

EMERGING DIMENSIONS OF BLOCKCHAIN TECHNOLOGY

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Emerging Technologies in the Digital Universe

Scientists and business executives have classified recent developments in digital technology field into two important groups. The first one is expected to bring groundbreaking transformational changes and the second has potentials for value additions to business in varying degrees of value-adding impacts in monetary terms. Until late 2015 Blockchain was regarded as a technology that has potentials to create high-value impacts through industrial and commercial applications. This does not include all that is being talked about for dealings on cryptocurrencies. Blockchain technology is also known as distributed ledger technology (DLT), and hence will synonymously be used in this paper.

It is already an established fact that during the foreseeable Industry 4.0 era 3D Printing, Autonomous Vehicles, Brain-Computer Interface, Artificial Intelligence (AI), Machine and Deep Learning, Robots and Drones powered by AI, etc. will bring in transformational impacts for the commercial world. Innovations in areas of Swarm Computing, Privacy-Enhancing Technologies, Self-adaptive Security, Quantum and Cognitive Computing, etc. will contribute towards generating higher levels of business values.

All these developments are also being predicted to hasten the process of ushering in Industry 5.0, when customers and users of the technology will be able to customise the given digital facility for meeting their unique requirements, as compared to the programmed solutions, albeit versatile, being offered now. But not much is being talked about what will be their contributions for reaching the fruits of such technological developments to people at all levels of societies across all countries and for the overall wellbeing of humanity.

However, the said limited level of views and appreciation for Blockchain technology seems to have started changing. It is increasingly being considered as a technology with capabilities to create transformational impacts on industry trade and commerce, as we have experienced for the internet. Some thought leaders are also indicating its foundational impacts. Besides commercial and industrial applications, digital scientists are testing its efficacy across many kinds of applications, viz., environment and biodiversity management, resolution of impoverishment and related societal issues, protecting peoples' rights, delivery of services by national governments, voting in a democratic political system, management of charities and donations, old age home and correction houses, improvement in lives of impoverished children and many more. The present author is of the perception that Blockchain technology will emerge as the powerhouse of Industry 4.0.

Objective

Almost every single day an agile digital enthusiast is reading about one more innovative development in the field of digital transformations as have briefly been stated above. Blockchain is one of those which is increasingly being applied for providing innovative solutions for minimisation of value destruction and maximization of value creation across all spectrum of applications. Nothing is more important than more and better services to humanity and sharing the sustainable benefits of Industry 4.0 with all levels of citizens across all corners of our world when distance has summerly been killed by digital interventions. The predominant objective of this paper is to bring out these dimensions of blockchain technology.

Attempts will be made to demystify many misunderstandings of a common man about Blockchain because it has erroneously been touted to be synonymous to cryptocurrency. Multifarious challenges are being faced by digital scientists for applying Blockchain, and more are expected in the forward path. The present author will also try to ideate risks and challenges in embedding DLT's backbone, i. e., a 'Smart Contract', and other critical success factors for Blockchain technology.

The objective of this paper also includes setting certain directional guidelines for digital scientists to keep in view at every step of application development. Multifarious use cases of Blockchain technology, as revealed through the present author's research, will briefly be narrated for readers to be informed about application-oriented developments. Efforts will be made to also refute the allegation about Blockchain's net excess carbon footprint at a conceptual plane.

No commercial application can function without being audited by credible attestation agencies to ensure good governance and keeping in abeyance, if not kill, attempts of unscrupulous elements making use of these invaluable gifts of 'innoventors' for selfish, ulterior motives. Therefore, this paper will also delineate the developments in areas of risk management and application of validation and audit tools for Blockchain based solutions.

Above all, efforts will also be made to bring out the emerging humane dimensions of Blockchain.

Research Methodology

This paper is being written as a sequel to the earlier two published papers^{1&2} of the present author. Readers are being urged to please read those two papers. For the sake of brevity, sections like narratives about the technology and how does it function, its genesis and evolution, past developments etc. will not be covered in this paper.

Blockchain technology is fast evolving through intensive research and 'innoventive' explorations by the digital scientist, consulting professionals and commercial houses across the world. Most of the organisations are keeping their detailed knowledge, learning points and experience about successful use cases, pilot runs and commercial applications of Blockchain close to the chest. Not many books and scholarly research papers are available in credible journals. That because the application of DTL for cryptocurrencies is not the focus area of this paper, the availability of researched based inputs is further getting restricted.

Therefore, even after extensive research, it is extremely challenging to hunt out hardcore facts about use cases, commercial data and authentic operational statistics on impacts and results from applications of Blockchain for uses other than cryptocurrencies. This leaves one with the options for extensive desktop research of digital media through news items; viewpoints expressed in blogs by professionals, startups, world-class consulting firms, thought leaders and opinion makers.

The present author has delivered several keynote speeches, conducted panel discussion sessions and workshops on Blockchain and digital transformation in various summits and conferences in India and abroad. He had benefits of listening and viewing many seminal presentations, interacting with a large number 'startupians', first generation entrepreneurs, digital scientists CXOs from large MNCs, investors, thought leaders and academicians, the practising professional and opinion makers; who are directly / indirectly associated with exploration and applications of Blockchain. Besides all these, the direct application-oriented experience is also being gathered from a consulting assignment. Information and knowledge acquired from all these sources and personal involvements have also been used in this paper.

