Transforming Government banking by leveraging the potential of blockchain technology

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Abstract

Finance is the backbone of any Organization. Government is no different. The financial health of the Government is critically dependent on the efficiency with which its banking needs are managed. The Central Bank is generally the banker to the Governments. In India, Reserve Bank of India and Government have been in the forefront of implementing various reforms to strengthen and streamline the processes involved in tax collections and transfer payments. Despite these reforms, some issues still persist and are having detrimental effect on overall efficiency of Government banking. One important factor for existence of these issues is the fact that every government transaction has to pass through a long chain of stakeholders before it is accounted with finality. Blockchain technology is an emerging technology that promises to facilitate speedy and efficient collaboration among all the stakeholders and also facilitates disintermediation to the extent possible. Further, during the crisis like situations (floods, earthquakes or COVID 19 like pandemics), immediate relief is of utmost importance and government aid should reach the vulnerable/affected citizens at a very high speed. However, it is during these stress times that physical access to banking channel gets restricted. Blockchain can facilitate decentralization of last mile delivery channel, by enabling peer-to-peer and cashless transactions even among the unbanked population. This paper identifies the current issues in Government banking ecosystem, analyses the root causes behind such issues, introduces Blockchain based distributed ledger technology, examines the extent to which this emerging technology can address such issues and describes the way forward.

Keywords Blockchain technology · Transfer payments · Central Bank Digital Currency · Government banking · Public finance management · Distributed ledger technology

1 Introduction to existing Government banking arrangement and the current issues

- (a) Like any other company or individual, Governments require a bank to carry out their banking activities. The Central Banks of respective countries extend banking services to the Government. In case of India, RBI provides these banking services to the Government. In order to meet their banking needs, Central Government ministries/departments and State Governments maintain bank accounts at RBI (RBI's Core Banking Solution). Governments are expected to maintain minimum balances in such accounts and RBI provides short-term interest-bearing advances (Ways and Means Advances) to the Governments, to meet temporary mismatches in their receipts and payments. At the same time, RBI also arranges for investments of surplus cash balances of the Governments.
- (b) In addition to Central Bank, some commercial banks are also appointed as agents to undertake Government transactions on behalf of Central Bank. Such Agency banks are compensated for the costs involved in providing the agency services by way of agency commission.
- (c) Major issues effecting the efficiency of Government banking operations are listed below:
 - (i) *Government funds float and interest loss*: Under the existing system, interest has to be borne by governments for shortage of cash balance in the account maintained at Central Bank at the end of the day, while at the same time the government funds may lie idle at

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intermediaries such as accounts of agency banks (pre-funded schemes), Project Offices, autonomous bodies etc.

- (ii) *High costs*: Transactional costs are very high as it involves lot of paper movement (scrolls, passbooks etc.), reports exchanges, reconciliation costs etc. In case of India, as per the RBI annual report 2019, agency commission paid for intermediaries is around ₹ 38 billion for the year 2018–19 alone [1]. In addition to this, other costs are also incurred by Central Banks and Government systems for maintaining their respective systems and payment system related costs.
- (iii) *Reconciliation issues*: Presence of multiple entities in life cycle of a government transaction necessitates reconciliation. Government Treasuries/PAOs, agency bank branches, DTAs/Finance Departments, Agency bank link Offices/Focal Point branches, central bank and finally Accounting Authority's Office are all involved at different stages before a transaction reaches its finality. The reconciliation is, currently, a post-facto exercise (i.e. post accounting) and is done at multiple places and the discrepancies are resolved through operationally complex processes such as exchange of Memorandum of errors (MoEs), raising error scrolls and passing rectification entries.
- (iv) *Delays in credit of receivables to the Government account*: The delay refers to the time elapsed between the debit to the tax payers bank account to the credit to the respective Government's account maintained at Central Bank. This delay is primarily because of the fact that the transaction has to flow through multiple entities in its life cycle.
- (v) *Dependency on the banking channel*: In several Government aid programs, the benefits are routed through the bank accounts of the eligible beneficiaries. However, as per the "The Little Data Book on Financial Institution 2018" by World Bank, only 67% of the adults (age > 15 years) across the globe have an account with Financial Institution. 13% of the accounts are inactive. Among those active, digital transactions account for only 52% [2]. While Governments across the globe are promoting financial inclusion to migrate unbanked population to banked, a considerable percentage of accounts are inactive. In such situations and especially during the crisis like situations (pandemics, floods and other disasters), when the physical access to banking channel gets restricted, the ability of the government to disburse government aid to provide immediate relief gets limited.
- (d) Most of these issues are a result of presence of intermediary agencies, retrospective reconciliation techniques and the limited applicability of just-in-time payments.

