BlockBill: The Blockchain-Powered Paperless Billing Solution

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1 ABSTRACT

Every second, across the globe, millions of receipts get printed and/or stored digitally. A receipt is a written/printed acknowledgement from the seller to the buyer of the received payment for a good or service. Most, if not all, of these receipts are printed on thermal paper; while a few get printed on non-thermal paper.

Recently, digital receipt systems, which involve electronic versions of traditional paper-receipts, have also gained popularity because of certain advantages, such as receipts can be easily stored on computers or smartphones and are accessible on demand. Figure 1-1 shows a queue-line at the till of a shop, to the left is a scenario where a buyer is receiving a paper-based bill, while to the right is blockchain-based paper-free billing system in action.

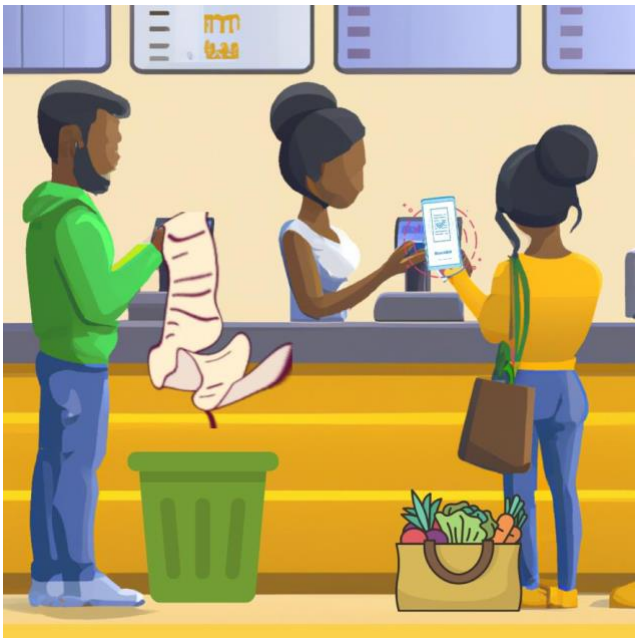

Figure 1-1: Billing systems: The traditional paper version vs the digital blockchain version.

Thermal paper and traditional paper usage have devastating environmental and health impacts [1], [2], [3], while digital receipts risk tampering and trust issues [4]. In this work, we propose a paperless digital receipt solution which is environmentally sustainable, tamper-free, and trustful based on a systematic application of Blockchain technology.

The MVP (Minimum Viable Product), on both web and android platforms, of this billing system, called BlockBill, has been submitted to the "8th Global Best M-Gov Award" competition at the "World Government Summit 2023, where we bagged the first position globally among submissions from around 60 countries [20], [21], [22].

This solution is valid for both Business-to-Consumer (B2C) and Business-to-Business (B2B) transactions. However, in this article, we present our implementation for all Retail and Wholesale

transactions focusing on FMCG (Fast Moving Consumer Goods) scenarios, which most of us encounter daily. This solution not only eradicates the overhead costs of printing, the environmental impact, and security concerns but also enables a new business plan that creates fortune-making opportunities for participating players by virtue of the underlying Blockchain technology that involves setting up several nodes, which owners with computing infrastructure can host.

We aim to build a distributed and decentralized (third-party) billing system that stores the receipts of transactions on a Blockchain layer, providing security, trust, and transparency while ensuring data privacy and preventing misuse. This product would be the first of its kind in the market globally.

This digital solution preserves the ease of paper receipts for both buyers and sellers, making management more efficient. Since encryption is applied extensively, no personal and/or private data is stolen/exploited, as no centralized organizations are involved in the Blockchain architecture. As we explain later, our *paper-free blockchain-based billing solution* presented in this article contributes towards several UN Sustainable Development Goals [5], namely:

- SDG #3: Ensure healthy lives and promote well-being for all at all ages;
- SDG #8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;
- SDG #12: Ensure sustainable consumption and production patterns;
- SDG #13: Take urgent action to combat climate change and its impacts and
- SDG #16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

2 OVERVIEW

In today's world, if you are making a purchase and ask for a receipt, there is a very high chance that you will get one printed on thermal paper. This thermal paper [9] is a special paper on which a thermal printer [10] prints by just heating; ink is unnecessary. During the manufacturing process of this thermal paper, a mixture of heat-sensitive dyes and color developers is coated onto the base paper to create the desired effect [11]. Leuco dyes, organic acid developers, and sensitizers are some of these substances.

The market for thermal paper was valued at USD 3.45 billion in 2019 and is anticipated to grow to USD 5.85 billion by 2027, with a CAGR (Compound Annual Growth Rate) of 6.9% [6]. In this chapter, we introduce the current scenario of the billing system, highlighting its negative impact on our society. We also define the problem statement, list the possible use cases for the same, and present the novelty of our solution.

2.1 CURRENT SCENARIO

The thermal paper market is highly competitive, involving several large firms which control the majority of the market in terms of market share. The presence of numerous reputable paper-producing firms is also said to have further accelerated the expansion of the thermal paper market on a global scale. Businesses involved in the thermal paper market trends are using tactics including new capacity expansions, collaborations and acquisitions, and product launches to bolster their market positions, enhance their current offers, and target a more extensive client base.

From an environmental perspective, the current problems can be divided into three primary subproblems:

2.1.1 THERMAN PAPERS GROWING TREND

According to Grand View Research's analysis [6], receipts are increasingly being printed on thermal paper domestically and internationally. Furthermore, this study demonstrates that the price of thermal paper is increasing annually due to a shortage of the leuco dye used in thermal paper, a trend that is anticipated to last through 2025.

2.1.2 HEALTH IMPACT

Receipts can present health problems because they typically include bisphenol-A (BPA) or bisphenol-S (BPS), endocrine disruptors used as color-developers to make the text visible are estimated to be coated on 93 per cent of paper receipts. The chemical coating on receipts is absorbed into our bodies through our hands when we touch them [12]. BPA affects fetal development and is linked to numerous health issues such as thyroid disorders, type 2 diabetes, and reproductive problems.

Businesses have sought out "non-BPA" paper, but it is frequently replaced by BPS, a chemical comparable to BPA and which, according to research, has similar negative consequences [13]. These receipts are almost impossible to recycle because of those chemicals, which are also present in single-use plastics and contaminate other recycled goods in the recycling process. Studies have shown that attempts to recycle BPA-coated paper contaminate water bodies and leach into waterways, causing an imbalance in the natural aquatic ecosystem and causing reproductive problems for fishes, mammals and birds. Over 120 tons of BPA are reportedly used annually in the UK to produce receipts [7]. Thus both variants of thermal paper are not healthy options.

2.1.3 ENVIRONMENTAL IMPACT

If we even take out the additional damage caused by thermal paper, the continual use of traditional paper receipts also causes substantial damage to our environment on its own. Our individual carbon footprints make an impact as they add up, especially in scenarios where practically everyone contributes in some way or the other.

Let us take a look at a small business that, on average, conducts about 20,000 transactions in a week and provides receipts for the same then, and it will have an annual carbon footprint of 26,000 kg of Carbon Dioxide emission just from receipt production and usage; This is the equivalent of producing 2,600,000 plastic bags.

