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Lightning Network Interest Rate

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Executive Summary

As of date, Bitcoin is the largest cryptocurrency measured by market capitalization. The Bitcoin blockchain can support somewhere between 4 and 7 transactions per second, preventing BTC from achieving the status of a truly modern method of payment. The Lightning Network is a secondary layer protocol designed to solve the problem of scalability for Bitcoin. The Lightning Network enables efficient micropayments of BTC between two parties in a network of nodes connected via channels. When two parties wish to transact with each other, they can open a channel between their respective nodes. Each party commits a certain amount of BTC to the channel, which is recorded on-chain. Subsequent transactions between the parties are reflected by updating the balances of each party within the channel; these cryptographically-secured transactions are recorded off-chain. Thus, rather than recording each transaction on the Bitcoin blockchain, only two transactions are ever recorded on-chain — the channel's opening and closing — and all other transactions take place off-chain, vastly improving Bitcoin's processing capacity.

A key feature of the Lightning Network is multi-hop payments: the ability to route transactions through a node path. That is, if a channel exists between Alice and Bob and another channel exists between Bob and Claire, then Alice can pay a certain amount of BTC to Claire even if there is no channel between the two of them: Alice can route the payment through Bob, so that Alice first transfers some BTC to Bob and then Bob transfers the same amount to Claire (minus a fee Bob chooses to charge for routing through his node). Thus, the more channels and nodes there are in the Lightning Network, the more potential payment routes exist, thus solving the problem of scalability. Due to the design of multi-hop payments, it is possible for nodes to generate a profit by charging a routing fee on transactions; the interest rate of a node is the proportion of BTC earned for routing transactions divided by the total liquidity committed to the node.

In this report, our objectives are (1) to calculate the reference interest rate of the Lightning Network, derived from the interest rate of a node we ran ourselves during experimentation as well as the interest rates of other nodes in the Network, and (2) to provide a strategic vision

exploring future developments in the Lightning Network and assessing the potential profitability of the Network. Data from the Network was gathered via setting up our own node, scraping public online repositories, and conducting interviews with other node owners. The key takeaways of our research are as follows:

- Being a small node owner is expensive and unrewarding. Over the course of our experimentation, our node received zero routing transactions through it even though channels were open and liquidity was sufficient, thus generating zero revenue. In fact, we were losing money due to the operating costs of hosting a virtual server on Google Cloud.

- Interest rates for even the largest nodes in the network by capacity and number of channels is virtually zero. From conducting interviews with large node owners and aggregating public data, we found that most nodes do not generate any profit from routing fees, and the ones that do have an average interest rate of $< 0.1\%$.

- While a benchmark reference interest rate may not make sense in the current state of the Lightning Network, we identified two possible future outcomes that are likely within the next two to five years.
    - **Scenario 1: Profit derived from neo-banks**
      Routing fees gradually increase as the Lightning Network grows and large nodes consolidate into a small group of *neo-banks*. Users are able to deposit Bitcoin into neo-banks and receive interest payments on their deposit, while the capital is used as liquidity for the neo-bank's node.
    - **Scenario 2: Profit derived from third-party services**
      Routing fees are kept close to zero by low barriers to entry in the Lightning Network. Instead, nodes can charge users for third-party services such as providing liquidity to a node or connecting to an external recipient outside the Network. As the Network expands and takes over the majority of Bitcoin transactions, demand for third-party services will increase, driving up profits.

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Introduction: What is the Lightning Network?

Given that Lightning Network is quite a new platform, we believe it makes sense to dedicate a section of this thesis to explaining the basics of the network, in case the reader is not familiarized with it.

The lightning network is a layer on top of bitcoin that allows for fast micropayments off-blockchain. The main pain points that Lightning Network tries to address are the high transaction fees and processing time for bitcoin.

Types of Transactions

Lightning Network allows users to open a channel between two people by creating a multi-signature wallet, which is a wallet that they can both access with their respective private keys. Then, the users deposit a certain amount of Bitcoin - say, 3 BTC each - into that wallet. From then on, they can perform unlimited transactions between the two of them. These transactions are 2-of-2 multisig, meaning that you need the two keys (one per person) to commit to a transaction. At a high level, these transactions are redistributions of the funds stored in the shared wallet.

