(De)centralization of Ethereum's builder market

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Joint work with Sen Yang (Yale) and Kartik Nayak (Duke)

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Decentralized Systems Group @ Yale CS
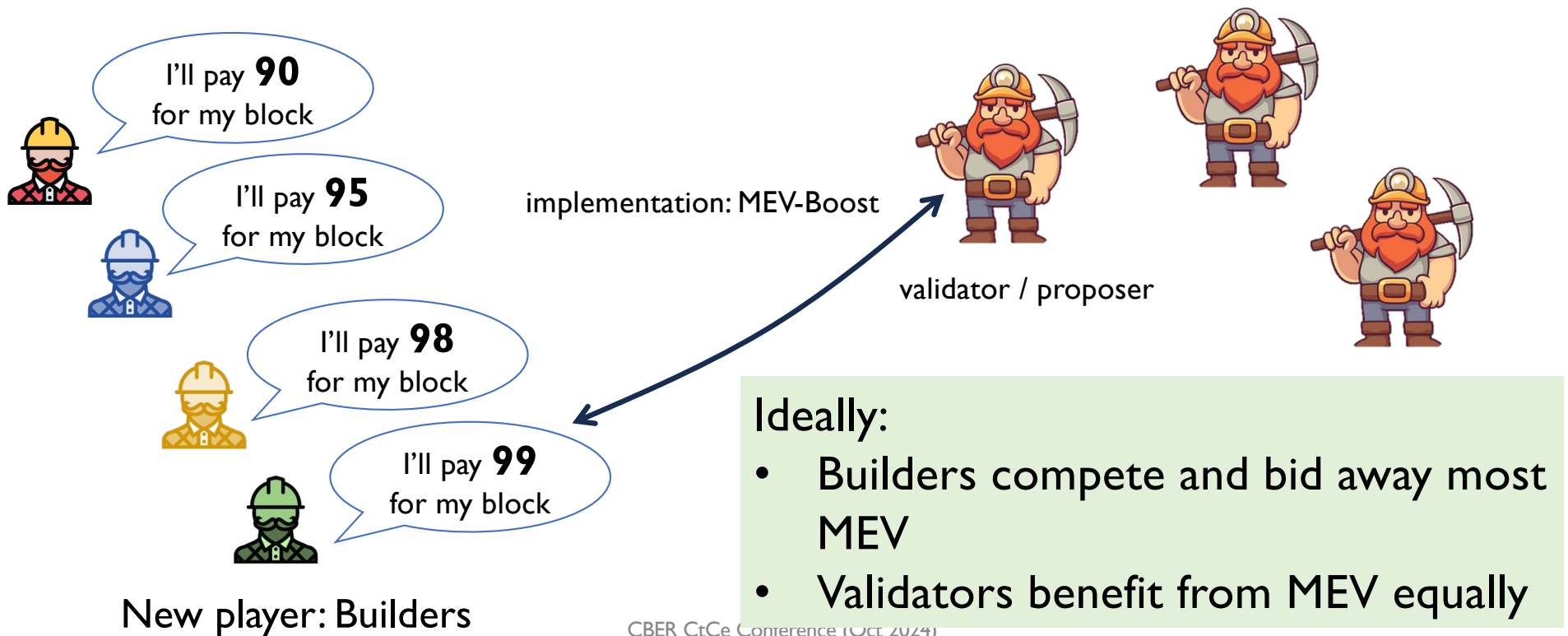
https://www.fanzhang.me/

We work on security and privacy problems in distributed and decentralized systems.

