The Disruptive Blockchain: Types, Platforms and Applications

Article by Mahendra Kumar Shrivas[1,] Dr. Thomas Yeboah[2]
[1]Research Scholar, School of Information Technology, Texila American University, Guyana, South America
[2]Head of Department, Department of ICT Christian Service University College, Kumasi, Ghana
E-mail: [1]mshrivas@texilaconnect.com [2]tyeboah@csuc.edu.gh

Abstract

Organizations with high motivation for growth and cost-effective operation efficiencies, are always trying to bring new technologies to their operations. These organizations are very sensitive to change and value driven thus constant change is the only law for them to achieve their goals and to be in the market. When Bitcoin jumps into the market, the whole world wanted to own it but now after Bitcoin and Cryptocurrency bubble, there are significant shift towards Blockchain related products, services, solution developments, researches and use-case studies. From technical-financial opportunist, to evangelist, to researchers, to Tech enterprises, to financial institutions, to governments, the whole world is behind Blockchain and now it has the technological spot light. Blockchain has left behind all other technologies as far as research initiatives, investments and financial funding are concern. There are substantial research growth on, how Blockchain can be useful in specific area? Objectives of this paper are to highlight some facts about Blockchain that were misinterpreted and misrepresented due to this sudden shift. In this research article, authors are presenting comprehensive literature review of Blockchain Technologies and its applications in various sectors. Our research supports that Blockchain is revolutionizing and disrupting organizations across all industries. Blockchain is really a next big technological invention after Internet. In Blockchain Code is the law and Smart Contracts are the new way of doing business.

Keywords: Blockchain, Permissioned, Permission less, Smart Contract, Bitcoin, Ethereum, Hyperledger Fabric, Corda R3, Quorum, IOTA, Ripple, Kadena, Tezos, Sawlooth, NEM, MultiChain, HydraChain, BigChainDB, OpenChain.

Introduction

Industrial revolution, computer revolution and power of internet have transformed various economies in the past and were main driving force of growth. Today we are in the next transition phase, new technologies like Cloud Computing, Big Data, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), Quantum Computing, etc. are going become de facto standard of next era of driving force of economic growth and Blockchain is going to be integral part of all technologies.

Blockchain was originally used in Bitcoin by a pseudonym called Satoshi Nakamoto in 2009, which is a digital cryptocurrency. Blockchain facilitates transfer of digital currency between parties without need of any central bank or intermediator in Bitcoin network (Shrivas & Yeboah, 2017; Nofer, Gomber, Hinz, & Schiereck, 2017; Tama, Kweka, Park, & Rhee, 2017). While Bitcoin is designed to store state of ownership of coins, Ethereum can be used to store state of ownership of any items in digital form using smart contracts (Dinh, et al., 2017).

Blockchain is just two-decade-old young disruptive technology and now getting popularity after success of Cryptocurrency. Most of the facts about Blockchain are either exaggerated, misinterpreted, little known or still unknown. The main objectives of this paper are to highlight some important phenomena about Blockchain that were misinterpreted and misrepresented. Exploratory research methodology is used in this comprehensive research study. The Standard Exploratory Method Type I, Exploratory method type 5 and 6 (Swedberg, 2018) were employed to explore various Blockchain related concepts. We tried to explore all

possible secondary sources to understand Blockchain related phenomena. We explored thousands of resources mainly research articles from Google Scholar, IEEE Explore, Whitepapers, Discussion forums, Websites, Blogs, Developer Documentations from Blockchain Projects, Project Codes from GitHub, etc. and presented it in this publishable research paper (Miscione, Ziolkowski, Zavolokina, & Schwabe, 2018). In the exploration phase we used all possible key combination like "Blockchain and Open Chain", "Blockchain and Project Funding", etc. in search query and choose most relevant and reliable source for the study.

This paper has been organized in various sections. Section II focuses on Blockchain and types while Blockchain Platform reference architecture and Blockchain platforms have been discussed in Section III. Section IV covers current and future status of financial infusion and Blockchain project initiatives while there is detailed discussion on applications of Blockchain in Section V. Conclusion is given in Section VI at the end.

Blockchain and types

A distributed ledger that holds collection of interlinked blocks along with block hash is called Blockchain (Shrivas & Yeboah, 2017). Blockchain is distributed registry, which records transactional data blocks initiated by participating notes in the Blockchain network. Block is basic unit in Blockchain, which is generally combinations of block header and block data as depicted in Figure 1. Block header generally holds information like current block hash, root hash, timestamp, nonce, previous block hash while block data portion contains total number of transaction, transaction details (sender address, value being transfer, receiver address, transaction fee, etc.) (Dinh, et al., 2017; Zheng Z. , Xie, Dai, Chen, & Wang, 2017; Fernàndez-València, Caube, & Vila, 2018). A cryptographic hash algorithm like SHA-256, SHA2-512, SHA-256d (Glabb, Imbert, Jullien, Tisserand, & Veyrat-Charvillon, 2007), SHA3-256 (Dworkin, 2015), SHAKE256, Winternitz hash (Buchmann, Dahmen, Ereth, Hülsing, & Rückert, 2011), BLAKE2 (Patent No. IETF RFC 7693, 2015), Keccak256 (Bertoni, Daemen, Peeters, & Assche, 2009), Scrypt (Patent No. No. RFC 7914, 2016), etc. is used to generate hash value of block that is stored in the block. Therefore, each blocks hold the value of either current block & previous block or only previous block hash (Tama, Kweka, Park, & Rhee, 2017). Each blocks are inter-linked in Blockchain generally by Merkle tree or acyclic directed graph, etc. and can be retrieved using underline protocol scheme. Figure 1 shows sample Block structure, while Figure 2 represent sample blocks in Blockchain, which is high level and general representation to understand Blockchain architecture. Hash values are unique for blocks thus it is very hard to change block data once it is recorded in the distributed Blockchain. Firstly, Blockchain is distributed, so if anyone wanted to change any one block, they have to alter the records everywhere and secondly they have to change all forward blocks because change in one block will generate a different hash causing different hash value for all foremost blocks, which require consent of all participating parties and required lots of computing power. This makes Blockchain transparent, temper proof, and ensure trust between parties. Third parties, intermediary or agents can be eliminated using Blockchain thus Blockchain just not ensure trust between parties but also help in lowering down the cost. Blockchain allows participants to query each transaction or transaction paths thus each transactions can be traceable from originating address/note to receiver address/node from tamperproof-distributed records.

Block Header					
Block Hash	**Tree Root Hash**	**Timestamp**	**Nonce**	**Previous Block Hash**	**Other Metadata**
Block Data					
Transaction Counter		**Total Block Value**		**Total Block TX Fee**	
Transaction(TX1)	Transaction(TX2)	Transaction(TX3)	Transaction(TX4)	Transaction(TX5)	Transaction(TXn)
Sender Address	Sender Address	Sender Address	Sender Address	Sender Address	Sender Address
Value	Value	Value	Value	Value	Value
TX1 Fee	TX2 Fee	TX3 Fee	TX4 Fee	TX5 Fee	TXn Fee
Receiver Address	Receiver Address	Receiver Address	Receiver Address	Receiver Address	Receiver Address