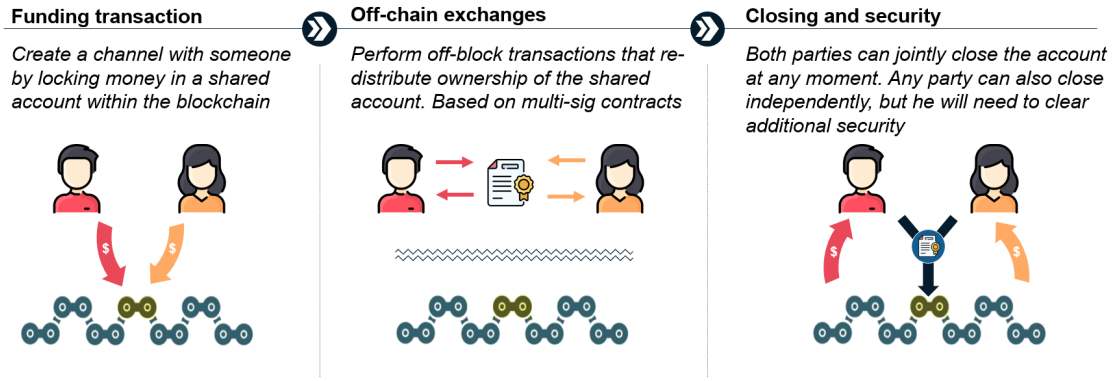

Figure 1: Opening and closing a channel.

After certain transactions, the users can decide to close the account and get their bitcoin back. If the two parties close the account cooperatively the shared account refunds the updated amounts

through a blockchain transaction. However, if only one part tries to close the channel the transaction is not executed immediately. Instead the counterpart has some time to present a signed more recent contract (stating the wealth ownership of the channel). If that happens it would be shown that the first person was trying to cheat (by presenting an old contract and not the most current one. When that happens the violator would lose all the money in his account.

Lightning network transactions are not in the blockchain, and there is no need for mining. Unlike the blockchain where you need to perfectly order all the transactions (and re-verify the whole blockchain), in the LN you only care about which balance is the current and which ones are the old ones. The only transactions that are recorded on the blockchain are the opening and closing of a channel. Therefore the two users of a channel can timestamp new contracts with redistribution of wealth without any processing time or fee.

Multi-Hopped Payments

The lightning network would not be very scalable if all users had to be connected between them in order to transact. LN solves this problem by allowing multi-hopped payments, which basically allow you to route transactions through third parties and reach users you are not directly connected to. The technology that the Lightning Network uses for multi-hopped payments is Hash-time locked contracts (HTLC).

Let's illustrate how HTLCs and Multi-Hopped payments work through an example. Imagine that John wants to send money to Mary, but given that they are not directly connected they will need to route the payment through 2 friends (Zach and Laura). To do that John sets up a contract with Zach where he deposits the money but protects it with a public key (a lock) so that Zach can only access the money when he gets the private key. The contract is also time bound, so that if Zach does not access the money in a certain time, then John recovers it.

Zach creates the same contract with Laura (with the same public key). And Laura does the same with Mary. When all the contracts are set up John gives Mary the private key so that she can unlock the last contract. When that happens Laura can see the private key that Mary used and in

turn can unlock the contract she had with Zach. Then Zach does the same and gets the money from John.

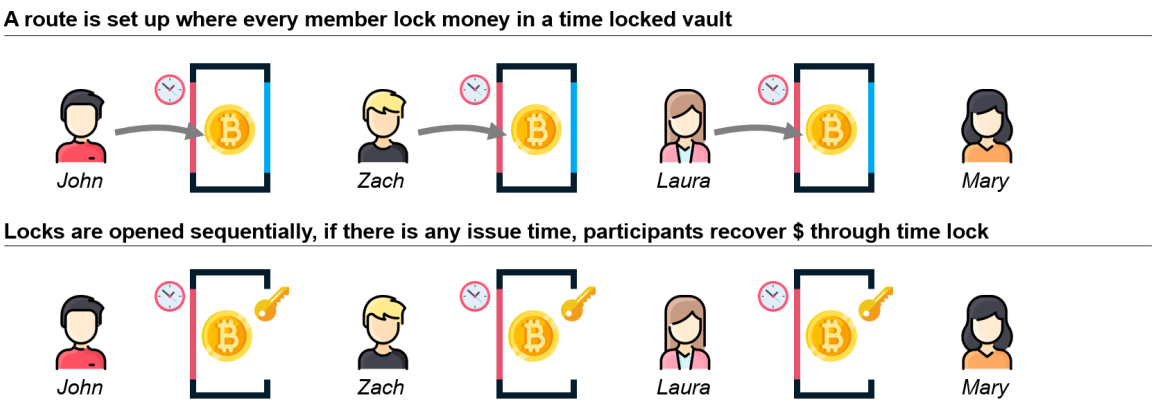

Figure 2: Routing transactions via multi-hopped payments and HTLCs.

Fees

In multi-hopped payments the third parties that help with routing require small fees to compensate them for their collaboration. We call these fees routing fees. There are two types of routing fees (1) a base fee flat rate (which is paid for every routing performed) and (2) a liquidity provider fee that is proportional to capital used.

