MEMORANDUM

TO: Mayor and Council Members

FROM: Daniel Culotta, Interim Chief Innovation Officer

THROUGH: Jason Alexander, Chief of Staff

DATE: September 14, 2022

SUBJECT: **Blockchain Technologies (Resolution No. 20220324-057)**

This memo provides an overview of staff efforts in response to Resolution No. 20220324-057 which include creating a supportive environment for blockchain and Web 3.0 development in Austin. It has an attached report, written with inputs from multiple City departments, which explores blockchain technology in more detail and describes areas for potential applications in municipal government. The report also provides guidelines for evaluating blockchain technologies for the City organization.

Creating a Supportive Environment

Since March 2022, City staff have worked to create an environment in Austin that supports the creation and development of new blockchain technologies, protocols, and applications. Actions include speaking engagements and collaborations that covered blockchain topics at the following conferences and events:

- Launch of the Capital Factory and DivInc Blockchain Challenge and Accelerator
- Government Finance Officers Conference
- Consensus Conference
- Accenture AustInnovation Day (alongside UT President Jay Hartzell)
- The Friedrich Naumann Foundation International Delegation on blockchain and cryptocurrency

City staff met with multiple blockchain and cryptocurrency experts, organizations, and companies to understand what they value in a supportive community for Web 3.0 development. Staff also collaborated on the Consensus Web3athon hackathon, which has convened teams to work on blockchain solutions to some of Austin's most pressing social and environmental challenges.

The Innovation Office continues to promote and share knowledge on LifeFiles, which is a grant-funded prototype platform created in 2019-2020 that incorporates blockchain technology to allow people experiencing homelessness to secure, store, and share documents that are vital to accessing supportive services. We continue to generate media attention with this project, and though we have not identified a collaborator to continue developing the platform, we are optimistic we will do so in the future.

Key Considerations for the City organization
The ecosystem of products and services which incorporate blockchain technology is rapidly expanding and evolving. In the attached report we highlight areas of opportunity and provide general knowledge and guidance on the current blockchain ecosystem. We hope City departments can use these guidelines and information in the creation, development, and adoption of blockchain and Web 3.0 solutions.

There are municipal use cases which could benefit from blockchain solutions. These primarily involve validating, tracking, and improving transparency for certain types of records and transactions. However, many blockchain-based solutions and their providers are still being proven, and there are environmental, equity, and ethical concerns with the space in general. Considering this, we recommend that City departments create a deep understanding of the challenges that a blockchain solution purports to solve, and work with the Communications and Technology Management Department (CTM), Office of Innovation, or other technologists to evaluate alternative proven technologies or approaches that may provide the same level of utility and outcomes. More details on all these points are contained in the attached report.

Staff will continue to monitor the blockchain and Web 3.0 space and create a supportive environment for its development in Austin. We will also continue to evaluate appropriate use cases and opportunities to deploy blockchain technologies in the City organization.

If you have additional questions, please contact me at daniel.culotta@austintexas.gov or 512-710-9503.

cc: Spencer Cronk, City Manager

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/ City of Austin Office of Innovation

Understanding and evaluating blockchain solutions

Date / August 2022
Version / 1.0

1.0 / Purpose

This report accompanies the memo in response to City Council resolution 20220324-057, which asks City staff to explore potential applications of blockchain technologies for the City organization.

The ecosystem of products and services which incorporate blockchain technology is rapidly expanding and evolving. This report highlights areas of opportunity, and provides general knowledge and guidance on the current blockchain ecosystem. Others have written extensively on this topic ([e.g. 1]), but we hope City of Austin departments can use these guidelines and information to understand, contextualize, and evaluate blockchain solutions and the use cases that may benefit from them.

The report is organized into the following sections:

[1] OECD Blockchains Unchained: Blockchain Technology and its Use in the Public Sector

2.0 / Blockchain Basics

Blockchains are immutable, distributed ledgers (which are often public, but do not have to be)[2]. They are typically used to record transactions or events. The consensus process used to validate information on blockchains produces cryptocurrency for the validator, which is what incentivizes nodes[3] to participate as validators on public chains.

Many applications write data to, or reference data from, public blockchains such as Bitcoin and Etherium, and do not have their own blockchains. Others may have their own chain, but many of these chains are less stable, mature, or widely accepted than the preeminent chains. When considering a technology, it is important to understand which blockchain(s) it utilizes, and how.

