National Blockchain Strategy: Bangladesh

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Executive Summary

With the advent multiple emerging technologies, we are on the verge of information-driven Fourth Industrial Revolution (FIR). This revolution exposes new challenges as well as exciting opportunities. Only the countries with expertise in these emerging technologies can successfully meet these challenges and exploit the opportunities. Blockchain technology is widely regarded as one of the core and foundational technologies that will one of the driving forces for the upcoming FIR. Realising its potential, many developed as well as developing countries around the world have started exploring how blockchain technology can prepare them for the future challenges and benefit them to solve many existing complex problems in their race to achieve the Sustainable Development Goals (SDGs) by 2030. Bangladesh, unfortunately, is lagging behind in this regard. It is the first official effort from the Government of Bangladesh that recognises the need to explore blockchain technology in order to advance its technical capacity, increase efficiencies in e-Governances and foster innovations. Here, we would like to highlight our extraordinary ambition: to guide Bangladesh into a blockchain-enabled nation. With this vision in mind, this document explores different aspects of this vision with a particular focus on formulating the strategies and different long, mid and short-term goals to achieve this vision.

Overview of Blockchain

Blockchain or Distributed ledger technology (DLT) can be used to store permanent and tamper-proof records of digital data (digital assets). A blockchain is a distributed ledger consisting of consecutive 'blocks' of digital data chained together following a strict set of rules. The ledger is distributed and stored by the nodes (computers) of a peer-to-peer (P2P) network. Each block of data is periodically added to the ledger in a decentralised fashion. The order of the blocks is confirmed through the use of a distributed consensus algorithm. There are major two types of blockchain: private and public, both systems exhibit desirable properties such as immutability and irreversibility of ledger state, data persistence and provenance, accountability and transparency, etc. An extended overview of the types and properties of blockchain are presented in Section 2.

Blockchain agendas of Bangladesh

In our quest to create a blockchain-enabled nation, it is useful to examine the paths taken by other countries currently exploring blockchain technology from an official stance. Our findings are presented in Section 3 with a specific focus on the strategies they have adopted. There must be some technological visions which will be essential ingredients to realise this notion of a blockchain-enabled nation. We also need to ensure that these visions enable the country to achieve and maintain a sustainable development growth. In Section 4, we present the technological visions and analyse how blockchain technology can be effectively leveraged to fulfil these visions. In addition, we also propose a few

strategic blockchain agendas that lay down the pathway to guide Bangladesh towards a blockchain enabled nation.

Pathway to a blockchain-enabled nation

Following the outlined pathway, we, at first, explore different use-cases in multiple application domains and briefly investigate the suitability of blockchain in Bangladesh perspective. This analysis is presented in Section 5. Then, we survey different technical and organisational challenges that we may face in our blockchain adoption pathway. Next, we consider different other aspects of the proposed agendas. These challenges and a detailed discussion on the agendas are presented in Section 6.

Strategic Goals

To fulfil the desire of a blockchain-enabled nation, we must strive to achieve the outlined visions and take appropriate measures to address the agendas. Transforming visions and agendas into measurable goals is often useful as goals are easy to track and are more concrete in nature in comparison to visions and agendas. Therefore, we have formulated a series of a series of long, mid and short-term goals. Long-term goals are mostly visionary in nature and generally can be achieved in six to ten years. Short-term goals, on the other hand, are preparatory in nature and easier to achieve in less than three years. Mid-term goals can act as a bridge between short and long-term goals and can be useful in transition phases. These goals are then transformed into action points for subsequent follow-up. The goals and their corresponding action points are presented in Section 7.

Summary of action points

Here, we summarise the key action points.

- Build a team of blockchain experts, seasoned technologists, academicians, government officials and other stakeholders.
- Prioritise use-cases for initial piloting. Highlight those use-cases that can bring huge benefits to government service delivery models.
- Formulate plans to develop a blockchain integrated national information infrastructure.
- Develop plans to integrate the most relevant online services with a suitable blockchain platform.
- Develop capacity by promoting research, innovation and training and by increasing awareness.
- Release funds to initiate and maintain these activities.

Conclusion

The Fourth Industrial Revolution will entirely depend on a few cutting-edge technologies. This revolution will introduce new challenges as well as exciting opportunities. Tackling these challenges and exploiting the opportunity will solely rely on the effective usage of

these emerging technologies. Countries who are better equipped and prepared to embrace these emerging technologies will have a greater chance of success in this upcoming revolution. Blockchain is often considered as the foundational technology for this revolution. Realising its potential, many countries around the world are exploring the ways blockchain technology can be effectively leveraged

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1. Introduction

With the introduction of multiple emerging technologies, we are experiencing an unprecedented transformation in our lives and societies in general. These technologies are having a major impact on the economy throughout the world. Their impact on the societies and the economy is providing novel ways by which we can address Sustainable Development Agendas 2030. Furthermore, coupled with the Internet, the influence of the emerging technologies is acting as the driving force towards an information-driven Fourth Industrial Revolution (FIR) which itself is creating unprecedented challenges and exciting opportunities. According to the Digital Economy Report 2019 by UNCTAD (United Nations Conference on Trade and Development), only the countries that have prepared themselves can meet these challenges and exploit the opportunities [1].

Blockchain technology is an emerging and foundational technology which is regarded as one of the core ingredients of FIR. Blockchain provides a novel mechanism to store data and facilitate transactions in a distributed and decentralised fashion without relying on a single trusted intermediary. It can provide resiliency in the face of adversity and has strong support for data integrity, authenticity and provenance. With all these advantages, blockchain has opened up the door of opportunities in different domains and has the potential to disrupt a wide range of existing applications domains.

Realising its potential, many countries in the world have either explored the ways to harness blockchain technology or in the process of initiating the procedure. Many of these countries have already published their national blockchain strategies to highlight how each of the countries is going to explore the blockchain technology.

With an impressive track record for forward progress, Bangladesh has become a role model for growth and development for the whole world. However, it still faces a lot more challenges many of them can be effectively tackled with proper and intelligent usage of emerging technologies such as blockchain. This can even help Bangladesh to fulfil its commitment to achieve the Sustainable Development Goals by 2030.

Unfortunately, in comparison to many parts of the world, Bangladesh is lagging far behind in blockchain sector. There are a few Bangladeshi universities, public and private organisations in which different blockchain projects have been carried out. However, the examples are a few and far between. Also, these initiatives have been carried out sporadically without any coordination and cooperation between themselves. All in all, we do not have any combined strategies which can outline the pathways to march forward in the blockchain sector. We aim to fill in this gap with this document. It is the first official effort from the Government of Bangladesh that recognises the need to explore blockchain technology in order to advance its technical capacity, increase efficiencies in e-Governances and foster innovations. This document in essence sets out an ambitious goal: the transformation of Bangladesh as a blockchain-enabled nation.

1.1 Scope of the document

The principal motivation of this document is to explore different aspects of blockchain technology, its advantages, limitations and misconceptions and how this technology help Bangladesh to achieve its development goals. This document outlines a series of agendas to outline a visionary idea: blockchain-enabled Bangladesh. Towards this aim, it identifies a series of technical visions to realise this ground-breaking idea and sketches out the challenges to realise these visions. Then, it discusses different strategies to tackle these challenges. Finally, the document lays down a number of long, mid and short-term goals to advance towards a blockchain-enabled nation. It is to be noted that it is not a policy document. Our main focus has been to define the strategies to follow to create a cultural and technical shift towards a blockchain-based society.

1.2 Structure of the document

We present a brief introduction and different aspects of blockchain technology in Section 2. We explore different blockchain initiatives carried out in different governments in Section 3 with a specific focus on the strategies they have adopted. Section 4 presents technological visions and blockchain agendas. We discuss different use-cases in multiple application domains and briefly investigate the suitability of blockchain in Bangladesh perspective in Section 5. Section 6 elaborates on the identified agendas and technical challenges to fulfil these agendas. In Section 7, we present a series of long, mid and short-term trackable goals and a series of action points to realise the notion of a blockchain-enabled Bangladesh. We conclude in Section 8.

2. Blockchain in Brief

In recent years, blockchain technology, also known as Distributed Ledger Technology (DLT), has received widespread attention among the industry, the Government and academia. Many regards it as a foundational technology that can revolutionise the landscapes of several application domains. It was introduced in 20019 as the underlying technology of Bitcoin [2], the world's first widely used digital currency and since then, it has been used in a wide range of applications. A blockchain is a ledger consisting of consecutive blocks chained together following a strict set of rules. The ledger is then distributed in a P2P (Peer-to-Peer) network which is then stored by all nodes within the network. Each block is created at a predefined interval in a decentralised fashion by using a consensus algorithm. This algorithm guarantees several properties (discussed below) which make blockchain an exciting proposition.

The terms blockchain and distributed ledger are often used synonymously in the literature, however, there is a subtle difference which is worth highlighting. A blockchain can be thought of as an example of a particular type of ledger in which data is stored in a specific format. Interestingly, there are other types of ledger with different data formats. Examples of some other types of ledgers are DAG (Directed Acyclic Graph) and hash graph. When a ledger (including a blockchain) is distributed across a network, it can be regarded as a Distributed Ledger or simply a ledger. In the centralised database a central authority is needed and the data authentication process is completed centrally. The main idea behind being decentralised is to deliver a more secure and trustworthy system without a need of a trusting authority. Among all this, blockchain is the most widely used distributed ledger [4].

Advancing from the Bitcoin blockchain, a new class of blockchain has emerged which enables the deployment and execution of computer programs, known as *smart-contracts*, on top of the respective blockchain. Using these smart-contracts, a new breed of applications, the so-called *de-centralised applications* (DAPPs), can be created that allows the execution of autonomous programs without relying on any central entity. As smart-contract is effectively stored in the blockchain, their executions become *immutable* and *irreversible*. These are sought-after properties in different application domains.

Depending on the applications domains, there can be different strategies by which a blockchain can be deployed. These strategies dictate two predominant ledger types: *Public* and *Private*. These are discussed below:

- **Public ledger**, also known as the permission-less ledger, allows anyone to create and validate blocks as well as to modify the state and data of with the help of transactions. This means that the transactions and the corresponding data remain transparent, visible and accessible to everyone. This raises privacy concerns in certain application domains where the privacy of such data must be preserved.
- **Private ledger**, also known as the *permissioned* ledger, can be restricted in nature in the sense that it allows only authorised and trusted entities to participate in the

activities within the system. In this way, a private blockchain system can ensure the privacy of blockchain data, which might be desirable in some use-cases.

