

CSE 484/M584: Computer Security (and Privacy)

Spring 2025

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Admin

- Lab 1b due Wednesday.
 - Ask questions!
 - Do the exercises!
 - Read the readings and the clarifications thread on ed!
 - Remember: C code may be deceptive, disassemble the program (objdump or disassemble)
- Late days:
 - If you go over 3 late days for an assignment, email me to hand it in.
 - Barring a pre-agreed reason, this will result in -20% per day over the limit.

Threat modeling again^4

- You notice that people seem to be writing code with LLMs... a lot!
- These have a habit of ‘hallucinating’ (bullshitting) package names to import that don’t exist
 - E.g. `import huggingface-cli`
- What might a clever adversary do?
- What behavior by a victim would they be relying on?
- How might they be caught?

Common Communication Security Goals

Confidentiality of data:

Prevent exposure of
information

Integrity of data:

Prevent modification of
information



Alice



Bob

passwd = foobar ; transfer \$100

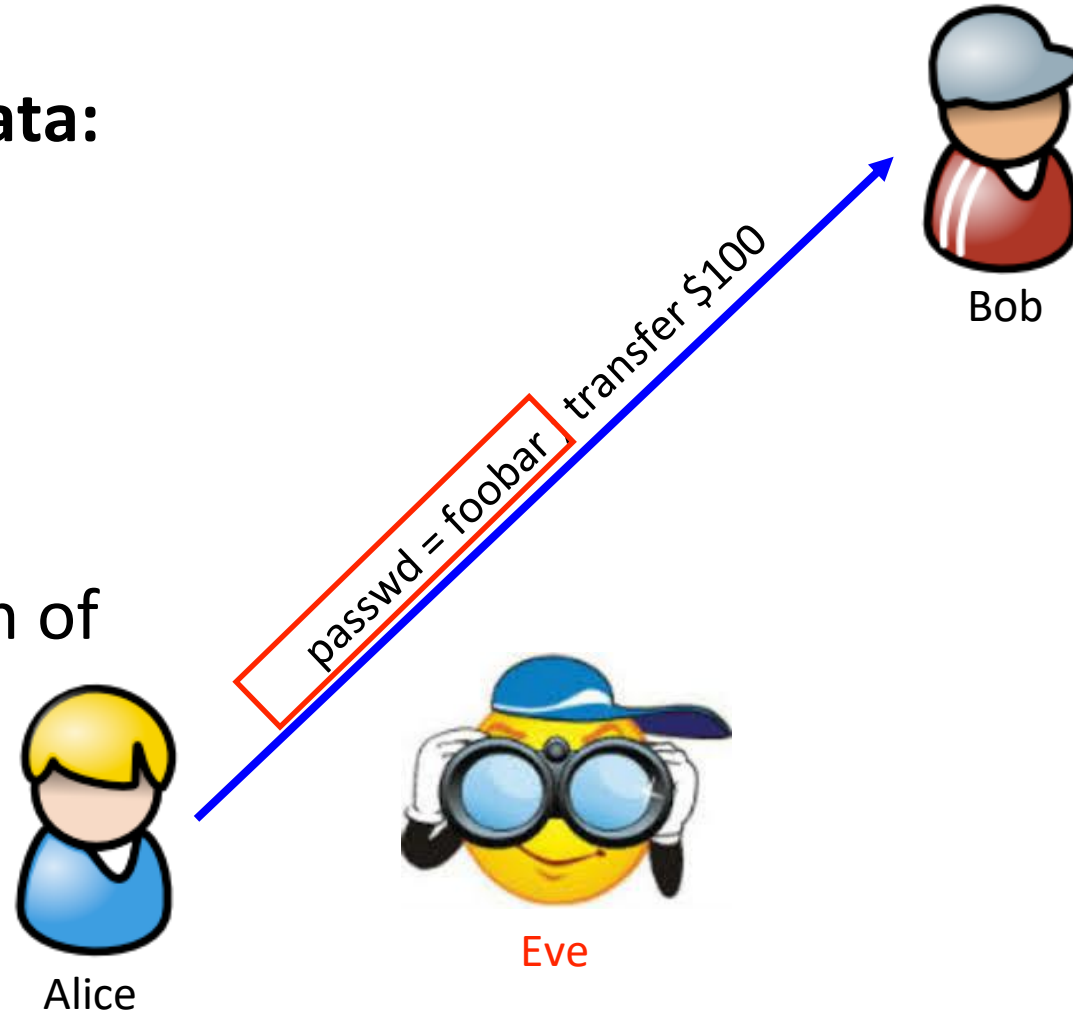
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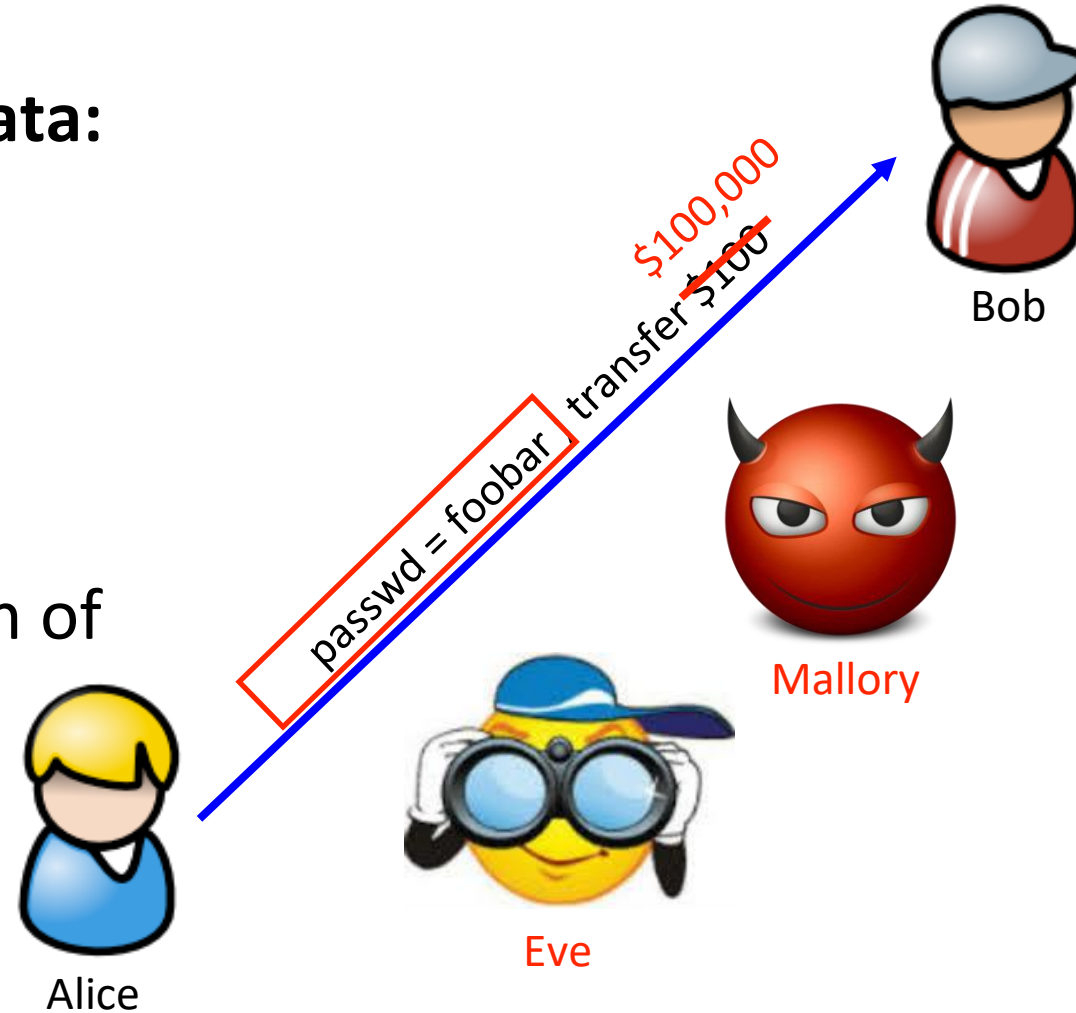
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Recall Bigger Picture

