CSE 484 / CSE M 584: Computer Security and Privacy

Software Security [Wrap-Up] Cryptography [Intro]

Autumn 2020

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Thanks to Dan Boneh, Dieter Gollmann, Dan Halperin, Yoshi Kohno, Ada Lerner, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

Admin

- Lab 1
  - Checkpoint due today (11:59pm)
  - Sploits 4-7 due 10/28 (11:59pm)
  - Reminder that you have 5 late days you can use throughout the quarter
    - Up to 3 at a time
    - Everyone in a group uses them simultaneously

Software Security:
So what do we do?

Some General Principles

- Check inputs; Check all return values
- Least privilege: limit access to what is needed
- Failsafe defaults
- Testing (e.g., fuzz testing)
- Defense in depth
  - Also: prevent, detect, respond
- NOT (only): security through obscurity

General Principles

- Reduce size of trusted computing base (TCB)
- Simplicity, modularity
  - But: Be careful at interface boundaries!
- Minimize attack surface
- Use vetted components
- Security by design
  - But: tension between security and other goals
- Open design? Open source? Closed source?
  - Different perspectives

Vulnerability Analysis and Disclosure

- What do you do if you've found a security problem in a real system?
- Say
  - A commercial website?
  - UW grade database?
  - Boeing 787?
  - TSA procedures?

