Computer Networks - Exercise 11

Stephan Sigg

Georg-August-University Goettingen, Computer Networks

22.01.2015

11.1

Q11.1 a) Name key differences between public and private key cryptography.

Q11.1 b) Which two protocols utilising private key cryptography have been discussed in the lecture?

11.1 a)

Q11.1 a) Name key differences between public and private key cryptography.

Public key cryptography	**Private key cryptography**
Key consists of public and private part	Sender and receiver share private key

11.1 b)

Q11.1 b) Which two protocols utilising private key cryptography have been discussed in the lecture?

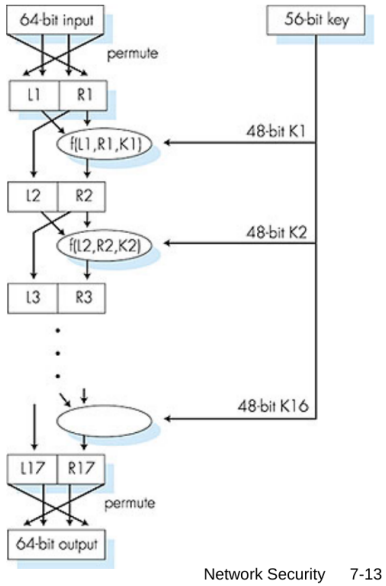
AES Advanced Encryption Standard

DES Data Encryption Standard

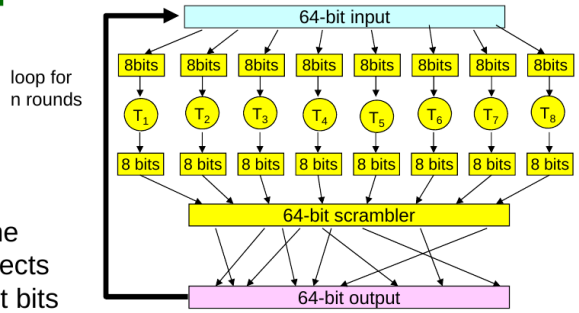
Symmetric key crypto: DES

DES operation

- initial permutation
- 16 identical "rounds" of function application, each using different 48 bits of key
- final permutation



Block Cipher



- one pass through: one input bit affects eight output bits
- multiple passes: each input bit afects all output bits
- block ciphers: DES, 3DES, AES

11.2

Q11.2 a) What are the security concerns network security is targeting at?

Q11.2 b) What main areas of protection does network security cover?

11.2 a) + b)

Confidentiality only sender and intended receiver should *understand* message contents

- sender encrypts message
- receiver decrypts message

Authentication sender and receiver should be able to confirm identity of each other

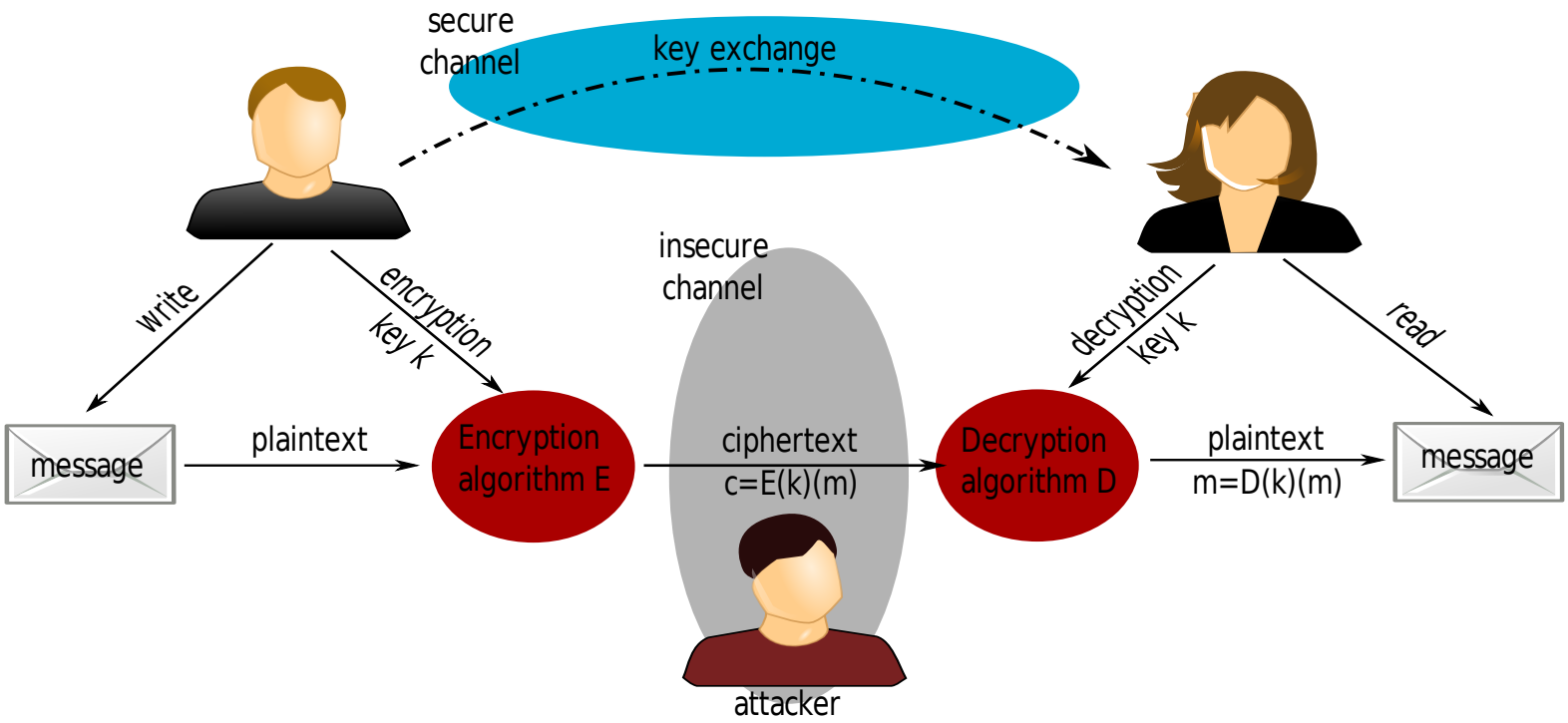
Message integrity message should not be altered (in transit, or afterwards) without detection