In the US, receipt production annually uses more than 3 million trees and 9 billion gallons of water and produces 302 million pounds of solid trash while emitting over 4 billion pounds of CO2 (the same amount as 450,000 cars on the road) [8].

To meet the demand for paper receipts in the UK, about 200,000 trees are cut down each year. This same number of trees would have removed 4000 tons of carbon dioxide from the atmosphere annually.

All of these statistics become more concerning when we consider the fact that around 90% of the receipts are thrown away lost or damaged, rendering them useless, which means that the bulk of resources being consumed, and the carbon footprint being generated, majorly end up as trash.

Considering the devastating impact of the paper receipt industry on the environment, and its serious health concerns, it is imperative that steps be taken to counteract these effects by halting its production and meeting its demand with an encompassing solution. **Error! Reference source not found.** gives an infographic illustrating the emission and associated environmental impacts.

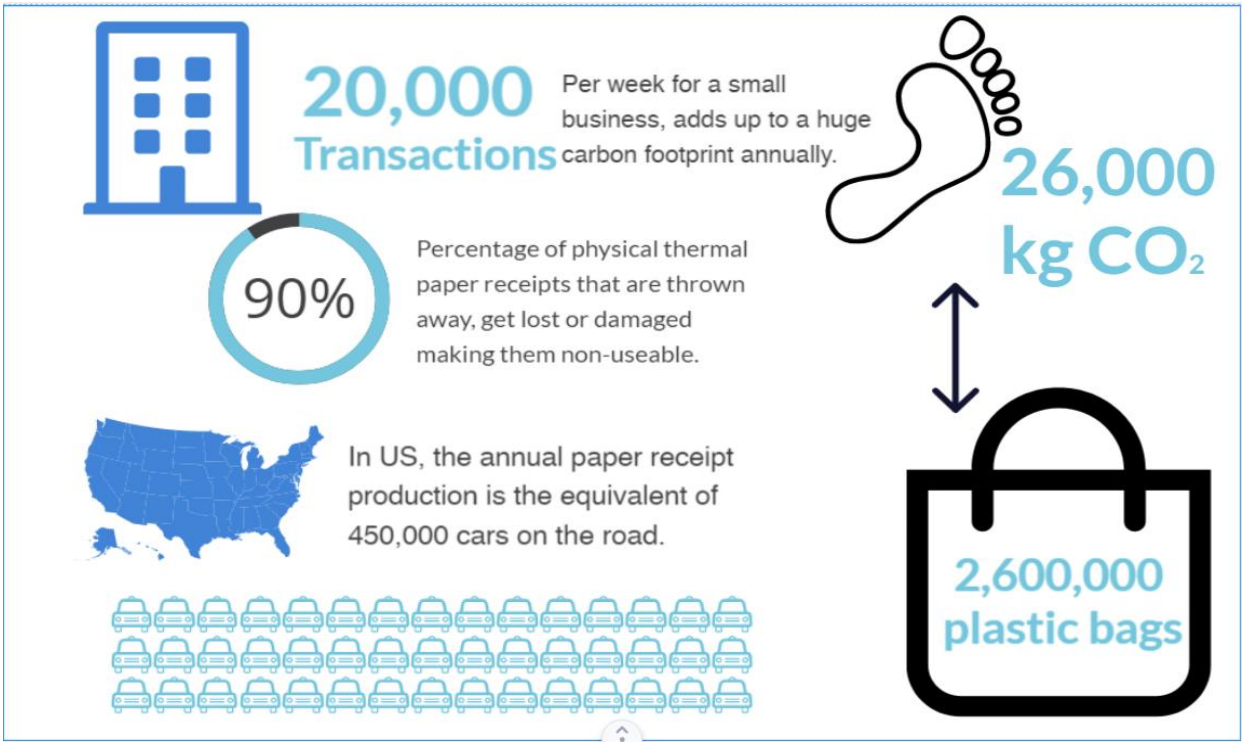

Figure 2-1: An infographic showing the Environmental impact of paper-billing systems.

2.2 PROBLEM STATEMENT

We aim to build a decentralized, distributed (third-party) billing system that stores the receipts of transactions on a Blockchain layer. This billing system is both tamper-proof and eradicates the paper-based billing system that is non-sustainable. Its initial scheme focuses on business segments of FMCG (Fast Moving Consumer Goods), which include food and beverages, personal healthcare and catering to Retail and Wholesale transactions. The main actors in this scenario would be Customers and Vendors, with a bulk of business being taken up by B2B (Business-To-Business) and B2C (Business-To-Customer) entities.

2.3 INCENTIVES FOR ADOPTION OF NEW SYSTEM

One of the main drivers of technology adoption is cost reduction, and in today's world, environmental sustainability is increasingly becoming a key factor in adoption decisions. Any organization's management will start to see an operational expense line that any financial expert would be happy to cut after you factor in the upfront and ongoing costs of the printers and the energy needed to run them.

Branding is essential and enhancing sustainability performance builds brand strength. Customers consider a brand's corporate sustainability reputation and initiatives when making purchases. While consumers may not be prepared to pay extra for environmentally friendly products, they are more inclined to buy products from brands that practice more social responsibility.

When we reuse or recycle paper, we often believe we are acting ethically. However, the chemicals in thermal register receipts make paper receipts non-recyclable and introduce phenol into the remainder of the stream, contaminating food and water sources.

Receipt sorting can be done quickly and accurately using paperless digital solutions. Permissioned access to receipts can offer a better security level in large businesses than putting them away in a room or filing cabinet.

The existing current digital solutions are centralized ones. One of the principal concerns about adopting centralized digital receipt systems is data misuse and cyber security; this is where our solution gains an edge as the product being implemented on Blockchain ensures Transparency, Enhanced Security and True Traceability.

2.4 THE NOVELTY OF OUR SOLUTION

To the best of our knowledge there is no system that replaces physical receipts with digital ones using decentralized Blockchain Technology. If you opt for a digital receipt, in the existing systems, customers are asked to provide their contact details, which usually include email address(es), phone number/s, and/or snail address(es). Then centralized authorities store these in databases, allowing marketers and data brokers to connect a person's identification with their particular activity by spreading their mail addresses to different companies. Digital receipts are "a cheap

way to get your email address and to build their database to track your shopping habits" for firms, according to John Zhang, a University of Pennsylvania marketing professor [14].

Furthermore, any sort of record of financial transactions has a higher risk of being misused in a myriad of ways. Combined with identity theft and tracking an individual's patterns in all spheres of life, the danger of data leaks or impersonation proves grievous. The problem is further aggravated when the data lies with a central authority, and there is no public scrutiny and transparency in the pipeline.

Blockchain Technology helps us deal with these concerns about data privacy and preventing data misuse, security and trust, through strong encryption. As the name suggests, a blockchain is a collection of digital blocks that list transactions. All the blocks before and after a given block are related, which makes it strenuous to alter a single record since, to evade detection, a hacker would have to alter the block that contains the record and all those linked to it.

The blockchain's records are protected by encryption. Each network participant has a private key to sign transactions with their unique digital signature. If a record changes, the signature will no longer be valid, and the peer network will immediately become aware of the situation.

