OSEK/VDX

OS Test Plan

Version 2.0

16th April 1999

What is OSEK/VDX?

OSEK/VDX is a joint project of the automotive industry. It aims at an industry standard for an open-ended architecture for distributed control units in vehicles.
A real-time operating system, software interfaces and functions for communication and network management tasks are thus jointly specified.
The term OSEK means ”Offene Systeme und deren Schnittstellen für die Elektronik im Kraftfahrzeug” (Open systems and the corresponding interfaces for automotive electronics).
The term VDX means „Vehicle Distributed eXecutive“. The functionality of OSEK operating system was harmonized with VDX. For simplicity OSEK will be used instead of OSEK/VDX in this document.

OSEK partners:

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Motivation:

- High, recurring expenses in the development and variant management of non-application related aspects of control unit software.
- Incompatibility of control units made by different manufacturers due to different interfaces and protocols.

Goal:

Support of the portability and reusability of the application software by:

- Specification of interfaces which are abstract and as application-independent as possible, in the following areas: real-time operating system, communication and network management.
- Specification of a user interface independent of hardware and network.
- Efficient design of architecture: The functionality shall be configurable and scaleable, to enable optimal adjustment of the architecture to the application in question.
- Verification of functionality and implementation of prototypes in selected pilot projects.

Advantages:

- Clear savings in costs and development time.
- Enhanced quality of the control units software of various companies.
- Standardized interfacing features for control units with different architectural designs.
- Sequenced utilization of the intelligence (existing resources) distributed in the vehicle, to enhance the performance of the overall system without requiring additional hardware.
- Provides absolute independence with regards to individual implementation, as the specification does not prescribe implementational aspects.

OSEK conformance testing

OSEK conformance testing aims at checking conformance of products to OSEK specifications. Test suites are thus specified for implementations of OSEK operating system, communication and network management.

Work around OSEK conformance testing is supported by the MODISTARC project sponsored by the Commission of European Communities. The term MODISTARC means ”Methods and tools for the validation of OSEK/VDX based DISTributed ARChitectures”.

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1 Introduction

This document contains the test plan for the conformance test of the operating system. This means definition of the test cases, which are used to certify conformance of an OS implementation.

According to the Conformance Testing Methodology [1], definition of the conformance test is a two-stage process. In the first stage, the OS specification is analysed and the test purposes are extracted from it. The assembly of the test purposes makes up the test plan. In the second stage test cases are defined, which specify the sequence of the interactions between the test application and the implementation to verify one or more test purposes. The assembly of the test cases makes up the test suite. Together with all information needed to implement and execute the conformance tests make up the test procedure.

According to the different functionalities of the operating system (task management, resource management, ...) it is reasonable to structure and group the test purposes. This structure is explained in chapter 1.

The test purposes are developed by analysing the specification and extracting checkable assertions. The assertions determine what can and what must be tested. Testable assertions are, on the one hand observable actions (task switches, interrupts, etc.) performed by the operating system, on the other hand the correctness of the return status of OS services. Thus, during the conformance test each OS service routine has to be called at least once for each specified return status.

In order to define the test cases it is necessary to further refine the assertions developed before. Refinement means that it is necessary to analyse the assertions and detect all situations and states of the system which may have an influence on the behaviour of a special assertion. This task will be done by means of the classification-tree method which provides a systematic way for generating test cases. A classification tree describes a complete decomposition of all possible situations and states of the system. On this basis, test sequences have to be evolved which execute and verify these test cases.

This document describes the test purposes and assertions which are derived from the specification of the operating system. First, the structure of the assertions will be shown. This includes the grouping of assertions according to the OS's service groups as well as determining to which variants of the operating system they rely on. In the second part the test cases as derived from the Classification Tree Editor (CTE) will be presented.

2 Test suite structure

It is reasonable to group the assertions derived from the specification according to the service groups and functionalities of the operating system. They will be classified according to the following service groups:

- Task management,
- Interrupt processing,
- Event mechanism,
- Resource management,
- Alarms,
- Error handling, hook routines and OS execution control (including start-up/shutdown of OS).

To deal with various requirements of the application software for the system and various capabilities of a specific system (e.g. processor, memory) the OSEK OS offers the possibility to generate several variants of a system. The variants apply to the following categories:

- Conformance class:
  - BCC1 (only basic tasks, limited to one request per task and one task per priority, while all tasks have different priorities)
  - BCC2 (like BCC1, plus more than one task per priority possible and multiple requesting of task activation allowed)
  - ECC1 (like BCC1, plus extended tasks)
  - ECC2 (like BCC2, plus extended tasks without multiple requesting admissible)
- Scheduling policy:
  - non-preemptive
  - mixed-preemptive
  - full-preemptive
- Return status:
  - standard (return values of system services provided in the standard version)
  - extended (return values of system services provided in the extended version for debugging purposes)

For each assertion has to be checked for which variants it is relevant, because some assertions are not checkable under certain circumstances. E.g. the assertions about the event mechanism are not relevant for the conformance classes BCC1 and BCC2, as they don't support events.

3 Test purposes

This chapter describes the test purposes relevant to the functionality and behaviour of the operating system. They were established by reading the specification and extracting checkable assertions. The assertions were analysed to remove redundancies. These assertions build the basis on which the test cases and the test suite are developed. Therefore, it is necessary to further refine these assertions. According to the Conformance Testing Methodology [1] this refinement will be done by means of the classification-tree method (see chapter 4). This method was developed at Daimler-Benz AG and is supported by the commercial tool CTE by ATS Automated Testing Solution GmbH [6]. The resulting test cases and the sequences used to evaluate them will be described in the test procedure.

As mentioned in the previous chapter, the assertions are grouped according to several aspects of the operating system. Each of the following chapters represents one group of test purposes. The test purposes are listed in a table which contains for each assertion:

- a sequence number used as a reference for test suite traceability,
- the description of the test purpose extracted from the specification,
- the variants of the specification to which the purpose applies,
- a reference to the paragraph in the specification allowing traceability to be provided against the specification.

3.1 Implementation specific parameters

In accordance with the specification 2.0 of the OSEK operating system, the vendor has to provide a list of parameters specifying the implementation. This list gives detailed information concerning the functionality, performance and memory demand, as well as the basic conditions to reproduce the measurement of those parameters.

In order to test the conformance of a specific implementation to the OSEK OS specification, one has to ensure that the list with implementation-specific parameters provided by the vendor exists, and contains all prescribed parameters. It is important to point out that the conformance test neither includes a test for the correctness of these parameters, nor does it specify any limit for hardware requirements or performance figures that must be kept. To achieve conformance it is sufficient for the operating system vendor to provide a list of parameters specifying the implementation's behaviour. To allow their verifications, this list must include a sufficient description of the methods used to collect the presented informations.

This chapter refers to those parameters which describe basic functionalities of the OS implementation. Therefore, they are needed in order to build and execute the test applications. It is reasonable to provide additional parameters, like required hardware resources and performance issues. They are listed in appendix I which may be changed in the future. Indeed it is not obvious, from today's point, which parameters are relevant for customers to evaluate an OS implementation.

The following table lists each parameter which must be contained in the list of parameters as one assertion.

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	Maximum number of tasks	63	12.2.1	All

No.	Assertion	Page	Paragraph in spec.	Affected variants
2	Maximum number of active tasks (*running*/ *ready*/ *waiting*) (≥8 for BCC1/BCC2, ≥16 for ECC1/ECC2)	63	12.2.1	All
3	Maximum number of priorities (≥8)	63	12.2.1	All
4	Number of tasks per priority (>1)	63	12.2.1	BCC2, ECC2
5	Upper limit for number of task activations	63	12.2.1	BCC2, ECC2
6	Maximum number of events per task (≥8)	63	12.2.1	ECC1, ECC2
7	Limits for the number of alarm objects (per system/ per task)	63	12.2.1	All
8	Limits for the number of nested resources (per system/ per task)	63	12.2.1	All
9	Lowest priority level used internally by the OS	63	12.2.1	All
10	Timer units reserved for the OS	63	12.2.2	All
11	Interrupts, traps and other hardware resources occupied by the OS	63	12.2.2	All

3.2 Task management

Task management concerns the activation and scheduling of tasks. The behaviour of the scheduler depends on the conformance class and the scheduling policy.