Access and availability services must be accessible and available to users

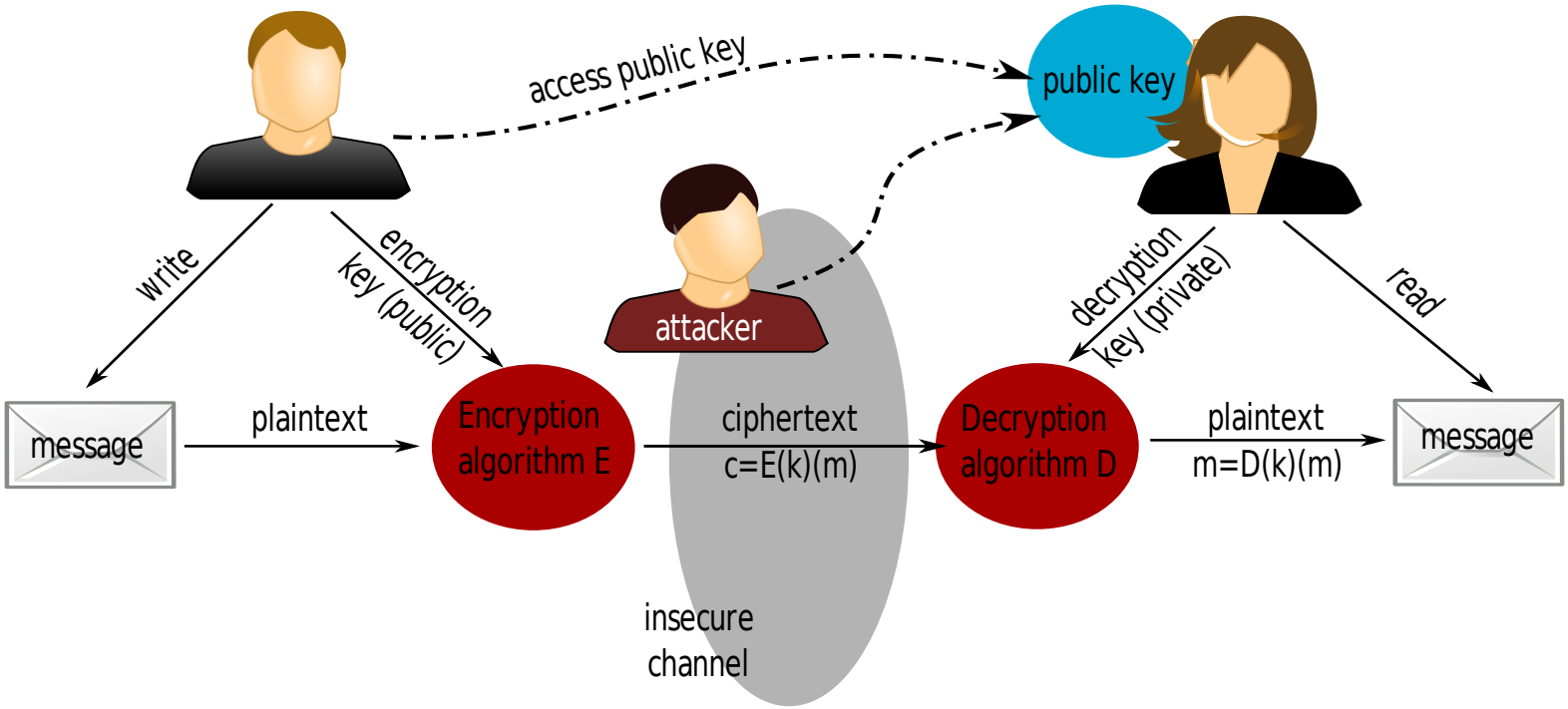
11.3

Q11.3 What are pro's and con's for public vs. private key crypographic systems in computer networks?

11.3 – Symmetric encryption



11.3 – Asymmetric encryption



11.4

Q11.4 RSA public key cryptography: Let $p = 3$ and $q = 11$. Use appropriate values for e and d and encrypt the value '3'

11.4 – RSA public key cryptography

Example

RSA key generation

1. Select two large random prime numbers p and q
2. Compute $n = p \cdot q$
3. Compute $\theta(n) = (p-1) \cdot (q-1)$
4. Select small odd integer e that is relatively prime to $\theta(n)$

11.4 – RSA public key cryptography

Example

RSA key generation

5. Compute d as the multiplicative inverse of $e \mod \theta(n)$
6. Publish $P = (e, n)$ as the RSA public key
7. Keep the secret pair $S = (d, n)$ as the RSA secret key

11.4 – RSA public key cryptography

Example

RSA key generation

8. Encrypt a message M
   - $C = M^e \mod n$
9. Decrypt a message C
   - $M = C^d \mod n$

11.4 – RSA public key cryptography

RSA key generation – example

- Select two prime numbers p and q
  - $p = 3; q = 11$
- Compute $n = p \cdot q$
  - $n = 33$
- Compute $\theta(n) = (p - 1) \cdot (q - 1)$
  - $\theta(n) = 20$

11.4 – RSA public key cryptography

RSA key generation – example

