES	resume notification

Return Parameter

ER	ercd	≧ 0	normal termination (if D_CHECK, suspend prohibit request count)
		＜ 0	error code

Error Code

E_BUSY	unable to suspend because of suspend inhibited state
E_PAR	illegal parameter
E_LIMIT	suspend prohibit request count limit exceeded
E_DISWAI	processing suspended because message handler is invoked

Description

Controls system suspend.

Retrieve Device Name

tkse_get_dev

C Language Interface

```
ID pdid = tkse_get_dev( ID devid, UB *devnm )
```

Parameter

ID	devid	device ID
UB*	devnm	storing area of device name

Return Parameter

ID	pdid	≧ 0	normal termination (physical device ID)
		＜ 0	error code

Error Code

E_MACV	access to address (dev) not allowed
E_NOEXS	device ID not present

Description

Retrieves the device name of the device with device ID specified by devno, and stores it to the area specified by devnm. Then, the device IS of the physical device to which the device belongs is returned as a return value.

The specified device ID is a device number fetched by a device event.

Retrieve Device Information

tkse_ref_dev
tkse_oref_dev

C Language Interface

```
ID devid = tkse_ref_dev( UB *devnm, T_RDEV *rdev );
ID devid = tkse_oref_dev( ID dd, T_RDEV *rdev ) ;
```

Parameter

UB*	devnm	target device name
ID	dd	target device descriptor
T_RDEV*	rdev	storing area of device management information

Return Parameter

ID	devid	≧ 0	normal termination (device ID)
		＜ 0	error code

device management information

```
        typedef struct   {
                ATR       devatr;       /* device attribute */
                INT       blksz;        /* physical block size (-1: unknown) */
                INT       nsub;         /* number of subunits */
                INT       subno;        /* 0: physical device, 1-nsub: subunit number + 1 */
        } T_RDEV;
```

Error Code

E_MACV	not allowed to access address
E_NOEXS	device not present

Description

Retrieves information of the device specified by devnm or dd, and stores it to the area specified by rdev.

Retrieve Registered Devices

tkse_lst_dev

C Language Interface

```
INT num = tkse_lst_dev( T_LDEV *ldev, INT start, INT ndev ) ;
```

Parameter

T_LDEV	*ldev	storing area of registered device information (array)
INT	start	start number
INT	ndev	retrieved number

Return Parameter

INT	num	≧ 0	normal termination (remaining registered number)
		＜ 0	error code

```
typedef struct {
        ATR     devatr;         /* device attribute */
        INT     blksz;          /* specific data's block size (-1: unknown)
        INT     nsub;           /* number of subunits */
        UB      devnm[L_DEVNM]; /* physical device name */
} T_LDEV;
```

Error Code

E_MACV	access to address (dev) not allowed
E_NOEXS	start exceeds the registered number
E_PAR	illegal parameter (ndev＜ 0)

Description

Retrieves registered device information and stores it to the area specified by ldev. Then, remaining device number is returned as a return value.

4.10 Time Management

4.10.1 Time Management Overview

The time management function of Standard Extension provides such functions as to retrieve and set the system time as base time held within system, and to convert between system time and calendar date and time.

The system time is used to represent system's internal times such as the date and time to create, update or access files.

The system time is a 32 bit value represented by seconds since the date and time at 00:00:00 GMT (Greenwich Mean Time), Jan 1, 1985, and is defined as follows:

```
typedef W   STIME;
```

As opposed to system time, the time of the region in which the machine actually exists is called local time. The time management function also holds the time difference between system time and local time, and provides functions to retrieve and set date and time based upon local time.

The relationship between system time and local time is defined as time compensation data as follows:

```
typedef struct {
            W           adjust;       /* time difference with system time (second) */
            W           dst_flg;      /* DST application type */
            W           dst_adj;      /* DST running-in time (minute) */
} TIMEZONE;
```

dst_flg indicates the application type of Daylight Saving Time (DST), and zero value indicates no application. The values other than zero indicates application. The value other than zero is meaningless in the time management function, only whether the data is zero or not is important .

dst_adj is a value in the range - (12 x 60) - + (12 x 60) which indicates DST running-in time (minute). The time management function does not determine whether to apply DST or not. At the start time of the period during which DST is actually applied, the system program is assumed to set an appropriate value to dst_adj, and at the end time of the period during which DST is applied, it is assumed to set zero to dst_adj.