Next Major Section of the Course: Cryptography

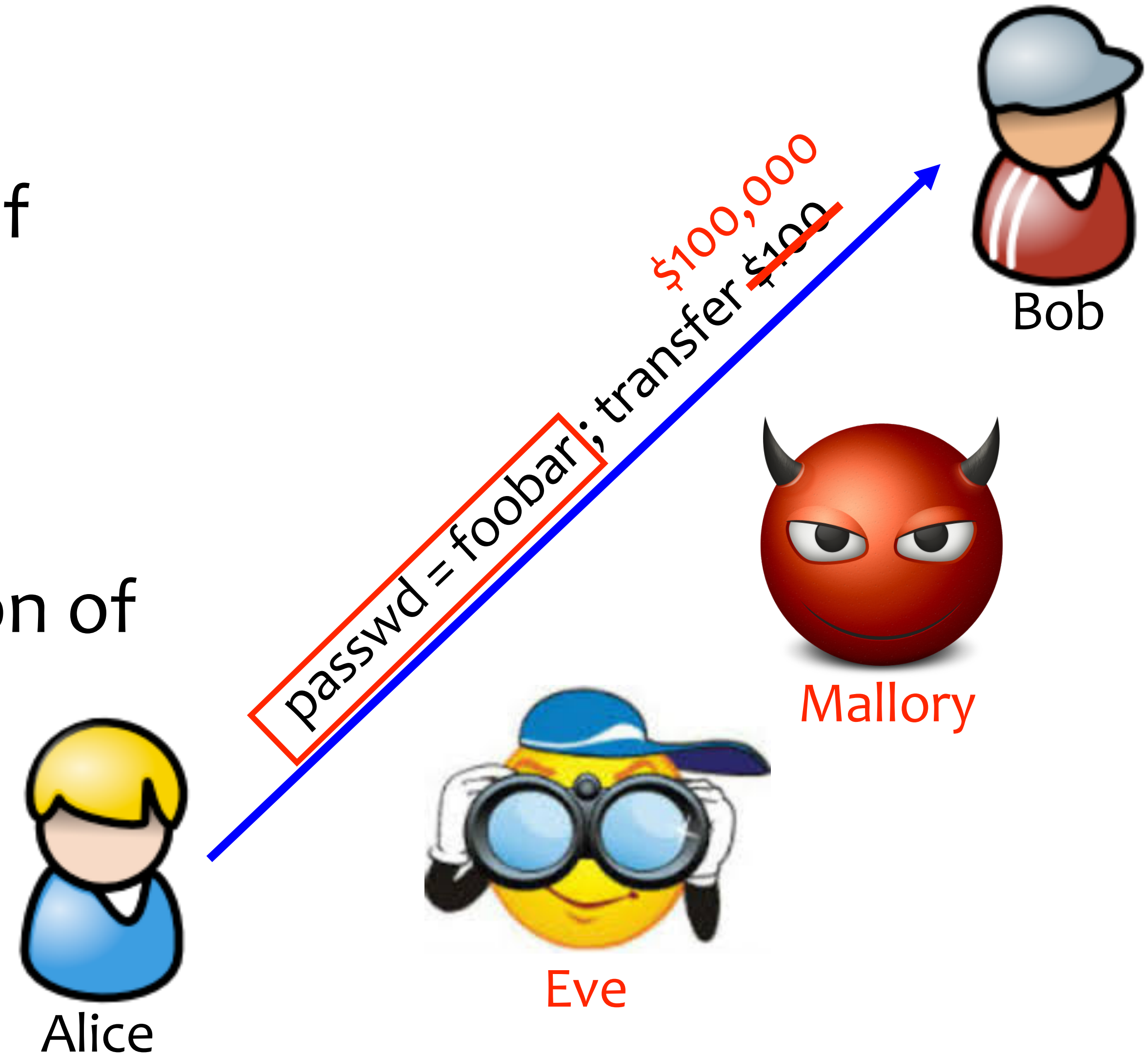
Common Communication Security Goals

Privacy of data:

Prevent exposure of information

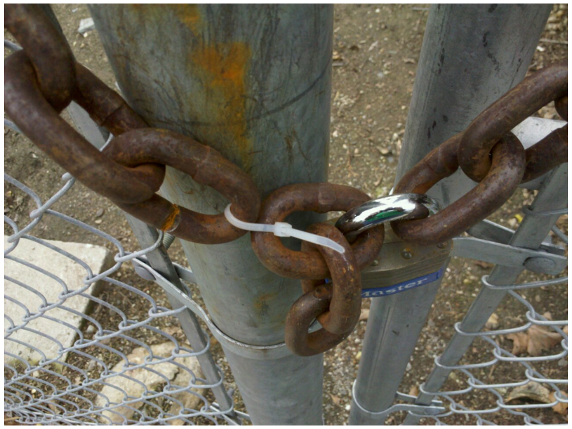
Integrity of data:

Prevent modification of information



Recall Bigger Picture

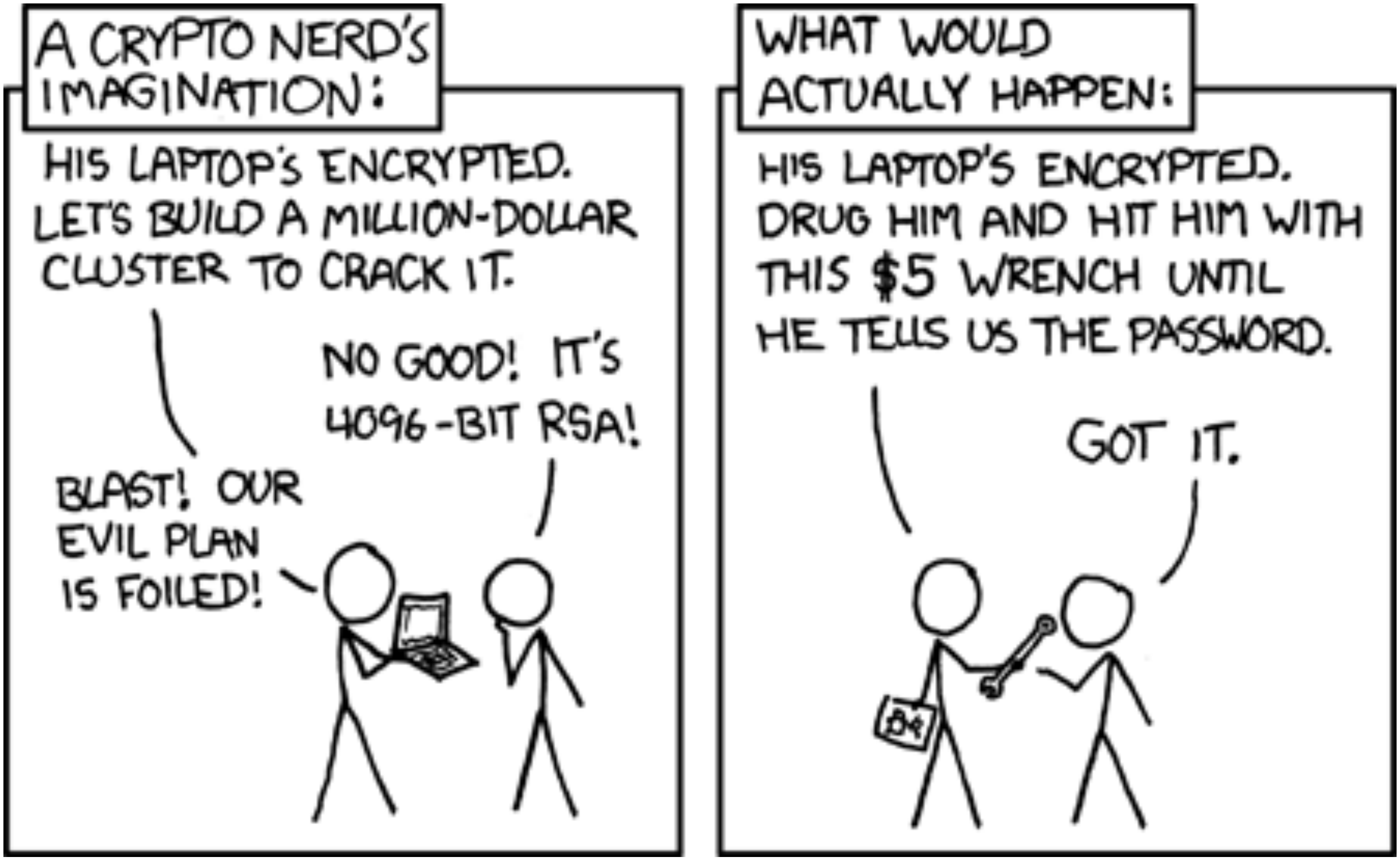
- Cryptography only one small piece of a larger system
- Must protect entire system
  - Physical security
  - Operating system security
  - Network security
  - Users
  - Cryptography (following slides)



