# NATIONAL STRATEGY

## ON

# BLOCKCHAIN

*Towards Enabling Trusted Digital Platforms*

सत्यमेव जयते

Ministry of Electronics & Information Technology (MeitY)

Government of India

December 2021

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## MINISTRY OF ELECTRONICS & INFORMATION TECHNOLOGY
## Government of India

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# 1. VISION, MISSION, OBJECTIVES AND SCOPE

## 1.1.    Vision

To create trusted digital platforms through shared Blockchain infrastructure; promoting research and development, innovation, technology and application development; and facilitating state of the art, transparent, secure and trusted digital service delivery to citizens and businesses, thus making India a global leader in Blockchain Technology.

## 1.2.    Mission

Endeavour to evolve a vigilant and trusted collaborative digital ecosystem to provide a consensus based, tamper-evident, transparent and open framework for offering e-Governance services to citizens and businesses involving multiple organizations in a participating environment assuring trust, security, track and trace, integrity and regulatory compliance.

## 1.3.    Objectives

1.  Create a trusted digital platform by evolving a national Blockchain infrastructure that can be used for development and deployment of applications supported with a sandbox for testing multiple Blockchain based solutions.
2.  Foster research & development in Blockchain technology to address challenges related to rapid application development & deployment, interoperability, scalability, security and privacy.
3.  Create and update an innovation roadmap for trusted digital platform, addressing various challenges towards Blockchain technology adoption
4.  Plan for production grade applications of national interest focusing on providing faster, secure, transparent, trusted and efficient delivery of services to the citizens and businesses.
5.  Encourage development of standards in the area of Blockchain technology.
6.  Identify the legal and policy requirements towards regulating Blockchain for offering services to citizens and businesses.
7.  Encourage multi stakeholder model in evolving national Blockchain infrastructure for offering citizen services thereby assuring transparency, trust and provenance.
8.  Strengthen India's collaboration with global organizations and innovation and

research centres working in the area of Blockchain technologies.

9. Evolve a centralized planning and decentralized execution model for large scale adoption.

10. Promote capacity building, skill development and innovation in Blockchain technology.

## 1.4.   Scope

This document provides an insight on strategies and recommendations for creating a trusted digital platform using Blockchain Technology facilitating trusted service delivery to citizens and businesses and also make India a global leader in terms of research and development and harnessing the benefits of this emerging technology by focusing on the following elements:

## 1.5.   Technological Aspects

1. Evolve a national Blockchain infrastructure that can be used for development and deployment of Blockchain applications supported with a sandbox for testing multiple Blockchain solutions.

2. Provide support to stakeholders who are in need of distributed data provenance architectures with inherent scalability, security resilient and privacy-based data sharing capabilities.

3. Provide support for naturally evolving interoperability across different Blockchain platforms amongst participating entities.

4. Focus on capacity building and skill development to ramp-up technology insight and encourage innovation across various stakeholders including students, practitioners, management executives, policy and decision makers, etc.

5. Contribute towards creation of Intellectual Property Rights (IPR).

6. Enable global access to the developed technology as necessary and contribute towards development of cross-border solutions.

7. Contribute towards development of national and global level standards.

### 1.5.1 Administrative Aspects

1. Carryout detailed study and identify the legal and policy requirements towards Blockchain regulation and governance for offering citizen services.

2. Evolve multi stakeholder model towards creating the national Blockchain infrastructure.

# 2. INTRODUCTION

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 innovations, with a clear business value. Blockchain enables a shared ledger among the various parties involved in business transactions, which acts as the single source of truth. Blockchain eliminates the need for a central entity to validate the transactions.

Blockchain can be used in both Permissioned and Permissionless models. These models have applications in various domains such as education, governance, finance & banking, healthcare, logistics, cyber security, media, legal, power sector, etc.

Globally and nationally, various efforts are being made towards implementing Blockchain based applications. Proof-of-concepts (PoCs) and pilot deployments have been successfully carried out.  In order to reap the benefits of this technology, there is a need for a national level strategy on Blockchain technology.

## 2.1.    Technology Overview

Blockchain, a distributed ledger technology, enables a layer of trust and eliminates the need for a third party to validate the transactions. Blockchain technology is an amalgamation of various technologies such as distributed systems, cryptography, etc.. Data and transactions stored in blocks of Blockchain are secured against tampering using cryptographic hash algorithms. Blocks are linked with each other with proper security using hash function. This leads to a Blockchain, which is a distributed ledger stored at various nodes in the network. Each block contains details of transactions, hash of the previous block, timestamp etc., as shown in Figure 2.1. It is difficult for an adversary to modify the stored details at majority points. Therefore, Blockchain provides better security when compared with a centralized system.
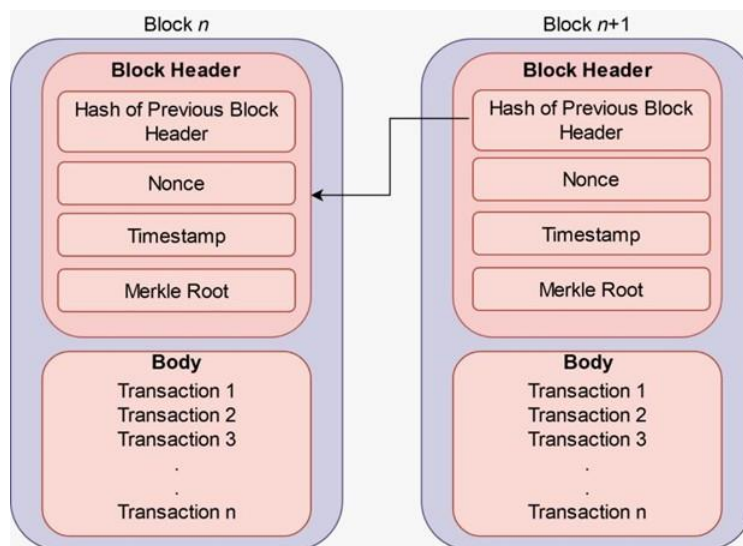
*Figure 2.1 Block Structure*

Data and transactions executed over the network are stored in the ledger in a decentralized manner over peer-to-peer network. Transactions are validated and verified through consensus (consensus protocols) across nodes of the Blockchain network. Figure 2.2 shows the online transaction flow in a Blockchain network.
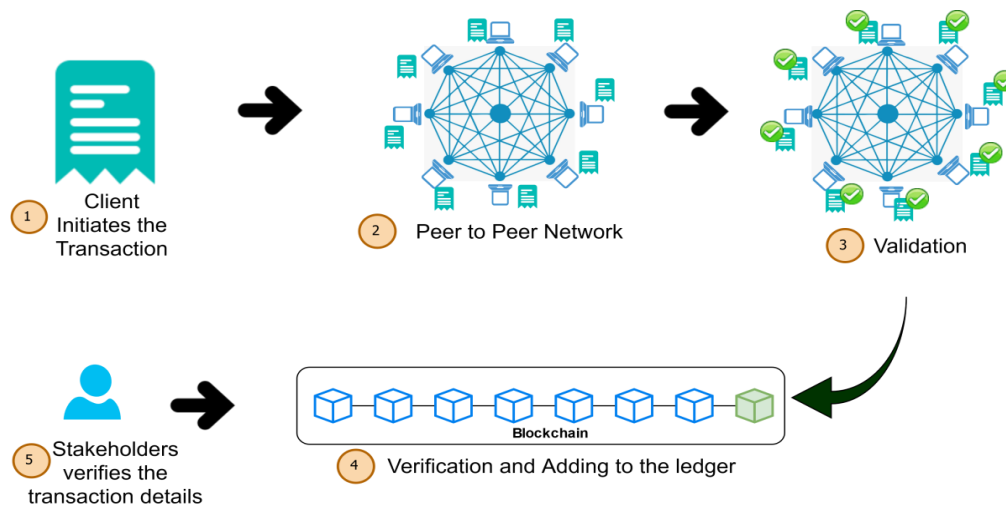


*Figure 2.2 Blockchain Network and the Process of Adding New Transaction to Ledger*

## 2.2.  Importance of Blockchain Technology

Blockchain technology harnesses the distributed software architecture and provides a shared ledger with a single source of truth for the recorded transactions without depending on a centralized entity for trust. Hence, it helps in enabling trust in the digital world using technology. Any tangible or intangible asset of value can be represented and tracked on a Blockchain network, which brings transparency, increases processing speed and reduces cost. On top of Blockchain network, contracts can be automated through smart contracts. Therefore, benefits of Blockchain technology include transparency, security, and efficiency, which make it unique in enabling a layer of trust over Internet for various applications.