Figure-1. Sample Block Structure

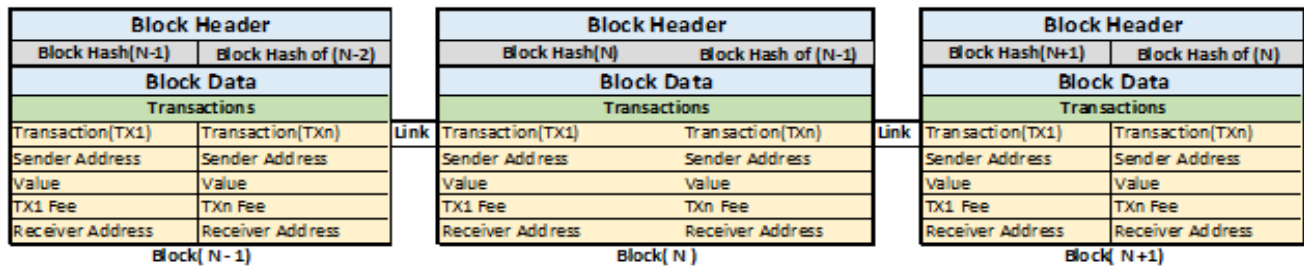| Block Header			Block Header			Block Header	
Block Hash(N-1)	Block Hash of (N-2)		Block Hash(N)	Block Hash of (N-1)		Block Hash(N+1)	Block Hash of (N)
Block Data			Block Data			Block Data	
Transactions			Transactions			Transactions	
Transaction(TX1)	Transaction(TXn)	Link	Transaction(TX1)	Transaction(TXn)	Link	Transaction(TX1)	Transaction(TXn)
Sender Address	Sender Address		Sender Address	Sender Address		Sender Address	Sender Address
Value	Value		Value	Value		Value	Value
TX1 Fee	TXn Fee		TX1 Fee	TXn Fee		TX1 Fee	TXn Fee
Receiver Address	Receiver Address		Receiver Address	Receiver Address		Receiver Address	Receiver Address
Block(N - 1)			Block(N)			Block(N +1)	

Figure-2. Sample Blocks in Blockchain

Blockchain types

Based on the nature of data accessibility (Lin & Liao, 2017) **Blockchain can be categories as below**

1. **Public Blockchain:** - In this type of Blockchain, anyone one can read and submit transaction.
2. **Private Blockchain: -** In this type of Blockchain only one organization or all subsidiary organization within same group are allowed to read and submit transaction.
3. **Community/Consortium Blockchain: -** In this type of Blockchain multiple group of organizations form a consortium and are allowed to submit transactions and read transactional data.
4. **Hybrid Blockchain: -** This is new category where any of three Public, Private or Community/Consortium, Blockchain can be combined to facilitate transactions. A Blockchain platform can be configured in multi-mode using Hybrid Blockchain.

Based on the need of authorization to participate in Blockchain it can be categories (Michael, Cohn, & Butcher, 2018) **as below**

1. **Permission less Blockchain: -** No prior permission is needed to participate in this type of Blockchain, everyone allowed to participate in verification process and can join Blockchain network with their own computational power.
2. **Permissioned Blockchain**: - To join this type of Blockchain prior permission is needed. Only authorized parties are allowed to run nodes to verify transactions in Blockchain network.
3. **Hybrid Blockchain: -** There could be possibility that a node is participating in Permission less and Permissioned Blockchain together to facilitate inter-Blockchain communication such Blockchain can be called Hybrid Blockchain. A Blockchain platform can also be configured to support Permissioned and/or Permission less model.

As far as core functionality and smart contract support in concern, Blockchain can be categories (Hileman & Rauchs, 2017) **into following: -**

1. **Stateless Blockchain: -** Stateless Blockchain system only focus on transaction optimization and chain functionality that is verifying the transaction by computing hashes. It is independent from smart contract logic layer thus unaffected from smart contract code bugs and vulnerabilities.
2. **Stateful Blockchain: -** This type of Blockchain provide smart contract logic optimization along with optimized transaction computing capabilities.

Blockchain platforms

Blockchain is emerging technology and reaching to maturity as adoption is growing. Bitcoin was the first Blockchain powered platform launched in 2009 and was designed to exchange digital cryptocurrency without any need of central authority. Bitcoin revolutionizes exchange of money by using distributed technology and cannot counterfeited due to strong cryptographic protocol and hash function. New coins can only be generated by mining process as a reward for solving computation hashes and verifying transactions (Zheng Z. , Xie, Dai, & Wang, 2016).

In last one decade there are various Blockchain platforms that are somehow similar to Blockchain platform but with added functionalities, have been developed. Blockchain platform is core of Blockchain network and provides key services to participating nodes. A typical Blockchain platform (Cloud Standards Customer Council, 2017) should have following modules as depicted in Figure 3:-

1. **Blockchain Runtime Environment: -** To be able to process Blockchain transactions and smart contracts Blockchain needed a secure hosting environment. Generally secure operating system, programming language, runtime libraries and supporting libraries reside in this layer.
2. **Cryptographic Services: -** This layer provides access to cryptographic algorithms like hash function, digital signature, etc.
3. **Smart Contract Module: -** Smart contract module is optional and only applicable to Stateful Blockchain. It encapsulates business logics that can be implemented using programming language like go, solidity, java, Rust, C++, etc.
4. **Blockchain Secondary Storage: -** Blockchain platform process high amount of transactions and needs highly secure, reliable and scalable storage solution to store block data in Blockchain distributed ledger. This layer provides permanent storage capabilities to platform. Generally Level DB, Rocks DB, H2 Database, Mongo DB is being used as storage along with other distributed data storage solutions to store ledger information.
5. **Blockchain Memory Store: -** This layer stores latest transactions in memory for faster data retrieval and to speed up the transaction execution. Merkle Tree, Trie, Acyclic Directed Graph, Associative Array, etc. are some of the data structures that are being used as a memory storage in various Blockchain platforms.
6. **Consensus Protocol Module: -** This module contains mechanism to achieve agreement between nodes about transaction validity and authenticity. Once majority of nodes are agree and consensus level is achieved then the given transaction is treated as valid and recorded in the distributed ledger. Proof of Service (Pow), Proof of Stake (PoS), Proof of Importance (PoI), Raft, Byzantine Fault Tolerance (BFT), etc. are some of the famous Blockchain Consensus Protocol in use.
7. **Blockchain Services Layer: -** Using this layer Blockchain platforms can be leverage with extra capabilities such as membership management, authorization and access management, event distribution and notification services, exposing platform services using Application Programing Interface (API), etc. However, some of the services like membership management, authorization, access management, etc. are mean only for Permissioned Blockchain and not applicable to Permission less Blockchain.
8. **Communication Protocol:** Blockchain Protocol implements standard rules that facilitates distributed peer-to-peer communication between participating nodes in Blockchain network. Bitcoin uses broadcasting over TCP connection (Bitcoin Community, 2018) and Hyperledger Fabric is powered by a gossip data dissemination protocol (Hyperledger, 2018) while Ethereum uses devp2p protocol (Ethereum Community, 2018).

Generally, users send transaction to a node in Blockchain network. The Node groups set of transactions into one block and then broadcast this Block to all nodes for processing. Nodes compute cryptographic hashes, process Blockchain transactions, and broadcast success result to all Nodes in Blockchain network. Based on Consensus and agreement block is added to distributed ledger and transaction is completed successfully. In case of Bitcoin and Ethereum the node that is successfully verified the transaction is rewarded and this process is called mining.

Table 1 shows most popular Blockchain Platforms and its categorization while Blockchain Platforms and its technical specifications have been pretested in Table 2.
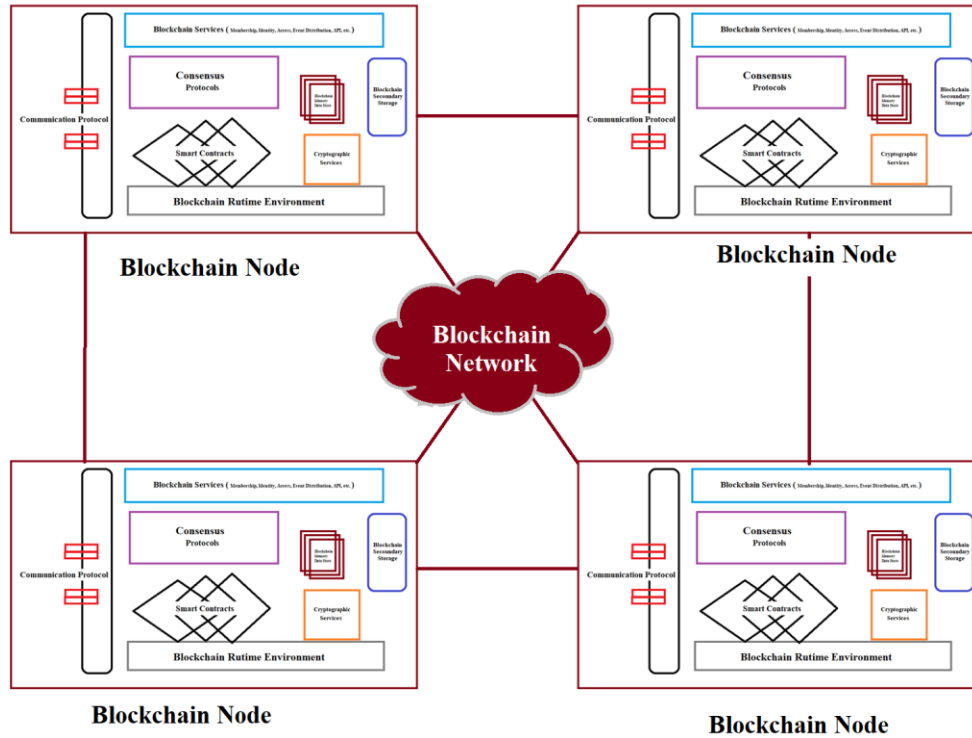
Figure 3. Sample high-level blockchain and network architecture

