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Information technology — Open Systems Interconnection — The Directory: Procedures for distributed operation

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO/IEC 9594 may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 9594-4 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*, in collaboration with ITU-T. The identical text is published as ITU-T Recommendation X.518.

This third edition cancels and replaces the second edition (ISO/IEC 9594-4:1995), of which it constitutes a minor revision.

ISO/IEC 9594 consists of the following parts, under the general title *Information technology — Open Systems Interconnection — The Directory*:

— *Part 1: Overview of concepts, models and services*

— *Part 2: Models*

— *Part 3: Abstract service definition*

— *Part 4: Procedures for distributed operation*

— *Part 5: Protocol specifications*

— *Part 6: Selected attribute types*

— *Part 7: Selected object classes*

— *Part 8: Authentication framework*

— *Part 9: Replication*

— *Part 10: Use of systems management for administration of the Directory*

Annexes A and D form a normative part of this part of ISO/IEC 9594. Annexes B, C, E and F are for information only.

Introduction

This Recommendation | International Standard part together with other Recommendations | International Standards, has been produced to facilitate the interconnection of information processing systems to provide directory services. A set of such systems, together with the directory information which they hold, can be viewed as an integrated whole, called the *Directory*. The information held by the Directory, collectively known as the Directory Information Base (DIB), is typically used to facilitate communication between, with or about objects such as application entities, people, terminals and distribution lists.

The Directory plays a significant role in Open Systems Interconnection, whose aim is to allow, with a minimum of technical agreement outside of the interconnection standards themselves, the interconnection of information processing systems:

- from different manufacturers;
- under different managements;
- of different levels of complexity; and
- of different ages.

This Recommendation | International Standard specifies the procedures by which the distributed components of the Directory interwork in order to provide a consistent service to its users.

This third edition technically revises and enhances, but does not replace, the second edition of this Recommendation | International Standard. Implementations may still claim conformance to the second edition. However, at some point, the second edition will not be supported (i.e. reported defects will no longer be resolved). It is recommended that implementations conform to this third edition as soon as possible.

This third edition specifies version 1 and version 2 of the Directory protocols.

The first and second editions also specified version 1. Most of the services and protocols specified in this edition are designed to function under version 1. When version 1 has been negotiated, differences between the services and between the protocols defined in the three editions are accommodated using the rules of extensibility defined in this edition of ITU-T Rec. X.519 | ISO/IEC 9594-5. However some enhanced services and protocols, e.g. signed errors, will not function unless all Directory entities involved in the operation have negotiated version 2.

Implementors should note that a defect resolution process exists and that corrections may be applied to this part of this International Standard in the form of technical corrigenda. The identical corrections will be applied to this Recommendation in the form of Corrigenda and/or an Implementor's Guide. A list of approved technical corrigenda for this part of this International Standard can be obtained from the subcommittee secretariat. Published technical corrigenda are available from your national standards organization. The ITU-T Corrigenda and Implementor's Guides may be obtained from the ITU Web site.

Annex A, which is an integral part of this Recommendation | International Standard, provides the ASN.1 module for directory distributed operations.

Annex B, which is not an integral part of this Recommendation | International Standard, describes an example of distributed name resolution.

Annex C, which is not an integral part of this Recommendation | International Standard, describes authentication in the distributed operations environment.

Annex D, which is an integral part of this Recommendation | International Standard, provides the definitions of the ASN.1 information object classes introduced in this Directory Specification.

Annex E, which is not an integral part of this Recommendation | International Standard, illustrates knowledge maintenance.

Annex F, which is not an integral part of this Recommendation | International Standard, lists the amendments and defect reports that have been incorporated to form this edition of this Recommendation | International Standard.

INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – THE DIRECTORY: PROCEDURES FOR DISTRIBUTED OPERATION

SECTION 1 – GENERAL

1 Scope

This Recommendation | International Standard specifies the behaviour of DSAs taking part in the distributed Directory application. The allowed behaviour has been designed so as to ensure a consistent service given a wide distribution of the DIB across many DSAs.