In subsequent sections, it would be examined if blockchain based distributed ledger can help solve these issues.

2 Blockchain based distributed ledger technology: definition, benefits, characteristics and types

2.1 Definition and nature

Blockchain technology is still an emerging technology and as on date, there is no standard/formal definition. The innovation is more in the way several existing technologies are combined than on the technology itself. Well established technologies such as Cryptography, digital signatures, Hashing techniques, TCP/IP and peer-to-peer networking protocols are uniquely combined to arrive at what is described as blockchain or distributed ledger. Distributed ledger, from the functional perspective, can be referred to as a decentralized database where in all the stakeholders of the network maintain and control a copy of the same synchronised ledger. New records can be added to the ledger only if the stakeholder's nodes are in agreement i.e., after the consensus is reached among the nodes. Blockchain based distributed ledger can be better understood from its features.

2.2 Key features of blockchain technology

- (a) *Distributed database*: Unlike in centralized setups, all the peers/nodes (stakeholders) maintain a copy of the ledger and updates are possible only after consensus is achieved among the peers. This facilitates collaboration among the pre-determined stakeholders in a much more efficient manner.
- (b) *Peer-to-Peer*: The transactions that update the ledger are peer to peer without the need for intermediaries.
- (c) *Smart contract driven*: Smart contracts contain the business logic (e.g.: transaction validation logic, consensus logic, reconciliation logic etc.) and are deployed on to the pre-determined nodes. Such contracts are immutable i.e. cannot be unilaterally changed by any stakeholder(s).
- (d) *Append only*: The transactions once added to the distributed ledger cannot be modified. For modifications, new transactions have to be proposed and would get committed only after consensus. In other words, there is no possibility of "back-end corrections" of already put-through transactions.
- (e) *Highly secure*: The transactions are combined into blocks and newly generated block of transactions is cryptographically linked to previous block using Hash algorithms and therefore cannot be tampered with by

malicious actors(internal or external). Unlike in centralized architecture, there is no single point of failure and therefore there is no single place for attackers to target.

- (f) *Transparent*: The ledger is transparent as it is decentralized and is visible to all the stakeholders. The transparency can, however be controlled. In other words, transactions relevant to a set of stakeholders will only be visible to those stakeholders while other stakeholders will not be able to view them.

2.3 Key benefits of blockchain technology

- (a) *Instant settlement*: The transactions are peer-to-peer and different stages of a transaction in the existing centralized architecture i.e. authorization, clearing and settlement can all be combined into one step which is settlement. Such settlements can be instantaneous mitigating the counter-party risk.
- (b) *Instant reconciliation*: The transactions get recorded only after consensus is achieved among the stakeholders ie in essence the transactions are reconciled first and only then accounted/settled. Such reconciliation driven by consensus mechanism can be instantaneous.
- (c) *Reduced costs*: The role of intermediaries is virtually eliminated and so is the time and cost consumed by such intermediaries in processing the transactions. Further, even in situations where intermediaries' presence cannot be removed, the whole process becomes transparent and therefore the ability to monitor the intermediaries' activities increases significantly.
- (d) *Fraud proof*: As the decentralized ledger cannot be modified without consensus among all the stakeholders, no unauthorized entries can be done to the ledger.
- (e) *Transparency and auditability*: The distributed ledger copy is available with all the participants making the system very transparent and audit friendly.

