

TANDEM STRING

Precision In Every Pixel



1. Abstract

The innovation of blockchain technology since the start of the 21st century is nothing short of an ever evolving door. The essence behind blockchain technology revolves around trust in smart contracts which automatically implements, regulates, or logs events and actions. With the rise of public attention behind cryptocurrencies and non-fungible tokens (NFT), the idea behind decentralized computing grew rapidly for those aiming to confront the currency monopoly and emancipate money from regulatory oversight. The Bitcoin boom brought forth the popularity of an open-source market where the concept of decentralized finance (DeFi) attained tremendous popularity and market growth. Now, in 2024, the global crypto market cap is estimated at roughly \$1.73T, up from 1.5B 10 years ago and the global NFT market cap is estimated at roughly \$34.13B where it was first created 10 years ago. The craze behind blockchain technology is making waves in banking, healthcare, government, and supply chain management just to list the tip of the iceberg. Momentum must be seized with rapid market growth.

2. Blockchain and Barcodes

The key attributes of traceability and transparency are the backbone of blockchain technology. To include barcodes on the blockchain will make supply chain management

a more trustworthy and transparent process of a product throughout its life-cycle.

To express the value of barcodes on the blockchain the following example can be used: Advancements in food safety and traceability are incorporating blockchain technology tied to barcodes, particularly in the context of produce recalls due to bacterial issues. If there is an E. coli outbreak, grocery chains will have to throw away all produce that can be tied to the outbreak, but with blockchain technology, the produce is logged at every stage from harvest to market display. Once a problem is discovered, identifying and tracing impacted products can be achieved efficiently and with great precision and speed.

In addition to supply chain management, blockchain technology is a vital ally to identity verification, often tied to digital identity authentication. Blockchain technology is highly fraud proof. The concept in its simplicity, is that information is stored in blocks on a chain, each block receives a key known as a hash. Once a block is created it cannot be altered or changed, which characterizes authenticity to each block.

In order to leverage blockchain technology for a tangible identity verification process requires logging a barcode on the blockchain. When a barcode is logged on the blockchain it is given a unique key identifier. When a barcode is scanned, it must match its personal key. If a barcode that is not on chain is scanned it will not match any key, resulting in fraudulent barcodes.

3. Logistical Blockchain Solution

Tandem String is focused on using blockchain technology for tamper-proof product records, geolocation tracking for precise location accuracy, and continuous real-time tracking for efficient recalls. With the use of an immutable ledger, a product's barcode will be logged at every step of its life-cycle to retain complete transparency of supply chain management.

3.1 Tamper Proof Product Records

When a UPC code is logged on the blockchain it cannot be altered or changed. At the moment the barcode is scanned its geolocation is documented as well as the time, date, and product information. When the product is at point A it's scanned, when it's transferred to point B it's scanned again, so on and so forth providing a record at each point. This concrete track record is referred to as an immutable ledger. Data is organized into blocks, and each block contains a reference to the previous block in a chain-like structure. Each block's unique key ensures that changing the information in any block would require changing the entire subsequent chain, making it practically impossible to alter data without detection. This immutability is a principal aspect that enhances the security and transparency of transactions or information stored in the ledger.

3.2 Geolocation Tracking

When a barcode is affixed to the blockchain, every time the barcode is scanned it becomes logged as a block on chain. This immutable and time stamped record is constantly updated following a product's journey from its origin to its current location. Geolocation tracking adds an extra layer of contextual information, capturing the specific location where each scan occurs. Industries such as supply chain management, logistics, and retail can leverage this innovative system to precisely monitor the movement of goods, verify authenticity, and swiftly address issues such as recalls. The result is a secure, transparent, and verifiable record that instills trust throughout the entire life-cycle of a product.

3.3 Efficient Recalls

By employing blockchain technology for product tracking, companies gain continuous, real-time visibility into each item's location and origin. In case of a recall, this technology enables swift and precise identification of the location of each product slated for retrieval, enhancing operational efficiency and instilling confidence in the accuracy of the recall process.

