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Information security — Key management —

Part 5: Group key management

Sécurité de l'information — Gestion de clés —

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 27, *Information security, cybersecurity and privacy protection*.

This second edition cancels and replaces the first edition (ISO/IEC 11770-5:2011) which has been technically revised.

The main changes compared to the previous edition are as follows:

— the document has been modified to be consistent with use of the key deriviation specifications from ISO/IEC 11770-6;

— the use of a "trapdoor" in key derivation has been removed. Consequently, unlimited forward key chains can no longer be calculated.

A list of all parts in the ISO/IEC 11770 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In some applications, it is necessary for a secret cryptographic key to be shared by a group of entities. Moreover, in some cases the exact membership of a group of entities that share a key may change over time.

This document is concerned with techniques that enable a secret key to be shared by all members of a defined group with the assistance of a trusted third party known as a key distribution centre. Provisions for adding and removing members of a group are also made.

Information security — Key management —

Part 5: Group key management

1 Scope

This document specifies mechanisms to establish shared symmetric keys between groups of entities. It defines:

— symmetric key-based key establishment mechanisms for multiple entities with a key distribution centre (KDC); and

— symmetric key establishment mechanisms based on a general tree-based logical key structure with both individual rekeying and batch rekeying.

It also defines key establishment mechanisms based on a key chain with group forward secrecy, group backward secrecy or both group forward and backward secrecy.

This document also describes the required content of messages which carry keying material or are necessary to set up the conditions under which the keying material can be established.

This document does not specify information that has no relation with key establishment mechanisms, nor does it specify other messages such as error messages. The explicit format of messages is not within the scope of this document.

This document does not specify the means to be used to establish the initial secret keys required to be shared between each entity and the KDC, nor key lifecycle management. This document also does not explicitly address the issue of interdomain key management.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 19772, *Information technology — Security techniques — Authenticated encryption*

ISO/IEC 11770-6, *Information technology — Security techniques — Key management — Part 6: Key derivation*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
active
state of an entity in which the entity can obtain the *shared secret key* (3.24)

3.2
ancestor key
ancestor key of an entity *x*
cryptographic key in a *logical key hierarchy* (3.17) that is assigned to a node on the direct path from the *leaf node* (3.16) corresponding to the *individual key* (3.11) for *x* and the *root node* (3.23)

Note 1 to entry: An ancestor key is either the shared secret key or a key encryption key.

3.3
backward secrecy with interval *T*
security condition in which an entity joining a set of entities at time $t = t_0$ cannot obtain any secret keys established between these entities at any time prior to $t_0 - T$

3.4
batch rekeying with interval *T*
rekeying method in which the *shared secret key* (3.24) and, optionally, *key encryption keys* (3.15) are updated at every time interval *T* (see Clause 4)

3.5
child key
child key for a node *w*
cryptographic key in a *logical key hierarchy* (3.17) assigned to a non-root node *w*

Note 1 to entry: A child key shall be a key encryption key or individual key.

3.6
child node
child node of a node *w*
node in a *tree* (3.25) that is adjacent to *w* and for which *w* lies on the unique path between it and the *root node* (3.23)

3.7
***d*-ary tree**
tree (3.25) where each node has *d child nodes* (3.6) except the *leaf nodes* (3.16) in the tree

3.8
forward secrecy with interval *T*
security condition in which an entity leaving a set of entities at time $t = t_0$ cannot obtain any secret keys established between these entities at any time subsequent to $t_0 + T$

3.9
group backward secrecy
security condition in which an entity joining a set of entities cannot obtain any secret keys previously established between these entities

3.10
group forward secrecy
security condition in which an entity leaving a set of entities cannot obtain any secret keys subsequently established between these entities

3.11
individual key
key shared between the *key distribution centre* (3.14) and each entity

3.12
individual rekeying
rekeying method in which the *shared secret key* (3.24) and, optionally, *key encryption keys* (3.15) are updated when an entity joins or leaves

3.13
key chain
set of cryptographic keys which are not necessarily independent

3.14
key distribution centre
KDC
entity trusted to generate or acquire and distribute keys to entities

3.15
key encryption key
cryptographic key that is used for the encryption or decryption of other keys

[SOURCE: ISO/IEC 19790:2012, 3.62]

3.16
leaf node
node in a *tree* (3.25) that has no *child nodes* (3.6)

3.17
logical key hierarchy
tree (3.25) used for managing the shared secret key and *key encryption keys* (3.15)

3.18
logical key structure
logical structure to manage keys

Note 1 to entry: The choice of the logical key hierarchy is independent of the network topology.