$p = 3; q = 11; n = 33; \theta(n) = 20$

- Select a small odd integer e that is relatively prime to $\theta(n)$
  - $e = 3$
- Compute d as the multiplicative inverse of $e \mod \theta(n)$
  - $d = 7$
  - Test: $3 \cdot 7 \mod 20 = 21 \mod 20 = 1$

11.4 – RSA public key cryptography

RSA key generation – example

$p = 3; q = 11; n = 33; \theta(n) = 20; e = 3; d = 7$

- Publish $P = (e, n)$ as the public key
  - Key pair: $(3, 33)$
- Keep $S = (d, n)$ as the RSA secret key
  - Secret key pair: $(7, 33)$

11.4 – RSA public key cryptography

RSA key generation – example

$p = 3; q = 11; n = 33; \theta(n) = 20; e = 3; d = 7$

$P = (3, 33)$

$S = (7, 33)$

- Encrypt the message '3':
  - $C = M^e \mod n$
  - $C = 3^3 \mod 33 = 27 \mod 33 = 27$

11.4 – RSA public key cryptography

RSA key generation – example

$p = 3; q = 11; n = 33; \theta(n) = 20; e = 3; d = 7$

$P = (3, 33)$

$S = (7, 33)$

- Decrypt the message $C = 27$:
  - $M = C^d \mod n$
  -

$$\begin{aligned} M &= 27^7 \mod 33 \\ &= 10460353203 \mod 33 \\ &= 3 \end{aligned}$$

11.5

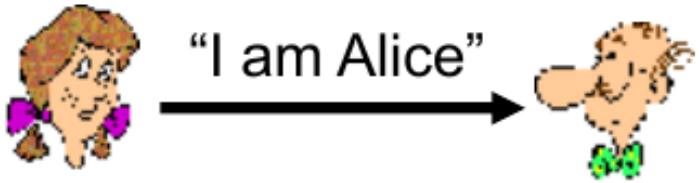
Q11.5 Which tricks might attackers use to overcome authentication protection? Please explain using the AP protocols presented in the lecture.

11.5

Authentication

Goal: Bob wants Alice to "prove" her identity to him

Protocol ap1.0: Alice says "I am Alice"



Failure scenario??

