Understanding Lightning

Opening a new era of frictionless bitcoin payments

2022.7 - Original Report
2023.3 - Updated Vietnam Ecosystem Report

Diamond Hands

INDEX

Lightning Network development and adoption is accelerating globally.

Bitcoin is quickly becoming a household name in the U.S. and Latin America, with governments and municipalities adopting it as legal tender, and popular online services beginning to accept it for payments over the Lightning Network.

This report aims to provide a basic introduction to Lightning for those who are interested in the significant impact and societal benefits that large-scale adoption will bring to businesses, governments, and the individual. In particular, we focus on the technological foundations, how Lightning is being used and what it enables, and what we can expect in the future of Lightning. We hope this document is especially useful to decision makers interested in using Bitcoin and Lightning at their firm.

While this report alone cannot provide a comprehensive understanding of the rapidly evolving details of the Lightning Network, it will act as a practical guide to important long-term trends and concepts that drive adoption.

Bitcoin has been long touted as a Store of Value (SoV), commonly referred to "digital gold" for its predictable monetary policy. Adoption of the Lightning Network will transform Bitcoin into a foundation for a flexible, powerful payment network. We hope to help readers understand and contemplate the possibilities Lightning can enable.

About Diamond Hands

Diamond Hands

Diamond Hands: Japan's largest Lightning Network user community

Diamond Hands aims to facilitate the international development and adoption of Lightning through the experimental operation of its routing node, a key technological component of the network, as well as through the development of useful products and provision of information and advisory to users and businesses.

Sponsors

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Executive Summary

Superior payments technology

The Lightning Network is a layer-2 technology built upon the most decentralized and secure Bitcoin block-chain, enabling rapid, cheap, and practical payments without compromising Bitcoin's decentralization. Lightning is more performant than other blockchain technologies or even traditional payment rails such as credit cards, and is expected to see increased worldwide adoption as its usability, function-ality, and stability improves.

Multilateral benefits

By combining multiple technologies, Lightning minimizes trust in the third parties who route payments while drastically im-proving Bitcoin's transaction throughput. The Lightning Network removes single points of failure and achieves stability as a result of fee competition between routing nodes, which forward payments across the

Foundation for the Distributed Web

Decentralized, but efficient

starting in 2021, with governments, municipalities, major web services and retailers adopting the technology, particularly in the U.S. and Latin America.

Cheap and instant payments enable significant cost reductions and improved capital efficiency, but also provide better UX and may unlock new business models, with many practical use cases already being explored. Furthermore, Bitcoin's global nature combined

Accelerating growth

The Japanese market

usion

the world.

In addition to efficient Bitcoin transfers, Lightning can be adapted to handle stablecoins and other financial contracts, making it a potential foundation for decentralized financial applications.

Further, micropayments over Lightning can be integrated in various services and protocols to help remedy problems that the current Web is facing, such as the influence of major tech platforms' access to user data, censorship, and privacy issues.

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Although Asia is lagging in Lightning Network adoption, Japan has a regional lead in this regard, positioning itself as an important potential market. Specific use cases in the country

3. What is the Lightning Network?

The Lightning Network is a layer-2 (second-layer) technology developed to improve Bitcoin's transaction speed, cost, and throughput limitations.

By establishing a payment layer atop the Bitcoin blockchain, Lightning maintains Bitcoin's decentralization and neutrality while vastly improving its transaction efficiency, enabling millions of cheap, fast payments per second.

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                    ┌──────────────────────┐
                    │        3-1.          │
                    │   The scalability    │
                    │    problem and       │
                    │ second-layers (L2)   │
                    └──────────────────────┘
              ┌──────────────────────────────────┐
              │     3-2. How Lightning works     │
              └──────────────────────────────────┘
    ┌──────────────┐   ┌──────────────┐   ┌──────────────┐
    │      ①       │   │      ②       │   │      ③       │
    │   Payment    │   │  Multi-hop   │   │   Routing    │
    │   Channels   │   │  Payments    │   │   Network    │
    └──────────────┘   └──────────────┘   └──────────────┘
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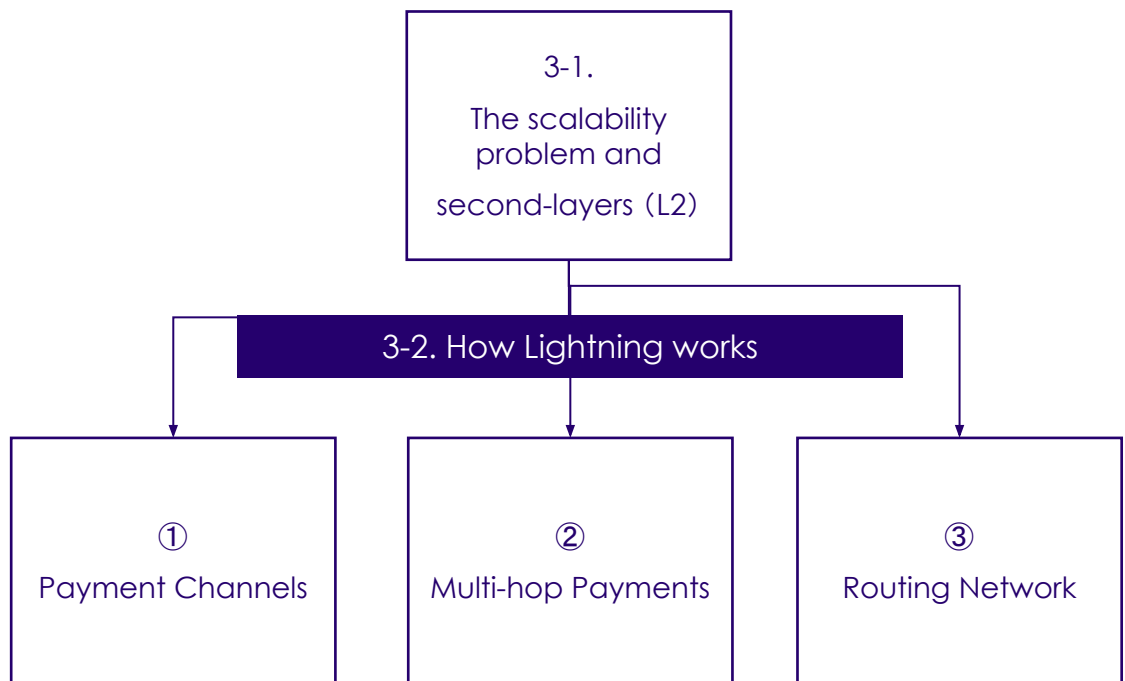
3-1. The scalability problem and second-layers (L2)

Scaling without compromising decentralization

**Building a powerful payment layer atop the
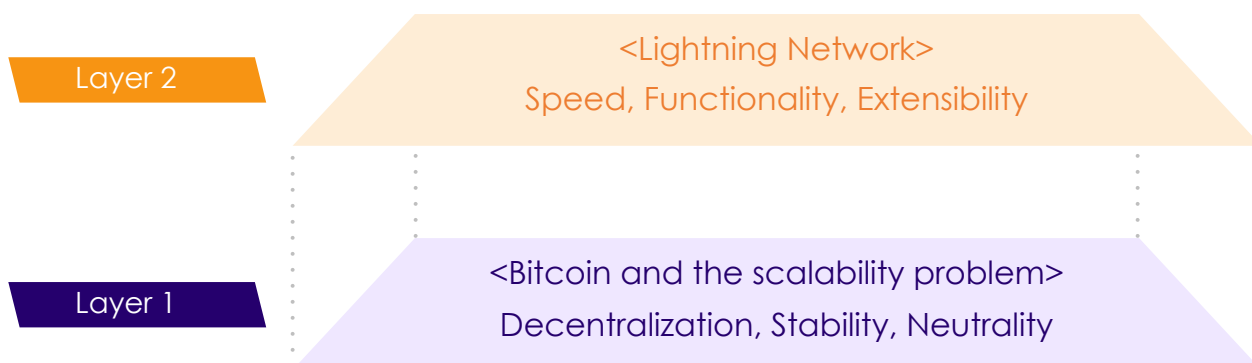most decentralized and stable Bitcoin blockchain**

In order to understand the engineering and the necessity of the Lightning Network, we must consider the limitations of transferring bitcoin on-chain and the intentional tradeoff between throughput and decentralization.

Currently, Bitcoin blocks which store on-chain transactions are limited to roughly 1MB each, which limits transaction throughput to a maximum of about 10,000 transactions every 10 minutes. Therefore, if users all around the world were to attempt to transfer their bitcoin at once, delays will result as pending transactions can only clear at that pace. Additionally, this demand shock will force people to bid higher fees to get their transaction confirmed before others.

This issue has recently become more prevalent on other blockchains such as Ethereum, and the inability of blockchains to scale with increasing users and transactions is commonly referred to as the *scalability problem*.

Simply increasing limits to tackle on-chain scalability is complicated by the tradeoffs that result in compromises in decentralization and lower stability, which hurt some of the core value propositions of blockchain technology.

For example, there are blockchains with very short block intervals enabling vast transaction throughput at a low cost, but lower block times come with an increased risk of double-spends, and the higher costs of storing, validating, and updating the blockchain result in reduced decentralization and fault tolerance.

Layer 2
<Lightning Network>
Speed, Functionality, Extensibility

Layer 1
<Bitcoin and the scalability problem>
Decentralization, Stability, Neutrality

Better than the competition

Lightning payments have significant advantages in speed, cost, throughput, privacy, and fault tolerance

There are multiple approaches to solving the blockchain scalability problem, each with varying tradeoffs. The Lightning Network uses the Bitcoin blockchain as its layer 1 (base layer), extending its capabilities on a second layer to improve scalability without compromising on decentralization.

Lightning is especially capable as a payments technology, with superior throughput and settlement times compared to existing networks such as Visa, and with lower costs and better fault tolerance than alternative blockchains and second layers.

