LightLink: Infrastructure for the New Internet

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v2.0

Abstract

LightLink is a high-performance, secure, and scalable network, built on Ethereum. The network leverages the power of layer 2 scaling solutions to provide fast and low-cost transactions. Built to onboard new users, LightLink supports both Enterprise mode and standard transacting, unlocking the power of gasless execution with optionality to proactively pay fees in either ETH (at launch) or LL (when released). The platform's novel architecture includes a sequencer, which orders transactions and a batching mechanism that increases the overall efficiency of the network. Combined with LightLink's highly composable nature, these features render the network suitable for a wide range of applications, including enterprise ecosystems, gaming and metaverse projects, ticketing, and identity management. Further, with cheap fees and fast block speed, LightLink eclipses similar platforms in terms of its ability to support enterprises and users in their pursuit of an on-chain future.

1 Problem

In the early 2010s, enterprises began adopting blockchains for their ability to provide secure and transparent transaction recording and verification. This digital ledger technology allowed businesses to create a shared record of transactions that could not be easily altered, making it useful for a variety of enterprise applications such as supply chain management and financial transactions.

In practice, blockchain technology provides an array of value propositions. However, in most enterprise cases, transaction speeds and privacy are often focal points when compared to decentralisation. To achieve these ends in a secure manner, private blockchain infrastructure is commonly utilised. As a result, enterprises miss out on the opportunity to leverage the network effects of public blockchains like Ethereum. Network effects refer to the phenomenon where a product or service's value grows exponentially as more individuals use it. Public blockchains, such as Bitcoin [1]

and Ethereum [2], benefit from strong network effects. As more individuals participate in a network, utility and hence network value increases. This effect compounds as subsequent users join and capitalise on the value created by the prior phase of onboarded users. This allows public chains to attract a large and diverse user base, improving their security, stability, and liquidity. In contrast, private blockchains are only used by a limited number of participants, restricting their network effects and preventing them from realising the full benefits of a decentralised network. All private chains are siloed, ergo lacking the interoperability that gives rise to the network effect. This has limited the potential advantages of blockchain technology for enterprises and has hindered their wider adoption of the infrastructure.

A key issue facing the on-chain gaming and metaverse industry is the lack of scalability of the underlying blockchain technology. Due to the limited throughput of most blockchain networks, it is difficult to support large numbers of users and transactions without encountering significant delays or detrimental spikes in gas fees. Limited throughput has hindered on-chain gaming and metaverse platforms' ability to attract large user bases and provide a smooth and seamless user experience (UX). Another issue facing the industry is the lack of interoperability between different blockchain platforms, which creates barriers to entry across different on-chain gaming and metaverse applications. Overall, these challenges have made it difficult for the on-chain gaming and metaverse industries to fully realise their potential and become mainstream.

Transaction fees on blockchain networks are traditionally paid in the native gas token of the network, which is a special type of cryptocurrency that is used to power the network and incentivise transaction processing. End users who are not familiar with cryptocurrency may find it difficult or intimidating to purchase and manage native gas tokens in order to pay transaction fees and thus use the network. Additionally, the volatility profile of most cryptocurrencies forms a sense of transactional cost unpredictability, further impeding the usability of a network. Ultimately, the use of native gas tokens as a means of paying transaction fees can be a barrier to entry for end users who are not familiar with cryptocurrency and blockchain technology.

2 Solution

Our remedy for these challenges and problems is LightLink - an enterprise-focused, layer 2 blockchain that is specifically designed for the on-chain gaming and metaverse industry. The network is built atop

Ethereum and concentrates on providing the necessary scalability, interoperability, and user-friendly features that are required to support the growth and adoption of on-chain blockchain applications for enterprises.

LightLink scales far better than Ethereum's maximum capacity of 15 transactions per second (tps) [2] given its use of optimistic rollup technology. High gas fees and execution bottlenecks often faced by layer 1 blockchains supporting projects with significant transaction throughput (games and metaverses) can be avoided by LightLink's processing of transactions off-chain. Periodically, these transactions are compressed into a rollup by a sequencer node and posted onto Ethereum. This enables LightLink to exceed efficiency levels of other layer 2 networks, on average facilitating over 400k transactions per day at a maximum capacity of 5,172 tps. Gas fees incurred by the sequencer node, when pushing transaction proofs on Ethereum, are distributed between all transactors involved in the batch. As a result, LightLink's fees will be as low as $0.001.

Rather than requiring the use of its own token, LL, as the native token for gas fees, LightLink enables users to satisfy these costs with ETH. Users can simply bridge their ETH from Ethereum's Mainnet onto LightLink via the official bridge. This singular feature acts to differentiate LightLink from other layer 2 rollups, making the former more user friendly than alternatives. Nevertheless, gas can still be paid in LL once it has been launched as a transferable token; at this point, the cost of transactions paid with LL will be slightly discounted given the absence of additional costs to the sequencer. Notably, any revenue accrued by the sequencer because of gas discrepancies will be directed back to the community through staking incentives.

Additionally, LightLink renders itself more unique with its Enterprise Mode. This feature enables enterprises to proactively subsidise the cost of transactions through paying for the creation of a gas station. By enabling said gas station, a smart contract running on the network nullifies gas costs for user transactions on that enterprise's protocol over a predetermined period of time. Accordingly, protocols leveraging Enterprise Mode are able to offer its clients feeless transactions, removing traditional barriers that discourage businesses from moving their products on-chain.

As an optimistic rollup, when transactions are compressed into a batch which are eventually posted on the Ethereum mainnet, an assumption is made that all transactions are valid. Over a short period of time, network participants can challenge this assumption with cryptographic proofs which locate flaws in the transaction batch. These individuals are incentivised with rewards for successful fraud proofs from additional funds accrued by LightLink's sequencer node. Once the window to challenge batches has ended, the relevant transactions have reached finality given that they cannot be reversed. The use of this technology allows LightLink to be highly compatible with Ethereum,

encouraging developers that desire to use the optimised technology to move to the layer 2 and bring along existing Solidity-based smart contracts.

