Table 2 Electronic voting systems based on blockchain around the world

Nation or Organization	System Name	Base Technology	Application
Abu Dhabi Securities Exchange (Stock Exchange)	–	–	Shareholder voting system
Australia Postal Service	–	Digital Assets Holdings	Digital voting of Victoria government
Denmark Liberal Alliance	Follow My Vote	Graphene Blockchain Framework	Ballot system for political party
Estonia	i-Voting	KSI	National voting system
London Stock Exchange(LSE)	–	Hyperledger	Shareholder voting system
Moscow government	–	Ethereum	Digital voting of Moscow government
Nasdaq	–	–	Shareholder voting system
Podemos (Spain)	Agora-Voting	Bitcoin	Ballot system for political party
Texas Libertarian Party	VoteWatcher (by Blockchain Technologies Corp)	Florincoin Blockchain	Ballot system for political party
Ukraine	E-vox	Ethereum	Voting system for various voting
Utah Republican party	Blockchain Apparatus	Smartmatic (private blockchain)	Ballot system for political party

Weak coercion, strong coercion, and absolute coercion

Here, however, a new problem arises. Because of the ways in which technology mediates individuals, individuals interact with each other in ways defined by technology. That is, new technology allows individuals to interact in an unprecedented manner, while also restricting them to interact within the limits of "the specific way that the technology allows." This implies that technology can be considered a coercive force that restricts individuals' activities.

Particularly in our era, the coercive force of technology should not be treated trivially. We are moving to an automated algorithm society[9] based on artificial intelligence coupled with big data already. Algorithms are composed of logic and control. An algorithm society is a society wherein the coercive force of algorithms is generalized in society as a whole. The software that implements the algorithm is not merely a collection of strings written in a software language, but an enforcing constraint that specifically limits how individuals behave and how they interact within these technologies. Therefore, Professor Lawrence Lessig formulated the proposition "Code is Law" or "Code as Law" to capture this idea.[10]

Blockchain is also an algorithm implemented by software. In particular, the Smart Contracts[11] feature, which is regarded as the greatest potential of the blockchain, makes it possible to set rules that define conditions for executing pre-defined contracts automatically.[12] In other words, because of the nature of the blockchain that prevents it from being hacked or faked, the code of Smart Contracts in blockchain has a coercive force. Blockchain makes it possible to build an "absolute law" that cannot be forged or violated.

Therefore, I distinguished three types of coercion: weak coercion, strong coercion, and absolute coercion. The coercion in the laws of the real world is a "weak coercion." It is a type of coercion that can be violated if you choose to violate it, such as ignoring the red light when crossing the road. The enforcement that is implemented in the

Table 3 Digital currency projects based on blockchain

Status	Nation	Status
In use	Barbados	Launched a blockchain-based version of the Barbadian dollar in 2016.
	Tunisia	Upgraded the e-dinar with blockchain based technology in 2016.
	Senegal	Launched a blockchain-based version of the eCFA(digital currency) in 2016. This currency will be used as the official currency of The Western African Economic and Monetary Union.
Pilot testing or considering	Canada	'Project Jasper' phase II was started at December 2016 and announces phase 3 of 'Project Jasper' DLT Trial in October, 2017.
	China	Completed a trial run of digital currency in January 2017.
	Denmark	Planning to Introduce E-Krone based on blockchain in February 2017.
	England	Approved the digital currency issued by fintech company in 2016.
	Estonia	Estcoin, a government backed cryptocurrency, announced in August 2017.
	France	Tested blockchain technology in October 2016.
	Germany	Tested blockchain technology in December 2016 with Hyperledger blockchain technology.
	India	Finished testing blockchain solutions for core banking processes in the country in May 2017.
	Japan	Japanese banks are planning to introduce a digital currency for the 2020 Tokyo Olympics.
	Netherland	Preparing an ambitious experiment aimed at discerning if an entire financial market can be built on a blockchain and testing a prototype "DNBcoin."
	Russia	Developing a national digital currency based on Ethereum in June 2017.
	Singapore	Completed the first phase of that pilot in March 2017 with the Private Ethereum Blockchain.
	South Africa	Planning to Introduce national digital currency based on blockchain in February 2017.
	Sweden	Considering the possibility of issuing blockchain based digital currency in November 2016(no update as of December, 2017).
	Ukraine	The central bank began working on a blockchain-based system in November 2016 to develop a "cashless economy" and expanded and reinforced the team in December, 2017

software code is a strong coercion because the law implemented in the software is difficult to violate. For example, in 2007, when the presidential election was held, Korea's No. 1 internet portal Naver, who was afraid of the conservative party, blocked the comment field of political news articles. Therefore, netizens in Korea were unable to comment at all on political news. They abruptly lost the space where they had expressed their political views or opinions so far. (I think everyone may have experienced similar situations where they could do or could not do something depending on the functions implemented in Internet services.)