	Solana ⚡ SOLANA	Visa **VISA**	Rollup ◆	**Lightning** ₿⚡
Speed	0.4 secs	3 – 5 secs (+ Risk of chargebacks)	14 secs	**Immediate**
Cost	0.025 cents	20 cents～	1 cent – 2 dollars	**0 – several cents**
Throughput （per second）	65,000	65,000	500 - 5000	**1,000,000 -**
Privacy	Poor	Poor	Poor-Medium	**Good**
Fault tolerance	Low-Medium	Medium	Low-Medium	**Medium-High**

*This table concerns smaller transactions, where the value transferred less than $100
*Data sources: Solana.com、Visa Fact Sheet, L2fees.info、Matter Labs、zkSync、Bottlepay

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3-2. How Lightning works

The Lightning Network uses payment channels and multi-hop payments for fast, cheap, and safe bitcoin transfers between users. A decentralized market for payment routing, consisting of routing nodes, enables these payments to be made reliably.
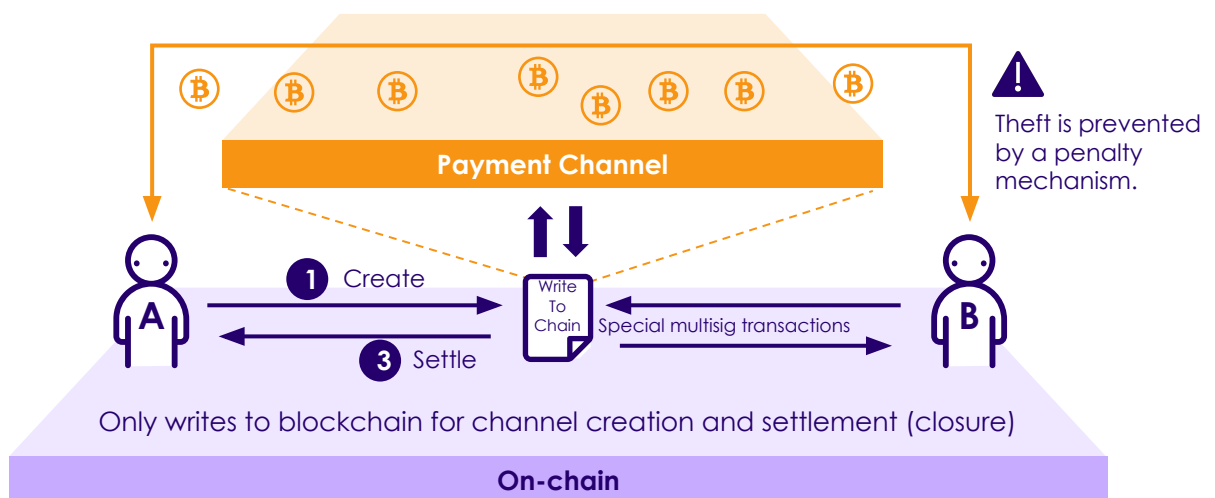
(1) Payment Channels

Fast & cheap off-chain payments

Payment channels enable rapid, cheap, safe off-chain transfers between two parties, contributing to on-chain scalability

Payment channels are a "tab" between two parties that enables them to send payments to each other without going on-chain. Both parties record all transactions that occur on the channel locally, removing the need to go on-chain for each payment, resulting in cheaper and faster transactions.

In order to create a payment channel, the sender and receiver create a special 2-of-2 multisig contract and deposit bitcoin to it on-chain. After the channel is created, the two parties can update their channel balances within the amount deposited, and can eventually settle the channel by broadcasting the latest state to the blockchain.

2 Fast and cheap transfers between payment channel participants

Payment Channel

Theft is prevented by a penalty mechanism.

1 Create

Write To Chain   Special multisig transactions

3 Settle

Only writes to blockchain for channel creation and settlement (closure)

On-chain

Regardless of the number of transactions that take place within the channel, only the channel creation and closure are recorded on-chain, resulting in a drastic reduction of writes to the blockchain, contributing to scalability.

If a counterparty of a channel attempts to broadcast an old state (where they have more money) to steal funds, the special multisig contract enables the victim to penalize the malicious party by taking their balance, preventing theft of channel funds altogether.

The Internet's layered structure influenced the Lightning Network

The Internet is a network that connects computers across different networks. When computers began communicating with each other, each network used different communications protocols. The TCP/IP model was standardized as an international communication protocol, comprised of 4 layers that are encapsulated to work independently of each other.

The Lightning Network protocol has its own set of layers. The lowest layer is the Bitcoin base layer (layer 1), the second layer is the off-chain Lightning layer (layer 2), and the third layer is the application layer. Since each layer is independent of each other, developers can work on them individually without having to worry about breaking compatibility. This also helps prevent outages and the introduction of bugs. Furthermore, using Bitcoin as the first layer allows the stability and security that comes from its decentralization to act as a strong foundation for the higher layers.

A more in-depth look will show that the Lightning protocol specifications (BOLTs) are also layered, with a network layer, messaging layer, P2P layer, routing layer, and payment layer, in ascending order. Layering and encapsulation are engineering choices influenced by the Web which underpin Lightning Network development.
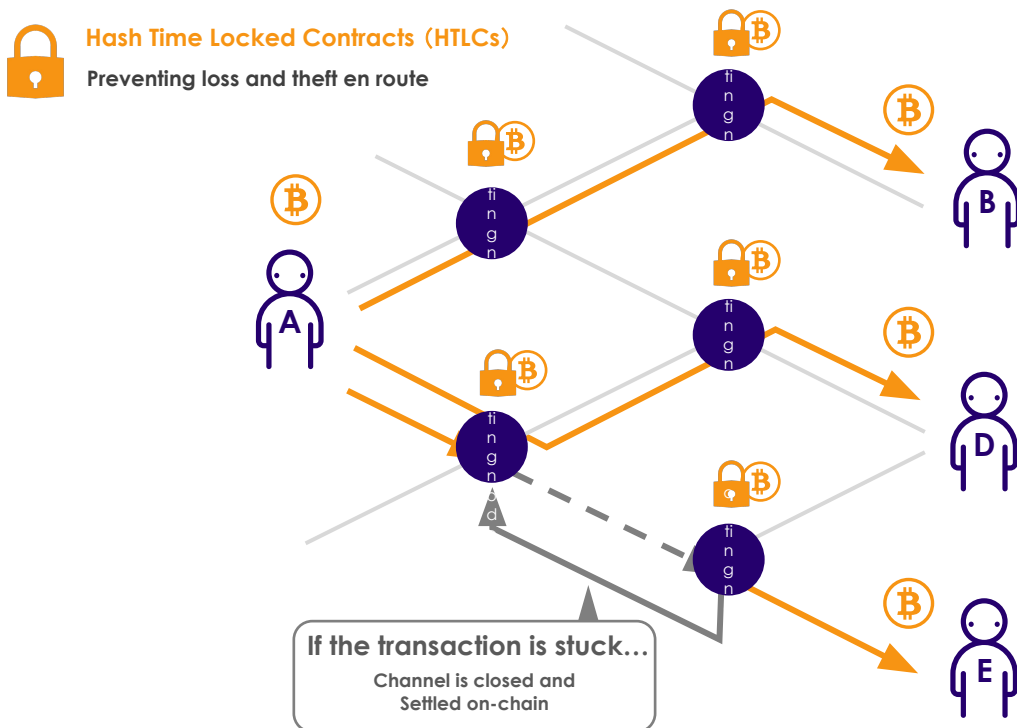
(2) Multi-hop Payments

Connecting payment channels

Hash Time Locked Contracts (HTLCs) minimize trust in third parties, opening up many destinations & further improving scalability.

Payment channels allow repeating bitcoin transactions between two parties efficiently, but ideally we want to be able to transact with other users as well. Multi-hop payments enable payments that use channels owned by other users in a trust-minimized way, opening up countless destinations and further improving scalability.

On the surface, it would seem that sending over channels owned by third parties would require trust. For instance, if A were to send to C via B (A→B→C), what is to prevent B from halting the payment, taking the funds that should be paid to C?

Lightning uses a technique called *HTLCs (Hash Time Lock Contracts)* to enable multi-hop payments that minimize trust and dependency on intermediary nodes. These are special Bitcoin transactions with a time limit; a smart contract of sorts.

Hash Time Locked Contracts (HTLCs)
Preventing loss and theft en route

If the transaction is stuck…
Channel is closed and Settled on-chain

When making a payment that spans several channels, the receiver first generates a secret value (preimage) and a hash of that value is used to lock the bitcoin along the route to prevent theft by routing nodes. Settlement is achieved by each node in the path revealing the preimage to the next node before a deadline, unlocking the coins in a way that completes the payment along the entire route without the need for trust.

This mechanism using HTLCs also enables nodes to punish other nodes that try to steal funds from a channel via a penalty transaction that confiscates a node's channel balance if they attempt to broadcast an invalid state to the blockchain, making completed off-chain payments irreversible.

Thus, even multi-hop payments can typically be conducted without any on-chain footprint, allowing users with even a single channel to repeatedly transact with anyone on the network, drastically improving the practicality of off-chain payments with payment channels.

(3) Routing Network

Incentivising payment routing

Free market competition among routing nodes underpins cheap and stable payments over the Lightning Network

In the previous section, we explained how payment channels and HTLCs are used to enable multi-hop payments over the Lightning Network, resulting in safe, trust-minimized payments to various third parties that are more efficient than on-chain transactions. For this system to work stably, a healthy ecosystem of routing nodes which forward payments is necessary.

