DISTRIBUTED LEDGER TECHNOLOGY

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I.   INTRODUCTION

Distributed Ledger Technology (DLT) is an emerging new spectrum of technologies focused on revolutionizing how data is stored.[1] While often discussed in tandem with cryptocurrencies, not all DLTs are cryptocurrencies; instead the term DLT covers any approach to data storage across multiple ledgers.[2] A ledger is a record of ownership and what is exchanged in transactions.[3] The concept of a ledger is a foundational principle in modern

[1] U.K. GOVERNMENT CHIEF SCIENTIFIC ADVISER, DISTRIBUTED LEDGER TECHNOLOGY: BEYOND BLOCK CHAIN 7 (2015), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_dat a/file/492972/gs-16-1-distributed-ledger-technology.pdf [https://perma.cc/HW7G-ENHL]; WORLD BANK GRP., DISTRIBUTED LEDGER TECHNOLOGY (DLT) AND BLOCKCHAIN 1 (2017), http://documents.worldbank.org/curated/en/177911513714062215/pdf/122140-WP-PUBLIC-Distributed-Ledger-Technology-and-Blockchain-Fintech-Notes.pdf [https://perma.cc/M2JL-CK8W].
[2] WORLD BANK GRP., *supra* note 1.
[3] REED SMITH LLP, BLOCKCHAIN: DISTRIBUTED LEDGER TECHNOLOGY AND DESIGNING THE FUTURE 3 (3rd Ed. 2019); Sys. Innovation, *Token Economics Distributed Ledgers*, YOUTUBE (Apr. 3, 2018), https://www.youtube.com/watch?v=2eyXeINe8IU [https://perma.cc/5Y5T-D6NL].

economics with roots as far back as the 15th century.[4] Traditionally, these records have been maintained in one centralized location, either with the government or with institutions such as banks and insurance companies.[5] This centralized system requires all citizens to place significant amounts of trust in these entities to ensure accurate documentation of ownership within a ledger.[6] Further, keeping the ledger in one place leaves it open to threats because it has a single point of failure for hackers and power outages. These centralized ledgers also create inefficiencies within transactions between parties.[7]

With the growth of computing power and digital advancements, an alternative approach is now available: distributed ledger technology (DLT).[8] With these new developments, a copy of a ledger can be changed in one node (a computing unit participating in distributed ledger network),[9] and that copy can be distributed throughout a global network to all other nodes—in some cases within seconds of the change.[10] In theory, DLT removes the need for trust required in our current economic system and replaces it with cryptography governing the distributed ledger.[11] While this technology is in its infancy, there has been considerable investment in developing these technologies.[12] DLT's applications are growing and have significant implications within the legal environment.[13] In order for practitioners to understand how to apply the law to DLT, they need to have an understanding of the technology.

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[4] MANAV GUPTA, BLOCKCHAIN FOR DUMMIES: 3RD IBM LIMITED EDITION 15 (2020), https://www.ibm.com/downloads/cas/OK5M0E49 [https://perma.cc/RL2L-S62L]; Margaret Rouse, *Distributed Ledger Technology (DLT),* SEARCHCIO (August 2017), https://searchcio.techtarget.com/definition/distributed-ledger [https://perma.cc/JTV3-8Q8C].

[5] WORLD BANK GRP., *supra* note 1, at 5; Systems Innovation, *supra* note 3.

[6] WORLD BANK GRP., *supra* note 1, at 5.

[7] *Id.* at 5, 16; *What is Ethereum. Guide for Beginners*, COINTELEGRAPH, https://cointelegraph.com/ethereum-for-beginners/what-is-ethereum [https://perma.cc/S8BE-4YXH]; Sloane Brakeville & Bhargav Perepa, *Blockchain Basics: Introduction to Distributed Ledgers,* IBM (Mar. 18, 2018), https://developer.ibm.com/technologies/blockchain/tutorials/cl-blockchain-basics-intro-bluemix-trs/ [https://perma.cc/64MM-5EMR].

