INTERNATIONAL STANDARD

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Information technology — Open Distributed Management Architecture —

Technologies de l'information — Architecture de gestion répartie ouverte

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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. 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.

International Standard ISO/IEC 13244 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 33, *Distributed application services*, in collaboration with ITU-T. The identical text is published as ITU-T Recommendation X.703.

Annex A to F of this International Standard are for information only.

INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN DISTRIBUTED MANAGEMENT ARCHITECTURE

1 Scope

This Recommendation | International Standard describes the Open Distributed Management Architecture (ODMA). ODMA provides an architecture for the specification and development both of systems management as an open distributed application and of the management of open distributed applications. ODMA also provides the architectural framework for the development of the standards needed within the architecture. The management will be of a distributed nature; this implies:

- distribution of the managing activity;
- management of distributed applications; and
- management of resources that may be distributed.

ODMA is compliant with the ODP-RM, so that in a distributed environment OSI Systems Management can be used in combination with other techniques that are engineered and implemented according to ODP principles.

This Recommendation | International Standard is the base document of a (potential) range of standards and Recommendations to be developed within ODMA. Figure 1 provides an overview of the relationship between this Recommendation | International Standard and other standards.

Other standards that may be developed within ODMA are:

- ODMA supports: Based on the General Framework of ODMA, these standards give descriptions of specific systems support of ODMA. For example, the OSI Systems Management and CORBA support of ODMA have been identified.

- ODMA viewpoint notations: These component standards provide standardised notations for describing the ODP viewpoints for ODMA (see for example Annex D). These notations are described in separate documents for the ODMA viewpoint notations.
- ODMA functions: These component standards describe functions that are necessary for the construction of an Open Distributed Management System. Some example functions like the operation dispatcher function or the notification dispatcher function are outlined in this Recommendation | International Standard.
- ODMA inter-domain functions: These component standards describe the interworking between different paradigms providing support for ODMA, for example, between OSI Systems Management and CORBA.

As illustrated in Figure 1 this Recommendation | International Standard only elaborates a subset of supporting ODMA systems but allows for developments of other clauses. As a consequence, this Recommendation | International Standard consists of two sections:

1) General Framework

   This clause describes ODMA as a specific interpretation of the Reference Model of Open Distributed Processing for the purpose of management. It introduces general terms that are needed for open distributed management. It may also identify tools for the description of the open distributed management applications.

2) OSI management support for ODMA

   This clause describes the OSI management support for ODMA. It relates the current OSI systems management concepts to ODMA concepts. However, it extends the current systems management standards to support the distribution of the management activities and the distribution of resources to be managed. As this specific interpretation reflects the current OSI standards, limitations may be imposed. For instance, only a number of distribution transparencies may be supported by the (extended) OSI management mechanisms.

Table 1 illustrates which viewpoints are of relevance for which documents (indicated by plus sign). A plus sign indicates that a document describes the viewpoint.

Although the document is divided in clauses, the concepts of the ODMA are overarching and are meant to be used as a bridging architecture between the different paradigms supporting ODMA.

In Figure 1 the 'standards and specifications based on ODMA' represent all the specifications and standards that will be developed using the ODMA standards.