Blockchains do not have a single point of failure and cannot be altered by a single machine because they are not maintained in a single location. To access every instance (or at least a 51 per cent majority) of a specific blockchain and change them all simultaneously, enormous computer power would be needed. Your blockchain will be more tamper-resistant the more extensive your network grows.

While moving from one form to another, functionalities are often lost, and spirit needs to be captured. To replace paper receipts with digital ones, we must ensure that convenience and privacy are preserved. Paper receipts, once printed, cannot be altered; you have to generate a new one with the consent of both parties - which is the case here as well in a CR (Create-Read) environment contrasted with that of traditional CRUD (Create-Read-Update-Delete) environment of databases, as followed by everyone in Web2 architecture. In Chapter 3, we highlight the detailed benefits of using blockchain.

As observed and mentioned, about 90% of paper receipts wound up in situations where their usage is rendered non-usable. These situations are acceptable when it comes to trivial purchases. However, when it comes to important and large transactions - a proof of record holds weight, and we need a queryable system where people can efficiently store, sort and find the relevant receipts in a timely manner when needed. This is easily achieved securely through our blockchain-based digital transformation of processes that are virtually missing in today's traditional hard copy as well as digital systems.

Our solution successfully tackles all these challenges with its features and technological infrastructure.

3 TECHNOLOGY

In this chapter, we briefly describe the technological concepts involved in this product to facilitate understanding.

3.1 BLOCKCHAIN TECHNOLOGY

David Chaum, in his 1982 doctoral dissertation at Berkeley [23], proposed every element of the technology, which was going to become Blockchain in 2005, when Satoshi Nakamoto launched the cryptocurrency Bitcoin by adding the *Proof of Work algorithm*, which was missing Chaum's work [15]. Blockchain, in essence, is a persistent storage system that permits only Create and Read operations, unlike traditional Database systems that support Create, Read, Update and Delete operations.

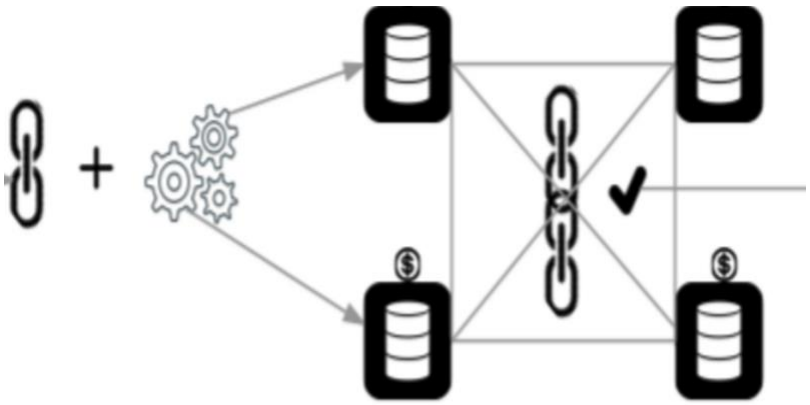

Figure 3-1: Blockchain process block diagram.

Blockchain is a decentralized distributed system that makes it possible to implement immutable records, making it easier to track assets and record transactions. Since the operations of Update and Delete are unavailable in Blockchain Technology, there are protocols to compensate for those operations. These protocols mandate the blockchain to be realized through a set of nodes that interact via peer-to-peer network architecture. Each of these nodes has a copy of the ledger (the entire blockchain, i.e. a chain of blocks which record the transactions between parties), which periodically receives updates whenever the blockchain is changed. Each of these nodes has the ability to contribute blocks to the blockchain and can originate, initiate, and receive transactions. Figure 3-1 shows the process of creation of a Block on the Blockchain.

3.2 ADVANTAGES OF BLOCKCHAIN

3.2.1 TRANSPARENCY

Blockchain enables a decentralized network without the need for a central authority, resulting in increased transparency. The network consists of peers responsible for transactions and validation through consensus mechanisms. Each node keeps a copy of the transaction/s record on a

distributed ledger that records data consistently across all locations. Immutable, time-stamped transactions with full transparency minimize the risk of fraud to an absolute minimum and hence can be used to record transaction/s between parties across various application domains, including government administration, elections and record maintenance.

3.2.2 Enhanced Security

Consensus protocols must be followed before any transactions can be recorded on the blockchain, even the same for origination and initiation as well. These protocols mandate that at least 51% of nodes are in consensus for any operation to be carried out on the blockchain. A block of transactions is stored after being grouped. Each block contains a link to the preceding block, which is the previous block's hash.

Since each node has a copy of the entire blockchain, any attempt to corrupt mandates that at least 51% of nodes have to be compromised, which requires extensive effort, thus increasing security considerably; this means that even if a bad actor tried to add a flawed transaction or change some of the earlier transactions, other nodes would reject the request, making it very difficult, if not impossible, for them to do so. Additionally, as blockchain networks are immutable, data that has been written cannot ever be changed in any way. All of this contributes to the fact that blockchain technology is far more secure than other platforms or record-keeping systems.

3.2.3 True Traceability

Blockchain provides an audit trail that records a product's journey, helping to prove its origin and address concerns in industries dealing with environmental or human rights issues or fraud and counterfeiting. It enables businesses to focus on building a transparent supply chain and tracking goods, preventing theft, circulation of fake goods, and product loss. Blockchain traceability makes it possible for all parties to monitor the goods and communicate provenance information directly to customers. It can also reveal weak points in the supply chain through traceability data. For these reasons, blockchain is starting to be applied in supply-chain-based businesses across a wide range of industry verticals.

3.2.4 Reduced Costs

Organizations can significantly reduce the costs related to third-party providers by embracing blockchain. Blockchain eliminates the requirement for any vendor charges because it lacks a centralized player. Additionally, authenticating a transaction requires less engagement, reducing the need for spending money or effort on simple tasks. Further, it streamlines reporting and auditing procedures and lessens manual activities like data aggregation and amendment. Blockchain technology's capacity to simplify clearing and settlement directly translates into process cost savings.

3.2.5 IMPROVED EFFICIENCY

Traditional paper-intensive procedures take a long time, are subject to human errors, and frequently call for third-party mediation. Transactions can be finished more quickly and effectively by automating these operations with blockchain. The blockchain may hold documentation and marketing information together, eliminating the necessity for paper exchange. Clearing and settlement can happen considerably more quickly because there is no need to reconcile various ledgers.

3.3 NEAR BLOCKCHAIN

NEAR [19] is a user-friendly and carbon-neutral blockchain built to be performant, secure, and infinitely scalable. In technical terms, NEAR is a layer one, sharded, Proof-of-Stake blockchain built with usability in mind.

It doesn't matter if certain participants in a decentralized protocol like NEAR are not carbon neutral; what matters is that the network as a whole is carbon neutral. The use phase, or the online activity around the start of a transaction, only makes up a tiny portion of the footprint. With future expansion, NEAR's footprint is anticipated to grow. Still, both validator activity and use phase are anticipated to remain well below the massive climate footprint of Proof-of-Work networks. This result confirms that Proof-of-Stake offers a more environmentally friendly alternative to proof-of-work.

