INTERNATIONAL STANDARD

ISO/IEC 9594-8

Second edition
1995-09-15

Information technology — Open Systems Interconnection — The Directory: Authentication framework

Technologies de l'information — Interconnexion de systèmes ouverts (OSI) — L'Annuaire: Cadre général d'authentification

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Foreword

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

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 9594-8 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 21, *Open systems interconnection, data management and open distributed processing*, in collaboration with ITU-T. The identical text is published as ITU-T Recommendation X.509.

Implementors should note that a defect resolution process exists and that corrections may be applied to this part of ISO/IEC 9594 in the form of technical corrigenda. A list of approved technical corrigenda for this part of ISO/IEC 9594 can be obtained from the subcommittee secretariat. Published technical corrigenda are available from your national standards organization.

This second edition technically revises and enhances ISO/IEC 9594-8:1990. It also incorporates technical corrigendum 1:1991. Implementations may still claim conformance to the first edition of this part of ISO/IEC 9594. However, at some point, the first edition will no longer be supported (i.e. reported defects will no longer be resolved). It is recommended that implementations conform to this second edition as soon as possible.

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*

Annex A forms an integral part of this part of ISO/IEC 9594. Annexes B to J are for information only.

Introduction

This Recommendation | International Standard, 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.

Many applications have requirements for security to protect against threats to the communication of information. Some commonly known threats, together with the security services and mechanisms that can be used to protect against them, are briefly described in Annex B. Virtually all security services are dependent upon the identities of the communicating parties being reliably known, i.e. authentication.

This Recommendation | International Standard defines a framework for the provision of authentication services by the Directory to its users. These users include the Directory itself, as well as other applications and services. The Directory can usefully be involved in meeting their needs for authentication and other security services because it is a natural place from which communicating parties can obtain authentication information of each other – knowledge which is the basis of authentication. The Directory is a natural place because it holds other information which is required for communication and obtained prior to communication taking place. Obtaining the authentication information of a potential communication partner from the Directory is, with this approach, similar to obtaining an address. Owing to the wide reach of the Directory for communications purposes, it is expected that this authentication framework will be widely used by a range of applications.

This second edition technically revises and enhances, but does not replace, the first edition of this Recommendation | International Standard. Implementations may still claim conformance to the first edition.

This second edition specifies version 1 of the Directory service and protocols. The first edition also specifies version 1. Differences between the services and between the protocols defined in the two editions are accommodated using the rules of extensibility defined in this edition of X.519 | ISO/IEC 9594-5.

Annex A, which is an integral part of this Recommendation | International Standard, provides the ASN.1 module which contains all of the definitions associated with the authentication framework.

Annex B, which is not an integral part of this Recommendation | International Standard, describes security requirements.

Annex C, which is not an integral part of this Recommendation | International Standard, is an introduction to public key cryptography.

Annex D, which is not an integral part of this Recommendation | International Standard, describes the RSA Public Key Cryptosystem.

Annex E, which is not an integral part of this Recommendation | International Standard, describes hash functions.

Annex F, which is not an integral part of this Recommendation | International Standard, describes threats protected against by the strong authentication method.

Annex G, which is not an integral part of this Recommendation | International Standard, describes data confidentiality.

Annex H, which is an integral part of this Recommendation | International Standard, defines object identifiers assigned to authentication and encryption algorithms, in the absence of a formal register.

Annex J, 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.

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INTERNATIONAL STANDARD

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – THE DIRECTORY: AUTHENTICATION FRAMEWORK

SECTION 1 – GENERAL

1 Scope

This Recommendation | International Standard:

- specifies the form of authentication information held by the Directory;
- describes how authentication information may be obtained from the Directory;
- states the assumptions made about how authentication information is formed and placed in the Directory;
- defines three ways in which applications may use this authentication information to perform authentication and describes how other security services may be supported by authentication.

