

Blockchain as a Next Generation Government Information Infrastructure: A Review of Initiatives in D5 Countries

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Abstract Blockchain or distributed ledger technology; a distributed and open data infrastructure enabling secure transactions without centralised trust party on the Internet, is considered to have disruptive potentials comparable to that of the Internet. This technology innovation is driving major strategic and policy actions in several economies around the world and particularly in the Digital 5 (D5) countries which include United Kingdom, United States, Estonia, New Zealand and Israel. This chapter provides some background to the new technology and reviews flagship blockchain related initiatives in the D5 countries. It concludes with recommendations for policymakers on emerging governance topics that require investigation in order to realise the full potentials of blockchain innovation in public administration and the government domain.

Introduction

Blockchain could be described as a distributed information infrastructure or an open, distributed database on the internet (Ølnes 2008). Blockchain technology maintains continuous update of all transactions occurring across large fully distributed or peer-to-peer network, that are either private or public (Srisukvattananan 2016). The technology enables secure and private transactions among involved parties without the need for any intermediary to guarantee trust (Kosba et al. 2016).

The technology has triggered interest from all industry sectors due to its capability to store the history of every transaction sent and confirmed over the network, including information included as a part of those transactions (Kaye 2016). One of

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the motives for adopting this technology is that it affords transparent real-time transaction settlement and auto-executing so-called smart contracts with business logic encoded into the ledger (Wyman 2016). Another significant motive for the adoption of this innovation is its extended capabilities to provide significant impacts to different economics and social activities in the society (Taylor, 2016)

Blockchain according to findings can be used to address inefficiencies in current systems and increase the effectiveness of public service activities (Drucker 2016). It can also create a data network platform where citizens, private companies, and governments can access for the verification of information (Oscar 2016). The adoption of Blockchain in the public sector is expected to reduce the cost of operations particularly by eliminating fraud, error in payments, providing greater transparency of transactions between government, other agencies and citizens. It strengthens citizens data protection and encourages data sharing among entities (Taylor, 2016). In general, government entities can perform the following activities on the Blockchain¹: (1) verification of documents such as licenses, proofs of records, transactions, processes or events such as birth of a child, (2) movement of assets such as transferring money from one entity to another after some work conditions are met, (3) asset ownership registers such as land registries, property titles and other types of ownership of physical assets and (4) management of identities like e-identities for citizens and city residents.

Interestingly, while there is growing literature on Blockchain applications in the private sector, the literature on possible applications of this new generation information infrastructure in the government domain are few (Ølnes 2008). This chapter addresses this knowledge gap by examining some of the flagship Blockchain initiatives in leading five digital champion (so-called D5) countries including United Kingdom, United States, Estonia, New Zealand and Israel.

The rest of the chapter is organized as follows: section “**Background**” provides a brief background on Blockchain and Distributed Ledger technology. The approach for the study is presented in section “**The Digital 5 Countries as Innovators**” while the case studies selected from the D5 countries are laid out in section “**Cases**”. We provide some analysis of these initiatives in section “**Discussion**” and conclude in section “**Conclusion**”.

Background

The blockchain is a digital ledger and a “database that can be shared across a network of multiple sites, geographies or institutions” (Taylor 2016). It could also be described as a database of secure transaction ledgers only accessible to all parties involved in a distributed network. It has the capacity to record and save every transaction which occurs in the network and also create an irrevocable and auditable transaction history (Finextra 2016). Other authors consider the Blockchain as

¹ <http://observer.com/2016/09/why-the-Blockchain-is-perfect-for-government-services/>

consensus-based, tamper-proof data structure that delivers a shared public ledger open to all connected parties (Cappemini 2016).

The goal of the Blockchain innovation is to create trust, enhance transparency and eliminate unnecessary intermediate parties among involved parties in digital transactions (Wyman 2016). The technology supports basic payments (including micropayments), decentralised exchange, token earning, digital asset transfer, as well as smart contract issuance and execution (Froystad and Holm, 2016). Smart contracts are specific programs used by users of blockchains in order to decide whether a specific operation, say a given payment or transfer of digital asset should be permitted or not (Pilkington 2016).

