INTERNATIONAL STANDARD

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Information technology — Open Systems Interconnection — Systems management: Scheduling function

Technologies de l'information — Interconnexion de systèmes ouverts (OSI) — Gestion-systèmes: Fonction de programmation

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 10164-15 was prepared by ITU-T (as ITU-T Rec. X.746) and was adopted, under a special "fast-track procedure" by Joint Technical Committee ISO/IEC JTC 1, in parallel with its approval by national bodies of ISO and IEC. The identical text is published as ITU-T Rec. X.746.

This second edition cancels and replaces the first edition (ISO/IEC 10164-15:1995), which has been technically revised.

ISO/IEC 10164 consists of the following parts, under the general title *Information technology — Open Systems Interconnection — Systems management*:

— *Part 1: Object management function*

— *Part 2: State management function*

— *Part 3: Attributes for representing relationships*

— *Part 4: Alarm reporting function*

— *Part 5: Event report management function*

— *Part 6: Log control function*

— *Part 7: Security alarm reporting function*

— *Part 8: Security audit trail function*

— *Part 9: Objects and attributes for access control*

— *Part 10: Usage metering function for accounting purposes*

— *Part 11: Metric objects and attributes*

— *Part 12: Test management function*

— *Part 13: Summarization function*

— *Part 14: Confidence and diagnostic test categories*

— *Part 15: Scheduling function*

— *Part 16: Management knowledge management function*

— *Part 17: Change over function*

— *Part 18: Software management function*

— *Part 19: Management domain and management policy management function*

— *Part 20: Time management function*

— *Part 21: Command sequencer for systems management*

— *Part 22: Response time monitoring function*

Introduction

ITU-T Rec. X.746 | ISO/IEC 10164-15 is a member of a family of Recommendations | International Standards dealing with *Systems Management*:

- X.730 (1992) | ISO/IEC 10164-1:1993: Object management function.
- X.731 (1992) | ISO/IEC 10164-2:1993: State management function.
- X.732 (1992) | ISO/IEC 10164-3:1993: Attributes for representing relationships.
- X.733 (1992) | ISO/IEC 10164-4:1992: Alarm reporting function.
- X.734 (1992) | ISO/IEC 10164-5:1993: Event report management function.
- X.735 (1992) | ISO/IEC 10164-6:1993: Log control function.
- X.736 (1992) | ISO/IEC 10164-7:1992: Security alarm reporting function.
- X.737 (1995) | ISO/IEC 10164-14:1996: Confidence and diagnostic test categories.
- X.738 (1993) | ISO/IEC 10164-13:1995: Summarization function.
- X.739 (1993) | ISO/IEC 10164-11:1994: Metric objects and attributes.
- X.740 (1992) | ISO/IEC 10164-8:1993: Security audit trail function.
- X.741 (1995) | ISO/IEC 10164-9:1995: Objects and attributes for access control.
- X.742 (1995) | ISO/IEC 10164-10:1995: Usage metering function for accounting purposes.
- X.743 (1998) | ISO/IEC 10164-20:1999: Time management function.
- X.744 (1996) | ISO/IEC 10164-18:1997: Software management function.
- X.745 (1993) | ISO/IEC 10164-12:1994: Test management function.
- X.746 (2000) | ISO/IEC 10164-15:2001: Scheduling function.
- X.748 (1999) | ISO/IEC 10164-22:2000: Response time monitoring function.
- X.749 (1997) | ISO/IEC 10164-19:1998: Management domain and management policy management function.
- X.750 (1996) | ISO/IEC 10164-16:1997: Management knowledge management function.
- X.751 (1995) | ISO/IEC 10164-17:1996: Changeover function.
- X.753 (1997) | ISO/IEC 10164-21:1998: Command sequencer for systems management.

INTERNATIONAL STANDARD
ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – SYSTEMS MANAGEMENT: SCHEDULING FUNCTION

1 Scope

This Recommendation | International Standard defines the scheduling function. The scheduling function is a systems management function which may be used by an application process in a centralized or decentralized management environment to exchange information and commands for the purpose of systems management, as defined by CCITT Rec. X.700 | ISO/IEC 7498-4. This Recommendation | International Standard is positioned in the application layer of ITU-T Rec. X.200 | ISO/IEC 7498-1 and is defined according to the model provided by ISO/IEC 9545. The role of systems management functions is described by CCITT Rec. X.701 | ISO/IEC 10040.