3 Design Principles

LightLink represents the work of a group of experienced blockchain developers all driven by 3 design principles and philosophies: ease of use, adoption and composability. As detailed throughout the remainder of the whitepaper, LightLink's underlying architecture and UX is fundamentally focused on achieving these guiding principles.

3.1 Ease of Use

In the ever-changing context of blockchains, simplicity and ease of use are two features that are invariably challenging to come by. Hence, through a number of features, LightLink strives to offer its users with a superior user interface (UI) and UX.

As detailed above, rollups are typically limited in their usability because of the need to pay gas in its native token. LightLink renders itself a usable platform given that users will never be solely required to pay for transaction execution with LL, but can additionally decide to utilise their bridged ETH. This feature means that users can efficiently bridge their ETH onto the layer 2 and immediately be able to transact, interact and utilise the various applications present on the network. Simultaneously, once the token is launched, we do not want to prohibit users from leveraging their LL to pay gas fees if they elect to hold tokens for their utilities. One such utility is the ability to pay gas fees at a discounted rate. Accordingly, following the public launch of the token, users satisfying transaction costs with LL on the LightLink network, will receive a 10% reduction in fees.

With the optimistic rollup technology used by LightLink, compatibility with the Ethereum Virtual Machine (EVM) [2] can be optimised. As such, smart contracts can be executed in the EVM bytecode, enabling developers to create and deploy their contracts on LightLink using the same tools and languages used for the Ethereum mainnet. In addition, this feature ensures interoperability between LightLink, other layer 2s as well as other EVM-compatible blockchains.

Finally, LightLink champions ease of use for its enterprise partners and their clients through gasless transactions and unparalleled speed. Enterprises running protocols on LightLink pay an amount of money each month to cover all gas fees that would typically be incurred by transactors. On the front-end, users transact for free, resulting in more demand for the network from these individuals and

correspondingly, larger enterprises. Whether the application relates to supply chains, ticketing or metaverse projects, if the execution of transactions were to halt, the resulting impact would be severely negative. LightLink guarantees constant uptime with no stagnation with respect to transactions, offering a seamless experience for users and encouraging enterprises to leverage the network given the absence of detrimental UI bugs.

3.2 Composability

To support a range of different enterprise and non-enterprise applications, LightLink is driven to offer unparalleled composability and flexibility in its design. Composability is an important design principle for blockchains, as it allows the technology to be used in combination with other systems and technologies. This design principle is important because it allows businesses to tailor the technology to their specific needs. Indeed, LightLink is able to support custom smart contracts that enable enterprises to automate complex processes and reduce the need for manual intervention.

LightLink's composability as it relates to NFT games and metaverses drives adoption given that it allows for one in-game item to be used across multiple platforms. Notably, due to LightLink's prioritisation of composability and thus interoperability, NFTs minted on the layer 2 can be used on games and metaverses that exist on other blockchains and networks. This results in each NFT having more utility and value as they are not siloed to a single protocol. Accordingly, the composability feature has the potential to drive the development and use of a wider ecosystem, correspondingly catalysing adoption.

With respect to the network effect, composability is crucial for layer 2s, like LightLink, given that it results in more interoperability whereby Solidity, the coding language for Ethereum [3], contracts and compilers can be used. LightLink's composability as an EVM-compatible chain permits efficient communication with numerous blockchains and other layer 2 networks. This heralds benefits for the protocol as it captures more liquidity, inevitably leading to stability and further adoption.

3.3 Adoption

Since the Bitcoin whitepaper established the presence of blockchain technology, cryptocurrency platforms have constantly been seeking to bring this technology into the mainstream. Rather than the mere presence of blockchain technology being a selling point, successful adoption is often achieved

when the benefits that distributed computation brings to businesses and individuals is a focus. Many enterprises make use of blockchain or distributed ledger technology for multiple reasons:

- **Increased transparency and traceability**: Blockchain technology enables enterprises to create transparent, secure, and auditable systems for tracking the movement of goods, assets, and data within a supply chain. This can help improve supply chain management, reduce the risk of fraud, and increase trust between different parties.
- **Improved security and data integrity**: Blockchains use cryptography and distributed consensus mechanisms to create secure and tamper-resistant systems for storing and sharing data. This can help enterprises protect sensitive information from unauthorised access and tampering, and ensure the accuracy and integrity of their records.
- **Reduced costs and increased efficiency**: Blockchains can help enterprises streamline their operations and reduce the need for intermediaries, lowering costs and increasing efficiency. For example, blockchain-based payment networks can enable faster and cheaper transactions, while supply chain management systems can help reduce the need for manual tracking and reconciliation.
- **Greater interoperability and network effects**: Blockchains can help enterprises to more easily and securely collaborate with other organisations, both within and outside their industry. By using standardised protocols and open networks, enterprises can connect with a wider range of partners and customers, and exchange value and information more seamlessly. These levels of trustless interoperability are unparalleled, giving rise to significant network effects for businesses that are leveraging blockchains.

With a large client base and the undeniable benefits of using blockchain technology, enterprises have a meaningful role to play in taking cryptocurrencies and web3 into the mainstream. LightLink's enterprise clients are currently leveraging this technology on private networks, however, are moving onto the public layer 2 to obtain the initial benefit of the network effect.

Outside the context of enterprise blockchains, LightLink is purposefully built for metaverse, NFT and gaming applications with its speed, security and cost-effectiveness. These features further extend to decentralised finance (DeFi) applications. With support from the LightLink's ecosystem fund (detailed below), a thriving, interoperable ecosystem of applications will exist on the layer 2. This generates incentives for developers to build projects on the network as they too obtain the network effect benefit.

