Relays are a Latency Game

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TLDR:

- Our study focused on the influence of latency on the relationships between builders, relays, and proposers in the MEV ecosystem.
- We found that builders typically share winning bids with relays within milliseconds of the start of the slot.
- Due to latency and limited builder-relay vertical integration, proposers often do not receive the block with the highest value, but this has a minimal impact on their revenues.
- Going forward, we believe that latency will play an increasingly significant role in the MEV supply chain.
- This may necessitate the development and adoption of new relaying models to address the challenges posed by latency.

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MEV-Boost Background

Since the Merge, Flashbots' MEV-Boost has become the de facto method for building Ethereum blocks, accounting for over 90% of all blocks. Validators run MEV-boost, an open-source middleware implementation of proposer builder separation (PBS), to gain access to a block-building marketplace. Through MEV-Boost, validators can increase their staking rewards by selling their block space on an open market. The MEV-Boost supply chain has the following players:

1. Searchers

use bots and algorithms to identify transactions that could yield MEV. They create bundles (ordered sets of transactions) to extract MEV.

1. Block Builders

aggregate bundles of transactions received from multiple searchers to create a block that maximizes block reward. Builders send their profit maximized blocks to Relays.

1. Relays

are trusted entities that validate blocks received from Builders and select the most profitable one.

1. Validators/Proposers

use MEV-Boost to register with specific Relays that will provide the most profitable, validated blocks.

MEV-Boost Flow

Every slot (12 seconds), a randomly selected validator, determined epochs in advance, has the opportunity to propose a block. When a validator uses MEV-Boost, they register with relays, and the software queries those registered relays for bids. The bids contain the block header, block hash, and the value the validator will receive if that block is proposed. Builders send hundreds of blocks to relays as the mempool keeps evolving with new transactions leading to fresh MEV opportunities. The constant evolution of the mempool, combined with the builders' objective of constructing the most valuable block, encourages them to continuously build and submit blocks to the relays. Relays are accountable for processing and validating each block. While doing so, they constantly evaluate new blocks from builders to determine the most profitable one, which they then submit to the validator.

Examining the builder-relay-validator dynamic is even more interesting with a new dimension: time.

Builder — Relay Relationship

First, we wanted to observe the impact of time on the builder-relay relationship for MEV-Boost blocks. Over a span of three days (from 2023–02–23 16:15:35 UTC to 2023–02–27 14:29:23 UTC), we collected all blocks constructed by builders and sent to relays, which was equivalent to 22,820 non-missed unique slots and more than 6 million blocks. The relays included in this analysis are: Aestus, bloXroute Ethical, bloXroute Max Profit, bloXroute Regulated, Eden, Flashbots, Gnosis Agnostic, Manifold, Relayooor and ultra sound.

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NOTE

: Blocknative was unfortunately not included in this analysis because their block timestamp is reported in seconds, and not milliseconds, which impeded parts of the analysis.

In our analysis, we found that an average of 300 unique blocks are built and submitted to relays for every proposed block, with some slots having up to 600. Keep in mind that the number of blocks built and submitted may actually be higher than the values presented here, as some relays only report a portion of the blocks they receive, rather than all of them.

In the final moments before the slot is started, the process of building and submitting blocks becomes even more intense. Builders hurry to create and send their highest-value blocks, leveraging their most recent mempool transactions and Searcher bundles in the hopes of maximizing their block's worth.

The graph below displays the time when relays provided blocks to the proposer for All Blocks (orange) and Proposed Blocks (blue). The x-axis indicates the time to the start of the slot, where negative values indicate the remaining time until the slot starts and 0 denotes the start of a slot, which is generally when validators propose the block. The y-axis represents how many blocks were made available to the proposer at a particular moment relative to the start of the slot. It is important to mention that the left y-axis is scaled for All Blocks, whereas the right y-axis employs a distinct scale only for Proposed Blocks.