[8] U.K. GOVERNMENT CHIEF SCIENTIFIC ADVISER, *supra* note 1, at 5; WORLD BANK GRP., *supra* note 1, at VII.

[9] BANK INT'L SETTLEMENTS, COMM. PAYMENTS & MKT. INFRASTRUCTURES, DISTRIBUTED LEDGER TECHNOLOGY IN PAYMENT, CLEARING AND SETTLEMENT 2 (2017), https://www.bis.org/cpmi/publ/d157.pdf [https://perma.cc/9RQY-KKWT].

[10] *Id.*; U.K. Government Chief Scientific Adviser, *supra* note 1, at 5.

[11] U.K. GOVERNMENT CHIEF SCIENTIFIC ADVISER, *supra* note 1, at 5.

[12] European Cent. Bank, *Distributed Ledger Technology*, IN FOCUS, 2016, at 1, https://www.ecb.europa.eu/paym/pdf/infocus/20160422_infocus_dlt.pdf [https://perma.cc/9BL5-NMNZ].

[13] REED SMITH LLP, *supra* note 3, at 1.

II. WHAT IS DISTRIBUTED LEDGER TECHNOLOGY?

A distributed ledger is a traditional ledger that is recorded and stored in a number of data storage units.[14] These data storage units are often referred to as nodes and can number in the hundreds or thousands across the world.[15] While the underlying technology used to achieve a distributed ledger varies widely, all types of DLT use this concept of decentralized nodes.[16] The nodes are connected through a shared software that allows them to communicate to each other through the network as they verify and record transactions.[17] The ledger is stored within each node and when a change is made to one node's ledger, a communication is sent out to other nodes to update the ledger.[18]

The distributed ledger may be hosted on either a public or private network.[19] Public networks are accessible to the general public and anyone may join the network to see the stored data.[20] Becoming a node in a public DLT network can be as simple as downloading the software and connecting your computer to the Internet.[21] An example of a public network is the Ethereum blockchain.[22] In contrast, private networks require permission for entities such as users and nodes to join and may be preferred in sectors or industries that handle more sensitive information.[23]

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[14] *Id.*

[15] Adedamola Bada, *What's the Difference Between Blockchain and Distributed Ledger Technology (DLT)?*, COINSPEAKER (Jan. 28, 2020), https://www.coinspeaker.com/guides/difference-blockchain-distributed-ledger-technology-dlt// [https://perma.cc/ZC3S-UG5C]; Jordan Heal, *How Network Nodes Are Used in Cryptocurrency,* COIN RIVET (Mar. 2, 2019), https://coinrivet.com/guides/what-is-cryptocurrency/how-network-nodes-are-used-in-cryptocurrency/____[https://perma.cc/E23P-SJV4].

[16] Hasib Anwar, *Distributed Ledger Technology: Where Technological Revolution Starts*, 101 BLOCKCHAINS (Jan. 30, 2019), https://101blockchains.com/distributed-ledger-technology-dlt/#3 [https://perma.cc/AH7B-D7RU]; Camilo Tellez-Merchan & Rodrigo Mejia Ricart, *Distributed Ledger Technology: What Is It and Why Do We Care,* BETTER THAN CASH ALLIANCE (Jun. 6, 2019), https://www.betterthancash.org/news/blogs-stories/distributed-ledger-technology-what-is-it-and-why-do-we-care [https://perma.cc/29YB-PKCG].

[17] Heal, *supra* note 15.

[18] Forex Academy, *How Is Distributed Ledger Technology Different From Blockchain?*, YOUTUBE (Oct. 18, 2019), https://www.youtube.com/watch?v=xFVjQv3cuYw&t=61s [https://perma.cc/85PM-BRW7].

