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NUTXO: A Potent Transaction Tracing System using Centralized Block chain Model

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Abstract*: Currency refers to money in any form when in actual use or circulation as a medium of exchange, especially circulating banknotes and coins. Currency is a very important asset to a country. The existing system has some major flaws when it comes to tracking the amount being transferred between several parties. Such details can easily be tampered by a corrupt party in order to gain an unfair advantage. In our proposed system, each serialized currency note can be tracked end-to-end by introducing blockchain. Changes are updated by a trusted centralized party such as the RBI that issues the notes in India. Using blockchain improves privacy as the hash values are updated only by the aforementioned party and any other changes can easily be tracked down to the source which is the underlying principle of a blockchain.

***Keywords*: Currency, Tracking, Ledger, Privacy, Blockchain**

I. INTRODUCTION

The aim of this project is to minimize and/or eradicate corruption from our country.[18] Our goal is to track every currency note published by any central body that is responsible for the circulation of notes in a country.[5] Our proposition to achieve this is using Blockchain.[2][6][8] Blockchain acts as the decentralized ledger which will hold all the details regarding the transactions taking place in the system thus making it impossible for a third-party to edit the details.[5][7][8] Every currency will have a unique identifiable ledger and a block which will be referred on tracing back the journey of a particular note of the currency. With the use of Blockchain, we will be able to use and trace each every note of the currency which starts its journey from a Mint House to the last transaction that took place. All will be easily governed and tracked by the said trusted central body, therefore decreasing the chances of any sort of forgery or misconduct. [18]

A. Existing System

Certain reforms were put in place after November 8, 2016, when the Prime Minister, Narendra Modi, announced his demonetization policy as a measure to fight corruption and other monetary issues in the system.[13][14][15] This system includes the following policies:

- Put in place a reporting system to keep track of notes being released from currency chests.
- Banks advised to maintain, at the Currency Chest level and at link branches level, a Daily Record of Issuances showing the serial numbers of Mahatma Gandhi (New) Series banknotes in the denominations of Rs 500 and above received from RBI as remittance and issuance thereof to their own branches, branches of other banks and post offices, branch wise and denomination wise on daily basis.
- In order to facilitate identification of people abetting circulation of counterfeit notes, banks have been told to cover banking hall/area and counters under CCTV surveillance and have been told to record and preserve the recording.
- Banks have been told to preserve CCTV recordings of operations at bank branches and currency chests for the period from November 08 to December 30, 2016, until further instructions, to facilitate coordinated and effective action by the enforcement agencies in dealing with matters relating to illegal accumulation of new currency notes.

Demonetisation as a whole had a huge impact after it was implemented -- for good or for bad, that is subjective to one's opinion.

B. Proposed System

History of India's economy stands testimony to how an immediate change is the need of the hour, and a robust system with strong policies needs to be implemented as soon as possible.[11][12] Our proposition is to change the very roots of the currency we have been using so far. Taking some inspiration from the Prime Minister's policy of demonetization, our proposition is to attain serialization of every currency note using Blockchain.

The blockchain is a decentralized, growing list of records which are connected together using cryptography.[2] Each block contains the hash value of the previous block along with data and timestamp. This makes it a robust ledger of information which can be transacted among other users with proper verification.

Our motive behind implementing Blockchain is to maintain a ledger so strong and transparent that regulatory bodies will be able to track every single currency note circulating in the financial system. Implementing this system will be a Herculean task and will require a good amount of time, but once it is done the system will be self-sustained and will be able to do most of the work automatically.

Implementing this system will require the following:

- Serializing every currency note that is being published and being circulated (this has been further elaborated under Preliminaries).

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- Updation of existing bank balance in bank accounts.
- Allocating separate databases for serialized currency and bank account holders
- An efficient mapping system that can map transactions from one account to another and update the transacted information in both databases

C. Need for the Proposed System

The main motive behind this project is to make a significant impact in reducing corruption and scams. Corruption in India has had adversely affected our economy and growth as a country. Not only has it stunted our country's progress, it has also made the lives of citizens difficult by adding to factors like inflation, reduction in the value of Indian Rupee [12], increase in poverty, etc.

