Updates

- A3 due Sunday
- Example client code was corrected (see @220)
- Send Finn your A3 trace.json files (see @232)
- Jaafar is leaving us: his office hours end this week
    - Two TAs joining over next two week. Their office hours schedule TBD
- A4 will not be released until *after* the reading week

BitCoin

↑

Digital Currency

Alternatives
Smart Contracts

Key ideas: Concepts

+ Proof of Work (PoW)

Alternatives
Proof of
stake
(PoS)

⇒ Cryptopuzzle — originally invented for SPAM email

+ BlockChain (Dist. Ledger)

⇒ Ordering on operations (txns)

Read/Write
shared State

+ P2P + Byzantine threat model

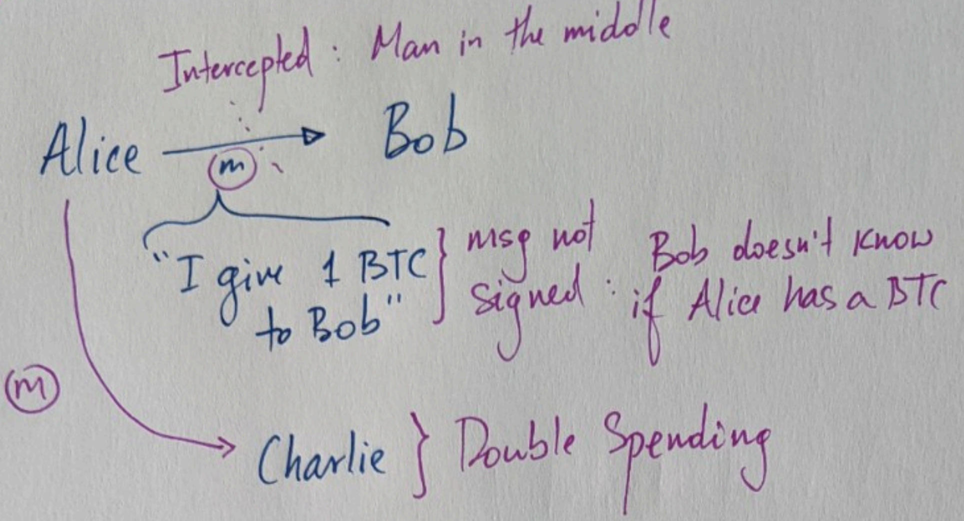
Alternatives
Private
BChains
(not open)

Arbitrary peer
Behavior

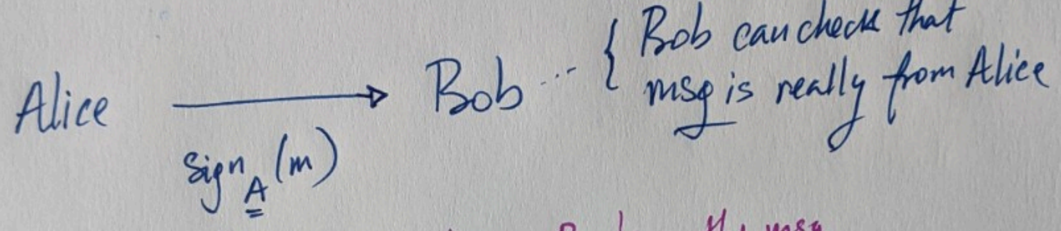
+ Eventually Consistency ?

If you wait long enough
then everyone will observe same state

Blockchain


Intercepted : Man in the middle
Alice
m
Bob
"I give 1 BTC to Bob"
msg not signed : Bob doesn't know if Alice has a BTC
m
Charlie
Double Spending