> **Blockchain characteristics such as tamper-evident, consensus based transaction validations and secured data storage act as key driving forces for its adoption in various sectors.**

## 2.3.  Blockchain Models

Blockchain can be set up either in Public / Permissionless or Private / Permissioned configurations, each of which has its own advantages and disadvantages as given in the table below:

*Table 2.1 Blockchain Models*

| PUBLIC/PERMISSIONLESS | PRIVATE/PERMISSIONED |
|---|---|
| No permission required to participate | Permission required to participate |
| Anyone can join, read, write and commit | Only authorized participants can write and commit |
| All are allowed to participate in consensus and anonymous resilient | Authorized nodes only can participate in consensus |

| | |
|---|---|
| Truly decentralized because of participation of unknown actors | Partially decentralized because of participation of known actors |
| Highly secure due to more participants | Also secure depending on the size of the network |
| Finality of transaction could take longer time due to more number of participants in the network compared to private network | Finality of transactions could be better in this model due to less number of participants compared to public networks |
| Some consensus algorithms are better for public networks such as Proof of Work, BFT variants etc. | Some consensus algorithms are better for private networks such as Proof of Elapsed Time, Paxos, RAFT, Proof of Stake etc |

## 2.4. Value Addition of the Technology in e-Governance Domain

In the e-governance domain, usage of Blockchain technology ensures vigilance, transparency and possibly avoids insider attacks on the crucial data related to governance matters. The key features of e-governance are trust and accountability which are very well supported by the Blockchain technology. Since every data or transaction that is recorded in Blockchain is near impossible to tamper with and also due to consensus-based transaction data replication across Blockchain distributed nodes, this technology assures trust among its stakeholders in the digital world. The trust is especially brought in since all the stakeholders access the same source of truth in terms of application data stored on the Blockchain network.

> **Blockchain follows secure by design paradigm which makes it a unique system that makes business transactions transparent and trusted in a consortium environment without any reliance on a centralized or third-party authority.**

This kind of technology can bring significant changes in e-governance where several services have societal impact. For example, in educational system, student's certificates, scholarship details etc., can be stored in a Blockchain network. Various stakeholders such as educational institutions, different departments entrusted with disbursement of

==scholarships and respective administrative boards can become partners and have student's records stored on consensus basis.== Likewise, in supply chain domain, the track and trace capability of Blockchain network makes it possible to avoid any inadvertent mistakes or insider attack with regard to data maintenance across various stakeholders.

Thus, this technology can effectively be used in situations where multiple organizations or departments are involved in a particular workflow which not only makes the underlying system more efficient but also brings trust and transparency in the system.

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

## 2.5. SWOC Analysis

### 2.5.1. Strengths

1. Blockchain technology provides a decentralized, vigilant, time stamped, immutable and consensus based data storage for the stakeholders.

2. Blockchain technology provides efficient ledger storage mechanism in distributed environment with appropriate authentication and authorization based on the role of the stakeholder.

3. Depending on the need of the application domain, either permissioned or permissionless Blockchain environment can be setup.

4. Blockchain-as-a-Service allows for seamless integration for using Blockchain features in various application domains.

### 2.5.2. Weaknesses

Every technology brings in its own disadvantages, but identification of these weaknesses early would help in preparation to tackle the problems well before they affect the developed Blockchain ecosystem. Following are some of the concerns that need to be addressed before deploying Blockchain based systems:

1. Scalability: The current transaction processing rate of Blockchain platforms varies

from 7tps (transactions per second) to 3500 tps depending on individual platform's applicability to a particular domain, architectural considerations, consensus approach, number of nodes in deployment, etc. The generic architectural platforms such as HyperLedger Fabric, though apparently suitable for requirements of various domains, still have scalability as a major concern and researchers are striving to get better results.

2. <u>Security</u>: As some literature depict, not all weaknesses apply to all Blockchain platforms or corresponding application domains. A threat model needs to be evolved on similar lines of threat perception models such as STRIDE. Efforts are in progress to create a public repository of known Blockchain vulnerabilities.

   (a) Smart Contract Weakness Classification and Test cases (https://swcregistry.io/)

   (b) Cloud Security Alliance (https://cloudsecurityalliance.org)

3. <u>Interoperability</u>: Interoperability across various Blockchain platforms is still in its infancy and lot of work is required to address this issue. Interoperability mainly is required in the following situations: (a) when an entity moves to a new Blockchain platform, it has to support legacy platform, (b) when participating entities use different platforms, then they need to interoperate with each other, (c) when an existing platform exhausts its storage capacity, then a new platform may have to be set up which needs to interoperate with the earlier platforms.

4. <u>Data Localization</u>: Data localization requires data about citizens or residents of a country to be collected, stored and processed inside the country, before being transferred / shared internationally. In order to restrict the data flow and localizing the data, countries have introduced new data laws. European Union introduced data protection law called the GDPR (General Data Protection Regulation). In the Indian context, the proposed Personal Data Protection Bill would govern the collection, storage and processing of personal data, including their transfer outside the country under certain conditions.

5. <u>Disposal of Records</u>: *Right to be forgotten* is one of the requirements in the proposed Personal Data Protection Bill. As records stored on Blockchain are immutable, in order to enforce this requirement, appropriate measures have to be taken while implementing the Blockchain technology.

### 2.5.3. Opportunities

1. Blockchain technology provides an excellent technological framework for preservation of classified and unclassified data in a reduced risk environment. Hence, it is suitable for entities requiring such capability.

2. Blockchain technology provides an opportunity for transparent transaction processing in any domain as it supports track and trace capability.

3. With Blockchain-as-a-Service paradigm, revenue generation models can be evolved for offering various services (G2C, G2G, B2B etc.).

**Blockchain Business Value, Worldwide 2017-2030**

1. Technology provides a platform for future economic development and possible growth that is worthy of valuation. 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.

2. 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.

3. 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. Details are given in  Figure 2.3.
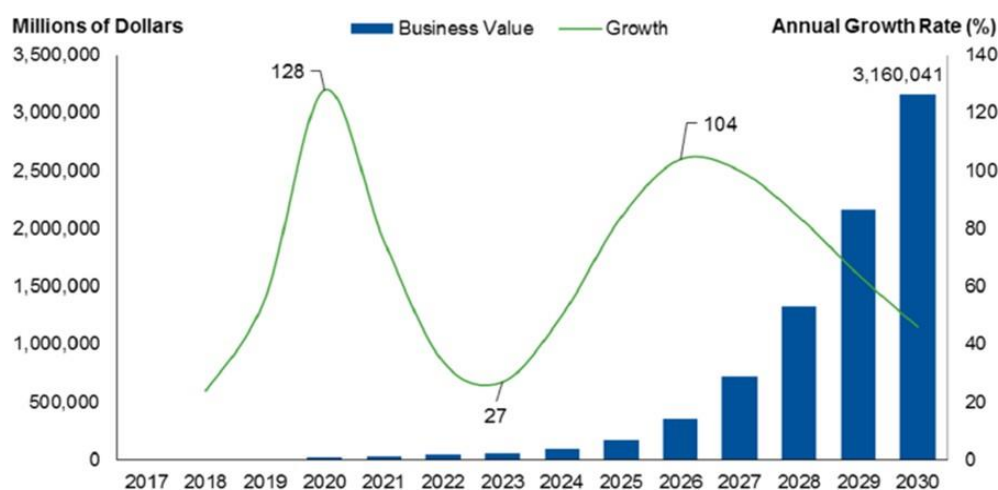


*Figure 2.3: Forecast: Blockchain Business Value, Worldwide 2017-2030 (Source: Gartner 2017)*

Forecast on Global Blockchain Government Market by Geography during the period 2020-2027 from Maximize Market Research Pvt. Ltd is given in Figure 2.4. The statistics depicts the adoption of Blockchain technology for Government use cases and provides an insight that it will rise over time.
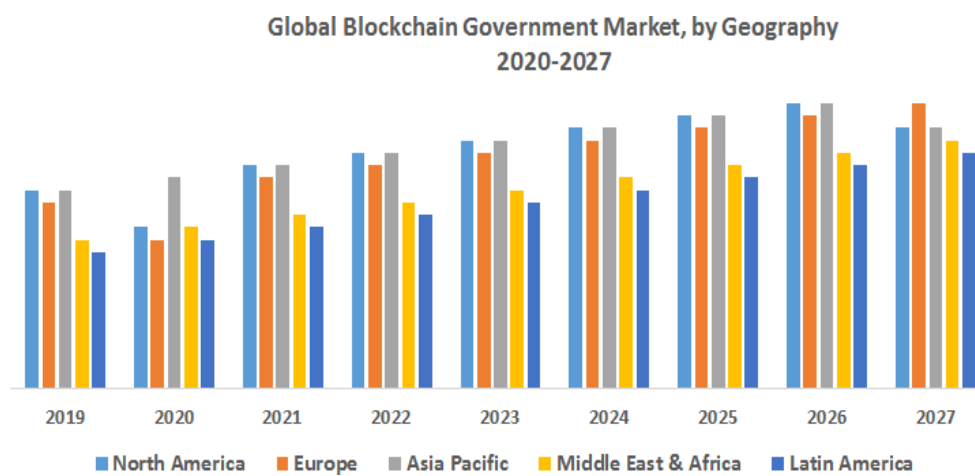


*Figure 2.4: Forecast on Global Blockchain Government Market by Geography during the Period 2020-2027*

### 2.5.4. Challenges

1. Technology Adoption: With plethora of Blockchain platforms being developed, a careful analysis of return on investment, governance, security & privacy and throughput has to be taken into consideration while understanding suitability of Blockchain in an application context.

