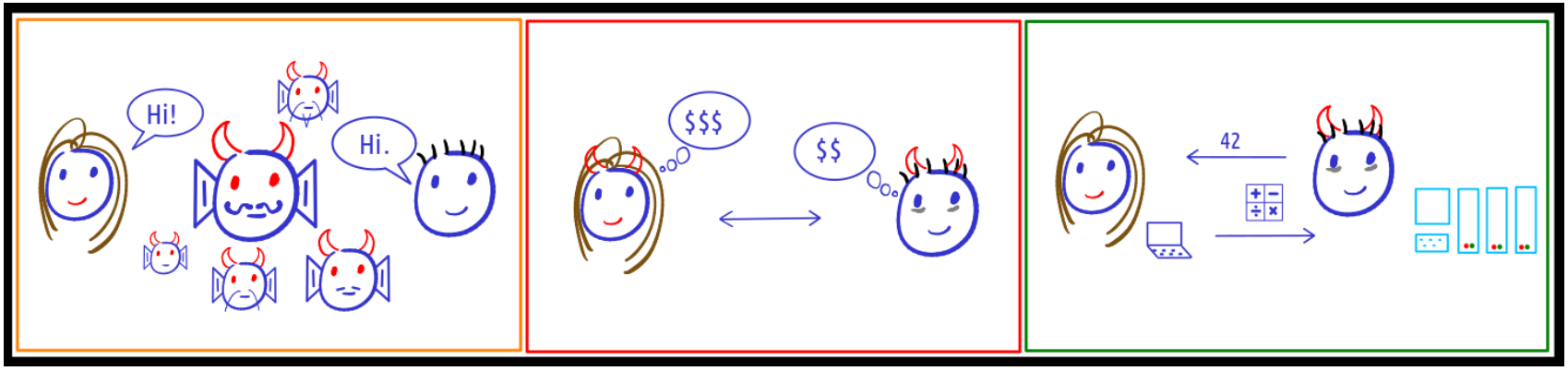

CS783: Theoretical Foundations of Cryptography

Lecture 1 (30/Jul/24)

Instructor: Chethan Kamath

Administrivia...

- Timing and Venue: Slot 10 (14:00–15:25, Tuesdays and Fridays) in CC105
- Contact hours: after lectures, or appointment by e-mail
- Teaching assistants:
  - Sarthak Sharma (23M0789) and Nivesh Aggarwal (22b0912)

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- Resources
  - Slides and other resources will be posted on my website
    - cse.iitb.ac.in/~ckamath/courses/2024/CS783.html
  - Announcements/online discussion on Moodle:
    - moodle.iitb.ac.in/course/view.php?id=4702

Administrivia...

- Grading Scheme
  - Six ungraded assignments to help with quizzes and exams

Weightage	Towards
35%	Final
25%	Mid-term
20%	Two quizzes, one each after Modules I and III
15%	Group project/chalk-talk
5%	Class participation, pop-quiz

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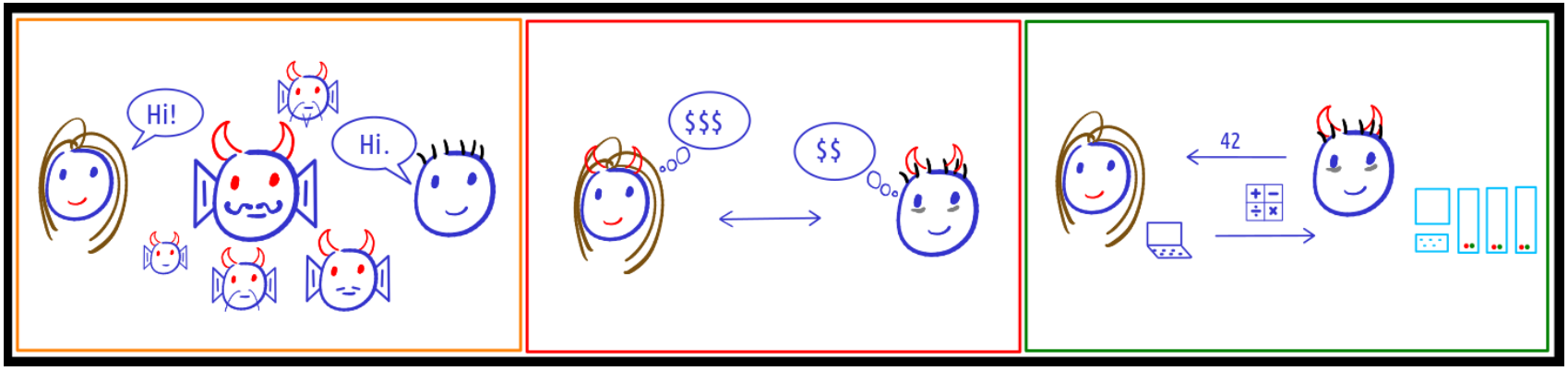
- Will scrap group project/chalk talk if number of creditors > 30 and grade will be redistributed
- Attendance is not mandatory (but encouraged)
- Any volunteers for class rep?



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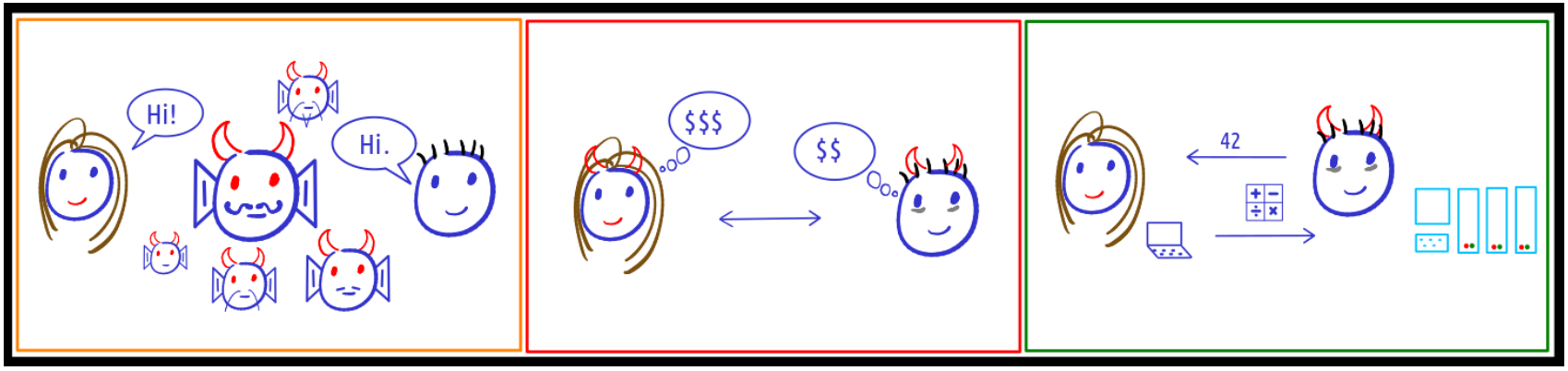

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You Use Cryptography all the Time!

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Using internet

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Secure communication

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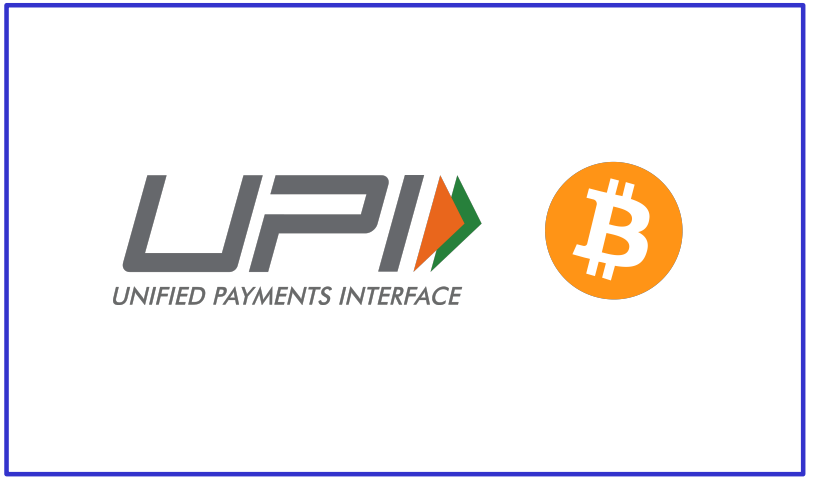

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What is Cryptography?

- Science of carrying out *tasks* securely in an adversarial setting

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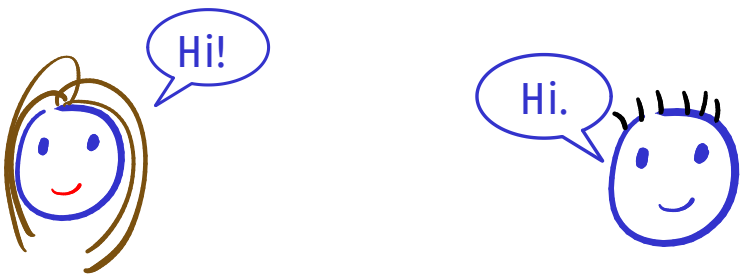

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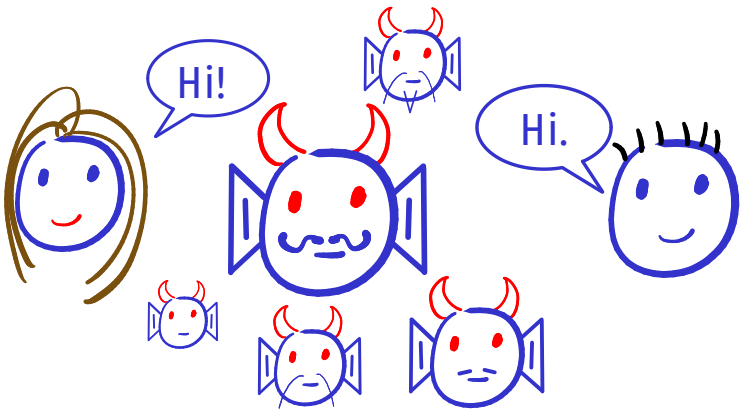

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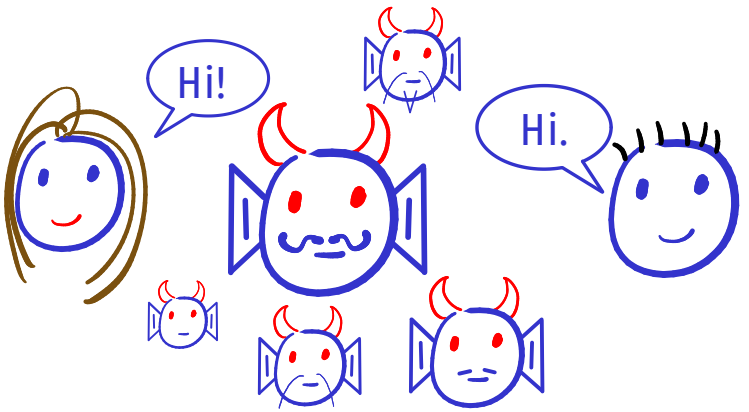

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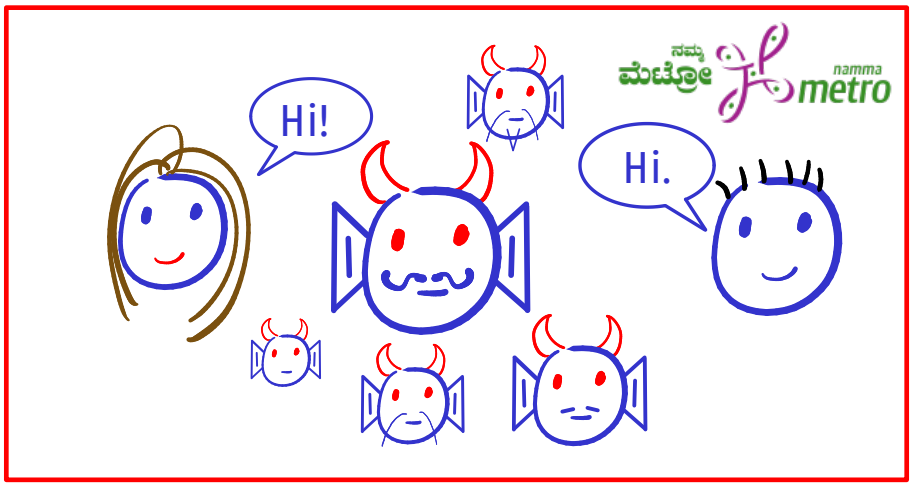

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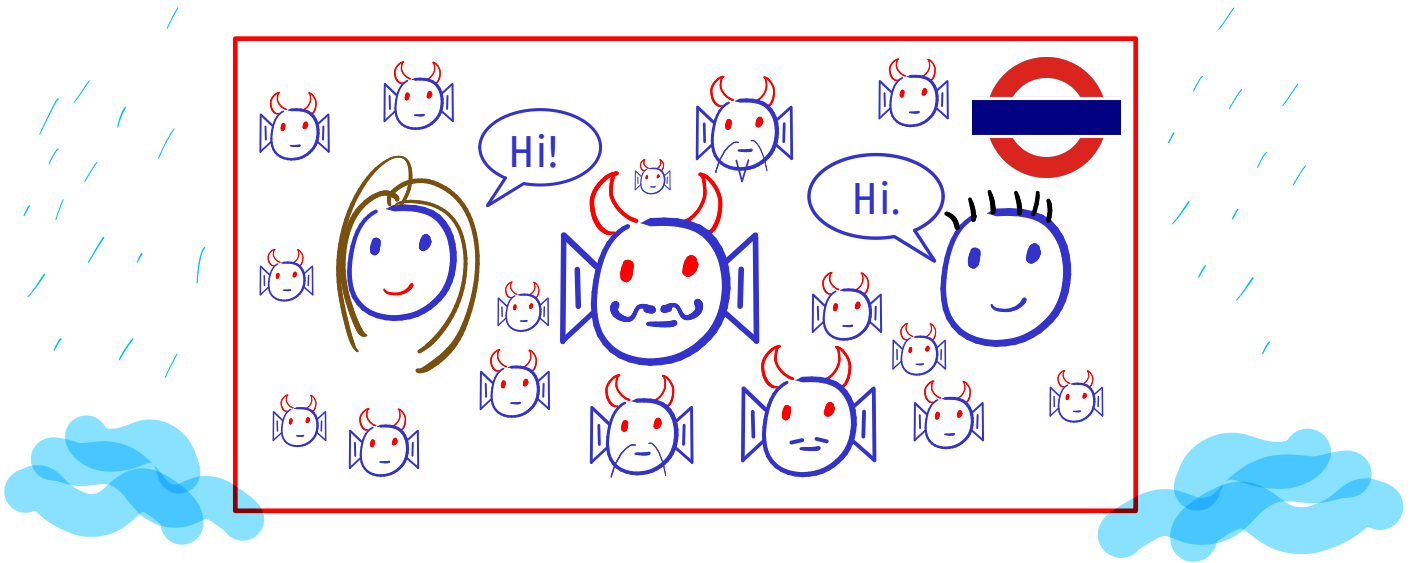

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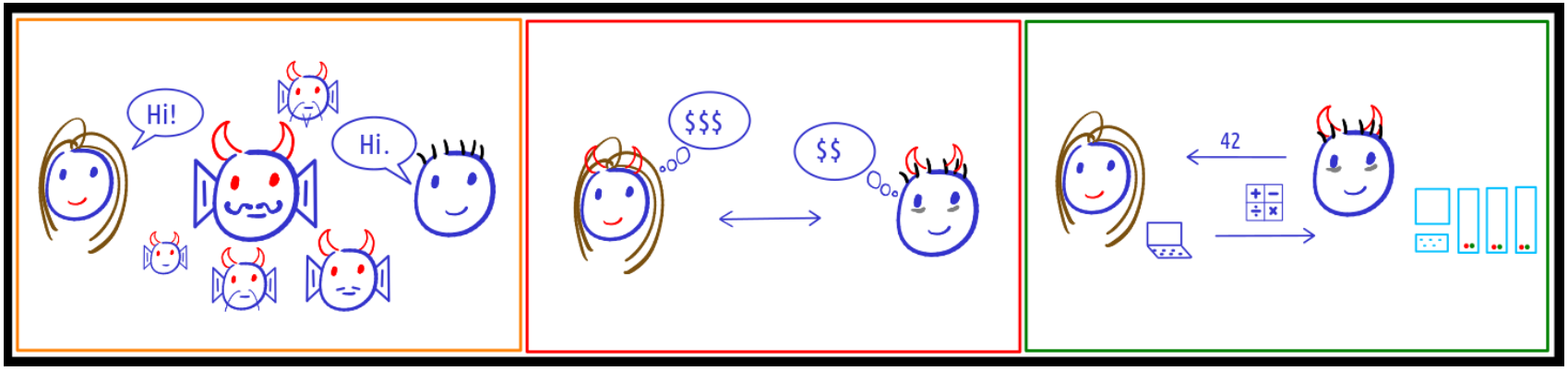

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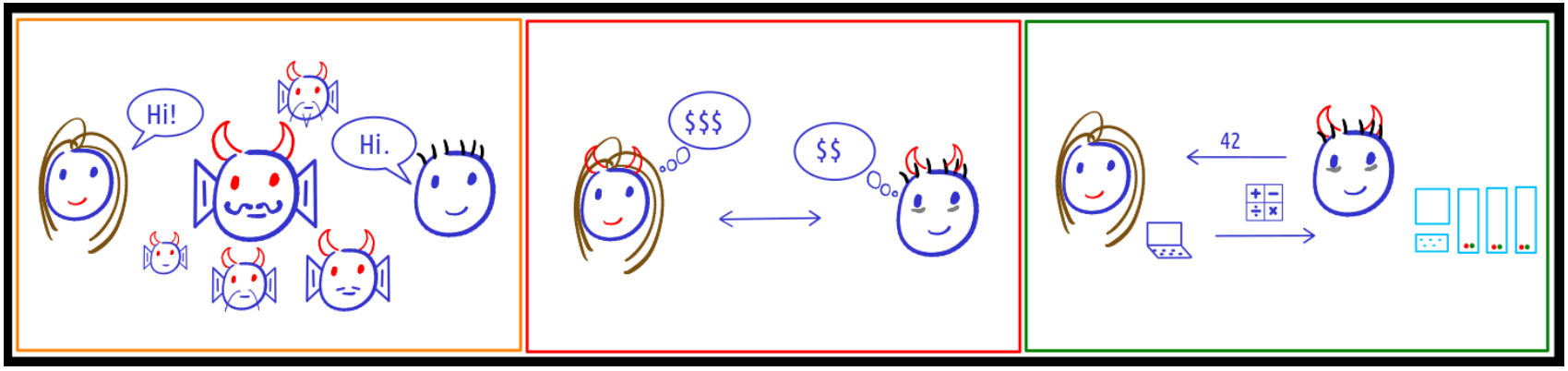

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- Soft prerequisites: discrete mathematics, probability theory, some familiarity with formal proofs

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This Lecture: An Overview of the Tasks Covered...