11.5

Authentication

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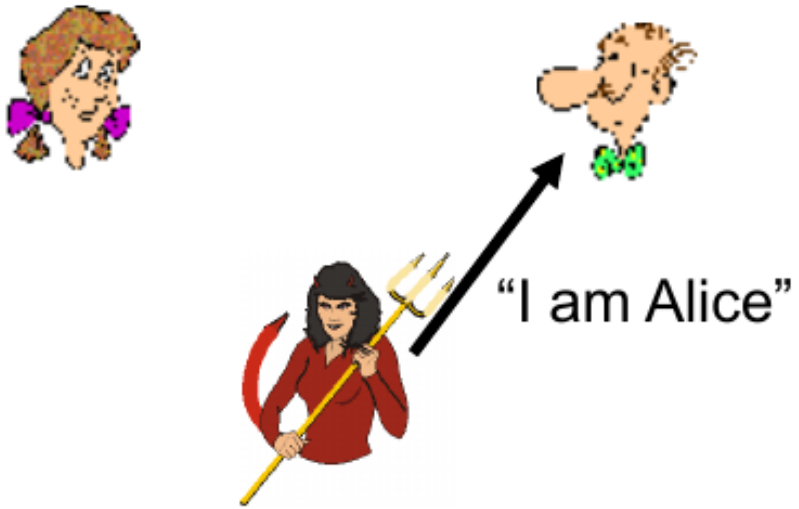
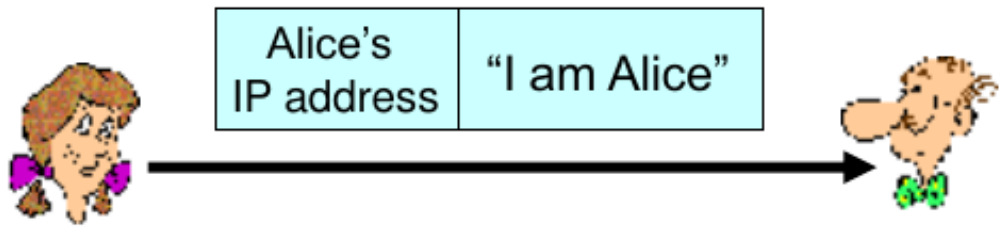


in a network,
Bob can not "see" Alice,
so Trudy simply
declares
herself to be Alice

11.5

Authentication: another try

Protocol ap2.0: Alice says “I am Alice” in an IP packet containing her source IP address

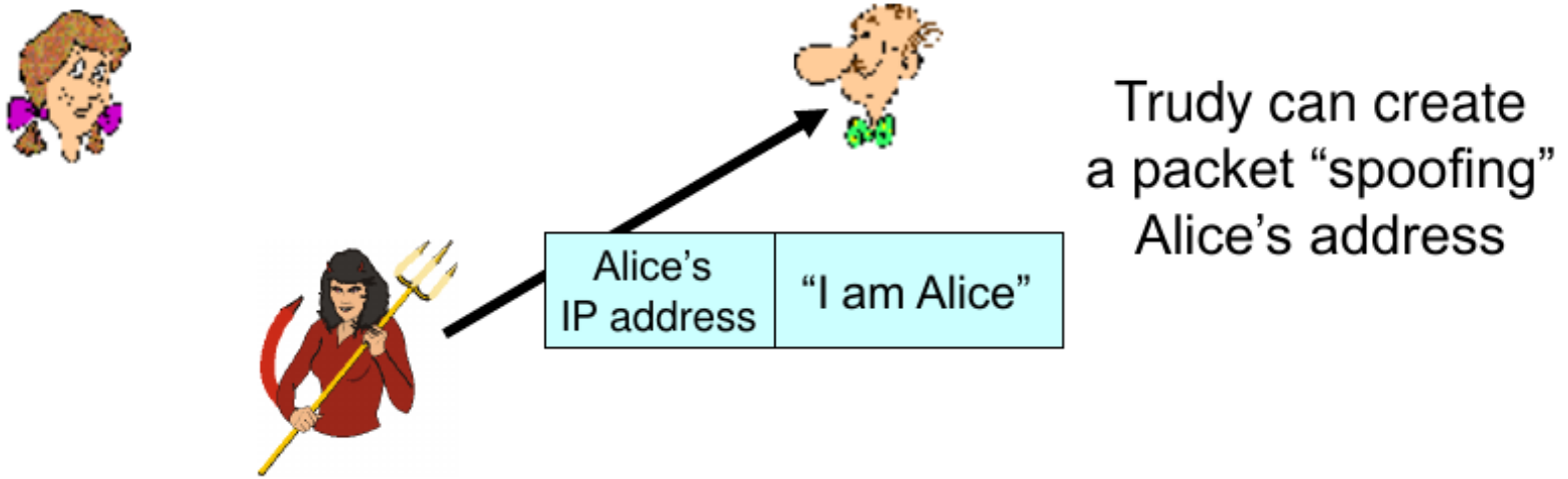


Failure scenario??