2. Regulatory Compliance: While advocating the usage of Blockchain for an application domain, it is important to study compliance to applicable regulatory provisions and their implications, if any, with respect to the chosen application domain. Based on the requirements, additional regulatory policies may be evolved.

3. Identification of Suitable Use Cases: Different applications have different levels of security, privacy and data storage requirements depending on the number of participating entities and hence suitability of Blockchain in a particular application

context needs to be analysed carefully.

4. <u>Data Format</u>: The success of utilizing Blockchain capabilities depends on how well the transaction data format has been defined in a multi-party environment and keenly observing its related characteristics such as its dependency on other information.

5. <u>Awareness and Skill Set</u>: Availability of skilled manpower who understands Blockchain potential and its applicability to a particular application domain is required for successful implementation of the technology.

# 3. ROADMAP FOR BLOCKCHAIN TECHNOLOGY ADOPTION

As Blockchain technology is an emerging area, there are various challenges that need to be addressed to adopt and effectively use it in different applications. Roadmap for Blockchain technology adoption along with details of important milestones is given in Figure 3.1. 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 have been successfully carried out. In order to effectively utilize the technology, there is a need for scaling-up the deployments, exploring other domains and developing it as a shared infrastructure for cross domain applications.
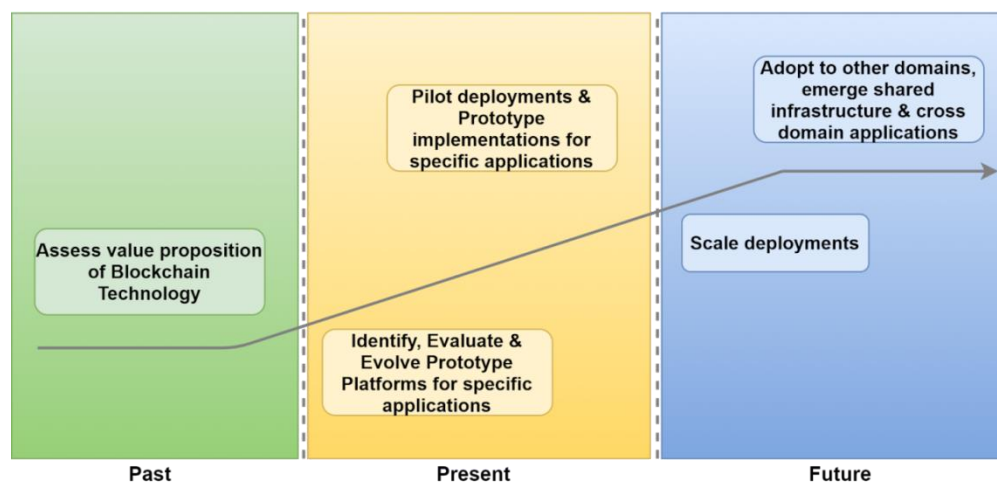


*Figure 3.1: Roadmap for Blockchain Technology Adoption*

For example, in healthcare domain, patient health records can be stored in a tamperproof manner on national level Blockchain. Role based and privacy enabled access can be given to patient data stored on Blockchain. This helps doctors of any hospital across India to access patient history, when a patient approaches them for treatment. Shared Blockchain infrastructure avoids duplication of asset data and maintains transaction history on assets in a consistent manner. E-Courts is another example where data from multiple entities such as police, judiciary, legal department, etc. needs to be stored in a coordinated manner, where the requirement may be fulfilled effectively using Blockchain technology. Some of the potential application domains of Blockchain are depicted in Figure 3.2.

*Figure 3.2: Applications of Blockchain Technology*

# 4. INTERNATIONAL SCENARIO

Blockchain technology and cryptocurrencies have become globally famous and known to most of the people. Usage and awareness levels related to Blockchain technology are growing fast. Many countries have recognized the potential of Blockchain technology and are trying to become the global pioneers.

## 4.1.    Applications in Prototype, Pilot and Production

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

1. Blockchain-based Service Network (BSN) initiative of **China** aims at helping companies and individuals deploy Blockchain applications faster and cheaper. BSN hosts a number of tools for developers which aid in developing applications majorly focused on smart cities and digital economy.

2. **China** has planned 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. China has also planned Blockchain enabled Notary Service.

3. **European Blockchain Partnership (EBP)** aims to use Blockchain and distributed ledger technologies to develop a trusted, secure and resilient European Blockchain Services Infrastructure (EBSI) to meet the highest standards in terms of interoperability, privacy, cyber security and regulation in applying policies.

4. Keyless Signature Infrastructure (KSI) is a kind of Blockchain designed in Estonia. This technology is used in **Estonian government** to prove the authenticity of the electronic records. They have also implemented X-Road, which is an open source data exchange layer. X-Road enables different organization to exchange information securely.

5. **United Arab Emirates** has Smart Dubai initiative, which aims to become the first city fully powered by Blockchain by 2021 and enhance everything from healthcare and education to traffic management and environmental sustainability.

6. In the **US**, food and drug inspection to address the problem of lack of transparency and security in health data processing is using Blockchain. In the UK, Food Standards agency is using Blockchain to track the distribution of meat to enhance food

traceability.

7. The **Brazilian** government is focusing on Ethereum platform for developing various applications including voting. Brazil is also focusing on public bidding of contracts with the government's on-line bid solution to ensure secure and transparent deals for agriculture applications, student certificates and tracking student performance.

8. **Chile** is using Ethereum platform to enable transparency in energy grid by tracking data and finances related to it. Switzerland is offering digital IDs through Ethereum platform.

9. **Canada** is using Ethereum platform to bring transparency in the spending of government grants. Sweden 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.

10. The Monetary Authority of **Singapore** (MAS) is focusing on using Blockchain technology in financial and technological domains. Blockchain technology is used to enable cross-border payments. They are working towards designing a solution for securing healthcare data and also smart contracts are adopted by Insurance companies.

11. Zug, in **Switzerland,** is the first place in the world to accept Bitcoin payments for tax purposes. They have successfully developed Blockchain based voting system and also created Blockchain TaskForce, for guiding companies towards implementing Blockchain framework.

12. Samsung Blockchain Wallet powered by COSMOCHAIN Blockchain has developed CosmeeDApp for purchase of contents using cryptocurrency. If a company utilized information provided or created by customers, the information providers get rewards for using Blockchain in a completely transparent manner.

13. LG has launched Blockchain platform with applications for digital authentication, community token and supply chain management.

14. Amazon Managed Blockchain, Microsoft Azure Workbench, IBM Blockchain, Oracle Blockchain and BlockappsStrato are some of the Blockchain services offered.

## 4.2. Platform Development

Blockchain platforms are being developed across the globe by academia, research organizations and industry focusing on improving performance in terms of throughput, scalability, security, etc., with an aim to offer Blockchain based digital transaction platforms enabled with interoperability across various chains. Some of the initiatives are depicted in the Figure 4.1 for quick reference.

**1**

Hyperledger is an open source global collaboration under Linux Foundation to work on enterprise grade Blockchain technologies. This includes global leaders in Banking & Finance, Information Technology, Manufacturing, Logistics and so on. Focus is on developing platforms, tools, libraries etc.

**2**

Cosmos, Polkadot, Aion, Ark, Wanchain, Atomic Swap and Chainlink are some of the global research initiatives in Blockchain Interoperability.

