

CS 5523 Lecture 19: Security Case Studies

- Questions on laboratory 3
- Introduce laboratory 4
- Review scenarios
- Needham-Schroeder
- Brief summary of common algorithms
- Kerberos

Simplified overview of secret key encryption:

Encrypted message:

$$E(K, M) = \{M\}_K$$

Decrypted message:

$$D(K, E(K, M)) = D(K, \{M\}_K) = M$$

It is hard to get M from $\{M\}_K$ without knowing K

Scenario 1. Secret communication with shared secret key

Alice and Bob share a secret key K_{AB} . Alice wants to send a secret message M to Bob.

1. Alice uses K_{AB} and an agreed encryption function $E(K_{AB}, M)$ to encrypt and send message M to Bob
2. Bob reads the encrypted messages using the corresponding decryption function $D(K_{AB}, M)$

How can Bob and Alice safely get the shared key K_{AB} ?

How can Bob know that M wasn't a replay?

Scenario 2. Authenticated communication with a server

Alice wants to access Bob's files on a local file server. Sara is a trusted authentication server that holds passwords and current secret keys.

1. Alice sends a message to Sara asking for a ticket to access Bob
 2. Sara sends Alice a response encrypted with K_A that is a ticket encrypted with K_B and a new secret key K_{AB} for communication: $\{\{ticket\}_{K_B}, K_{AB}\}_{K_A}$
 3. Alice decrypts response with K_A
 4. Alice sends ticket, her ID and request R to Bob: $\{ticket\}_{K_B}, Alice, R$
 5. Bob decrypts ticket using K_B (the ticket was $\{K_{AB}, Alice\}_{K_B}$)
- This is the simplified scenario for Kerberos. K_{AB} is the session key.

Simplified overview of public key encryption:

Keys come in pairs K_1 and K_2 . Keep one public and one private.
If you encrypt with K_1 , you can decrypt with K_2 and vice versa:

$$D(K_2, E(K_1, M)) = M$$

and

$$D(K_1, E(K_2, M)) = M$$

Scenario 3. Authenticated communication with public keys

Bob has generated a public/private key pair. There is a trusted authority that gives out key certificates

1. Alice accesses a key distribution center to obtain a public key certificate with Bob's public key. Alice extracts Bob's public key K_{Bpub}
2. Alice creates a new secret key K_{AB} and encrypts $\{K_{AB}, \text{known string}\}$ with K_{Bpub}
3. Alice sends $\{\{\text{unique keyname}\}, \{K_{AB}, \text{known string}\}_{K_{Bpub}}\}$ to Bob.
4. Bob decrypts $\{K_{AB}, \text{known string}\}_{K_{Bpub}}$ using K_{Bpriv}
5. Bob and Alice now communicate with K_{AB}

This is the scenario for the widely used hybrid cryptographic protocol.

Scenario 4. Digital signatures with a secure digest function

Alice wants to sign document M so that any recipient can verify it came from Alice. This assumes that Alice has a private-public key pair. A digest is like a checksum.

1. Alice computes a fixed-length digest $Digest(M)$.
2. Alice encrypts $Digest(M)$ with her private key certificate with Bob's public key and makes $\{M, \{Digest(M)\}_{K_{Apriv}}\}$ available.
3. Bob reads $\{M, \{Digest(M)\}_{K_{Apriv}}\}$, extracts M and computes $Digest(M)$.
4. Bob applies K_{Apub} to $\{Digest(M)\}_{K_{Apriv}}$ to obtain $Digest(M)$ and compares the value with his computed value.

