Protokollsicherheit

Protocol Goals and Protocol Design Principles

Motivation

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Simple Example

1. $A \rightarrow B : N_A$
2. $B \rightarrow A : \mathrm{MAC}_{K_{AB}}(B, A, N_A), N_B$
3. $A \rightarrow B : \mathrm{MAC}_{K_{AB}}(A, B, N_B)$

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1. $C(A) \rightarrow B : N_C$
2. $B \rightarrow C(A) : \text{MAC}_{K_{AB}}(B, A, N_C), N_B$
3. $C(B) \rightarrow A : N_B$
4. $A \rightarrow B : \text{MAC}_{K_{AB}}(A, B, N_B), N_A$
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This seems to be an attack. **But did the protocol fail?** From the sequence above, one could establish that A is willing to communicate with B using K_{AB}.

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A Recent Example [Basin et al. POST'12]

“The **ISO/IEC 9798** standard **neither** specifies a threat model **nor** defines the security properties that the protocols should satisfy. Instead, the introduction of **ISO/IEC 9798** simply states that the protocols should satisfy mutual or unilateral authentication.”

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Unfortunately, there are no general precise definitions for the goals of protocols.

Definitions

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One can distinguish some types goals. The first two are basic goals:

- **User-oriented goals** – concerning entity authentication;
- **Key-oriented goals** – concerning key establishment;
- **Enhanced goals** – some additional goals associated to key establishment;

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User-Oriented Goals

Definition: Entity authentication is the process whereby one party is assured (**through the acquisition of corroborative evidence**) of the identity of a second party involved in a protocol, and that party has actually participated.

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User-Oriented Goals

1. $A \rightarrow B : N_A$
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However, B has not indicated that she is aware of A.

Definition: A principal A is said to have *knowledge* of A as his peer entity if A is aware of B as his claimed peer entity in the protocol.

1. $A \rightarrow B : N_A$
2. $B \rightarrow A : \text{Sign}_B(A, N_A)$

Definition: *Strong entity authentication* of A to B is provided if B has *fresh* assurance that A has knowledge of B as his peer.

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Key-Oriented Goals

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As we have seen, protocols have three entities, which we can use for establishing a key exchange:

- **keys** – which may be long-term or session keys.
- **identifiers** for principals;
- **nonces** which may be random values, timestamps or counters.

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Session Keys

Definition: The shared session key is a *good* key for A to use with B only if A has assurance that:

- the key is **fresh** also called **key freshness**;
- the key is known only to A and B which are **mutually trusted parties**, also called **key authentication**.

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Definition: Key confirmation of A to B is provided if B has assurance that a key K is a good key to communicate with A and that principal A has possession of key K.

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Not really standard definition. In ISO/IEC the following definition appears:

"Key confirmation: the assurance for one entity that another identified entity is in possession of the correct key."

Not clear what correct key means.

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Definition: Explicit key authentication is the property obtained when both **key authentication** and **key confirmation** hold.

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Definition: Mutual belief in the key K is provided for B only if K is a good key for use with A and A wishes to communicate with B using key K, which A **believes is good for that purpose**.

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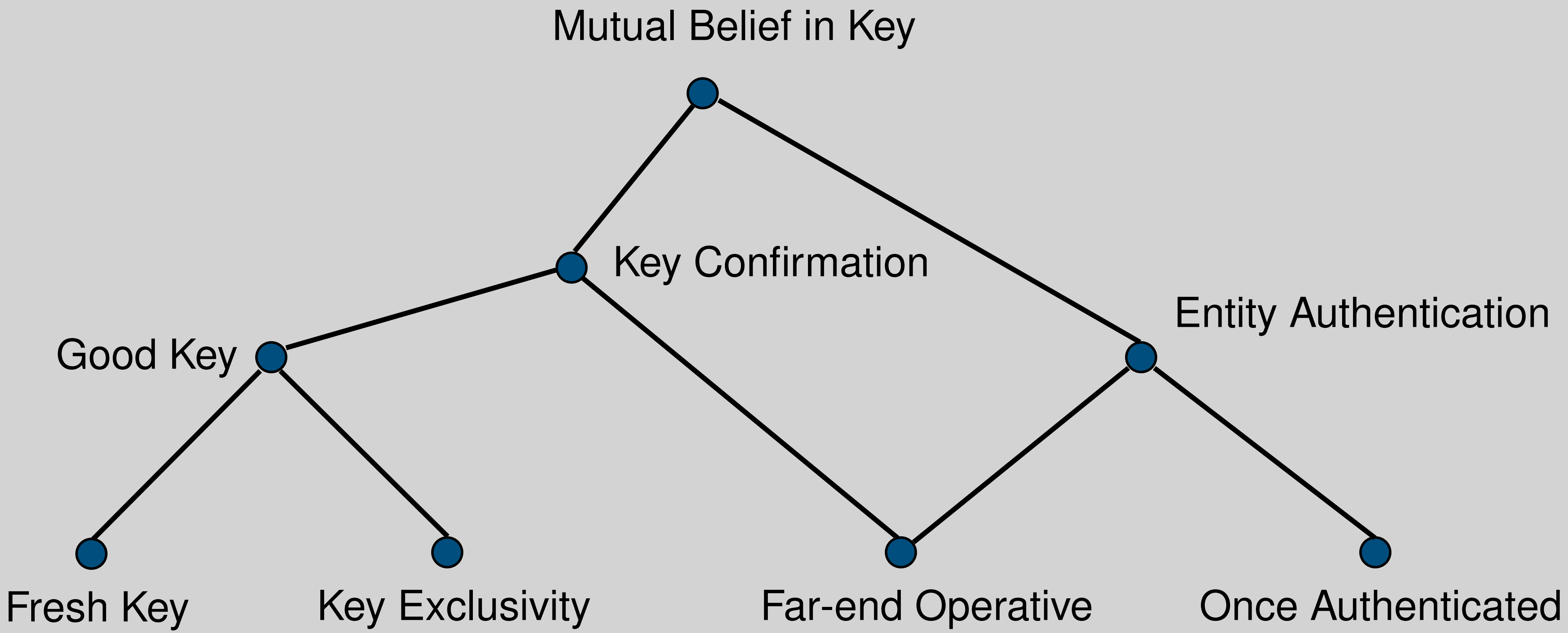
Goal Hierarchy