Table 1. Blockchain Platform and Categorization

S.N.	Blockchain Platform	Start Year	Category 1 (Private/Public/Consortium/Hybrid)	Category 2 (Permission less/Permissioned/Hybrid)	Category 3 (Stateless/Stateful)	Project Website
1	**Bitcoin**	2009	Public	Permission less	Stateless	https://bitcoincore.org https://bitcoin.org
2	**Ethereum**	2015	Public	Permission less	Stateful	https://ethereum.org/
3	**Hyperledger Fabric**	2016	Consortium	Permissioned	Stateful	https://www.hyperledger.org/
4	**Corda R3**	2015	Consortium	Permissioned	Stateful	https://www.corda.net/
5	**Quorum**	2016	Consortium	Permissioned	Stateful	https://www.jpmorgan.com/global/Quorum
6	**IOTA**	2015	Public	Permission less	Stateless	https://www.iota.org/
7	**Ripple**	2012	Consortium	Permissioned	Stateless	https://ripple.com/
8	**Kadena**	2016	Hybrid	Hybrid	Stateful	https://kadena.io
9	**Tezos**	2018	Public	Permissioned	Stateful	https://tzscan.io

10	**Sawlooth**	2016	Hybrid	Hybrid	Stateful	https://www.hyperledger.org/projects/sawtooth
11	**NEM**	2015	Hybrid	Hybrid	Stateless	https://nem.io/
12	**Multi Chain**	2015	Private	Permissioned	Stateless	https://www.multichain.com
13	**Hydra Chain**	2016	Hybrid	Hybrid	Stateful	https://github.com/HydraChain
14	**Big ChainDB**	2016	Hybrid	Hybrid	Stateless	https://www.bigchaindb.com
15	**Open Chain**	2015	Hybrid	Hybrid	Stateless	https://www.openchain.org/

Table 2. Blockchain platform and technical specification

S.No.	Blockchain Platform	Hash Function	In Memory Data Structure	Secondary Storage	Consensus Protocol	Programming Languages
1	**Bitcoin**	SHA-256	Merkle Tree	Level DB	Proof of Work	C++
2	**Ethereum**	Keccak256	Trie	Level DB, Rocks DB	Proof of Work (Ethash)	Go, C++, Rust, Solidity
3	**Hyperledger Fabric**	SHA3 SHAKE256	Bucket-tree, Merkle Tree	Rocks DB	Supports pluggable consensus like Practical Byzantine Fault Tolerance (PBFT), Raft, PoW, PoS	Go, JavaScript, Java
4	**Corda R3**	SHA-256	Merkle tree	H2 database	Validity consensus, Uniqueness consensus, pluggable consensus	Java, Kotlin
5	**Quorum**	Keccak256	Trie	Level DB	QuorumChain pluggable consensus (PoS, Raft, Istanbul - BFT)	Go
6	**IOTA**	Winternitz hash	Acyclic Directed Graph	Trytes, Balanced Trinary System	PoW	Go, C, C++, Java, JavaScript
7	**Ripple**	SHA2-512	Merkle Tree, Knowledge Grap	Rocks DB, NuDB	XRP Ledger Consensus Protocol	C++ , JavaScript
8	**Kadena**	BLAKE2	Merkle	Oracle	BFT Raft, ScalableBFT	Pact

9	**Tezos**	SHA-256,BLAKE 2	Merkle	Distributed Database	Proof-of-Stake	Michelson
10	**Sawlooth**	SHA-512,SHA256	BlockCache, Radix Merkle Tree	BlockStore	Pluggable consensus algorithms Proof of Elapsed Time (PoET), PoW, PBFT	Rust, Python, JavaScript, Go, C++, Java
11	**NEM**	SHA-256d	Web, Portable or Network database	Web Database, Access database	Proof of Importance	Java, C++
12	**Multi Chain**	SHA3-256	Merkle Tree	Level DB	PoW	C++
13	**Hydra Chain**	SHA3-256	Merkle tree	Level DB	PBFT	Python
14	**Big ChainDB**	SHA3-256	Associative Array	Mongo DB	BFT	Python, JavaScript, Java
15	**Open Chain**	SHA-256	Associative Array	SQLite, SqlServer, Mongo DB	Proof of Work	C#

Blockchain current and future status

Blockchain has left behind all other technologies as far as research initiatives, investments and financial funding are concern. Resource ready Cloud Computing platforms are also fueling adoption of Blockchain. Blockchain-as-a-Service (BaaS) is new service offering category after SaaS, PaaS and IaaS from various Cloud Computing providers (Hiran, Henten, Shrivas, & Doshi, 2018).

Blockchain is going to generate new business value of $176 billion by 2025, which will grow to $3.1 trillion by 2030 further (Lovelock, Reynolds, Granetto, & Kandaswamy, 2017). Value generation of Blockchain in 2030 is greater than individual Gross Domestic Product (GDP) of France (2.6 trillion), United Kingdom (2.6 trillion) and India (2.4 trillion) (statista.com, 2018) in 2017.

A. Financial infusion and project initiatives

As per PricewaterhouseCoopers (PwC) 2018 survey with 600 global executives 84% of executives were actively involved with Blockchain. As per the survey, various organizations reported their Blockchain based project status as 20% research stage, 32% development stage, 10% Pilot stage and 15% projects were live. In First five-month of 2018, various start-ups & market leaders raised $13.7 billion for Blockchain based products and services via Initial Coin Offerings (ICOs). Industry wide Blockchain leadership were reported as Financial services 46%, Industrial products and manufacturing 12%, Energy and utilities 12%, Healthcare 11%, Government 8%, Retail and consumer 4% while Entertainment and media 1% (PricewaterhouseCoopers (PwC) Ltd., 2018).

In another global survey on Blockchain in 2018 by Deloitte found Blockchain working use-case Supply chain 53%, Internet of Things 51%, Digital identity 50%, Digital records 44%, Digital currency 40%, Payments 30% and Voting 12%. Organizations from Canada (36%), China (49%), France (37%), Germany (36%), Mexico (48%), United Kingdom (40%) and United States (14%) reported that Blockchain is currently in production. While Organizations from Canada (51%), China (86%), France (44%), Germany (40%), Mexico (56%), United Kingdom (49%) and United States (24%) are investing in hiring staff with Blockchain experience now and in the future (Pawczuk, Massey, & Schatsky, 2018).

Figure 4 suggests that Various Venture capital firms have invested total $1,222 million in 558 companies. While they have funded total 295, Blockchain projects in last 12 months. As per Figure 4 New York (NY) gets highest amount of $268 million investment followed by Menlo Park (CA) $163 million, San Francisco (CA) $125 million and Beijing (China) $102 million and where top four city getting funding from Venture Capital firms respectively. Beijing (China) gets 48 highest number of funding for Blockchain projects followed by Palo Alto (CA) 44, New York (NY) 41 and Menlo Park (CA) 33 projects. While Venture Capitals firms have funded total 121 projects in New York, 83 projects in San Francisco, 63 projects in Menlo Park and 57 projects in Beijing.