Several attributes are assigned to each task:

- task type: basic, extended
- priority
- scheduling type: full-, non-preemptive

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	Interrupts and OS have higher priority than tasks.	14	3.1	All
2	OS has to provide at least 8 levels of task priorities.	63	12.2	All
4	States for EXTENDED tasks are: *running*, *ready*, *suspended*, *waiting*. EXTENDED tasks release the processor, if • they terminate • they are preemptive and OS is executing a higher priority task • an Interrupt is executed • they go to *waiting* state • a transition from *running* to *waiting* state occurs, if the task waits for an event.	17	4.2.1	ECC1, ECC2
5	Tasks in *ready* state wait for allocation of the processor. When no task with higher priority is in *ready* or *running* state, this task is put to *running* state, if no interrupt is processed.	17	4.2.1	All

No.	Assertion	Page	Paragraph in spec.	Affected variants
6	A task in *suspended* state is not active. Task activation puts it to *ready* state.	17	4.2.1	All
7	A task in *waiting* state waits at least for one event. With the occurrence the task is set to *ready* state.	17	4.2.1	ECC1, ECC2
8	Pre-empted task is treated as the first task in the *ready* list of its priority.	17	4.2.1	All
9	States for BASIC tasks are: *running, ready, suspended.* BASIC tasks release the processor, if • they terminate • they are preemtive and OS is executing a higher priority task • an Interrupt is executed	18	4.2.2	All
10	The OS ensures that after a task has been activated its execution will start with the task's first instruction.	20	4.3	All
11	Multiple activation is supported in BCC2/ECC2 for basic tasks, a task attribute limits the number of multiple activation.	20	4.3	BCC2, ECC2
12	Multiple task activations are stored in a FIFO structure in order to preserve activation order	20	4.3	BCC2, ECC2
13	Bigger Numbers refer to higher priorities. (0 is lowest)	20	4.5	All
14	In BCC2 and ECC2 tasks with same priority are possible. Processing of the tasks with same priority depends on their order of activation.	20	4.5	BCC2, ECC2
15	A task being released from *waiting* state is treated like the newest task in the *ready* queue of its priority.	21	4.5	ECC2
16	Points of rescheduling (possible task switch) with non-preemptive scheduling: • A task terminates itself via *TerminateTask* or *ChainTask* • An explicit call of the scheduler (*Schedule*) • The task waits for an event	21	4.6.1	Non-preemptive
17	Within full-preemptive scheduling a task switch occurs, whenever a task with higher priority is set to *ready* state.	22	4.6.2	Full-preemptive
18	Scheduling policies can be mixed. A task can be defined non-preemptive in a mixed-preemptive OS, i.e. no preemption can occur as long as this non-preemptive task is running.	23	4.6.3	Mixed-preemptive

3.3 Interrupt processing

The OSEK OS provides several services to handle interrupts. They can be used to enable and disable interrupts and to allow the use of OS services within an interrupt service routine. But the handling of interrupts is very hardware specific.

This concerns in particular interrupts of category 1, as no ISR-frame is prepared for the operating system. Therefore, it is not allowed to call any OS service, which prevents observation of the behaviour of the interrupt service routine.

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	Interrupts of category 2: Calls to OS services are restricted. Calling a forbidden OS service produces the error E_OS_CALLEVEL.	26	5	Extended error status [1)]
2	Interrupts of category 3: Calls to OS services are restricted. They are allowed if enclosed within a *Enter/LeaveISR* frame. Within this frame calling a forbidden OS service produces the error E_OS_CALLEVEL, outside this frame the behaviour is not defined.	26	5	Extended error status [1)]

[1)] These assertions are optional, because these test can be made at precompile time. This allows the OS to be more efficient in handling interrupts.

3.4 Event mechanism

The event mechanism is a means of synchronisation. It is provided for extended tasks only. Events are objects managed by the operating system. Each event is assigned to an extended task. Various system services are provided to manipulate events.

Events are supported in the extended conformance classes (ECC1, ECC2) only.

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	An event is assigned to an extended task.	28	6	ECC1, ECC2
2	One task can own at least 8 events. This is the minimum value for the parameter „Number of events per task“	63	12.2	ECC1, ECC2
3	When at least one event a task is waiting for occurs, this task is set to *ready* state.	28	6	ECC1, ECC2
4	An event can only be cleared by its owner by calling *ClearEvent*.	28	6	ECC1, ECC2
5	When activating an extended task by calling *ActivateTask*, its events are cleared by the OS.	28	6	ECC1, ECC2
6	Any task can set events.	28	6	ECC1, ECC2
7	If an extended task tries to wait for an event, which has already occurred at least once, it remains in *running* state.	28	6	ECC1, ECC2

3.5 Resource management

The resource management is used to co-ordinate concurrent accesses of several tasks to shared resources. It has to ensure that two tasks cannot occupy the same resource at the same time and that priority inversion or deadlocks cannot occur. The specification implies to use the priority ceiling protocol even when it is not mandatory. However, the behaviour of the system must be identical to the priority ceiling protocol whether the implementation uses it or not.

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	A task cannot terminate or switch to *waiting* state, while it occupies a resource. This can only be checked if OS supports extended error states, otherwise the behaviour is undefined.	30	7.2	Extended error status
2	The scheduler is treated like a resource which is accessible to all tasks. A standard resource with a defined name (constant RES_SCHEDULER) is generated. It can be occupied to prevent interruptions by other tasks.	30	7.3	All
3	OS ensures (e.g. by priority ceiling protocol) that tasks are only transferred from the *ready* state to the *running* state, if all resources, the task might need, are released.	30	7.1	All
4	After a task has occupied a resource any other task which might occupy the same resource does not enter the *running* state, even if its priority is higher than the priority of the task occupying this resource. This behaviour is equivalent to the priority ceiling protocol.	32	7.5	All

3.6 Alarms

Expiration of alarms is determined on the basis of counters. As there exists no API for counters their functionality cannot be tested. The same holds true for non-variant alarms.

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	Alarm will expire when a predefined counter value is reached	33	8.2	All
2	Alarms are statically assigned to • One counter • One task • A notation, if that task is to be activated or an event is to be set (only in ECC1, ECC2)	33	8.2	All ECC1, ECC2
3	Alarms can be manipulated by the user.	34	8.2	All
4	Absolute and relative alarms are supported, both may be set to cyclic or single alarms.	34	8.2	All
5	The OS provides at least one counter which is derived from a timer. User can assume existence of this counter.	34	8.2	All

3.7 Error handling, hook routines and OS execution control

The OSEK operating systems provides hook routines which allow user-defined actions within the OS internal processing, e.g. at task switches. The interface of hook routines is implementation dependant except the first parameter which is fixed.

Error handling of the OSEK operating system is limited to a status information returned by the system services. If fatal errors occur a centralised system shutdown is called. But, as the conditions for this shutdown are implementation dependant, this is not testable.