As an enterprise-focused, layer 2 network, LightLink delivers on all the above verticals. LightLink heralds more scalability and transparency than layer 1 blockchains, offering enterprise protocol users gasless transactions and other network participants cheap fees. Importantly, as detailed below, LightLink further increases adoption by avoiding the need for users to swap ETH (or other ERC-20 tokens) into LL by having both ETH and (eventually) LL as the native gas token.

4. The LightLink Protocol

4.1 Layer 2

To optimise on the current roadmap of Ethereum, LightLink is launching as a layer 2 network. In this context, LightLink is built on top of Ethereum to improve its scalability and performance by executing transactions off-chain and post batches on the layer 1 mainnet which encapsulate proofs of the validity of such transactions in a compressed manner. Initially, with a focus on bootstrapping the growth of the layer 2 network, LightLink will optimise its network's scalability and gas fees, leveraging Ethereum for security and decentralisation. Through the passage of time, LightLink plans to increase its degrees of native security and decentralisation. Nevertheless, LightLink's effective use of Ethereum enables it to meet all three prongs of the Blockchain Trilemma [4] as scalability is achieved on the layer 2 and security as well as decentralisation is obtained via the underlying layer 1.

4.2 Optimistic Rollup

LightLink is a bottom-up optimistic rollup; after a number of transaction blocks on the network, a proof is generated that can be verified efficiently by network participants. LightLink is optimistic by nature as all proofs computed by the sequencer are assumed to be correct, relying on the existence of honest actors to authenticate the proofs when searching for monetisation opportunities via errors in transaction batches. In the case where a network participant finds such an error, they will receive a reward to incentivise this type of behaviour in the future, and the batch will not reach finality, with the relevant transaction(s) and their impact on the LightLink state being reversed. Honest network participants verifying the validity of LightLink blocks will have a challenge window to locate any false transactions in batches.

Notably, with the launch of other numerous rollup networks in the past few years, it is clear that the layer 2 wars are beginning. Most involved parties have leveraged Optimism forks to enter into the space. However, LightLink is not a fork of Optimism. Instead, LightLink has been built up independently of other layer 2s and coded using Go, focusing on providing the best experience for ecosystem partners and other participants.

4.3 EVM-Compatibility

Unlike zero knowledge rollups, LightLink is directly compatible with the Ethereum Virtual Machine (EVM). This means that developers can efficiently migrate from the Ethereum mainnet to LightLink whereby Ethereum-native smart contracts can be deployed and executed on LightLink. This compatibility enables LightLink to utilise Ethereum's go-ethereum (Geth) codebase, including the layer 1's extensive ecosystem of tools and libraries. Furthermore, at its core, LightLink makes use of the same JSON RPC endpoints as Ethereum and can thereby be used as a direct drop-in replacement for the blockchain.

4.4 A Green Network

Similarly, to better the Ethereum ecosystem and its energy consumption, LightLink strives to be a green network. With an average of less than 200 kilograms in carbon emissions per year, LightLink performs significantly better than other chains; Ethereum and Solana respectively emit over 900 tons of CO_2 and 1.65k tons [5] of CO_2 per year. By striving to be a green network, LightLink is helping to reduce the environmental impact of blockchain technology and improve the overall sustainability of the Ethereum ecosystem.

4.5 LightLink's Use of ETH and LL For Gas Fees

Further differentiating itself from many alternative layer 2 rollups, LightLink does not dogmatically stipulate that its users must acquire its own native token, LL, to satisfy gas fees. Instead, both LL and ETH act as the tokens that can be used by addresses on non-enterprise protocols to transact. This enables LightLink to make strides on its design philosophy of ease of use - there is no necessity for everyday-users of the rollup to purchase LL or swap other tokens for it in order to execute transactions. Enabling ETH to join the ranks of LL as the tokens which can be used for gas fees effectively reduces the time taken between bridging assets and subsequently transacting on the network when compared to

other rollups. Further to this, initially, LL will not be a token that individuals can use to pay gas, instead, ETH will be the only native token.

Nonetheless, upon the token being released, users are incentivised to obtain LL in the long run given its various utilities. As a means to encourage the adoption and usage of the token, those choosing to transact with LL covering their gas fees will pay 10% less than they would have with ETH. Notably, at the price of gas on LightLink, users transacting a few times will only notice a marginal difference between satisfying gas with LL and ETH. Despite this, for those transacting frequently, this reduction will become quite significant.

4.6 LightLink Blocks

Each LightLink node runs their own copy of the network's transaction pool which acts as a memory pool (mempool) akin to that of Ethereum [2]. To prevent scam transactions from inundating the mempool, a number of variables are required to be included in transactions, including tx per account limit, total txn limit and tx size limit. Before transactions are submitted to the mempool, they are initially validated by the sequencer node that is currently operated by LightLink. Upon entering the mempool, transactions are sorted based on nonce, the nonce of the sender account, and gasPrice, the gas cost in wei. Beyond these variables, as LightLink mirrors Ethereum's legacy transaction type, the following data is included in each transaction:

- gas - the gas limit
- to - the recipient address
- value - the amount of wei to be transferred
- data - contract invocation input data

Every 500 milliseconds, the sequencer node creates a block, taking transactions from the mempool in order of the transaction's gas fee (not considering the eventual LL gas reduction), timestamp and nonce. The sequencer selects transactions from the transaction pool and places them into a new block. This process continues until either the block gas limit or the predefined block transaction limit variable is reached. If there are no transactions in the pool, the sequencer will still create an empty block and add it to the blockchain. As LightLink uses its own version of blocks, certain data points are included:

- hash - Keccak256 [6] hash of block data
- previousHash - hash of the previous block in the chain