The Directory is not intended to be a general purpose database system, although it may be built on such systems. It is assumed that there is a considerably higher frequency of queries than of updates.

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.500 (1997) | ISO/IEC 9594-1:1998, *Information technology – Open Systems Interconnection – The Directory: Overview of concepts, models and services.*
- ITU-T Recommendation X.501 (1997) | ISO/IEC 9594-2:1998, *Information technology – Open Systems Interconnection – The Directory: Models.*
- ITU-T Recommendation X.509 (1997) | ISO/IEC 9594-8:1998, *Information technology – Open Systems Interconnection – The Directory: Authentication framework.*
- ITU-T Recommendation X.511 (1997) | ISO/IEC 9594-3:1998, *Information technology – Open Systems Interconnection – The Directory: Abstract service definition.*
- ITU-T Recommendation X.519 (1997) | ISO/IEC 9594-5:1998, *Information technology – Open Systems Interconnection – The Directory: Protocol specifications.*
- ITU-T Recommendation X.520 (1997) | ISO/IEC 9594-6:1998, *Information technology – Open Systems Interconnection – The Directory: Selected attribute types.*
- ITU-T Recommendation X.521 (1997) | ISO/IEC 9594-7:1998, *Information technology – Open Systems Interconnection – The Directory: Selected object classes.*
- ITU-T Recommendation X.525 (1997) | ISO/IEC 9594-9:1998, *Information technology – Open Systems Interconnection – The Directory: Replication.*

- ITU-T Recommendation X.530 (1997) | ISO/IEC 9594-10:1998, *Information technology – Open Systems Interconnection – The Directory: Use of System management for Administration of the Directory.*
- 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.683 (1997) | ISO/IEC 8824-4:1998, *Information technology – Abstract Syntax Notation One (ASN.1): Parametrization of ASN.1 specifications.*
- ITU-T Recommendation X.880 (1994) | ISO/IEC 13712-1:1995, *Information technology – Remote Operations: Concepts, model and notation plus Technical Corrigendum 1 (1995).*
- ITU-T Recommendation X.880 (1994)/Amd. 1 (1995) | ISO/IEC 13712-1:1995/Amd. 1: 1996, *Information technology – Remote Operations: Concepts, model and notation – Amendment 1: Built-in operations.*
- ITU-T Recommendation X.881 (1994) | ISO/IEC 13712-2:1995, *Information technology – Remote Operations: OSI realizations – Remote Operations Service Element (ROSE) service definition.*
- ITU-T Recommendation X.881 (1994)/Amd. 1 (1995) | ISO/IEC 13712-2:1995/Amd. 1: 1996, *Information technology – Remote Operations: OSI realizations – Remote Operations Service Element (ROSE) service definition – Amendment 1: Mapping to A-UNIT-DATA and built-in operations.*

3 Definitions

For the purpose of this Recommendation | International Standard the following definitions apply:

3.1 OSI Reference Model Definitions

The following term is defined in ITU-T Rec. X.200 | ISO/IEC 7498-1:

- *application entity title.*

3.2 Basic Directory Definitions

The following terms are defined in ITU-T Rec. X.500 | ISO/IEC 9594-1:

a) *(the) Directory;*

b) *Directory Information Base.*

3.3 Directory Model Definitions

The following terms are defined in ITU-T Rec. X.501 | ISO/IEC 9594-2:

a) *access point;*

b) *alias;*

c) *distinguished name;*

d) *Directory Information Tree;*

e) *Directory System Agent (DSA);*

f) *Directory User Agent (DUA);*

g) *relative distinguished name.*

3.4 DSA Information Model definitions

The following terms are defined in ITU-T Rec. X.501 | ISO/IEC 9594-2:

a) *category;*

b) *commonly usable;*

c) *context prefix;*

d) *cross reference;*

e) *DIB fragment;*

f) *DSA information tree;*

g) *DSA Specific Entry (DSE);*

h) *DSE type;*

i) *immediate superior reference;*

j) *knowledge information;*

k) *knowledge reference category;*

l) *knowledge reference type;*

m) *naming context;*

n) *non-specific knowledge;*

o) *non-specific subordinate reference;*

p) *operational attribute;*

q) *reference path;*

r) *specific knowledge;*

s) *subordinate reference;*

t) *superior reference.*

3.5 Directory replication definitions

The following terms are defined in ITU-T Rec. X.525 | ISO/IEC 9594-9:

a) *attribute completeness;*

b) *shadowing operational binding;*

c) *subordinate completeness;*

d) *unit of replication.*

3.6 Distributed operation definitions

The following terms are defined in this Recommendation | International Standard:

3.6.1 base object: The object or alias entry that is the target for an operation as issued by the originator.

3.6.2 chaining: The generic term for uni-chaining or multi-chaining.

3.6.3 context prefix information: Operational and user information supplied by the superior DSA to the subordinate DSA in a RHOB regarding DIT vertices superior to the subordinate context prefix.

3.6.4 distributed name resolution: The process by which name resolution is performed in more than one DSA.

3.6.5 error: Information sent from the performer to the requester conveying a negative outcome of a previously received request.

3.6.6 hard error: A definite error which indicates that the operation cannot currently be performed without external intervention.

3.6.7 hierarchical operational binding (HOB): Relationship between two master DSAs holding naming contexts, one of which is immediately subordinate to the other, in which the superior DSA holds a subordinate reference to the subordinate DSA.

3.6.8 modification operations: These are the Directory Modify Operations, i.e. Modify Entry, Add Entry, Remove Entry and Modify DN.

3.6.9 multi-chaining: A mode of interaction in which a DSA processing a request itself sends multiple requests either in parallel or sequentially to a set of other DSAs.

3.6.10 multiple entry interrogation operations: These are the Directory Search Operations, i.e. List and Search.

3.6.11 name resolution: The process of locating an entry by sequentially matching each RDN in a purported name to a vertex of the DIT.

3.6.12 non-specific hierarchical operational binding (NHOB): Relationship between two master DSAs holding naming contexts, one of which is immediately subordinate to the other, in which the superior DSA holds a non-specific subordinate reference to the subordinate DSA.

3.6.13 NSSR decomposition: Decomposition of non-specific knowledge references into subrequests for other DSAs to pursue; these subrequests may be either chained to these DSAs by the DSA performing the decomposition, or a continuation reference identifying the DSAs may be returned to the requester for it to pursue, or the decomposing DSA may pursue some of the subrequests, leaving others unexplored for the requester to pursue.

3.6.14 operation progress: A set of values which denotes the extent to which name resolution has taken place.

3.6.15 originator: The DUA that has initiated a specific (distributed) operation.

3.6.16 performer: DSA receiving a request (i.e. to perform an operation).

3.6.17 procedure: An (informal) specification of how a DSA maps a given set of input arguments and its DSA information tree into a result.

NOTE – Input arguments and results may correspond to information received in a requested operation and information sent in a reply, or they may represent intermediate stages in the computation of a reply from a requested operation. In 14.2 the former variety of input arguments and results are termed external.

3.6.18 relevant hierarchical operational binding (RHOB): Either a HOB or a NHOB, depending on the context.

3.6.19 referral: An outcome which can be returned by a DSA which cannot perform an operation itself, and which identifies one or more other DSAs more able to perform the operation.

3.6.20 reply: A result or an error.

3.6.21 request: Information consisting of an operation code and associated arguments to convey a directory operation from a requester to a performer.

3.6.22 request decomposition: Decomposition of a request into subrequests for other DSAs to pursue; these subrequests may be either chained to these DSAs by the DSA performing the decomposition, or continuation references identifying the DSAs may be returned to the requester for it to pursue, or the decomposing DSA may pursue some of the subrequests, leaving others unexplored for the requester to pursue.

