

BITCOIN LIGHTNING NETWORK

THE FUTURE OF PAYMENTS?

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The authors appreciate the great support and feedback from René Pickhardt. His insights and comments were essential to making this article a reality.

DISCLAIMER

This report does not constitute financial advice, advertising, or the like.

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Executive Summary

The Lightning Network is the next evolutionary step of Bitcoin. With the Lightning Network as the rails and Bitcoin as the vehicle, there is tremendous disruptive potential in how payments are conducted for countless industries, and far-reaching implications for companies, non-profits, merchants, and consumers alike.

Bitcoin enables global transactions without intermediaries. However, settling all payments via the Bitcoin Blockchain has limitations. The Lightning Network can significantly increase payment throughput, which is necessary for the mainstream adoption of Bitcoin as a payment system. In the future, it might even be possible to send other assets, such as the euro or tokenized bonds, via the Bitcoin Lightning Network.

The Bitcoin Lightning Network combines highly sophisticated technological concepts to provide users with a quick and cheap international payment system without intermediaries. The basis of this is a network of payment channels. Cryptographic concepts such as multi-signature wallets and commitment transactions ensure that account balances in payment channels can be updated and paid out at any time by the parties to the payment channel, while ensuring a high level of security. Additionally, hash time-locked contracts ensure that transactions are sent efficiently from sender to receiver when there is no direct payment channel between the parties.

Setting up a Lightning wallet takes only a few minutes, with initial deposits to the wallet and payment channel taking about an hour each on average. Once liquidity is available in the wallet and payment channel, low-cost real-time payments can be made via Lightning worldwide within milliseconds. This makes making daily purchases like paying for a cup of coffee or even micro-transactions possible.

Adoption is currently happening in two ways.

- Innovative companies recognize the potential of the technology and offer payments via Bitcoin Lightning to their customers without a middleman based on freely available open-source solutions.
- Professional payment processors, such as Worldline Global, enable fully integrated Lightning payments as a payment method for their merchants

The use of the Lightning Network differs regionally, with some countries using it extensively for remittances to developing countries (e.g., cross-border payments), while in some countries like South Africa, Lightning is gradually finding its way into the daily payment process in stores and online retail outlets.

The adoption of Lightning will continue to increase in the coming years as soon as a broader audience becomes aware of the added value and beneficial applications. Also the possibility to send other assets, such as stablecoins, via the Lightning Network, might positively impact its development. Similar to the evolution of the Internet, Lightning's technical complexity will soon be abstracted away which will reduce barriers to entry by providing a more intuitive user experience.

Although Lightning has great potential, we also need to acknowledge that a lot of work needs to be done as the technology matures (see Figure 1).

As Lightning moves from research and development to more commercial applications, it is clear that various aspects like usability need to be improved to ensure that non-technical users can take advantage of the Lightning Network.

People and businesses, alike, should be able to run nodes that send and receive invoices without needing an extensive technical background or knowledge. Similarly, legal, compliance, and operational issues must be addressed globally before Lightning's network effects are fully realized.

The Lightning Network has made major improvements in transaction resilience over the past few years. However, proper liquidity management to enable seamless routing, especially for large payments, needs further progress. Moreover, on- and off-ramp costs and volatility issues need to be addressed, which currently can negate near-zero costs and instant settlement benefits of the Lightning Network itself.

Luckily, many people and companies (e.g., [Strike](#), [Lightspark](#), [Lightning Labs](#), [Opennode](#), [Bitcoin Suisse](#), and [Galoy](#), to name a few) are working to address these challenges. In time, many of these challenges will be solved, similar to the development of other technologies that were introduced in the past. For example, VOIP was virtually unusable when it first came out in the mid-90s, given bandwidth constraints. Yet today half the planet unconsciously uses it to communicate.