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- Roughly corresponds to four "eras"

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(Shared keys)

For a large part of history

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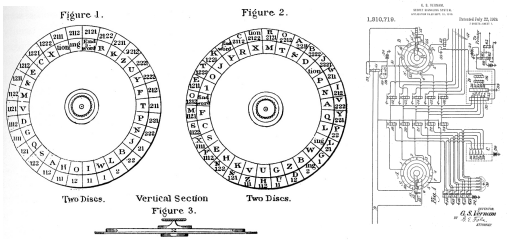

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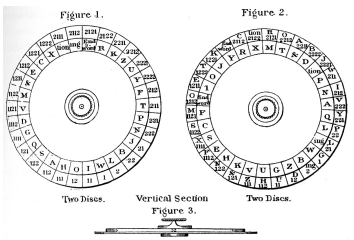

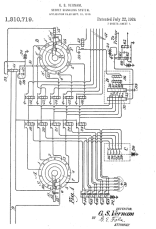

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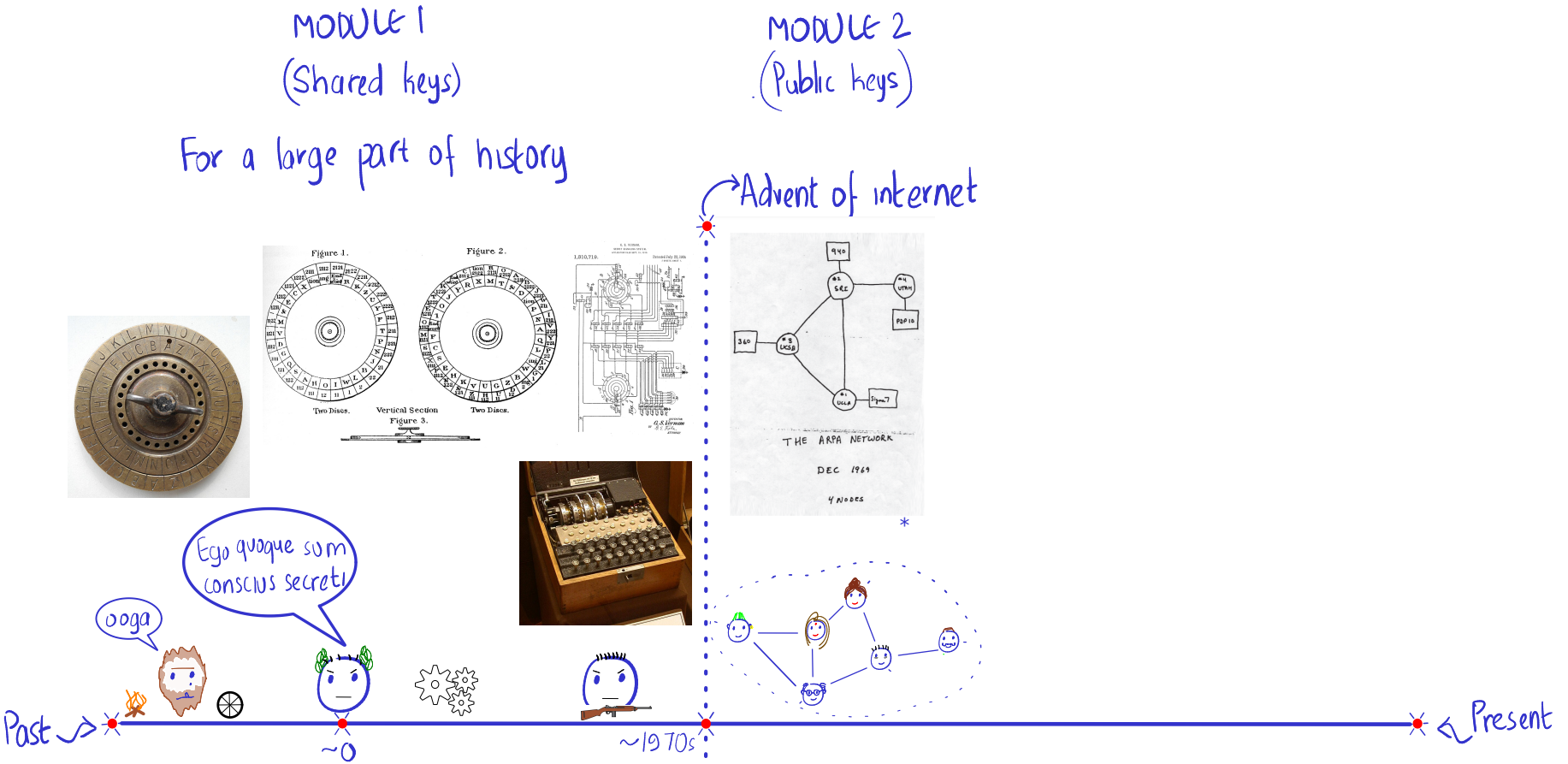

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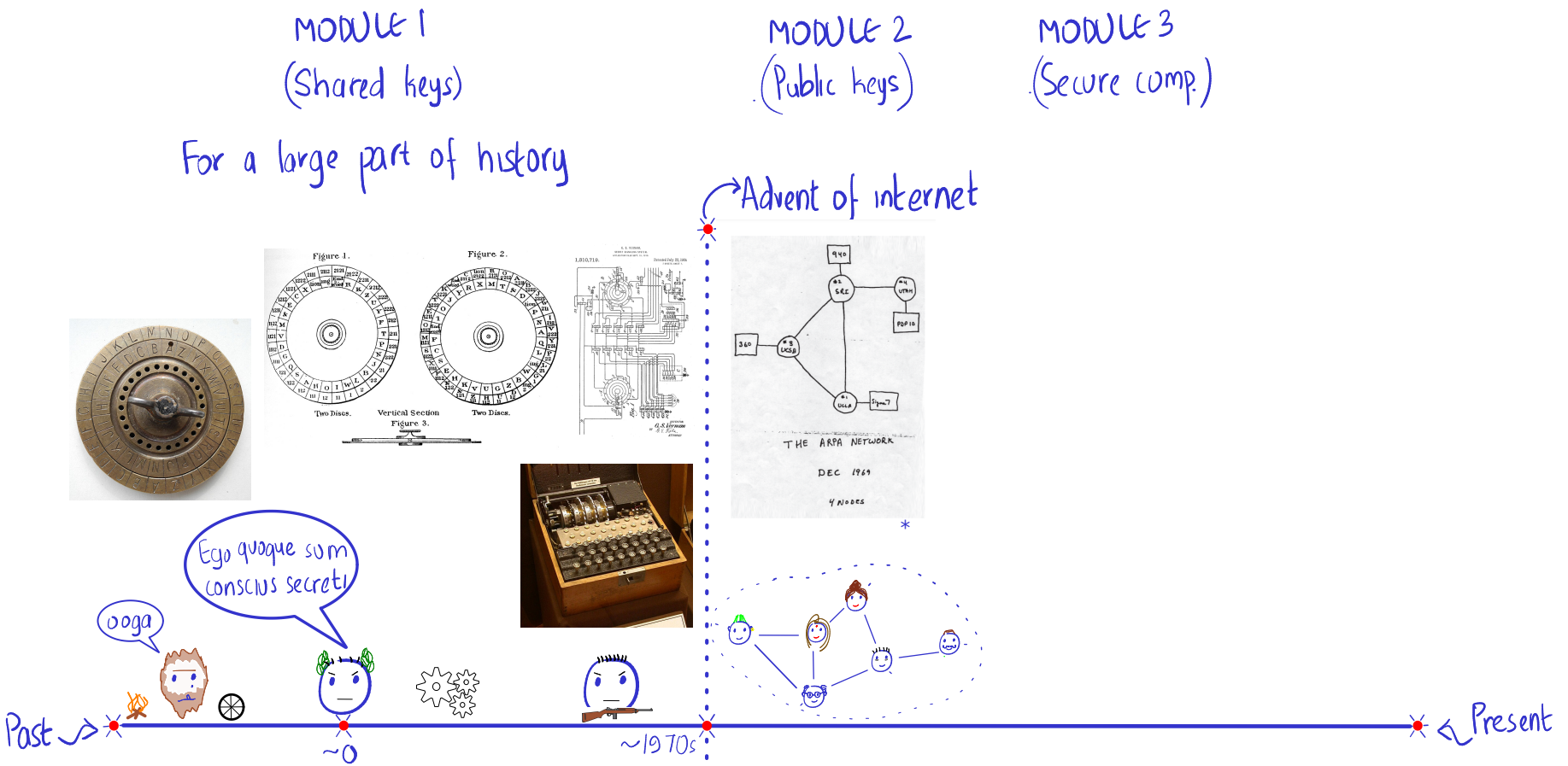

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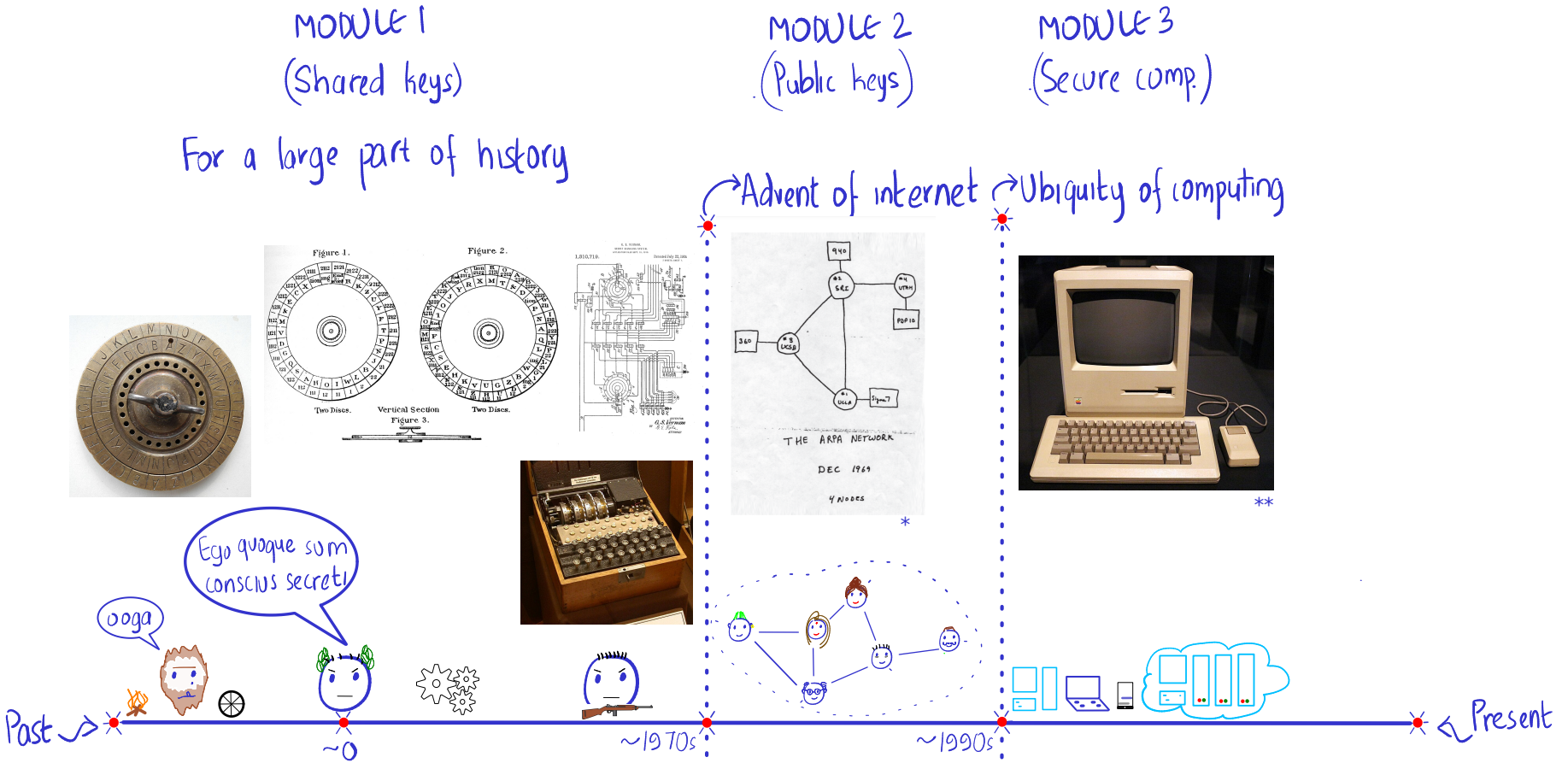

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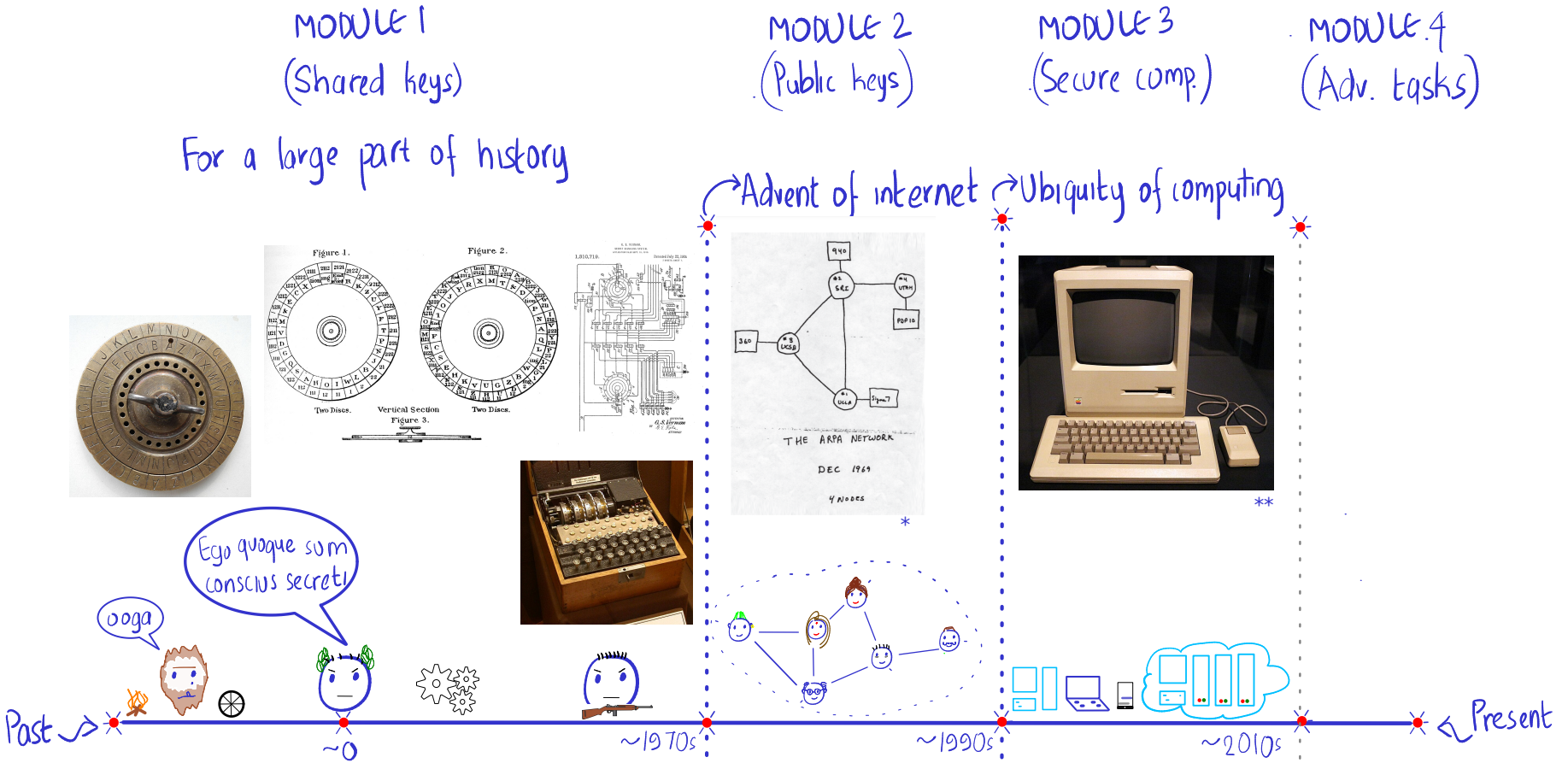

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An Overview of the Course

1. Module I: Secure Communication in Shared-Key Setting
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The Universal Need for Private Communication

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(Shared keys)

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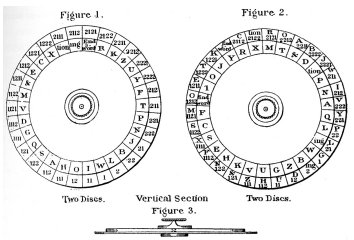

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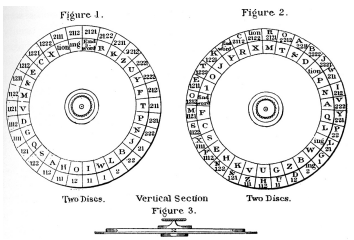

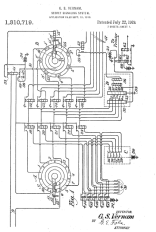

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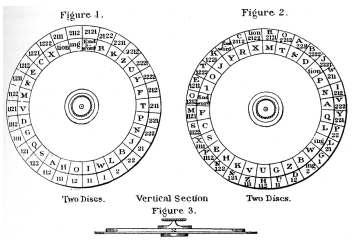
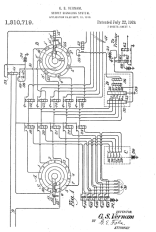
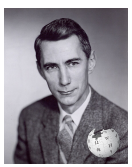




Birth of information theory & CS

Foundations of modern cryptography



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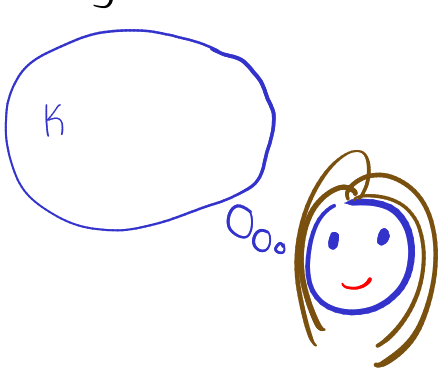

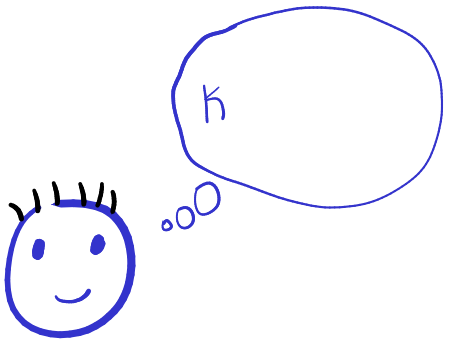

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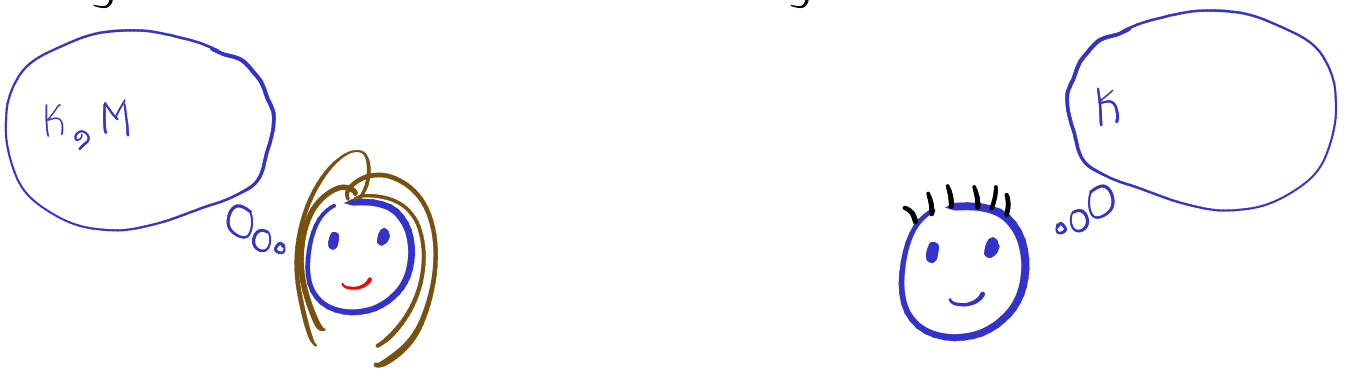

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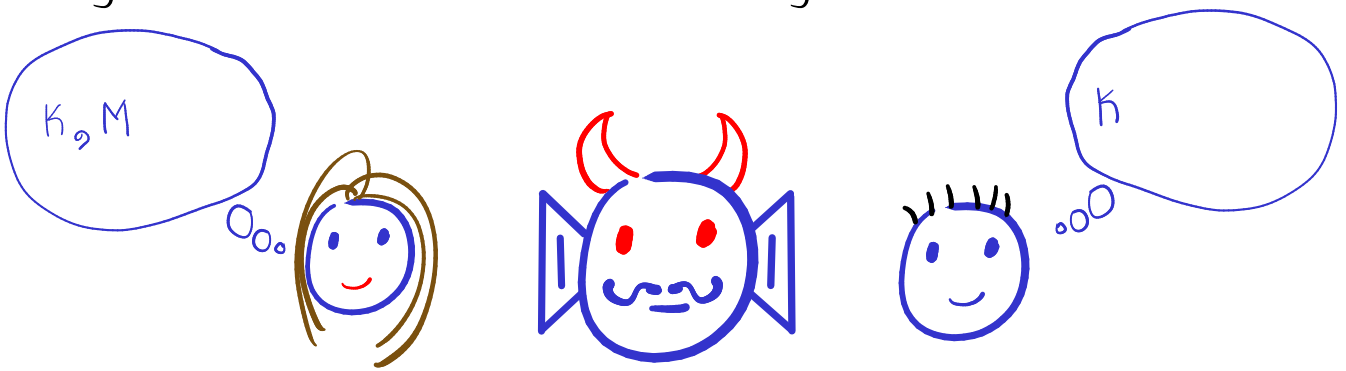