Some applications and ecosystems utilize private blockchains. Access to private blockchains is restricted by the companies that own them (access is typically granted to their application's users). In addition to regulating access and permissions, private blockchain operators can override, edit, or delete entries on their blockchain. Permissioned blockchains are a middle ground; they can be accessed and used by anyone that has been permitted to do so by administrators. Often, their information is visible to all, and administrators do not have the ability to override, edit, or delete entries. In contrast, public blockchains are the most widely known, and are what is referenced when the aspects of transparency, accessibility, and immutability are touted by blockchain advocates. Their access is unrestricted, and they have no centralized operator or regulating authority.

Applications based on private and permissioned blockchains can be attractive because they are often comprehensive, tightly controlled, and robust because the companies that create them control all aspects of the ecosystem. However, because private blockchains lack the transparency, accessibility, and immutability of public chains, they forfeit most of the attributes that make blockchain technology conceptually attractive in the first place. However, permissioned blockchains may have increased applications for government since they still allow for transparency but their access is governed, which would help decrease fraudulent or erroneous information from being permanently recorded and subsequently used.

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[2] There are many visual representations of how blockchain works, this one for example.
[3] Nodes are computers that run the software that validates and stores the history of transactions on the blockchain network.

3.0 / Advantages of Blockchain

Immutable

One of the primary advantages of well-established public blockchains is their immutability, i.e. they cannot be changed. This is due to their reliance on a distributed network without a central administrator or arbiter of truth. Because identical copies of the blockchain are distributed across thousands of computers on the network, each of which is updated simultaneously, any attempt to change a record on one copy of the chain would be immediately apparent because it would not match all the other copies. In order to modify information on a blockchain, someone would have to change the majority (i.e. 51 percent) of all copies of a blockchain in the same way at the same time across the globe, which is effectively impossible on large, established chains. Because there is no way to change the majority of the copies of a blockchain, the information written on them is permanent. This is the case even if the information recorded to the blockchain is incorrect. In that case, appending the blockchain with the correct information is the only option, and the incorrect information will also remain.

Immutable is often used interchangeably with secure, but this is incorrect. Security implies something cannot be taken; just because information on blockchains cannot be changed does not mean it cannot be accessed. In fact, public blockchains are accessible and transparent, so all information contained on them is free to be viewed or taken for all time. The security of the information provided to an application that interacts with a blockchain is based on the design of the application itself, not on the blockchain that it writes to and/or references.

Transparent

Public blockchains offer a high level of transparency and accessibility. Anyone can see all of the information recorded on public chains, which means they can view the details of any transactions recorded on the chain. This can be an advantage in situations where information about transactions can be disputed, there is a need for increased auditability and accountability, there is low trust in the institution which is responsible for maintaining transaction records, or the institution responsible for governing transactions is vulnerable to security risks.

Accessible

The decentralized nature of blockchains means they require no centralized authority to enter or validate the data that is written to them. This is what is meant when blockchains are referred to as “trustless”; there is no authority you must trust to enable or uphold transactions or recorded information. For example, with cryptocurrency, banks are not necessary because users exchange cryptocurrency directly, and use the blockchain as the irrefutable record of the transaction. “Smart contracts”[4] can be written which trigger transactions on a blockchain when certain conditions are met, further reducing the need for institutions or authorities to enable or validate transactions.

4.0 / Disadvantages and tradeoffs

Regulation, Governance, and Security

Because there is no institution which governs blockchain transactions, it places the onus for establishing transaction rules and submitting the correct data (and completing the actual events that produce that data) on the users involved in the transaction, and the authors of smart contracts. If there is error or fraud, there is little opportunity for recourse. People are also not prevented from submitting incorrect or fraudulent information in a blockchain transaction. In this case permanence can be a liability since the incorrect information cannot be removed from the blockchain, and a correction or retraction can only be submitted as a subsequent transaction. If the incorrect or fraudulent transaction led to a distribution of resources or a provision of services, there is no way to recover or reverse them.

A lack of regulation and governance also extends to security and access. For example, if a user loses access to their cryptocurrency wallet credentials (or they are stolen), there is no central organization or authority which can help recover them. In 2021, it was estimated that 20 percent of the 18.5 million Bitcoin mined at that time were rendered inaccessible in wallets with lost credentials[5]. At the time the article was written, this represented about $140 billion. These assets can never be recovered if the access credentials remain lost.