Complete names of projects/organizations who have get funding from Venture capital firms have been given in Appendices A - Top 50 Venture Capital Firms Investing in Blockchain Project/Organization). While Figure 5 shows data of top 50 global public companies, their fortune. Public companies from various countries are aggressively working on Blockchain use cases. Top 50 global public companies with total $11,678.1 billion market valuation and $44,089 billion assets are generating yearly sales volume of $5,505.1 billion and making $661.2 billion profits yearly. All these top public companies are exploring Blockchain and pumping huge money in Blockchain related technologies. Public companies from China and United States are showstopper in this Blockchain play as depicted in Figure 5.
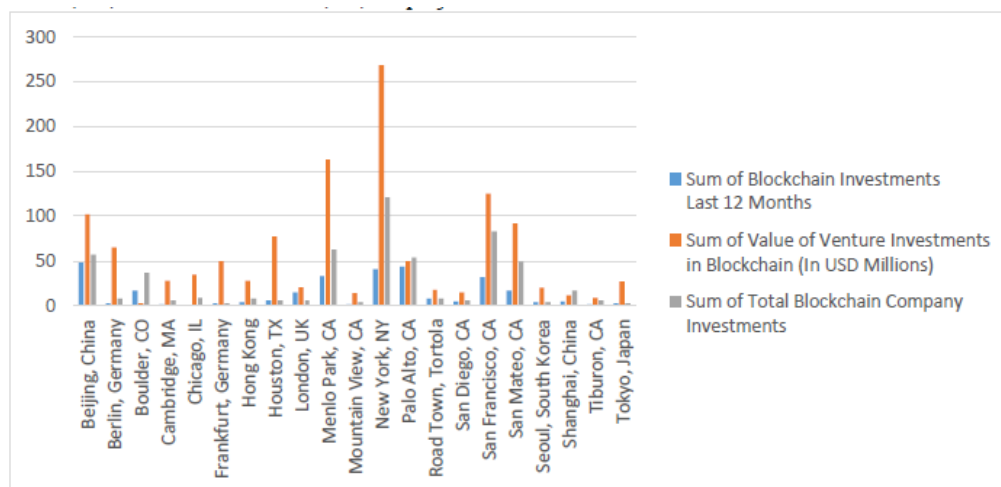

Figure 4. City wise Investment by Venture Capital Firm in Blockchain Projects (through 15 June 2018)
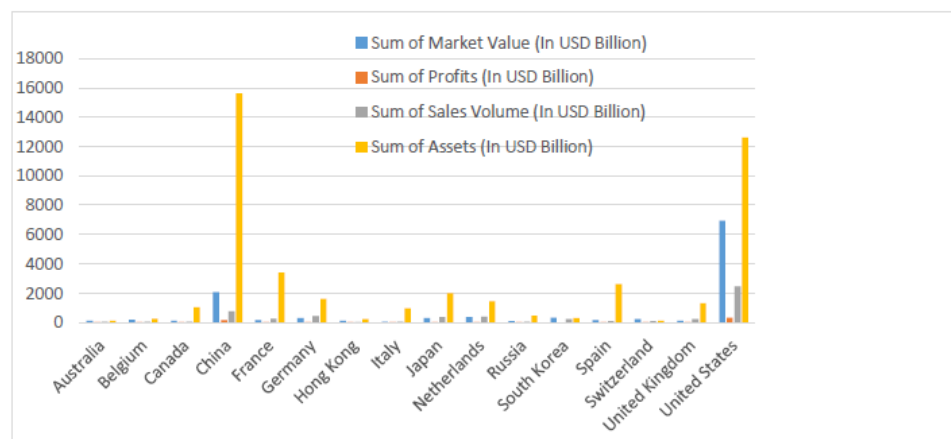

Figure 5. Country wise financial of Top 50 Global Public Companies investing in Blockchain

B. Human capital

Human capital is very important factors to sustain growth and achieve technological maturity specifically in Blockchain like young technology. As being the new and evolving technology, there are huge demand of skilled human resources in Blockchain sector. There is huge gap in supply and demand. China has evolved as global hub of Blockchain based investment while United States has largest number of Blockchain developer communities followed by India. Top five country wise total estimated Blockchain developers head count stood as 27,876(US), 12,509(India), 7,656(UK), 4,544(Canada) and 4,283(France) as depicted in Figure 6 (Filatov, 2018).

There is huge demand of Blockchain related skills in job market. As per Burning Glass Technologies in 2016, there were 1,838 job openings, that grew to 3,958 job opening, clocking 115% job growth (Bittle, 2017). As per Indeed.com Blockchain based job openings increased by 207% in 2016-2017. While demand for Blockchain engineers has grown up 700% from Jan-2017 to Jan-2018. Job openings grown-up from 1,037 jobs in December 2016 to 4,541 job opening in Dec. 2017 on LinkedIn (HowToToken Team, 2018). At the time of writing this article, there were total 13,831 active job openings Worldwide in LinkedIn while industry wise distribution of job opening were Information Technology and Services (9205), Computer Software (8566), Financial Services (4798), Internet (4047), Staffing and Recruiting (1659), Hospital & Health Care (163), Insurance (135), Computer Hardware (112), Investment Management (92), Fund-Raising (15). Job Function wise job openings were Information Technology (7875), Engineering (5236), Business Development (998), Marketing (911), Finance (672), Writing/Editing (321), Product Management (296), Human Resources (168), Administrative (114) and other (1547). While Location wise job openings recorded as United States (4042), United Kingdom (1417), London, United Kingdom (1042), Germany (933), Netherlands (761), Greater New York City Area (711), India (590), Amsterdam Area, Netherlands (318), Hong Kong (197) and Chennai Area, India (35). As per Figure 7 Malta is having highest 46 Blockchain developers per 100K Population followed by Luxembourg 36 developers, Singapore 36 developers, Switzerland 24 developers and Netherlands 19 developers respectively. Blockchain development is hottest skills and demands has grown more than 6000% within a year as far as Blockchain related Freelancing work is concern. In Free Launching job market specialist are making between $50 to $150 per hours based on their experience level while Blockchain full time developer earns between $50K and $180K yearly (Mearian, 2018). Apart from technical skills demand there are significant demand for Marketing Manager, Community Manager, Relations Manager, Product Manager, Risk Analyst, etc. (Walters, 2018).
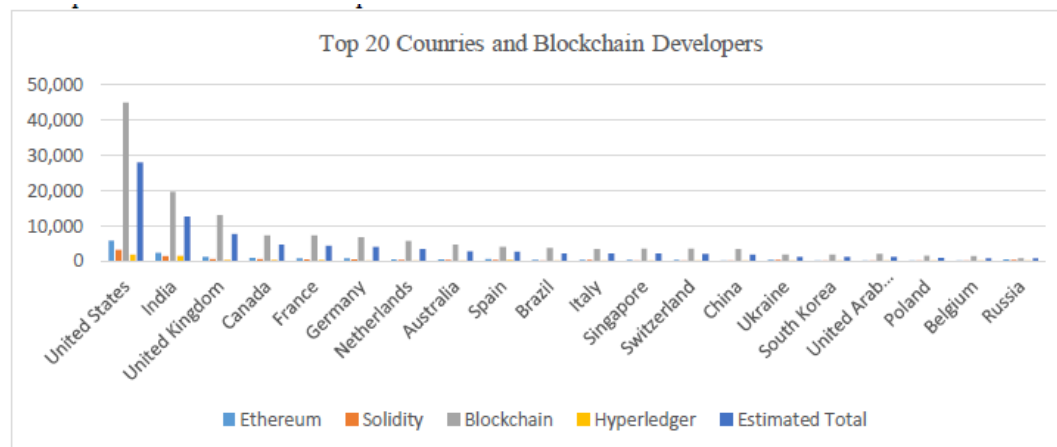