2.1 Blockchain Ideology

Generally, Blockchain, as its name suggests, is a chain of blocks where every block contains transaction data (not necessarily financial transactions) and each of the blocks linked with a cryptographic hash (generated by a mathematical algorithm which acts as a pointer) of its previous block. Each "block" on the blockchain is made up of digital pieces of information. There are three parts of information in each block [5]:

- information about transaction such as date, time and amount (if it is a financial transaction),
- information about participants (identities of participants in the transactions and their digital signature) and
- in case of a public blockchain, information that makes a block unique from other previous blocks (a unique code called 'hash').

Depending of the type of a blockchain, different mechanisms are required to add a block in the blockchain. However, a generalised mechanism will require, basically, four things to take place, i) a digitally signed transaction (not necessarily financial) must be submitted by a participant, ii) the submitted transaction must be verified by other participants of the network, iii) the verified transaction must be stored in a block and finally iv) the block must be added into the blockchain following a strict set of rules, unique for each blockchain and a consensus algorithm. The algorithm is executed by the special nodes in the network which must reach an agreement, in a distributed fashion, if the blockchain can be added in the blockchain. This algorithm essentially provides the computational guarantee that, once the block is added, it is very difficult to go back and alter the contents of the block. This is because if anyone changes a single information in any of the previous blocks, this will change the hash pointer of the block. This will break the chain of links which can be easily identified. In addition, this change needs to be approved by every participant (the special nodes) of the consensus algorithm. Therefore, as long as the majority of the special nodes is compromised, the consensus algorithm will tend to provide the intended security of the blockchain.

In order to deal with the trust issue, blockchain networks have implemented tests for participants that want to join and add blocks to the chain. However, the exact mechanism will depend on the blockchain type. In a public blockchain, any participant can participate, but a participant (their computer) must "prove" that it has done a "work" by solving a complex computational math problem. That is why such a mechanism is called *Proof of Work*. It is not be noted that the proof of work system does not rule out any attack by an attacker. However, to execute such an attack successfully, the attacker must amass a huge computational power at his disposal. The cost of gathering such computational power often outweighs the benefit of launching such attacks.

The trust in a private blockchain, however, is not measured using the mechanism of a public blockchain systems. Instead, only trusted and authorised participants are allowed to join the network and participate in the block creation process.

2.2 Blockchain Proposition

A blockchain system is a promising technology that make it a suitable candidate for several application domains. This is because its technical properties which provide a range of values for any organisation. Next, we explore this technical property and discuss different organisational values. In addition, we argue why blockchain technology is regarded as a foundational technology.

2.2.1 Technical property

Blockchain has some exciting properties which are sought after in different application domains. Next, we highlight a few of such exciting properties.

- **Distributed consensus on the ledger state**: A crucial properties of a blockchain is how it achieves a distributed consensus on the blockchain state without relying on any Trusted Third Party (TTP). This important property can open up the door of opportunities for a system where every interaction is verifiable by any authorised entities.
- **Immutability and irreversibility of ledger state**: A distributed consensus achieved using a large number of nodes ensures that the blockchain and its data becomes practically immutable and irreversible after a certain period of time. This is true for smart-contracts, thus facilitating the deployment and execution of immutable computer programs.
- **Data (transaction) persistence**: Data in a blockchain is stored in a distributed fashion. This ensures data persistency as long as the blockchain remains functional.
- **Data provenance**: Each data in a blockchain is stored by means of a transaction which must be digitally signed using public key cryptography. This facilitates data provenance as well as data authenticity of the source of data. By combining this with the immutability property, a blockchain can be an important tool for non-repudiation for any data stored in the chain.
- **Distributed data control**: A blockchain enables the storage and retrieval of data in a distributed fashion. This can guard against a single point of failure as blockchain data can be retrieved even in the presence of a number of nodes.
- **Accountability and transparency:** Since the blockchain data, every transaction and the interactions among the participants are all visible to any authorised node, it promotes accountability and transparency.
- **Decentralised services:** Traditional online systems rely on servers to provide online services which often create a single point failure. This is because when a

server becomes faulty and hence, ceases to serve the clients, the whole service depending on the server collapses. Even though there are many cloud-based architectures to rectify this situation, they are often expensive to maintain. Also, relying on a cloud provider is not always an option for Government services due to regulatory restrictions. A smart-contract supporting blockchain system can provide an effective alternative fault-tolerant service provisioning architecture without relying on a single server.

2.2.2 Organisational value

In an organisation, business or functional value depends on the enhancement of organisational performance through improving productivity, gaining competitive advantage, ensuring transparency, achieving cost-efficiency and gaining profit. Different blockchain properties can facilitate a number of values for any organisation. Next, we are discussing a few of such values.

- **Increased trust:** A blockchain system can increase the level of trust among they users of an organisation. This is because of the unique technical advantages, such as data immutability, verification by multiple nodes, accountability, transparency and so on.
- **Removal of intermediate-authorities:** The state and data of blockchain is updated using a consensus algorithm in a distributed fashion without relying on a single party. Thus, blockchain essentially removes the need for an intermediate authority which is traditionally being used to enforce trust or carry out any validation work, most notably in financial domains.
- **Reduced cost:** The exploitation of smart-contract and the removal of intermediate authorities can reduce the associated cost significantly for any organisation, particularly for financial applications.
- **Avoiding fraud and manipulation:** Fraudulent activities and unauthorised manipulation become difficult to carry out. This is because blockchain data is stored in multiple places and unauthorised tampering data in just one copy of the blockchain will essentially be eradicated by the underlying consensus algorithm. This is a major benefit for any organisation as this is an extremely difficult task to maintain in any existing transaction systems.
- **Reducing corruption:** Blockchain systems provide unparalleled accountability and transparency. The utilisation of smart-contracts for carrying out complex transactions automatically will foster the notion of immutable code that cannot be manipulated. All these can attribute towards corruption reduction in many application domains.
- **Increasing productivity:** Blockchain can reduce the burden of transactional work for the administrative staff. Therefore, they can focus more on decision making sectors. Ultimately, by eliminating error in clerical area and by speeding up the process, the productivity of an organisation can be increased.

- **Gaining competitive advantage:** Organisation can gain competitive advantage by taking first follower advantage through adopting a disruptive technology such as blockchain. By streamlining operation process, reducing cost, speeding process, organisations can be the market leader among the competitors.

2.2.3 Blockchain as a foundational technology

There are many existing systems which can exhibit a few of the properties that a blockchain system has. However, a blockchain system is a unique proposition because no other system can deliver these many properties which can provide so many organisational values. In many ways, a blockchain is like the Internet, it has the potential to be foundation upon which new social and economic applications can be develop which might have far-reaching impact for our societies in general. Because of this, blockchain is widely regarded as a foundational technology.

2.3 Blockchain limitations

The concept of blockchain emerged with the introduction of Bitcoin in the public blockchain domain. However, it soon emerged that such a public blockchain is unsuitable for many applications, specifically in the financial and Government sectors for the following critical reasons [5]:

- **Privacy/data visibility:** In a public blockchain, every single piece of data is visible to everyone. This raises huge privacy concern, particularly in financial transactions and Government use-cases. However, a private blockchain system can tackle many of these privacy issues by reducing the visibility of data only to the authorised entities.
- **Power consumption:** Consensus algorithms (such as Proof of Work) used in major public blockchain systems consume a huge amount of electricity. For example, according to [6], the current electricity consumption of Bitcoin network is around 73 TWH, which is equivalent to the electricity consumption of Austria. The nature of the consensus algorithm used in Bitcoin is that this electricity consumption rate increases as the popularity of Bitcoin grows. Because of this, many doubts if this is going to sustain in future. There are new consensus mechanisms, such as Proof Stake, Tangle and so on, which consume considerably less electricity. Unfortunately, the usages of these novel consensus algorithms are not wide-spread yet, hence their security and sustainability are still questionable. Private blockchain systems, however, do not require to consume this much power and hence, are devoid of this limitation.
- **Scalability/Transaction rate:** Scalability is used to indicate how much data a system can process within a certain period of time. It is predominantly determined by the combination of the following two parameters:

- *Block size* indicates the maximum allowed size of a block in a blockchain system. A higher block size indicates a higher data processing capability for a particular blockchain system.
- *Block creation time* specifies the average block creation time for a particular system. It is, in turn, dependent on the consensus algorithm utilised by the system.

Popular public blockchain systems have a restricted block size with a certain block creation time. These two parameters can be factored together to create a more popular parameter, called *transaction rate*, for scalability. According to [7], the current transactions is around 3-5 transactions per second. This is an extremely low number for in any large-scale systems where thousands of users may interact in between a very short period of time. Ethereum, the second most popular public blockchain system has a transaction rate of around 15 per second [8]. Even though there are a few public blockchain systems which claim to have a considerably higher transaction rate, their usage is limited. Hence, many are concerned about their sustainability. Interestingly, private blockchain systems can provide considerably higher scalability by providing a vastly improved transactions per second.

- **Cost:** It outlines the associated cost incurred, if any, for any transaction to process or store data in the ledger. Cost is often referred as "transaction fee" in blockchain domain. All major public blockchain systems have considerable associated cost for sending transactions or storing data in the blockchain. Conversely, Private blockchain systems do not have any associated cost to store data in the blockchain or execute smart contract code.

- **Blockchain bloating:** A blockchain is inherently an add-only data system where data, in the form of transactions, are being added constantly. As a public blockchain system becomes increasingly popular, more and more users start using it. This implies more and more data being stored in the blockchain ledger and the size of the ledger keeps increasing. For example, the current size of Bitcoin ledger is around 250 GB. Blockchain bloating refers to the problems associated with distributing and maintaining this huge size of ledger in hundreds/thousands of nodes of a public blockchain system. Since a private blockchain system requires to distribute its blockchain only in a few authorised nodes which might be easier to manage, there is potentially a less concern of block bloating. However, it is often advisable not to store a massive amount of data even in a private blockchain system.

- **Code upgradability:** A blockchain is by nature an immutable system. This sought-after advantage creates a certain type of problem for a smart-contract supporting blockchain systems. A code immutability means that a smart-contract once deployed in the blockchain, it cannot be modified without disrupting/upgrading (colloquially known as *forking* in blockchain domain) the whole blockchain. Even

though a bug is found, the corresponding smart-contract cannot be patched in any traditional software patching mechanism.

- **Governance:** A public blockchain system is governed openly using the philosophy of open-source software. A foundation or a public governing body is generally responsible for creating the rules for governing the system and then the open source community is tasked to maintain its code base. As evident in many open source systems, the community loses its interest when the system fails to attract a large amount of developers to maintain it. This means there is always a probability that a certain blockchain system may not be governed properly in future which in turn will decrease its security and increase it risks. A private blockchain system is governed by authorised entities with a common goal. As long as the authorised entities have a common interest and mutual understanding with regard to the security of the blockchain, the corresponding systems will be governed properly.
- **Anonymity and Crime:** Ransomware and other crimes are enabled by anonymous payment methods such as Bitcoin, since the transaction is untraceable. On the other hand, the proper use of blockchain technology has the ability to reduce the fraudulent activities. Hence, blockchain technology and crime might create a multifaceted ethical consideration. Permissioned or private blockchain systems can play a more controlled role regarding this.