- **Interoperability**
  - b/t web3 systems (CCS'22)
  - b/t web2 and web3 (aka zkTLS) (CCS'16, CCS'21, SP'21)
  - b/t web2 systems (EuroSP'23)
- **Strategic behaviors and mechanism design**
  - Maximal Extractable Values (MEV) (CCS'24)
  - Bribery attacks (NDSS'23)
- **Distributed consensus**
  - Resource efficiency (UseSec'17,'24)
  - Order fairness (CRYPTO'20)
  - TEEs (EuroS&P'19)
- **Anonymity**
  - Anonymous broadcast (PETS'25)
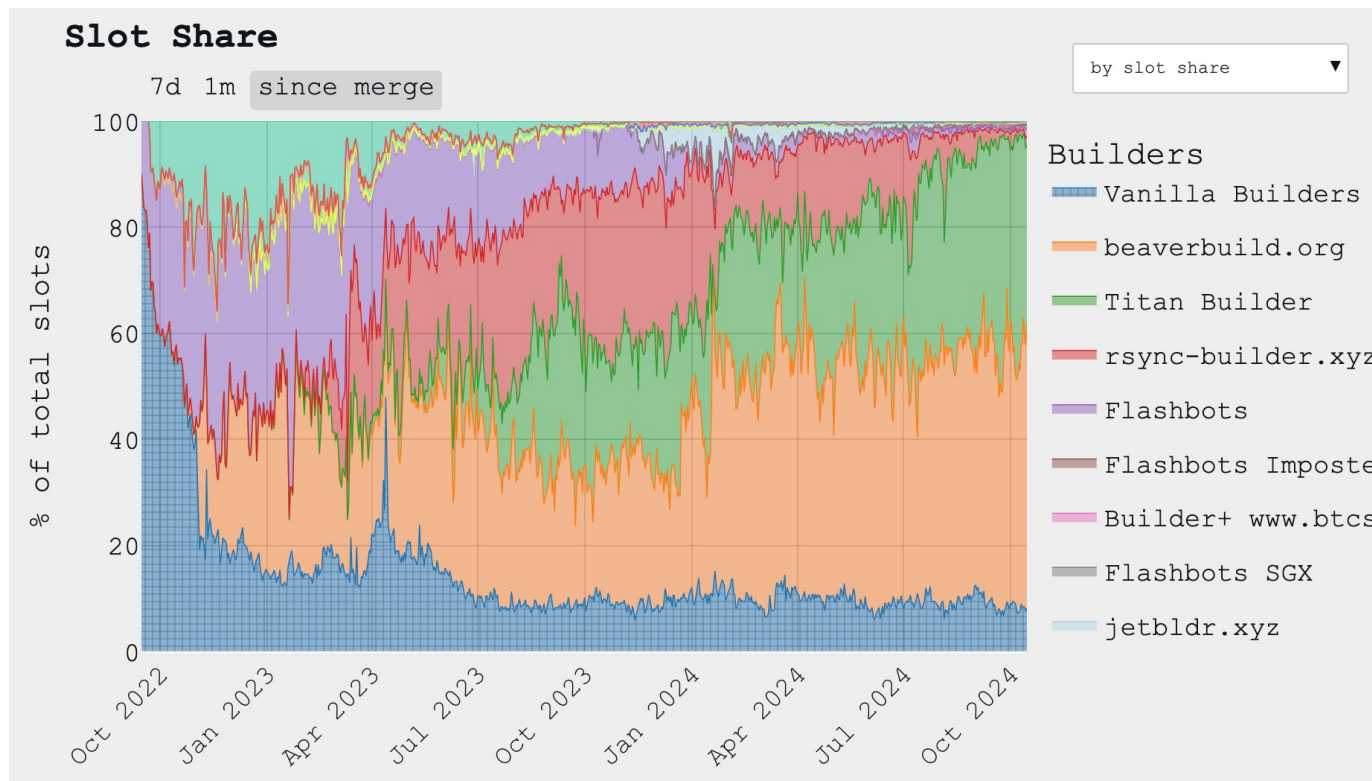 - Secret single-leader election (SSLE)