3.19
one-way function
function with the property that it is easy to compute the output for a given input but it is computationally infeasible to find for a given output an input which maps to this output

[SOURCE: ISO/IEC 11770-3:2015, 3.30]

3.20
one-step key derivation function
OKDF
key derivation function which operates in a single stage, in contrast to key derivation functions involving separate key-extraction and key-expansion stages

[SOURCE: ISO/IEC 11770-6:2016, 3.9]

3.21
random number
time variant parameter whose value is unpredictable

[SOURCE: ISO/IEC 11770-1:2010, 2.39]

3.22
rekeying
process of updating and redistributing the *shared secret key* (3.24) and, optionally, *key encryption keys* (3.15)

Note 1 to entry: This process is executed by the key distribution centre.

3.23
root node
unique identified special node in a *tree* (3.25)

3.24
shared secret key
key which is shared with all the active entities via a key establishment mechanism for multiple entities

3.25
tree
connected, acyclic graph with an identified special node, the *root node* (3.23)

4 Symbols and abbreviated terms

COM(X,Y)	function which generates from the data items X and Y a key designed to be applied as a key for the encryption algorithm in use
CUT(k,S)	function which outputs a substring of length k equal to the least significant bits of a string of bits S
d	number of child nodes for a non-leaf node (see term d-ary tree)
$e(K,Z)$	result of encrypting data Z with a symmetric encryption algorithm using the secret key K
h	number of nodes in the direct path from a leaf node to the root node
$K_{A,i}(x)$	ancestor key for entity x at the i-th layer from the root node
$K_{BW,i}$	backward key for the time instance i
$K_{C,w}$	child key assigned to the node w
$K_{FW,i}$	forward key for the time instance i
K_I	individual key
$K_I(x)$	individual key shared between entity x and the key distribution centre
$K_{KE,w}$	key encryption key assigned to a node w
K_{SS}	shared secret key
KDC	key distribution centre
m	number of entities connected to the hub in a star structure
OKDF1	one-step key derivation function that takes a single input as defined in ISO/IEC 11770-6
OKDF6	one-step key derivation function that takes a key and input data as defined in ISO/IEC 11770-6
OWF	one-way function used in the calculation of a key chain
$r_{BW,init}$	random number to initialize the backward key chain
$r_{FW,init}$	random number to initialize the forward key chain
T	length of the time interval used in batch rekeying
||	binary operator indicating the concatenation of data items

5 Requirements

The key establishment mechanisms specified in this document enable the establishment of shared secret keys within a defined group of entities using multicast communication. In order to maintain security, the mechanisms incorporate a key updating process to be used when a new entity joins or an existing entity leaves the group.

a) The mechanisms specified in this document provide either group backward secrecy and group forward secrecy, or backward and forward secrecy with intervals. The type of group backward/forward secrecy should be chosen depending on the security requirements of the particular application. The type of group backward/forward security property is determined by the choice of rekeying method: individual rekeying provides group backward/forward secrecy, and batch rekeying provides backward/forward secrecy with intervals. The use of batch rekeying requires the choice of a time interval parameter *T*. The rekeying method and parameter setting have a strong influence on the security requirements. Thus, they shall be determined according to the security policy of the application.

b) Symmetric encryption techniques, as required for the mechanisms specified in Clause 6, shall be chosen from amongst those standardized in ISO/IEC 19772.

c) The shared secret key is established using either a secure or an insecure communication channel. Each individual key shall be exchanged between the KDC and each entity using a secure channel in order to allow secure communication. A secure communication channel is one where an attacker cannot eavesdrop or tamper with messages in the channel.

d) The key establishment mechanisms in this document require the use of random numbers to generate the shared secret key, and optionally, key encryption keys. For means of generating random numbers, see ISO/IEC 18031.

e) Annex A defines object identifiers in accordance with ISO/IEC 9834 (all parts) that shall be used to identify the mechanisms specified in this document. Any change to the specification of the mechanisms resulting in a change of functional behaviour results in a change of the object identifier assigned to the mechanisms.

6 Tree-based key establishment mechanisms

6.1 General model

Use of the mechanisms specified in this document enables the establishment of a secret key shared by all the entities in a defined group. This enables any member of the group to send an encrypted message to all the other group members such that only group members (and the key distribution centre) can decrypt it. The mechanisms also enable the key distribution centre to update the established secret key to ensure that an encrypted message can only be decrypted by entities who are group members at that time the message was encrypted.

Figure 1 shows the general model of key establishment for multiple entities, in which the key distribution centre can communicate with all the entities. The communication between the key distribution centre and entities does not need to be secure. The key distribution centre and each entity shall share a distinct individual key. The key distribution centre is responsible for distributing the shared secret key to all the active entities. A join/leave request is shown as (1) and the distribution of keys to the entities as (2), (3), ..., (n + 1). From (2) onward, the order in which the updates take place is not important.

NOTE If one of the entities that knows the shared secret key cannot be contacted for a period of time, that entity can miss a key update message, and as a result will not be able to compute the updated shared secret key.