2.4 Types of blockchain technology

Over a period of time, to meet different use cases, various variants of blockchain ledger have been introduced, in terms of the extent of decentralisation and/or openness:

- (a) *Permission-less public blockchain ledger*: No centralized authority, anyone can join the network and everyone can view all the transactions.
- (b) *Permissioned public blockchain*: Access is restricted to only those who are pre-selected or pre-determined based on some criteria such as KYC. However, read-only access to all the public subject to meeting certain eligibility criteria.
- (c) *Permissioned private blockchain*: Accessible only to a certain group of participants and the transactions privacy is also ensured.

The choice of the model can be based on the use case and the need for regulation (Table 1).

2.5 Can blockchain be controlled/regulated?

Owing to its anonymous, decentralized and peer-to-peer nature, it is sometimes believed that the blockchain cannot be regulated. However, it is only a myth as the extent of anonymity and decentralization can be controlled and necessary regulation can be enforced. The distributed ledger can be regulated and the extent of regulation depends on the type and architecture of the blockchain model deployed. Governance of a blockchain can be decided prior to implementation and the rules such as who can access the distributed ledger, who can participate in the consensus, what is the role/responsibility of each peer, action to be taken on malicious/compromised peer, extent of transparency etc. can be predefined.

3 Application of blockchain technology to Government banking ecosystem

3.1 Approach

- a. Different approaches can be followed to implement the blockchain solution. The decision parameters generally include who should be part of the network, who should validate the transactions, who can access the distributed ledger, privacy and access restrictions.
- b. One good approach would be to build a blockchain layer on top of the existing infrastructure rather than

Table 1 Major differences between public and private Blockchain

Item	Public	Private
Identity	Anonymous	Known, i.e., KYC verified
Participants	Anyone	Authorized only. Membership is controlled
Transparency	All transactions visible to everyone	Access control based on role (privacy)
Through put	Slower	Faster

build from scratch. Such an approach would be least disruptive and cost effective as well. Accounts can be created for every stakeholder on the distributed ledger. The Government Stakeholders can connect to the blockchain network from their existing applications such as PFMS or treasury portals. Identity of the Government accounts can be ensured through cryptographic keys and digital signatures, while the accounts of the citizens can be linked to their unique Government issued ID (such as Aadhaar) or biometrics. Since the transactions are peer-to-peer, the intermediary agencies such as commercial banks, payment aggregators can be avoided in the network.

- c. The distributed ledger should be accessible only to pre-approved stakeholders and the transactional data should be private to the parties involved in the transaction. Therefore private permissioned blockchain is more suited to our use-case. In permissioned blockchain, only pre-determined stakeholders can submit the transactions, while other stakeholders can validate them. Following are the advantages of the private permissioned blockchain compared to other types:

- (a) *Speed*—Transactions can get validated very fast compared to public blockchains.
- (b) *Scalability*—The blockchain can be easily scaled for adding new peers or nodes.
- (c) *Latency*—The time taken between initiation of a transaction and its execution is also less.
- (d) *Privacy of the transactions*—i.e. only the concerned parties can see the transactions.
- (e) *Restricted access*.

3.2 Network and participants

A Government transaction flows through multiple stakeholders before it is accounted with finality. Apart from citizens (tax payers/citizens) these stakeholders include the treasuries, accounting Office, audit bodies, banker to Government (Central Bank) and agency banks. The key participants of the network can operate the full nodes i.e. nodes that store the distributed ledger and are also part of the consensus mechanism. For example, they can include (Fig. 1):

- (a) *Government treasuries*—Who initiate payment transaction or receives tax payment.
- (b) *Accounting authorities (e.g.: AG's Office)*—Who prepares and reconciles the accounts.
- (c) *Audit bodies*—Who audit the transactions.
- (d) *Central Bank*—Where the bank account(s) of the treasury(s) are maintained.

