HOUSE JOINT RESOLUTION 25

ILLINOIS BLOCKCHAIN AND DISTRIBUTED LEDGER TASK FORCE

FINAL REPORT TO THE GENERAL ASSEMBLY

January 31, 2018

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Dear Chamber Leaders and Members of the General Assembly:

We are pleased to deliver to you the attached Final Report of the Illinois General Assembly Blockchain and Distributed Ledger Task Force.

This Report is the first official government report in Illinois to be permanently certified in a public blockchain, a small gesture that we believe will demonstrate our desire to see government begin to use this technology. Though the mathematics behind the unique digital fingerprint assigned to this Report may be difficult to understand, it is clear that distributed ledgers can begin a transition to a smarter, cheaper and safer way to administer government.

On June 28th 2017, this Task Force was charged by HJR 25 with studying: 1) opportunities and risks associated with using blockchain and other distributed ledger technologies, 2) the different types of blockchains, public and private, 3) projects and use cases in other states/nations that Illinois could consider, 4) how current state laws could be modified to support this technology, 5) encryption technology, including Illinois' digital signature infrastructure, and 6) official reports and recommendations from the Illinois Blockchain Initiative. The attached Report will provide more detail in each of these areas, and we urge you to read it and contact any member of the Task Force if you would like to learn more.

To broadly summarize our findings, this Task Force believes that blockchain technology and its built-in encryption can facilitate highly-secure methods for interacting with government and keeping paperless records, increasing data accuracy and providing better cybersecurity protections for Illinois residents. Though the technology still needs refinement, government has an opportunity to help shape and adopt innovative solutions.

As you may know, the State of Illinois has a strong reputation as a leader in supporting blockchain and distributed ledger technologies, and maintaining a "light touch" and progressive regulatory approach. Our ongoing studies and pilot programs through the Illinois Blockchain Initiative are talked about across the globe. We believe our unique intergovernmental partnerships demonstrate how all layers of government can work together to jointly develop this "digital infrastructure" and build resilient networks that protect each other's data and share the cost of hardware and software.

Make no mistake, blockchain technology must improve its scalability and smart contract security before government adoption becomes widespread. But, we must remember that every day more and more Illinoisans are losing time and money due to hacks of their personal data, and government owes it to its taxpayers to lead a shift away from centralized servers full of sensitive data to a decentralized network that is more secure and easier to administer.

Sincerely,

Members of the Blockchain and Distributed Ledger Task Force

The Next Generation of the Internet

The first digital revolution brought endless innovations as the internet, social media, mobile and big data have changed nearly every aspect of our lives. Though the internet may have revolutionized communication, it has not necessarily transformed business and commerce in terms of trust.

Establishing identity and transacting value online still requires verification from a trusted third party (banks, governments, big technology companies).

While intermediaries fill a vital role in transacting value, relying too heavily on them often comes at the expense of inclusive prosperity. Intermediaries add costs and frictions to our economy for both businesses and consumers. They monetize vast amounts of data privacy and leave over a quarter of the world's population out of the global economy.[7]

The Internet of Value

Enter the blockchain, the first "native" digital medium for peer to peer value exchange. Anything of value, money, titles, deeds and identity attributes can be exchanged, stored, and managed securely and privately. Trust is not established exclusively by powerful intermediaries, but through network consensus, cryptography and code. [15]

The Promise of Blockchains

Blockchains as peer-to-peer digital economies have the capability to address fundamental societal issues:

- They create a secure platform that enables immutable, irrevocable digital identities.
- They have the ability to provide universal access to financial services and government benefits
- They spur a stronger economy and create social stability through greater economic participation

Blockchains are rapidly becoming the foundation of the Fourth Industrial Revolution: [13]

- They are being used to create distributed market structures to address security risks and eliminate single points of infrastructure failure.
- Supplying regulators with real time data on financial flow and asset class risks, they stand poised to improve the oversight of international markets.
- They are integrating granular provenance tracking, identity management and concepts of digital scarcity horizontally and vertically through global supply chains. [11]

- In a 2015 World Economic Forum survey of global business and government leaders 58% of respondents believe that 10% of global gross domestic product (GDP) will be stored on blockchain technology. [19]

The Unanswered Questions

Although blockchain technology may prove to be one of the most disruptive innovations of the 21st century, it currently is discussed as if it were more mature than it actually is. Many implementation hurdles at the technical, regulatory and governance level continue to hinder widespread adoption for both open and private blockchain networks. Blockchains are inherently a "network" technology meaning that without wide-scale collaboration and coordination, their power to improve society will never be realized. [1]

Few Impactful Implementations

Since 2015, banks, regulators, tech giants and startups all over the world have raised billions of dollars to explore the promise of the blockchain. Despite the exuberance for the technology to date, Bitcoin still stands to be the only successful, scalable implementation of blockchain and distributed ledger technology.

The Limits of Open Governance

Contrary to popular belief, open and decentralized governance does not automatically mean fair and equitable rule of law. Democracy cannot be reduced to majority rule and consensus is a complex construct that requires concepts such as minority rights, equal access to decision making and legitimacy of procedure. Bitcoin's recent scaling debate and Ethereum's Decentralized Autonomous Organization or DAO scandal have brought to light the notion that "code is not law" and that a 51% majority does not always equal democracy. [2]

Decentralized Market Structures are Untested

Blockchains and decentralized market structures are relatively untested in our global economy, which could either (a) be less preferable than "trust taxes" or (b) introduce fundamentally new risks into the global economy. By displacing intermediaries who policymakers have historically relied on to implement regulatory safeguards, it is unclear who or how broader systemic policy changes can get implemented when necessary. [11]

Charting a Path Forward

Although government appear to be the antithesis of a technology that decentralizes economies and places trust in code over law, it is incumbent on the public sector to help catalyze the growth of this technology. Furthermore, the greatest risk may be letting of blockchain technology's potential fade, stagnate in its fractured status quo or be implemented in a non-inclusive way. Ultimately, code, algorithms, policy and rule of law are all artefacts of human design. Technology alone does not create prosperity, people do.

In Illinois, we believe it is imperative for government to take affirmative steps to harness the tremendous opportunities and minimize the risks of blockchain technologies during this critical period of development. In doing so, the state of Illinois will be able to:

1. Catalyze an Ecosystem for Growth and Collaboration

   Although, the long-term benefits of blockchain are clear, blockchains and DLTs are still very much nascent technology. Governments can play a role in catalyzing its maturity as a technology by supporting grassroots developer innovation and encouraging collaboration among enterprises, countries and entrepreneurs.

2. Rethink Governance for a Distributed Economy

   Effective governance in a distributed economy will require legislative agility beyond what rules and regulations can provide. Modern governance will need to carefully balance a combination of broad policy principles, technology standards and "code".

3. Create Hyperconnected Services for a Highly Efficient Government

   A "hyperconnected" government enables unprecedented integration and efficiency, where services are tailored to each individual's needs. Blockchains will be used to connect disparate entities within and across regional, municipal, and state entities around citizens, businesses and assets. [9]

What is Blockchain?

In simple terms, a blockchain is a type of database that is replicated over a peer-to peer (P2P) network. However, this definition could also apply to other types of distributed databases that have no central database manager. So, what makes a blockchain special?

The principal way in which a blockchain is different from other distributed databases is that a blockchain is designed to achieve consistent and reliable agreement over a record of events (often referred to as the "state") between independent participants who may have different motivations and objectives. Put in a slightly different way, participants in a blockchain network reach consensus about changes to the state of the shared database (i.e., transactions amongst participants) without needing to trust the integrity of any of the network participants or administrators.