- Recall the weakest link

- Still, cryptography is a crucial part of our toolbox

XKCD: http://xkcd.com/538/



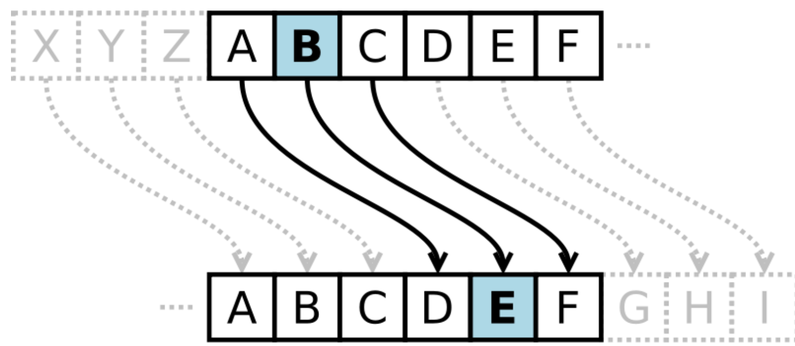
History

- 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

    `ABCDEFGHIJKLMNOPQRSTUVWXYZ`

    `DEFGHIJKLMNOPQRSTUVWXYZABC`

  - Ciphertext: `WKHTX LFNEU RZQIR AMXPS VRYHU WKHOD CBGRJ`

History: Caesar Cipher (Shift Cipher)