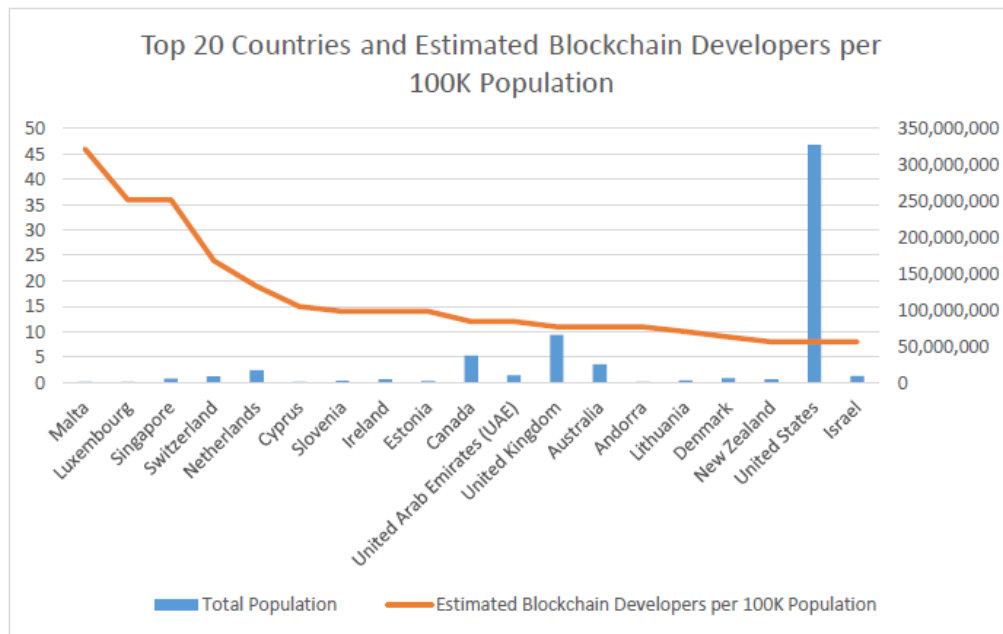**Figure 6.** Global blockchain developers counts (Top 20 Countries)

Figure 7. Estimated global blockchain developers per 100k population (Top 20 Countries)

C. Blockchain applications

Governments in Dubai, United States, Korea China and India are planning to launch public services using Blockchain to prevent fraud and better data management. Blockchain is disrupting all sectors and going to become most widely adopted technology of this era. It is having vast area of applications although some of the applications of Blockchain are listed below

1. **Land Registry:** The Swedish Lantmäteriet has successfully tested a Blockchain Platform for Land Registry with the help of SBAB, Telia Company, Landshypotek Bank, Kairos Future and ChromaWay. The Land Registry System (Figure 8) stores purchase/sale bills and contracts, signatures of parties, their identity documents and ownership information in Blockchain. Edition of records are allowed through administrative interface only but record all the transactions in Blockchain, which can be viewed by all stakeholders like buyers, sellers, agents, banks including public (Kempe, 2017). Ghana government and IBM have signed Memorandum of Understanding (MoU) to develop Blockchain based Platform (ghanaweb.com, 2018). An Indian state government, Andhra Pradesh has also piloted land registry and registered 100,000 land records in Blockchain (Haridas, 2018).

2. **International Trade:** World Trade Organization (TWO) is looking at various feasibility to bring International Trade in Blockchain (Ganne, 2018). In January 2018 Maersk and IBM come up together to develop Blockchain based solution to Digitize Supply Chains and Improve Global Trade (White, 2018) and in August, 2018 Maersk and IBM Introduce a robust Blockchain Platform called TradeLens with Shipping Solution 90 organizations participated in this solution and 154 million events captured. TradeLens is recording one million trade-based events on daily basis (IBM, 2018). Singapore and Hong Kong are jointly developing Global Trade Connectivity Network (GTCN) using Distributed Ledger Technology (DLT) (Hong Kong Monetary Authority (HKMA), 2017).

3. Customs: The World Customs Organization (WCO) has already initiated feasibility study to transform custom processes into Blockchain. They are exploring the option to join TradeLens platform jointly developed by IBM and Maersk including Global Trade Connectivity Network (GTCN) (Okazaki, 2018). U.S. Customs and Border Protection (CBP) agency is also testing Blockchain based shipment tracking system developed by the Department of Homeland Security (Partz, 2018). Samsung SDS is

developing a Blockchain based platform for an export and customs clearance system for The Korea Customs Service (KCS) (Das, 2018).
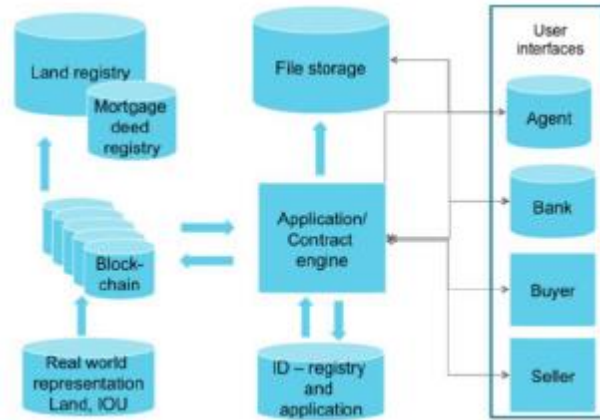

Figure 8. The swedish lantmäteriet land registry blockchain platform

As shown in Figure 9 Banking, Financial Service and Insurance are most disrupted sectors by Blockchain followed by Conglomerate and Automotive sectors, and are the consumers of Blockchain. While Technology sectors are Blockchain platform and service providers in general. We have listed top 50 global public companies in Table 3 who are exploring/adopting Blockchain in their businesses. Blockchain application use cases are also listed along with it.
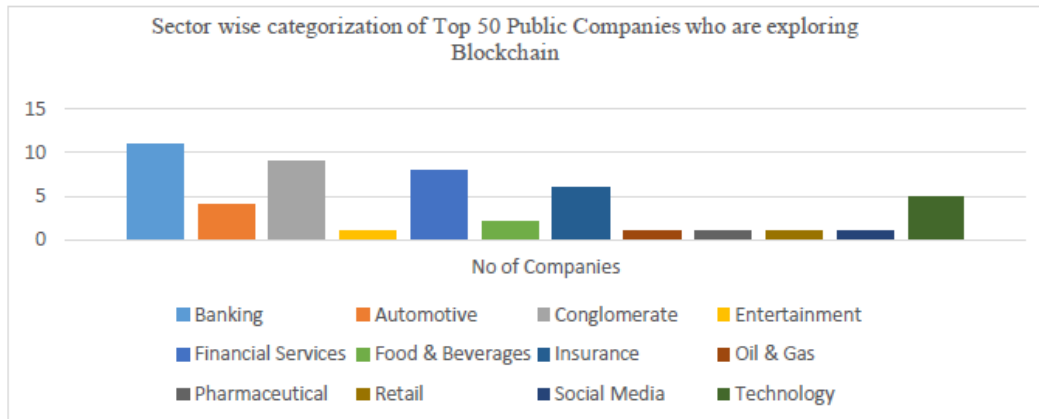

Figure 9. Sector wise categorization of top 50 public companies who are exploring blockchain