**3**

Redbelly, Ehtereum, R3Corda, Ripple, Stellar, Quorum, OpenChain and Hedera Hashgraph are some of the platforms that are being used by the organizations or being developed with different consensus approaches.
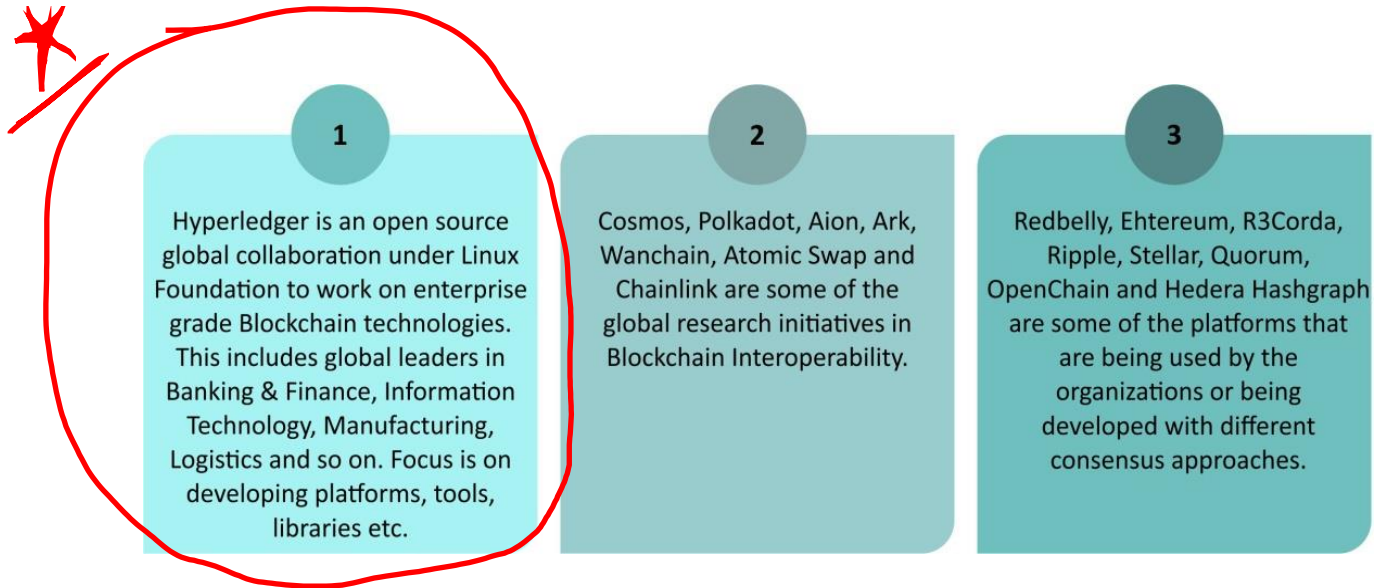
*Figure 4.1: Popular Blockchain Platforms*

# 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, cybersecurity, etc.

## 5.1. National Efforts: Applications Developed and Piloted

### 5.1.1. Meity

MeitY has supported a multi-institutional project titled "Distributed Centre of Excellence in Blockchain Technology" with C-DAC, Institute for Development & Research in Banking Technology (IDRBT), Hyderabad and Veermata Jijabai Technological Institute (VJTI), Mumbai as executing agencies. As part of this initiative, agencies have carried out research on the use of Blockchain technology in various domains and developed Proof-of-Concept solutions. Blockchain technology based solution for property registration has been developed and is piloted at Shamshabad District, Telangana State. Proof-of-Concept solutions have been developed for enabling Cloud Security Assurance, Central Know Your Customers (CKYC) and trade finance. Generic Blockchain based Proof-of Existence (PoE) Framework has been developed to enable PoE for digital artifacts, used to check the integrity of academic certificates, sale deed documents, MoUs, etc. By using PoE framework, a solution has been developed to authenticate academic certificates and is being piloted at the C-DAC Advanced Computing Training School (ACTS) and also for issuing the participation certificates while conducting online seminars and workshops. MeitY has initiated a project on design and development of a National Blockchain Framework (NBF) for creation of a shared Blockchain infrastructure and offering Blockchain as-a-Service (BaaS).

### 5.1.2. NIC

NIC along with NICSI has established a Centre of Excellence (CoE) in Blockchain technology. The objectives of the CoE are to accelerate adoption and deployment of Blockchain technology in Government, execute projects focusing 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 Back Office and Excise Management System.

### 5.1.3.  NeGD

NeGD has released an approach paper on National Strategy for Blockchain which provides details about the Blockchain application domains, challenges in adoption of the technology, societal impact, role of the government and principles to guide national strategy and is currently working on e-Attestation using Blockchain for the State of Karnataka.

### 5.1.4.  C-DAC

Successful pilot deployments and PoCs on Blockchain by C-DAC have given confidence on C-DAC's vision 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 on Blockchain technology includes: (a) National Blockchain Framework for cross domain applications addressing the performance, scalability, interoperability, security and privacy challenges; (b) eSign integration with Blockchain based proof-of-existence (PoE); and (c) development and large-scale deployment of applications.

### 5.1.5.  Academia

IIT Kanpur is working on Blockchain technology focused on developing e-governance solutions. The project spans across three phases which comprises of feasibility report on the technology, development of protocols and research on validating the *property of tamper resistance* which is prominently used in Blockchain and application development. Ripple has launched University Blockchain Research Initiative (UBRI). Ripple has chosen IIIT Hyderabad as one of the early university partners to promote Blockchain research and set-up a Center of Excellence in Blockchain. Through this COE, IIITH is working on Blockchain research challenges related to security, exploring use of game-theoretic techniques, and evolving next-gen Blockchain.  The team is also looking at using Machine Learning in Blockchain.

### 5.1.6.  NITI Aayog

NITI Aayog is working on various Blockchain use cases. NITI Aayog in collaboration with Gujarat Narmada Valley Fertilizers & Chemicals Limited (GNFC) has developed a Blockchain based system for fertilizer subsidy. The team has also partnered with PwC and Intel to optimize supply chain for the fertilizer subsidy. The application demonstrates the utilization of Blockchain features such as tamper-proof and transparency for efficient movement of fertilizer across the value chain and reduction of time to activate subsidy. Several transactions related to challans, claims and invoices are recorded on ledger in this

Blockchain implementation.

### 5.1.7. Govt. of Telangana & Govt. of Tamil Nadu

Telangana and Tamil Nadu have released the policy documents towards adopting the Blockchain technology. Telangana Government is also actively promoting the Blockchain technology. Various use cases have been successfully developed under Blockchain District initiative of Telangana State. 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.

### 5.1.8. Banking Sector

Reserve Bank of India (RBI) is exploring on applying Blockchain technology in banking domain. Mahindra and IBM are jointly collaborating on supply chain management solutions. State Bank of India (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.

### 5.1.9. IDRBT

IDRBT has released a whitepaper describing the roadmap for the adoption of BCT to banking and finance in India via 3 steps: (a) Intrabank: a private Blockchain for the banks internal purpose; (b) Interbank: Implementation of PoCs and testing them; (c) Central bank: for initiating suitable efforts towards digitizing the Indian Rupee through BCT. They have also released a Blueprint of Blockchain Platform for Banking sector with a focus on architecture, governance and technology aspects for a business network leveraging Blockchain.

### 5.1.10. Capacity Building

Government of India has started a Future Skills Prime program (https://futureskillsprime.in/standalonetechnology/blockchainspecifically) for upskilling and reskilling in the domain of Blockchain to address the need for growing the talent pool in the country through NIELIT and C-DAC.

# 6. SUGGESTIONS FROM PUBLIC CONSULTATIONS

Several inputs and feedback were received from various stakeholders including industry, government departments / societies / R&D labs, individuals, banks, start-ups, etc. Based on the inputs and feedback, actionable recommendations have been identified. Considering the essence of these inputs and feedback, suggestions are broadly categorized into the following:

1.  Industry
2.  Technology and Research & Development
3.  Security and Privacy
4.  Standards
5.  Government
6.  Legal and Regulatory
7.  Financial Inclusion
8.  Education, Awareness and Academia
9.  Other Important Suggestions
10. List of Potential Applications

The inputs and feedback in the above categories are elaborated below.

## 6.1. Industry

1.  To promote entrepreneurial development and involve premier research institutions, Blockchain technology stack may be collaboratively evolved by involving various stakeholders from Government, premier research institutes, startups and industry.

2.  To facilitate and evolve a mechanism for innovation, healthy competition and a platform for industry, startups and academia to contribute for the National Blockchain Framework (NBF), the industry, startups and academia may be supported and incentivized to undertake application oriented research and technological grand challenges in the domain of Blockchain Technology.

3.  To encourage Public Private Partnership (PPP), relevant joint initiatives may be explored wherever necessary in specific technology areas / applications.

4.  Mechanisms may be identified to incorporate feedback and involve industry and other stakeholders.

5. To provide benefits or incentives for stakeholders, efforts should be made to utilize existing schemes of the Government, such as Make in India, for promoting Blockchain.

## 6.2.     Technology and Research & Development

1. Advanced research may be focused upon in the domain of Blockchain technology and various challenges in adopting the technology towards building a trusted public digital platform may be addressed.

2. There should be more 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. This should essentially result in indigenous Blockchain platform.