Because of these limitations, it is envisioned that the private blockchain systems will be used predominantly in financial and Government application domains. To realise this vision, a number of private blockchain systems have been introduced in the market. Examples of some private blockchain systems are Hyperledger Fabric, Hyperledger Sawtooth, Hyperledger Burrow, Hyperledger Indy, Corda, R3, Multichain and so on. The energy consumption of these systems is comparable to any traditional existing system. Moreover, they are regarded as highly scalable with a better transaction rate. Furthermore, the governance of such a blockchain system can be controlled by the respective authority which can dictate the rules as required and enforce them when needed.

Unfortunately, almost all of these private blockchain systems are yet to provide a reasonable solution with respect to data visibility and code upgradability. In all these systems, except Hyperledger Fabric, data and transaction are completely visible to any authorised entity. This means that anyone who has access to the network can essentially observe any data and transaction stored in the blockchain. Fabric has tackled this issue very intelligently with the concept of channel which enables a strict private commissioning of data and its related transactions between any two entities in the network. All other entities simply cannot observe such data. In a similar fashion, unlike other private systems, Fabric provides a mechanism by which different versions of a smart-contract can be patched without disrupting the whole blockchain.

For all these reasons stated above, it is easy to draw conclusions that a private blockchain system or a mixture of different private blockchain systems is/are the most suitable

choice for any Government and financial applications, at least before the current limitations of any public blockchain system are addressed properly.

2.4 Public blockchain systems: Bangladesh perspective

Even though there are different ways public blockchain systems can be utilised, crypto-currency still remains the most widely used application not only in public blockchain domain, but also for the whole blockchain domain in general. Bitcoin is the mostly wide-used crypto-currency so far, however, Ethereum, the world's first fully-fledged smart-contract platform, provides exciting propositions. It is in fact Ethereum that is leading the innovation in the public blockchain domain and is being explored in a multitude of application areas.

Unfortunately, Ethereum and other public blockchain-based smart-contract platforms heavily rely on their underlying crypto-currencies. One major concern, particularly in the governments throughout the world, for these crypto-currencies is their support for pseudonymous or even fully anonymous payment mechanisms. Such mechanisms, being untraceable to a legal entity, often are abused by criminals for a wide range of criminal activities. Because of this, many governments remain extremely cautious for adopting any public blockchain system. Bangladesh, like a few other countries, have explicitly banned the usage of Bitcoin and other crypto-currencies in Bangladesh.

Despite all these negativities, public blockchain domain is considered one of the very few domains with strong disrupting capabilities. This is indicated by the amount of investments attracted by this domain. A recent study reports that (mostly public) blockchain start-ups have managed to raise a huge 23 Billion USD of investments since 2013 [9] which is expected to grow in the future. These investments are used in legitimate existing propositions aiming to disrupt many existing application domains. There is an opportunity for Bangladeshi software industries to grab a certain portion of these investments. Banning the usages of any crypto-currency ultimately prevents our software industries to explore this lucrative domain. We also understand that, without a proper technical, legal and policy framework in place, opening up this domain might open up the door of many hard-to-tackle criminal activities. Therefore, we should adopt a **"curious-but-cautious"** approach and explore how this dilemma can be effectively tackled.

2.5 Blockchain misconceptions

There is no doubt that Blockchain technology has the potential of heralding a new era in multiple application domains. However, due to misconceptions and lack of knowledge, it is sometimes hyped in wrongful ways. In order to harness the true potential of blockchain technology, it is imperative to have a clear understanding of these misconceptions. Next, we present some of these misconceptions with appropriate clarification.

- **Crypto-currency and blockchain:** Many have the misconception that the notion of crypto-currency and blockchain is synonymous. One cannot live without the other. However, a crypto-currency, in reality, is just, and currently the most

popular, application of a blockchain system. There are many other applications of a blockchain system which do not rely on or require any crypto-currency to function.

- **Data immutability:** Data stored in blockchain is considered immutable. However, there are two types of data that can be stored in a smart-contract supporting blockchain. One is related to any transactional data that is recorded when a certain amount of crypto-currency of a particular blockchain system is transferred between two accounts. Another type can be considered as a smart-contract data that is required to execute the smart-contract code. A smart-contract utilises such data using a variable and a variable, as its name suggests, can be updated with different values. Interestingly, such data transferred to a smart-contract using a transaction which recorded in the blockchain in an immutable fashion. All this means is that a transactional data is immutable, however, a smart-contract data can be changed. But, the ways the value of a variable change is recorded in an immutable and auditable fashion.
- **Large-scale data storage:** The data immutability feature tempts many to store as much as possible data in the blockchain. However, as explained before, a blockchain is not a database and should not be considered as such. The rate by which data can be stored and accessed in any traditional database is far better than any blockchain system as of now. This applies not only to any public blockchain system, but also to any private system. Therefore, it is advisable to store as minimum data as possible in the blockchain.
- **Data integrity:** A blockchain can guarantee the integrity of data only after it is stored in the blockchain. It cannot provide any such guarantee if the data is corrupted in the source or during transmission. In this sense, a blockchain system is essentially a "*Garbage-in-garbage-out*" system where a corrupted data will be stored and remain as corrupted.
- **Data encryption:** Many believe that a blockchain provides data encryption by default. This is a serious misconception. A blockchain system strongly depends on cryptographic mechanisms, such as digital signature and cryptographic hash, to function. Digital signature is used for data provenance while a cryptographic hash is used to ensure data integrity. In a blockchain system, data encrypted is never provided. However, anyone can use any encryption algorithm to any data before it is stored in a blockchain.
- **Power consumption:** Because of the huge power consumption by a number of popular public blockchain systems, many people believe that every blockchain system consumes considerable electricity. As explained before, the power consumption of any private blockchain system will be comparable to any existing system. Hence, this concern can be effectively addressed by leveraging a private blockchain system.

3. Government Blockchain Initiatives in Other Countries

Blockchain technology is a phenomenal development that has great potential to revolutionise different industries across the world. From physical asset traceability, clinical supply chain, global trade finance, cross-border payments and remittances, post-trade processing to voting and digital identity—blockchain technology is being explored in all types of application domains. Currently, new ecosystems are developing blockchain solutions to create innovative business models to replace traditional ones, which are occurring in most jurisdictions globally. Realising its potential, many governments around the world are exploring the ways this technology can advance and improve different aspects of their governance. In this section we summarise a few such initiatives around the world.

3.1 Asia

The Government of Japan is one of the earliest adopters of the technology of blockchain [10]. Japan is home to Mt. Gox, which was one of the largest exchanges of Bitcoin until recently. The Japanese government has played a proactive role in developing regulations and a solid framework for companies to flourish in the blockchain sector.

The Chinese government has more than 500 blockchain based open projects [11]. The Government of China has added blockchain into its 13th five-year plan and prioritised its usage for key strategic initiatives. Xiong'an, a state of China, is using the blockchain along with big data to create an online platform to monitor an afforestation project. The government is also utilising a decentralised blockchain network to supervise and introduce more efficiency within the different branches of their departments. It is being actively promoted by the private sector in China and various Information Technology platforms have already started to function collaborating with blockchain technology.

The Malaysian government has introduced a pilot project to implement the blockchain for a work visa program so that tech freelancers can stay in the country on a short-term basis and work in their AI, Big Data and Blockchain industries [11].

The government of Singapore is promoting the widespread usage of cryptocurrencies unlike China [12]. It has not only introduced various tax benefits and legislation to help companies that utilise blockchain, but it has also allocated funds to accelerate the adoption of this disruptive technology. The Singaporean Central Bank Monetary Authority has started to explore the potentials of blockchain technology in its central banking initiatives. This project has successfully implemented real-time gross settlement systems and introduced greater privacy and ease of settlements.

The government of South Korea has implemented the blockchain technology in its customs department to enhance its import and export management capabilities [11]. They have created a $9 million fund for 6 pilot projects involving this technology.

The Government of Indonesian has allowed the blockchain community to grow organically for many years, but amid concerns for fraud and corruption, has only started to introduce legislation to regulate this industry [13]. As Indonesia aims to be one of the fastest growing major economies of the world, the government has identified the technology of blockchain to play a pivotal role in achieving their economic aspirations.

The Government of the Socialist Republic of Vietnam has decided to build a brand-new infrastructure project based on the blockchain platform to transform its smart city. Blockchain will be used for communications, energy, transportation and payments to increase efficiency in the smart city project and streamline all the activities for greater transparency [14].

The Government of Thailand has initiated the use of the blockchain technology in the Railway Department to track the shipment of high-value parcels [11].

Israel is leading the blockchain initiatives in the Middle East [12]. Also, spurred by their government, the private sector has aggressively rallied behind this technology. Most of the digital assets such as cryptocurrencies are actively being promoted, and the government has invested heavily behind research and development of type of blockchain systems. An Israeli governmental agency has already started to use blockchain to improve their messaging services. Due to proper regulations adopted by the Israeli government, many start-up companies are using blockchain in the cyber security, shipping, data storage as well as other industries. The efforts of the Israeli government have helped Israel to be one of the leading countries in Asia that has adopted blockchain to shore up their data security and traceability initiatives.

The United Arab Emirates Government has started the Smart Dubai project which will see them leveraging the technologies of blockchain and A.I. to turn Dubai into a technologically advanced city [11]. The Emirates Blockchain Strategy 2021 aims to capitalise on the blockchain technology to transform 50 per cent of government transactions into the blockchain platform by 2021.

The Government of India is exploring the blockchain technology in their voting platform and is consulting with the citizens of India for policy-making decisions [11]. The government is actively researching the future potential of this technology to be used in sectors such as the banking and financial industry. The state of Maharashtra partnered up with a hybrid open-source platform based on the blockchain technology to complete a project on the land records of the state.

Aon, Oxfam, and Etherisc launched first blockchain-based agricultural insurance policies for smallholder farmers in Sri Lanka [15]. To pave the way for Blockchain-based financial service solutions in Sri Lanka, CBSL is developing a national project, a Proof of Concept (POC) of the Blockchain-based Shared Know-Your-Customer (KYC) facility [16]. Moreover, Commercial Bank Srilanka utilises blockchain technology for remittances to ensure the transfer is transparent and tamper-proof, which also allows more accurate tracking of remittances [17].

