Cryptography (a short intro)

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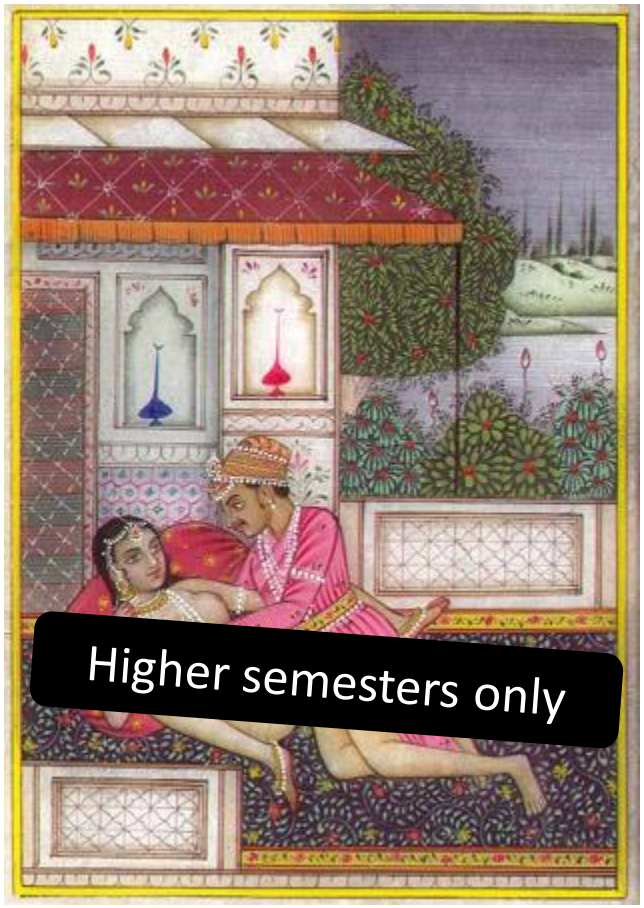
What is Cryptography?

Communication in the presence of an adversary

- More than just encryption
- Protection of data integrity
- Communication *with* the adversary

Cryptography in History

Kama Sutra recommends…



The following are the arts to be studied, together with the Kama Sutra:

[...]

The art of understanding writing in cypher, and the writing of words in a peculiar way.

(Translation by Richard Burton)

Caesar Cipher

- Shift each letter by three places

CAESAR

↓

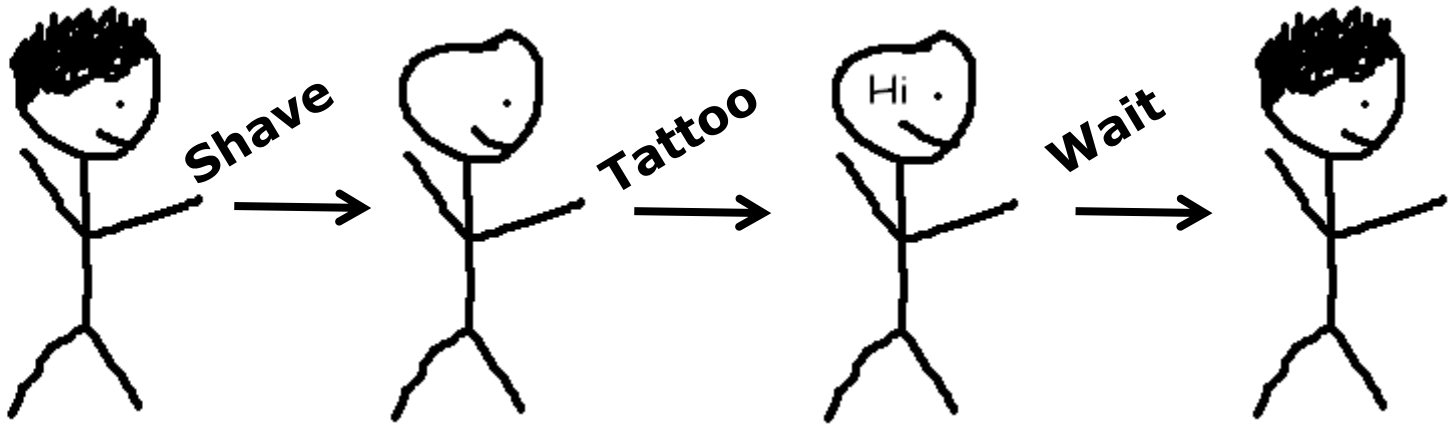
FDHVDU

- Supposedly used by Julius Caesar

Scytale

Sparta… 2500 years ago…

Herodotus and the Slave Cipher



(5. century BC)