The agreement between blockchain network participants over the state of the database is achieved through a consensus mechanism, which ensures that each participant's view of the shared database matches the view of all other participants. The combination of the consensus mechanism with a specific data structure allows blockchains to solve the so-called 'double spending' problem. [10]

All participants have a consistent view of the shared database state. As a result, any improper alteration of the data (e.g., tampering by a malicious actor) will be immediately detected and rejected by all participants.

Components of Blockchains and Distributed Ledgers

Blockchains and distributed ledgers generally have the following five components:

1. Cryptography	Use of a variety of cryptographic techniques including cryptographic one-way hash functions, Merkle trees and public key infrastructure
2. P2P Network	Network for machine-readable data discovery and replicated peer-to-peer data sharing
3. Consensus Mechanism	Algorithm that determines the ordering of transactions in an adversarial environment (assuming not every participant is honest)
4. Ledger	List of cryptographically linked transactions (e.g. bundled in "blocks" for blockchains, direct acyclic graph DAG in IOTA)
5. Validity Rules - Access and Validation	Common set of rules of the network (i.e., what transactions are considered valid, how the ledger gets updated, etc.)[9]

Types of Distributed Ledgers

Generally, a blockchain or distributed ledger can be either **public** or **private** and *permissionless* or *permissioned.*

Access \ Validation	**Permissionless**	**Permissioned**
Public	Bitcoin IOTA Ethereum	Sovrin
Private	Hyperledger Sawtooth	Hyperledger Fabric R3 Corda Quorum

Permissionless
A permissionless blockchain or distributed ledger generally refers to a ledger where anyone may operate a validator node, i.e., a node that participates in the consensus protocol to validate transactions.

Permissioned
A permissioned blockchain or distributed ledger refers to a ledger where permission from some governing entity is required to operate a validator node.

Public
A public blockchain or distributed ledger refers to a ledger that is "open to the public" for usage, i.e., anyone can create transactions on the ledger

Private
A private blockchain or distributed ledger refers to a ledger where permissions to write entries are restricted to a single organization and read permissions can be either public or restricted. [5]

Consensus Mechanisms

A consensus mechanism is the process in which a majority (or in some cases all) of network validators come to agreement on the state of a ledger. It is a set of rules and procedures that **allows maintaining coherent set of facts between multiple participating nodes.**

Proof of Work

A proof-of-work (PoW) protocol generally involves proving that some resource has been expended (typically processing time by a computer). It is a method to deter an abuse of service (i.e. denial of service attacks, spam, double spending) by requiring some form of "work". In a public blockchain, such as Bitcoin, PoW removes the need for trust amongst anonymous actors by reducing the likelihood of an attack by a single malicious actor. In this case, PoW aims to prevent one party from holding a majority of computational resources at one given time. Examples include:

Bitcoin	Ethereum	Dash
IOTA	Z-Cash	Monero

Proof of Stake

Proof of stake is a newer consensus mechanism designed to be less resource intensive. The key motivation for proof of stake is that consensus is performed by stakeholders who have the strongest incentive to be good and honest stewards of the system. Put differently, the nodes that validate transactions have 'skin in the game.' The major benefit of this consensus mechanism, as compared to proof of work, is that there is a

large reduction in energy consumption resulting from a decreased need for hashing power.

Tezos	Ethereum (Casper Release)	NEO
Qtum	Nxt	Cardano

Majority Voting (Variants of Practical/Federated Byzantine Fault Tolerance)
In majority voting systems, consensus is determined by a 2/3rds majority vote, designed to achieve byzantine fault tolerance for smaller networks where actors or participants are known and generally trusted. [22] Examples include:

Hyperledger Fabric	Tendermint	Hashgraph
Ripple	Quorum	Stellar
Zilliqa	Sovrin	Corda

Additional Blockchain Concepts

Smart Contracts

A smart contract is a collection of code and data (sometimes referred to as functions and state) that is deployed to a blockchain (e.g., Ethereum). Future transactions sent to the blockchain can then send data to public methods offered by the smart contract. The contract executes the appropriate method with the user provided data to perform a service. The code, being on the blockchain, is immutable and therefore can be used (among other purposes) as a trusted third party for transactions that are more complex than simply sending funds between accounts. A smart contract can perform calculations, store information, and automatically send funds to other accounts.

Forking

Changes to the blockchain software and implementation are called forks. A ***soft fork*** is a change to the technology that will not completely prevent users who do not adopt the change (e.g., an update to the latest version) from using the changed blockchain system. Since non-updated nodes will recognize the new blocks as valid, a soft fork can be backwards compatible, only requiring that a majority of nodes upgrade to enforce the new soft fork rules.

A ***hard fork*** is a change to the technology that will completely prevent users who do not adopt it from using the changed blockchain system. Under a hard fork, the blockchain protocol will change in a manner that requires users to either upgrade to stay with the developer's "main fork" or to continue on the original path without the upgrades. Users on different hard forks cannot interact with one another. Any change to the block structure, such as the hashing algorithm choice, will require a hard fork.

With cryptocurrencies, if there is a hard fork and the blockchain splits, the coins each person has at the time of the split will be mirrored on each fork. If all the activity moves to the new chain, the old one will eventually not be used. [22]

Benefits and Opportunities

Transaction = Reconciliation

Reconciliation is the process of ensuring that two sets of records agree. Particularly in the financial industry, the reconciliation of transaction records is critical to the accounting process. Bank A engages in a transaction with Bank B, and each bank records an entry in its respective ledger. At some point in the future, the entries are reconciled to ensure accuracy. The need for reconciliation extends beyond finance, and can include any data set or record that is maintained by more than one party.

Blockchain technology addresses data reconciliation by requiring network participants to share data points. In the banking example above, instead of Bank A and Bank B maintaining separate entries for a single transaction, they would share a single entry maintained on a shared ledger, eliminating the need to reconcile entries later.

Another subtle, but powerful impact of blockchain technology is the standardization of data and transactions formats. When users join a blockchain network, they (and their computers) agree to a protocol – a format for transmitting data between nodes on a network. By virtue of their participation, users are bound by the data and transaction formats of the network. Not only are the parties communicating in the same "language", they are sharing a place of record.[18]

Immutability and Data Integrity

The permanent and persistent storage of transactions on blockchains, it's "immutability", is particularly useful for trusted governance, evidentiary or audit purposes. For example, forensic analysis and legal discovery processes could be conducted without the need for special methods, expensive technologies, or significant resources being employed. The clear benefit here is reduced court costs where a jurisdiction recognizes the facts in the distributed ledger as admissible. These reduced costs would could also create positive externalities such as improved behaviors, like honesty, encouraged by the transparency and immutability of the ledger.

Blockchains present opportunities for regulators to access high integrity records of transactions in real or near-real time. A persistent and machine-readable history of transactions would allow regulators a macro-view of an institution's compliance with assurance that no transactions had been tampered with. This unprecedented view into regulated industries would open pathways to productivity gains and risk management if managed appropriately.