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	The first parameter of hook routines is fixed, additional parameters are optional and implementation specific.	35	9.1	All
2	Hook routines are a part of the OS, but user-defined. Therefore they are higher prior than all tasks and thus can't be preempted.	35	9.1	All
3	Hook routines are only allowed to use a subset of OS services. It can not be checked if a OS service is called which is not part of this subset.	35	9.1	All
4	Every OS call returns the status code. If the OS could not execute the requested service correctly, status code is not equal E_OK.	37	9.2.1	All
5	The operating system starts with a call to *StartOS* with the application mode as a parameter.	38	9.3	All
6	After the OS is initialised (scheduler not running), it calls the *StartupHook* before starting the first user task.	38	9.3	All
7	During execution of StartupHook, all user interrupts are disabled.	38	9.3	All
8	After *StartupHook*, the interrupt mask is set according to INITIAL_INTERRUPT_DESCRIPTOR.	38	9.3	All
9	When *ShutdownOS* is called with a defined error code, the OS will shutdown and call the hook routine *ShutdownHook*.	60	11.7	All
10	*PostTaskHook* is called after executing the current task, but before leaving the task's *running* state.	60	11.7	All
11	*PreTaskHook* is called before executing the new task, but after the transition of the task to the *running* state.	60	11.7	All
12	*ErrorHook* is called if a system call returns a value not equal to E_OK.	60	11.7	All
13	Naming convention for status information: • all return status information of API services start with E_ • errors of OS start with E_OS_ • internal errors of OS (implementation specific) start with E_OS_SYS_	43	11.1	All
14	Values of the status information API services offer: • E_OK = 0 • E_OS_ACCESS = 1 • E_OS_CALLEVEL = 2 • E_OS_ID = 3 • E_OS_LIMIT = 4 • E_OS_NOFUNC = 5 • E_OS_RESOURCE = 6 • E_OS_STATE = 7 • E_OS_VALUE = 8	43	11.1	All

No.	Assertion	Page	Paragraph in spec.	Affected variants
15	The application mode that is passed to the StartOS function can be detected by the *GetActiveApplicationMode* function.	59	11.6	All

4 Test cases

This chapter contains the test cases which will be used to test an implementation of an operating system to be OSEK conform. Thus, they are developed on the basis of the OSEK OS specification.

4.1 Classification Tree Method

4.1.1 Introduction

The Classification Tree Method supports in a systematic and methodical way the determination of test cases. It helps to realize the test object and its mostly unclear input data range, in order to get structured test cases.

The input data range of a test object is classified by the Classification-Tree Method into test relevant aspects. These classifications divide the data range disjunctively and completely into a finite number of classes.

Using the Classification-Tree Method it is possible to identify exactly the input parameters relevant for testing by combining classes of different classifications. In doing so, exactly one class from each classification must be considered. For complex systems, it is necessary to check the combinations for logical compatibility.

If the concept of classification is used recursive on classes, then these classes are further refined.

4.1.2 Test case Trees for OSEK OS

The aim of classifying the OSEK OS in the classification trees was to describe every possible system state and its reactions to a call of an API service or an internal event like expiring of an alarm or occurring of an interrupt. This ensures that every situation that may occur during execution of an application is covered by the conformance tests.

The OSEK OS was divided into eight test groups which are handled separately. These groups are

- Task Management,
- Interrupt processing,
- Event mechanism,
- Resource management,
- Alarms, and
- Error handling, hook routines and OS execution control.

A test case is defined by a call to a OS service within a special system state and the reactions and answers performed by the system. The test trees ensure that each possible state is taken into account.

To keep the test trees simple the following conventions have been reached.

- The test trees don't contain the static properties of the OS (conformance class, scheduling policy, return status). This information is redundant and can be recovered from the test cases itself and is attached to the textual description of the test cases.

- Only the system environment (runtime properties) that influences the performed OS call is modelled in the test trees (execution level, running task's type, etc.).
- The reaction (answer) of the executed is not contained in the test trees (except for the return status). This can again be recovered from the test case itself and is attached to the textual description.

The test cases are chosen in that way that the OS service are called that often that each situation which is described in the specification is provoked at least once.

Each test case is defined by one line of a classification tree and the corresponding textual description which is printed below the classification tree. The textual description is presented in a table of the following structure:

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
1	n, m, f B1, B2, E1, E2 e	Call `ActivateTask()` from task-level with invalid task ID (task does not exist)	Service returns E_OS_ID

Scheduling policy of OS
n: non-preemptive
m: mixed-preemptive
f: full preemptive

Actions that must be executed for this test case

Expected result of this test case

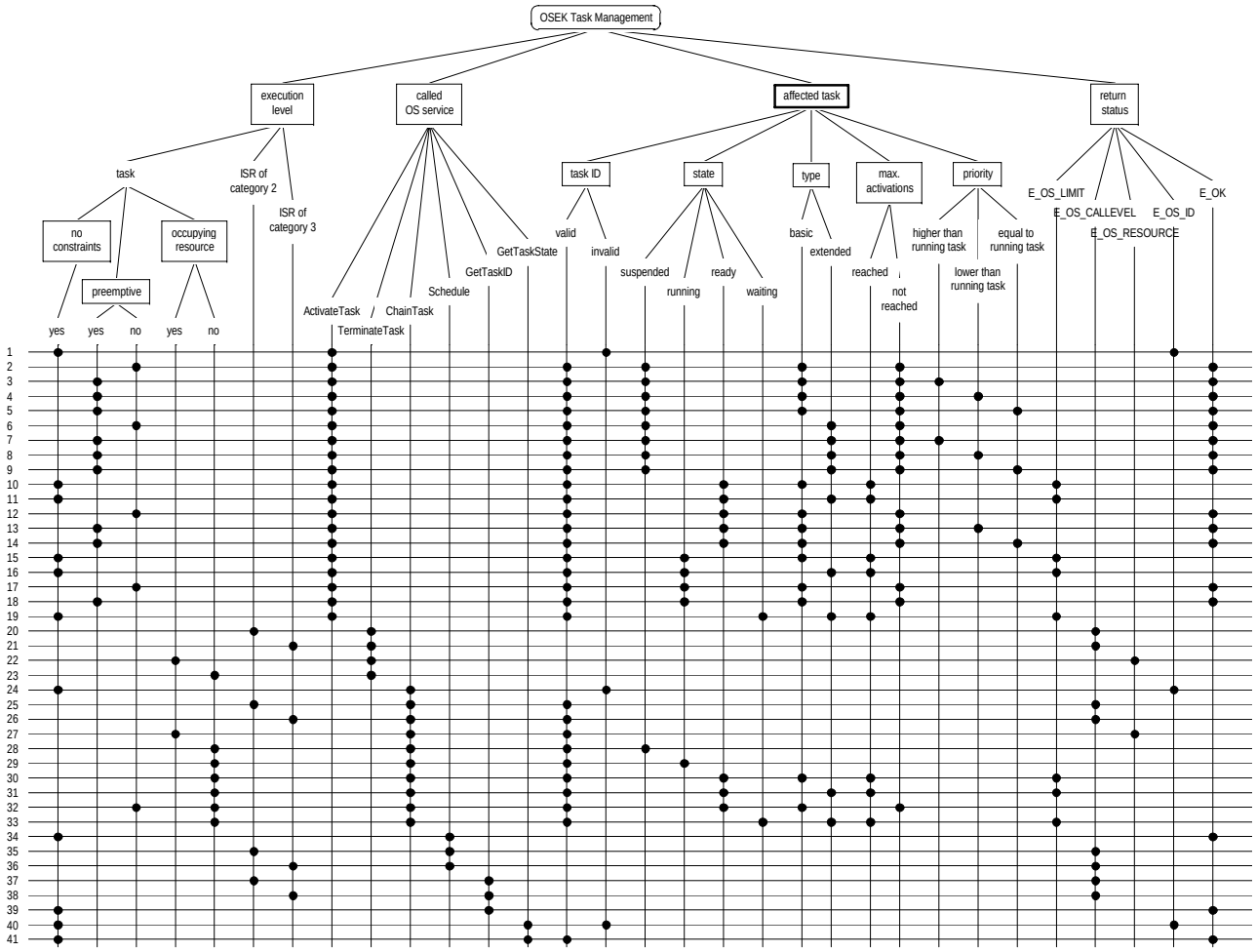
Conformance class of OS
B1: BCC1
B2: BCC2
E1: ECC1
E2: ECC2

OS status of OS services
s: standard
e: extended

The specification of OSEK OS in its current version (2.0 rev 1) is at some points ambiguous. This leads to wholes, which allow ambiguous interpretation of the specification. In order to do conformance tests this wholes had to be filled. Thus, some assumption had to be made, what is the correct interpretation in the "spirit" of OSEK. In the introduction to each of the following tables those assumption are expressed.