According to (Froystad and Holm, 2016), there are different types of blockchains implementations available today since the first Blockchain developed based on the Bitcoin protocol. The Bitcoin protocol is what really enables secure transactions to be carried out on the Internet without the need for a trusted third-party or intermediary (Ølnes 2008). Other blockchain and distributed ledger implementations include Ethereum,² Gridcoin,³ and Ripple⁴ (Pilkington 2016).

According to (Wyman 2016), The *blockchain innovation* is built on the three complementary solutions namely encryption, mutual consensus verification, and smart contracts. The encryption component protects the sensitive data exchanged on the bitcoin network. The mutual consensus verification element is the network protocol which ensures the integrity of the bitcoin ledger or database by approval or denying changes made to the database after verifying that the overall state of distributed ledger remains accurate at all times without any interference from external or central governing authority. This element is central to preventing malicious manipulation and failures. The third component called the smart contracts provide the mechanism for automating governance of transactions among bitcoin users. Smart contracts are implemented as codes written in a special language and stored on the bitcoin ledger the same way data are stored (Wyman 2016).

From the perspective of authors of (Crawford et al. 2016), blockchain provides the users a more secure, decentralized transactions through common access to a ledger that has a secure audit trail. This enhances support for non-repudiation, governance, fraud prevention and reporting. From a technical standpoint, it allows users to recognize the opportunity to integrate an ecosystem of trusted third parties for the purpose of reducing the costs of their global platforms, advance customer and market reach and develop new propositions (Crawford et al. 2016).

Network security provided by Blockchain is also a benefit because of the use of cryptographic and decentralized protocols. This reduces the risk of a brute force hack or an accidental instance of two users generating the same private key (Kaye 2016).

While the blockchain innovation comes with many attractive benefits, there are however some drawbacks associated with it. These drawbacks have been highlighted by (Shrier et al. 2016) as follows: the platform is relatively complex and not

²<https://www.ethereum.org/>

³<http://www.gridcoin.us/>

⁴<https://ripple.com/>

user-friendly and transactions made on the blockchain are not reversible, so genuine errors cannot be corrected by any administrator.

The popularity of the blockchain technology is driven by a number of factors (ODI 2016) including: (1) The capabilities of the platform to store data that is very robust in nature and that cannot be tampered with; the highly distributed nature of Blockchain platform comprising of nodes managed by different parties making collusion to compromise the infrastructure difficult. Another driving factor of the Blockchain technology is the optimization of cost and time efficiency in both public and private sectors. For instance, it is now faster through this innovation to move funds between two different institutions and geographical zones without any interference of intermediaries (Probst et al. 2016).

Finally, the Blockchain technology has potential to impact any industry or product line that relies on the storage and verification of information or value. Blockchain technology's programmable aspects can also facilitate the development of independent governance systems, contracts and legal constructs (e.g., "smart contract") or the ability of interrelated devices to interact with and even pay each other in the "Internet of Things" (Kaye 2016).

The Digital 5 Countries as Innovators

We have chosen to review some past and ongoing Blockchain innovation in Digital countries due to the strong commitment that these countries have for undertaking digital transformations and serving as innovators and early adopters with respect to emerging technologies. The Digital 5 or D5 is a networking group of leading digital government countries with the objective of strengthening the digital economy. There is a promise among the members to be open while they aim at how to transform government's relationship with technology through the espousal of open standards and open source software and also increasing the effectiveness of digital government. Furthermore, these countries are also working towards encouraging digital skills in-house and also short-term contracts with small and medium business suppliers (Wikipedia 2016).

This network group was founded on the 9 December 2014. The founding members of the group are Estonia, Israel, New Zealand, South Korea and the United Kingdom. These countries possess mutual agreement to create this network group and develop a platform where best practice will be shared and also collaborate on common projects that will provide support in growing digital economies. Some of the goals of the D5 countries according to (Palo et al. 2015) are:

- *User needs* – provide citizen-centric public services taking into consideration specific needs of different segments of the citizenry.
- *Open standards* – employ technologies that are interoperability and show a clear commitment to a credible royalty free open standards policy.
- *Open source* – ensure that future government systems, tradecraft, manuals, and standards are created as open resources and shareable among members.

