# Role of the Bitcoin Lightning Network in Digital Micro-Payments
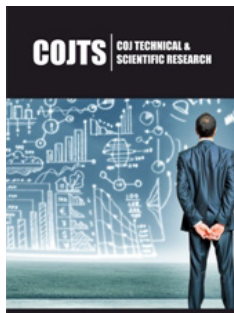
**Esad K[1], Natasa Z[2]\*, Narcisa H[3] and Rejhan K[4]**

[1]University of Sarajevo, Sarajevo, Bosnia & Herzegovina

[2]University of Applied Sciences, Leipzig, Germany

[3]University of Zenica, Bosnia and Herzegovina

[4]University of Novi Pazar, Novi Pazar, Serbia

**Abstract**

Lightning Network is an applicative solution to the scalability problem of the Bitcoin blockchain. As a second layer on top of the Bitcoin, Lightning Network can scale the Bitcoin transaction rate from 7 transactions per second to millions of transactions per second. There are already thousands of payment channels established inside the Lightning Network that enable cheap and fast small payments. These payments can have the size of one Satoshi, the smallest fraction of one BTC. In this paper, the benefits and challenges, as well as the proposed solutions to the issues in Lightning Network have been discussed. As analysis and current growth trends show, Lightning Network is a promising technology that has the potential to make Bitcoin the main digital currency over the internet.

**Keywords:** Lightning Network; Blockchain; Bitcoin; Cryptocurrency; Micro-payment; Scalability; Transaction Rate

**\*Corresponding author:** Natasa Zivic, University of Applied Sciences, Leipzig, Germany

## Introduction

Blockchain is the underlying technology of cryptocurrencies ensuring the correctness and worthiness of cryptocurrencies without any central custody or authority like traditional banks. As so, it has contributed to the establishment of decentralized finance reducing and simplifying the costs of banking transactions and excluding the involvement of a third-party authority [1]. Blockchain technology is based on a chain of blocks that generate unchangeable publicly distributed ledgers using incentive cryptographic mechanisms. It is a form of Distributed Ledger Technology (DLT) where each new transaction needs to be confirmed by all the participants in the network. After the confirmation, the transaction is added as a new block to the chain [2-4].

## Bitcoin and the Challenges

The most known cryptocurrency, Bitcoin (BTC), is becoming globally accepted as a medium of exchange. Bitcoin and other cryptocurrencies have been mainly used for trading and investment, but innovative approaches are suggesting Bitcoin become the digital currency of the Internet. The pillar of the Bitcoin is the Blockchain technology making it decentralized and borderless. So, all the transactions made in the Bitcoin network reach all network peers based on the fundamental rule of the consent of users to confirm if transaction data is true in the peer-to-peer network. Each new transaction adds a new block to the chain that remains there unchangeable. However, the construction of a new block takes about 10 to 60 minutes for a 1MB block. The main reason for this delay is the Proof-of-Work (PoW) consensus which secures BTC from fraud [2,5]. The Bitcoin network inherits the nature of blockchain and, in practice, can support only up to seven transactions per second (tps). This rate is much lower than the Visa financial systems supporting an average of 2000tps or a peak of up to 50, 000

transactions per second [5,6]. The main issues that are on the way to Bitcoin becoming the native currency of the Internet for massive micropayments and e-commerce are the problems of scalability and low transaction speed due to the time needed to generate each block of transaction. Many practical solutions have been suggested to solve these problems. The best known approaches are layer-2 technologies that add an applicative layer on top of the Bitcoin network to handle off-chain transactions. Such solutions can correspond to hundreds of times the current e- commerce transaction rates [2].