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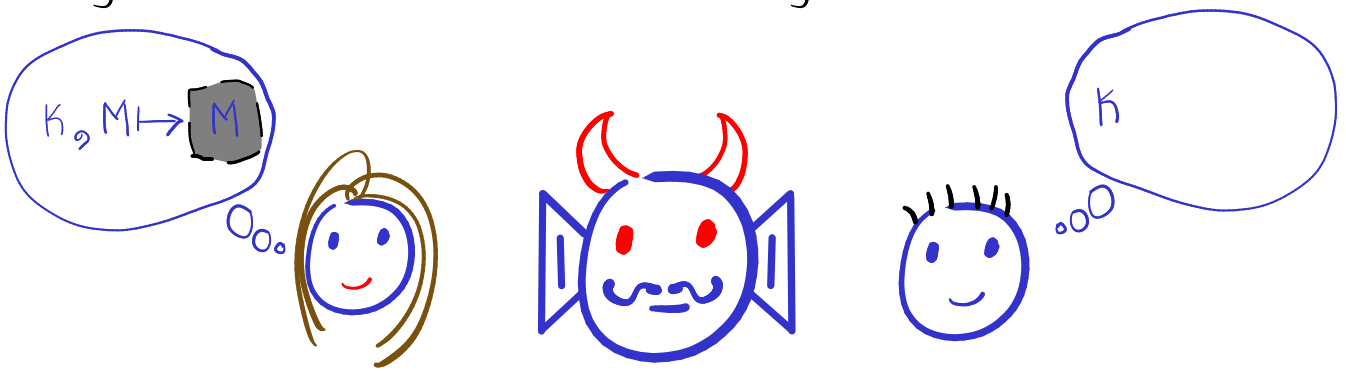

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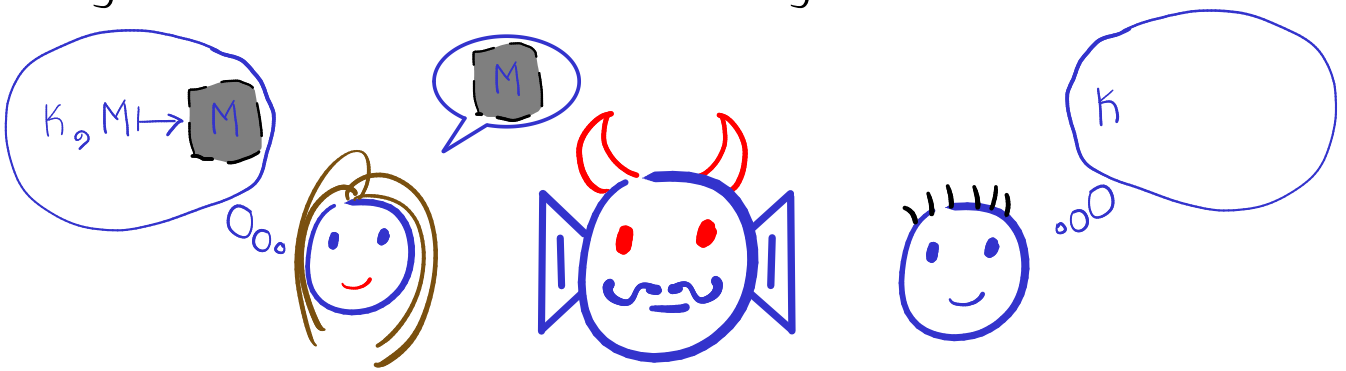

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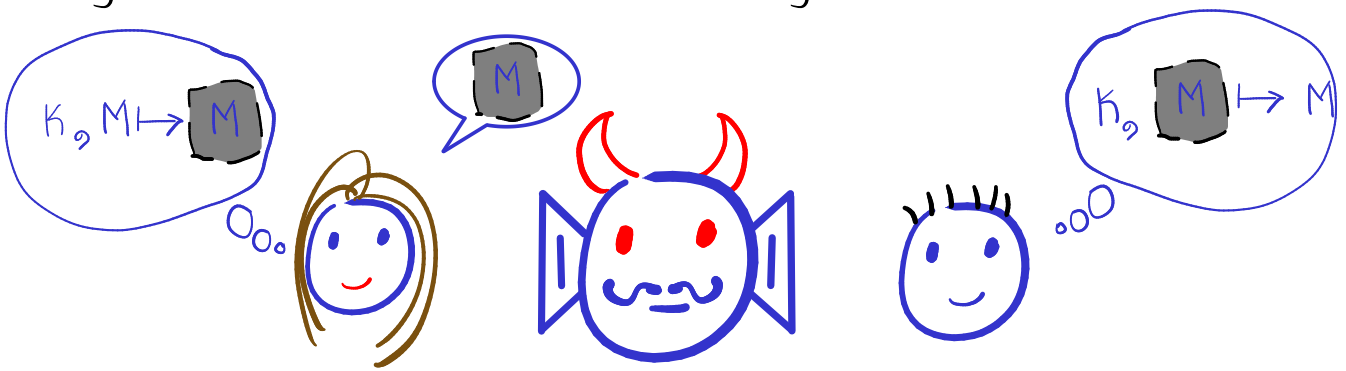

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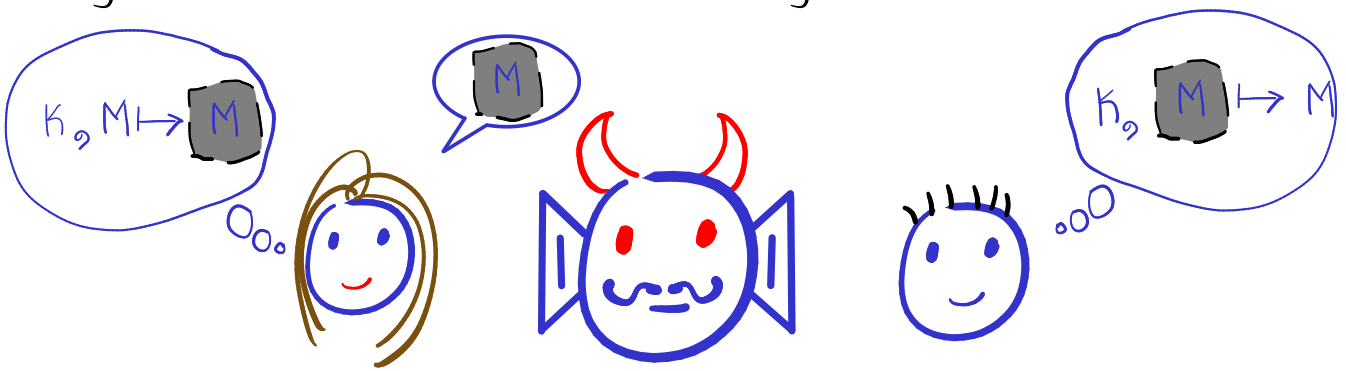

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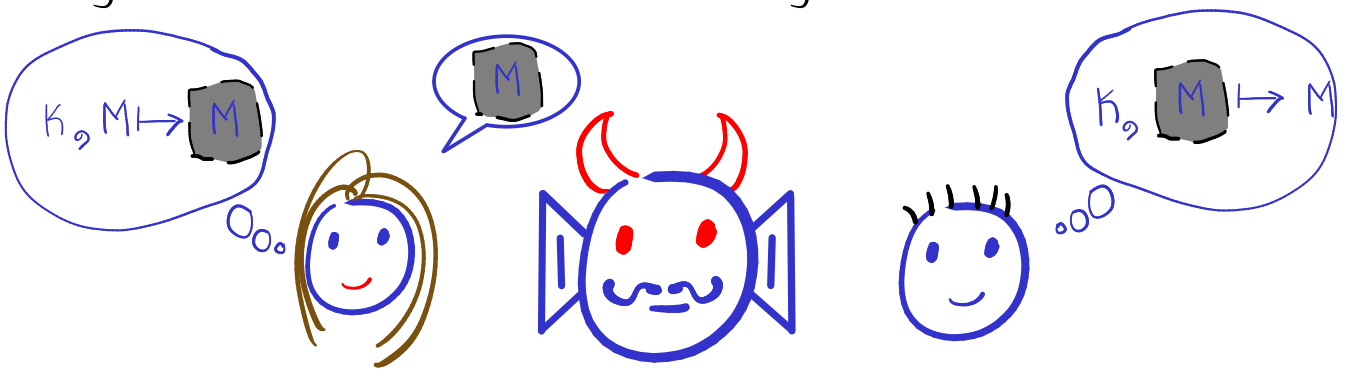

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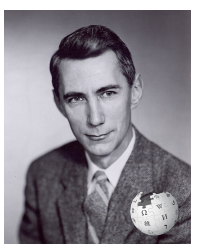
- What we will learn:
  - Classical ciphers, and why they are not perfectly secure
  - One-time pad (OTP), and why it is perfectly secret
  - Shannon's impossibility: for perfect secrecy, $|\mathtt{K}| \geq |M|$



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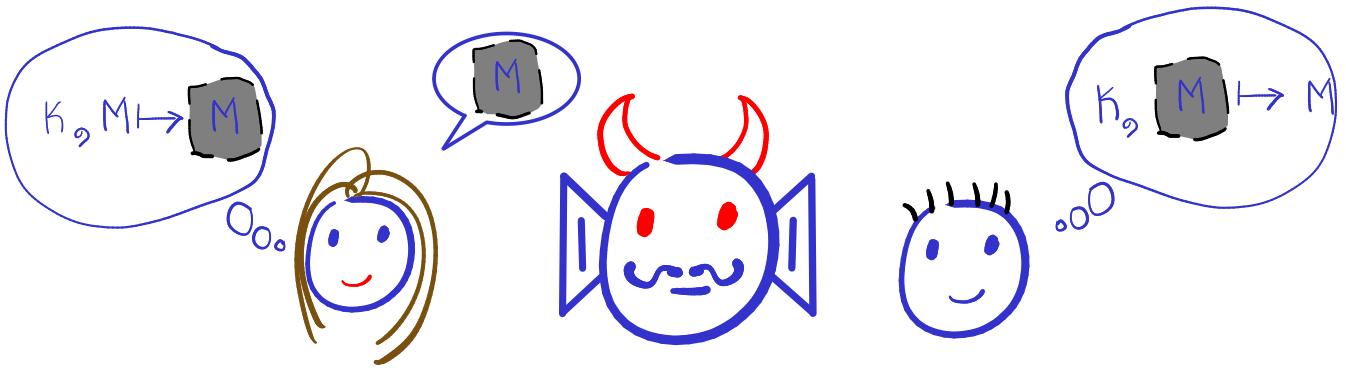

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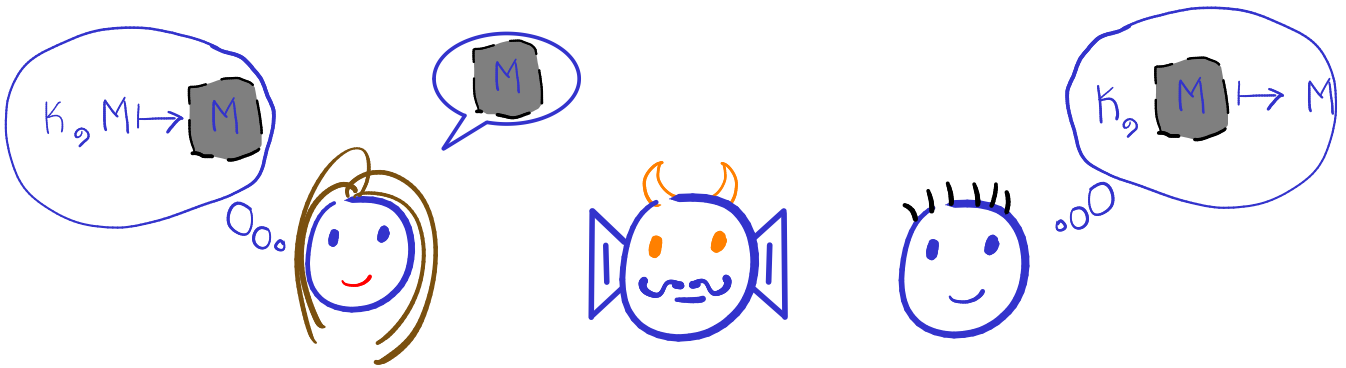
  - *Restrict/bound* the adversary's computational capabilities



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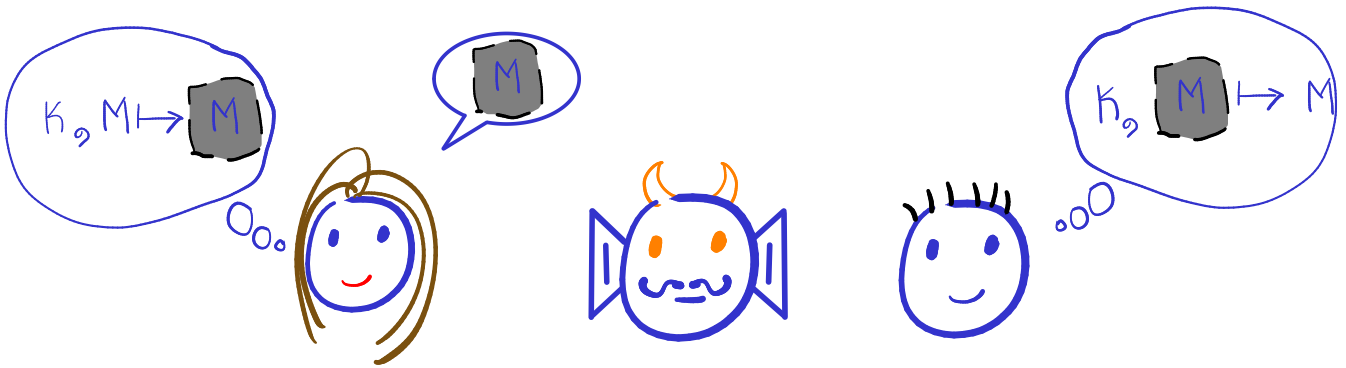

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Task 1: Secret Communication with Shared Keys...

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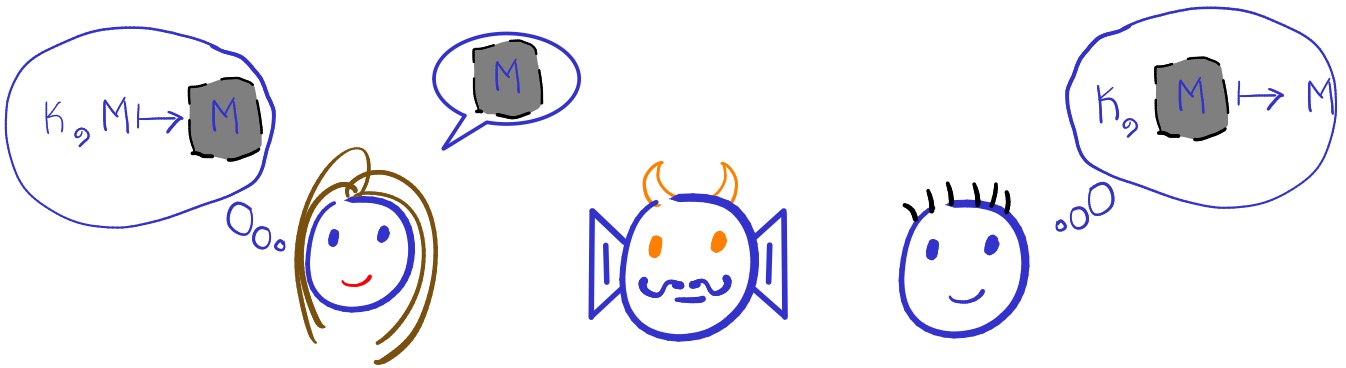

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- What we will learn:
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Dealing with More Resourceful Adversaries

- What if Eve *also* has control over the messages?
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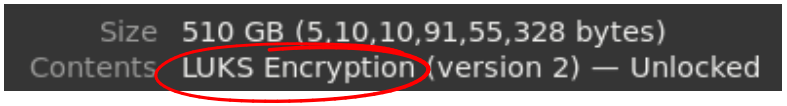

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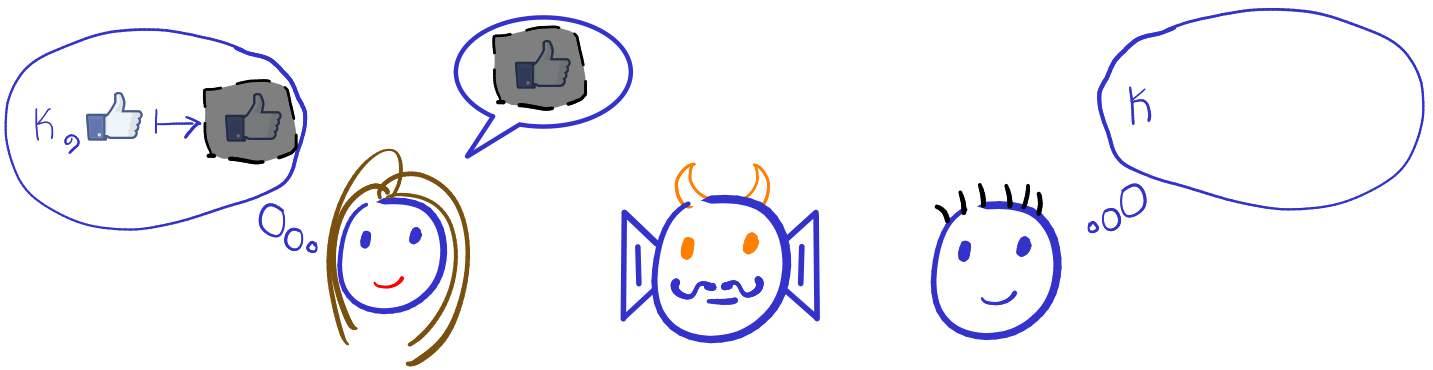

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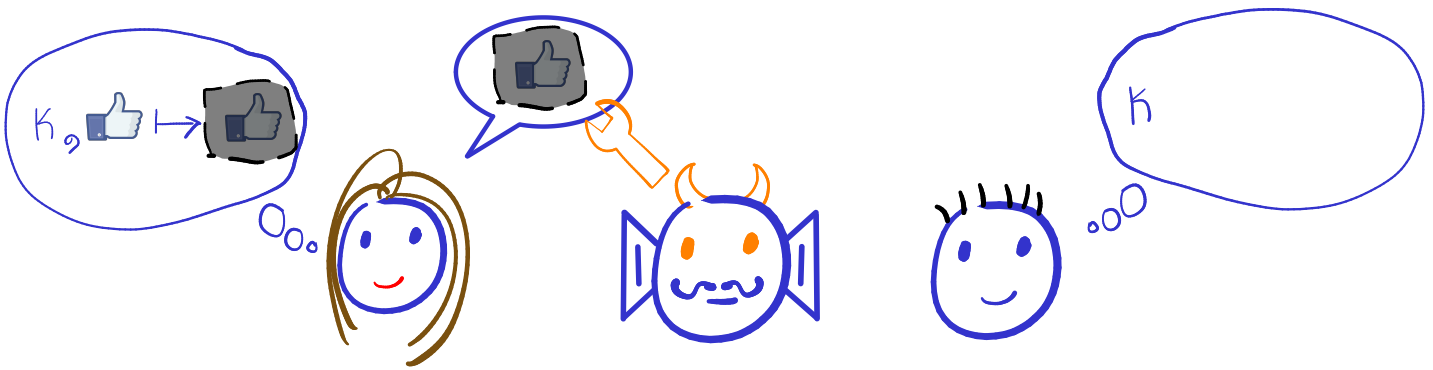

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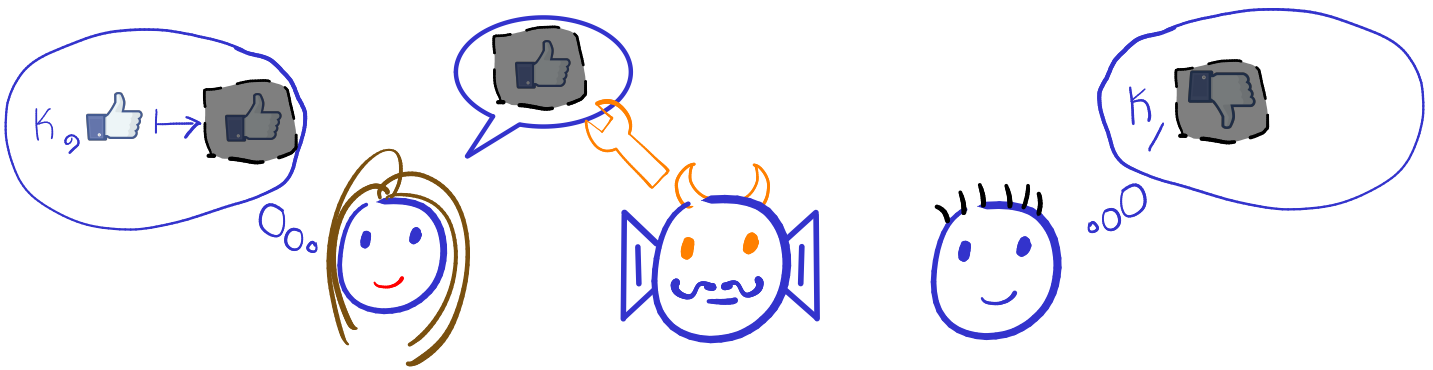

