The drawings contained in this Recommendation have been done in AUTOCAD

Recommendation X.511

THE DIRECTORY - ABSTRACT SERVICE DEFINITION [1)]

(Melbourne, 1988)

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0 Introduction

0.1 This document, together with the others of the series, has been produced to facilitate the interconnection of information processing systems to provide directory services. The set of all 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.

0.2 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

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1) Recommendation X.511 and ISO 9594-3, Information Processing Systems - Open Systems Interconnection - The Directory - Abstract Service Definition, were developed in close collaboration and are technically aligned.

- of different ages.

0.3 This Recommendation defines the capabilities provided by the Directory to its users.

0.4 Annex A provides the ASN.1 module which contains all the definitions associated with the abstract service.

1 Scope and field of application

1.1 This Recommendation defines in an abstract way the externally visible service provided by the Directory.

1.2 This Recommendation does not specify individual implementation or products.

SECTION 1 - General

2 References

Recommendation X.200 - Open Systems Interconnection - Basic Reference Model.

Recommendation X.208 - Specification of Abstract Syntax Notation One (ASN.1).

Recommendation X.500 - The Directory - Overview of Concepts, Models and Services.

Recommendation X.501 - The Directory - Models.

Recommendation X.518 - The Directory - Procedures for Distributed Operation.

Recommendation X.519 - The Directory - Protocol Specifications.

Recommendation X.520 - The Directory - Selected Attribute Types.

Recommendation X.521 - The Directory - Selected Object Classes.

Recommendation X.509 - The Directory - Authentication Framework.

Recommendation X.219 - Remote Operations - Model, Notation and Service Definition.

Recommendation X.229 - Remote Operations - Protocol Specification.

Recommendation X.407 - Abstract Service Definition Conventions.

3 Definitions

3.1 Basic Directory definitions

This Recommendation makes use of the following terms defined in Recommendation X.500:

a) Directory;
b) Directory Information Base (DIB);
c) (Directory) User.

3.2 Directory model definitions

This Recommendation makes use of the following terms defined in Recommendation X.501:

a) Directory System Agent;
b) Directory User Agent.

3.3 Directory information base definitions

This Recommendation makes use of the following terms defined in Recommendation X.501:

a) alias entry;
b) Directory Information Tree;
c) (Directory) entry;
d) immediate superior;
e) immediately superior entry/object;

f) object;

g) object class;

h) object entry;

i) subordinate;

j) superior.

3.4 Directory entry definitions

This Recommendation makes use of the following terms defined in Recommendation X.501:

a) attribute;

b) attribute type;

c) attribute value;

d) attribute value assertion.

3.5 Name definitions

This Recommendation makes use of the following terms defined in Recommendation X.501:

a) alias, alias name;

b) distinguished name;

c) (directory) name;

d) purported name;

e) relative distinguished name.

3.6 Distributed operations definitions

This Recommendation makes use of the following terms defined in Recommendation X.518:

a) chaining;

b) referral.

3.7 Abstract service definitions

This Recommendation defines the following terms:

a) filter: an assertion about the presence or value of certain attributes of an entry in order to limit the scope of a search;

b) service controls: parameters conveyed as part of an abstract-operation which constrain various aspects of its performance;

c) originator: the user that originated an operation.

4 Abbreviations

This Recommendation makes use of the following abbreviations:

AVA	Attribute Value Assertion
DIB	Directory Information Base
DIT	Directory Information Tree
DMD	Directory Management Domain
DSA	Directory System Agent
DUA	Directory User Agent
RDN	Relative Distinguished Name

5 Conventions

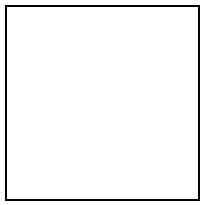
This Recommendation makes use of the abstract service definition conventions defined in Recommendation X.407.

SECTION 2 - Abstract service

6 Overview of the directory service

6.1 As described in Recommendation X.501 the services of the Directory are provided through access points to DUAs, each acting on behalf of a user. These concepts are depicted in Figure 1/X.511.

FIGURE 1/X.511 - T0704480-88



6.2 In principle, access points to the Directory may be of different types, providing different combinations of services. It is valuable to consider the Directory as an object, supporting a number of types of port. Each port defines a particular kind of interaction which the Directory can participate in with a DUA. Each access point corresponds to a particular combination of port types.

6.3 Using the notation defined in Recommendation X.407 the Directory can be defined as follows:

```
directory
    OBJECT
        PORTS {     readPort [S],
                    searchPort [S],
                    modifyPort [S]}
    ::= id-ot-directory
```

The Directory supplies operations via: Read Ports, which support reading information from a particular named entry in the DIB; Search Ports, which allow more "exploration" of the DIB; and Modify Ports, which enable the modification of entries in the DIB.

Note - It is intended that in the future there may be other types of Directory port.

6.4 Similarly, a DUA (from the viewpoint of the Directory) can be defined as follows:

```
dua
    OBJECT
        PORTS {     readPort [C],
                    searchPort [C],
                    modifyPort [C]}
    ::= id-ot-dua
```

The DUA consumes the services provided by the Directory.

6.5 The ports cited from 6.2 to 6.4 can be defined as follows:

readPort
PORT
CONSUMER INVOKES {
Read, Compare, Abandon}

::= id-pt-search

searchPort
PORT
CONSUMER INVOKES {
List, Search}
::= id-pt-search

modifyPort
PORT
CONSUMER INVOKES {
AddEntry, RemoveEntry,
ModifyEntry, ModifyRDN}
::= id-pt-modify

6.6 The operations from the **readPort**, **searchPort** and the **modifyPort** are defined in 9, 10, and 11 respectively.

6.7 These ports are used only as a method of structuring the description of the Directory service. Conformance to the Directory operations is specified in Recommendation X.519.

7 Information types

7.1 Introduction

7.1.1 This paragraph identifies, and in some cases defines, a number of information types which are subsequently used in the definition of Directory operations. The information types concerned are those which are common to more than one operation, are likely to be in the future, or which are sufficiently complex or self-contained as to merit being defined separately from the operation which uses them.

7.1.2 Several of the information types used in the definition of the Directory service are actually defined elsewhere. Paragraph 7.2 identifies types and indicates the source of their definition. Each of the remaining (7.3 to 7.10) identifies and defines an information type.

7.2 Information types defined elsewhere

7.2.1 The following information types are defined in Recommendation X.501:

a) **Attribute;**

b) **AttributeType;**

c) **AttributeValue;**

d) **AttributeValueAssertion;**

e) **DistinguishedName;**

f) **Name;**

g) **RelativeDistinguishedName.**

7.2.2 The following information type is defined in Recommendation X.520:

a) **PresentationAddress.**

7.2.3 The following information types are defined in Recommendation X.509:

a) **Certificate;**

b) **SIGNED;**

c) **CertificationPath.**

7.2.4 The following information type is defined in Recommendation X.219:

a) **InvokeID.**

7.2.5 The following information types are defined in Recommendation X.518:

a) **OperationProgress;**

b) **ContinuationReference.**

7.3 Common arguments

7.3.1 The **CommonArguments** information may be present to qualify the invocation of each operation that the Directory can perform.

```
CommonArguments ::= SET {
    [30] ServiceControls DEFAULT { },
    [29] SecurityParameters DEFAULT { },
    requestor [28] DistinguishedName
                                    OPTIONAL,
    [27] OperationProgress DEFAULT notStarted,
    aliasedRDNs [26] INTEGER OPTIONAL,
    extensions [25] SET OF EXTENSION OPTIONAL}

Extension    ::=  SET {
    identifier   [0] INTEGER,
    critical     [1] BOOLEAN DEFAULT FALSE,
    item         [2] ANY DEFINED BY identifier}
```

7.3.2 The various components have the meanings as defined in 7.3.2.1 to 7.3.2.4.

7.3.2.1 The **ServiceControls** component is specified in 7.5. Its absence is deemed equivalent to there being an empty set of controls.