3.2 North America

The United States of America being the biggest economy in the world has been one of the first countries to adopt the blockchain technology [11]. The Homeland Security department which acts on behalf of the US government has awarded a contract to implement blockchain technology to improve the data capabilities of Border Security. The FDA (Food and Drug Administration) has also awarded another contract to enhance the real-time sharing of data between two health departments.

The Canadian government has already started using blockchain to issue digital CVs for its employees and secure the data permanently. Other state governments in Canada have collaborated to form the Verifiable Organizations Network, which is a framework to enhance data integrity between businesses to conduct their operations reliably [11].

The government of Mexico is using the blockchain technology to verify bids placed in the public procurement sector [11]. Several departments are also utilising this decentralised network to reduce corruption inside the government.

3.3 South America

The Argentinian government has created a $50,000 fund to support start-up companies based on blockchain technology [11]. The government is also utilising this technology to improve the delivery of its services and enhance access among its citizens.

The government of Brazil is using blockchain to actively fight corruption amongst different agencies [18]. The state is also aiding start-up companies by providing funds and introducing blockchain-friendly policies to support their initiatives.

3.4 Europe

The European Commission has created a 300 million Euro fund to invest in blockchain technologies and help member states to accelerate the implementation of this technology [11]. The EU Commission is actively researching the capabilities of blockchain for future applications.

The government of the United Kingdom conducted a successful pilot project on the blockchain's system of distributed ledger to ensure greater compliance in the food sector. This technology is also being used for land registration and to buy and sell properties in the country [19]. The Ministry of Justice, in a joint project with the Cabinet Office and Police, also has explored how blockchain technology can be utilised for securing digital evidence [20].

The Austrian government has started an 8 million Euro fund to support different projects based on the blockchain technology [11].

The Liberal Alliance party in Denmark was the first country that used the blockchain technology in order to successfully conduct a democratic election [11].

The Estonian government started exploring the possibilities of blockchain since 2008 [11]. It has used blockchain to store almost 99 percent of its data and conduct more than 90 percent of all its services online. Due to the utilisation of this technology on a national level, the country enjoys faster judicial proceedings than many other developed nations.

Malta is the first country in the world with clearly established regulatory frameworks for DLTs, ICOs and virtual currencies [21]. They have introduced legislation along with other initiatives that will start attracting various Fintech companies to its shores. The country has already been praised for its activities in the crypto space. A Blockchain island will be created that will attract investments which will enable this initiative to be a grand success.

The Irish government is actively promoting the concept of blockchain and started a fund to help entrepreneurs invest in this technology [11].

The government of Spain has used the blockchain to bring more efficiency and better management tactics to its ports [11].

The land registry department of Sweden is currently testing some transfers of real estate as well as other transactions involving more than two parties on the blockchain tech [11].

3.5 Africa

The government of Ethiopia is using blockchain to improve farming practices in the country and enhance productivity in the agricultural sector [11].

The Ghanaian government has started a project, and the purpose of this project is to allow its citizens the ability to register land that is supported by the blockchain network [11].

The Kenyan government created a bond supported by blockchain technology. The government is trying to introduce more digital currency so that its citizens can have access to the financial industry without the need to open a bank account [11].

The government of Nigeria is exploring the possibilities of the blockchain and introducing policies to support the implementation of this technology [11].

The government of South Africa has started exploring the concept of blockchain to enhance its financial services industry. The government has created various frameworks and policies to implement blockchain on a wide scale. The government has introduced a pilot project to register land on the blockchain network [11].

3.6 Oceania

The Commonwealth Bank of Australia issued a bond based on the cryptocurrency for the Treasury Corporation of Queensland [11]. The government of Queensland has awarded $100,000 to install the cryptocurrency point of sale systems. The government also used blockchain to conduct a successful election and is investing half a million dollars to investigate the vast potential and different applications of blockchain.

The government of New Zealand is highly motivated by the vast economic opportunities that are offered by the blockchain technology and actively researching to implement this technology on a nationwide scale [22].

As per our findings, it is clear that all six of the continents have started implementing or have already implemented the blockchain technology to some extent in different aspects of their operations, which can be analysed based on the bigger picture. But not all countries in these continents and major economies have implemented even in some of the basic governmental or business operations. To be the game changer, the governments along with their major business have to step up and take initiatives in order to implement the blockchain technology.

4 Technology Vision and Blockchain Agenda

With an impressive track record for growth and development, Bangladesh is marching forward to become a middle-income country in the next few years or so and has become a role model for growth and development for the whole world. However, Bangladesh still faces a lot of challenges that need to be effectively addressed to continue its tremendous growth for a long period of time. It is undeniable that the proper usage of cutting-edge technology, such as blockchain technology, will play a significant role to meet these challenges.

To elaborate this argument, we consider the case of SDGs (Sustainable Development Goals). The SDGs are a set of 17 global goals which are designed to be a "blueprint to achieve a better and more sustainable future for all" [23]. These goals, set by the United Nations General Assembly in 2015, are intended to be achieved by the year 2030. Bangladesh has a strong commitment to achieve these goals as much as possible within the stipulated time period. In this regard, we highlight one crucial yet relevant goal regarded as *SDG 9*.

"SDG 9: Build a resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"

Throughout this document, we will explore how the resilient and transparent nature of the blockchain technology can help to create and maintain a resilient and inclusive information infrastructure and to foster innovation.

4.2 Technological Visions

In the long run, Bangladesh has an ambitious dream which is not only to realising these SDG goals, but also to promote itself in the same stature of a developed nation in the next few decades. Information technology being a crucial enabler to achieve this ambitious dream, it is important to assume a few crucial technological visions. Next, we elaborate a few of such visions:

a) **Develop resilient infrastructure:** A resilient information infrastructure will be act as the backbone upon which we can create, deploy and manage different applications and services. Decentralisation of applications can add another dimension to the resiliency as it can counteract the issue of a single point of failure which is prevalent in traditional legacy online systems.

b) **e-Governance:** e-Governance (Electronic Governance, also known as Digital Governance) outlines the method in which information and communication technologies are used to provide public services to citizens and other entities within a country. It enables digital interactions in different modes between a citizen and the government (C2G or G2C), among different government agencies (G2G), between the government and other private businesses (G2B) and so on. e-Governances can ensure functional and financial efficiencies and reduce

corruption. Hence, it is considered an indispensable part of sustainable development.

c) **Promote innovation:** Many obstacles to accomplish SDGs will require out-of-the-box solutions which can only be achieved with innovative ideas. The more innovation-friendly a country is the more chance it has to achieve the SDGs. Therefore, it is crucial that innovations are promoted in different ways.

d) **Facilitate fair competition:** Innovative ideas can only thrive in an environment which supports a fair competition. It is therefore the duty of the government to ensure a fair competition everywhere within the corresponding country. It is even more applicable in technology sphere where ideas often emerge from small start-ups and can grow very fast. Unfortunately, the inadvertent side effect is that such ideas may die even faster if the competition is not fair.

e) **Reduce intermediary:** There are necessities for intermediaries in a few applications domains. However, they can create huge bottlenecks, introduce inefficiencies and attain additional monetary burden in many application domains such as agricultural and financial sectors. A sustainable development will need to reduce intermediary as much as possible in a wide-range of application domains.

f) **Ensure accountability and transparency:** One of the key obstacles in any developing country is the lack of accountability and transparency both in the public and private sectors. For a sustainable development of a country, it is imperative to adopt mechanisms that will increase the accountability and transparency in different sectors.

g) **Increase trust:** Ensuring accountability and transparency has added advantages. For example, it increases trust and instils confidence in the Government and public sectors. That is why it is important that the Government adopts mechanisms by which trust can be increased.

h) **Guarantee information security and privacy:** A fundamental requirement for any technology adoption is to ensure that different security and privacy issues are properly considered. With more and more reliance on technology to carry out businesses and financial transactions, hackers and attackers are more interested to abuse a system to attain financial gain.

i) **Involve all stakeholders:** Technological solutions often consist of heavy technical jargons which might be difficult for different stakeholders to understand. This may lead to a situation when an application fails to fulfil its objective. That is why it is important to involve the representatives of different groups of stakeholders when developing a technical solution.

The blockchain technology with its wide range of advantages can be the most effective tool to realise the most of these technological visions. For example, a blockchain integrated national information infrastructure can provide the required level of resiliency

and decentralisation which effectively can handle the issue of any single point of failure. Any blockchain based application can ensure accountability and transparency which in turn can increase trust. Furthermore, such a system can reduce intermediary and facilitate a fair competition. A clever integration with a blockchain system can guarantee different security and privacy properties of an application. All these will also help to facilitate and maintain e-Governance in an effective way. However, not all these visions can be realised by technical means. Indeed, visions like "*Promote innovation*" and "*Involve all stakeholders*" will require strategic plans and well-formulated roadmaps both from the Government and the private sectors.

4.3 Blockchain Agendas

Because of the prominent role the blockchain technology can play in realising the above-mentioned visions, it is important to explore the ways how it can be achieved. Different countries have already explored this avenue and formulated different strategies suitable for them. In a similar vein, we must investigate how we can take advantage of this foundational technology for realising the identified visions. Towards this goal, we propose a set of agendas for Bangladesh that, we believe, will lay down the pathway for a blockchain enabled nation. The agendas are presented next:

- Identifying application domains and use-cases where blockchain technology can play a vital role.
- Identifying the challenges to create a blockchain-enabled nation with a strong root of e-Governance.
- Formulating mitigating strategies for the identified challenges.
- Increasing awareness so that the stakeholders know the benefits of a blockchain-based solution.
- Fostering blockchain-based innovations in order to mitigate issues in the existing systems which ultimately will create the demand for blockchain workforces
- Developing capacity in order to cater to the demand.

In the subsequent sections, we will explore these agendas in a detailed fashion.

5 Blockchain Application Domains: Bangladesh Perspective

It has been envisioned that blockchain technology can disrupt a wide range of application domains. These application domains cover a plethora of use-cases. It will be an overwhelming experience to assess the impact of blockchain technology over all these use-cases. Instead, a more practical approach would be to prioritise a subset of use-cases, among the whole set of use-cases, which are fundamental as well as hugely important with respect to Bangladesh in order to achieve the vision and goals as outlined in Section 4. Towards this aim, we have identified a number of application domains and their respective use-cases. These application domains and their use-cases are presented in Figure 1. A brief discussion of these is presented below.

5.1 Identity Application Domain

- **E-KYC:** KYC refers to Know Your Customer which is a mandatory procedure to carry out by maximum financial institutions for the customers. In order to comply with KYC, banks and other Financial Institutions must dedicate a huge amount of resources. This is particularly wasteful since each single financial institution has to satisfy KYC requirements for each new customer, even though that customer has probably completed a KYC process somewhere else before. A blockchain-based KYC solution will enable a seamless of KYC state between different financial institutions. The transparency of a blockchain system provides a perfect opportunity for any financial institution to streamline the KYC process and enhance and speed up the customer on boarding experience are clear [24]. It is particularly a lucrative proposition for Bangladesh, since the KYC process is mainly carried out manually and sharing KYC data is almost non-existent.

