TLDR

: We suggest a strategy to centralise validator penalties in the beacon chain via an artificial penalty scheme. The accounting trick simplifies the enforcement of [interest on margin and the forced ejection of validators](#)

Construction

Let SHARDS_MAX_PENALTY_PER_EPOCH

be the maximum penalty a validator is liable to within one epoch across all shards. Instead of applying shard penalties we apply a default penalty of SHARDS_MAX_PENALTY_PER_EPOCH

per epoch in the beacon chain. To compensate for this artificial penalty every shard is awarded SHARDS_MAX_PENALTY_PER_EPOCH / NUM_SHARDS

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(For concreteness, if the only shard penalty is 2^{-20} ETH

for every missed attestation on a canonical shard block, NUM_SHARD = 2^7

, and there are 2^7

periods per shard, then SHARDS_MAX_PENALTY_PER_EPOCH = 2^{-6} ETH

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Discussion

The above accounting trick means that penalties accrue in the beacon chain only, i.e. shard balances cannot go negative. This makes it especially easy to charge interest on "margin" (any balance deficit below the 32 ETH deposit) and kick out validators if the margin grows too large.

Assuming the expected profit in the beacon chain (e.g. from crosslink and FFG rewards) for an active validator surpasses this artificial worst-case penalty then beacon chain balances can stay afloat.

If shards balances could go negative we would likely need a mechanism for the shards to inform the beacon chain when their balances get too low. This communication protocol would come at the cost of increased design complexity and beacon chain overhead.