NATIONAL STRATEGY ON BLOCKCHAIN

Government of India
Ministry of Electronics and Information Technology (MeitY)

January 2021

Table of Contents

1. ABSTRACT 4
2. OVERVIEW OF BLOCKCHAIN TECHNOLOGY AND APPLICATIONS 5
2.1 INTRODUCTION 5
2.2 IMPORTANCE OF BLOCKCHAIN TECHNOLOGY 6
2.3 ARCHITECTURE OPTIONS 6
2.4 POTENTIAL BLOCKCHAIN APPLICATIONS OF NATIONAL INTEREST 7
2.5 VALUE ADDITION FOR BLOCKCHAIN IN E-GOVERNANCE 8
3. GLOBAL EFFORTS 10
4. FORECAST 12
5. NATIONAL SCENARIO 14
6. CHALLENGES TO THE ADOPTION OF BLOCKCHAIN TECHNOLOGY 15
6.1 TECHNOLOGICAL CHALLENGES 15
6.2 LEGAL CHALLENGES IN ADOPTION IN INDIA 17
7. SWOT ANALYSIS 19
8. ROADMAP FOR BLOCKCHAIN TECHNOLOGY ADOPTION 20
9. NATIONAL LEVEL BLOCKCHAIN FRAMEWORK 22
9.1 NEED FOR NATIONAL LEVEL BLOCKCHAIN FRAMEWORK 22
9.2 INTEGRATION OF IMPORTANT NATIONAL LEVEL SERVICES TO BLOCKCHAIN 23
eSign *23*
ePramaan *23*
DigiLocker *23*
10. MULTI-INSTITUTIONAL COE FOR NATIONAL LEVEL BLOCKCHAIN FRAMEWORK AND COLLABORATING ORGANIZATIONS 24
11. CONCLUSIONS/RECOMMENDATIONS TOWARDS IMPLEMENTING NATIONAL LEVEL BLOCKCHAIN FRAMEWORK 26
12. REFERENCES 28

Table of Figures

FIGURE 1:BLOCKCHAIN NETWORK AND THE PROCESS OF ADDING NEW TRANSACTION TO LEDGER 5
FIGURE 2: BLOCK STRUCTURE 6
FIGURE 3: BLOCKCHAIN ARCHITECTURE OPTIONS 7
FIGURE 4:APPLICATIONS OF BLOCKCHAIN TECHNOLOGY 7
FIGURE 5: FORECAST: BLOCKCHAIN BUSINESS VALUE, WORLDWIDE 2017-2030 (SOURCE: GARTNER 2017) 12
FIGURE 6: FORECAST ON GLOBAL BLOCKCHAIN GOVERNMENT MARKET BY GEOGRAPHY DURING THE PERIOD 2020 – 2027 .. 13
FIGURE 7: ROADMAP FOR BLOCKCHAIN TECHNOLOGY ADOPTION 20
FIGURE 8: A NATIONAL LEVEL BLOCKCHAIN FRAMEWORK 22
FIGURE 9: MULTI-INSTITUTIONAL COE AND COLLABORATING ORGANIZATIONS 24

1. Abstract

Blockchain is an innovative distributed ledger Technology which was first introduced in the design and development of cryptocurrency, Bitcoin in 2009 by Satoshi Nakamoto. Blockchain is an amalgamation of various inventions, with a clear business value. Blockchain enables a shared ledger between the various parties involved in business transactions, which is going to act as a single source of truth. Blockchain eliminates the need for central entity to validate the transactions. As it is based on peer-to-peer networks, all nodes would involve in validating the transactions rather than depending on a central entity. The data structure used in Blockchain Technology helps to maintain unchangeable record of transactions in a time sequenced manner. So, Blockchain Technology improves transparency, immutability and efficiency aspects, which make it unique and potential to use in various application domains.

Blockchain can be used in Permissioned and Permission less models. Permissioned model has applications in various domains such as healthcare, cyber security, Governance, media, logistics & hospitality, education, legal, energy, smart cities and so on.

Globally and nationally various efforts are being made in implementing Blockchain based applications. PoCs and pilot deployments are successfully carried out. In order to reap the benefits of the technology, there is a need for National level Strategy in Blockchain Technology.

This document provides an insight on the strategies for metamorphosing Indian Blockchain ecosystem to make India as one of the leading countries in terms of harnessing the benefits of this emerging technology by focusing on following aspects:

1) **Technological Aspects**
   a) Evolving a National Blockchain Infrastructure for hosting regulatory sandbox that can be used for building and deploying Blockchain applications.
   b) Fostering Research & Development to solve challenges related to interoperability, faster development and security.
   c) Deploying Production Grade Applications of National interest focusing towards providing faster, secure, transparent and efficient delivery of services to the citizens.
   d) Awareness and Capacity Building to ramp-up technology insight across various stake-holders including students, practitioners, management / executives, decision makers and so on.
2) **Administrative Aspects**
   a) Implementing appropriate legal and regulatory architectures including formulation of standards.
   b) Formulating policies and incentive models for academic, start-ups and industry for promoting and adopting Blockchain technology.

2. Overview of Blockchain Technology and Applications

2.1 Introduction

Blockchain technology is a distributed ledger technology suitable for decentralized and transactional data shared across a large network of untrusted entities. This technology allows new type of distributed software architecture capable of finding concurrence on their shared states without need to establish online trust with any central entity/participant. All the transactions shared across entities, along with the timestamp are maintained as records and placed in blocks. These blocks are further linked as Blockchain and stored in a distributed manner across various nodes of the network. Copy of each transaction along with its hash is stored in the ledger shared across all participants of the network. Salient properties of the Blockchain technology are pseudonymity, cryptographic guarantees, immutability, shared read & write, accountability, transparency and distributed ownership.

This technology eliminates the requirement of central entity / third party to validate the transactions over the peer-to-peer network. Transactions are validated by considering the history of transactions stored at each node of the network and the consensus of the participants, as shown in Figure 1. As the transactions are distributed over the network, it is tough for adversary to alter the stored data at majority points. So, decentralized storage provides better security compared to centralized storage.

.