Thus, individuals can only engage in activities that are allowed by the Internet services. Internet services are built by software, so we can say that software exerts "a strong coercive force" on individuals' activities. The law implemented on software is significantly stronger than the law written on paper.

The blockchain goes one step further and is an example of "absolute coercion." A blockchain cannot be tempered or forged, and therefore, the rules implemented on a blockchain cannot be changed. If we consider the code to be law, the blockchain allows the implementation of "absolute laws" that no one can violate. Blockchain can be the beginning of an entirely different phase in the history of laws. Furthermore, with this

feature, the blockchain makes it possible to ensure "absolute trust" in society. We should note that trust has never been guaranteed absolutely before blockchain technology emerged throughout human history.

In terms of social devices that ensure trust in society, we find three kinds of trust machines in history: the reputation system, the state including government and bureaucracy, and the blockchain technology.

Three types of trust machines in human history

I distinguish here the three trust machines, or social devices, of human history that allow people to believe in and act with each other.

The first trust machine is the reputation system. This system is invisible, but regardless is functional in our daily lives. Particularly in primitive tribal communities with a small population of a hundred or so, the role of the reputation system was significantly more important than anything else. We can say that the primitive tribal communities are the pure peer-to-peer societies where everyone can interact with face-to-face communication. Through anthropology and brain science research, Robin Dunbar presented the famous Dunbar's number, 150,[13] indicating the number of people who can know each other well and live together with close intimacy. This scale indicates the number on which a reputation system can effectively operate. The reputation system is now a part of our daily lives, particularly in our social network.

However, beyond this number, the reputation system does not work in ordinary lives, because there is no reputational information about others. Therefore, when the number of community members exceeds the Dunbar's number, 150, society needs another trust machine to ensure the trust of the extended community. This second machine in human history is the state composed of the government and the bureaucracy that has been introduced for this purpose. There are many arguments about the origin and role of the state and government, but I think that their ultimate role is to guarantee trust in our society. In fact, the state guarantees trust in society by taking complete responsibility for jurisdiction, security, diplomacy, and national defense. Historically, if the trust in society collapses, the dynasties or political powers that have operated or dominated the state or nation also collapse and become replaced with others. Therefore, the most fundamental role of the state and government is to ensure the trust of a large community that cannot be maintained by a reputation system alone. The bureaucracy can be said to be the execution tool of the state and government to ensure trust in society.

The third trust machine, blockchain technology is emerging now.[14] Blockchain technology ensures trust among anonymous individuals. Someone said that blockchain is the technology that creates the real peer-to-peer society. Interactions among people in the twenty-first century are more likely to be mediated by technology than face-to-face communication. So, peer-to-peer in twenty-first century means that the interactions of individuals are mediated not by other people, other companies, or other organizations but by technologies. Therefore, it is easy to understand if we translate the word "to" in "peer-to-peer" as "technology." In other words, it would be correct to interpret peer-to-peer as "person-technology-person," or as "technology-mediated human interaction." In the era of blockchain, we must reinterpret the meaning of "to" in "Peer to Peer" as "Trust technology." We can say that the era of blockchain is one where people (peer) connect and interact with each other using trust technology.

With the emergence of blockchain technology, the role of the state and the government that has functioned as a trust machine until now are bound to change and the mode of operation of bureaucracy will consequently change as well.

The nature of bureaucracy

The analyses of bureaucracy, so far, have focused on its moral and emotional aspects such as its inhuman characteristics or inefficiency. If you study bureaucracy only as an inhuman tool or in terms of efficiency, you will not be able to grasp why bureaucracy emerged in society. Additionally, you will also be unable to grasp how bureaucracy survived in human society for thousands of years despite the heavy and severe criticism it received. In addition, this view makes it impossible to see the essential role that bureaucracy plays in society, which also makes it impossible to see how its role will change in the future, especially in the era of blockchain.