Distributed ledger systems are transparent in that all transactions are traceable, and permanently stored by the network of participants. While a private distributed ledger network may add restrictions to who can write or read transactions, it preserves the feature of stakeholders having common access to their set of common transactions. The moment anyone starts transacting on the system, a history of all interactions is immediately logged in the

system. This high level of transparency and reliability is an important factor in building trust in the integrity of the network not just from a regulatory oversight perspective, but can also reduce counterparty risk for participants in the network. [8]

Improving Resilience and Security in Transactional Systems

Blockchains have the potential to increase the resilience of systems and data storage due to its distributed nature and its lack of a central point of. The ledger is owned by all participating parties which means that in the event of failure everyone can keep their own copy of data and transactions. This form of resilience and security provides the opportunity to create new identity systems where users own the data, which remains universally consistent and cannot be destroyed. Minimizing single points of failure in transactional systems is thus a key differentiator when compared with existing or legacy systems which often have centralized mechanisms of verification and security. [18]

Challenges and Risks

Energy Consumption and Computer Processing Power

The proof-of-work competition also has the added cost of the wasted computational power and energy used by all the miners involved in the process. The snapshot below depicts the Bitcoin miners as currently consuming over 11 Terra Watt hours per year. To put this in context, Bitcoin mining currently accounts for 0.05% of the world's energy consumption, which could power over a million households in the United States of America.

Scalability and Performance

As ledgers are designed to retain all previous transactions, the ledger's size will increase. This increase in size will continually need to be forecast against both the capabilities of the network and the future behavior of the users. For example, the increasing popularity of Bitcoin is having an exponential influence on the size of that blockchain. Sometimes referred to as "network bloat" has the potential to detract from the technology's utility if the size becomes too great for everyday participants to readily use in a cost-effective way. [8]

Interoperability

To realize the full benefits of distributed ledger technology, it will be critical for ledgers to be able to exchange information with other ledgers and with legacy IT systems. In the short and medium term, it is unclear whether businesses would be prepared to overhaul their existing operations.

Blockchains are designed for decentralized control and not for decentralized semantics. Blockchains don't have the equivalent of JSON or HTTP for Blockchains. They are highly specific to their application area and lack the flexibility required for a variety of different storage and

provenance models. They possess no mechanism for extending their data model in a self-discoverable or machine-readable way. This makes tuning the existing monolithic blockchain designs to meet new use cases a challenging, if not financially and technically prohibitive undertaking.

Currently there are hundreds of fragmented blockchains competing, each with their proprietary, non-interoperable standards and protocols. Wider adoption for blockchains depends on enabling seamless interaction, not just between blockchain-based systems, but also with existing IT infrastructure.

Assuming there will be many different types of blockchains and distributed ledgers, then it follows that a generalized format for expressing and accessing these ledgers is desirable and a requirement for interoperability. Transactions on blockchains will need to have stable URLs and an equivalent of HTTP redirection to point to updated locations. Further standardization efforts are needed to create URL schemes for blockchain transactions.

Privacy and Correlation

If illegal, personal, classified or otherwise objectionable data is entered onto a public blockchain ledger, it is there forever. This means that situations may arise where information is recorded inappropriately or illegally, and cannot be removed. The potential impacts of the permanence and persistence of this information could potentially impact the privacy of individuals.

These potential privacy challenges will require thoughtful design and good governance to be prevented and managed. Even improper use of simple metadata, can have unintended consequences on privacy, allowing anyone to correlate data about an individual in a publicly discoverable way. Strong governance models and controls around data security and privacy will have to be examined carefully and have been demonstrated to be problematic. Information security would need to consider the potential for breaches where previous responses and mitigations are no longer effective. [8]

1. Catalyzing an Ecosystem for Growth and Collaboration

Essential Questions

- What role should government play in developing an ecosystem?
- What unique areas of opportunity can we capitalize on in Illinois?

The State of Illinois as a Catalyst for Growth

Illinois regards its role in the development of the blockchain ecosystem as one which supports the distinct needs of the respective ecosystem stakeholders: entrepreneurs, capital providers, developers, governments, and academics to support and encourage the creation and growth of

blockchain companies in Illinois. To accomplish this mission the Illinois Blockchain Initiative created the role of the State of Illinois Blockchain Business Liaison, which is responsible for the engagement of these stakeholders within the ecosystem to identify and conclusively work to resolve their respective needs. As noted in the Tapscott Group's 2017 Blockchain Corridor Report: "many entrepreneurs are seeing a healthy dialogue with government, and a focus on governance more broadly, as a good thing. Companies like Coinbase, Circle and Gemini have joined trade organizations, and some even maintain close relations emerging governance institutions". [16]

Reciprocally, the Illinois Blockchain Initiative has taken the unique step of directly joining blockchain industry participants in membership within industry organizations and blockchain consortiums such as the Chamber of Digital Commerce, R3, Hyperledger, the Enterprise Ethereum Alliance and the Chicago Blockchain Center. The access to current market knowledge and highly regarded subject matter participants, which these industry organizations and consortium memberships provide, ensure the Illinois Blockchain Initiative is highly informed and thus well positioned to execute effective strategy to catalyze an ecosystem for growth and collaboration.

Areas of Opportunity for Illinois

Illinois is uniquely positioned to take a leadership role in the development of blockchain technology due to the critical mass of industries leveraging blockchain technology located in Illinois (financial services, insurance, supply chain and logistics etc.), access to talent, support of entrepreneurship, and collaboration with enterprises.

Further supporting Illinois exceptional position to become the home of blockchain technology, Deloitte's 2017 Global FinTech Hub Ranking Report placed Chicago as a top five global fintech hub, outperforming cities like Hong Kong, Zurich and Sydney: "Chicago acts as the epicenter for all FinTech activity in the Midwest, representing well over 20,000 financial institutions. It is home to two fifths of the top business universities in the US and over 6% of the Chicago workforce are focused on the financial ecosystem contributing to its already significant talent pool.

With government support, Chicago companies are able to quickly innovate to create groundbreaking technology". Notably the Deloitte report explicitly articulated the Illinois government's support of blockchain technology: "over the next 12 months, we expect to see state and local government partnering with the private sector and NGOs to pursue greater adoption of blockchain as well as creating an innovation friendly environment. [6]

Fostering a Talent Pipeline

Ensuring that businesses have access to the right employees and skill sets, a pipeline, is strategically important because it has a long-term talent-supply focus, which means that critical jobs can be filled faster and with higher quality and more interested prospects. The cost of

talent is the largest expense for most firms, and the quality of that tech talent is becoming one of the most important considerations.

In a 2017 CBRE Report: Scoring Tech Talent in North America, noted that the Chicago area is the fourth-ranked market in the country for tech degrees, with 7,866 degree completions from 2014-2015, demonstrating a growth of 15.6 percent from 2011-2015, trailing only New York, Washington, D.C. and Los Angeles. Furthermore, Chicago was among the best value markets for tech talent, due to its moderate labor costs (averaging $95,180 for software developers) and "very-high"-quality labor pool.

Blockchain technology talent pools will require education in computer science and engineering. The University of Illinois system graduates more computer science and computer engineering students than CalTech, MIT, Stanford and Berkley combined. Furthermore, University of Illinois Urbana Champaign is ranked as the #5 top undergraduate schools for computer engineering by US News College Rankings. Although Illinois is well positioned to leverage its world class academic institutions, the Illinois Blockchain Initiative can provide additional bespoke blockchain education and programming outside of academia to supplement the talent pool.[23]

The Illinois Blockchain Initiative has been and is positioned to continue to be an effective mechanism to facilitate educational workshops and conferences in which experienced practitioners and experts provide knowledge, specific insight and practical application and fosters grassroots innovation through hackathons national challenges, boot camps, and accelerators. Looking forward, the Illinois Blockchain Initiative will partner with educational institutions to incorporate blockchain curriculum into schools and colleges and to support blockchain workforce development.