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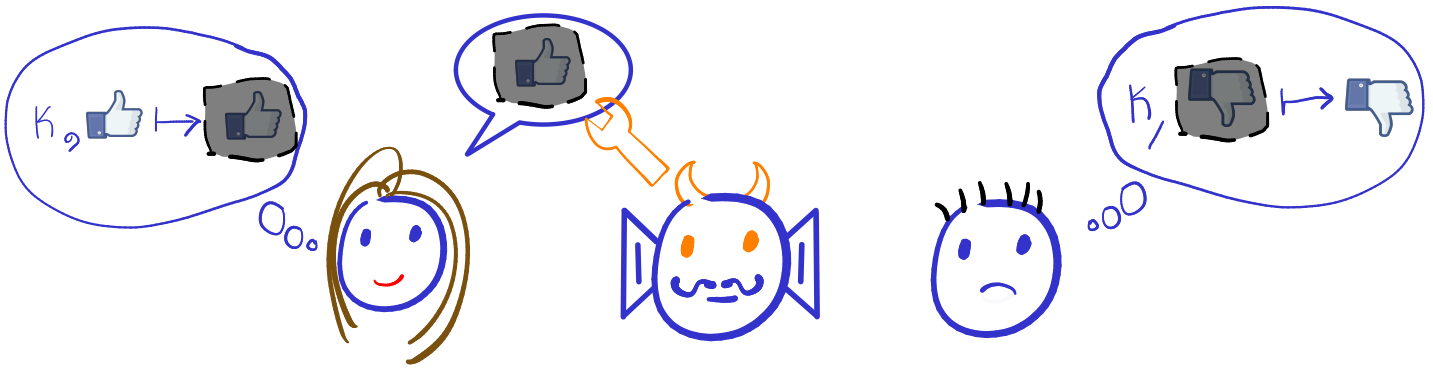

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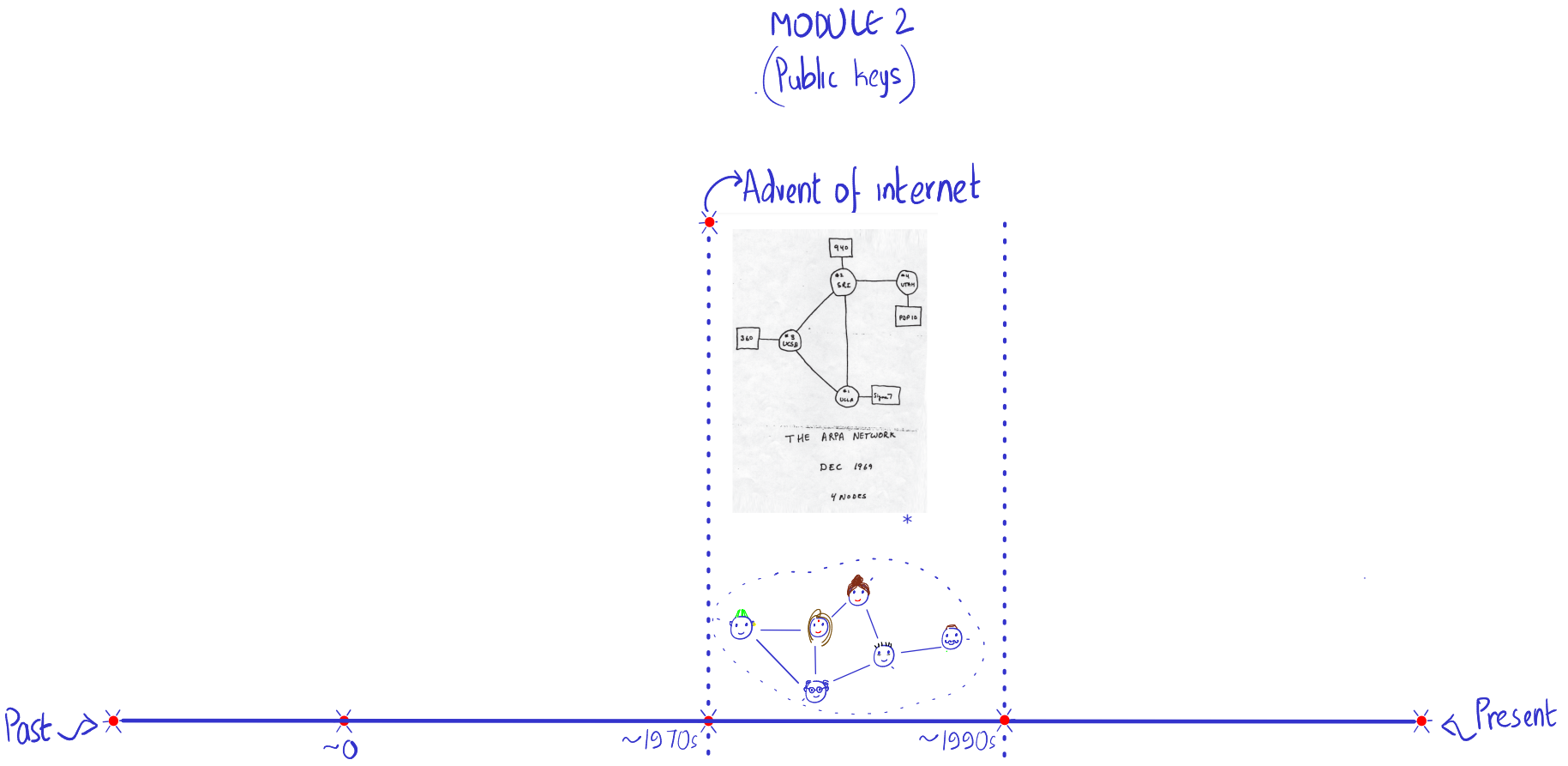
Advent of Internet and the Scaling Problem



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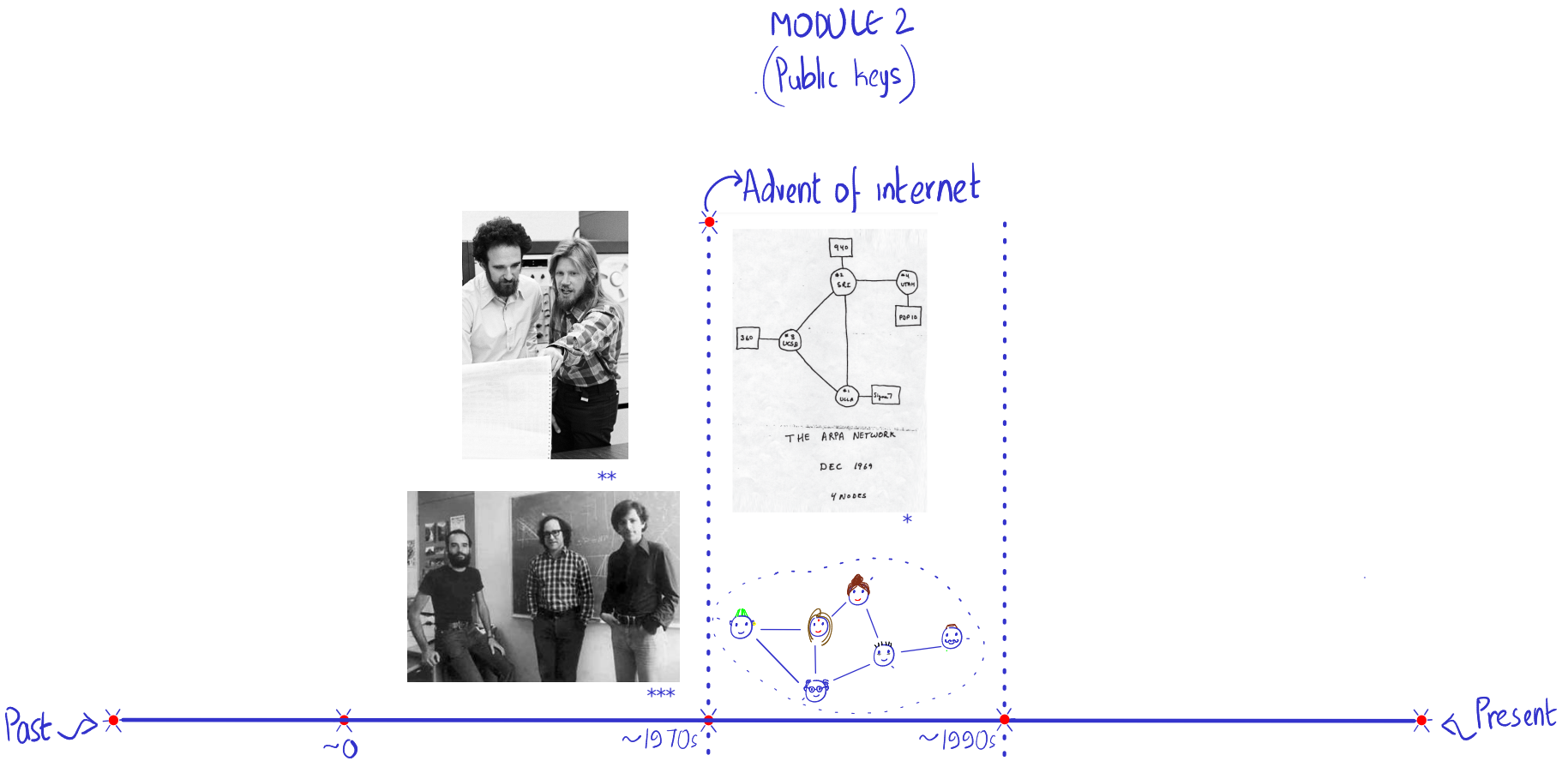

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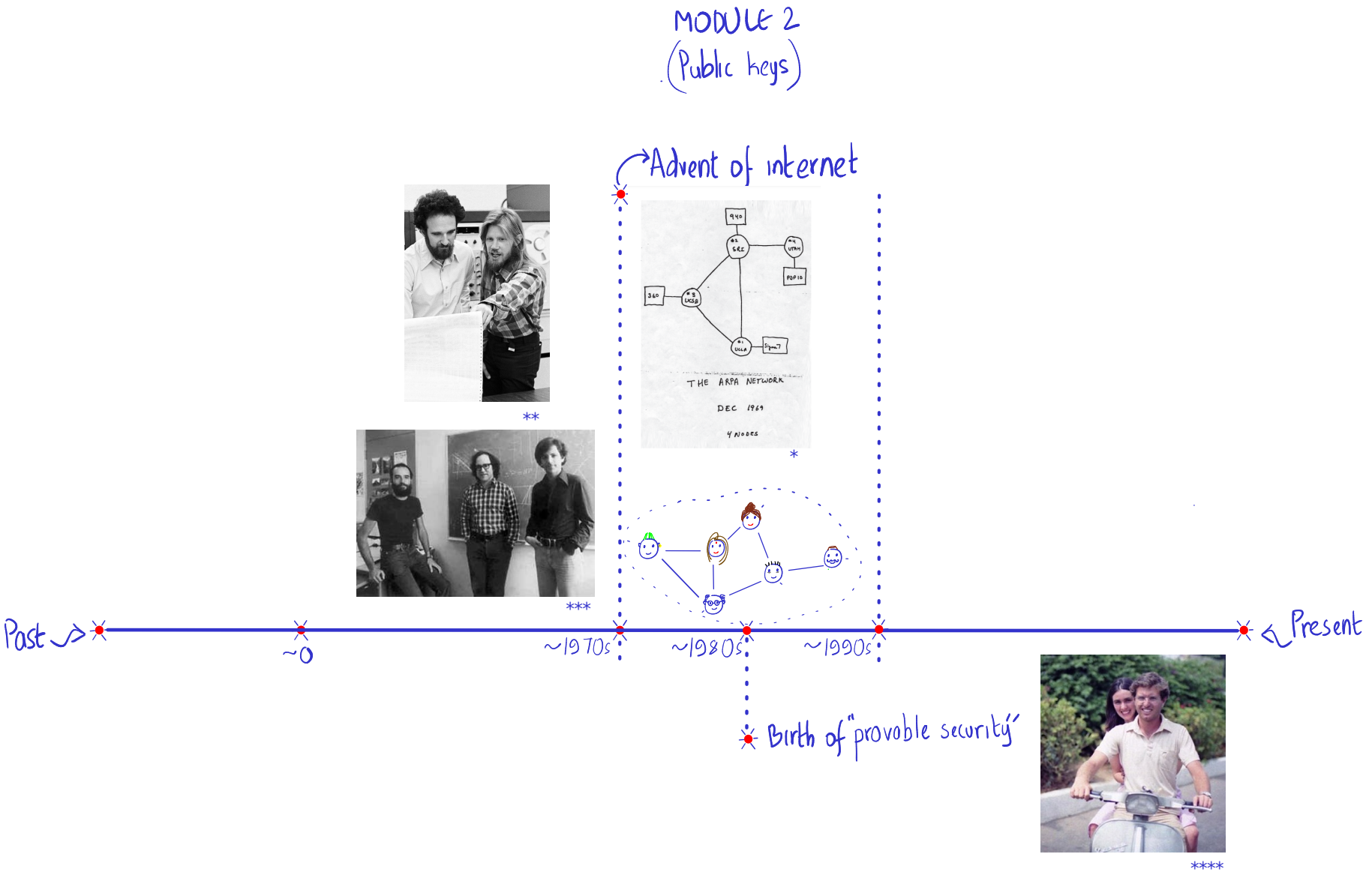

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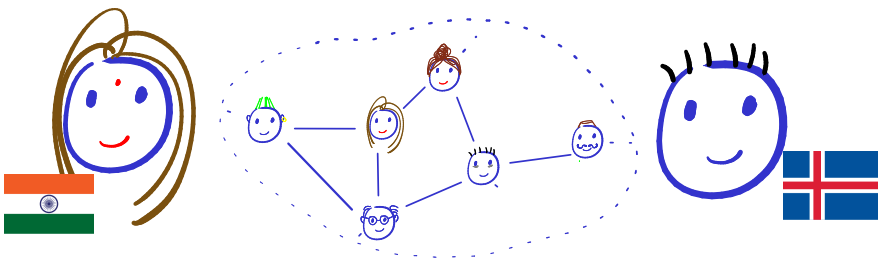

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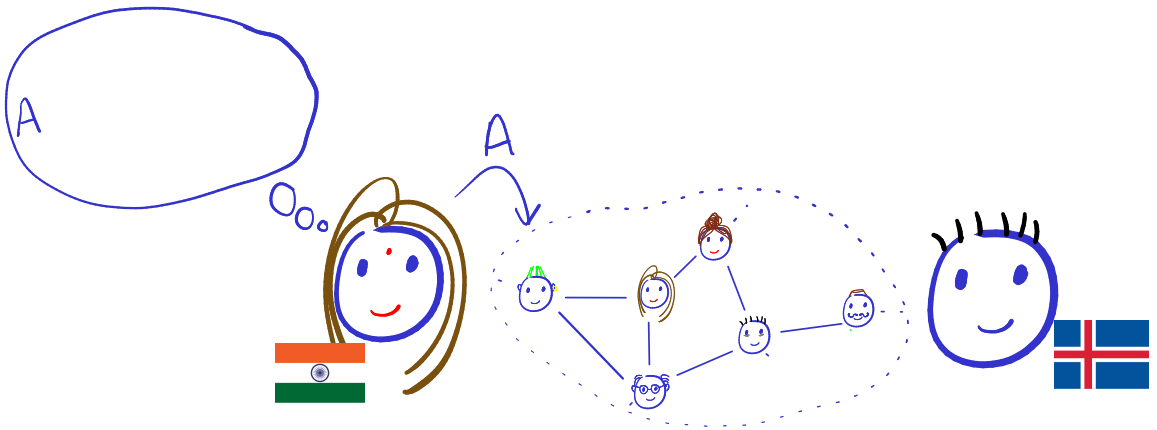

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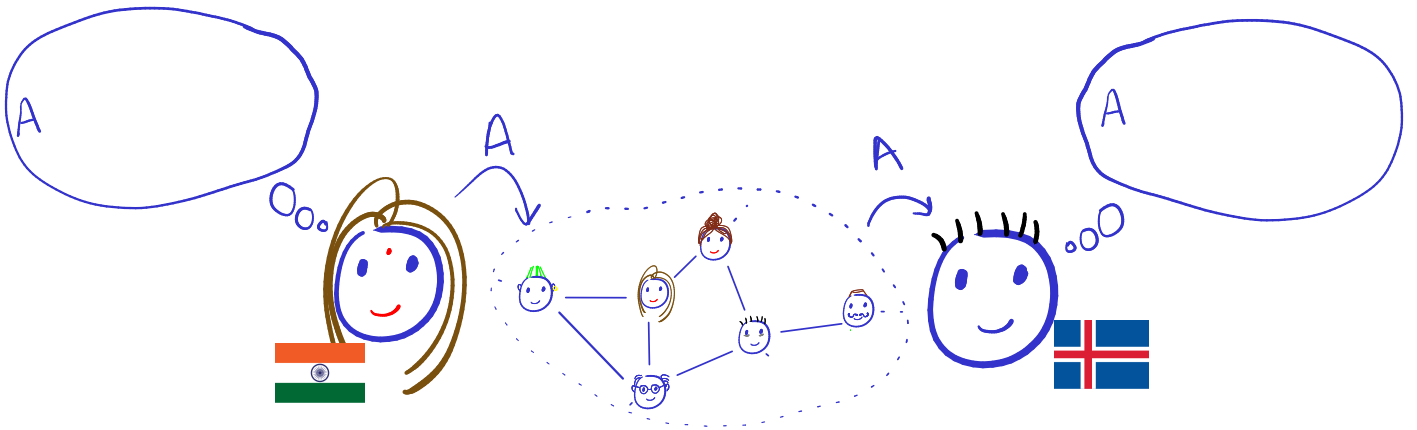

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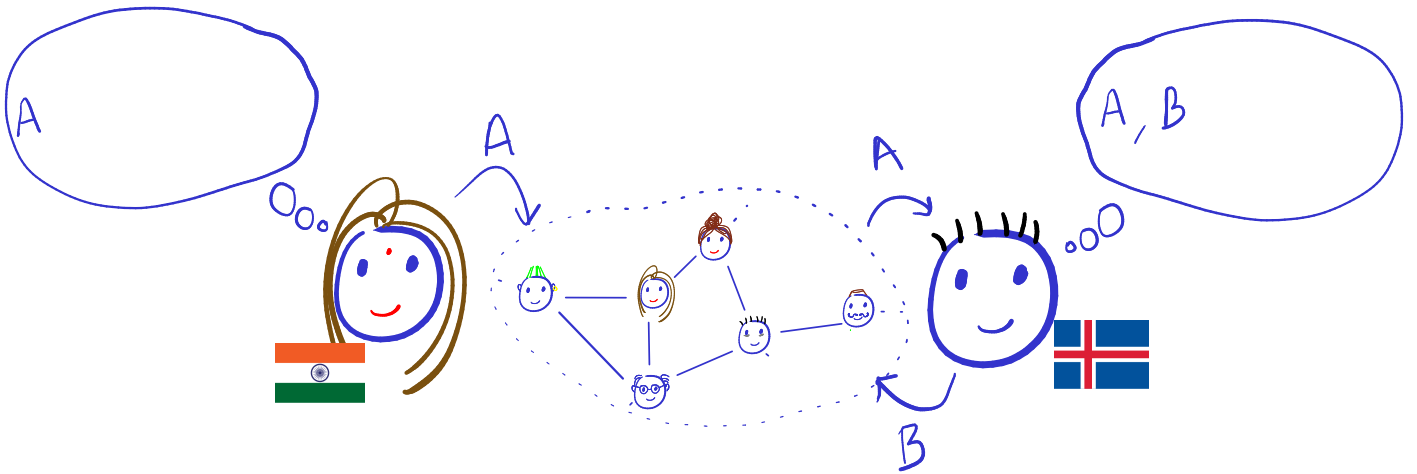