7.3.2.2 The **SecurityParameters** component is specified in 7.9. Its absence is deemed equivalent to there being an empty set of security parameters.

7.3.2.3 The **requestor DistinguishedName** identifies the originator of a particular abstract- operation. It holds the name of the user as identified at the time of binding to the Directory. It may be required when the request is to be signed (see 7.10), and shall hold the name of the user who initiated the request.

7.3.2.4 The **OperationProgress** defines the role that the DSA is to play in the distributed evaluation of the request. It is more fully defined in Recommendation X.518.

7.3.2.5 The **aliasedRDNs** component indicates to the DSA that the object component of the operation was created by the dereferencing of an alias on an earlier operation attempt. The integer value indicates the number of RDNs in the object that came from dereferencing the alias. (The value would have been set in the referral response of the previous operation.)

7.3.2.6 The **extensions** component provides a mechanism to express standardized extensions to the form of the argument of a Directory abstract-operation.

Note - The form of the result of such an extended abstract-operation is identical to that of the non-extended version. (Nonetheless, the result of a particular extended abstract-operation may differ from its non-extended counterpart).

The subcomponents are as defined in 7.3.2.6.1 to 7.3.2.6.3.

7.3.2.6.1 The **identifier** serves to identify a particular extension. Values of this component shall be assigned only by future versions of this series of Recommendations.

7.3.2.6.2 The **critical** subcomponent allows the originator of the extended abstract-operation to indicate that the performance of only the extended form of the abstract-operation is acceptable (i.e. that the non-extended form is not

acceptable). In this case the extension is a critical extension. If the Directory, or some part of it, is unable to perform a critical extension it returns an indication of **unavailableCriticalExtension** (as a **ServiceError** or **PartialOutcomeQualifier**). If the Directory is unable to perform an extension which is not critical, it ignores the presence of the extension.

7.3.2.6.3 The **item** subcomponent provides the information needed for the Directory to perform the extended form of the abstract-operation.

7.4 Common results

7.4.1 The **CommonResults** information should be present to qualify the result of each retrieval operation that the Directory can perform.

```
CommonResults          ::=     SET {
    [30] SecurityParameters    OPTIONAL,
    performer [29] DistinguishedName
                               OPTIONAL,
aliasDereferenced [28]         BOOLEAN
                   DEFAULT FALSE}
```

7.4.2 The various components have the meanings as defined in 7.4.2.1 to 7.4.2.3.

7.4.2.1 The **SecurityParameters** component is specified in 7.9. Its absence is deemed equivalent to there being an empty set of security parameters.

7.4.2.2 The **performer DistinguishedName** identifies the performer of a particular operation. It may be required when the result is to be signed (see 7.10), and shall hold the name of the DSA which signed the result.

7.4.2.3 The **aliasDereferenced** Component is set to **TRUE** when the purported name of an object or base object which is the target of the operation included on alias which was dereferenced.

7.5 Service controls

7.5.1 A **ServiceControls** parameter contains the controls, if any, that are to direct or constrain the provision of the service.

```
ServiceControls          ::=     SET {
    options [0] BIT STRING {
        preferChaining(0)
        chainingProhibited (1),
        localScope (2),
        dontUseCopy (3),
        dontDereferenceAliases(4)}
        DEFAULT {},
priority [1] INTEGER {
    low (0),
    medium (1),
    high (2) } DEFAULT medium,
timeLimit     [2]       INTEGER OPTIONAL,
sizeLimit     [3]       INTEGER OPTIONAL,
scopeOfReferral [4] INTEGER {
                        dmd(0),
                        country(1)}
                        OPTIONAL }
```

7.5.2 The various components have the meanings as defined in 7.5.2.1 to 7.5.2.5.

7.5.2.1 The **options** component contains a number of indications, each of which, if set, asserts the condition suggested. Thus:

a) **preferChaining** indicates that the preference is that chaining, rather than referrals, be used to provide the service. The Directory is not obliged to follow this preference;

b) **chainingProhibited** indicates that chaining, and other methods of distributing the request around the Directory, are prohibited;

c) **localScope** indicates that the operation is to be limited to a local scope. The definition of this option is itself a local matter. For example, within a single DSA or a single DMD;

d) **dontUseCopy** indicates that copied information (as defined in Recommendation X.518) shall not be used to provide the service;

e) **dontDereferenceAliases** indicate that any alias used to identify the entry affected by an operation is not to be dereferenced;

Note - This is necessary to allow reference to an alias entry itself rather than the aliased entry, e.g. in order to read the alias entry.

If this component is omitted, the following are assumed: no preference for chaining but chaining not prohibited, no limit on the scope of the operation, use of copy permitted, and aliases will be dereferenced (except for modify operations where aliases will never be dereferenced).

7.5.2.2 The **priority** (low, medium or high) at which the service is to be provided. Note that this is not a guaranteed service in that Directory, as a whole, does not implement queuing. There is no relationship implied with the use of "priorities" in underlying layers.

7.5.2.3 The **timeLimit** indicates the maximum elapsed time, in seconds, within which the service shall be provided. If the constraint cannot be met, an error is reported. If this component is omitted, no time limit is implied. In the case of time limit exceeded on a List or Search, the result is an arbitrary selection of the accumulated results.

Note - This component does not imply the length of time spent processing the request during the elapsed time: any number of DSAs may be involved in processing the request during the elapsed time.

7.5.2.4 The **sizeLimit** is only applicable to List and Search operations. It indicates the maximum number of objects to be returned. In the case of size limit exceeded, the results of List and Search may be an arbitrary selection of the accumulated results, equal in number to the size limit. Any further results shall be discarded.

7.5.2.5 The **scopeOfReferral** indicates the scope to which a referral returned by a DSA should be relevant. Depending on whether the value dmd or country are selected, only referrals to other DSAs within the selected scope will be returned.

This applies to the referrals in both a **ReferralError** and the **unexplored** parameter of **List** and **Search** results.

7.5.3 Certain combinations of **priority, timeLimit**, and **sizeLimit** may result in conflicts. For example, a short time limit could conflict with low priority; a high size limit could conflict with a low time limit, etc.

7.6 Entry information selection

7.6.1 An **EntryInformationSelection** parameter indicates what information is being requested from an entry in a retrieval service.

```
EntryInformationSelection ::= SET {
    attributeTypes
        CHOICE {
                allAttributes [0] NULL,
                select [1]] SET OF AttributeType
                - -empty set implies no attributes
                - -are requested- -}
        DEFAULT allAttributes NULL,

    InfoTypes [2] INTEGER {
        attributeTypesOnly (0),
        attributeTypesAndValues (1) }
        DEFAULT attributeTypesAndValues }
```

7.6.2 The various components have the meanings as defined in 7.6.2.1 and 7.6.2.2.

7.6.2.1 The **attributeTypes** component specifies the set of attributes about which information is requested:

a) if the **select** option is chosen, then the attributes involved are listed. If the list is empty, then no attributes will be returned. Information about a selected attribute shall be returned if the attribute is present. An **AttributeError** with the **noSuchAttribute** problem shall only be returned if none of the attributes selected is present;

b) if the **allAttributes** option is selected, then information is requested about all attributes in the entry.

Attribute information is only returned if access rights are sufficient. A **SecurityError** (with an **insufficientAccessRights** problem) will only be returned in the case where access rights preclude the reading of all attribute values requested.

7.6.2.2 The **infoTypes** component specifies whether both attribute type and attribute value information (the default) or attribute type information only is requested. If the **attributeTypes** component (7.6.2.1) is such as to request no attributes, then this component is not meaningful.