Anyone can operate a routing node as long as they own some bitcoin and a computer, and users are incentivized to do this for transaction routing fees, charged per payment routed. The number of routing nodes has increased significantly in 2021, with operators aiming to earn fees and to research business opportunities related to routing on Lightning.
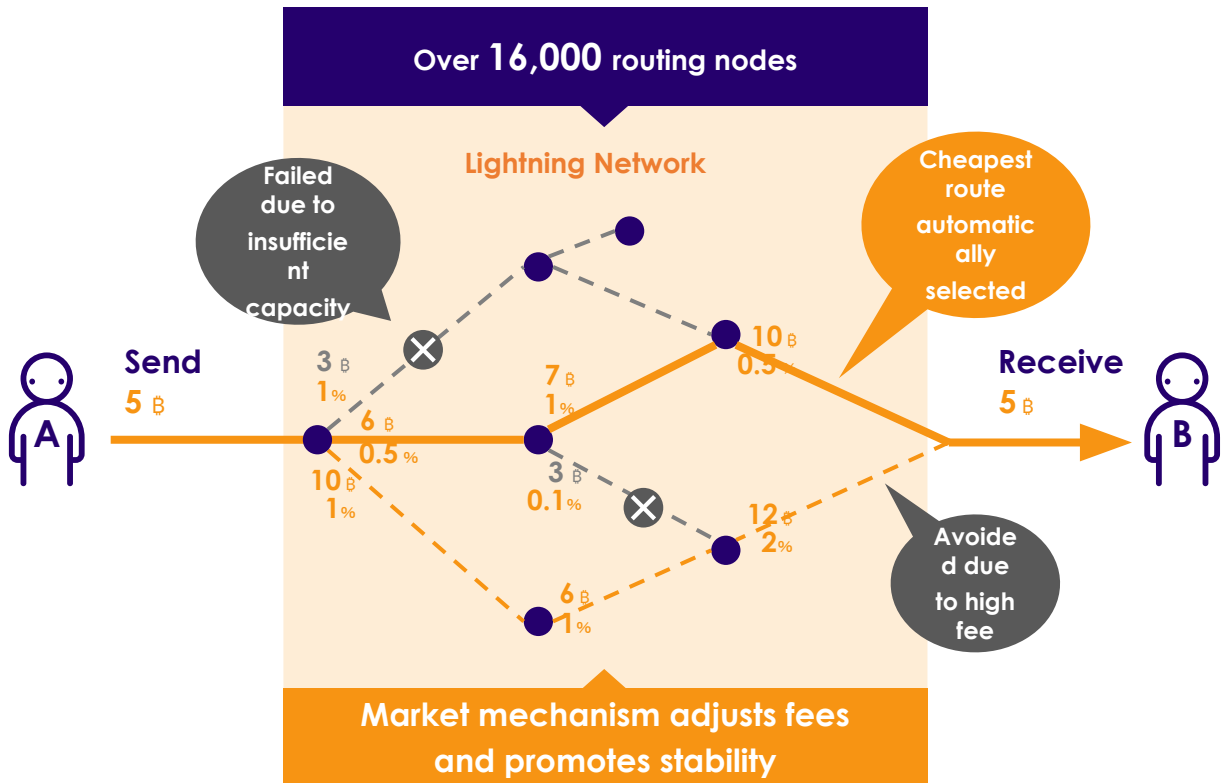
Each node can freely set a payment routing fee to charge for each channel, but since payers typically choose Lightning payment paths that minimize the total fee, routing nodes compete with each other to discover the fair market price for payment forwarding.

While undercutting the competition may seem like a good strategy, setting a fee that is "too low" can result in a channel becoming quickly unbalanced as payments deplete its forwarding capacity, causing further routing attempts to fail. Therefore, node operators dynamically adjust their fees and channel balances to maximize the value of their services, which has the effect of maintaining the stability of the Lightning Network as a whole.

Lightning payments even offer a high level of privacy as they use onion routing, which prevents routing nodes from distinguishing the ultimate sender and receiver of the payment, instead only revealing to them the previous and next node in the path. In addition to the obvious privacy benefits, this has the effect of making attacks and censorship on specific nodes more difficult.

To summarize, free market competition between routing nodes promotes efficient allocation of capital and optimal fees on the Lightning Network, and therefore the participation of a large ecosystem of routing nodes helps maintain its characteristics as a decentralized, censorship-resistant payment network.

3-3. Technological challenges

So far we have covered the mechanisms which Lightning employs to achieve its goals. Here we introduce some significant technological challenges that result from these mechanisms.

⚠️ **Onlineness requirement**

Receiving bitcoin transactions on-chain can be done while offline, as the sender need only know the destination address. In Lightning, both the sender and receiver must be online for the payment to properly complete, since payment channels require interaction.

⚠️ **Hot wallet security**

Lightning Network nodes should be online most of the time to maintain the security of its channels against potentially malicious peers. Unfortunately, being online classifies the node as a *hot wallet*, making cyberattacks a concern especially if operating with large amounts of bitcoin.

⚠️ **Channel capacity management**

Payments over Lightning require the payer to select a path to the payee. If a node along the path is offline, or has insufficient capacity to route the payment, an error is returned upon the attempt, forcing the sender to select another path. Depending on the amount being sent or the maximum fee the sender is willing to pay, payments may frequently fail or take more than 30 seconds to succeed.

⚠️ **Emergence of routing "hubs"**

While Lightning is technically decentralized, there are some nodes with large balances that are well-connected and involved in the routing of a significant share of payments. If users continue to prefer using these exchanges and whales to route payments, there may be consequences to privacy and censorship-resistance as the network is more easily segmented by these "hubs."
On the other hand, since routing is permissionless and users are free to open channels and choose paths that avoid these nodes, some believe this concern is overblown.

While Lightning vastly improves Bitcoin's scalability for payments without harming its decentralization, the above issues regarding security and usability leave room for improvement.

The good news is that there are development efforts to mitigate these issues, such as *Fast-Forwards* which enable receiving Lightning payments while offline, and *PeerSwap*, a protocol for optimizing channel capacity trustlessly. We believe that the technological challenges which Lightning currently faces will gradually be mitigated, further improving the network's utility.

4. Growth of the Network

The Lightning Network whitepaper was published in 2015, before launching on mainnet in 2018 with multiple implementations released that year. Network growth is accelerating, particularly since 2021.

In this chapter, we cover the market size and rapid growth of Lightning using useful metrics and data from Bitcoin Visuals and *The State of Lightning Volume 2* by Arcane Research, explaining growth factors and sharing our expectations for the coming years.

The Rapid Growth of Lightning

4-1.	4-2.
Quantifying growth	Trends driving adoption

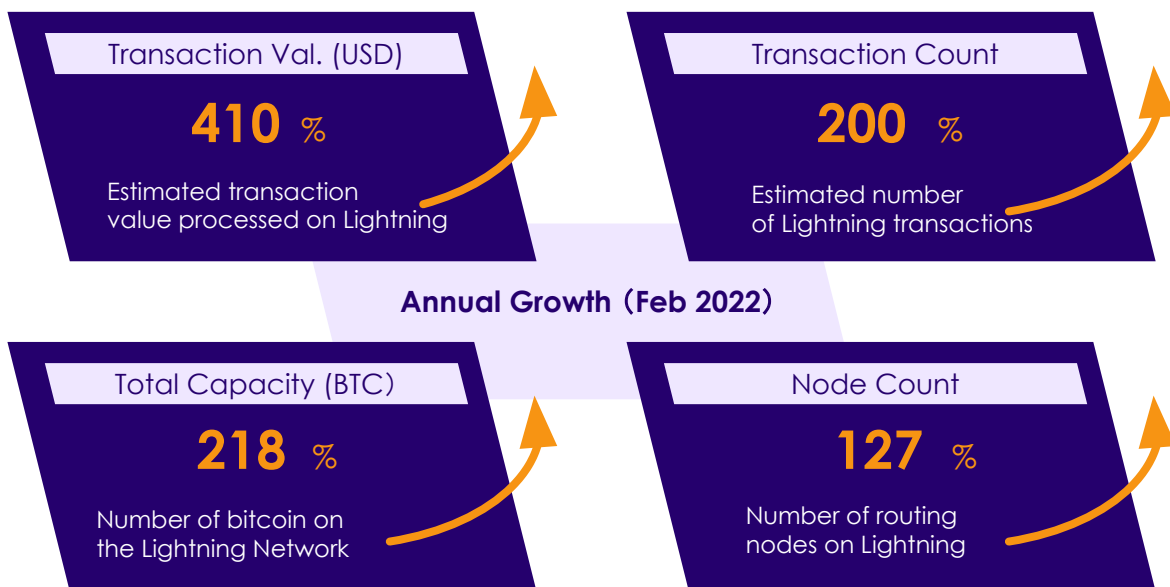## 4-1. Quantifying growth

Entering a period of rapid growth

Technological maturation and user communities drive growth since 2021

One important metric used to track the growth of Lightning is public capacity on the network. This represents the total amount of bitcoin provably locked up on-chain for use on Lightning, and theoretically responds to increased demand for payment routing on the network. In section (3) of the previous chapter, we covered how more capacity leads to more stability and better usability.

According to statistics from Bitcoin Visuals, the total capacity of public channels on Lightning grew by over 150% in five months, from 1,169 BTC in April 2021 to 2,968 BTC in September 2021.

The main reason for this growth is identified as companies and individuals responding to increased demand for payment routing, brought about by El Salvador's adoption of bitcoin as legal tender. Exchanges and businesses adopting Lightning has also been a tailwind, driving capacity to above 4,000 BTC in June 2022.

Other network metrics such as number of nodes and payment channels also show accelerating adoption. However, note that these metrics observed publicly may not accurately represent the growth rate or the substance of that change.

Transaction Val. (USD)

410 %

Estimated transaction
value processed on Lightning

Transaction Count

200 %

Estimated number
of Lightning transactions

Annual Growth（Feb 2022）

Total Capacity (BTC)

218 %

Number of bitcoin on
the Lightning Network

Node Count

127 %

Number of routing
nodes on Lightning

*Estimates based on surveys conducted by Arcane Research

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As explained in the previous chapter, Lightning payments are off-chain payments conducted peer-to-peer, which cannot be observed by a third party in the way that on-chain payments can. Since network capacity does not limit the throughput of the network, changes in capacity may not accurately track changes in payment volume.

According to estimates by Arcane Research, based on a March 2022 survey among major Lightning service providers, the dollar value of all transactions (including payments and exchange deposits, withdrawals) on Lightning is at least $20 million per month, with an annual growth rate of 410%, a much greater rate than the growth in network capacity.

Of course, some point out the small scale of Lightning compared to existing payment processors or blockchain-based solutions. While not entirely without merit, we believe many such comparisons fail at providing an accurate, nuanced argument.

For instance, Lightning capacity is often compared to the Total Value Locked (TVL) in Defi applications. According to Defi data provider DeFi Llama, approx. $50 billion worth of coins are locked up in Defi applications on Ethereum as of June 22, 2022, including $800 million on Ethereum layer 2 project Arbitrum, which alone is roughly 10 times more than the capacity of the Lightning Network.