Objectives and Scope

The two central objectives of this report are: first, to develop a framework for measuring the realized interest rate of a node in the Lightning Network and subsequently derive an aggregated reference rate for the entire Network; and second, to provide a strategic vision for the future of the Lightning Network based on its current state.

Our approach to the first objective can be broken down into three parts:

1. Observe routing and fee dynamics within the Lightning Network via (1) setting up a node in the Network and routing payments through it, and (2) gathering data from public repositories such as 1ml.com and yalls.org and/or obtaining information through interviews with large node owners.

2. Leveraging the collected data, calculate a risk-free interest rate for nodes in the Lightning Network.

3. Assess how to convert this interest rate into a benchmark reference rate for the Network.

Lastly, in addition to establishing a quantitative framework for the Lightning Network interest rate, our second objective is to present a strategic perspective on the current and future states of the Network, or in other words:

4. Explore how interest rates may evolve as the market dynamic shifts, and discuss the potential future outcomes experts predict for the Lightning Network.

Data Limitations

Over the course of our research, we discovered that data is extremely scarce in the Lightning Network. One major limitation of running our own node in the Network is that even after opening multiple channels with well-connected nodes, the frequency of routing transactions through our node is virtually zero. Thus, it is unfeasible to rely on our node to obtain sufficient data from the Network, and instead we leverage the publicly-accessible information available from several online websites and scrape these websites for data. In addition, through conversations with other node owners we are able to get data on the performance of nodes other than our own, though it should be noted that oftentimes this information is given up reluctantly as the majority of node owners would like it to be private.

Experimentation Approach

To host our lightning network client, we decided to rent a virtual instance on the cloud to ensure the connectivity. Lightning Network is compatible with the pruned bitcoin core, so the cheapest server would satisfy our needs.

After setting up the client, we need to create a wallet on our server to host the bitcoins that we are going to use for the channels. The wallet here works the same way as the traditional bitcoin wallet, and the users are able to directly withdraw their bitcoins from the exchange to this wallet. Setting up the channels is more subtle. In order to set up a channel, the other party also needs to lock down the same amount of bitcoins with us, so it's necessary to get the permission of the other party.

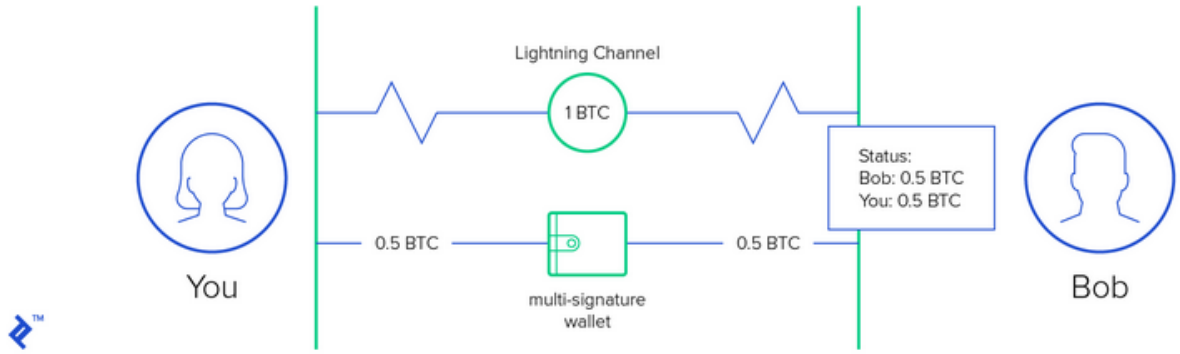

Figure 3: A channel in the Lightning Network.

However, if we could not find our "Bob"s to create channels with us, then it would be frustrating. To solve this problem, there are liquidity providers that will create channels with us if we are willing to pay for the liquidity.

LNBIG	You can buy 1M Satoshis ($500) in inbound capacity for $10. You can not buy any lower amount
LightningConductor	If you create a channel with them for 250k Sat ($125) they will create the same one with you.
Bitrefill	You can buy 1M Satoshis ($500) in inbound capacity for $12. You can not buy any lower amount
Y'alls	You can buy 200k Satoshis ($500) in inbound capacity for $5

Figure 4: Liquidity providers.

As we have discussed above, it's economically irrational to create lightning channels, because the fee collected is relatively insignificant in comparison to staking bitcoins with institutions. Therefore, it seems reasonable to charge on LN liquidity. After conducting research on several liquidity providers, we've decided to create channels with lightning conductor and bitrefill, and put $100 worth of bitcoins into each channel.

Costs of Maintaining a Lightning Network

Based on our experience with running the lightning network, there are two major sources of the costs: the operation cost of a server and channel creations.

