mobile business

Exercise 2 - Cryptography

Mobile Business II (SS 2024)

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Exercise 1: Caesar Cipher

- Decrypt the following word, encrypted with the Caesar cipher:

JYFWAVNYHWOF

Caesar Cipher

A	B	C	D	E	F	G	H	I	J	K	L	M
0	1	2	3	4	5	6	7	8	9	10	11	12

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
13	14	15	16	17	18	19	20	21	22	23	24	25

- We assign a number for every character.
- This enables us to calculate with letters as if they were numbers.

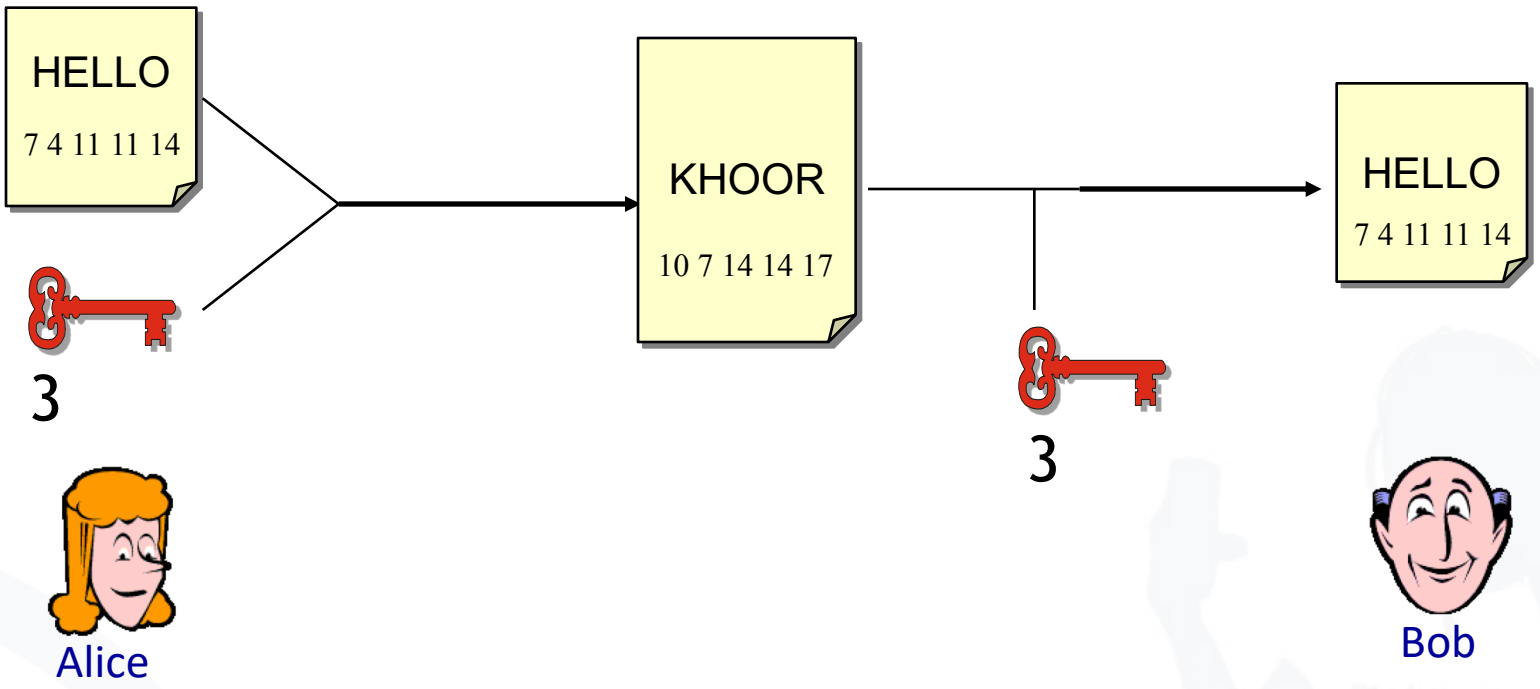
Caesar Cipher

- Encryption:
  1. Assign numbers to characters (A=0, B=1,…)
  2. Choose key k (0,…, 25)
  3. Compute (num(char) + k) mod 26, where char is the character to encrypt and num(x) the number assigned to character x (e.g. num(A) = 0)

Caesar Cipher

- How to decrypt?
- Decryption:
  1. Choose key k (0,…, 25)
  2. Assign numbers to characters (A=0, B=1,…)
  3. Compute (num(char) - k) mod 26, where char is the character to encrypt and num(x) the number assigned to character x
  4. Repeat steps for all characters
  5. Stop, if decrypted word makes sense

Caesar Cipher: Example



Caesar Cipher

- Let‘s try:

Key	J	Y	F	W	A	V	N	Y	H	W	O	F
1	I	X	E	V	Z	U	M	X	G	V	N	E
2	H	W	D	U	Y	T	L	W	F	U	M	D
3	G	V	C	T	X	S	K	V	E	T	L	C
4	F	U	B	S	W	R	J	U	D	S	K	B
5	E	T	A	R	V	Q	I	T	C	R	J	A
6	D	S	Z	Q	U	P	H	S	B	Q	I	Z
7	**C**	**R**	**Y**	**P**	**T**	**O**	**G**	**R**	**A**	**P**	**H**	**Y**

Assessment of Caesar Cipher

- Very simple form of encryption.
- The encryption and decryption algorithms are very easy and fast to compute.
- It uses a very limited key space (n=26)
- Therefore, the encryption is very easy and fast to compromise.

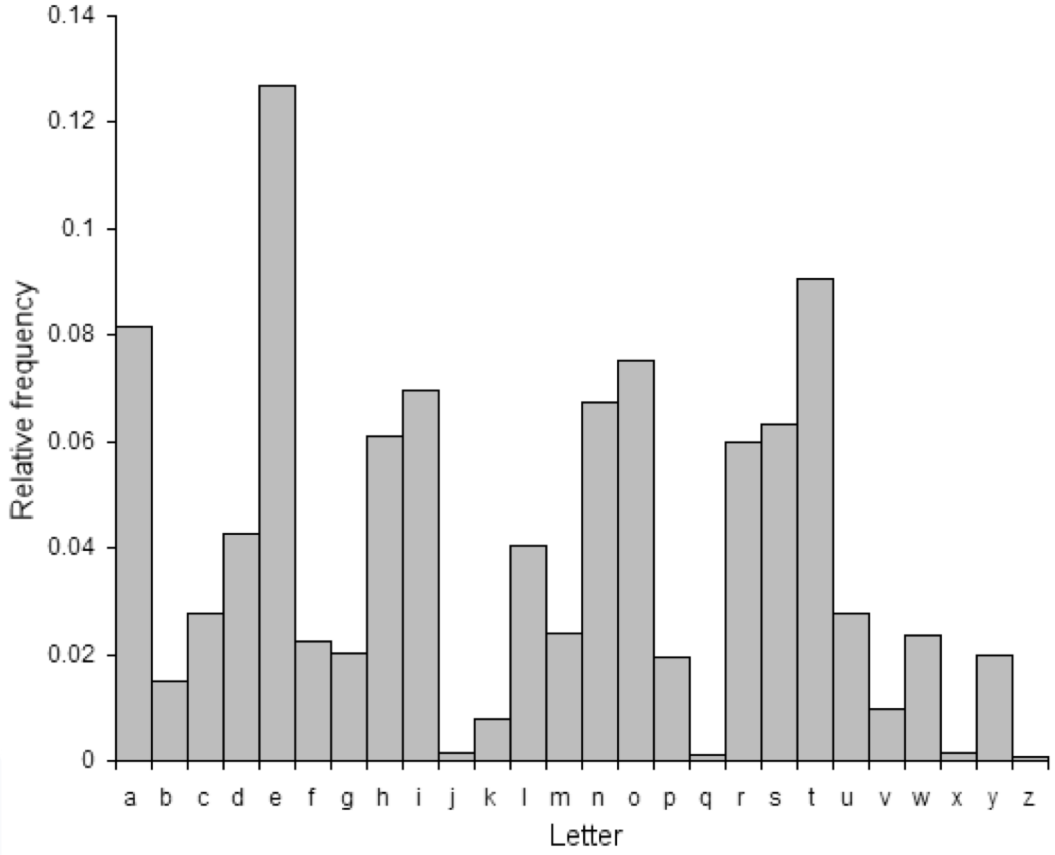
Some Cool Stuff!
Can a Tool Decrypt This?

pelcgbtencul cevbe gb gur zbqrea ntr jnf rssrpgviryl flabalzbhf jvgu rapelcgvba, gur pbairefvba bs vasbezngvba sebz n ernqnoyr fgngr gb nccnerag abafrafr. gur bevtvangbe bs na rapelcgrq zrffntr funerq gur qrpbqvat grpuavdhr arrqrq gb erpbire gur bevtvany vasbezngvba bayl jvgu vagraqrq erpvcvragf, gurerol cerpyhqvat hajnagrq crefbaf gb qb gur fnzr. fvapr jbeyq jne v naq gur nqirag bs gur pbzchgre, gur zrgubqf hfrq gb pneel bhg pelcgbybtl unir orpbzr vapernfvatyl pbzcyrk naq vgf nccyvpngvba zber jvqrfcernq.