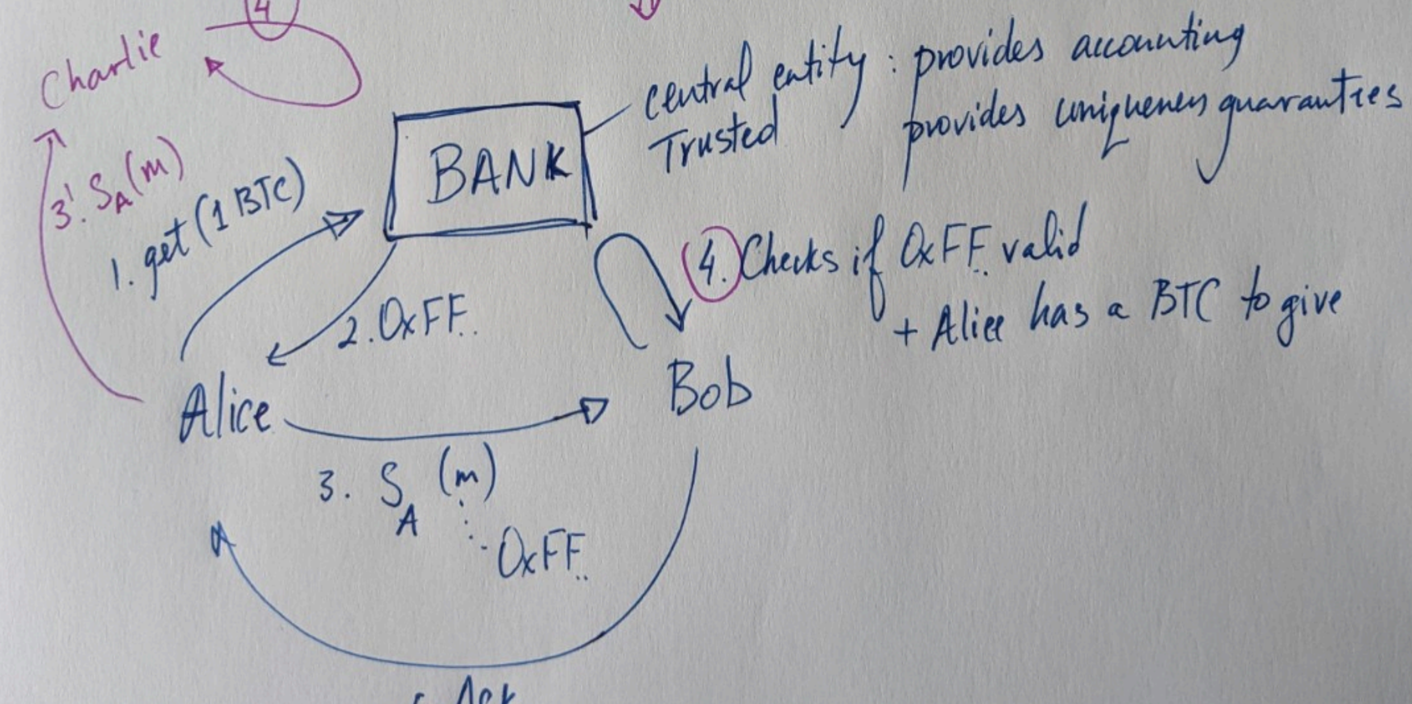
⇓


Alice
$\mathrm{sign}_{\underline{A}}(m)$
Bob
Bob can check that msg is really from Alice

× MIM : at most can Replay the msg

× Double Spending still a problem

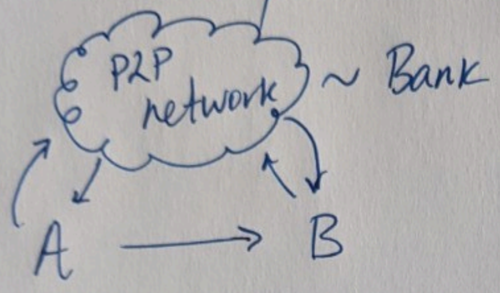
⇓


Charlie
4'
3'. $S_A(m)$
1. get (1 BTC)
BANK
central entity : provides accounting
Trusted provides uniqueness guaranties
2. 0xFF..
4. Checks if 0xFF.. valid
+ Alice has a BTC to give
Alice
Bob
3. $S_A(m)$ .. 0xFF..
5. Ack

