CSCI 1515 Applied Cryptography

Course Homepage: https://brownappliedcryptography.github.io/

- Introduce Staff
- Syllabus
- Q & A

What is Cryptography (used for)?

Study of techniques for protecting (sensitive/important) information.

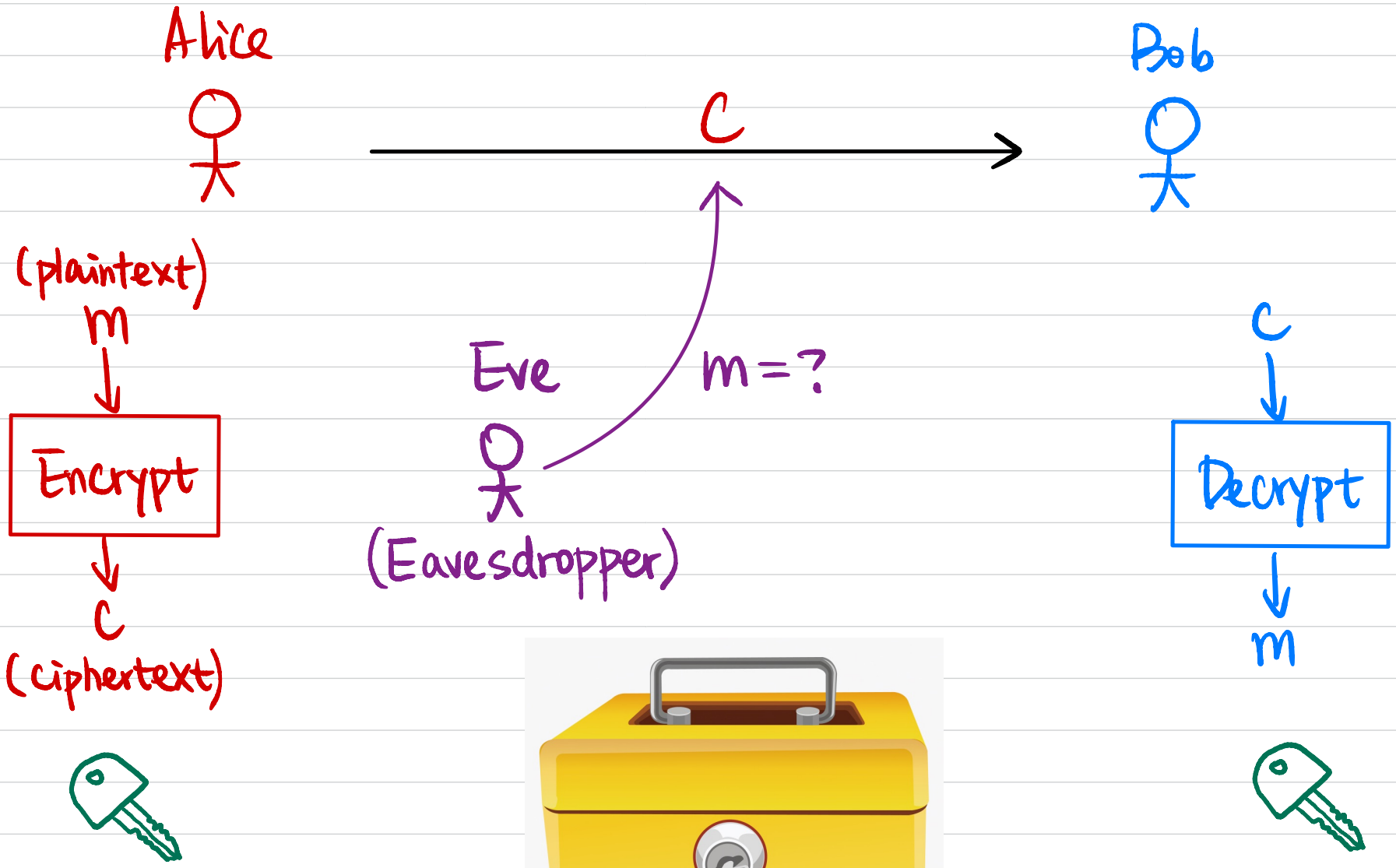
Where is cryptography used in practice?

What guarantees do we want in these scenarios?