3.6.23 requester: A DUA or DSA sending a request to perform (i.e. invoke) an operation.

3.6.24 single entry interrogation operations: These are the Directory Read Operations, i.e. Read and Compare.

3.6.25 soft error: An error which may be transient, or which may indicate a localized problem, in which case the use of a different knowledge reference or access point may enable a result or hard error to be obtained.

3.6.26 subordinate DSA: Of the two DSAs sharing a HOB or a NHOB, the DSA holding the subordinate naming context.

3.6.27 subrequest: A request generated by request decomposition.

3.6.28 superior DSA: Of the two DSAs sharing a HOB or a NHOB, the DSA holding the superior naming context.

3.6.29 superior, subordinate DSA: Two master DSAs holding naming contexts, one of which is immediately subordinate to the other; the relationship between the two DSAs is managed explicitly via a HOB (or NHOB), or exists implicitly by virtue of the superior DSA holding a subordinate (or non-specific subordinate) reference to the subordinate DSA.

3.6.30 target object name: The name of an entry either to which the operation is to be directed at a particular stage of name resolution, or which is involved in the evaluation of the operation.

3.6.31 uni-chaining: A mode of interaction optionally used by a DSA which cannot perform an operation itself. The DSA *chains* by invoking an operation of another DSA and then relaying the outcome to the original requester.

4 Abbreviations

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

ASN.1	Abstract Syntax Notation One
DOP	Directory Operational Binding Management Protocol
DISP	Directory Information Shadowing Protocol
DMD	Directory Management Domain
DSE	DSA Specific Entry
HOB	Hierarchical Operational Binding
NHOB	Non-specific Hierarchical Operational Binding
NSSR	Non-specific Subordinate Reference
RHOB	Relevant Hierarchical Operational Binding

5 Conventions

With minor exceptions this Directory Specification has been prepared according to the "Presentation of ITU-T/ISO/IEC common text" guidelines in the Guide for ITU-T and ISO/IEC JTC 1 Cooperation.

The term "Directory Specification" (as in "this Directory Specification") shall be taken to mean ITU-T Rec. X.518 | ISO/IEC 9594-4. The term "Directory Specifications" shall be taken to mean the X.500-series Recommendations and all parts of ISO/IEC 9594.

This Directory Specification uses the term "1988 edition systems" to refer to systems conforming to the first (1988) edition of the Directory Specifications, i.e. the 1988 edition of the series of CCITT X.500 Recommendations and the ISO/IEC 9594:1990 edition. This Directory Specification uses the term "1993 edition systems" to refer to systems conforming to the second (1993) edition of the Directory Specifications, i.e. the 1993 edition of the series of ITU-T X.500 Recommendations and the ISO/IEC 9594:1995 edition. Systems conforming to this third edition of the Directory Specifications are referred to as "1997 edition systems".

This Directory Specification presents ASN.1 notation in the bold Helvetica typeface. When ASN.1 types and values are referenced in normal text, they are differentiated from normal text by presenting them in the bold Helvetica typeface. The names of procedures, typically referenced when specifying the semantics of processing, are differentiated from normal text by displaying them in bold Times. Access control permissions are presented in italicized Times.

If the items in a list are numbered (as opposed to using "–" or letters), then the items shall be considered steps in a procedure.

This Directory Specification defines directory operations using the Remote Operation notation defined in ITU-T Rec. X.880 | ISO/IEC 13712-1.

SECTION 2 – OVERVIEW

6 Overview

The Directory Abstract Service allows the interrogation, retrieval and modification of Directory information in the DIB. This service is described in terms of the abstract Directory object as specified in ITU-T Rec. X.511 | ISO/IEC 9594-3.

Necessarily, the specification of the abstract Directory object does not in any way address the physical realization of the Directory: in particular it does not address the specification of Directory System Agents (DSA) within which the DIB is stored and managed, and through which the service is provided. Furthermore, it does not consider whether the DIB is centralized, i.e. contained within a single DSA, or distributed over a number of DSAs. Consequently, the requirements for DSAs to have knowledge of, navigate to, and cooperate with other DSAs, in order to support the abstract service in a distributed environment is also not covered by the service description.