Abadi-Needham's 11 Principles

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Principle 2: The conditions for a message to be acted upon should be clearly set out so that someone reviewing a design may see whether they are acceptable or not.

Handshake

i. $A \rightarrow B : \{N_A\}_K$

i+1. $A \rightarrow B : \{N_A + 1\}_K$

N_A is a challenge nonce and K is the exchanged session key.

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Example

1. $A \rightarrow S : A, B$
2. $S \rightarrow A : C_A, C_B$
3. $A \rightarrow B : C_A, C_B, \{\text{sign}((K_{ab}, T_a), K_a)\}_{K_b}$

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Attack

3'. $B \rightarrow C : C_A, C_C, \{\text{sign}((K_{ab}, T_a), K_a)\}_{K_c}$

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Solution

3. $B \rightarrow C : C_A, C_B, \{\text{sign}((A, B, K_{ab}, T_a), K_a)\}_{K_b}$

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Principle 4: Be clear about why encryption is being done. Encryption is not wholly cheap, and not asking precisely why it is being done can lead to redundancy. **Encryption is not synonymous with security**.

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Possible Uses of Encryption

- **Preservation of confidentiality:** $\{X\}_K$ only those that have K may recover X.
- **Guarantee authenticity:** The partner is indeed some particular principal.
- **Guarantee confidentiality and authenticity:** binds two parts of a message – $\{X, Y\}_K$ is not the same as $\{X\}_K$ and $\{Y\}_K$.
- **Produce random numbers:** This is not really explicit in our symbolic model. In practice, however, encryption techniques can also be used to produce random numbers.

Abadi-Needham's 11 Principles

Kerberos

1. $A \rightarrow S : A, B$
2. $S \rightarrow A : \{T_s, L, K_{ab}, B, \{T_s, L, K_{ab}, A\}_{K_{bs}}\}_{K_{as}}$
3. $A \rightarrow B : \{T_s, L, K_{ab}, A\}_{K_{bs}}, \{A, T_a\}_{K_{ab}}$
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Message 3: The purpose of the encryption with K_{ab} is to prove knowledge of K_{ab} near T_a. The same use happens in message 4. However, if T_a is **not** that different from T_s it could be eliminated. In this case, B uses T_s in message 4.

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Principle 5: When a principal signs material that has already been encrypted, it should **not be inferred** that the principal knows the content of the message. On the other hand, it is **proper to infer** that the principal that signs a message and then encrypts it for privacy **knows the content** of the message.

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1. $A \rightarrow B : A, \text{sign}((T_a, N_a, B, X_a, \underbrace{\{Y_a\}}_{}{}_{K_b}), K_a)$

A might not know this message!

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Encryption is for binding the messages.

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Principle 7: The use of a predictable quantity such as the value of a counter **can serve in guaranteeing newness**, through a challenge-response exchange. But if a predictable quantity is to be effective, it should be protected so that an intruder **cannot** simulate a challenge and later replay a response.

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If N_a is predictible, then the intruder could request the current time using a **future nonce**. Then the intruder could use the returned message in the future to set A's time to the past.

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Principle 8: If timestamps are used as freshness guarantees by reference to absolute time, then the **difference between local clocks** at various machines must be much less than the allowable age of a message deemed to be valid. Furthermore, the time maintenance mechanism everywhere becomes part of the trusted computing base.

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Principle 9: A key may have been used recently, for example to encrypt a nonce, **yet be quite old, and possibly compromised**. Recent use does not make the key look any better than it would otherwise.

Example: Denning-Sacco attack on **Needham-Schroeder**

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Principle 11: The protocol designer should **know which trust relations his protocol depends on, and why the dependence is necessary**. The reasons for particular trust relations being acceptable should be explicit though they will be founded on judgment and policy rather than on logic.

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Example Kerberos: Server providing false timestamps leads to an attack.

Example Certification Authorities (CAs): CAs are trusted to certify a key only after proper steps have been taken to identify the principal that owns it.