This Recommendation | International Standard:

- identifies a set of requirements satisfied by the function;
- provides a model for scheduling;
- specifies the management requirements of the function and how these are realized by specification of managed objects and their behaviour;
- defines the conformance requirements to be met by implementations of this Recommendation | International Standard;
- defines managed objects.

This Recommendation | International Standard does not define:

- the manner in which management is to be accomplished by the user of the scheduling function;
- the nature of any implementation intended to provide the scheduling function;
- the nature of any interactions which result in the use of the scheduling function;
- the interactions which result by the simultaneous use of several management functions;
- the occasions where the use of the scheduling function is appropriate;
- the services necessary for the establishment, normal and abnormal release of a management association.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

2.1 Identical Recommendations | International Standards

- ITU-T Recommendation X.200 (1994 | ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model.*
- ITU-T Recommendation X.210 (1993) | ISO/IEC 10731:1994, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services.*
- ITU-T Recommendation X.680 (1997) | ISO/IEC 8824-1:1998, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation.*
- ITU-T Recommendation X.681 (1997) | ISO/IEC 8824-2:1998, *Information technology – Abstract Syntax Notation One (ASN.1): Information object specification.*

- ITU-T Recommendation X.682 (1997) | ISO/IEC 8824-3:1998, *Information technology – Abstract Syntax Notation One (ASN.1): Constraint specification.*
- ITU-T Recommendation X.690 (1997) | ISO/IEC 8825-1:1998, *Information technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER).*
- ITU-T Recommendation X.691 (1997) | ISO/IEC 8825-2:1998, *Information technology – ASN.1 encoding rules: Specification of Packed Encoding Rules (PER).*
- CCITT Recommendation X.701 (1992) | ISO/IEC 10040:1992, *Information technology – Open Systems Interconnection – Systems management overview.*
- ITU-T Recommendation X.710 (1997) | ISO/IEC 9595:1998, *Information technology – Open Systems Interconnection – Common management information service.*
- CCITT Recommendation X.721 (1992) | ISO/IEC 10165-2:1992, *Information technology – Open Systems Interconnection – Structure of management information: Definition of management information.*
- CCITT Recommendation X.722 (1992) | ISO/IEC 10165-4:1992, *Information technology – Open Systems Interconnection – Structure of management information: Guidelines for the definition of managed objects*.
- ITU-T Recommendation X.724 (1993) | ISO/IEC 10165-6:1994, *Information technology – Open Systems Interconnection – Structure of management information: Requirements and guidelines for implementation conformance statement proformas associated with OSI management*.
- CCITT Recommendation X.730 (1992) | ISO/IEC 10164-1:1993, *Information technology – Open Systems Interconnection – Systems Management: Object management function*.
- CCITT Recommendation X.731 (1992) | ISO/IEC 10164-2:1993, *Information technology – Open Systems Interconnection – Systems Management: State management function*.
- CCITT Recommendation X.734 (1992) | ISO/IEC 10164-5:1993, *Information technology – Open Systems Interconnection – Systems Management: Event report management function*.
- ITU-T Recommendation X.738 (1993) | ISO/IEC 10164-13:1995, *Information technology – Open Systems Interconnection – Systems Management: Summarization function*.
- ITU-T Recommendation X.739 (1993) | ISO/IEC 10164-11:1994, *Information technology – Open Systems Interconnection – Systems Management: Metric objects and attributes*.
- ITU-T Recommendation X.745 (1993) | ISO/IEC 10164-12:1994, *Information technology – Open Systems Interconnection – Systems Management: Test Management Function*.

2.2 Paired Recommendations | International Standards equivalent in technical content

- CCITT Recommendation X.291 (1992), *OSI conformance testing methodology and framework for protocol Recommendations for CCITT applications – Abstract test suite specification.*

  ISO/IEC 9646-2:1994, *Information technology – Open Systems Interconnection – Conformance testing methodology and framework – Part 2: Abstract Test Suite specification*.
- CCITT Recommendation X.700 (1992), *Management framework for Open Systems Interconnection (OSI) for CCITT applications*.

  ISO/IEC 7498-4:1989, *Information processing systems – Open Systems Interconnection – Basic Reference Model – Part 4: Management framework.*

2.3 Additional references

- ITU-T Recommendation M.3100 (1995), *Generic network information model*.
- ISO/IEC 9545:1994, *Information technology – Open Systems Interconnection – Application Layer structure*.

3 Definitions

For the purposes of this Recommendation | International Standard, the following definitions apply.

3.1 Basic reference model definitions

This Recommendation | International Standard makes use of the following terms defined in ITU-T Rec. X.200 | ISO/IEC 7498-1.

a) open system;

b) systems management.