- merkleRoot - Merkle root of the transactions within the block
- timestamp - when the block was created
- nonce - integer used to find the correct difficulty level was reached
- index - index position of the block in the chain
- transactions - transactions which have been committed to the block
- miner - the address of the Sequencer which mined the block
- state - PENDING or PROCESSED
- protocol - version number of the protocol which the block was created on
- stateRoot - Merkle root of the account states after this block is processed
- signature - ECDSA signature of the hash of the block

Using the Keccak256 function, the following function is used to determine the block hash:

Block Hash = keccak(b.PreviousHash + b.TimeStamp + b.Nonce + b.MerkleRoot + b.Index

Once computed, the sequencer will sign the hash of the block using geth's crypto.Sign() function; this signature is then appended to the block, indicating that the block was minted by the sequencer node and not another network participant. Before the sequencer compresses all of the blocks on LightLink, a transformation will occur such that the LightLink block is identical to the Ethereum format JSON blocks. As such, blocks returned via the eth_ JSON RPC endpoints will be in the Ethereum block format whilst blocks in the LightLink format can be retrieved using the prime_ JSON RPC endpoints.

4.7 Storing and Posting Batch Information

The need for rollups emerged from the scalability limitations of Ethereum. Before layer 2s had dominated blockspace on Ethereum, calldata was not an issue as nodes only stored the state of the chain at each block. Calldata is the data that is passed to the smart contract as part of a transaction, and it is used to provide input to the contract and specify how it should be executed. With the rise of rollups, many more state changes required validation and storage along with the functions executed by smart contracts, resulting in expensive calldata structures for the Ethereum-native contracts. Consequently, many of the potential cost benefits of rollups have been cut short by the continued and asymmetric price increase of storing layer 2 calldata.

However, Ethereum's rollup-centric roadmap [7] seeks to resolve these issues through the establishment of a sharded, data availability layer which stores information in Binary Large Objects (BLOBs). This layer is an important step that must be taken to reduce rollup fees and scale Ethereum; yet, effective innovation that lowers calldata costs is needed now.

Accordingly, LightLink is presently using a modular solution whereby only transaction batches, which purely store the changing state of the rollup each block, are posted on-chain, incurring the normal Ethereum gas fees. On the other hand, the calldata from the execution of LightLink smart contracts is zipped and subsequently stored on the InterPlanetary File System (IPFS) [8] or other data availability systems to ensure that it is secured in a decentralised fashion. Utilising IPFS for storage call data simultaneously guarantees that fraud proofs can be levied against transaction batches as all relevant information is available and that network transactors do not incur elevated fees due to the data availability guarantee [9]. This innovation is an early step toward a fully modular Ethereum blockchain, whereby different layers, such as the Execution Layer and the Data Availability Layer operate independently.

4.8 Batch Production

The sequencer additionally assumes the role of leveraging Patricia Merkle Trees [10] to compress and minimise the amount of state data published onto Ethereum. The computation of the compressed batch of transactions results in the sequencer incurring gas fees. These fees, along with the fees of pushing transactions onto Ethereum, are distributed amongst all network users through the sequencer gathering gas fees when said users submit transactions.

After a number of blocks are dynamically determined by the network, the sequencer nodes processes all transactions in said blocks, computationally compressing them into a transaction batch that is posted onto the Ethereum layer 1 Anchor contract (0xa653486b6a89281D8354CAdD406793872D69F633). Each batch pushed on-chain contains the following information:

- the start block: the LightLink block number of the first block in the range of blocks on the layer 2 that have been compressed.
- end block: the LightLink block number of the last block in the range of blocks on the layer 2 that have been compressed.
- transaction root: the Merkle root of all transactions in the block range generated by the LightLink sequencer

- state root: the Merkle root of the layer 2 account state after all transactions in the block range have been processed by the sequencer on LightLink
- cid: the content identifier of the layer 2 calldata stored on IPFS for the range of blocks compressed into the current transaction batch block range transactions