A general assumption that had to be taken is about the minimum number of task supported by the OS for applications. The specification doesn't provide this number. Therefore it is assumed that there are at least 8 tasks available in BCC1/BCC2 and at least 16 tasks in ECC1/ECC2. This numbers conform to fig. 12-1 of the specification.

4.2 Task management



Test case No.	Sched. policy Conf. class Status	Action	Expected Result
1	n, m, f B1, B2, E1, E2 e	Call `ActivateTask()` from task-level with invalid task ID (task does not exist)	Service returns E_OS_ID
2	n, m B1, B2, E1, E2 s, e	Call `ActivateTask()` from non-preemptive task on *suspended* basic task	No preemption of *running* task. Activated task becomes *ready*. Service returns E_OK
3	m, f B1, B2, E1, E2 s, e	Call `ActivateTask()` from preemptive task on *suspended* basic task which has higher priority than running task.	*Running* task is preempted. Activated task becomes *running*. Service returns E_OK
4	m, f B1, B2, E1, E2 s, e	Call `ActivateTask()` from preemptive task on *suspended* basic task which has lower priority than running task.	No preemption of *running* task. Activated task becomes *ready*. Service returns E_OK

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
5	m, f B2, E2 s, e	Call `ActivateTask()` from preemptive task on *suspended* basic task which has equal priority as running task.	No preemption of *running* task. Activated task becomes *ready*. Service returns E_OK
6	n, m E1, E2 s, e	Call `ActivateTask()` from non-preemptive task on *suspended* extended task	No preemption of *running* task. Activated task becomes *ready* and its events are cleared. Service returns E_OK
7	m, f E1, E2 s, e	Call `ActivateTask()` from preemptive task on *suspended* extended task which has higher priority than running task.	*Running* task is preempted. Activated task becomes *running* and its events are cleared. Service returns E_OK
8	m, f E1, E2 s, e	Call `ActivateTask()` from preemptive task on *suspended* extended task which has lower priority than running task.	No preemption of *running* task. Activated task becomes *ready* and its events are cleared. Service returns E_OK
9	m, f E2 s, e	Call `ActivateTask()` from preemptive task on *suspended* extended task which has equal priority as running task.	No preemption of *running* task. Activated task becomes *ready* and its events are cleared. Service returns E_OK
10	n, m, f B1, B2, E1, E2 e	Call `ActivateTask()` on *ready* basic task which has reached max. number of activations	Service returns E_OS_LIMIT
11	n, m, f E1, E2 e	Call `ActivateTask()` on *ready* extended task	Service returns E_OS_LIMIT
12	n, m B2, E2 s, e	Call `ActivateTask()` from non-preemptive task on *ready* basic task which has not reached max. number of activations	No preemption of *running* task. Activation request is queued in ready list. Service returns E_OK
13	m, f B2, E2 s, e	Call `ActivateTask()` from preemptive task on *ready* basic task which has not reached max. number of activations and has lower priority than running task[1]	No preemption of *running* task. Activation request is queued in ready list. Service returns E_OK
14	m, f B2, E2 s, e	Call `ActivateTask()` from preemptive task on *ready* basic task which has not reached max. number of activations and has equal priority as running task	No preemption of *running* task. Activation request is queued in ready list. Service returns E_OK
15	n, m, f B1, B2, E1, E2 e	Call `ActivateTask()` on *running* basic task which has reached max. number of activations	Service returns E_OS_LIMIT

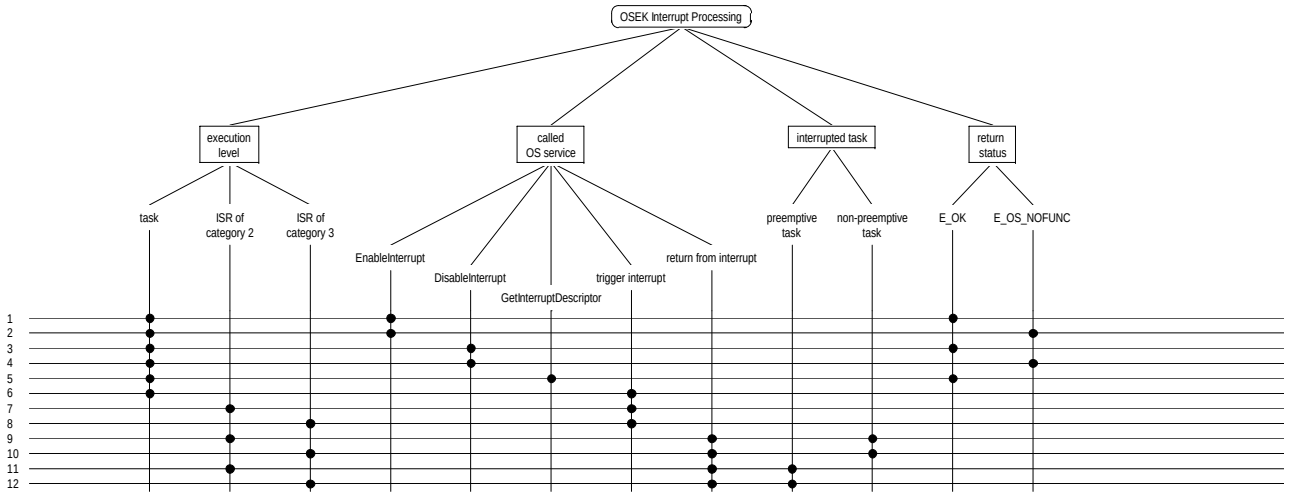
[1] Activating a higher priority task which is already ready from a preemptive task is not possible as the higher priority task would be running.

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
16	n, m, f E1, E2 e	Call `ActivateTask()` on *running* extended task	Service returns E_OS_LIMIT
17	n, m B2, E2 s, e	Call `ActivateTask()` from non-preemptive task on *running* basic task which has not reached max. number of activations	No preemption of *running* task. Activation request is queued in ready list. Service returns E_OK
18	m, f B2, E2 s, e	Call `ActivateTask()` from preemptive task on *running* basic task which has not reached max. number of activations	No preemption of *running* task. Activation request is queued in ready list. Service returns E_OK
19	n, m, f E1, E2 e	Call `ActivateTask()` on *waiting* extended task	Service returns E_OS_LIMIT
20	n, m, f B1, B2, E1, E2 e	Call `TerminateTask()` from ISR category 2	Service returns E_OS_CALLEVEL
21	n, m, f B1, B2, E1, E2 e	Call `TerminateTask()` from ISR category 3	Service returns E_OS_CALLEVEL
22	n, m, f B1, B2, E1, E2 e	Call `TerminateTask()` while still occupying a resource	*Running* task is not terminated. Service returns E_OS_RESOURCE
23	n, m, f B1, B2, E1, E2 s, e	Call `TerminateTask()`	*Running* task is terminated and *ready* task with highest priority is executed
24	n, m, f B1, B2, E1, E2 e	Call `ChainTask()` from task-level. Task-ID is invalid (does not exist).	Service returns E_OS_ID
25	n, m, f B1, B2, E1, E2 e	Call `ChainTask()` from ISR category 2	Service returns E_OS_CALLEVEL
26	n, m, f B1, B2, E1, E2 e	Call `ChainTask()` from ISR category 3	Service returns E_OS_CALLEVEL
27	n, m, f B1, B2, E1, E2 e	Call `ChainTask()` while still occupying a resource	*Running* task is not terminated. Service returns E_OS_RESOURCE
28	n, m, f B1, B2, E1, E2 s, e	Call `ChainTask()` on *suspended* task	*Running* task is terminated, chained task becomes *ready* and *ready* task with highest priority is executed
29	n, m, f B1, B2, E1, E2 s, e	Call `ChainTask()` on *running* task	*Running* task is terminated, chained task becomes *ready* and *ready* task with highest priority is executed