Some of the most infamous scams that have robbed the country of financial stability are:

- Punjab National Bank Scam of 2018 (13,600 crores) [13]
- Commonwealth Games Scam of 2010 (70,000 crores) [14]
- Indian Coal Allocation Scam of 2012 (1,85,591 crores) [15]
- Arms Deals Scam of 2012 (80,000 crores) [16]
- 2G Scam of 2008 (1,76,000 crores) [17]

These above-mentioned scams of such dastardly nature were only facilitated by the fact that there were no stringent laws put in place to keep a proper track of the amount of money flowing from the accounts of accused personnel. An argument could be put up saying that all feasible measures were put up by the concerned bodies to prevent scams of such nature but the frequency with which these scams occurred only goes to show that the measures taken were not robust enough.[18] Also, these scams do not seem to end. One could blame the Government for not enforcing proper protocols or not taking proper steps to ensure proper tracking of cash flow in the economy. This can be contradicted by the fact that the reforms brought about by the current Government seemed secure enough to not facilitate another scam. Much to the Government's dismay, the Punjab National Bank Scam did take place in 2018 even after implementing new measures and policies. [13]

What can be inferred from these never-ending scams is there are a lot of loopholes in the current financial system and a complete overhaul may be required to prevent such horrid cases of corruption from happening again. Implementing Blockchain to the current system not only has the potential to prevent corruption cases, but it can also provide transparency to regulatory bodies to track money properly to avoid any mishaps from happening. [7][8]

II. Related Work

A. "Bitcoin: A Peer-to-Peer Electronic Cash System"

Journal: metzdowd.com
Year: 2008

It has a decentralized ledger containing all transactions. The transactions are transparent, while the personal information is kept private. It is not widely accepted and requires a heavy computational power to mine. Wallets can be lost and the value fluctuates constantly.

B. "An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends"

Journal: IEEE Congress
Year: 2017

It utilizes consensus algorithms. Blocks with invalid transaction are discovered immediately. Transactions are easily verified. It does have an imperfect privacy due to intrinsic constraints, may also be victim to selfish mining.

C. "An Abstract Model of UTXO-based Cryptocurrencies with Scripts"

Journal: iacr.org
Year: 2018

It gives a good relation between abstract model and Bitcoin, as well as explaining the UTXO concept in brief. It gives an abstract model to showcase the working of UTXO-based currencies. Although, this concept is limited to crypto-currencies.

D. "Digi Locker (Digital Locker - Ambitious Aspect of Digital India Programme)"

Journal: GE-IJMR
Year: 2015

It ensures privacy and authorized access of the user for their Digital Lockers. It is a vast concept that has not been conceived yet at this scale for crypto-currencies.

E. "Ring Signatures: Stronger Definitions, and Constructions without Random Oracles"

Journal: iacr.org
Year: 2005

It uses the standard schemes and semantics of public key infrastructure. Also, it provides a strong anonymity guarantee. It showcases limited functionality and only supports rings of size-2.

Referring to the above papers, the existing system involves requiring a high computational power and is not widely accepted. There is a possibility of selfish mining especially in developing countries. The main issue with the current UTXO system is that it is limited to online transactions and crypto-currencies. Because of the aforementioned issues, we are proposing a system that overcomes these shortcomings and provides a robust platform.

Problem Statement

Corruption in India has increased drastically in the last decade and it has led to inflation, the rise in poverty, dramatic fall of the Indian Rupee, poor Foreign Exchange, etc. These grave consequences of corruption have also retarded the growth and development of our country[11]. Our aim is to minimize and eradicate corruption with this project and to also build a strong financial architecture which not only protects the privacy of every individual [6][7] but also helps in maintaining a private ledger of all the transactions that have taken place in its lifetime. [4]

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III. PRELIMINARIES

In order to implement our platform, the following pre-requisites help in understanding the Serialization of the currency as well as the existing UTXO Model.

A. Serialization

The Banks hold the serialization and legitimization of Money inflow and outflow. This involves the incoming of the unserialized currency to the bank, applying the SHA-3 algorithm and then storing the secured hash values to the Serial Database to further keep track of the currency. The currency may now exist in form of cash i.e., the serial will be updated in the digital locker of the user holding the said notes. It may also exist in the form of Bank's ledger balance that is now available to be withdrawn from banks and ATMs and subsequently get updated to the digital locker of a new user.