There are two popular ways of maintaining a bitcoin node: purchasing a hardware device (such like a raspberry pi) or renting an online server. Since we only want to maintain a bitcoin node to collect data for our experimentation temporarily, we decided to rent an online server from Google Cloud Platform. To satisfy the minimum requirements for a pruned bitcoin node, we chose an E2-small server with 2 cores CPU, 2GB memory, and 50 GB hard disk space. The monthly renting fee is $17, equivalent to 34,590 satoshis (at the time of writing, 1 BTC is worth 49,146.48 USD). For long-term maintainers, it will be more economical to purchase a hardware device to even out the cost per month.

It takes the similar amount of fee for creating a channel as transacting bitcoins, because it would also require sending information on the main ledger of bitcoin. However, since the channel is bidirectional, there is a risk that the other party might close the channel. If the other party closes the channel, then people could not transfer money through our channel any more, and we need to repay the channel creation fees to create a new channel. Therefore, for small individual players, it's rather easy for them to lose money because of the repetitive transaction fees.

Steps to Create a Lightning Network Channel

Then we want to give a detailed description of the process of creating a channel and the liquidity providers we choose to use, because it might be easier for them to repeat the experimentations if they are interested to do so.

We first installed bitcoin core on our server: either a full node or a pruned node, the later will take less disk space. After syncing with the mainnet, then we can install the lightning network client (lnd) on the server.

We need to use lnd to create a bitcoin wallet so that we can host our bitcoins on the server. Because many liquidity providers have a lower bound for the amount of bitcoins we deposit in the channel, it's necessary to put in enough bitcoins.

Then, we can select the liquidity providers we listed above. It might be hard to generate enough data, so we've decided to create 2 channels: one with Bitrefill, and the other with Lightning Conductor considering the lower bound of bitcoins and the fee they collect.

We would first need to add the address of liquidity providers as our trusted peers, and then initiate a channel towards them. With Bitrefill, we need to purchase liquidity inbound and fill out our wallet address. With Lightning Conductor, we only need to create a channel towards them with bitcoins greater than the lower bound, then it will automatically create a channel back to us.

Data Gathering Approach

For this project we relied mostly on qualitative, public data from node owners. Some of those participating in the lightning network do so for the ease of making bitcoin micropayment, but others participate in the network, operating as "payment routers" and intermediary hops for transactions on lightning, Because of the highly experimental nature of lightning, its short lifespan, and the complexities of the network, many of these node operators gather around on multiple online spaces including Slack, Telegram, Discord, Twitter, Reddit, and Clubhouse. Members of these communities are a blend of professional lightning developers like Alex Bosworth, Ryan Gentry and those who are completely new to the network, these become spaces for sharing ideas, troubleshooting nodes, discussing strategies to increase one's reputation and ranking in lightning, finding other nodes to establish channels with, and sometimes sharing data on profits and fee policies.

Our studies of these public sources came in multiple forms:

1) "Lurking": we used "lurking" as an ethnographic method which involves passively following conversations on different topics, sorting through them by keywords like "fee", "interest", "transaction", etc, and identifying potential node owners who might be of interest for one-on-one interviews. At the same time, Twitter has become an important site where developers like Alex Bosworth sporadically post updates on their profits, and

sometimes create anonymous polls on different issues like fees, etc. A very common trend in all these platforms is new users asking advice on setting fee policies, optimum number for channels to open, and the optimum amount of capital to dedicate to each channel.

2) Individual interviews.
3) One group interview with lighting developers and researchers.
4) Sporadic, semi-structured group chats with participants from the Telegram lightning group.

The two major lightning node operators we spoke with were Alex Bosworth, the owner of Y'alls, and Fabrice Drouin, the owner of Acinq. As depicted in the image below, Acinq (the node with a black circle around it) is the largest public node in the network, meaning it has the highest number of channels and the largest capacity. Fabrice refused to provide us with precise data on their gains and losses but he did mention that after months of running their node, they had only recently managed to break even and no longer incur loss operating their node.