Blockchain– Reasons for Attraction

Don Tapscott, one of the world's leading authorities on innovation, media, and the economic and social impact of technology, and advisors to business and government said *"The technology most likely to have the most profound impact on the next few decades has arrived. And it is neither social media nor big data. It's not robotics. It is not even AI. You'll be surprised to learn that it's the underlying technology of digital currencies like Bitcoin. It's called the blockchain."*³ Since its very first application for virtual currency Bitcoin, such a powerful technology is being tried and tested for very many industrial and commercial applications including delivery of services by governments to citizens. Marco Iansiti and K. R. Lakhani⁴ observed that *"Blockchain could dramatically reduce the cost of transactions and if widely adopted could widely reshape the economy."*

Without getting into the narratives of how a DLT framework functions to achieve all these, the major reasons for users' attractions toward Blockchain technology can briefly be summarised in the following lines:

- Blockchain is an internet-based facility for initiating and completing peer to peer transactions and securely transmitting information without any intermediation enable the system to be broad-based across geographies;
- The Smart Contract embedded in a Blockchain based application, with pre-provisioned compliance requirements, can be self-initiated without any intermediation and in a much faster and cost-effective manner;
- Decentralised Data Storage Mechanism (DDSM) of a DLT allows each participant to be known by a public key and has access to the entire history and data of transactions conducted by all participants stored in their own computing system;

- Transparency with anonymity is ensured, as each participant digitally signs into the system with a digital private key and thereafter can be identified only by a different public key.
- There is no need for any central authority to keep the master data of participants. The entry of each participant is post completion of KYC formalities, with uploaded documentary evidence, in compliance with regulatory requirements of the concerned country/countries if transcended by the participation of users.
- All transactional data are uniquely encrypted by complex algorithms which can be programmed to change automatically from time to time in a permissioned blockchain framework.
- Whenever a participant in the Blockchain initiates a transactional message from his / her computing system, called a 'Node', a digital signature is generated attaching the participant's public key, and other participants from all Nodes can view that.
- Once a piece of transactional information with the digital signature is authenticated by other nodes, it gets pooled into and added to the chain as another block. Every block is encrypted with a cryptographic hash function which cannot be manipulated ever after.
- Persistency and ability of the system for validation of each transaction spreading across the network;
- System based applications are programmed with cryptographed computational logic and algorithmic rules for triggering transactions, storage and retrieval;
- Cryptography and DDSM render the entire system almost non-hackable as one needs a computer with a hitherto unobserved supersonic speed to hack all the Nodes at a time.

All these facilities and features for enhanced security and safety of data and privacy of participants cannot be ensured by any hitherto developed digital technology.

Blockchain Demystified

In common parlance, Blockchain has become near cent per cent synonymous to cryptocurrency in general and Bitcoin in particular. Let this author shout from the rooftop conveying that Blockchain is not equal to cryptocurrency. This erroneous perception may be due to the following reasons:

- Bitcoin, the very first cryptocurrency and all its subsequent varieties were offered and transacted on Blockchain platforms since 2009 and for this more than warranted hypes and hoopla have been created;
- Since then a common man has not yet experienced even one groundbreaking application of Blockchain technology for his / her day to day operations.

- Readers will recall that in the early stage of internet people considered www as a technology capable of only sending and receiving mails crisscrossing geographical boundaries. That misconception has successfully been erased from memory because even for hailing a cab and getting cooked food to doorsteps internet is now being used by a common man.

The reader may be surprised by a prediction of Christopher Fabian, Co-founder of UNICEF's Innovation Effort⁵ way back in 2016 which has almost come to reality today. He said, in an interview to Stan Higgins, as published by Coindesk in February 2016, that *“Blockchain technology could provide a solution to issues facing the world’s impoverished children. ... I don’t think it’s quite there yet, but when we’re looking at problems like giving someone an identity when they don’t have a sovereign identity granted to them, or how you allow movement of money from one place to another quickly, those are things that blockchain starts to hint at. Many of our teams in the field and our labs and country offices have expressed need for things that we think could be answered with an application of blockchain.”*

Digital scientists were amazed by observing the functionalities of DLT that was displayed by Bitcoin. Their innovative imagination was genuinely tickled for finding out other applications of Blockchain. In his second paper, the present author quoted the observation of Bernard Marr's⁶. He mentioned that Vitalik Buterin, one of the co-founders of Ethereum and contributors to Bitcoin codebase, wanted to remove this technology's limitation of only dealing with a digital currency. He launched in 2015 the second public Blockchain called Ethereum, which could handle different types of transactions with the help of a built-in 'Smart Contract'. This version of Ethereum attracted the attention of multinational corporations like Microsoft, BBVA and UBS, because of its vast business potentials, robust ability to disrupt legacy systems and ushering in a new era.

In Exhibit - 1 an illustrative list of 36 generic line items of various applications of Blockchain technology have been listed. All these have been identified through extensive research work. Under each line item, there can be three to five use cases. By a perusal of the list, readers will pleasantly be surprised to note the expanse and variety of critical problems and business applications that are being successfully resolved/handled using Blockchain. Since the preparation of that list, information about many more inimitable applications has been reported in digital media. Some of such unique cases and/or explorative work have been listed below:

- Daniel Palmer narrated the findings of a research study conducted jointly by PwC and World Economic Forum⁷. This study has identified numerous ways blockchain could address some of the most critical challenges in environmental management, e. g., conservation of biodiversity, natural disaster, climate change, ocean management, clean air and water security, underground water reserve management, etc.
- Paul De Raeve⁸, Secretary General of the European Federation of Nurses Association, has narrated in August 2018 how Blockchain technology supports nurses in Europe where the continuity of healthcare is a concern. He observed that *“Blockchain has the potential to modify the way health and social data are traditionally collected, interpreted and connected, shifting*

from different bits of information held by a single 'owner', to the lifetime history, supporting the efficient and effective continuity of care, by offering a whole and secure way to capture, track and share a citizen's/patient's entire health and social experience."

- Unique solutions features of DLT are being applied by football clubs in Europe to resolve long drawn problems related to ticketing, fan engagement, payment of players' salaries, etc.⁹
- Blockchain News quoted in their report that "US Navy Naval Air Systems Command (NAVAIR) is exploring Blockchain to enhance tracking of aviation parts throughout its lifecycle."¹⁰
- IBM has announced the general availability of 'Food Trust'¹¹ with the application of Blockchain for trust through track and trace of food items. Momentum for application of such a solution is expanding for medicine, perfume, jewellery etc. has started to be used by world-renowned retailers like Amazon, Carrefour and Walmart.
- The World Bank has launched 'bond-i' in August 2018, which is fully managed by Blockchain, for A\$ 110 million, which is the first of its kind in the world. The Bonds will be fully managed by blockchain right from creation to allocation, transfer and thus through its life cycle. It received encouraging support from the investors.¹²
- It was a momentous achievement for an Indian state Bengal when a baby's parent received the 1st Blockchain based birth certificate. It was issued by the New Town Kolkata Development Authority (NKDA). The birth certificate was showcased at the two-day global blockchain congress in Kolkata held on December 18 and 19, 2018.¹³

The list will tend to be unending and occupy rest of the pages of this paper if the author has readers' indulgence to continue with such success stories of explorations for Blockchain applications. It will be useful to note two more allied information here. Teaching at the world's first Blockchain University will start in 2019. This University has been founded by a team of academics from Oxford University with the objective of the 21st century.