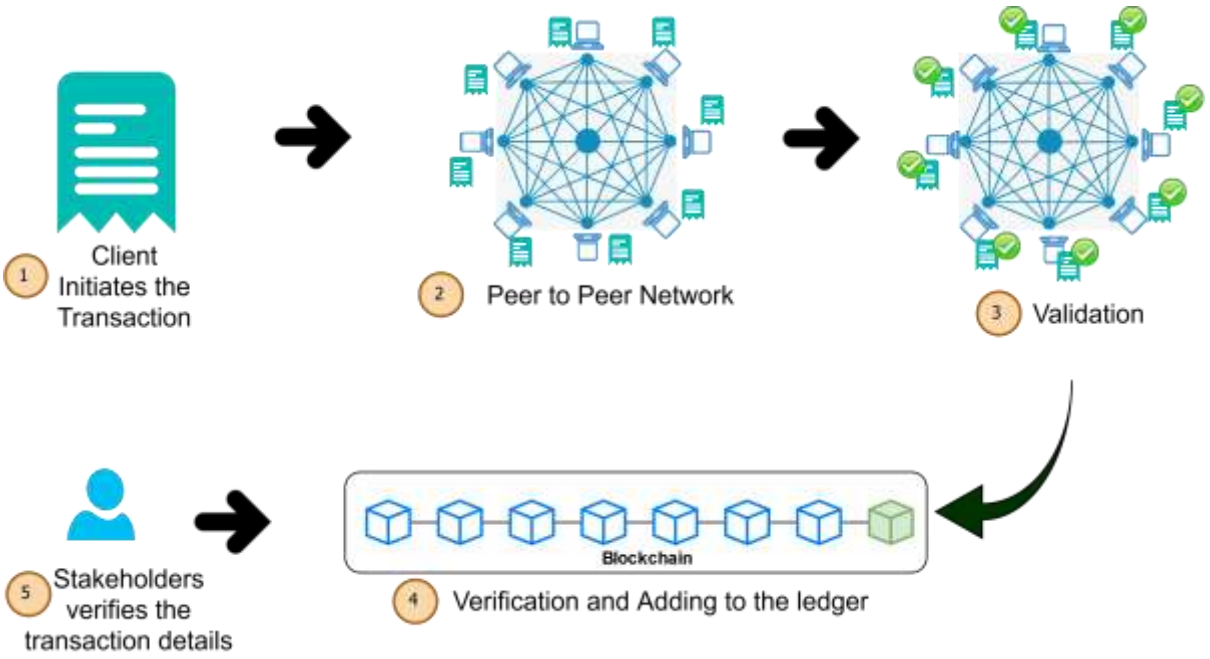


Figure 1:Blockchain Network and the process of adding new transaction to ledger

2.2 Importance of Blockchain Technology

Blockchain uses a unique data structure where verification data related to the transactional records is cryptographically secured against tampering and stored in blocks. Each block contains details of transactions, hash of the previous block, timestamp etc., as shown in Figure 2.

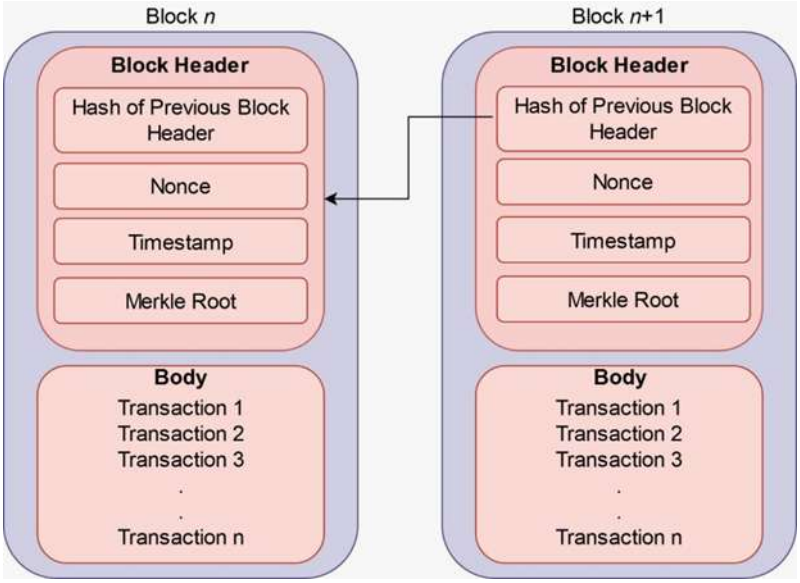


Figure 2: Block Structure

Blocks are linked with each other, leading to a Blockchain. Linkage across Blocks is also cryptographically secured and this is stored at every node in the network. This makes it a unique solution to the problem of trust in the digital world, leading towards decentralized trust. Anything of value can be tracked and traded on a Blockchain network, reducing risk and cutting costs for all involved. Contracts can be automated through Smart Contracts.

2.3 Architecture Options

Blockchain can be set up in either Public / Permission less or Private / Permissioned configurations, each of which has its own advantages and disadvantages. Figure 3 shows the potential architecture options for Blockchain deployments and depicts that private Blockchain allow only known entities to join the Blockchain network, while public Blockchain have no central authority (Brant et al 2018).

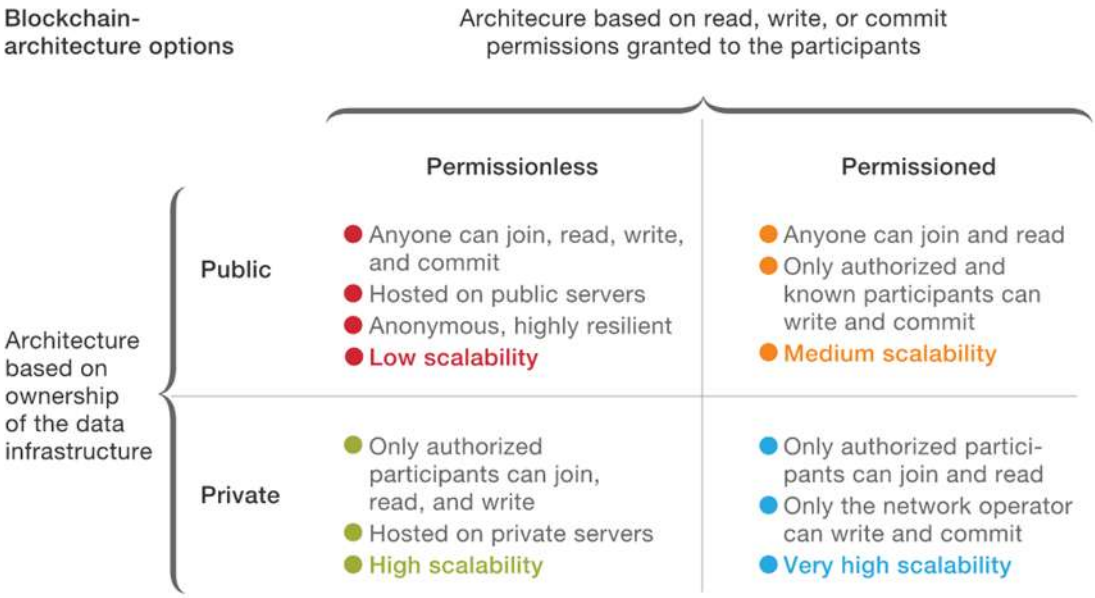


Figure 3: Blockchain Architecture options

2.4 Potential Blockchain Applications of National Interest

Blockchain Technology provides transparency, security and efficiency in business operations. It enables a layer of trust over Internet in a unique way, which was first tried for cryptocurrency application, Bitcoin. Blockchain Technology is going to revolutionize the functionality of B2B, G2C, G2G, B2G services corresponding to various application domains. It has applications in healthcare, Governance, cyber security, automobiles, media, travel, logistics & hospitality, education, legal, energy, smart cities and so on as given in Figure 4.