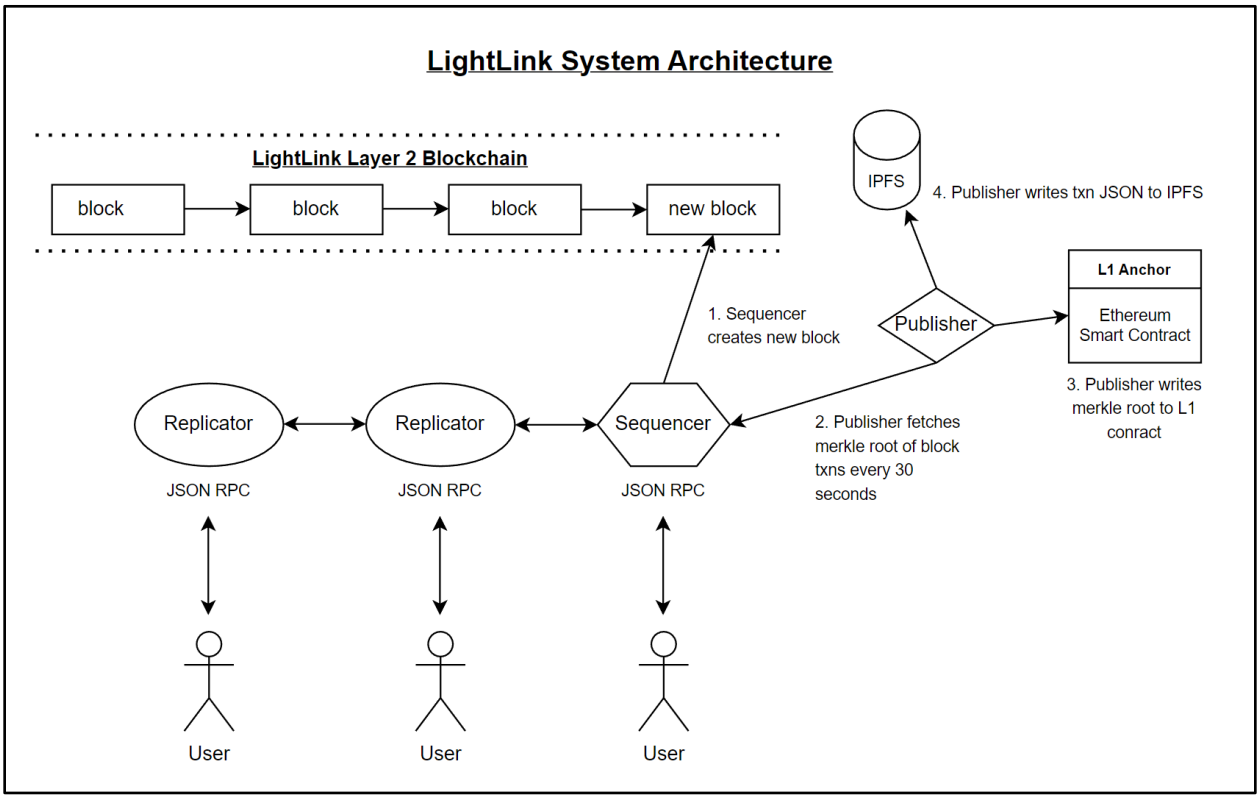

Figure 1: LightLink system architecture

4.9 Fraud Proofs

Leveraging optimistic rollup technology allows LightLink to execute transactions efficiently as a layer 2 without losing EVM-compatibility like zero knowledge rollups. As well as deriving security from Ethereum, LightLink enables network participants to use fraud proofs to demonstrate that a transaction in a batch, that is pending approval on the Ethereum mainnet, is true or false. If the fraud proof is valid, that is, an incorrect, impossible or imperfect transaction was appended to the batch by the sequencer node, the rollup will negate and revert any of the state changes impacted by the transaction.

LightLink will provide the specific infrastructure to create fraud proofs via github docs. However, the process is as such: users must utilise the smart contract on the Ethereum mainnet to obtain the proof, and subsequently compare it with their own generated proof that is generated from hashed transactions that were executed and calldata stored via IPFS. Notably, as LightLink will be an open source software, the computational approach used by sequencer to compress transactions will be publicly available.

Taking inspiration from the unparalleled mechanism design of the PoS consensus algorithm, those seeking to raise fraud proofs against a transaction batch must first provide collateral. This is because the incentives offered for successful fraud proofs must be balanced by disincentives for unsuccessful, obstructive fault proofs considering the computation burden on the network when determining the validity of said proofs. In this way, users who initiated a successful fraud proof will receive a reward from a contract funded by network revenue. Simultaneously, if any user sequentially puts in 3 unsuccessful fraud proofs, they will have 20% of their collateralised ETH/LL slashed, that is, burnt. This number can change in the future based on analysing network data relating to fraud proofs and the portion of users raising the proofs to slow down LightLink. If, as a result of the slashing, the user no longer has the collateral, they will be unable to raise additional fraud proofs until they collateralise more tokens.

Fraud proofs are a key part of the security and trustlessness nature of LightLink as they allow users to verify the correctness of the rollup's state without placing all their faith in the sequencer, a third party or an off-chain oracle. During a period of time, known as the challenge window, participants are able to verify transactions; this is possible because the batch has not reached finality on the Ethereum blockchain, meaning that the rollups state can be reversed. For the foreseeable future, LightLink will be utilising a 7 day challenge window. Accordingly, 7 days after the compressed transaction rollup has been posted on chain, it will reach finality.

In the case of a fraud proof being levied against a transaction batch, network participants initiate a validation process to determine whether the relevant transaction was valid or invalid. In the case of successfully challenged batches, the invalid transaction will be rolled back on LightLink and removed from the commitment posted on the Ethereum Anchor. Notably, this ensures that all the blocks in the batch do not need to be reversed, saving users gas fees in the face of reverifying and publishing state changes.

4.10 Democratising MEV Through the Sequencer

Initially written about in 2019 [11], Maximal Extraction Value (MEV) is now understood to be an intrinsic feature in all permissionless blockchains that can execute smart contracts. Traditionally, MEV has been viewed as a negative feature in the blockchain industry, where bad actors capture value that should be allocated to the community. However, through optimising the LightLink sequencer, the network will be inverting the net-zero nature of MEV, making it a positive-sum game whereby excess value is harnessed to ensure an efficient market and is distributed back to the community.

At launch, the sequencer will order transactions based on gas fees, the time in which each transaction arrived in the mempool and the nonce, as mentioned above. Nonetheless, following the launch, development will begin to design a MEV extracting sequencer node. Few changes will be made to the sequencer; instead, it will refer to a logic gate that orders transactions based on the value of their MEV opportunity when batching transactions in the mempool. The timeline around incorporating the MEV extracting sequencer will be specified in the roadmap.

The rewards obtained from this version of the sequencer will be distributed back to the community in a multitude of ways. Though exact values have not yet been determined, a portion of the MEV will go to buying LL on the open market (when launched) and subsequently burning it. Additionally, MEV captured will be directed to the LightLink Foundation's treasury to fund future ecosystem grants and developments for the layer 2. Moreover, a majority of the rewards will be distributed to the staking rewards pool, ensuring that yield is sustainable. Overall, this excess network value will either directly or indirectly go back to the community whilst simultaneously creating an efficient market.

5 Protocol Economic Parameters

Early predictions paint a positive picture relating to the performance of LightLink. The use of optimistic rollup proving technology enables LightLink to reach a theoretical capacity of 5,712 tps, far outpacing Ethereum's maximum throughput of 15. Whilst the layer 2's throughput will only get this high during times of substantial demand, the network is estimated to facilitate over 400k transactions per day. Concurrently, on LightLink, transactions reach finality, that is, they cannot be reversed directly on the layer 2 network, after 500 milliseconds – this value far eclipses the finality speed of other networks.