7.7 Entry information

7.7.1 An **EntryInformation** parameter conveys selected information from an entry.

```
EntryInformation        ::=     SEQUENCE {
    DistinguishedName,
    fromEntry BOOLEAN DEFAULT TRUE,
    SET OF CHOICE {
        AttributeType,
        Attribute} OPTIONAL }
```

7.7.2 The **DistinguishedName** of the entry is always included.

7.7.3 The **fromEntry** parameter indicates whether the information was obtained from the entry (**TRUE**) or a copy of the entry (**FALSE**).

7.7.4 A set of **AttributeTypes** or **Attributes** are included, if relevant, each of which may be alone or accompanied by one or more attribute values.

7.8 Filter

7.8.1 A **Filter** parameter applies a test that is either satisfied or not by a particular entry. The filter is expressed in terms of assertions about the presence or value of certain attributes of the entry, and is satisfied if and only if it evaluates to **TRUE**.

Note - A Filter may be TRUE, FALSE, or undefined.

```
Filter    ::=  CHOICE {
    item      [0]       FilterItem,
    and       [1]       SET OF Filter,
    or        [2]       SET OF Filter,
    not       [3]       Filter }

FilterItem ::=  CHOICE {
    equality    [0]     AttributeValueAssertion,
    substrings  [1]     SEQUENCE {
        type    AttributeType,
        strings SEQUENCE OF CHOICE {
                Initial         [0]     AttributeValue,
                any             [1]     AttributeValue,
                final           [2]     AttributeValue}},
```

greaterOrEqual [2] AttributeValueAssertion,
lessOrEqual [3] AttributeValueAssertion,
present [4] AttributeType,
approximateMatch [5] AttributeValueAssertion }

7.8.2 A **Filter** is either a **FilterItem** (see 7.8.3), or an expression involving simpler **Filters** composed together using the logical operators **and**, **or**, and **not**. The **Filter** is undefined if it is a **FilterItem** which is undefined, or if it involves one or more simpler Filters, all of which are undefined. Otherwise, where the **Filter** is:

a) an **item**, it is **TRUE** if and only if the corresponding **FilterItem** is **TRUE**;

b) an **and**, it is **TRUE** unless any of the nested **Filters** is **FALSE**;

Note - Thus, if there are no nested **Filters** the **and** evaluates to **TRUE**.

c) an **or**, it is **FALSE** unless any of the nested **Filters** is **TRUE**;

Note - Thus, if there are no nested **Filters** the or evaluates to **FALSE**.

d) a **not**, it is **TRUE** if and only if the nested **Filter** is **FALSE**.

7.8.3 A **FilterItem** is an assertion about the presence or value(s) of an attribute of a particular type in the entry under test. Each such assertion is **TRUE, FALSE**, or undefined.

7.8.3.1 Every **FilterItem** includes an **AttributeType** which identifies the particular attribute concerned.

7.8.3.2 Any assertion about the value of such an attribute is only defined if the **AttributeType** is known, and the purported **AttributeValue**(s) conforms to the attribute syntax defined for that attribute type.

Note 1 - Where these conditions are not met the **FilterItem** is undefined.

Note 2 - Access control restrictions may require that the **FilterItem** be considered undefined.

7.8.3.3 Assertions about the value of an attribute are evaluated using the matching rules associated with the attribute syntax defined for that attribute type. A matching rule not defined for a particular attribute syntax cannot be used to make assertions about that attribute.

Note - Where this condition is not met, the **FilterItem** is undefined.

7.8.3.4 A **FilterItem** may be undefined (as described in 7.8.3.2 and 7.8.3.3 above). Otherwise, where the **FilterItem** asserts:

a) **equality**, it is **TRUE** if and only if there is a value of the attribute which is equal to that asserted;

b) **substrings**, it is **TRUE** if and only if there is a value of the attribute in which the specified substrings appear in the given order. The substrings shall be non-overlapping, and may (but need not) be separated from the ends of the attribute value and from one another by zero or more string elements.

If **initial** is present, the substring shall match the initial substring of the attribute value; if **final** is present, the substring shall match the **final** substring of the attribute value; if any is present, the substring may match **any** substring in the attribute value;

c) **greaterOrEqual**, it is **TRUE** if and only if the relative ordering (as defined by the appropriate ordering algorithm) places the supplied value before or equal to any value of the attribute;

d) **lessOrEqual**, it is **TRUE** if and only if the relative ordering (as defined by the appropriate ordering algorithm) places the supplied value after or equal to any value of the attribute;

e) **present**, it is **TRUE** if and only if such an attribute is present in the entry;

f) **approximateMatch**, it is **TRUE** if and only if there is a value of the attribute which matches that which is asserted by some locally-defined approximate matching algorithm (e.g. spelling variations, phonetic match, etc.). There are no specific guidelines for approximate matching in this version of the Recommendation. If approximate matching is not supported, this FilterItem should be treated as a match for **equality**.

7.9 Security Parameters

7.9.1 The **SecurityParameters** govern the operation of various security features associated with a Directory operation.

Note - These parameters are conveyed from sender to recipient. Where the parameters appear in the argument of an abstract-operation the requestor is the sender, and the performer is the recipient. In a result, the roles are reversed.

```
SecurityParameters      ::=             SET {
    certification-path                  [0]
    CertificationPath   OPTIONAL,
    name        [1]     DistinguishedName
                            OPTIONAL,
time            [2]     UTCTime OPTIONAL,
random          [3]     BIT STRING OPTIONAL,
target          [4]     ProtectionRequest OPTIONAL
                                        }

    ProtectionRequest ::=   INTEGER {
                                none(0),
                                signed (1)}
```

7.9.2 The various components have the meanings as defined in 7.9.2.1 to 7.9.2.5.

7.9.2.1 The **CertificationPath** component consists of the sender's certificate, and, optionally, a sequence of certificate pairs. The certificate is used to associate the sender's public key and distinguished name, and may be used to verify the signature on the argument or result. This parameter shall be present if the argument or result is signed. The sequence of certification pairs consists of certification authority cross certificates. It is used to enable the sender's certificate to be validated. It is not required if the recipient shares the same certification authority as the sender. If the recipient requires a valid set of certificate pairs, and this parameter is not present, whether the recipient rejects the signature on the argument or result, or attempts to generate the certification path, is a local matter.

7.9.2.2 The **name** is the distinguished name of the first intended recipient of the argument or result. For example, if a DUA generates a signed argument, the name is the distinguished name of the DSA to which the operation is submitted.

7.9.2.3 The **time** is the intended expiry time for the validity of the signature, when signed arguments are used. It is used in conjunction with the random number to enable the detection of replay attacks.

7.9.2.4 The **random** component is a number which should be different for each unexpired token. It is used in conjunction with the time parameter to enable the detection of replay attacks when the argument or result has been signed.

7.9.2.5 The **target ProtectionRequest** may appear only in the request for an operation to be carried out, and indicates the requestor's preference regarding the degree of protection to be provided to the result. Two levels are provided: **none** (no protection requested), and **signed** (the Directory is requested to sign the result, the default). The degree of protection actually provided to the result is indicated by the form of result and may be equal to or lower than that requested, based on the limitations of the Directory.

7.10 OPTIONALLY-SIGNED

7.10.1 An **OPTIONALLY-SIGNED** information type is one whose values may, at the option of the generator, be accompanied by their digital signature. This capability is specified by means of the following macro:

```
OPTIONALLY-SIGNED MACRO         ::=
BEGIN

TYPE NOTATION       ::=     type (Type)
VALUE NOTATION      ::=     value (VALUE
            CHOICE      { Type, SIGNED Type})

END
```

7.10.2 The **SIGNED** macro, which describes the form of the signed form of the information, is specified in Recommendation X.509.

8 Bind and unbind operations

The **DirectoryBind** and **DirectoryUnbind** operations, defined in 8.1 and 8.2 respectively, are used by the DUA at the beginning and end of a particular period of accessing the Directory.