Figure 4: Applications of Blockchain Technology

For example, Blockchain is an apt technology for applying to resolve shortcomings of any Property Record Management System. Immutability in Blockchain can provide an assurance to citizens that their property records are never tampered. Important

events such as registration process can be captured as transaction on Blockchain, which are also timestamped and hence can keep a track of the property as it propagates from one citizen to another.

Potential Blockchain applications of National interest include:

- Transfer of Land Records (Property Record Management)
- Digital Certificates Management (Education, Death, Birth, agreements, sale deeds …)
- Pharmaceutical supply chain
- e-Notary Service (Blockchain enabled e-Sign Solution)
- Farm Insurance
- Identity management
- Power distribution
- Duty payments
- Agriculture and other supply chains
- eVoting
- Electronic Health Record Management
- Digital Evidence Management System
- Public Service Delivery
- IoT Device Management and Security
- Vehicle lifecycle management
- Chit fund operations administration
- Microfinance for Self-Help Groups (SHG)

2.5 Value addition for Blockchain in E-Governance

- Blockchain can bring lot of value addition in e-Governance: Improves Transparency & Accountability, Building Trust with Citizens, Speed up transactions, Protecting Sensitive Data and Reducing Costs & Improving Efficiency.
- Government procedures require involvement of multiple departments towards providing service to the citizens. Seamless data exchange across departments is an important requirement towards providing efficient service delivery. Inter-departmental processes can be tracked using smart contract enabled workflows and shared ledgers. This results in transparency and accountability in the system.
- Blockchain being a single source of truth can be used for authentication and verification of all the transactions and data, produced by various government departments.
- Blockchain can be used to create and enable smart contracts, supply chains

for various government processes, trusted inter-department communication and tamper evident storage.

- Blockchain can enable the officials to verify the proof of existence of documents by comparing the provided document copy against a version stored in a Blockchain. Storing the digital artefacts / documents in a Blockchain makes it secure and immune to tampering.

3. Global Efforts

Globally many countries have launched platforms and services using Blockchain technology and many vendors are offering Blockchain as a service to the customers.

- **Blockchain-based Service Network (BSN)** initiative of **China** aims at helping companies and individuals deploy Blockchain applications faster and cheaper. The BSN has components that provide developer tools for application development and focuses on standardizing it across public networks, regions and business sectors. The thrust is to support digital economy and smart city initiatives.
- **European Blockchain Partnership (EBP),** aims to use blockchain and distributed ledger technologies and develop a trusted, secure and resilient **European Blockchain Services Infrastructure (EBSI)** which will meet the highest standards in terms of privacy, cybersecurity, interoperability, regulation in applying policies etc. **China** has introduced an independently developed Blockchain-based identification system for smart city infrastructure. This system will assign a unique, global digital ID to Chinese smart cities, aiming to improve the connectivity and data sharing between these cities. The notary application based on Blockchain in **China's** offices is functional from April 2019.
- **Keyless Signature Infrastructure (KSI)** is a Blockchain technology designed in **Estonia** and KSI Blockchain is deployed in Estonian government networks, this helps to prove the authenticity of the electronic data (records) mathematically. They have implemented **X-Road** which is a "centrally managed distributed Data Exchange Layer (DXL) between information systems". Organizations can exchange information over the Internet using X-Road to ensure confidentiality, integrity and interoperability between data exchange parties.
- **United Arab Emirates** has "**Smart Dubai**" initiative, which aims to become the "first city fully powered by Blockchain by 2021," and enhance everything from health care and education to traffic management and environmental sustainability.
- In **US**, **Food and Drug inspection** is using Blockchain to address the problem of lack of transparency and security in health data processing. In **UK**, **Food standards agency** is using Blockchain to track the distribution of meat to enhance food traceability.
- **Brazil** government announced to move applications and popular voting onto Ethereum. Brazil is also focusing on public bidding of contracts with the governments, on-line bid solution to ensure secure and transparent deals for agriculture applications, student certificates and tracking student performance.
- **Chile** uses Ethereum to track the data and finances from the energy grid to resist corruption and exploitation through transparent, immutable data available for every citizen to see. Digital IDs in **Switzerland** are offered and registered on Ethereum in 2017.
- **Canada** is using Ethereum to provide transparency to the use of government

grants to ease citizens' concerns of corruption. **Swedan** is focusing on conducting real estate deals and **Ghana** on **land registry** and **cadastral register** based on the blockchain to collect **property taxes** on them.

- **Samsung Blockchain Wallet** powered by COSMOCHAIN Blockchain has developed CosmeeDApp for purchasing of contents using cryptocurrency. If a company utilized information provided or created by customers the information providers gets rewards with using Blockchain in a completely transparent manner.
- **LG Blockchain** is specialized for digital authentication, community token and supply chain management for the enterprise.
- **Amazon Managed Blockchain, Microsoft Azure Workbench, IBM Blockchain, Oracle Blockchain** and **BlockappsStrato** are some of the Blockchain services offered.
- **Cosmos, Polkadot, Aion, Ark, Wanchain, Atomic Swap and Chainlink** are some of the **global research initiatives** in Blockchain Interoperability.

4. Forecast

Blockchain Business Value, Worldwide 2017-2030: The Blockchain opportunities provide a landscape for future economic development and potential growth that is worthy of assessment, especially as Gartner predicts that:

- By 2022, many new innovative companies will start using Blockchain Technology and at least one business created using Blockchain technology will be worth $10 billion.
- By 2030, Blockchain would be used as a foundational technology for 30% of the global customer base that will be made up of things, and these things will be used for conducting commercial activities.
- By 2025, Blockchain would add a business value that will grow to over $176 billion. This would increase further to $3.1 trillion by 2030 (see Figure 5 below).