Secure Communication

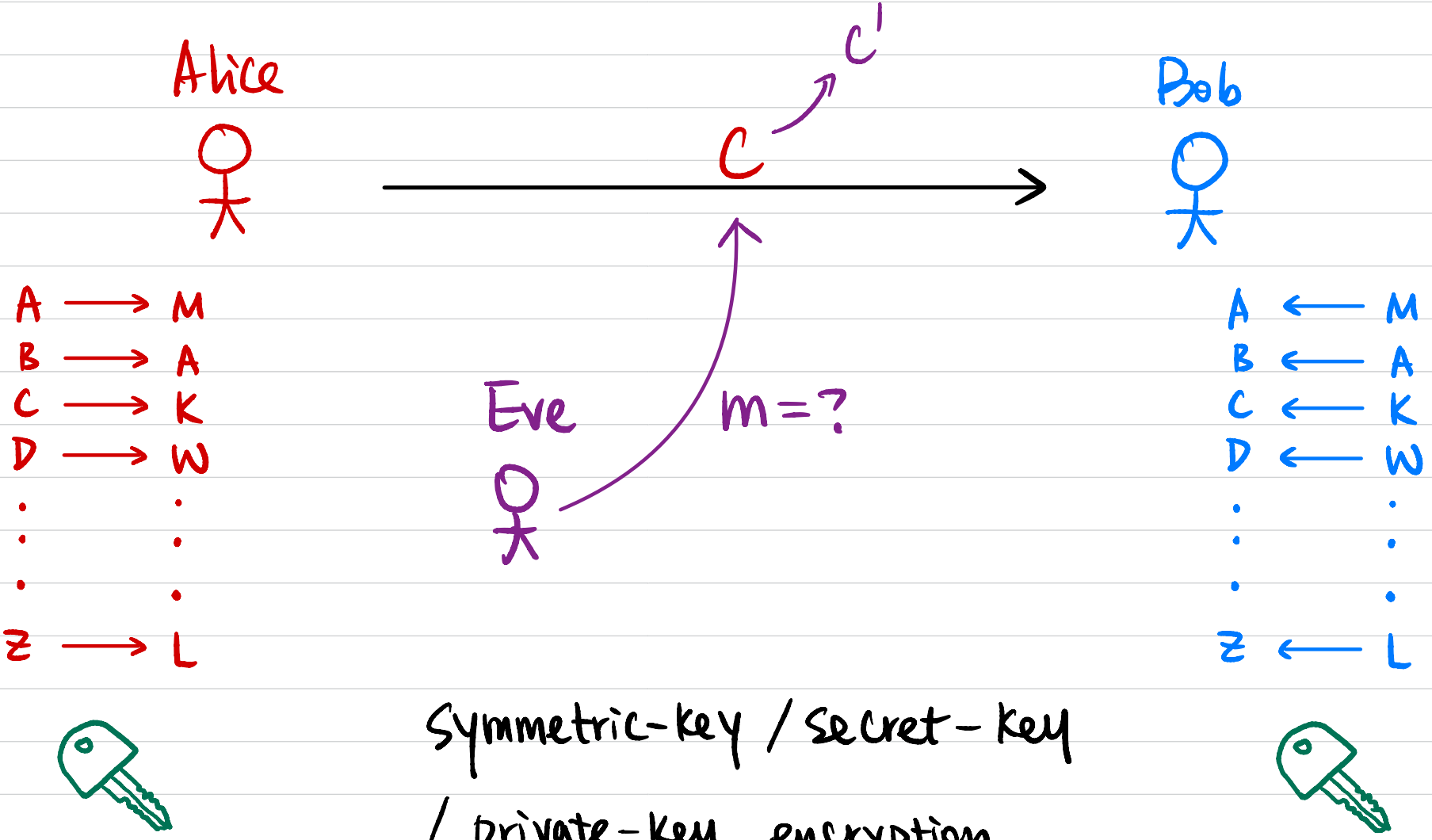
What security guarantee(s) do we want?