8.1 Directory bind

8.1.1 A **DirectoryBind** operation is used at the beginning of a period of accessing the Directory.

```
DirectoryBind          ::=    ABSTRACT-BIND
    TO { readPort, searchPort, modifyPort }
    BIND
    ARGUMENT       DirectoryBindArgument
    RESULT         DirectoryBindResult
    BIND-ERROR     DirectoryBindError

DirectoryBindArgument      ::=    SET {
    credentials        [0]    Credentials  OPTIONAL,
    versions           [1]    Versions DEFAULT
                                  v1988}

Credentials    ::=    CHOICE {
    simple             [0]    SimpleCredentials,
    strong             [1]    StrongCredentials,
    externalProcedure [2] EXTERNAL }

SimpleCredentials      ::=    SEQUENCE {
    name               [0]    DistinguishedName,
    validity           [1]    SET {
        time1          [0]    UTCTime OPTIONAL,
        Time2          [1]    UTCTime OPTIONAL,
        random1        [2]    BIT STRING OPTIONAL,
        random2        [3]    BIT STRING OPTIONAL } OPTIONAL,
        -- in most instances the argument for
        -- time and random are relevant in
        -- dialogues employing protected password
        -- mechanisms and derive their meaning
        -- as per bilateral agreements

password     [2]       OCTET STRING OPTIONAL }
    -- the value could be an unprotected
    -- password or Protected1 or Protected2
    -- as specified in Recommendation X.509.

StrongCredentials      ::=    SET {
    certification-path[0]     CertificationPath
                                  OPTIONAL,
    bind-token         [1]        Token }

Token          ::=    SIGNED SEQUENCE {
    algorithm          [0]    AlgorithmIdentifier,
    name               [1]    DistinguishedName,
    time               [2]    UTCTime,
    random             [3]    BIT STRING }

Versions       ::=    BIT STRING {v1988(0)}

DirectoryBindResult    ::=    DirectoryBindArgument

DirectoryBindError             ::=            SET {
    versions  [0]      Versions DEFAULT v1988,
    CHOICE {
        serviceError           [1]    ServiceProblem
        securityError          [2]    SecurityProblem

}}
```

8.1.2 The various arguments have the meanings as defined in 8.1.2.1 to 8.1.2.2.

8.1.2.1 The **Credentials** of the **DirectoryBindArgument** allow the Directory to establish the identity of the user. They may be either **simple, strong** (as described in Recommendation X.509) or externally defined (**externalProcedure**).

8.1.2.1.1 **SimpleCredentials** consist of a name (always the distinguished name of an object) and (optionally) a password. This provides a limited degree of security. If the password is protected as described in 5 of Recommendation X.509, then **SimpleCredentials** includes name, password and (optionally) time and/or random numbers which are used to detect replay. In some instances a protected password may be checked by an object which knows the password only after locally regenerating the protection to its own copy of the password and computing the result with the value in the bind argument (password). In other instances a direct compare may be possible.

8.1.2.1.2 **StrongCredentials** consist of a bind token and, optionally, a certificate and sequence of certification-authority cross-certificate (as defined in Recommendation X.509). This enables the Directory to authenticate the identity of the request establishing the association, and vice versa.

The arguments of the bind token are used as follows: **algorithm** is the identifier of the algorithm employed to sign the information; name is the **name** of the intended recipient. The time parameter contains the expiry time of the token. The **random** number is a number which should be different for each unexpired token, and may be used by the recipient to detect replay attacks.

8.1.2.1.3 **If externalProcedure** is used then the semantics of the authentication scheme being used is outside the scope of the Directory document.

8.1.2.2 The **Versions** argument of the **DirectoryBindArgument** identifies the versions of the service which the DUA is prepared to participate in. For this version of the protocol the value shall be set to **v1988**(0).

8.1.2.3 Migration to future versions of the Directory should be facilitated by:

a) any elements of **DirectoryBindArgument** other than those defined in this Recommendation shall be accepted and ignored;

b) additional options for named bits of **DirectoryBindArgument** (e.g. **Versions**) not defined shall be accepted and ignored.

8.1.3 Should the bind request succeed, a result will be returned. The result parameters have the meanings as defined in 8.1.3.1 and 8.1.3.2.

8.1.3.1 The **Credentials** of the **DirectoryBindResult** allow the user to establish the identity of the DSA. They allow information identifying the DSA (that is directly providing the Directory service) to be conveyed to the DUA. They shall be of the same form (i.e. **CHOICE**) as those supplied by the user.

8.1.3.2 The **Versions** parameter of the **DirectoryBindResult** indicates which of the versions of the service requested by the DUA is actually going to be provided by this DSA.

8.1.4 Should the bind request fail, a bind error will be returned as defined in 8.1.4.1 and 8.1.4.2.

8.1.4.1 The **Versions** parameter of the **DirectoryBindError** indicates which versions are supported by this DSA.

8.1.4.2 A **securityError** or **serviceError** shall be supplied as follows:

- **securityError** **inappropriateAuthentication**
  invalidCredentials
- **serviceError** **unavailable.**

8.2 Directory unbind

8.2.1 A **DirectoryUnbind** operation is used at the end of a period of accessing the Directory.

```
DirectoryUnbind ::= ABSTRACT-UNBIND
    FROM {readPort, searchPort, modifyPort }
```

8.2.2 The DirectoryUnbind has no arguments.

9 Directory read operations

There are two "read-like" operations: **Read** and **Compare**, defined in 9.1 and 9.2, respectively. The **Abandon** operation, defined in 9.3, is grouped with the Read operations for convenience.

9.1 Read

9.1.1 A **Read** operation is used to extract information from an explicitly identified entry. It may also be used to verify a distinguished name. The arguments of the operation may optionally be signed (see 7.10) by the requestor. If so requested, the Directory may sign the result.

```
Read ::= ABSTRACT-OPERATION
    ARGUMENT                ReadArgument
    RESULT      ReadResult
    ERRORS {
        AttributeError, NameError,
        ServiceError, Referral, Abandoned,
        SecurityError }

ReadArgument ::=    OPTIONALLY-SIGNED SET {
    object      [0]     Name,
    selection   [1]     Selection F[13] EntryInformationSelection
                        DEFAULT {}
    COMPONENTS OF CommonArguments }

ReadResult          ::=     OPTIONALLY-SIGNED SET {
    entry               [0]     EntryInformation,
    COMPONENTS OF CommonResults }
```

9.1.2 The various arguments have the meanings as defined in 9.1.2.1 to 9.1.2.3.

9.1.2.1 The **object** argument identifies the object entry from which the information is requested. Should the Name involve one or more aliases, they are dereferenced (unless this is prohibited by the relevant service controls).

9.1.2.2 The **selection** argument indicates what information from the entry is requested (see 7.6).

9.1.2.3 The **CommonArguments** (see 7.3) include a specification of the service controls applying to the request. For the purposes of this operation the sizeLimit component is not relevant and is ignored if provided.

9.1.3 Should the request succeed, the result will be returned. The result parameters have the meanings as defined in 9.1.3.1 and 7.4.

9.1.3.1 The **entry** result parameter holds the requested information (see 7.7).

9.1.4 Should the request fail, one of the listed errors will be reported. If none of the attributes explicitly listed in **selection** can be returned, then an **AttributeError** with problem **noSuchAttribute** will be reported. The circumstances under which other errors will be reported are defined in 12.