Further, the functions taking place before updating the hash values to the Serial Database can be made possible by using the following algorithms for making the transactions accountable and traceable throughout.

B. Unspent Transaction Output (UTXO) Model

Unspent Transaction Output or UTXO Model is used in Bitcoin to calculate the amount of Bitcoins a user has their wallet. [1][3]

To understand how UTXO facilitates the calculation of the unspent amount, it is important that we understand the structure of such transactions first. Fig. 1 depicts the steps involved in a UTXO based transaction.

Fig. 1 UTXO Transaction

a) Version

This step assigns a version number to the transaction(s) that will take place.

b) Input Counter

The main motive of this step is to check the number of Bitcoin inputs in the payer's wallet. For example, Bob has 5 BTC in his wallet. This step will count how many Bitcoins are there in Bob's wallet that amount to 5 BTC.

c) Input

In this step, all the inputs from the payer's wallet are locked and the transaction takes place. The inputs are then debited from the payer's account.

d) Output Counter

Similar to Input Counter, this step checks the number of inputs received from the payer. The output count should match the input count.

e) Output

From the outputs received, the amount that was supposed to be transferred is credited into Payee's account and the remaining outputs are then credited back to the Payer's account. For example, Bob is supposed to pay Alice 2 BTC. Bob's 5 BTC are then debited from his account and 2 BTC are credited to Alice's account. The remaining 3 BTC are then credited back into Bob's account.

f) Lock Timestamp

The transaction is then appended with a timestamp and is then locked. This marks the end of a transaction.

IV. PROPOSED ARCHITECTURE

Fig. 2 depicted below illustrates how the proposed system handles transactions. The trusted centralized party such as RBI would hold the system to check and verify balance that also involve transactions using NUTXO. It would track the flow of currency using the system. It would govern over the primary components i.e. Digital Locker, Serial Database, and NUTXO Database.

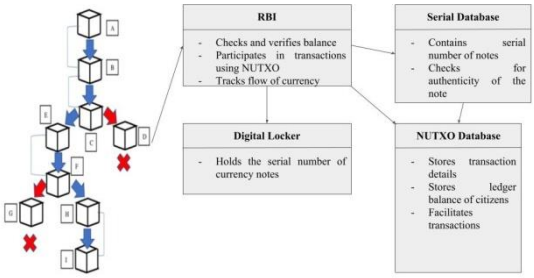

Fig 2. System Architecture

The Digital Locker holds the serial number of the currency notes that exist in form physical currency with the legitimate owner. Serial Database holds the record of serial numbers of notes, as well as checking the authenticity for an incoming note. The NUTXO database is a buffer that holds the transaction details using the unspent amount. This unspent amount is calculated each time using virtual transactions as well as those which affected the physical currency in Digital Locker. It facilitates transactions and stores unrecorded exchanges after authenticating them. The modules of this proposed architecture are explained below.

A. NUTXO System

NUTXO stands for New Unspent Transaction Output which is the proposed system to enhance the existing UTXO system. The existing UTXO system for real-time tracking and storing of unspent transactional information is restricted to virtual exchanges. We are proposing a system to integrate the existing platform to also handle transactions having Physical sources. This can be done by tracking the serial numbers of the currency involved in the transaction to the NUTXO database. Further, these serial numbers from digital lockers can be linked to any further transaction taking place regardless of it being Virtual or Physical i.e. linked to a digital locker.

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B. Balance Check

The RBI is responsible for preliminary checking of the user and the balance. Refer Fig. 3. This involves legitimizing sources of transactions leading to the current balance. Also, it involves using NUTXO database as a reference for the previous transactions that have or have not been locked as transactional inputs and outputs. It includes combining the digital lockers having information on serial numbers of the pre-existing notes with virtual transactions. The following notations illustrate how this transaction takes place:

NUTXORecord → Record of previous transactions in the NUTXO Database
Bal(User) → Balance of User
DigitalLocker → Ledger containing information of cash in the user's wallet
$NUTXO_{user}$ *→ New Unspent Transaction Output*
init(transaction) → Initializes Transaction
A,B → Participants
t1, t2.....tn → timestamps
$sign_k^i$ *→ Transaction Signature*
Blockchain → (T_i, t_i)
T → Transactions