Table 3. Global Top 50 Public Companies[1] and their Blockchain Use Case Plan

S. No	Rank[2]	Public Company Name	Company Category	Country	Blockchain Application Use Case	Website
1	1	Industrial and Commercial Bank of China (ICBC)	Banking	China	Trying to verify digital certificates using Blockchain	http://www.icbc-ltd.com/icbcltd/en/
2	2	China Construction Bank	Banking	China	Using IBM Blockchain for financial products	http://www.ccb.com/en/home/indexv3.html
3	3	JPMorgan Chase	Financial Services	United States	Contributed to Quorum Project	https://www.jpmorganchase.com/
4	4	Berkshire Hathaway	Conglomerate	United States	Blockchain base supply chain	http://www.berkshirehathaway.com/
5	5	Agricultural Bank of China	Banking	China	Unsecured agricultural loans on Blockchain for e-commerce merchant	http://www.abchina.com/en/
6	6	Bank of America	Banking	United States	Trying to use Ethereum Blockchain to automate issue of letters of credit	https://www.bankofamerica.com/
7	7	Wells Fargo	Financial Services	United States	Member of R3 and trying to simplify tracking of securitized home mortgages.	https://www.wellsfargo.com/
8	8	Apple	Technology	United States	Registered a patent to timestamp data using Blockchain	https://www.apple.com/
9	9	Bank of China	Banking	China	Working with Tencent to develop financial solutions using Blockchain.	www.boc.cn/en/
10	10	Ping An Insurance Group	Insurance	China	Member of R3 and working with various insurance firm to develop Blockchain solution	http://www.pingan.cn/en/index.shtml

---

[1] Source:- Big Blockchain:: The 50 Largest Public Companies Exploring Blockchain(https://www.forbes.com/sites/michaeldelcastillo/2018/07/03/big-Blockchain-the-50-largest-public-companies-exploring-Blockchain/588939c92b5b) and Global 2000: The World's Largest Public Companies (https://www.forbes.com/global2000/list/)
[2] Rank is based on 16th annual Forbes Global 2000 list which include topmost public companies from 60 countries

11	11	Royal Dutch Shell	Oil & Gas	Netherlands	Funding Blockchain projects and working with BP to develop Energy Commodities Platform	https://www.shell.com/
12	12	Toyota Motor	Automotive	Japan	Founder member of Blockchain Mobility Consortium and developing Blockchain based payment system for self-driving cars	https://www.toyota-global.com/
13	14	Samsung	Conglomerate	South Korea	Own Nexledger platform to track global supply chains	https://www.samsung.com
14	19	BNP Paribas	Banking	France	Blockchain platform for internal treasury operations	https://group.bnpparibas/en/
15	20	Microsoft	Technology	United States	Offering Blockchain as a services on Azure Platform	https://www.microsoft.com
16	22	Allianz	Financial Services	Germany	Working on self-insurance Platform	https://www.allianz.com
17	23	Alphabet	Conglomerate	United States	Working on various Blockchain projects	https://abc.xyz/
18	24	Walmart	Retail	United States	Supply Chain on Hyperledger Fabric	https://www.walmart.com/
19	29	Daimler	Automotive	Germany	Corporate bond using Ethereum Blockchain	https://www.daimler.com/en/
20	31	Banco Santander	Banking	Spain	Funded to Ripple and Digital Asset Holdings and own a payment platform on Ripple	https://www.santander.com
21	33	AXA Group	Insurance	France	Own 'Fizzy' smart contract platform to execute flight insurance payments	https://www.axa.com/
22	34	Comcast	Conglomerate	United States	Indirectly investing in enterprise Blockchain startups.	https://www.xfinity.com/
23	41	Anheuser-Busch InBev	Food & Beverages	Belgium	Blockchain based logistics Platform	https://www.ab-inbev.com/
24	42	Royal Bank of Canada	Banking	Canada	Automating credit scores on Blockchain	www.rbcroyalbank.com
	44	Pfizer	Pharmaceutical	United States	Blockchain based supply chains solution	https://www.pfizer.com/
26	47	Sberbank	Banking	Russia	Blockchain lab, Blockchain solution for corporate bonds	https://www.sberbank.ru

27	48	Nestle	Food & Beverages	Switzerland	Working with IBM to develop Blockchain based supply chain solution	https://www.nestle.com/
28	49	Intel	Technology	United States	Part of Hyperledger consortium & Developing Hardware for Blockchain Platforms	https://www.intel.com
29	50	Morgan Stanley	Financial Services	United States	Clearing house for bitcoin futures contracts	https://www.morganstanley.com/
30	51	Siemens	Conglomerate	Germany	Blockchain for energy Sector	https://www.siemens.com
31	53	Amazon.com	Conglomerate	United States	Blockchain & Cloud integration, working with Ethereum startup ConsenSys for Blockchain solutions	https://www.amazon.com/
32	56	ING Group	Financial Services	Netherlands	User Identity	https://www.ing.com
33	60	Goldman Sachs Group	Financial Services	United States	Trading Platform	https://www.goldmansachs.com/
34	61	Intesa Sanpaolo	Banking	Italy	Using Public Bitcoin Blockchain to timestamp records and Ethereum Blockchain for derivatives	https://www.intesasanpaolo.com/
35	66	Prudential Financial	Insurance	United States	Financing Blockchain Companies	https://www.prudential.com
36	66	Prudential	Insurance	United Kingdom	Trade platform for SME	https://www.prudential.co.uk/
37	67	IBM	Technology	United States	Contributor to Hyperledger Fabric and have multiple Blockchain initiatives, Blockchain Technology Provider	https://www.ibm.com
38	67	Ford Motor	Automotive	United States	Blockchain research group for the auto industry Has a patent for controlling traffic flow	https://www.ford.com/
39	72	Walt Disney	Entertainment	United States	Developing various Blockchain solution and own Dragonchain platform	https://www.thewaltdisneycompany.com/
40	77	Facebook	Social Media	United States	Exploring Blockchain Use-Cases	https://newsroom.fb.com/company-info/
41	78	MetLife	Insurance	United States	Own Blockchain platform for Insurance	https://www.metlife.com/

42	81	Alibaba	Conglomerate	China	Food supply chain, Blockchain technology Provider	https://www.alibaba.com/
43	92	AIA Group	Insurance	Hong Kong	Developed Bancainsurance platform using Hyperledger Fabric and runs its own Blockchain accelerator	http://www.aia.com/en/index.html
44	105	Tencent Holdings	Conglomerate	China	Developing Blockchain for taxes	https://www.tencent.com/en-us/
45	107	Oracle	Technology	United States	Contributor to Hyperledger Fabric and Own Enterprise Blockchain Platform	https://www.oracle.com
46	108	BHP Billiton	Conglomerate	Australia	Blockchain for Supply chain	https://www.bhp.com/
47	112	Mitsubishi	Automotive	Japan	Using Ripple payments network and Planning to launch their own Blockchain Platform	https://www.mitsubishicars.com/
48	114	Mizuho Financial	Financial Services	Japan	Funding Blockchain projects	https://www.mizuho-fg.com
49	116	BBVA-Banco Bilbao Vizcaya	Banking	Spain	Developing platform for Corporate loan in Ethereum and Hyperledger Fabric.	https://www.bbva.com/en/
50	119	American Express	Financial Services	United States	Membership rewards using Blockchain	https://www.americanexpress.com/

Conclusion

This is certain that Blockchain is new technology and disrupting almost all sectors. Various organizations are pouring lots of money into Blockchain Platform development and transforming their businesses and operation by adopting Blockchain but the big question on hand is, why? Because these organizations knows that, there are various complexities and loopholes in their existing systems, which Blockchain is addressing. Data is stored in distributed ledger, secured using cryptographic functions and almost temper resistance. Blockchain promote trust and transparency between participating parties and elements need of third parties that is huge cost saving and operational plus point. Smart contracts are the digital agreements between parties and a new way of doing business while Code is the law in Blockchain and records in ledger are proof of an event.

References

[1]. Bertoni, G., Daemen, J., Peeters, M., & Assche, G. V. (2009). Keccak sponge function family main document. NlST. Retrieved 2018, from http://131002.net/data/papers/AK09.pdf

[2]. Bitcoin Community. (2018). Network. Retrieved from en.bitcoin.it: https://en.bitcoin.it/wiki/Network

[3]. Bittle, S. (2017, 10 30). Job Postings for Blockchain Skills Double Over 2016. Retrieved from burning-glass.com: https://www.burning-glass.com/blog/job-postings-blockchain-skills-double-2016/

[4]. Buchmann, J., Dahmen, E., Ereth, S., Hülsing, A., & Rückert, M. (2011). On the security of the Winternitz one-time signature scheme. International Conference on Cryptology in Africa (pp. 363-378). Berlin, Heidelberg: Springer.