The time compensation data allows you to define local time with the following expression:

```
local time (second)
            = system time (second) - adjust + (dst_flg ? (dst_adj x 60): 0)
```

The time management function also supports calendar date and time defined by the following structure, and provides a function to convert between this and system time:

```
typedef struct {
        W       d_year;     /* offset from 1985 (85-) */
        W       d_month;    /* month ( 1 - 12, 0) */
        W       d_day;      /* day ( 1 - 31 ) */
        W       d_hour;     /* hour ( 0 - 23 ) */
        W       d_min;      /* minute ( 0 - 59 ) */
        W       d_sec;      /* second ( 0 - 59 ) */
        W       d_week;     /* week ( 1 - 54 ) */
        W       d_wday;     /* a day of the week (0 - 6, 0: Sunday) */
        W       d_days;     /* day ( 1 - 366 ) */
} DATE_TIM;
```

d_week represents a week number when week 1 starts at the week of Jan 1 of the year, and d_days represents a day number when day 1 starts on Jan 1 of the year. In addition, d_month = 0 is used to hold a special meaning.

4.10.2 System Calls

Refer System Time

tkse_get_tim

C Language Interface

```
ER ercd = tkse_get_tim(SYSTIM *pk_tim);
```

Parameter

SYSTIM*	pk_tim	packet address which returns current time

content of pk_tim

SYSTIM	systim	current time for system setting

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_PAR	illegal parameter (illegal pk_tim)

Description

Reads current value of the system time and returns it in the pk_tim.
The system time may be consecutive seconds since the date and time at 00:00:00 GMT, Jan 1, 1985.

Set System Time

tkse_set_tim

C Language Interface

```
ER ercd = tkse_set_tim(SYSTIM *pk_tim);
```

Parameter

SYSTIM*	pk_tim	packet address which indicates current time

content of pk_tim

SYSTIM	systim	current time for system setting

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_PAR	illegal parameter (illegal pk_tim)

Description

Sets the value denoted by pk_tim to system time value.

The system time may be consecutive seconds since the date and time at 00:00:00 GMT, Jan 1, 1985.

Refer System Uptime

tkse_get_otm

C Language Interface

```
ER ercd = tkse_get_otm(SYSTIM *pk_tim);
```

Parameter

SYSTIM*	pk_tim	packet address which returns uptime

content of pk_tim

SYSTIM	opetim	current time for system setting

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_PAR	illegal parameter (illegal pk_tim)

Description

Retrieves the system uptime.

The system uptime is different from system time, and it represents simply increasing uptime from system startup. Not affected by the time setting using tkse_set_tim. The system uptime should have the same precision as system time.

4.10.3 Library Calls

Conversion functions for system time, calendar date, local time, and Greenwich mean time (GMT).

The valid value for total number of seconds is in the range of 0x00000000-24*60*60 - 0x7fffffff+24*60*60 (including a day before or after system time for time compensation by TIMEZONE). The valid years are 1985-2053. For functions which take calendar time as a parameter, the operation is not ensured when illegal calendar time is specified.

Convert Calendar Date to total number of seconds

DATEtoTIME

C Language Interface

```
void DATEtoTIME(STIME *time, DATE_TIM *date);
```

Parameter

STIME	*time	storage area of total number of seconds
DATE_TIM	*date	calendar time

Return Parameter

none

Description

1

Convert the calendar date specified by “date” to total number of seconds starting from 00:00:00 GMT, Jan 1, 1985 to be stored in “*time”.

Convert consecutive seconds the total number of seconds to Calendar Date TIMEtoDATE

C Language Interface

```
void TIMEtoDATE(DATE_TIM *date, STIME time);
```

Parameter

DATE_TIM	*date	storage area of calendar time
STIME	time	total number of seconds

Return Parameter

none

Description

Convert the total number of seconds specified by “time” starting from 00:00:00 GMT, Jan 1, 1985 to calendar time to be stored in “*date”.

local time compensation

GMTtoLT

C Language Interface

```
STIME ltim = GMTtoLT(STIME time, TIMEZONE *tz);
```

Parameter

STIME	time	storage area of total number of seconds
TIMEZONE	*tz	time compensation

Return Parameter

STIME	ltim	local time

Description

Apply time compensation specified by “tz” to system (GMT) time specified by “time”, and return the time after the conversion to local time.

standard time compensation

LTtoGMT

C Language Interface

```
STIME gtim = LTtoGMT(STIME time, TIMEZONE *tz);
```

Parameter

STIME	time	
TIMEZONE	*tz	time compensation

Return Parameter

STIME	gtim	system (GMT) time

Description

Apply time compensation specified by “tz” to local time specified by “time”, and return the time after the conversion to local time to system (GMT) time.