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
30	n, m, f B1, B2, E1, E2 e	Call `ChainTask()` on *ready* basic task which has reached max. number of activations	*Running* task is not terminated. Service returns E_OS_LIMIT
31	n, m, f E1, E2 e	Call `ChainTask()` on *ready* extended task	*Running* task is not terminated. Service returns E_OS_LIMIT
32	n, m B2, E2 s, e	Call `ChainTask()` from non-preemptive task on *ready* basic task which has not reached max. number of activations	*Running* task is terminated, activation request is queued in ready list and *ready* task with highest priority is executed
33	n, m, f E1, E2 e	Call `ChainTask()` on *waiting* extended task	Service returns E_OS_LIMIT
34	n, m, f B1, B2, E1, E2 s, e	Call `Schedule()` from task.	*Ready* task with highest priority is executed. Service returns E_OK
35	n, m, f B1, B2, E1, E2 e	Call `Schedule()` from ISR category 2	Service returns E_OS_CALLEVEL
36	n, m, f B1, B2, E1, E2 e	Call `Schedule()` from ISR category 3	Service returns E_OS_CALLEVEL
37	n, m, f B1, B2, E1, E2 e	Call `GetTaskID()` from ISR category 2	Service returns E_OS_CALLEVEL
38	n, m, f B1, B2, E1, E2 e	Call `GetTaskID()` from ISR category 3	Service returns E_OS_CALLEVEL
39	n, m, f B1, B2, E1, E2 s, e	Call `GetTaskID()` from task	Return task ID of currently *running* task. Service returns E_OK
40	n, m, f B1, B2, E1, E2 e	Call `GetTaskState()` with invalid task ID (task does not exist)	Service returns E_OS_ID
41	n, m, f B1, B2, E1, E2 s, e	Call `GetTaskState()`	Return state of queried task. Service returns E_OK

4.3 Interrupt processing

No conformance tests will be made for interrupt service routines (ISR) of category 1 because they do not run under the control of the OS. Thus, there is no possibility to check if an ISR1 is active or not. The same holds true for ISRs of category 3 outside the ISR frame build by the calls to `Enter/LeaveISR()`.

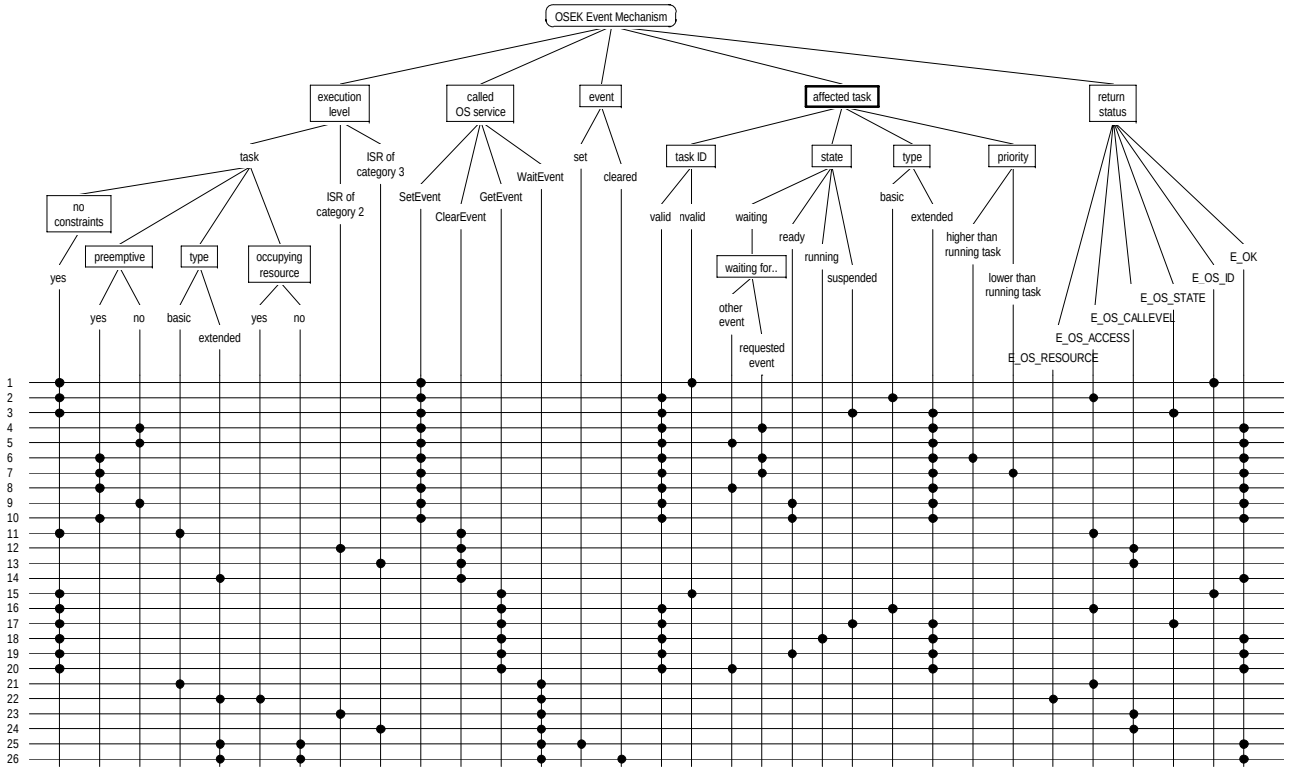


Test case No.	Sched. policy Conf. class Status	Action	Expected Result
1	n, m, f B1, B2, E1, E2 s, e	Call `EnableInterrupt()`. All requested interrupts are disabled	Enable interrupts. Service returns E_OK
2	n, m, f B1, B2, E1, E2 e	Call `EnableInterrupt()`. At least one of the requested interrupts is already enabled	Enable interrupts. Service returns E_OS_NOFUNC
3	n, m, f B1, B2, E1, E2 s, e	Call `DisableInterrupt()`. All requested interrupts are enabled	Disable interrupts. Service returns E_OK
4	n, m, f B1, B2, E1, E2 e	Call `DisableInterrupt()`. At least one of the requested interrupts is already disabled	Disable interrupts. Service returns E_OS_NOFUNC
5	n, m, f B1, B2, E1, E2 s, e	Call `GetInterruptDescriptor()`	Returns current interrupt descriptor. Service returns E_OK
6	n, m, f B1, B2, E1, E2 s, e	Interruption of *running* task	Interrupt is executed
7	n, m, f B1, B2, E1, E2 s, e	Interruption of ISR2	Interrupt is executed
8	n, m, f B1, B2, E1, E2 s, e	Interruption of ISR3	Interrupt is executed
9	n, m B1, B2, E1, E2 s, e	Return from ISR2. Interrupted task is non-preemptive	Execution of interrupted task is continued
10	n, m B1, B2, E1, E2 s, e	Return from ISR3. Interrupted task is non-preemptive	Execution of interrupted task is continued

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
11	m, f B1, B2, E1, E2 s, e	Return from ISR2. Interrupted task is preemptive	*Ready* task with highest priority is executed (Rescheduling)
12	m, f B1, B2, E1, E2 s, e	Return from ISR3. Interrupted task is preemptive	*Ready* task with highest priority is executed (Rescheduling)

4.4 Event mechanism

Events are not queued. I.e. if an event is set twice before it could be cleared, then the task owning this event is notified only once. Therefore one event gets lost. This behaviour is not clearly expressed by the specification and is therefore not object of conformance testing.