Yet, as NYDIG points out in On Impossible Things Before Breakfast, TVL in Defi is the result of repeated rehypothecation of questionable assets in a circle, such as newly minted governance tokens, and therefore is useless to measure a product's true scale or safety.

Indeed, most Defi projects boost their TVL by attracting capital with "yield" in the form of tokens issued proportionally to assets locked up in the project, whereas Lightning capacity increases only in response to transaction demand on the network. In short, Lightning may appear insignificant when compared to the TVL of some Defi projects, but this is the result of differing attitudes towards sustainability and decentralization.

Lightning certainly still is a small, budding market, with less transaction volume than 0.01% of the existing payment processing industry. However, we must note that the new possibilities it creates, the security and decentralization properties above and beyond the technologies it is compared to, and the relative maturity of the tech, infrastructure, and tooling have prepared it for its next stage: explosive growth.

4-2. Trends driving adoption

Lightning Network adoption is here

Major services integrating Lightning and governments promoting bitcoin represent a new phase of adoption

For the same reason that we cannot accurately observe all Lightning transactions, it is impossible to know exactly how many users the network has. However, major services accepting payments over Lightning and governments and municipalities promoting bitcoin has brought a trend of adoption, which is expected to continue accelerating.

According to Arcane Research, the theoretical maximum number of Lightning wallet users in August 2021 was roughly 150,000 users, but with El Salvador adopting bitcoin as legal tender in September, and P2P trading giant Paxful enabling Lightning deposits and withdrawals, the number had grown to 10 million by October. Govern-mental promotion of Bitcoin and Lightning has continued, with the city of Lugano in Switzerland adopting it as legal tender, and Miami declaring itself a "Bitcoin City."

Simultaneously, popular web-based services and major payment processors are increasingly adopting Lightning, particularly in the U.S.

Business and Government adoption

Businesses
- Kraken, Block Inc.'s Cash App (both U.S.A.) enable Lightning payments
- Major online retailers such as Shopify announce intent to support Lightning

Governments
- El Salvador, Lugano (Switzerland) adopt Bitcoin as legal tender
- Miami (U.S.A.) declares itself a "Bitcoin city"

Users with access to Lightning Network payments

Aug 2021	Oct 2021	Mar 2022
100K ~150K	**10M**	**80M**

Source: Arcane Research

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In 2022, Block Inc. payment platform Cash App officially started supporting Lightning payments, further expanding the number of users with access to Lightning payments to a maximum of 80 million. Other platforms such as Robinhood have expressed their intent to support Lightning, and a partnership between Strike and major payment processors is likely to result in Lightning payments becoming a reality in major retailers across the U.S., all signs of rapid adoption of Lightning for payments.

The trend of major businesses and governments adopting Lightning and bitcoin can be considered signs of the Lightning ecosystem maturing to the point where the technology can be expected to support significant payment volumes and user activity.

Since its mainnet launch in 2018, the Lightning Network has seen several years of protocol enhancements and stability improvements, the emergence of a thriving routing network, and development of useful tooling, placing it as the layer 2 payment technology closest to mass adoption, which indeed seems to have begun in 2021.

Of course, the maximum user count mentioned previously is only theoretical, and in reality it is highly likely that active users are a small fraction of that figure. In El Salvador, issues with the official Chivo Wallet and obstacles to local adoption have been reported, suggesting that more educational efforts, improved usability, and increased adoption for retail payments is necessary to continue driving the adoption of the Lightning Network.

"Digital Gold" vs. the payment network of the future

Bitcoin is often compared to gold for its scarcity, and is frequently referred to as "Digital Gold." Its advantages compared to gold in terms of easy of storage and transfer, as well as censorship-resistance, make it a desirable store of value (SoV) to investors who treat it as such.

On the other hand, applications are being built on Bitcoin that see it as more than a simple SoV, but as a base for sophisticated layers to be built upon. As Lightning matures and becomes commonly accepted, bitcoin will become an efficient payment network that can be embedded in various services and applications, leading to a change in the narrative surrounding Bitcoin.

Policy is being shaped to accommodate this change, with a bill that makes cryptocurrency transactions of less than $200 exempt from income tax proposed to the U.S. Senate in June 2022.

5. Overview of the Lightning ecosystem

The Lightning Network ecosystem evolves day by day, and is already difficult to follow in its entirety. Rapid growth since 2021 and mainstream adoption is likely to cause an explosive increase in projects utilizing Lightning.

While we expect more novel use cases to be discovered as time progresses, micropayments, low fees, instant settlement, and the permissionless nature of Lightning are already clear benefits. We are certain that real use cases leveraging these characteristics will also see considerable growth.

This chapter covers major businesses and use cases in this space as of June 2022, and the tangible benefits of integrating Lightning. Technologically viable future use cases and concepts beyond what we are seeing now will be covered in the following chapter.

The Lightning Network Ecosystem
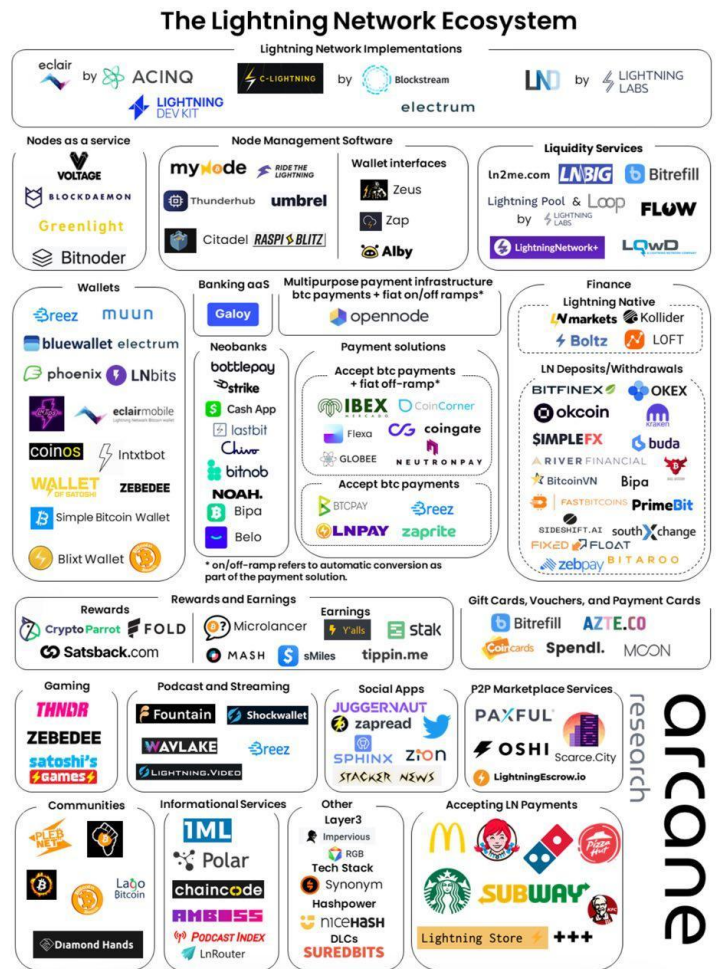
5-1. Infrastructure

Solid infrastructure

Applications thrive with a backstop of routing network growth and maturation of interoperable implementations and wallets

One of the major factors that drove Lightning's rapid growth from 2021 to 2022 is the maturation of infrastructure and tooling.

The three main protocol implementations are interoperable, yet each offer stability and functionality with large-scale operation in mind. Wallets are either custodial or non-custodial, but both have improved their usability and functionality greatly in the last two years. New routing node tooling and node operator communities support the sustainable growth of Lightning and its cheap, fast payments from behind the scenes.

1) Node implementations

Software implementations of Lightning nodes follow a standard called BOLT (Basis of Lightning Technology), ensuring compatibility between implementations. The three top implementations are LND, Core Lightning, and Eclair.

- Market leaders: Lightning Labs, Blockstream, Acinq, Spiral

LND, developed by Lightning Labs, is the market leader with the largest user base and developer community, and therefore has a large ecosystem of tooling supporting it.

2) Wallets

Core Lightning, developed by Blockstream, has a and is popular among developers. Eclair is developed by Acinq, who also operates one of the largest Lightning routing nodes in the world.

Additionally, Block project Spiral released Lightning Dev Kit (LDK), which allows for the rapid development of Lightning nodes.

With different strengths and tradeoffs, users and developers choose the tool for the job.

When a user sends or receives bitcoin on Lightning, the interface they use is a wallet. Wallets in Lightning are broadly classified as custodial or non-custodial.

Custodial wallets abstract away the concept of channels to provide a beginner-friendly, fast

On the other hand, non-custodial wallets require the user to manage their coins on Lightning by themselves, minimizing reliance on the wallet provider, but resulting in a less refined experience in terms of UX and stability that stem from protocol requirements.

Exchanges and services that focus on casual users tend to select a custodial model, but some non-custodial wallets have also cleverly abstracted channel management away from users to provide a better UX.

Both custodial and non-custodial wallets are improving their usability and security by the day, but users are recommended to choose an appropriate wallet based on their needs and risk tolerances.

■ Market leaders:
<Custodial>
Bluewallet, Wallet of Satoshi

<Non-custodial>
Breez, Phoenix

Operating routing nodes, the backbone of the Lightning Network, is not just an important infrastructure project but also a potentially lucrative business.

Umbrel provides node management software targeted at individuals, which can run on a small computer such as a Raspberry Pi, and comes preinstalled with the necessary software out of the box. This simplicity has contributed significantly to the increase in routing nodes. Voltage focuses on providing businesses with an easy way to run a Lightning node, supporting ork.

3) Node and Routing services

■ Market leaders:
<Node operation> Umbrel, Voltage

<Liquidity management> Loop, Boltz

Operating Lightning applications (Lapps) also requires some level of channel management to enable other nodes on the network to interact with it. Loop and Boltz offer such services to retailers and businesses, facilitating application-related payments.