Invisible Ink

- Lemon juice as invisible ink

- After heating, ink becomes brown

The Kerckhoffs principle

Auguste Kerckhoffs

- “La cryptographie militaire”, Journal des sciences militaires, 1883
- “The system must not require secrecy, and it can fall into enemy‘s hands without causing trouble“

Kerkhoffs Principle - Consequences

- Separation of cryptosystem and key
- System must stay secure
  even if only key is secret
- Design-principle for modern cryptogrphy

The enemy knows the system.

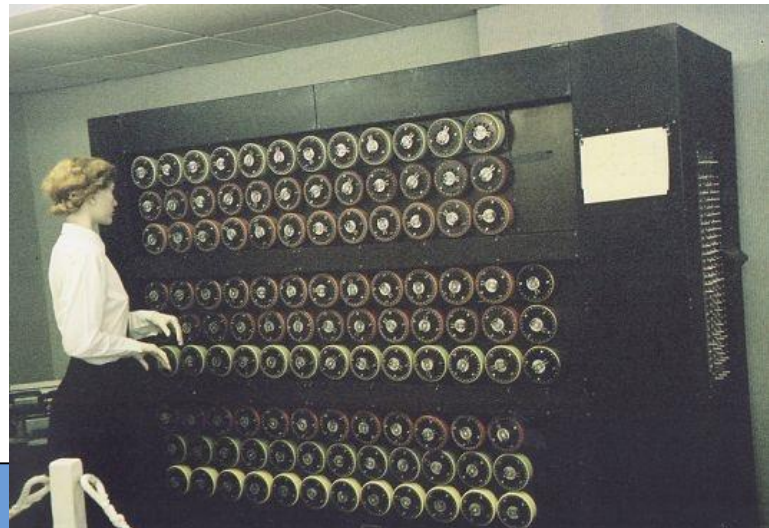
Claude Shannon

Enigma

- German cipher machine from World War II
- 3-4 wheels (rotors) with electrical wires
- Rotor position determines the wire connections
- Key press → Lamp lights up, rotor rotates

Enigma

- Rotor position = key
- Even after the British got an Enigma, immense work needed for breaking it
- Alan Turing's team had >10000 helpers
- A success for the Kerkhoffs principle



Modern Cryptography

Information theory

Claude Shannon

- Shannon, “A mathematical theory of communication”, 1948
- Information as a mathematical object
- Security can be defined, analyzed, and proven!

One-time-pad

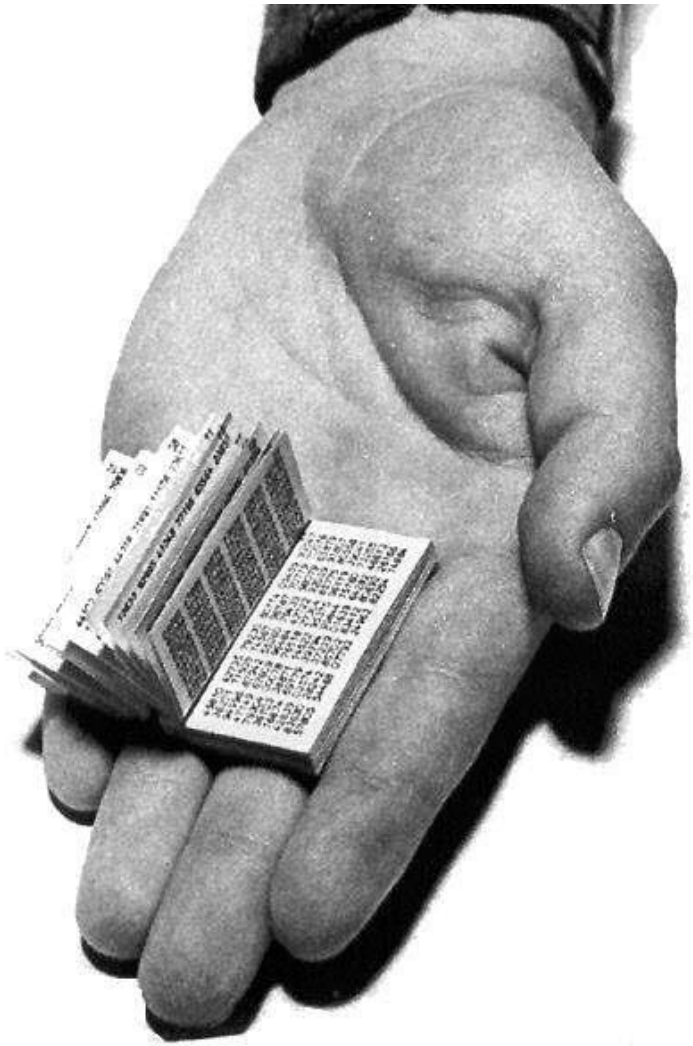
Message: 00111010010011110010
+
Key: 10101110010100101100
=
Ciphertext: 10010100000111011110