This Directory Specification specifies the refinement of the abstract Directory object, the refinement being expressed in terms of a set of one or more DSA objects which collectively constitute the distributed directory service.

In addition, this Directory Specification specifies the permissible ways in which the DIB may be distributed over one or more DSAs. For the limiting case where the DIB is contained within a single DSA, the Directory is in fact centralized; for the case where the DIB is distributed over two or more DSAs, knowledge and navigation mechanisms are specified which ensure that the whole of the DIB is potentially accessible from all DSAs that hold constituent entries.

Portions of the DIB may also be replicated in multiple DSAs. The protocols described in this Directory Specification allow the use of replicated information to improve the availability, performance and efficiency of the distributed directory service. The use of replicated information is, to some extent, under the user's control, through the use of service control options. The procedures described in this Directory Specification also indicate some of the opportunities for design optimizations when using the replicated information.

Additionally, request handling interactions are specified that enable particular operational characteristics of the Directory to be controlled by its users. In particular, the user has control over whether a DSA, responding to a directory inquiry pertaining to information held in other DSA(s), has the option of interrogating the other DSA(s) directly (chaining) or, whether it should respond with information about other DSA(s) which could further progress the inquiry (referral).

Generally, the decision by a DSA to chain or refer is determined by the service controls set by the user, and by the DSA's own administrative, operational or technical circumstances.

Recognizing that, in general, the Directory will be distributed, and that directory inquiries will be satisfied by an arbitrary number of cooperating DSAs which may arbitrarily chain or refer according to the above criteria, this Directory Specification specifies the appropriate procedures to be effected by DSAs in responding to distributed directory inquiries. These procedures will ensure that users of the distributed Directory service perceive it to be both user-friendly and consistent.

SECTION 3 – DISTRIBUTED DIRECTORY MODELS

7 Distributed Directory System Model

The Directory abstract service, as defined in ITU-T Rec. X.511 | ISO/IEC 9594-3, models the Directory as an object which provides a set of directory services to its users. Users of the Directory access its services through an access point. The Directory may have one or more access points and each access point is characterized by the services it provides and the mode of interaction used to provide these services.

Figure 1 illustrates the distributed directory model which will be used as the basis for specifying the distributed aspects of the directory. It illustrates the Directory as comprising a set of one or more DSAs.

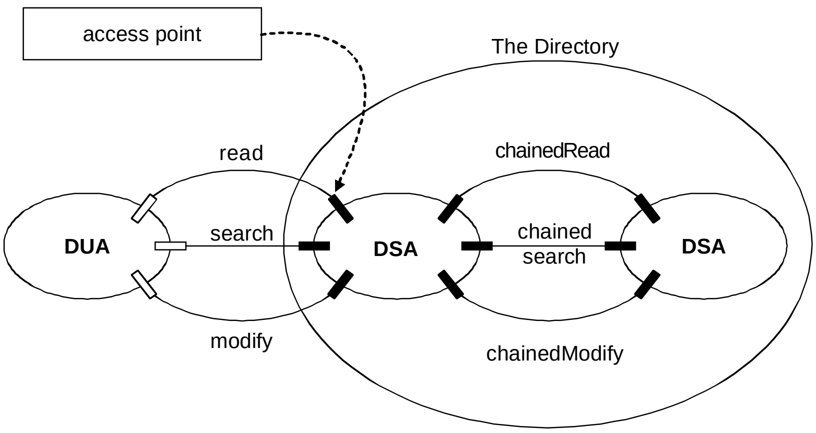

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Figure 1 – Objects of the distributed Directory model

DSAs are specified in detail in the subsequent clauses of this Directory Specification. This clause merely states a number of their characteristics in order to serve as an introduction and to establish the relationship between this Directory Specification and the other Directory Specifications.