3. To encourage research on Blockchain and extend funding support, a Working Group may be formed to facilitate premier R&D and academic institutions in the country to take up research activities in the core research areas in the domain of Blockchain. Research focus should be on standards & interoperability, personal/ non-personal data protection, scalability & performance, consensus mechanisms and security & privacy.

4. As cryptographic algorithms play an important role in Blockchain technology, academia, practitioners and experts in cryptography/ PKI may be involved in evolving the core cryptography functionality that is desired for Blockchain. Also, feasibility study on integration and use of Quantum Computing/ Post Quantum Blockchain may be carried out.

5. Building a Blockchain/ DLT Technology stack as India's own platform should be explored. Premier R&D and academic institutions should be involved in evolving the platform from ground up, including addressing technology specific challenges through research.

6. As indigenous technology stack with open APIs may be evolved, 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. A balanced approach towards technology stack development and implementation of use cases should be adopted. There should be a clear focus on creation of infrastructure as a national resource and offering Blockchain-as- a-Service (BaaS).

7. Interoperability should be ensured at the application and core platform layers.

Application layer interoperability may be handled using Open API architecture while platform layer interoperability may be taken care of at the Blockchain protocols and core components of the platform. Cross application layer access APIs may be enabled.

8.  Design aspects related to the integration of existing systems such as e-sign, Aadhaar etc. should be considered right from the start of the National Blockchain Framework design.

9.  We may explore & harness relevant existing technologies such as Self Sovereign Identity, Zero Knowledge Proof, Baseline Protocol, Confidential Computing, Trusted Execution Environment and DAML for possible integration into appropriate layers of the framework.

10. Technical challenges, resource requirements and implementation details towards design and development of National Blockchain Framework should be included as it increases visibility and clarity.

11. Efforts should be made to include designing of customized consensus algorithms meeting the requirements of specific applications having smart contracts.

12. The growth of computational devices to manage large storage of the system, with complex Indian geographical dispersion poses a challenge to data integrity. But at the same time, the lack of scalability poses a threat to the sustainability of any Blockchain system. Hence, scalability and sustainability aspects should be thoroughly analyzed and addressed in the framework.

13. It is well understood that transactions in Blockchain platform takes more time and also computationally intensive hence consume lot of energy. It is suggested that any application that has been visualized to be implemented must audit its transaction time and provide the estimate of the energy cost for the same.

## 6.3. Security and Privacy

1.  Security audit and assessment processes / guidelines may be evolved considering the smart contract and other specific constructs of Blockchain. Smart Contract security research efforts may be initiated to understand the threat scenario and evolve audit guidelines and processes.

2.  Data localization should be enabled in the framework. This may be achieved by hosting

the Blockchain infrastructure, data and smart contracts within the country. In future, infrastructure from various organizations and state data centres within the country may be contributed through crowd-sourcing mechanisms towards implementation of the framework.

3. Security and privacy should be considered as vertical components and it should be addressed across various layers in the Blockchain infrastructure. Personal data protection, data life cycle management, provisions relating to right to be forgotten/right to erasure, etc. may be taken care of as per the legal provisions and the requirements of applications.

4. In permissioned Blockchain framework, identity, authentication and role based access control should be enforced at appropriate layers of the technology stack. Access to the Blockchain data may be enabled for LEA as per the applicable legal provisions.

## 6.4.    Standards

1. Standardization across the various layers of Blockchain technological stack and applications should be considered as one of the important activities in the framework development.

2. Indian stakeholders should work with the Bureau of Indian Standards (BIS) and other standard bodies to participate in various global/ regional technical committees such as ISO standards related to Blockchain and DLT technologies. They should contribute to the Indian requirements, study standards relevant to the Indian context/ strategy and decide on their adoption and implementation plans.

## 6.5.    Government

1. Government should foster and act as a catalyst for the development of the framework involving all the stakeholders including industry/ startups/ R&D institutes/ academia/ Government departments. It should also facilitate state-wise Blockchain adoption and synergy across potential inter-sector/ inter-ministerial use cases.

2. Working Group/ Councils/ Project Review & Steering Committees should be formulated by Government to address various aspects related to execution of the strategy and creation of national level Blockchain infrastructure.

3. The basic technical parameters for onboarding any entity (industry/ startups/

Government organisations) should be defined by the Government. Interested entities must undergo security audit and assessment by empanelled agencies before being part of the national level Blockchain infrastructure.

4. National Blockchain Framework should initially focus on consortium model to address the various research challenges and implement relevant use-cases in e-governance domain for providing citizen services enabling tamper-evident and transparency features of Blockchain technology. Subsequently, transition should be made to incorporate various use cases beyond e-governance and the framework would be open for anyone to use. Government can define the policies & guidelines and any application / use case complying with the policies can be onboarded on the framework.

5. 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 domains such as oil industry, pharmaceutical industry, Government enabled marketing and so on, can be identified to bring transparency and harness other benefits from Blockchain Technology.

## 6.6. Legal and Regulatory

1. Initial use cases may be chosen such that they do not require the contractual obligations and legal aspects to be changed. The main focus in the beginning should be to utilize the technology to enhance transparency/ openness.

2. Update in the existing regulations and policies may be taken up as the national Blockchain framework evolves and based on the experiences gained during the implementations. MeitY along with the other ministries in the Government of India may work on specific regulations and policies for the framework as it evolves as per the needs of various application domains.

3. To address the legal challenges in making Smart Contracts admissible in the courts, relevant stakeholders may be consulted.

4. Cross-border regulations are long term goals and may be considered as the use cases evolve.

## 6.7. Financial Inclusion

1. Decentralized finance applications having permissioned Blockchain requirements may

be developed and hosted along with application domains on national Blockchain infrastructure.

## 6.8.    Education, Awareness and Academia

1. Government has started Future Skills PRIME program specifically for upskilling and reskilling in emerging technologies including Blockchain. The program has an ecosystem backed by the IT industry, NASSCOM and the Government. This program may be effectively leveraged to identify the industry requirements and create the required talent pool in the country in Blockchain.

2. Government may work with academia to retrofit Blockchain course in the existing curriculum of UG/ PG courses.

3. Capacity building can be promoted by conducting short term courses or bootcamps.

4. Sandbox environments may be created for development & testing of applications and for offering virtual training.

5. Collaboration with start-ups and innovators to develop this cutting-edge technology further and proper implementation and development of capacities & skills within the country may be ensured. Startups / innovators may be on-boarded through grand challenges.

6. Blockchain technology is inherently complex, and, hence, academia should be involved in designing and developing undergraduate courses to address the skill requirements for implementing the National Blockchain Strategy and development of the Blockchain platform. The courses may be conducted in various institutions of repute.

7. As Blockchain technology is evolving at a fast pace, there is an imperative need for studies & research at postgraduate level and encouragement to PhD students to take up challenging problems in the domain of Blockchain technology.

8. As Blockchain applications have legal and regulatory dimensions, appropriate courses should be designed for law schools.

9. A repository of use cases / whitepapers / lessons learnt may be created to enable access to real life use cases related to different sectors. This may be used in education, training and awareness activities.
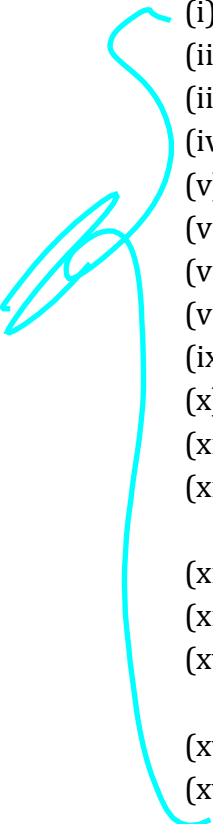
10. Awareness workshops may be organized to sensitize the MSME sector and Government departments to enhance adoption of this technology and find new innovative use cases based on Blockchain.
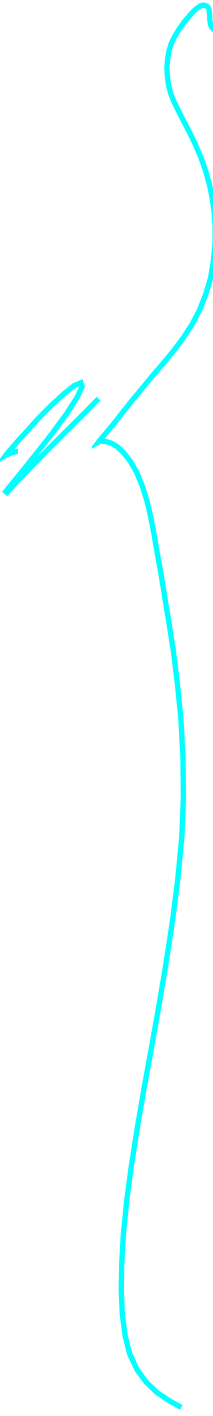
## 6.9.    Other Important Recommendations

1. A National Blockchain Framework (NBF) may be created with three types of participants: a) confident user of technology (application developers), b) provider or operator of technology (infrastructure and services, BaaS), and c) complete technology stack builder (IP creator). Multi-institutional model can be created for architecting the NLBF. Organizations must be identified along with their roles & responsibilities. Involvement of innovative start-ups and industry would bring in the agility. Institutional mechanism within MeitY and a collaborative framework with other ministries/ departments and states may be evolved.