Trescon Global, one of the leading organisers of knowledge sharing events on information technology and digital transformation, has conducted World Blockchain Summits (WBS) in a series of global events. Those were centred on research, development and ultimate adoption of DLT based solutions. The summits were conducted in strategic locations such as Kenya, Germany, Russia, Singapore, Netherlands, Mauritius, India and the UAE. Many more such WBSs have already been planned for coming months. This global series has hosted over 15,000 delegates, 500+ internationally renowned 'startupians', speakers and thought-leaders, 300+ investors, 450+ exhibitors and over 200 media houses. The present author has chaired and delivered keynote addresses in two of the WBSs in Moscow and Dubai.

Status of Applications – Present and Foreseeable Future

PwC Global¹⁴ has conducted a worldwide survey in early 2018 covering 600 executives in 15 regions of the world. They have come up with specific startling facts about the status of commercial organisations being engaged with Blockchain technology. The same can be summarized in the following tables.

<u>Stage - Progress in Blockchain Project (%)</u>		<u>Industries have seen as Leaders (%)</u>	
Development	32	Financial Services	46
Research	20	Manufacturing	12
Live	15	Energy & Utilities	12
Pilot	10	Healthcare	11
Paused	8	Government	8
None	15	Retail and Consumers	4
		Entertainment and Media	2
		Others	5

Thus 84% of the above 600 respondents are actively involved with Blockchain. 45% of them were of the view that the adoption of Blockchain may be delayed due to trust. This, according to the present author, may be due to the undue negative aspersions that have been cast on Blockchain technology arising from matters related to illegal trading activities and volatilities in valuation cryptocurrencies. 28% of those respondents have identified interoperability between two or more Blockchain based platforms is critical for achieving success. The present author, with his interactions with various officials, as detailed above in research methodology section, could gather that resolution of this and drafting of 'Smart Contracts' will continue to pose challenges for success with DLT.

In terms of leading the journey, the respondents were of the view that by 2023 China will supersede the USA with 30% share in applications of Blockchain. The later's share will drop from 29% in 2018 to 18%. Australia will be in the third position far away with an estimated 8% share in 2023. India's share is estimated to increase from the present 5% to 6%.

Analysts John David Lovelock et al.¹⁵ from Gartner published their estimate in March 2017 for the value of DLT technology innovation rather than the dollars spent on it". According to them value addition by this technology will be around \$176 billion by 2025 and will such value additions will exceed \$3.1 trillion by 2030.

It will be useful to note the report of Melanie Kremer¹⁶ on government's initiative in Dubai, which is currently working on a total of 20 use cases for Blockchain technology to complement its existing operations. This initiative is a part of the overarching objective to establish Smart Dubai to make Dubai the 'Smartest and Happiest City' in the world. Around the time this was reported, the Dubai government's payment portal became blockchain-based. Dubai's government has strategic partnerships with IBM and Consensys, as advisors, for Smart Dubai achieving the dream goals.

TrustBar¹⁷ reported that an early survey-based report of the World Economic Forum indicated that around 10% of global gross domestic product (GDP) is likely to be stored on the blockchain by 2027. The report reflected expectations of eight hundred

business executives and technical experts from the information and communications technology sector. In this report Blockchain has been termed as a ‘Deep Shift Technology’. According to a recent research report Global GDP has been estimated to be USD 110 Trillion by 2030. One can, therefore, infer that that by 2027 about USD 10 Trillion will be stored on Blockchain which is an amazing number to be transacted through and stored in Blockchain.

Smart Contracts – Challenges in Backbone Construction

Execution of any business or quasi-commercial activity, the government's committed services to citizens and even charities and donations, collectively being referred hereinafter as transactions, must be executed in compliance with the related laws, regulations and/or laid down policies and procedures. All these must also cover legal and regulatory compliance requirements of more than one country when the transacting parties transcend more than one sovereign boundary. Again, the offer, acceptance and specific terms and conditions for execution of transactions, remaining within the ambit of relevant provisions, are to be duly pre-accepted by parties participating in the transactions.

This tantamount to a binding contract being self-initiated and getting pre-executed by and between the parties with equal gain and sacrifice, except in cases of services by a governmental authority, e. g., issuing a birth certificate of a newborn baby. It is, therefore, obvious that systems and processes for executing a transaction in a Blockchain based platform, must have to be in pursuance of a digitally effected contract by and between the parties in compliance with all relevant legal requirements. The system should enable the user to self-initiate the process.

Such an agreement is technically termed as the ‘Smart Contract’ for Blockchain. Each such agreed offer and acceptance along with related documentary evidence are also to be stored in a chronologically sequenced digital library for reference and retrieval as and when necessary.

Such a Smart Contract is, therefore, considered to be the digital lawyer and backbone of any DLT. Some experts say that “*Smart Contracts are where the rubber hits the road for business and Blockchain.*” When a series of multiple contracts are to be executed through the same Blockchain based platform, e. g., supply chain management in an export-import transaction right from placement of order till receipt by the importer and payment, such a Smart Contract will be the superset of more than one contracts. Those are to be executed by parties like importer, exporter, quality verifier, insurer, local cargo handlers, shippers, banks and so on.

The above is a daunting and arduous challenge not only for system developers but also legal professionals to ensure the success of any Blockchain based application. The present author could gather that MNCs like Microsoft and IBM are developing ‘Smart Contract Libraries’ the required version from which can be identified and adopted by system developers with needful changes befitting their applications.

While drafting such a Smart Contract, the challenge is to ensure the following critical aspects. The objective is to bring in speed without intermediation by any physical lawyer, simplicity, trustworthiness, quality, compliance and substantial cost savings:

- The legal identity of parties, the validity of offer and acceptance and mutual consents are conclusively established;
- The offer and acceptance were in good faith and with commitments of reasonable efforts for full execution, and binding rights and responsibilities of all parties;
- The flow of equal financial considerations except for use cases like free services by Government;
- There is no force or duress for securing consent for execution;
- There is no partial performance or excuses for breach of contract;
- There is no breach of any applicable law and/or regulation;
- Any other terms and conditions to be specifically agreed upon to meet requirements related to country-specific regulations; and
- Availability and retrieval are ensured for all the transactional information, evidence and data with digital signature, date and time stamp, hash value verification, etc.