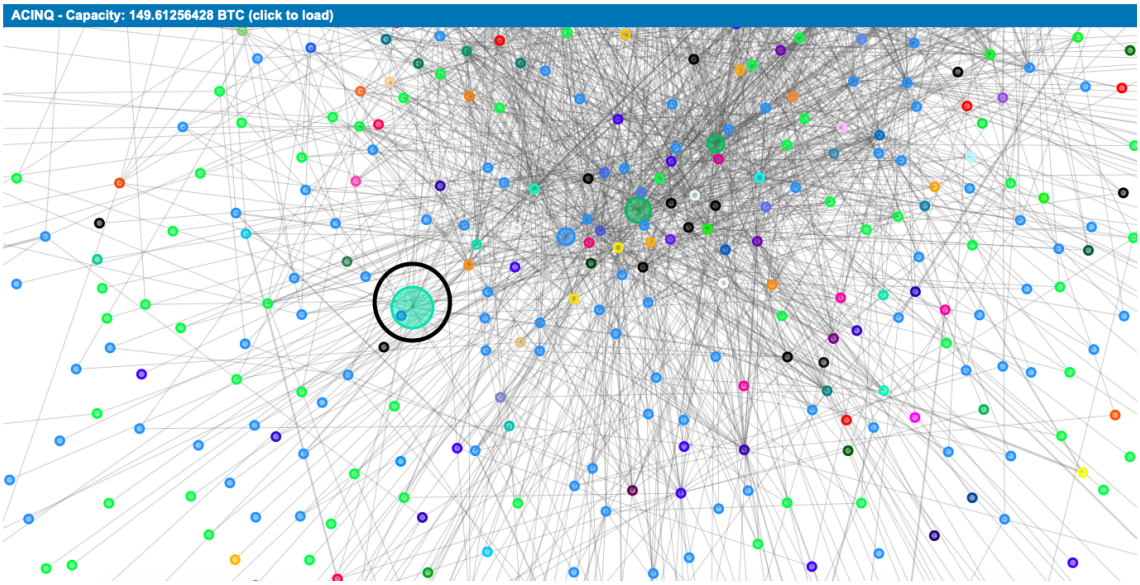

Figure 5: Snapshot of the Lightning Network.

Small and Medium Sized Routing Nodes

Gaining profit on lightning depends both on the node (amount of capital, number of channels, nodes connected to) and also on whether or not the node owners actively optimize their node's performance. Those who do optimize, consider operating a node as a "full time job" that requires constantly monitoring payments, channel balances, etc. For example, "KryptoSphere" is run by a group who devoted 5-6 months experimenting with routing, running special scripts to save transaction flows, dynamically changing fee policies to rebalance and to increase volume of transactions. According to Guillaume Girarad, the owner of the node, their experiment only yielded 854 Satoshis. They managed to route more than 1000 payments (in the amount of 1BTC total), and they had 0.3BTC on their node. Below you can see a diagram of volume of transactions they routed. Instead of total fees earned, he measured success in terms of "total volume routed/total capital engaged in a node".

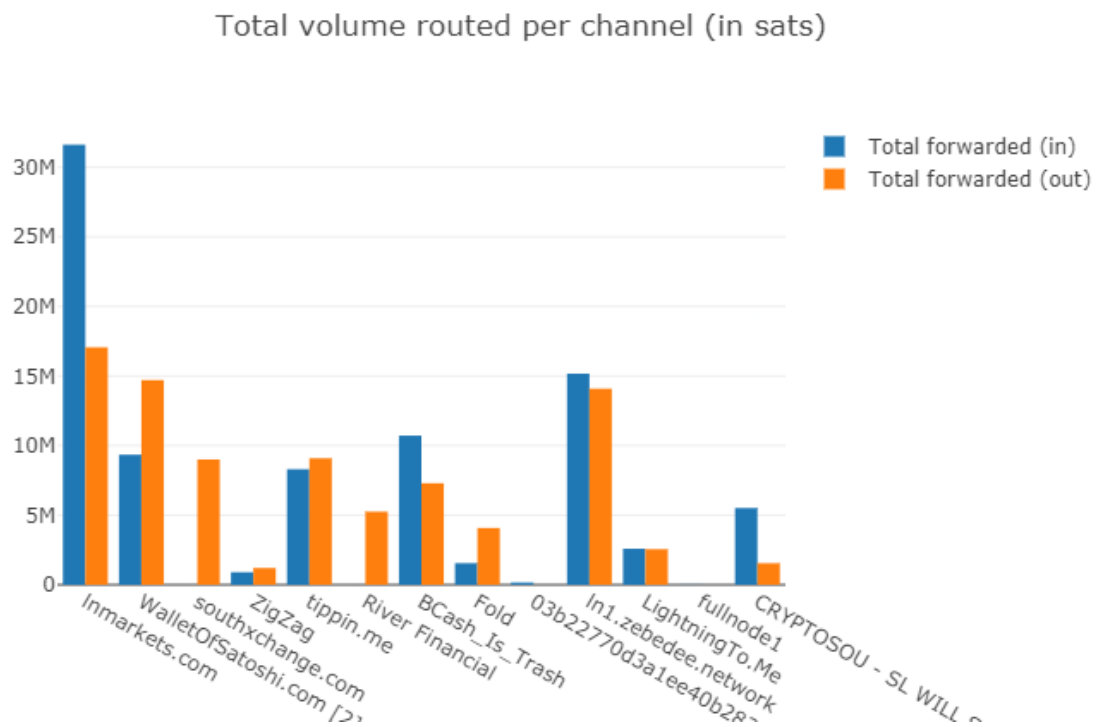

Figure 6: KryptoSphere transaction volume per channel.