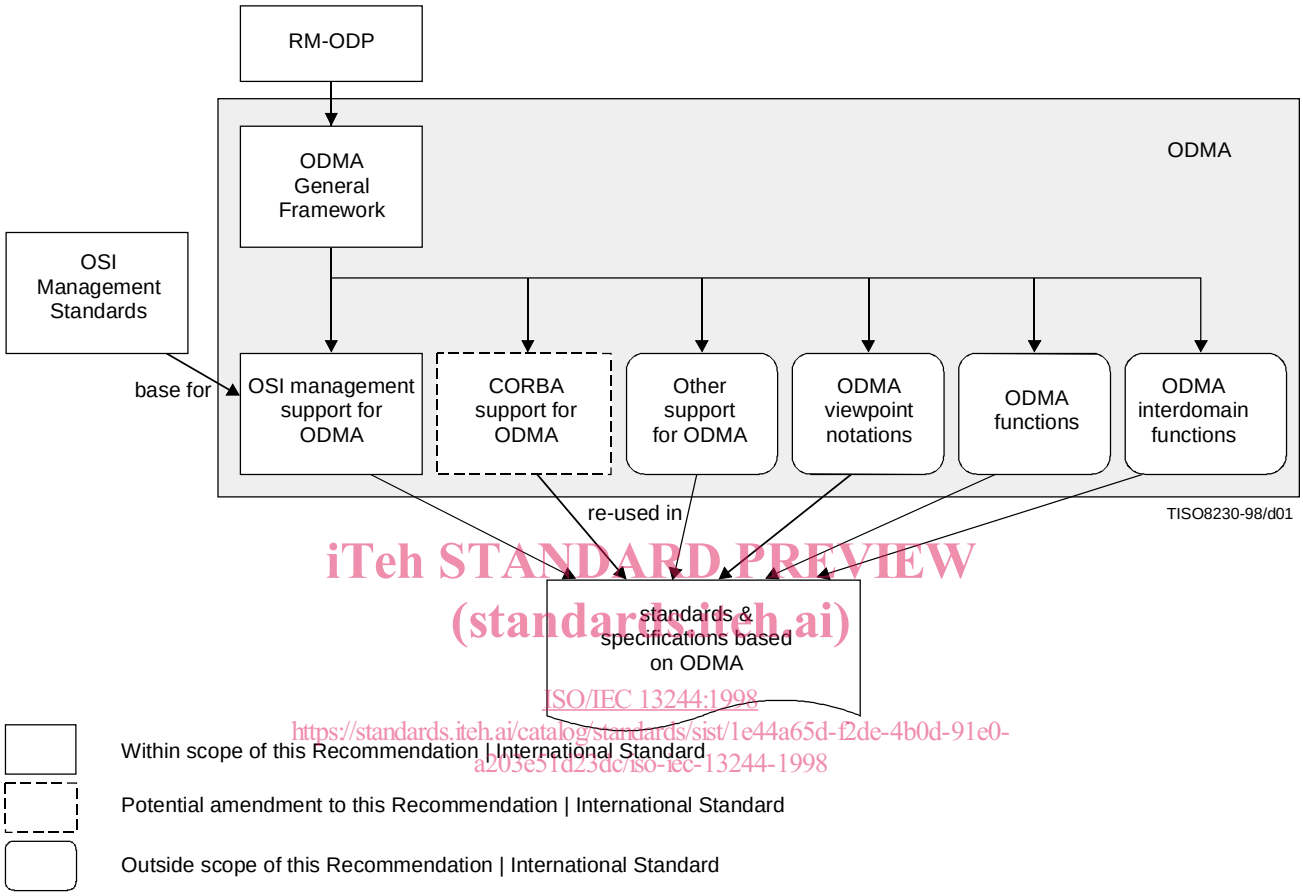

Figure 1 – ODMA document roadmap

Table 1 – Organisation of ODMA documents

	General Framework	OSI management support	CORBA support	...	ODMA functions
Enterprise	+				+
Information	+				+
Computational	+	+	+		+
Engineering	+	+	+		+
Technology					

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 Standardisation Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