Message Secrecy



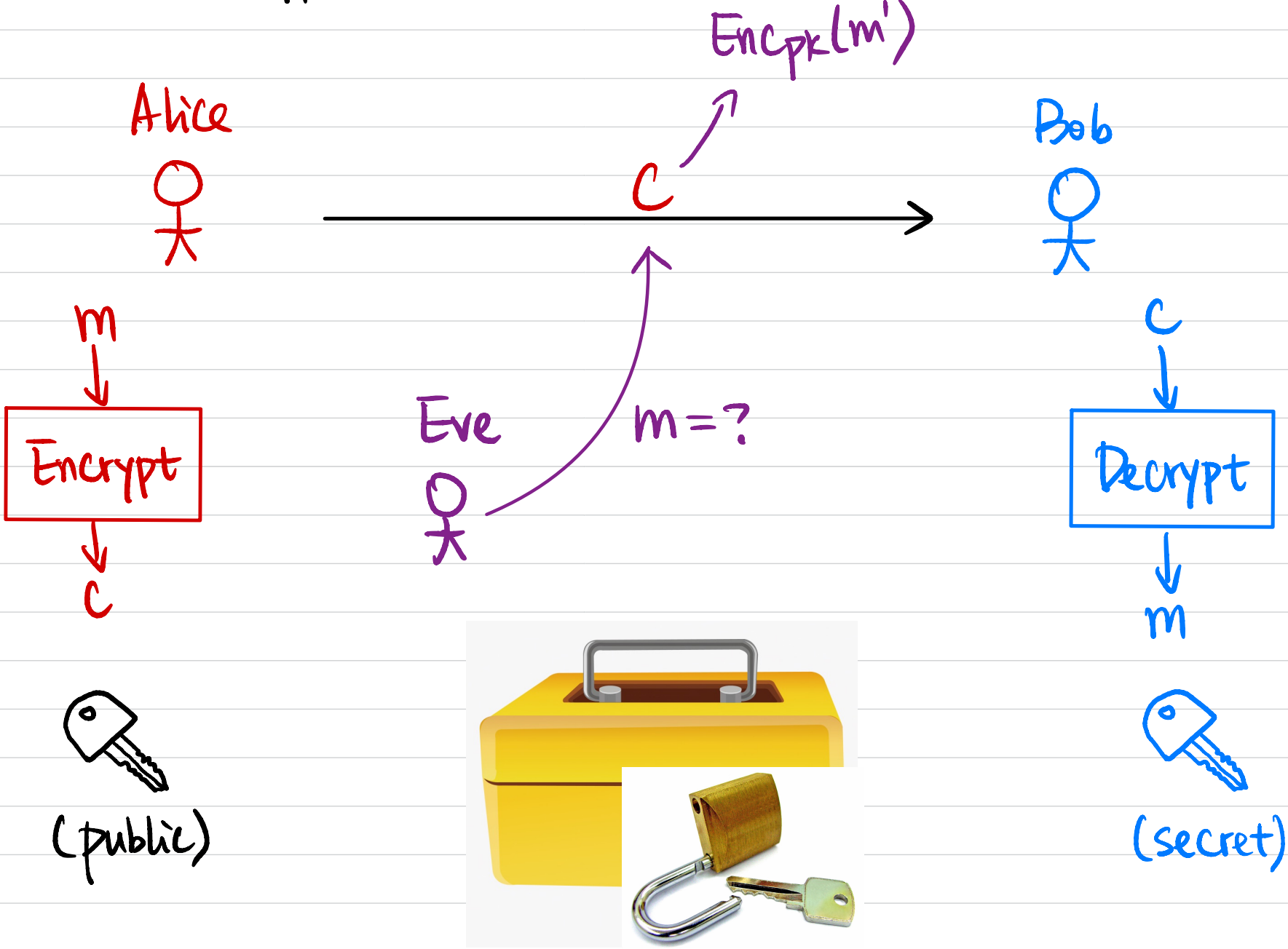
Historical Ciphers

Ex: Substitution Cipher

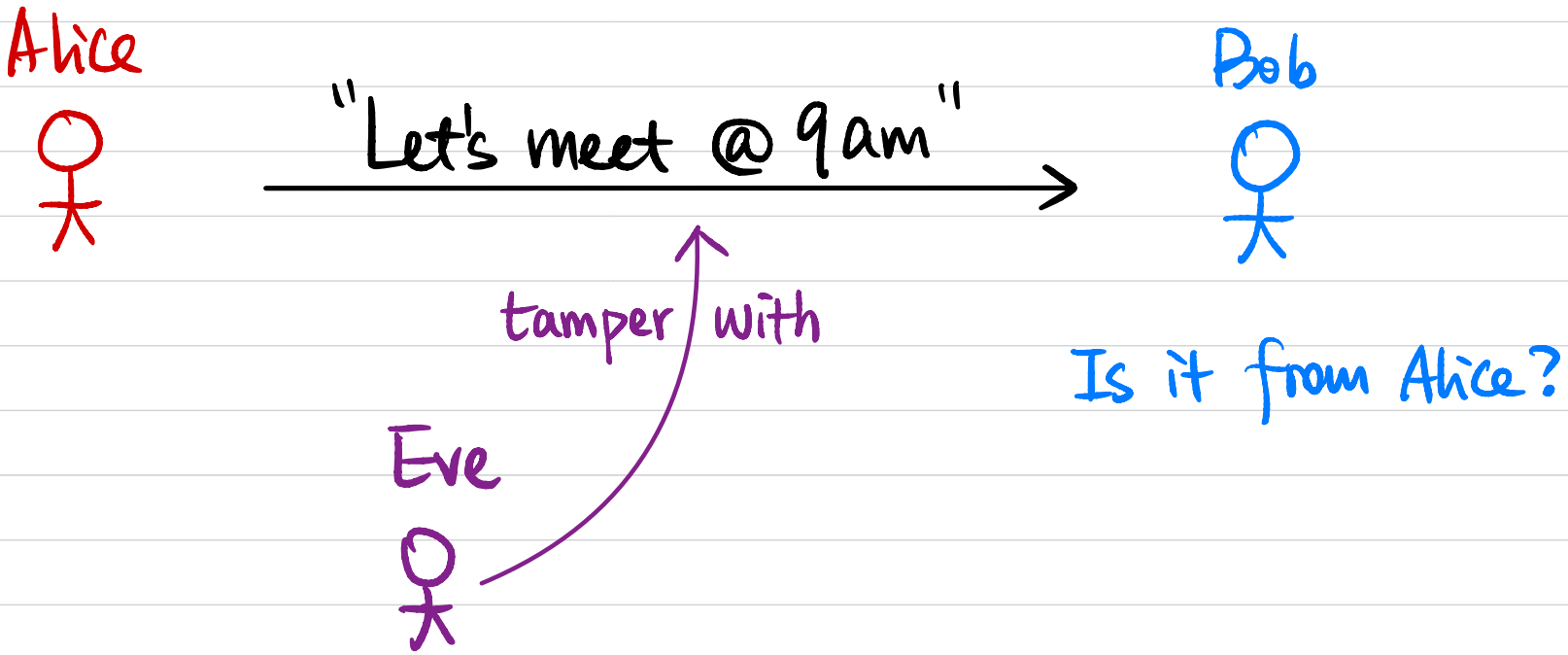


Symmetric-key / secret-key / private-key encryption

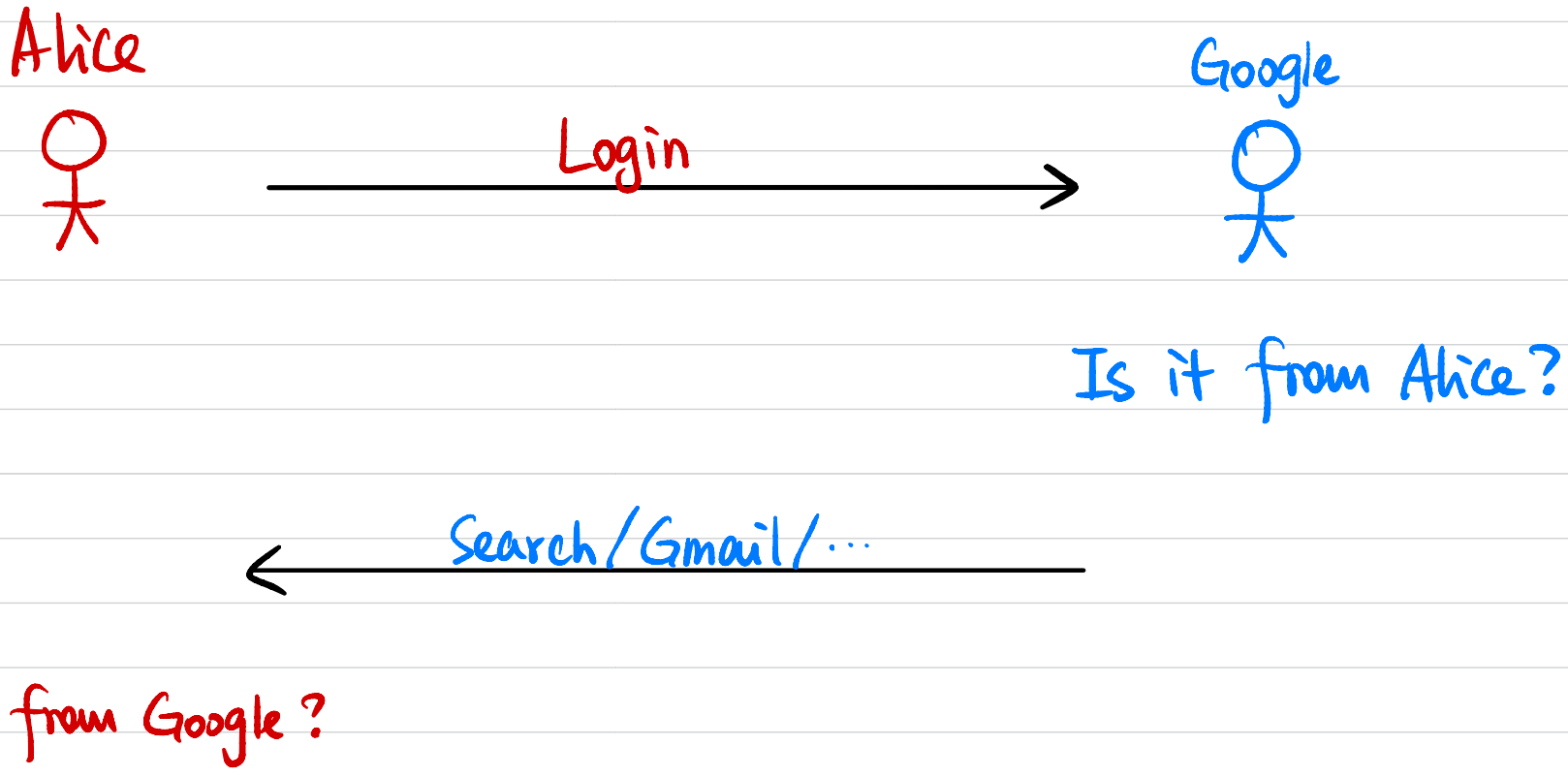
Public-Key Encryption



Message Integrity