[19] FIN. INDUS. REGULATORY AUTH., DISTRIBUTED LEDGER TECHNOLOGY: IMPLICATIONS OF BLOCKCHAIN FOR THE SECURITIES INDUSTRY 2 (2017), https://www.finra.org/sites/default/files/FINRA_Blockchain_Report.pdf [https://perma.cc/3ZZE-2LVN].

[20] *Id.* at 3.

[21] WORLD BANK GRP., *supra* note 1, at 11.

[22] *Id.*

[23] FIN. INDUS. REGULATORY AUTH., *supra* note 19.

III. DLT IN PRACTICE:
BLOCKCHAIN AND DIRECTED ACYCLIC GRAPH

As previously mentioned, DLT is used in a wide spectrum of unique technologies.[24] Two prime examples of this technology are blockchain and directed acyclic graphs (DAG). Blockchain is arguably the most famous example of DLT; it is the backbone infrastructure supporting some of the most recognizable cryptocurrencies.[25] In a blockchain, transactions are bundled together into blocks which are added to the chain of previous blocks.[26]

Ethereum is a good example to illustrate the process of verifying and storing information in blocks. Ethereum is a public programmable blockchain—which means it allows individuals to build applications using the blockchain as storage—and has a cryptocurrency called Ether that is used to pay for the computational power to run the applications.[27] Within the Ethereum blockchain network, new transactions and updates to applications on the blockchain are periodically bundled into a "block" and broadcast to all nodes in the system.[28] Nodes then race to validate the data in the block before it is added to the permanent ledger.[29] If the new block is validated, the ledger is updated across all nodes and the nodes begin work on the next group of transactions.[30] The confirmed block is then added to the linear chain of previous blocks and the updated chain of blocks is sent to all of the nodes in the system.[31] Thus, the blockchain system works by distributing the data ledger across a network of nodes.[32]

While blockchain may be the most famous example of distributed ledger technology, there are other competing approaches that also hold promise.[33] An alternative approach using DLT is Directed Acyclic Graph (DAG) technology. Instead of storing transactions and data on one linear blockchain, with DAG-based technologies, each individual node

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[24] U.K. GOVERNMENT CHIEF SCIENTIFIC ADVISER, *supra* note 1, at 7.

[25] *What is the Difference Between DLT and Blockchain*, BBVA (Apr. 26, 2018), https://www.bbva.com/en/difference-dlt-blockchain/ [https://perma.cc/8892-YBSJ]; Bada, *supra* note 15.

[26] Anwar, *supra* note 16.

[27] *What is Ethereum*, ETHEREUM (Apr. 11, 2020), https://ethereum.org/what-is-ethereum/ [https://perma.cc/ZA2Y-KZTG]; Alyssa Hertig, *What is Ether*, COINDESK (Mar. 30, 2017), https://www.coindesk.com/learn/ethereum-101/what-is-ether-ethereum-cryptocurrency [https://perma.cc/56PG-7Y6D].

[28] COINTELEGRAPH, *supra* note 7.

[29] *Id.*

[30] *Id.*

[31] Nathan Reiff, *Blockchain Explained,* INVESTOPEDIA (Feb. 1, 2020), https://www.investopedia.com/terms/b/blockchain.asp [https://perma.cc/FJ43-VQF2].

[32] Tellez-Merchan & Ricart, *supra* note 16.

[33] Anwar, *supra* note 16.