The author mentioned in his second paper² on Blockchain about the work being done by International Decentralized Association of Cryptocurrency and Blockchain (IDACB), Their efforts are for establishing basic principles of market legal regulation and synchronising legal initiatives for various countries in Blockchain and cryptocurrencies. Efforts are on to propose legal initiatives for regulators based on best countries' practices. By a visit to their website, one can observe that IDACB has already garnered memberships of ninety-five countries as on the date of writing this paper.

It is very encouraging to note here that Blockchain News¹⁸ reported on September 10, 2018, that Blockchain records will now onward be accepted as legal evidence by the Supreme Court of China. They have quoted in the report an announcement by the Supreme People's Court which said: *"Internet courts shall recognize digital data that are submitted as evidence if relevant parties collected and stored these data via blockchain with digital signatures, reliable timestamps and hash value verification or via a digital deposition platform, and can prove the authenticity of such technology used."*

Blockchain – Challenges in Adoption for Problem Solution

Since the onset of industrial automation around 1970 through computing systems and its evolution from time to time, business executives always suffered from skepticism and paranoia before adopting IT system-based solutions for their business processes and activities. While return on investments always remained the overarching criterion, the fitness of the solution, quality, time, speed, obsolescence, maintenance and training requirements of staff members etc., always featured in their questions. Most rightly their objective should not be to ride on the wave and hype about any emerging

technology but to ensure that they adopt the most appropriate one for ensuring sustainable success in their respective businesses.

Global consulting firm EY¹⁹ has come up with a set of 'Five Point Test' to determine whether Blockchain is the right solution for a business problem. If answers to three of the five questions are in affirmative, a CXO can reasonably conclude that Blockchain is the solution. Questions to be raised for conducting the test are as under:

1. *Are there multiple parties in this ecosystem? (Blockchains are fundamentally multiparty collaboration.)*
2. *Is establishing trust between all parties an issue? (Blockchains improve trust between participants by having multiple points of verifications.)*
3. *Is it critical to have a detailed transactional record for activity? (If everyone agreed on everything, you wouldn't need a blockchain to verify who did what and when it was done.)*
4. *Are we securing the ownership or management of a finite source? (Core logic in the blockchain system is designed to prevent double-counting of assets and to record ownership and transfers.)*
5. *Does the network of partners benefit from increased transparency across the ecosystem? (Blockchains are transparent by design.)*

If any business executive suffers from further skepticism about the application of Blockchain, he/she can get a more demystified view about blockchain by referring to the researched-out report of McKinsey & Co²⁰. The following is a neat summary of the narratives provided in the report:

- Blockchain is not Bitcoin, but the just one and the first application for cryptocurrency.
- Blockchain, on a single firm basis, may not be equal to a traditional database, but its advantages come with significant technical trade-offs particularly in a low trust environment.
- In terms of tamperproof quality of Blockchain, its platform can tamper if 50% of its network-computing power can be controlled and rewriting of the previous transactions is possible. Such an assumption is not a practical one.
- Blockchain's security is almost cent per cent as it uses an immutable data structure, which is cryptographed.
- Blockchain is not a truth machine, but it can verify all transactions and data completely involved in a blockchain platform.

The network of Blockchains and KYC

Network for Blockchains

Presently more than one hundred blockchain based transactional platforms is in operation, other than for cryptocurrencies. In all these participants are transacting live and adding values in millions of dollars. However, these are individually operating in isolated silos, and none of the platforms is inter-operating with each other. This is a critical issue, particularly for the sustainable success of Blockchain with wider applications.

For any digital technology to be successful in a country-wide and/or world-wide business ecosystem, it must have interconnections and interoperability with other similar systems. This should be like banks conducting operations on a bank to customer and bank to bank basis with the host to host integration of computing systems. If individual blockchain solutions, albeit generating large value additions, continue to operate in such a disjointed environment question ought to arise as to how long this will continue and how many such will sustain and exist? One single business entity or an individual might have to join many blockchain platforms for addressing different problems and business requirements.

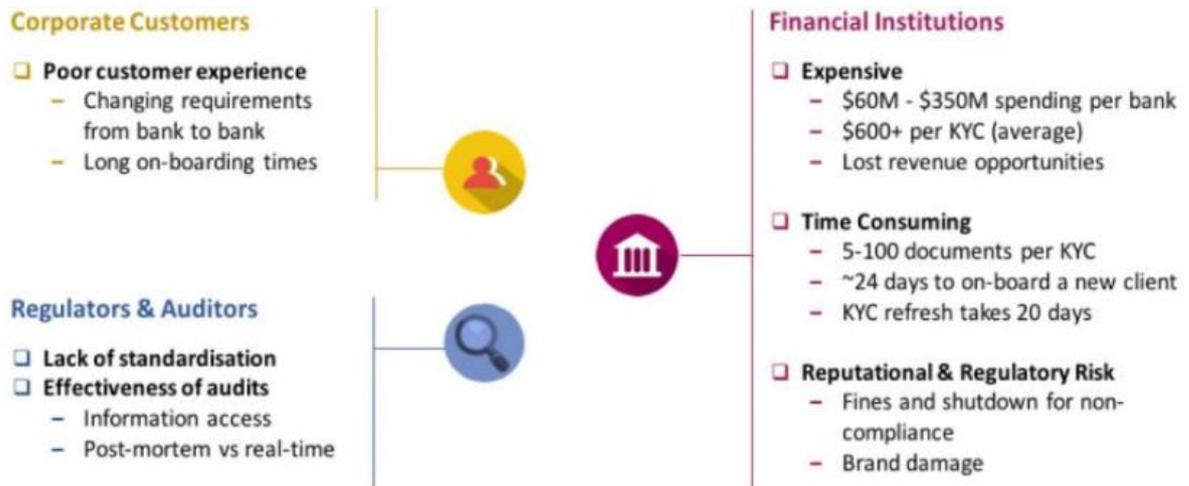
Therefore, innovative solutions are essential for need-based integration of individual Blockchains to enhance their applicability, reciprocity and wider applications with interoperability? IBM²⁰ has come up with a solution for networking of isolated Blockchain platforms with a vision for liberating each one from its self-created silo. The ultimate objective is to establish a 'Web of Blockchain Networks'. One does hope that many more such MNCs will take up this kind of initiatives. It will be useful to keep watching developments in this front.