3.2 Abstract syntax notation one definitions

This Recommendation | International Standard makes use of the following term defined in ITU-T Rec. X.680 | ISO/IEC 8824-1.

a) object identifier.

3.3 Management framework definitions

This Recommendation | International Standard makes use of the following term defined in CCITT Rec. X.700 | ISO/IEC 7498-4.

a) managed object.

3.4 Common management information service definitions

This Recommendation | International Standard makes use of the following terms defined in ITU-T Rec. X.710 | ISO/IEC 9595.

a) attribute;

b) common management information service.

3.5 Systems management overview definitions

This Recommendation | International Standard makes use of the following terms defined in CCITT Rec. X.701 | ISO/IEC 10040.

a) agent;

b) managed object class;

c) manager;

d) notification;

e) systems management operations.

3.6 Management information model definitions

This Recommendation | International Standard makes use of the following terms defined in CCITT Rec. X.720 | ISO/IEC 10165-1.

a) action;

b) actual class;

c) behaviour;

d) characteristic;

e) conditional package;

f) inheritance;

g) instantiation;

h) mandatory package;

i) name binding;

j) package;

k) subclass;

l) superclass.

3.7 Additional definitions

3.7.1 aperiodic scheduling: A type of scheduling that controls the triggering of activities at certain specified times within specified managed object instances.

3.7.2 interval scheduling: A type of scheduling that controls a number of intervals of operation of activities within specified managed object instances.

3.7.3 periodic scheduling: A type of scheduling that controls the repetitive triggering of activities within specified managed object instances.

3.7.4 scheduling: The method of controlling the timing of the execution of a scheduled activity within or represented by a managed object.

3.7.5 scheduled managed object (SMO): The managed object whose activities are to be scheduled.

3.7.6 scheduler object (SO): The managed object that defines the type and values of the schedule to be applied to activities within SMOs.

3.7.7 trigger scheduling: A type of scheduling that controls the triggering of activities within specified managed object instances.

4 Abbreviations

For the purposes of this Recommendation | International standard, the following abbreviations apply:

ASN.1	Abstract Syntax Notation One
CMIS	Common Management Information Service
ICS	Implementation Conformance Statement
MAPDU	Management Application Protocol Data Unit
MCS	Management Conformance Statement
MOCS	Managed Object Conformance Statement
NE	Network Element
OC	Object Class
OS	Operation System
SMO	Scheduled Managed Object
SO	Scheduler Object

5 Conventions

The ICS proformas specified in this Recommendation | International Standard (see Annexes C to G) use the common notations, defined in CCITT Rec. X.291 | ISO/IEC 9646-2 and CCITT Rec. X.296 | ISO/IEC 9646-7.

6 Requirements

In terms of functionality, the requirements to be satisfied are:

- Provide a function that can schedule a number of activities within multiple managed objects according to a single schedule.
- Be able to specify the time duration that the schedule is active.
- For schedules that control the interval of operation of an activity within a managed object, the start and stop time should be defined as the actual time within a 24-hour clock.
- Provide a function that can schedule aperiodic and periodic triggering of an activity.
- Allow that the scheduling information communicated to the scheduled object be independent of the action the scheduled object performs. The scheduler may have no knowledge about this action. As a consequence, the relations between the scheduler, the scheduling information and the corresponding actions to be performed are existing in the scheduled object.
- Several independent schedulers can coexist.
- Scheduling shall be possible on base of type of day (e.g. weekend, Christmas, bank holiday).

Interval scheduling

- Provide a function that controls the scheduled activities of one or more managed objects.
- Provide a configurable schedule that repeats over a specified time period. The specified time period may be a day, a week or a month.
- Provide a user defined number of intervals together with the start and stop times of each of these intervals within the specified period.
- Overlapping intervals shall be allowed. Precedence rules are therefore needed in order to decide which interval is active.

Trigger scheduling

- Provide a function that controls the triggering of an activity of one or more managed objects.
- Provide a configurable period for the repetitions of the triggering.
- Provide a user defined list of trigger times.

7 Model

Scheduling can be modelled as a part of the managed object whose operation or activity is to be scheduled, or as a separate managed object.

Characteristics for the control of a schedule can be imported into a managed object class or can be defined as a separate managed object. These two ways of defining scheduling of a managed object are termed internal and external scheduling, respectively. This Recommendation | International Standard describes models for both internal and external scheduling.