2.1 Identical Recommendations | International Standards

- ITU-T Recommendation X.500 (1993) | ISO/IEC 9594-1:1995, *Information technology – Open Systems Interconnection – The Directory: Overview of concepts, models and services*.
- ITU-T Recommendation X.701 (1997) | ISO/IEC 10040:1998, *Information technology – Open Systems Interconnection – Systems management overview*.
- ITU-T Recommendation X.702 (1995) | ISO/IEC 11587:1996, *Information technology – Open Systems Interconnection – Application context for systems management with transaction processing*.
- ITU-T Recommendation X.710 (1997) | ISO/IEC 9595:1998, *Information technology – Open Systems Interconnection – Common management information service*.
- CCITT Recommendation X.720 (1992) | ISO/IEC 10165-1:1993, *Information technology – Open Systems Interconnection – Structure of management information: Management information model*.
- 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.725 (1995) | ISO/IEC 10165-7:1996, *Information technology – Open Systems Interconnection – Structure of management information: General relationship model*.
- CCITT Recommendation X.734 (1992) | ISO/IEC 10164-5:1993, *Information technology – Open Systems Interconnection – Systems Management: Event report management function*.
- CCITT Recommendation X.735 (1992) | ISO/IEC 10164-6:1993, *Information technology – Open Systems Interconnection – Systems Management: Log control 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.749 (1997) | ISO/IEC 10164-19:1997, *Information technology – Open Systems Interconnection – Systems management domain and management policy management function.*
- ITU-T Recommendation X.750 (1996) | ISO/IEC 10164-16:1997, *Information technology – Open Systems Interconnection – Systems Management: Management knowledge management function*.
- ITU-T Recommendation X.901 (1997) | ISO/IEC 10746-1:1998, *Information technology – Open Distributed Processing – Reference model: Overview*.
- ITU-T Recommendation X.902 (1995) | ISO/IEC 10746-2:1996, *Information technology – Open Distributed Processing – Reference model: Foundations*.
- ITU-T Recommendation X.903 (1995) | ISO/IEC 10746-3:1996, *Information technology – Open distributed processing – Reference Model: Architecture.*
- ITU-T Recommendation X.920 (1997) | ISO/IEC 14750:1998, *Information technology – Open Distributed Processing – Interface Definition Language.*
- ITU-T Recommendation X.950 (1997) | ISO/IEC 13235-1:1998, *Information technology – Open distributed processing – Trading function: Specification.*

2.2 Additional references

- ITU-T Recommendation G.805 (1995), *Generic functional architecture of transport networks.*
- ITU-T Recommendation G.851.1 (1996), *Management of the transport network – Application of the RM-ODP framework.*
- ITU-T Recommendation G.852.1 (1996), *Management of the transport network – Enterprise viewpoint for simple subnetwork connection management.*
- ITU-T Recommendation G.853.2 (1996), *Subnetwork connection management information viewpoint.*
- ITU-T Recommendation M.3100 (1995), *Generic network information model.*
- ITU-T Recommendation Q.821 (1993), *Stage 2 and stage 3 description for the Q3 interface – Alarm surveillance.*

3. Definitions

Unless qualified by the word “managed”, the term “object” in this Recommendation | International Standard refers to an ODP object as defined in ITU-T Rec. X.901 | ISO/IEC 10746-1.

3.1 ODP-RM definitions

This Recommendation | International Standard makes use of the terms defined in ITU-T Rec. X.902 | ISO/IEC 10746-2 shown in the Table 2.

Table 2 – Terms taken from ITU-T Rec. X.902 | ISO/IEC 10746-2

abstraction;	distributed processing;	ODP system;
action;	distribution transparency;	open distributed processing;
activity;	entity;	permission;
architecture;	environment contract;	persistence;
behaviour;	failure;	policy;
binding;	fault;	portability;
class;	identifier;	postcondition;
client object;	information;	precondition;
communication;	instance;	prohibition;
compliance;	interaction;	quality of service;
composition;	interface;	role;
configuration;	interface signature;	server object;
conformance;	invariant;	state;
contract;	management information;	system;
creation;	name;	type;
data;	naming action;	viewpoint.
decomposition;	object;	
deletion;	obligation;	

This Recommendation | International Standard makes use of the terms defined in ITU-T Rec. X.903 | ISO/IEC 10746-3 shown in the Table 3.

Table 3 – Terms taken from ITU-T Rec. X.903 | ISO/IEC 10746-3

announcement;	dynamic schema;	parameter
basic engineering object;	engineering interface;	protocol object;
binder;	invariant schema;	reactivation;
channel;	node;	static schema;
cluster;	operation;	stub.
communication domain;	operation interface signature;	

3.2 OSI Management definitions

This Recommendation | International Standard makes use of the term defined in ITU-T Rec. X.950 | ISO/IEC 11235-1.

– trader.

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

– agent;

– manager;

– managed object class;

– MIS-user.