I define the nature of bureaucracy as a social technology that works as an "information processing machine" for the community to which it belongs. In other words, bureaucracy is a social technology dedicated to the distribution and processing of information that is needed in a specific community. This is illustrated by the fact that the first bureaucrats recorded in history in the world were "scribes" in Sumer; scribes were people who recorded and managed various kinds of information on tablets. They made a lot of tablets with their early letters, which provide information of lending, debt, interest, and so on.[15] Why did they have to write down the lending, debt, interest? It was an effort to maintain the trust of society in the extended community. In a large community where a reputation system does not works as a trust machine, the society can not maintain trust unless someone is managing these information. Therefore, bureaucracy is not an organization for charity, cooperation, or innovation, but an "information processing machine" that processes all kinds of information according to predefined laws. The primary role of bureaucracy is to produce and circulate information forcibly within a large community.

There are close similarities between the blockchain and bureaucracy. Bureaucracy is very similar to the tasks performed by computer systems. First, both of them are defined by the rules and execute predetermined rules. The blockchain technology is, of course, a kind of computer system and works according to the predetermined rules. Therefore, it is theoretically not problematic to claim that the blockchain technology would replace the role of bureaucracy. Second, both of them work as society's information processing machines. Third, both of them work as trust machines. Therefore, I think that not only is it possible to replace bureaucracy with the blockchain system, but that it is unavoidable.

In addition, the blockchain technology make it possible to implements the "absolute law," so it can process information more efficiently and accurately than does the bureaucracy. In addition, Smart Contracts can automate the administrative process. New bureaucratic systems based on blockchain technology would be faster, more secure, more accurate, and more efficient than traditional bureaucracies. This is why it is inevitable that the current bureaucratic system based on human activities will be replaced by a new system based on blockchain. This is why so many projects are being driven by the governments of over 40 countries within a span of 2 years.

Blockchain technology can act as a precise technology that can replace the bureaucracy, because it can create, store, and process information with safety and non-falsification.

Furthermore, blockchain technology can handle existing governments' tasks significantly more faster and efficiently. I will call a government that uses blockchain technology as a key instrument in its work a "Blockchain Government." If this concept of a blockchain government is realized, our society will undergo revolutionary changes. Blockchain technology is a really innovative technology that can transform the very basis of our society.

Blockchain government

I suggest the principles for implementing a blockchain-based government system.

The first principle is the "Blockchain Statute law." Blockchain technology ensures "absolute coercion," thus enabling the creation of a law that cannot be violated. We can put this law on the blockchain and allow it to run automatically with Smart Contracts. We have already discussed how the code is law. It means that we should treat the rules written on the software as a level of law. The concept of Blockchain Statute law should now be introduced, since blockchain enables "absolute law" that cannot be tampered or violated. In addition, this is the only way to prevent society from falling into a catastrophe with unintended mistakes or bad intentions, particularly in the era of the Fourth Industrial Revolution[16] wherein we cohabit with living things everywhere.

The second principle is "transparent disclosure," or open source strategy. The scope of the disclosure here contains from the blockchain software code itself that constitutes the public infrastructure to the data contained in it. They must be disclosed to the maximum extent possible. The Government 2.0 guide, formulated by the Australian government,[17] already claims that all data, excluding the data having clear reasons for non-disclosure, should be disclosed. In addition, since the blockchain technology is a distributed ledger, it is suitable for disclosing and sharing information. There are two other reasons for claiming "Transparent disclosure." One reason why blockchain software should be disclosed is that it is necessary for everyone to be able to verify the laws embedded in the code. The other reason is that open source strategy is the best way to make software more secure and to encourage the development of an ecosystem.

The third principle is the implementation of "An automated process." This would allow us to build a significantly faster and more efficient government system. The automation of government administrative systems using Smart Contracts is already being conducted in several places. We do not need to be afraid of the automation of government administrative systems because it is possible to manage the laws implemented in the blockchain with the consent of all the community members. This leads to the following fourth principle.