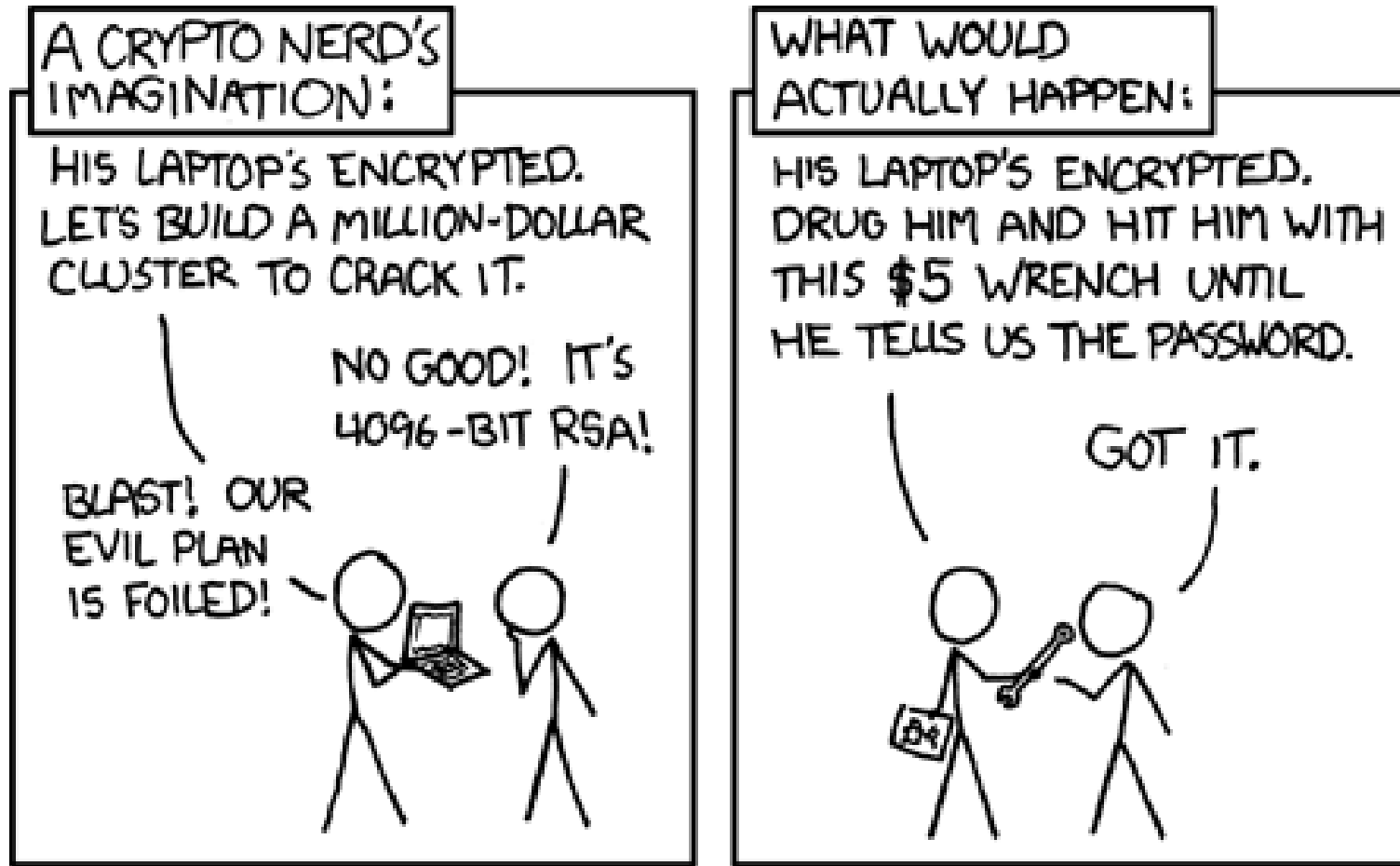
- Cryptography only one small piece of a larger system
- Must protect entire system
 - Physical security
 - Operating system security
 - Network security
 - Users
 - Cryptography (following slides)
- Recall the weakest link
- Still, cryptography is a crucial part of our toolbox

Recall Bigger Picture

- Cryptography only one small piece of a larger system
- Must protect entire system
 - Physical security
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XKCD: <http://xkcd.com/538/>



History

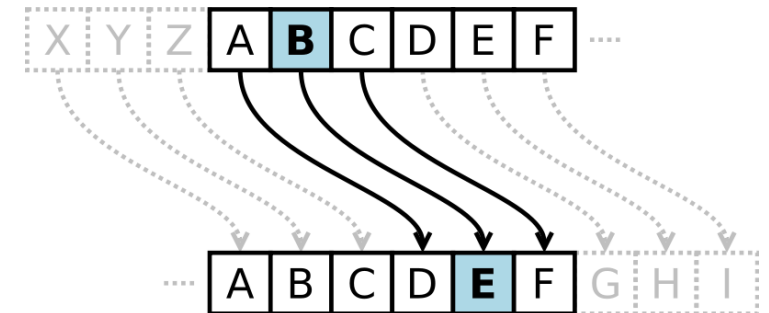
- Substitution Ciphers
 - Caesar Cipher
 - Transposition Ciphers
 - Codebooks
 - Machines
-
- Recommended Reading: **The Codebreakers** by David Kahn and **The Code Book** by Simon Singh.