- *Open markets* – ensure true competition for companies regardless of size in government procurements, promote and support start-up culture as well as economic growth through open markets.
- *Open government (transparency)* – be a member of the Open Government Partnership and use open licences to produce and consume open data.
- *Connectivity* – develop an online population through comprehensive and high-quality digital infrastructure.
- *Teach children to code* – show commitment to offer children the opportunity to learn to code and acquire next generation skills.
- *Assisted digital services*– show commitment to supporting all its citizens to access digital services.
- *Commitment to share and learn* – commit to work together to help solve each other’s issues wherever they can.

Our study examined public sector innovation activities of these countries related to the use of blockchains through exploratory desktop research. Information was consolidated from scholarly and online articles and news on Blockchain technologies. We outline the identified initiatives in section “[Discussion](#)” and discuss them in section “[Conclusion](#)”.

Cases

In this section, we describe some of the major innovations in D5 countries in which the blockchain technology has exploited for improving the delivery of public services. In all 13 initiatives are described across the five countries with a summary of the initiatives presented in [Table 1](#). Information on these cases were collected and analysed largely between May and December 2016.

Estonia Estonia is one of the countries with very high E-Government Development Index. Specifically, it ranks in the 13th position globally based on the 2016 UN Global E-Government Index (United Nations Department of Economic and Social Affairs [2016](#)). It also ranks as one of the most innovative countries in the world; ranking at 24th position out of the 128 countries surveyed in the 2017 edition of the Global Innovation Index report (Cornell University, INSEAD, and WIPO [2016](#)). Since 2014, the topic of Blockchain innovation has gained significant popularity among private and public institutions in Estonia. Several prototypes and concepts involving Blockchain technology have been announced by the government of Estonia. Three notable cases of these innovations involving management of access to health records, provision of notary services to e-residents and authentication of shareholders for e-voting in meetings are briefly described below.

- *Migration of government data to Blockchain* (Oscar [2016](#)): The initiative aimed at securing access to over 1 million public health records to eliminate unauthorised access to the records without the need of a centralised trust party in or outside government. The initiative relies on the technology developed by Guardtime;

Table 1 Summary of blockchain related initiatives across D5 countries

No.	Initiative	Participants	Goal	Strategy	Other stakeholders	Sector
1	Migration of government data to Blockchain – <i>Estonia</i>	Estonian e-Health Authority, Information System Authority & Guardtime (SME)	Solution for securing access and integrity of public health records using Blockchain technology	Integration of guardtime's keyless signature infrastructure into Oracle database engine of the health sector	Citizens, third-party private companies that require access to health records	Health sector
2	Public notary to e-residents (<i>Estonia</i>)	e-Residency Programme, Bitnation	Giving citizen the right to exercise notary act regardless of their geographical location and set up businesses in <i>Estonia</i>	Leveraging Bitnation digital nation platform and providing public key infrastructure card (PKI) to both residents and non-residents to access services	Government agencies and private sector organizations (e.g. banks) interested in making services available to e-residents	Economy
3	e-Voting Scheme (<i>Estonia</i>)	Tallinn Stock Exchange, Nasdaq, e-Residency Programme	Giving the <i>Estonia</i> citizens that are shareholders in firms listed on Tallinn Stock Exchange the opportunity to vote securely online in shareholders meetings	Using the <i>Estonia</i> e-residency platform to authenticate e-resident shareholders in shareholders meetings	US stock market, shareholders, <i>Estonia</i> e-residents and <i>Estonia</i> citizens	Economy
4	Joint research with Commonwealth Bank of <i>Australia</i> (<i>Israel</i>)	<i>Israel</i> ministry of economy, Commonwealth Bank of <i>Australia</i>	Exporting blockchain expertise to other countries (<i>Australia</i>) and establish the country as the knowledge hub for blockchain.	Provision of research grants to attract researchers in the areas of disruptive technology including Blockchain	Other global firms like Microsoft, General Electric, Procter and Gamble.	Finance

