ARIEL UNIVERSITY

אוניברסיטת אריאל בשומרון

Foundations of Modern Cryptography

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Neapolis University Pafos

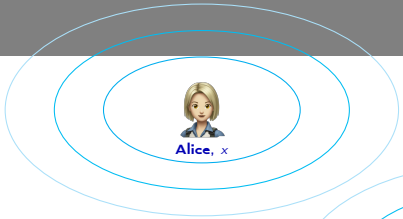
Lecture 10: December 19, 2024

Lecture Plan

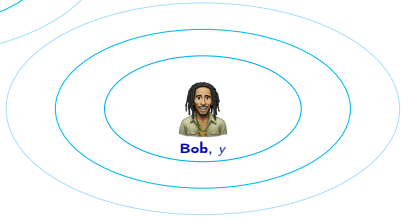
- Blockchains.

If the screen seems frozen and I do not respond,
please call me in Telegram.

Task: Blockchain



$f_{\mathbf{1}}(x, y, z, \ldots)$



Pictures courtesy AI Emojis Generator

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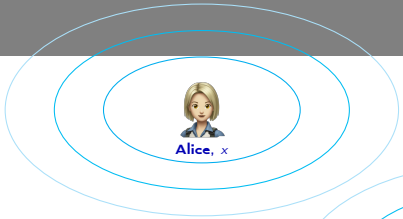

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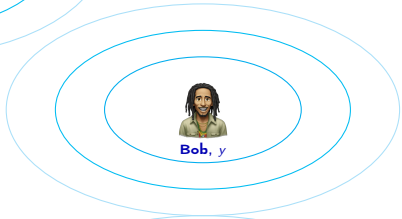

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Alice, x

Anon4, w

Bob, y

Anon3, v

Anon1, z

Anon2, u

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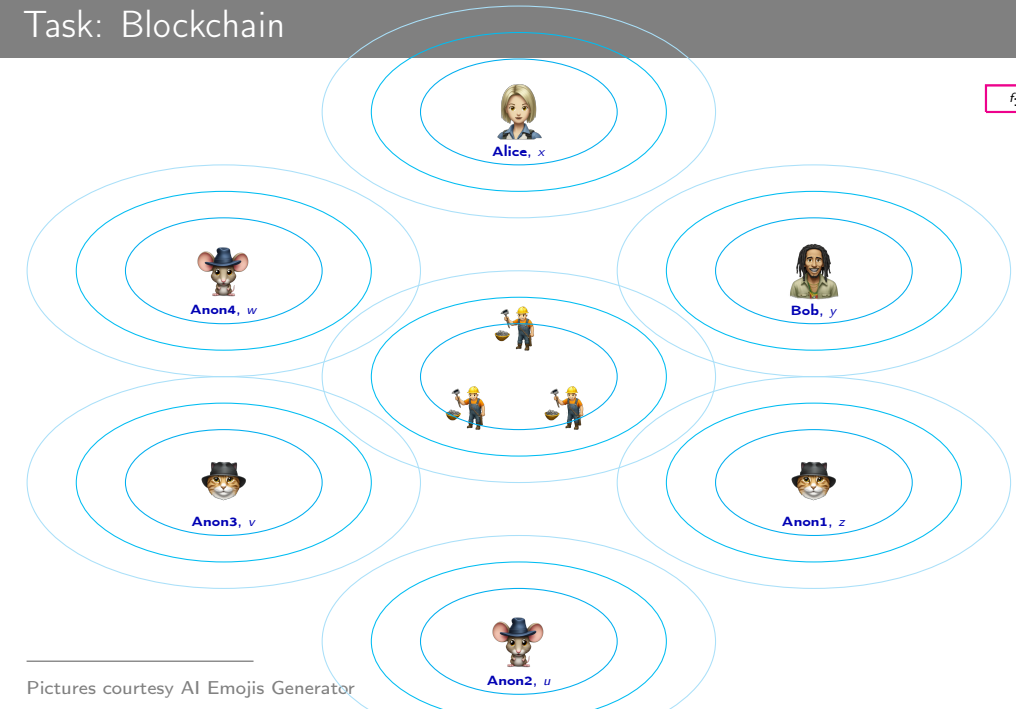

