Lecture #28: A Glimpse of the Cutting Edge

COMS 4995-001: The Science of Blockchains

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

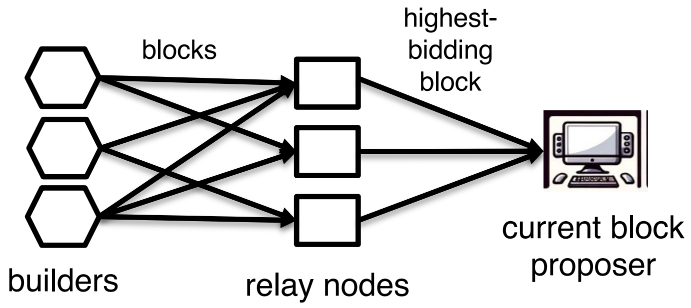
Tim Roughgarden

Goals for Lecture #28

1. Censorship-resistance.
   – experimental ideas to mitigate dangers with centralized builders
2. Protocols from principles.
   – recap of everything you now know about Bitcoin and Ethereum
3. "SNARK-ify everything."
   – scaling an L1 by outsourcing execution to builders via SNARKs
4. Some future directions.
   – e.g., "zk co-processors" to guarantee correctness of off-chain computation

Proposer-Builder Separation + MEV-Boost

- specialized builders submit blocks (with bids) to trusted relay nodes



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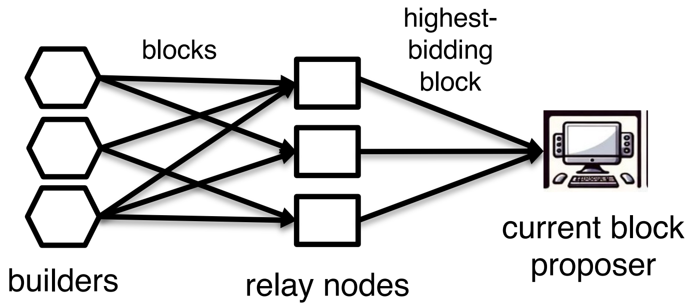

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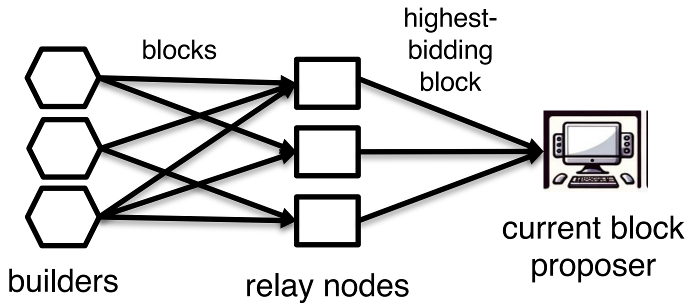

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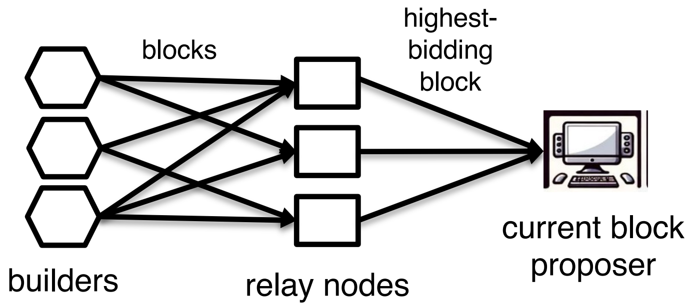

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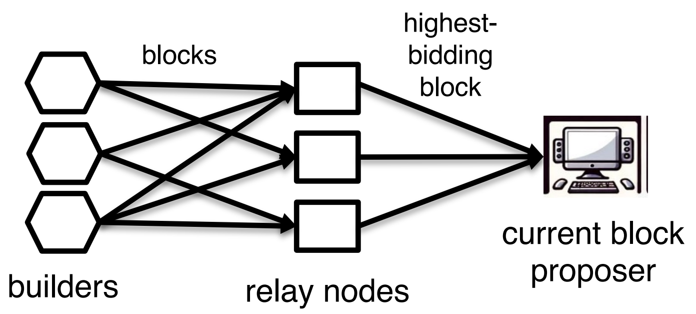

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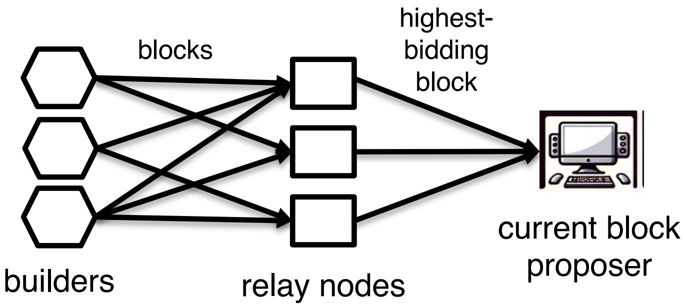

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- MEV rewards (per-unit-stake) equalized across validators