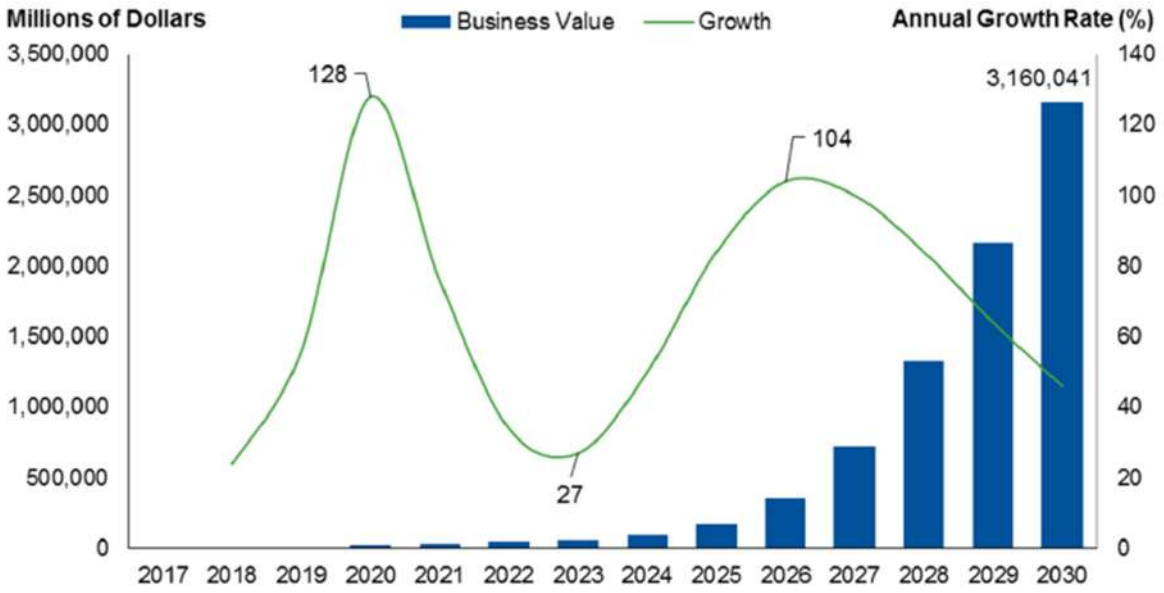


Figure 5: Forecast: Blockchain Business Value, Worldwide 2017-2030 (Source: Gartner 2017)

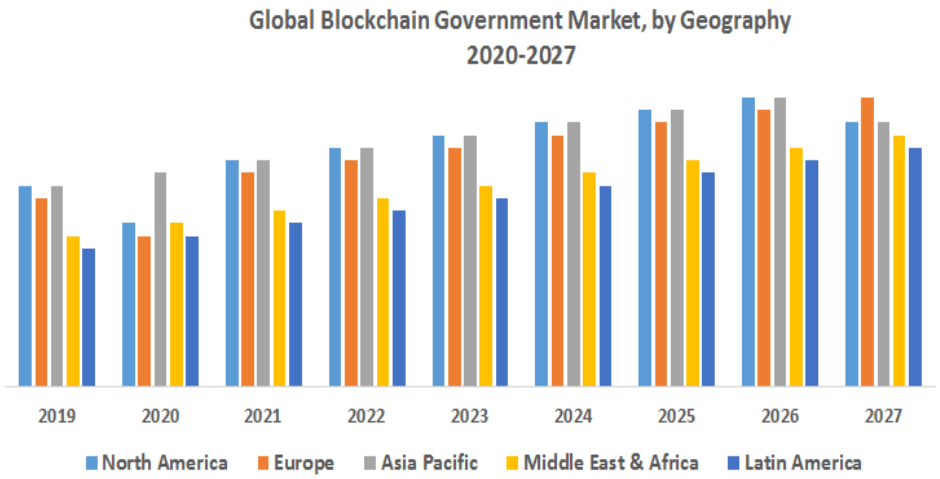


Figure 6: Forecast on Global Blockchain Government Market by Geography during the period 2020 – 2027

Forecast on Global Blockchain Government Market by Geography during the period 2020 – 2027 from Maximize Market Research Pvt Ltd is given in Figure 6. The statistics depicts the adoption of Blockchain technology for Government use case and provides an insight that it will rise over time.

5. National Scenario

Ministry of Electronics and Information Technology (MeitY) has identified Blockchain Technology as one of the important research areas having application potential in different domains such as Governance, Banking & Finance, Cyber Security and so on. MeitY has supported a multi institutional project titled **Distributed Centre of Excellence in Blockchain Technology** with **C-DAC, IDRBT and VJTI** as executing agencies. As part of this initiative, agencies have carried out research on the use of Blockchain Technology in identified domains and developed Proof-of-Concept solutions and piloted them. Blockchain Technology based solution for property registration has been successfully developed and is piloted at Shamshabad District, Telangana State. Proof-of-Concept solutions are developed for enabling Cloud Security Assurance, CKYC and trade finance. Generic Blockchain based Proof-of Existence (PoE) Framework is developed to enable PoE for digital artifacts, used to check the integrity of academic certificates, sale deed documents, MoU etc. By using PoE framework, a solution is developed to authenticate academic certificates and is being piloted at C-DAC Advanced Computing Training School. To promote the development of Blockchain ecosystem the team has also demonstrated the implemented solutions to various other states and has successfully conducted capacity building programs specifically for user agencies. C-DAC is also a founding member of Blockchain District initiative of Telangana State.

Centre of Excellence (CoE) in Blockchain technology was established by **NIC** in association with **NICSI**. The objectives of CoE are to accelerate adoption & deployment of Blockchain technology in Government, execute projects focussing on different use cases, pilot deployment, offer Blockchain-Platform as a service to ramp up the design and development of solutions, offer consultancy services and capacity building. CoE is focusing on collaboration across Government, public & private sectors. The application areas identified and developed through CoE are Blood Bank, Digidhan, Public Distribution System, Land Registration, GST Backoffice, Excise Management System and so on.

NITI Aayog has recognized Blockchain as a promising Technology enabling features such as decentralization, transparency and accountability. **NITI Aayog** has executed various use cases in Blockchain Technology and piloted them in association with various Government departments and Private agencies. These use cases include land records, pharmaceutical supply chain, fertilizer subsidy disbursement, educational certificates.

C-DAC has successfully carried out PoCs and pilot deployments, which has given confidence that Blockchain Technology is going to play a transformative role for the industry 4.0, Government and public sectors. C-DAC has identified Blockchain Technology as one of the mission areas. **C-DAC's vision** is to design and develop Blockchain Technology solutions to provide trusted & auditable shared infrastructure for cross domain application development and large scale deployment.

C-DAC's mission in Blockchain Technology in categorized in the following top level

components:

- **Unified Blockchain Framework:** Unified Blockchain Platform for cross domain applications addressing the performance, scalability, interoperability, security and privacy challenges
- **Blockchain Services:** eSign integrated with Blockchain based Proof-of-Existence (PoE)
- **Blockchain Applications for different domains:** Blockchain for Track and Trace, Blockchain for Electronic Health Record (EHR), Blockchain based Digital Evidence Management System, Security for IoT Deployment, Blockchain for Self-Sovereign Identity, Blockchain Technology for APEDA TraceNet, Blockchain Technology for Government e-Marketplace (GeM) Platform, Blockchain Technology for Voting and Blockchain based Property Record Management System.

Reserve Bank of India (RBI) is exploring on applying Blockchain Technology in banking domain. **Mahindra** and **IBM** are jointly collaborating on supply chain management solution. **SBI** has associated with commercial banks and financial institutions for Blockchain based application pilot. **Yes Bank**, **Axis Bank** and **ICICI Bank** are also adopting Blockchain in their banking business.

As per Blockchain Report 2019 of NASSCOM Avasant India, different states across India have initiated Blockchain based use cases. **Land registry, Farm insurance** and **Digital Certificates** are the top three use cases.