Secure Authentication



Projects Overview

Project 0 (warm-up): Basic Schemes

Project 1: Secure Communication

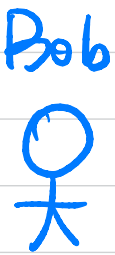
Project 2: Secure Authentication

Project 3: Zero-Knowledge Proofs

Project 4: Secure Multi-Party Computation

Project 5: Fully Homomorphic Encryption
(Post-Quantum Cryptography)

Project 3: Zero-Knowledge Proofs



Coca-Cola & Pepsi taste differently

There is a bug in your code

I have the secret key for this ciphertext

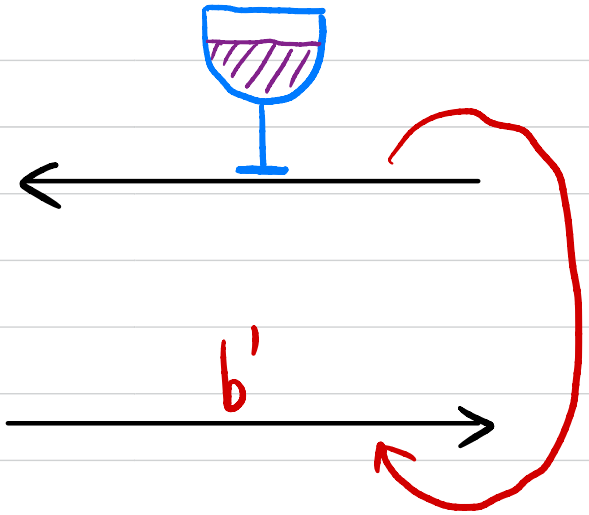
Ex: Coca-Cola & Pepsi

Alice

Bob

[Coca-Cola & Pepsi taste differently]