  – hopefully, no economic barriers to decentralized validator set

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Block	Slot	Age	Txn	Fee Recipient	Gas Used	Gas Limit	Base Fee	Reward	Burnt Fees (ETH)
22330775	11548010	14 secs ago	184	Titan Builder	14,024,967 (38.96%)	35,999,965	1.166 Gwei	0.01742 ETH	0.016360 (48.42%)
22330774	11548009	26 secs ago	228	Titan Builder	17,704,576 (49.23%)	35,964,845	1.168 Gwei	0.02039 ETH	0.020692 (50.36%)
22330773	11548008	38 secs ago	204	beaverbuild	20,131,027 (55.92%)	36,000,000	1.151 Gwei	0.01934 ETH	0.023184 (54.52%)
22330772	11548007	50 secs ago	173	beaverbuild	16,695,651 (46.38%)	36,000,000	1.162 Gwei	0.01824 ETH	0.019404 (51.53%)
22330771	11548006	1 min ago	324	Titan Builder	35,644,314 (99.01%)	36,000,000	1.035 Gwei	0.0492 ETH	0.036904 (42.86%)
22330770	11548005	1 min ago	115	quasarbuilder	7,545,978 (20.96%)	36,000,000	1.116 Gwei	0.00557 ETH	0.008424 (60.18%)
22330769	11548004	1 min ago	186	beaverbuild	17,009,799 (47.25%)	35,999,965	1.124 Gwei	0.04548 ETH	0.019121 (29.59%)
22330768	11548003	1 min ago	214	beaverbuild	21,519,909 (59.84%)	35,964,845	1.097 Gwei	0.04709 ETH	0.023610 (33.39%)
22330767	11548002	1 min ago	244	Titan Builder	21,948,869 (60.97%)	36,000,000	1.067 Gwei	0.01889 ETH	0.023438 (55.37%)
22330766	11548001	2 mins ago	146	beaverbuild	10,282,523 (28.56%)	36,000,000	1.128 Gwei	0.00775 ETH	0.011602 (59.95%)
22330765	11548000	2 mins ago	211	Titan Builder	22,679,059 (63.00%)	35,999,931	1.092 Gwei	0.01958 ETH	0.024784 (55.85%)
22330764	11547999	2 mins ago	315	Titan Builder	30,120,386 (83.75%)	35,964,811	1.007 Gwei	0.0271 ETH	0.030355 (52.82%)
22330763	11547998	2 mins ago	43	Lido: Execution Layer Rew...	2,326,986 (6.48%)	35,929,725	1.13 Gwei	0.00809 ETH	0.002631 (24.52%)
22330762	11547997	2 mins ago	274	Titan Builder	25,964,257 (72.19%)	35,964,845	1.071 Gwei	0.03609 ETH	0.027818 (43.53%)
22330761	11547996	3 mins ago	216	beaverbuild	24,057,554 (66.83%)	36,000,000	1.028 Gwei	0.04062 ETH	0.024735 (37.84%)
22330760	11547995	3 mins ago	165	Lido: Execution Layer Rew...	11,446,914 (31.80%)	36,000,000	1.077 Gwei	0.00408 ETH	0.012330 (75.12%)

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One issue: censorship --- i.e., systematic exclusion of certain txs.

- e.g., for financial or legal/regulatory reasons

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- idea #2: multiple concurrent proposers (MCP) --- take union of multiple validator block proposals ➔ censoring requires large bribes to multiple validators [Fox/Pai/Resnick 23]

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- misc. trivia/lore (blocksize wars, SegWit, etc.)

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    - slashing for consistency, liveness violations

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  - tx dissemination via public mempool (gossipsub) or sent directly (as private order flow) to searchers/builders

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  - validity rollups: guilty until proven innocent with a SNARK for SRV
    - L1 verifies SNARK directly

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Approach #2: directly scale the core Ethereum protocol.

- e.g., 100x throughput (1.8 billion gas/block), lower latency
- "preconfirmations" for sub-second latency (even with > 1M validators)
- see e.g. Justin Drake's CBER seminar on May 8th

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  - perhaps collaborating with 3rd-party provers to do this quickly
  - Ethereum validators now effectively become stateless
    - don't need blockchain state to verify block validity (just check SNARK)
    - like stateless clients, but still with consensus voting power

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3. Will SNARK generation ever be fast enough for this vision?

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- commitment z to a (possibly large) model posted on-chain
- for query x and alleged output y, SNARK asserts existence of model M with h(M) = z and M(x) = y

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Note: SNARKs can be used to prove correctness of *any* (NP) computation, not just state root verification.

- buzzword: “zk co-processors”

Example: ML inference.

- commitment z to a (possibly large) model posted on-chain
- for query x and alleged output y, SNARK asserts existence of model M with h(M) = z and M(x) = y
- upshot: results of complex inference queries can be verifiably posted on-chain (no trust required)

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- or even ML training: w.r.t. on-chain commitment w to some data set and commitment z to alleged training output, SNARK asserts existence of D and M s.t. (i) h(D) = w; (ii) h(M) = z; and (iii) training a model (with an agreed-upon algorithm) with training data D results in the model M

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Example: "zkTLS."

- TLS: how two parties can communicate securely over Internet
- zkTLS: proving results of such a secure communication to a third party (without e.g. leaking your login password)
  - one application: getting Web2 data on-chain in verifiable way

Epilogue

Benefits of learning a mature field:

- agreed-upon models and definitions
- agreement on the most important open problems
- agreement on what constitutes a “solution” or “progress”
- shared language and knowledge base
- comprehensive textbooks, MOOCs, etc.

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Opportunity: get in on the ground floor, shape the technology!

Upcoming Conferences in NYC

- May 12-13 @ Columbia: TLDR (The Latest in DeFi Research)
- May 19-23 in NYC: Accelerate (Solana)
- June 24-26 in Brooklyn: Permissionless IV
- August 4-6 @ Berkeley: Science of Blockchains Conference (SBC)
- December @ Columbia: Columbia Cryptoeconomics Workshop
- etc.

THANKS!