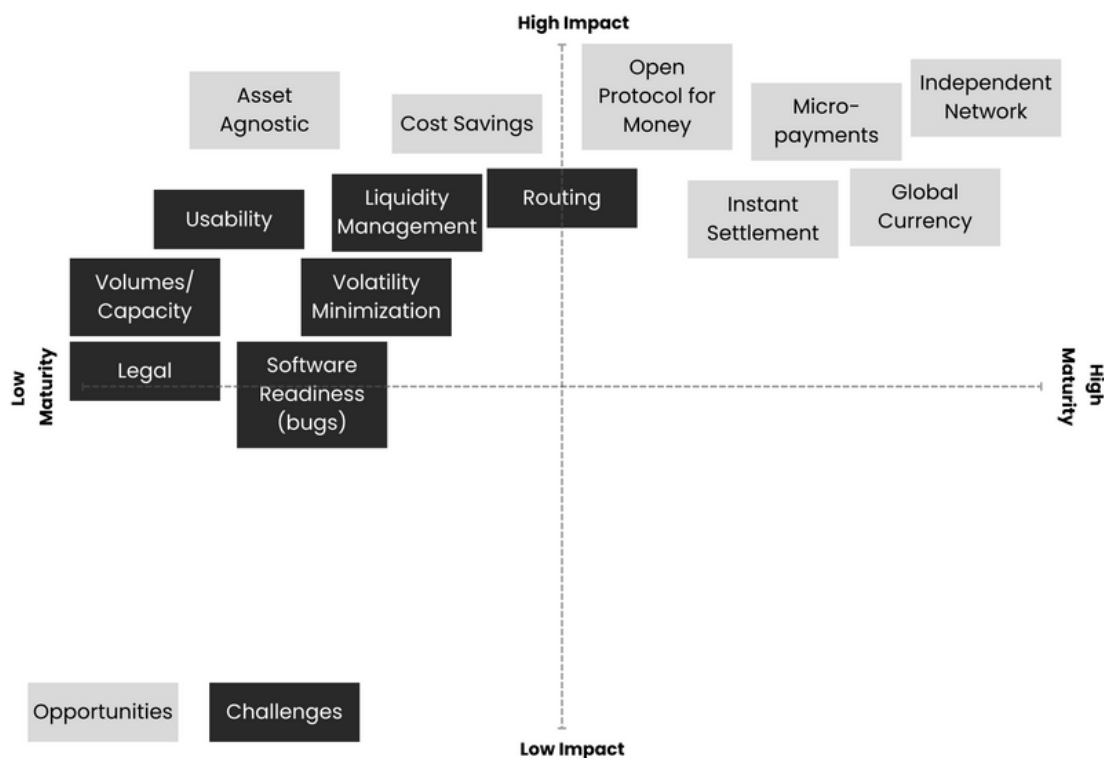
Addressing those challenges will make the Bitcoin Lightning Network's inherent advantages shine even brighter:

- an independent network (unfreezable, censorship-resistant),
- a cash-like bearer instrument with near-instant finality with no chargebacks or reversals,
- near-zero costs for even micropayments,
- a globally recognized and inclusive currency that is the same everywhere, and
- Lightning's potential interoperability to be used with other assets or blockchains

Ultimately, the Lightning Network has the potential to live up to its promise of becoming a global value transfer settlement network that acts as an open protocol for money. The open source movement showed us over the past several decades the innovative power that can be released with that approach.

This report highlights the first sprouts of those innovations and the art of the possible, covering the motivation, functionality, and use cases, as well as the future of Lightning. ⚡

Figure 1: Challenges and Opportunities of the Bitcoin Lightning Network



Why We Need the Bitcoin Lightning Network

This chapter addresses the benefits of the Bitcoin Lightning Network, how it stacks up against Bitcoin, and why the network is needed.

BITCOIN AS A GLOBAL PAYMENT SYSTEM?

Bitcoin offers numerous advantages as a decentralized payment system through which money can be sent worldwide without intermediaries. Chief among these is the low entry thresholds for participants: any citizen in the world with an Internet-enabled device can use the bitcoin protocol. No one can be excluded, which positively impacts financial inclusion. Moreover, Bitcoin represents a scarce digital asset, a kind of "digital gold." Each bitcoin can be divided into 100 Million satoshis, just like you can split one euro into 100 cents. Unlike fiat currencies, according to the Bitcoin protocol, the money supply is limited to roughly 21 million bitcoin. Thus, a debasement via dilution of Bitcoin is impossible.

Despite the advantages mentioned, the technology's current state also has limitations. For transactions via the Bitcoin blockchain, the significant decentralization of the network comes at the expense of transaction throughput, i.e., the number of transactions that can be carried out per second. A maximum of seven transactions per second ("on chain") can be confirmed via the Bitcoin Network.

To function as a payment system, this low transaction throughput is insufficient. Established payment service providers such as Visa or Mastercard enable several thousand transactions per second and thus scale much better - even if being completely centralized. Transactions on the Bitcoin Network usually need longer time windows until they are confirmed ("mined") and are therefore not suitable for everyday payment transactions. Another limitation is small payments via Bitcoin. Each transaction incurs a fee based on its storage size. The more storage used, the more expensive the payment. On average, a transaction, regardless of volume, today costs

approximately 1 USD. At times of increasing demand, such as in 2017, transaction fees have peaked at more than 60 USD. For large payments, transaction fees may seem relatively cheap; however, small payments are usually uneconomical due to the relatively high transaction costs.

LIGHTNING ADDRESSES BITCOIN'S DISADVANTAGES

The goal of the Lightning development is to make Bitcoin suitable for everyday use as a means of payment. The top priority is to increase payment throughput without centralization, which is the basis of payment networks, such as Visa or Mastercard. More specifically, this means more payments at mostly cheaper rates. While Bitcoin's whitepaper was published by Satoshi Nakamoto as early as 2008, the idea of the Lightning Network dates back to 2015. The first implementations began in 2016. In 2018, the first users started to use Lightning implementations. Since then, the technology and the network have evolved rapidly. However, despite a heavy transaction volume and recent progress in adoption, it is still in its infancy in 2022.

How does Lightning solve the problems of low transaction throughput and relatively high transaction fees? Not all payments are written to the blockchain (i.e., "on-chain"). Most payments are made to each other "off-chain," and only in extreme cases or when a financial relationship between two network participants is terminated are they written to the blockchain ("settled"). As a result, payments from users can be processed in real-time and at a low cost. Users who send money via Lightning do not have to wait for mining; payments are processed directly and finalized immediately.