This Recommendation | International Standard describes two levels of authentication: simple authentication, using a password as a verification of claimed identity; and strong authentication, involving credentials formed using cryptographic techniques. While simple authentication offers some limited protection against unauthorized access, only strong authentication should be used as the basis for providing secure services. It is not intended to establish this as a general framework for authentication, but it can be of general use for applications which consider these techniques adequate.

Authentication (and other security services) can only be provided within the context of a defined security policy. It is a matter for users of an application to define their own security policy which may be constrained by the services provided by a standard.

It is a matter for standards defining applications which *use* the authentication framework to specify the protocol exchanges which need to be performed in order to achieve authentication based upon the authentication information obtained from the Directory. The protocol used by applications to obtain credentials from the Directory is the Directory Access Protocol (DAP), specified in ITU-T Recommendation X.519 | ISO/IEC 9594-5.

The strong authentication method specified in this Recommendation | International Standard is based upon public-key cryptosystems. It is a major advantage of such systems that user certificates may be held within the Directory as attributes, and may be freely communicated within the Directory System and obtained by users of the Directory in the same manner as other Directory information. The user certificates are assumed to be formed by "off-line" means, and placed in the Directory by their creator. The generation of user certificates is performed by some off-line Certification Authority which is completely separate from the DSAs in the Directory. In particular, no special requirements are placed upon Directory providers to store or communicate user certificates in a secure manner.

A brief introduction to public-key cryptography can be found in Annex C.

In general, the authentication framework is not dependent on the use of a particular cryptographic algorithm, provided it has the properties described in 7.1. Potentially a number of different algorithms may be used. However, two users wishing to authenticate shall support the same cryptographic algorithm for authentication to be performed correctly. Thus, within the context of a set of related applications, the choice of a single algorithm will serve to maximize the community of users able to authenticate and communicate securely. One example of a public key cryptographic algorithm can be found in Annex D.

Similarly, two users wishing to authenticate shall support the same hash function [see 3.3 f)] (used in forming credentials and authentication tokens). Again, in principle, a number of alternative hash functions could be used, at the cost of narrowing the communities of users able to authenticate. A brief introduction to hash functions can be found in Annex E.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Recommendation | International Standard part. 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 editions 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.500 (1993) | ISO/IEC 9594-1:1995, *Information Technology – Open Systems Interconnection – The Directory: Overview of concepts, models and services.*
- ITU-T Recommendation X.501 (1993) | ISO/IEC 9594-2:1995, *Information Technology – Open Systems Interconnection – The Directory: Models.*
- ITU-T Recommendation X.511 (1993) | ISO/IEC 9594-3:1995, *Information Technology – Open Systems Interconnection – The Directory: Abstract service definition.*
- ITU-T Recommendation X.518 (1993) | ISO/IEC 9594-4:1995, *Information Technology – Open Systems Interconnection – The Directory: Procedures for distributed operation.*
- ITU-T Recommendation X.519 (1993) | ISO/IEC 9594-5:1995, *Information Technology – Open Systems Interconnection – The Directory: Protocol specifications.*
- ITU-T Recommendation X.520 (1993) | ISO/IEC 9594-6:1995, *Information Technology – Open Systems Interconnection – The Directory: Selected attribute types.*
- ITU-T Recommendation X.521 (1993) | ISO/IEC 9594-7:1995, *Information Technology – Open Systems Interconnection – The Directory: Selected object classes.*
- ITU-T Recommendation X.525 (1993) | ISO/IEC 9594-9:1995, *Information Technology – Open Systems Interconnection – The Directory: Replication.*
- ITU-T Recommendation X.680 (1994) | ISO/IEC 8824-1:1995, *Information Technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation.*
- ITU-T Recommendation X.681 (1994) | ISO/IEC 8824-2:1995, *Information Technology – Abstract Syntax Notation One (ASN.1): Information object specification.*
- ITU-T Recommendation X.682 (1994) | ISO/IEC 8824-3:1995, *Information Technology – Abstract Syntax Notation One (ASN.1): Constraint specification.*
- ITU-T Recommendation X.683 (1994) | ISO/IEC 8824-4:1995, *Information Technology – Abstract Syntax Notation One (ASN.1): Parameterization of ASN.1 specifications.*
- ITU-T Recommendation X.690 (1994) | ISO/IEC 8825-1:1995, *Information Technology – ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER).*
- ITU-T Recommendation X.880 (1994) | ISO/IEC 13712-1:1995, *Information technology – Remote Operations: Concepts, model and notation.*
- ITU-T Recommendation X.881 (1994) | ISO/IEC 13712-2:1995, *Information technology – Remote Operations: OSI realizations – Remote Operations Service Element (ROSE) service definition.*