This Recommendation | International Standard also describes four types of scheduling in 7.3 below: interval, trigger (periodic and aperiodic), operations and index ("multi-scheduler") scheduling. These scheduling types can be used with internal and external scheduling mechanisms.

The activities which can be controlled by scheduling are defined as part of the scheduled managed object (SMO) class. There need to be characteristics in the SMO related to these scheduled activities.

7.1 Internal scheduling mechanism

It is appropriate to define the scheduling mechanism within a managed object class if it will not need to be altered in the future and the managed object is to be individually scheduled. The scheduling mechanism can be defined within a managed object class by including the appropriate scheduling components (e.g. attributes and behaviour). If more than one type of scheduling is defined within a managed object class, the conditions for instantiation of each type of scheduling must be defined in the managed object class definition.

When the scheduling mechanism is defined within the managed object whose activity is scheduled, no additional objects are required and the scheduling may be manipulated through the use of systems management operations. However, when multiple activities within a managed object are to be scheduled using this mechanism, separate scheduling characteristics are required for each activity.

Scheduling characteristics for each activity may include more than one type of scheduling (see 7.3) and the conditions for instantiation of each type shall be defined in the managed object class definition.

7.2 External scheduling mechanism

It is beneficial to define an external scheduling mechanism so that schedules may be determined independently of SMOs. Many managed objects may be controlled by a single schedule. If a single scheduler object (SO) provides the schedule, there may be no need for scheduling components in the SMOs: in such a case, this eliminates the need to replicate and coordinate schedules across SMOs.

The scheduling function is represented by SOs which are separate from the SMOs, as shown in Figure 1. One SO may control activities in any number of SMOs. Multiple external schedules are allowed for the same activity. The approach for defining more than one type of scheduling for the same activity is described in 7.3.

The scheduler object provides a schedule to a SMO. SMOs shall have attributes which identify the SOs providing schedules. Each of these attributes shall have and be associated with behaviour which describes the effect of the schedule upon the SMO. It may not be necessary to use several SOs to provide this, when using the index SO.

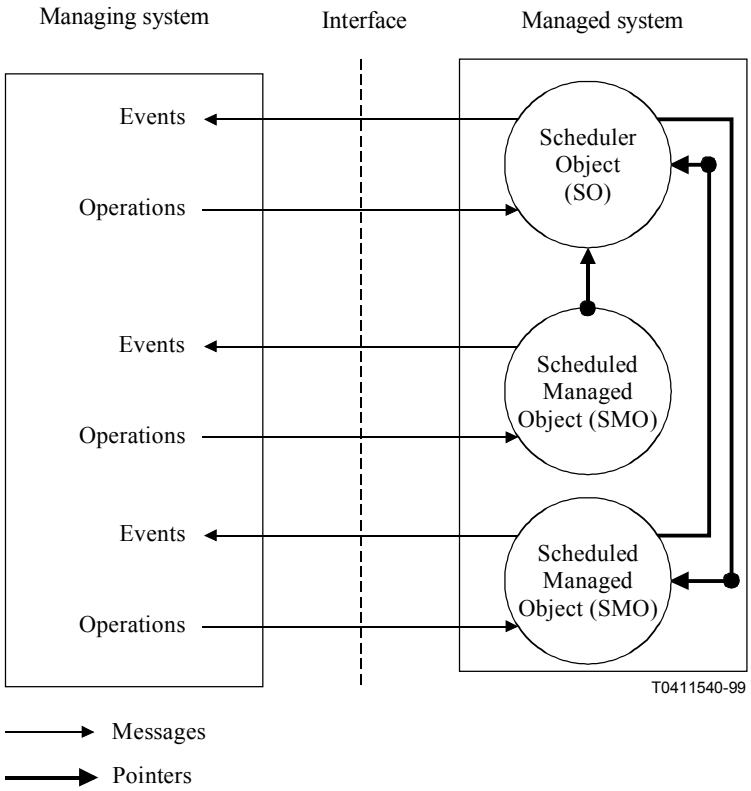

Figure 1 – Scheduler Object model

7.3 Types of scheduling

There are four specific types of scheduling: interval scheduling, trigger scheduling, operations scheduling and index scheduling. This Recommendation | International Standard describes four types of interval scheduling – daily, weekly, monthly and type-of-day interval scheduling (see 7.3.1); two types of trigger scheduling – periodic and aperiodic scheduling (see 7.3.2), operations scheduling (see Operations scheduling) and index scheduling (see Index scheduling). These types of scheduling are defined by packages which may be included in managed objects for the purpose of internal scheduling (except for the operations scheduling) or in a scheduler object for external scheduling.