Fig. 1 Sample Blockchain network—Government banking ecosystem

The citizens at large can access their accounts on blockchain by connecting to blockchain through authorized middleware Mobile/web applications.

3.3 Smart contract and distributed ledger

A copy of the distributed ledger is maintained by every stakeholder described above. It essentially can include two things—(a) list of all validated transactions and (b) current state—i.e. account balances. Each transaction can contain details such as sender, beneficiary, amount, transaction ID or Challan ID etc. A sample distributed ledger can be as described in the diagram below (Fig. 2).

Smart contract is also deployed on top of every node operated by each stakeholder. The smart contract essentially is the business logic for validating the transaction. Such validation can include if the sender has sufficient balance, beneficiary details are valid, challan ID is valid etc. Such validations can be done by validator nodes in an automated fashion as the copy of the distributed ledger is available with them. New transactions gets added to the ledger only if all the stakeholders successfully validate the transaction i.e. after consensus is achieved.

3.4 Transaction process flow

- (a) Transactions can be proposed by Government treasuries or the tax payers. Such transaction can be Government to Government (G2G), Government to Citizen (G2C), Citizen to Government (C2G) and Citizen to Citizen (C2C).
- (b) The transaction is first proposed by the concerned stakeholder node (e.g.: Treasury in case of G2C) and the same is broadcasted to all the other validators nodes. All the validators nodes execute the smart contract and validate the proposed transaction. The successfully validated transactions gets grouped into a

Sample Distributed Ledger					
From(ID)	To(ID)	Amount(Rs)	Trans. Type	Bill/Challan No.	Timestamp
Treasury 111	<<Aadhaar No.1>>	3000	Scholarship payment	x123y	10-04-2019;12:00:17
Treasury 111	<<Aadhaar No.2>>	2000	DBT Schme XYZ	x456y	10-04-2019;12:01:10
Treasury CG1	Treasury 222	2000000000	Inter-Govt. Transfer	y789z	10-04-2019;12:02:13
<<Aadhaar No.7>>	<<Shop.ID. 123>>	300	PDS Cashless Transfer	z1011a	10-04-2019;12:03:09
<<Aadhaar No.11>>	Treasury 111	2150	Tax Payment	C1234ID	10-04-2019;12:04:19

Fig. 2 Sample distributed ledger

- block and the block is cryptographically linked to the existing blockchain. The will also update the distributed ledger at all the stakeholders. At the same time, the off-chain databases can also be updated using API calls, to be in sync with distributed ledger.
- (c) In case of tax payment, since the tax payer is not part of the network, the concerned beneficiary treasury can initiate the transaction on behalf of the tax payer. Tax payer can follow the usual procedure to create challan number etc. in the concerned treasury portal or through mobile/web application interface to the blockchain. Subsequently the concerned treasury node can propose the transaction to blockchain network.
- (d) The process flow essentially includes following steps:
- Transaction creation*: By any of the stakeholder nodes.
 - Transaction broadcast to all the other nodes in the network.
 - Transaction validation*: By all the validator nodes along with timestamp.
 - Transaction grouping into block*: Consensus mechanism triggers and all validated transactions are chronologically grouped into a block.
 - Block of transactions is broadcasted to all the stakeholders nodes and the same gets cryptographically linked to existing blockchain, i.e., distributed ledger.
 - All the nodes sync and update their copy of distributed ledger. Concerned nodes trigger off chain accounting for updating their legacy systems.

For instance, the transaction flow for a government transaction is depicted in the below diagram (Fig. 3).

Fig. 3 Transaction process flow—Government transaction

3.5 Consensus mechanism

Consensus mechanism refers to the process by which all the peers of the blockchain network agree to the current state of the distributed ledger. It is process by which the new block of transactions is agreed upon by all the peers and finally added to the existing blockchain or distributed ledger. In general there are two way of achieving this- (a) voting based consensus, (b) lottery based consensus. Voting based consensus involves all the validating nodes achieve consensus through voting among themselves. This is best suited for our use case and a new block can be added to the blockchain only after all the validating nodes vote for it. This way at any point of time, there is only one version of truth (distributed ledger) which is distributed among all the peers.