History: Caesar Cipher (Shift Cipher)

- Plaintext letters are replaced with letters a fixed shift away in the alphabet.
- Example:
 - Plaintext: The quick brown fox jumps over the lazy dog
 - Key: Shift 3
 - Ciphertext: WKHTX LFNEU RZQIR AMXPS VRYHU WKHOD CBGRJ

ABCDEFGHIJKLMNOPQRSTUVWXYZ

DEFGHIJKLMNOPQRSTUVWXYZABC



History: Caesar Cipher (Shift Cipher)

- What is the key space?
- How to attack shift ciphers?



History: Caesar Cipher (Shift Cipher)

- What is the key space?
 - 26 possible shifts.
- How to attack shift ciphers?
 - Brute force.



History: Substitution Cipher

- **Superset of shift ciphers:** each letter is substituted for another one.
- One way to implement: **Add a secret key**
- Example:
 - Plaintext: ABCDEFGHIJKLMNOPQRSTUVWXYZ
 - Cipher: ZEBRAS CDEFGHIJKLMNOPQTUVWXY
- “State of the art” for thousands of years

History: Substitution Cipher

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History: Substitution Cipher

- What is the key space?
- How to attack?

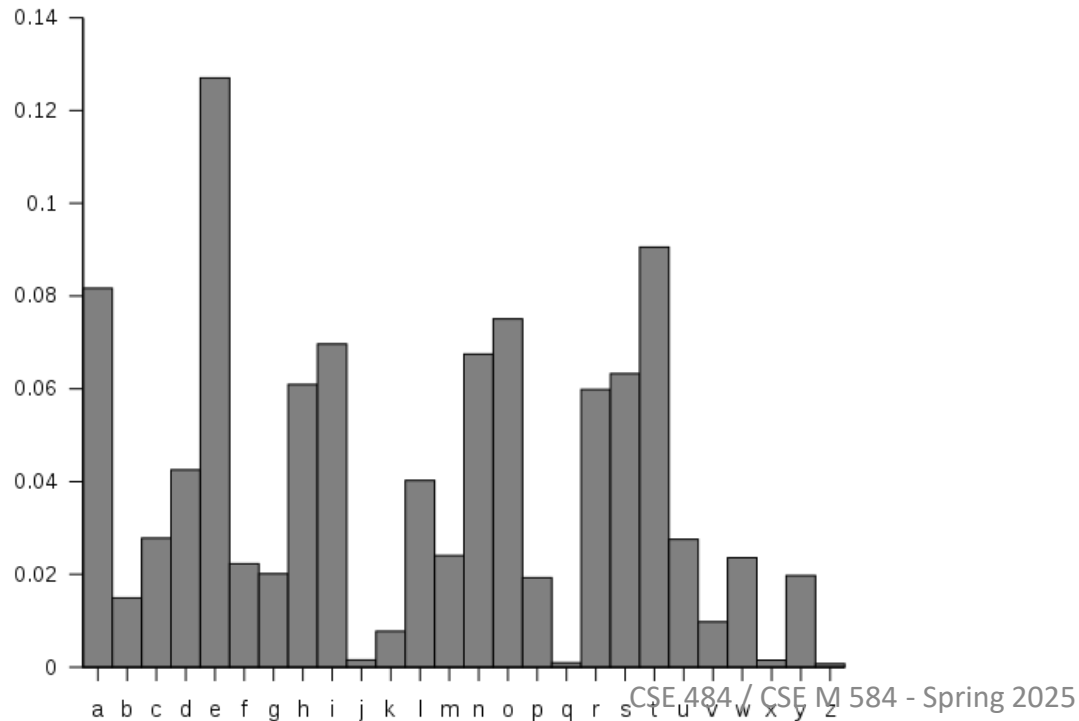
$$26! \sim 2^{88}$$

History: Substitution Cipher

- What is the key space?
- How to attack?

$$26! \approx 2^{88}$$

— Frequency analysis.