zbqrea pelcgbtencul vf urnivyl onfrq ba zngurzngvpny gurbel naq pbzchgre fpvrapr cenpgvpr; pelcgbtencuvp nytbevguzf ner qrfvtarq nebhaq pbzchgngvbany uneqarff nffhzcgvbaf, znxvat fhpu nytbevguzf uneq gb oernx va cenpgvpr ol nal nqirefnel. vg vf gurbergvpnyyl cbffvoyr gb oernx fhpu n flfgrz ohg vg vf vasrnfvoyr gb qb fb ol nal xabja cenpgvpny zrnaf. gurfr fpurzrf ner gurersber grezrq pbzchgngvbanyyl frpher; gurbergvpny nqinaprf, r.t., vzcebirzragf va vagrtre snpgbevmngvba nytbevguzf, naq snfgre pbzchgvat grpuabybtl erdhver gurfr fbyhgvbaf gb or pbagvahnyyl nqncgrq. gurer rkvfg vasbezngvba-gurbergvpnyyl frpher fpurzrf gung cebinoyl pnaabg or oebxra rira jvgu hayvzvgrq pbzchgvat cbjre—na rknzcyr vf gur bar-gvzr cnq—ohg gurfr fpurzrf ner zber qvssvphyg gb vzcyrzrag guna gur orfg gurbergvpnyyl oernxnoyr ohg pbzchgngvbanyyl frpher zrpunavfzf.

http://nayuki.eigenstate.org/page/automatic-caesar-cipher-breaker-javascript

Cryptanalysis



English letters frequency

Exercise 2: Cryptosystems

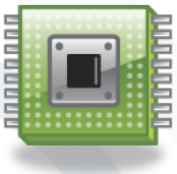
1. Imagine the following situation: Alice wants to share a secret with Bob and therefore sends an encrypted message to Bob.

   1.1 Sketch the process by using symmetric encryption/decryption.
   a. Complete the illustration by highlighting each step and adding all missing elements – such as keys, involved 3rd parties,…