9.2 Compare

9.2.1 A **Compare** operation is used to compare a value (which is supplied as an argument of the request) with the value(s) of a particular attribute type in a particular object entry. The arguments of the operation may optionally be signed (see 7.10) by the requestor. If so requested, the Directory may sign the result.

```
Compare     ::=     ABSTRACT-OPERATION
    ARGUMENT            CompareArgument
    RESULT      CompareResult
    ERRORS {
        AttributeError, NameError,
        ServiceError, Referral, Abandoned,
        SecurityError }
```

```
CompareArgument     ::=     OPTIONALLY-SIGNED
SET {
    object          [0]     Name,
    purported       [1]     AttributeValueAssertion,
    COMPONENTS OF CommonArguments }

CompareResult       ::=     OPTIONALLY-SIGNED
SET {
    DistinguishedName       OPTIONAL,
    matched         [0]     BOOLEAN,
    from Entry      [1]     BOOLEAN DEFAULT TRUE,
    COMPONENTS OF CommonResults }
```

9.2.2 The various arguments have the meanings as defined in 9.2.2.1 to 9.2.2.3.

9.2.2.1 The **object** argument is the name of the particular object entry concerned. Should the Name involve one or more aliases, they are dereferenced (unless prohibited by the relevant service control).

9.2.2.2 The **purported** argument identifies the attribute type and the value to be compared with that in the entry.

9.2.2.3 The **CommonArguments** (see 7.3) specify the service controls applying to the request. For the purposes of this operation the **sizeLimit** component is not relevant and is ignored, if provided.

9.2.3 Should the request succeed (i.e. the comparison is actually carried out), the result will be returned. The result parameters have the meanings as described in 9.2.3.1, 9.2.3.2 and 7.4.

9.2.3.1 The **DistinguishedName** is present if an alias was dereferenced and represents the distinguished name of the object itself.

9.2.3.2 The **matched** result parameter, holds the result of the comparison. The parameter takes the value **TRUE** if the values were compared and matched, and **FALSE** if they did not.

9.2.3.3 If **fromEntry** is **TRUE** the information was compared against the entry; if **FALSE** some of the information was compared against a copy.

9.2.4 Should the request fail, one of the listed errors will be reported. The circumstances under which the particular errors will be reported are defined in 12.

9.3 Abandon

9.3.1 Operations that interrogate the Directory may be abandoned using the Abandon operation if the user is no longer interested in the result.

```
Abandon     ::=     ABSTRACT-OPERATION
    ARGUMENT            AbandonArgument
    RESULT              AbandonResult
    ERRORS  {AbandonFailed}

AbandonArgument     ::=     SEQUENCE {
    InvokeID        [0]     InvokeID}

AbandonResult       ::=     NULL
```

9.3.2 There is a single argument, the **InvokeID** which identifies the operation that is to be abandoned. The value of the **invokeID** is the same **invokeID** which was used to invoke the operation which is to be abandoned.

9.3.3 Should the request succeed, a result will be returned, although no information will be conveyed with it. The original operation will fail with an **Abandoned** error.

9.3.4 Should the request fail, the **AbandonFailed** error will be reported. This error is described in 12.3.

9.3.5 **Abandon** is only applicable to interrogation operations, i.e., **Read**, **Compare**, **List** and **Search**.

9.3.6 A DSA may abandon an operation locally. If the DSA has chained or multicasted the operation to other DSAs, it may in turn request them to abandon the operation. A DSA may choose not to abandon the operation and shall then return the **AbandonFailed** error.

10 Directory search operations

There are two "search-like" operations: **List** and **Search**, defined in 10.1 and 10.2 respectively.

10.1 List

10.1.1 A **List** operation is used to obtain a list of the immediate subordinates of an explicitly identified entry. Under some circumstances, the list returned may be incomplete. The arguments of the operation may optionally be signed (see 7.10) by the requestor. If so requested, the Directory may sign the result.

```
List ::= ABSTRACT-OPERATION
    ARGUMENT            ListArgument
    RESULT      ListResult
    ERRORS {
                        NameError
        ServiceError, Referral, Abandoned,
        SecurityError }

List Argument       ::=     OPTIONALLY-SIGNED SET {
    object          [0]     Name,
    COMPONENTS OF CommonArguments }

ListResult  ::=     OPTIONALLY-SIGNED
CHOICE {
    listInfo SET {
    DistinguishedName OPTIONAL,
    subordinates [1]    SET OF SEQUENCE {
        RelativeDistinguishedName,
        aliasEntry [0]  BOOLEAN DEFAULT FALSE
        fromEntry  [1]BOOLEAN DEFAULT TRUE},
    partialOutcomeQualifier [2]
                            PartialOutcomeQualifier     OPTIONAL
    COMPONENTS OF CommonResults },
    uncorrelatedListInfo    [0] SET OF
                        ListResult }

PartialOutcomeQualifier ::=     SET {
    limitProblem        [0]   LimitProblem
        OPTIONAL,
    unexplored          [1]     SET OF
        ContinuationReference       OPTIONAL,
    unavailableCriticalExtensions [2] BOOLEAN DEFAULT FALSE }

LimitProblem ::= INTEGER {
    timeLimitExceeded (0),
    sizeLimitExceeded (1),
    administrativeLimitExceeded (2) }
```

10.1.2 The various arguments have the meanings as defined in 10.1.2.1 and 7.3.

10.1.2.1 The **object** argument identifies the object entry (or possibly the root) whose immediate subordinates are to be listed. Should the **Name** involve one or more aliases, they are dereferenced (unless prohibited by the relevant service control).

10.1.3 The request succeeds if the object is located regardless of whether there is any subordinate information to return. The result parameters have the meanings as defined in 10.1.3.1 to 10.1.3.4 and 7.4.

10.1.3.1 The **DistinguishedName** is present if an alias was dereferenced. It represents the distinguished name of the object itself.

10.1.3.2 The **subordinates** parameter conveys the information on the immediate subordinate, if any, of the named entry. Should any of the subordinate entries be aliases, they will not be dereferenced.

10.1.3.2.1 The **RelativeDistinguishedName** is that of the subordinate.

10.1.3.2.2 The **fromEntry** parameter indicates whether the information was obtained from the entry (TRUE) or a copy of the entry (**FALSE**).

10.1.3.2.3 The **aliasEntry** parameter indicates whether the subordinate entry is an alias entry (TRUE) or not (**FALSE**).

10.1.3.3 The **PartialOutcomeQualifier** consists of three subcomponents as defined in 10.1.3.3.1 to 10.1.3.3.3. This parameter shall be present whenever the result is incomplete.

10.1.3.3.1 The **LimitProblem** parameter indicates whether the time limit, the size limit, or an administrative limit has been exceeded. The results being returned are those which were available when the limit was reached.

10.1.3.3.2 The **unexplored** parameter shall be present if regions of the DIT were not explored. Its information allows the DUA to continue the processing of the **List** operation by contacting other access points if it so chooses. The parameter consists of a set (possibly empty) of **ContinuationReferences**, each consisting of the name of a base object from which the operation may be progressed, an appropriate value of **OperationProgress**, and a set of access points from which the request may be further progressed. The **ContinuationReferences** that are returned shall be within the scope of referral requested in the operation service control.

10.1.3.3.3 The **unavailableCriticalExtensions** parameter indicates, if present, that one or more critical extensions were unavailable in some part of the Directory.

10.1.3.4 When the DUA has requested a protection request of **signed**, the uncorrelatedListInfo parameter may comprise a number of sets of result parameters originating from and signed by different components of the Directory. If no DSA in the chain can correlate all the results, the DUA must assemble the actual result from the various pieces.

10.1.4 Should the request fail, one of the listed errors will be reported. The circumstances under which the particular errors will be reported are defined in 12.