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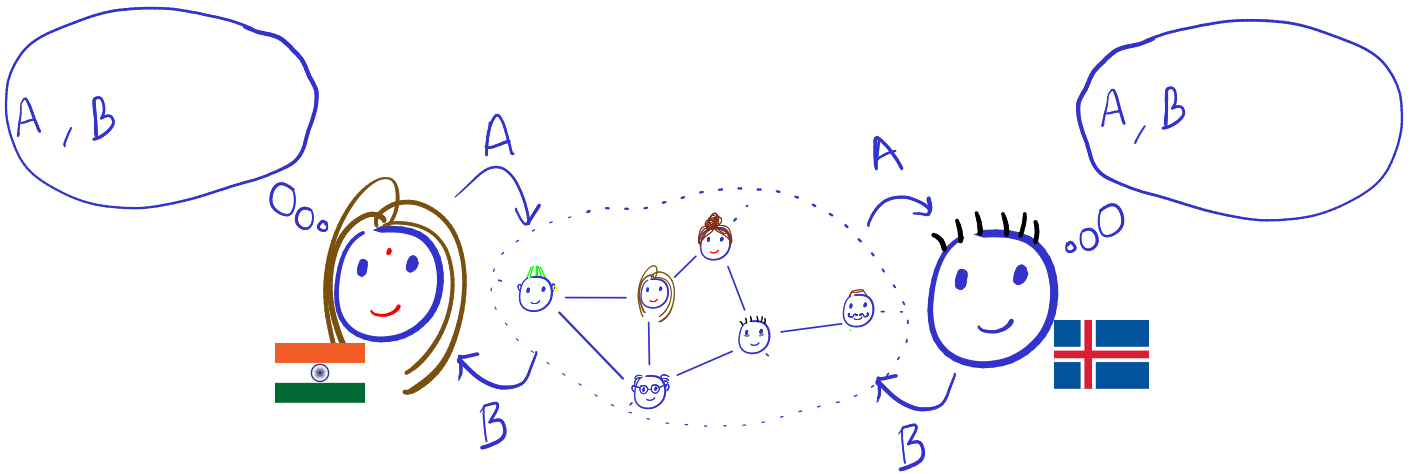

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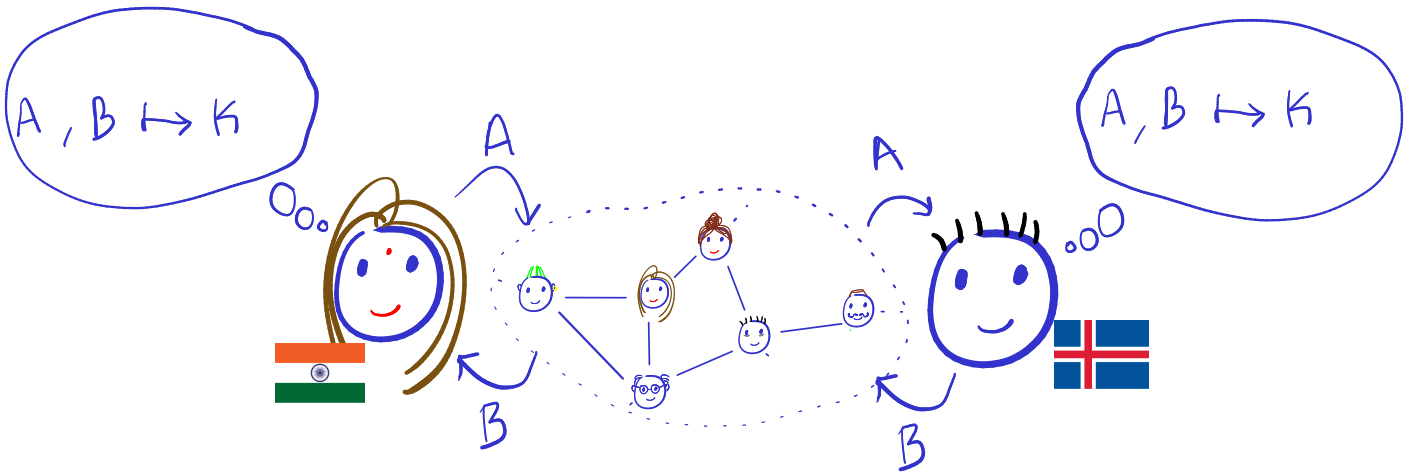

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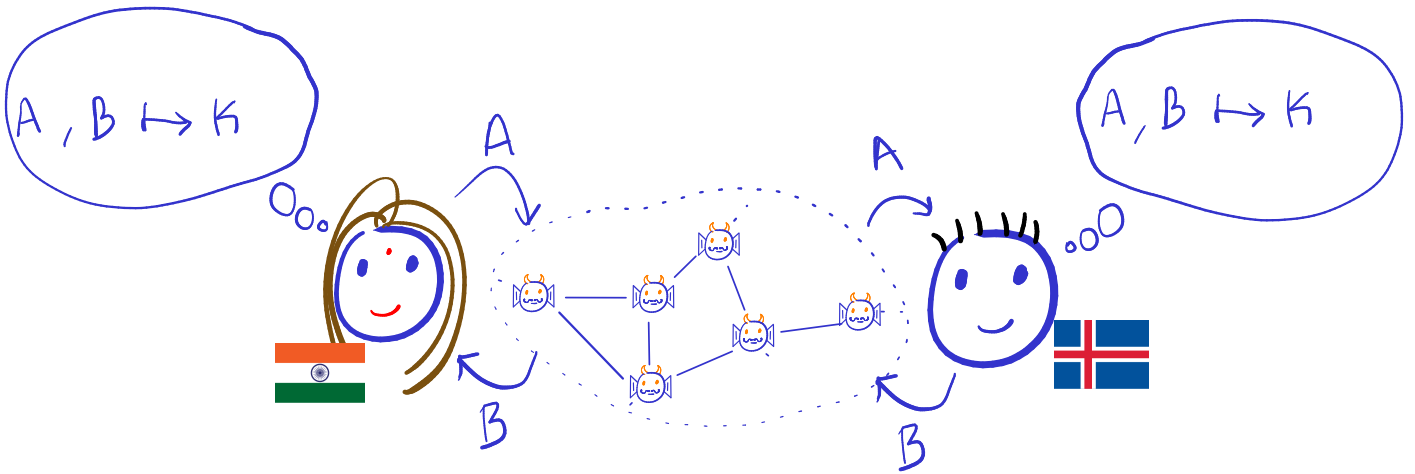

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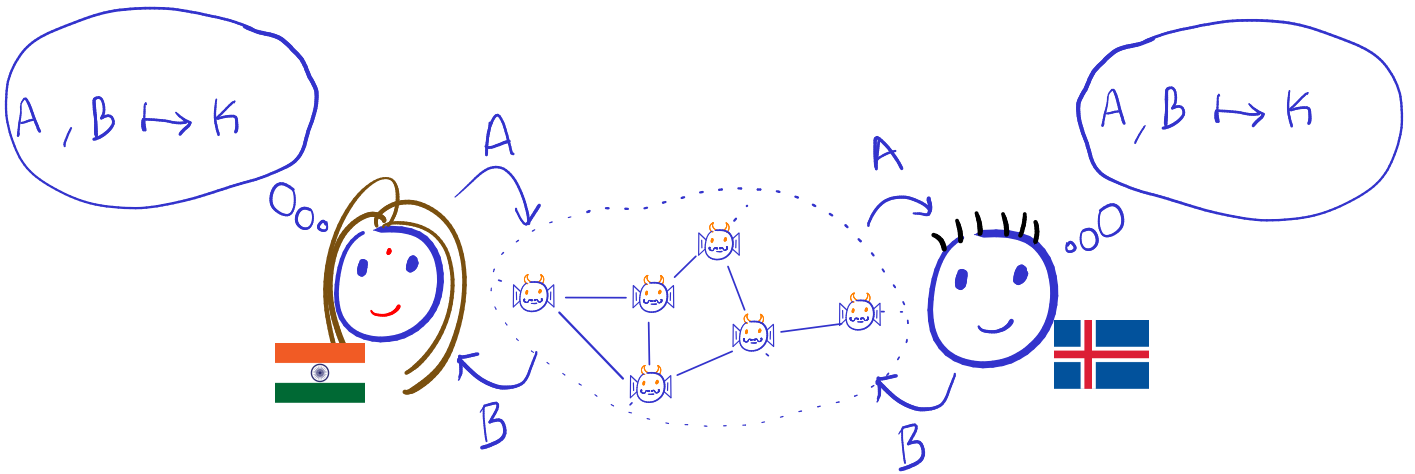

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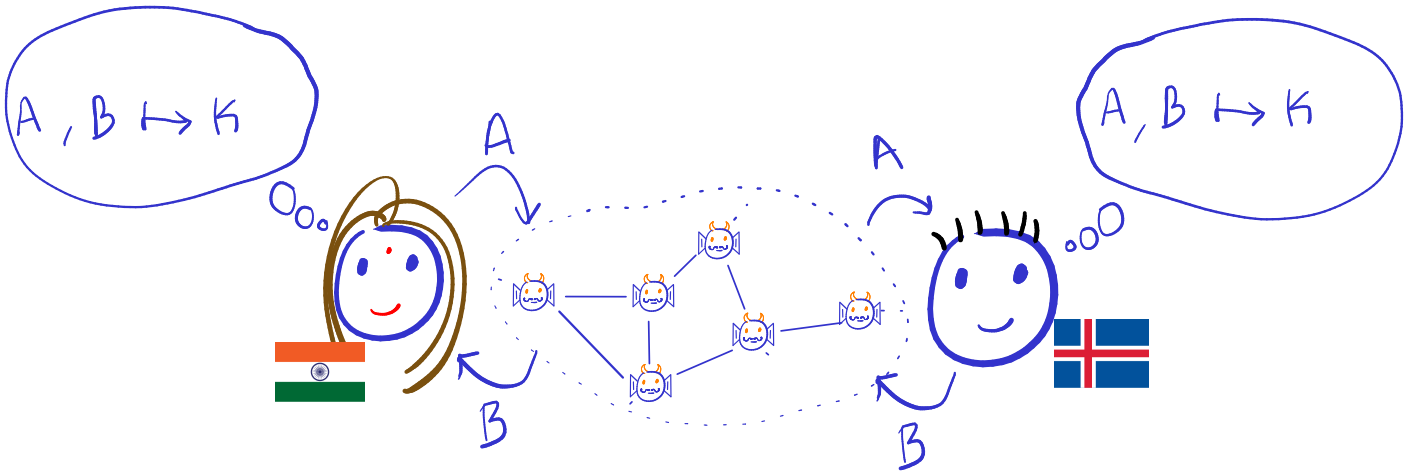

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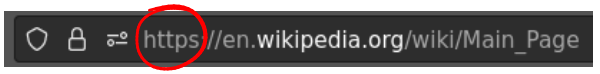

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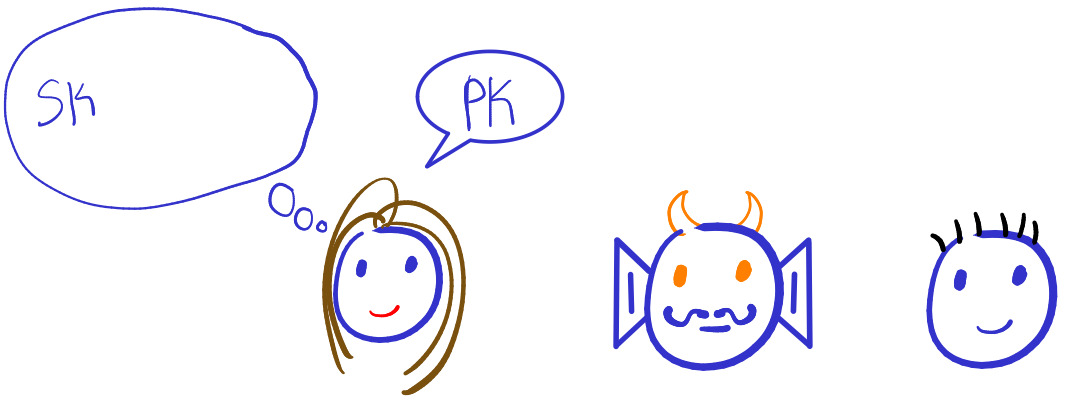

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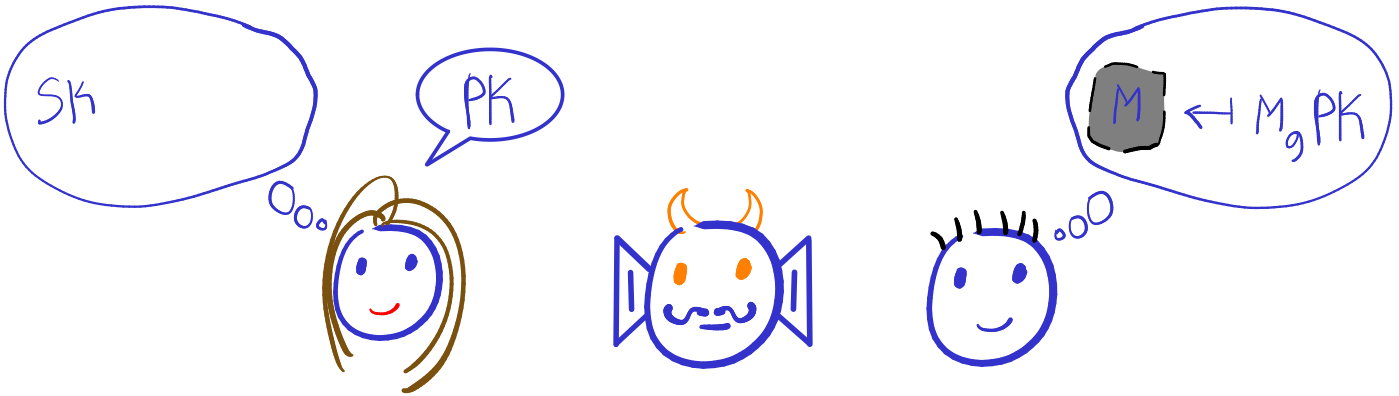

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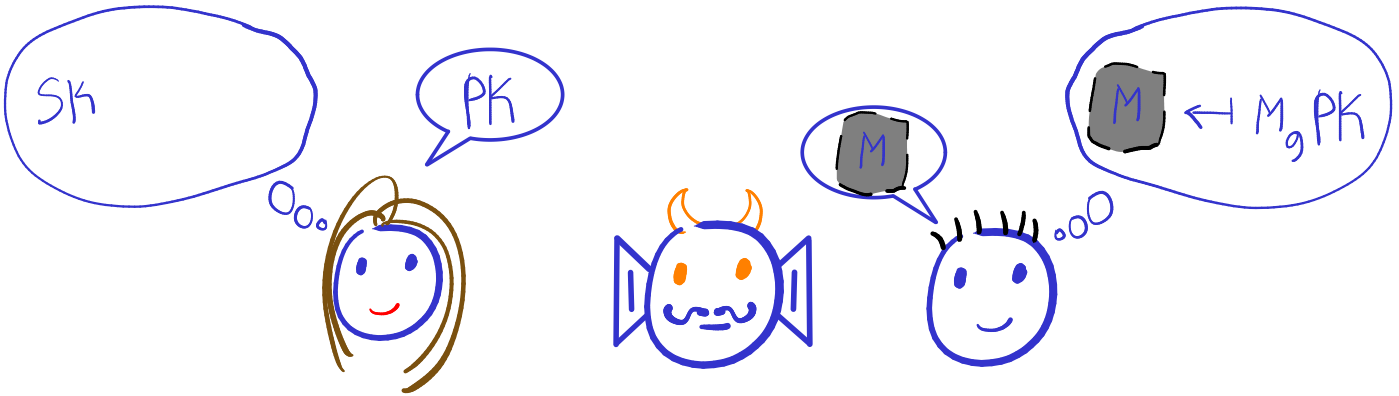

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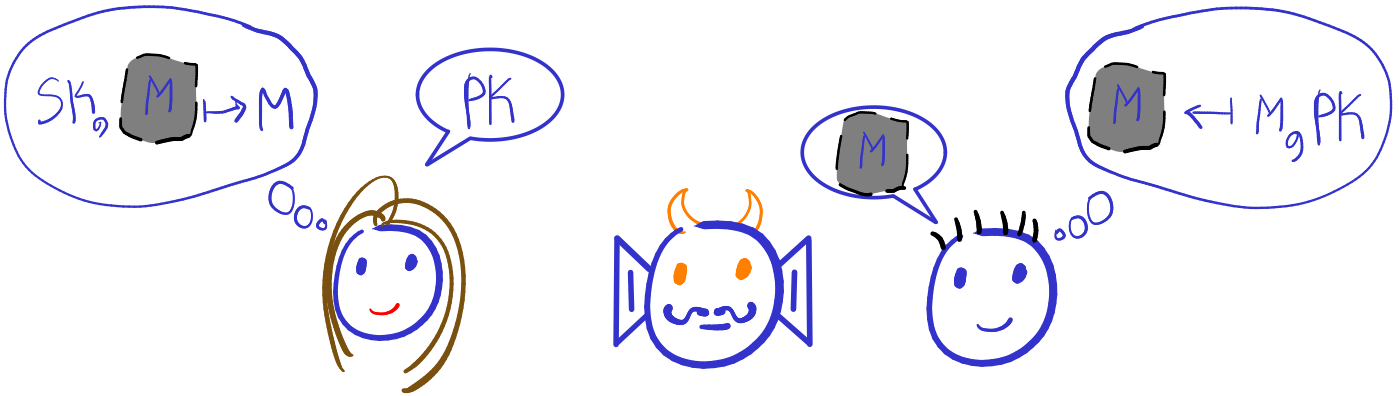

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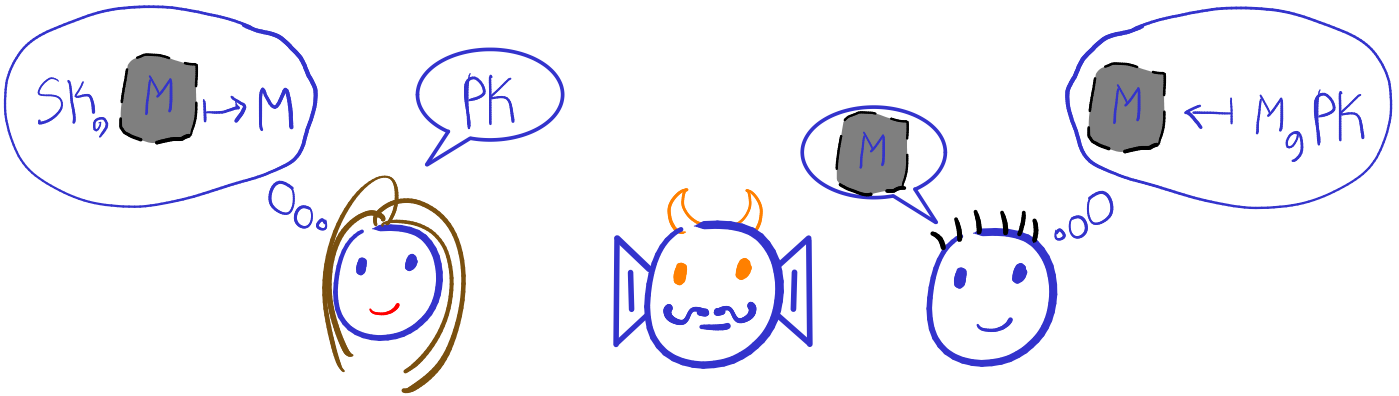

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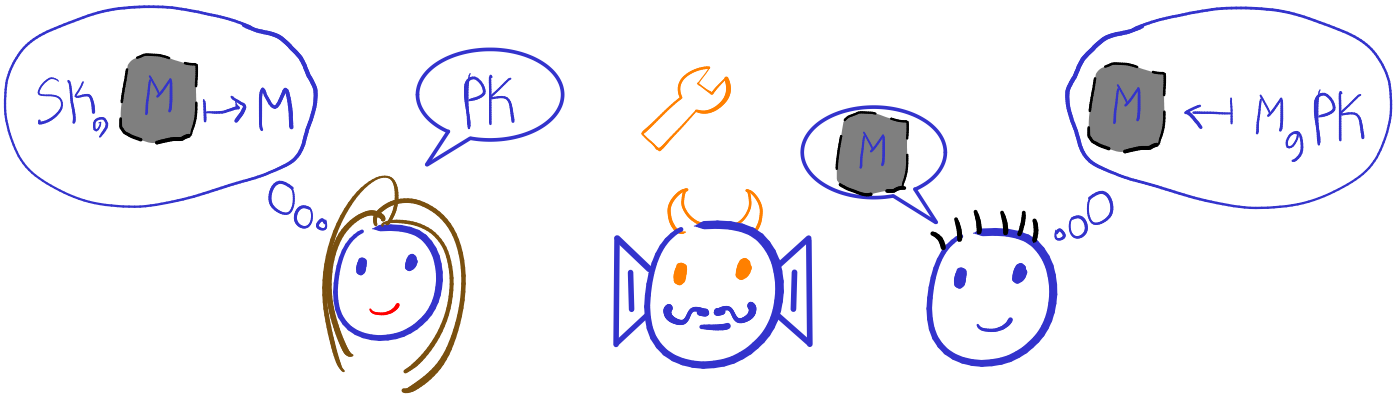