Applied Crypto

Distributed Computing

Game theory / Mechanism design
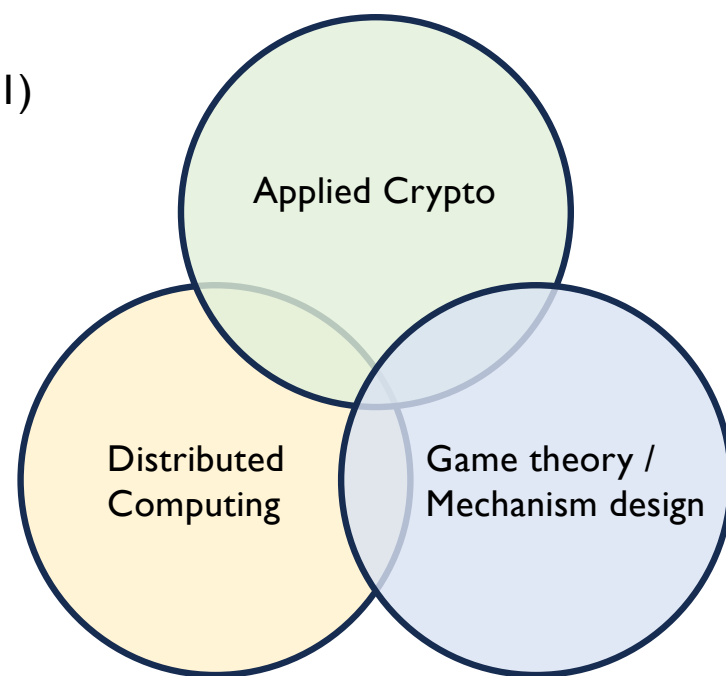
MEV and PBS

- Idea: allow outsourcing of block building (i.e., MEV extraction) to builder market.

I'll pay **90** for my block

I'll pay **95** for my block

I'll pay **98** for my block

I'll pay **99** for my block

New player: Builders

implementation: MEV-Boost

validator / proposer

Ideally:
- Builders compete and bid away most MEV
- Validators benefit from MEV equally

Fact: builder market highly centralized

Top-two builders build ~87% blocks as of Oct 2024.

https://mevboost.pics/

Fact: Builders earn a lot more than validators

% of MEV captured by builders
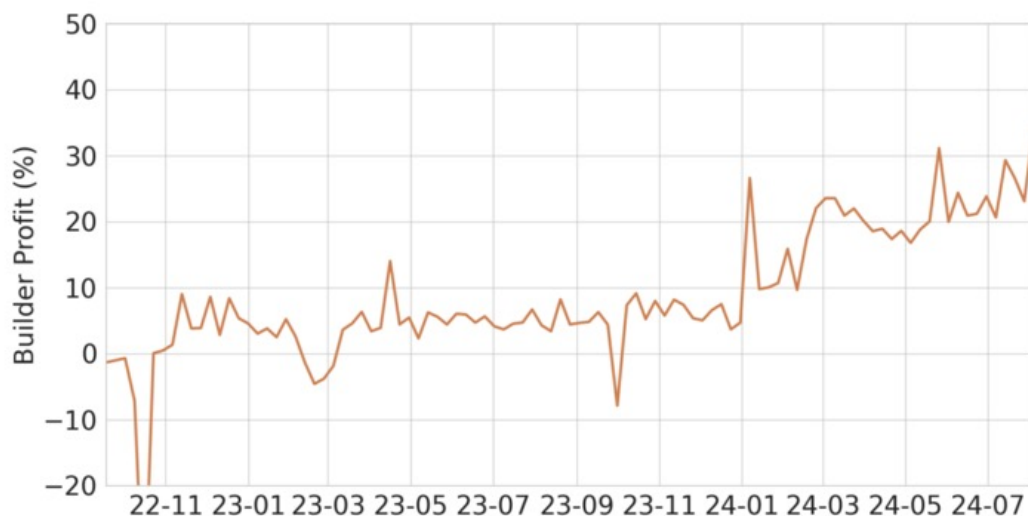
MEV distribution in PBS last week:

- Titan received ~1000 ETH, Beaverbuild received ~500 ETH.

- All proposers together received ~4000 ETH in MEV

* Data from https://www.relayscan.io/builder-profit, https://mevboost.pics. These are not necessarily their net profits, as they may have costs.

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Implications?

- "centralized block production is fine as long as [validators are decentralized]" --- ethereum.org
- Is it?