NEAR has a lot of benefits, especially from the perspective of developers and for the widespread adoption of mainstream applications based on blockchain, which includes, but are not limited to:

1. NEAR's consensus mechanism "Nightshade" is energy efficient [19], which means it consumes less energy than other blockchain platforms. This reduction in energy consumption helps lower the carbon footprint of the network.
2. Transactions are incredibly fast, about 1 second per transaction and with reasonably economical transaction fees under 1 Cent in fees, and the system is certified carbon neutral. NEAR consumes in a year the same energy bitcoin consumes in three minutes [24].
3. NEAR operates as a decentralized network with a governance model that includes community participation. This community-driven approach ensures that the network aligns with the values and goals of its users, promoting sustainable practices and reducing waste. Furthermore, there is an opportunity for passive income by hosting a NEAR node on the computer infrastructure.
4. It is quite simple for beginners as users, given that it uses human-readable account names, operates through a web-based wallet without the need to install programs or browser extensions and has an easy-to-use yet sophisticated system of access keys to manage account permissions.

5. Thanks to its sharding, it scales endlessly, withstands sudden spikes, and is much more resistant to outages than other blockchain networks observing trends from the past few years.
6. 30% of the gas fees go to the Developers. Pushing transaction information on a blockchain involves a sequence of computations together with several read-and-write operations across multiple nodes. The cost of energy spent for these operations on the blockchain is referred to as *Gas-fees*.

A blockchain-based app faces certain problems and NEAR provides solutions for most of these problems [20]. These are discussed in Chapter 6.

3.4 IPFS: INTER-PLANETARY FILE SYSTEM

Storing data on the blockchain can be very expensive, so we need something else to store a large amount of information; this is necessary and inevitable to make it cost-effective. There is a peer-to-peer hypermedia protocol known as the InterPlanetary file system (IPFS) for this particular purpose.

IPFS [25] provides us with a decentralized, trustful database. It is tamper-proof; once added, data present cannot be changed, but a new version can be added, as it loads material from thousands of peers rather than a single centralized server. Each piece of information is cryptographically hashed to provide a secure, distinctive content identifier, or CID. The validity of IPFS content can be cryptographically verified. There is no duplicate content in IPFS. For example, two identical 1MB files would be saved only once on the same IPFS node if you tried to put them there, removing the need for duplication because their hash would provide the same CID.

4 SOLUTION

We will discuss how the old billing systems transfer to our digital architecture in this chapter and how we implemented the various features, the technical choices we took, and their applicability.

4.1 ARCHITECTURE

The components that connect the various layers of the overall architecture are shown in Figure 4-1.

1. Frontend

A General Purpose Dashboard serves as the primary UX (User Experience) component that users will interact with and acts as the skeleton on which all the functionalities are erected. The user will navigate between all the functionalities available through the dashboard. The functions will hit the appropriate destinations (Smart Contract or IPFS), giving or receiving data. It has a clean, pleasing and intuitive UI (User Interface) design with appropriate entry fields relevant to the purpose of that screen. For instance, in the screen, enter the text/data corresponding to the sequence diagram in a given flow to where this screen belongs.

2. Backend Server (Smart Contracts)

Smart Contract layer is needed to utilize the functionalities of the blockchain layer and provide service to the frontend layer based on the blockchain layer. The backend service is required to contact and store data on the IPFS network.

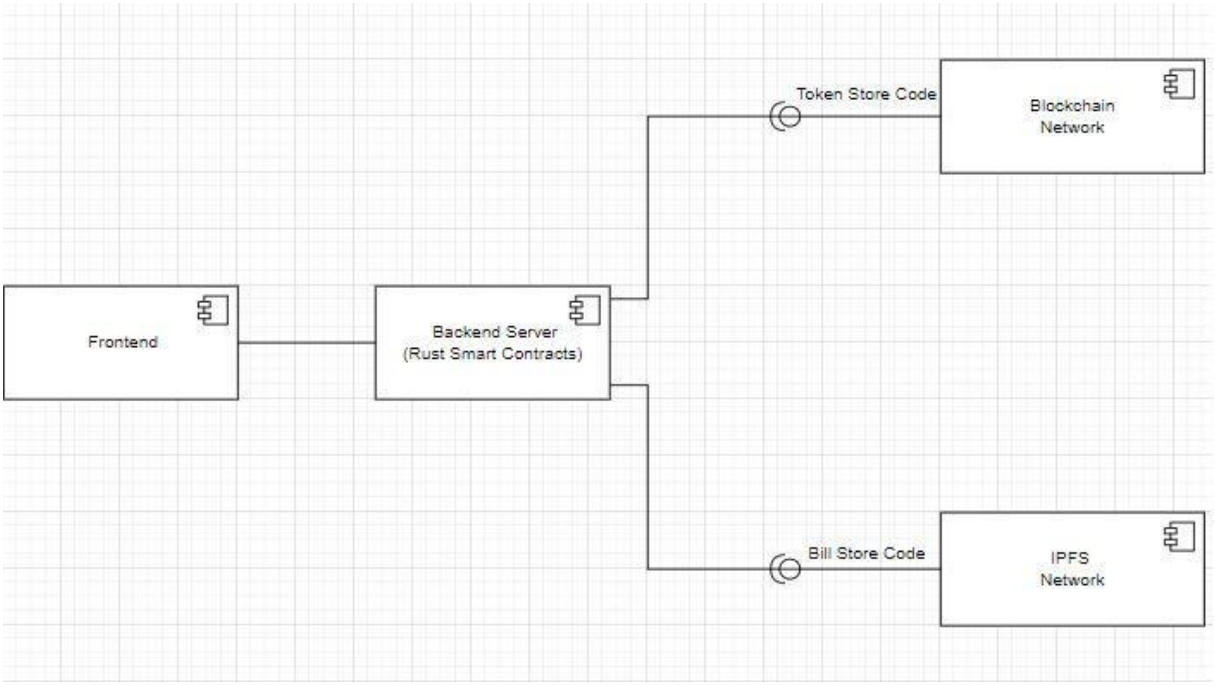

Figure 4-1: Component diagram of system.

3. IPFS Network

The storage of data on a blockchain costs, which increases with the size of the data. If the data associated with a transaction is extensive, recording it on the blockchain becomes expensive. Therefore, storing some of the details in bills on the blockchain makes sense, while the rest can be stored on IPFS. The hash of that data on the IPFS gets generated and gets stored along with the transaction on the blockchain layer. The IPFS layer thus provides us with the functionalities of a Database; while being decentralized and distributed.

4. Blockchain Layer

IPFS provides a hash key to access data stored within a file. This hash is maintained on the blockchain blocks as a reference, timestamp, and other relevant information.

4.2 Tech Stack of Our Solution

- The Frontend of this project was built using the ReactJS library. React is an open-source JavaScript library for building user interfaces. It creates self-contained encapsulated components and combines them to create intricate user interfaces.

- The project's Backend (Smart Contract) was written using Rust. Smart Contracts in NEAR can be written in any language that can be compiled to WebAssembly, but NEAR provides already written and maintained libraries (that wrap around low-level runtime APIs) in Rust and Javascript. Rust is a statically typed programming language for performance and safety, especially in the context of safe concurrency and memory management. It won the “Most Beloved Language” award conducted by StackOverflow for seven consecutive years [29]. After compiling to WASM, the smart contract can then be deployed to the NEAR Network.
- The actual bill, i.e. receipt for the purchase, is kept on the IPFS network. Each bill stored will generate a hash which gets stored on the blockchain corresponding to the transaction.
- The essential information of the bill is recorded on the blockchain. We are currently using the testnet on the NEAR blockchain.