Exercise 2: Cryptosystems – Symmetric Encryption

Alice

Bob



Key generator

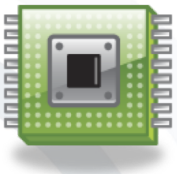
Area of attack

Area of Trust

Exercise 2: Cryptosystems – Symmetric Encryption

Alice

1. Generate key ***k***



Key generator

Area of attack

Area of Trust

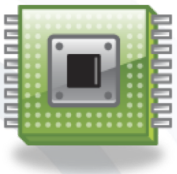
Bob

Exercise 2: Cryptosystems – Symmetric Encryption

Alice

Bob

1. Generate key *k*

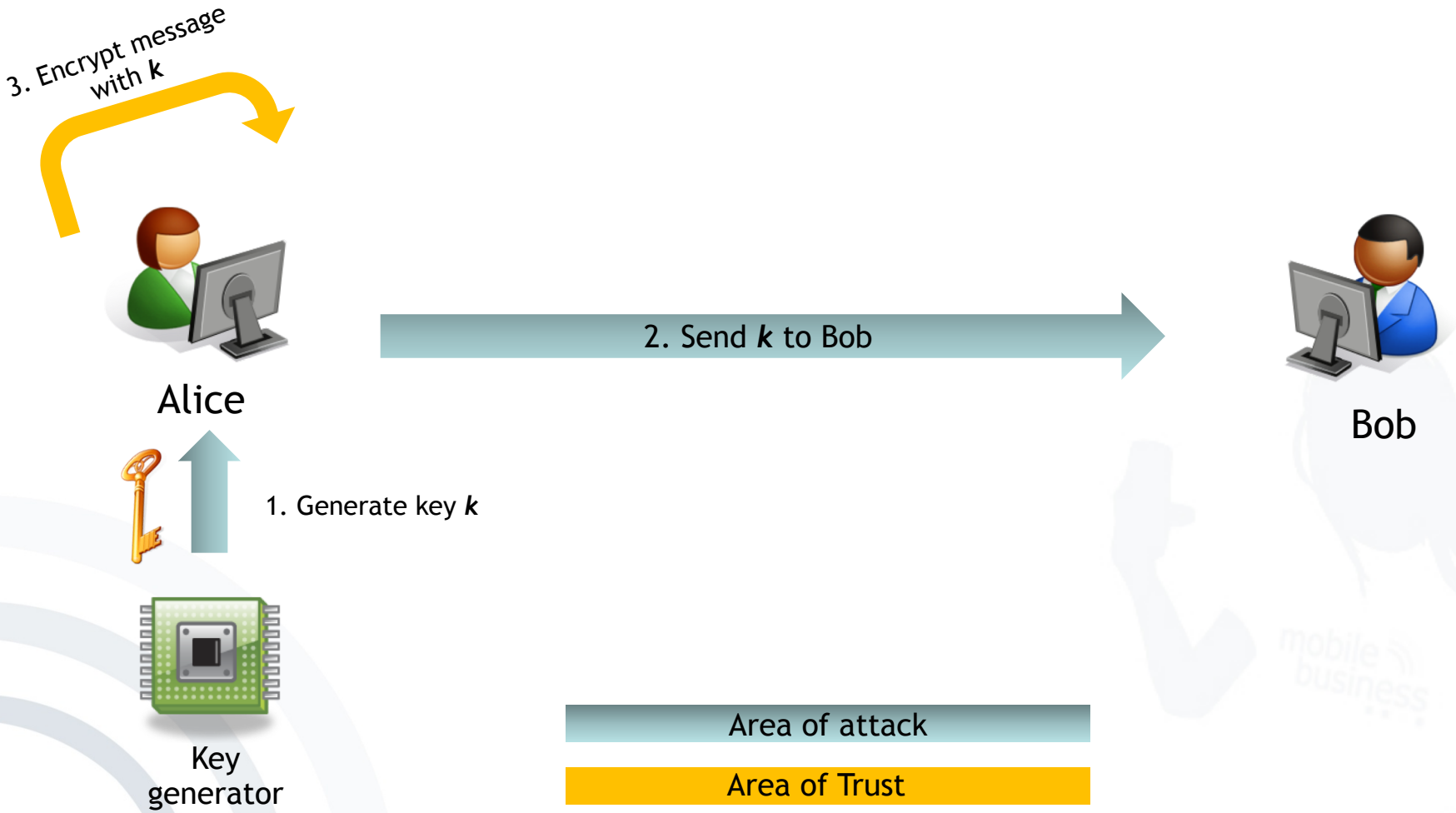


Key generator

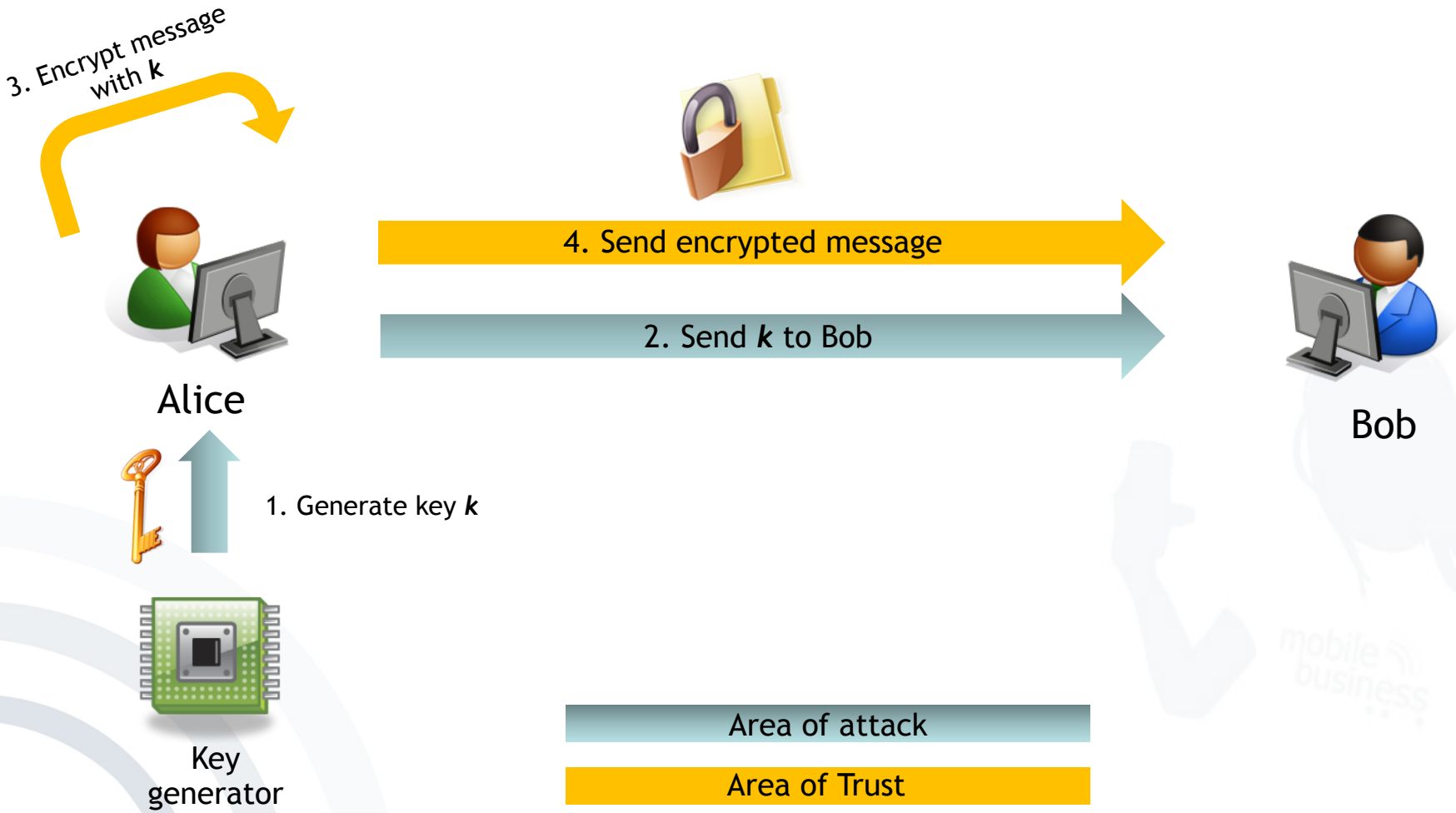
Area of attack

Area of Trust

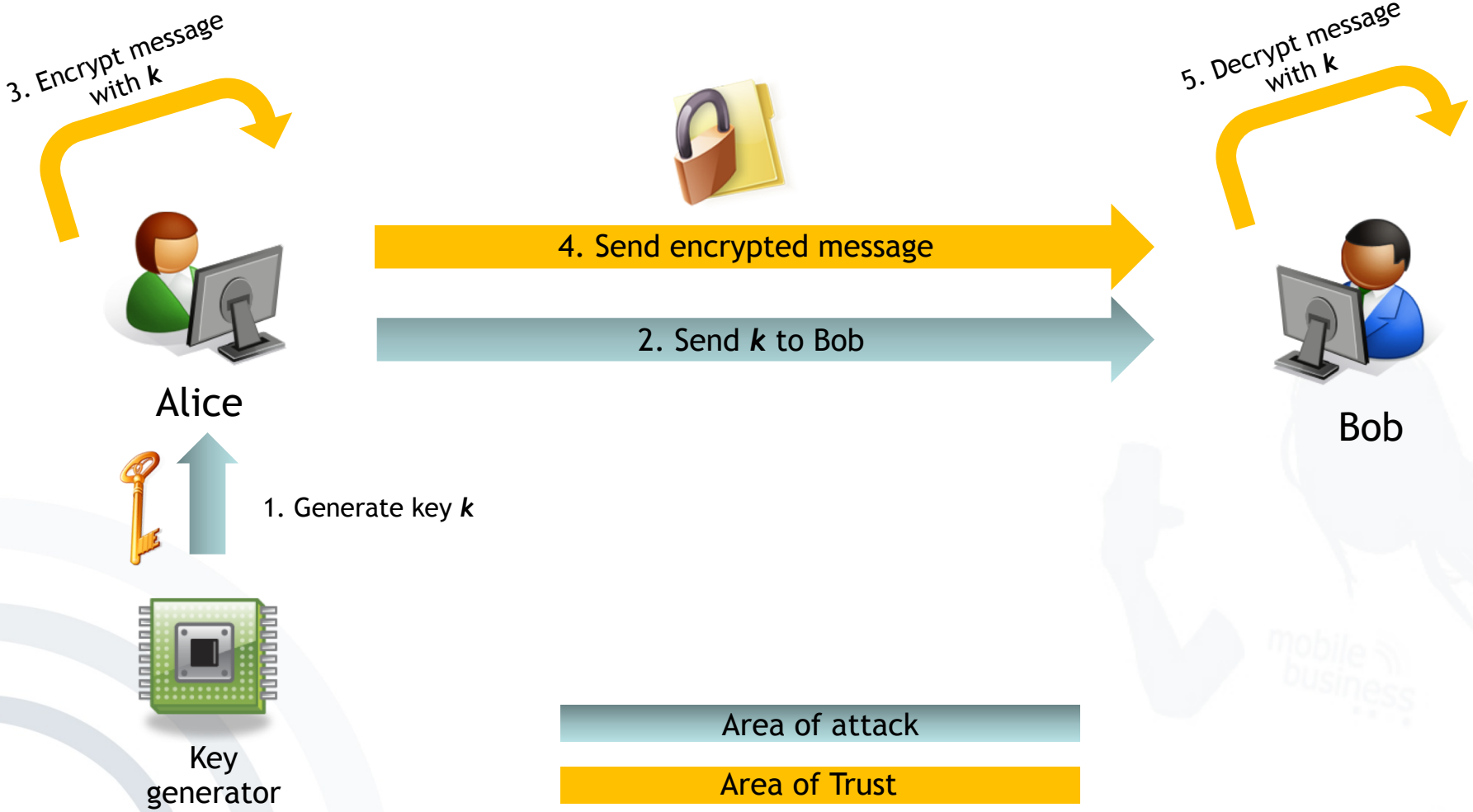
Exercise 2: Cryptosystems – Symmetric Encryption



Exercise 2: Cryptosystems – Symmetric Encryption



Exercise 2: Cryptosystems – Symmetric Encryption



Exercise 2: Cryptosystems

b. What are pre-conditions for this approach?

Exercise 2: Cryptosystems

b. What are pre-conditions for this approach?

→Generation of shared symmetric key

→Exchange of (secret) shared key

→Need for secure channel

Exercise 2: Cryptosystems

c. What are advantages and disadvantages of symmetric encryption/decryption?

Symmetric Encryption: Advantage

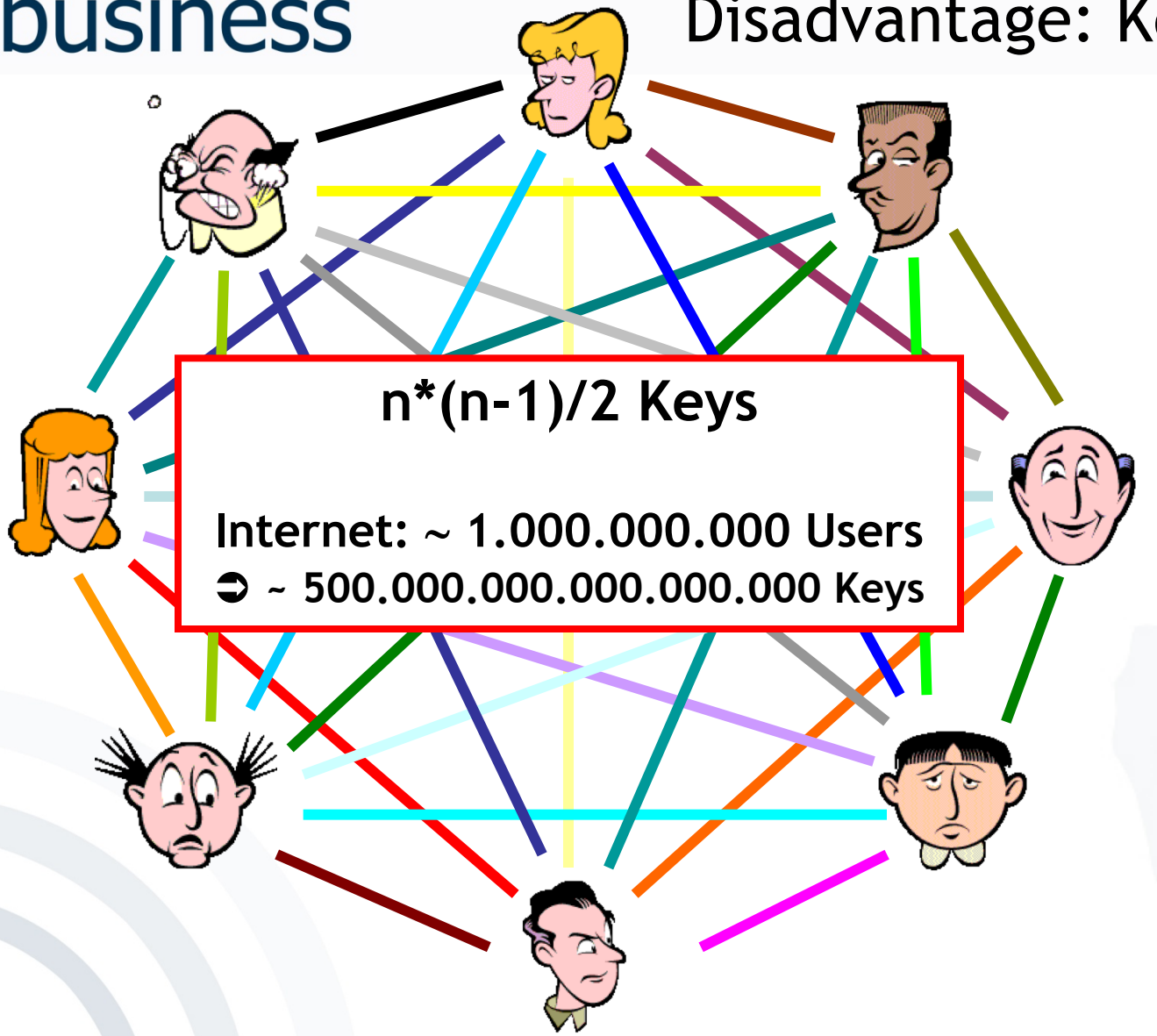
Advantage: Algorithms are very fast

Algorithm	Performance*
RC6	138 ms
AES	173 ms
SERPENT	200 ms
IDEA	288 ms
MARS	394 ms
TWOFISH	697 ms
DES-ede	726 ms