10.2 Search

10.2.1 A **Search** operation is used to search a portion of the DIT for entries of interest and to return selected information from those entries. The arguments of the operation may optionally be signed (see 7.10) by the requestor. If so requested, the Directory may sign the result.

```
Search ::= ABSTRACT-OPERATION
    ARGUMENT            SearchArgument
    RESULT              SearchResult
    ERRORS {
        AttributeError, NameError,
        ServiceError, Referral, Abandoned,
        SecurityError }

SearchArgument ::= OPTIONALLY-SIGNED
SET {
    baseObject          [0] Name,
    subset              [1] INTEGER {
        baseObject      (0),
        oneLevel        (1),
        wholeSubtree(2)} DEFAULT baseObject,
    filter              [2] Filter DEFAULT and {},
    searchAliases       [3] BOOLEAN DEFAULT TRUE,
    selection           [4] EntryInformationSelection DEFAULT {}
        COMPONENTS OF CommonArguments }
```

```
SearchResult ::= OPTIONALLY-SIGNED
    CHOICE {
    searchInfo SET {
    DistinguishedName OPTIONAL,
    entries [0] SET OF EntryInformation,
    partialOutcomeQualifier
        [2]PartialOutcomeQualifier OPTIONAL,
COMPONENTS OF CommonResults },
uncorrelatedSearchInfo [0] SET OF
    SearchResult }
```

10.2.2 The various arguments have the meanings as defined in 10.2.2.1 to 10.2.2.3, 10.2.2.5, and 7.3.

10.2.2.1 The **baseObject** argument identifies the object entry (or possibly the root) relative to which the search is to take place.

10.2.2.2 The **subset** argument indicates whether the search is to be applied to:

a) the **baseObject** only;

b) the immediate subordinates of the base object only (**oneLevel**);

c) the base object and all its subordinates (**wholeSubtree**).

10.2.2.3 The **filter** argument is used to eliminate entries from the search space which are not of interest. Information will only be returned on entries which satisfy the filter (see 7.8).

10.2.2.4 Aliases shall be dereferenced while locating the base object, subject to the setting of the **dontDereferenceAliasesServiceControl**. Aliases among the subordinates of the base object shall be dereferenced during the search, subject to the setting of the **searchAliases** parameter. If the **searchAliases** parameter is **TRUE**, aliases shall be dereferenced, if the parameter is **FALSE**, aliases shall not be dereferenced. If the **searchAliases** parameter is **TRUE**, the search shall continue in the subtree of the aliased object.

10.2.2.5 The **selection** argument indicates what information from the entries is requested (see 7.6).

10.2.3 The request succeeds if the base object is located, regardless of whether there are any subordinates to return.

Note - As a corollary to this, the outcome of an (unfiltered) **Search** applied to a single entry may not be identical to a **Read** which seeks to interrogate the same set of attributes of the entry. This is because the latter will return an **AttributeError** if none of the selected attributes exist in the entry.

The result parameters have the meanings as defined in 10.2.3.1 to 10.2.3.4 and 7.3.

10.2.3.1 The **DistinguishedName** is present if an alias was dereferenced, and represents the distinguished name of the base object.

10.2.3.2 The **entries** parameter conveys the requested information from each entry (zero or more) which satisfied the filter (see 7.5).

10.2.3.3 The **PartialOutcomeQualifier** consists of two subcomponents as described for the List operation in 10.1.3.4.

10.2.3.4 The **uncorrelatedSearchInfo** parameter is as described for **uncorrelatedListInfo** in 10.1.3.4.

10.2.4 Should the request fail, one of the listed errors will be reported. The circumstances under which the particular errors will be reported are defined in 12.

11 Directory modify operations

There are four operations to modify the Directory: **AddEntry**, **RemoveEntry**, **ModifyEntry** and **ModifyRDN** defined in 11.1 to 11.4 respectively.

Note 1 - Each of these abstract-operations identifies the target entry by means of its distinguished name.

Note 2 - The success of **AddEntry**, **RemoveEntry**, and **ModifyRDN** operations will be dependent on the physical distribution of the DIB across the Directory. Failure will be reported with an UpdateError and problem **affectsMultipleDSAs**. See Recommendation X.518.

11.1 Add entry

11.1.1 An **AddEntry** operation is used to add a leaf entry (either an object entry, or an alias entry) to the DIT. The arguments of the operation may optionally be signed (see 7.10) by the requestor.

```
AddEntry        ::=     ABSTRACT-OPERATION
    ARGUMENT            AddEntryArgument
    RESULT              AddEntryResult
    ERRORS {
        AttributeError, NameError,
        ServiceError, Referral, SecurityError,
        UpdateError }

AddEntryArgument    ::=     OPTIONALLY-SIGNED
SET {
    object          [0]     DistinguishedName,
    entry           [1]     SET OF Attribute,
    COMPONENTS OF CommonArguments }

AddEntryResult      ::=     NULL
```

11.1.2 The various arguments have the meanings as defined in 11.1.2.1 to 11.1.2.3.

11.1.2.1 The object argument identifies the entry to be added. Its immediate superior, which must already exist for the operation to succeed, can be determined by removing the last RDN component (which belongs to the entry to be created).

11.1.2.2 The **entry** argument contains the attribute information which, together with that from the RDN, constitutes the entry to be created. The Directory shall ensure that the entry conforms to the Directory schema. Where the entry being created is an alias, no check is made to ensure that the **aliasedObjectName** attribute points to a valid entry.

11.1.2.3 The **CommonArguments** (see 7.3) include a specification of the service controls applying to the request. For the purposes of this operation the **dontDereferenceAlias** option and the sizeLimit component are not relevant and are ignored if provided. Aliases are never dereferenced by this operation.

11.1.3 Should the request succeed, a result will be returned, although no information will be conveyed with it.

11.1.4 Should the request fail, one of the listed errors will be reported. The circumstances under which the particular errors will be reported are defined in 12.

11.2 Remove Entry

11.2.1 A **RemoveEntry** operation is used to remove a leaf entry (either an object entry or an alias entry) from the DIT. The arguments of the operation may optionally be signed (see 7.10) by the requestor.

```
RemoveEntry ::=     ABSTRACT-OPERATION
    ARGUMENT        RemoveEntryArgument
    RESULT          RemoveEntryResult
    ERRORS {
        NameError,
        ServiceError, Referral, SecurityError,
        UpdateError}

RemoveEntryArgument ::= OPTIONALLY-SIGNED SET {
    object      [0]     DistinguishedName,
    COMPONENTS OF CommonArguments }

RemoveEntryResult   ::= NULL
```

11.2.2 The various arguments have the meanings as defined in 11.2.2.1 and 11.2.2.2.

11.2.2.1 The **object** argument identifies the entry to be deleted. Aliases in the name will not be dereferenced.

11.2.2.2 The **CommonArguments** (see 7.3) include a specification of the service controls applying to the request. For the purposes of this operation the **dontDereferenceAlias** option and the **sizeLimit** component are not relevant and are ignored if provided. Aliases are never dereferenced by this operation.

11.2.3 Should the request succeed, a result will be returned, although no information will be conveyed with it.

11.2.4 Should the request fail, one of the listed errors will be reported. The circumstances under which the particular errors will be reported are defined in 12.

11.3 Modify Entry

11.3.1 The **ModifyEntry** operation is used to perform a series of one or more of the following modifications to a single entry:

a) add a new attribute;

b) remove an attribute;

c) add attribute values;

d) remove attribute values;

e) replace attribute values;

f) modify an alias.

The arguments of the operation may optionally be signed (see 7.10) by the requestor.

```
ModifyEntry ::= ABSTRACT-OPERATION
    ARGUMENT    ModifyEntryArgument
    RESULT      ModifyEntryResult
    ERRORS {
        AttributeError, NameError,
        ServiceError, Referral, SecurityError,
        UpdateError }

ModifyEntryArgument ::=          OPTIONALLY-SIGNED SET {
    object          [0]     DistinguishedName,
    changes         [1]     SEQUENCE OF EntryModification,
    COMPONENTS OF CommonArguments }

ModifyEntryResult ::=        NULL

EntryModification     ::=    CHOICE {
    addAttribute      [0]          Attribute,
    removeAttribute            [1] AttributeType,
    addValues                  [2] Attribute,
    removeValues      [3]      Attribute }
```

11.3.2 The various arguments have the meanings as defined in 11.3.2.1 and 11.3.2.2.

11.3.2.1 The **object** argument identifies the entry to which the modifications should be applied. Any aliases in the name will not be dereferenced.