Figure 7.4
Alice's bank account certificate

1. Certificate type	Account number
2. Name:	Alice
3. Account:	6262626
4. Certifying authority:	Bob's Bank
5. Signature	$\{Digest(\text{field 2} + \text{field 3})\}_{K_{Bpriv}}$

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Figure 7.5
Public-key certificate for Bob's Bank

1. Certificate type	Public key
2. Name:	Bob's Bank
3. Public key:	K_{Bpub}
4. Certifying authority:	Fred – The Bankers Federation
5. Signature	$\{Digest(\text{field 2} + \text{field 3})\}_{K_{Fred}}$

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Figure 7.13
X509 Certificate format

Subject	Distinguished Name, Public Key
Issuer	Distinguished Name, Signature
Period of validity	Not Before Date, Not After Date
Administrative information	Version, Serial Number
<u>Extended Information</u>	

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Some popular encryption schemes:

- TEA = tiny encryption algorithm – Wheeler and Needham, 1994 uses 32 rounds with combinations of XOR, text shifts
- DES = Data Encryption Standard – National Bureau of Standards 1977 – obsolete because of short keys – successfully cracked by brute force attacks in 1997 and a machine was built in 1998 that could crack keys in 3 days. Replaced by AES (Advanced Encryption Standard, NIST 1999)
- RSA – Rivest Shamir and Adelman – public key encryption based on factoring products of large primes – widely used (RSA's patent just expired)

Some popular encryption schemes (continued):

- 3DES = triple-DES – ANSI 1985 – apply DES 3 times with two keys – very slow
- IDEA = International Data Encryption Algorithm – Lai and Massey, 1990 – based on group algebra with 8 rounds of XOR
- MD5 = used for data digests – Rivest 1992 – four rounds applying 4 nonlinear functions to each of 16 32-bit segments
- SHA - NIST 1995 – based on Rivest's MD4 algorithm to produce a 160 bit digest

Figure 7.14
Performance of encryption and secure digest algorithms

	Key size/hash size (bits)	Extrapolated speed (kbytes/sec.)	PRB optimized (kbytes/s)
TEA	128	700	-
DES	56	350	7746
Triple-DES	112	120	2842
IDEA	128	700	4469
RSA	512	7	-
RSA	2048	1	-
MD5	128	1740	62425
SHA	160	750	25162

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Figure 7.15
The Needham-Schroeder secret-key authentication protocol

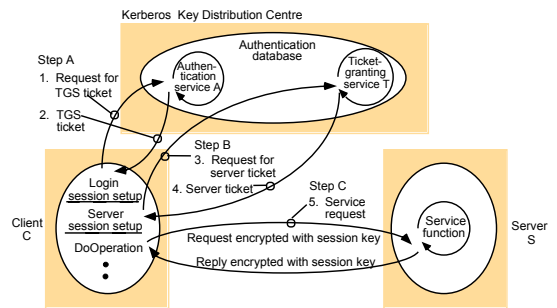
Header	Message	Notes
1. A->S:	A, B, N_A	A requests S to supply a key for communication with B.
2. S->A:	$\{N_A, B, K_{AB}\}_{K_A}$ $\{K_{AB}, A\}_{K_B}$	S returns a message encrypted in A's secret key, containing a newly generated key K_{AB} and a 'ticket' encrypted in B's secret key. The nonce N_A demonstrates that the message was sent in response to the preceding one. A believes that S sent the message because only S knows A's secret key.
3. A->B:	$\{K_{AB}, A\}_{K_B}$	A sends the 'ticket' to B.
4. B->A:	$\{N_B\}_{K_{AB}}$	B decrypts the ticket and uses the new key K_{AB} to encrypt another nonce N_B .
5. A->B:	$\{N_B - 1\}_{K_{AB}}$	A demonstrates to B that it was the sender of the previous message by returning an agreed transformation of N_B .

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Kerberos:

- Follows Needham and Schroeder very closely
- Uses time values as nonces
- When user logs in, the login program sends user's name to the kerberos authentication server
- If user is known, server replies with a session key and a nonce encrypted in the user's password and a ticket for TGS
- After login program authenticates the information, it can erase the user's password from memory

Figure 7.16
System architecture of Kerberos



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Kerberos (continued):

- When a program needs a service, it requests a ticket from TGS
- Server machines must take care to store their keys in a safe place
- Kerberos is implemented as a server running on a "secure" machine
- DES encryption is used, but it can be replaced
- Kerberos is scalable – world divided into realms
- Processes can authenticate themselves to servers in other realms through their local TGS
- Ticket lifetimes of 12 hours are typically used

For next time:

- Finish reading Chapter 7
- Start reading Chapter 9 of Core Java Volume 2