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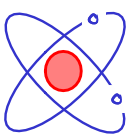

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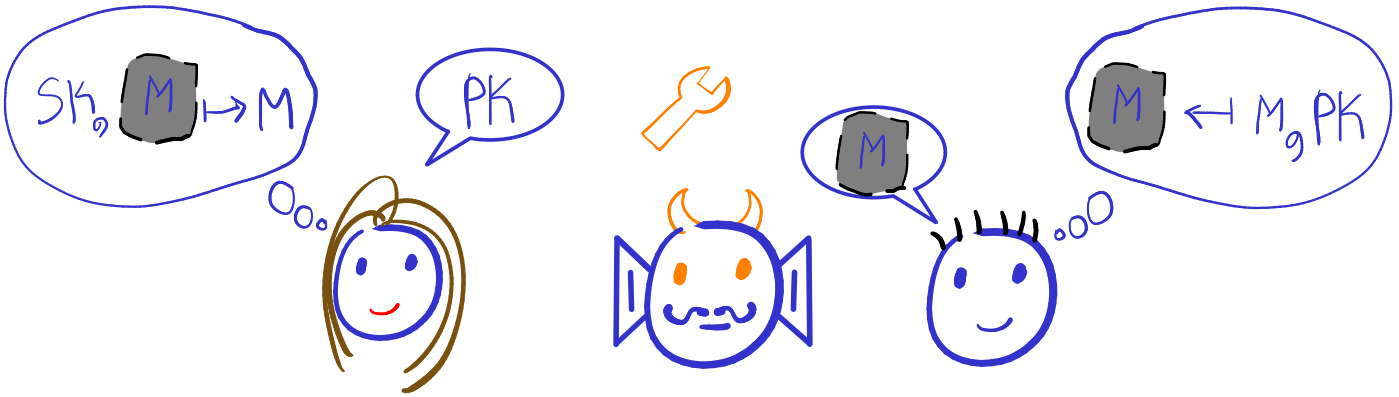

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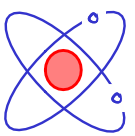

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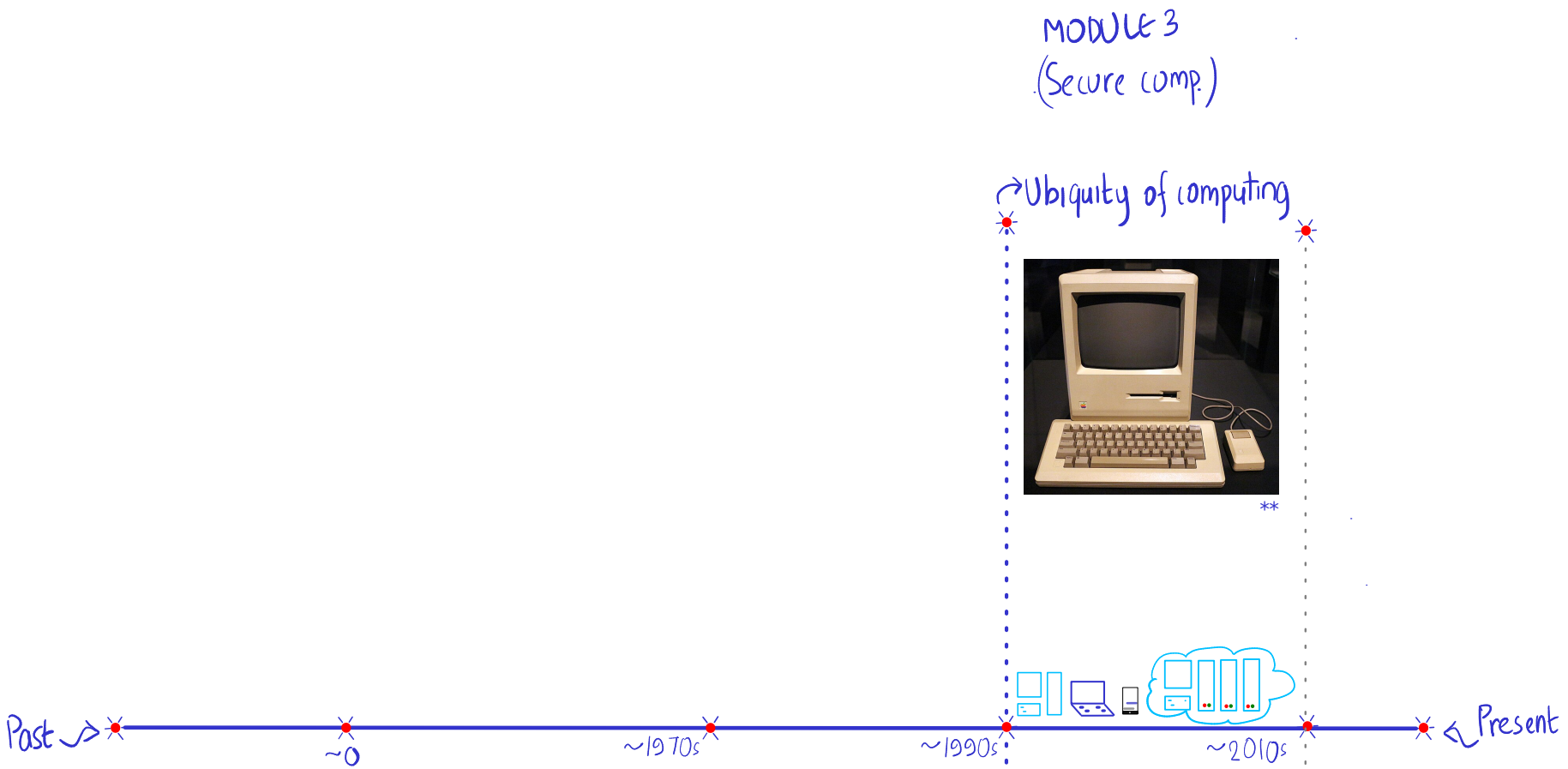
Ubiquity of Computing and Need for Privacy



Credit for images: Wikipedia (**User:Saliko)

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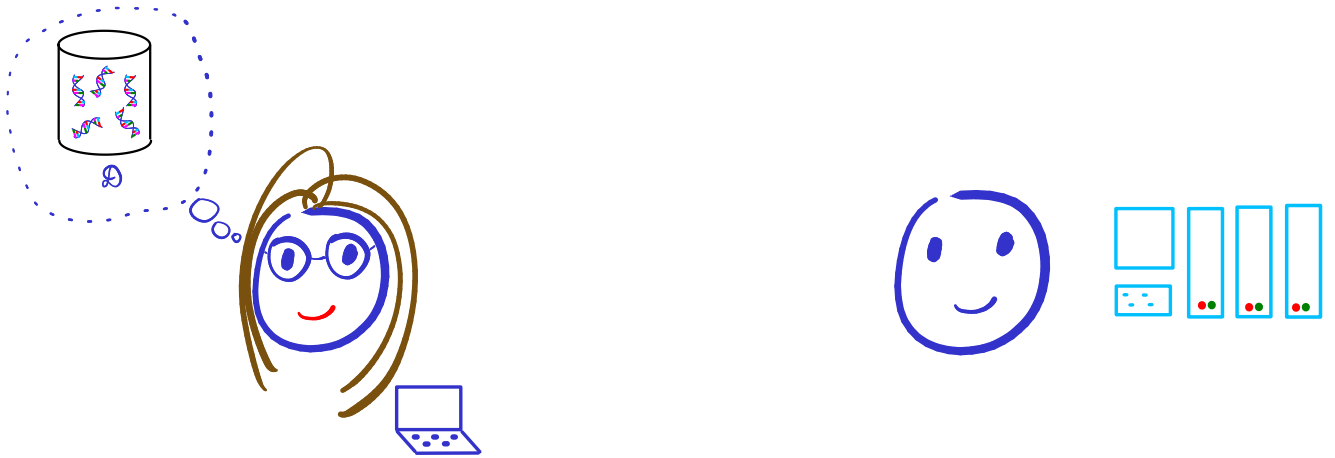

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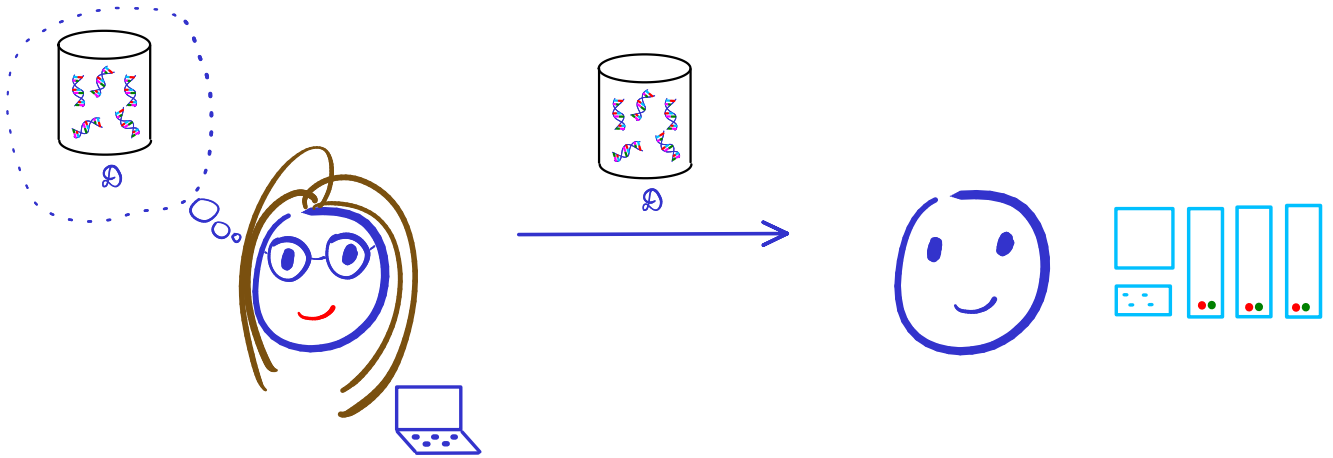

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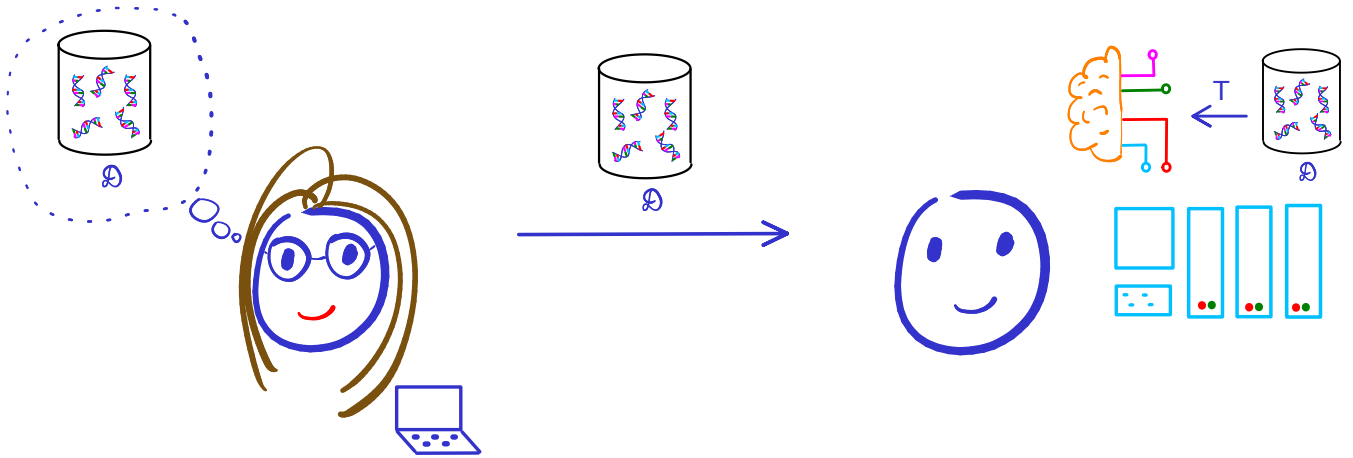

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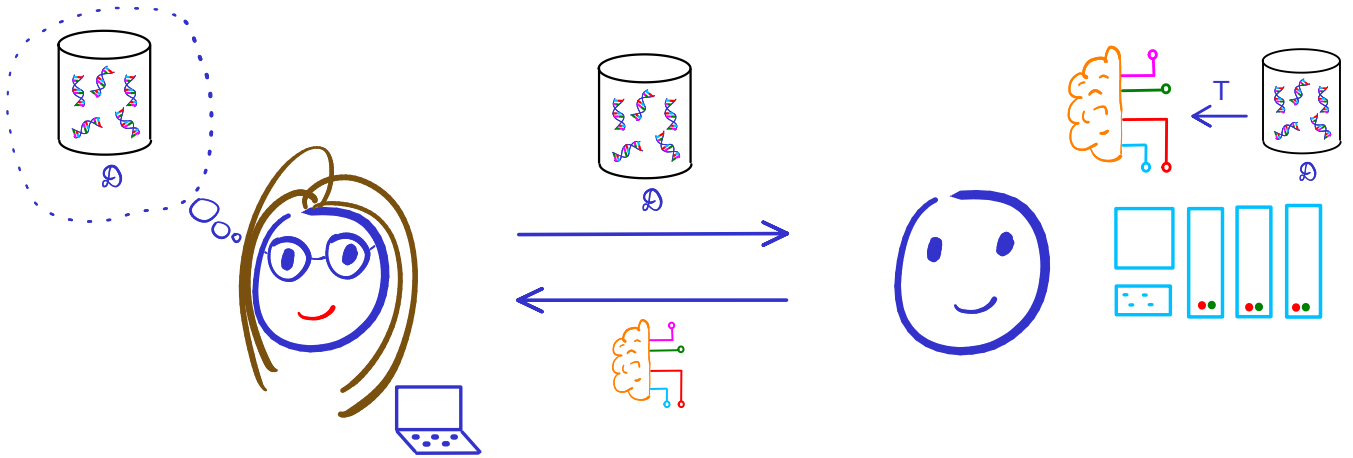

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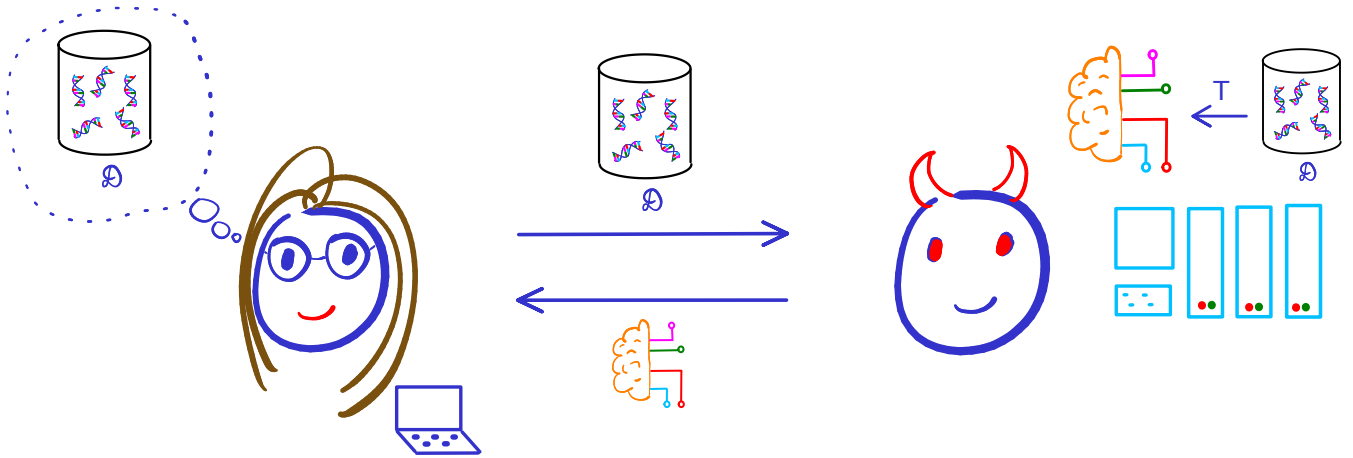

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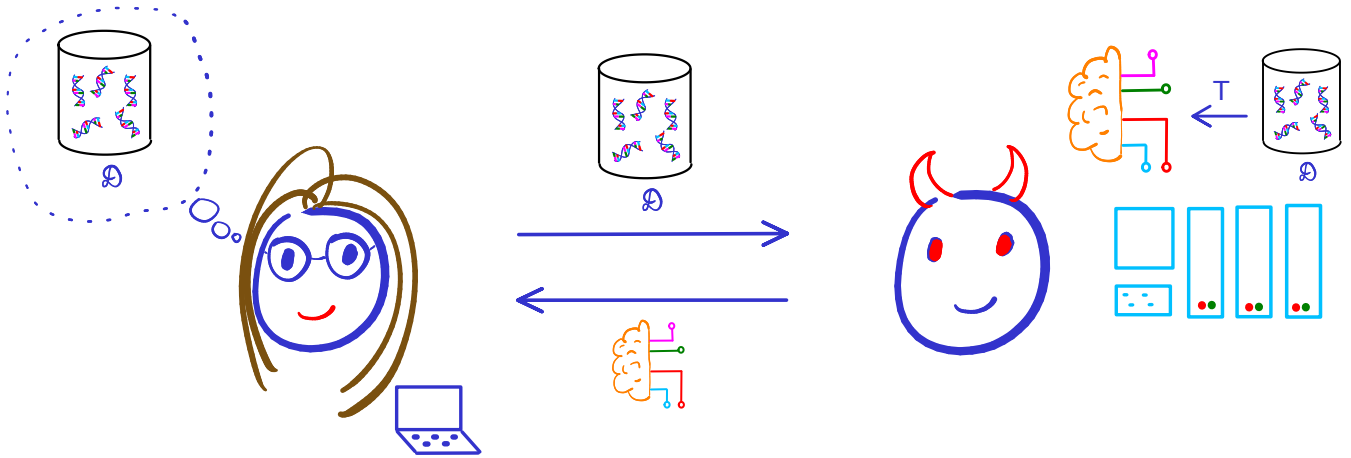

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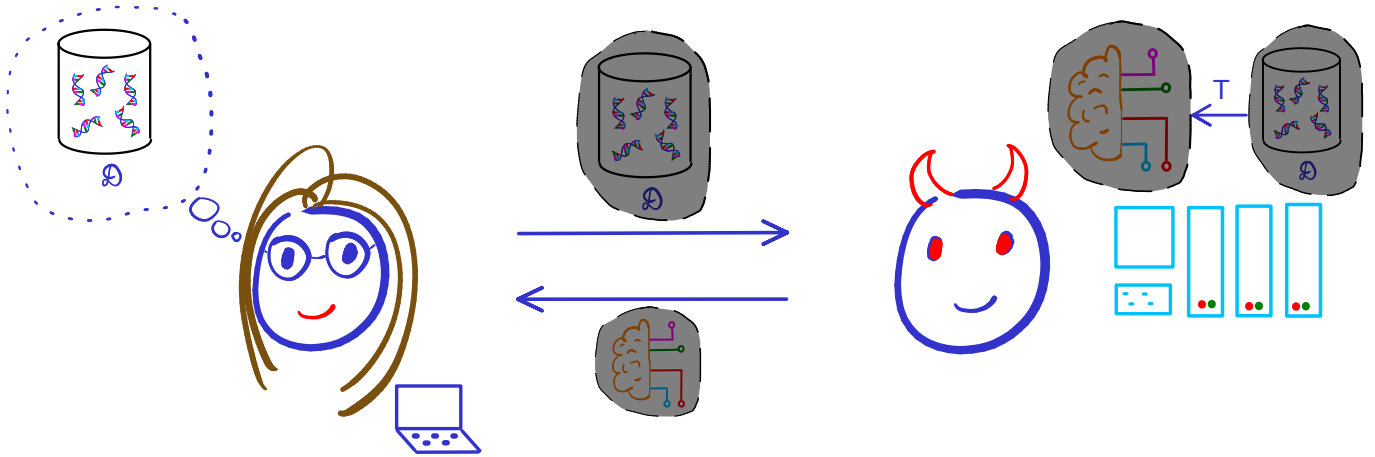