4.3 USER FLOW

Two main actors are involved in interacting with this product: the Vendor and the Customer. The diagram below highlights the functions the actors can execute and how they interact with each other. **Error! Reference source not found.** illustrates the *Use Case Functional Diagram* to h ighlight the User Flow.

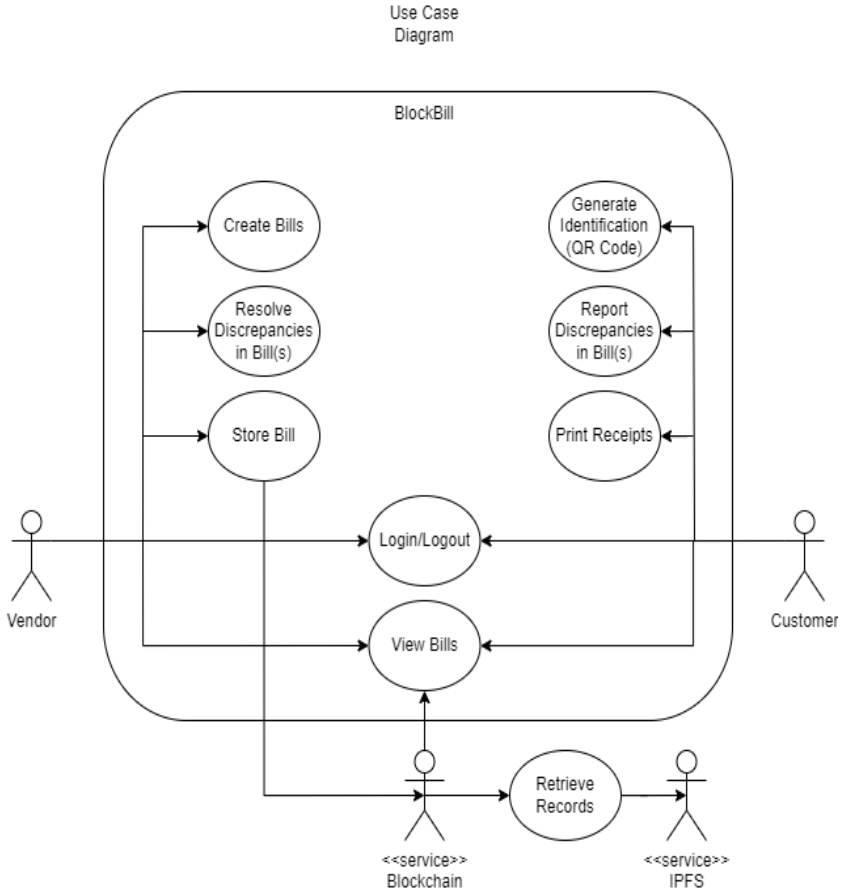

Figure 4-2: Use case functional diagram of product.

Some of the main functionalities are also described as follows:

4.3.1 Locking In As a User

A customer/vendor wishing to log in to the system must have a NEAR Blockchain account. Then, the user will be prompted to log in using account credentials through a login gateway (our implementation currently uses MyNearWallet) [28]. All operations on the blockchain have an associated cost. To pay these costs, the service takers have to pay the costs, and these payments are automatically taken from the corresponding wallets. Upon logging in, the user will be directed to the dashboard.

4.3.2 Viewing Bills

Every user can view all the bills created, where they acted as the customer during the creation of that bill. These bills will be available under the "Personal Bills" section. The user can check out any bill and all relevant details under this section and can sort and search through them.

4.3.3 Registering as Vendor

All users who log in qualify as customers by default. To register as a vendor, one must submit their Unique Identity, which is based on the country of deployment. We implemented this solution for India, where every vendor has a Goods & Services Tax (GST) number. So a vendor registers with its GST number and their registered full name; these details would then be verified via a GST API. Upon verification, a few more options will be visible on the dashboard, accessible only to registered users as vendors, like “Generate Bills,” “Update Bills,” etc. This is illustrated in Figure 4-3. They will also be able to view all the bills they generate for any customer and have the capacity to sort and search through their bills.

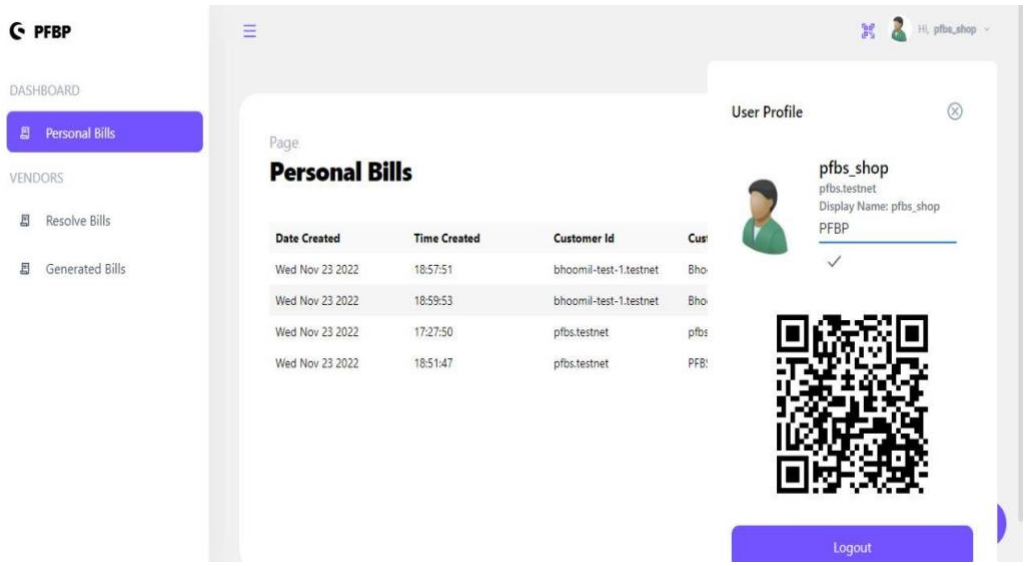

Figure 4-3: Product dashboard overview.

4.3.4 ADDING NEW BILLS

The vendor will link to the customer using the integrated QR scanner and scan the customer's QR code, which the customer can also display directly on the site. The vendor has a "Generate Bill" button on their dashboard. It opens up a fixed format bill in which the customer and vendor details are auto filled using their account details. They add the items and then verify them from their end. The customer can see the bill's status on their dashboard - initially, it will be "Verified by Vendor," which changes to "Verified on Blockchain" once the block is validated and added to the Blockchain. Figure 4-4 shows the GST and name details fields associated with a bill.