Bigrams:

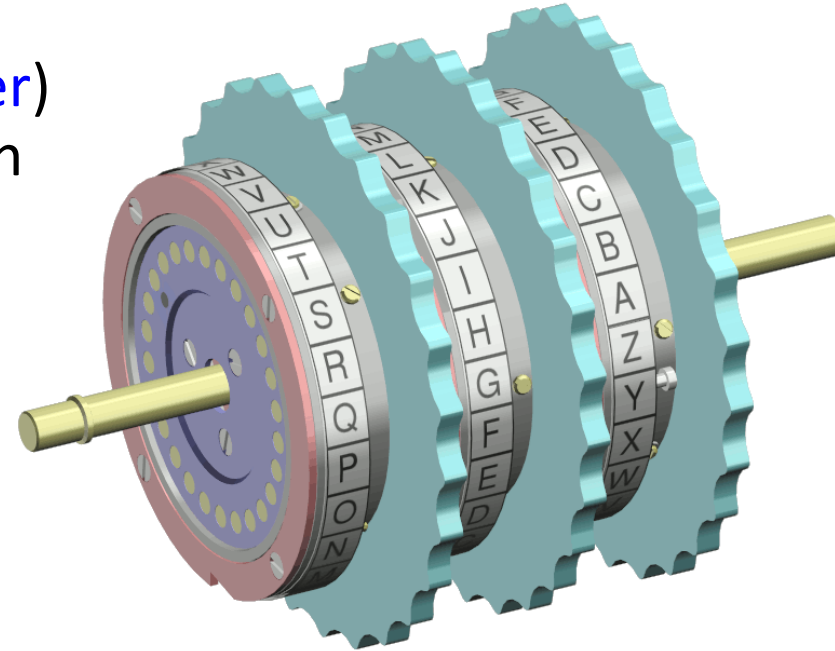
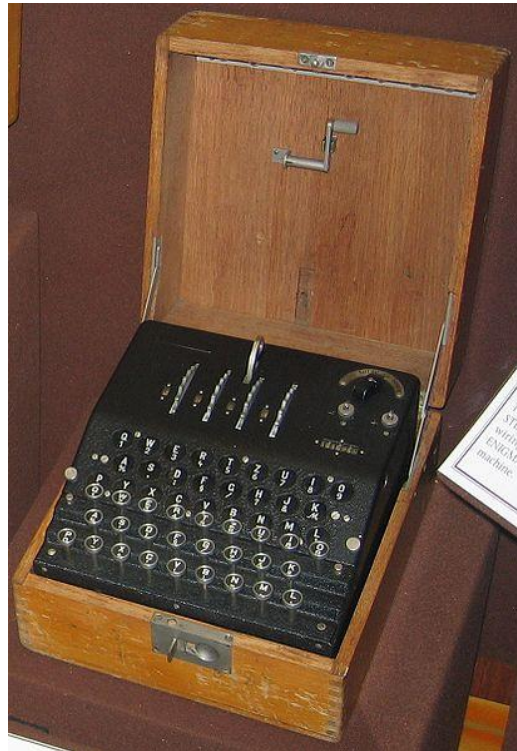
th 1.52%	en 0.55%	ng
0.18%		
he 1.28%	ed 0.53%	of
0.16%		
in 0.94%	to 0.52%	al
0.09%		
er 0.94%	it 0.50%	de
0.09%		
an 0.82%	ou 0.50%	se
0.08%		
re 0.68%	ea 0.47%	le
0.08%		
nd 0.63%	hi 0.46%	sa
0.06%		
at 0.59%	is 0.46%	si
0.05%		

Trigrams:

on 0.57%	1. the	6. ion	11. mee
0.04%	2. and	7. tio	12. edt
nt 0.52%	3. tha	8. for	13. tis
0.04%	4. ent	9. nde	14. oft
ha 0.56%	5. ing	10. has	15. sth
0.04%			
es 0.56%			
0.02%			
st 0.55%			
		et 0.19%	ur

History: Enigma Machine

Uses rotors ([substitution cipher](#)) that change position after each key.