5	The Israeli Blockchain Ecosystem (Israel)	Blockchain start-ups, Deloitte	Develop a critical mass of the Blockchain start-up and attract investors to create a strong and viable blockchain ecosystem	Foster collaboration among global consulting firms, other private sector organizations and Blockchain start-ups	Start-up firms, potential investors	Economy
6	Improving the agriculture sector through Blockchain (New Zealand)	Food Agility, Ministry of Agriculture and Forestry	To acquire knowledge on how Blockchain can be used to improve Agricultural sector	Funding long-term research initiatives to identify how Blockchain technology can be used to provide high-value products with solid provenance	Farmers and citizens	Agriculture
7	Energy and the Blockchain in New Zealand	P2 power	Providing a platform for the sale, purchase and distribution of energy via Blockchain platform	Using Blockchain technology to deliver a peer-to-peer grid of green energy.	Citizens, Energy Providers	Energy
8	Blockchain for Local Community Voting (South Korea)	Gyeonggi-do, Blocko	Enable direct participation of community residents in determining community initiatives to fund	Leveraging Blocko's blockchain based voting system to supporting both online and offline voting.	Community residents	Governance

(continued)

Table 1 (continued)

No.	Initiative	Participants	Goal	Strategy	Other stakeholders	Sector
9	Blockchain-based financial innovation (South Korea)	Investment banks	Enable innovation in the financial technology arena through blockchain technology.	Government facilitating the use of blockchain for managing asset ownership and settlement in the financial technology sector	Blockchain start-ups, Citizens, Businesses	Finance
10	Distributed ledger gross settlement system (UK)	Bank of England	Replacement of its aging real-time gross settlement (RTGS)	Use of Blockchain to revamp the RTGS	Bank of England, Financial Institutions	Finance
11	Blockchain for benefit payment (UK)	Department of Work and Pensions, Barclays, Npower, University College London, GovCoin	Improve welfare payment system and track payments made to claimants	Creation of a mobile app and a Blockchain that records payments sent and received by claimants	Claimants, Citizen	Welfare and Social Security
12	Monitoring research grants (UK)	Paymaster general office, government,	Solving the monitoring complexity of research grants	Use of Blockchain to manage the distribution of grants given to researchers	Researchers	Education
13	Blockchain-as-a-Service for the Public Sector (UK)	Credits	Making Blockchain services available to public agencies	Allowing credits Blockchain-as-a-service platform to be accessible through the Digital Marketplace to reduce the barrier to access.	Government agencies	Public service

a Blockchain start-up. The solution is based on Guardtime's *Keyless signatures* technology which can establish the integrity of any data without the use and exchange of the traditional private and public keys. The *keyless signature infrastructure* (KSI) Blockchain will be integrated with the e-Health Authority health (Oracle) database for "real-time visibility" into the state of patient records. This initiative is expected to significantly improve the process used in recording and updating health records in terms of efficiency (including cost) and effectiveness. The use of Blockchain technology will provide the creation of a secured and trusted care records into electronic chains of events while preserving the provenance and integrity of those health records. The solution will also enable strong identity proofing by preserving immutable records of the declared identities of both patients and healthcare professionals. Equally important, the initiative will empower patients through the recording of consent decisions and patient directives within the secured healthcare record.

- *Public notary to e-residents* (Ian 2015): In late 2014, Estonia made history by becoming the first country to offer electronic residency to people located both in and outside the country. This was regarded by the Estonian government as a step towards "the idea of a country without borders. It is essentially a transnational digital identity, available to anyone in the world interested in operating a location-independent business online. The project was developed in partnership with Bitnation; a distributed governance and blockchain-based virtual nation project. The platform has been used for providing emergency identity and registry services. The platform enables Estonia to provide its residents a public key infrastructure (PKI) card, which grants access to over 1000 electronic government services. Non-residents are also able to apply for a PKI card, which is issued by the state. The card comes with a four digit pin number, which authorises digital signatures for online documents, which is considered legally binding throughout the EU. This initiative provides some validation for Bitnation is an open source protocol and sovereign entity. With applications over 9,200 from over 127 countries, about 291 companies have been opened through the e-residency programme as at February 2016 (Kalev 2016). This initiative involves several government agencies and private organizations willing to make their services available to e-residents through the Bitnation's platform.
- *E-voting for E-Resident Shareholders* (Kalev 2016): the US stock-market firm Nasdaq in collaboration with the Estonian e-residency programme aims to provide e-Residents and Estonian citizens who are shareholders in firms listed on the Tallinn Stock Exchange an opportunity to vote securely online in shareholder meetings. The Estonia's e-residency platform will be used to authenticate e-resident shareholders while the Nasdaq's Blockchain technology will be employed to record votes securely. The agility and size of Estonia coupled with its robust Information Society created the favourable environment for the Nasdaq-Estonian Government collaboration in piloting the e-voting programme.