$b \xleftarrow{\$} \{0,1\}$



$b=0$, Coca-Cola

$b=1$, Pepsi

If statement is true: $b'=b$

If statement is false: $Pr[b'=b] = (1/2)^k$

Project 4: Secure Multi-Party Computation

Alice  $x \in \{0,1\}$ Second date? $y \in \{0,1\}$  Bob

$$f(x,y) = x \wedge y$$

$x \in \{0,1\}^{1000}$ Who is richer? $y \in \{0,1\}^{1000}$

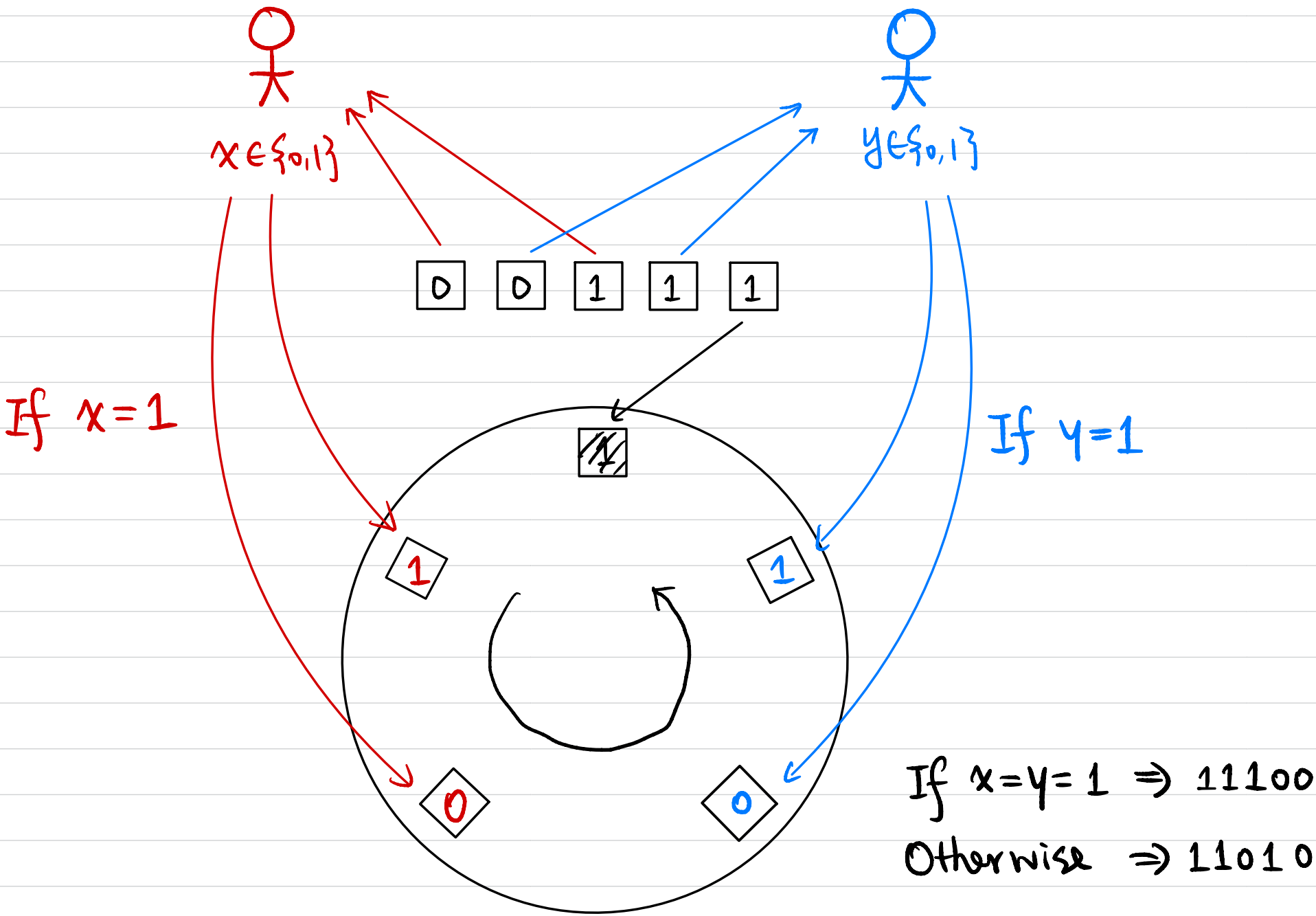
$$f(x,y) = \begin{cases} \text{Alice} & \text{if } x > y \\ \text{Bob} & \text{otherwise} \end{cases}$$

$$X = \begin{Bmatrix} friend_A^1 \\ \vdots \\ friend_A^n \end{Bmatrix}$$ Common friends? $$Y = \begin{Bmatrix} friend_B^1 \\ \vdots \\ friend_B^m \end{Bmatrix}$$

$$f(X,Y) = X \cap Y$$

$$X = \begin{Bmatrix} (username, password) \\ \vdots \end{Bmatrix} \qquad Y = \begin{Bmatrix} (usr, psw) \\ \vdots \end{Bmatrix}$$