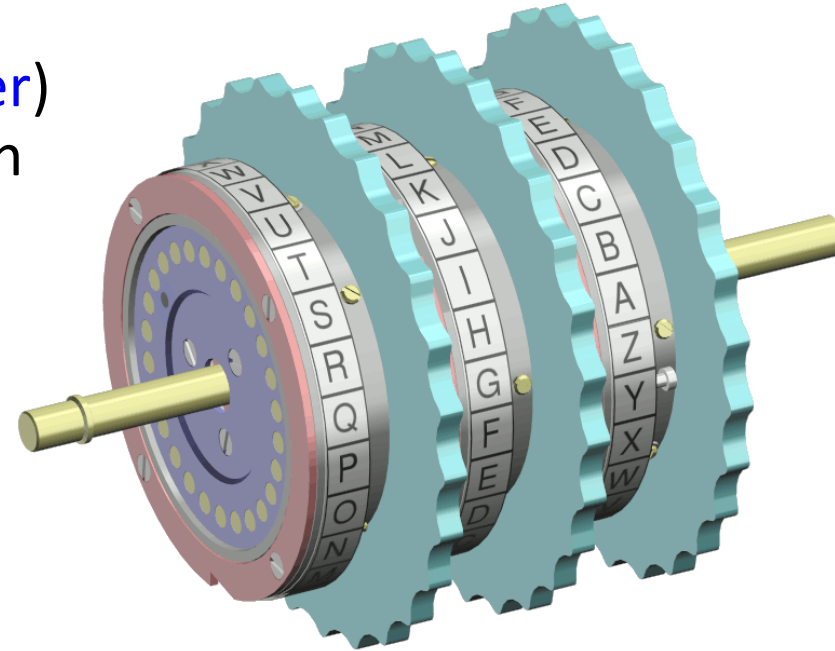
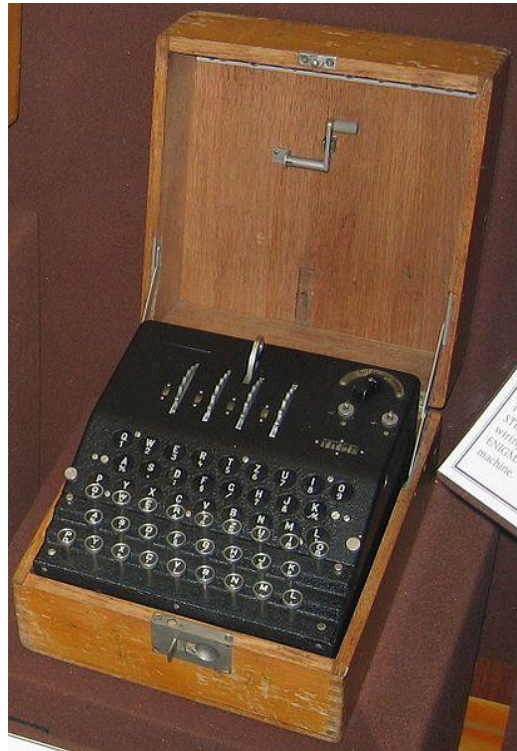


Key = initial setting of rotors

Key space?

History: Enigma Machine

Uses rotors ([substitution cipher](#)) that change position after each key.



Key = initial setting of rotors

Key space?

26^n for n rotors

How Cryptosystems Work Today

- **Layered approach:** Cryptographic protocols (like “CBC mode encryption”) built on top of cryptographic primitives (like “block ciphers”)
- **Flavors of cryptography:**
 - Symmetric (secret key) and asymmetric (public key)
- Public algorithms (Kerckhoff’s Principle – next slide)
- Security proofs based on assumptions (*not this course*)
- Be careful about inventing your own!
(If you just want to use some crypto in your system, use vetted libraries!)