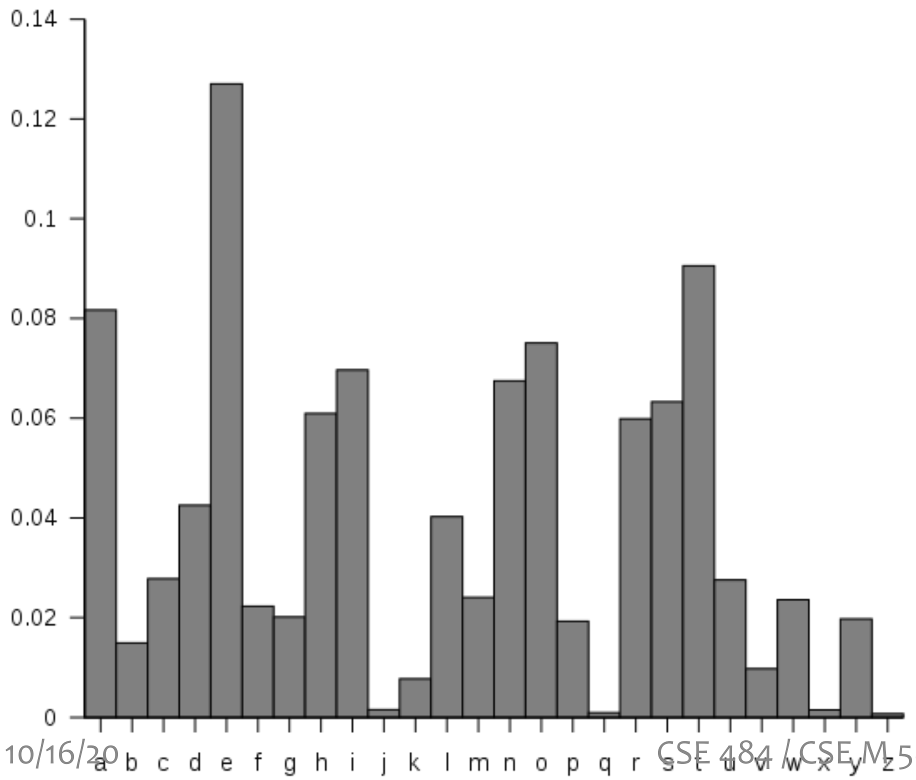
- ROT13: shift 13 (encryption and decryption are symmetric)
- What is the key space?
  - 26 possible shifts.
- How to attack shift ciphers?
  - Brute force.

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: `ZEBRASCDFGHIJKLMNOPQTUVWXY`
- "State of the art" for thousands of years

History: Substitution Cipher

- What is the key space? 26! ~= 2^88
- How to attack?
  - Frequency analysis.



Bigrams:

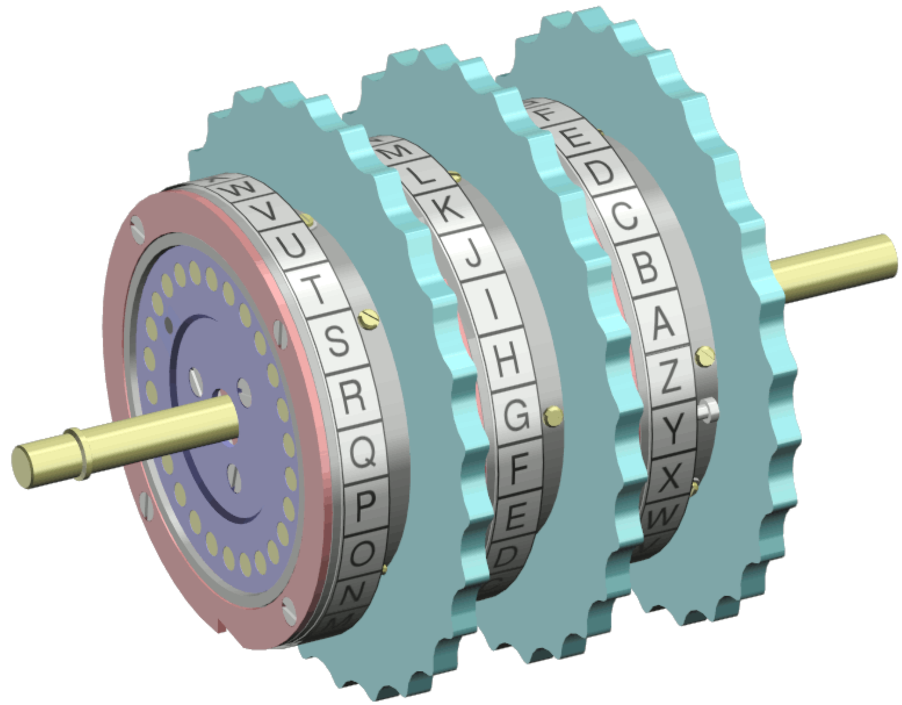
th	1.52%	en	0.55%	ng	0.18%
he	1.28%	ed	0.53%	of	0.16%
in	0.94%	to	0.52%	al	0.09%
er	0.94%	it	0.50%	de	0.09%
an	0.82%	ou	0.50%	se	0.08%
re	0.68%	ea	0.47%	le	0.08%
nd	0.63%	hi	0.46%	sa	0.06%
at	0.59%	is	0.46%	si	0.05%
on	0.57%	or	0.43%	ar	0.04%
nt	0.56%	ti	0.34%	ve	0.04%
ha	0.56%	as	0.33%	ra	0.04%
es	0.56%	te	0.27%	ld	0.02%
st	0.55%	et	0.19%	ur	0.02%