User(Owner) {
if(NUTXORecord) {
Bal(User) = DigitalLocker + $UTXO_{user}$
init(transaction) = request[Bal(User)] }
$NUTXO[A(T_i, t_i), sign_k^i]$
else
TxnHistory = ver($UTXO_{user}$*)*
init(transaction) = request[Bal(User)] }
$NUTXO[A(T_i, t_i), sign_k^i]$
}

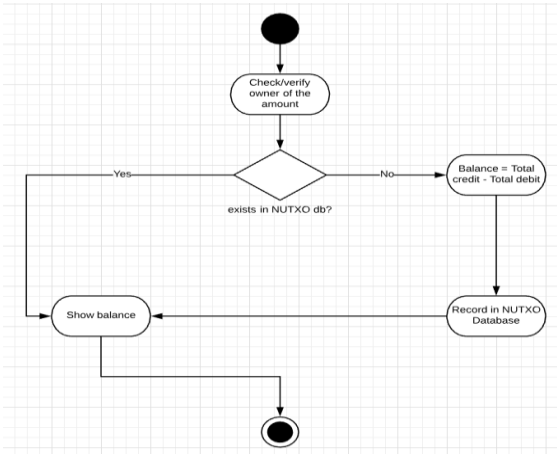

Fig. 3 Balance Check (Activity Diagram)

C. Transactions

Currency in transactions exists as Physical (Cash) or Virtual. Any transaction that a citizen makes will be of the following kind:

- Cash-to-Cash— The user must notify in real-time to update the serial numbers of the currency he has in form of cash to the bank. Refer Fig. 4. When the user decides to undertake a cash-based exchange further, the user must notify the bank to update the digital locker regarding him undertaking the same to some other party. Here, the NUTXO stores in its database the transaction affecting the digital locker of the user as well as the unspent transaction i.e., in case a change is issued during the transaction, the serial of those new notes are updated as the unspent transaction to replace the current in the digital locker.[4] The following notations illustrate how this transaction takes place:

Payer → Person who is going to deposit money
Payee → Person who is going to receive money in their account
$v_{i...n}$ *→ Value of currency being deposited*
DigitalLocker → Ledger containing information of cash in the user's wallet
CashTxn → Cash Transaction
update, delete → Update, Remove in DigitalLocker

Payer(Payee, $v_{i...n}$*) {*
init(CashTxn)
DigitalLocker(Payer, $v_{i...n}$*) {*
delete($v_{i...n}$*) }*
Payee(Payer, $v_{i...n}$*) {*
receive(CashTxn)
DigitalLocker(Payee, $v_{i...n}$*) {*
update($v_{i...n}$*) }*

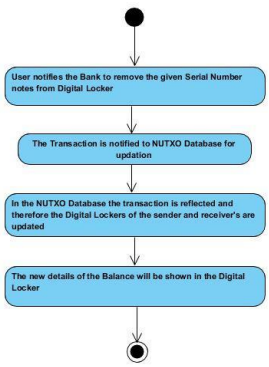

Fig. 4 Cash-to-Cash (Activity Diagram)

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- Virtual-to-Virtual— The currency that exists in a Virtual form stores its data about transactions and user balances in the form of unspent transaction outputs (UTXO): a list of "unspent" amounts that have been sent to a user but not yet sent from him/her. The sum of these outputs is the user's total balance. Refer Fig. 5. On the blockchain, they appear to be a collection of amounts on different addresses, and the role of a wallet is to identify which addresses the user has keys to. Individual amounts are easy to track because they are signed from one person to another. A transaction is valid if one can prove ownership over the actual amount the user is trying to send. Furthermore, in case a Physical transaction is a source to the amount being transferred virtually in the current state, the transaction can be directly linked to the time when the digital lockers had been unlinked during the Cash-to-Virtual transaction. The following notations illustrate how this transaction takes place:

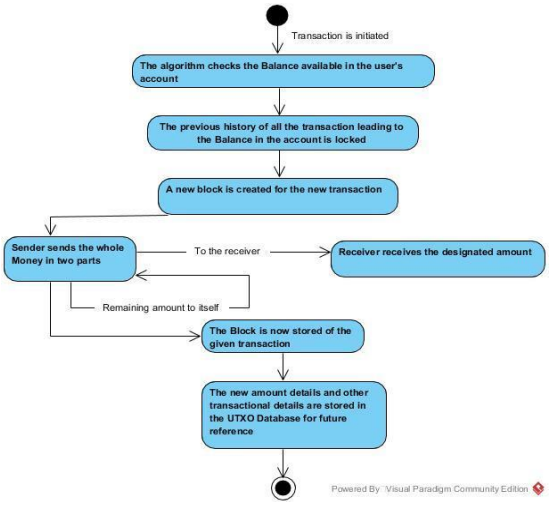

Fig 5. Virtual-to-Virtual (Acitvity Diagram)

$A,B \rightarrow$ Participants

$t1, t2.....tn \rightarrow$ timestamps

$v, v' \rightarrow$ currency values

$Sign_k^i \rightarrow$ Transaction Signature

$ver_k(\sigma, T, i) \rightarrow$ Signature Verification

$Blockchain \rightarrow (T_i, t_i)$

$T \rightarrow$ Transactions

$\sigma \rightarrow$ Signature Vector

$i \in N \rightarrow$ Natural Numbers

$DM \rightarrow$ Data Miner

$NUTXO \rightarrow$ New Unspent Transaction Output

$KI \rightarrow$ Key Image

$\lambda \rightarrow$ Expression for Block

User(Sender A){
Access Wallet
Balance Checking
Initiates Transaction
DM(walletInfo, UTXO, TransHistory)
}
DM(){
Wallet Info Accessed
$Bal(User) = DIgitalLocker + UTXO_{user}$
$TransHistory = ver(UTXO_{user})$
if(send(amount)<= Bal(User){
initTransaction
}
$NUTXO(B(T_i, t_i), ver_k(\sigma, T, i), sign^i_k)$
}
$NUTXO(B(T_i, t_i), ver_k(\sigma, T, i), sign^i_k)${
$In.\ \lambda \Rightarrow B(T_1, T_2 .....T_i)$
$for(T_1\ to\ T_i)$
$ver(KI_T)$
$if(KI_T == KI_{Ti})${
return false
$Stack(T_{i-1})$
exit(1)
// Key Image Matches to the transaction at i^{th} *place*
} else{
return true
}
$out.\ versign(\sigma_A, T, i)${
$if(true){$ *init(newTrans)*
}
$sign^i_{kA} \Rightarrow KI_{gp}$
$Unspent = Bal(A) - amount(T_A)$
$T_{AB} \Rightarrow in.\ \ (T_A, amount)$
$Signature(K_A, K_{gp}, T_{i+1})$
$in.\ (T_A, amount, K_{gp})$
$(T_A, unspent, K_{gp})$
$out.\ T_{AB}\ (T_B, amount, K_{gp})$
$T_A(T_{i+1}, t_{i+1})$
$T_B(T_{i+1}, t_{i+1})$
$T_B\ (newBal(amount + Bal(B)))$
$T_{AB} \sim> T_A \Rightarrow T_B$
$Bal(A) = unspent(T_i)$
}
}

- Cash-to-Virtual— In this type of transaction, following cases will be looked into;

The Currency that is being converted into virtual form will be serialised and stored in the database, in the case where they haven't been on the record yet. Refer Fig. 6. In case the currency has been serialized and legitimized already, the existing record for those notes involved in the transaction is removed from the digital locker and the notes now belong to the Bank's ledger balance. While the currency in form of Physical notes now belongs to the bank, the amount of the said notes will be updated to the directed account in the Virtual form. Since the digital locker linked to the serial of these notes is now unlinked, these notes can now be transacted out and linked to some new digital lockers. The following notations illustrate how this transaction takes place:

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Payer → Person who is going to deposit money

Payee → Person who is going to receive money in their account

$v_{i...n}$ *→ Value of currency being deposited*

Bal(Payer) → Balance in the Payer's wallet

DigitalLocker → Ledger containing information of cash in the user's wallet

TxnHistory → Transaction History

ver(DigitalLocker) → Verification of DigitalLocker

InitDeposit() → Initiates Deposit

Payer(Payee, $v_{i...n}$*) {*
WalletInfoAccessed
Bal(Payer) = DigitalLocker
TxnHistory = ver(DigitalLocker)
InitDeposit($v_{i...n}$*)*
DigitalLocker(Payer, $v_{i...n}$*)*
}
DigitalLocker(Payer, $v_{i...n}$*) {*
delete($v_{i...n}$*)}*