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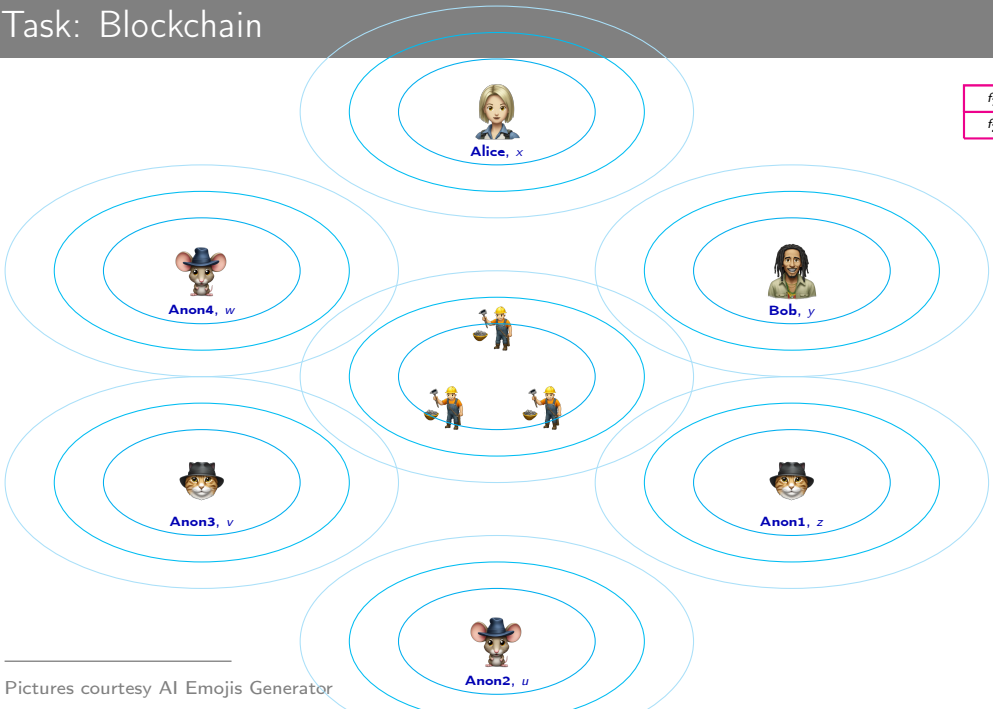