This Recommendation | International Standard makes use of the term defined in ITU-T Rec. X.500 | ISO/IEC 9594-1.

– directory.

3.3 Additional definitions

3.3.1 computational management object: A specific name for ODP conformant computational objects that offer at least a managing or managed interface.

3.3.2 engineering management object: A specific name for ODP conformant basic engineering objects that offer at least a managing or managed interface.

3.3.3 linked reply operation: A sequence of operations between computational management objects in managing and managed role. The first operation is initiated by the object in the managing role. The subsequent operations are initiated by the objects in the managed role and convey replies to the managing object.

3.3.4 linked reply client interface: An operation interface of a computational management object that can emit multiple replies.

3.3.5 linked reply server interface: An operation interface of a computational management object that can accept multiple replies from multiple systems management operation messages.

3.3.6 management object: An object that can take either a managing or a managed role or both.

3.3.7 managed role: The behaviour of a computational management object with respect to its performing of systems management operations and its emission of systems management notifications in interactions with another computational management object.

3.3.8 managing role: The behaviour of a computational management object with respect to its handling of systems management notifications and its initiation of systems management operations in interactions with another computational management object.

3.3.9 notification: An interaction for which the contract between the invoking object (client) and the receiving object (server) is restricted to the ability of the server to receive the contents of information sent by the client.

3.3.10 notification client interface: An operation interface of a computational management object that can only emit systems management notification messages.

3.3.11 notification server interface: An operation interface of a computational management object that can only accept systems management notification messages

NOTE – Client and server are used in the ODP sense.

3.3.12 management-operation server interface: An operation interface of a computational management object that can only accept systems management operation messages.

3.3.13 management-operation client interface: An operation interface of a computational management object that can only emit systems management operation messages.

4 Abbreviations

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

ACID	Atomic Consistent Isolated Durable
ACSE	Association Control Service Element
AE	Application Entity

API	Application Programming Interface
ASN.1	Abstract Syntax Notation One
CMIP	Common Management Information Protocol
CMIS	Common Management Information Service
CMISE	Common Management Information Service Entity
CORBA	Common Object Request Broker Architecture
GDMO	Guidelines for the Definition of Managed Objects
GRM	General Relationship Model
IDL	Interface Definition Language
lr	linked reply
lrc	linked reply client
lrs	linked reply server
MOC	Managed Object Class
moc	management-operation client
mos	management-operation server
nc	notification client
ns	notification server
ODMA	Open Distributed Management Architecture
ODP	Open Distributed Processing
ODP-RM	Reference Model for Open Distributed Processing
OSI-SM	OSI Systems Management
QoS	Quality of Service
RC	Relationship Class
RPC	Remote Procedure Call
SMA	Systems Management Architecture
SMASE	Systems Management Application Service Element
SNC	Subnetwork Connection
TP	Transaction Processing

5 Requirements

This clause describes a set of requirements that are to be fulfilled in order to allow open distributed management. ODMA shall support:

- management of resources including those resources that are required for management;
- modularity with the identification of the parts that may be distributed;
- delegation of responsibility from one manager to another manager for issuing management operations;
- co-ordination of distributed management activities;
- management of systems of any scale;
- modelling of open distributed management systems assuming distribution transparency;
- tools for selected distribution transparency;

- management specific notational techniques for object-oriented modelling;
- hand-over of management responsibility from one system to another;
- mechanisms to determine management responsibility with respect to components of a managed system;
- several forms of distribution transparencies are defined by ODP-RM. Not all of them are used for management applications or the underlying systems that have to provide all these transparencies;
- access transparency (e.g., CMIP or RPC based...) so as to allow several implementations of the same application specification parts of a given application to interwork if implemented in different ways (different APIs and different communication protocols);
- ensure interworking with pre-existing OSI-SM applications and systems and specify how concepts and notation of OSI-SM can be used to specify ODMA systems and applications;
- interworking of management and non-management applications (e.g. network management and intelligent network applications);
- portability of management applications;
- the use of existing management information models into ODMA with a minimal adaptation;
- guidelines on the development of new information models based on ODMA.