  Reputation System: Currently, consumers rely heavily on online reputation systems (such as rating and recommendation through social media) in order to make online purchase decisions. Unfortunately, there are several issues in the existing online reputation systems as the manipulation of reputation data can be easily carried out by malicious entities to make customer fool. Some fake customers even give fake rating based on payments. A blockchain-enabled reputation system can obsolete this malicious activity and aggregate reputation data across the web through verifying and creating unique digital identities for all users. Therefore, the trust and transparency in the reputation system will be ensured [25]. With respect to Bangladesh, online shopping is just starting to get popular. The trust and confidence of the consumers in this emerging domain will be a key factor to ensure its long-term sustainability. A blockchain-based reputation system can be a huge catalyst in this regard.

5.2 Finance Application Domain

- **Pension:** In Bangladesh, the retirement system is reconciled on the time of paying pensions. During this time, the calculation of pension is done manually where there always remains a chance to manipulate data. In some cases, pensions were

even paid to dummy workers by manipulation and fraud which ultimately cost millions to Bangladesh government. A blockchain-based pension system can guard against this manipulation and guarantee transparency.

- **Payment:** There is a huge potential for blockchain technology in the payment industry. Traditionally, financial institutions rely heavily on middlemen to conduct any type of settlement. A blockchain-based payment system can facilitate a more direct approach which effectively could cut out any middlemen during the settlement process. This can ensure huge savings for such institutions. Furthermore, international payments can be carried quickly and cheaply in

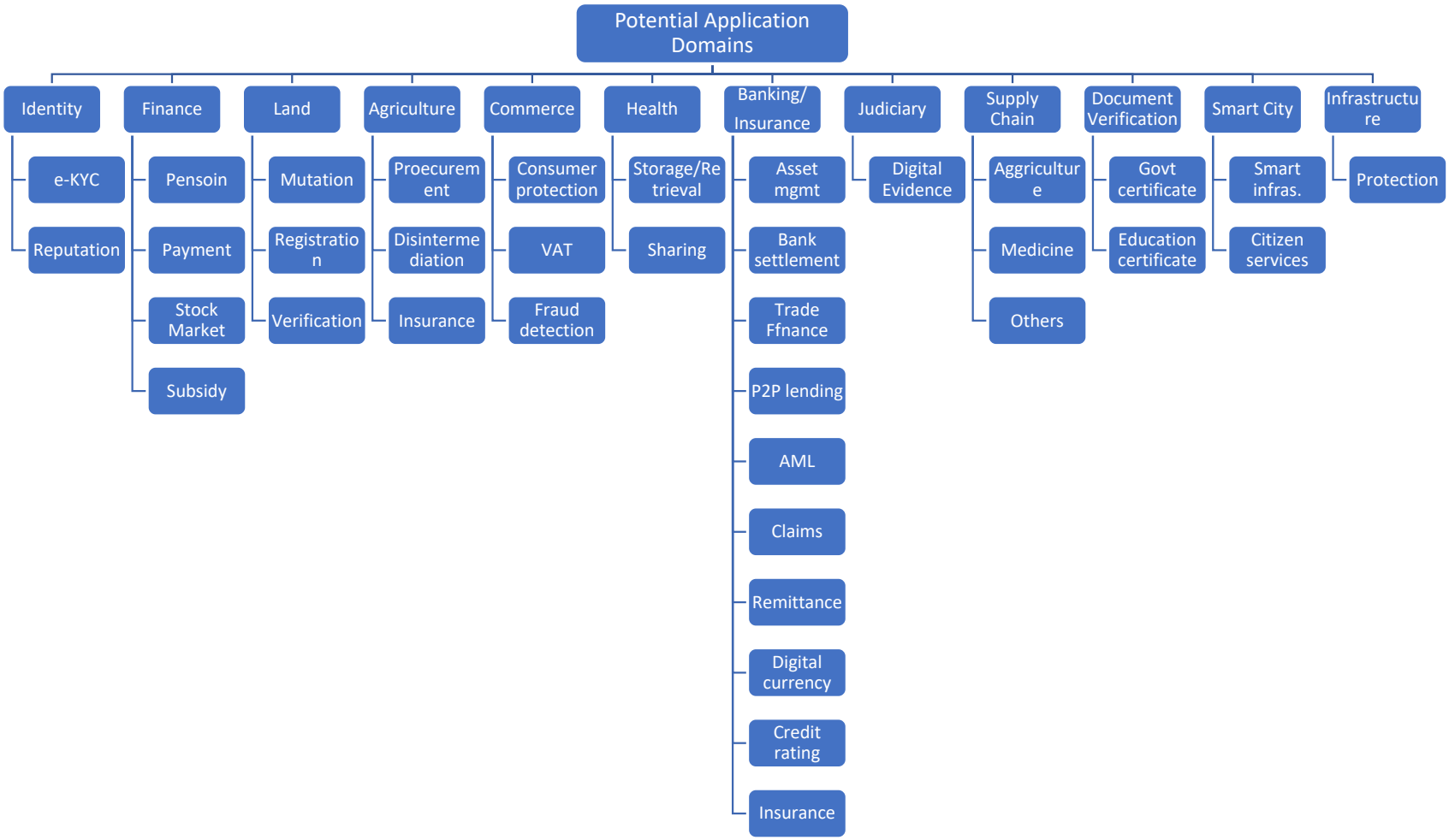

Figure 1: Taxonomy of applications and their use-cases

comparison to how long it takes and how much it costs now. The payment system can also be revolutionised using a blockchain-based payment system.

- **Stock market:** Currently, the transaction settlement process in the stock market mainly depends on the presence of intermediaries, such as brokers, regulators and so on. Overall, the settlement process takes time and the presence of intermediaries entails additional cost to the trader and the organisation. A blockchain based system can reduce the cost by eliminating intermediaries, increase speed by regulating and settling transactions without a need for central authority through smart contracts. Bangladeshi stock markets are no exception and can easily be benefited with a blockchain-based solution.
- **Subsidies:** In economic systems subsidies are often used as a tool to deal with deficit and short time poverty. In order to assess the eligibility of recipients of the fund and the utilisation of the fund, the government needs proper tracking systems. With a blockchain subsidy distribution platform, Governments can easily assess the eligibility of recipients to get various forms of subsidies and track them easily. This will be particularly useful for Bangladesh where there are manipulations during subsidy assessment and delivery.

5.3 Land Application Domain

- **Mutation:** In Bangladesh, the property documents can be easily counterfeit and manipulated by malicious people. Blockchain technology can play a key role to guard against such unauthorised manipulations because of its immutability and transparency properties. The introduction of a blockchain-based system thus can enhance trust in the trade of property in Bangladesh.
- **Registration:** Land registration generally describes systems by which different associated activities such as ownership, possession or other rights in land can be carried out with a respective government agency. Such systems must facilitate transactions and prevent unlawful disposal of land [26]. A blockchain based system can be beneficial by reducing Land selling/buying processing time from months to few days through eliminating paperwork and in purchase system, preventing fraud, manual intervention, and providing a high level of security in ownership by digital signature. Blockchain technology can be really promising for Bangladesh as land registration and ownership transfer are still manual and less transparent.
- **Verification:** Once the registration of property is completed using a blockchain based solution, a legal authority which has access to the same system can easily verify it. In addition to this, such a system can be used to provide the title certification and right of ownership deeds and land recording [26]. In Bangladesh, where verification can be quiet challenging because of the manual and error-prone process, such a solution will be really useful.

5.4 Agriculture Application Domain

- **Procurement:** The main challenge for the agriculture sector is proper tracking of agricultural products and ensuring payment after product delivery. The whole process of coordination currently depends on third parties. Both the seller and the buyer have their agent for delivery and payment of food, ultimately these agents add additional cost to the system. If blockchain technology can be leveraged, buyers and sellers can directly interact with each other which would speed up the process and reduce time and cost for the farmers. A blockchain system thus will ensure that farmers will receive a large share of sale [27]. In Bangladesh, it is a common phenomenon that farmer does not get fair price of their products. To handle this situation, a blockchain system will highly impactful.
- **Disintermediation:** With the features like traceability and auditability of Blockchain, farmers of Bangladesh can directly sell crops or foods to the consumers, thereby reducing the need for intermediaries. Therefore, it will reduce the cost incurred by intermediaries and ensure proper distribution of agro-products within Bangladesh and surplus in foreign countries.
- **Agricultural insurance:** In Bangladesh Agricultural insurance systems are mainly the collection of non-formal private mutual and community-based crop and livestock initiatives. For ensuring social protection to various natural disasters affected people, still some low-cost agricultural insurance schemes are used. The adoption rate of insurance is very low as the benefits are not well communicated. A blockchain based insurance system can help the insured farmer to get the benefit instantly in adverse weather though automatic data feed and local hype data without the need for any claim assessment [28].

5.5 Commerce Application Domain

- **Consumer protection:** In Bangladesh, consumer rights are not always protected from fraud and dishonest seller. When transparency will be provided, fraud sellers can be detected and the consumer rights will be protected. Through a blockchain based system consumer information and overall rights also can be protected from any misuse.
- **VAT:** Currently, in Bangladesh VAT collection is ensured through a challan number in every transaction of registered point only. However, there are lots of pitfalls and scope for manipulation exit in the payment of VAT. If a smart-contract supported blockchain system can be integrated with the VAT collection system, VAT can be automatically calculated, collected and recorded without any human intervention. This will reduce manipulation and ensure the timely collection of VAT during each sale of a product.
- **Fraud detection of consumer products:** Fraud happened when there is no presence of transparency. As transparency is one of the major benefits of Blockchain, therefore it can be used in prevention of fraud in consumer products. Bangladeshi organisations face a lot of loss for the dishonest sellers who sell counterfeit products. If a product record is stored in a blockchain which can only be updated by authorised entities, it will prevent any fraudulent occurrence or if this happens, it can be easily detected. In addition, such an

information recorded on a blockchain can easily be traced back to its origin because the information is shared in the distributed ledger.