11.5

Authentication: another try

Protocol ap2.0: Alice says "I am Alice" in an IP packet containing her source IP address

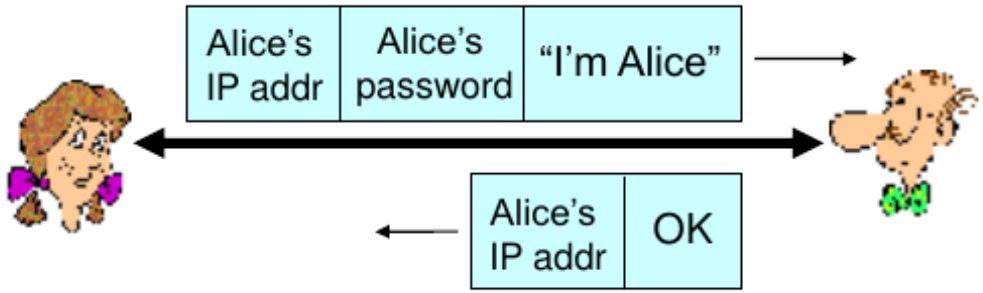


Trudy can create a packet "spoofing" Alice's address

11.5

Authentication: another try

Protocol ap3.0: Alice says "I am Alice" and sends her secret password to "prove" it.

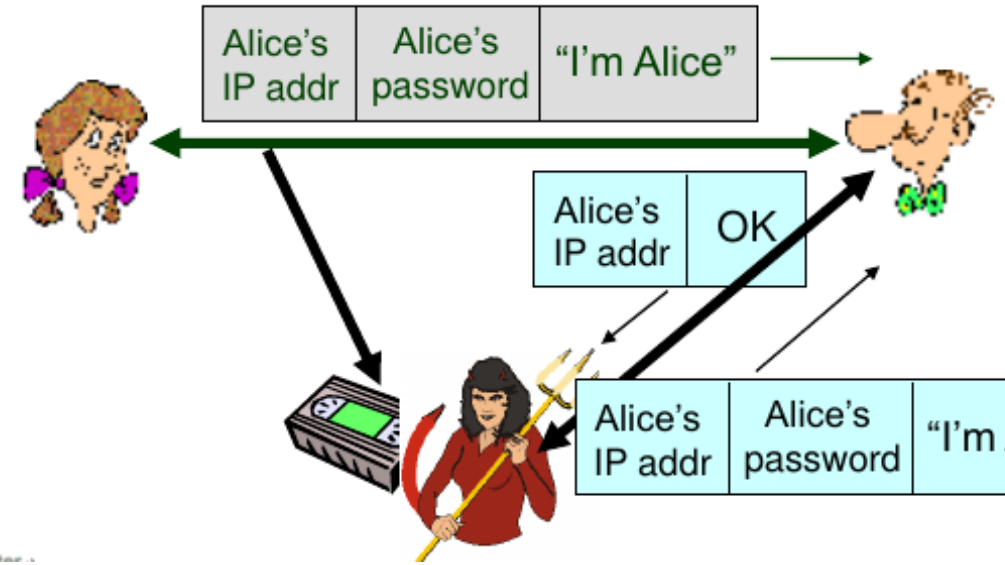


Failure scenario??

11.5

Authentication: another try

Protocol ap3.0: Alice says "I am Alice" and sends her secret password to "prove" it.