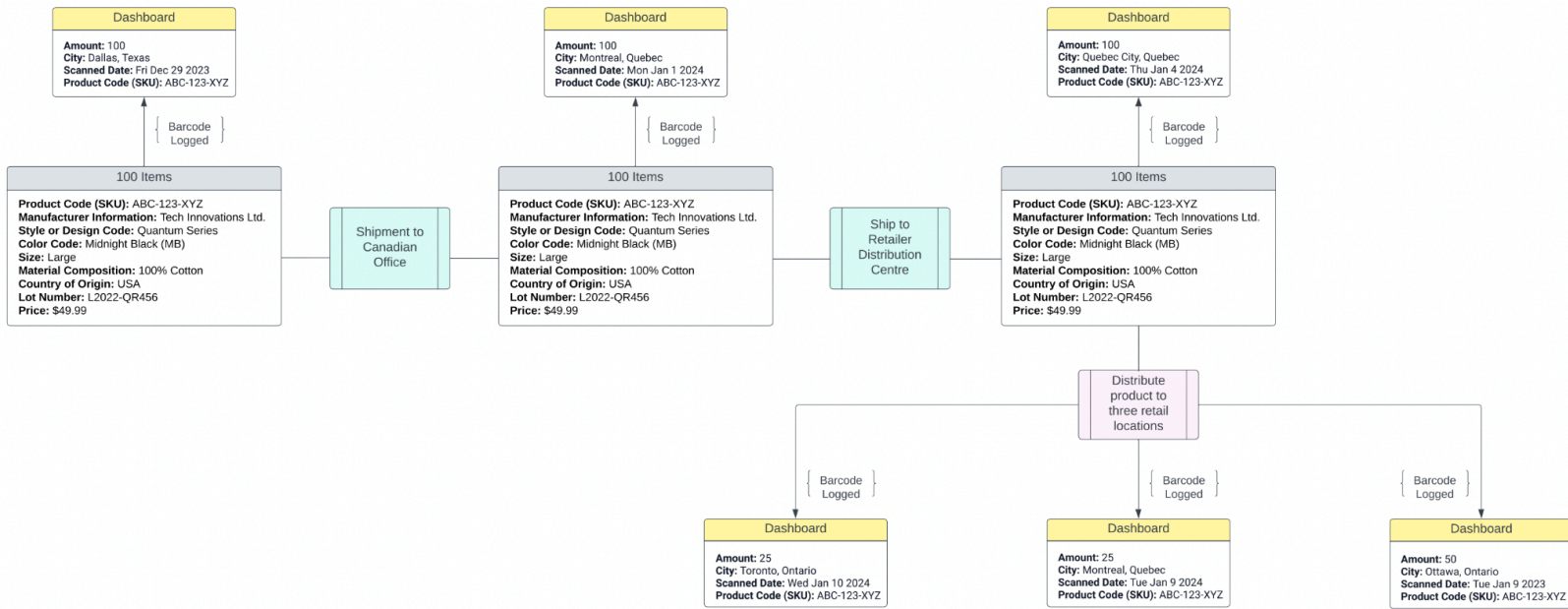


Fig.1. Traceability of Barcodes Throughout the Entire Product Life-Cycle

3.4 The User Interface Dashboard

Fig.1. is a simplistic visualization of product tracking when barcodes are linked to the blockchain. Starting at the product's origin, the barcode is attached to the blockchain and given a unique hash. Everytime the product changes locations the barcode is scanned, instantly creating a new block to the blockchain. The barcode is scanned and the information is uploaded to the dashboard.

To illustrate the integration of blockchain technology with the common UPC barcode, Tandem String uses the following format and example: *Note* The “Result” section refers to the 12-digit UPC number and the “Hash” is a unique key generated by the blockchain and not uploaded by the end user.

- **Result:**036000291452
- **Hash:**2548cc2004fdc08a3d64539b899b0ecf3773c551
- **Product Code (SKU):** ABC-123-XYZ
- **Manufacturer Information:** HACO
- **Style or Design Code:** Quantum Series
- **Color Code:** Midnight Black (MB)
- **Size:** Large
- **Material Composition:** 100% Cotton
- **Country of Origin:** USA
- **Lot Number:** L2022-QR456
- **Price:** \$49.99



4. Identity Verification

Identity document forgery is a self explanatory issue that has existed for over a century. Ultraviolet (UV) ink, holograms, physical engravings, microprint, and raised texts are all security features governments may employ on their driver's licenses to attempt to stay one step ahead of skilled counterfeiters. However, all features above are being used by counterfeiters daily and governments continue to fail at maintaining strict identity security. With a fake drivers license one can purchase alcohol or cannabis (in selected areas) underage, commit bank fraud, or even rent a home with peer-to-peer housing rentals on sites such as Airbnb and Vrbo, just to scratch the

surface of ways those using counterfeit driver's licenses can manipulate the law.

4.1 Tandem String Solution

All security features put in place by governments can exorbitantly be swept under the rug, if the PDF417 barcode on the back of the drivers license was concrete and non counterfeitable. Tandem String aims to integrate a unique key for every card holder. As indicated on Fig.2., when a barcode is scanned it must match the unique key in order to be verified. The unique key is private and is refrained from public viewership. Each unique key equals a barcode on chain.