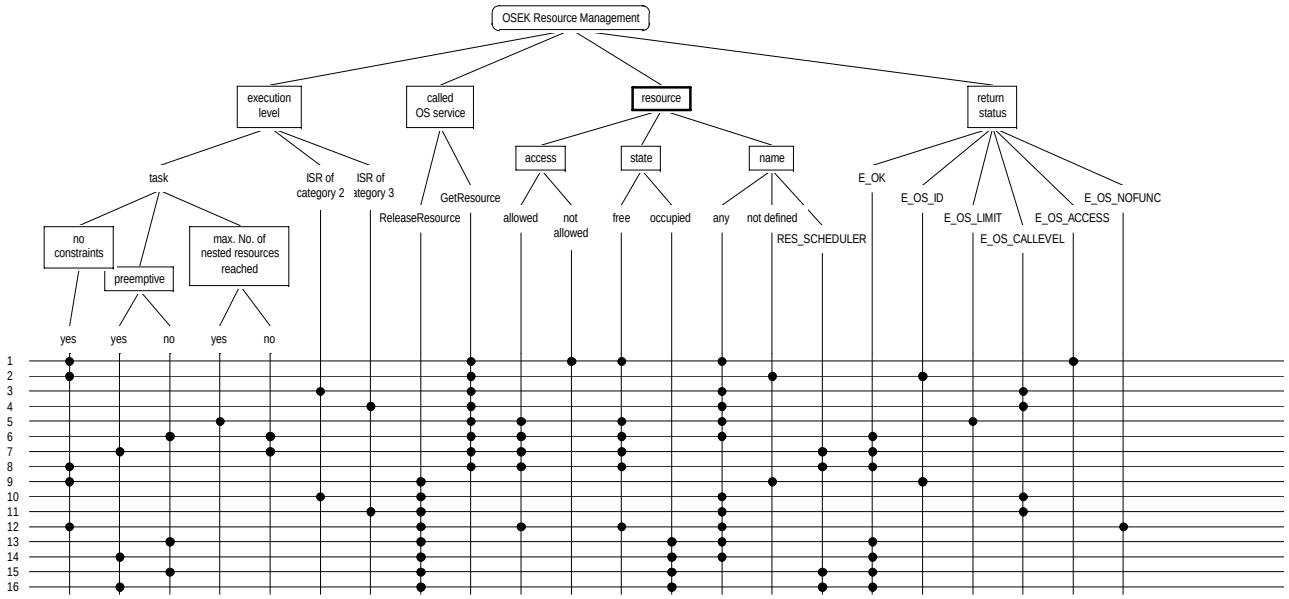


Test case No.	Sched. policy Conf. class Status	Action	Expected Result
1	n, m, f E1, E2 e	Call `SetEvent()` with invalid Task ID	Service returns E_OS_ID
2	n, m, f E1, E2 e	Call `SetEvent()` for basic task	Service returns E_OS_ACCESS
3	n, m, f E1, E2 e	Call `SetEvent()` for *suspended* extended task	Service returns E_OS_STATE

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
4	n, m E1, E2 s, e	Call `SetEvent()` from non-preemptive task on *waiting* extended task which is waiting for at least one of the requested events	Requested events are set. *Running* task is not preempted. *Waiting* task becomes *ready.* Service returns E_OK
5	n, m E1, E2 s, e	Call `SetEvent()` from non-preemptive task on *waiting* extended task which is not waiting for any of the requested events	Requested events are set. *Running* task is not preempted. *Waiting* task doesn't become *ready*. Service returns E_OK
6	m, f E1, E2 s, e	Call `SetEvent()` from preemptive task on *waiting* extended task which is waiting for at least one of the requested events and has higher priority than *running* task	Requested events are set. *Running* task becomes *ready* (is preempted). *Waiting* task becomes *running*. Service returns E_OK
7	m, f E1, E2 s, e	Call `SetEvent()` from preemptive task on *waiting* extended task which is waiting for at least one of the requested events and has equal or lower priority than *running* task	Requested events are set. *Running* task is not preempted. *Waiting* task becomes *ready*. Service returns E_OK
8	m, f E1, E2 s, e	Call `SetEvent()` from preemptive task on *waiting* extended task which is not waiting for any of the requested events	Requested events are set. *Running* task is not preempted. *Waiting* task doesn't become *ready*. Service returns E_OK
9	n, m E1, E2 s, e	Call `SetEvent()` from non-preemptive task on *ready* extended task	Requested events are set. *Running* task is not preempted. Service returns E_OK
10	m, f E1, E2 s, e	Call `SetEvent()` from preemptive task on *ready* extended task	Requested events are set. *Running* task is not preempted. Service returns E_OK
11	n, m, f E1, E2 e	Call `ClearEvent()` from basic task	Service returns E_OS_ACCESS
12	n, m, f E1, E2 e	Call `ClearEvent()` from ISR2	Service returns E_OS_CALLEVEL
13	n, m, f E1, E2 e	Call `ClearEvent()` from ISR3	Service returns E_OS_CALLEVEL
14	n, m, f E1, E2 s, e	Call `ClearEvent()` from extended task	Requested events are cleared. Service returns E_OK
15	n, m, f E1, E2 e	Call `GetEvent()` with invalid Task ID	Service returns E_OS_ID
16	n, m, f E1, E2 e	Call `GetEvent()` for basic task	Service returns E_OS_ACCESS

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
17	n, m, f E1, E2 e	Call `GetEvent()` for *suspended* extended task	Service returns E_OS_STATE
18	n, m, f E1, E2 s, e	Call `GetEvent()` for *running* extended task	Return current state of all event bits. Service returns E_OK
19	n, m, f E1, E2 s, e	Call `GetEvent()` for *ready* extended task	Return current state of all event bits. Service returns E_OK
20	n, m, f E1, E2 s, e	Call `GetEvent()` for *waiting* extended task	Return current state of all event bits. Service returns E_OK
21	n, m, f E1, E2 e	Call `WaitEvent()` from basic task	Service returns E_OS_ACCESS
22	n, m, f E1, E2 e	Call `WaitEvent()` from extended task which occupies a resource	Service returns E_OS_RESOURCE
23	n, m, f E1, E2 e	Call `WaitEvent()` from ISR2	Service returns E_OS_CALLEVEL
24	n, m, f E1, E2 e	Call `WaitEvent()` from ISR3	Service returns E_OS_CALLEVEL
25	n, m, f E1, E2 s, e	Call `WaitEvent()` from extended task. None of the events waited for is set	*Running* task becomes *waiting* and *ready* task with highest priority is executed. Service returns E_OK
26	n, m, f E1, E2 s, e	Call `WaitEvent()` from extended task. At least one event waited for is already set	No preemption of *running* task. Service returns E_OK

4.5 Resource management



Test case No.	Sched. policy Conf. class Status	Action	Expected Result
1	n, m, f B1, B2, E1, E2 e	Call `GetResource()` from task which has no access to this resource	Service returns E_OS_ACCESS
2	n, m, f B1, B2, E1, E2 e	Call `GetResource()` from task with invalid resource ID	Service returns E_OS_ID
3	n, m, f B1, B2, E1, E2 e	Call `GetResource()` from ISR2	Service returns E_OS_CALLEVEL
4	n, m, f B1, B2, E1, E2 e	Call `GetResource()` from ISR3	Service returns E_OS_CALLEVEL
5	n, m, f B1, B2, E1, E2 e	Call `GetResource()` from task with too many resources occupied in parallel	Service returns E_OS_LIMIT
6	n, m B1, B2, E1, E2 s, e	Test Priority Ceiling Protocol: Call `GetResource()` from non-preemptive task, activate task with priority higher than running task but lower than ceiling priority, and force rescheduling	Resource is occupied and *running* task's priority is set to resource's ceiling priority. Service returns E_OK. No preemption occurs after activating the task with higher priority and rescheduling
7	m, f B1, B2, E1, E2 s, e	Test Priority Ceiling Protocol: Call `GetResource()`from preemptive task, and activate task with priority higher than running task but lower than ceiling priority	Resource is occupied and *running* task's priority is set to resource's ceiling priority. Service returns E_OK. No preemption occurs after activating the task with higher priority