HOW DOES THE LIGHTNING NETWORK WORK IN GENERAL?

To understand how the Lightning Network works, consider the following real-world example. Assume you are going to a bar with a few friends to have a fun evening. You want to invite them for drinks, but it is too burdensome for you to pay for every drink separately. Thus, you leave your credit card with the bartender to open a tab. Every time you or one of your friends orders a drink, the bartender keeps a tab. At the end of the evening, the bartender closes the tab and gives you the final bill to conduct the payment. Such bar tab payment is a common practice in the US and UK.

The bar tab example is similar to the Lightning Network: Individuals send IOUs to other individuals or merchants via so-called Lightning Channels (off-chain). They open a 'payment channel' just like one would 'open a bar tab' with a bartender. Theoretically, the two parties can exchange an infinite amount of IOUs. At some point, the payment is finally settled in bitcoin (on-chain). Note that this example is somewhat incomplete since the Lightning Network can do much more: It does not require trust in the other party. You can also make payments to people with whom you do not directly maintain a payment channel via so-called routing. ⚡

How to Conduct Transactions Using Lightning

This chapter explains step-by-step how payments via the Lightning Network are performed.

SETUP THE WALLET

The first step requires you to download and set up a Lightning wallet on your smartphone or computer. Setting up a Lightning wallet is relatively intuitive and similar to setting up a self-hosted Bitcoin wallet, where you are in possession of your private key. This contrasts with hosted wallets, where third parties such as crypto exchanges can access your private keys.

Today, there are a variety of Lightning wallet providers, such as [Zeus](#), [Bluewallet](#), [Phoenix](#) or [Breeze](#). Let's take a closer look at the Phoenix wallet (see Figure 2). The setup only takes a few minutes.

1. After downloading the Phoenix wallet in the app store press the "Create new wallet" button in the Phoenix app.
2. Immediately afterwards, the app is ready to receive funds. For this, you need to click on "receive".
3. Please note that the first payment you receive is at least 10,000 satoshi (0.0001 BTC).
4. As the app provides a self-hosted wallet, you are responsible for securing and storing your seed phrase. If you click on the "recovery phrase" button in the Phoenix app, the seed phrase is shown. Please write it down and store it in a safe place. This seed phrase is necessary to generate private and public keys.

It is important to note that the Phoenix wallet is a self-hosted wallet. This means you are solely in possession of the seed phrase and the private key. For Lightning specifically, you also need to backup the state of your open channels to be able to recover your funds.

Never share the seed phrase, the private key or the backup of your channels with anyone and always keep them inaccessible to third parties. To safeguard yourself from hacker attacks, it is crucial to store this information in a place that is not connected to the internet.

DEPOSIT FUNDS INTO THE WALLET

The next step is to deposit funds into the Lightning wallet. Therefore, you need to transfer bitcoins from your self-hosted Bitcoin wallet or your account at custodial service providers, such as Coinbase and Binance, to the Lightning wallet you have set up. All you have to do is enter the Lightning receive address via the Bitcoin wallet (for example via a QR code scan) and authorize the payment by signing with the private key.

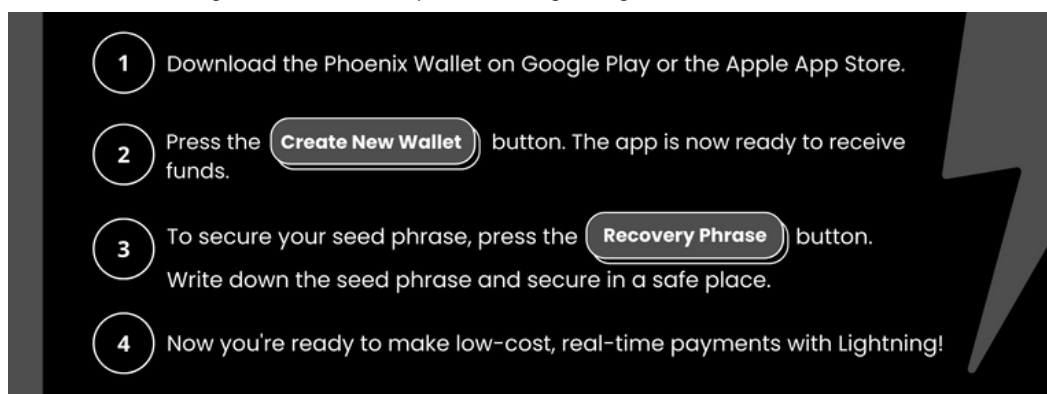
For security reasons, you should wait for several confirmations of the Bitcoin blockchain (typically 6 confirmations which take approximately 60 minutes) to be sure of the final settlement of the deposit.

If you don't have any bitcoins yet, some wallets like Bluewallet or Bison offer you the possibility to buy bitcoin directly via the app, e.g. by credit card or bank transfer. Another possibility is to "earn" them, e.g. by getting donations or value-4-value approaches. This allows you to easily enter the world of Lightning.

OPEN A PAYMENT CHANNEL AND MAKE A DEPOSIT

Next, you need to open a payment channel with your transaction partner. For example, if you want to pay for a coffee with Lightning, you can open a payment channel with the cafe where you want to buy your coffee. Payment channels are essential for Lightning to make fast and inexpensive Bitcoin payments.