## Lightning Network

The major proposed layer-2 technology is the Bitcoin Lightning Network (BLN), which is considered a revolutionary approach in enabling scaling up the BTC transaction rate. Lightning Network (LN) is in fact a payment protocol on top of BTC as a base layer. So, LN is not a substitute for BTC but rather a tool for making huge numbers of smaller transactions (micropayments) in less time. Theoretically, LN can upscale BTC transactions up to billions [7]. In Lightning Network, off-chain payment channels are created (Figure 1) as logical connections between any two end-nodes. An initial balance is needed to open a payment channel on the LN network. The BTC transaction that opens the channel is called a Funding Transaction and it locks an amount of BTC Satoshis in it. As long as there is a balance in a channel, micro-transactions can be made. After closing the channel, one summative transaction block of the channel is added to the BTC Blockchain [8]. The popularity of LN is growing since its launch in 2018. Over 10000 nodes and 35000 payment channels hold more than 950 BTCs inside the LN network [7,9]. The newest analysis even reports that $110 million in Bitcoin is locked inside LN channels that represent users paying for various services and digital or physical goods [10]. LN benefits from various advantages. The main one is upscaling transaction rates from a couple to thousands or millions per second due to the crucial off-chain support that LN provides as an applicative layer. As there is no minimum transaction value, the smallest unit of BTC, a single Satoshi, can be sent via an LN channel [7]. LN can operate across Blockchains with heterogeneous consensus rules as long as they support the same cryptographic hash functions [11]. Using Lightning Network for micropayments is much faster and economically feasible. While a traditional credit card transaction has from 1.4% to 3.5% transaction fee, an LN transaction fee is only a fraction of a penny [2,7]. Lightning networks may also be run on IoT devices that are constrained in terms of power consumption, processing needs, and memory capacities. Such implementation is possible through a gateway LN node, which requests the cryptographic signature of the IoT device for all the operations on the channel [12]. Besides all the benefits, Lightning Networks encounter some problems. Some of the challenges include finding the best transaction routes i.e., path lengths (nearest and the most feasible nodes to establish payment channels), the imbalances inside the channels as transactions cannot be made without sufficient balance in the channel (fund depletion) [13], and security issues like the problem of offline transaction scams [10]. However, there are continuous attempts to find and suggest practical solutions for the problems without modifying the protocol [6]. One suggestion is to use important nodes as connecting hubs to maintain a stable communication which resolves the routing problem. A weighted system of node evaluation can help users to find neighbor nodes more efficiently [5]. Other approaches suggest multipath payment schemes to reduce transaction and channel establishment fees while keeping the network balanced [8]. Some solutions include proposing new fee policies to enable the channels to be open longer, which reduces the fees paid by users [13].
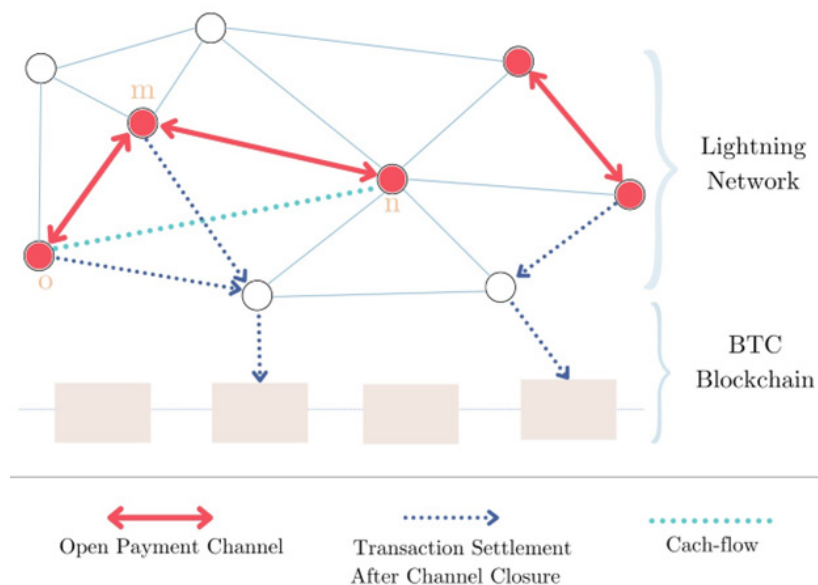


**Figure 1:** Lightning Network comes as a layer on top of the BTC Blockchain. By routing the payments between the nodes n and o via the node m, there is no need to open a new payment channel between the nodes o and n. This is called routing or path finding in LN.

A third-party protection service can be used to prevent transaction scams. Such service is based on specialized nodes inside the Lightening Network or watchtowers. Other participant nodes can pay a small fee to the watchtowers to watch over the channel when a participant leaves it unattended. Any malicious attack (like closing the payment channel from the opposing party) will be caught and the funds will be automatically sent back to the offline participant. Also, Lightening Network benefits from the security protocols of the base layer, the BTC Blockchain [10]. Although the issues are not yet fully resolved, the Lightening Network is being widely adopted. The public channel capacity of LN is annually growing by over 30%. Initially, the public LN channel size was limited to a maximum of 0.1677 BTC. Since 2020, the constrains are announced to be removed so that users can benefit from larger channel capacities [14,15]. LN may not be needed for the purposes of mere investment. However, when it comes to the needs of the constantly growing digital economy, LN can represent an excellent tool to leverage the features of Bitcoin (and other cryptocurrencies) for millions of fast micro-payments throughout the global internet connection.

## Conclusion

Bitcoin is a widely known cryptocurrency benefiting from the features of Blockchain that enables decentralized transactions without the involvement of any third parties. Bitcoin Blockchain, as a type of Distributed Ledger Technology (DLT), ensures the security and authenticity of transactions. However, the Proof-of-Work consensus slows the transaction time and limits the transaction rate to up to 7tps. A promising solution to these issues is a second-layer protocol called Lightning Network (LN) on top of the base BTC Blockchain. LN generates payment channels in an off-chain mode that scales the transaction rate to millions of transactions per second. LN is constantly growing and appealing but with its own challenges like routing and offline transaction scams. However, practical and promising solutions have been proposed to tackle the problems. LN technology can be Bitcoin's first ticket to becoming the main digital currency introducing a new era of global and decentralized micro-payment systems. Future works include more innovative approaches to resolve the challenges of the adoption of the Lightening Network and new ways to make the transactions more feasible and time efficient.

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