KYC for Onboarding of Participants

Another major point of concern for any Blockchain application is establishing truthful, legal identity of an individual participant before onboarding into the platform for conducting transactions. This is in common parlance termed as 'Know Your Customer'(KYC). In many countries, there are legal provisions and other regulatory pronouncements to be compiled for conducting such a KYC process. For any blockchain platform, this will pose an onerous challenge. The task also includes safe storage of all evidence submitted by each participant with the ability to retrieve if necessary.

IBM²¹ is said to have established a DLT based KYC solution which any individual blockchain platform can use. The following is a graphical presentation of the issues they said to have addressed through this new platform.

KYC and Data Privacy - IBM's Solution for Regulatory Compliance



IBM claims that its solution will be a single integrated platform using a DLT in which KYC will be stored. By adopting this, business entities for their applications of Blockchain can enhance the experience by increasing speed for onboarding, reducing costs by 20% and associated risks. However, the present author is of the view that integration and interoperability of this DLT for KYC with business-specific applications will continue to be a big challenge to be met.

Blockchain and Carbon Foot Print

In some corners of the world, noise is being heard about the growing carbon footprint of Blockchain. Desktop research on this reveals that one bitcoin transaction guzzles more than a megawatt-hour of power resulting in the emission of about 500 Kilos of carbon dioxide. Ethereum consumes about 78 KWH of power per transaction. There are perceptible initiatives by several startups to find out innovative solutions for reducing such carbon footprints. One such initiative is being supported by the United Nations. Jason Deign²² reports that “*Carbon Grid Protocol, owned by the Singapore-based New Era Energy, has developed a blockchain-based framework that is intended to help other blockchain players offset emissions.*” Interested readers may like to gather more knowledge.

While it is true that DLT will consume more electricity as all the nodes will be touched by each transaction of any blockchain framework, digital scientists are making all possible efforts to increase the speed of computing for DLT. Thus, all such arguments of environmentalists in this regard prima facie have some bases. Jason Deign quoted in his report some encouraging note of the CEO of a startup who said, “*There is an expectation that corporate social responsibility, environmental, social and governance factors will creep up the management agenda within mature blockchain companies striving for corporate credibility to attract institutional investors, the CEO noted.*”

It is more than obvious that all responsible organisations while adopting Blockchain in their digital transformation strategy, will responsibly be conscious about compensating actions to be taken for both reducing and neutralizing the carbon footprint. Besides these, the present author would like to put forward the following argument in support of Blockchain which needs further review and assessment.

Use of Blockchain for transacting cryptocurrencies like bitcoin is mainly for investment and/or payment management purposes. It does not have benefits of eliminating a series of disjointed and repetitive transactions like when a Blockchain is used for conducting transactions in an integrated platform. For example, in cases of transactions in a DLT platform for say fintech, supply chain, health care, or property registration and deal-making, one can imagine how much computing work and digital storage requirements will be saved at each point. Blockchain will eliminate all these decentralized activities for the same transaction by avoiding duplications and intermediations. Technological trade-offs for actual work done in a DLT platform vis-à-vis eliminations of decentralized legacy processes will perhaps more than compensate additional energy consumption by Blockchain solutions.

Risk Management and Transaction Audit

Readers must be aware by now that gigantic volumes of value additions are expected to be generated and stored in worldwide Blockchain based applications. As has been stated above this will be in trillions of dollars and measure up to about 10% of global GDP by 2027. Such a powerful digital transformation can, therefore, be logically expected to be shrouded with many systemic and non-systemic risks. In this section, the author has tried to summarise recent developmental work done by Big4 accounting firms for the audit of blockchain-based applications.

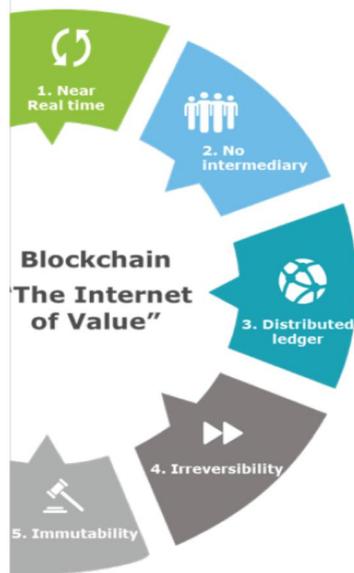
Deloitte

In their publication on risk-based audit approach for Blockchain Deloitte²³ quoted that “*While the benefits are clear there are myriad risks that may be imposed by this nascent technology.*” They have cautioned against two specific points:

- Blockchain may not be at the top of CEO's and CFO's' agenda; and
- The audit team may not have the expertise in ensuring how to gain comfort with a system that puts trust in advanced cryptographic algorithms.

The present author has summarized in the following manner his learning points from the said Deloitte’s literature on audit friendly features of Blockchain technology:

Typical Audit Friendly Features of Distributed Ledger Technology



1. Near real time – Efficiency

- Near real-time settlement of recorded transactions
- Removes frictions
- Reduces risks

2. No intermediary - Disintermediation

- Cryptographic proof instead of trust
- Two parties transact directly
- No need for a trusted third party

3. Distributed Ledger – Audit Trail

- Peer-to-peer distributed network records a public history of transactions
- Blockchain is distributed and highly available
- Preserves only the proof of the transaction existence