Management applications based on ODMA must be capable to adapt to changes in their environment. These environment changes include but are not limited to:

- internal administrative organisations: different administrative organisation within enterprises have different static configurations of management functionality. Reconfiguration of management functionality may result from administrative decisions. ODMA should allow permanent management application specifications to be produced irrespective of the variety of possible management organisations;
- quality of service of management applications: time constraints, reliability, availability and others;
- growth of management network size: ODMA should permit the evolution from centralised management to distributed management as small networks grow beyond a size that can be effectively managed by a centralised management system;
- evolution of management services: ODMA must support the evolution of existing management services into distributed management services. The specification of new services must be possible without the need to refer to the location of existing services;
- technological change: the specification of a management system must persist over changes in implementation technology.

6 General framework

The Reference Model for Open Distributed Processing is a joint ISO/ITU Standard which provides a framework for the specification of large scale, heterogeneous distributed systems. It defines an architecture with a set of five viewpoints concentrating on different parts of the distribution problem and a set of functions and transparency mechanisms which support distribution. The resulting framework is being populated by more detailed standards dealing with specific aspects of the construction and operation of distributed systems. ODMA provides such a specialised architecture reference model for the distributed management of distributed resources, systems and applications. The following description of ODMA focuses on the specific features or requirements of management which are not already reflected in the ODP-RM. When unqualified, the term object refers to the abstraction of ODMA objects with respect to the ODP viewpoint under consideration in the current clause. Unless otherwise indicated, the concepts presented in this clause are as specified in ODP-RM.

6.1 Foundations

The general framework of ODMA is based on the following foundations:

- computational management object;
- engineering management object;
- managed role;

- managing role;
- management-operation server interface;
- management-operation client interface;
- notification client interface;
- notification server interface.

6.2 Architecture

In the following, each viewpoint within ODMA is described using those concepts of the ODP architecture and ODP foundations, which are necessary for management purpose. Additional ODMA concepts are described in the respective viewpoint, which are not defined in ODP but needed for management purpose and defined in 6.1, Foundations.

6.2.1 Enterprise viewpoint

The enterprise viewpoint is a view on the system and its environment that focuses on the purpose, scope and policies of the system.

The enterprise viewpoint description within ODMA is not different from similar descriptions in other applications of ODP-RM. However, the roles of special interest to ODMA are various cases of managing role and managed role, and that there is possibly a more frequent requirement for real-time data acquisition.

An enterprise specification should define contracts between objects in relation to the managing and managed roles.

An object performing in the managing role may require one or more objects performing the managed role to execute some management activity subject to a given contract.

ODMA does currently not prescribe the use of any particular notational technique for specifying the enterprise viewpoint (i.e. enterprise viewpoint notation). However, the description must unambiguously identify (i.e. name) the various constituent parts of the enterprise viewpoint description, for example, as illustrated in Annex F. The constituents are:

- Contract;
- Enterprise role;
- Community;
- Policy;
- Action;
- Activity.

6.2.2 Information viewpoint

The information viewpoint is a view on the system and its environment that focuses on the meaning of the information manipulated by and stored within the system. A detailed description can be found in the ODP-RM documents (Parts 1 and 3).

The information viewpoint description within ODMA is not different from similar descriptions in other applications of ODP-RM. Except that there is possibly a more frequent requirement that the information involved must correspond to actual values concerned with the equipment represented by the information objects.

The information specification has to ensure that the interpretation of the information handled by the objects in the system is consistent independently of the way the information processing functions themselves are distributed (defined in the computational viewpoint). This requires a specification of the invariant, static and dynamic schema.

The information objects together with their relationships are specified by a static schema. Assertions expressed specify the initial state of each object at a certain point in time. The relationship between the information objects should reflect the invariant schema expressing the invariants.

The dynamic schema is used to express how the information changes over time. It is used to specify the valid changes of states of the information objects. An information viewpoint specification, compliant with ODP-RM Part 3, may include definitions of dynamic schema, by specifying the valid state transitions of one or more information objects. In contrast, operations on interfaces that can trigger the state transitions are specified in the computational viewpoints.