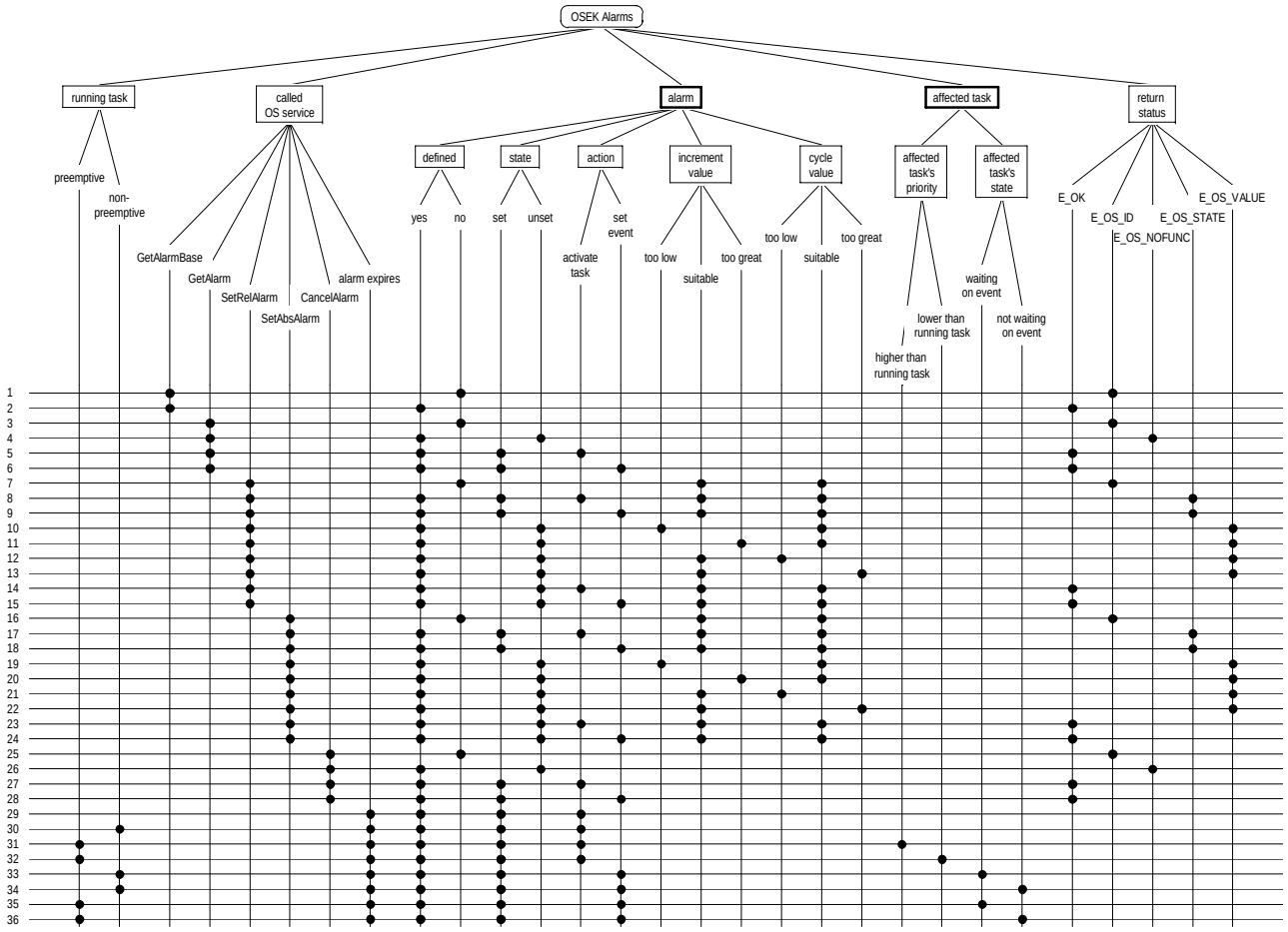
Test case No.	Sched. policy Conf. class Status	Action	Expected Result
8	n, m, f B1, B2, E1, E2 s, e	Call `GetResource()` for resource RES_SCHEDULER	Resource is occupied and *running* task's priority is set to resource's ceiling priority. Service returns E_OK
9	n, m, f B1, B2, E1, E2 e	Call `ReleaseResource()` from task with invalid resource ID	Service returns E_OS_ID
10	n, m, f B1, B2, E1, E2 e	Call `ReleaseResource()` from ISR2	Service returns E_OS_CALLEVEL
11	n, m, f B1, B2, E1, E2 e	Call `ReleaseResource()` from ISR3	Service returns E_OS_CALLEVEL
12	n, m, f B1, B2, E1, E2 e	Call `ReleaseResource()` from task with resource which is not occupied	Service returns E_OS_NOFUNC
13	n, m B1, B2, E1, E2 s, e	Call `ReleaseResource()` from non-preemptive task	Resource is released and *running* task's priority is reset. No preemption of *running* task. Service returns E_OK
14	m, f B1, B2, E1, E2 s, e	Call `ReleaseResource()` from preemptive task	Resource is released and *running* task's priority is reset. Ready task with highest priority is executed (Rescheduling). Service returns E_OK
15	n, m B1, B2, E1, E2 s, e	Call `ReleaseResource()`from non-preemptive task for resource RES_SCHEDULER	Resource is released and *running* task's priority is reset. No preemption of *running* task. Service returns E_OK
16	m, f B1, B2, E1, E2 s, e	Call `ReleaseResource()`from preemptive task for resource RES_SCHEDULER	Resource is released and *running* task's priority is reset. Ready task with highest priority is executed (Rescheduling). Service returns E_OK

4.6 Alarms

The behaviour of the OS is not defined by the specification if the action assigned to the expiration of an alarm can not be performed, because

- it would lead to multiple task activation, which is not allowed in the used conformance class or the max. number of activated tasks is already reached, or
- it would set an event for a task which is currently suspended.

The expected behaviour is, that at least the error hook is called. But as this situation is not covered by the specification, it is not part of conformance testing.



Test case No.	Sched. policy Conf. class Status	Action	Expected Result
1	n, m, f B1, B2, E1, E2 e	Call `GetAlarmBase()` with invalid alarm ID	Service returns E_OS_ID
2	n, m, f B1, B2, E1, E2 s, e	Call `GetAlarmBase()`	Return alarm base characteristics. Service returns E_OK
3	n, m, f B1, B2, E1, E2 e	Call `GetAlarm()` with invalid alarm ID	Service returns E_OS_ID
4	n, m, f B1, B2, E1, E2 s, e	Call `GetAlarm()` for alarm which is currently not in use	Service returns E_OS_NOFUNC
5	n, m, f B1, B2, E1, E2 s, e	Call `GetAlarm()` for alarm which will activate a task on expiration	Returns number of ticks until expiration. Service returns E_OK
6	n, m, f E1, E2 s, e	Call `GetAlarm()` for alarm which will set an event on expiration	Returns number of ticks until expiration. Service returns E_OK
7	n, m, f B1, B2, E1, E2 e	Call `SetRelAlarm()` with invalid alarm ID	Service returns E_OS_ID