4.11 System Management Function

4.11.1 System Management Function Overview

The system management function provides the following functions:

- get version information
- load/unload system programs

4.11.2 System Calls

Get version

tkse_get_ver

C Language Interface

```
ER ercd = tkse_get_ver(T_VER* version);
```

Parameter

T_VER	*version	storage area of version

```
typedef struct {
        UH      maker;      /* maker*/
        UH      id;         /* style number */
        UH      spver;      /* specifications version */
        UH      prver;      /* product version */
        UH      prno[4];    /* product management information */
        UH      cpu;        /* CPU information */
        UH      var;        /* variation descriptor */
} T_VER;
```

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_MACV	access to inaccessible address (version) not allowed

Description

Fetch version.

Load System Programs

tkse_lod_spg

C Language Interface

```
ER ercd = tkse_lod_spg(T_LSPG *pk_sysprg, TC *arg, VW info[N_SPG_INFO]);
```

Parameter

T_LSPG	*pk_sysprg	system program information
TC*	arg	string passed as arguments during loading system programs
VW	info[N_SPG_INFO]	storing area of loading information (N_SPG_INFO=2)

```
typedef struct {
        ATR     spgatr      system program attribute
        VP      spghdr      handle to system program to load

        /* other implementation-dependent information */

} T_LSPG;
```

spgatr indicates process attribute and specifies the following:

spgatr := (TMA_SEIO || TMA_LINK || TMA_PTR)

TMA_SEIO	a handle for the program is a path name of standard input/output file
TMA_LINK	a handle for the program is a link to the file of the standard file system
TMA_PTR	a handle for the program is a pointer to the codes loaded in memory

Return Parameter

ER	ercd	≧ 0	normal termination (system program ID)
		＜ 0	error code

Error Code

E_FACV	no access privileges (E) for the file (when TMA_SEIO, TMA_LINK is specified)
E_MACV	access to address (info, hdr(when TMA_PTR is specified)) not allowed
E_BUSY	could not open the file because it is already opened exclusively
E_IO	input/output error occurred

E_NOEXS	no file present
E_NOFS	the file system to which the file belongs is not connected
E_NOMEM	insufficient memory area (insufficient memory area to load)
E_REC	no program record present in the file. Or the content of program record is unusual (when TMA_LINK is specified).

Description

Loads program codes as a system program and assigns system program ID to it.

spgatr of T_LSPG structure indicates the attribute of a created process.

If TMA_SEIO attribute is specified, the content of the specified file is loaded as a program code. Specify the path name of the standard input/output of the target file for spghdr.

IF TMA_LINK the attribute is specified, the content of the first executable program record in the file of the specified standard file system is loaded as program codes.　Specify the link (LINK*) to the standard file system file for spghdr.

If TMA_PTR attribute is specified, program codes in memory may be set to system program. Specify the pointer of the program codes in memory for spghdr. Note that the format of the program codes in memory and the running methods are implementation-dependent.

If load is successful, loaded start address is returned to info[0], and loaded last address is returned to info[1].

Unload System Programs

tkse_unl_spg

C Language Interface

```
ER ercd = tkse_unl_spg(W progid);
```

Parameter

W	progid	system program ID

Return Parameter

ER	ercd	error code

Error Code

E_OK	normal termination
E_ID	no system program (progid) existent

Description

Unload the loaded system program specified by “progid”.

4.12 Shared Library Function

4.12.1 Shared Library Function Overview

The shared library function of Standard Extension manages the program codes (libraries) shared from multiple processes loaded at runtime.

Shared libraries are present as shared library files in file system, and are loaded using a library function at program's runtime, and become available after symbols resolution.

The loading and symbols resolution of shared libraries are performed by a function call provided as a library. The shared libraries also allow you to load and resolve symbols automatically by placing them on shared library path specified when building the system.