<Data provider> Amboss, TML

<Community> Plebnet, Rings of Fire

Other players in the space include data providers such as Amboss that enable node operators to improve efficiency based on public data, and software that automates or visualizes node operations. User communities such as Plebnet and Rings of Fire also play a significant role in Lightning adoption, helping users share information, troubleshoot their nodes, and partner with businesses.
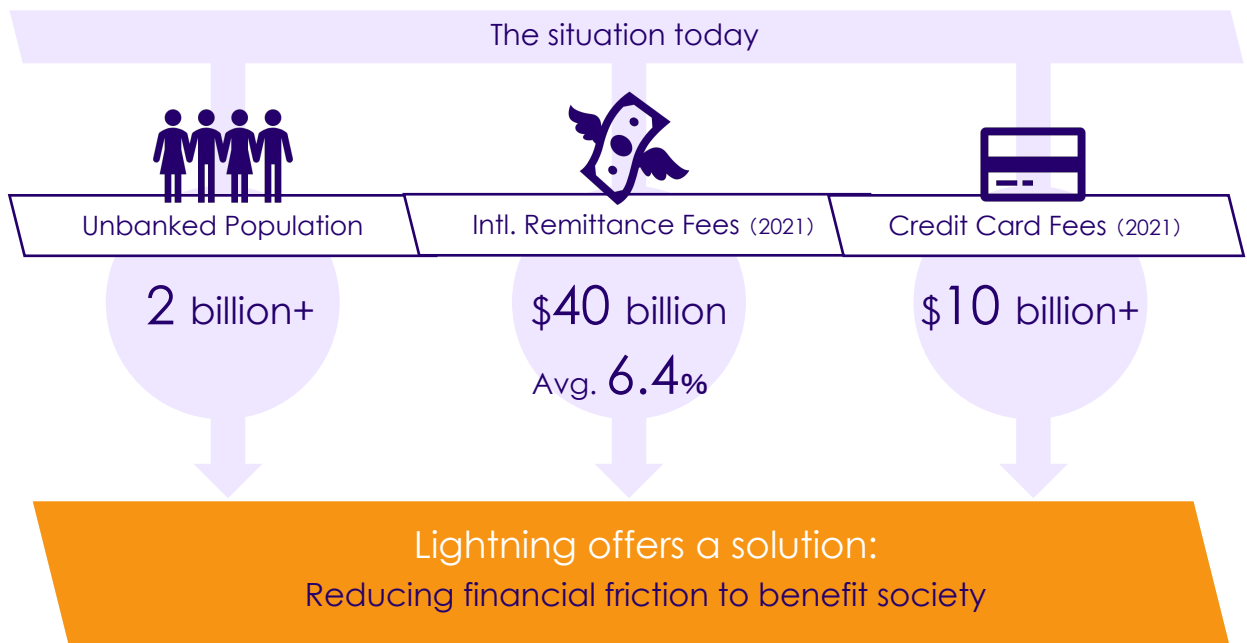
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5-2. Popular use cases

The Lightning Network and its significant strengths in terms of cost and speed may promote financial inclusion to a greater degree than possible, in addition to the benefits to businesses and better user experiences it delivers. Globally accepted bitcoin micropayments, integrated in retail stores and services worldwide, may create novel business models previously hindered by financial friction. Interoperable Lapps may also create a network effect which further increases the utility of Lightning-enabled services in a positively reinforcing cycle.

Reducing friction for billions

Drastic reduction of costs promotes financial inclusion and improves the baselines of existing services

Lightning enables transfers of small amounts for near-zero cost. By reducing the cost of moving capital, we expect Lightning to compress international remittance fees which are said to cost an average of 6.4%, and to reduce costs and friction in existing financial and payment services.

The situation today

Unbanked Population	Intl. Remittance Fees (2021)	Credit Card Fees (2021)
2 billion+	$40 billion	$10 billion+
	Avg. 6.4%	

Lightning offers a solution:
Reducing financial friction to benefit society

*Data Sources: World Bank, IMARC Group

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Payments and remittances

Lightning enables cheaper, faster, and more private money transfers using abundant liquidity available in bitcoin.

One use case where this property shines is international remittances, where users are charged extortionate fees that average 6.4% to send money abroad. Indeed, one stated reason for El Salvador adopting bitcoin and publishing an official Lightning Network wallet was to cut its citizens' remittance costs, which totaled more than 20% of the country's GDP.

In addition to payments made in bitcoin, services like Strike and Chivo allow users to use bitcoin on Lightning only as the medium of exchange, focusing on the aforementioned cost reductions for fiat-denominated user-to-user payments, remittances, and for converting bitcoin to fiat.

Major online commerce and payments platforms such as Stripe and Shopify have also announced their intent to integrate Lightning, representing a trend of Lightning adoption by major businesses. With low fees, instant settlement, and no chargebacks, Lightning Network payments are likely to become more common. Early adopters also benefit from appealing to the growing crowd of bitcoin holders around the world.

- Market leaders:
  OpenNode, Strike, BTCPayserver

Gift cards, vouchers

Gift cards and digital merchandise have long been a popular use case for bitcoin, but the advent of Lightning has made smaller payments more viable, expanding the user base of this existing market.

Although bitcoin is not yet universally accepted as a payment method, gift cards are, particularly in developing nations where digital currency exchanges are not well established. Some also use gift cards as a substitute for international remittances, essentially as a bridge between bitcoin and the economy.

Services providing vouchers, prepaid cards, and debit cards that can be charged via Lightning are also gaining popularity, and in combination with exchanges supporting Lightning withdrawals, improve the accessibility of bitcoin payments for those with smaller accounts.

- Market leaders:
  BitRefill, Spendl

Micro-rewards

Giving small amounts of bitcoin away as rewards is another Lightning Network use case gaining popularity. Near-zero fees on Lightning enable transferring tiny amounts, reducing the threshold of viable payments for micro-tasks.

Fold operates a debit card with "sats-back" (bitcoin rewards), which uses Lightning to send users small amounts of bitcoin after purchases. Users can even choose to send the bitcoin directly to an exchange, or to use them at a local retailer, things that cannot be done with typical rewards points.

Microlancer is a micro-task marketplace, where users can be paid small amounts over Lightning in exchange for completing tasks such as installing apps or writing articles. It is gaining users primarily in Latin America.

Lightning may also revolutionize the digital advertising market. Experimental services where users are rewarded with micro-payments for receiving ads have been created, giving us a hint as to what advertising may look like in the future.
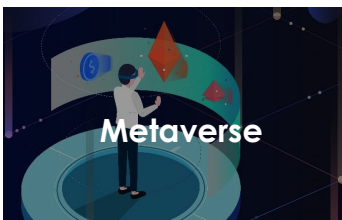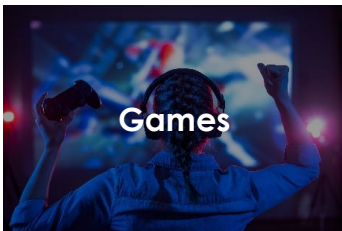
- Market leaders:
  Fold, Satsback.com, Microlancer

Unlocking new user experiences

Businesses are experimenting with new ways to utilize Lightning's settlement speed and low costs

Payments over Lightning can also create new user experiences that utilize instant settlement, give content creators more options for monetization, and vastly improve capital efficiency for traders. These effects are already visible with games and exchanges which have adopted Lightning, and are expected to be core drivers of business adoption in the future.

UX improvements & User stimulation	Creator Economy	Better capital efficiency for traders
• Micro-rewards and micro-payments for activities in games and the metaverse • Payments have real-time effects in-game • Designing new, stimulating user experiences	• Tip your favorite artist from anywhere in the world, in real-time • New business models, such as sharing ad revenue with viewers • Stronger relationships with users improve profitability for creators	• Transfer bitcoin between exchanges instantly • Improve capital efficiency when margin trading by depositing only the requisite amount of collateral • Offer new opportunities, such as arbitrage

Games

Metaverse

Arbitrage

Market Making
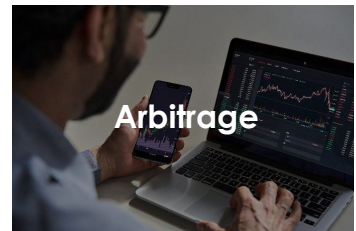
Games & digital content

Games integrating Lightning are a leading driver of adoption today.

Ways games can integrate Lightning include so-called Play-to-Earn games where players may receive micro-rewards via Lightning, or selling in-game items to players immediately with low fees. Micro-rewards in particular enable game creators to maintain their focus on core game mechanics and existing users while lowering user acquisition costs and improving retention.

While ZEBEDEE leads Lightning-enabled games with their game studio and developer-oriented services, THNDR develops its own titles such as the popular Bitcoin Bounce game, reaching thousands of players. Satoshi's Games takes a different approach, combining Lightning with NFTs, pioneering the combination of Lightning-powered micro-rewards with other blockchain technologies.

Lightning also works well with payments for digital content. Auction house Scarce City focuses on NFTs and physical art relevant to bitcoin, using bitcoin and Lightning not only as a cheap payment method but also to accept deposits for bidding in their auctions.

- Market leaders:
  ZEBEDEE, THNDR, Satoshi's Games, Scarce City

Creator Economy

Donations to creators, commonly referred to as tipping, is another use case gaining traction.

The most popular example is streaming payments for podcasts, where listeners make payments in real-time to continue listening to the podcast. Low fees also enable real-time and smaller tips, resulting in an interactive tipping experience.

Small, real-time payments may also have potential outside of podcasts, such as in video streaming to increase content creator revenue, and to create stronger bonds between the users and content creator.

- Market leaders:
  Fountain, Breez, Sphinx

Exchange transfers

Digital currency exchanges can use Lightning to reduce deposit and withdrawal costs and times for users, providing them with new options.

■ Market leaders:

<Major exchanges>

For instance, if an exchange supports Lightning deposits, traders may be able to keep less collateral on the exchange for margin trading, as they would be able to quickly add more when it becomes necessary. No longer will delayed deposit transactions result in liquidation, and arbitrage traders who want to quickly transfer funds between exchanges will be able to.

Bitfinex, Kraken, Cash App

<Lightning-only exchanges>

LNMarkets, Kollider

Indeed, major exchanges in the U.S. such as Kraken and Cash App have added Lightning support in 2022, and the network effect benefits of doing so are likely to further increase as more exchanges follow.

Another benefit of exchanges enabling Lightning withdrawals is use for payments. Exchange mobile apps can be used as wallets from which users can pay at stores and online, unlocking a myriad of potential use cases. Casual bitcoin users may be more likely to choose an exchange that offers this ability.