5.6 Health Application Domain

- **Privacy-preserving collection, storage and retrieval of health data:** Health data is collected when a patient undergoes some medical treatments including tests and diagnosis. Generally, in Bangladesh, the results are signed by the doctor and are delivered to the patient which they can keep with a full control. Unfortunately, such a process imposes several challenges: it has a very limited scope to preserve, storage and retrieve such information for further consultation. An automated system is the solution; however, a centralised system has a single point of failure and they do not promote transparency. A blockchain based solution which stores and retrieves medical data in a privacy-friendly way is the perfect solution in this scope.
- **Privacy-preserving sharing of personal health data:** Sometimes patients in Bangladesh share their sensitive personal health data to various marketing and pharmaceutical officers without realising its implications. Any existing centralised solution cannot provide enough control to the user by which they can exercise their privacy rights. A smart-contract supported blockchain system can ensure privacy in such cases as patients can control who will have access to his or her medical data [29].

5.7 Banking/Insurance Application Domain

- **Digital Asset Management:** Nowadays organisations are being transformed digitally where the management of digital assets have become a crucial part. Many Bangladeshi organisations are also focusing on asset digitisation. However, the concern lies on managing those assets through controlling misuse and protecting privacy. A blockchain-based system can be used to manage the ownership and transfer of intellectual property of these digitised assets and to guard against the misuse of the assets.
- **Inter-bank settlement:** In Bangladesh, the inter-bank settlement is mainly done through the reconciliation process which is time-consuming. We can speed up and enhance this process by using a blockchain system that will streamline the transaction process through their shared ledger. Therefore, we can get rid of the reconciliation process by which a settlement is not carried out manually and separately.
- **Trade finance:** Trade finance refers to financial transactions that relate to both domestic and international trade. In Bangladesh, the whole trade finance mechanism currently is composed of complex lengthy process through the presence of intermediaries. A blockchain-based trade finance could streamline this process as soon as transactions occur in the network. There is no need to have multiple copies of documents related to a single transaction in the database of different stakeholders. Ultimately, it will speed up the transaction settlement time, increasing transparency between all parties. In this way, the available capital, that in the traditional setting waiting to be transferred between concerned parties in the transaction, can be unlocked, thereby increasing efficiency [30].

- **P2P lending:** Through Blockchain borrowers and lenders can exchange funds without a need of intermediaries such as bank, underwriter and others. This will reduce the time and cost. The rate of interest will also be determined according to the profile of the borrower in the smart contract. Therefore, the lending process in Bangladesh will be more efficient and effective.
- **Anti-money Laundering:** When customer data such KYC data is kept in a blockchain, it will be beneficial for Anti-Money Laundering (AML) procedure as well. In Bangladesh, as the KYC data in still not shared with various financial organisations, it is impossible to keep track of individual transaction records. Blockchain technology can help immensely in this regard and will be an essential tool to track any illegal financial activities.
- **Remittance:** Remittance is one the potential sectors of Bangladesh where blockchain technology can play a crucial role. Because of the excessive expense of sending through banks and legal channels, many expats send money through personal channels or illegally. The implication is that this reduces government revenue substantially and the actual remittance income of Bangladesh cannot be properly tracked. A blockchain-enabled remittance service will have no-intermediaries which ultimately will reduce cost and expats will be encouraged to send money through a proper channel. The currency fluctuation risk also can be minimised with the help of digital currency on top of a blockchain.
- **Digital Currency:** A blockchain-based digital currency (not a crypto-currency) can be beneficial for banking and financial industry. In Bangladesh we have already experienced the emergence of several digital currency services such as bKash, Rocket and so on. However, all of them are centralised in nature providing less transparency than desired. A blockchain-based digital currency can be more efficient than the existing and could provide better transparency and accountability.
- **Credit rating:** Currently, the credit rating mechanism in Bangladesh is mostly manual and is done without accurate data about borrowers and investors. A blockchain-based rating will be better than the manual system with a decentralised credit rating agency, the credit rating process is transparent to all parties including the regulators and would leave no room for manipulation [31].
- **Insurance:** The claim settlement process in Bangladesh is a complex manual. In a blockchain-based insurance system, an insurance claim cannot be modified. It can facilitate a faster claim settlement. The terms and conditions will be in the smart contract, the claim settlement process will be executed automatically and the fund will be released to the policyholder instantly. In the case of reinsurance, data sharing can be done between insurers and reinsurers [32]. Ultimately, blockchain technology will unlock the lots of hassle-free insurance opportunities to insurance company and potential policy takers.

5.8 Judiciary Application Domain

- **Securing digital evidence:** Blockchain technology can be used to secure digital evidence. For example, CCTV footage, mobile phone data, internet usage data, important files retrieved from the seized computes all represent important evidence which can be used as evidence in many countries in the world. However, digital evidence can be manipulated easily, thereby the authenticity and integrity of such evidence is often questioned. Blockchain technology can be an effective tool to mitigation this situation. Currently, in Bangladesh, digital evidence has limited opportunities to be used as evidence for judiciary purposes. However, with the increasing usage of computers, mobile phones and the Internet, such evidence will be crucial in Bangladesh. A blockchain-based solution will open many ways to verify and secure digital evidence when this happens.

5.9 Supply Chain Application Domain

- **Agricultural supply chain:** In agricultural supply chain Blockchain can help to remove the intermediaries and ensure that the Bangladeshi farmers get the proper payment as discussed earlier.
- **Medicine supply chain:** In the medicine industry of Bangladesh, there is a constant risk for the supply of fake and adulterant medicine. This is very hazardous for the customers and is also risky for the medicine manufacturers. Through blockchain technology, the origin of the medicine can be tracked and the risk of fraud can be reduced. Ultimately, both the customer and medicine producer will be benefited.

5.10 Document Verification Application Domain

- **Government certificate:** In Bangladesh, government certificates and documents can be counterfeit easily for dishonest purposes, which is challenging to deal with. Here, a blockchain-based system can be used as a solution to issue different certificates with a proper verification mechanism which is impossible to counterfeit. This will help various Bangladeshi government organisations to eliminate the risk, thereby increasing trust and transparency to the concerned authority.
- **Educational certificate:** Educational certificates in Bangladesh are used for different purposes. However, it is not free from the risk of fake and falsified certificates. A blockchain-based solution can be used to store, educational Certificates on a distributed ledger so that people can access it anytime, anywhere without the fear of unauthorised modifications. Such a solution can also ensure that only authorised entities can verify the certificates. It will ultimately help to track any fake certificate holders in the job market of Bangladesh and other important positions within and outside of Bangladesh.

5.11 Smart City Application Domain

- **Smart infrastructure:** In a smart city all the resources are integrated using information technology to ensure effective and efficient use of the resources. With the help of emerging technology i.e. IoT, cloud computing, machine learning, real time direct benefit can be provided by the government to the citizens. Blockchain technology can add more

values by connecting all the technologies together. It will also provide additional security. Bangladesh in her march towards a developed nation, should embrace a blockchain-based smart infrastructure.

- **Citizen services:** A blockchain-enabled smart city can facilitate many citizen services in an automated and decentralised fashion. Such services can issue e-ID for identity verification for their citizens which in turn can be used for e-voting system, recording and sharing medical information, property management, the use of crowdfunding platform and so on. Therefore, for the future planned smart-city of Bangladesh, blockchain technology can help to unlock above advantages for its citizens.

5.12 Infrastructure

- **Protection of Critical Information Infrastructure:** Blockchain provides an array of advantages, as outlined in Section 2.2 which can be utilised to protect the national information infrastructure which is critical to digitise different aspects of the country and to facilitate e-Governance.

6 Pathway to a blockchain-enabled nation

The Fourth Industrial Revolution demands a technology-infused paradigm and cultural shift in societies. It will create new models of economy and business and unprecedented value propositions. All these can be pursued only with right preparations and accessed only with proper technologies. Blockchain technology being a foundational technology for the upcoming fourth industrial revolution, Bangladesh must prepare herself to embrace it wholeheartedly. In this document, we lay down our ambition towards a blockchain-enabled nation where every aspect of the government is one way or another integrated and managed with a blockchain system as to create a corruption free, transparent and accountable society. Next, we explore the challenges we might face and present a pathway towards realising this dream.

6.1 Challenges

It is always a challenging task to disrupt any established paradigm. The scenario becomes more complex when the major tool for disruption is completely nascent and evolving technology like Blockchain. Understandably, there will be many challenges to face. Some of these challenges are technical while others are more organisation oriented. We explore these challenges below.

6.1.1 Technical challenges:

- **Immaturity:** One major limitation of blockchain technology is that it is still evolving. The majority of the existing blockchain systems are still immature and not production-ready for any wide-scale adoption. However, there are just a few, particularly in private blockchain domains, which have matured to be used in production-ready environments.
- **Vendor lock-in:** Because of only a few production-ready blockchain systems, there is always the risk of locking to the product (a blockchain system) of a particular vendor. If a system is built upon such a product, the risk is that the system ceases to function when the product is removed from the market. The lack of option is thus a major hurdle for the wide-scale adoption of any new technology. The adoption of a fully-open source technology can effectively handle this challenge.
- **Scalability:** As discussed previously, the scalability of major public blockchain systems is not satisfactory. In theory, the private blockchain systems seem to offer better scalability. However, there is no conclusive proof of their scalability as it is not well documented so far for any large-scale adoption.
- **Privacy:** A private blockchain system does not allow everyone to access the blockchain data, only authorised users can access it. Nevertheless, it must be noted that anyone, who has access to the blockchain network, can access every single piece of data in the blockchain, unless special measures are taken. This may undermine the privacy of different organisations who are part of the same private blockchain network, but do not want to share sensitive information with one another. There are advanced cryptographic solutions such as Zero-knowledge Proof that can be used to tackle this challenge.

Alternative, a privacy overlay can be created on top of a blockchain platform to ensure the privacy of data between different organisations.

- **Lack of interoperability/compatibility:** The existence of different blockchain systems provide a wide-range of options for organisations. It also offers an opportunity for them to select the appropriate one for their particular use-cases. On the other hand, the inadvertent side-effect of this is the creation of blockchain silos that might need to be inter-connected in future. However, the lack of interoperability and compatibility among these blockchain systems will be a major hurdle to bridge these disconnected silos. An interoperability framework can be created to bridge different silos and address this challenge.
- **Lack of technical expertise:** Every new technology faces a shortage of expertise, especially during its evolving period. Blockchain technology is no exception; there is an acute shortage of blockchain experts all over the world. This is even more true in Bangladesh. In addition, the lack of knowledge about blockchain and its benefits among the practitioners, both in private and government organisations in Bangladesh, is a major challenge for a wide-scale blockchain adoption.
- **Support infrastructure:** Because of the lack of required technical expertise or lack of other technical resources, many organisations are hesitant to explore the ways a blockchain system can help them. This is prohibiting them to harness the potential benefits of any blockchain system. A support infrastructure provided by the government would be great enabler in such cases.
- **Usability:** The usability aspects of any customer-facing software, such as online services, is often overlooked in many developing countries like Bangladesh. Blockchain is a cutting-edge technology which is full of technical jargons which even the seasoned tech-enthusiasts and programmers find hard to grasp. For any successful adoption of any blockchain-based service, it is absolutely imperative that the usability of such service is analysed so that all types of users can use it effectively.