11.3.2.2 The **changes** argument defines a sequence of modifications, which are applied in the order specified. If any of the individual modifications fails, then an **AttributeError** is generated and the entry left in the state it was prior to the operation. That is, the operation is atomic. The end result of the sequence of modifications shall not violate the Directory schema. However, it is possible, and sometimes necessary, for the individual **EntryModification** changes to appear to do so. The following types of modification may occur:

a) **addAttribute**: This identifies a new attribute to be added to the entry, which is fully specified by the argument. Any attempt to add an already existing attribute results in an AttributeError;

b) **removeAttribute**: The argument identifies (by its type) an attribute to be removed from the entry. Any attempt to remove a non-existing attribute results in an AttributeError;

Note - This operation is not allowed if the attribute type is present in the RDN.

c) **addValues**: This identifies an attribute by the attribute type in the argument, and specifies one or more attribute values to be added to the attribute. An attempt to add an already existing value results in an error. An attempt to add a value to a non-existent type results in an error;

d) **removeValues**: This identifies an attribute by the attribute type in the argument and specifies one or more attribute values to be removed from the attribute. If the values are not present in the attribute, this results in an AttributeError. If an attempt is made to modify the object class attribute, an update error is returned.

Note - This operation is now allowed if one of the values is present in the RDN.

Values may be replaced by a combination of **addValues** and **removeValues** in a single **ModifyEntry** operation.

11.3.2.3 The **CommonArguments** (see 7.3) include a specification of the service controls applying to the request. For the purposes of this operation the dontDereferenceAlias option and the sizeLimit component are not relevant and are ignored if provided. Aliases are never dereferenced by this operation.

11.3.3 Should the request succeed, a result will be returned although no information will be conveyed with it.

11.3.4 Should the request fail, one of the listed errors will be reported. The circumstances under which the particular errors will be reported are defined in 12.

11.4 Modify RDN

11.4.1 The **ModifyRDN** operation is used to change the Relative Distinguished Name of a leaf entry (either an object entry or an alias entry) in the DIT. The arguments of the operation may optionally be signed (see 7.10) by the requestor.

```
ModifyRDN ::=                ABSTRACT-OPERATION
    ARGUMENT                 ModifyRDNArgument
    RESULT              ModifyRDNResult
    ERRORS {
        NameError,
        ServiceError, Referral, SecurityError,
        UpdateError }

ModifyRDNArgument  ::=   OPTIONALLY-SIGNED SET {
    object           [0]     DistinguishedName,
    newRDN           [1]     RelativeDistinguishedName,
    deleteOldRDN     [2]     BOOLEAN DEFAULT FALSE,
    COMPONENTS OF CommonArguments }

ModifyRDNResult    ::=   NULL
```

11.4.2 The various parameters have the meanings as defined in 11.4.2.1 to 11.4.2.5.

11.4.2.1 The **object** argument identifies the entry whose Relative Distinguished Name is to be modified. Aliases in the name will not be dereferenced. The immediate superior entry shall not have any Non-Specific Subordinate References (see Recommendation X.518).

11.4.2.2 The **newRDN** argument specifies the new RDN of the entry.

11.4.2.3 If an attribute value in the new RDN does not already exist in the entry (either as part of the old RDN or as a non-distinguished value) it is added. If it cannot be added, an error is returned.

11.4.2.4 If the **deleteOldRDN** flag is set, all attribute values in the old RDN which are not in the new RDN are deleted. If this flag is not set, the old values should remain in the entry (not as a part of the RDN). The flag shall be set where a single value attribute in the RDN has its value changed by the operation. If this operation removes the last attribute value of an attribute, that attribute shall be deleted.

11.4.2.5 The **Common Arguments** (see 7.3) include a specification of the service controls applying to the request. For the purposes of this operation the dontDereferenceAlias option and the sizeLimit component are not relevant and are ignored if provided. Aliases are never dereferenced by this operation.

11.4.3 Should the request succeed, a result will be returned, although no information will be conveyed with it.

11.4.4 Should the request fail, one of the listed errors will be reported. The circumstances under which the particular errors will be returned are defined in 12.

11.4.5 As defined in this Recommendation this operation may only be used on a leaf entry.

12 Errors

12.1 Error Precedence

12.1.1 The Directory does not continue to perform an operation beyond the point at which it determines that an error is to be reported.

Note 1 - An implication of this rule is that the first error encountered can differ for repeated instances of the same query, as there is not a specific logical order in which to process a given query. For example, DSAs may be searched in different orders.

Note 2 - The rules of error precedence specified here apply only to the abstract service provided by the Directory as a whole. Different rules apply when the internal structure of the Directory is taken into account.

12.1.2 Should the Directory simultaneously detect more than one error, the following list determines which error is reported. An error higher in the list has a higher logical precedence than one below it and is the error which is reported.

a) **NameError**

b) **UpdateError**

c) **AttributeError**

d) **SecurityError**

e) **ServiceError.**

12.1.3 The following errors do not present any precedence conflicts:

a) **AbandonFailed**, because it is specific to one operation, **Abandon**, which can encounter no other error;

b) **Abandoned**, which is not reported if an **Abandon** operation is received simultaneously with the detection of an error. In this case an **AbandonFailed** error, reporting the problem tooLate is reported along with the report of the actual error encountered;

c) **Referral**, which is not a "real" error, only an indication that the Directory has detected that the DUA must present its request to another access point.

12.2 Abandoned

12.2.1 This outcome may be reported for any outstanding directory enquiry operation (i.e. **Read**, **Search**, **Compare**, **List**) if the DUA invokes an **Abandon** operation with the appropriate **InvokeID**.

Abandoned ::= ABSTRACT-ERROR -- not literally an "error"

12.2.2 There are no parameters associated with this error.

12.3 Abandon Failed

12.3.1 The **AbandonFailed** error reports a problem encountered during an attempt to abandon an operation.

```
AbandonFailed ::=     ABSTRACT-ERROR
    PARAMETER SET {
        problem       [0] AbandonProblem,
        operation     [1] InvokeID}

AbandonProblem ::=    INTEGER
                      noSuchOperation (1),
                      tooLate (2),
                      cannotAbandon (3) }
```

12.3.2 The various parameters have the meanings as defined in 12.3.2.1 and 12.3.2.2.

12.3.2.1 The particular problem encountered is specified. Any of the following problems may be indicated:

a) **noSuchOperation**, when the Directory has no knowledge of the operation which is to be abandoned (this could be because no such invoke took place or because the Directory has forgotten about it);

b) **tooLate**, when the Directory has already responded to the operation;

c) **cannotAbandon**, when an attempt has been made to abandon an operation for which this is prohibited (e.g. modify), or the abandon could not be performed.