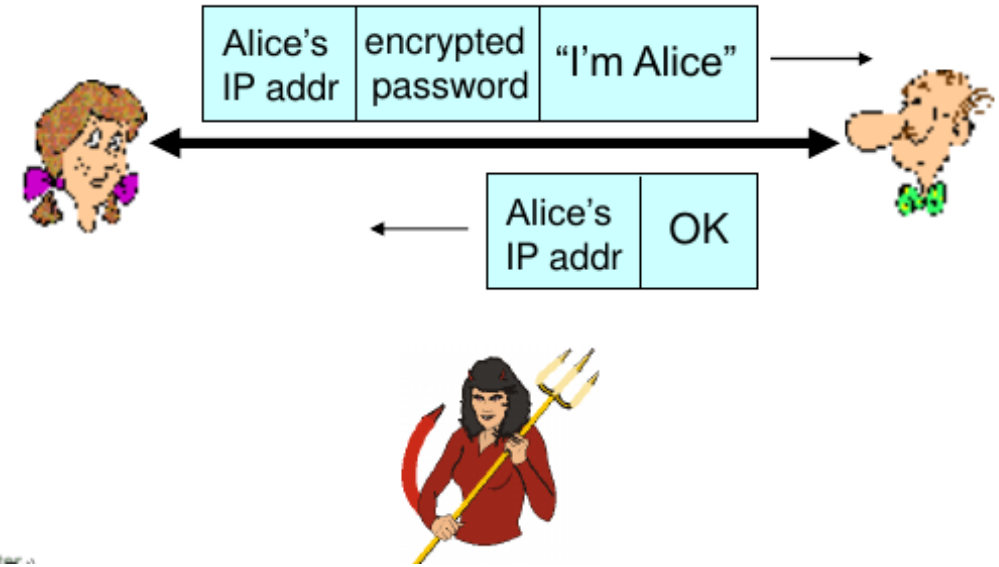


playback attack: Trudy records Alice's packet and later plays it back to Bob

11.5

Authentication: yet another try

Protocol ap3.1: Alice says "I am Alice" and sends her *encrypted* secret password to "prove" it.



Failure scenario??

11.5

Authentication: another try

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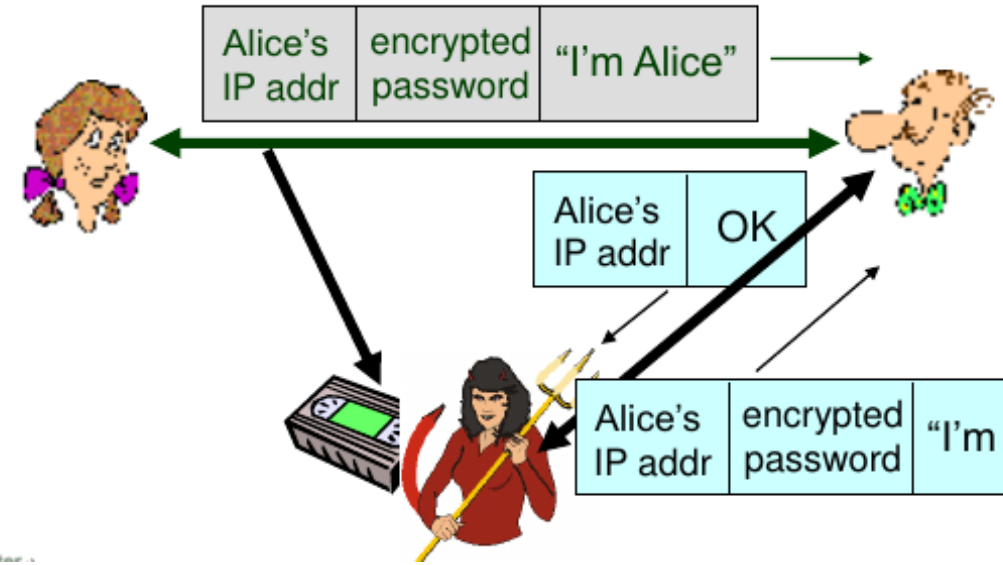


record and playback still works!

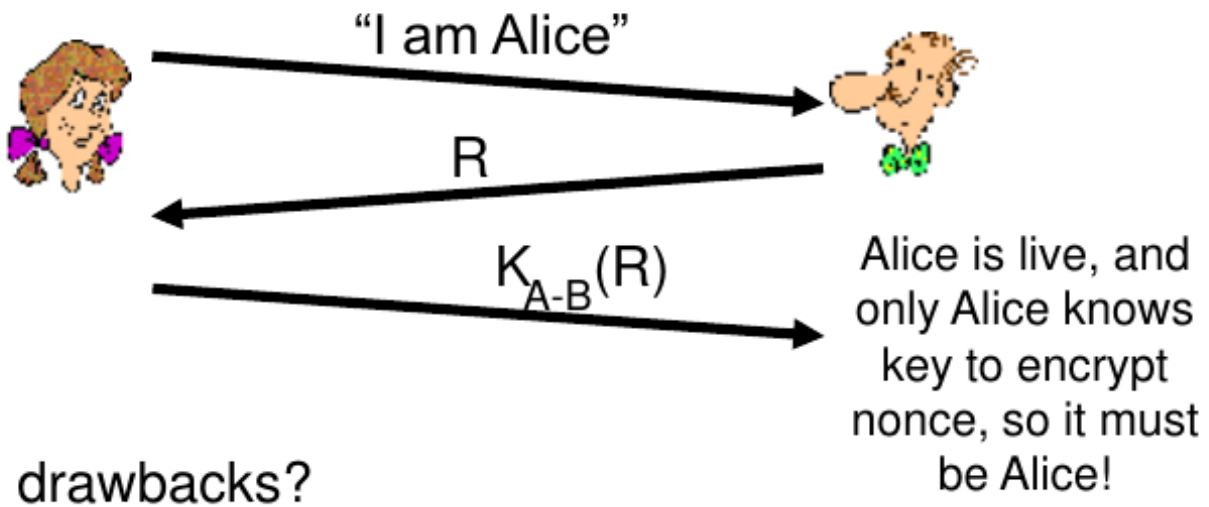
11.5

Authentication: yet another try

Goal: avoid playback attack

Nonce: number (R) used only *once –in-a-lifetime*

ap4.0: to prove Alice "live", Bob sends Alice a nonce, R. Alice must return R, encrypted with shared secret key



Failures, drawbacks?