Thomas Jestopher (owner of satbase.org node) owns 5.5 BTCs on his node and has established 60 channels. He claimed (although he refused to share any proof for privacy concerns) that he

will be gaining 1.2% APY by the end of May which is substantially higher than the number reported by other nodes.

Other node owners did not even keep track of their traffic, volume of transactions and profits made. For example, John O'Hare, one of the interlocutors based in the UK, began the interview with, "I'm hoping we can omit me from any questions on routing fees because I'm not doing this to gain fees." In a period of 8 months, he had only managed to gain 45 Sats in fees, while he had spent a few hundred GBP setting up and maintaining the node during this period. Another person, Josel, a microbiologist in Spain, mentioned he has completely given up on keeping track of transactions as he is not making any money off of routing. He and others who incurred loss identified a number of reasons for their participation:

1) Participating in the growing lightning gaming community.
2) Helping the network grow.
3) Establishing their place as a reputable, high ranking node in the network in anticipation of future growth of the network.

Similarly, our studies of online communities revealed that conversations around increasing one's BOS Scores (a ranking system published by Lightning Labs) were much more common than conversation around fee policies. Overall, our data shows that operating a routing node for profit could only make sense for large nodes with large capitals and those who can invest significant time and expertise in optimizing their node operations. Even in that case, it will not be risk free. For small nodes, the interest rate is close to zero.

Node: ACINQ | 1ML - Lightning

1ml.com/node/03864ef025fde...

1ML

Node: ACINQ

Follow

Public Node

Capacity

149.33559003 BTC (11.212%)
14,933,559,003 sat
$6,026,249.57

Channel Count

1,826 (3.989%)

Connected Node Count

1,512 (13.377%)

Color

#49daaa

IP Addresses

34.239.230.56:9735
of7husrflx7sforh3fw6yqlpwstee3wg5imvvmkp4bz6rbjxtg5nljad.onion:9735

Node: KryptoSphere | 1ML - Lig

1ml.com/node/027175da98e8...

1ML

Node: KryptoSphere

Follow

Public Node

Capacity

0.28338185 BTC (0.021%)
28,338,185 sat
$11,456.57

Channel Count

6 (0.013%)

Connected Node Count

6 (0.053%)

Color

#3399ff

IP Addresses

86.192.234.20:9735
7kummelm2lppti7no63rbjtkekc52jyum34quiqrup7e37im4htwlqid.onion:9735

Node: netgear | 1ML - Lightnin

1ml.com/node/03488475e50e...

1ML

Node: netgear

Follow

Public Node

Capacity

0.30590480 BTC (0.023%)
30,590,480 sat
$12,367.13

Channel Count

8 (0.017%)

Connected Node Count

8 (0.071%)

Color

#68f442

IP Addresses

uuxjzp573kgck7o5qr6cblbtulvhva4rgvmoh2peno5aeydfu3tnkuad.onion:9735

Node: gandalf.cash | 1ML - Lig

1ml.com/node/024537120d82...

1ML

Node: gandalf.cash

Follow

Public Node

Capacity

1.56517722 BTC (0.118%)
156,517,722 sat
$63,277.05

Channel Count

53 (0.116%)

Connected Node Count

52 (0.460%)

Color

#3399ff

IP Addresses

173.48.157.250:9735
b57rizfhpgmypiafqdpnspj756yp3hiawswt5k34pqnzpvx7tju6yrad.onion:9735