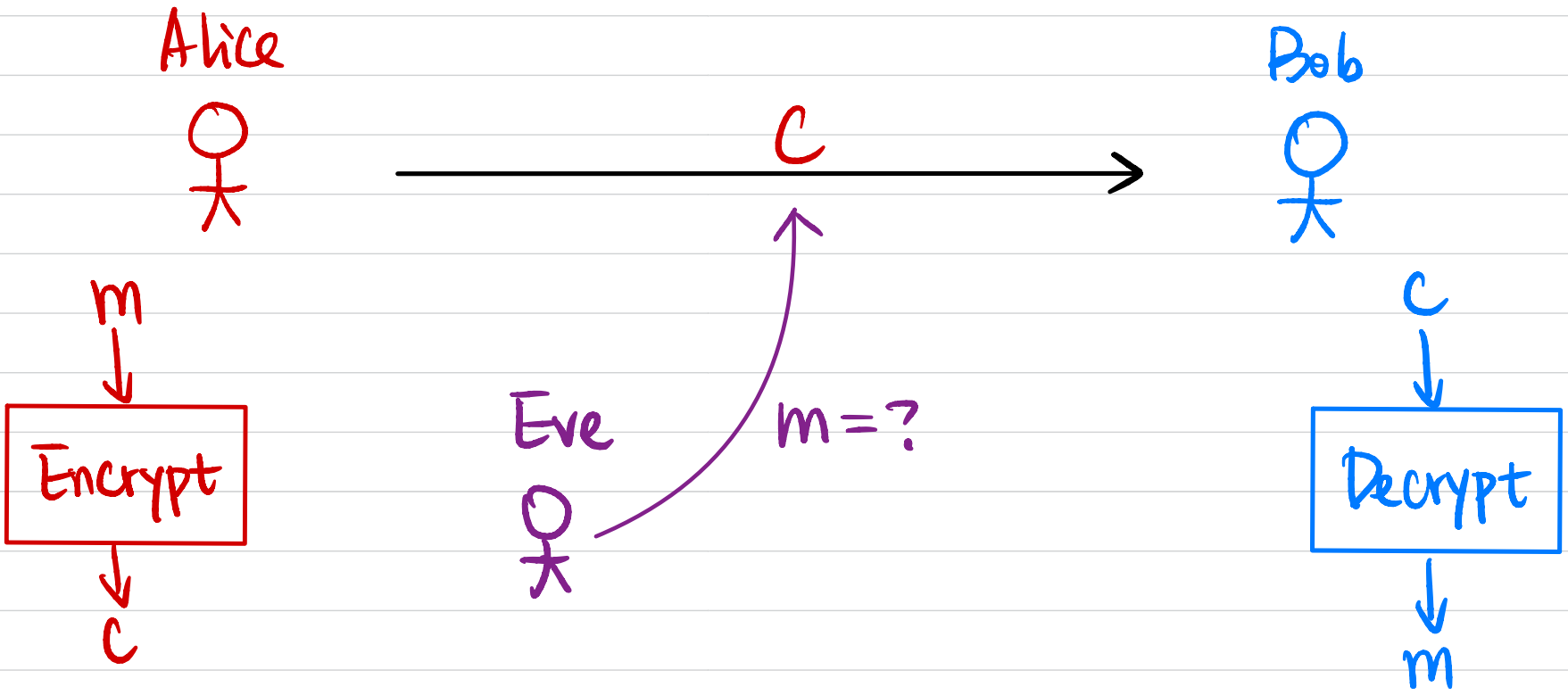
Ex: Private Dating



If $x=y=1 \Rightarrow 11100$

Otherwise $\Rightarrow 11010$

Project 5: Fully Homomorphic Encryption



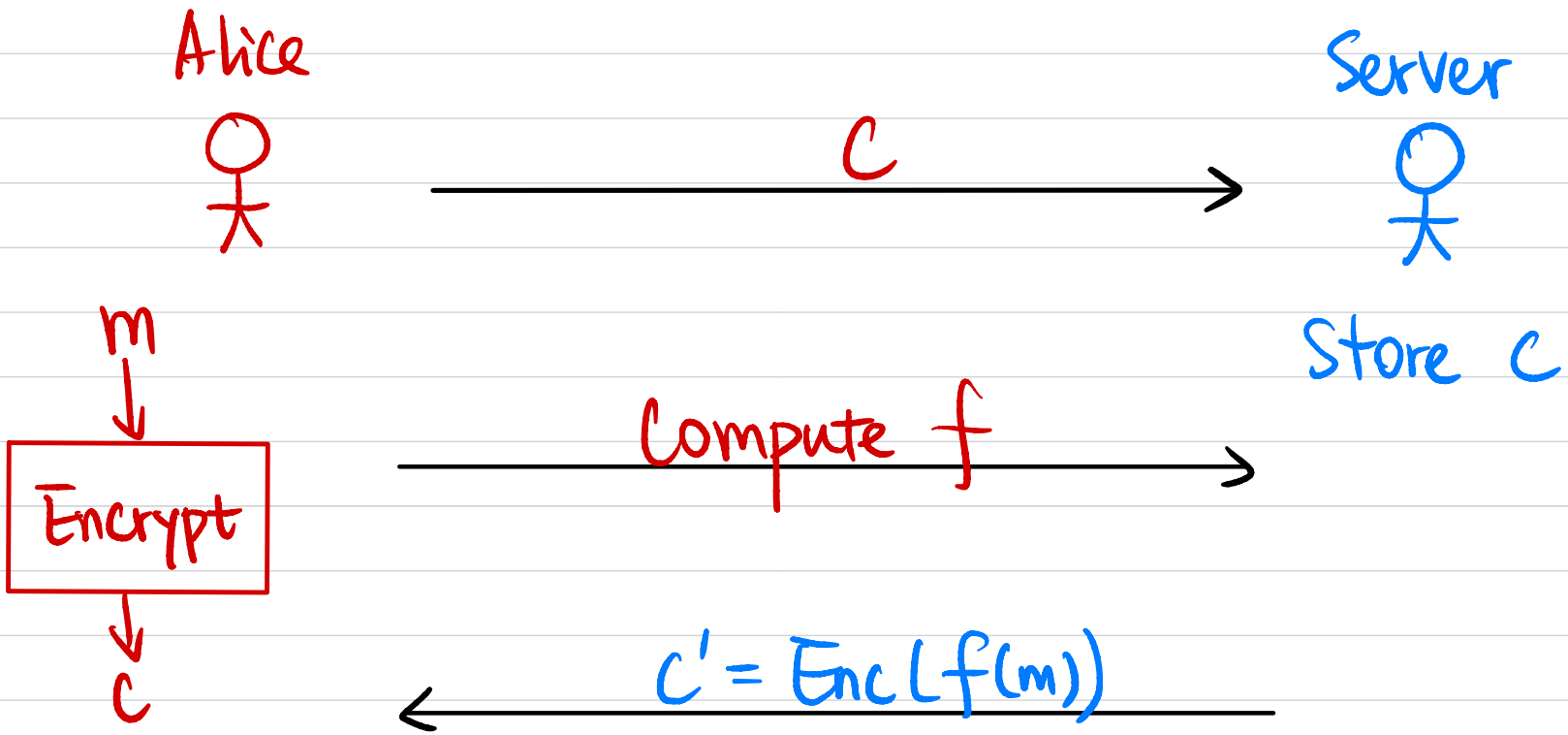
$$c_1 = Enc(m_1)$$

$$c_2 = Enc(m_2)$$

$$\Rightarrow \quad c' = Enc(m_1 + m_2)$$

$$c'' = Enc(m_1 \cdot m_2)$$

Ex: Outsourced Computation



What else would you like to learn?

- Differential Privacy
- Crypto applications in machine learning
- Crypto techniques used in blockchain

Quick Survey

Do you know what this means:

- polynomial-time algorithm
- NP-hard problem
- a divides b ($a \mid b$)
- greatest common divisor gcd(a,b)
- (Extended) Euclidean Algorithm
- Groups
- One-Time Pad
- RSA encryption / signature
- Diffie-Hellman key exchange
- SHA (hash functions)