independently stores and verifies transactions and data.[34] Each node operates as a part of a one-way street, directing information to only ever pass in one direction (such as from older nodes to newer nodes), resulting in a structure known as a directed acyclic graph.[35] This graph is acyclic in that one vertex cannot loop back around and reference itself.[36]
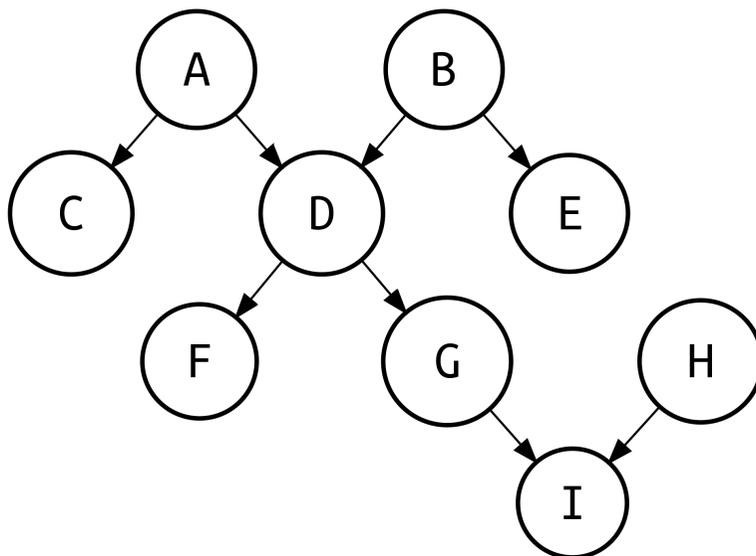
Within a DAG-based network, users conduct transactions through their own nodes which appear on the network and are broadcast to the other nodes.[37] Instead of using third parties to confirm the legitimacy of transactions on the ledger, each transaction itself either references or verifies previous

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[34] ANTON CHURYUMOV, BYTEBALL: A DECENTRALIZED SYSTEM FOR STORAGE AND TRANSFER OF VALUE 4, https://obyte.org/Byteball.pdf [https://perma.cc/653H-2G34]; Frisco D'Anconia, *Future of Digital Currency May Not Involve Blockchains*, COINTELEGRAPH (Nov. 2, 2017), https://cointelegraph.com/news/future-of-digital-currency-may-not-involve-blockchains [https://perma.cc/K7KP-FDGW].

[35] *An Introduction to DAGs and How They Differ From Blockchain*, FANTOM FOUND. (Jun. 20, 2018), https://medium.com/fantomfoundation/an-introduction-to-dags-and-how-they-differ-from-blockchains-a6f703462090 [https://perma.cc/YLC5-LPDA].

[36] Malcolm Barrett, *An Introduction to Directed Acyclic Graphs*, INST. FOR SCI. AND MATHEMATICS OF WIRTSCHAFTSUNIVERSITÄT WEIN (Feb. 12, 2020), https://cran.r-project.org/web/packages/ggdag/vignettes/intro-to-dags.html [https://perma.cc/2B87-76T3]

[37] CHURYUMOV, *supra* note 34; *Meet the Tangle*, IOTA FOUND., https://www.iota.org/research/meet-the-tangle [https://perma.cc/97ZH-BZYJ]; Suirelav, *Introduction to Byteball - Part 2: The DAG,* MEDIUM (Dec. 27, 2017), https://medium.com/@Suirelav/introduction-to-byteball-part-2-the-dag-ce84ca4c4e01 [https://perma.cc/JU7X-4JQ9].

transactions.[38] Ultimately, because each transaction has to reference its parent transactions, the transactions can be traced back through the ledger's history.[39] The primary benefit for DAG over blockchain is scalability.[40] Whereas blockchain limits the amount of transactions within a period of time, transactions on a DAG system eliminate the idea of blocks on the ledger and instead add transactions as the occur.[41]

IV.   WHAT MAKES DISTRIBUTED LEDGER TECHNOLOGY APPEALING?

DLT is beginning to expand across industries and sectors.[42] Two of the most important benefits of DLT are increased efficiency and security. Because there is no middleman required to facilitate transactions, transactions can be conducted more quickly and efficiently.[43] DLT can save businesses billons by accelerating the time it takes for a transaction between parties to settle and allowing transactions to be constantly processed every minute of the day as opposed to certain business hours dictated by third parties.[44] Further, regarding supply-chains or transactions that require monitoring during the transaction, DLT reduces these monitoring costs by sharing verified information through the shared ledger.[45] Distributed ledgers also solve a problem in Internet commerce known as the "double-spending problem" wherein someone can use the same asset in two separate transactions.[46]

DLT provides the means to maintain trust in a decentralized data system.[47] Because the records are distributed and held in multiple locations,

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[38] CHURYUMOV, *supra* note 34; *Meet the Tangle*, *supra* note 37.