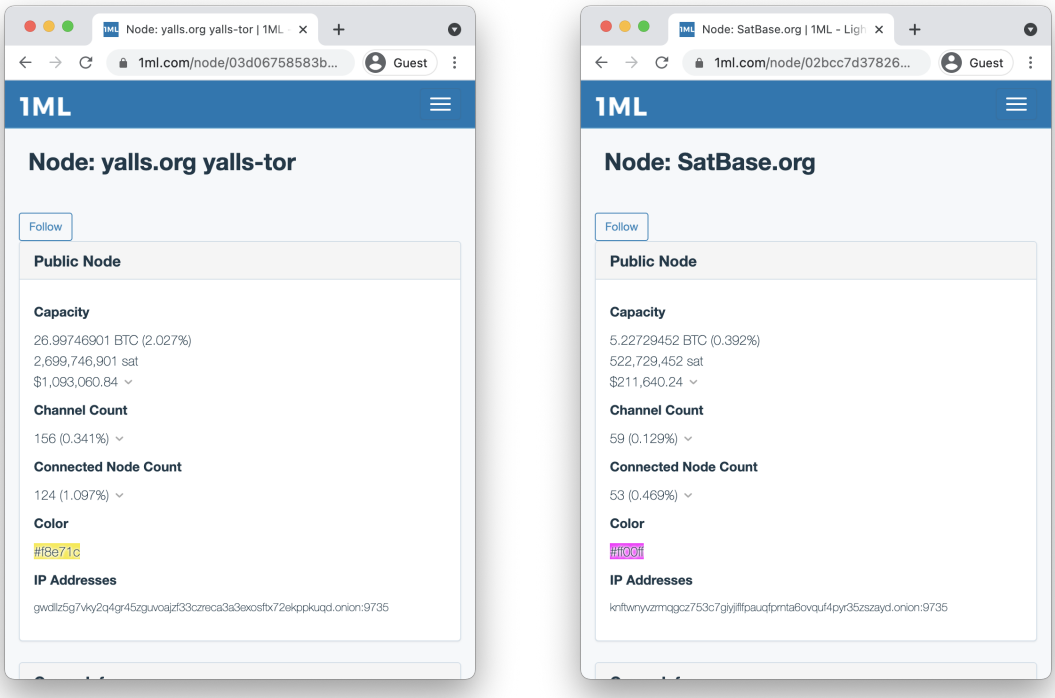

Figure 7: [1ml.com](1ml.com) screenshots of nodes interviewed. From top left to bottom right: ACINQ (Fabrice Drouin), KryptoSphere (Guillaume Girard), netgear (John O'Hare), gandalf.cash, yalls.org (Alex Bosworth), SatBase.org (Thomas Jestopher).

Paths for Future Collection of Public Data on Lightning:

There were a number of directions for this research that we did not get the time and resources to initiate in-time to get meaningful data from but could be potential routes to explore in future studies.

1) Leveraging tipping networks: users of lightning often use lightning to collect tips. Tipping is a common practice on the network used for different purposes including tipping for podcasts, Twitter posts, etc. One node owner has created a Telegram tipping tool for Telegram users to store Satoshis and tip each other for different occasions. Tipping could be a way to encourage data sharing with researchers. It could create more engagement without having to create incentive for participation through substantial

compensations.

2) Writing an opt-in script for collecting data: Some lightning routing nodes run customized scripts on their node to collect transaction data. Writing a short script that would only collect and store information that would not risk privacy, could be used as a data collection tool.

3) It should also be noted that many node owners themselves have incentive for sharing and gathering data on transactions routed, and understanding where in the network most transactions are happening in order to identify market opportunities. So future iterations of this study could benefit from identifying such nodes.

Strategic Perspective

Currently, there are two potential future outcomes for the Lightning Network identified by major players in the field, including large node owners and one of the co-founders of the Lightning Network. Exploring these scenarios in greater detail will hopefully allow us to better understand the findings from the previous sections and offer a strategic outlook on how the Lightning Network may develop over the next few years, and consider whether it could be profitable in the future.

Scenario 1: Lightning Network as an Investment Vehicle

The first scenario proceeds with the assumption that as the Lightning Network expands, routing fees will eventually increase to a point where a significant profit can be generated. Under this assumption, as large nodes within the Lightning Network consolidate, a small group of nodes will emerge controlling the lion's share of traffic flowing through the Network. These nodes, which can be thought of as *neo-banks*, would operate similar to current banking institutions and allow individual users to deposit Bitcoin into accounts under the neo-bank, using the bitcoin as liquidity for the neo-bank's node. Due to the high volume of transactions routed through the neo-bank, we can expect there to be a steady level of interest fees, which would then be translated into interest yield payments distributed to users based on the amount they have deposited into

their account. Additionally, inherent variability in routing transaction fees and potential routing failures through untrustworthy nodes would be covered by the neo-bank, thus eliminating any risk in the Lightning Network.