Supporting Entrepreneurship

The government is well placed to support blockchain technology entrepreneurship by providing fiscal and educational resources to startups. The State of Illinois currently provides fiscal resources such as the recently renewed Angel Investment Tax Credit and R&D Tax Credit programs. It also provides educational resources such as the Small Business Development Center network, and has funded collaborative spaces which ease entrance into entrepreneurship such as 1871, MATTER and UILabs/DMDII. The Illinois Blockchain Initiative is a founding member of the Chicago Blockchain Center, created in June 2017, where services are focused on providing bespoke programming and education to the various segments of the local blockchain community.

Even as the government supports blockchain entrepreneurs' efforts to advance the technology, there is still a need to come up with new applications that will broaden the technology's appeal. The Illinois Blockchain Initiative will play a supporting role in the identification of the most important applications and opportunities for blockchain technology in business and government. In doing so, the Illinois Blockchain Initiative will build relationships with

entrepreneurs and leaders that will in turn foster a supportive environment for startups and investment in the blockchain community.

Collaborating with Enterprises

The collaboration between corporations and startups has become crucial. Corporates collaborate with startups to fast-track disruptive, game-changing products and services and startups leverage corporates advantages in procurement, distribution, manufacturing, and sales and marketing. With 37 Fortune 500 companies headquartered in Illinois, Illinois is well positioned to connect the startup community residing in the network of over 100 incubators, accelerators, co-working spaces and academic labs (such as Built in Chicago, Clean Energy Trust, Energy Foundry, iBIO Institute, the Illinois Technology Association, and facilities such as 1871, MATTER, mHUB, and TechNexus) to these world class corporate partners.

2. Governance, Law and Distributed Economies

Essential Questions

- How can legislators ensure distributed ledger systems balance enduring policy goals while also mitigating new or unforeseen risks?
- Why might current regulatory and legal systems be redundant in a fully distributed economy?

Governing Distributed Ledger Technology

Effectively governing blockchain and distributed ledger technology will require finding an optimum balance between governance, regulation, legal code and technical code and will require a unique mix of skills and perspectives from a variety of stakeholders, including lawyers, mathematicians, business experts and computer scientists. For purposes of analysis governance, regulation, legal code and technical code are defined below:

- **Governance:** Rule-making by the owners or participants of a system with the purpose of safeguarding private interests.
- **Regulation:** Rule-making by an outside authority tasked with representing the broader interests of the public.
- **Legal Code:** Rules consisting of legal obligations set by either statute, administrative code or regulatory guidance.
- **Technical Code:** Rules defined in systems and code, executed and enforced by software and protocols. [18]

Legislative Recommendations

Illinois' lack of "blockchain legislation" to date should not be viewed as a failure to act, but rather, as a recognition that many activities, transactions, agreements and events facilitated by the technology are probably already legal, so long as they are performed in good faith, without deception, and can be proven. For example, the state statutes governing county land records offices (55 ILCS 5/3-5005.2) provide that "...The Recorder shall have the right to select the computer or micrographic system to be used for document storage and retrieval." The Cook County Recorder of Deeds interprets this to mean that if the office so chooses, it can implement a blockchain or distributed database to store records without need for a state law to authorize it.

Illinois has instead chosen a more restrained regulatory path, actively studying design principles rather than simply envisioning every possible use case and affirming its "legality." It can also be tempting to make a list of all the things the private sector *can't or shouldn't* do with blockchain in the name of consumer protection, but it seems that such a heavy-handed approach is more likely to send the message that Illinois is not friendly towards this technology. Recommendations that follow will thus reflect necessary changes to the way information is submitted, stored and transmitted.

The recommendations available in appendix A are heavily focused in the areas of state law that affect property law and public recording, mainly because that is the area most heavily studied in Illinois thus far (*see Cook County Recorder of Deeds Blockchain Final Report, May 31, 2017*). It is the opinion of the Task Force that because property law continues to rely on archaic standards and paper-based regulatory guidance, that an overhaul of these sections could provide impetus and direction to lawmakers interested in carrying similar updates into other Sections of law.

It is beyond the abilities and mandate of this Task Force to analyze every corner of the Illinois Compiled Statutes and every opportunity. It is also important to remember that the purpose of this Task Force is to analyze opportunities and risks *for government usage*, which means this report will not directly consider legislation that is tangential to the delivery of government services.

3. Creating a Hyperconnected Government

Essential Questions

- How can distributed ledger technology help governments deliver more responsive, trusted and integrated public services?
- How can these technologies be utilized with other emerging technologies to radically rethink how government services are delivered?

Building a Hyperconnected Government with Blockchains

An important function of government is to maintain trusted information about individuals, organizations, assets, and activities. Local, regional and national agencies are charged with maintaining records that include, for instance, birth and death dates or information about marital status, business licensing, property transfers, or criminal activity. Managing and using these data can be complicated, even for advanced governments. Some records exist only in paper form, and if changes need to be made in official registries, citizens often must appear in person to do so. Individual agencies tend to build their own silos of data and information-management protocols, which preclude other parts of the government from using them. And, of course, these data must be protected against unauthorized access or manipulation, with no room for error.

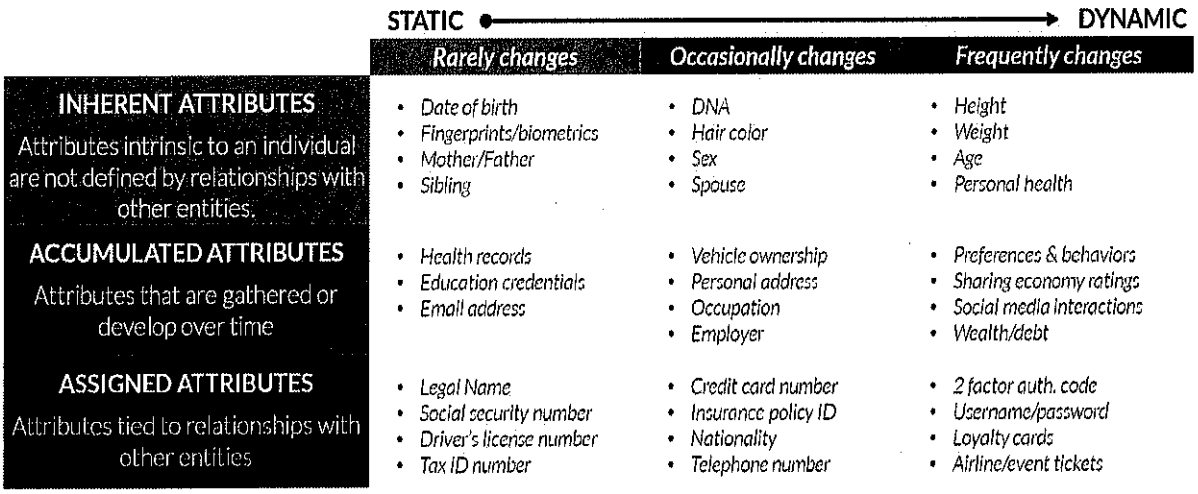
Blockchain technology could simplify the management of trusted information, making it easier for government agencies to access and use critical public-sector data while maintaining the security of this information. At a high level blockchain and distributed ledger-enabled technologies enable government efficiencies in three ways:

- Integrating government services with distributed identity
- Efficiently and effectively managing the flow of digitized assets
- Combining blockchain with other emerging technologies to "reinvent public services"

Integrating Government Services with Identity

What is Identity?

Identity is a collection of attributes about an individual. Identity attributes can relate to an individual's preferences, personality or more sensitive information such as biometrics, healthcare records or criminal history. Attributes can be collected and used for a particular purpose such as verifying an individual is over the age of 21 in order to legally purchase age-restricted goods. Identity attributes can be broadly categorized into three groups: inherent, accumulated and assigned. Some identity attributes rarely change while others change frequently.