[5]. Cloud Standards Customer Council. (2017). Cloud Customer Architecture for Blockchain. Object Managment Group (OMG).

[6]. Das, S. (2018, September 17). https://www.ccn.com/samsung-sds-to-power-worlds-first-exports-customs-clearance-blockchain-in-korea/. Retrieved from ccn.com: https://www.ccn.com/samsung-sds-to-power-worlds-first-exports-customs-clearance-blockchain-in-korea/

[7]. Dinh, T. T., Wang, J., Chen, G., Liu, R., Ooi, B. C., & Tan, K.-L. (2017). Blockbench: A framework for analyzing private blockchains. In Proceedings of the 2017 ACM International Conference on Management of Data, 1085-1100.

[8]. Dworkin, M. J. (2015). SHA-3 standard: Permutation-based hash and extendable-output functions. United States: NIST FIPS.

[9]. Ethereum Community. (2018). devp2p Application Protocol. Retrieved from github.com/ethereum/: https://github.com/ethereum/devp2p/blob/master/devp2p.md

[10]. Fernàndez-València, R., Caube, J., & Vila, A. (2018). Cryptography Working Group Introduction to Blockchain Technology. bigdatabcn.com, 1-18.

[11]. Filatov, T. (2018, 09 30). Blockchain developers worldwide stats (absolute vs relative to population). Retrieved from Analytics, Blockchain Developers: https://www.dappros.com/201809/blockchain-developers-worldwide-stats-absolute-vs-relative-to-population/

[12]. Ganne, E. (2018). Can Blockchain revolutionize international trade? World Trade Organization (WTO).

[13]. ghanaweb.com. (2018, July). Blockchain technology to revolutionise land administration processes. Retrieved from ghanaweb.com: https://www.ghanaweb.com/GhanaHomePage/business/Blockchain-technology-to-revolutionise-land-administration-processes-666920

[14]. Glabb, R., Imbert, L., Jullien, G., Tisserand, A., & Veyrat-Charvillon, N. (2007). Multi-mode operator for SHA-2 hash functions. Journal of Systems Architecture, 127-138.

[15]. Haridas, S. (2018). This Indian City Is Embracing BlockChain Technology -- Here's Why. Retrieved from forbes.com: https://www.forbes.com/sites/outofasia/2018/03/05/this-indian-city-is-embracing-blockchain-technology-heres-why/#437312dd8f56

[16]. Hileman, D. G., & Rauchs, M. (2017). Global Blockchain Benchmarking Study. Cambridge Centre for Alternative Finance. Cambridge, United Kingdom: SSRN Electronic Journal.

[17]. Hiran, K. K., Henten, A., Shrivas, M. K., & Doshi, R. (2018). Hybrid EduCloud Model in Higher Education: The case of Sub-Saharan Africa, Ethiopia. 2018 IEEE 7th International Conference on Adaptive Science & Technology (ICAST) (pp. 1-9). Accra, Ghana: IEEE.

[18]. Hong Kong Monetary Authority (HKMA). (2017, November 15). Hong Kong and Singapore launch a joint project on cross-border trade and trade finance platform. Retrieved from hkma.gov.hk: https://www.hkma.gov.hk/eng/key-information/press-releases/2017/20171115-6.shtml

[19]. HowToToken Team. (2018). Blockchain Developer Salaries – 2018 Report. Retrieved from howtotoken.com: https://howtotoken.com/career/blockchain-developer-salaries-2018-report/

[20]. Hyperledger. (2018). Gossip data dissemination protocol. Retrieved from hyperledger-fabric.readthedocs.io: https://hyperledger-fabric.readthedocs.io/en/release-1.3/gossip.html

[21]. IBM. (2018, August 9). Maersk and IBM Introduce TradeLens Blockchain Shipping Solution. Retrieved from newsroom.ibm.com: https://newsroom.ibm.com/2018-08-09-Maersk-and-IBM-Introduce-TradeLens-Blockchain-Shipping-Solution

[22]. Kempe, M. (2017). The Land Registry in the blockchain - testbed. Retrieved from chromaway.com: https://chromaway.com/papers/Blockchain_Landregistry_Report_2017.pdf

[23]. Lin, I.-C., & Liao, T.-C. (2017). A Survey of Blockchain Security Issues and Challenges. IJ Network Security, Vol. 19(Issue 5), 653-659.

[24]. Lovelock, J.-D., Reynolds, M., Granetto, B., & Kandaswamy, R. (2017). Forecast: Blockchain Business Value, Worldwide, 2017-2030. Stamford, USA: Gartner.

[25]. Mearian, L. (2018). Blockchain moves into top spot for hottest job skills. Retrieved from computerworld.com: https://www.computerworld.com/article/3235972/it-careers/blockchain-moves-into-top-spot-for-hottest-job-skills.html

[26]. Michael, J., Cohn, A., & Butcher, J. R. (2018). BlockChain technology. The Journal, 34-44.

[27]. Miscione, G., Ziolkowski, R., Zavolokina, L., & Schwabe, G. (2018). Tribal governance: The business of blockchain authentication. In Proceedings of the 51st Hawaii International Conference on System Sciences. Hawaii: SSRN.

[28]. Nofer, M., Gomber, P., Hinz, O., & Schiereck, D. (2017). Blockchain. Business & Information Systems Engineering, Vol. 50(Issue No.-3), 183-187.

[29]. Okazaki, Y. (2018). Unveiling the Potential of Blockchain for Customs. World Customs Organization.

[30]. Partz, H. (2018). US Customs and Border Protection to Test Blockchain Shipment Tracking System. Retrieved from cointelegraph.com: https://cointelegraph.com/news/us-customs-and-border-protection-to-test-blockchain-shipment-tracking-system

[31]. Pawczuk, L., Massey, R., & Schatsky, D. (2018). Deloitte's 2018 global blockchain survey. London, United Kingdom: Deloitte Consulting LLP.

[32]. Percival, C., & Josefsson, S. (2016). Patent No. No. RFC 7914.

[33]. PricewaterhouseCoopers (PwC) Ltd. (2018). PwC's Global Blockchain Survey 2018. Hong Kong: PricewaterhouseCoopers (PwC) Ltd.

[34]. Saarinen, M. J., & Aumasson, J.-P. (2015). Patent No. IETF RFC 7693. doi:DOI: 10.17487/RFC7693

[35]. Shrivas, M. K., & Yeboah, D. T. (2017). A Critical Review of Cryptocurrency Systems. TEXILA INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH, Vol. 4(Issue 2), 116-131. doi:DOI: 10.21522/TIJAR.2014.04.02.Art012

[36]. statista.com. (2018, 04). Gross domestic product (GDP) ranking by country 2017 (in billion U.S. dollars). Retrieved from statista.com: https://www.statista.com/statistics/268173/countries-with-the-largest-gross-domestic-product-gdp/

[37]. Swedberg, R. (2018). On the Uses of Exploratory Research and Exploratory. Retrieved from people.soc.cornell.edu/swedberg:
http://people.soc.cornell.edu/swedberg/On%20the%20Uses%20of%20Exploratory%20Research%20and%20Exploratory%20Studies%20in%20Social%20Science.pdf

[38]. Tama, B. A., Kweka, B. J., Park, Y., & Rhee, K.-H. (2017). A critical review of blockchain and its current applications. In Electrical Engineering and Computer Science (ICECOS), 2017 International Conference on, pp. 109-113.

[39]. Walters, S. (2018). Blockchain Salaries: How Much Do Blockchain Professionals Earn? Retrieved from bitcoinmarketjournal.com: https://www.bitcoinmarketjournal.com/blockchain-salary/

[40]. White, M. (2018, January 16). Digitizing Global Trade with Maersk and IBM. Retrieved from ibm.com: https://www.ibm.com/blogs/blockchain/2018/01/digitizing-global-trade-maersk-ibm/

[41]. Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017). An overview of blockchain technology: Architecture, consensus, and future trends. In Big Data (BigData Congress), 2017 IEEE International Congress on, 557-564.