2.2 Paired Recommendations | International Standards equivalent in technical content

- CCITT Recommendation X.800 (1991), *Security Architecture for Open Systems Interconnection for CCITT Applications.*
- ISO 7498-2:1989, *Information processing systems – Open Systems Interconnection – Basic Reference Model – Part 2: Security Architecture.*

3 Definitions

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

3.1 OSI Reference Model security architecture definitions

The following terms are defined in CCITT Rec. X.800 | ISO 7498-2:

a) *asymmetric (encipherment)*;

b) *authentication exchange*;

c) *authentication information*;

d) *confidentiality*;

e) *credentials*;

f) *cryptography*;

g) *data origin authentication*;

h) *decipherment*;

i) *encipherment*;

j) *key*;

k) *password*;

l) *peer-entity authentication*;

m) *symmetric (encipherment).*

3.2 Directory model definitions

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

a) *attribute*;

b) *Directory Information Base*;

c) *Directory Information Tree*;

d) *Directory System Agent;*

e) *Directory User Agent;*

f) *distinguished name*;

g) *entry*;

h) *object*;

i) *root.*

3.3 Authentication framework definitions

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

3.3.1 authentication token (token): Information conveyed during a strong authentication exchange, which can be used to authenticate its sender.

3.3.2 user certificate; certificate: The public keys of a user, together with some other information, rendered unforgeable by encipherment with the private key of the certification authority which issued it.

3.3.3 certification authority: An authority trusted by one or more users to create and assign certificates. Optionally the certification authority may create the users' keys.

3.3.4 certification path: An ordered sequence of certificates of objects in the DIT which, together with the public key of the initial object in the path, can be processed to obtain that of the final object in the path.

3.3.5 cryptographic system, cryptosystem: A collection of transformations from plain text into ciphertext and vice versa, the particular transformation(s) to be used being selected by keys. The transformations are normally defined by a mathematical algorithm.

3.3.6 hash function: A (mathematical) function which maps values from a large (possibly very large) domain into a smaller range. A "good" hash function is such that the results of applying the function to a (large) set of values in the domain will be evenly distributed (and apparently at random) over the range.

3.3.7 one-way function: A (mathematical) function f which is easy to compute, but which for a general value y in the range, it is computationally difficult to find a value x in the domain such that f(x) = y. There may be a few values y for which finding x is not computationally difficult.

3.3.8 public key: (In a public key cryptosystem) that key of a user's key pair which is publicly known.

3.3.9 private key; secret key (deprecated): (In a public key cryptosystem) that key of a user's key pair which is known only by that user.

3.3.10 simple authentication: Authentication by means of simple password arrangements.

3.3.11 security policy: The set of rules laid down by the security authority governing the use and provision of security services and facilities.

3.3.12 strong authentication: Authentication by means of cryptographically derived credentials.

3.3.13 trust: Generally, an entity can be said to "trust" a second entity when it (the first entity) makes the assumption that the second entity will behave exactly as the first entity expects. This trust may apply only for some specific function. The key role of trust in the authentication framework is to describe the relationship between an authenticating entity and a certification authority; an authenticating entity shall be certain that it can trust the certification authority to create only valid and reliable certificates.

3.3.14 certificate serial number: An integer value, unique within the issuing CA, which is unambiguously associated with a certificate issued by that CA.