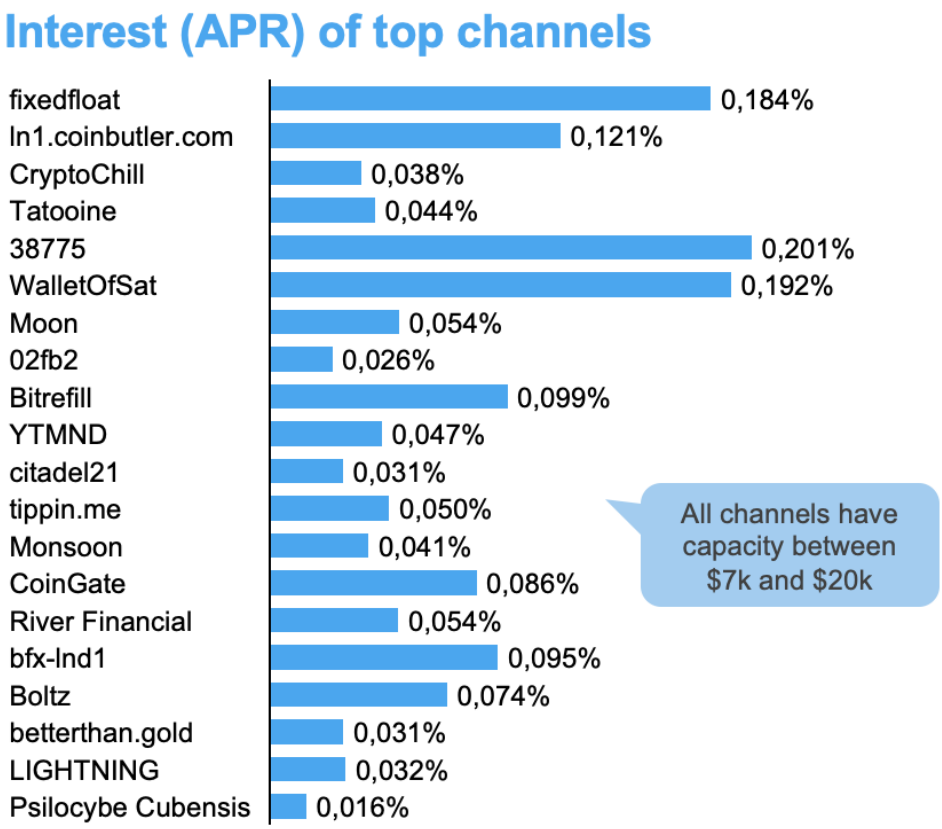

Figure 8: Interest rates for the channels with the most liquidity connected to the Y'alls node (the 12th largest node in the Lightning Network by capacity). Interest rates for a large node like Y'alls are still extremely low.

Scenario 2: No Investments in the Lighting Network

The second scenario proceeds instead with the assumption that low barriers of entry prevent routing fees from ever rising to a level where nodes can make a profit. In this scenario, there is no option for independent investors to deposit money into the Lightning Network and receive interest on the deposit; rather, liquidity for the nodes comes directly from private capital. Since there is virtually no profit in routing transactions through nodes (i.e. routing is net break-even),

nodes generate profit via third-party services, such as providing inbound liquidity or connecting lightning channels to an external recipient. As the Lightning Network expands and gradually takes over many of the transactions that currently occur on-chain, the need for third-party services will rise and thus profit will increase.

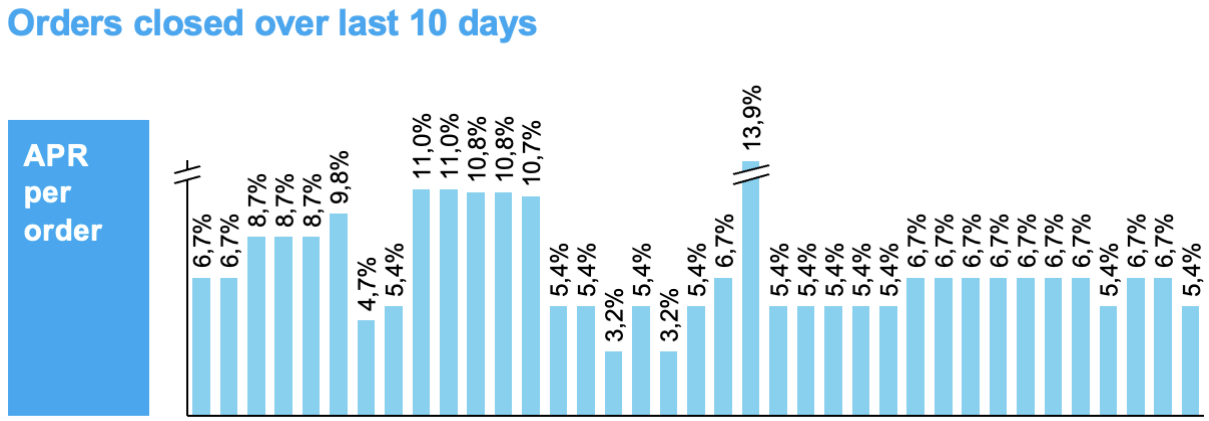

Figure 9: Annual percentage rate (APR) per order closed by Lightning Pool, a liquidity-providing service. The average APR was 5.9%.

Conclusion

Over the course of our research, we came to two key takeaways corresponding to our two original objectives. The first takeaway is that interest rates in the Lightning Network, in its current state, are either virtually zero (< 0.1%for large nodes with many channels) or zero (for small nodes such as the one we ran), and therefore establishing a benchmark reference rate for the Lightning Network is not meaningfully significant. The second key takeaway are that there are two contrasting future directions in which the Lightning Network may develop. In Scenario 1, the Lightning Network can serve as an investment vehicle through the formation of *neo-banks* which allow users to deposit capital and receive interest on it. In Scenario 2, routing fees remain close to zero and nodes instead generate profit via third-party services; as the Lightning Network grows and takes over the responsibility of the majority of transactions involving Bitcoin, the demand for these services will increase.

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Josel Smith
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