2. 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 a crowd-sourced model.

3. Major Global initiatives may be studied and the learnings may be incorporated in National Blockchain Framework.

4. Private chain rewriting, chameleon hashes, patches as well as mutable transaction sets and circuit breakers may be explored and incorporated appropriately in relevant components of the National Blockchain Framework and Infrastructure.

5. As the framework evolves, marketplace for Blockchain specific technologies and applications can be hosted which will act as a single point reference to user agencies.

6. Tokenization may be explored and implemented for relevant applications as part of the National Blockchain framework.

7. Sandbox should be supported in framework in a way that will allow hosting and testing of multiple Blockchain solutions. The framework should be envisioned to integrate with various existing infrastructure and service components.

8. The initial infrastructure should be distributed across the country and scalability and performance should be considered during architecting and implementing the framework/ applications.

9.  Careful cost-benefit analysis may be carried out jointly with domain & technology experts before applying Blockchain to any specific application domain.

10. While evolving the National Blockchain Framework, various aspects such as standardization, governance, processes and SOPs specific to domains of smart cities, healthcare, etc. may be separately evolved by identifying and involving various stakeholders as part of the National Blockchain Framework.

11. Identifying off-chain and on-chain data as part of the application implementation is an important requirement across all domains.

12. Pilot projects in the regulatory framework should be considered as a precondition for production hosting.

13. The potential of BCT may be explored in the proposed public digital platforms in various sectors like agriculture, health, energy etc., for meeting enhanced security requirements.

## 6.10.    List of Potential Applications

(i)  Transfer of land records / property
(ii) Digital certificates management
(iii)        Pharmaceutical supply chain
(iv)        e-Notary service
(v) Blockchain enabled e-Sign solution
(vi)        Farm insurance
(vii)        Identity management
(viii)        Duty payments
(ix)        Automated customs enforcement and compliance
(x) Agriculture / farm produce supply chains
(xi)        E-Voting
(xii)        Smart Grid applications include energy transmission, distribution, trading and marketing of energy
(xiii)        Authorized access to relaying in the substation protection system
(xiv)        Government crypto wallet platform for selling, buying and trading
(xv)        Multiple layer and multiple level access Blockchain based cloud storage of health test records
(xvi)        Validation of Bill of Lading in cross-border transport
(xvii)        Ease of validation of documents at the customs at the ports of entry and exit

(xviii)     Electronic health record management
(xix)       Digital evidence management system
(xx)        Public service delivery
(xxi)       Blockchain for social good use cases (charity, donations)
(xxii)      Metering and settlement
(xxiii)     Payment security mechanism
(xxiv)      Authentication and authorization services
(xxv)       Automated control of decentralized power
(xxvi)      Smart grid application and grid management
(xxvii)     Microfinance for Self-Help Groups (SHG)
(xxviii)    Customs and trade finance
(xxix)      Cross border trade
(xxx)       Renewable energy trading and management
(xxxi)      Insurance underwriting and claims management
(xxxii)     Aggrotech environment
(xxxiii)    Micro-financing, financing small businesses or individuals
(xxxiv)     Secured logistics document exchange (SLDE)
(xxxv)      Cold chain for supply chain
(xxxvi)     National and state highways, toll collection, tracking of public infrastructure
(xxxvii)    Blockchain for urban development tracking through Public Private Partnership
(xxxviii)   Tracking the progress on climate agreement through Blockchain
(xxxix)     Asset transfer across different government departments
(xl)        Digital identities, verifiable credentials to secure privacy and enable new use cases
(xli)       Safe and secure vaccine distribution and administration
(xlii)      IoT device management and security
(xliii)     Vehicle lifecycle management
(xliv)      Chit fund operation and administration.

# 7. STRATEGIES AND OUTCOMES TARGETED FOR THE NEXT 5 YEARS

## 7.1. Strategies and Outcomes

### 7.1.1. National Blockchain Framework (NBF)

In order to effectively utilize the Blockchain technology in different domains such as health, agriculture, education, finance, etc., a geographically distributed national level shared infrastructure is required to enable citizen services at large scale and enable cross domain application development. This National Blockchain Framework (NBF) with core research components would be developed with intermediate milestones consisting of basic framework for reference implementation, integration with various existing infrastructure and services, reference implementations of real-life projects and sandbox environments for development and testing of applications. A multi-institutional collaborative approach (involving Government, academia, industry, R&D labs, etc.) need to be adopted for this purpose.

### 7.1.2. Geographically Distributed Nodes

National Blockchain Framework would be hosted on nodes which are geographically distributed across the country, enabled as shared Blockchain infrastructure. For onboarding any entity (industry/ startups/ Government), basic technical parameters may be evolved. Interested entities need to undergo security audit and assessment by empanelled agencies before being part of the national level Blockchain infrastructure.

### 7.1.3. Blockchain-as-a- Service

National Blockchain Framework would be used for development and large-scale hosting of Blockchain applications in different areas such as agriculture supply chain, electronic health records, education certificate chain, drug supply chain, etc. This infrastructure will be used for providing Blockchain-as-a-Service.

### 7.1.4. Collaborative Efforts

National Blockchain Framework development is proposed as a collaborative effort involving various stakeholders from Government, premier academic & research institutions, startups and industry. Collaboration with startups and innovators would be facilitated through grand challenges.

### 7.1.5. Initial Application Domains

Initially, National Blockchain Framework would be used for e-governance domain.

Transition would be made to incorporate various use cases beyond e-governance and the National Blockchain Framework would be open for relevant stakeholders. Government would define the policies & guidelines and any application / use case complying with the policies would be on-boarded on the framework.

### 7.1.6. R&D for Blockchain Challenges

MeitY, through its working group mechanism, shall initiate various research projects to focus on advanced research in the domain of Blockchain technology and contribute in addressing various challenges such as standards & interoperability, scalability & performance, consensus mechanisms, security & privacy, secure smart contracts and detection of vulnerabilities in Blockchain technology based solutions.

### 7.1.7. Awareness Creation

MeitY shall organize user awareness workshops to sensitize the MSME/ Government departments to boost the adoption, which would lead to new innovative use cases based on Blockchain.

### 7.1.8. Policies & Regulations

The existing regulations and policies would be updated as needed as the National Blockchain Framework evolves and more experience is gained during the implementation. MeitY along with the other ministries in the Government of India would plan stakeholder meetings to work out for specific regulations and policies for the framework as it evolves as per the needs of application domains.

### 7.1.9. Awareness among Judiciary & LEAs

To create awareness about Smart Contracts among judiciary and law enforcement agencies (LEAs), necessary sensitisation workshops will be conducted.

### 7.1.10.     Human Resource Development in Blockchain

Government has started the Future Skills Prime program specifically for upskilling and reskilling in emerging technologies including Blockchain in association with NASSCOM to provide the required talent pool in the country.  Under this initiative, it is planned to offer training programmes to Government officials, training of trainers, bridge courses, foundation courses, deep skilling courses, etc.  In addition, various capacity building initiatives in Blockchain and its implementation in e-governance and other applications would be taken up on a continuous basis.

### 7.1.11. Implementation Strategy

Centralized planning and decentralized execution will be followed for the overall strategy implementation.

### 7.1.12. Adoption Incentives

Central and state Governments shall formulate their respective schemes and guidelines detailing out fiscal and non-fiscal incentives in this sector to enable large scale adoption of Blockchain in the country. Special incentives may be considered for providing sandbox environments for the Blockchain infrastructure.

Figure 7.1 depicts the strategies and outcomes targeted to be achieved during the next 5 years (upto 2026-27) of implementation of the National Strategy on Blockchain.

### 7.1.13. Institutional Mechanism

An Institutional mechanism within MeitY and a collaborative framework with other ministries/ departments and states would be evolved. While evolving the National Blockchain Framework, various aspects such as standardization, governance, processes and SOPs specific to domains like smart cities, healthcare, etc. would be separately evolved by identifying and involving various stakeholders. It would also facilitate state-wise Blockchain adoption and synergy across potential inter-sector/ inter-ministerial use cases leveraging the expertise and national footprint of NIC and other MeitY organisations.

A Blockchain Advisory Council under the chairmanship of Hon'ble Minister of Electronics and IT with representatives from various central Government ministries/ departments, states, academia and industry shall be constituted to provide overall guidance at policy level for the Blockchain initiatives in the country.