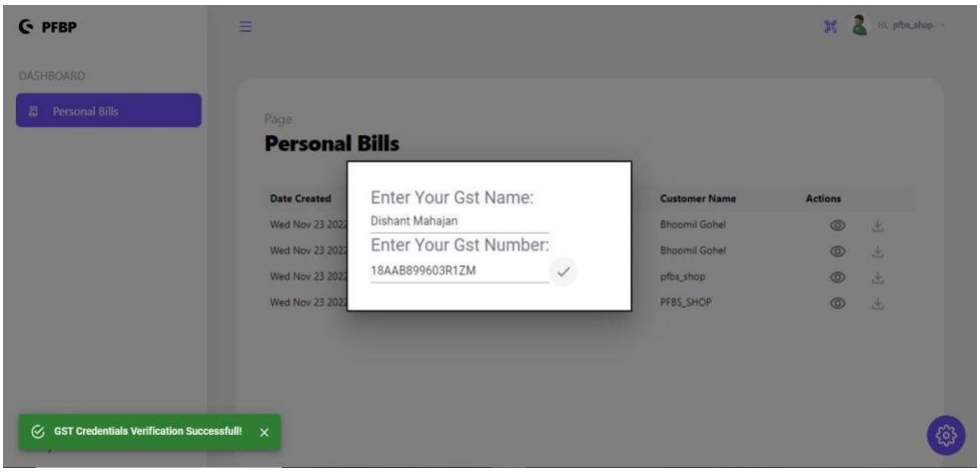

Figure 4-4: Entering GST details for vendor registration.

Figure 4-5 shows an invoicer sample.

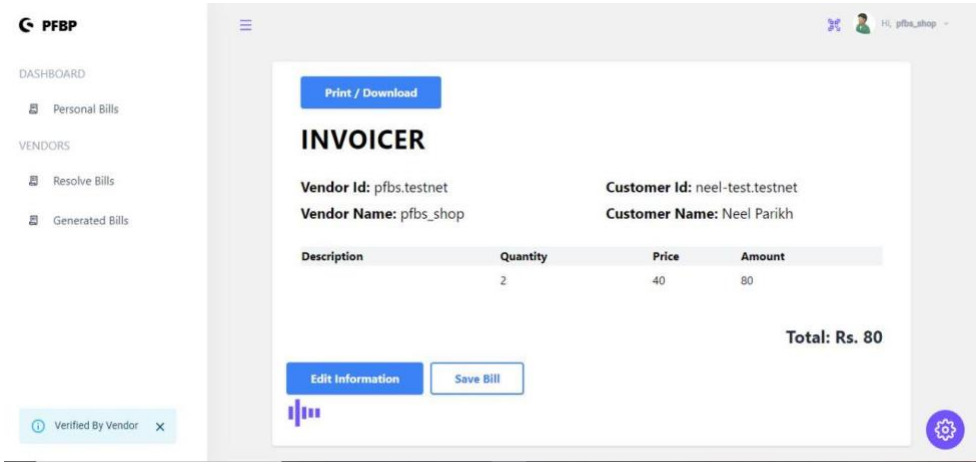

Figure 4-5: Addition of a new bill.

4.3.5 UPDATING AN EXISTING BILL

In this use case of bills, buyers shall always have the option to return the purchase for whatever reason. On the other hand, there could be billing errors. The bill needs to be updated in case of such a discrepancy or a refund/return scenario. Our solution permits this possibility. The customer can request a review by clicking on the "Review Bill" option on the bill of their choice from their dashboard. The Vendor will receive the request on their dashboard and can make the changes accordingly by updating the necessary information and generating a new block. This new bill will also contain the hash of the original unmodified bill as a reference.

4.3.6 AUGUMENTED USE CASES WITH DIVERSE USERS SUCH AS TAX-AUTHORITIES AND REGULATORS

In our solution, during the registration of vendors and users, our system has access to records that provide their addresses, billed items, bill amounts, etc. with full detail basis. To accommodate the tax authorities, insurance companies, and service agencies for appropriate products and regulators, we have to create these user categories besides the already existing vendors and buyers' categories. These categories would be given permissions as appropriate with respect to their profiles. Thus, our current implementation has the required interface to realize these user categories and associated use-cases.

4.3.7 PERFORMANCE EVALUATION OF OUR SOLUTION

Blockbill, being based on blockchain, inherits performance traits associated with blockchain. The blockchain-based solutions can be evaluated to assess their efficiency, effectiveness, and quality, and identify venues for improvement. This evaluation can be carried in the context of performance parameters [30], [31], such as: Consensus mechanism, Energy consumption, Latency, Network size, Scalability, Security and Transaction fees. It should be noted that not all these parameters are disjoint.

Furthermore, depending on the use case and the specific instance of the blockchain fabric used to realize the solution, not all parameters need to be considered. For instance, in the context of crypto-currency systems, since "No double spending" is an essential requirement, all the earlier listed parameters remain important. However, in the case of our Blockbill, there are different use-cases with varying occurrence frequency. For instance, the most frequent use-case is "Bill generation for the purchase," while the less frequent one is that of "Return of product" use-case. For the former use-case, Latency and/or Consensus are not important, while the latter case involves *Latency*. However, it is to be noted that we can ignore those performance parameters that are significant only with regard to the low-frequency use-cases. The National Retail Federation (NRF) reports [32], [33] that on average the return merchandise amounts to about 10% of the total sales.

Currently, Blockbill is based on the *NEAR* blockchain, which finalizes 100,000 transactions per second. The cost per transaction amounts to US$ 0.01 i.e. 1 US Cent. The idea is to have our own NEAR installation on a dedicated blockchain-network that is customized for our use-case. Even

on this own setup model, as per [34], we can achieve similar per transaction costs, and can outperform in the number of transaction throughput rates. Of course, even when considering consensus protocol, it is worth noting that since NEAR uses the *Proof of Stake* mechanism, the energy consumption is about 0.5 to 1% in comparison to the *Proof of Work.* In connection with the size of the deployed blockchain network [35], [36], we shall pay attention to the propagation delay by parameterizing with respect to the size of the block. Wherever and whenever, if the need arises, to address scalability, we shall be going in for the off-chain transactions with staged commission on the main network.

5 OBSTACLES IN ADOPTION

As with any new technological advent, there are obstacles in adopting the new idea and widespread usage of the product among the general public and affected organizations alike.

Analyzing from a historical perspective, two factors influence the development of a foundational technology and its business use cases [17]. The first is the novelty, i.e. how novel a certain application is to the outside world. It will take more work to make sure people grasp what problems it answers the newer it is. The level of ecosystem coordination required—the quantity and variety of partners collaborating to produce value using the technology—represents the second dimension of complexity [16].

A new product built on a relatively uncharted technology can fall under different categorization labels. Our product falls under the "Substitution" category, where we substitute an existing system without losing its original functionalities while enhancing its previous shortcomings. Products falling under this category rely heavily on public coordination for their adoption. Resolving this bottleneck becomes more crucial than any technological hurdles that crop up with the passage of time.

Disruptive technologies disrupt existing markets, displacing established market leaders by filling voids with added value and might create new markets with value networks. The blockchain-based digital transformation technology proposed in this paper is a disruptive technology that fills the void in the existing products or services in the realm of billing solutions. Our solution, which is currently an MVP, is constrained by established companies' existing market structures or legacy systems. Thus based on our market research, we firmly believe we can improve and gain market share, ultimately leading to significant changes in the current billing systems' ecosystem.