6.1.2 Organisational challenges

- **Lack of awareness:** Many organisations are not aware of the advantages private blockchain technology can bring for their businesses. Many regard cryptocurrencies as the only application for blockchain and hence they treat these two synonymously. Also, the lack of expertise and local resources also play a key role to demotivate an organisation towards a blockchain-based solution. All this makes it challenging for these organisations to adopt blockchain to transform their business models.
- **Organisational acceptability** & **readiness:** The organisational acceptability and readiness for blockchain technology will depend on several factors: their understanding of the blockchain technology and the advantages it might bring to them, the motivation to adapt to changes accordingly, access to technical expertise and the blockchain-friendly government incentives and policies. The lack of a combination of these factors impose a challenge to embrace blockchain technology for any organisation.

- **Governance:** The governance of any blockchain system is a critical issue which is often overlooked. How a blockchain is governed defines its success and adoption in many ways. Interestingly, different aspects of a blockchain governance is analogue to how an organisation or a consortium or organisations distribute responsibilities among themselves. Each organisation must understand this before they decide to adopt blockchain for their solutions. This calls for a new governance model which itself might be challenging for any organisation. A managed blockchain platform (either by the government or by any private organisation) can be an immense help for other organisations as they do not need to worry about any governance issue.
- **Lack of regulatory framework:** A regulatory framework surrounding any novel technology instils confidence among the adopters. On the contrary, the lack of any such framework creates uncertainties. This is why a blockchain-friendly regulatory framework can be an effective tool to overcome many challenges within an organisation.
- **Legal Issues:** Since it is possible for the nodes of a decentralised (particularly public) ledger to span multiple locations around the world so it becomes tough to establish a specific application of jurisdictions' laws and regulations. But the risk of transaction of an organisation falling under every jurisdiction still remains. This results in an overwhelming number of rules and regulations that can be applicable on transactions in a blockchain based system. The laws that might apply to transactions of public blockchain systems have to be considered beforehand so that necessary measures can be taken to mitigate the risks. On the contrary in a private or permissioned blockchain the process is quite easy because it has the provision of creating a form of legal framework and internal governance structure [32].
- **Integration with legacy systems:** One of the crucial challenges for any organisation to adopt a blockchain system will come to this factor: how easy it is to integrate with their legacy systems. If it is too complicated which outweighs its benefits according to their business model, it is unlikely that they will adopt it. A simple mechanism for integration will thus be invaluable to drive changes for any organisation.
- **Business model transformation:** A blockchain adoption for any organisation implicates a new model of thinking which would require to transform their business model. If a drastic transformation is required, many business organisations will be unwilling to adopt any blockchain system soon.
- **Risk estimation:** Risk estimation is an intrinsic process for any organisation when it decides to adopt a new technology which would require significant business model transformation. The challenges to estimate risks in adopting the blockchain technology for any organisation are manifolds: i) the technology is not mature enough, ii) it evolves rapidly and thus volatile in nature and iii) its understanding is not clear.

Next, we elaborate on different strategies to overcome these challenges.

6.2 Technical Readiness & Adoption

The major challenges that we will face to achieve our vision of a blockchain-enabled nation will be difficult to address within a short period of time. It will require a combination of a clear strategy and substantial investment with a short and long-term planning to overcome these challenges. Many of the challenges presented above tend to be technical, however, there are other challenges that can be linked to capacity development, regulatory and legal framework, policy formulation and so on. In this section, we focus on mostly technical challenges, analyse how we can make ourselves technically prepared to meet these challenges and finally, highlight the guidelines for adoption pathways. Other challenges are explored in the subsequent sections.

6.2.1 Adoption pathway

The first step towards the adoption pathway is a clear understanding on blockchain technology. However, the knowledge on blockchain is not wide-spread and there is an acute shortage of competitive and knowledgeable workforces in this domain, both in Bangladesh and around the world. In addition, blockchain technology has many perspectives which may not be clear in the first instance. Because of these issues, it becomes a challenging task for anyone inexperienced to understand how blockchain technology can help someone to solve a particular problem or enhance the existing method in a corresponding use-case. The long-term solution for this problem is capacity building which has been explored in details in Section 6.3. Here, we outline an alternative short-term solution to mitigate this issue. We propose to create a blockchain feasibility testing framework according to certain criteria. If someone has the domain knowledge on a particular use-case he/she should be able to use this framework to test if blockchain technology is suitable for the respective use-case. SWOT analysis can also be an effective companion to this framework. Other additional capabilities that can be integrated with the framework are threat modelling and risk analysis so that the framework will cover a wide spectrum of perspectives. This framework needs to be developed by a team of experts on blockchain technology with at least one of the members having expertise in SWOT analysis, threat modelling and risk analysis. This team can then be leveraged for different associated blockchain related activities.

6.2.2 Prioritisation of use-cases

As per our analysis in Section 5, there are a plethora of use-cases for which we can leverage blockchain technology. However, it will be impractical to rush and to try to develop blockchain-enabled solutions for all these use-cases all at once. A reasonable approach would be to prioritise a subset of use-cases from a few applications domains which will have the maximum impact in Bangladesh. Then, we should focus to develop prototypes or MVP (Minimum Viable Products) for these use-cases by allocating a certain amount of funds which can be competitively distributed according to the plan discussed in the next section.

6.2.3 Technical framework

Blockchain technology is currently in an evolving stage at a very fast rate. Many of its aspects are rudimentary in nature and in many ways are regarded as immature by many blockchain experts. Because of these issues, it is a challenging task even for an expert programmer to handle and develop a blockchain system, particularly at the initial stage. Unfortunately, the number of

blockchain experts is few and far between throughout the world. In addition, the distributed nature of a blockchain system imposes significant cost, in comparison to any traditional system, to maintain such a system, particularly for the storage of transactions and the underlying blockchain across multiple nodes. All these contribute to the reason that many organisations do not have access to the proper computing, storage and human resources to explore this avenue. This often can be regarded as one of the major technical obstacles to materialise the vision of a blockchain enabled nation. A quick solution to this is to utilise the managed blockchain platforms provided by different cloud service providers. Major cloud providers such as Amazon, IBM, Azure and others provide services for such managed blockchain platforms which are relatively easier to deploy and maintain. However, one crucial issue to consider in this regard is the Bangladesh Digital Security Act which does not allow the storage of sensitive data into any public cloud server. This unfortunately limits the usage of such managed blockchain platforms. All these issues can be effectively addressed if there would be a National Blockchain Platform, a cloud-based managed and private blockchain platform hosted under the authority of the corresponding agency of the Government of Bangladesh. Such a platform could facilitate a Blockchain-as-a-Service provisioning mechanism that other Bangladesh organisations, both public and private, could leverage to experiment, deploy and maintain different blockchain based services. The associated data then could be stored in the national fourth-tier data centre, thus ensuring the compliance of the Digital Security Act. In order to streamline the integration process with the national blockchain platform, we envision that the platform the creation of a blockchain integration framework which would be the enabler tool that will help any organisation to integrate their applications into the hosted blockchain platform. Another useful mechanism would be to provide a sandboxed environment within the blockchain platform for different organisations. This environment would be made accessible to these organisations so that they can deploy and test their blockchain applications utilising the blockchain integration framework and their associated APIs. Initially, the blockchain platform should be released on a trial basis accessible only to a highly selective public and private organisations and its performance should be continuously monitored for a certain period of time. Based on the performance data, different levels of tweaks might be required. Once a satisfactory level of performance is achieved, the blockchain platform, the integration framework and their associated APIs should be opened for a wider range of organisations.

6.3 Capacity Development

The core of many challenges highlighted above can be attributed to a single source: lack of expertise in blockchain within the country. There is indeed an acute shortage of experts who have a deeper understanding on the technology with hands-on experiences. If we are to build a blockchain-enabled nation, it is of high priority that this shortage is addressed and its technical capacity is developed. There are many ways the capacity can be developed which are discussed next.

6.3.1 Identifying experts

The first step in this regard should be to identify existing blockchain experts within the country. Measures must be taken so that we can utilise their expertise and leverage their experiences in as many ways as possible.

6.3.2 Training & increasing awareness

One of the key mechanisms for capacity building is training. The training itself can be divided into different categories: beginner, intermediate and advanced. In addition, there are different aspects to consider for a blockchain system, e. g. core blockchain development, smart-contract development, blockchain governance, blockchain integration & deployment, blockchain testing and so on. Depending on the category, different aspects need to be covered. For example, an advanced training should cover all these aspects whereas a beginner level training should mostly concentrate on the core blockchain development. Local experts and academicians can play a crucial role for developing the course contents for this training program. Another important aspect is that the high level practitioners and policy makers, located both in public and private sectors, do not have proper knowledge about blockchain. They might be not aware of the potential a blockchain system may offer. To increase awareness, the dissemination of blockchain potentials to the correct stakeholders is crucial. In addition, creating a common knowledge base both in English and Bangla might help to increase awareness among the general people and the practitioners.

6.3.3 Research & innovation

Promoting research and innovation plays a key role for developing capacity in any domain. This culture helps to create new knowledge which often proves invaluable. This is particularly true for any disruptive technology such as blockchain. For example, disrupting any existing mode of government service delivery will require to develop a new model which was not explored before. In such cases, it is often the case that there will be no blue-print to follow; it might often feel like travelling to an uncharted territory. Carrying out research in many ways will be the only way to move forward in such situations. Therefore, it is imperative that research on blockchain is highly promoted. Supporting research also fosters exciting innovations which can create novel services and delivery methods which in turn can generate revenues. Local universities, research centres and industries have crucial roles to play in this regard.

6.3.4 Expansion of Centre of Excellence

The activities and their related action points suggested above are of wide verities. To get the best result of out these, an effective coordination will be essential. The Centre of Excellence (CoE) established at BCC can play a leading role in this regard. To widen the reach of this CoE, several other Centres of Excellence can be established in different universities across the country. These other Centres of Excellence will function under the authority of BCC CoE which will strictly control different aspects of activities carried out in these centres. These centres can be the focal by which research and innovation can be expanded across the country. These centres can also take initiatives to sign MoU (Memorandum of Understanding) with different universities, research centres, forums societies and other public and private organisations, both at home and abroad.

This will help the CoE to initiate different joint initiatives, research programs and knowledge exchange programs as suggested above.