Immediate problems

- Censorship by builders
  - A malicious builder may refuse censor transactions to exit from CDP for higher gain in liquidation

- Builder frontrunning
  - Builders see all transactions
  - If you don't like Titan or Beaverbuild, you need to wait ~8x longer

- Builder boycotts
  - If builders doesn't like certain protocols (e.g., those reducing their profits), they can block them.

Long-term implications

- **Long term problem: Proposer's share of MEV diminishes**
- #1: Instability of PBS
    - Proposers might be incentivized to extract MEV themselves.
- #2: inaccurate MEV oracles
    - proposer loss $\Longrightarrow$ inaccurate MEV oracles
- Our work: quantify the loss, understand its causes, and explore mitigation.

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Potential reasons for proposer loss

- Loss due to lack of competition
  - E.g., Fixed deadline may not allow full competition. Builders may collude.
- Loss due to different true values
  - E.g., Alice extracts 100 ETH, Bob extracts 10 ETH, Charlie extracts 9.5 ETH. Assuming competitive auctions, auction revenue is 10 + ϵ (far from 100)
  - i.e., Proposer can get up to 90 ETH more if they build blocks.
- Q: Which was more important empirically?
- **A: The latter is the dominant factor.**

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What accounts for builder's inequality?

- Regular users
- Wallets
- Trading bots
- **Searchers***

} TXs

*) Searchers read from mempool and private channels

Public mempool (p2p network)

Third-party private channels (MEV-Share, MEV Blocker, etc)

Direct channels

Builders

Public Order Flow

Private Order Flow
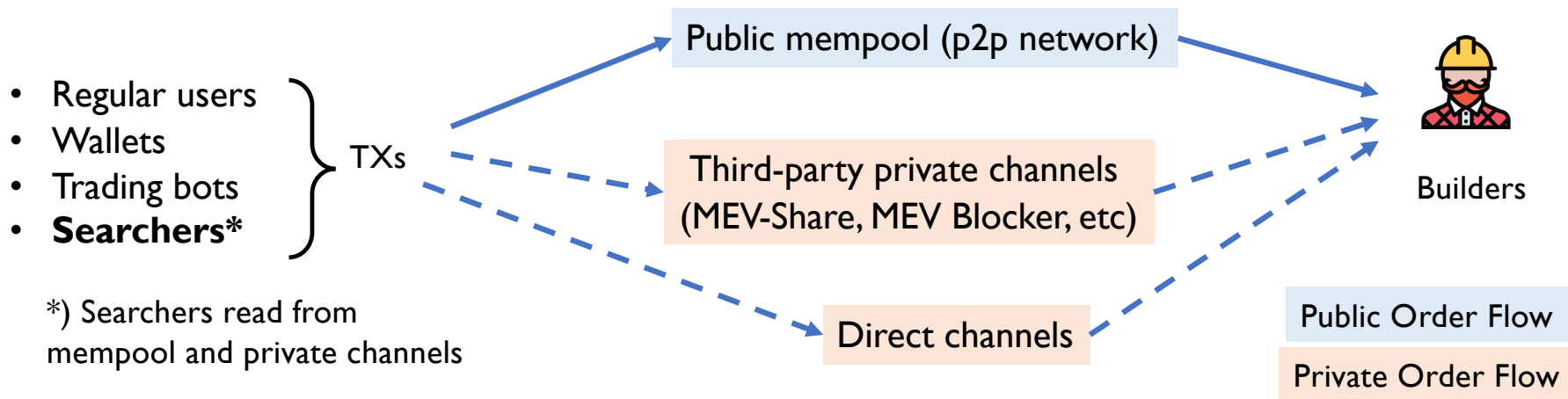
- Q: Why do builders have different true values?
- **A: exclusive order flows (aka integration)**, e.g., via closed-door deals with telegram bots, wallets, etc.

Paths forward?

Can new builders join to increase competition?