6. Challenges to the adoption of Blockchain Technology

Despite the fact that Blockchain technology is very encouraging and with immense potential, it still encounters a few challenges for adoption in India. Apart from the technological challenges, there also exists legal challenges that needs to be resolved before adopting this technology.

6.1 Technological Challenges

Overall the technological challenges are from the perspective of performance & scalability, security & privacy, geographically distributed infrastructure requirements, lack of skillset & awareness among user agencies. Some of technological challenges for the large scale adoption of Blockchain are elaborated below:

Performance and Scalability challenges:

- Unlike traditional centralized systems, the decentralized architecture of Blockchain means it will be slower than traditional systems. Considering this, designing a system that provides faster synchronization is important. While significant research are being made in this area, initial use-cases should be

chosen with care so as not to require real-time processing and results.

- In Blockchain data is replicated on each node and this may lead to performance issues many a times. Further, the performance also is affected due to calculations associated with encryption- decryption and hashing at every node.
- Scalability aspects of Blockchain systems are affected by the factors such as architecture, configuration of the Blockchain platform, variable requirements for processing power, network bandwidth, block size, Consensus, transaction validation mechanisms, privacy requirements, file system and data storage. The design architecture of Blockchain network and platform should address these scalability requirements.
- Storage – Blockchain is considered to be an append only data storage mechanism. As data stored in the Blockchain cannot be modified, it becomes perpetual and also is replicated at all the nodes in the network. This demands a heavy resources in terms of storage and may become an issue as the chain of blocks grow.
- Transaction details and interoperability – A design decision on what part of the application data goes offchain and onchain is crucial for establishing good performance benefits. The details of the transactions which need to be kept should be minimum and would depend on the targeted application. In order to get the benefit of interoperability across similar applications, transaction standardization for certain class of applications has to be evolved.
- Being distributed in nature, resource allocations for the network & node infrastructure would vary and would depend on the cost of network maintenance, peripheral security and other essential requirements. Lower resource allocations in such cases may have performance impact on the entire system. Moreover, challenges related to deploying Blockchain Infrastructure spanning across the country also needs to be addressed.

Skillset and Awareness related challenges:

- Lack of awareness with regard to nature of Blockchain platforms is a major challenge. There a number of open source Blockchain platforms, but considerations such as flexibility to add new components, security, scalability and performance are not well documented in many cases. This requires skilled manpower in multiple technologies to understand and tweak their functionality to specific requirements.
- The underlying technology that builds Blockchain is still emerging and is slowly reaching a level of maturity for production deployments. The users should be sensitized of the benefits of the technology and how it can cater to solve problems in the specific domain of national importance.

- Supply chain tracking is an important and relevant application of Blockchain. A number of domain experts are not eager on adopting the technology due to the lack of awareness and trust issues in technology. Therefore, accelerated adoption of Blockchain requires more digitization and awareness.
- A successful large scale execution of PoC (Proof of Concept) requires the users to hire blockchain experts or data scientists which is a costly affair as compared to hiring software developers, making its adoption difficult.
- Manpower who knows both Domain & Technology is rare to find. Many projects which have started implementing Blockchain based applications are confronted with a resource crunch of the skilled manpower. India's scale and needs (including catering to global needs) will be far greater and if the manpower requirements are not addressed timely and adequately manner, the resultant effect will have severe impact on the nation's journey to adopt Blockchain.

Security, Privacy and regulation challenges

- Privacy – Blockchain data is stored on every node on the network and hence privacy is not an inherent feature that Blockchain traditionally provides. This is a area of active research and several solutions are proposed and emerging in this space. The data should be stored in such a way that the privacy of an individual is not compromised and appropriate consent mechanisms should be adopted in line with data protection laws.
- Use of existing CAs – Every entity including the node and the users in Blockchain own a public keys, private keys and certificates. The use of existing CAs for certificates is a important integration point. The choice of CA would depend on the nature of application that is targeted. Specifically for applications demanding transaction signing using certificates from licensed CA needs to be considered as a part of implementation from the begining.
- The state of regulations and compliance for Blockchain applications is still ambiguous. The regulations mainly relate to the privacy of the information shared through Blockchain which can be health records or user identity documents etc. The adoption would accelerate when the regulations are well-defined..

These challenges are referenced from National Blockchain Strategy report prepared by NIC.

6.2 Legal Challenges in Adoption in India

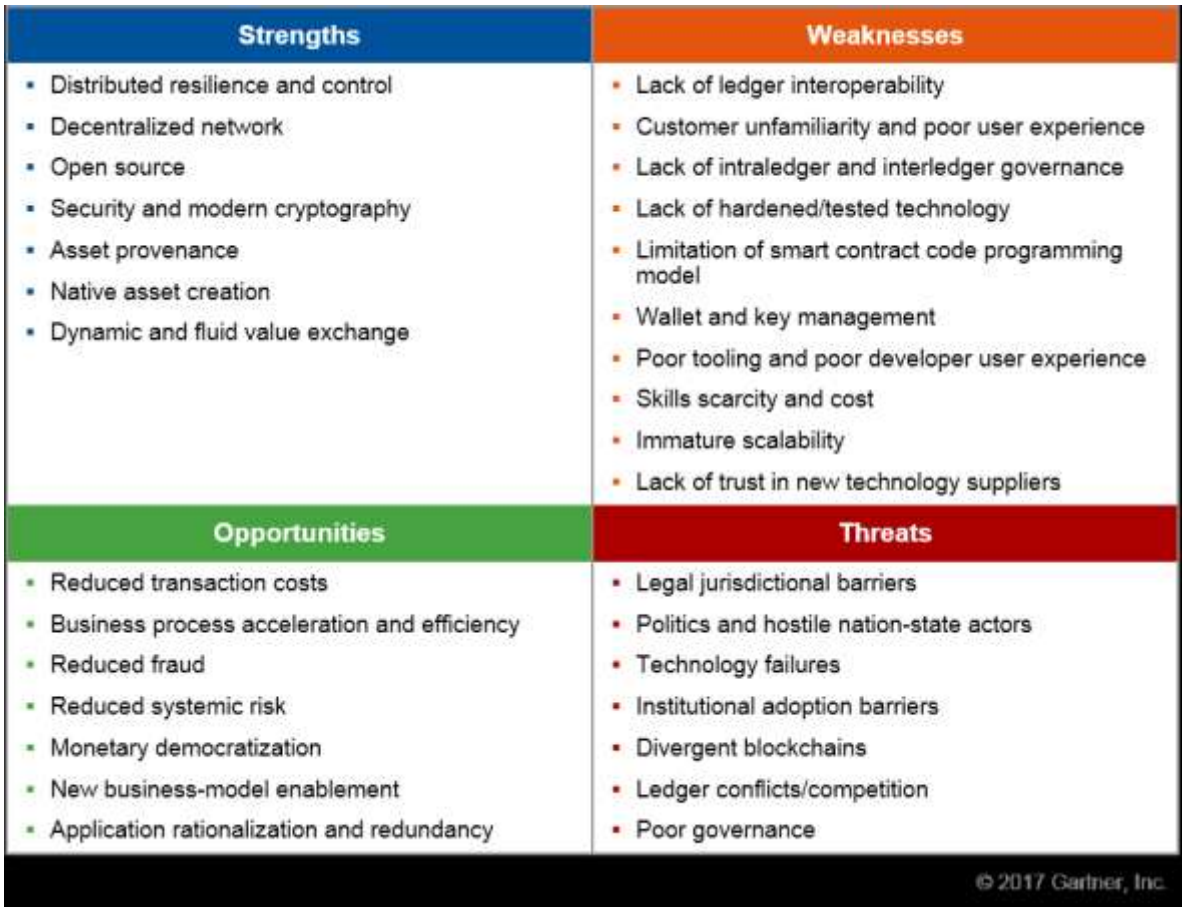
- The Reserve Bank of India (RBI) has put forth restriction with respect to virtual currencies based on Blockchain technology and there is circular to halt the usage of crypto-currency transactions in India. The aspect of activities involving