Though our MVP demonstrated the absence of uncertainty, like with any disruptive technology, we must overcome onerous obstacles like Cost, Resistance to change, Integration with legacy systems, Interoperability, Regulatory compliance, Data security and privacy concerns, etc.

5.1 TECHNICAL AND ECONOMICAL PERSPECTIVE ON BLOCKCHAIN-BASED SOLUTIONS

The above-mentioned obstacles, both of technical and economic nature, can be overcome by the inherent features of our product as explained below:

1. Cost

For small-time vendors, especially those with limited resources, our solution might seem expensive and require significant financial investment, which can be a possible barrier for adoption. Often with digital transformation tech, these costs are due to initial costs for hardware, software, and learning/training.

Our solution requires users (both sellers and buyers) to have access to a smartphone/PC with Internet access. As per world bank statistics [27], the number of smartphones in active usage is encouraging, with only a handful of countries lacking the necessary threshold. Regarding internet access, about twenty countries have sub-threshold access to the Internet [28]. By deploying our solution on the cloud, these costs are within affordable limits.

Wherever these costs are above the spending threshold, we plan to seek funding from the agencies such as World Bank, ADB, IMF, etc. With such support, the solution can reach every country. We have also conducted a per-transaction cost analysis that supports our product and will provide a helping hand in convincing users to onboard. This is explained below.

For a small vendor in India, the costs associated with having a Paper-Based Billing system involve two major expenses: Thermal Paper Billing Machine and the Thermal Paper Refills for the machine. The price of a typical Billing Machine in India can range from Indian Rupees (Rs.) 10000 to Rs. 20000. A single roll of thermal paper refill costs around Rs. 40 lasts for approximately 170 transactions. Thus the total amounts to around Rs. 15000 + Rs 0.25 per transaction. This is an estimate not considering the associated maintenance costs.

On the other hand, we don’t need Thermal Paper Machines or Refills for our product. Functions on NEAR Smart Contracts can be characterized into two types: View functions and Call functions. No charge is incurred for all the features that call “View Functions” underneath.

Since approximately 100 characters can be stored on the blockchain upon adding a new bill, it will consume around 6.75 TGas, which is 0.675 milliNEAR spent as Gas Fee. At present, 1 Near is around $2.23. So translating to rupees, the cost borne by a vendor is around Rs. 0.12 per transaction.

This concludes that, apart from the one-time cost of Rs. 15000 for a paper billing machine, a vendor spends twice the amount for a single transaction in paper-based systems than in our system.

2. Resistance to Change

For small and large organizations, we anticipate some inertia in adopting new disruptive technologies, especially as it requires changes to existing processes or ways of working. But with our product's value proposition, these operational issues can be addressed with sufficient marketing.

3. **Integration with Legacy Systems and Interoperability Issues**

Many businesses have age-old legacy systems that would be required to interface with our product. But with appropriate plumbing interfaces and adapter software, a systematic integration is very much achievable.

4. **Regulatory Compliance**

In the realm of billing systems, there are inevitable entanglements with regulations and compliance requirements specific to the law of the land. We will be addressing it with a Compliance-wrapper module, which will be based on a library of Smart contracts.

5. **Data Security and Privacy Concerns**

The concerns regarding users' data security and privacy are resolved with Blockchain-based solutions and become narrower compared to the existing centralized solutions, which not only sets us apart but gives us an upper hand over all other existing solutions.

5.2 WIDESPREAD ADOPTION

From the above, we see that there are many significant and challenging obstacles as explained above. Our solution can be scaled and adapted to dissolve most of them. The residual obstacles, if any, would be screened out because of our product's benefits. These benefits are as follows:

1. **Competitive Advantage**

Since this is a blockchain-based product, it removes the cyber-security, trust, transparency and accountability issues associated with a single point of failure/compromise, centralization, provide an augmented querying capability, and these advantages act as motivation for adopting the product. Big and small vendors see the tradeoff of potential benefits against adoption costs and can make an informed decision.

2. **Time to Market**

We have a multi-platform operational version of the product, working as both a website and android application, which can be deployed instantaneously, enabling organizations to capitalize on the new product quickly.

3. **Customer Satisfaction**

Buyers and sellers have improved customer satisfaction due to the complete realization of all required features needed for a billing system.

4. Environmental Inclusion

As highlighted before, with the rising awareness and growing urgency to work towards combating climate change, every person tries to contribute from their end. Since our product is a step towards that direction, customers and vendors will opt for this green alternative, compared to the damaging actions doled out by thermal paper usage. Moreover, as emphasized before, the blockchain we operate on is carbon-neutral, as the organization plants trees to offset whatever carbon footprint its activities generate.

6 SCALABILITY AND ADAPTABILITY TO MARKET

Scalability represents the capability of an information system to maintain its equilibrium condition with increased storage volume [18]. The growing volume of transactions and the inadequacies of consensus protocols are the root causes of this problem. As a result, considering design and architectural factors is essential for ensuring the ledger performs satisfactorily while remaining lightweight.

Vertical scaling of blockchain applications refers to increasing the computational power and capacity of a single node in a blockchain network, while horizontal scaling involves adding more nodes to the network by onboarding new users or additional resources to distribute the workload and increase the overall capacity of the system. Adaptability to market refers to our product's ability to mold itself according to customer preferences and market trends for greater ease of use and relevance.

6.1 TECHNOLOGICAL SCALING

In blockchain applications, vertical scaling means enhancing the capabilities and efficiency of an individual node in the network. It involves upgrading the node's hardware, such as improving its memory capacity or processing power, to enable it to handle an increased number of users or transactions. This results in an initial increase in productivity, but future progress is restricted to the rate at which computing technology advances (known as "Moore's Law"). As a result, the network cannot expand at a pace that matches its growing popularity.

In blockchain applications, horizontal scaling involves adding more nodes to the network to enhance its capacity and performance, enabling it to support more users and process additional transactions. The number of nodes in the network can be increased by adding to the existing network or by connecting new networks using interoperability protocols.

With the help of NEAR's sharding strategy, the network's capacity can grow as more nodes join. The network nodes are dynamically split into many “shards.” NEAR blockchain tackles horizontal scaling by allowing multiple shards to operate in parallel and supporting interoperability between different networks.

By partitioning the network into smaller sub-networks, each shard can process a subset of the total transactions, improving the network's overall transaction throughput. In addition, NEAR supports cross-shard transactions that enable the transfer of tokens and data between different shards. This allows for the creation of specialized shards that can handle specific use cases, such as gaming or social media, while still being able to interact with the broader NEAR network.

The network must permit permissionless participation from potential node operators and not reward pooling to sustain true decentralization. To overcome these issues NEAR employs a staking method known as "Thresholded Proof of Stake," which was created to be generally fair and deterministic to discourage the pooling of large validators and promote widespread node involvement. As a result, the nodes don't need a lot when demand is large enough to warrant it out of processing power to verify the network's transactions. Additionally, it implies that programmers can scale linearly and entirely dispersed among millions of nodes. Consequently, it is theoretically possible to validate several billion transactions.

Decentralizing the network is only one benefit of lowering entry barriers for nodes. The more nodes that can join in a system that scales horizontally, like NEAR's, the more it can scale as well.