[42]. Zheng, Z., Xie, S., Dai, H.-N., & Wang, H. (2016). Blockchain challenges and opportunities: A survey. International Journal of Web and Grid Services, 1-25.

Appendices

Table 4. Top 50 venture capital firms investing in blockchain project/organization

S. No.	Venture Capital Firms Name	Blockchain Investments, Last 12 Months	Value of Venture Investments in Blockchain (In millions)	Total Blockchain Company Investments	Top Blockchain Project/Organization funded	City	Website
1	Digital Currency Group	15	78	58	Basis, Ledger, Circle, Blockchain Inc.	New York, NY	http://dcg.co
2	Pantera Capital	13	65	31	Basis, Circle, Harbor, Dmarket	Menlo Park, CA	https://www.panteracapital.com
3	Blockchain Capital	12	71	37	Circle, Coinbase, Blockstream, Ripple	San Francisco, CA	http:/blockchain.capital
4	Andreessen Horowitz	9	55	14	Basis, Coinbase, DFINITY, Harbor	Menlo Park, CA	https://www.a16z.com
5	Node Capital	21	20	22	Trip.io, HuoBi, Delphy Foundation, Fengwo	Beijing, China	http://www.nodecap.com
6	Boost VC	11	67	32	BlockCypher, Tezos, Ledger, Coinbase	San Mateo, CA	https://www.boost.vc/
7	IDG Capital	4	31	8	Ripple, Circle, Mars Finance, imToken	New York, NY	http:/en.idgcapital.com

19

#	Name				Portfolio	Location	URL
8	Draper Associates	6	25	17	Coinbase, Ledger, Factom, CryptoMove	San Mateo, CA	http://www.draper.vc
9	Ceyuan Ventures	4	36	6	Basis, Mars Finance, Trip.io, OkCoin	Beijing, China	http://www.ceyuan.com/en/index.html
10	Lightspeed Venture Partners	3	24	6	Basis, Blockchain Inc., Saga Foundation, BTCC	Menlo Park, CA	http://lsvp.com
11	Techstars	17	3	37	Filament, Tok.tv, Storj Labs, Chainalysis	Boulder, CO	https://www.techstars.com
12	RRE Ventures	2	32	12	Paxos, Ripple, Abra, Gem	New York, NY	http://www.rre.com/
13	Union Square Ventures	3	28	9	Coinbase, CryptoKitties, Polychain Capital	New York, NY	https://www.usv.com/
14	General Catalyst	2	28	6	Circle, Bitwise, Bluzelle	Cambridge, MA	http://generalcatalyst.com
15	Liberty City Ventures	2	29	5	Paxos, Libra	New York, NY	https://www.libertycityventures.com/
16	500 Startups	4	5	16	Libra Credit Network, BlockCypher, Hijro, Stably Blockchain Lab	San Francisco, CA	https://500.co
17	DHVC (Danhua Capital)	19	20	21	Libra Credit Network, Hedera Hashgraph, Origin Protocol	Palo Alto, CA	http://www.danhuacap.com/
18	18 Kindred Ventures	5	15	6	Radar Relay, TruStory, dYdX, Rare Bits	San Diego, CA	https://kindredvc.com

#	Name				Portfolio	Location	Website
19	Sequoia Capital	5	12	8	Guanguan Coin, String Labs, Binance	Menlo Park, CA	www.sequoiacap.com
20	Future Perfect Ventures	2	15	11	Blockstream, Blockchain Inc.., Harbor, Abra	New York, NY	http://futureperfectventures.com
21	Fenbushi Capital	5	12	17	Symbiont, Gem, Stream Token, Ripio	Shanghai, China	http://fenbushi.vc
22	ZhenFund	7	11	10	Basis, LIno, Silot, BlockSeer	Beijing, China	http://www.zhenfund.com
23	First Round Capital	3	6	8	Abra, Rare Bits, Amino Payments, Gem	San Francisco, CA	http://firstround.com
24	Limitless Crypto Investments	6	77	6	Tezos, Power Ledger, 0x, Kadena LLC	Houston, TX	https://www.limitlesscryptos.com/
25	FBG Capital	14	30	14	Ripio, Origin Protocol, Eximchain, Lino	Beijing, China	https://www.fbg.capital/
26	Tally Capital	1	35	9	Blockstream, Civic, MaidSafe, Blockchain Capital	Chicago, IL	http://tallycapital.com/
27	GV (Google Ventures)	2	14	4	Basis, Blockchain Inc., Veem, Ripple	Mountain View, CA	https://www.gv.com/
28	Polychain Capital	8	40	8	Basis, DFINITY, MakerDAO, CoinList	San Francisco, CA	http://polychain.capital/
29	Earlybird Venture Capital	1	15	5	Traxpay, XAIN Group, BigChainDB	Berlin, Germany	https://earlybird.com
30	InBlockchain	8	18	8	Eximchain, Lino, ONO, Trip.io	Road Town, Tortola	http://inblockchain.com

31	Galaxy Asset Management	6	23	6	VideoCoin, WePowerNetwork, StormX, NuCypher	New York, NY	http://www.galaxyllc.com/
32	8 Decimal Capital	15	6	15	BluZelle, Libra Credit Network, 0x	Palo Alto, CA	https://www.8dcap.com
33	Mosaic Ventures	15	21	6	Blockstream, Blockchain Inc.	London, UK	http://www.mosaicventures.com/
34	Mandra Capital	1	24	4	PINTEC, OKCoin, Chronicled, Overnest Inc.	Hong Kong	http://www.mandracapital.com/
35	Camp One Ventures	2	2	6	Ripple, Augmate, Mobius	San Francisco, CA	http://www.camponeventures.com/
36	PreAngel	2	5	5	Origin Protocol, OkCoin, Sensay, LendChain	Beijing, China	http://www.preangelfund.cn
37	Abstract Ventures	2	9	6	Ripple, Harbor, Compound Labs, TruStory	Tiburon, CA	https://www.abstractvc.com
38	Foundation Capital	3	7	4	Basis, Origin Protocol, BlockCypher, OpenSea	Menlo Park, CA	https://foundationcapital.com
39	Right Side Capital Management	3	1	8	Airfox, Chroma, Elemetric, Hanzo	San Francisco, CA	http://rightsidecapital.com/
40	AME Cloud Ventures	1	12	6	Blockstream, Ripple, ShoCard, BlockCypher	Palo Alto, CA	https://www.amecloudventures.com/
41	1confirmation	7	10	7	Basis, Harbor, MakerDAO, OpenSea	Palo Alto, CA	http://www.1confirmation.com
42	Hashed	4	20	4	StormX, Origin Protocol,	Seoul, South Korea	https://www.hashed.com

					Bluezelle, SureRemit		
43	FinLab	3	50	3	Iconiq Lab, Vaultoro, Abra	Frankfurt, Germany	https://finlab.de/
44	Streamlined Ventures	2	2	5	BlockCypher, Chronicled, PiggyBank, PayStand	Palo Alto, CA	http://streamlinedventures.com
45	Greycroft	3	4	5	Sensay, BitPesa, The Block	New York, NY	https://www.greycroft.com
46	Tusk Ventures	2	26	3	Circle, Coinbase	New York, NY	http://tuskventures.com/
47	Catagonia	2	50	3	Envion, AppCoins, HydroMiner, Basis	Berlin, Germany	http://www.catagonia.com/
48	Compound	2	2	4	Compound Labs, NuCypher, Gem	New York, NY	https://compound.vc/
49	Arbor Ventures	3	4	4	Abra, Silot, Global ID	Hong Kong	http://www.arborventures.com/
50	JAFCO Japan	3	27	3	Nayuta, Tech Bureau, COMSA	Tokyo, Japan	http://www.jafco.co.jp