Kerckhoff's Principle

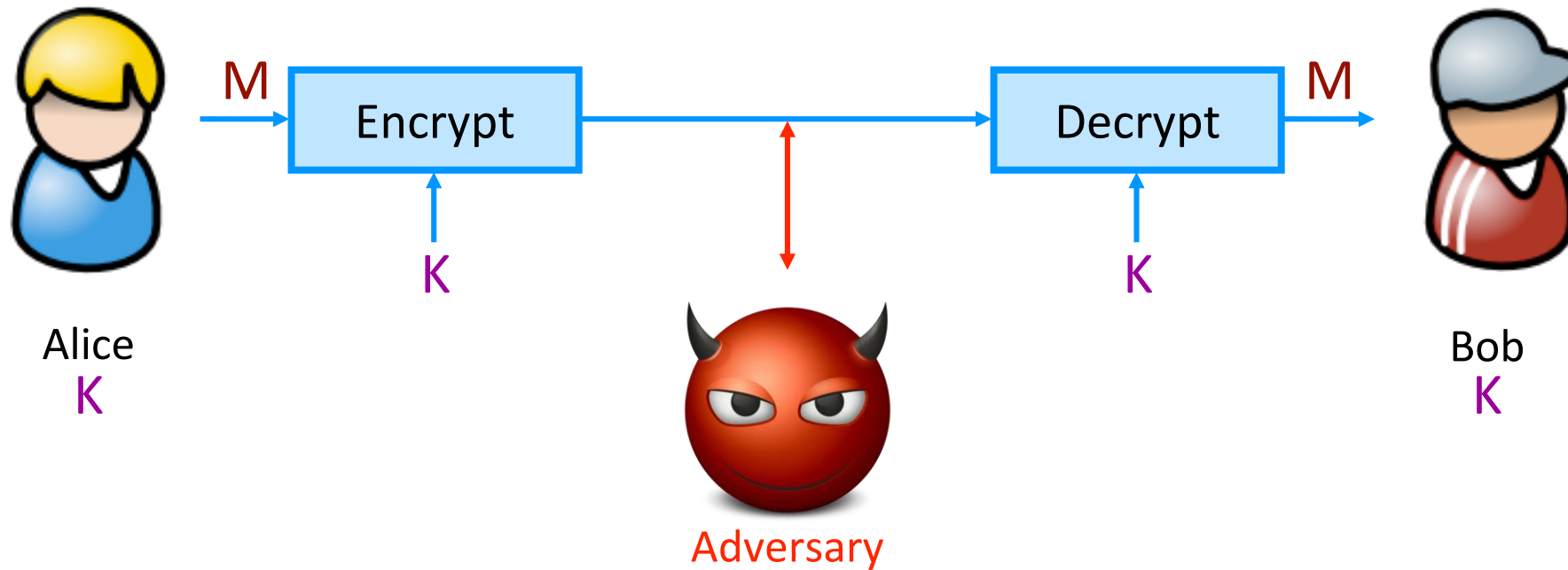
- Security of a cryptographic object **should depend only on the secrecy of the secret key.**
- Security should not depend on the secrecy of the algorithm itself.
- Foreshadowing: **Need for randomness**
 - the key is unpredictable and cannot be guessed

Flavors of Cryptography

- Symmetric cryptography
 - Both communicating parties have access to a **secret shared random string K** , called the **key**
- Asymmetric cryptography
 - Each party creates a public key **pk** and a secret key **sk** .
 - Communicating parties have access to each other's public key