DSAs are defined in order that distribution of the DIB can be accommodated and that a number of physically distributed DSAs can interact in a prescribed, cooperative manner to provide directory services to the users of the directory (DUAs).

Figure 1 illustrates the relationship between the Directory abstract service and the DSA abstract service. The Directory abstract service defined in ITU-T Rec. X.511 | ISO/IEC 9594-3 is provided through a number of Directory operations. To realize this service, the DSAs that comprise the Directory interact with one another. The nature of this interaction is defined in terms of the service that one DSA may provide to another DSA, the DSA abstract service. The DSA abstract service is provided through a number of operations, termed chained operations, each having a counterpart in the Directory abstract service. Thus, a given operation in the Directory abstract service, e.g. Read, may require that the DSA providing the service interact with one or more other DSAs using chained operations, e.g. Chained Read.

8 DSA Interactions Model

A basic characteristic of the Directory is that, given a distributed DIB, a user should potentially be able to have any service request satisfied (subject to security, access control, and administrative policies) irrespective of the access point at which the request originates. In accommodating this requirement, it is necessary that any DSA involved in satisfying a particular service request have some knowledge (as specified in ITU-T Rec. X.501 | ISO/IEC 9594-2) of where the requested information is located and either return this knowledge to the requester or attempt to have the request satisfied on its behalf. (The requester may either be a DUA or another DSA: in the latter case both DSAs shall support the DSP.)

Three modes of DSA interaction are defined to meet these requirements, namely "uni-chaining", "multi-chaining", and "referral". Throughout the remainder of this Directory Specification, the generic term chaining is used to refer to uni-chaining and/or multi-chaining as appropriate to the context. "Chaining" refers to the attempt by a DSA to satisfy a request by sending one or more chained operations to other DSAs; "referral", to the return of knowledge information to the requester, which may then itself interact with the DSA(s) identified in the knowledge information.

Uni-chaining or a referral interaction may result from a single request. Alternatively, the request may be decomposed into several subrequests prior to the interaction. Multi-chaining or referral interactions, or a mixture of the two, may result from a decomposed request. Two types of decomposition are defined; NSSR decomposition and request decomposition.

8.1 Decomposition of a request

8.1.1 NSSR decomposition

NSSR decomposition is the process of preparing identical requests ready for transfer (either sequentially or in parallel) to several subordinate DSAs as a result of encountering an NSSR during name resolution. Non-specific subordinate references do not hold the RDNs of the referenced subordinate naming contexts, so the referencing DSA is unable to tell which subordinate DSA holds which subordinate naming context(s). During name resolution, a DSA encountering NSSRs shall send an identical request to each subordinate DSA (in the absence of shadowing). This may be done sequentially or in parallel. Typically, only one DSA will be able to continue with name resolution; the others will return the Service Error **unableToProceed**. In certain (rare) circumstances it is possible that more than one DSA will continue with name resolution, giving rise to duplicate results.

8.1.2 Request decomposition

Request decomposition, the other form of decomposing a request, is a process performed internally by a DSA prior to communication with one or more other DSAs. A request is decomposed into several, possibly different, subrequests such that each of the subrequests accomplishes a part of the original task. Request decomposition can be used only during operation evaluation of a List or Search. After request decomposition, each of the subrequests may then be chained to other DSAs to continue the task, or a partial result (an embedded referral) may be returned to the requester. An example of the same subrequest being generated to different DSAs is when an entry has subordinate references and/or NSSRs that together reference more than one DSA. An example of different subrequests being generated to the same or different DSAs is when two different entries are encountered during a Search (subtree), and each has a subordinate reference.

8.2 Uni-chaining

This mode of interaction (depicted in Figure 2) may be used by one DSA to pass on a request to another DSA when the former has knowledge about naming contexts held by the latter. Uni-chaining may be used to contact a single DSA pointed to in a cross reference, a subordinate reference, a superior reference, a supplier reference, or a master reference.

NOTE – In Figure 2, the order of interactions is defined by the numbers associated with the interaction lines.