Shannon: One-time-pad is provably secure!

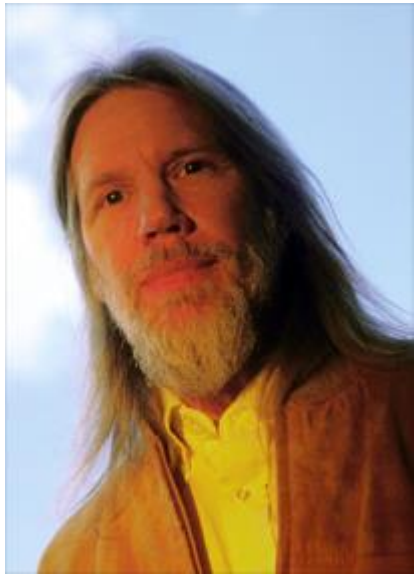
One-time-pad in Practice

Not practical:

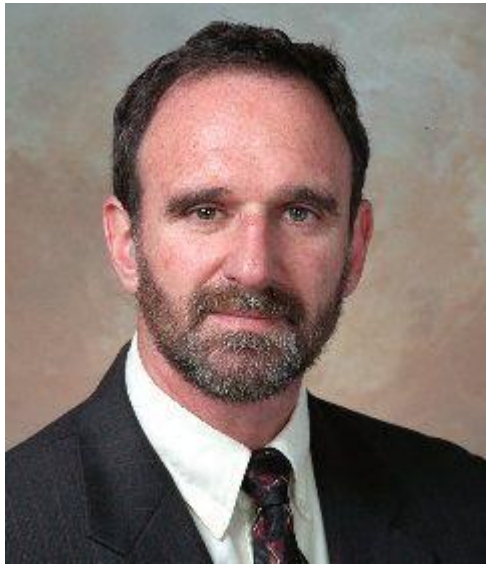
- Long key
- May only be used once
- Useful auxiliary tool