An example specification of the static schema using OMT's[1)] (Object Modelling Technique, Rumbaugh) basic and enhanced object model is shown in Annex C.

6.2.3 Computational viewpoint

The computational viewpoint is a view on the system and its environment that enables distribution through functional decomposition of the system into objects which interact at interfaces. A detailed description can be found in the ODP-RM documents (Parts 1 and 3).

6.2.3.1 Computational management object template specification

A computational management object template specification comprises a set of computational interfaces which the object can instantiate, a behaviour specification and an environment contract specification.

Computational interface: A computational interface is characterised by a signature, a behaviour and an environment contract. An operation interface signature defines the set of operations supported at the interface, whether the operations are related to systems management operations or notifications, and the interface role (client or server).

Behaviour specification: The behaviour specification of an object is defined as the sequencing constraints, timing constraints, and concurrency constraints applicable to the object. It defines the overall behaviour of the object which might constrain the behaviour as specified for each interface that is supported by the object.

Environment contract: The environment contract specification of the object template applies to the object as a whole including the interfaces it supports. Examples of items specified in the object environment contract could be:

- that the object can only be located in a certain domain (security constraint, location constraint);
- that the object has a specified maximum probability of failure (reliability constraint).

This implies that for each computational object (including binding objects) a template should be specified that contains the elements described above.

6.2.3.2 Computational management interfaces

There are three kinds of computational management interfaces:

- management-operation;
- notification; and
- linked replies.

NOTE – Whenever the term 'operation' appears without qualifier it is used as defined in ODP-RM.

A computational management interface is an operation interface which can have one of the following roles:

- managing client role: which invokes operations on management-operation client interfaces;
- managed server role: which receives operations from management-operation server interfaces;
- managed client role: which invokes notifications on notification client interface;
- managing server role: which receives notifications from notification server interfaces;
- managed client role: which invokes operations on linked reply client interfaces;
- managing server role: which receives operations from linked reply server interfaces.

For management purposes, operations (e.g. get, replace, action operations as defined in GDMO) can be either announcements or interrogations. Operations are emitted by a management-operation client interface and received by a management-operation server interface. Notifications are emitted by a notification client interface and received by a notification server interface.

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1) The Object Modelling Technique (OMT) is a method developed by J. Rumbaugh.

In the computational viewpoint, the interface is specified by an ODP operation interface signature, composed of:

- an indication of the management interface role;
- notifications or operations signatures (name of the notification or operation invocation, names, number and types of parameters, action templates for possible terminations).

NOTE – Within this Recommendation | International Standard, parameter is used as in ODP and is not to be confused with the GDMO term.

Examples of notational templates that can be used to express management interfaces are presented in Annex E.

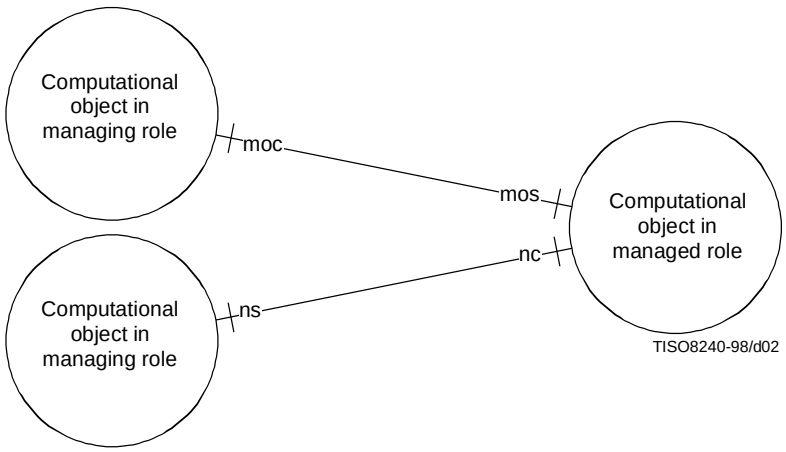
A computational management object can have multiple managed and multiple managing interfaces. For the OSI management support this enables the use of existing managed object class descriptions for describing managed interfaces for different purposes, e.g. one for configuration management (according to ITU-T Rec. M.3100) and one for fault management (according to ITU-T Rec. Q.821). Also having the possibility to define multiple management interfaces can lead to simpler relationship descriptions between the various interfaces of a management object. The managed system modeller therefore has the alternative of modelling management information for different purposes either by supplying multiple management interfaces to a management object or by providing different management objects for different purposes.