*) Encryption of 1 MB-blocks with an Athlon 1GHz processor

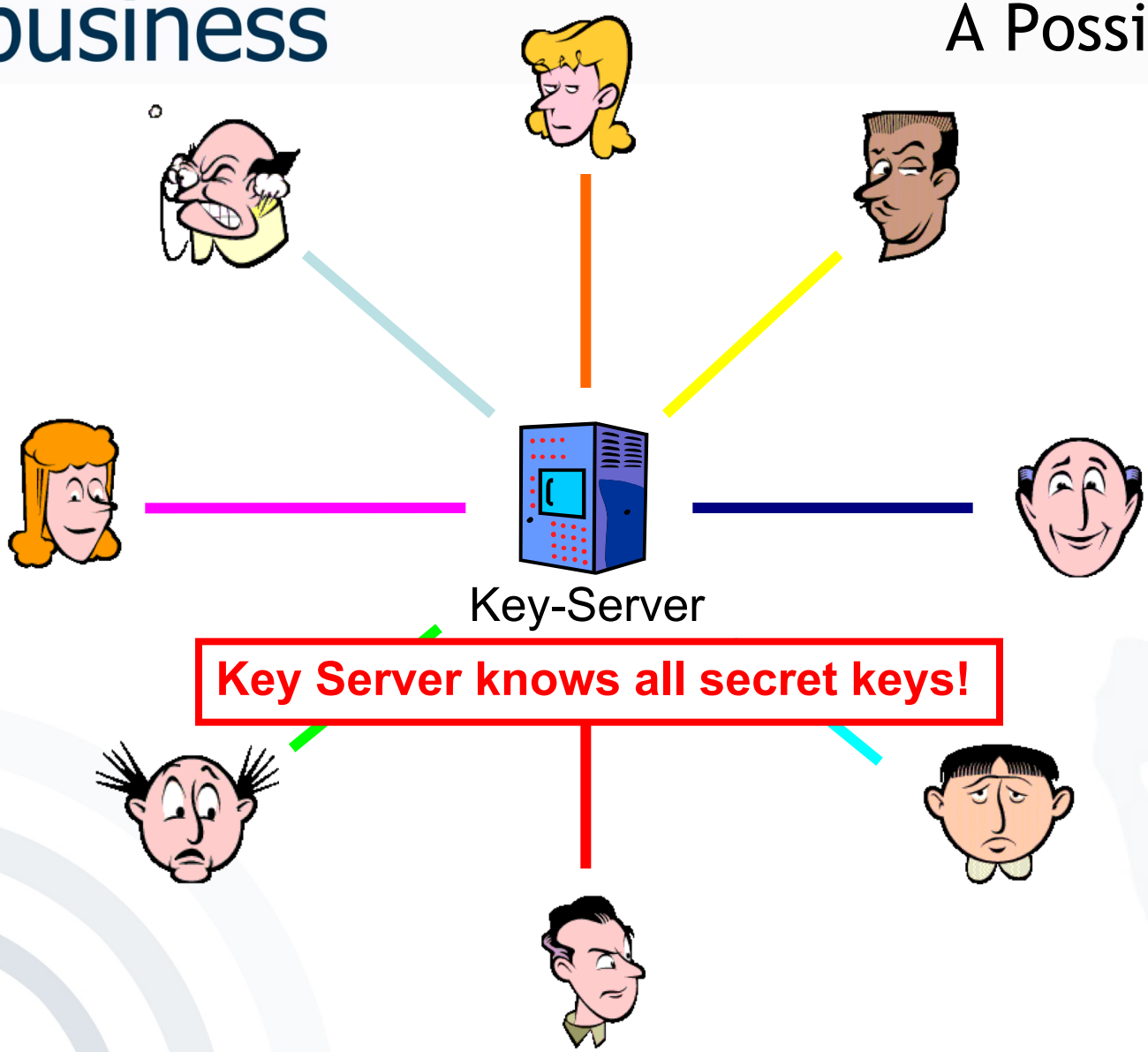
[J. Buchmann 2005: Lecture Public Key Infrastrukturen, FG Theoretische Informatik, TU-Darmstadt]

Symmetric Encryption
Disadvantage: Key Exchange



[adopted from J. Buchmann 2005: Lecture Public Key Infrastrukturen, FG Theoretische Informatik, TU-Darmstadt]

Symmetric Encryption: A Possible Solution



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Exercise 2 – Asymmetric Encryption

1.2 Sketch the process by using asymmetric encryption/decryption.

a. Complete the illustration by highlighting each step and adding all missing elements – such as keys, involved 3rd parties,…