4. Irreversibility – Audit Trail

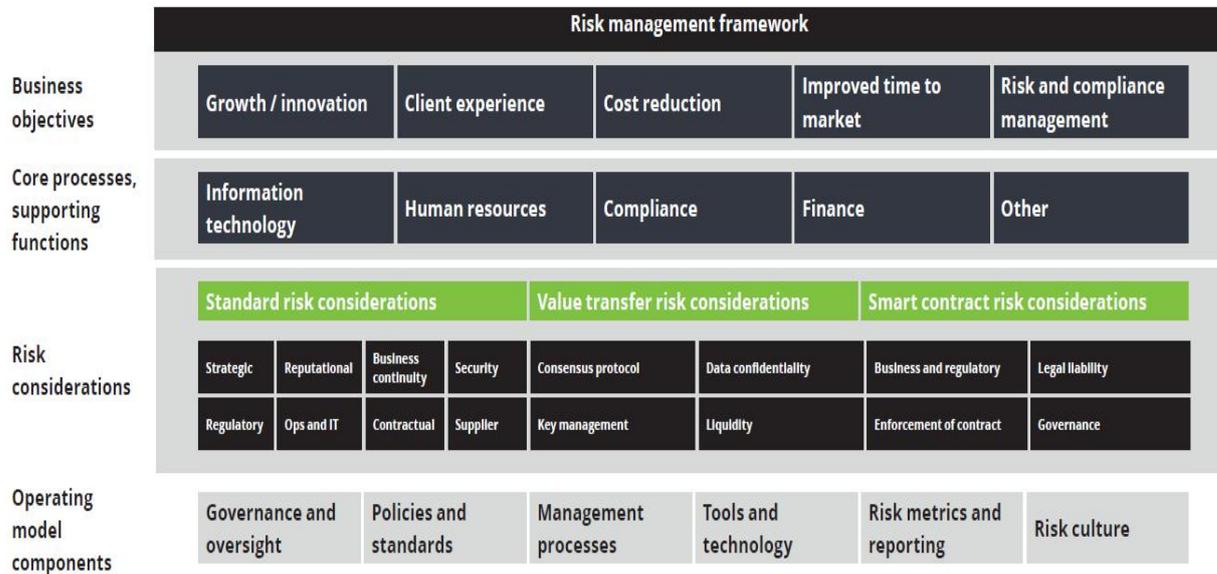
- Contains certain, verifiable records of every transaction
- Helps prevent double spending, fraud, abuse and manipulation of transaction

5. Immutability – Audit trail

- Chained cryptographic framework prevents past blocks from being altered²³

Source: Deloitte Development LLC 'Blockchain Risk Management – Risk Function need to play and active role in shaping blockchain strategy' <https://www2.deloitte.com/us/en/pages/consulting/articles/blockchain-risk-management.htm>

They have suggested the following risk management framework for risk-based audit approach for blockchain based transactions:



PwC

The following approach has been adopted by PwC²⁴ for validation and audit of Blockchain based digital solutions. They have recognized that the traditional audit approach and tools cannot be applied for an audit of transactions in a Blockchain. Certain unique features of Blockchain have been identified by them which are to be addressed while developing the approach and tools to be applied:

- No standard way to validate blockchain-based business processes and the related control environment;
- Blockchain environments have unique architectures and lack standardisation;
- Each client must design a customised control environment based on use case;
- Lack of knowledge and expertise within organisations for the design of control environments; and
- Traditional audit techniques leverage readily available historical data ledger or audit trail. Blockchain environments are real-time and do not include historic ledgers.

They have also used a risk-based framework to identify the factors against six different risk categories and 100 plus risks. They have developed a validation software which is configurable before applying to any Blockchain platform based on nature or risks gathered through their firsthand study of the platform, broad nature of transactions performed, and other factors considered for designing the specific solution. The following is a graphical illustration of the features of their Blockchain validation tool²⁴.

Blockchain Validation Software

Real-time

Machines test for anomalies as a part of the flow



Full population

Every transaction tested



Built-in

Audit becomes just another part of the system



Macro-level trend spotting

Machines find longer-term patterns of indicators not evident to humans



Immediate/predictive

Spots a problem right away and helps anticipate other issues too



Objective results

Results machine ranked and rated



The above seems to be a unique, innovative solution for approaching the process of validation and audit of Blockchain based transactions. It is sure the tool and the methods for applications will continue to evolve with more perfection.

EY

A 'Blockchain Analyzer' has been developed by EY²⁵. Their claims about this tool are the following:

- The Analyzer will facilitate EY audit teams review and analysis of transactions on the blockchain;
- The pilot will lay the foundation for automated audit tests of blockchain assets, liabilities, equity and smart contracts; and

- The technology is built to support the testing of multiple cryptocurrencies.

The above tool seems to be specifically useful for the audit of transactions related to digital assets. The present author could not yet trace further development of the tool by EY since April 2018 which can be useful for the audit of all blockchain based other commercial transactions. At this stage, it will be useful to quote Jeanne Boillet, EY Global Assurance Leader. *“As digital technology continues to advance, we are focused on developing innovative approaches to the audit process and providing confidence and trust to the capital markets. As companies are also focusing on how they embed technologies like blockchain into their financial processes, we are innovating the audit to meet their evolving needs and those of investors.”*

KPMG

The power of ‘Cognitive Technology’, has been identified by KPMG²⁶ for audit in the era of digital transformation. They are of the view that this will help auditors to deliver higher quality audits based on increased coverage, more granular analysis and deeper focus into controls, accounting practices and reporting processes. They continue to add that increased focus on higher-value audit activities in areas of heightened business risks, and reporting complexities will facilitate the process of validation and auditing of digital technology-based solutions applied by business organisations.

Mark McAulay, KPMG’s U.S. Cognitive Technology Audit Leader, says that *“When it comes to audit, cognitive technology has brought us to the brink of unprecedented breakthroughs.”* The present author could not yet trace KPMG’s specific plans, approach and tools for validation and audit of transaction in a Blockchain platform.

It will be useful to quote at this stage a news item reported by Wolfie Zhao²⁷ on July 19, 2018, regarding initiatives of all the Big4 audit firms about the audit of Blockchain based transactions, He reported that. *“The world's four biggest auditing firms – Deloitte, EY, KPMG and PwC – are joining a group of 20 banks in Taiwan to trial a blockchain service for auditing public companies' interim financial reports. According to a local news report on Thursday, the blockchain trial will initially allow the auditing firms to conduct so-called external confirmation – the process of obtaining and evaluating audit evidence – for a group of selected companies that are publicly traded in the island.”*

All these are developments in the right direction because facilities for risk management of any business process and government service related activities should be embedded in the process itself to render it to be a proactively risk-enabled process. It has comprehensively been established in this section, through the words of the world's large accounting and auditing firms, that blockchain has enormous capability to be proactively risk enabled. Yet there will remain the need for conducting better validation checks and audit of any blockchain based transactions because the technology is still evolving. Moreover, any regulatory process needs validation and attestation by a third party for rendering the outcomes to be acceptable by all stakeholders.