NEAR also supports cross-chain interoperability through its Rainbow Bridge, which enables the transfer of assets and data between NEAR and other blockchain networks. These features enable NEAR to tackle horizontal scaling by allowing the network to expand within and outside its own ecosystem.

The figures below show the comparison of NEAR blockchain with various other blockchain with respect to Block Time and rate of Transactions per second:

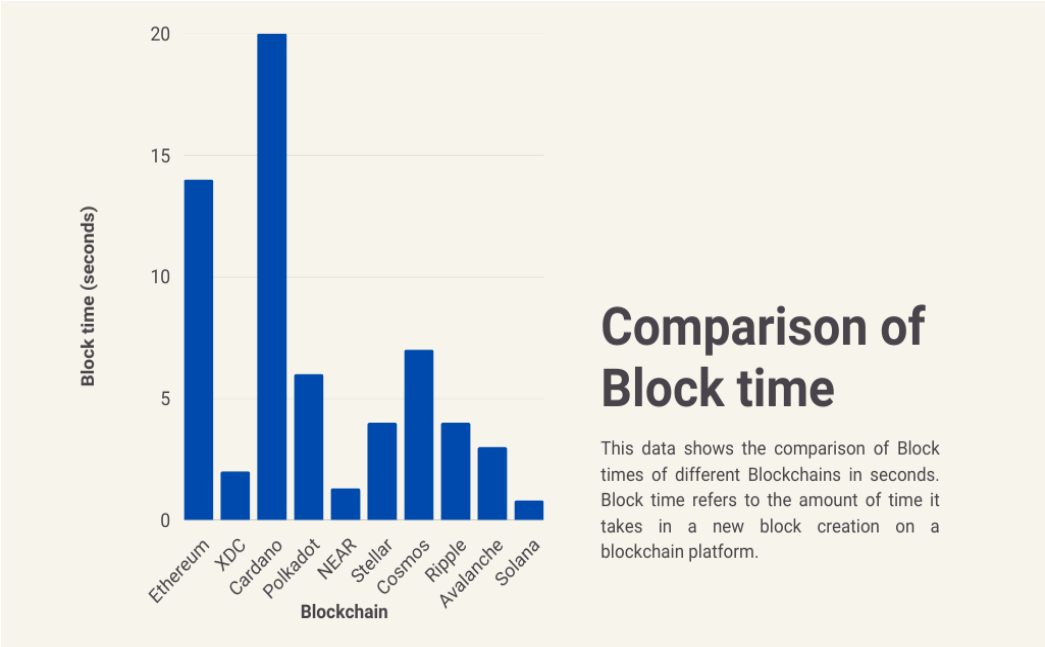

Figure 6-1: Bar Graph comparing block time of various blockchains.

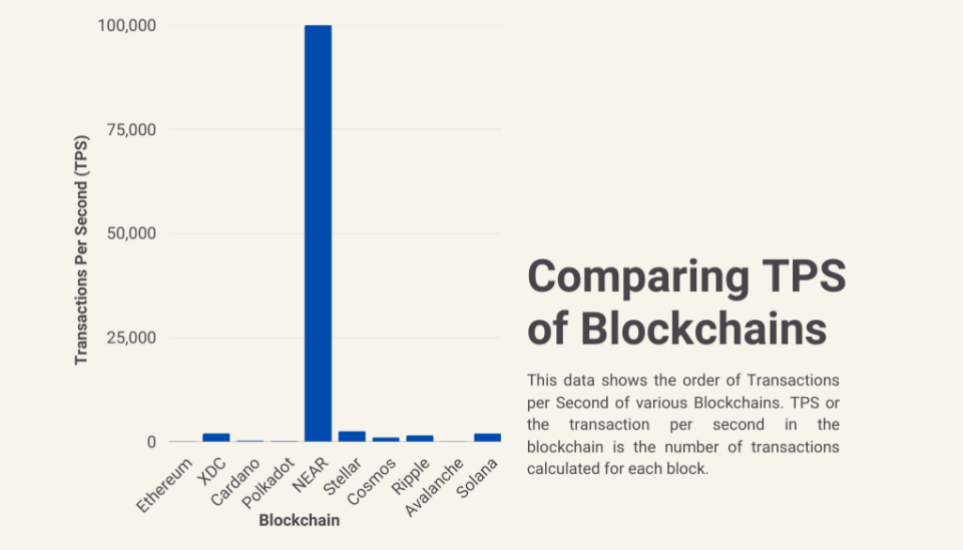

Figure 6-2: Bar Graph comparing TPS of various blockchains.

6.2 INTEROPERABILITY

Interoperability refers to the ability of different blockchain networks and systems to communicate and exchange data. Blockchain interoperability allows decentralized applications (dApps) to interact with multiple networks, access a wider range of resources and assets, and leverage the benefits of different blockchain platforms.

NEAR blockchain has a strong focus on interoperability, which means it has the ability to communicate and share data with other blockchains and systems. NEAR's interoperability approach is based on creating bridges to other blockchain networks, such as Ethereum and Bitcoin, using a mechanism called "Rainbow Bridge." This allows developers to access a wide range of assets and resources across different blockchain platforms, making it easier to build decentralized applications that can interact with multiple networks. By emphasizing interoperability, NEAR blockchain aims to create a more connected and accessible ecosystem for blockchain developers and users. This is the main reason for our choice of NEAR Blockchain.

6.3 ADAPTABILITY TO MARKET

We have implemented the Proof-Of-Concept for our product as of now. However, there is still a considerable journey ahead in making meaningful and sustained progress in a positive direction to make it a widespread successful product.

7 CONCLUSION

In this article, we presented the blockchain-based digital transformation of the billing ecosystem which is environmentally sustainable and gives many sought after features that are missing in

the existing paper-based and/or centralized digital billing systems. So developed paper-free blockchain based billing is at the MVP phase. To make a product that is truly adaptable to markets, it is essential to have a deep understanding of the target market. This understanding encompasses the target audience's demographics, needs, wants, and pain points.

By thoroughly researching and analyzing the target market, one can gain valuable insights into what makes their products unique and how they can better meet the needs of their target audience. Additionally, this research can also reveal gaps in the market that the product can fill, providing a clear direction for product development and marketing efforts. We are currently working towards scaling the current implementation and adding the category of users other than buyers and sellers.

While upgrading the existing MVP, our primary focus would be to incorporate user-centric accessibility and ease of use while maintaining and upgrading the technological backbone supporting it (as discussed in the last subsection). There is a well-established billing system architecture in place that caters to the varied needs of its users depending on assorted criteria like the size of the business, range of products, any other unique considerations, etc.

In the future, the vendor dashboard could have the option of maintaining a product database. A product database will be a collection of product information that the vendor is willing to offer to the customers. There will be an input through which the vendor can add a product's information.

Our Blockbill product has a base for more than one feature. First, each good/service in the billing-collection can have an associated *Product Id*, which can be input instead of the full name of the product and its price in the invoice, this can be further automated with barcode related mapping. Second, the product database can also be used to update the products directly for any price changes or even special offers and discounts associated with the product.

These changes will automatically reflect on the invoice when the product is scanned. We can also devise specialized systems that address the personalized demands of businesses, working with them to better understand their needs and providing them with a configuration that is tailored to their requirements. These are the functionalities that can be integrated into the present offering.

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