Exercise 2: Cryptosystems – Asymmetric Encryption

Alice

Bob

Public key server

Area of Trust

Exercise 2: Cryptosystems – Asymmetric Encryption

Alice

Public key server

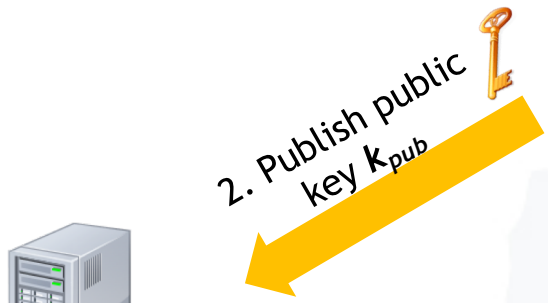
Bob

1. Generate asym. key pair (k_{pub}, k_{priv})

Area of Trust

Exercise 2: Cryptosystems – Asymmetric Encryption

Alice

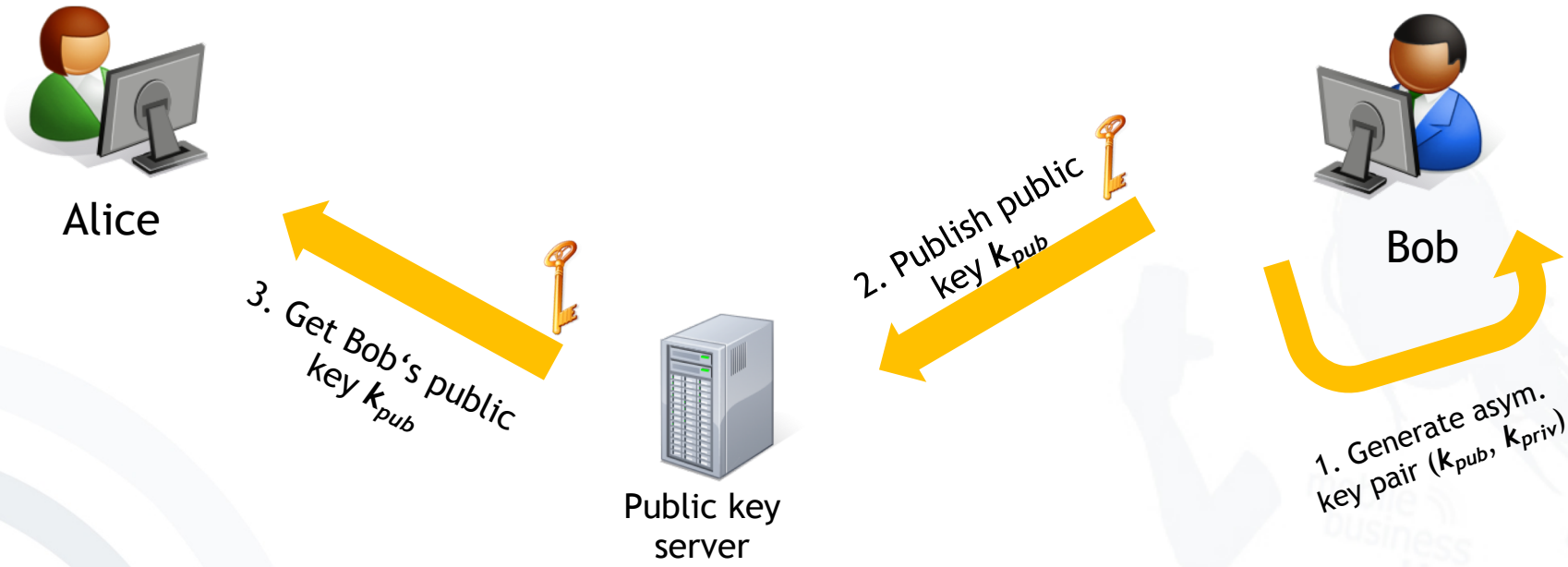


Public key server

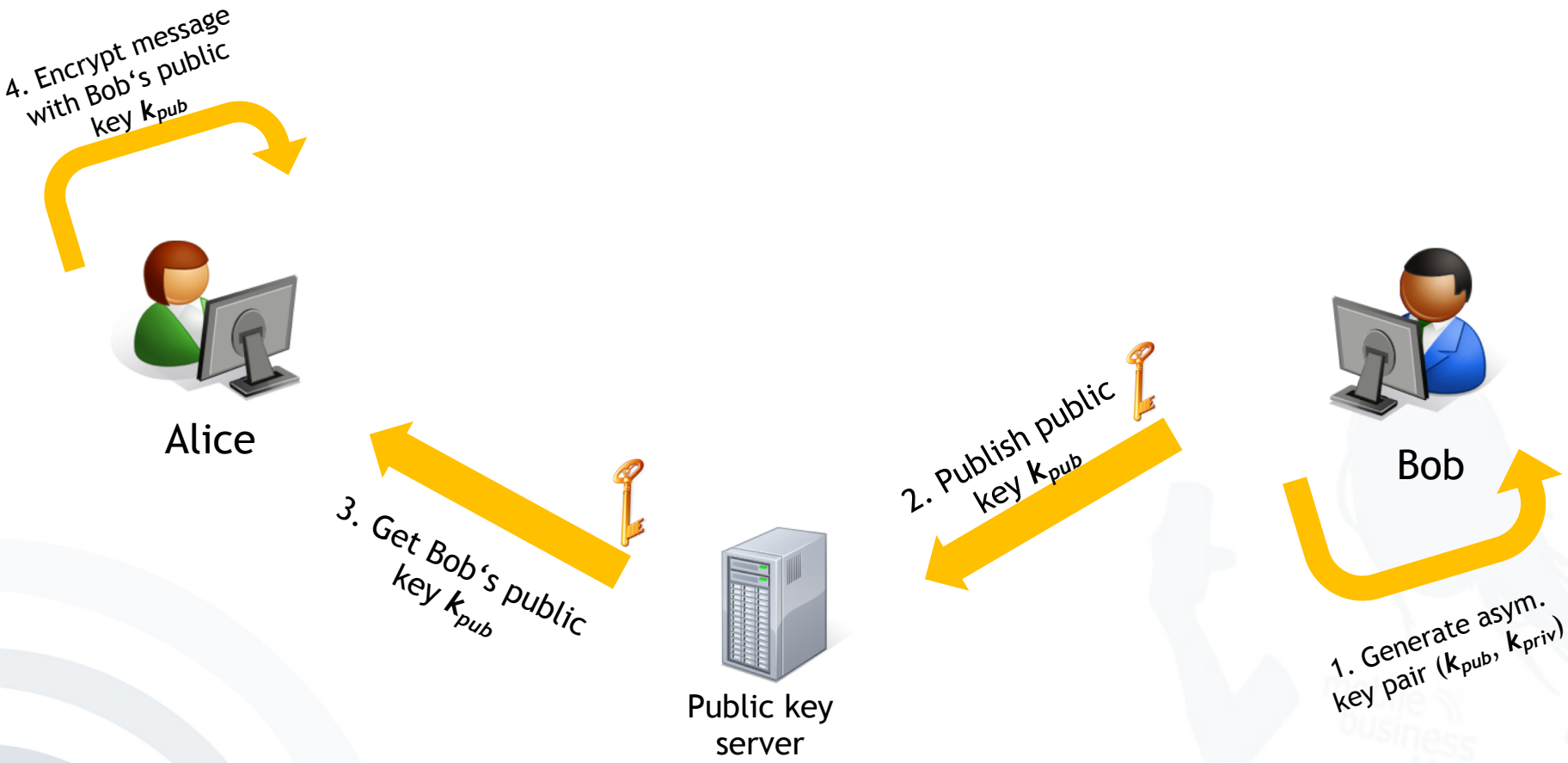
Bob

Area of Trust

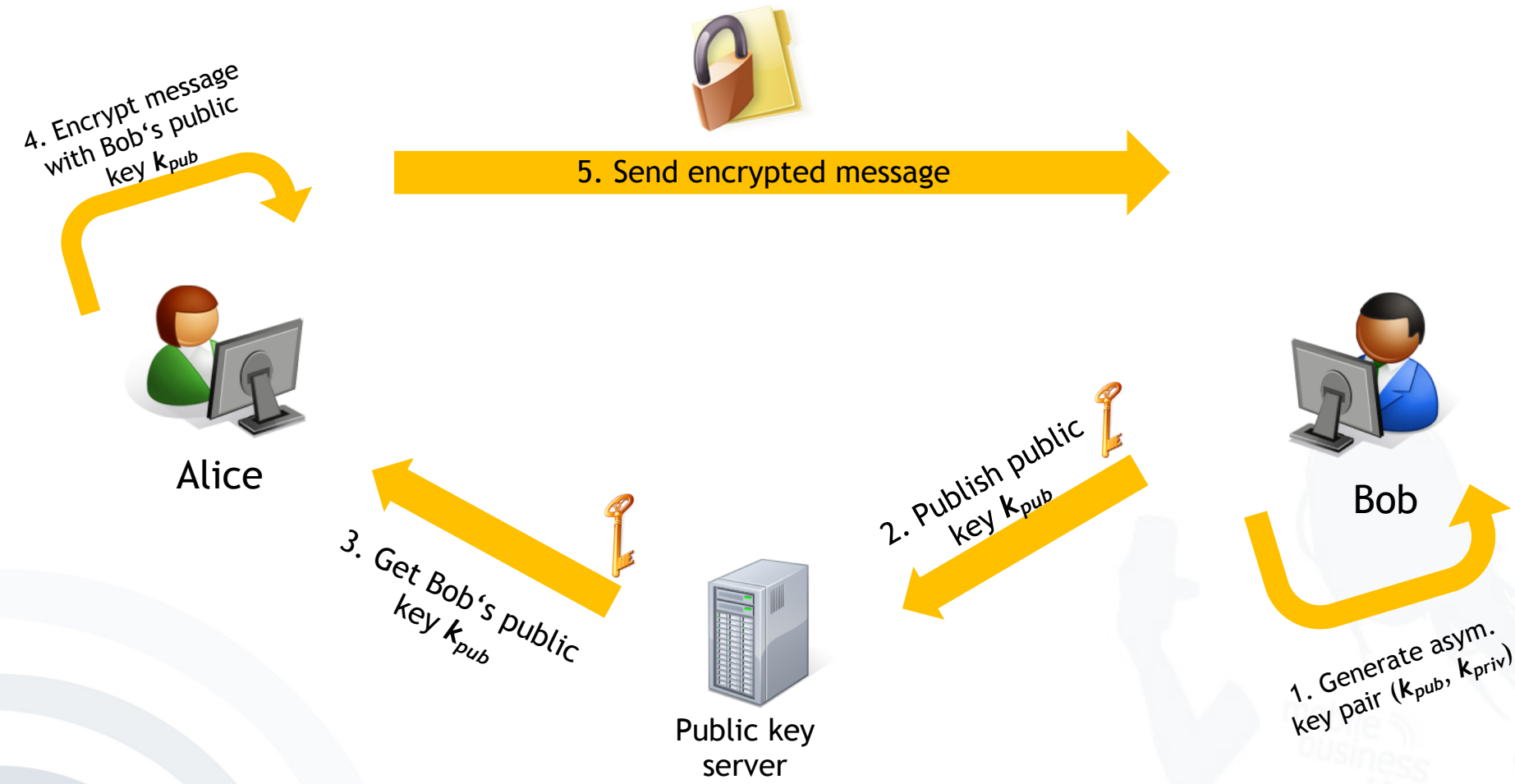
Exercise 2: Cryptosystems – Asymmetric Encryption



Exercise 2: Cryptosystems – Asymmetric Encryption



Exercise 2: Cryptosystems – Asymmetric Encryption



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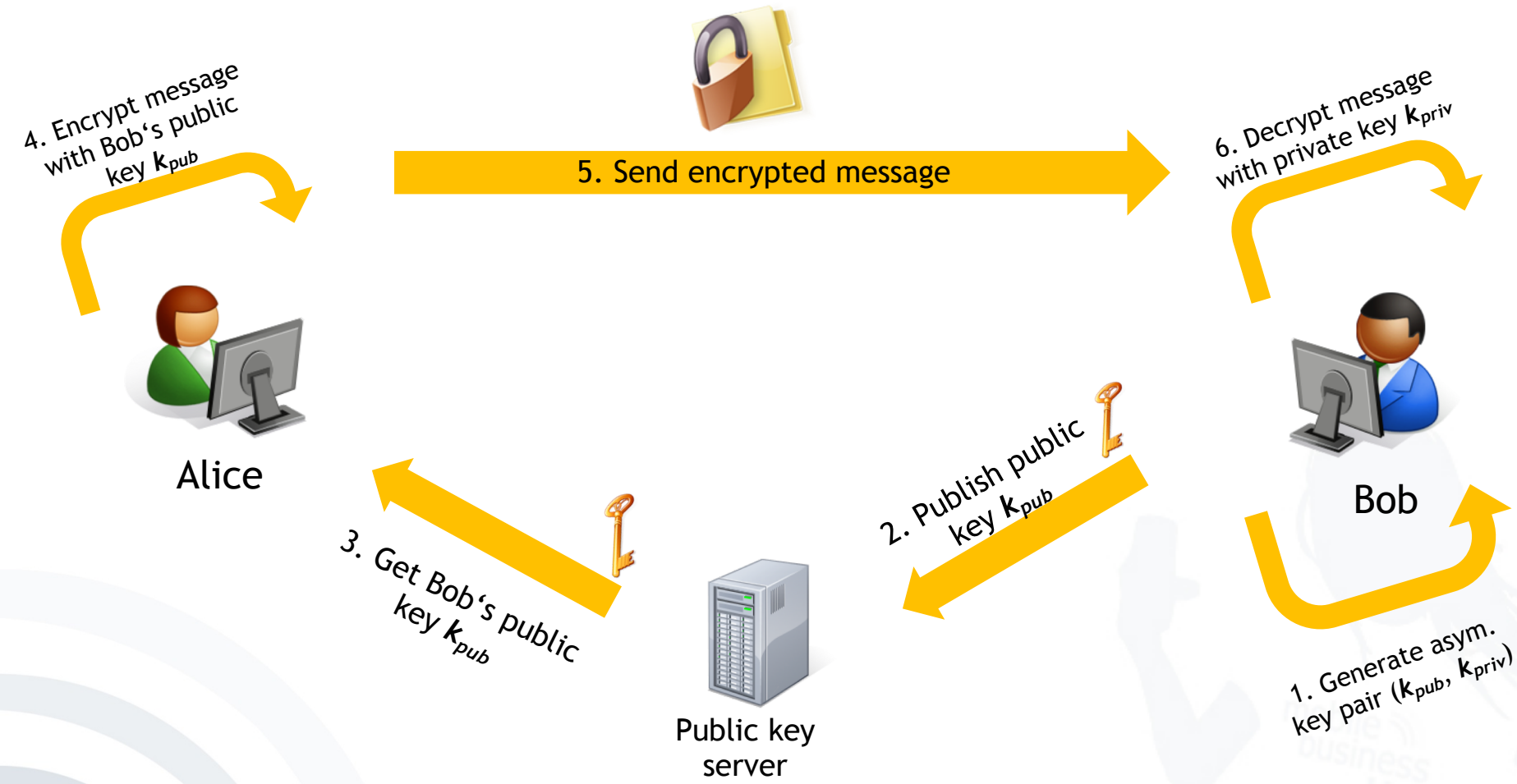


Exercise 2: Cryptosystems

b. What are pre-conditions for this approach?