Trigrams:

1. the	6. ion	11. nce
2. and	7. tio	12. edt
3. tha	8. for	13. tis
4. ent	9. nde	14. oft
5. ing	10.has	15. sth

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 (private key) and asymmetric (public key)
- Public algorithms (Kerckhoff's Principle)
- 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 (private) key.
- Security should not depend on the secrecy of the algorithm itself.

Flavors of Cryptography

- Symmetric cryptography
  - Both communicating parties have access to a shared random string K, called the key.
- Asymmetric cryptography
  - Each party creates a public key pk and a secret key sk.
  - *Hard concept to understand, and revolutionary! Inventors won Turing Award* ☺

Received April 4, 1977

A Method for Obtaining Digital Signatures and Public-Key Cryptosystems

R.L. Rivest, A. Shamir, and L. Adleman*

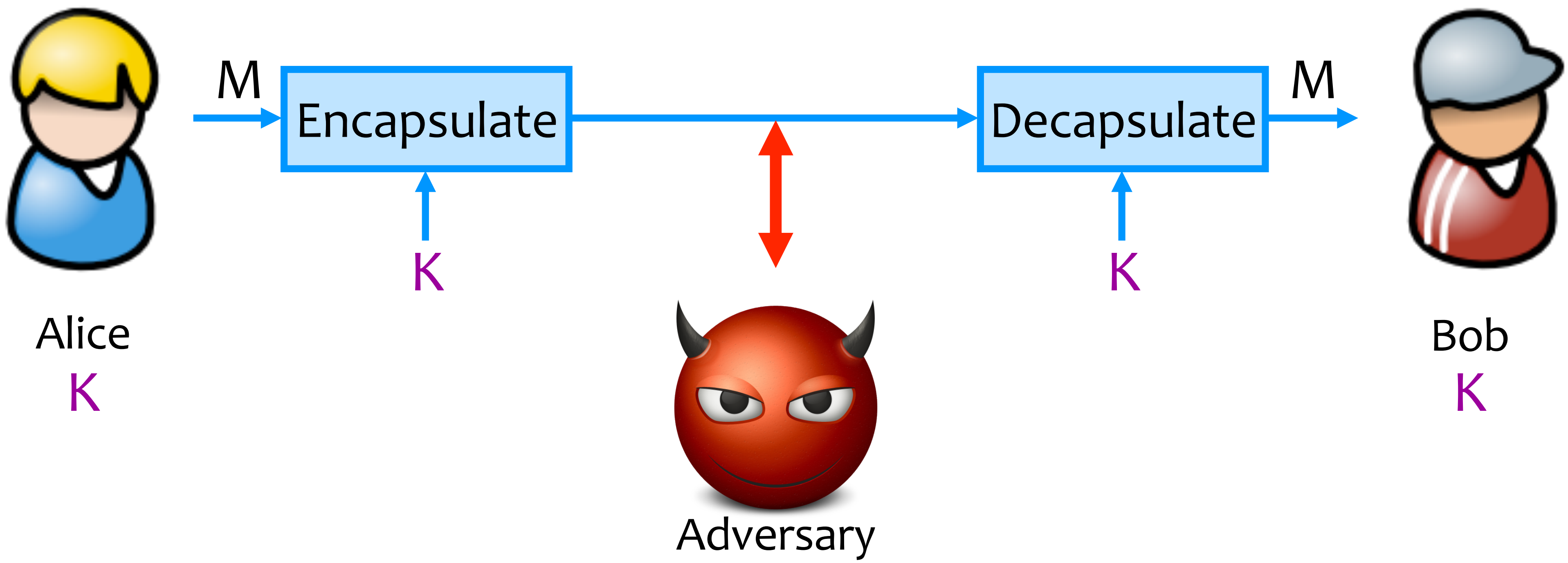
Abstract

An encryption method is presented with the novel property that publicly revealing an encryption key does not thereby reveal the corresponding decryption key. This has two important consequences:

1. Couriers or other secure means are not needed to transmit keys, since a message can be enciphered using an encryption key publicly revealed by the intended recipient. Only he can decipher the message, since only he knows the corresponding decryption key.
2. A message can be "signed" using a privately held decryption key. Anyone can verify this signature using the corresponding publicly revealed encryption key. Signatures cannot be forged, and a signer cannot later deny the validity of his signature. This has obvious applications in "electronic mail" and "electronic funds transfer" systems.

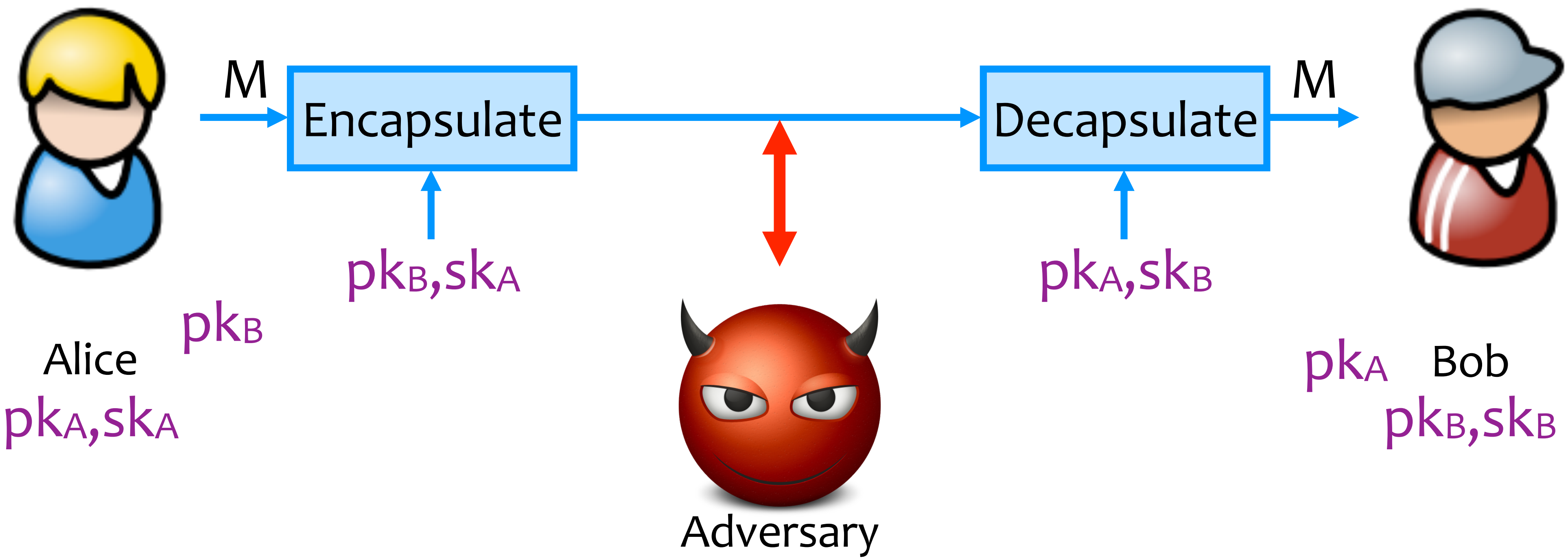
Symmetric Setting

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



Asymmetric Setting

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



Flavors of Cryptography

- Symmetric cryptography
  – Both communicating parties have access to a shared random string K, called the key.

- Asymmetric cryptography
  – Each party creates a public key pk and a secret key sk.

Flavors of Cryptography

- Symmetric cryptography
  - Both communicating parties have access to a shared random string K, called the key.
  - Challenge: How do you privately share a key?
- Asymmetric cryptography
  - Each party creates a public key pk and a secret key sk.
  - Challenge: How do you validate a public key?