NOTE – Other scheduling packages are defined in CCITT Rec. X.734 | ISO/IEC 10164-5.

If a combination of interval and trigger scheduling is required for one activity, the triggering is effective only within the intervals defined by the interval schedule.

7.3.1 Interval scheduling

Interval scheduling is used to define a schedule that controls a sequence of transitions of an activity of a SMO between the active and inactive state. The schedule may repeat in one of the following ways: a given number of days with specified intervals for each day, a given number of weeks with specified intervals for specified days of each week or a given number of months with specified intervals for specified days of each month. Each of these types of interval scheduling, daily, weekly and monthly is specified by selecting the intervals of day parameter for the day, week or month mask attribute in the appropriate scheduler object class.

The duration over which interval scheduling affects the operation of the SMOs may be controlled by the specified duration start time and duration stop time (date and time).

The intervals of operation are specified by a set of interval start and interval stop times.

The operation of the interval schedulers can be suspended by setting their administrative state attribute to locked and resumed by setting their administrative state attribute to unlocked.

7.3.2 Trigger scheduling

7.3.2.1 Periodic scheduling

Periodic scheduling is used to define a schedule that repetitively triggers specified activities at regular time intervals within specified managed object instances. The time duration over which the activities, specified in the SMOs, can be triggered, may be controlled by the specified duration start time and duration stop time (date and time). When a periodic scheduler is created, it either triggers at the specified duration start time (which may be the object creation time) or it synchronizes the first triggering point to a specified synchronization time. It then synchronizes the period to this initial triggering point.

The operation of a scheduler can be suspended and resumed by setting its administrative state attribute. Two methods of synchronization of the triggering points can be used when the operation of the scheduler is resumed, either period synchronization time or resynchronize mode. If a period synchronization time is specified, the triggering will always be synchronized to that time. If a resynchronize mode has been specified in the SO, the triggering may be synchronized to the specified duration start time, or it may be synchronized to the time of resumption of the SO, depending on the resynchronize mode selected. If period synchronization time and resynchronize mode are absent, the period will always be synchronized to the specified duration start time.

7.3.2.2 Aperiodic scheduling

An activity in a managed object can be triggered at scheduled times. This is achieved by specifying a set of trigger times for the activity rather than specifying an interval for the operation of that activity. This mechanism allows activities in a managed object to be triggered at absolute times as opposed to the triggering of activities at regular intervals relative to a start time as defined for periodic scheduling (see 7.3.2.1).

An aperiodic trigger schedule may repeat in one of the following ways: a given number of days with specified trigger times for each day, a given number of weeks with specified trigger times for specified days of each week or a given number of months with specified trigger times for specified days of each month. Each of these types of aperiodic scheduling, daily, weekly and monthly is specified by selecting the trigger times parameter for the day, week or month mask attribute in the appropriate scheduler object class.

7.3.3 Operations scheduling

In accordance with its schedule, a scheduling object which uses the operation scheduling approach determines operations performed upon SMOs.

In this case the SO may have notifications to report success and failure in the execution of the operations. A scheduling object which uses the operation scheduling approach has attributes to identify a schedule, the SMOs which are being scheduled and the operations and parameters which are to be requested in accord with the schedule. When the result notification is issued, the managed object class and managed object instance parameters shall be present in the operation result(s).

NOTE – The sending of messages between managed objects in the same system, either expressed on implied in this model, does not imply any need for conformance testing of these inter-object interactions.

7.3.4 Index scheduling

This index scheduling functions is an enhancement to the previous schedulings.

The multiScheduler scheduling extends the functionality of the interval scheduling and aperiodic scheduling:

- for interval scheduling, the multiScheduler allows the transition of an activity between several (two or more) states. Each such state is associated with an index value. The multiScheduler also allows overlapping intervals;
- for aperiodic scheduling, the multiScheduler allows the triggering of (possibly different) activities depending on an index value. Aperiodic scheduling in the multiScheduler can also be used for operation scheduling.

For both types of scheduling, the index scheduling allows to schedule activities depending on the type of day, e.g. holidays, weekdays. For this purpose, a type-Of-Day Controller is used to group days into categories according to their type, e.g. 1st January can be classified as specialDay1.

7.4 Relationships between SOs and SMOs

A SMO may be scheduled by more than one SO. In order to be scheduled by an external interval or trigger scheduler, a SMO shall have an attribute which points at the SO (the external scheduler name attribute). The SO may optionally have an attribute which points at the SMO (the scheduled managed objects attribute). SMOs which have multiple activities to