Importantly, the state of LightLink, and hence transactions, can be reversed, in the face of successful fraud proofs whereby invalid transactions are located in a batch posted on Ethereum. Network participants will have 7-day challenge window when they can question the validity of transactions in a batch, through the process detailed above, before batches are deemed final on the

Ethereum mainnet; at this point, the transactions that were executed on LightLink have reached finality on both the layer 1 and layer 2.

As explained in section 4.6., after a number of blocks of transactions on the layer 2, a Patricia Merkle Tree is used to compress transactions into a batch. The hashed root transaction from the compression approach is included in the block posted on the Ethereum mainnet. With thousands of LightLink-facilitated transactions being included in each batch, layer 1 gas fees and Merkle Tree computation fees are distributed amongst a large number of transactors. Accordingly, it is predicted that the average transaction cost is $0.01, yet can be as little as $0.001. These low fees are possible for LightLink given its use of IPFS when storing compressed calldata that do not relate to the state of the network. Notably, upon the implementation of ProtoDanksharding and Danksharding [12] at the Ethereum-base layer, these gas costs are expected to drop further.

6 Enterprise Mode

Unique to LightLink is its Enterprise Mode. This feature is analogous to a gas station whereby the enterprise running the protocol tops up the funds in the gas station each month in order to ensure that those utilising the platform are not subject to transaction fees. On LightLink, Enterprise Mode is facilitated through the use of unique smart contracts, be they ERC-20 or ERC-721 contracts – depending on the application.

In collaboration with LightLink administrators, enterprises can be set up with their own smart contract for their protocol(s). On the LightLink network, enterprises will register by providing organisation name, LightLink wallet address, gas units and gas price. The latter two variables will be initialised as zero, increasing relative to the payment described below. Correspondingly, based on the gas price per user interaction with the contract, the gas units will be equated to the quota × gas price, ensuring enterprise users receive the fair number of transactions for what the underlying organisation paid.

Each enterprise client gets a single smart contract whitelisted on LightLink. At the beginning of every month, the enterprise that is running their protocol on the layer 2 pays a fixed fee based on a tier structure outlined below. These costs equate to a quota, determined by the tiers outlined below, for enterprises which cover the gas fees that users on that platform would normally incur when actioning transactions. Furthermore, the monthly amount collected from these enterprise transactions go to purchasing LL and subsequently burning them, applying upwards pressure on the token's price. These users will interact with the enterprise's whitelisted smart contract which permits them to not pay gas

fees. Contingent on the enterprise's fee tier, the daily cumulative gas fees that users avoided through interacting with the whitelisted smart contract is capped as the quota approaches 0; at this point, protocol users on Enterprise Mode will need to pay transaction fees in ETH like normal users. If this daily maximum is frequently reached as result of growing platform demand, the enterprise will need to increase tiers so as to raise the smart contract cap.

Currently, there are three tiers that enterprises can opt into:

- **Tier 1** – Enterprises will satisfy a monthly charge of $5k; users of the enterprise's protocol will be able to push through 1k transactions per day before incurring gas fees
- **Tier 2** – Enterprises will satisfy a monthly charge of $10k; users of the enterprise's protocol will be able to push through 10k transactions per day before incurring gas fees
- **Tier 3** – Enterprises will satisfy a monthly charge of $20k; users of the enterprise's protocol will be able to push through 50k transactions per day before incurring gas fees

Enterprises looking to determine which tier is right for them are requested to engage in discussions with the Pellar Technology team.

This novel approach is significant as it enables enterprises to move their protocols off private networks and onto public networks with minimal backlash from their users given that they are not required to pay expensive gas fees. In this context, Enterprise Mode allows LightLink to act on its design philosophy of ease of use; at any moment, one of two events can be occurring:

1. **Available Transactions in the Smart Contract** – in these cases, the daily transaction allocation that bypasses the need to pay gas fees has not been reached. Hence, users do not need to spend ETH on satisfying transaction fees.
2. **No Available Transactions in the Smart Contract** – in these cases, the daily transaction allocation that bypasses the need to pay gas fees has been reached. Subsequently, enterprise users pay in the ETH that they bridged to LightLink

In either of the above situations, the enterprise user is able to efficiently transact on the LightLink network without reaching an inconvenience impasse whereby a decentralised exchange to swap into LL is needed.

There are many examples as to when Enterprise Mode can herald substantial benefits to the business' users. One such example is an on-chain game which leverages NFT technology. If a player must pay transactions for every action they make, including picking up tokens and moving their avatar, the game would become unbearable. In situations where players sign a contract to autopay gas fees for

on-chain transactions such that they are not distributed by constant private key signature requests, they are at risk of being exposed to severe spikes in gas fees. For example, if a user allows transactions to be auto-signed on the assumption that gas will remain at gwei = 10, then a jump occurs, resulting in gwei = 30, this user will continue paying for exorbitant transactions without knowledge of the tokens they are spending. However, if the business offering that game were to opt into using LightLink's Enterprise Mode, their users would not face any inconveniences in engaging with the game or be at risk of accidentally paying exorbitant gas fees.

Furthermore, as detailed in the tokenomics section of the whitepaper, the impact of Enterprise Mode is meaningful given its constant burn pressure on the token. With less tokens in supply, this initiative will both increase the scarcity of LL and reduce the majority of negative price influences from token unlocks.