Figure 2: How to set up a Bitcoin Lightning Wallet via the Phoenix Wallet



Instead of conducting all payments on-chain through the Bitcoin blockchain, payments are conducted bilaterally and off-chain via the corresponding payment channels and are not written to the blockchain. This can save transaction costs and reduce waiting times.

Within the opening process, money is deposited into the payment channel. This step is also referred to as a 'funding transaction'. The deposited money is subsequently available for payments within the payment channel. The deposit transaction constitutes an on-chain transaction, which is why the receiver should wait again for several confirmations from the Bitcoin blockchain to ensure your payment is indeed settled and funds are not double spent.

PAY VIA LIGHTNING

After the money is deposited, transactions can be made between each other within the payment channel. For example, a coffee can then be paid for via Lightning. For this to happen, the cafe requests a payment and issues a so-called Lightning Invoice. This can be in the form of a QR code, which is scanned via a wallet such as the Phoenix wallet mentioned above. Afterwards, the payment only needs to be confirmed in the app. The app then reports that the payment has been made successfully. ⚡

How Does Lightning Work Technically

This chapter covers cryptographic concepts used in the Lightning Network to enable fast, scalable, and cost-effective transactions.

KEY TECHNOLOGICAL CONCEPTS

The technical functionality of Lightning seems relatively intuitive due to the ease of use of Lightning. However, in the background, the network is highly complex. Creating a global payment system without intermediaries is no simple undertaking. The Lightning Network draws on numerous innovative technical concepts that are interconnected and integrated to enable low-cost global payments with real-time settlement. The basis for this is a global network of payment channels based on multisig wallets, commitment transactions and hash time-locked contracts.

Multisignature (Multisig) Wallets

From a technological point of view, a Lightning payment channel between two people or between a person and a merchant is a multisignature wallet (also called "multisig wallet"). When money is deposited into a payment channel through a so-called "funding transaction" on the Bitcoin blockchain, the money can only be spent after both payment channel parties agree to the transactions. Therefore, both parties must always confirm updates to the account balances. When a transaction is carried out via Lightning, new account balances are ultimately negotiated in the background.

We can use the example of Alice and Bob to illustrate how this works. Assuming Alice has deposited 0.5 BTC into a payment channel with Bob, this payment channel has a maximum capacity of 0.5 BTC. For example, if Alice now wants to send 0.1 BTC to Bob via Lightning, then Bob's account balance in the payment channel is increased by 0.1 BTC (new account balance Bob: 0.1 BTC) and Alice's is reduced by 0.1 BTC (new account balance Alice: 0.4 BTC). To finally execute the payment of the 0.1 BTC via Lightning, this account update must be confirmed, i.e., signed, by both Alice and Bob.

However, this signed account update is not published as a transaction via the Bitcoin blockchain but is created and held back as a so-called "commitment transaction."

Commitment Transaction

In a commitment transaction, both parties commit to the payment of the last agreed-upon account balance. This ensures that payment partners do not have to trust each other to complete a transaction but rather rely on the Lightning Network. By signing the commitment transaction, the payment channel partners commit to the current account balance and allow the other party to pay out their money when needed, without needing the other party to agree again.

Assume that after Alice has sent 0.1 BTC to Bob, Bob stops responding to Alice's messages. He does not get back to her for days and is offline. The current account balances are 0.1 BTC for Bob and 0.4 BTC for Alice. Since Bob must also agree to new transactions, Alice would normally not be able to get her 0.4 BTC back. Consequently, they would be "locked" in their payment channel - Alice would have to rely on Bob's cooperation. To solve this trust problem, Alice and Bob have previously created a commitment transaction. The commitment transaction now allows Alice to get back the last agreed balance without Bob's cooperation (i.e., Bob: 0.1 BTC, Alice 0.4 BTC). Thus, Alice can now initiate an on-chain transaction that will pay out the 0.4 BTC.

It should be noted that the commitment transactions are only published in extreme cases - e.g. when the counterparty can no longer be reached. This is because high transaction costs and a relatively long waiting period for transaction execution are generally incurred for the on-chain execution of a commitment transaction.

Commitment transactions, therefore, provide security in an emergency - but can be published at any time if required.

Hash Time-Locked Contracts

Hash time-locked contracts (HTLCs) are another core technical component of the Lightning Network. HTLCs are particularly important for routing. Let's assume Alice wants to send money to another person, Charles. As we know from the aforementioned example, Alice already has a payment channel with Bob. We now assume that Bob maintains a channel with Charles. Alice can now use Bob's channel with Charles to send money to Charles. She does not need to open her own payment channel with Charles. Bob acts as a "middleman" in the payment process here. This process is called routing. For Bob to have the incentive to route the payment to Charles, Bob receives compensation in the form of a transaction fee. In this context, the capacity of the payment channel mentioned at the beginning also plays an important role. In order to send a transaction of 0.5 BTC from one party to the other, all channels along the way must have this capacity.

In the Lightning Network, the routing process works as follows. Alice wants to send money to Charles. As a start, Charles defines a secret that only he knows.