Israel Israel currently ranks in the 20th position in the UN E-Government Development Index (United Nations Department of Economic and Social Affairs 2016) and 21st in the global innovation index (Cornell University, INSEAD, and WIPO 2016). It is a country that is driven by a strong defence industry, technological military units, and world-class academic institutions. Israel is also developing a reputation as a hub for innovation and technology. The country's unique experience in Fintech, cybersecurity and cryptography makes it a hotspot for Blockchain innovation. Notable examples of Blockchain-based initiatives in public sector in Israel include:

- *Israel joint research with Commonwealth Bank of Australia* (Marine and Chloé Gueguen 2016): Israel is currently working jointly with Australia to achieve a goal of making Australia as a leading hub in Asia pioneering global initiatives in Blockchain, cybersecurity, international settlement and big data. To make this goal a reality, Commonwealth Bank of Australia (CBA) has signed an agreement with the Israel government to access Blockchain related technology and innovation developed by Israel's flourishing start-up ecosystem. The initiative will also benefit from the support of global firms such as Microsoft, General Electric, and Procter & Gamble are the sources in the area of funding. However, the bank, other firms and the Ministry will provide research grants in the areas disruptive technologies in Blockchain and related areas of Internet of Things and Big Data Analytics.
- *The Israel Blockchain Ecosystem* (Amit 2016): In addition to enabling Blockchain-based innovation in other countries, Israel has successfully built an ecosystem of Blockchain. At least eleven Blockchain start-up firms are already in operations in the country. The thrust here is to employ Blockchain as an information infrastructure for digital, chronologically updated, distributed and cryptographically record of data. By digital, we understand that almost all types of information can be expressed in digital format and referenced later through a ledger entry. The chronological order enables verification and authentication through permanent time stamping. These start-ups are employing blockchain technology to secure online purchases, protect digital rights to songs, enable the conversion of cryptocurrencies to bills at ATM, send cryptocurrencies as messages, operate decentralised organizations, buying bitcoin over credit card transactions. These technology companies are collaborating with global technology consulting firms like Deloitte and banks in and outside Israel to realise these innovations.

New Zealand The country ranks 8th in the E-Government Development Index and 17th in the Global Innovation Index. Over 40 top financial institutions and a growing number of businesses are experimenting with Blockchains in the country as a way of doing business. A few of the Blockchain-based government initiatives that are also under development include:

- *Improving the agricultural sector through Blockchain* (Corner 2016): The Government of New Zealand aims to attract leading entrepreneurial researchers to the country to increase knowledge in the key areas that can contribute to the economic and environmental needs of the country. One of the strategies of the government is to build capabilities which will enable the country to stay at the forefront as the digital revolutions by leveraging emerging technology such as the Blockchain. This technology is specifically targeted at the agriculture sector to provide food products with solid provenance. This will enable consumers to determine where a food item is produced, its freshness, safety and quality.
- *Energy and the Blockchain technology in New Zealand* (Phillippa 2016): A private energy firm (P2 power) is working with the government to provide a platform for the sales, purchase, and distribution of energy via Blockchain innovation. In April 2016, the firm launched a platform which enables the production of up to green energy delivered from a peer-to-peer grid. It is estimated that consumers will save about 4c per kWh buying from the peer-to-peer network. Currently, it takes 30 min to scan the networks for excess power generated by those who are part of it and when that is unavailable, energy will be provided by local power stations. The planned migration to the 'Ethereum' blockchain is expected to deliver a better experience in terms of speed for the peer-to-peer matching.