The Role of Identity in Government

Government has an important role to play in the development of any digital identity ecosystem. Identity is not only foundational to nearly every government service, but is the basis for trust and legitimacy in the public sector. It is the starting point of confidence in citizen's interactions with government and is a critical enabler of service delivery, security, privacy, and public safety activities. How identity attributes are collected, used, managed, and secured is and will continue to be of critical interest to leaders in the public sector charged with protecting the rights of citizens, ensuring privacy, and ensuring national security and public safety.

In government, a variety of attributes are used to verify a person's identity, allowing them to gain access to government services. Government also provide registers for recording of essential personal identity information. Despite being the primary registers personal identifiable information, government identities are often siloed in databases across agencies, increasing opportunities for fraud, security breaches and errors. [8]

Government identity attributes can be organized into four categories based on their general characteristics and types of services they enable:

Core Attributes

Inherent or assigned personal identity attributes that are generally registered by a government authority. These registers are maintained by entities such as the post office or vital records office.

Core Identity Attributes		
Legal Name (First, Middle, Last, Suffix)	Spouse(Marriage or Civil Union)	Birth Certificate
Date of Birth	Mother/Father/Sibling	Death Certificate
Physical and Mailing Address	Email(s)	Organ Donor
Gender	Phone Number(s)	Criminal History

Service Identifiers

Identifiers assigned to individuals after gaining access to certain government services, mandatory enrollment in government programs, or to exercise legally ordained rights and obligations such as paying taxes or voting.

Service Identifiers		
Medicaid/Medicare number	Unemployment Insurance ID	Passport (Citizenship)
Social Security Number	Voter ID	Prisoner/Correctional ID
Tax ID	Veteran ID	Student ID

Ownerships

Legal instruments that allow individuals or entities to track manage and maintain possession and ownership of high-value physical assets. Ownerships and transfer of ownership is generally maintained by relevant federal, state and local governments in asset registries.

Title/Ownerships		
Land Title	Vehicle Title (Car/Boat)	Firearm Owner's ID (FOID)

Attestations

Information corroborated or certified by a government authority. Attestations either (1) provide individuals permission to perform certain tasks within government or outside of government or (2) substantiate qualifications that were achieved.

Attestations		
Driver's License (Other Vehicles)	Concealed Carry Firearm Permit	Fishing License
Professional/Occupational License	Academic Credential	Travel Visa
Continuing Education Certifications	Pilot License	Military Service

Illinois' PKI Infrastructure

At a high level, Public Key Infrastructure (PKI) is a set of requirements that allow for the creation of digital signatures. Through PKI, each digital signature transaction includes a pair of cryptographic keys: a private key and a public key. The private key, is not shared and is used only by the signer to electronically sign documents. The public key is openly available and used by those who need to validate the signer's electronic signature. PKI enforces additional requirements, such as the Certificate Authority (CA), a digital certificate, end-user enrollment software, and tools for managing, renewing, and revoking keys and certificates.

In 2001, the State of Illinois received certification as a self-signed Public Key Infrastructure (PKI) Certificate Authority (CA) and Registration Authority (RA) following an independent audit. Currently the Department of Innovation and Technology (DoIT), by legislative directive, is the sole source of digital certificates for State of Illinois agencies, boards, commissions, universities, municipal governments and business partners.

Illinois' PKI is governed by roles, policies and procedures to ensure the appropriate management of digital certificates and public-key encryption. Illinois' PKI functions through the creation and issuance of cryptographic keys by the Illinois Certificate Authority (CA) which provides a public key for distribution throughout the user base and a secret key for private use by the entity (or individual) to which it belongs.

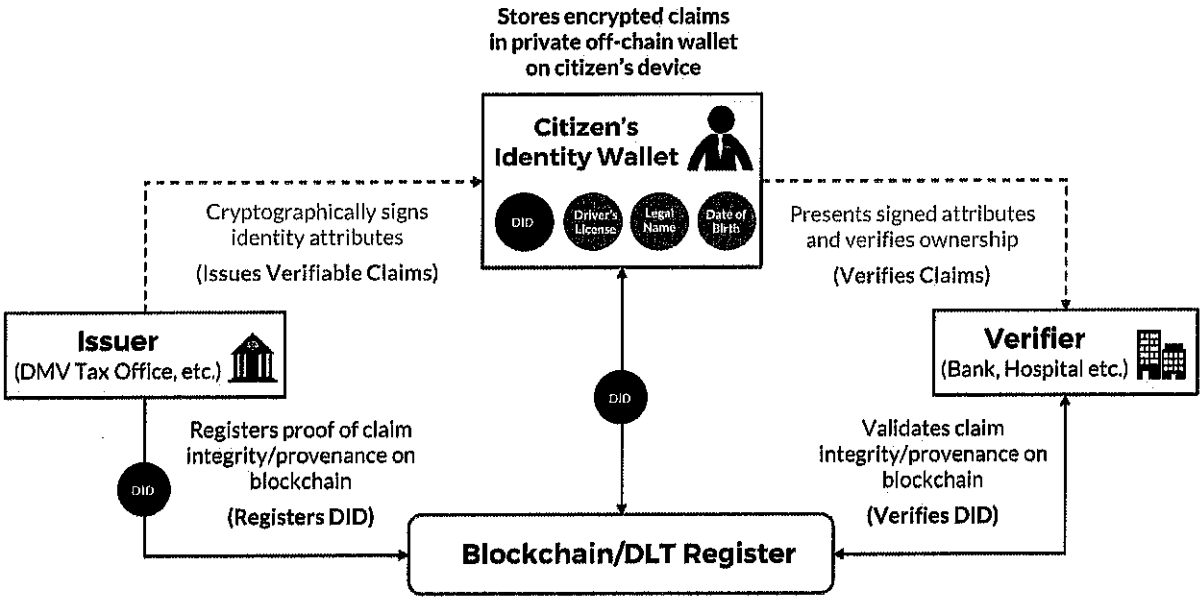
Despite the incremental benefits that PKI affords government services, it cannot be viewed as a cure all data security and identity management solution, rather it is one piece of the puzzle.

Why Decentralized Identity Management on Blockchains?

Related to innovations in blockchain and distributed ledger technologies, decentralized public key infrastructure (DPKI) leveraging blockchains as a machine-readable key-value store is rapidly emerging as a more resilient form of managing public key infrastructure for personal identity data.

The blockchain-enabled identity model relies on the combination of four important standards: decentralized identifiers (DIDs), DID documents, verifiable claims and blockchain/distributed ledgers. ***decentralized identifiers (DIDs)*** are stored on a ***blockchain or distributed ledger*** with a corresponding DID document where collectively they form a key-value pair relationship **(not to be confused with a cryptographic key but rather linked data items: a key, which is a unique identifier for some item of data, and the value, which is either the data that is identified or a pointer to the location of that data).

The DID acts as a globally unique index and the DID document contains a number of essential items including (1) a public key, (2) service endpoint (3) authentication mechanism (how a user cryptographically asserts they are the owner or controller of the DID/DID Document) and (4) ways in which keys can be revoke, rotated or replaced.