Public-Key Cryptography



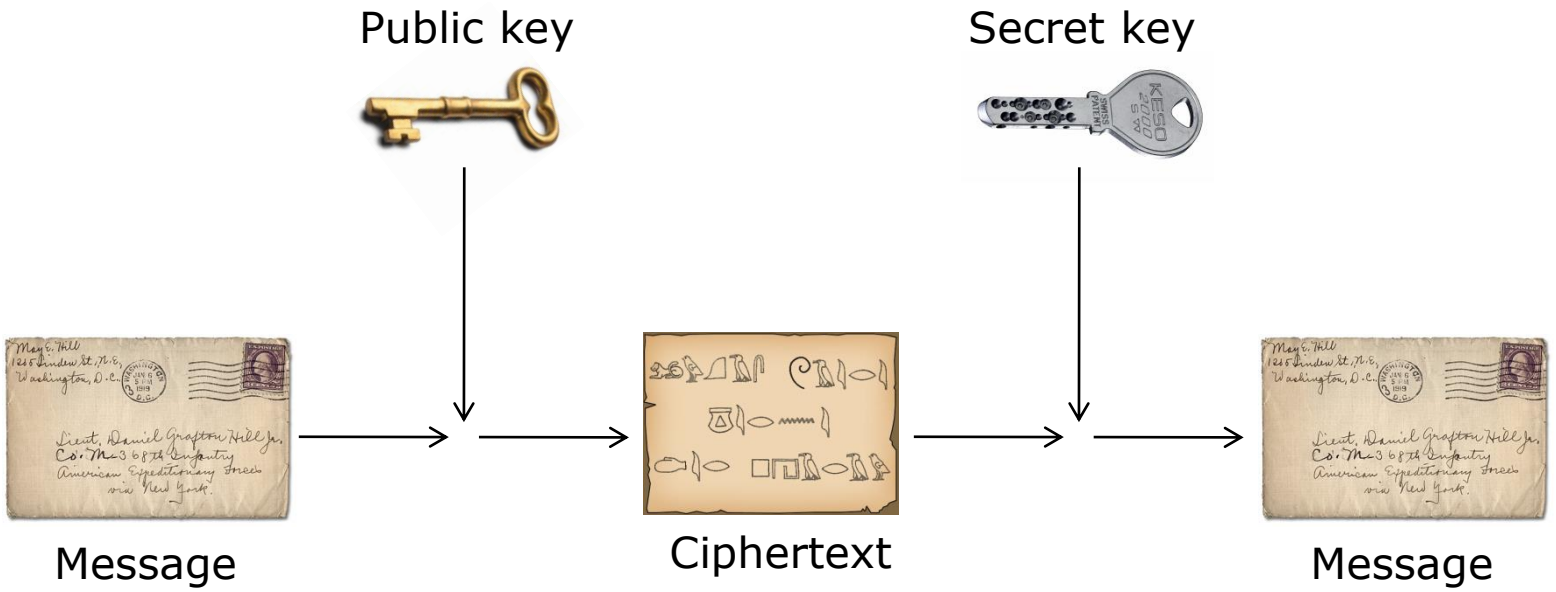
Whitfield Diffie



Martin Hellman

"New Directions in Cryptography", 1976

Public Key Cryptography



Advantage: Public key may be published

More than just encryption

Millionaire's Problem

Who is richer?