South Korea The country is well known for its global leadership in the area of technological innovation. It currently ranks 3rd in the E-Government Development Index and 11th on the Global Innovation Index. South Korea has in the past few years been actively involved in the development of Blockchain technologies. On 28 February 2015, the government opened its doors becoming a common ground for Korean Blockchain enthusiasts. Among the government initiatives in this space is the organization of weekly bitcoin trading programming classes. The government is also supporting the hosting of the bitcoin start-up competition where five companies participated. Two notable blockchain initiatives in the country are:

- *Using Blockchain for Local Community Voting* (Keirns 2017): In collaboration with Blocko, the provincial government of Gyeonggi-do employed a voting solution for community funding. Specifically, the blockchain- and smart contract-based voting platform enables members of the community and local residents to propose and vote on community aid initiatives. Over 9,000 votes were submitted by residents through online and offline channels resulting in the selection of 527 projects by the provincial government. The blockchain-based solution according to provincial government allowed the possibility of complementing traditional representative democracy with direct democracy. The collaborator in this initiative; Blocko, is a blockchain research and services start-up in Korea and the developer of the CoinStack platform.
- *Blockchain-based financial innovation* (Buntinx 2016): the South Korean Government is looking to provide venture capital opportunities to SMEs involved in blockchain related innovation. The strategy employed by the government is to

invest in financial technology and an ICT-based start-up that can develop creative ideas on innovation and change project based on the Blockchain technology. The government and its partners have identified Blockchain innovation as a tool that can be used for asset ownership and settlement management. The government also believes that Blockchain will pave the way for new technologies and solutions in the Fintech industry.

United Kingdom The country ranks in 1st position in the 2016 E-Government Development Index and the 3rd place in the 2016 Global Innovation Index. UK Government through its Office of Science published a report on Distributed Ledger Technology: Beyond blockchain (Taylor 2016). The report expressed the transformational potential of distributed ledger and also advanced a number of technology, governance, security and privacy, and trust and interoperability related recommendations. Furthermore, the UK government believes that it stands in a good position to leverage the benefits and address the challenges related to the use of distributed ledgers in the public service and economy because of the digital capability, innovative financial services, the effective research community and growing private service. Some of the ongoing blockchain based initiatives in the UK include:

- *Distributed ledger based Gross Settlement System* (Peter 2016): the Bank of England is currently working on replacing its current real-time gross settlement (RTGS) system to be ready for future demands. Specifically, the future system must address the following strategic RTGS requirements: (1) capability of responding to the changing structure of the financial system; (2) recognising that payment system users want simpler and more resilient pathways for their payments; (3) capability of interfacing with a range of new technologies being used in the private sector, including distributed ledgers, if/when they achieve critical mass; (4) to remain highly resilient to the increasingly diverse range of threats to continuity of service, and (5) develop capacity to support the future evolution of regulatory and monetary policy tools. From the bank point of view, the new system will change a lot of features between the existing system which was built in 1996 and its successor. Some of these changes will include and enhanced security, which could be provided through the use of distributed ledger/blockchain solutions.
- *Blockchain for benefit payment* (Lynsey 2016): the government is currently test-running a blockchain based social welfare payment mobile app. Claimants in receipt of this payment are advised to download the app on their phones which will enable them to receive and spend their benefit payments. With their consent, their transactions are being recorded on a distributed ledger to support their financial management. This initiative focuses on adding an additional layer of richer data and identity onto payments so that a deeper and more effective relationship can be established between the government and claimants. The aim of this project is to identify the possibility for welfare payment to citizens to be sent through a secure app and also to see if people reliant on welfare payments would benefit from this approach. This new system consists of a mobile app and a Blockchain system that records payments sent

and received by beneficiaries. This initiative is a joint effort of the Department of Work and Pensions, Barclays, Npower, University of London and UK-based blockchain start-up GovCoin.