The features of both methods mentioned above are as follows:

(1) Available using library function from user program

- Load and symbols resolution explicitly call library function
- Shared library files can be placed anywhere in the system

(2) Automatically used when process is created

- Loading is done automatically when process is created
- Symbols resolution is done automatically at runtime
- Shared library files should be placed on the path specified when building the system

Shared library function depends on language processor functions such as compiler, linker. To create shared library files, language processor should have the function to create position independent codes.

4.12.2 System Calls

Open Shared Library

dlopen

C Language Interface

```
void *handle = dlopen(const char *filename, int flag);
```

Parameter

const char*	filename	path name of shared library files
int	flag	symbols resolution setting

flag = (RTLD_LAZY || RTLD_NOW) | [RTLD_GLOBAL]

RTLD_LAZY (0x01)	resolves ambiguous symbols in order at runtime
RTLD_NOW (0x02)	resolves all ambiguous symbols at loading time
RTLD_GLOBAL (0x100)	set symbols to global

Return Parameter

void *	handle	＞ 0	normal termination (handle to shared library)
		＝ 0	error exit

Description

Loads shared library in the path specified by filename to the local space of this process. The path name follows the path name specification of standard input/output function. If loading is successful, a handle to shared library (>0) is returned as a return value.

If path name is NULL pointer, shared library is not loaded and a handle to main program is returned.

The retrieved handle is used as an argument to dlsym().

The symbols resolution is set by specifying either RTLD_LAZY or RTLD_NOW to flag. At the same time, RTLD_GLOBAL is also set by taking the logical union (OR).

If RTLD_NOW is specified, dlopen() returns after resolving all the undefined symbols in libraries. If unsuccessful, an error will be returned.

If RTLD_LAZY is specified, symbols values are resolved the first time they are required at runtime. The operation is not ensured when ambiguous symbols are not resolved (normally, exception occurs).

If RTLD_GLOBAL is specified, external symbols of loaded shared library can be used to resolve symbols of other shared libraries opened afterward.

If filename is NULL pointer, a handle to main program is returned.

Find Symbol of Shared Library

dlsym

C Language Interface

```
void *val = dlsym(void *handle, const char *symbol);
```

Parameter

void *	handle	handle to shared library
const char *	symbol	specified symbol

Return Parameter

void *	val	symbol value

Description

Finds the symbol specified by symbol from shared library specified by handle and returns the value. If symbol is not found, NULL will be returned.

Special handles such as RTLD_NEXT, RTLD_DEFAULT can be set to handle.
If RTLD_NEXT is set to handle, symbols search begins with "next" shared library after the shared library which called dlsym().
If RTLD_DEFAULT is set to handle, symbols search is done in the scope of the shared library which called dlsym().

Close Shared Library

dlclose

C Language Interface

```
int rtn = dlclose( void *handle );
```

Parameter

vois *	handle	handle to shared library

Return Parameter

int	rtn	＝ 0	normal termination
		＜ 0	error

Description

Closes the shared library specified by handle.

If the shared library was called by dlopen() multiple times, it is at last closed after it was called by dlclose() that many times.

If shared library is closed, symbols in the library will become unavailable.

Retrieve Symbol Information of Shared Library dladdr

C Language Interface

```
int rtn = dladdr( void *addr, Dl_info *info );
```

Parameter

void *	addr	symbol's address
Dl_info *	info	specified symbol information

```
typedef struct {
        const char  *dli_fname;   /* file name */
        void        *dli_fbase;   /* base address */
        const char  *dli_sname;   /* symbol name */
        void        *dli_saddr;   /* symbol's address */
} Dl_info;
```

Return Parameter

int	rtn	＝ 0	error
		≠ 0	normal termination

Description

If the address specified by addr is inside the one of shared libraries, symbol information at the address is returned to info.

The pointer to the file name of shared library is stored to dli_fname. The file name convention complies with standard input/output specification.

The base address (load offset) of shared library is stored to dli_fbase. This is used as an argument to dlsym() as a handle to shared library.

The pointer to the name of closest symbol is stored to dli_sname with the same or smaller value specified by addr.

The symbol value (address) of dli_sname is stored to dli_saddr.

5. Implementation Method

5.1 Overview

Standard Extension is a function extension program for T-Kernel, and its functions are implemented as T-Kernel subsystems.　The following shows a list of subsystems used by Standard Extension.