Exercise 2: Cryptosystems

b. What are pre-conditions for this approach?

→Generation of asymmetric key pairs

→Publishing public part of key

→Private key must be kept secret (!)

Exercise 2: Cryptosystems

c. What are advantages and disadvantages of asymmetric encryption/decryption?

Performance of Public Key Algorithms

Algorithm	Performance*
El Gamal	1826 s
RSA	16 s

Disadvantage: Complex operations with very big numbers

➲ **Algorithms are very slow**

*) Encryption of 1 MB-blocks with an Athlon 1GHz processor

[J. Buchmann 2005: Lecture Public Key Infrastrukturen, FG Theoretische Informatik, TU-Darmstadt]

Exercise 2: Cryptosystems

c. What are advantages and disadvantages of asymmetric encryption/decryption?

Advantages:

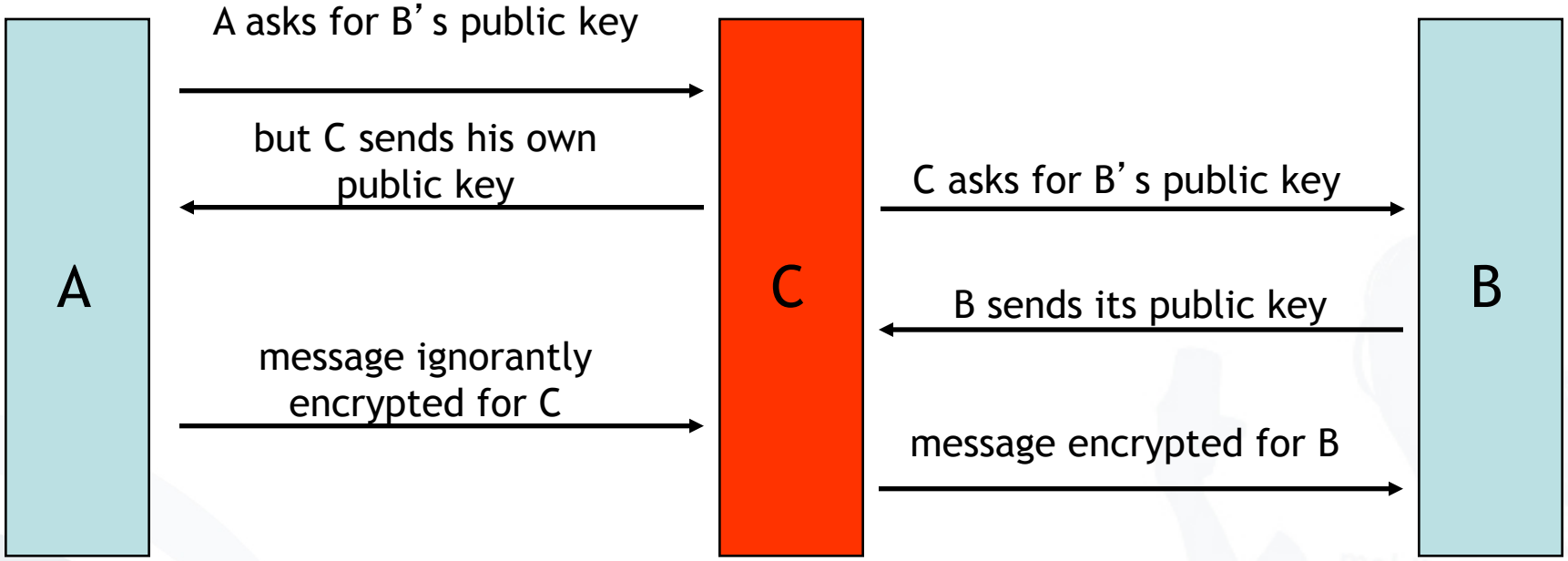
- No secret must be shared
- Only one key per endpoint

Disadvantages:

- Algorithms are very slow
- Man-in-the-middle-attack

Attacks on Public Key Distribution

"Man in the middle attack"



- Keys are certified, that means a third person/institution confirms (with its digital signature) the affiliation of the public key to a person

PGP

1.3 Sketch the process by using PGP.

a. Complete the illustration by highlighting each step and adding all missing elements – such as keys, involved 3rd parties,…

Exercise 2: Cryptosystems – PGP

Alice

Bob

Public key server

Area of attack

Area of Trust

Exercise 2: Cryptosystems – PGP

Alice

Bob

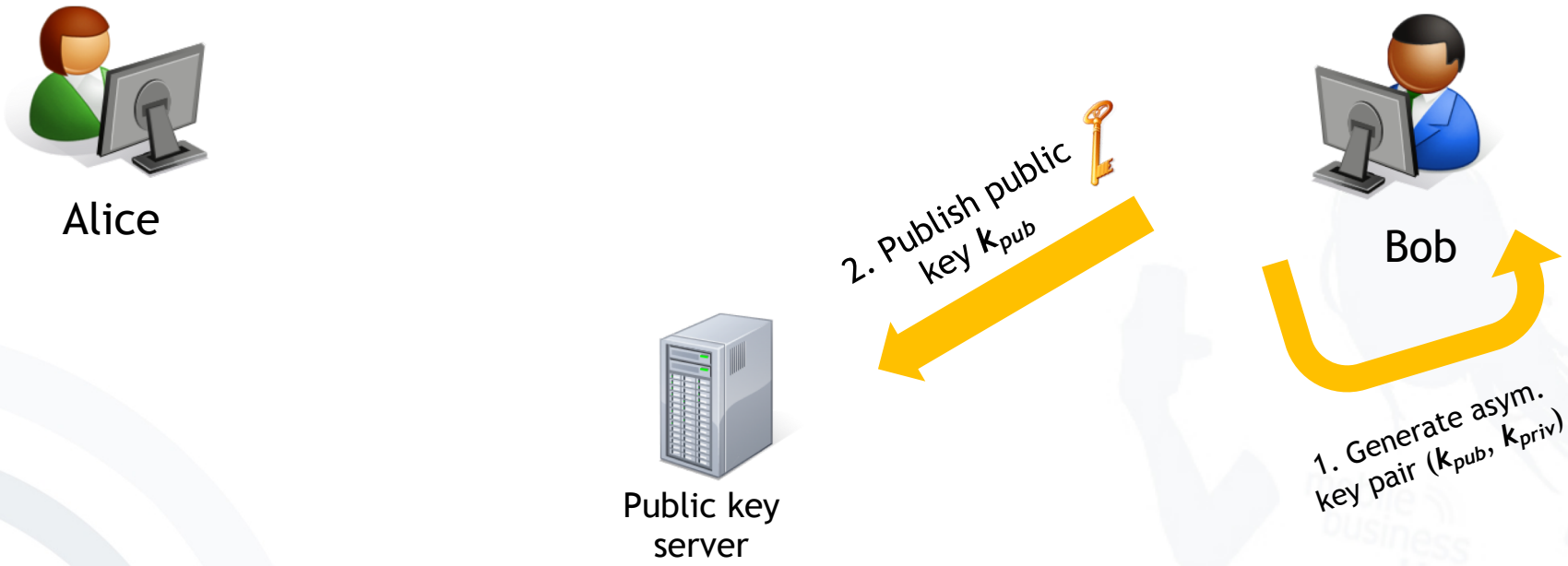
1. Generate asym. key pair (k_{pub}, k_{priv})