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
8	n, m, f B1, B2, E1, E2 s, e	Call `SetRelAlarm()` for already activated alarm which will activate a task on expiration	Service returns E_OS_STATE
9	n, m, f E1, E2 s, e	Call `SetRelAlarm()` for already activated alarm which will set an event on expiration	Service returns E_OS_STATE
10	n, m, f B1, B2, E1, E2 e	Call `SetRelAlarm()` with increment value lower than zero	Service returns E_OS_VALUE
11	n, m, f B1, B2, E1, E2 e	Call `SetRelAlarm()` with increment value greater than `maxallowedvalue`	Service returns E_OS_VALUE
12	n, m, f B1, B2, E1, E2 e	Call `SetRelAlarm()` with cycle value lower than `mincycle`	Service returns E_OS_VALUE
13	n, m, f B1, B2, E1, E2 e	Call `SetRelAlarm()` with cycle value greater than `maxallowedvalue`	Service returns E_OS_VALUE
14	n, m, f B1, B2, E1, E2 s, e	Call `SetRelAlarm()` for alarm which will activate a task on expiration	Alarm is activated. Service returns E_OK
15	n, m, f E1, E2 s, e	Call `SetRelAlarm()` for alarm which will set an event on expiration	Alarm is activated. Service returns E_OK
16	n, m, f B1, B2, E1, E2 e	Call `SetAbsAlarm()` with invalid alarm ID	Service returns E_OS_ID
17	n, m, f B1, B2, E1, E2 s, e	Call `SetAbsAlarm()` for already activated alarm which will activate a task on expiration	Service returns E_OS_STATE
18	n, m, f E1, E2 s, e	Call `SetAbsAlarm()` for already activated alarm which will set an event on expiration	Service returns E_OS_STATE
19	n, m, f B1, B2, E1, E2 e	Call `SetAbsAlarm()` with increment value lower than zero	Service returns E_OS_VALUE
20	n, m, f B1, B2, E1, E2 e	Call `SetAbsAlarm()` with increment value greater than `maxallowedvalue`	Service returns E_OS_VALUE
21	n, m, f B1, B2, E1, E2 e	Call `SetAbsAlarm()` with cycle value lower than `mincycle`	Service returns E_OS_VALUE
22	n, m, f B1, B2, E1, E2 e	Call `SetAbsAlarm()` with cycle value greater than `maxallowedvalue`	Service returns E_OS_VALUE

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
23	n, m, f B1, B2, E1, E2 s, e	Call `SetAbsAlarm()` for alarm which will activate a task on expiration	Alarm is activated. Service returns E_OK
24	n, m, f E1, E2 s, e	Call `SetAbsAlarm()` for alarm which will set an event on expiration	Alarm is activated. Service returns E_OK
25	n, m, f B1, B2, E1, E2 e	Call `CancelAlarm()` with invalid alarm ID	Service returns E_OS_ID
26	n, m, f B1, B2, E1, E2 s, e	Call `CancelAlarm()` for alarm which is currently not in use	Service returns E_OS_NOFUNC
27	n, m, f B1, B2, E1, E2 s, e	Call `CancelAlarm()` for already activated alarm which will activate a task on expiration	Alarm is cancelled. Service returns E_OK
28	n, m, f E1, E2 s, e	Call `CancelAlarm()` for already activated alarm which will set an event on expiration	Alarm is cancelled. Service returns E_OK
29	n, m, f B1, B2, E1, E2 s, e	Expiration of alarm which activates a task while no tasks are currently *running*	Task is activated
30	n, m B1, B2, E1, E2 s, e	Expiration of alarm which activates a task while *running* task is non-preemptive	Task is activated. No preemption of *running* task
31	m, f B1, B2, E1, E2 s, e	Expiration of alarm which activates a task with higher priority than *running* task while *running* task is preemptive	Task is activated. Task with highest priority is executed
32	m, f B1, B2, E1, E2 s, e	Expiration of alarm which activates a task with lower priority than *running* task while *running* task is preemptive	Task is activated. No preemption of *running* task.
33	n, m E1, E2 s, e	Expiration of alarm which sets an event while *running* task is non-preemptive. Task which owns the event is not *waiting* for this event and not *suspended*	Event is set
34	n, m E1, E2 s, e	Expiration of alarm which sets an event while *running* task is non-preemptive. Task which owns the event is *waiting* for this event	Event is set. Task which is owner of the event becomes *ready.* No preemption of *running* task
35	m, f E1, E2 s, e	Expiration of alarm which sets an event while *running* task is preemptive. Task which owns the event is not *waiting* for this event and not *suspended*	Event is set

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
36	m, f E1, E2 s, e	Expiration of alarm which sets an event while *running* task is preemptive. Task which owns the event is *waiting* for this event	Event is set. Task which is owner of the event becomes *ready.* Task with highest priority is executed (Rescheduling)

4.7 Error handling, hook routines and OS execution control

The specification doesn't provide an error status when calling an OS service which is not allowed on hook level from inside a hook routine. It is assumed that the correct behaviour would be to return E_OS_CALLEVEL. As this is not prescribed by the specification, this will not be used as a criteria for the conformance of the implementation. Anyway, the conformance tests will check that restricted OS services return a value not equal E_OK.

Test case No.	Sched. policy Conf. class Status	Action	Expected Result
1	n, m, f B1, B2, E1, E2 s, e	Call `GetActiveApplicationMode()`	Return current application mode
2	n, m, f B1, B2, E1, E2 s, e	Call `StartOS()`	Start operating system
3	n, m, f B1, B2, E1, E2 s, e	Call `ShutdownOS()`	Shutdown operating system
4	n, m, f B1, B2, E1, E2 s, e	Check PreTaskHook/PostTaskHook: Force rescheduling	PreTaskHook is called before executing the new task, but after the transition to *running* state. PostTaskHook is called after exiting the current task but before leaving the task's *running* state
5	n, m, f B1, B2, E1, E2 s, e	Check ErrorHook: Force error	ErrorHook is called at the end of a system service which has a return value not equal E_OK
6	n, m, f B1, B2, E1, E2 s, e	Check StartupHook: Start OS	StartupHook is called after initialisation of OS
7	n, m, f B1, B2, E1, E2 s, e	Check ShutdownHook: Shutdown OS	ShutdownHook is called after the OS shut down
8	n, m, f B1, B2, E1, E2 e	Check availability of OS services inside hook routines according to fig. 9-1 of OS spec.	OS services which must not be called from hook routines return status not equal E_OK

5 Appendix I

This appendix list implementation specific parameters which are proposed by the specification to be provided by the vendor. Anyway, as they are too dependant on the environment and the applications running on the system, to be useful to customers, it doesn't seem to be reasonable to determine them. Thus, the MODISTARC OS group decided not to use them as criteria for compliance and therefore put them into this appendix.

No.	Assertion	Page	Paragraph in spec.	Affected variants
1	RAM and ROM requirement for each of the OS components	63	12.2.2	All
2	Size for each linkable module	63	12.2.2	All
3	Application dependant RAM and ROM requirements for OS data (e.g. bytes RAM per task, RAM required per alarm, ...)	63	12.2.2	All
4	Execution context of the OS (e.g. size of OS internal tables)	63	12.2.2	All
5	Total execution time for each service	63	12.2.3	All
6	OS start-up time without invoking hook routines	63	12.2.3	All
7	Interrupt latency for ISR of category 1, 2 and 3	63	12.2.3	All
8	Task switching times for all types of switching	63	12.2.3	All
9	Idle CPU overhead	63	12.2.3	All

6 Abbreviations

API	Application Programming Interface
COM	Communication
DLL	Data Link Layer
ECU	Electronic Control Unit
ISO	International Standard Organization
ISR	Interrupt Service Routine
IUT	Implementation Under Test
LT	Lower Tester
NM	Network Management
OPDU	OSEK Protocol Data Unit
OS	Operating System
PDU	Protocol Data Unit
PCO	Point of Control and Observation
SDL	Specification and Description Language
TMP	Test Management Protocol
TM_PDU	Test Management - Protocol Data Unit
TTCN	Tree and Tabular Combined Notation
UT	Upper Tester

7 References

[1] OSEK/VDX Conformance Testing Methodology - Version 1.0 - 19th of December 1997

[2] OSEK/VDX Certification Procedure - F. Kaag, J. Minuth, K.J. Neumann, H. Kuder - Proceedings of the 1st International Workshop on Open Systems in Automotive Networks - October 1995.

[3] OSEK/VDX Operating System - Version 2.0 revision 1 - 15th of October1997

[4] ISO/IEC 9646-1 - Information technology, Open Systems Interconnection, Conformance testing methodology and framework, part 1 : General Concepts, 1992.

[5] ISO/IEC 9646-3 - Information technology, Open Systems Interconnection, Conformance testing, methodology and framework, part 3 : The Tree and Tabular Combined Notation (TTCN), 1992.

[6] Benutzerdokumentation "Classification-Tree Editor - CTE für MS-Windows", Version 1.2 - ATS Automated Testing Solutions GmbH, Daimler-Benz AG, 1st of February 1998.