7 Business Applications

LightLink's unique structure and architecture render it suitable for a multitude of both untapped and/or sectors with insufficiently developed infrastructure. There are 4 primary applications that LightLink focuses on improving and benefiting:

- **Enterprise Size Protocols** – As previously mentioned, many enterprises are utilising private, scalable blockchains for their protocols, thereby failing to obtain the benefits of the network effects. LightLink is a highly secure, cheap and efficient blockchain that can scale horizontally. Irrespective of the size of the protocol and its throughput, LightLink's composable nature can be tailored to respond to the enterprises' specific needs.
- **Gaming & Metaverse** – With NFT-based gaming and metaverse projects often failing to take off due to scalability limitations and the frequent stagnation of transaction, LightLink concentrates on providing constant uptime, security and execution of all transactions. The layer 2 provides the foundations for ownable, unique digital assets that can be utilised and transferred at scale, allowing for the existence of interoperable games and metaverses.
- **Ticketing** – Among the many benefits that blockchain technology can bring to enterprise businesses, on-chain, NFT-based ticketing is a strong example. Through LightLink, tickets can be represented as NFTs that are tied to individuals. This rectifies many of the issues facing the ticketing industry as NFTs are 1:1, meaning no two wallets can hold the same NFTs. Furthermore, the NFT can shuffle the ticket code upon use, meaning that they cannot be shared

once the first individual has been permitted entry. LightLink's efficiency facilitates growth in this industry on the blockchain.

- **Identity** – The LightLink network can be used for identity management by allowing users to create and manage their own digital identities on the layer 2 in a decentralised manner. This can be done using smart contracts and other blockchain technology to securely store and verify identity information. Using LightLink's scalable and interoperable infrastructure, users can easily access their digital identities and share them between protocols. The use of LightLink for identity management can provide enhanced security, privacy, and control over personal data.

8 Tokenomics

8.1 Allocations & Vesting Schedules

When launched, LL tokens are allocated to ensure the long-term health and sustainability of the layer 2 network.

20% of unissued tokens have been allocated to a seed round to raise funds to build LightLink. To ensure that these early investors are unable to apply significant downward pressure on the token price, there is an initial 12 month cliff period, afterwhich LL is issued in monthly payments over 20 months. This vesting period ensures that the seed investors have skin in the game to continue improving and involving themselves in the growth of the network. A further 9% of tokens are allocated to the Future Reserve category for forthcoming usage of tokens to fuel collaborations and partnerships. Additionally, the team behind LightLink will receive a 17% allocation to be distributed over 32 months in a similar fashion to seed round investors; 12 month cliff period then linear monthly emissions over 20 months.

Further, 6.5% of tokens have been allocated to a public sale that is expected to take place in early 2023. These tokens will be fully unlocked upon being issued. Due to the current market dynamics and sentiment, there is a chance that not all 6.5% of tokens allocated are purchased. In this case, the residual tokens in this category will be distributed to both the LightLink Foundation to be utilised as ecosystem support funds and the staking reserve. This will ensure that the full 6.5% allocated to the community through the public sale will directly or indirectly end up in the wallets of the LightLight community.

Upon launch, LightLink will not rely on staking to guarantee the security of the layer 2. However, as the sole Enterprise focus is sharded to consider crypto-native applications, staking will be introduced. 8% of the tokens will be allocated to our Staking Reserve and will be vested linearly over 3 years with monthly unlocks. The initial date for the introduction of staking for LightLink will be formalised in the roadmap. Nonetheless, a potential design being considered by the LightLink team is included in section 8.4..

To ensure a thriving ecosystem for both enterprise and retail users, 39.5% of LL tokens have been allocated to the LightLink Foundation. This is a bucket of tokens that will be utilised for bootstrapping growth with token incentives, grant funds, supporting the token economy on LightLink, providing liquidity to LL and more. Depending on the vertical in the fund, tokens are unlocked based on different schedules – all concentrate on stimulating interest and growth on LightLink to achieve adoption from users in the long-run. Notably, upon the launch of the LightLink network, the Foundation will not be in operation. For this reason, tokens will be allocated to a multi-sig wallet and the keys will be transferred to the LightLink Foundation upon its establishment which is anticipated to be a year after the network goes live. Despite this, given the need to utilise Foundation funds for the ecosystem within the first year of LightLink's operation, a team of individuals working on LightLink will be able to provide LL for grants and liquidity requirements prior to the creation of the LightLink Foundation.

The tokens allocated to the LightLink Foundation will be broken down into a number of smaller categories. 10% of LL's supply is allocated to the Enterprise Fee Reserve. These tokens will ensure that enterprise customers can leverage OTC desks when purchasing LL to limit slippage. The 10% of LL will be unlocked based on a mint & burn mechanism to provide sufficient liquidity for enterprises. Once burned, the LL will subsidise gas fees used by transactors on enterprise protocols.

LightLink is fundamentally different to other layer 2s given its use of an Enterprise mode and a normal mode; in the long-run, each will be equally important to the ecosystem. With numerous enterprises already committed to LightLink, 24% of LL has been allocated to Ecosystem Support. These tokens will begin unlocking at launch and linearly continue with monthly unlocks over a 3 year period. This will include providing grants to new projects looking to build decentralised applications (Dapps) on LightLink across a range of vertices like DeFi, decentralised social media, NFT platforms and many more. Further, tokens in this category will be utilised to bootstrap community growth and incentivise dominant DeFi protocols to launch on LightLink. Under the funds allocated to the Ecosystem Support, an additional focus will be on funding community events and projects based on the guidance of LightLink users and community.

Finally, 5.5% of LL will be minted and allocated to liquidity provisions for trading pools across multiple decentralised and centralised exchanges. Said tokens will be in a public, multi-signature locked wallet, enabling tokens to be minted as and when needed. With a small initial supply of LightLink, compressing the spread of trades on centralised and decentralised exchanges will prove arduous. These funds will go to assisting market makers in compressing spreads and deepening liquidity across LL trading pairs.