- Memory management subsystem
- Segment management subsystem
- Process/Task management subsystem
- Interprocess message subsystem
- Global name subsystem
- Intertask synchronization and communication subsystem
- Standard input/output subsystem
- Standard file management subsystem
- Event management subsystem
- Device management subsystem
- Time management subsystem

An application invokes a Standard Extension function using a system call (`tkse_xxx_yyy`) implemented as the subsystem extended SVC.　This system call is usually invoked via an interface library linked to the application.

5.2 Memory Management and Segment Management

The memory space of Standard Extension is managed by two subsystems: Memory management subsystem and segment management subsystem.
The memory management subsystem executes block-by-block memory area management.
When a memory area is allocated, each of the memory blocks making up this area is registered to a page table.　A page table is a data structure used to retain associations between logical and physical addresses and various attributes of memory blocks.　MMUs realize conversions between logical and physical addresses and restriction on access to memory areas using the information in a page table.　A page table, existing independently for each process, is initialized at process creation and discarded at process exit.
The segment management subsystem conducts virtual memory and memory space management such as mapping of a memory space to a disk or setting of resident/non-resident attributes.
If the physical memory runs short while virtual memory is enabled, segment management writes out a memory page currently not in use to a page file, discards the memory page (page-out), and allocates it as a new memory area.　If there is memory access to a memory page that has been paged out, segment management reads this memory page into the memory (page-in) and executes the access.
The page-in and page-out processes are executed in a task context.　While the task-independent portion is executed, therefore, the physical memory must not run short or the memory area that has been paged out must not be accessed.　The codes that run as the task-independent portion and the data that it references while running must be located in resident memory.

5.3 Process/Task Management

(1) Memory space

The local memory space of a process is implemented as a task space of T-Kernel. All the processes have an independent task space, and the tasks in a process belong to the task space of this process.

(2) Resource group

Each process has an independent resource group. A new resource group is created at process creation and deleted at process exit.

A resource group is used to keep information unique to its process such as process management information, file descriptor, and current directory information.

(3) Task protection level

A task in a user process runs at protection level 3 and a task in a system process runs at protection level 1. These processes cannot access the system area used by drivers and the OS (area at protection level 0).

As an exception, the initial process runs at protection level 0. Therefore, the initial process can access the system area.

(4) Task priority allocation and scheduling

The task priority (`sepri`) of Standard Extension is allocated to the T-Kernel task priority (`kpri`) as follows:

[Table 1] Task priority allocation

Standard Extension task priority (`sepri`)	T-Kernel task priority (`kpri`)	Priority assignment method	Slice time (milliseconds)
–	1 to 7	Not assigned	–
0 to 127 (Absolute priority group)	8 to 135	kpri = sepri + 8	10 (Fixed value)
–	136 to 137	Not assigned	–
128 to 191 (Round robin group 1)	138	kpri = 138 (Fixed value)	192 - sepri
192 to 255 (Round robin group 2)	139	kpri = 139 (Fixed value)	256 - sepri
–	140	Not assigned	–

For a task in the absolute priority group, the sum of the Standard Extension task priority and the offset value (plus eight) is assigned to the T-Kernel task priority. Since relative relationship of priorities is preserved, a task in the absolute priority group is scheduled in the same order of priorities as in T-Kernel. If there are multiple tasks with the same priority, Standard Extension schedules them equally in a round robin fashion at fixed intervals (10 msec), but T-Kernel does not automatically pass the execution privilege among them unless the slice time of a task is explicitly set.

All the tasks in round robin group 1 are allocated to the T-Kernel task priority of 138 regardless of the Standard Extension task priority. The round robin algorithm is realized by setting the task time slice according to the Standard Extension task priority and by changing precedences the same T-Kernel task priorities. The task slice time is as follows; (slice time) = 192-(sepri).
Likewise, all the tasks in round robin group 2 are set to the T-Kernel task priority of 139. The round robin algorithm is realized in the same way as in round robin group 1. The task slice time is as follows;(slice time) = 256-(sepri).

The T-Kernel task priorities (1 to 7, 136 and 137, and 140) not allocated as the Standard Extension task priorities are not available in Standard Extension. However, the T-Kernel applications can freely use these priorities.