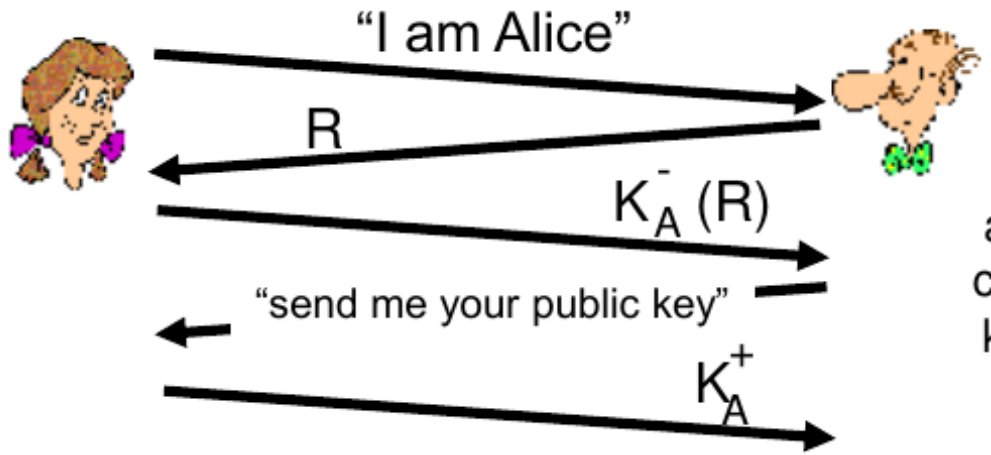
11.5

Authentication: ap5.0

ap4.0 requires shared symmetric key

- can we authenticate using public key techniques?