In Lightning, this secret is typically a very long number that cannot be guessed within a reasonable time. Charles then sends a hash of the secret to Alice and Bob. The payment chain is now rolled up "back to front." Bob sends money to Charles when he has received the secret. Alice, in turn, sends money to Bob only when she has received the secret. Thus, it is a conditional payment that only occurs when Alice and Bob know the secret.

What happens if Charles does not forward the secret? Then, no payment would take place because the conditions for payment are not met. In Lightning, there is a deadline for forwarding the secret. The payment is canceled if the secret is not forwarded within the specified deadline. Technologically, this is implemented via HTLCs. These HTLCs expire after a certain amount of time, typically two weeks. The payment is only executed if the secret is entered correctly within this timeframe. If the time expires or the secret is incorrect, the payment is canceled. This mechanism is very important so that the network is not clogged and liquidity is available to individuals again. After all, while the money is locked in HTLCs, this liquidity cannot be used elsewhere. ⚡

Industry Use Cases of the Network

This chapter highlights key industrial use cases of the Lightning Network.

IMPORTANCE OF LIGHTNING FOR THE INDUSTRY

While Lightning development is still in its infancy, more and more companies are getting on board with the network. MicroStrategy, known for its Executive Chairman Michael Saylor and holds over 100,000 Bitcoin, announced in summer 2022 that it plans to make Lightning software available for industrial applications and has set up an internal Lightning Research Lab for this purpose. This year, David Marcus, former Board Member of Diem (Libra) Association and Head of Facebook's Novi, launched Lightspark, a company exploring the utility of Bitcoin for payments with a strong focus on Lightning to develop software for enterprise applications.

The interoperability of Lightning's various use cases is groundbreaking. As an open and distributed payment standard, different platforms and applications can be built that are compatible with each other at the payment level. For example, think of a crowdfunding campaign on Kickstarter. Imagine payment processing going beyond Kickstarter's website onto a social media post, a private message, or even posters and flyers, without the backer ever having to visit the website. In the same way, consumer applications are interoperable with industry applications via the Lightning Network and can be seamlessly integrated.

INDUSTRIAL USE CASES

One of the most exciting features of Lightning is the viability of nano-payments, i.e., payments that can be arbitrarily small, e.g. in the sub-cent range. This possibility of nano-payments enables companies to not only create new business models, but also optimize existing business models.

In many industries, high costs arise due to downstream payment processing and financial intermediaries.

Companies sometimes must make payments months or even quarters in advance before the goods or services are delivered. Thanks to the feasibility of nano-payments over the Lightning Network, deliveries and payment flows can theoretically take place simultaneously, and, as a result, financial inefficiencies can be massively reduced. Selected industry use cases are detailed below.

Machine-to-Machine Payments

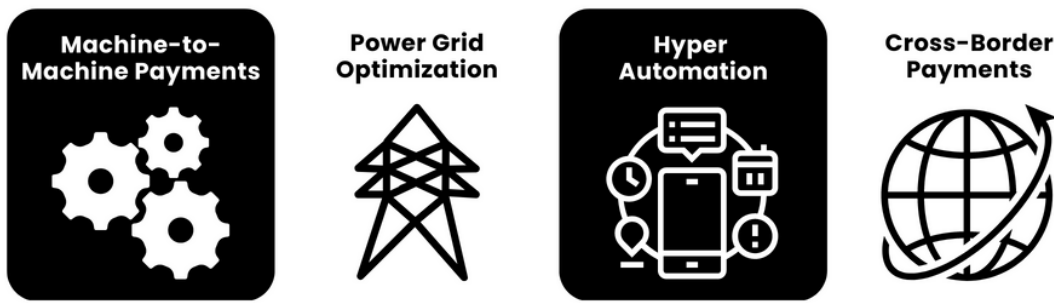
In addition to payments manually triggered by humans, machines can also trigger a payment with final settlement due to the programmability of payments via Lightning. These payments can also be sent directly to other machines. Today, when we talk about M2M payments, we should be talking about M2M accounting. Machines do not usually have their own "payment accounts"; these are usually run through the machines' owners. However, the machine can be granted authorization for certain payments. Thanks to the economics of nano-payments via Lightning, machines can theoretically send or receive a payment for every action.

For example, without registration, KYC processes, and human interaction, one could:

1. charge an e-car at any charging station
2. pay for the charge via Lightning
3. drive off anonymously.

Today, such a process is not easy to perform, but it will become more relevant with future applications such as self-driving cars or robotics. A self-driving car should ideally work as an autonomous cab, which can ideally be used and paid for by the minute. In addition, payment flows can be split and forwarded via Lightning in a fully automated way. For example, the owner of an e-car charging station can forward the incoming payments

Figure 3: Industrial Use Cases of the Bitcoin Lightning Network



per kilowatt hour directly to the landlord of the property, the electricity supplier, or the maintenance company and only retain their own margin.

Power Grid Optimization

Today, the energy market is particularly plagued by financial inefficiencies. For example, payments for electricity consumption currently flow much more slowly than the electricity itself. Electricity producers, traders, and grid operators prepay for months until they receive payment for the electricity from the consumer in bundled form. Although electricity prices can vary widely over time and space, companies in the energy industry need to make a blended calculation for the price and hedge against the associated volatility risk. Currently, it is only possible in a few cases to pass on short-term price fluctuations to the consumer.