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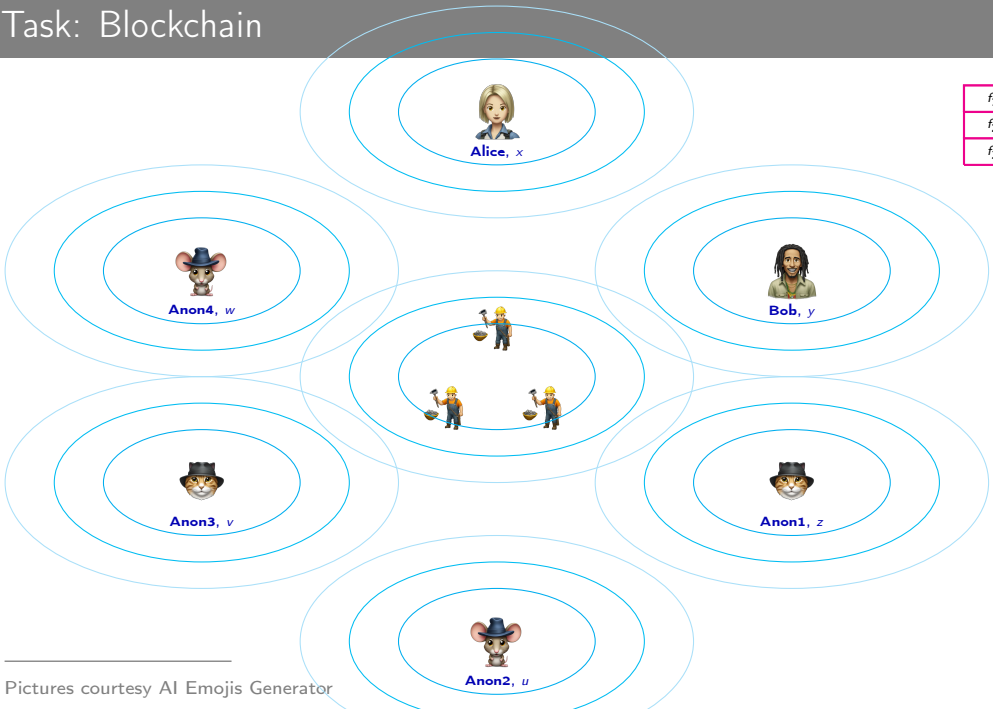

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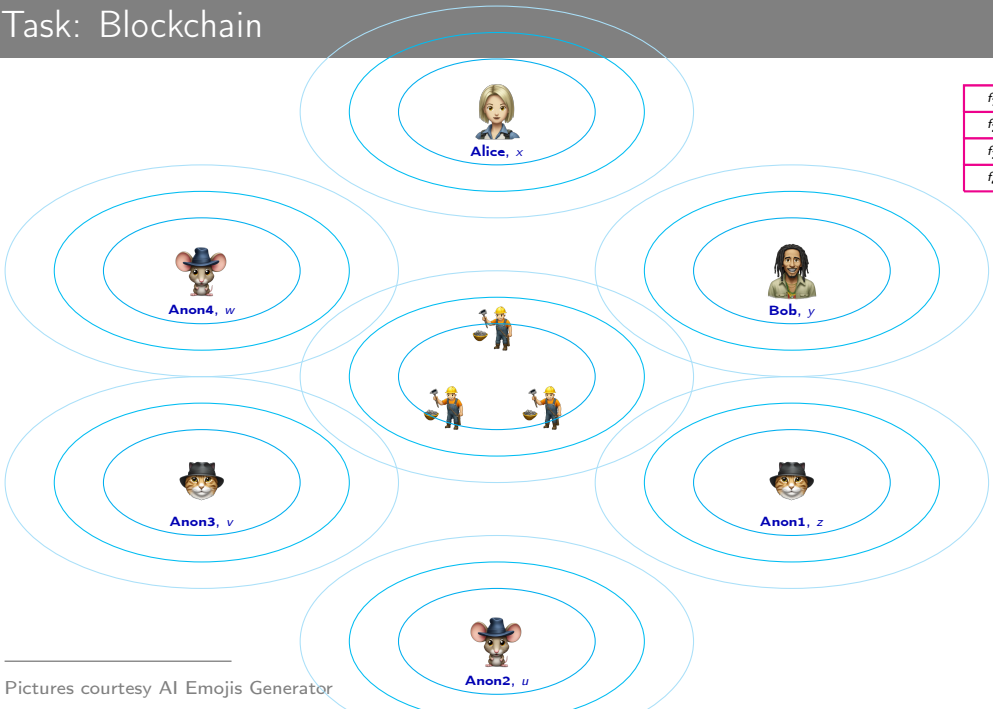