tokenization however is ambiguous.

- In banking regulation there is a need to satisfy non-repudiation requirements through in-person verification, and there is a challenge to implement technological solutions for such requirements especially for crypto-currency based on Blockchain.
- Digital Signatures are core part of Blockchain networks and application. Currently there exist no details in the Schedule I of the Information Technology Act, 2000 in context to transactions involving immovable property, wills and negotiable instruments and thus this provision excludes the applicability of the technology for such activities.
- The Section 43A of the IT Act currently does not have safeguards mentioned from the perspective of Privacy when applied to Blockchain. The 'Right to be Forgotten', which is a prevailing feature of data protection legislation such as the Draft Personal Data Protection Bill, 2019, has contradictions with the inherent feature of Blockchain where data cannot be deleted and history of data is always accessible.
- Localization: Since public Blockchain automatically store data redundancies across all nodes on a network, the technology may hit a hurdle with localization requirements, even if they are restricted to solely critical personal data as is being considered by the Ministry of Electronics and Information Technology (MeitY).

7. SWOT Analysis

The SWOT analysis is referenced from the report "Practical Blockchain: A Gartner Trend Insight Report". Considering the SWOT analysis, it is crucial to identify and apply Blockchain to the right application which can harness the benefits from the technology. Blockchain application requirement factors that should be considered include multiple untrusted stake holders involvement including regulatory body, smart contracts that do not alter very often, data that needs permanent storage and so on.



8. Roadmap for Blockchain Technology Adoption

As Blockchain Technology is an emerging area, there are various challenges to be addressed in order to adopt it and effectively use it in different applications. Roadmap for Blockchain Technology adoption along with details of important mile stones is given in Figure.7. Globally, many countries have assessed the value proposition of Blockchain Technology in different domains. Currently efforts are being made in identifying, evaluating and evolving prototypes for specific applications. Prototype implementations and Pilot deployments for specific applications are ongoing. In order to effectively utilize the technology there is a need for scaling deployments, explore to other domains, emerge shared infrastructure and cross domain applications.

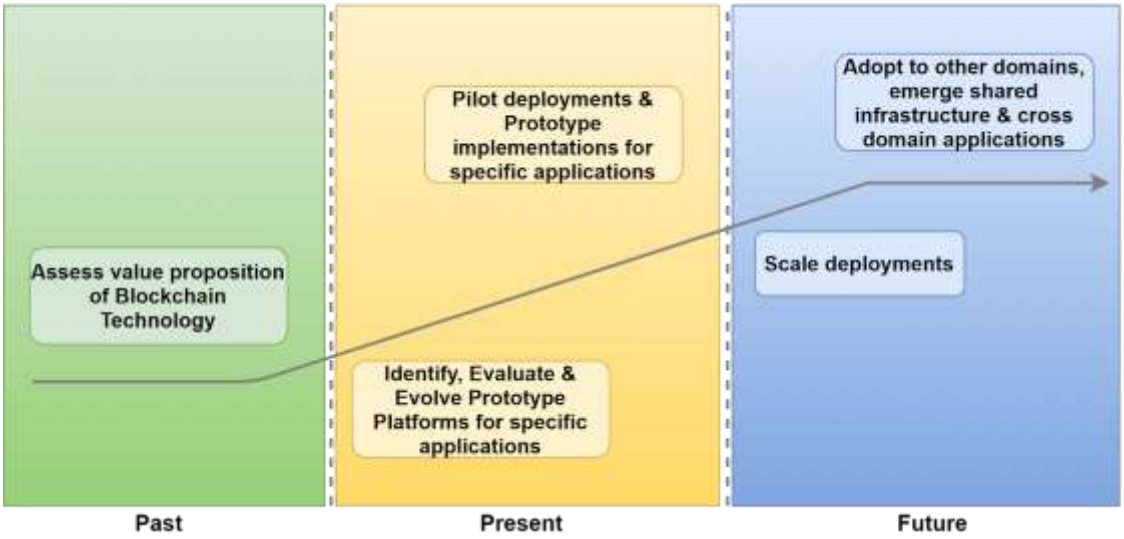


Figure 7: Roadmap for Blockchain Technology Adoption

For example, in health care domain, patient health records can be stored in tamperproof manner on National Level Blockchain. Role based privacy enabled access can be given to patient data stored on Blockchain. This helps doctors of any hospital across India access patient history, when patient approaches them for treatment. Shared Blockchain infrastructure avoids maintaining duplication of asset data and maintains transaction history on assets in a consistent manner.

Potential Challenges to be addressed towards evolving Shared Blockchain Infrastructure and Cross Domain Applications

- Scalability and Transaction Speed (achieving higher number of transactions per second)
- Data Security and Privacy
- Standardization and Interoperability (cross-platform and cross-chain protocols)
- Applying AI & Data Analytics
- Regulatory Aspects
- Ecosystem and supporting framework
- Decentralized Infrastructure

- Skilled Manpower (Talent)

These challenges specific to Shared Blockchain infrastructure are referenced from the report “Blockchain Mission” prepared by C-DAC.

9. National Level Blockchain Framework

9.1 Need for National Level Blockchain Framework

As a country, a National Level Blockchain Framework can aid in scaling deployments for developed applications, emerge shared infrastructure and also enable cross domain application development. So there is a need to build infrastructure that is spread across multiple zones across the country as shown in the Figure 8. Since no single platform is capable to meet the requirements of different application domains of the country, the proposed infrastructure can help in hosting multiple Blockchain platforms. This will provide each application to take benefit of the platform specific strengths. It is also proposed to design and develop an indigenous Blockchain platform.

On each of these platforms, the domain specific chain such as property chain, health chain, education chain and so on would be hosted. These chains would be a shared ledger and would be controlled using the smart contract logic.