Developments in India

India is commended by the world as one of the largest providers of innovative human resources for information technology. With the advent of entrepreneurial culture by 'startupians' and initiatives of the Indian Government at the federal level and State Governments, there are significant developments in the fintech space. India has ushered in Industry 4.0 with great initiatives. Blockchain received specific attention when the Finance Minister of India post his budget speech for 2018-19 stated that, "... the government will explore the use of blockchain technology proactively for ushering in the digital economy." Several actions have also been taken for bringing in related laws and regulations to facilitate establishing a digitally transformed India.

With the encouragement through Digital India Initiatives of Indian Government and adoption of digital transformation strategies by corporate houses, Blockchain has started finding its rightful place in their business plan for execution. Certain large banks in India have conducted in 2017 explorative pilot run of 'Bank chain' to introduce Blockchain based banking solutions. State Governments of Andhra Pradesh, Telangana, Karnataka, Bengal and Maharashtra, have launched initiatives of rendering governments' services through blockchain platforms. Information technology and consulting giants, viz., TCS, Infosys, Wipro, Cognizant and EY have indicated plans for investing more and developing DLT based solutions for clients.

Mint newspaper in their special edition²⁸ of December 28, 2018, has reported that, "... NITI Ayog and Oracle plan to start a drug supply-chain blockchain ledger, which will help to fight counterfeit drugs. The Telangana State ITEC department has tied up with TechMahindra to launch India's first Blockchain district. Most of such pilot runs are being conducted using permissioned private Blockchains.

Blockchain for All – Humane Dimension

Humane Dimension

Extensive reading of published literature from various sources including from the Harvard University one can infer that Blockchain is not a disruptive technology. It is a foundational innovation and has all potential and prospects to create new foundations for both economic and social structure of any country.

The present author is of the view that no technological innovation can be foundational and having groundbreaking impacts like the world-wide-web (www) unless its benefits can be shared with people across all levels of any society of any country. In other words, it should not be meant for the benefits of only business organisations and high net worth individuals.

This critical criterion can only be met by Blockchain when it will be applied for sharing benefits of Industry 4.0 across all levels of society in all corners of the world. It should be for use by all and must contribute toward inclusive growth, inclusive happiness and inclusive smile. The present author craves the indulgence of readers for quoting, at the cost of repetition from his earlier papers the following few paragraphs related to human dimensions of Blockchain and regulatory needs.

Technology does not have morality, passion, emotion, ethics and value generation skills. Technologists have. The success of Blockchain will depend on those good

qualities of solution builders, leaving the least scope for the user to deploy against humanity with an ulterior greedy motive. Blockchain will attain 'Darling of the Mass' status like 'Internet' if it is adopted and applied with the mindset of universal altruism. It should be grounded on the foundation of sustainable shared values. Blockchain technologists cannot become just another 'Technology Tribe'. They should be harbingers of shared developments for inclusive happiness of mass. Blockchain should have its own ism irrespective of globalisation and protectionism.

Regulatory Need

By now it has summarily been established that www has transcended geographical boundaries, Blockchain will have to transcend sovereign/political boundaries for achieving its dream to be the 'Powerhouse of Industry 4.0' with ground-breaking and multidimensional successes. Humanity is one, and the world is its home. Hence there is a definite need of a global regulatory body for setting directional policy guidelines, defining the international code of conduct, work process standards, and tracking and monitoring of applications, etc. Those must be followed by all nations, besides their own internal regulations. Institutions like the UN, IMF, and WTO can take up this role. The objective will be to ensure that this powerful technology can also achieve, besides success for industry, trade and commerce; shared developments for inclusive happiness of all till the lowest strata of society across the world.

Conclusion

The present author will consider that this paper on Blockchain has met a bit of feat if it can contribute toward demystifying the misgivings about Blockchain technology and its pervasive impacts on business, society and environment. He will feel contended if the readers get some help in further developing their understandings about DLT and foundational impacts that it can generate for any economy and people across all levels of society. His appeal to digital scientists and 'startupians' is for applying this powerful technology to usher in inclusive growth, inclusive happiness and inclusive humane smile for all under the Sun.

Exhibit - I

Finance, Industry, Trade and Commerce	Government Service Functions and Others
1. Banking, Insurance, Credit history, FinTech	<i>I. Government functions and services</i>
2. Cross border P2P and B2B remittances	1. Citizens identity management, Passport
3. Investments in capital assets, Derivatives	2. Public voting
4. P2P Lending, Crowdfunding, Microfinance	3. Land registration, title deed and mortgage
5. eCommerce, Software Apps sale	4. Wills and inheritances
6. Health care	5. Underground water use management
7. End to end export-import business	6. Correction houses, orphanages

8. Multimodal supply chain	7. Gun safety management
9. Real estate – Ownership, transfer, rental	8. Law enforcement and crime management
10. Sea and dry port management	9. Disaster and Bio-diversity management
11. Security trading, stock exchange management	II. Others
12. Contracts – Digital Rights, Wagers, Escrows	10. Music streaming
13. Public transport and ride sharing	11. IPR of singers and musicians
14. Public car parking at airports	12. Donations and charity, old age home
15. Pollution control devices and carbon credit	13. Protection of the right to speak and write
16. Travel and leisure management	14. Documentation and preservation of testimonials and credentials
17. Warranty & maintenance services by OEMs	15. Cloud storage and cybersecurity
18. IOT and Blockchain of Things	16. Education
19. Spurious product detection	17. Human resource

Bibliography and Webliography

1. Dr Paritosh Basu, “*Blockchain Technology – A Prismatic Analysis*”, The Management Accountant, Volume 53, No. 2, February 2018.
2. Dr Paritosh Basu, “*Blockchain Technology – The Powerhouse for Industry 4.0*”, The Management Accountant, Volume 53, No. 6, June 2018.
3. Don Tapscott, “*How the blockchain is changing money and business*”, tinyTED, https://en.tiny.ted.com/talks/don_tapscott_how_the_blockchain_is_changing_money_and_business
4. Marco Inansiti, and K. R. Lakhani, “*The Truth about Blockchain*”, HBR Reprint, R1701J, February 2017.
5. Stan Higgins quoted Christopher Fabian, “*UNICEF Eyes Blockchain As Possible Solution to Child Poverty Issues.*”, February 3, 2016, <https://www.coindesk.com/unicef-innovation-chief-blockchain-child-poverty>
6. Bernard Marr, “*A Very Brief History Of Blockchain Technology Everyone Should Read*”, Forbes, February 16, 2018, <https://www.forbes.com/sites/bernardmarr/2018/02/16/a-very-brief-history-of-blockchain-technology-everyone-should-read/#16cda1ba7bc4>.