ap5.0: use nonce, public key cryptography

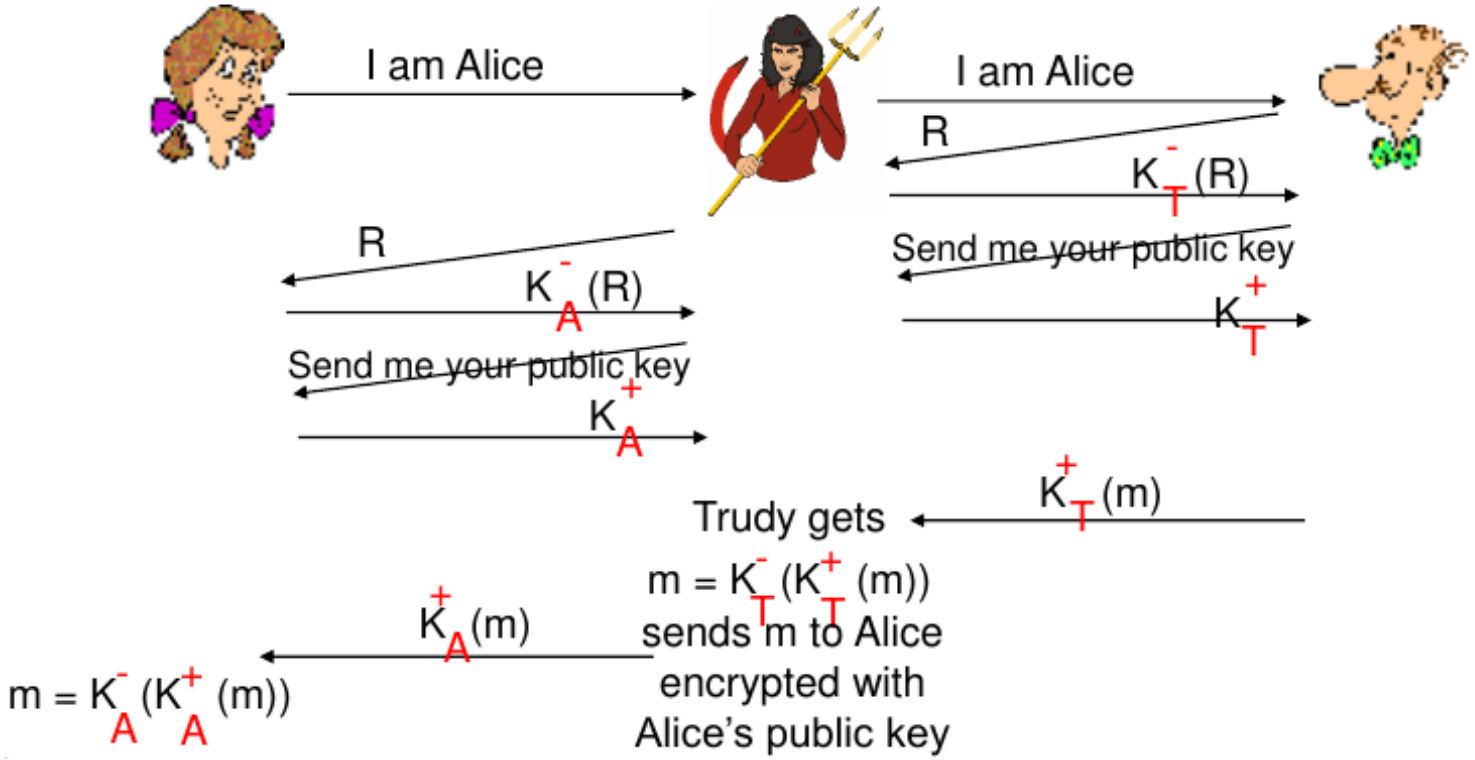


Bob computes $K_A^+(K_A^-(R)) = R$ and knows only Alice could have the private key, that encrypted R such that $K_A^+(K_A^-(R)) = R$

11.5

ap5.0: security hole

Man (woman) in the middle attack: Trudy poses as Alice (to Bob) and as Bob (to Alice)



11.5

ap5.0: security hole

Man (woman) in the middle attack: Trudy poses as Alice (to Bob) and as Bob (to Alice)

Difficult to detect:

- Bob receives everything that Alice sends, and vice versa. (e.g., so Bob, Alice can meet one week later and recall conversation)
- problem is that Trudy receives all messages as well!

11.5

AP 1.0/2.0	Just faking IDs ("I am Alice") or spoofing an IP address
AP 3.0/3.1	Often record and playback attacks
AP 5.0	Man-in-the-middle attack

11.6

Q11.6 What is the purpose of a nonce in an end-point authentication protocol?

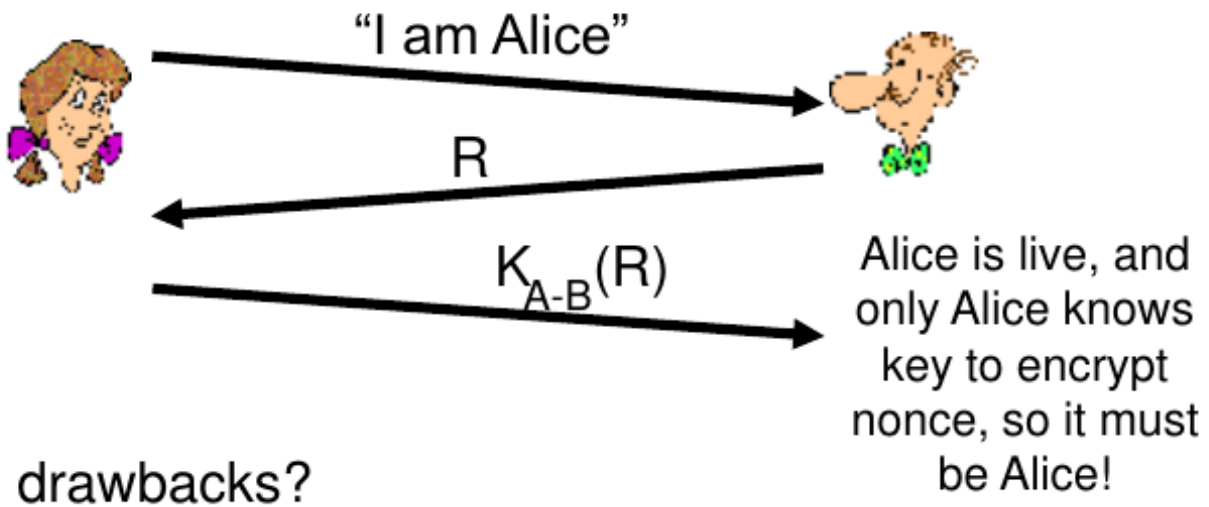
11.6

Authentication: yet another try

Goal: avoid playback attack

Nonce: number (R) used only *once –in-a-lifetime*

ap4.0: to prove Alice "live", Bob sends Alice a nonce, R. Alice must return R, encrypted with shared secret key



Failures, drawbacks?

11.6

- Brings freshness
- Prevents replay attacks