Decentralized public key infrastructure affords two improvements over existing public key infrastructure:

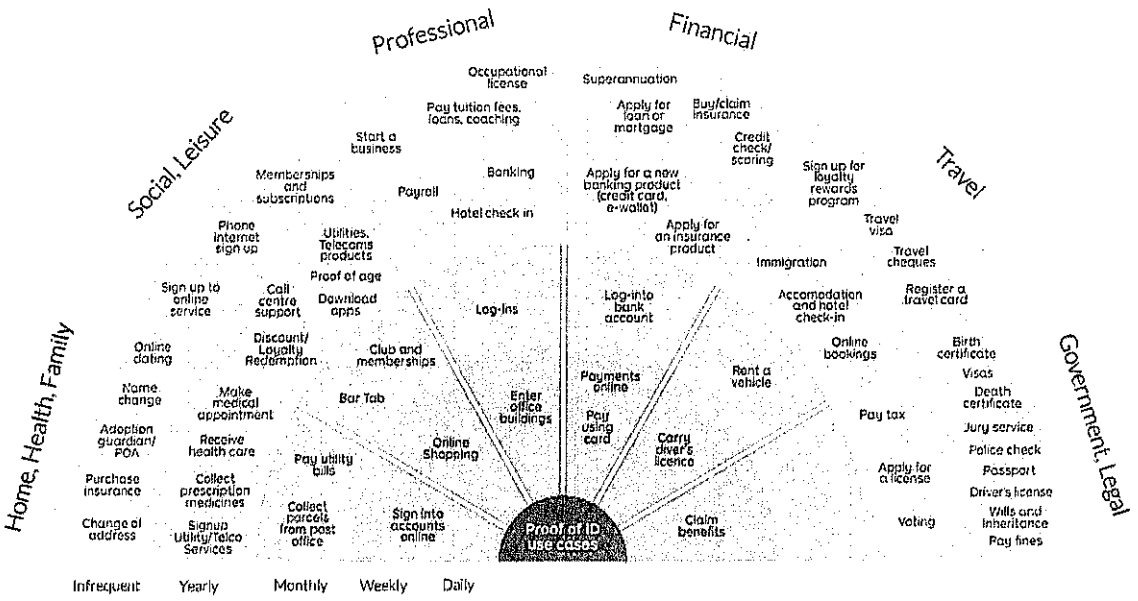
Decentralized Resilience

It does not rely on any single Certificate Authority to check for validity of public keys, rather it uses a globally available blockchain ledger for verification. This has the capability to reduce Man in the Middle (MITM) attacks that are difficult to detect and reduces the risk of a single Certificate Authority being a single point of failure.

Embedding PKI in Each Transaction

DPKI also leverages blockchains to make public key infrastructure more usable. Blockchains by nature require a built-in public key infrastructure mechanism which requires users to use public key infrastructure for every transaction, and if "wrapped" in a well-designed user experience, invisible to the end user. Furthermore, the key pair is pseudonymous, not revealing the actor's actual identity. However, supplemental information, such as name, contact information or professional credentials can be associated with these pairwise unique public-private key pair, merging on-chain and off-chain identity.

A Framework for Government-led Decentralized Identity



A citizen-centric digital identity model based on distributed ledger technologies could be used to consolidate disparate data that currently exists across multiple agencies and layers of government into a network centered around a citizen's or business' credentials, licenses and identity attributes. It would enable citizens to view their public service identity via an identity app on their smartphone and share relevant data with government to access public services. [3]

This new model would reimagine the relationship between state and individual, as government would become the verifier, rather than the custodian, of people's public service identity. Government would move from providing data storage to verifying identity, allowing users to store access to personal data securely on devices.

Protecting personal data in this manner makes it increasingly difficult and economically disadvantageous to hack because each citizen's data stored in encrypted in the cloud with the only keys to unlock the data stored on each citizen's personal device. An attack on this model would require hackers to simultaneously gain access to person data in the cloud, blockchain and a majority of the citizen's devices.

The distributed nature of blockchain means that all departments on the network agree to 'one version of the truth when information is added. Furthermore, if designed well, distributed ledgers have the potential to provide answers that do not present a risk to user privacy. These ledgers allow citizens to share selectively share verified attributes of an identity along with the provenance of the verification or source document. [8]

Efficiently and Effectively Managing Digital Assets

Government plays an important role in the distribution and administration of benefit and entitlement programs for citizens who meet certain eligibility requirements. Examples of programs include health care, welfare, unemployment, and housing assistance. Government could leverage blockchain and distributed ledger technology to distribute benefits more efficiently, reducing entitlement fraud and increasing asset transparency for taxpayers. Effectively managing assets in government can be thought of in two ways:

- Digitizing physical assets ("tokenizing assets") to increase asset transparency, improving liquidity and policy outcomes for incentive programs or titled assets.
- Managing revenue collection, or benefit and incentive distribution on a shared ledger with smart contracts to provide granular control over and real-time insight into complex administrative processes.

Digitizing Assets

Smart contract enabled distributed ledgers such as the Ethereum blockchain provide a standard for granularly representing physical assets on a blockchain in the form of a "token". Representing items such as shares, cars, property, or tax credits as tokens on a blockchain allows assets to be transacted, fractionalized or collateralized similar to a share or other financial instrument.

All users, transactions and data are digitally recorded on the blockchain, creating an immutable record. The irrefutable record can dramatically reduce the cost and complexity of auditing, reconciliation and issue resolution as there is a clear and traceable audit trail of transactions, data and user interactions. Not only can this can lead to a material reduction in paperwork and more efficient asset transfer processes, but by significantly reducing transaction costs, blockchains could help public sector open up credit and securities markets for whole new classes of lower-value or non-traditional assets. There is also a unique opportunities to create liquid secondary securities markets where assets can be fractionalized and traded as futures, options, or shares similar to oil, corn or other commodities.

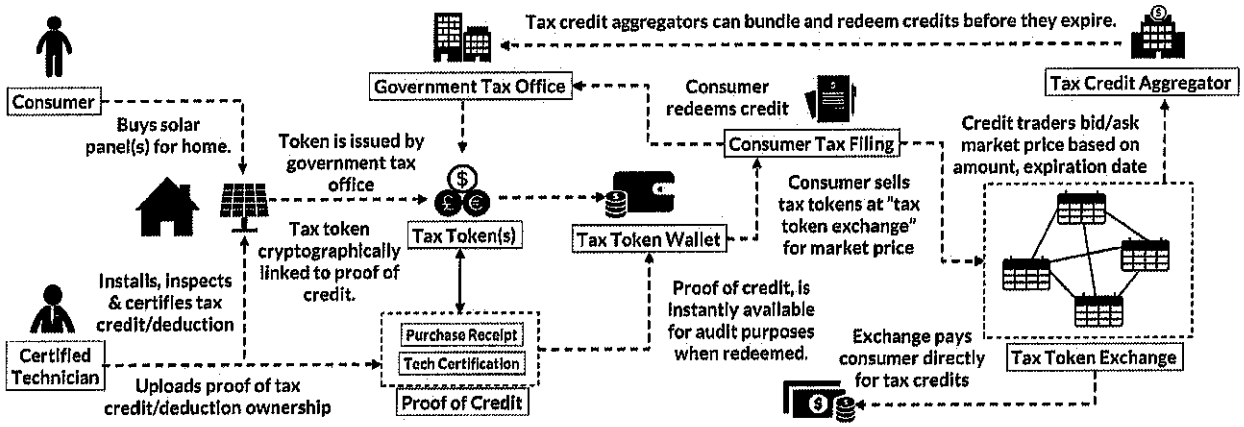
Examples of public sector assets that could be digitized include:

Loyalty Rewards	Pension Liabilities	Tax Credits
Digital Currencies or Tokens	Municipal Bonds	Unclaimed Property
Prison Commissary Funds	Affordable Housing Vouchers	Highway Tolls

Use Case Snapshot: Tokenizing Tax Credits

Tax credits could be categorically "tokenized" on a blockchain to improve market visibility and ensure asset provenance. Government could also open an exchange where the "tax credit tokens" could be traded, improving their liquidity and ensuring the efficacy of the policy goal that the credit incentivizes. A blockchain-based system of management also allows aggregators

granularly pool credit (or derivatives of) while maintaining direct visibility into its initial issuance.