In the U.S., about [10% of the price of energy can be attributed to the problem of financial inefficiency](#). These additional costs arise from intermediaries in payment processing, increased administrative overhead in billing, and risk management, among other things. These costs can be significantly reduced if energy and money can flow at the same speed and payments can be automatically routed to all participants in the value chain instantaneously. M2M payments also come into play here, as most households already have a smart meter, which could also make automated payments per unit of electricity.

Hyper Automation and Smart Contracts

Thanks to the ease with which Lightning payments can be programmed, companies can extend their process automation to

payment flows as well, not only reducing the burden on accounting staff through automation, but also reducing the chance of errors. For example, if an ERP system were directly connected to the Lightning Network, almost completely automated payments could be sent to all service providers, suppliers and partners, and incoming payments from customers could be posted directly in the system. A nice side effect: there is a complete documentation of all incoming and outgoing payments directly in the company's own cloud/IT environment, without the company still needing an intermediary for payment processing. This is possible because Bitcoin and the Lightning Network makes the vertical integration of financial services possible for the first time. Companies can be their own bank and thus become more independent and efficient.

Cross-Border Payments

Due to its high efficiency, the Lightning Network can also be used for cross-border payments by companies and address frictions in cross-border payments. Today, we are seeing an ever-increasing interest from financial institutions to use Lightning to settle dollars or any other currency internationally with other financial institutions and service platforms around the world. Due to Bitcoin's volatility, this involves exchanging the received payment directly into the local currency or hedging the risk via contracts. The Lightning enterprise software provider Galoy makes it possible to implement risk hedging on account of exchange rate fluctuations in an automated and cost-efficient manner. The process is explained in detail at [stablesats.com](#). ⚡

Retail Use Cases of the Network

This chapter highlights active retail use cases of the Lightning Network.

Figure 4: Retail Use Cases of the Bitcoin Lightning Network



Payments in Retail and Hospitality

Payment methods used in retail and hospitality need to process a large number of transactions quickly and reliably, which is why scalable payments are essential. Payments via the Lightning Network meet these requirements and, in combination with low transaction fees, ensure that payments with Bitcoin are increasingly in demand by retailers, restaurateurs, and end users. Technically, the morning coffee or lunch at your favorite Italian restaurant can already be paid for efficiently and cost-effectively via Lightning. However, both the merchant and the consumer must use Lightning payments. This is not yet the case on a broad scale. However, news such as the [introduction of Lightning payments in the CashApp](#) with more than 40 million monthly active users and the [acceptance of Lightning payments in all stores of South Africa's second-largest retailer Pick n Pay](#) shows that the acceptance of Lightning payments is developing dynamically.

E-Commerce Payments

Today, the payment process in online stores is optimized to motivate customers to make a purchase. Available payment methods play an important role. Online stores have a great interest in offering a wide selection of payment alternatives. Payment with Bitcoin appeals to new – typically younger – customer groups who already own Bitcoin.

Lightning payments are particularly noteworthy in this context, as Lightning payments already offer a comparable user experience to common payment methods (e.g., credit cards). In addition to the user experience, immediate payment confirmation is also an essential means of minimizing risk for merchants. Payments with fast payment confirmation reduce counterparty risk, ultimately resulting in low costs for the merchant and typically for the end users as well.

In addition to traditional e-commerce payments, some websites (e.g., substack) use a Lightning paywall. This Lightning paywall gives content providers the ability to have their content accessed in exchange for a Bitcoin Lightning payment. Such websites benefit from the monetization option from a growing number of content providers (e.g., independent writers and podcasters) who want to publish content on the website. The growing supply of content in turn leads to more traffic being directed to the website, which can be monetized.

Donation and Cross-Border Payments

The first international aid organizations see the acceptance of Lightning payments as a way to collect donations quickly and efficiently. Lightning is now used by [Unicef](#), [SOS Kinderdorf Liechtenstein](#) and [Child's Dream](#), among others, to collect online donations.

In addition to this, Lightning also offers the possibility to send funds to remote regions or crisis areas directly and around the clock. Thus, Lightning has the potential to be used extensively for cross-border payments in the future. Today, cross-border payments cost on average over 6% of the transaction amount in fees, according to the [World Bank](#). And in some corridors, the fees can be double or triple that amount. Furthermore, payments typically take several days to complete. On the other hand, payments via Lightning can be made in real-time at a cost of almost zero.

Financial Inclusion

Bitcoin and the Lightning Network are open systems where anyone with a smartphone and a wallet can participate. Barriers to entry due to tedious know-your-customer ("KYC") processes do not exist. Projects such as [Bitcoin Beach](#) in El Salvador or [Bitcoin Ekasi](#) in South Africa use Bitcoin to empower socially disadvantaged local people and provide access to an independent financial system.