The fourth principle is to build "A direct democratic governance system." Many projects have already been implemented to rebuild existing voting systems using blockchain technology worldwide, but we can think beyond the voting system we have known so far. The laws that are implemented in the blockchain can be determined and revised through a consensus process involving all community members. In other words, we can build a mechanism that allows to modify "the law" stored in the blockchain automatically through democratic voting and consent of all community members. Several blockchain projects that aim to overcome the shortcomings of Bitcoin or Ethereum blockchains are attempting to implement automated revision with the consensus of the participants of the blockchain network.[18] Although it is not easy to apply this

feature to the current administration system, we can apply this feature to the Blockchain government in the near future.

The fifth principle is building a Distributed Autonomous Government (DAG). If all of us, the entire community, participates and provides consent for government laws through a consensus process, and make it run on a blockchain automatically, we can create a government that is completely different from existing governments. It means that it is possible to construct a government system as a social operating infrastructure, as an information processing machine of the community that executes automatically and whose rules are decided with the consent of the whole community. Such a government can be termed DAG.

Conclusion

It can be said that the blockchain technology will be a great tool for social innovation not only for the enhancement of the effectiveness of government but for the innovation of society from the grassroot. But blockchain is not a fully developed technology but an emerging one. We need more time to harness the full potential of blockchain technology, and several tasks must be solved. Here, I suggest the tasks that need to be improved or supplemented in the future.

The first is to ensure the integrity of the program. We have experienced that there is a loophole in Ethereum's Smart Contracts with "The DAO" project.[19] Therefore, it is necessary to find a way to supplement the shortcomings of Smart Contracts. Several projects such as BOScoin, Tezos, Qtum, EOS and Cardano are aiming to find alternative ways to build a more secure and efficient Smart Contracts platform.

The second issue is to introduce a governance feature, a consensus mechanism involving all network participants, in order to modify and revise the blockchain algorithm itself. This function is introduced now in newly designed blockchains such as Tezos, BOScoin and Cardano. I think that these new concepts of Blockchains will form the third wave of blockchain technology.

The third issue is performance. Bitcoin processes transactions approximately four times per second, and Ethereum can only process transactions nine times per second at most. It is difficult to expand the usage of the blockchain technology without increasing the processing performance. Fortunately, many different algorithms have been developed now to improve the performance of blockchains significantly. Therefore, it is a matter of time before we can solve the performance issue.

The fourth is to make it possible to accommodate the private data in public blockchains, such as personal identity (sex, age, name, address and etc.), health record, private keys, or ownership of assets. Ordinarily, the data in public blockchains is made transparent to everyone; therefore, it is almost impossible to accommodate private data in it. However, if we plan to use blockchain technology widely including for identification, secret ballots, health record management or so, we need another technology, such as Zero knowledge proof, Multi-party computation, or Homomorphic Encryption algorithm, that can handle the secret and private data in the blockchain. Several projects, such as Zcash and Zcoin are currently attempting to develop this technology.

Finally, there may be an epistemological repulsion towards the idea of an automated system based on blockchains replacing our familiar public domains, such as bureaucracy. It is necessary for society to admit that these kinds of transformation are inevitable and to

conduct open discussions to reduce the fear and side effects of introducing new and revolutionary technologies.

Endnotes

[1]Walport 2015.

[2]Rizzo 2016.

[3]Higgins 2017.

[4]Jun 2017.

[5]Swan 2015.

[6]Nelson and Nelson 2002.

[7]Dougherty 2017.

[8]Nakamoto 2008.

[9]Kang 2014.

[10]Lessig 2000.

[11]Buterin 2014.

[12]Tapscott and Tapscott 2016.

[13]Dunbar 1993.

[14]Berkeley 2015.

[15]Robson 2000.

[16]To understand the features of Fourth Industrial Revolution, see Hang Sik Park (2017).

[17]Australian Government 2009.

[18]Bitcoin has not been able to improve performance for many years because the miners could not reach consensus on how to improve the algorithm. Ethereum also experienced same problem when The DAO accident happened. This resulted in the separation of Ethereum and Ethereum Classic. This allowed for two consensus blockchain algorithms: one for the data, and the other for the rules implemented in the blockchain. This mechanism is already being implemented in new blockchains like Tezos, BOScoin, Dfinity, Cardano, etc. See MyungSan Jun (2017).

[19]Siegel 2016.

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