[39] CHURYUMOV, *supra* note 34*, at 5; *Meet the Tangle*, *supra* note 37.

[40] IOTA Found., *Coordinator. Part 2: Iota Is a DAG, Not a Blockchain*, IOTA BLOG (Nov. 20, 2018), https://blog.iota.org/coordinator-part-2-iota-is-a-dag-not-a-blockchain-2df8ec85200f [https://perma.cc/QU4B-82SL]

[41] James Ovenden, *A DAG-Based Cryptocurrency Framework,* PRIMALBASE (Mar. 29, 2019), https://medium.com/primalbase/dag-based-cryptocurrency-frameworks-8b94fd1e7342 [https://perma.cc/R22K-FY2L].

[42] BBVA, *supra* note 25.

[43] REED SMITH LLP, *supra* note 3, at 11.

[44] MANAV GUPTA, *supra* note 4, at 4, 9; JEFFREY HOROWITZ & CARL SLABICKI, THE FUTURE OF PAYMENTS: A CORPORATE PERSPECTIVE 17 (2018), https://www.bnymellon.com/_global-assets/pdf/our-thinking/the-future-of-payments-a-corporate-perspective-report.pdf [https://perma.cc/LDG4-DZEG]; Oliver Belin, *The Difference Between Blockchain & Distributed Ledger Technology,* TRADEIX, https://tradeix.com/distributed-ledger-technology/ [https://perma.cc/HK69-JVML].

[45] Dominik Roeck, Henrik Sterberg & Erik Hofmann, *Distributed Ledger Technology in Supply Chains: A Transaction Cost Perspective*, 58 INT'L J. PRODUCTION RES. 2124, 2315 (2020), https://www.tandfonline.com/doi/pdf/10.1080/00207543.2019.1657247 [https://perma.cc/348R-XV3D].

[46] REED SMITH LLP, *supra* note 3, at 5.

[47] Tellez-Merchan & Ricart, *supra* note 16.

there is, in theory, transparency between parties with access to the ledger. DLT also provides the means to maintain immutability within the ledger as decentralization ensures copies are stored in a number of locations.[48] This decentralization protects the data within the nodes and decreases the risk of system failure.[49] If a node or data center is compromised, it can be checked against the other nodes and expelled from the network.[50] If someone were to infiltrate a node and change the data, the data would only be changed on that one node, not the rest of the network, and the network would reject that one compromised node.[51] It is important to note that DLT does not solve all security problems. By its very nature, DLT creates more potential targets for nefarious hackers to attack.[52] However, by distributing the ledger across a number of locations, the network becomes more resilient to certain types of attacks.[53]

These dual benefits of transparency and immutability are available for potentially every application of DLT. Further, DLT may provide unique benefits for institutions that rely heavily on maintaining multiple accurate ledgers. Two such institutions are governments and financial institutions.

A.   Benefits for Governments

Distributed ledger technologies may be used in the future to assist governments in collecting taxes, issuing passports, and maintaining government identification records.[54] Governments are often targets for data breaches and current government storage presents a potential single point of failure because the ledgers are stored in one centralized data management

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[48] REED SMITH LLP, *supra* note 3, at 5; BBVA, *supra* note 25; Svein Olnes, Marijn Janssen, & Jolien Ubacht, *Blockchain in Government: Benefits and Implications of Distributed Ledger Technology for Information Sharing*, 34 GOV. INFO. Q. 355, 356 (Oct. 2017); Sheba Karamat, *What is Distributed Ledger Technology (DLT)?,* COIN RIVET (May 22, 2018), https://coinrivet.com/guides/blockchain/distributed-ledger-technology-dlt/ [https://perma.cc/RHQ3-6327].