Streaming Payment Applications

Streaming payments are another application of Lightning. These are payments that are not made once but on a recurring basis, for example, during using a service. These include payments for music or video usage billed "per consumption" as opposed to monthly flat rates such as a Netflix, Apple Music or Kindle subscription. Under the heading of "Podcasting 2.0," Lightning payments can already be used to support podcasts. "Value-for-Value" micro-payments are made per minute while listening to the podcast. The user only pays for the exact amount of time they listen to the podcast. This is possible because micro- and nano-payments can be made efficiently via Lightning, which is not possible with current payment methods. ⚡

What's Next for the Bitcoin Lightning Network

This chapter reviews the current status of Lightning in charts, statistics, and visualizations, and examines how it is developing.

BUILDING A NEW PAYMENT INFRASTRUCTURE

As a payment network, Lightning has already achieved a critical mass in terms of liquidity and usability. How large is the Lightning Network today? The basic elements of the network can be described by three elements: Lightning Nodes, payment channels, and capacity.

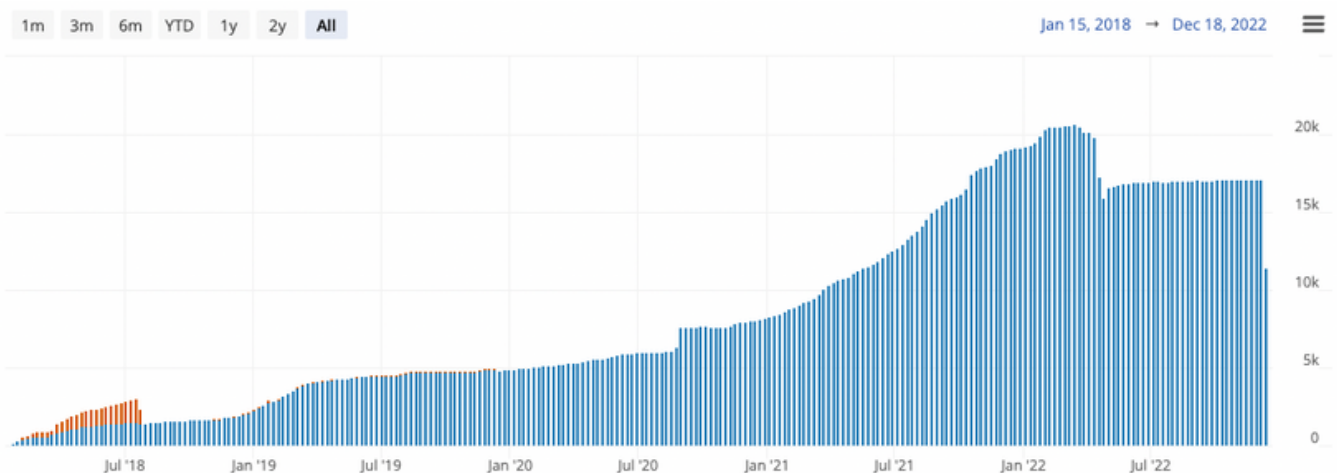
Lightning Nodes are the infrastructure operators and are each assigned their own unique identity within the network. Only nodes are capable of processing transactions. Their number has grown steadily since the early days of the network, albeit at different rates. After a period of slow growth between 2019 and 2021, growth began to accelerate in the spring of 2021. In March 2022, the number of Lightning Nodes reached an interim peak of over 20,000 nodes worldwide (see Figure 5); today, there are about 17,000 nodes, roughly doubling in number over the past year.

Because the network is a very dynamic construct, their numbers vary daily. The reason is that node owners - wherever they are physically located - turn their nodes on and off for various reasons.

80,000 Payment Connections in a Global Network

Payment channels are established between nodes using a Bitcoin on-chain transaction. On average, each node has ten payment channels with other nodes ([as of 11/14/2022](#)). A similar development can also be observed at the network level: More than 80,000 connections have already been opened between recurring transaction partners (Nodes). Each channel is capable of processing an unlimited number of payments. Only the liquidity in the payment channels limits the capability to execute payments as often as desired. The Lightning payment channels worldwide are visualized in Figure 6.

Figure 5: The growth of Lightning Nodes from 2018 to 2022.



Source: [Bitcoin Visuals](#)

Figure 6: The interconnectivity of the global Lightning Network



Source: [Mempool.space](https://mempool.space)

Average Capacities and their Limitations

For Bitcoin users to also be able to conduct their everyday payments via Lightning, sufficient liquidity is necessary on the network. This is expressed on an individual level by the capacity of a payment channel. It indicates the maximum size of payment volume that can be handled. Currently, a payment channel has a global average size of approx. 6.5 million satoshis, i.e., approximately 1,000 EUR (as of 11/14/22, [Amboss.space](https://amboss.space)). It is important to note that particularly active and most professionally operated Lightning nodes maintain several hundred to thousands of channels. In contrast, nodes of private individuals usually have only a few channels. This creates a network topology with powerful and "satellite nodes." This extreme difference also becomes evident in numbers: The smallest payment channel is only 1,100 satoshis (~0.21 EUR) in size, while the largest has a volume of around 14 bitcoin (~224,000 EUR). Adding all active payment channels, the network currently reaches a capacity of about 5,200 Bitcoin (~90 million EUR). The development of capacity is shown in Figure 7.

The number of bitcoins that are currently on the Lightning Network is relatively small, considering that billions of dollars in payments are processed daily on the Bitcoin blockchain. However, substantial growth is expected. In principle, Lightning allows to significantly increase the velocity of money in the Bitcoin system.