A Steering Committee under the chairmanship of Secretary, MeitY with the secretaries of various central line ministries dealing with key domains, selected state IT secretaries, and academia and industry representatives will be constituted for regular review and monitoring of the implementation of the National Blockchain Strategy.

**Year - 5**
- Convergence across Blockchain, IoT, Cloud and AI (BICA Stack)
- Enabling technology for Global usage
- Additional National Level Use cases harnessing the BICA Stack

**Year - 3**
- Large scale adoption & deployment of Applications
- Integration with other existing national services
- Enabling AI based analytics on Blockchain
- Standarize India Stack for Blockchain Adoption

**Year - 4**
- Promote adoption of Global Standards and Cross Border Applications
- Additional National Level Use cases with cross domain application focus
- Addressing regulatory challenges

**Year - 2**
- Offering Blockchain-as-a-Service
- Evolve & develop a framework to host Government Applications on the infrastructure
- Implementation of MeitY Applications
- Industry, MSME and Startup Onboarding
- Setting up of Institutional Mechanism

**Year - I**
- Geographically Distributed Shared Infrastructure
- Foster R&D efforts to address technology challenges
- National Blockchain Portal
- Technology Ecosystem (Academia, R&D, Government)
- Use case analysis (State and Central Government)
- Human Resource Development
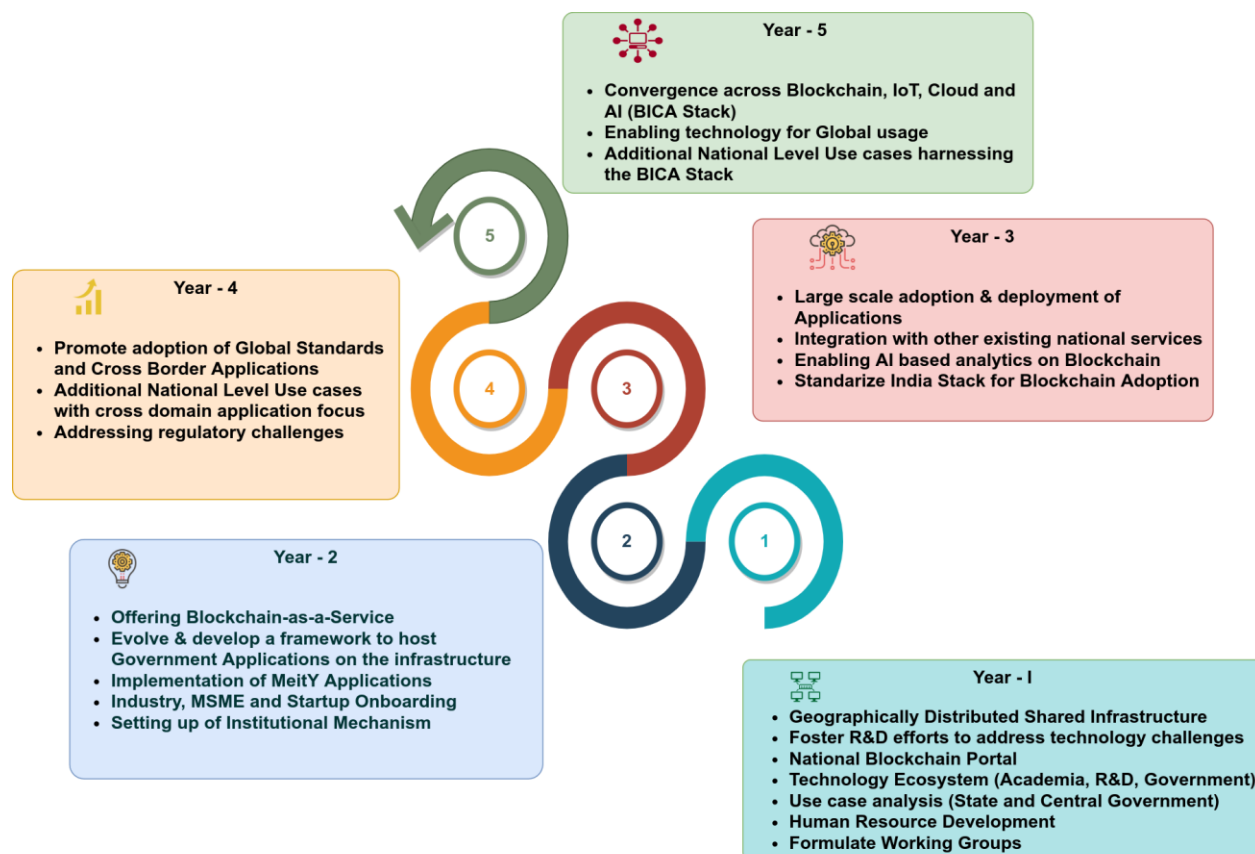- Formulate Working Groups

*Figure 7.1 Strategies and outcomes Targeted for the next 5 years*

# 8. NATIONAL BLOCKCHAIN FRAMEWORK

## 8.1. Key Learnings

1. There are many development frameworks with different scalability, throughput per second rate, transaction finality capability, security capabilities, etc. The suitability of these platforms across various application domains needs to be investigated and understood in depth. Hence, a detailed assessment of these platforms shall be carried out for selection of a suitable Blockchain platform as per the requirements.

2. The Blockchain adoption in the existing traditional transaction processing systems across various domains cannot be realized in a short span of time due to technological and administrative challenges and hence sector-wise migration plan shall be devised after understanding pilot implementations of Blockchain technology.

3. Standard operating procedures shall be developed based on the experiences gained in technology adoption, which eventually will lead to formulation of best practices or standards.

Research relating to adoption of Blockchain technology in specific application domains shall be carried out. Due to various challenges in adoption of Blockchain technology, a consortium approach shall be adopted to share the experiences gained and collaboratively work in this direction.

Figure 8.1 depicts a schematic diagram of the National Blockchain Framework.
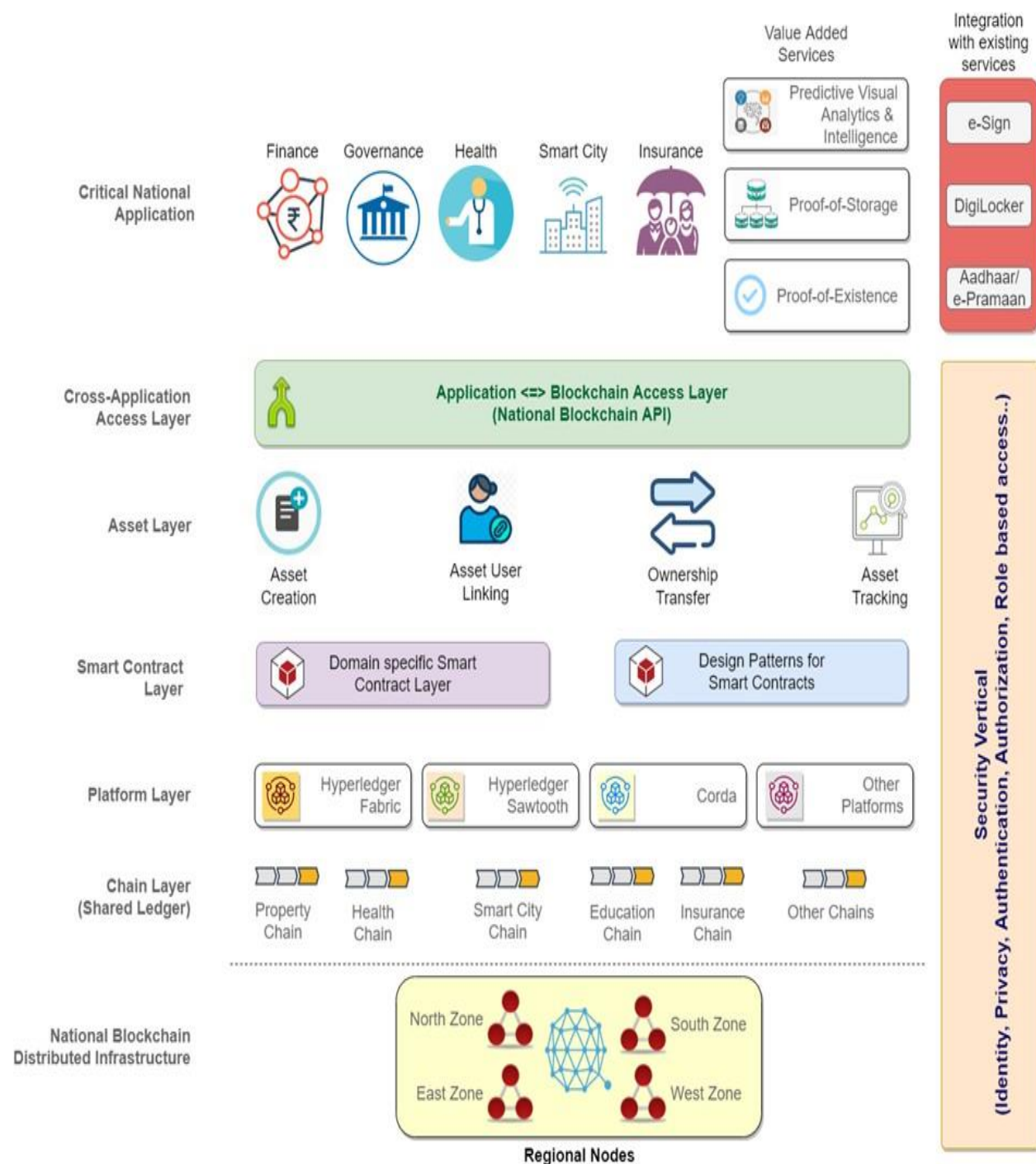
*Figure 8.1 National Blockchain Framework*