12.3.2.2 The identification of the particular operation (invocation) to be abandoned.

12.4 Attribute Error

12.4.1 An **AttributeError** reports an attribute-related problem.

```
AttributeError ::= ABSTRACT-ERROR
    PARAMETER SET {
        object   [0]    Name,
        problems [1]    SET OF SEQUENCE {
            problem     [0] AttributeProblem,
            type        [1] AttributeType,
            value       [2] AttributeValue
                                OPTIONAL }}

AttributeProblem  ::=  INTEGER {
    noSuchAttributeOrValue (1),
    InvalidAttributeSyntax (2),
    undefinedAttributeType (3),
    InappropriateMatching (4),
    constraintViolation (5)
    attributeOrValueAlreadyExists (6) }
```

12.4.2 The various parameters have the meanings as described in 12.4.2.1 and 12.4.2.2.

12.4.2.1 The **object** parameter identifies the entry to which the operation was being applied when the error occurred.

12.4.2.2 One or more **problems** may be specified. Each **problem** identified below is accompanied by an indication of the attribute **type**, and if necessary to avoid ambiguity, the **value**, which caused the problem:

a) **noSuchAttributeOrValue**: The named entry lacks one of the attributes or attribute values specified as an argument of the operation;

b) **invalidAttributeSyntax**: A purported attribute value, specified as an argument of the operation, does not conform to the attribute syntax of the attribute type;

c) **undefinedAttributeType**: An undefined attribute type was provided as an argument to the operation. This error may occur only in relation to Add, Remove, Modify or ModifyRDN operations;

d) **inappropriateMatching**: An attempt was made, e.g. in a filter, to use a matching rule not defined for the attribute type concerned;

e) **constraintViolation**: An attribute or attribute value supplied in the argument of abstract- operation does not conform to the constraints imposed by Recommendation X.501 or by the attribute definition (e.g. the value exceeds the maximum size allowed);

f) **attributeOrValueAlreadyExists**: An attempt was made to add an attribute which already existed in the entry, or a value which already existed in the attribute.

12.5 Name Error

12.5.1 A NameError reports a problem related to the name provided as an argument to an operation.

```
NameError  ::= ABSTRACT-ERROR
    PARAMETER SET {
        problem [0]  NameProblem,
        matched [1]  Name}

NameProblem  ::=  INTEGER {
    noSuchObject (1),
    aliasProblem (2),
    invalidAttributeSyntax (3),
    aliasDereferencingProblem (4) }
```

12.5.2 The various parameters have the meanings as described in 12.5.2.1 and 12.5.2.2.

12.5.2.1 The particular **problem** encountered. Any of the following problems may be indicated:

a) **noSuchObject**: The name supplied does not match the name of any object;

c) **invalidAttributeSyntax**: An attribute type and its accompanying attribute value in AVA in the name are incompatible;

d) **aliasDereferencingProblem**: An alias was encountered in a situation where it was not allowed.

12.5.2.2 The **matched** parameter contains the name of the lowest entry (object or alias) in the DIT that was matched and is a truncated form of the name provided or, if an alias has been dereferenced, of the resulting name.

Note - If there is a problem with the attribute types and/or values in the name offered in a directory operation argument, this is reported via a NameError (with problem invalidAttributeSyntax) rather than as an AttributeError or an UpdateError.

12.6 Referral

12.6.1 A **Referral** redirects the service-user to one or more access points better equipped to carry out the requested operation.

```
Referral ::= ABSTRACT-ERROR  -- not literally an "error"
    PARAMETER SET {
    candidate  [0]  ContinuationReference }
```

12.6.2 The error has a single parameter which contains a ContinuationReference which can be used to progress the operation (see Recommendation X.518).

12.7 Security Error

12.7.1 A SecurityError reports a problem in carrying out an operation for security reasons.

```
SecurityError ::=          ABSTRACT-ERROR
    PARAMETER SET {
    problem  [0]   SecurityProblem }

SecurityProblem   ::=  INTEGER {
            InappropriateAuthentication (1),
            InvalidCredentials (2),
            InsufficientAccessRights (3),
            InvalidSignature (4),
            protectionRequired (5),
            noInformation (6) }
```

12.7.2 The error has a single parameter, which reports the particular problem encountered. The following problems may be indicated:

a) **inappropriateAuthentication**: The level of security associated with the requestor's credentials is inconsistent with the level of protection requested, e.g. simple credentials were supplied while strong credentials were required;

b) **invalidCredentials**: The supplied credentials were invalid;

c) **insufficientAccessRights**: The requestor does not have the right to carry out the requested operation;

d) **invalidSignature**: The signature of the request was found to be invalid;

e) **protectionRequired**: The Directory was unwilling to carry out the requested operation because the argument was not signed;

f) **noInformation**: The requested operation produced a security error for which no information is available.

12.8 Service Error

12.8.1 A ServiceError reports a problem related to the provision of the service.

```
ServiceError ::= ABSTRACT-ERROR
    PARAMETER SET {
        problem [0] ServiceProblem },

ServiceProblem ::= INTEGER {
    busy (1),
    unavailable (2),
    unwillingToPerform (3),
    chainingRequired (4),
    unableToProceed (5),
    invalidReference (6),
    timeLimitExceeded (7),
    administrativeLimitExceeded (8),
    loopDetected (9),
    unavailableCriticalExtension (10),
    outOfScope (11),
    ditError (12) }
```

12.8.2 The error has a single parameter, which reports the particular problem encountered. The following problems may be indicated:

a) **busy**: The Directory, or some part of it, is presently too busy to perform the requested operation, but may be able to do so after a short while;

b) **navailable**: The Directory, or some part of it, is currently unavailable;

c) **unwillingToPerform**: The Directory, or some part of it, is not prepared to execute this request, e.g. because it would lead to excessive consumption of resources or violate the policy of an Administrative Authority involved;

d) **hainingRequired**: The Directory is unable to accomplish the request other than by chaining, however chaining was prohibited by means of the chainingProhibited service control option;

e) **unableToProceed**: The DSA returning this error did not have administrative authority for the appropriate naming context and as a consequence was not able to participate in name resolution;

f) **unvalidReference**: The DSA was unable to perform the request as directed by the DUA (in

g) **timeLimitExceeded**: The Directory has reached the limit of time set by the user in a service control. No partial results are available to return to the user;

h) **administrativeLimitExceeded**: The Directory has reached some limit set by an administrative authority, and no partial results are available to return to the user;

i) **loopDetected**: The Directory is unable to accomplish the request due to an internal loop;

j) **unavailableCriticalExtension**: The Directory was unable to execute the request because one or more critical extensions were not available;

k) **outOfScope**: No referrals were available within the requested scope;

l) **ditError**: The Directory is unable to accomplish the request due to a DIT consistency problem.

12.9 Update Error

12.9.1 An **UpdateError** reports problems related to attempts to add, delete, or modify information in the DIB.

```
UpdateError ::= ABSTRACT-ERROR
        PARAMETER SET {
            problem [0] UpdateProblem }
```

UpdateProblem ::= INTEGER {

namingViolation (1),

objectClassViolation (2),

notAllowedOnNonLeaf (3),

notAllowedOnRDN (4),

entryAlreadyExists (5),

affectsMultipleDSAs (6),

objectClassModificationProhibited (7) }

12.9.2 The error has a single **problem** parameter, which reports the particular **problem** encountered. The following problems may be indicated:

a) **namingViolation**: The attempted addition or modification would violate the structure rules of the DIT as defined in the Directory schema and Recommendation X.501. That is, it would place an entry as the subordinate of an alias entry, or in a region of the DIT not permitted to a member of its object class or would define an RDN for an entry to include a forbidden attribute type;

b) **objectClassViolation**: The attempted update would produce an entry inconsistent with the definition provided by its object class or with the definitions of Recommendation X.501 as they pertain to object classes;

c) **notAllowedOnNonLeaf**: The attempted operation is only allowed on leaf entries of the DIT;

d) **notAllowedOnRDN**: The attempted operation would affect the RDN (e.g. removal of an attribute which is a part of the RDN);

e) **entryAlreadyExists**: An attempted AddEntry operation names an entry which already exists;

f) **affectsMultipleDSAs**: An attempted update would need to operate on multiple DSAs, which is not permitted;

g) **objectClassModificationProhibited**: An operation attempted to modify the object class attribute.

Note - The **UpdateError** is not used to report problems with attribute types, values or constraint violations encountered in an **AddEntry**, **RemoveEntry**, **ModifyEntry** or **ModifyRDN** operation. Such problems are reported via an **AttributeError**.