None wishes to reveal the size of his fortune

None trusts the other

Secure Auctions

Buyers

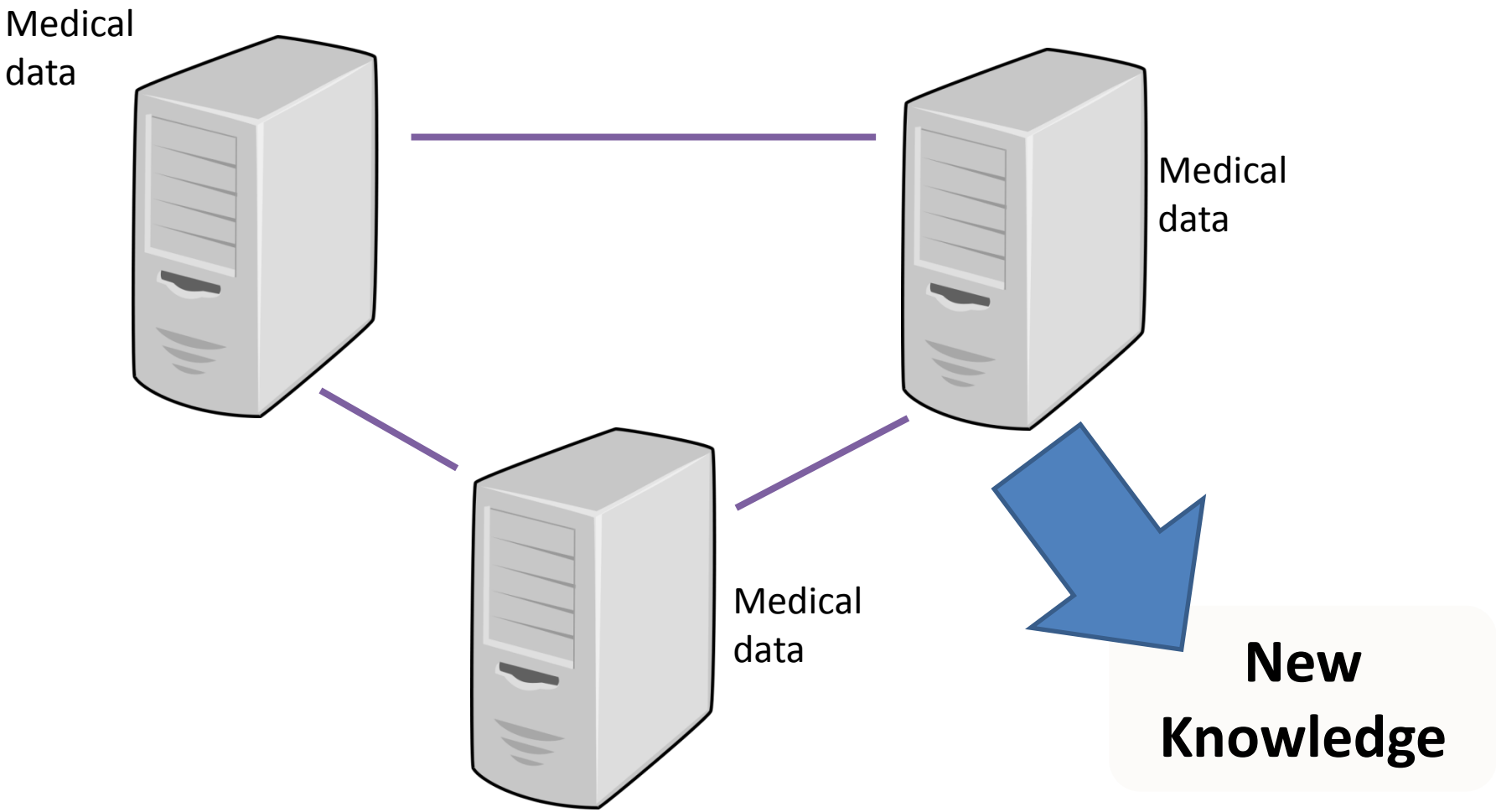
Sugar beet vendors

Offers

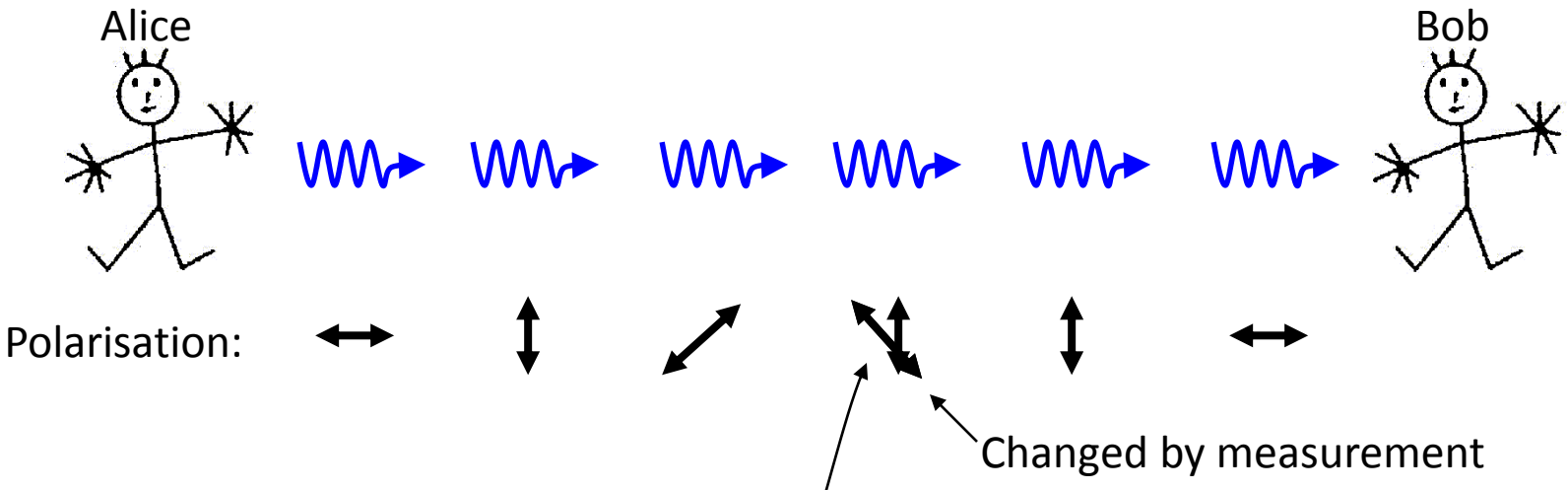
Production quantities

No-one wishes to reveal his prices
What shall the market price be?