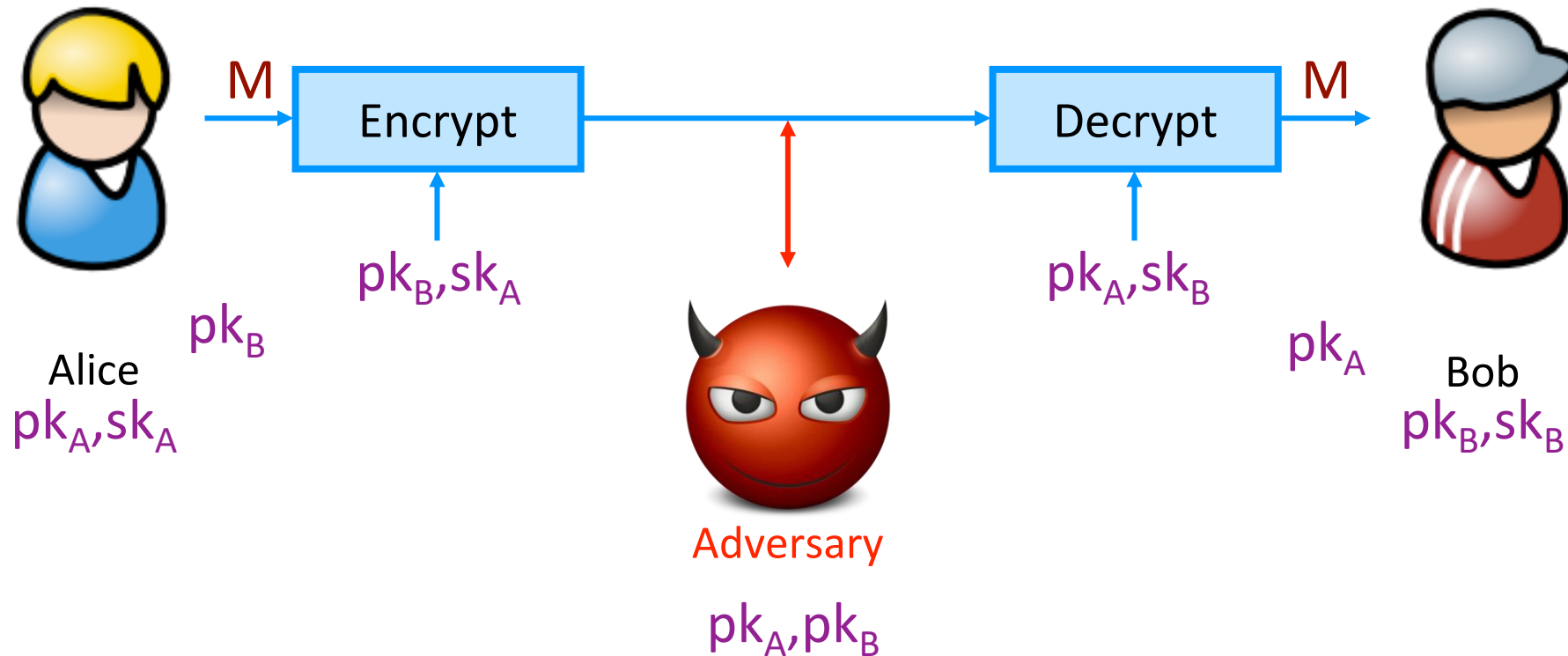
Symmetric Setting

Both communicating parties have access to a **secret shared random string K** , called the **key**.



Asymmetric Setting

Each party creates a public key pk and a secret key sk



Bootstrapping Secure Communication

In-class Activity 1/22

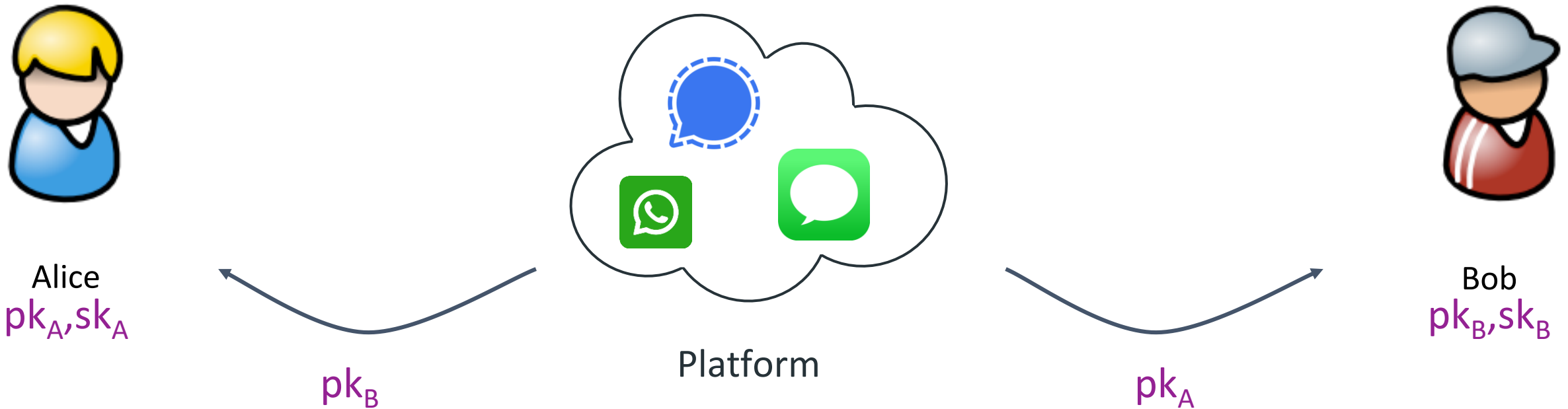
- Symmetric cryptography
 - How do both parties learn the shared secret key?

Bootstrapping Secure Communication

Gradescope!

- Symmetric cryptography
 - How do both parties learn the shared secret key?
- Asymmetric cryptography
 - How does a party learn the public key of the other party?

Preview: Public Key Infrastructure



Preview: Public Key Infrastructure



Alice
 pk_A, sk_A

pk_M



Adversary

pk_M, sk_M

pk_M



Bob
 pk_B, sk_B