Social Benefits and Incentive Program Distribution

The State could also consider creating a blockchain platform to increase efficiencies and reduce costs for companies to comply with the State's workers compensation system. With the State's creation of a private permissioned blockchain consortium for workers compensation, all transactions are logged, including information on the date, time and participants, as well as the amount of every single transaction in an immutable record. Each party in the network would be party to a complete copy of the blockchain, and the transactions are verified using advanced cryptographic algorithms. This is the equivalent of a free notary present at each transaction. The employer's workers compensation insurance companies pay for workers compensation healthcare expenses to certified medical practitioners in the system.

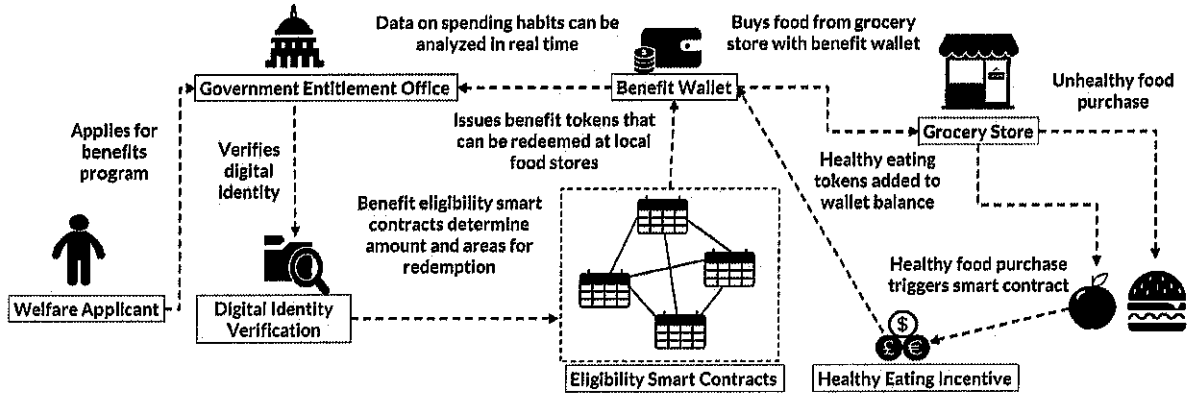
Similarly, many government grants and incentives programs are eligibility based, where a grant is either approved or denied based on the meeting of certain requirements. The difficulty in this process arises due to the data being held within disparate government and private entities, making the eligibility process time consuming and resource intensive to get right. Rolling up all of these systems into one distributed ledger simplifies the eligibility process. Upon eligibility, a smart-contract can trigger a grant payment to the recipient instantly.

A distributed ledger is an ideal technology to supplement the Medicaid enrollment and eligibility process. In this scenario, the State of Illinois maintains a distributed roster (ledger) of eligible Medicaid members. Data is fed into this ledger from various sources, including the member's employer or former employer and records from the federal and state government. This allows the eligibility status of a member to stay in constant sync. Should a member fall out of coverage once they find a stable job, a smart-contract would automatically terminate their enrollment in the program. A distributed ledger solution simplifies the system by rolling up the currently siloed databases and connecting them to shared eligibility ledger.

SNAP/TANF	Student Loans	Housing Support
Medicaid/Medicare	Disaster Recovery Grants	Tax Collection
Unemployment Insurance	Research Grants	Municipal Grants
Worker's Compensation	Agricultural Price Support	Conservation Grants

Social Benefits Distribution Use Case Snapshot

An interesting application could be an "entitlements digital currency" for benefit programs such as food stamps. Providing a digital identity verification would help the program accurately verify applicants and reduce fraud. Smart contracts could precisely determine eligibility efficiently and effectively. An additional "healthy eating token" incentive system could be offered to achieve ancillary health policy goals, providing additional cost savings for other health benefits systems.



Convergence: Reimagining Public Services

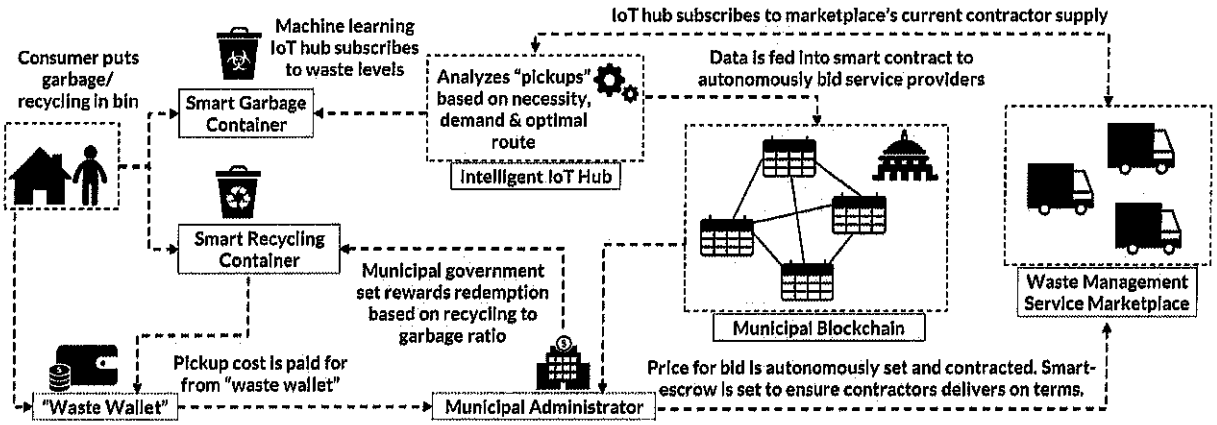
Illinois could also explore the feasibility of integrating other emerging technologies such as IoT or Artificial Intelligence with blockchain to (1) develop new products and (2) reinvent traditional services. New products could include peer-to-peer service marketplaces that monetize non-traditional datasets. Reinventing govt. services could involve using a combination of AI and smart contracts to automate complex eligibility processes or to re-engineer social benefits programs so that funds are pre-distributed to recipients.

For example, an interesting application of a blockchain-enabled public service application would be a sharing economy public transit service provided by the State of Illinois. With autonomous vehicles on the horizon, it is entirely possible to have a state-operated on-demand vehicle service that is hosted on a distributed ledger. In fact, private companies such as Arcade City are already providing rides to consumers by using a distributed ledger.