There are also Lightning-only exchanges, where order placement and collateral deposits are all done directly over Lightning. These may have some advantages in terms of speed, security, and capital efficiency compared to traditional exchanges.

An Open, Global Payment Network

Offer services globally with Lightning,

unlocking their potential with monetary interoperability.

Services integrating Lightning can take advantage of interoperability with other such services and the global nature of bitcoin. With more Lapps coming online, we believe network effects will make Lightning even more useful than it is today.

For instance, imagine a tourist making Lightning payments at a restaurant overseas directly from their favorite exchange app, or where entrepreneurs sell their merchandise or services to a global audience with ease.
The open and permissionless nature of Lightning has also enabled bottom-up innovations and improvements over time. LNURL and Lightning Address are examples of protocols that improve the Lightning user experience, and the community regularly comes up with innovative applications such as contactless NFC Lightning payments solution Bolt Card. Interoperability and bottom-up improvements offer Lapps immense potential, and will continue to deliver impactful features.

Payments by international visitors	• Accept Lightning payments from international visitors • Avoid exorbitant exchange rates and fees charged by credit cards • Appeal to bitcoin users globally, generating interest in the business
Exchanges as payment processors	• Pay Lightning invoices with your exchange balance from its mobile app • Instantly convert bitcoin earned to local currency • Exchanges provide more value than just an investment avenue
Bottom-up improvements	• Adoption of protocols that improve Lightning UX, such as LNURL • Contactless NFC Lightning payments with Bolt Card • Bottom-up functional and usability improvements on an open network

6. Advanced use cases for Lightning

In the previous chapter, we covered current use cases for the Lightning Network, focusing on the benefits to businesses in terms of cost, speed, and openness.

Retail spending and international remittances alone are extremely powerful use cases for Lightning, but there is room for much more. Instant settlement of microtransactions and a robust peer-to-peer network enable advanced use cases that synergize with much broader concepts such as decentralized finance and distributed web.

This chapter will introduce applied use cases that Lightning may enable in the future, focusing on those with existing prototypes and proofs of concept.

6-1. Decentralized Finance	1) DEX (Decentralized Exchanges)
	2) DLCs
	3) Token issuance

6-2. Distributed Web	1) Personal Servers
	2) Incentives in P2P software
	3) P2P Messaging

6-3. Data Economy	1) Payments for API calls
	2) Preventing spam
	3) IoT (Internet of Things)
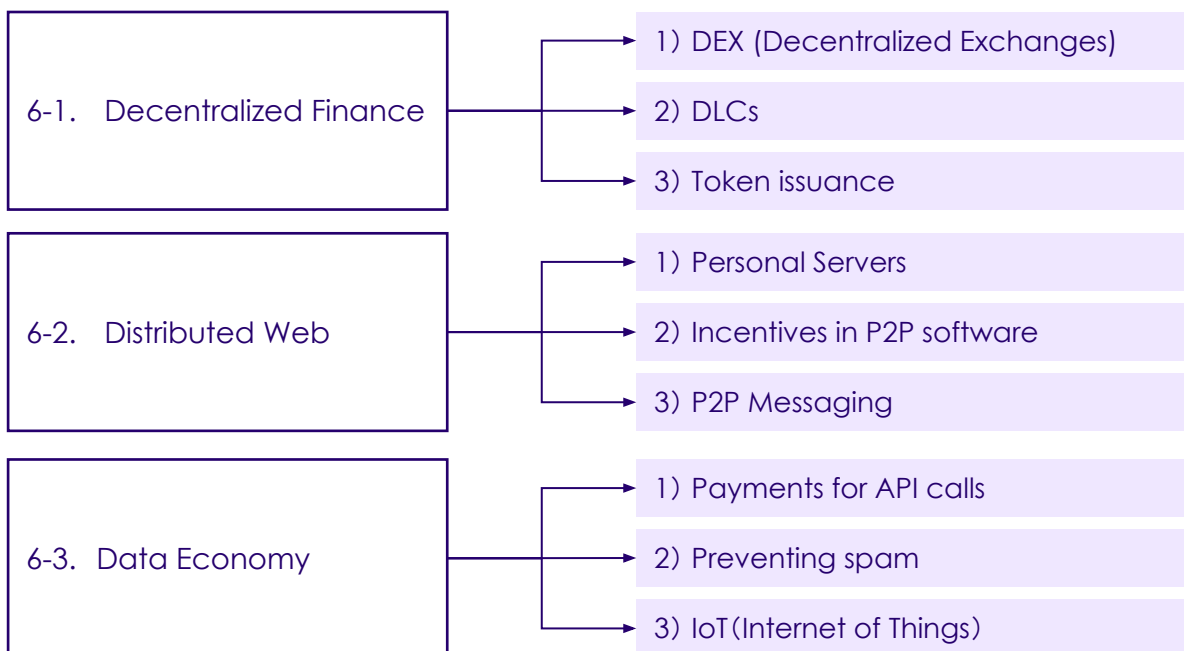
6-1. Decentralized Finance

Scalable Decentralized Finance

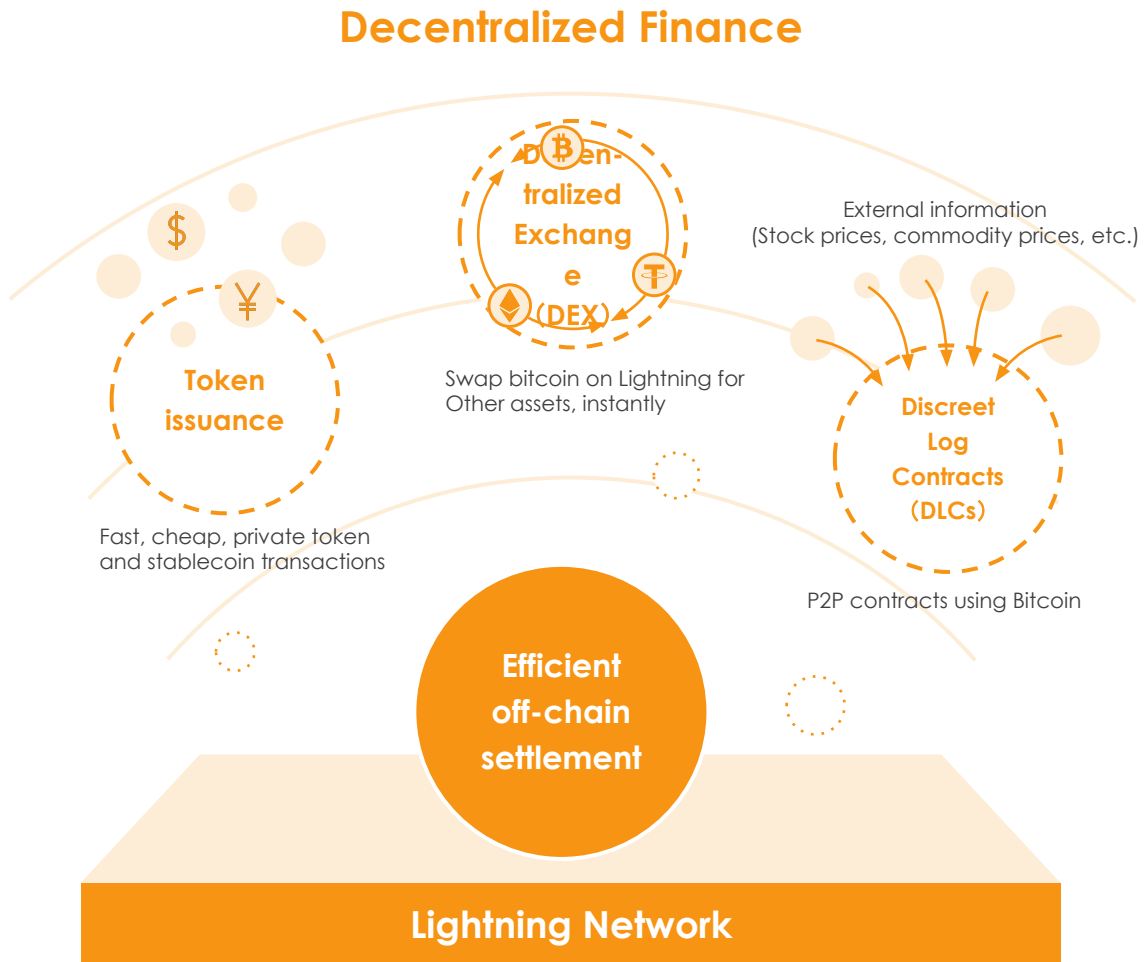**A financial layer built on Lightning will process custom transactions instantly at a low cost**

One of Lightning's core characteristics is that all transactions happen on a peer-to-peer basis. Thus, in theory peers can agree to perform complex financial transactions that go far beyond simple bitcoin transfers. These transactions need not conform to a public template, and are fully customizable.

Furthermore, since these contracts will typically not be published on-chain, there are privacy benefits crucial to financial applications in addition to instant settlement and low fees, making Lightning a desirable platform for scalable decentralized finance.

Decentralized Finance

Decentralized Exchange (DEX)

Swap bitcoin on Lightning for Other assets, instantly

Token issuance

Fast, cheap, private token and stablecoin transactions

External information (Stock prices, commodity prices, etc.)

Discreet Log Contracts (DLCs)

P2P contracts using Bitcoin

Efficient off-chain settlement

Lightning Network

Diamond Hands

1) DEX (Decentralized Exchanges)

Submarine swaps are a type of Bitcoin smart contract that enable bitcoin on Lightning to be traded for other tokens trustlessly. Lightning benefits traders with counterparty risk reduction by storing less on exchanges by enabling instant conversion to and from fiat and other tokens.

■ Examples:
Suredbits

Further, there are trust-minimizing protocols such as TBDEX that can be used in cases where trustless-ness is unachievable, such as conversion to and from fiat.

3) Token issuance

DLCs (Discreet Log Contracts) are a technology that enables private, peer-to-peer financial contracts on Bitcoin. Third parties cannot even detect the presence of DLCs, providing superior privacy to smart contracts published on-chain. Since the contract is between the two parties, they may both agree to update the contract at no cost if they believe the contract does not

■ Examples:
zigzag.io、sideshift.ai、Loop (Lightning Labs)、
TBDEX (Block)

reflect reality, sidestepping the exploitation risk of faulty smart contracts.