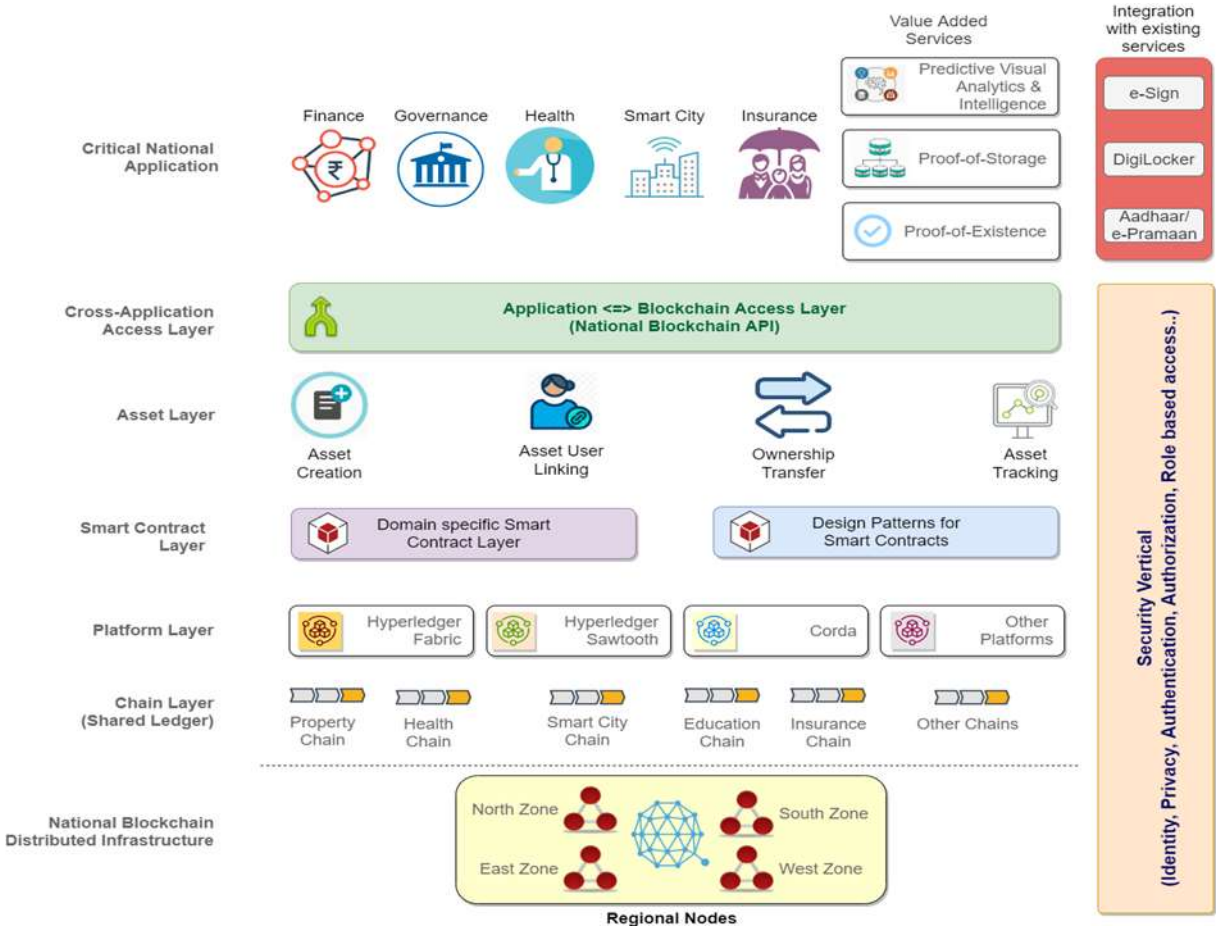


Figure 8: A National Level Blockchain Framework

The framework would hence be capable of hosting multiple smart contracts and

ledger meeting the broader requirements of the country. Basic process automation functional aspects related to assets such as asset creation, linking of asset to users, transferring or tracking of asset and so on would be provided using easy to use and standard APIs using the **National Blockchain API**. This will facilitate the application software to customize it for any of their work flow requirements and get the benefits of Blockchain infrastructure. Other generic value addition features such as Proof-of-Storage, Proof-of-existence and Predictive visual analytics and intelligence can be used by any applications to extend its functionality. Predictive visual analytics and intelligence will help to build business intelligence from the meta data of Blockchain. The applications can also have integration points with existing national services such as e-Pramaan / eAadhaar, E-Sign, Digilocker and so on. Security and Privacy aspects can be enabled across the layers of Blockchain Framework.

9.2 Integration of important National Level Services to Blockchain

The following national level services can be integrated with Unified Blockchain Framework

eSign

eSign is a Public Key Infrastructure (PKI) based on-line service. This service helps the citizens for instant signing of their documents, enabling non-repudiation and in a legally acceptable form. eSign service is being leveraged in various applications by government and private agencies are leveraging eSign service.

ePramaan

ePramaan is a standards based e-Authentication framework. It facilitates authentication and security of citizens while accessing different government applications.

DigiLocker

DigiLocker is an online service delivered under Digital India Initiative by Ministry of Electronics and Information Technology (MeitY), Government of India. It provides every citizen with an account in cloud to access documents / certificates such as vehicle registration, academic certificates & mark sheets, driving license and so on.

Devising National Level Blockchain Framework integrating with Online Electronic Signatures (e-Sign), ePramaan and Digilocker would be an added advantage.

These details are captured from Blockchain Mission document of C-DAC.