7. Daniel Palmer, “Blockchain Can Help Solve Swathe of Environmental Issues.” A blog on the joint study by World Economic Forum and PwC, <https://www.coindesk.com/blockchain-can-help-solve-swathe-of-environmental-issues-says-wef-study>
8. Paul De Raeve, Secretary General of European Nurses Association. On Blockchain Technology providing supports to nurses. <https://www.openaccessgovernment.org/blockchain-supports-nurses/48506/>
9. Star On Line, *From ticketing to salaries football, explores the power of blockchain*, September 27, 2018. <https://www.thestar.com.my/tech/tech-news/2018/09/27/from-ticketing-to-salaries-football-explores-power-of-blockchain/>
10. Blockchain News, “US Navy Explores Blockchain to Enhance Tracking of Aviation Parts” September 27, 2018, <https://www.ccn.com/us-navy-explores-blockchain-to-enhance-tracking-of-aviation-parts/>.
11. IBM News Room, *Food Trust Expands Blockchain Network to Foster a Safer, More Transparent and Efficient Global Food System*, October 8, 2018, <https://newsroom.ibm.com/2018-10-08-IBM-Food-Trust-Expands-Blockchain-Network-to-Foster-a-Safer-More-Transparent-and-Efficient-Global-Food-System-1>
12. The World Bank Press Release, *World Bank Prices First Global Blockchain Bond, Raising A\$110 Million.*, August 23, 2018. <https://www.worldbank.org/en/news/press-release/2018/08/23/world-bank-prices-first-global-blockchain-bond-raising-a110-million>
13. The network of Non-Resident Indians, *A 1st in Bengal, baby gets block chained birth certificate*”, www.NRIS.com, December 2018 <https://analytics.twitter.com/user/paritoshbasu/tweets?filter=top&origin=im&ef=gl-an-tw-im-desktop>
14. PwC Global, “Blockchain is here. What’s your next move?” <https://www.pwc.com/gx/en/issues/blockchain/blockchain-in-business.html>
15. John David Lovelock, Martin Reynolds, Binaca Granetto and Rajesh Kandaswamy, “Forecast: Blockchain Business Worldwide, 2017-2030,” <https://www.gartner.com/doc/3627117/forecast-blockchain-business-value-worldwide>
16. Melanie Kramer, “Dubai is Building a Blockchain-Powered Government”, September 24, 2018, <https://bitcoinist.com/dubai-is-building-a-blockchain-powered-government/>
17. TurstBar, “10% of total GDP will be stored on blockchain by 2027 – WEF report”, <https://medium.com/@trustbar/10-of-total-gdp-to-be-stored-on-blockchain-by-2027-wef-report-49181ceada71>

18. Blockchain News, "Blockchain Records Will now be Accepted as Legal Evidence, China's Supreme Court Rules", September 10, 2018. <https://www.ccn.com/blockchain-records-will-now-be-accepted-as-legal-evidence-chinas-supreme-court-rules/>
19. Ey.com/mena "Is it time to industrialize blockchain – Unlocking the potential of blockchain across organisations.", 2018, [https://www.ey.com/Publication/vwLUAssets/Is-it-time-to-industrialize-blockchain/\\$File/Is-it-time-to-industrialize-blockchain.pdf](https://www.ey.com/Publication/vwLUAssets/Is-it-time-to-industrialize-blockchain/$File/Is-it-time-to-industrialize-blockchain.pdf)
20. IBM Blockchain Unleashed, "Network of networks: Enabling the blockchain economy", December 3, 2018. <https://www.ibm.com/blogs/blockchain/2018/12/network-of-networks-enabling-the-blockchain-economy/>
21. IBM Blockchain Unleashed. "Blockchain for KYC: Game-changing RegTech innovation" <https://www.ibm.com/blogs/blockchain/2018/09/blockchain-for-kyc-game-changing-regtech-innovation/>
22. Jason Deign, "The Startup Aiming to Wipe Out Blockchain's Carbon Footprint", gtm: July 5, 2018, <https://www.greentechmedia.com/articles/read/the-startup-aiming-to-wipe-out-blockchains-carbon-footprint#gs.nLgBPf8>
23. Prakash Santhana, Abhishek Biswas, "Blockchain risk management", Deloitte, UK, 2017, <file:///C:/Users/Paritosh%20Basu/Downloads/us-fsi-blockchain-risk-management.pdf>
24. Chris Curran, George Galindo, A Michael Smith and Manoj Kashyap, "Blockchain Validation Solution – Innovate with confidence", PwC, 2017, <https://www.pwc.com/us/blockchain-validation>
25. EY Global, "EY announces blockchain audit technology", April 24, 2018. https://www.ey.com/en_gl/news/2018/04/ey-announces-blockchain-audit-technology
26. Mark T. Mcaulay, Roger O'Donnell, Vinod Swaminathan, "Harnessing the Power of Cognitive Technology to Transform the Audit", KPMG LLP, USA, 2017. <https://assets.kpmg/content/dam/kpmg/us/pdf/2016/11/us-audit-cognitivereport.pdf>
27. Wolfie Zhao, "All Big Four Auditors to Trial Blockchain for Audit of Financial Reporting", coindesk.com, July 19, 2018. <https://www.coindesk.com/all-big-four-auditors-trial-blockchain-platform-for-financial-reporting>
28. Live Mint Newspaper, "10 Groundbreaking technologies that matter in 2019", December 28, 2018, <https://www.livemint.com/Technology/R18ffAWsmQEh1AKcZ7AxfK/10-groundbreaking-technologies-that-will-matter-in-2019.html>