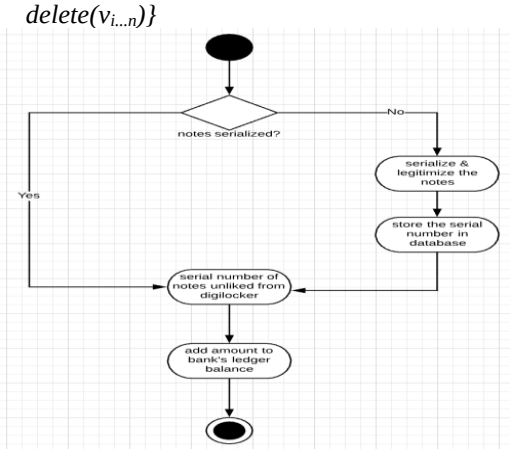

Fig. 6 Cash-to-Virtual (Activity Diagram)

- Virtual-to-Cash— The Bank will assign the designated serial numbers of notes of the amount being withdrawn and simultaneously update the same in the digital locker for accountability of the given amount and notes. Refer Fig. 7. This real-time updation as soon as an amount is transacted out helps keep track of notes in circulation. Also, the withdrawn notes are linked to the previous transactions leading up to it i.e., a physical source that could've deposited an amount to the account or a virtual source that could've transferred that amount via bank transfer. In any case, only the amount being withdrawn in form of notes is stored in digital locker using its serial number. The NUTXO database stores separate transaction information about the unspent i.e. remaining balance in the account. The following notations illustrate how this transaction takes place:

Debitor → Person who is withdrawing money from their account

v_n *→ Amount being debited*

Bal(Debitor) → Account balance of the Debitor

$NUTXO_{Debitor}$ *→ NUTXO Database of the Debitor*

TxnHistory → Transaction History

ver($NUTXO_{Debitor}$*) → Verification of the Debitor's NUTXO Database*

debit(v_n*) → Withdraw amount* v_n

InitDebit() → Initiate Withdrawal

update() → Update in the Debitor's DigitalLocker

Debitor(v_x*) {*
Bal(Debitor) = $NUTXO_{Debitor}$
TxnHistory = ver($NUTXO_{Debitor}$*)*
if(debit(v_x*)* $\leqq$ *Bal (Debitor)) {*
InitDebit($v_{i...n}$*)*
}
}
DigitalLocker(Debitor, $v_{i...n}$*) {*
update($v_{i...n}$*)*
}

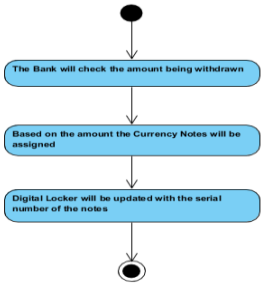

Fig. 7 Virtual-to-Cash (Activity Diagram)

D. Challenges

Our proposed system cannot factor in coins as currency because coins do not come with any indicators that could give them a unique identification and accommodate them within our system.[20]

V. RESULT AND DISCUSSION

This results in the active and prominent use of Blockchain in our system. The involvement of the Blockchain holds the key factor is completing all the transactions. The transactions are carried out using the given processes in the above explanation, this ensures that the currency whether it be physical or virtual can be tracked to the utmost point.

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This way the given system can be utilised to maintain a track of all the transactions throughout and hence ruling out the condition for any fraudulency. As physical currency is the major source of conducting any fraudulent activity, this system ensures different transactions involving any physical currency traceable and recording of the transactional details and credentials is taken to recover from any possible mislead.

VI. FUTURE AND CONCLUSION

The model of tracking currency using blockchain has a vast future. This system can include the exchanges of coins along with notes once a significant level of technology is evolved to accommodate the transactions. Developing countries, where the rate of corruption is high may be encouraged to adopt this system to keep track of their currency. If multiple countries adopt this system, it can accommodate users to make international purchases easily and more securely. This system can also accommodate eWallet of various big tech-companies in the future. In that case, any transaction taking place from regular currency to the specific eWallet currency may also be tracked. This proposed system is more secure, transparent and robust in terms of monetary transactions as opposed to the prevalent system which has numerous loopholes which can be easily exploited while not getting detected until it is too late.

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