5.4 Interprocess Messages

The content of a message that has been sent is copied to an area of system memory space reserved by the sender and is inserted to the message queue of a destination process.　The inserted data is copied again to the buffer area specified at message reception.
The synchronization at message transmission and reception is realized by a task event.　Task event number 1 is used to wait for message reception when CONFM was specified at message transmission.　Task event number 2 is used to release the wait state using `tkse_brk_msg()`.　Software other than message management must not send these task event numbers to any task in the process.
To use a message handler, it is necessary to realize asynchronous reception of a message by raising a task exception in the main task of the process in which the message handler has been registered.　Software other than message management must not raise a task exception in the main task in a process.　In the initial process that runs at protection level 0, no task exception can be raised due to a restriction on T-Kernel.　Therefore, asynchronous message reception using a message handler cannot be executed.

5.5 Intertask Synchronization and Communication Functions

The intertask synchronization and communication functions are realized by indirectly invoking a relevant system call of T-Kernel.
An extended function of Standard Extension is automatic object deletion at process exit (specification of `TA_DELEXIT`).　To realize this function, each process has the list information of objects that have been created as a resource group.　Furthermore, this list information is associated with each object using the extended information `exinf` of the object.　Therefore, the Standard Extension intertask synchronization and communication functions cannot use the extended information `exinf`.

5.6 Device Management Function

The device management functions are realized by indirectly invoking the device management functions of T-Kernel/SM.　However, devices cannot be registered or deleted from Standard Extension.

5.7 Time Management Function

The time management functions are implemented using the T-Kernel time management functions.
System time is initialized by reading the RTC time using the clock driver when Standard Extension is started.　If there is no clock driver or the RTC time is invalid, the system time is undefined.

6. Configuration

6.1 System Configuration Information

Standard Extension can be configured by changing the system configuration information in the same way as for T-Kernel.
The following information is defined as Standard Extension configuration information.
“N:” stands for numeric string information and “S:” stands for character string information.

- Product information

N: OS-Ver	Product version
	Product management information (four entries at the maximum)

Set the product version and the product management information in the version information that can be obtained using `tkse_get_ver`.
0 is set by default.

- Process/Task management

N: MaxProc	Maximum number of processes
N: MaxSubTsks	Maximum number of tasks in a process
N: SysStkSz	System stack size (in bytes) of tasks in a process
N: UsrStkSz	Default user stack size (in bytes) of tasks in a process
N: MaxSysPrg	Maximum number of system programs

- Segment management

N: MaxMapID	Maximum number of disk maps
N: MaxDiskID	Maximum number of disk connections
N: MaxPageIO	Maximum number of contiguous pages in disk input/output
N: SyncPeriod	Disk synchronization interval (in milliseconds)
	The content of the disk buffer is synchronized with that of the disk at specified intervals.
N: SafetyMargin	Safety margin pages to be left at memory allocation

- Memory management

N: SRsvMem	Minimum size of system memory to be reserved (in pages)

- Interprocess message

N: TotalMsgMax	Maximum message size (total of all messages)
N: MaxMsgSz	Maximum message size (maximum size of each message)

- Intertask synchronization and communication

N: TcBufLim	Upper limit of buffer size for intertask synchronization and communication

- Global name

N: GlobalNameLimit	Maximum number of global names

- Time management

N: CmClkUpd	Clock update notification (0: Enabled, 1: Disabled)

Issues a clock update notification at zero second every minute.　A notification is issued by invoking `tkse_brk_msg`.

- Standard file management

N: FmTskPri	File management task priority (common task)
	File management task priority (task of each file system)
N: MaxOpenF	Maximum number of files that can be opened simultaneously
N: SyncTimeOut	Synchronization timeout time (in milliseconds)
N: FmTimeStamp	Time stamp update control (0: Updated, 1: Not updated)
	Control whether or not to update the time stamp when reading a record.

Update when set to 0.　Don't update when set to 1.

- Event management

N: EmTskPri	Device event reception task priority
N: MaxEvtQ	Event queue size (in bytes)
N: MaxEvMsg	Maximum number of registrations of event message
N: EvtLife	Event lifetime (in milliseconds)

Set the lifetime of a wheel event.

- Standard input/output

N: UxMaxOpenF	Maximum number of files that can be opened simultaneously (in each process)
N: UxFsTskPri	File system task priority
N: UxSyncTimeOut	Synchronization timeout time (in milliseconds)