7 Strategic Goals

To fulfil the desire of a blockchain-enabled nation, we must strive to achieve the outlined visions and take appropriate measures to address the agendas. In this section, we outline a synopsis of strategic next steps that will be essential to accomplish what we desire. These strategic steps have been transformed into a series of long, mid and short-term goals which we present next. Transforming strategic steps into measurable goals is often useful as goals are easy to track and achieve in comparison to, say for example, visions and agendas which can be abstract. Finally, we have transformed those goals into concrete action points.

7.1 Short-term Goals

It might be difficult to put a numerical value in the time-span of a particular goal, however, a numerical time-span is often useful to strategize how to achieve goals within the stipulated duration. With this in mind, goals that will require less than two years (by 2021) to achieve will be regarded as short-term goals. Short-term goals are easier to achieve and are mostly preparatory in nature. These goals can be used to formulate plans, carry out feasibility tests, develop capacities and increase awareness. These goals are presented next.

SG-1 Prioritising use-cases for each application domain.

SG-2 Creating a feasibility framework to carry out feasibility analysis for prioritised use-cases.

SG-3 Developing capacity by promoting education and research, arranging training and increasing awareness.

SG-4 Exploring the ways, a national blockchain platform can be developed, deployed, maintained and provisioned.

SG-5 Analysing how different government services can be integrated with the national blockchain platform and piloting different projects to facilitate this.

SG-6 Formulating plans to integrate other online services from the private companies with the national blockchain platform or with their corresponding blockchain networks.

SG-7 Expanding the national Centre of Excellence with blockchain-based initiatives.

SG-8 Facilitating blockchain based innovations and start-ups.

SG-9 Allocating appropriate funds for these activities.

SG-10 Developing blockchain-friendly legal and policy frameworks to ensure a fast and smooth execution of all blockchain-related activities.

7.2 Mid-term Goals

In a similar fashion, goals that will require three to ten years (by 2030) to achieve will be regarded as mid-term goals. Mid-term goals can act as a bridge between short and long-term goals and can be used to facilitate the transition of the technological and cultural paradigm shift: from the existing legacy systems towards blockchain-enabled systems. These goals are presented next.

MG-1 Realising a national blockchain platform integrated with the national information infrastructure so as to create a resilient infrastructure for different services.

MG-2 Integrating at least half of the relevant government services with the blockchain platform.

MG-3 Integrating a certain portion of private services in the national blockchain platform. Alternatively, if the private companies have already equipped themselves with their own blockchain platforms, it is to take appropriate measures to integrate their platforms with the national blockchain platform.

MG-4 Promoting research and analysing impacts about public blockchain outsourcing opportunities and adoption in a few application domains upon feasibility.

MG-5 Promoting blockchain innovations with additional rewards and subsidies so as to create demands for blockchain resources.

MG-6 Expanding the scopes of blockchain research and education in different universities by facilitating graduate programmes such as Master's and PhD in the blockchain domains.

MG-7 Reduce intermediary as much as possible, particularly in the agricultural and financial sectors.

MG-8 Creating a thriving environment for blockchain so as to enable a smooth integration with other cutting-edge technologies such as IoT, AI and Big Data.

MG-9 Allocating enough funds to carry out these activities.

7.3 Long-term Goals

Within the scope of this document, goals which would require a significant time-span to achieve are regarded as long-term goals. Intuitively, we consider a goal as a long-term goal if it will require ten to twenty-one years (by 2041) to accomplice. These goals will attempt to achieve a nationwide technological paradigm shift that will be essential for a sustainable development growth. We have formulated a number of such long-term goals which are presented next.

LG-1 Developing a blockchain-supported national infrastructure which is resilient against the modern security and privacy threats and can be used for a wide-variety of applications.

LG-2 Adopting e-Governance at all aspects of the government covering all modes. The blockchain-supported national infrastructure can act as the backbone to support e-Governance mechanisms.

LG-3 Facilitating fair competitions and ensuring accountability and transparency for a wide range of applications using the blockchain-based infrastructure.

LG-4 Allocating appropriate funds for achieving these goals.

7.4 Action Points

Next, we have transformed the mid and short-term goals into concrete action points. The transformed actions points are presented in Table 1. It is to be noted that the action points do not embody any long-term goal as such a goal is often visionary in nature. The expectation is that achieving the mid-term and short-term goals and expanding them in a sustainable fashion for a long period of time will eventually enable the realisation of long-term goals. Each action point in Table 1 also highlights the challenge (if any and a '-' signifies not applicable) it aims to address and the responsibly government body who will take charge of initiate and execute the respective action point. Please note that the solutions for some organisational challenges (Business model transformation and risk estimation) are not directly provided in Table 1. This is because these challenges are effectively resolved once these action points are executed. For example, if a business is aware and motivated enough to integrate with the proposed national blockchain platform, it will need to transform its business model. On the other hand, the risk estimation process is unique for each business and their particular application. Hence, a generalised action point will not work in this regard.

Table 1: Transformed action points for short-term and mid-term goals

Action Point	Description	Goals	Responsible Body
AP-1	*Create a database/collection of blockchain experts within the Country. The database/collection should contain their CVs highlighting their detail experiences of working in different blockchain projects. In addition, the database/collection should emphasise the blockchain systems they are familiar with. This database/collection will act as the focal point in order to identify an expert should any need arise.*	SG-1	ICT Division, ICT Industries
AP-2	*Formulate a blockchain feasibility framework which can evaluate the feasibility of blockchain technology for a particular use-case. Different additional capabilities, such as SWOT analysis, threat modelling and risk analysis, can be integrated with the feasibility framework.*	SG-2	ICT Division, Academia, ICT Industries
AP-3	*Select a sub-set of prioritised use-cases covering different application domains. For this we should utilise the blockchain feasibility framework, if it is already available.*	SG-1	ICT Division

AP-4	*Identify the potential universities, research centres and private organisations who are actively involved in blockchain research and development.*	SG-3	ICT Division, Academia, ICT Industries
AP-5	*Increase the capacity of the identified and other universities and research centres so that they can carry out advanced research on blockchain.*	SG-3	ICT Division, UGC, Academia
AP-6	*With the help of local experts and academicians, develop course contents for blockchain training considering different categories and aspects. To save money, it is strongly recommended that the majority of the trainings are carried out in Bangladesh.*	SG-3	ICT Division, Academia, iCT Industries
AP-7	*A separate training program can be initiated which will train only trainers. To bootstrap this process, a small batch of trainers and practitioners can be sent abroad for their initial training, only if such facility is unavailable in Bangladesh.*	SG-3	ICT Division
AP-8	*Accreditation and certification are effective tools to promote the training program and to ensure its quality. This will also help to recognise a pool of trained resources. If this is considered, a set of rules and respective policies need to be defined.*	SG-3	ICT Division
AP-9	*Develop blockchain based POCs to solve public service platforms, if applicable*		ICT Division
AP-10	*A separate training program, with appropriate contents, targeting different policy makers and high-level practitioners of different public and private organisations should be planned and executed.*	SG-3	ICT Division, ICT Industries, Academia
AP-11	*To increase the awareness on the potential of the blockchain technology, organise seminars, round-table meetings, dialogue exchange programs, focused group meetings and so on among different stakeholders.*	SG-3	ICT Division
AP-12	*Create a knowledge base, both in English and Bangla, on blockchain fundamentals and different aspects for different stakeholders and networks. This knowledge base can even be made available for all citizen of the country so*	SG-3	ICT Division, Academia, ICT Industries

	that a country-wide awareness on blockchain is created.		
AP-13	*Develop and introduce blockchain courses at the Bachelor level in the syllabus of technology-oriented and business-related subjects at different universities and colleges that provide higher degrees. Facilitate blockchain-focused research and graduate programs at Master's and PhD level in top universities of Bangladesh.*	SG-3	UGC, Academia
AP-14	*Develop and deploy a national blockchain platform so that it can be leveraged to provide Blockchain-as-a-Service (BAAS) to different universities, research centres and organisations. The National Data Centre would be the ideal place to host this platform with their associated data.*	SG-4-, SG-6	ICT Division, Academia
AP-15	*Develop an inter-operability framework which can be plugged with the national blockchain platform. This will ensure that the blockchain platform can interact with other (possibly private) blockchain platforms.*	SG-5	ICT Division
AP-16	*Define governance rules to select the responsible authorities and maintain the blockchain platform in a continuous seamless fashion.*	SG-5	Cabinet Division, ICT Division
AP-17	*Design and expose APIs with respect to the platform for any application as well as for managing the underlying blockchain. The platform can utilise the national e-service bus (BNDA) to expose these APIs in order to ensure their security.*	SG-5	ICT Division
AP-18	*Formulate strategies and policies defining how this blockchain platform can be effectively shared among many entities without compromising the associated privacy issues.*	SG-4, SG-6	Cabinet Division, ICT Division
AP-19	*Create a privacy-preserving framework, using any existing solution or using advanced cryptographic solutions such as Zero-knowledge Proof, to ensure and guarantee privacy of each organisation and their associated data while using national blockchain platform.*	SG-4	ICT Division

AP-20	*Collect and analyse performance data of the blockchain platform and tweak different parameters until a satisfactory level of performance is achieved.*	SG-4	ICT Division
AP-21	*To widen the capacity of CoE at BCC, establish other subordinate Centres of Excellences in different universities across the country.*	SG-7	ICT Division
AP-22	*Develop a blockchain-friendly regulatory framework that will help to tackle any legal issues and accelerate innovations.*	SG-10	Cabinet Division, ICT Division
AP-23	*Formulate a blockchain-focused policy framework which will pave down the ways blockchain technology can be leveraged, integrated and provisioned in different application domains.*	SG-10	ICT Division
AP-24	*Allocate funds to initiate and carry out blockchain innovations of ministries.*	SG-9	Ministry of Finance
AP-25	*Initiate plans to migrate/integrate a certain portion of public and private services with a blockchain system. For public services, the proposed national blockchain framework will be the ideal choice for integration. On the other hand, private services can opt in for their preferred approved blockchain systems.*	MG-1, MG-2, MG-3	ICT Division
AP-26	*Promote blockchain research and innovation by allocating substantial funds, additional rewards and subsidies so as to create demands for blockchain resources.*	MG-5	Ministry of Finance, ICT Division
AP-27	*Expanding the scopes of blockchain research and education in different universities by facilitating graduate programmes such as Master's and PhD in the blockchain domains.*	MG-6	UGC, Academia,
AP-28	*Target some financial and agricultural domains to embrace blockchain-based solutions to remove intermediaries as much as possible.*	MG-7	Ministry of Finance, Ministry of Agriculture, ICT Division, all Ministries
AP-29	*Analyse the impact of opening up cryptocurrency in a restricted fashion for application adoption.*	MG-4	ICT Division, ICT Industries
AP-29	*Allocate funds to initiate and carry out blockchain innovations of ministries.*	MG-9	Ministry of Finance

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