[49] Karamat, *supra* note 48; Olnes, Janssen, & Ubacht, *supra* note 48.

[50] Karamat, *supra* note 48; Olnes, Janssen, & Ubacht, *supra* note 48.

[51] Anwar, *supra* note 16; Heal, *supra* note 15.

[52] FIN. INDUS. REGULATORY AUTH., *supra* note 19, at 11.

[53] ADVAIT DESHPANDE ET AL., UNDERSTANDING THE LANDSCAPE OF DISTRIBUTED LEDGER TECHNOLOGIES/BLOCKCHAIN: CHALLENGES, OPPORTUNITIES, AND THE PROSPECTS FOR STANDARDS   45   (2017), https://www.rand.org/content/dam/rand/pubs/research_reports/RR2200/RR2223/RAND_RR 2223.pdf [https://perma.cc/6WDC-ANTD]. For example, networks using DLT would be more resilient to distributed denial of service attacks (DDoS).

[54] U.K. GOVERNMENT CHIEF SCIENTIFIC ADVISER, *supra* note 1, at 6.

system.[55] DLT provides a security measure against malicious manipulation of the data because of it is stored across many different nodes.[56] For certain types of cyberattacks such as a Distributed Denial of Service attack, a distributed ledger provides heightened security simply because the data is stored on a number of different computer systems.[57] Also, citizen data maintained by the government would be harder to edit or erase on distributed ledgers without permission.[58] Further, DLT can remove the need for individual agencies to have to ask citizens for the same information another agency already has by storing it across an accessible ledger as has been demonstrated by Estonia's e-Estonia program.[59]

DLT also holds promise for government identification programs and services.[60] Digital identification offers a reliable and traceable record of transactions for vulnerable people who lack official identification.[61] Especially for individuals "engaged in cross-border trade, seasonal migrants, or individuals displaced by conflict or humanitarian disasters," DLT systems for storing personal data would provide stable digital identities that would be accessible anywhere in the world.[62] These programs do face challenges to

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[55] RISK BASED SEC., INC., DATA BREACH QUICKVIEW REPORT - FIRST QUARTER 2019 DATA BREACH TRENDS (Apr. 30, 2019), https://pages.riskbasedsecurity.com/hubfs/Reports/2019/2019%20Q1%20Data%20Breach%20QuickView%20Report.pdf [https://perma.cc/JUV4-G8M4]; UK GOVERNMENT CHIEF SCIENTIFIC ADVISER, *supra* note 1, at 11, 22.

[56] Ben Dickson, *How Blockchain Can Help Fight Cyberattacks,* TECHCRUNCH (Dec. 5, 2016), https://techcrunch.com/2016/12/05/how-blockchain-can-help-fight-cyberattacks/ [https://perma.cc/NS29-VQHK].

[57] *Id.*

[58] DOUG GALEN ET AL., BLOCKCHAIN FOR SOCIAL IMPACT: MOVING BEYOND THE HYPE 19 (2019), https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/study-blockchain-impact-moving-beyond-hype.pdf. [https://perma.cc/GM6G-FY2B]; Nathan Heller, *Estonia, the Digital Republic,* NEW YORKER (Dec. 11, 2017), https://www.newyorker.com/magazine/2017/12/18/estonia-the-digital-republic [https://perma.cc/U3PL-WXHQ].

[59] Heller, *supra* note 58.

[60] Camilo Tellez-Merchan & Rodrigo Mejia Ricart, *Distributed Ledger Technology and Digital Identity: Prospects and Pitfalls Ahead,* BETTER THAN CASH ALLIANCE (Jun. 6, 2019), https://www.betterthancash.org/news/blogs-stories/distributed-ledger-technology-and-digital-identity-prospects-and-pitfalls-ahead [https://perma.cc/TL9A-WV55].