Data-mining



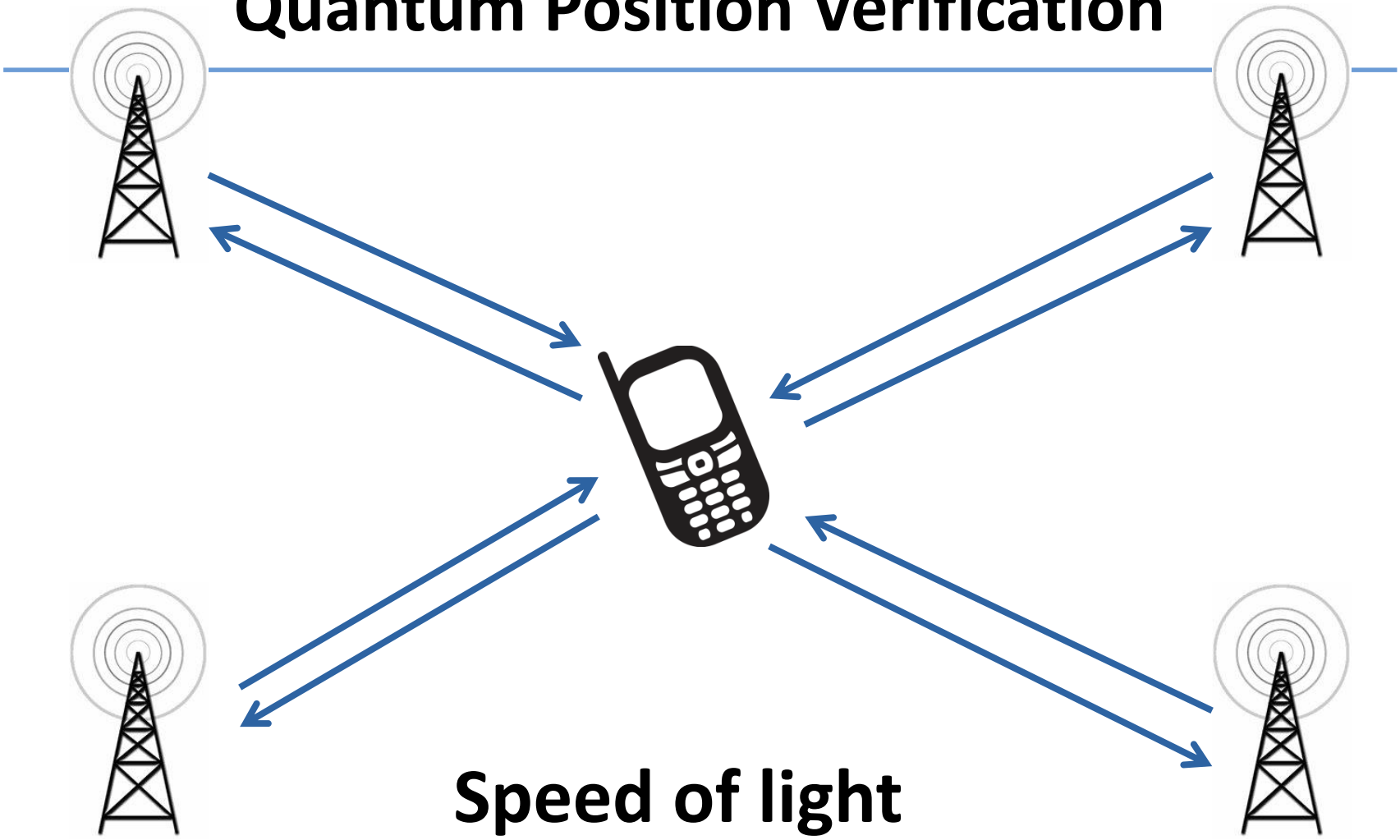
Quantum Key Exchange



measures

Alice and Bob notice attacks!

Quantum Position Verification



Speed of light

→ Position verified

Cryptography

More than encryption –
Communication in the presence of the adversary

A fascinating topic, combining relevance and challenging research questions

How to study crypto

- Security lectures at bachelor's level
  (e.g., applied crypto)
- Crypto more on master's level
  (or end of bachelor)
- Get a background in math in time

Q?