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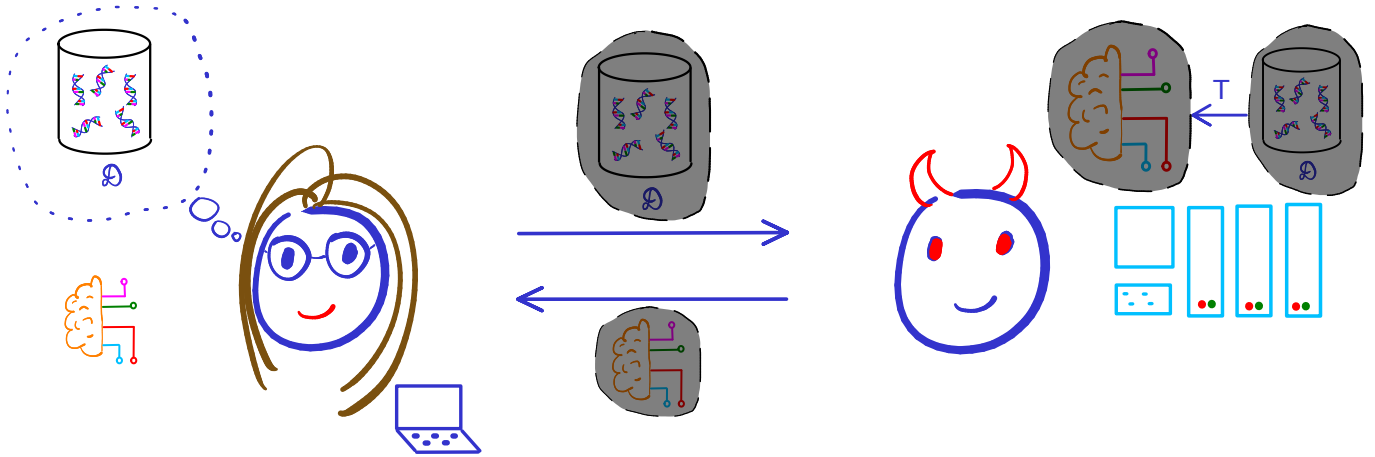

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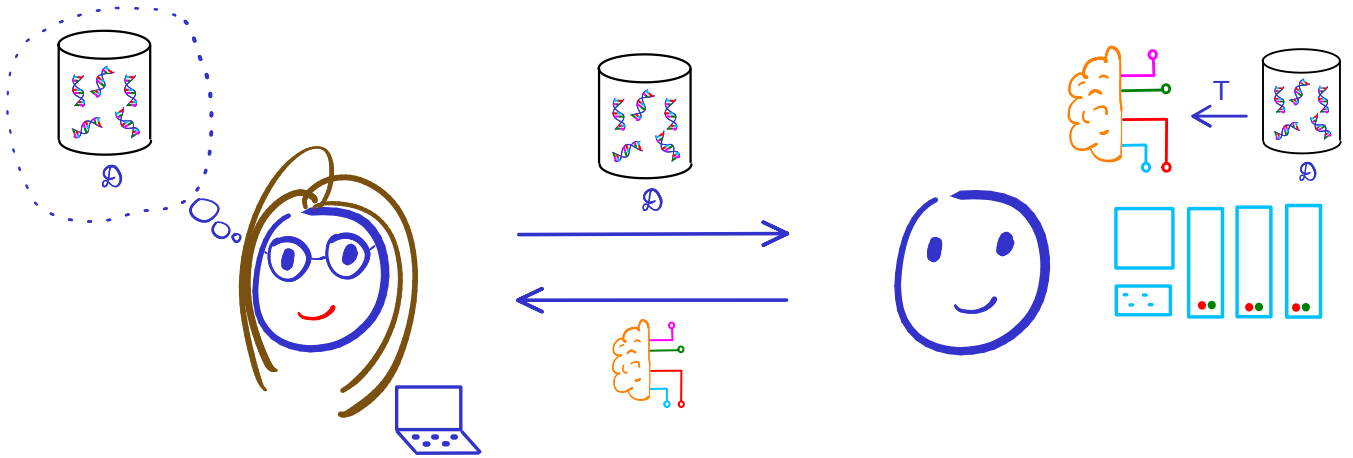

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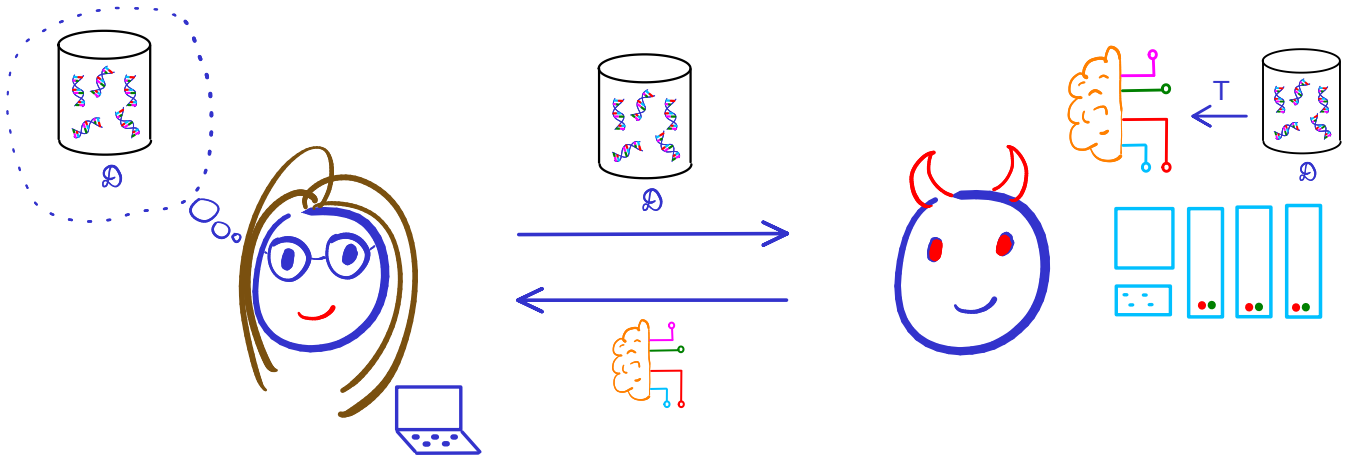

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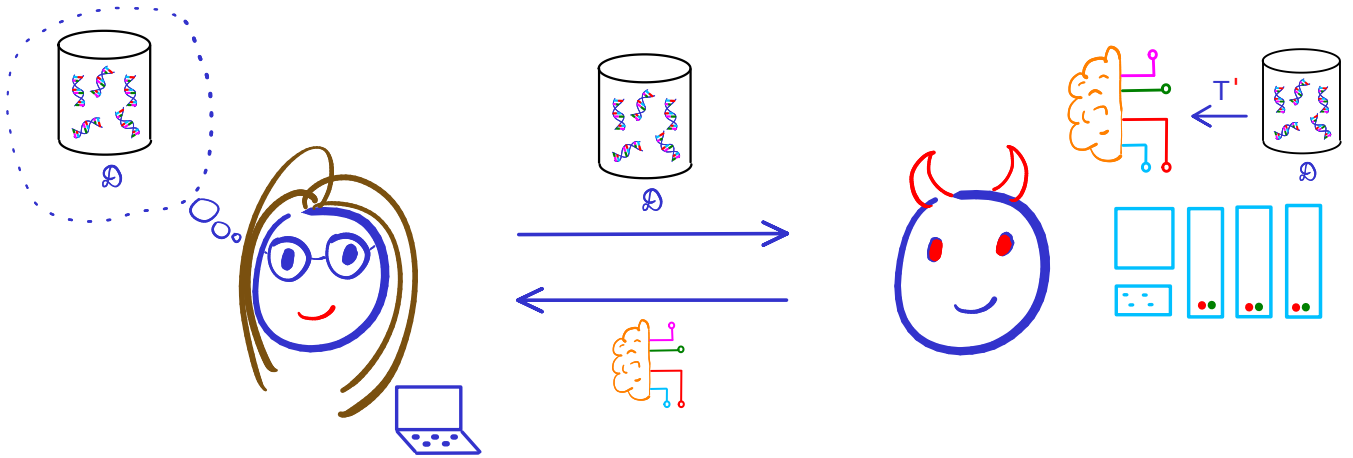

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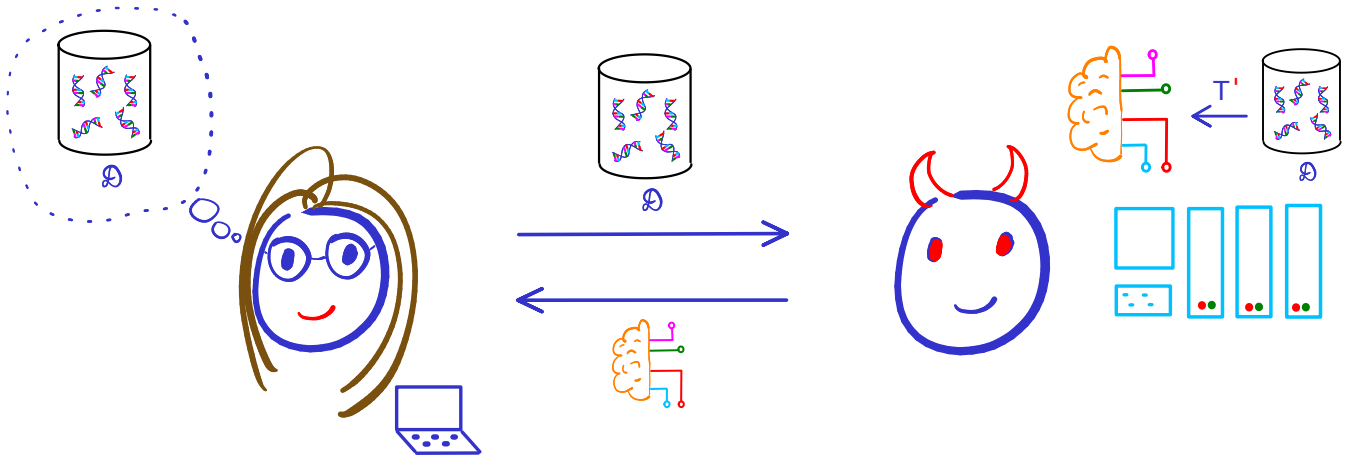

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  - Verifiable outsourcing using succinct proof systems (SNARGs)

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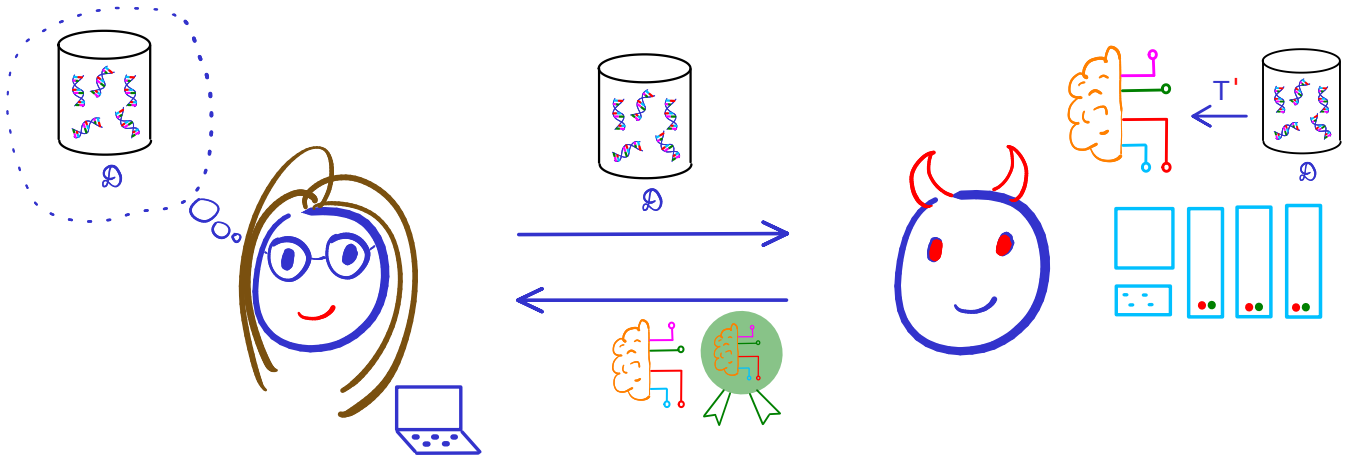

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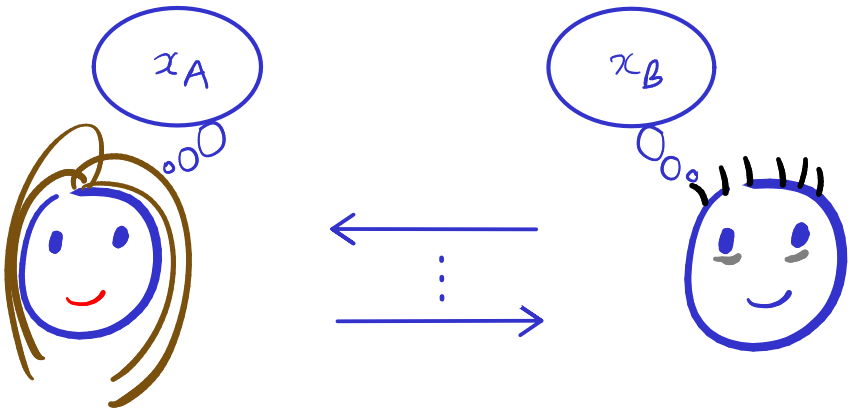

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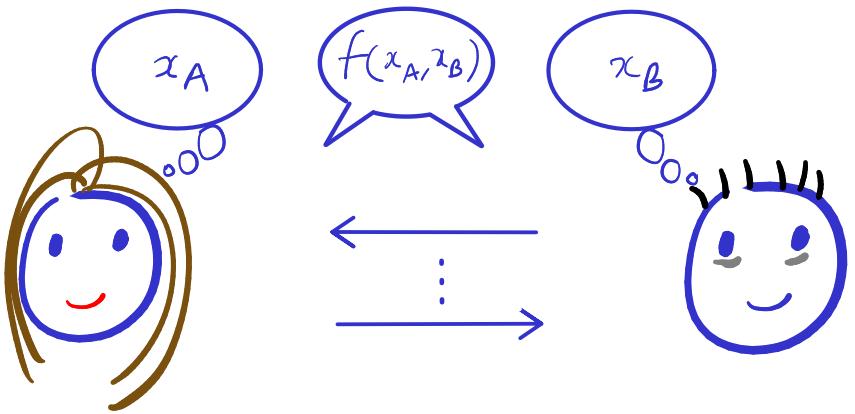

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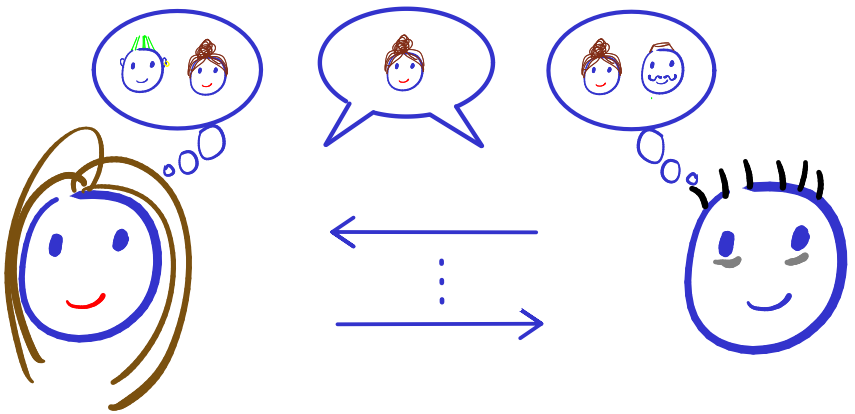

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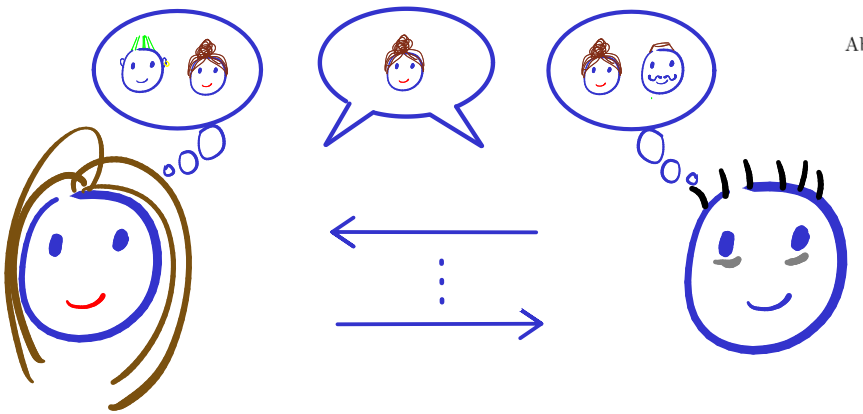

The Apple PSI System

Abhishek Bhowmick
Apple Inc.

Dan Boneh
Stanford University

Steve Myers
Apple Inc.

Kunal Talwar
Apple Inc.

Karl Tarbe
Apple Inc.

July 29, 2021

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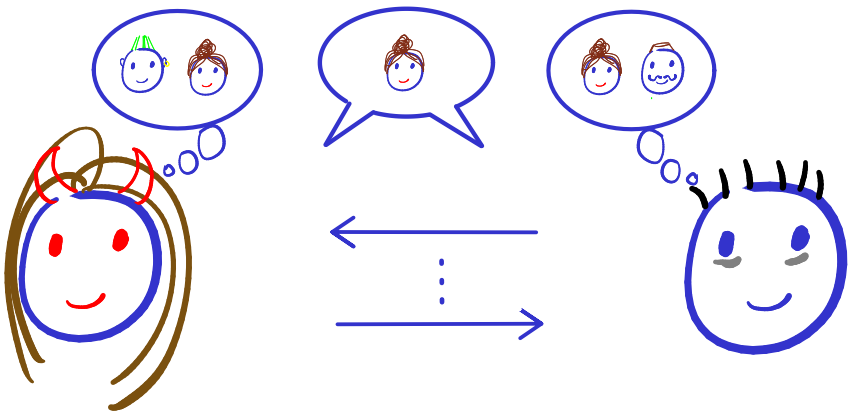

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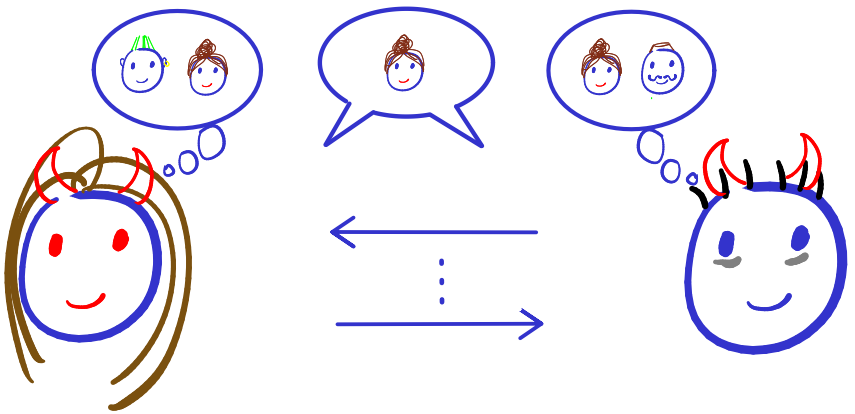

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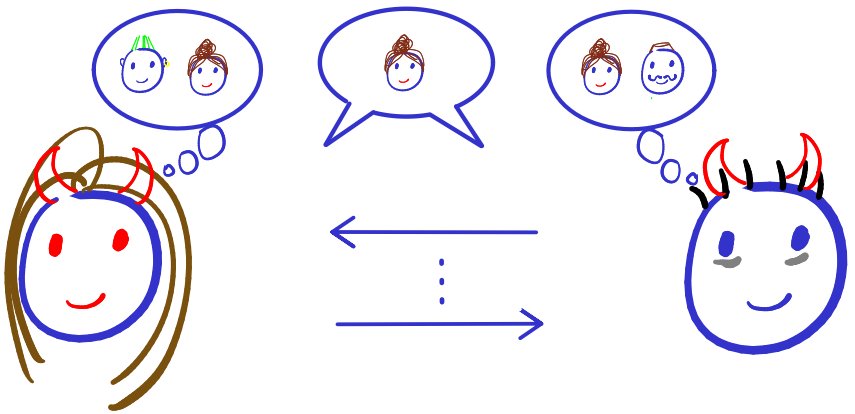

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- What we will learn:
  - How to model the security goal (via simulators)
  - Zero knowledge (ZK) proof, several ZK protocols
  - Yao's garbling, other two-party computation protocols

An Overview of the Course

1. Module I: Secure Communication in Shared-Key Setting
2. Module II: Secure Communication in Public-Key Setting
3. Module III: Secure Computation
4. Module IV: Some Advanced Tasks

Task 5: Obfuscate a Program...