- *Paying research grant through Blockchain* (Hopping, 2016): Monitoring and controlling the use of grants is incredibly complex. The government considers that a blockchain accessible to all the parties involved might be a better way of solving that problem. The government presently is looking into any sort of Blockchain technique, Bitcoin is one of those. Furthermore, it is open to all ideas because of the fact that there are a number of areas Blockchains can be used, including government grants which can be used to track the money and it gets taxpayers a better deal, potentially. The government is currently exploring future technologies so that new ways of doing old things can be identified to reshape the state through the best use of modern technology.
- *Blockchain-as-a-Service for Public Sector* (Hopping, 2016): The government in collaboration with Credits; a distributed ledger or blockchain service provider are working to provide *Blockchain-as-a-service* on the Government Digital Services' Digital Marketplace – UK Government's official platform for public agencies to access cloud and digital services. The initiative will enable central and local government, devolved administrations, health, education, emergency services, defence, and not-for-profits will all be able to take advantage of Credits' platform to build applications and services on a Blockchain. Delivering blockchain service on the Digital Marketplace provides public agencies some flexibility in accessing the service. Based on the framework agreements signed with suppliers of services on the Digital Market, public sector organizations can buy services without needing to run a full tender or competition procurement process. Access to Credit's Blockchain platforms–as-a-service will allow the public agencies to build robust Blockchain-based systems that address the challenges in establishing provenance, authentication service participants, reconciliation of transactions service in addition to seamless and secure interoperability with legacy and other Blockchain systems.

Discussion

We have reviewed 13 blockchain-related initiatives across five leading innovation and e-government countries; D5 countries. These initiatives span the Finance, Economy, Welfare & Social Security, Energy, Governance and Public Services sectors (summary in Table 1). In these cases, blockchain technologies have been deployed as secure information management and provenance infrastructure, authentication and validation infrastructure, financial settlement infrastructure, and transaction governance infrastructure. In all these cases, blockchain start-ups in the different countries have played pivotal roles in realizing the different initiatives.

These cases have also revealed some emerging patterns on the role of governments in developing blockchain applications. In most cases, government agencies

have simply leveraged the infrastructure and services provided by local blockchain start-ups to realise pilot initiatives. In other cases, the governments have sought to focus on developing the blockchain ecosystems (e.g. Israel) by facilitating the interaction of local start-ups and investors.

In addition to the various type of goals that emerged from the cases and described in Table 1, blockchain and distributed ledger technology could help in the specific area of governance including (Hopping 2016): traceability of government spending, protecting critical infrastructure, registering assets such as intellectual property, wills, and health data as well as reducing waste resulting from benefit fraud.

To further develop and mature blockchain initiatives, the UK Government Chief Scientific Office provided some recommendations in advancing blockchain innovations in government and society, which include (Taylor 2016): (1) establishing a ministerial level leadership to ensure that government provides the vision, leadership and the platform for distributed ledger technology within government; (2) that the research community invest in the research required to ensure that distributed ledgers are scalable, secure and provide proof of correctness of their contents; (3) that government supports the creation of distributed ledger demonstrators for local government that consolidates all the elements necessary to test the technology and its applications; (4) government should put in place the necessary regulatory framework for distributed ledger; (5) that government works with academia and industry to ensure that standards are set for the integrity, security and privacy of distributed ledgers and their contents which should be reflected in both regulations and software code; (6) that government works with academia and industry to ensure the most effective and usable identification and authentication protocols are implemented for organizations and individuals.

Similar recommendations have been advanced in other sources¹. For instance, it was recommended that Government leaders need to familiarise themselves with the potentials and benefits of the blockchain as a digital transformation technology before committing to exploring its potentials; and 3) commence experimentation with blockchain technology via proofs of concepts and small projects.

As indicated in many of the recommendations above, government's close collaboration with academia is critical to advancing research in blockchain and distributed ledger technology. From the different cases reviewed, we observe that a number of interesting concepts are emerging from the interaction of blockchain technology and governance. Some of the concepts that could redefine governance and definitely worth examining further include (James et al. 2016): "Do-it-Yourself" Governance, Decentralised Autonomous Organization, Decentralised Citizen Engagement,⁵ Provably Secure Governance, Provable Transparency, and Collaborative management of jointly owned digital assets.

⁵ <http://netfutures2016.eu/wp-content/uploads/2016/05/1-Project-presentation-net-futures-.pdf>

Conclusion

This chapter has directly contributed to addressing the paucity of scholarly literature on the application of blockchain and distributed ledger technology in the government domain as highlighted in (Ølnes 2008). We have reviewed several initiatives across the Digital 5 countries in which government has played various roles in blockchain initiatives. While some of the reviewed initiatives show great promise, most of these initiatives are far from operating at scale. At the same time, there are a number of legal, regulatory, ethical as well as technical barriers that must be addressed to fully harness the potentials of the blockchain and distributed ledger technology in government.

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