Lecture #22: Proof-of-Stake

COMS 4995-001:
The Science of Blockchains

URL: https://timroughgarden.org/s25/

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Goals for Lecture #22

1. Proof-of-stake: the high level idea.
   – sample validator with probability proportional to amount of locked-up stake
2. Proof-of-stake: pros and cons.
   – why isn’t proof-of-work good enough?
3. Mechanisms of staking.
   – warm-up and cool-down periods, delegation, etc.
4. Why proof-of-stake is hard.
   – lack of external randomness; quick + dirty solution: weighted round robin

Proof-of-Stake: The High-Level Idea

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Fact: proof-of-stake has become the dominant approach to sybil-resistance over past 5+ years.

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- proof-of-stake: validators' stake directly observable by protocol
  - energy consumption comparable to a typical Internet protocol

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  - even in synchrony, finality is only probabilistic (unavoidable for PoW)
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  – PoW alternatives with lower latency exist, but not in production
- proof-of-stake: pairs well with e.g. Tendermint (as we’ll see)
  – finality as soon as assemble relevant quorum certificate, even in partially synchronous setting (assuming ≤ 33% faulty stake)

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- proof-of-stake: can punish attacker by "slashing" their stake
  - e.g., slash any validators that are caught equivocating/double-voting
  - slashing could be programmatic or implemented via hard fork
  - for slashing, particularly convenient for stake to be in native currency

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  - counterpoint: extra complexity necessary for extra functionality

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- example ("long-range attack"): if validator's secret key is stolen, easy to fabricate signed blocks/votes allegedly from the past
  - e.g., in attempt to rewrite the past and break finality
  - with proof-of-work, need to actually do the work to produce valid blocks
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Upshot: all current proof-of-stake designs less battle-tested than Nakamoto consensus.

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  - effectively pre-selecting the initial set of potential validators
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  - various imperfect techniques for better decentralization of initial currency distribution (airdrops, secondary markets, etc.)

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  - in practice: use trusted source, or look for unanimity among 2-3 sources

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- validators (identified by public key) lock up funds in this contract
  - generally, funds in protocol’s native currency
  - in some PoS chain, register your IP address (in addition to pk)
  - alternative: communicate via gossip network (see future lecture)

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Design decisions:

1. Mininum/maximum staking duration. (e.g., days/weeks/months)
   – also: join/leave at any time, or only at prescribed points in time?

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   – cool down important for e.g. slashing
   – warm up important for e.g. some VRF designs

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   - e.g., inflationary block rewards a la Nakamoto consensus
   - increasingly common: pay fixed interest rate on stake, conditional on timely participation

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   – if not (e.g., in Ethereum), expect 3rd-party staking pools to arise

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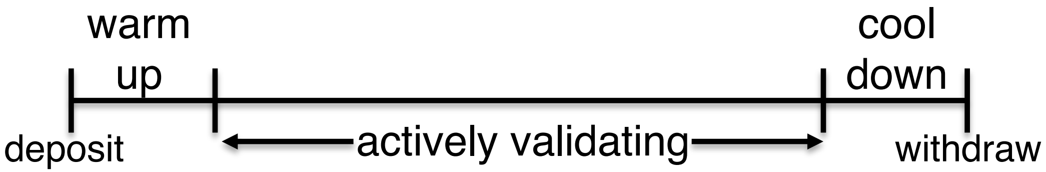

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- in warm up or cool down period ➔ not in this list

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- issue: opportunities for validators to manipulate the random selection process (e.g., when assembling a new block)

Weighted Round Robin

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- ➔ risk of bribery, coercion, DoS attacks
- also has its benefits (e.g., for tx dissemination)

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More sophisticated: verifiable random functions (VRFs).

– leader unknown prior to their block proposal (cf., Nakamoto consensus)