2) DLCs

DLCs on Lightning are more suited for short-term transactions, and are considered to be a base technology upon which prediction markets and leveraged trading products will be built. For example, "stablechannels" peg their balance to a fiat amount, allowing for users to be onboarded to Lightning without being exposed to its price volatility.

While the current use of Lightning concerns the efficient transaction of bitcoin, there are several protocols being developed to handle other tokens on the Lightning Network.

■ Examples:
RGB (LNP/BP), Taro (Lightning Labs),
OmniBOLT (OmniLAB)

Using Lightning to transfer tokens comes with the benefit of fast, cheap, private transactions, decentralized trading with bitcoin over Lightning, and use in financial contracts such as Lightning DLCs.

Note that even with protocols such as RGB and Taro, token issuance predicated on the use of Lightning is likely to result in centralizing tendencies, possibly more so than tokens issued on layer 1s. Even so, centralized tokens such as stable-coins, security tokens, and loyalty points are appropriate use cases for this technology.
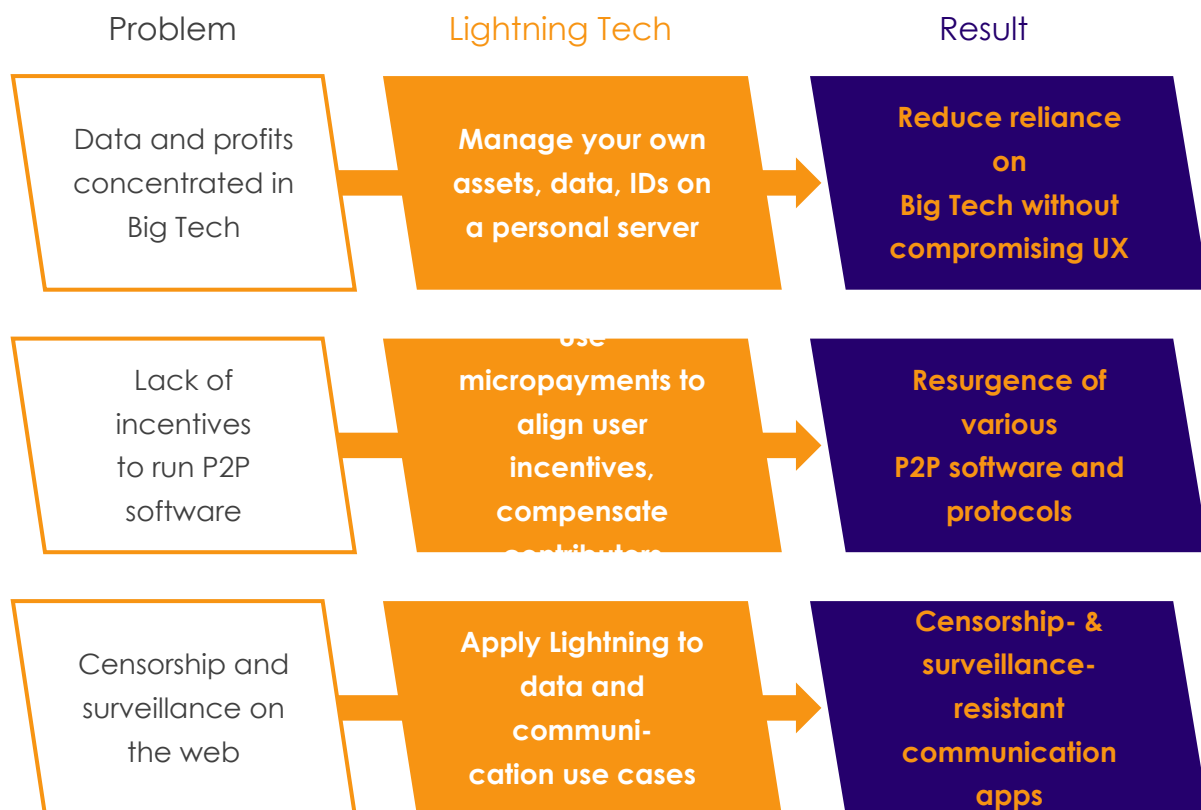
6-2. Distributed Web

Lightning as a Distributed Web foundation

Bitcoin micropayments solve issues such as censorship, privacy intrusion, and data leaks, leading to a safer, fairer web.

Web3.0 is taking the spotlight as a blockchain use case, typically pointing to login-with-wallet schemes and tokenized services as the base for a distributed web. However, we believe that bitcoin micro-payments over Lightning will be more effective at decentralizing the web, providing real and effective solutions to existing problems with the Internet.

Problem	Lightning Tech	Result
Data and profits concentrated in Big Tech	**Manage your own assets, data, IDs on a personal server**	**Reduce reliance on Big Tech without compromising UX**
Lack of incentives to run P2P software	**use micropayments to align user incentives, compensate contributors**	**Resurgence of various P2P software and protocols**
Censorship and surveillance on the web	**Apply Lightning to data and communi-cation use cases**	**Censorship- & surveillance-resistant communication apps**

Diamond Hands

1) Personal Servers

While some expect blockchain-based web3 to be a key piece to realizing a Distributed Web, network effects have so far resulted in reliance on a handful of centralized wallet providers and marketplaces. Applications using a common blockchain may prevent centralization and monopolization in some aspects, but long-term concerns regarding censorship-resistance and neutrality remain to be addressed.

If users were to run personal servers including a Lightning node on Raspberry Pis or small computers, they can further reduce their reliance on centralized service providers. In other words, hosting personal assets, data, and identity on a personal server, and interacting with other users through peer-to-peer software with Lightning payments, will allow users to be truly autonomous participants in a more decentralized web.

However, it is important to note that requiring users to run a node to store and verify information presents a barrier to entry, which makes it difficult for a decentralized web that depends on such a model to reach mass market.

■ Famous examples:
Umbrel、RaspiBlitz

2) Aligning P2P software incentives

P2P software plays an important role in realizing a censorship-resistant decentralized web without single points of failure. Yet, many peer-to-peer systems are reliant on flawed incentive structures, or on centralized tokens issued by an operating company.

Bitcoin and Lightning are a perfect match for decentralized peer-to-peer applications. Further, since Lightning enables secure transactions in exchange for data, it is particularly well suited to be implemented in peer-to-peer protocols where the "seller" can commit to the data being purchased beforehand.

For instance, torrenting is a popular way for files to be shared from peer to peer by breaking large files into small pieces and hosting them in a decentralized manner. Although often associated with piracy, torrenting can also provide better download speeds and file availability for legitimate file distribution. However, since there is no incentive for most users to host (seed) these files, users who only download (leech) vastly outnumber seeders. If file seeding could be incentivized by payments from leechers to seeders, torrenting could become faster and more reliable, as seeders have an incentive to host the files professionally.

■ Famous examples:
poof.run、Storm (LNP/BP)、Bitswarm

3) P2P Messaging

There are many popular messaging platforms such as LINE, Facebook Messenger, and Telegram, with some touting E2E (End-to-End) encryption and other privacy-focused features. Encrypted messaging platforms such as Signal are gaining users as companies continue to leak personal information and users become more interested in protecting their privacy.

Using Lightning to send P2P messages can provide an even higher degree of privacy, while also authenticating the sender. Common formats for messaging over LN could enable users to run different messaging software on the frontend without adding friction. This functionality may also be useful in e-commerce for providing support to clients after they purchase a product.

Communication over Lightning is likely to continue to develop as a feature, as evidenced by a recent prototype of P2P teleconferencing over Lightning.

- Famous examples:
  Sphinx.chat, Red Phone (Impervious.ai)

Tokenizing the web vs. Lightning

When people talk about decentralizing the web, the topic often drifts to "web3" entailing NFTs and governance tokens.

Indeed, projects issuing their own tokens can boost customer acquisition and growth in their early days, and may have more options to give back to early supporters and users when the project succeeds, compared to regular corporations.

However, not only are there legal risks to issuing tokens that result in higher compliance costs, but information asymmetry and lack of regulation often leads to fraud, with projects and early investors frequently dumping risk onto retail investors, often ditching the project itself.

In other words, token issuance can easily destroy the product it claimed to set out to build, while legal risks makes it difficult for established businesses to take that option.

Lightning, in contrast, uses globally accepted bitcoin micropayments to reduce friction within and between services to tangibly improve the user experience, a more straightforward value proposition for existing businesses.

For the time being, we consider it likely that these two approaches to decentralizing the web will continue to exist in parallel, with each evolving to meet different demands.
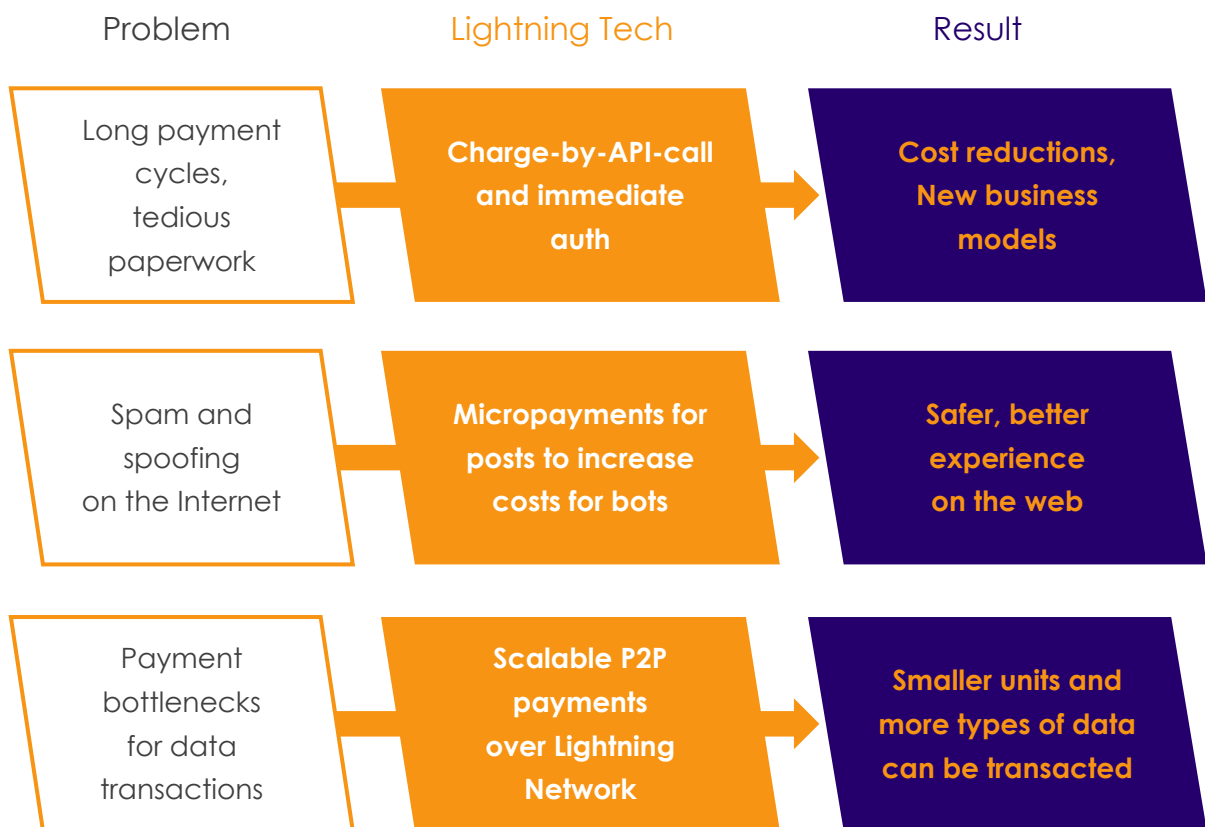
6-3. Data Economy