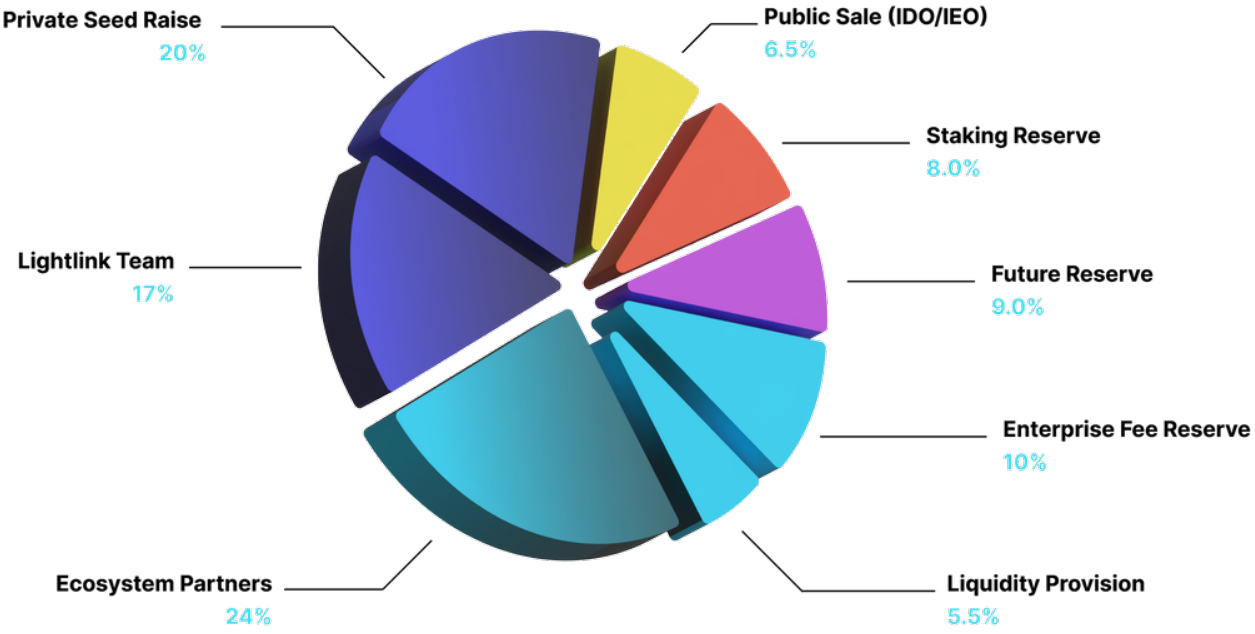

Figure 2: Proposed token distribution

8.2 Issuance & Burn Dynamics

Despite inflation arising from the vesting schedule, we anticipate that in the long-run LL will be deflationary. Deflationary mechanics within the tokenomics model works to reduce the supply of the token, theoretically resulting in a positive impact on the token price given that the equilibrium which determines the value a token is exchanged is heavily influenced by circulating supply. If demand remains the same and supply falls (due to token burns), the novel scarcity of LL would apply positive token pressure given there are less tokens available.

Every month all enterprises onboarded will purchase tokens using fiat currency depending on their tier; these tokens are set aside to subsidise gas fees used by transactors on the enterprise protocols. So as to apply positive price pressure, the value obtained monthly from this purchase is used to purchase LL tokens which are subsequently burnt.

Additionally, for protocols external to those using Enterprise mode, ETH is used for gas fees. An extra 20% will be levied to ensure further token buybacks and burns depending on the network demand. Following each transaction, the additional 20% collected will be transferred to a single multi-signature wallet. At the end of every month, this ETH is used to purchase LL via an OTC desk which is consequently burnt to decrease the circulating supply and offset the impacts of token unlocks.

Expansion of these dynamics such that stakers generate real yield based on network demand is under consideration and will be addressed in future roadmaps and iterations of the whitepaper.

8.3 Staking

The exact design mechanics of staking LightLink has thus far not been finalised. Accordingly, the structure explored throughout this section will not definitively be integrated into the architecture of LightLink.

Nevertheless, in designing our staking model, three key outcomes were considered and sought to be achieved. We were seeking to simultaneously balance sustainability through value generated by LightLink, adding necessary complexity and long-term loyalty incentives. The structure of the staking model includes two unique staking tiers which indicate a holder of LL's loyalty based on the length of their lockup time.

At the first tier, users will stake LL for a vote escrowed token, vLL, that receives rewards from the Staking Reserve and a portion of the value derived from the MEV sequencer. LL will be locked up for a month at a time, yet are restaked automatically after 3 days of sitting idle. Upon restaking LL at the end of the 30 days from the first stake, the APR will increase; this will continue to occur until a maximum rate has been reached. This mechanism design incentivises long-term loyalty as upon unstaking the LL, the additional loyalty rewards return to 0%.

Notably, vLL has utility; it can be restaked for veLL. Whereas the lockup period for vLL is one month, the lockup period for veLL is 6 months. Accordingly, it is anticipated that only those who support the LightLink ecosystem over a longer period of time will stake their vLL. Restaking the initially

locked up vLL will result in increased rates, similar to staking LL, based on a function to be detailed in a future piece. The veLL token will pay out rewards via those accumulated through the underlying vLL as well as gas-based rewards captured by the sequencer. This ensures that value, including gas fees and MEV, which is obtained by the sequencer from its advantage in building blocks is directed back to the community.

9 Conclusion

LightLink is a masterful symphony of technology, combining the power of blockchain with a focus on usability and efficiency. It presents a novel solution for enterprises and individuals seeking to unlock the full potential of blockchains and its network effect. With its lightning-fast transactions, robust security measures, and seamless interoperability with other blockchain networks, LightLink stands as a shining example of how blockchain can revolutionise various industries. The scalability and versatility of its architecture, combined with its strong partnerships with leading enterprises, renders LightLink well suited to assist businesses seeking new avenues for growth and innovation.

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