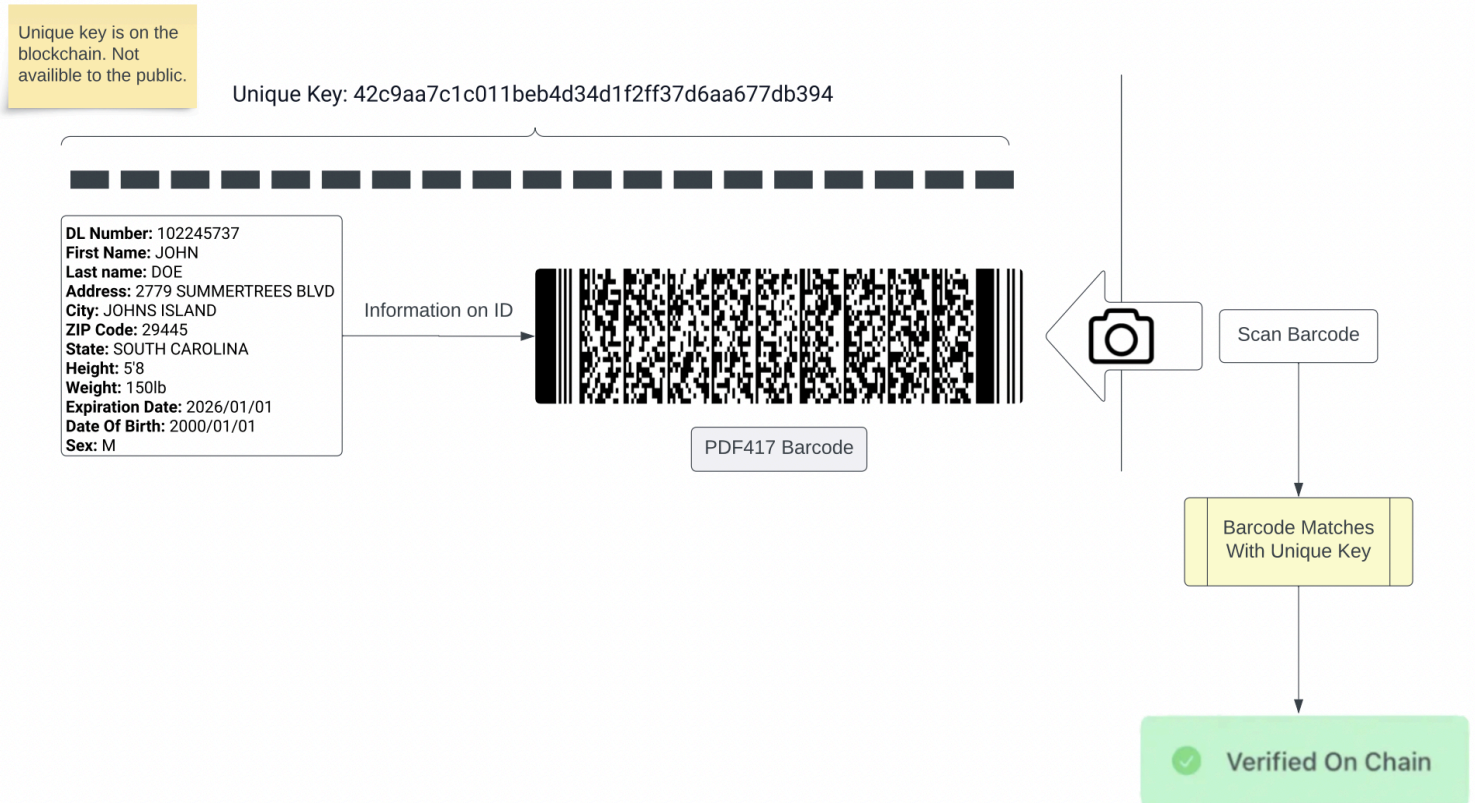


Fig.2. Identity Verification Process

4.2 Attempt To Counterfeit

When a counterfeiter creates a fraudulent barcode, they take the outline of a legitimate PDF417 barcode and then manipulate and encrypt the information they wish to embed within the barcode. In this context, the counterfeiter is exploiting the structure of the PDF417 barcode to insert falsified information. By doing so, they attempt to create a deceptive barcode that may look authentic at first glance but contains altered or entirely fabricated data.

Counterfeiters don't have access to the blockchain and can't align a made up key to the barcode. In order for the barcode to be verified it must match a key on the blockchain that was created by an authorized party. Counterfeit barcodes don't have a key to align with.

4.3 Safety Deposit Box Comparison

Our solution is similar to that of a safety deposit box. In regards to a safety deposit box, the box holder has a unique key (public key), when they open the box the bank's key must also be inserted (private key). The box will only open if both real keys are applied. In the case an imposter attempts to use a counterfeit key to open up someone else's box, it won't work since it won't match with the bank's key. Same goes for Tandem String's solution. A counterfeit barcode won't have the key to match with the unique key on the blockchain.