3.6 Access to accounts and permissible operations

- (a) Stakeholders who are part of the blockchain network can directly access the account balances in the blockchain from existing applications by integrating the same with blockchain. Network participants can be permitted to make G2C and G2G transactions.
- (b) On the other hand, since the citizens are not directly part of the network they can access respective accounts on blockchain linked to their respective unique IDs through a middleware interface- a web/mobile application built for this purpose. The citizens should be able to complete their KYC on this application to gain access to blockchain. Citizens without smart phones, should be enabled to complete their KYC through Government approved centres such as CSCs or other agents. Since citizens are not part of the network, they cannot broadcast the transactions directly to blockchain network. However, they can submit the proposed transaction to the relevant treasury node who would then verify and broadcast the transaction to the network.
- (c) **Withdraw cash:** Citizen can approach pre-authorized agencies (such as CSCs, Post Offices, banks etc.) for cash withdrawal. Such agencies should be able to submit, payment request to blockchain, authorized by the citizens (biometrics or Aadhaar OTP). After transaction is validated by blockchain, the citizen's account will get debited and agency's account get credited and would pay cash to the citizen. This would help unbanked also access to Government benefits.
- (d) **Withdraw balances to bank account:** Citizen can request for withdraw of funds to bank account. Central Bank can batch process such transactions offchain using existing payment systems such as NEFT.
- (e) **Invest in government bonds:** For better liquidity and fund management, Governments can consider floating bonds and raise funds directly from the citizen's account. This would lower the cost of borrowing and also provides safe investment options to the citizen's at large.
- (f) **Add balances to Blockchain account:** Citizen can add balances to blockchain account linked to his unique ID and the balances can be used only for permitted operations.
- (g) **General purpose remittance or funds transfer:** Allowing this operation, would mean that non-government related transactions are also allowed. While this would help increase the utility and retention rate of the blockchain balances, this would have impact on the banks and other financial intermediaries.

Permissible transactions for the accounts of citizens:

- (a) **Pay taxes:** The fund balance can be used to pay taxes and the settlement would be instantaneous.
- (b) **Cashless subsidy transactions:** Balances can be used for making payments to pre-authorized agencies such as PDS shops, fertilizer subsidy shops, healthcare centres, retail chains etc. Such agencies should be able to send payment requests to blockchain, duly authorized by the beneficiary (biometrics or Aadhaar OTP). This arrangement will decentralize the last mile delivery channel and reduce dependency on cash and especially important during times of crisis such as natural calamities or COVID-19 like situations.

As can be seen from above, the transactions happen directly between the citizen and the Government (peer-to-peer) and transactions are accounted on distributed ledger and finally settled at Central Bank where the banking account of Government lies. As such role of banking intermediaries acting as agency banks is done away with. The above list of transactions have to be carefully assessed from risk perspective and enable some/all of such transactions accordingly. This would also be a step towards Central Bank Digital Currency (CBDC) implementation.

3.7 Off chain accounting treatment

On the blockchain, the accounting happens in distributed ledger. However the blockchain network runs on top of existing infrastructure referred to as off chain. The ledgers in the offchain at respective stakeholders should be synced to the distributed ledger and thus appropriate accounting entries have to be passed, for e.g., In treasury systems and central bank's systems. This can be achieved through API calls or any other integration techniques. Distributed ledger is the single/only source of truth, agreed by all the stakeholders and is thus final.