- What does the following submission to *International Obfuscated C Code Contest* do?

```
#define F (getchar()&15)
#define v main(0,0,0,0,
#define Z while(
#define P return y=~y,
#define _ ;if(
char*l="dbcefcbddabcddcba~WAB+  +BAW~                +-48HLSU?A6J57IKJT576,";B,y,
b,I[149];main(w,c,h,e,S,s){int t,o,L,E,d,O=*l,N=-1e9,p,*m=I,q,r,x=10 _*I){y=~y;
Z--O>20){o=I[p=O]_ q=o^y,q>0){q+=(q<2)*y,t=q["51#/+++"],E=q["95+3/33"];do{r=I[p
+=t[l]-64]_!w|p==w&&q>1|t+2<E|!r){d=abs(O-p)_!r&(q>1|d%x<1)|(r^y)<-1){_(r^y)<-6
)P 1e5-443*h;O[I]=0,p[I]=q<2&(89<p|30>p)?5^y:o;L=(q>1?6-q?l[p/x-1]-l[O/x-1]-q+2
:0:(p[I]-o?846:d/8))+l[r+15]*9-288+l[p%x]-h-l[O%x];L-=s>h||s==h&L>49&1<s?main(s
>h?0:p,L,h+1,e,N,s):0 _!(B-O|h|p-b|S|L<-1e4))return 0;O[I]=o,p[I]=r _ S|h&&(L>N
||!h&L==N&&1&rand())){N=L _!h&&s)B=O,b=p _ h&&c-L<S)P N;}}}t+=q<2&t+3>E&((y?O<
80:39<O)||r);}Z!r&q>2&q<6||(p=O,++t<E));}}P N+1e9?N:0;}Z I[B]=-(21>B|98<B|2>(B+
1)%x),++B<120);Z++m<9+I)30[m]=1,90[m]=~(20[m]=*l++&7),80[m]=-2;Z p=19){Z++p<O)
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||!h&L==N&&1&rand()))){N=L _!h&&s)B=O,b=p _ h&&c-L<S)P N;}}}t+=q<2&t+3>E&((y?O<
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```
/**************************************************************************\
| Toledo Picochess (c) Copyright 2007 Oscar Toledo G. All rights reserved  |
| 944 non-blank characters. Evolution from my winning IOCCC 2005 entry.    |
| o Use D2D4 algebraic style for movements.  biyubi@gmail.com  Jan/21/2007 |
| o Only promotion to queen, no en passant or castling.  www.nanochess.org |
| o Press Enter alone for computer to play (num.args+5 == depth of search) |
| o Remove these comments to get 1009-bytes source code (*NIX end-of-line) |
\**************************************************************************/
#define F (getchar()&15)
#define v main(0,0,0,0,
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||!h&L==N&&1&rand()))){N=L _!h&&s)B=O,b=p _ h&&c-L<S)P N;}}}t+=q<2&t+3>E&((y?O<
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- It's a primitive chess engine! (nanochess.org/chess3.html)

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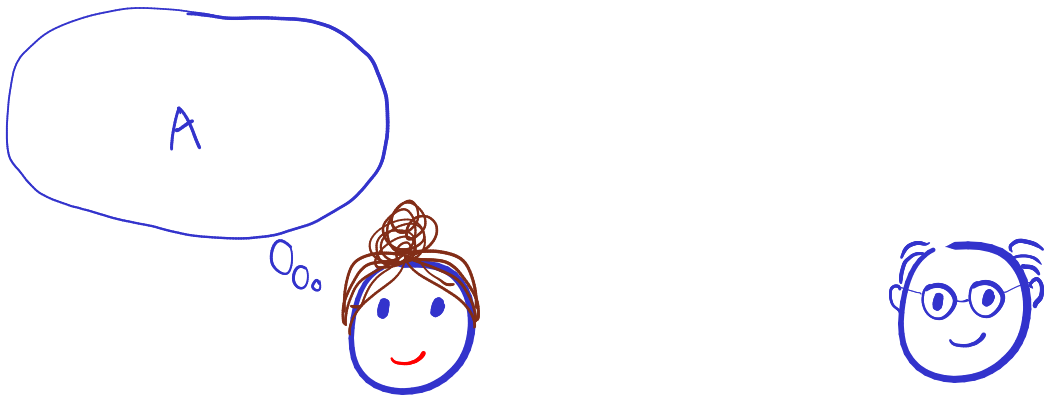
- Setting: Alice discovers algorithm A, which Bob wants to use



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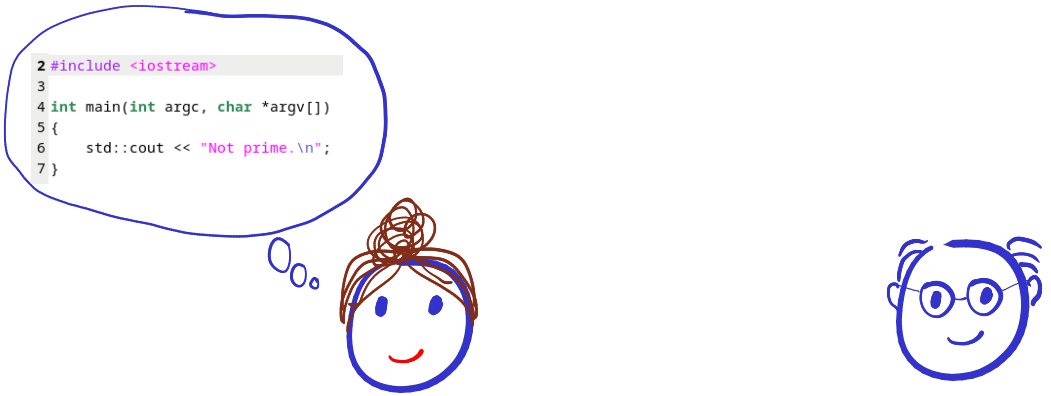

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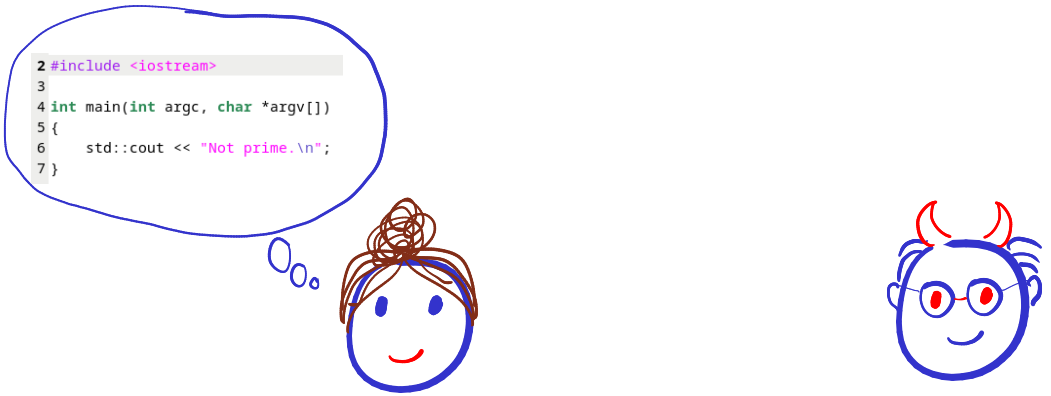

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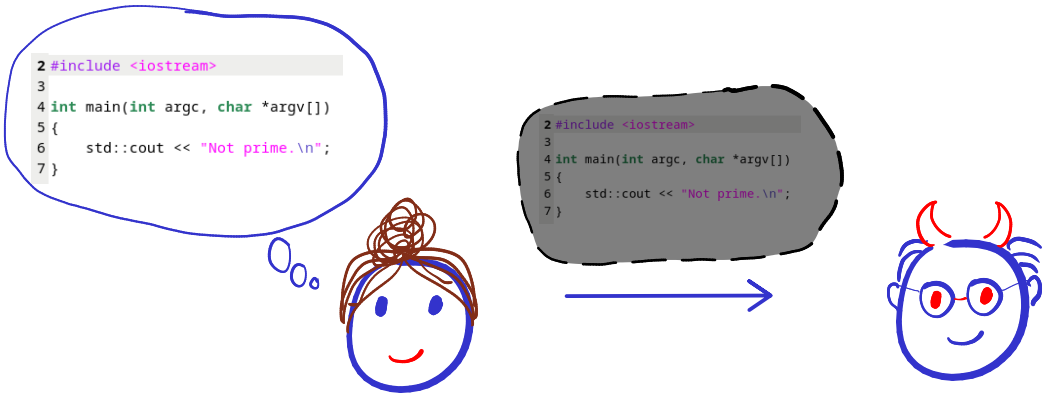

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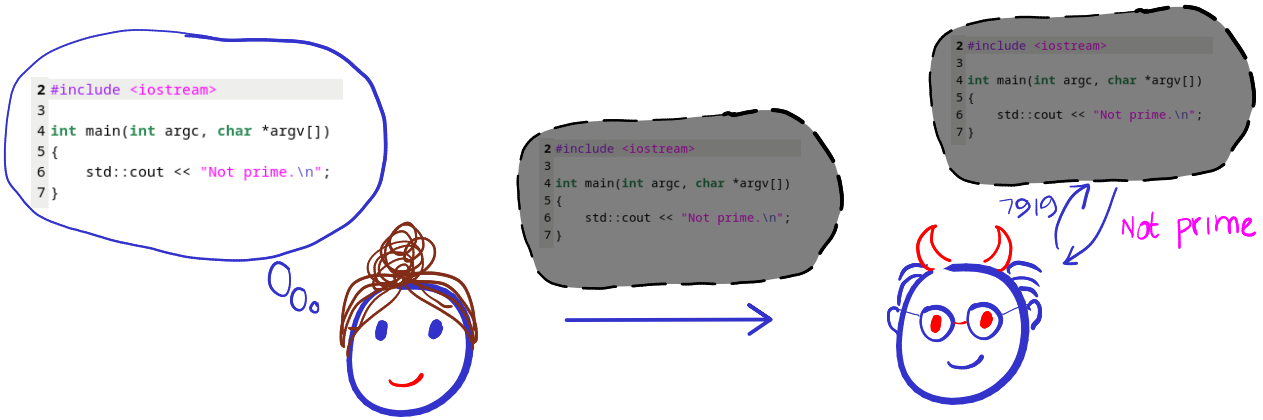

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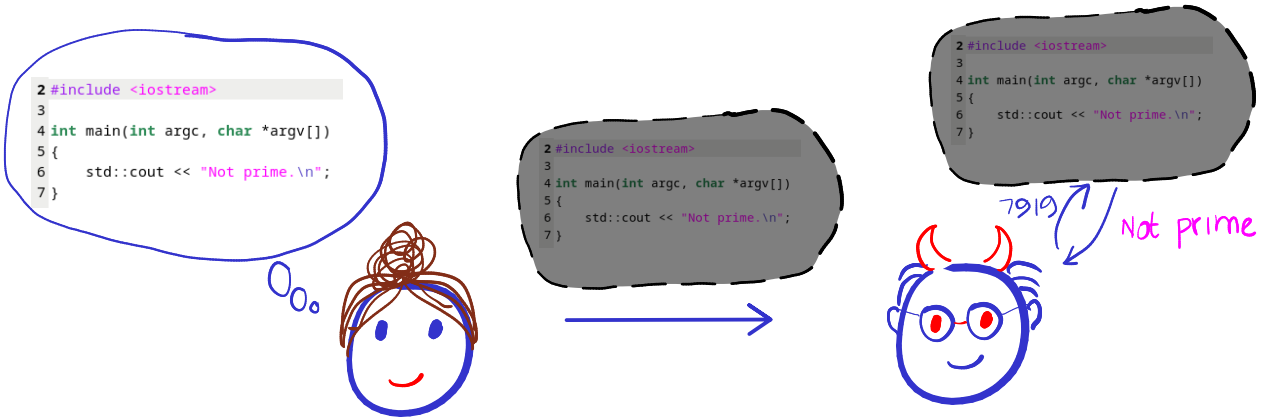

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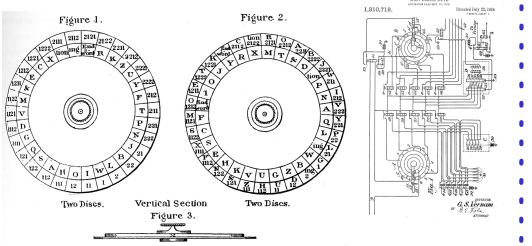
- What we will learn:
  - How to model the security goal
  - Why program obfuscation is a powerful tool!
    - Can be used to carry out all the tasks we have seen so far

Other Advanced Tasks

- If time permits:
  - Advanced notions of PKE (identity-based encryption, proxy re-encryption, functional encryption)
  - Secure messaging 
  - Digital currency without central authorities (cryptocurrency)

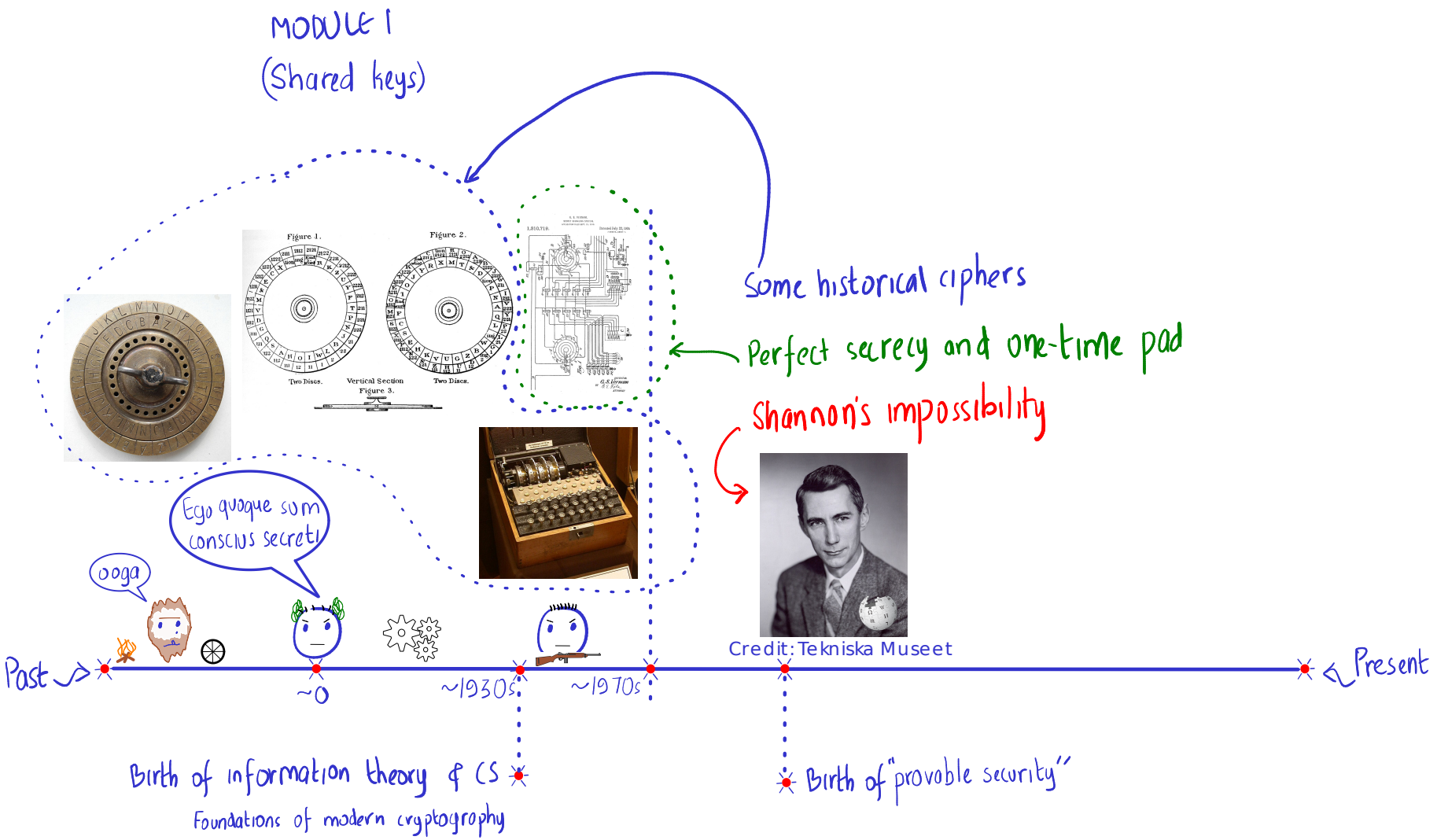
Next Lecture

MODULE 1
(Shared keys)



Credit for images: Wikipedia

Next Lecture



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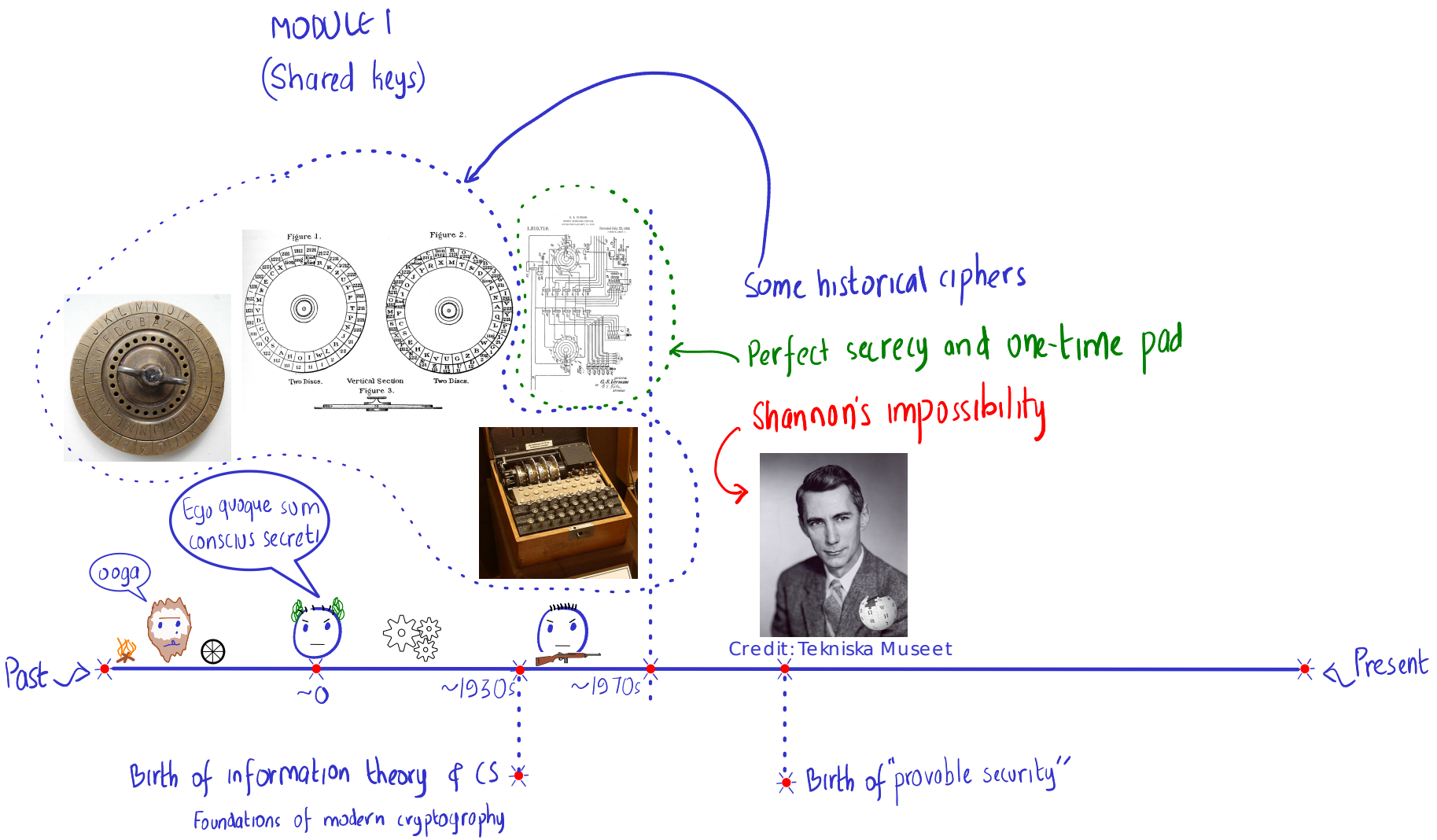

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More Questions?