Public key server

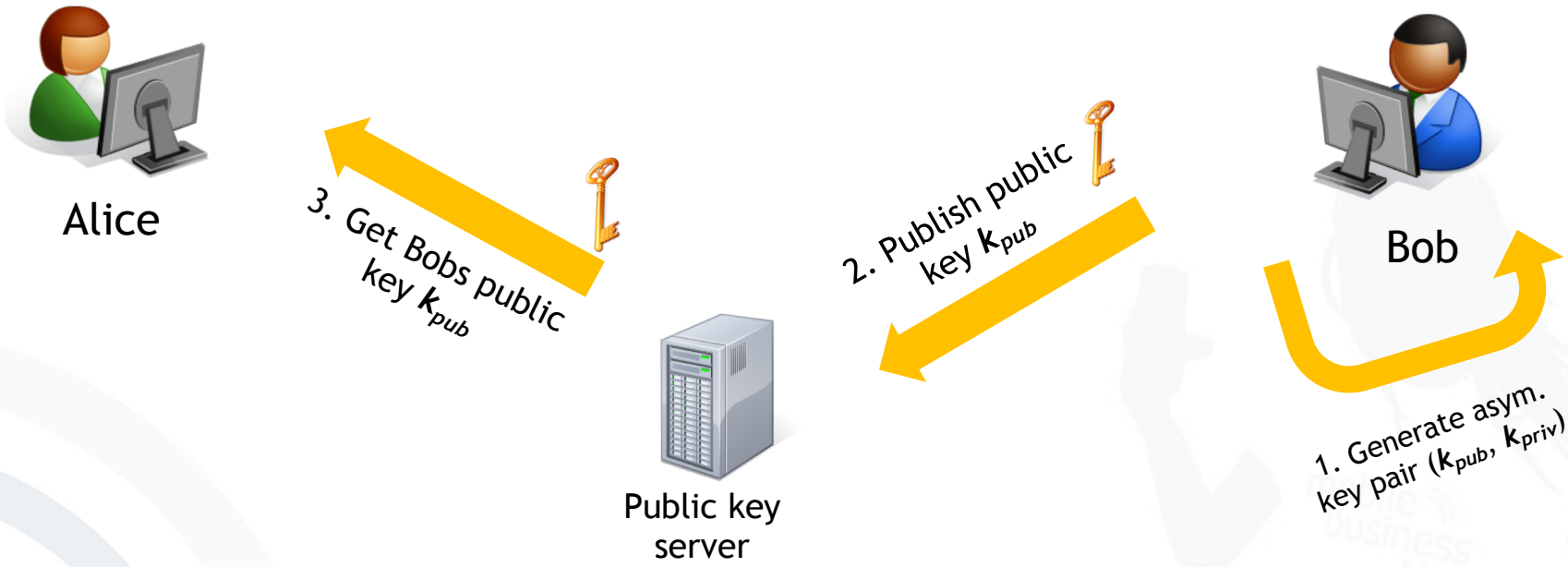
Area of attack

Area of Trust

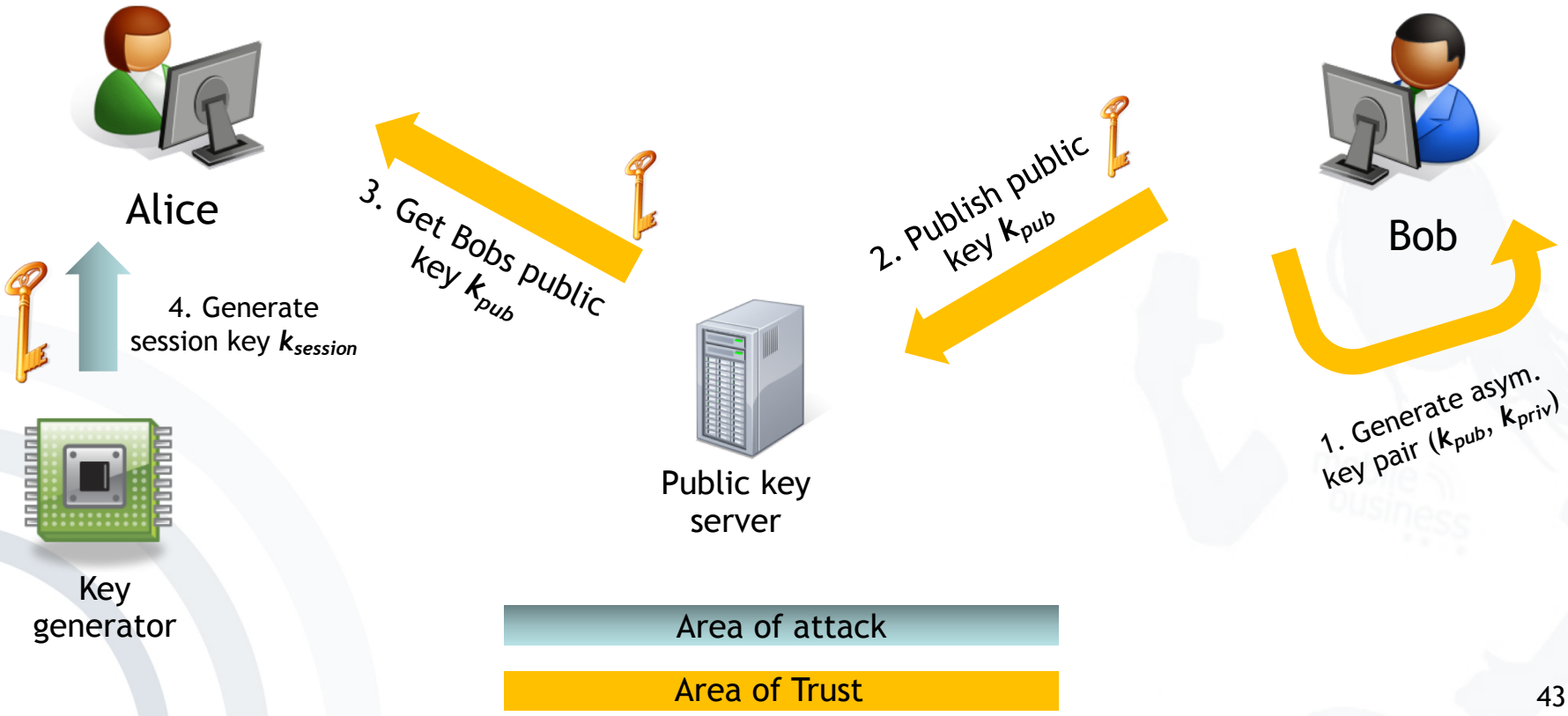
Exercise 2: Cryptosystems – PGP



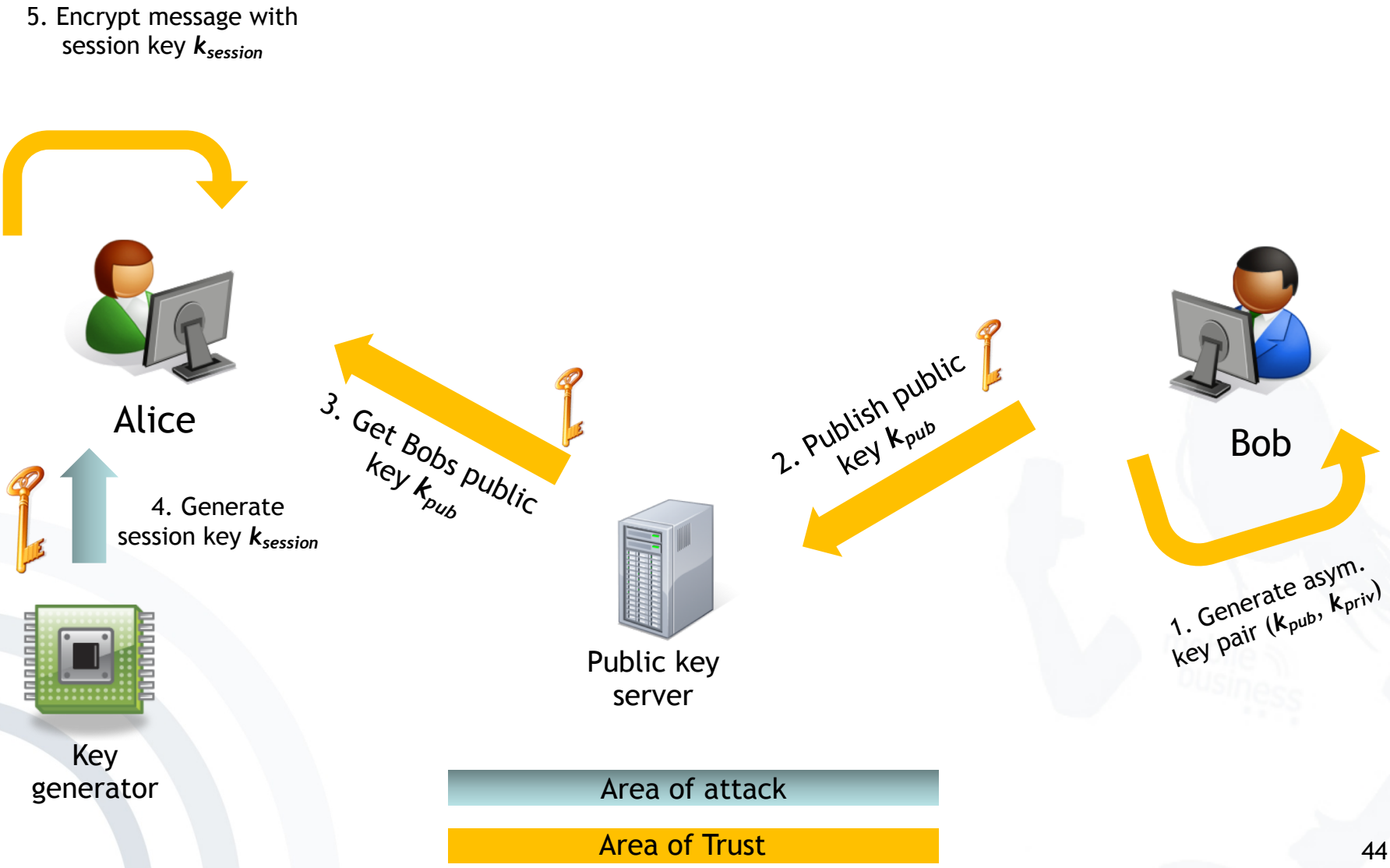
Exercise 2: Cryptosystems – PGP



Exercise 2: Cryptosystems – PGP



Exercise 2: Cryptosystems – PGP



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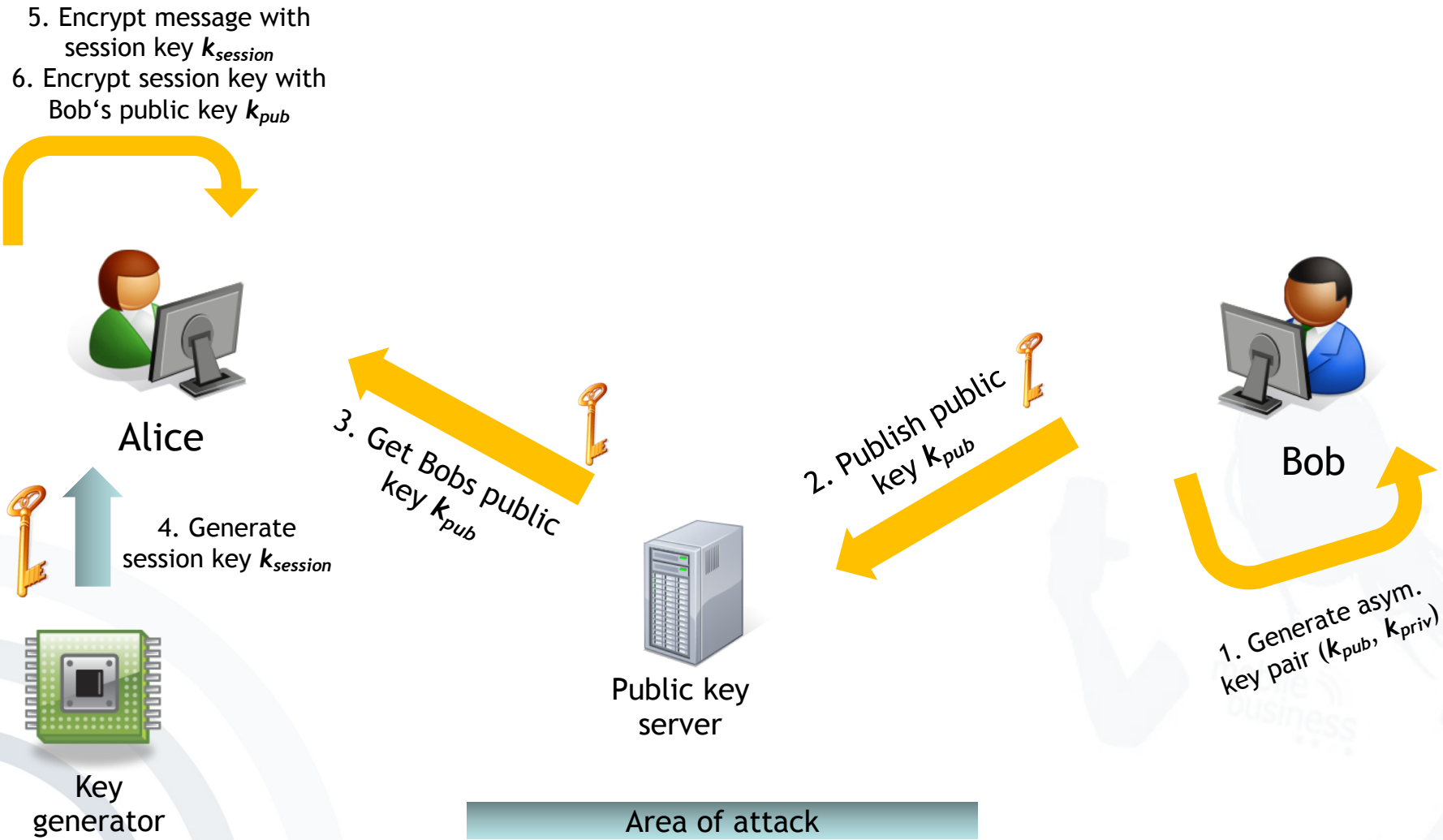
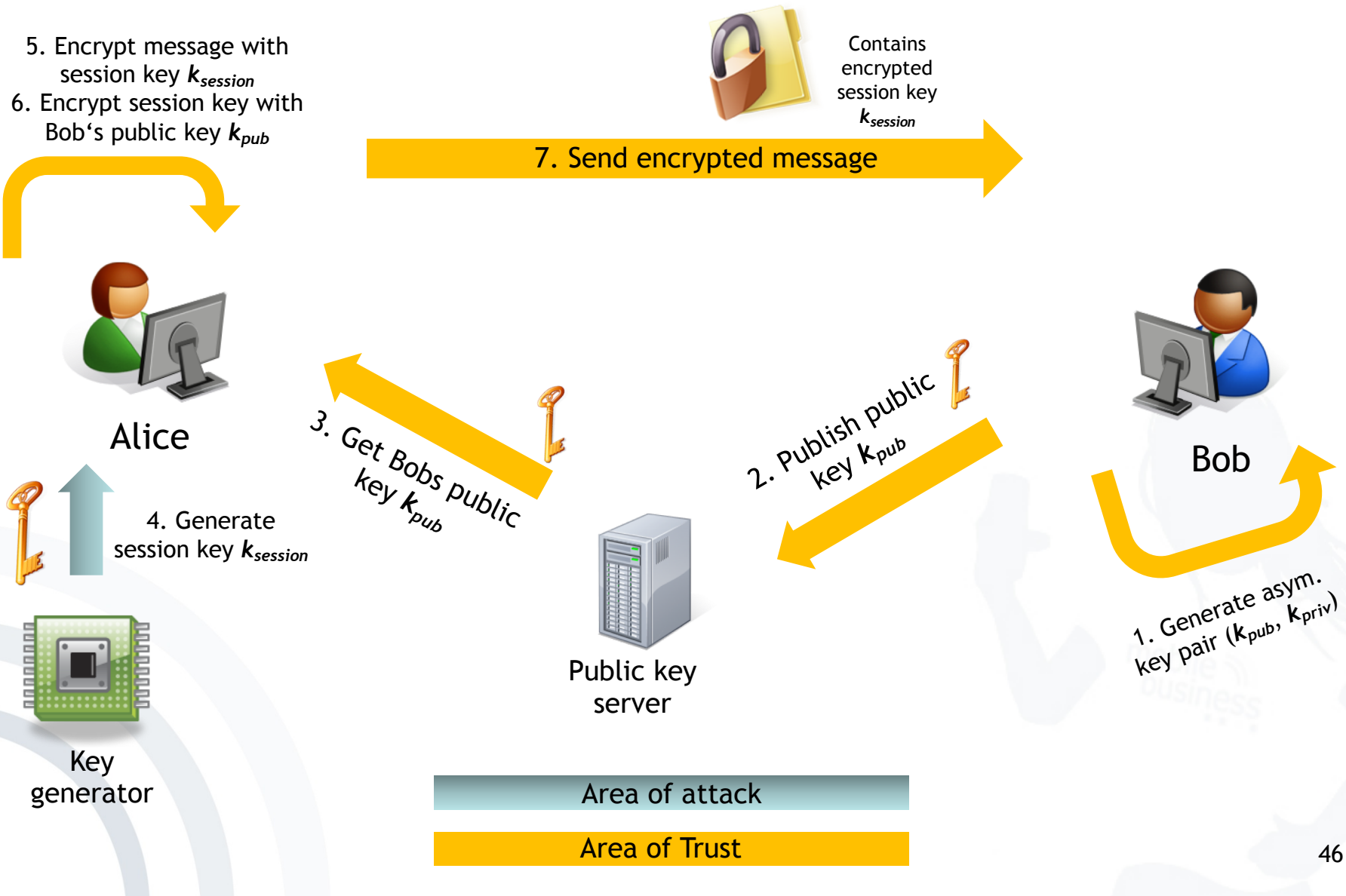


Exercise 2: Cryptosystems – PGP



Exercise 2: Cryptosystems – PGP

Contains encrypted session key $k_{session}$

8. Decrypt session key with private key k_{priv}

5. Encrypt message with session key $k_{session}$
6. Encrypt session key with Bob's public key k_{pub}

7. Send encrypted message

Alice

Bob

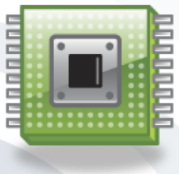
3. Get Bobs public key k_{pub}

2. Publish public key k_{pub}

4. Generate session key $k_{session}$

Public key server

1. Generate asym. key pair (k_{pub}, k_{priv})



Key generator

Area of attack

Area of Trust

Exercise 2: Cryptosystems – PGP

Contains encrypted session key $k_{session}$

8. Decrypt session key with private key k_{priv}
9. Decrypt message with session key $k_{session}$

5. Encrypt message with session key $k_{session}$
6. Encrypt session key with Bob's public key k_{pub}

7. Send encrypted message

Alice

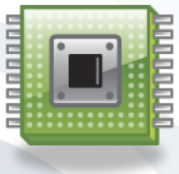
Bob

4. Generate session key $k_{session}$

3. Get Bobs public key k_{pub}

2. Publish public key k_{pub}

Public key server



Key generator

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Area of attack

Area of Trust

Exercise 2: Cryptosystems

b. What are pre-conditions for this approach?

Exercise 2: Cryptosystems

b. What are pre-conditions for this approach?

→Generation of asymmetric key pairs

→Publishing public part of key

→Private key must be kept secret (!)

→Generation of session key

Exercise 2: Cryptosystems

c. What are advantages and disadvantages of PGP?

Exercise 2: Cryptosystems

c. What are advantages and disadvantages of PGP?

→**Hybrid encryption**

→Advantages of both symmetric and asymmetric encryption

Exercise 3: Cryptosystems

Describe possible ways for distributing keys and discuss advantages as well as disadvantages.

Exercise 3: Cryptosystems

Mention possible ways for distributing keys and discuss advantages as well as disadvantages.

- Manually (e.g. on flash disc)
- Over existing secure channel
- Download from (trusted) key server
- Stored on Smart Card
- Based on certificates
- Key exchange protocols

Literature

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