Protocols I

Computer Security Lecture 7

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[1] Based on original lecture notes by David Aspinall

Outline

Introducing protocols

Simple authentication
- Password security

Authentication with shared keys
- Simple shared-key authentication
- Challenge and response
- Timestamps

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Protocols and attacks

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- This lecture introduces some simple protocols and common flaws.

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- At each step in the protocol, the **beliefs of participants** change. If something goes wrong, the protocol is aborted.
- This reasoning can be made formal with specialised logics and calculi for reasoning about protocol correctness. Formal protocol analysis has been a big success, uncovering flaws in real protocols that had been hidden for many years.

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- When multiple (independent) methods are used simultaneously, it is called a **multi-factor** authentication protocol

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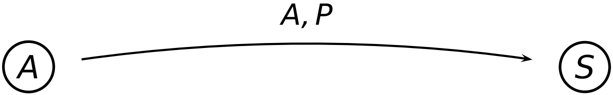

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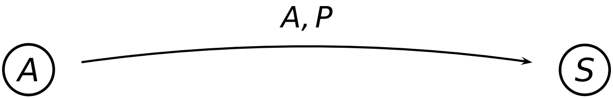

- The server then verifies Alice's password, and if it is correct, it lets her in to the system.

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  - And how does her password get sent to the server?

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- This is more secure than before: anyone who reads the file does not immediately learn all passwords.

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- Dictionary attacks which precompute many hash values can be thwarted by **adding salt** to passwords. Salt is a random number that is combined with the password before applying the hash, and stored along with the result. Still doesn't stop a determined attack on a single password.

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  3. (SecureID) Uses a token device which computes a new "password" every minute by computing a hash of the current time (to a granularity of minutes), and a secret key stored on the device.

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- Suppose that we have an in-car device C, which is a congestion-charging transmitter in a car window screen. C wishes to identify itself to a server S in an overhead charging point, which clocks cars passing. Suppose that C and S share a secret key K_{cs}. The in-car device might send a message with its name (a secret serial number) and an encrypted copy of its name, perhaps with some additional relevant data R (e.g., the time since it last passed a charge-point).

Protocol for shared-key authentication

$$C \rightarrow S : \quad C, \{\, C, R \,\}_{K_{cs}}$$

(the notation $\{\, C, R \,\}_{K_{cs}}$ stands for the combination of C and the rest R encrypted under the key K_{cs}).

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- Are there any other problems?
  - It is vulnerable to **replay attacks**. A device which captures and replays messages from windscreen beamers, they could rack up huge charges on another bill!

The need for nonces

- To prevent a replay attack, we need a method to ensure that messages are **fresh**.
- We can do this using **nonces** ("number used once").
- A nonce is a random number or a sequence number. The server S maintains a list of messages it has seen (or if the nonce is a sequence number, just the last value), and ignores those that have gone before.

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- But the counter may be distributed or may get incremented several times during faulty transmissions, etc. Can we remove the need to remember nonces?

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With a nonce N in the protocol, we now have:

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- This works, but has engineering drawbacks. The server S must remember a reasonable history of past messages, or the last value of the counter.
- But the counter may be distributed or may get incremented several times during faulty transmissions, etc. Can we remove the need to remember nonces?
- A solution is to introduce a two-way communication, based on **challenge and response**.

Challenge and response

Now the nonce is generated randomly by the server, and neither side needs to keep any (long-term) state:

Message 1. $S \rightarrow C$: N
Message 2. $C \rightarrow S$: $C, \{C, N, R\}_{K_{cs}}$

- Many protocols are based on this basic challenge-response idea, using nonces to guarantee freshness.

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- Many protocols are based on this basic challenge-response idea, using nonces to guarantee freshness.
- But challenge-response protocols are open to another form of attack, the **man-in-the-middle attack** (or to be politically correct, the **middleperson attack**).

Man-in-the-middle attacks

- In the car congestion charging scenario, suppose somebody builds a device which attaches to their back windscreen and charges the car behind them as they pass the barrier, simply by passing the communications back and forth.

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- To show this explicitly, let M be the middleperson:

Message 1.	$S \to M$:	N
Message 1'.	$M \to C$:	N
Message 2.	$C \to M$:	$C, \{C, N, R\}_{K_{cs}}$
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- Notice that M here is particularly stupid, and needs to understand nothing in the transmitted messages.

Foiling man-in-the-middle

- Man-in-the-middle attacks as passive and direct as the simple case above can be difficult to foil: the server on the overhead charging point may have no way of telling that it is not talking directly to the car that's actually passing.

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- One approach: **timestamps** instead of nonces, and check that messages are sent within tight time constraints. But in this case we would probably rely on other techniques, e.g. secondary authentication by number plate recognition, or at the least, good recording mechanisms so that *accountability* is maintained (somebody later questions their bill).

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- Other middleperson attacks are more sophisticated, e.g., typically the middle person taking an active role in decrypting and re-encrypting messages. Some of these other attacks do have defences in protocols.

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- Pros: reduced number of messages; no requirement to maintain (possibly pairwise) state information.
- Cons: clocks are required to be ("loosely") synchronized; state required for storing observed timestamps; synchronization itself may require secure authenticated protocols. . .

References

Interesting treatments of security protocols are given in Chapter 2 of Anderson and Chapters 3–5 of Schneier.

- Ross Anderson.
  Security Engineering: A Comprehensive Guide to Building Dependable Distributed Systems.
  Wiley & Sons, 2001.
- Bruce Schneier.
  Applied Cryptography.
  John Wiley & Sons, second edition, 1996.

Recommended Reading

Chapter 2 of Anderson.