5. Both Solutions Go Hand-In-Hand

Serverless = Vercel

Serverless functions on Vercel can generate and validate barcodes, embedding identity information that is associated with unique identifiers stored securely on a blockchain through smart contracts. Its ability to run code on-demand without needing to manage infrastructure, provision servers, or upgrade hardware is a crucial step for logistical real time tracking and product management.

As devices scan barcodes, serverless application programming interfaces (APIs) on Vercel handle geolocation tracking, collecting and updating data on the blockchain. Vercel's auto-scaling capability effectively handles different traffic volumes, and blockchain's decentralized and cryptographic characteristics guarantee safe, transparent, and unchangeable identity and logistical data storage. Vercel's serverless architecture, blockchain technology, and barcodes come together to provide a scalable, affordable, and safe solution for geolocation tracking and identity verification.

Tandem String is built on the polygon chain using Layer 2 (L2) to enhance transaction flow rate and reduce fees. Tandem String is able to have faster and more cost-effective transaction processes through Polygon's architecture. L2 highlights a constant increase in scalability through a decentralized application (DApp). This L2 blockchain technology enhances the overall efficiency and user

experience of DApps on the Ethereum ecosystem.

Tandem String operates with 100% on chain code. This allows secure data and trust from users. With the use of L2 technology, Tandem String is able to use attainable fees to monitor all transactions. With the ability to scale at a quick rate Tandem String has the capacity to create side chains for all Admins. Each sidechain will have complete autonomy over all data in and out of their respective chains.

5.1 Admin Access Only

Barcodes can only be added via authorized sources, known as an ‘Admin.’ The Admin has the ability to add and remove barcodes, but the unique key is randomized by the blockchain and unchangeable. Admins can sign in with an email, MetaMask, Coinbase and WalletConnect, where all data remains on chain.

Each Admin can add as many barcodes as needed. Admin 1 does not have access to Admin 2, Admin 3...

The Admin dashboard can only be accessed by a specific wallet address (admin wallet), which is hardcoded for security reasons. Smart contracts are deployed on the Polygon network using Solidity with two functions: AddCode and RemoveCode. Only the contract owner (Admin) can call these functions.

The Admin in the logistical section can search based on date scanned and for information regarding the contents of barcodes. The Admin for the identity verification section can only add or remove barcodes, but for security of cardholders the Admin can not search for specific PDF417 barcodes.

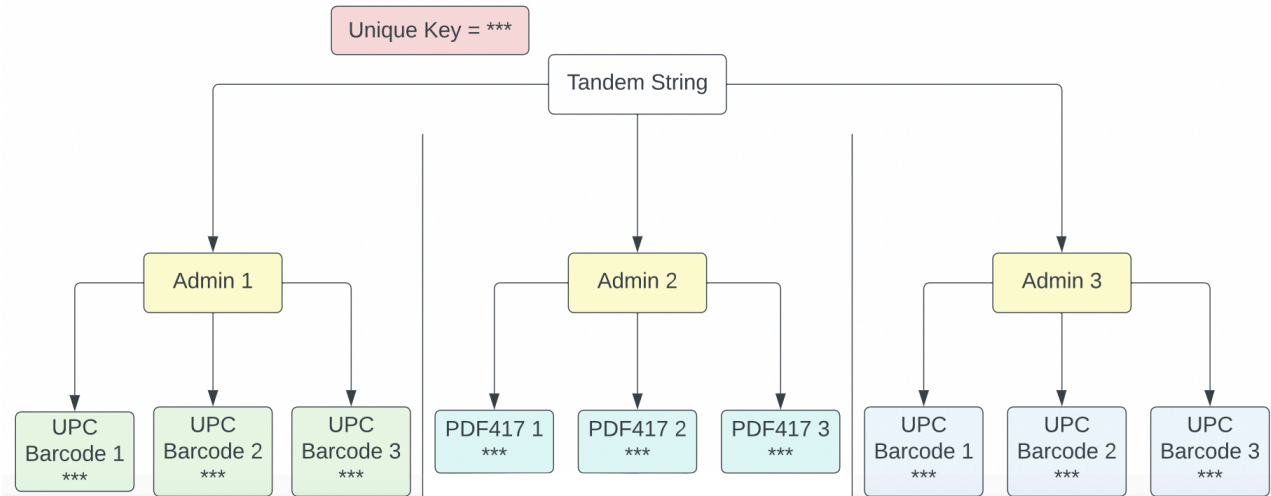


Fig.3. Tandem String’s Admin Process