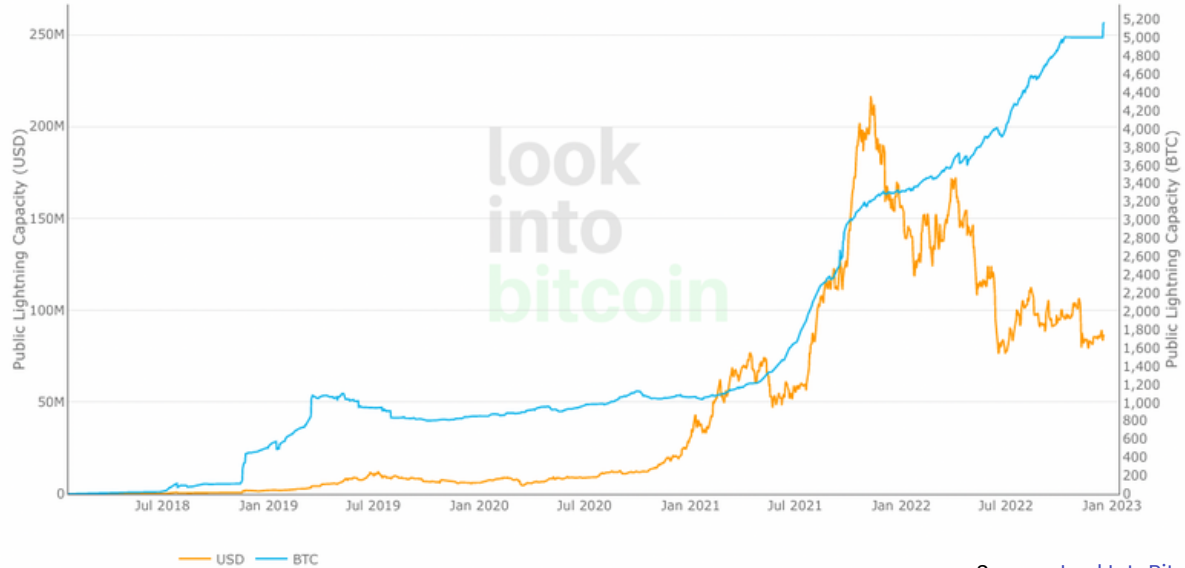
Profiting from the Growth of the Network

It is well-known that the Bitcoin ecosystem is an open monetary network. Of course, the same applies to the Bitcoin payment network. Only a Lightning wallet has to be chosen, downloaded, and set up to enable participation.

Less widely recognized is that private individuals can also actively contribute to expanding the infrastructure. If one sets up a node and opens a few payment channels, then one can earn fees by routing payments. For example, routing payments from El Salvador to Nigeria generates income for liquidity provision - without being aware of who the parties involved are.

The fact that liquidity allocation activities are becoming increasingly professional is also reflected in marketplaces such as [MAGMA](https://magma.exchange): The Lightning marketplace makes it possible to buy liquidity from well-connected Lightning nodes. On average, sellers receive an interest rate of 3.3 to 3.6 percent. The remarkable thing is that such a market incentive, driven by the behavior of individual participants, contributes to the organic growth of the network and concentrates liquidity where it is needed most. All this works without the respective parties knowing each other.

Figure 7: The increase in the number of Bitcoin on the Lightning Network.



Source: [LookIntoBitcoin](https://lookintobitcoin.com/)

INVESTMENTS IN LIGHTNING COMPANIES GAIN MOMENTUM

Lightning Labs, famous for developing the most widely used Lightning implementation, recently raised \$70 million in a Series B funding round. Voltage, a Lightning infrastructure-as-a-service provider, also raised about \$6 million in a seed funding round that included backing from Google Ventures.

The fact that venture capital funds are betting on Lightning technology - and backing infrastructure companies with millions of dollars - supports the assumption that a crypto winter will give the industry a chance to build, focus, and deliver successful projects.

GROWING IMPORTANCE OF INFRASTRUCTURE

Lighting Labs recently announced [a proposal to develop the Taro protocol](#), which would enable people without bank accounts to send and receive money via mobile apps in the form of stablecoins that correspond to their home fiat currency. [Pandora Core's RGB](#) is another project working on a similar use case.

It is also of particular importance because the Lightning Network is thus increasingly becoming an infrastructure network. In the future, users will not even notice when a fiat transaction is actually processed through the Bitcoin ecosystem.

However, the Lightning Network is also being used in less innovative use cases. While Lightning Labs is focused on optimizing global payments, trading platform Robinhood has discovered Lightning as a solution to reduce fees for its new crypto offering. Increasingly, firms are finding benefits in leveraging the technology and network as infrastructure.

CONCLUSION

The Bitcoin Lightning Network is as promising as it is innovative. This report has shown Lightning's many strengths, like cost-efficiently handling micro- and nano-payments as well as its instant settlement finality on a global scale, to name a few. There are still areas that need improvement as the technology is nascent and still under development, as is the case for all technologies at this level of maturity. With time, the Lightning Network has the potential to live up to its promise of becoming a global value transfer network & open protocol for money. ⚡