It's worth noting that the moment when the block is made available to the proposer by the relay occurs after the moment when the builder submits the block to the relay. This delay occurs because relays need to simulate the block to prevent it from causing a missed or invalid block. The peaks observed near the 0-second mark are the result of mass builder submissions. These peaks tend to occur within 0.5 seconds of each other, coinciding with the default submission rate value set in the Flashbots open-source builder. As anticipated, the proposed block that ultimately wins the auction out of all the constructed blocks tends to be very close to the start of the slot. As shown in the chart above, the majority of winning blocks were made available around the 0-second mark, which corresponds with the start of the slot. Our hypothesis is that blocks proposed significantly after the start of the slot (0-second mark) may be a result of the proposer making a late request for blocks.

Relay — Proposer Relationship

In 96% of the blocks we analyzed, the proposed block was not the one with the highest reward built by block builders. The reason for this is twofold: firstly, builders continue to transmit blocks to relays until a block is proposed, and secondly, relays validate each block before sending it to the validator. While the validation process is crucial in preventing the submission of invalid blocks, it also causes a delay that makes the latest block submitted by builders not immediately available. The chart below illustrates the large proportion of high-reward blocks made available after the slot started and the validator had already submitted the block. This suggests that proposers have the potential to obtain higher rewards since the block with the highest reward is not the one proposed in most cases.

The charts below illustrate the calculation of the difference between the time when the proposed block and the highest reward block for each slot were made available, which was used to understand the time variation by each relay. The x-axis represents the time delta between when the proposed block and the highest reward block were made available by the different relays. The y-axis represents the percentage of blocks over all blocks for a given bin. The higher the density of the distribution is to 0 or below, the greater the number of blocks with the highest rewards that are proposed.

The spikes observed at the 0 mark indicate instances where the proposed block also had the highest reward, implying a possible vertical integration between the builder and relay. Here, vertical integration refers to the scenario where builders halt block creation once the relay receives a query from the proposer, rather than waiting to witness the new block on the chain.

Latency Impact on Proposer Rewards

At first we thought proposers could potentially earn more rewards since the proposed block usually did not have the highest value. Turns out that in most cases the difference in value between the proposed block and the block with the highest reward is small. The table below shows the distribution of the difference between the highest block reward and the proposed block reward:

From the table we can conclude that the latency impact on proposer rewards is not substantial, with a median increase of 0.001 ETH or 3.7%. As a validator, delaying block proposals could hurt attestation rewards and increases the chances of the block being missed or forked. However, as a builder or relay, even the slightest increase in rewards could make a difference since the winner of the auction is purely based on the highest reward.

Conclusion

Latency is becoming increasingly significant for relays and the entire MEV supply chain, with notable consequences. One of these consequences is that latency acts as a centralizing force within the MEV supply chain. Relays with the shortest latency will likely be more successful in auctions, leading builders to preferentially send their blocks to those relays. Consequently, builders may concentrate on submitting blocks to only a few relays, resulting in the centralization of relays. Additionally, latency can encourage relays with a builder relationship to establish a vertical builder-relay integration or to improve their latency performance by investing in better hardware or software. This type of improvement, due to the non-profit nature of relays, could only be economically viable to some of them. Another option could be implementing new relaying models. An example is the Optimistic Relay proposal submitted by the ultra sound Team, which modifies the validation flow and reduces latency related to validation. The core idea of the Optimistic Relay proposal is to decouple availability and validation of blocks so that blocks are immediately made available instead of after validating them. As we move ahead, we are curious about the impact of the new validation flow on MEV supply chain centralization and their share of proposed blocks.

The relay ecosystem is undergoing rapid evolution, with compute and transport latencies emerging as key drivers of relay success and their ability to win auctions. The non-profit ethos of relays influences their ability to evolve and respond to changes in the environment. As a builder, it’s essential to take into account the latency of the relays when sending blocks. As a validator, it’s important to acknowledge that relays are not merely “dumb pipes” and that they can significantly impact your rewards. We will keep a close eye on how optimistic relaying and future enhancements shape the landscape. Stay tuned for updates!