Bank ⇒ Distributed P2P Context

" Make everyone the Bank" ⇒ Bank is public/transparent

⇒ all peers in the system track the ledger of txns

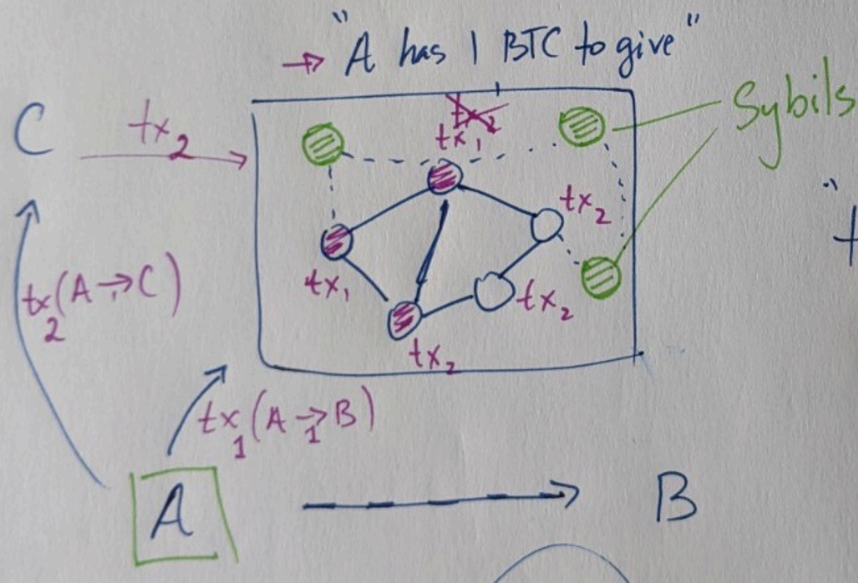


× double spending] PoW + Blockchain

× Concurrency

× Incentives] Reward P2P peers

× Trust] Assumptions about majority of nodes non-malicious



"txn committed" if majority of P2P netw. know about it

Any two majorities overlap

Requires to know the # of nodes in system ⇒ Easy to Join

⇓

Easy to create "Sybils" by 1 person

⇒ Sybil Attack

Proof of Work (PoW)

① Make validation of txns in the network "difficult" (Why? A: Sybils)

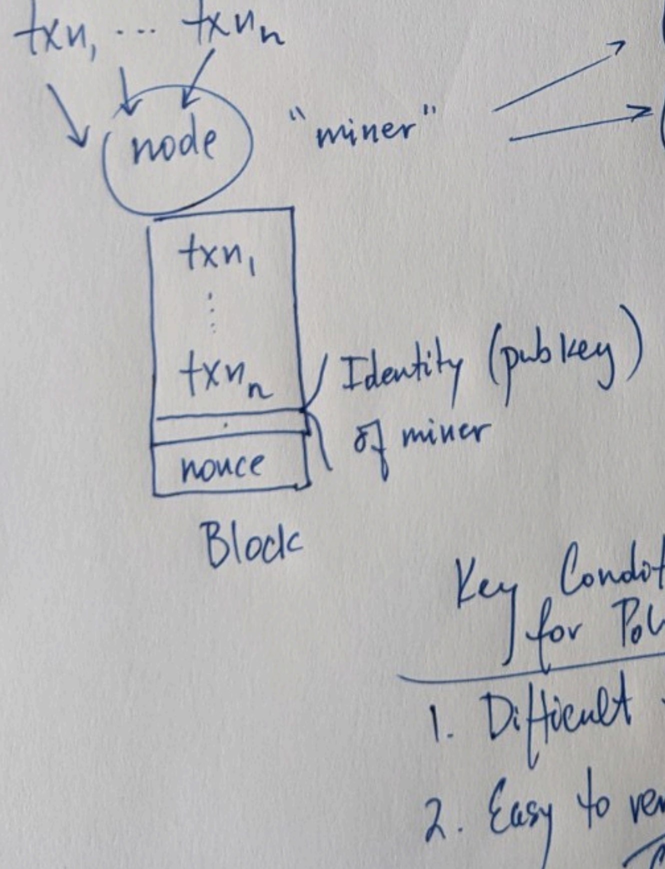
⇒ You need real physical resources (CPU cycles for comptuting PoW)

② Incentives for nodes to compute PoW

\ Reward for solving a PoW ⇒ # of BTC

\ Scales with amount of CPU cycles

③ Transactions come with a fee that is given to a node that "validates" it using PoW



(M1) Check txn$_i$ valid (consistency check)

(M2) Solve a cryptopuzzle (PoW)

h = sha-256 hashing fn.

Find a nonce value s.t.

$h(\text{Block}) \leq \underline{\text{target value}}$

i.e., $h(\text{Block}) = \underbrace{0\text{x}00\ldots00}_{}5\text{AF}42\ldots$

Dificulty for PoW task
# of leading zeroes

Key Conditions for PoW

1. Difficult to find nonce
2. Easy to ~~verify~~ check the nonce

Mining generates reward to miner (in BTC form)

⇒ Race between miners to mine blocks ⇒ Mining pools for cooperation

(Miners have to balance # of txns in a block with the fact that other Miners are already mining) — Select some # of txns (Bound on block size)