[61] *Id.* While outside the scope of this paper, arguments have been made against these programs in that they overlook limited abilities for individuals, especially vulnerable populations, to access required technology so as to access their digital identification. For a brief overview of the risk, see WHITE ET AL., DIGITAL IDENTIFICATION: A KEY TO INCLUSIVE GROWTH 83 (Apr. 2019), https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Digital%20identification%20A%20key%20to%20inclusive%20growth/MGI-Digital-identification-Report.ashx [https://perma.cc/J3QW-78ZV].

[62] Tellez-Merchan & Ricart, *supra* note 60.

adoption, including issues with "right-to-be-forgotten" laws and barriers to adoption due to unfamiliarity with the technology, and most of these projects remain in developmental stages.[63] There is an inherent conflict between "right-to-be-forgotten" laws, which provides that citizens may request personal data be erased from organizational records, and an immutable ledger.[64] Further, limited adoption due to the unfamiliarity of citizens with distributed ledger applications in a government context, most of these identification projects are in the developmental stage.[65] Nevertheless, given that success in this area could mean globally accessible, reliable records of identification for people, DLT holds true promise in the realm of government identification.[66]

B.   Benefits for Financial Institutions

DLT also shows great promise for the financial industry. Banks are required to manage large amounts of data under strict governmental regulation.[67] The application of distributed ledger technology to this data could cut down significantly on costs within the banking data systems.[68] One study conducted by Accenture showed that investment banks could reduce their compliance costs between 30% and 50% by 2025 using DLT.[69] Further, in regards to capital markets, DLT has the potential to reduce settlement times for securities transactions by facilitating the transfer of stocks and bonds simultaneously with the execution of a trade.[70]

V. CHALLENGES FACING DLT

While DLT already been implemented in many fields, it faces several hurdles to widespread adoption. These hurdles include limited awareness by potential users about the technology, issues of scalability, unsettled laws surrounding DLT applications, and a general acceptance of current traditional technologies.

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[63] GALEN ET AL., *supra* note 58, at 21, 28.

[64] *Id.*; *Everything You Need to Know About the "Right To Be Forgotten*,*"* GDPR.EU, https://gdpr.eu/right-to-be-forgotten/ [https://perma.cc/JW5E-KC4U].

[65] GALEN ET AL., *supra* note 58, at 21, 28.

[66] Tellez-Merchan & Ricart, *supra* note 60.

[67] BBVA, *supra* note 25.

[68] *Id.*

[69] ACCENTURE & MCLAGAN, BANKING ON BLOCKCHAIN: A VALUE ANALYSIS FOR INVESTMENT BANKS 5 (2017), https://www.accenture.com/t20170120T074124Z__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Consulting/Accenture-Banking-on-Blockchain.pdf%23zoom=50 [https://perma.cc/ZQ2N-NCJM].

[70] FIN. INDUS. REGULATORY AUTH., *supra* note 19, at 5–6; REED SMITH LLP, *supra* note 3, at 62.

In many applications of DLT, the technology is still in developmental stages.[71] This lack of development reflects in part the overall youth of DLT but also reflects a lack of awareness on the part of potential users.[72] Unaware potential users may not see the benefits presented by DLT to their current systems, which would limit their efforts to develop and adopt this technology in areas where it could be a benefit.[73] Another primary challenge faced in the adoption of DLT is an issue of scalability, particularly with blockchain technologies.[74] The Ethereum network processes only fifteen payments per second on average; that is significantly less than the average credit card company.[75] While DAG-based solutions process transactions much faster than blockchain technologies, the most prominent examples of DAG-based DLT processing rates are still not as fast as conventional verification methods used by institutions such as credit card companies.[76] Further, while DLT provides insulation from many types of security risks through its distributed nature, its distributed nature also exposes it more to potential risks outside the network.[77] Bad actors have many more opportunities to try and attack the network through holes in software.[78]

Another significant challenge specifically for financial institutions is unsettled and novel applications of law to DLT.[79] As previously mentioned, for governmental identification through DLT, issues arise concerning an inherent conflict between "right-to-be-forgotten" laws and an immutable ledger. Another example of this problem is within financial institutions. Financial institutions are heavily regulated and are often changing.[80]

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[71] FIN. INDUS. REGULATORY AUTH., *supra* note 19, at 10.