10. Multi-Institutional CoE for National Level Blockchain Framework and Collaborating Organizations

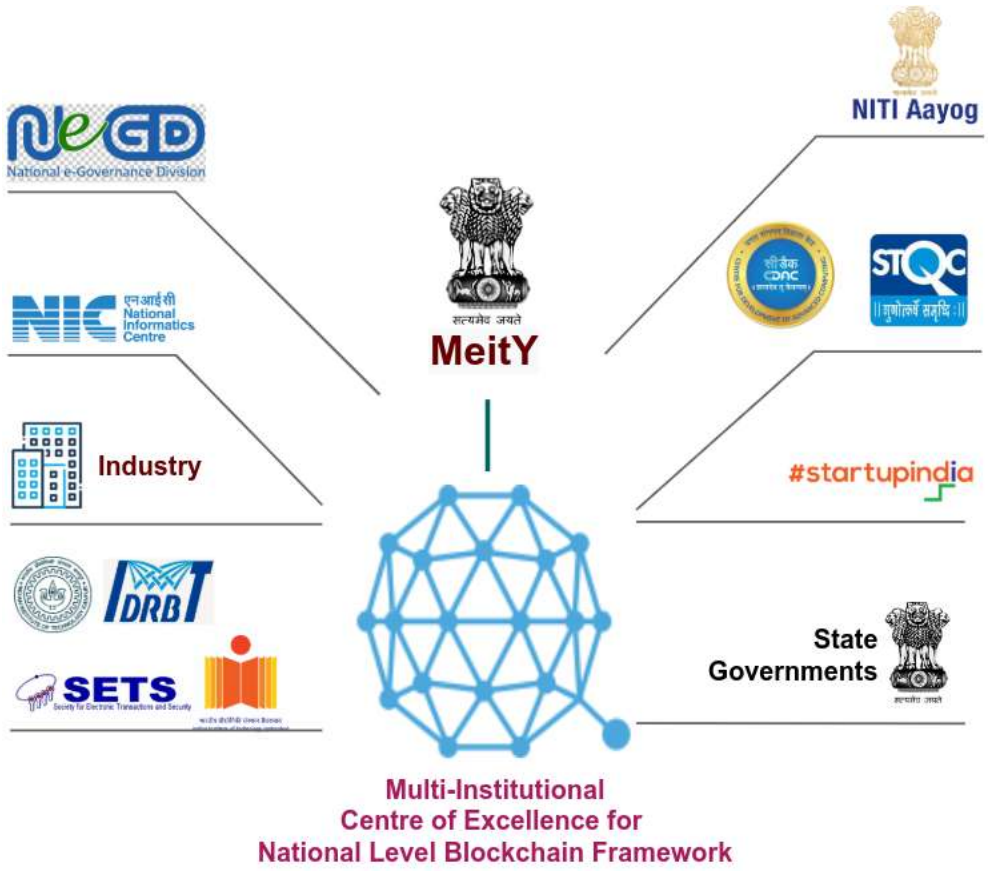


Figure 9: Multi-Institutional CoE and Collaborating Organizations

In order to plan and implement National Level Blockchain Framework, a multi-institutional Centre of Excellence is proposed. Collaborating organizations and their responsibilities are given below

S.No	Organization (s)	Responsibilities
1	NeGD	Implementation of Projects undertaken by various Ministries and Departments, at central as well as state levels. User Awareness and Skill Development Programs to sensitize about Blockchain Technology.
2	State Governments	Develop state specific Blockchain applications on the shared Blockchain infrastructure.
3	NIC and NICSI	Hosting the National level Blockchain infrastructure, development of Applications and offering Blockchain as a service. User Awareness and Skill Development Programs to sensitize about Blockchain Technology.

4	C-DAC	Research and Development of the National Level Unified Blockchain framework addressing the various technology challenges and application development and technology hand-holding. User Awareness and Skill Development Programs to sensitize about Blockchain Technology.
5	STQC	Testing and Certification.
6	IDRBT Hyderabad, IIT Hyderabad, IIT Kanpur, SETS Chennai, other premier academic institutes etc.	Addressing research challenges in implementing Blockchain Technology.
7	Regulatory and Legal aspects	Ministry of Electronics and Information Technology (MeitY) along with the other ministries of Government of India.
8	Industry and Start-ups	Spurring innovation by developing use cases solving generic needs of the country.

11. Conclusions/Recommendations towards implementing National Level Blockchain Framework

1) A plan for National Level Blockchain Framework (NLBF) enabled with three types of participants: a) Confident user of Technology (Application Developers), b) Provider or Operator of Technology (Infrastructure & Services, BaaS) and c) Complete Technology Stack Builder (IP Creator) has been proposed. Multi-institutional model need to be created for architecting the NLBF and organizations have to be identified along with their roles & responsibilities. Involvement of innovative start-ups and industry would bring in the agility.
2) As the Blockchain technology is still evolving and it has the potential for Government to adopt, it is recommended to focus on advanced research in the domain of Blockchain Technology and contribute in addressing various challenges in adopting the technology towards building a trusted public digital platform.
3) Focus on research in the domains of standards & interoperability, scalability & performance, consensus mechanisms, security & privacy, key management, secure smart contracts and detection of vulnerabilities in Blockchain Technology based solutions is required for sustainability. This should essentially result in indigenous Blockchain platform.
4) It is proposed to evolve an indigenous technology stack with open APIs, so that various use cases addressing the nation's requirements, can be built on top of it and also integration with existing applications can be carried out efficiently. It is suggested to have balanced approach towards technology stack development and use cases implementation. Also focus should be on creation of infrastructure as National Resource and offering Blockchain as a Service (BaaS).
5) Existing infrastructure (data centres) could be utilized for enabling BaaS, and such initiative requires planning at architecture level. Every organization should invest for infrastructure in crowd sourced model which could subsequently include infrastructure from neighbouring countries.
6) Consultancy services can be offered in architecting the Blockchain based applications as different ministries / departments are showing interest in adopting Blockchain Technology. Critical applications in the domains such as oil industry, pharmaceutical industry, Government enabled Marketing and so on., can be identified to bring transparency and also harness other benefits from Blockchain Technology.
7) Government's Strategy for Blockchain Technology, similar to the Strategy for Artificial Intelligence has to be evolved. Also it is proposed to integrate Blockchain Technology with other emerging technology areas such as AI in order to achieve the vision of becoming global leader in these technologies.
8) Capacity building in Blockchain Technology need to be promoted by conducting short term courses or bootcamps. It is proposed to create sandbox environments for

development & testing of applications and for offering virtual training.

9) Regulatory aspects & Polices also need to be focused along with Infrastructure, Research, Technology Stack, Testing & Certification and Capacity Building. It is proposed to evolve a legal and regulatory framework for Blockchain Technology.
10) Explore the potential of BCT in the proposed public digital platforms in various sectors like Agriculture, Health, Energy etc., for more security.

12. References

1. National Strategy on Blockchain, NISG
   https://www.nisg.org/blockchain
2. National Blockchain Strategy, NIC
3. Tamil Nadu Blockchain Policy 2020
   https://tnega.tn.gov.in/assets/pdf/BlockChain2020.pdf
4. Blockchain: The India Strategy: Part 1, NITI Aayog,
   https://niti.gov.in/sites/default/files/2020-01/Blockchain_The_India_Strategy_Part_I.pdf
5. Practical Blockchain: A Gartner Trend Insight Report, 2017
   https://www.gartner.com/en/documents/3628617/practical-blockchain-a-gartner-trend-insight-report
6. Blockchain Mission Document of C-DAC
7. Brant Carson, Giulio Romanelli, Patricia Walsh, and Askhat Zhumaev, June 2018, "Blockchain beyond the hype: What is the strategic business value?", https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/blockchain-beyond-the-hype-what-is-the-strategic-business-value
8. Blockchain Market – Industry Analysis and Forecast (2019-2027) _ by Provider (Application and solution, Middleware, Infrastructure and protocol), by Organization Size (SME and Large), by Application, by Industry Vertical and by Geography, Report by MAXIMIZE MARKET RESEARCH PVT. LTD.
9. Which Governments Are Using Blockchain Right Now?
   https://consensys.net/blog/enterprise-blockchain/which-governments-are-using-blockchain-right-now/