Table 4 describes the types of computational interfaces associated with roles within ODMA.

Table 4 – Type of computational interface associated with role

Interface role	Type of ODMA computational operation interface
managing client role	management-operation client (moc) interface
managing server role	notification server (ns) interface
managed client role	notification client (nc) interface
managed server role	management-operation server (mos) interface

Figure 2 depicts the types of interfaces together with the roles of the management objects.



NOTE – Due to the nature of notification operations, they may be invoked by a management object upon a notification distribution object, which can forward the contents to multiple destinations.

Figure 2 – Example of the relationship between roles and types for operations and notifications

Various computational interface definition notations can be used, some optimised for expressing interfaces to be carried by a particular engineering protocol objects. There may be benefit in a neutral computational interface definition notation, which refers to information objects and behaviour specified in the information viewpoint. Such neutral notations can be mapped via specification translations to the various interface definition notations.

From a management perspective there is a need to give identifiers (i.e. unambiguous names) to interfaces of objects in the managed role. Naming of the interfaces to objects in the managing role may be necessary when there is a need to bind to it. For example, naming of the interface of an object in the manager role is needed, if a notification dispatcher may push events to that object.

6.2.3.2.1 Linked replies operation

This subclause describes an example for the capability to support linked reply operations. Linked replies are used to return data as soon as they become available. Associated with the link reply operation is a final termination reply to indicate the operation has completed.

NOTE – The linked reply operation is a special operation of OSI management and not reflected in ODP-RM.

To provide this capability ODMA has to introduce two new interfaces. Table 5 describes the linked reply interfaces associated with roles within ODMA.

Table 5 – Type of computational interface associated with role

Interface role	Type of ODMA computational operation interface
managed client role	linked reply client (lrc) interface
managing server role	linked reply server (lrs) interface

Using the ODP-RM concepts these linked reply operations may be modelled as operations, which have to be linked. The linked reply (lr) interface is an interface in which all the interactions are operations and are related to the operation client interface.

The lr interface in the managing server role is related to the operation interface in the managing client role that initiates the action. Both belong to the same computational object in the managing role. The operation interface in the managed server role is related to the lr interface in the managed client role that responds to the action and belongs to the same computational object in the managed role.

The linked replies are specified in the operation invocation signature with an identifier for multiple operations.

NOTE – The operation interface may support an operation to stop the emission of replies.

For each operation in the lr interface signature an additional parameter is necessary to indicate the link to the requested operation.

Figure 3 shows how to deal with linked replies using the ODP concepts.

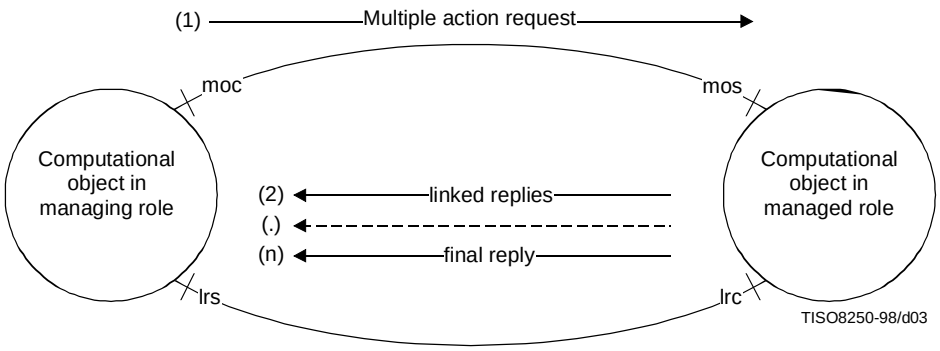


Figure 3 – Example of multiple linked replies from a single object