[72] DESHPANDE ET AL., *supra* note 53, at 13–14.

[73] *Id.*

[74] REED SMITH LLP, *supra* note 3, at 6.

[75] *Id.*; Daniel O'Keeffe, *Understanding Cryptocurrency Transaction Speeds,* COINMONKS (Jun. 5, 2018), https://medium.com/coinmonks/understanding-cryptocurrency-transaction-speeds-f9731fd93cb3 [https://perma.cc/6JD5-LSSX].

[76] Bin Cao, et al., *Performance Analysis and Comparison of PoW, PoS, and DAG Based Blockchains,* DIGITAL COMMS. & NETWORKS (Jan. 3, 2020), https://www.sciencedirect.com/science/article/pii/S2352864819301476?via%3Dihub [https://perma.cc/4FVR-MHBZ]; Jed Record, *DAG: A Buzz Or A Breakthrough*, HACKERNOON (Nov. 8, 2018), https://hackernoon.com/dag-a-buzz-or-breakthrough-9b433d0b5424 [https://perma.cc/9Z6V-ZNHQ]. *See* COTI, *COTI vs IOTA*, MEDIUM (Jun. 4, 2018), https://medium.com/@COTInetwork/coti-vs-iota-510a8869c8d3 [https://perma.cc/AY2V-Q5J9].

[77] FIN. INDUS. REGULATORY AUTH., *supra* note 19, at 11.

[78] DESHPANDE ET AL., *supra* note 53, at 21.

[79] Camilo Tellez-Merchan & Rodrigo Mejia Ricart, *DLT: Keep Calm and Let The Evidence Speak*, BETTER THAN CASH ALLIANCE (Jun. 6, 2019), https://www.betterthancash.org/news/blogs-stories/dlt-keep-calm-and-let-the-evidence-speak [https://perma.cc/KRV5-C8LJ].

[80] *Id.*

Therefore, institutions and organizations attempting to implement DLT will have to navigate the application of traditional securities law to brand new technology.[81]

With potential application concerns comes the issue of satisfaction with current systems. If DLT does not provide significant benefits over current systems, businesses will ask why they should deal with the costs. Especially where existing systems are already efficient and adopted by users, DLT may face slow adoption.[82] However, while this may be a barrier in established institutions, it may improve adoption efforts in new markets. New markets or areas without strong institutions may be the first to adopt DLT as its foundation because there is nothing for DLT to compete against.[83]

VI.   CONCLUSION

Distributed Ledger Technology has the ability to change our economy and the way we govern ourselves. Traditional institutions that rely on public trust can now be replaced with an open system that is checked and maintained by thousands of nodes all across the world.[84] Current applications of DLT such as blockchain technology and directed acyclic graph technology show the potential of DLT; it improves security, preserves data integrity, and reduces costs. Governments and financial institutions in particular stand to benefit from these systems because of their heavy reliance on maintaining a large number of individual ledgers. In short, distributed ledger technology provides new solutions to many of the problems that we face in our modern world today. As the world increasingly accepts the digital age, the law and its practitioners will be required to understand distributed ledger technology from applications in government services and digital identification to financial services and beyond.[85]

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[81] FIN. INDUS. REGULATORY AUTH., *supra* note 19, at 13.
[82] Tellez-Merchan & Ricart, *supra* note 79.
[83] *Id*.
[84] Systems Innovation, *supra* note 3.
[85] *See* Tellez-Merchan & Ricart, *supra* note 16.