4 Abbreviations

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

CA	Certification Authority
DIB	Directory Information Base
DIT	Directory Information Tree
DSA	Directory System Agent
DUA	Directory User Agent
PKCS	Public key cryptosystem

5 Conventions

With minor exceptions this Directory Specification has been prepared according to the "Presentation of ITU-TS/ISO/IEC common text" guidelines in the Guide for ITU-TS and ISO/IEC JTC 1 Cooperation, March 1993.

The term "Directory Specification" (as in "this Directory Specification") shall be taken to mean ITU-T Rec. X.509 | ISO/IEC 9594-8. 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 previous (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. Systems conforming to the current Directory Specifications are referred to as "1993 edition systems".

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

The notation used in this Directory Specification is defined in Table 1 below.

Table 1 – Notation

Notation	Meaning
Xp	Public key of a user X.
Xs	Private key of X.
Xp[I]	Encipherment of some information, I, using the public key of X.
Xs[I]	Encipherment of I using the private key of X.
X{I}	The signing of I by user X. It consists of I with an enciphered summary appended.
CA(X)	A certification authority of user X.
CA^n(X)	(Where n>1): CA(CA(...n times...(X)))
X_1«X_2»	The certificate of user X_2 issued by certification authority X_1.
X_1«X_2» X_2«X_3»	A chain of certificates (can be of arbitrary length), where each item is the certificate for the certification authority which produced the next. It is functionally equivalent to the following certificate X_1«X_{n+1}». For example, possession of A«B»B«C» provides the same capability as A«C», namely the ability to find out Cp given Ap.
X_1p • X_1«X_2»	The operation of unwrapping a certificate (or certificate chain) to extract a public key. It is an infix operator, whose left operand is the public key of a certification authority, and whose right operand is a certificate issued by that certification authority. The outcome is the public key of the user whose certificate is the right operand. For example: Ap • A«B» B«C» denotes the operation of using the public key of A to obtain B's public key, Bp, from its certificate, followed by using Bp to unwrap C's certificate. The outcome of the operation is the public key of C, Cp.
A→B	A certification path from A to B, formed of a chain of certificates, starting with CA(A)«CA^2(A)» and ending with CA(B)«B».
NOTE – In the table, the symbols X, X_1, X_2, etc., occur in place of the names of users, while the symbol I occurs in place of arbitrary information.	

SECTION 2 – SIMPLE AUTHENTICATION

6 Simple authentication procedure

Simple authentication is intended to provide local authorization based upon the distinguished name of a user, a bilaterally agreed (optional) password, and a bilateral understanding of the means of using and handling this password within a single domain. Utilization of simple authentication is primarily intended for local use only, i.e. for peer entity authentication between one DUA and one DSA or between one DSA and one DSA. Simple authentication may be achieved by several means:

a) the transfer of the user's distinguished name and (optional) password in the clear (non-protected) to the recipient for evaluation;

b) the transfer of the user's distinguished name, password, and a random number and/or a timestamp, all of which are protected by applying a one-way function;

c) the transfer of the protected information described in b) together with a random number and/or a timestamp, all of which is protected by applying a one-way function.

NOTES

1 There is no requirement that the one-way functions applied be different.

2 The signaling of procedures for protecting passwords may be a matter for extension to the document.

Where passwords are not protected, a minimal degree of security is provided for preventing unauthorized access. It should not be considered a basis for secure services. Protecting the user's distinguished name and password provides greater degrees of security. The algorithms to be used for the protection mechanism are typically non-enciphering one-way functions that are very simple to implement.

The general procedure for achieving simple authentication is shown in Figure 1.