## 8.2.    Need for a National Blockchain Framework

National Blockchain Framework can aid in scaling up the deployments for developed applications, developing shared infrastructure and enabling cross domain application development. Initially the framework may support Government applications and later it can be extended / adopted for other relevant applications. Hence, there is a need to build infrastructure that is spread across multiple regions across the country as shown in the Figure 8.1.

Since no single platform is capable of meeting the requirements of different application domains of the country, the proposed infrastructure can help in hosting multiple Blockchain platforms. This will enable each application to benefit from the platform specific strengths. It is also proposed to design and develop an indigenous Blockchain platform incorporating identified best practices and advanced technological features. On each of these platforms, the domain specific chain such as property chain, health chain, education chain, etc. may be hosted and controlled using the smart contract logic. The framework would 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, etc. could be provided using easy to use and standard APIs using the National Blockchain API. This will facilitate in customizing the application software for any workflow requirements and get the benefits of the National 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 application to extend its functionality. Predictive visual analytics and intelligence will help to build business intelligence from the metadata of Blockchain. The applications can also have integration points with existing national services such as e-Pramaan, Aadhaar, eSign, Digilocker, etc. Security and privacy aspects can be enabled across the layers of the Blockchain Framework.

## 8.3.    Integration of Important National Level Services to Blockchain

### 8.3.1.  eSign

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

### 8.3.2. ePramaan

ePramaan is a standards-based e-Authentication framework. It provides Security Assertion Markup Language (SAML) based Single Sign On which can seamlessly get integrated with state and national level applications. This makes it ideal to facilitate single window authenticated access to different government services and applications.

### 8.3.3. DigiLocker

DigiLocker is an online service delivered under the Digital India initiative by MeitY. It provides every citizen with an account in the cloud to access documents / certificates such as vehicle registration, academic certificates and mark-sheets, driving license, etc.

> **Integration of the National Blockchain Framework with online Electronic Signatures (e-Sign), ePramaan and Digilocker would be an added advantage.**

## 8.4. Multi-Institutional Approach for National Blockchain Framework

To plan and implement the National Blockchain Framework, a multi- institutional approach is proposed. Collaborating organizations and their responsibilities are given in the Table 8.1 below:

*Table 8.1*: *Multi-Institutional Approach for National Blockchain Framework and Collaborating Organizations*

| S.No | ORGANIZATION (S) | RESPONSIBILITIES |
|------|------------------|------------------|
| 1 | C-DAC | Research and Development of the National Blockchain Framework addressing various technology challenges and application development and technology handholding. User Awareness and Skill Development Programs to sensitize about Blockchain Technology. |
| 2 | 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. |

| 3 | STQC | Standardization, Testing and Certification. |
|---|---|---|
| 4 | IDRBT Hyderabad, SETS Chennai and premier academic institutes, etc. | Address research challenges in implementing Blockchain technology. |
| 5 | 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. |
| 6 | State Governments | Develop state specific Blockchain applications on the shared Blockchain infrastructure. |
| 7 | Regulatory and Legal aspects | Ministry of Electronics and Information Technology (MeitY) along with the other relevant domain ministries of the Government. |
| 8 | Industry and Startups | Promote innovation by developing use cases in various domains. |

# 9. CONCLUSION

The National Strategy to evolve a trusted digital platform for providing e-Governance services using Blockchain lays out overall vision and the development and implementation strategies for a National Blockchain Platform covering the technology stack, legal and regulatory framework, standards development, collaboration, human resource development and potential use cases. It is hoped that this strategy document would provide the necessary guidance and support for realizing the vision and creating a nationwide ecosystem for creating the National Blockchain Platform and development of relevant applications using this platform in various domains.

MeitY will work with various Government organizations and other stakeholders in implementing this strategy and realizing the various advantages of the Blockchain technology in terms of enhanced security, trust and its ability to ensure tamper-evident transactions. A dedicated team would be identified to hand-hold the implementers at various central / state government applications. Existing services offered by MeitY and other Government organizations would also be onboarded onto the trusted digital platform.

# 10. FEEDBACK & CONSULTATIONS

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(lxi)    Shri Rahul Kumar Neiwal, Scientist C, MeitY, New Delhi
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(lxiii)    Shri Nagesh Shastry, DDG, NIC, New Delhi
(lxiv)    Shri Brahmanand Jha, Sr. Consultant, NeGD, Ministry of Electronics & IT
(lxv)    Dr. Vinay Thakur, Senior Director (Research), Digital India Corporation
(lxvi)    Smt. P R Lakshmi Eswari, Senior Director & Centre Head, C-DAC Hyderabad
(lxvii)    Shri Mahesh Patil, Associate Director, C-DAC Hyderabad
(lxviii)  Smt K Radhika, Joint Director, C-DAC Hyderabad
(lxix)    Smt Jyostna G, Joint Director, C-DAC Hyderabad
(lxx)    Shri N Satyanarayana, Principal Technical Officer, C-DAC Hyderabad

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# 12. GLOSSARY

*Table 12.1: Glossary of Terms and Words*

| SR. NO | TERM/ WORD | DESCRIPTION |
|---|---|---|
| 1 | AI | Artificial Intelligence |
| 2 | API | Application Programming Interface |
| 3 | B2B | Business to Business |
| 4 | BRAI | Blockchain Regulatory Authority of India |
| 5 | BCT | Blockchain Technology |
| 6 | BFT | Byzantine Fault Tolerance |
| 7 | BSN | Blockchain-based Service Network |
| 8 | C-DAC | Centre for Development of Advanced Computing |
| 9 | CA | Certificate Authority |
| 10 | CoE | Centre of Excellence |
| 11 | DAML | Digital Asset Modeling Language |
| 12 | DLT | Distributed ledger technology |
| 13 | DXL | Data Exchange Layer |
| 14 | EBP | European Blockchain Partnership |
| 15 | EBSI | European Blockchain Services Infrastructure |
| 16 | G2C | Government to Citizen |
| 17 | G2G | Government to Government |
| 18 | GNFC | Gujarat Narmada Valley Fertilizers & Chemicals Limited |
| 19 | IDRBT | The Institute for Development & Research in Banking Technology |
| 20 | IDs | Identities |
| 21 | IIITH | International Institute of Information Technology Hyderabad |
| 22 | IIT | Indian Institute of Technology |
| 23 | KSI | Keyless Signature Infrastructure |
| 24 | MAS | Monetary Authority of Singapore |
| 25 | MeitY | Ministry of Electronics and Information Technology |
| 26 | NeGD | NATIONAL eGOVERNANCE DIVISION |
| 27 | NIC | National Informatics Centre |
| 28 | NICSI | National Informatics Centre Services Incorporated |

| 29 | NIELIT | National Institute of Electronics & Information Technology |
|----|--------|------------------------------------------------------------|
| 30 | NBF | National Blockchain Framework |
| 31 | PDP | Personal Data Protection |
| 32 | PKI | Public key infrastructure |
| 33 | PoC | Proof of Concept |
| 34 | PoE | Proof of Existence |
| 35 | PPP | Public Private Partnership |
| 36 | RBI | Reserve Bank of India |
| 37 | SDLE | Secured Logistics Document Exchange |
| 38 | SETS | Society for Electronic transaction and security |
| 39 | SHG | Self-Help Groups |
| 40 | SOI | Statement of Intent |
| 41 | SRO | Self-Regulatory Organisations |
| 42 | STQC | Standardisation Testing and Quality Certification |
| 43 | SWOC Analysis | Strengths, Weaknesses, Opportunities and Challenges Analysis |
| 44 | TPS | Transactions Per Second |
| 45 | UAE | United Arab Emirates |
| 46 | UK | United Kingdom |
| 47 | US | United States |
| 48 | VJTI | VeermataJijabai Technological Institute |