The emergence of new data markets

Micropayments enable automatic transactions for data, unlocking new markets and business models.

Lightning is most known for the micropayments it enables. While manually authorizing micropayments is tedious and will likely see limited use, automatic transactions for data that happen in the background has potential to unlock many use cases which were not previously possible.

Problem	Lightning Tech	Result
Long payment cycles, tedious paperwork	Charge-by-API-call and immediate auth	Cost reductions, New business models
Spam and spoofing on the Internet	Micropayments for posts to increase costs for bots	Safer, better experience on the web
Payment bottlenecks for data transactions	Scalable P2P payments over Lightning Network	Smaller units and more types of data can be transacted

1) Charging for API calls

Paying for API usage and cloud services is typically done by prepayment or monthly post-payment. Using Lightning enables shorter payment intervals, and digital certificates given in exchange for payment may also be used for authentication when using the service, reducing friction.

LSATs are a type of certificate that can use third-party caveats (external authentication). With LSATs, an exchange can require that a user authenticate at a KYC service and provide proof instead of implementing their own KYC system from scratch, reducing costs and sensitive user data. Unlike NFTs, LSATs do not use the blockchain, and therefore are cost efficient and scalable.

■ Example:
Lntxbot

3) Internet of Things (IoT)

Micropayments can also be used to deter spam. Since automated spam bots post large quantities of messages, charging a very small fee for posting comments may significantly reduce the profitability of spam while only being a minor cost to regular users. While UX improvements to reduce friction for regular users is necessary, this mechanism may be effective at reducing spam on social media.

■ Example:
Suredbits API

2) Preventing spam

Some communities are already using Lightning micropayments to limit participation in Telegram and Discord rooms to prevent spam, maintain quality, or to simply charge a subscription fee. The same tools often allow members to transact among themselves, effectively adding a money transmission function to the chat app.

The amount of data handled by Internet of Things (IoT) devices is projected to grow into the future. With a scalable P2P payments network, IoT devices will be able to participate in a new data market, enabling frequent micropayments for data with real-time settlement – something Lightning is uniquely positioned to enable.

The high degree of privacy provided by payments on Lightning is also a benefit, since IoT devices often handle sensitive personal information such as health data.

7. The Lightning ecosystem in Japan

Currently, Lightning Network adoption and development happens mostly in the U.S., Europe, and Latin America (particularly in El Salvador), with relatively few contributions from Asia.

However, there is a reasonably large community of users, developers, and businesses in Japan that are actively participating in the Lightning Network. Therefore, we believe Japan may become the leading Asian market for Lightning development and adoption.

Lightning Network use cases that are promising in Japan include adoption by exchanges, micro-rewards in games and marketing, cost reductions in existing services, payment processing for international visitors and stimulation of local economies, to name a few.

7-1. Lightning Network businesses & projects in Japan

1) Nayuta

Based in Fukuoka, Nayuta is one of the first companies to see the potential in bitcoin micropayments. Nayuta participates in Lightning Network protocol meetings, and maintains its own node implementation. They are currently developing Nayuta Core, a non-custodial Lightning wallet as part of their development efforts on both the protocol and application sides.

2) Bitbank

One of Japan's leading exchanges, Bitbank is the most proactive in developing Lightning related technologies. Bitbank released exchange-focused open-source channel capacity management tool NLoop in March 2022, and is preparing for Lightning adoption at exchanges and large-scale projects.

3) Fulgur Ventures

Fulgur Ventures is a U.S. venture capital firm that specializes in Lightning Network businesses. Showing interest in the Japanese market from early on, Fulgur Ventures established a Japanese subsidiary in 2021 to promote the adoption of Bitcoin and Lightning, support its portfolio companies in reaching the Japanese market, and explore investment opportunities.

4) Diamond Hands

Diamond Hands was born in June 2021 as a user community for routing node operators. Today, it also promotes Lightning adoption and education domestically, cooperates with international communities and businesses, and develops open source software and conducts experiments, expanding its activities with the goal of increasing Lightning adoption and growing the market.

5) Spotlight

Spotlight is a Lightning-enabled blogging platform, where users can find high-quality posts on topics including Lightning.

In addition to Lightning payments for articles and tips, users can enter a lottery, or try a swap application that uses Discreet Log Contracts (DLC) and Lightning, examples of Spotlight's eagerness to research and develop novel applications.

6) Paddle

Paddle is an auction platform that uses Lightning. Its main feature is its use of hodl invoices to minimize trust in the platform itself, enabling bidding and automated refunds in a non-custodial and capital efficient manner.

8. The Lightning ecosystem in Vietnam

Currently, Lightning Network adoption and development happens mostly in the U.S., Europe, and Latin America (particularly in El Salvador), with relatively few contributions from Asia.

While "crypto adoption" *(read: People gambling on random token prices going up or down)* in Vietnam is indeed one of the highest in the world, in terms of Bitcoin adoption it lags behind many of the more mature economies in above mentioned regions.

Nonetheless, Vietnam has made its own mark in regard to Lightning adoption in Asia and has even taken a pioneering role in some cases.

The first Lightning ATM in Asia ever was deployed in Vietnam back in 2020, Vietnamese Bitcoin Exchange VBTC was among the first exchanges globally to integrate Lightning withdrawals and Vietnamese-Canadian Lightning payment processor Neutronpay most recently raised the largest funding round for a Vietnamese Bitcoin startup ever.

Vietnamese Bitcoin exchange BitcoinVN operates currently one of the largest Lightning Routing Nodes in Asia with a capacity of close to 30 Bitcoin, while the Bitcoin Community in Saigon has been contributing to the local adoption of Lightning via "Lucky Money" giveaways, encouraging local merchants to adopt it and corralling together local Routing Node operators (Plebs & Business alike) in order to build out a strong localized network.

8-1. Lightning Network businesses & projects in Vietnam

1) BitcoinVN

BitcoinVN ("Bitcoin Vietnam") is Vietnam's premier Bitcoin Exchange service; launched in early 2014.

The service offers on- and offramp into Vietnamese Dong and has integrated Lightning deposits since last year; allowing users to fund any Vietnamese bank account via Lightning.

2) Neutronpay

Neutronpay was launched in 2018 by Canadian Viet Kieu Albert Buu.

The service has established itself as the country's leading Lightning Service provider, operates a Bitcoin-only merchant platform and mobile wallet.

Neutronpay has been raising the largest funding round for a Vietnamese Bitcoin startup to date.

3) VBTC

VBTC launched in fall 2014 the first VND-BTC trading platform in Vietnam.

In January 2021 it became one of the world's first exchanges to enable Lightning withdrawals for its userbase.

4) Future.Travel

Future.Travel is the "Bitcoin merchant OG" in Vietnam.

Founder David Watson has been accepting and promoting Bitcoin payments since 2015.

Flights, Hotels, Visas - all your travel needs covered and payable in Sats.

David has been hosting Asia's first Lightning ATM since the year 2020 in his office premises in Ho Chi Minh City (Saigon).

5) Bitcoin Saigon Community

The Bitcoin Community in Saigon is the longest running Bitcoin meetup in the country.
Launched in fall of 2014 by Diana Ngo, Khoa Tran and Dominik Weil, the meetup has been taken place in an uninterrupted basis since almost a decade.
The community regularly launches community initiatives such as "Lucky Money" or book giveaways and held in 2021 a fundraiser with over 10k$ raised to support the local lockdown victims..

6) Lightningcon / BitcoinBeach Da Nang

The very first Lightning focused international conference in Vietnam.

It will have its debut in March of 2023 with many internationally well-known names such as Peter Todd, Jimmy Song, Liz Stark (and many more…) at the beautiful beaches of Central Vietnam.

9. Resources

English

Lightning Network whitepaper
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9. Resources

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"Neutronpay raises largest funding ever for Vietnamese Bitcoin Startup"
(13.10.2022)

https://news.bitcoinvn.io/neutronpay-raises-largest-funding-ever-for-vietnamese-bitcoin-startup/

"BitcoinVN Lightning Node – now with its own subpage"
(04.01.2023)

https://news.bitcoinvn.io/bitcoinvn-lightning-node-now-with-its-own-subpage/

Vietnam Bitcoin community resources

"Bitcoin Saigon Lightning Community on Amboss"

(09.05.2022)
https://bitcoinsaigon.org/bitcoin-saigon-lightning-community-on-amboss/

"BitcoinBeach Da Nang / Lightning Con March 2023 - First Speakers announced and Ticket Sale opened"
(13.01.23)
https://bitcoinsaigon.org/lightningcon-2023-first-speakers-ticket-sale/

Official Lightningcon Da Nang website:

https://lightningcon.org/