BTC mining reward is generated until ~2140

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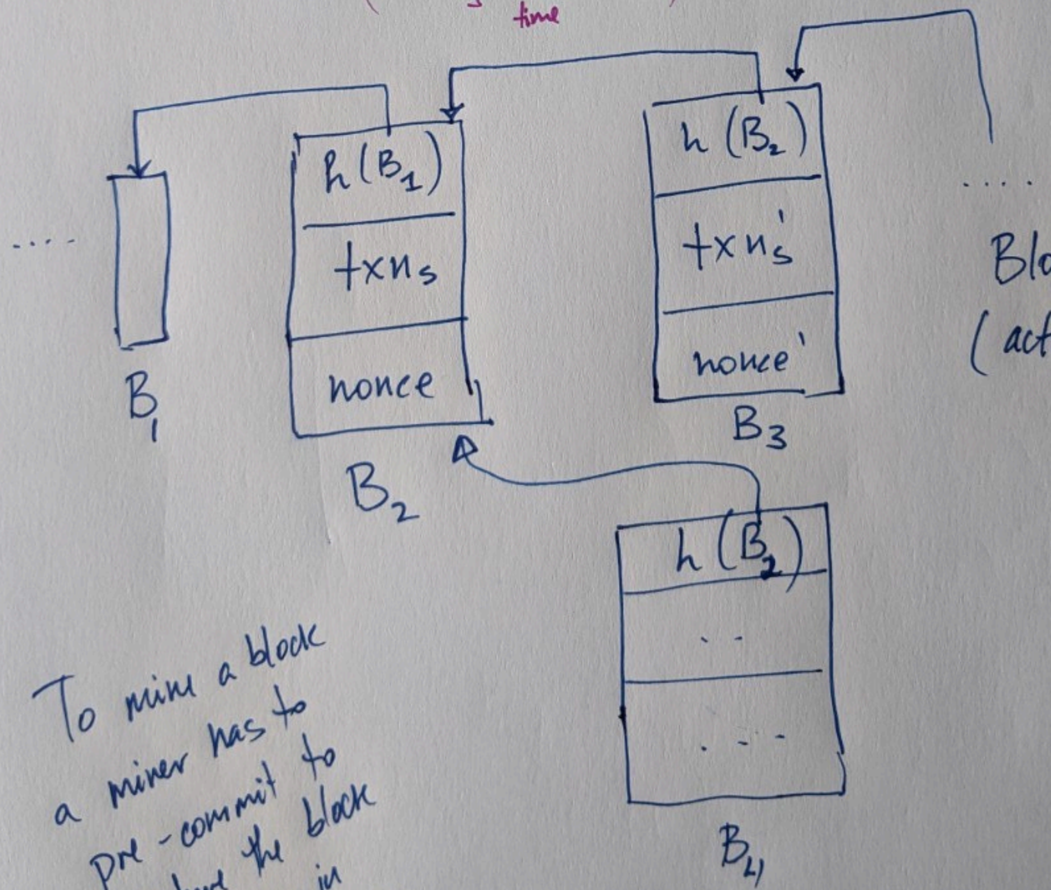
After 2140 Mining is incentivized using only txn fees

Missing: Ordering of txns

$(txn_1 \underset{time}{\leq} txn_2)$



Blockchain (actually a tree)

To mine a block a miner has to pre-commit to where the block will go in Blockchain

Miners
- Work along the longest Chain (that they know)
- Keep track of all forks (the entire tree)

In short term "longest chain" is unclear
- Race cond. in mining
- Network latency
- Network connectivity

But... in long term "longest chain" is stable

=> txn is not "confirmed" Unless

① txn is on longest chain } Essential for total order

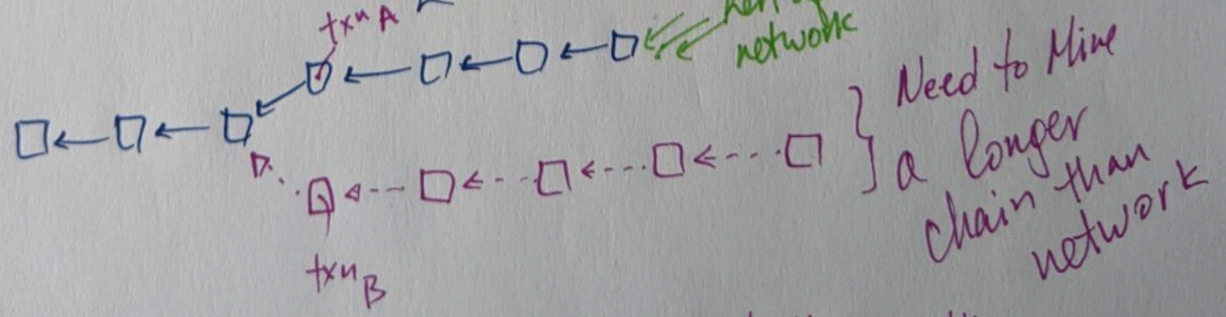
② Must have 5 blocks that follow it } heuristic
"6 confirmations"

Implications:

① Blocks are immutable: "ledger" -> Append Only

② Difficult to create a fork
+ Convince network to follow it

-> Requires maj. of CPU power



txn_A ; txn_B confict: "double spend"

BitCoin Overview

1. Flooding Txns
2. Mining process to
   1. Validate txns
   2. Generate blocks
3. Flooding Blocks (that include txns)

The End