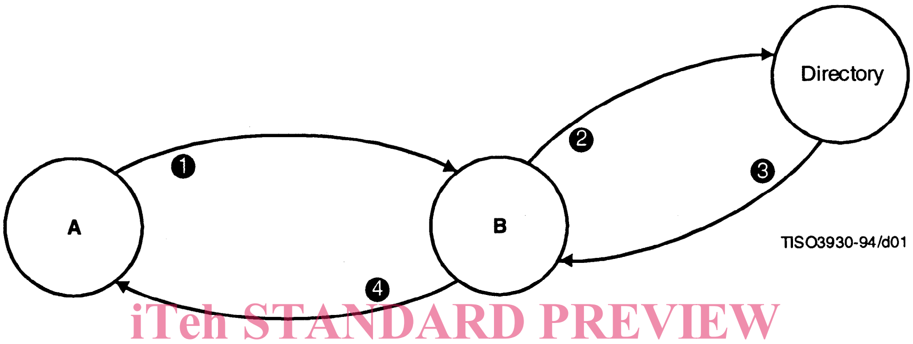


Figure 1 – The unprotected simple authentication procedure

The following steps are involved:

1) an originating user A sends its distinguished name and password to a recipient user B;

2) B sends the purported distinguished name and password of A to the Directory, where the password is checked against that held as the **UserPassword** attribute within the directory entry for A (using the Compare operation of the Directory);

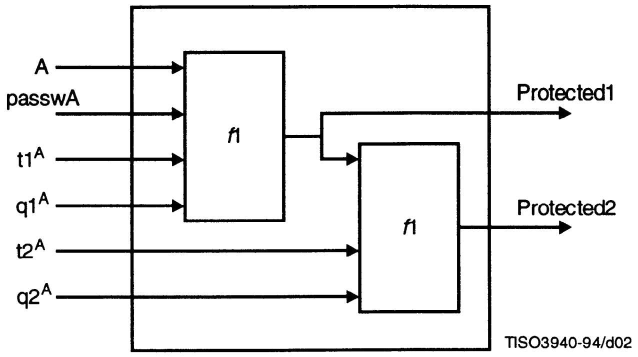
3) the Directory confirms (or denies) to B that the credentials are valid;

4) the success (or failure) of authentication may be conveyed to A.

The most basic form of simple authentication involves only step 1 and after B has checked the distinguished name and password, may include step 4.

6.1 Generation of protected identifying information

Figure 2 illustrates two approaches by which protected identifying information may be generated. *f*1 and *f*2 are one-way functions (either identical or different) and the timestamps and random numbers are optional and subject to bilateral agreements.



A	User's distinguished name
t^A	Timestamps
$passw^A$	Password of A
q^A	Random numbers, optionally with a counter included

Figure 2 – Protected simple authentication

6.2 Procedure for protected simple authentication

Figure 3 illustrates the procedure for protected simple authentication.

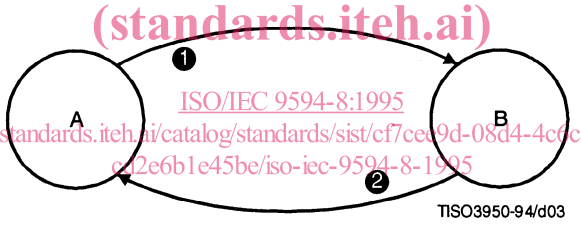


Figure 3 – The protected simple authentication procedure

The following steps are involved (initially using *f*1 only):

1) An originating user, user A, sends its protected identifying information (Authenticator1) to user B. Protection is achieved by applying the one-way function (*f*1) of Figure 2, where the timestamp and/or random number (when used) is used to minimize replay and to conceal the password.

   The protection of A's password is of the form:

   Protected1 = *f*1 ($t1^A$, $q1^A$, A, passwA)

   The information conveyed to B is of the form:

   Authenticator1 = $t1^A$, $q1^A$, A, Protected1

   B verifies the protected identifying information offered by A by generating (using the distinguished name and optional timestamp and/or random number provided by A, together with a local copy of A's password) a local protected copy of A's password (of the form Protected1). B compares for equality the purported identifying information (Protected1) with the locally generated value.

2) B confirms or denies to A the verification of the protected identifying information.