Use Case Snapshot - Device Marketplace for Waste Management

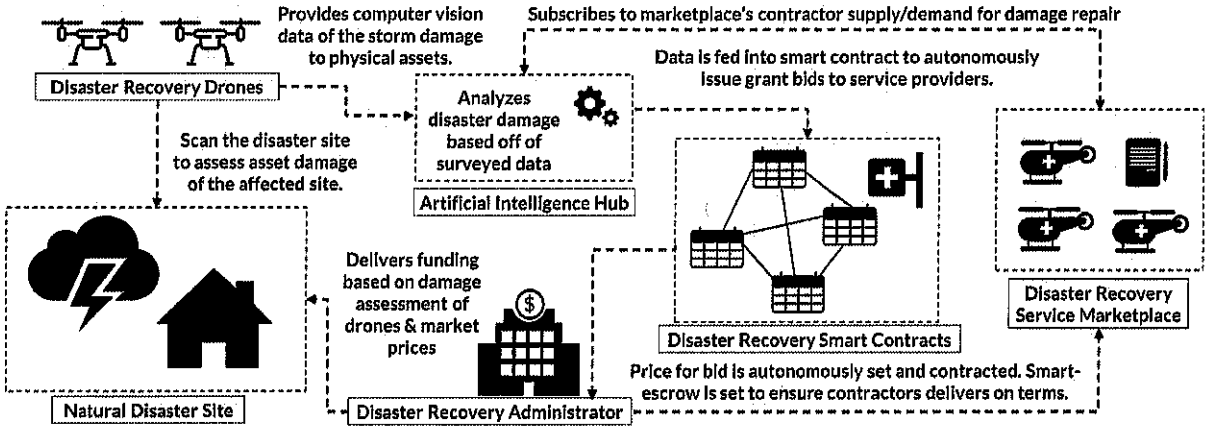
By combining blockchain, IoT, and big data, governments could create demand-based marketplaces for tasks such as waste management, recycling services or snow removal. Sensors data could be fed into a blockchain system, where it interacts with smart contracts to

determine demand autonomously. Price would be determined by sensors and service providers are sourced automatically based on conditions in the smart contract.



Use Case Snapshot – Disaster Recovery Grant Distribution

Many grants are based on eligibility criteria and are approved or denied based on a person or entity meeting pre-defined requirements. Rolling up all systems into smart-contracts managed by a distributed ledger could radically simplify the eligibility process. Upon eligibility, a smart-contract could trigger a grant payment instantly. For example, disaster recovery "smart contracts" could use a combination of computer vision data and IoT sensor data from drones providing an "oracle" to automate the disaster recovery eligibility process.



Blockchain in Government Pilot Database

Over the past year, the Illinois Blockchain Initiative has compiled a database of over 200 blockchain and distributed ledger technology pilots, projects and strategies announced by public sector entities. The database is an overview of how government at various levels globally

are employing blockchain technology in their efforts to govern, improve the competitiveness of their economy and also deliver high-quality services in a more efficient manner.

The public sector is one of the most active blockchain sector's exploring the technology for a wide variety of use cases. Adoption of the technology in the public section is accelerating at an extraordinary pace.

The database can be found at the following link: http://bit.ly/govt-tracker-database

Appendix A: Legislative Recommendations

Reconcile State Digital Signature Laws With UETA

The Uniform Law Commission created the Uniform Electronic Transactions Act in 1999, which provides standards for retention of electronic records and the validity and use of electronic signatures. Though Illinois has some statutory language allowing electronic signatures, a push towards a blockchain-based system is an opportunity to again review whether Illinois should make an effort to fully join the rest of the nation and place itself on a path towards more efficient and secure paperless recordkeeping.

Modernization of Notarial Statutes

The Uniform Law Commission has created the Revised Uniform Law on Notarial Acts (RULONA) to reflect the changing nature of technology. A shift towards allowing electronic or video notarizing, perhaps tracked and verified on a public blockchain, would help modernize Illinois law in a clear direction towards electronic commerce and away from the ease of fraud that can be committed by paper-and-stamp methods. A holistic look at state notary laws should include an analysis of remote video notarization enablement, biometric based notarization as well as other technology enabled methods which would be a move that would better facilitate electronic transactions.

Self-Notarization of Documents

One of the basic functions a blockchain can provide is proving that a specific computer file or document existed at a certain point in time (akin to a "poor man's copyright"). Allowing documents that have had their hash values permanently timestamped and embedded into a known, trusted and public blockchain to be admitted as evidence in state courts would create efficiencies by removing the need for a lawyer to visit an office, purchase paper, then have that office expend taxpayer resources to physically mark that printout as "certified." This is also a step towards streamlining Illinois' public land record to be a record of text-data, as opposed to a registry of PDF scans of legal instruments that must be independently verified and inspected each time they are used. A specific instrument's SHA 256 hash fingerprint could be included in the public record as a way to avoid having government foot the expense of storing terabytes of bulky PDF or TIFF files.

Clarity to "Pure Notice" Conveyance and Recording Statute

A central issue in the legality and validity of property records centers on whether a state is a "race to the courthouse" state, a "notice" state, or a "race-notice" state. This refers to how competing disputes by "subsequent purchasers" as to ownership of a property are resolved, focusing on whether ownership claims that are unrecorded and thus unknown to subsequent purchasers adversely affect these bona fide purchasers who took title in good faith with no

knowledge of previous claims or interest. It is the opinion of this Task Force that the case law that has misinterpreted the plain language of Illinois' "pure notice" statute to be a "race-notice" should be invalidated by clear instructions of the General Assembly, simply by adding a clarifying statement to the existing statute. [17]

Require Claims Against Real Estate to be Publicly Recorded

Though clarifying the notice requirements and effects in Illinois will go a long way towards shaping a logical public record and maximizing its benefit, allowing valid claims to remain unrecorded (including those by local governments) is something that should be re-examined in our modern age of computers, electronic recording, and overnight mail. It is no longer a burden for a person with a valid claim to simply place that claim in the public record, and it must be examined whether allowing uncertainty to exist in property records is truly serving the interests of taxpayers and property owners. This will make Illinois' public land record a true record that can be easily agreed upon, and not simply a record of those interests claimants felt like recording. A single record of claims will make title research easier and cheaper, and make a transition to a distributed ledger more attainable and valuable.

Reproduction Versus Storage

If the goal of a public land record is an accurate description of events between private parties, a system that manually recreates those records does not achieve this goal. Section 3-5010 of the Recorders Act, entitled "Duties of recorder", refers to duties related to "instruments in writing." This Section heavily focuses on reproducing written submissions and implies that a recorder must always "reproduce" what has already been created. This leads to inefficiencies and errors. A possible update to this section could allow for direct submission of plain-text data that was used to create the transaction into the public record, which would technically not be a "reproduction," but would provide 100% accuracy in the record of what actually occurred. As a background, recorder's office manually create indices of submitted records, a process that is vulnerable to human error and results in discrepancies that must be "insured" at the taxpayers' own expense. Such an update would not preclude private parties, through their settlement agents or attorneys, from providing hash-values for the lengthy contracts used in the transaction, allowing them to be used for evidentiary purposes in the future without requiring that costly client-server storage models be used to maintain millions of pages of unnecessary information.

Omnibus Real Estate Records Submission Modernization

Though Illinois law allows documents to be electronically submitted, industry conventions, and in some cases, the plain language of the law, confines practice to paper-based methods. For example, in outlining some duties of a Recorder, the law states "...No recorder shall record any instrument affecting title to real estate unless the name and address of the person who prepared and drafted such instruments is printed, typewritten or stamped on the face thereof in a legible manner..." (5/3-5022). A focused effort to update these laws to allow text-only

records that have no "face" but still contain the needed information would be a great facilitator of blockchain-based recordkeeping. This inquiry should also focus on the Conveyances Act, and any section that specifically states how a record must be worded and constructed. For example, language such as "..the name and address of the preparer shall accompany any record affecting title to real estate..." would begin a shift away from paper-based modes of document submission and retention.

Statewide Unique Real Property Parcel Numbering System

For a blockchain-based property registry to work, every parcel of real estate must have a unique number to identify it (much like the interstate and international VIN system for automobiles). Earlier this year, the Real Estate Standards Organization (RESO), issued guidance for creating a universal Property Unique Identifier for real estate, similar to the VIN number for a vehicle. It combines ISO Country and FIPS County codes and incorporates the local unique identifier to create a system to uniquely number and identify parcels across a state. Legislation could simply adopt this standard and require counties to report whether they use a unique numbering system and adopt one if it does not. [12]

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