- Unlikely. There is strong incentive for existing OFs to not work with new builders.
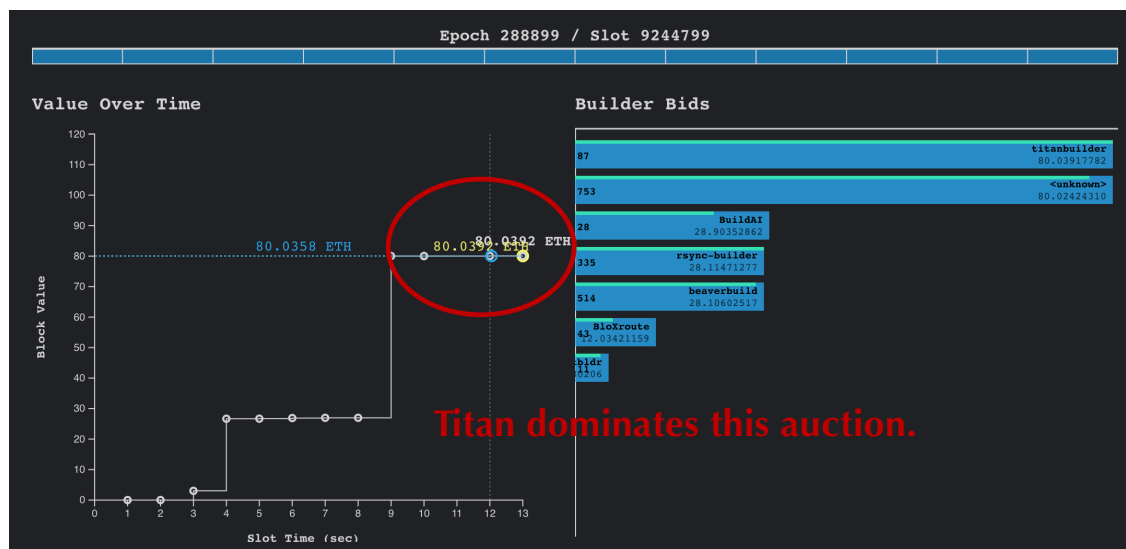
Example: Incentive for integration

- For example, in slot 8019594, about 340 ETH came from Banana Gun (OF), and all 340 ETH was captured by the proposer.

Example: Incentive for integration

- In slot 9244799, 208 ETH came from Banana Gun, and only Titan received it. Titan paid 80 ETH to the proposer.

- **128 ETH can be shared between Banana Gun and Titan!**

Paths forward?

Can new builders join to increase competition?

- Unlikely. There is strong incentive for existing OFs to not work with new builders.

- Also trust barriers

Is PBS stable in the long term?

- Recall: top-2 builders earned 1000, 500 ETH, while all validators earn 4000 ETH

- Proposers with large stake should think about building.

- Doesn't seem hard to do: much of builder's job is to simply *collect* transactions.

- E.g., Validator BTCS recently started building (we don't know why)

- Other changes might affect PBS too, such as app-level MEV redistribution.

Overall question: How should MEV be split among users, builders, validators, searchers?

A call for action

Where we are today:

- Two builders build >87% blocks in Ethereum

- Last week: PBS distributed ~1000 ETH to Titan, ~500 ETH to Beaverbuild [1]; All proposers together received ~4000 ETH [2]

- Losses mainly stem from exclusive OFs

How did we get here:

- Builders compete on two dimensions simultaneously: *MEV-carrying txns* and *extraction algorithms*.

- Builders cut closed-door deals to get *exclusive access* to the former.

- Without the former, the latter doesn't matter.

- Our conjecture: the solution may lie in decoupling the two.

[1]: https://www.relayscan.io/builder-profit
[2] https://mevboost.pics

Open challenges

- How to mitigate the negative impacts of integration?
  - Execution Auctions, PROF, etc, do not directly address this problem.
- How should MEV be allocated between users, searchers, builders, proposers?
- How to solve immediate problems like builder censorship resistance?

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Blog post: https://decentralizedthoughts.github.io/2024-05-07-decentralization-ethereum/
Paper: https://arxiv.org/pdf/2405.01329
X: 0xfanzhang

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