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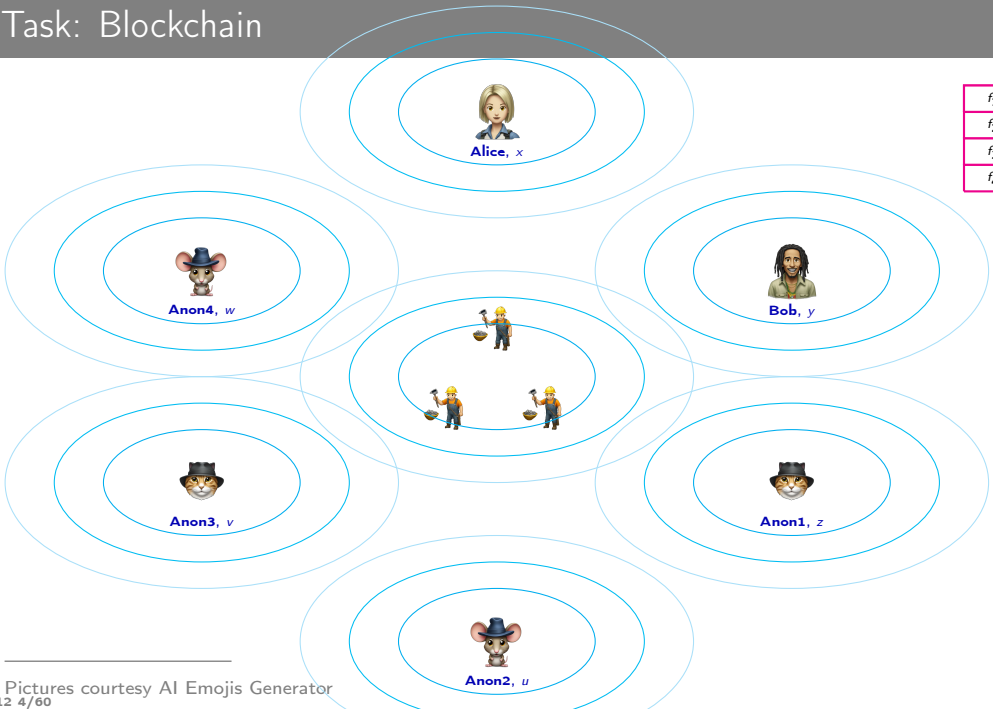

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This is a global database and a global computer on top of it

Layers

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  - perform local computations,
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  - send messages to other nodes (e.g., from local computations).
- Nothing comes "out of the blue", there is a reason for every record,
- There are additional checks of validity (who sent a command, was it a permitted sender, etc).

Byzantine agreement

Initial setting

- Fixed set of participants, at most f of them are "Byzantine".
- Each participant has a $(\mathtt{pk}_i, \mathtt{sk}_i)$ key pair for signing, everyone knows $\mathtt{pk}_i$'s.
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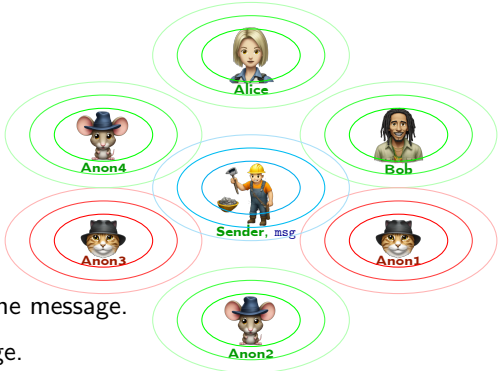

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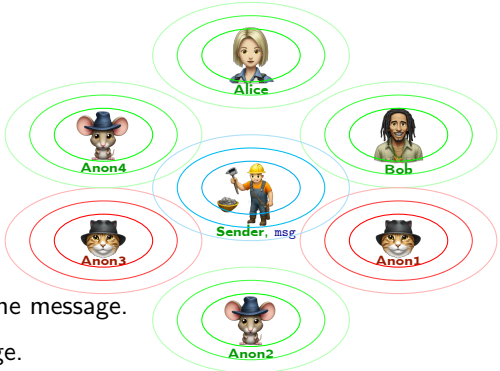