3.8 Benefits of deploying blockchain for Government banking

- (a) **Significant reduction in costs:** Since the transactions are peer-to-peer, the role of intermediaries such as agency banks is ceased and therefore significant savings in the agency commission paid (which is around ₹ 38 billion for year 2019–2020 in India) to intermediaries can be achieved. Further even in cases where intermediary help is required such as in making tax payments through cash, the transactional cost is significantly reduced as there would be no physical movement of paper, no complex reporting, no complicated reconciliation exercises and fraud proofing.
- (b) **Better cash/debt management for Government:** The real time cash balance position is available to government. The transactions also settle instantaneously. Government funds now lie in the blockchain and do not lie idle at agency banks (prefunded schemes) or other intermediary bank accounts such as project accounts, autonomous bodies accounts etc., enabling just-in-time payment in true sense. Governments can easily float bonds on this network and raise funds directly from public at large.
- (c) **Instant reconciliation:** Reconciliation becomes analogous to consensus. All the transactions are accounted for only after all the stakeholders agree (i.e. after consensus). Therefore reconciliations become instantaneous and happens even before the transaction gets recorded into single version of truth, i.e., Distributed ledger.
- (d) **Speedy settlement:** While the settlement is instant on the blockchain, the off chain accounting is also fast tracked as there is only a single version of truth i.e. distributed ledger and no separate reporting needs to be awaited from different stakeholders.
- (e) **Enhanced transparency:** The transactions can be easily audited and status of every transaction is visible. The problem of traceability of funds in case of return/failed transaction is done away with as the treasury account is debited only if the transaction is successful.
- (f) **Decentralization of delivery channels:** Blockchain model reduces dependency on the banking channel for last mile delivery and also promotes financial inclusion as the blockchain account balances are accessible to even those who are unbanked. This decentralization also helps in speedy delivery of benefits/aid to the affected beneficiaries during crisis like situation such as floods, earthquakes, COVID-19 like pandemics when access to banking channels gets restricted. Several innovative solutions can be built on top of the blockchain layer. For instance, United Nation's World Food Programme is leveraging Blockchain Technology

to disburse aid to the refugees in Syria without relying on banking channel as most refugees may not have a bank account/access to banking channel [3, 4]. Beneficiary accounts of refugees are created on the blockchain using biometrics (IRIS) as their identity and the aid is credited directly to those accounts. Over 100,000 refugees living in the camps can purchase groceries at retail shops by scanning their iris at checkout. This project, known as building blocks project, is powered by Private Permissioned blockchain and integrated with biometric authentication technology and saves on financial transaction fees and reconciliation challenges.

4 Conclusion and way forward

Blockchain implementation shifts the focus from being organization-centric to being eco-system centric. Blockchain achieves this through consensus driven distributed ledger and enhances the collaboration among all the stakeholders without necessity of relying on intermediaries. Governments' funds lying idle at intermediaries becomes history as the transactions are peer-to-peer and payments are processed just-in-time. Settlement and Reconciliation becomes instant, enabling the government to know its accurate funds position on real-time basis. Disintermediation ensures that the cost of transaction and cost of borrowing are significantly reduced. Delivery channels for disbursing entitlements/financial aid would be decentralized and dependency on the banking channel could be done away with, facilitating financial inclusion. Citizens would get empowered to easily take part in Government fund rising process and invest in Government bonds directly without the need of intermediary. In sum, Blockchain Based Distributed Ledger Technology has the potential to transform Government banking operations.

In order to realise the above benefits, Governments should first lay out comprehensive policy on blockchain along with facilitative legal framework and provide legal backing to various tenants of blockchain such as smart contracts and consensus protocols. Subsequent to that, Governments should take the lead and form blockchain Consortia comprising of key stakeholders. Such consortia should work towards a blockchain governance framework before implementing the blockchain. Implementation strategy should focus on rolling out pilot projects first before full-fledged roll out. Blockchain based payments can be first initiated for establishment payments such as salaries of Govt. employees and gradually extended to vendor payments and finally to citizens at large. It is also pertinent to note that blockchain Technology is still an emerging technology and a lot of research is currently under progress towards building more efficient, secure and interoperable blockchain ecosystem. Governments can play its role to further stimulate innovation

in this sector by way of drafting National Blockchain Policy. Further the legal and statutory requirements of accounting, settlement and reconciliation of government transactions, which the article did not take into account, also needs to be thoroughly analysed and reviewed.

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