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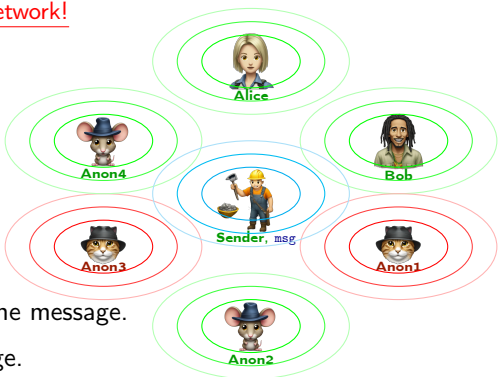
  - Broadcasting is implemented as a peer-to-peer network!



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Exercise: check that the more honest parties, the fewer rounds required.

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. . . and a more realistic setting

Reduction of agreement to broadcast Each of N participants takes the lead in their turn.

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Byzantine agreement (based on broadcast)

. . . and a more realistic setting

Reduction of agreement to broadcast Each of N participants takes the lead in their turn.

Epoch ("Superround") ℓ: ($\ell \mod N$)-th player is Sender.

Sender broadcasts all transactions he is aware of.
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- If a quorum for a later epoch eventually arrives, the player becomes unlocked.
  We assume that every message is delivered within "stabilization time" Σ.

Tendermint simulation

Alice

b_1

Anon4

b_1

Bob

Sender

b_1

Anon3

Anon1

Anon2

b_1

Tendermint simulation

Once it is confirmed by $n - 2f$, no incompatible block will ever get a quorum

Tendermint simulation

b_1

b'_2

Alice

Once it is confirmed by $n - 2f$, no incompatible block will ever get a quorum

b_1

b_2

Anon4

b_1

b''_2

Bob

Sender

Anon3

Anon1

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b_1

b'''_2

Anon2

Tendermint simulation

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b_1

b_2'

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Anon4

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b_1

b_2'''

Tendermint simulation

b_1
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Only f can stay locked

Anon3

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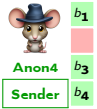
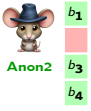


Only f can stay locked

Eventually quorum is received

One more voting allows for very late communication
as long as enough honest parties are communicating



Bitcoin and others: protocols allowing new users to come

New non-authenticated users come, billions of them!

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Going green: **Proof of Stake**

- Voting power is proportional to the money in posession.
- Then one can use protocol for authenticated users.

Layer 2: How can we optimize a blockchain?

. . . and a reminder of what is going on there

- We don't just put the transactions on the blockchain, we verify them:

  EXAMPLE: Alice wants to pay Bob 5 eth

  - Is this transaction correctly signed by Alice?
  - Does Alice has that much money?
  - In general, is the code executed correctly?
    (*oversimplified!*)

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if money[Alice] >= 5
then
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- For example, Succinct Non-interactive (Zero Knowledge) Argument of Knowledge (zk-SNARK)
- Even better: Let the handler do it for many transactions and submit one such proof for a block.
- The community now spends much less time on verification.

Takeout

- Blockchains.

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Coming next:

- *(right now) Homework.*
- *(maybe) Exercises and Repeat.*
- *(maybe) Anything left about the blockchains?*
- *(maybe) The real grounds of the security in modern cryptography.*
- *(maybe) A complete (universal) public-key cryptosystem.*

Homework assignment #2

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- User creates (pk, sk) and sends pk to the server (using an authenticated channel).

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Consider commonly used key types (type `ssh-keygen -h` and look for `-t`):

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-t dsa | ecdsa | ecdsa-sk | ed25519 | ed25519-sk | rsa
        Specifies the type of key to create.  The possible values are “dsa”, “ecdsa”,
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        This flag may also be used to specify the desired signature type when signing cer-
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More specifically, type `ssh -Q sig` to list the protocols.

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Telegram group: *Кто первый встал, того и тапки.*

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