However the blockchain and cryptocurrency ecosystem may not be as trustless and decentralized as they seem. Large exchange platforms and applications, which are owned and managed by companies, now house the vast majority of cryptocurrency and non-fungible token (NFT) transactions and purchases, essentially making them centralized authorities that one must trust to utilize blockchain services. Programmers can decide to fork chains or create new ones, essentially creating a new set of operating rules that they get to set. And blockchain applications piloted in developing nations have been accused of replacing state and government controls and processes, effectively turning the companies that own the applications

[4] Smart contracts are programs stored on blockchains that automatically run when certain conditions are met.

[5] NYT Lost Passwords Lock Millionaires Out of Their Bitcoin Fortunes

into the governing entities in these locations[6]. In Central America, multiple private cryptocurrency cities, which will be completely governed by the businesses that run them and operate independent of the country's laws, are actively being constructed[7].

Transaction Speed

Blockchain applications can be slow compared to other technologies. For example, the Bitcoin chain can process about seven transactions per second, and the Ethereum chain can process about 20. Depending on the number of transactions waiting to be processed into blocks, a transaction on the Bitcoin chain could take hours to validate. Traditional payment, transaction, and database systems can function many times faster (for example, the credit card company Visa can process 24,000 transactions per second). Because the transaction limits are part of the basic architecture of blockchains, speed will remain an issue as the technologies continue to scale.

Cost

Transactions or events recorded on a blockchain can be costly, and those costs can vary. Transaction fees are how miners are compensated for validating blocks. Transaction fees are based on the size of the transaction (more bytes in a transaction equates to more fees), the age of the block the transaction is written to (as the chain grows, fees grow), and the priority determined by those involved in the transaction (you can pay more to have your transaction processed faster, and fees increase when the number of transactions queued for validation is high). On top of that, there are usually service fees when transacting on cryptocurrency and NFT exchanges. These fees are on top of transaction fees for writing to the blockchain itself. Bitcoin transaction fees average $2-5 per transaction, and the service fees vary widely, from less than $1 to upwards of $500 depending on the type and size of the transaction. Costs also make clear that public blockchains are meant to function primarily as ledgers, and not for data storage. Storing a megabyte of data in a traditional cloud-based database costs a few cents. On the Bitcoin and Ethereum blockchains, it would cost over $15,000.

Maturity

The early-stage development of the blockchain and Web 3.0 ecosystem is a liability. Blockchain use cases are still being tested, and cryptocurrency markets are subject to extreme volatility (e.g. crypto markets fell approximately 70% in spring 2022, and such swings are not uncommon). In addition, many companies in the space are still in the startup stage. Uncertainty will persist until applications of these technologies are proven and markets stabilize.

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[6] Jutel (2021), Blockchain imperialism in the Pacific
[7] MIT Technology Review Crypto Cities

Equity

A number of practices and policies have excluded communities of color from aspects of the traditional financial system and mechanisms for wealth accumulation. Cryptocurrencies, stablecoins, and NFTs (collectively, cryptocurrencies) may appear to be answers to these challenges, but in reality involve significant equity and sustainability issues that stem from their easy access, lack of regulation, high energy use, and extreme volatility[8].

Companies are increasingly marketing cryptocurrencies to Black, Indigenous, and people of color (BIPOC) communities as a vehicle for rapid financial gain that does not require access to or regulation from banks or other financial or industry middlemen. Stories of small investments that turned into fortunes overnight are becoming more common in the media[9]. As a result of these marketing efforts, people of color are quickly becoming major adopters of cryptocurrency and related assets[10].

However, cryptocurrencies share many of the hallmarks of predatory financial products which have been focused on communities of color in the past, such as subprime mortgages, check cashing services, and payday loans. Such products seemingly offer an avenue to stability and wealth that circumvent the traditional and discriminatory financial system, but in fact carry extreme risk of fraud and loss, and little to no regulation to protect consumers.

To put the potential for volatility into perspective, investment in cryptocurrencies skyrocketed in 2020-2021. Yet in early-mid 2022, Bitcoin, the preeminent cryptocurrency, lost over 70 percent of its value from it's high the previous year, and the entire cryptocurrency industry was reduced in value by over two trillion dollars (about two thirds of its total value) due to a market collapse - and such swings are not unprecedented. For comparison, the S&P 500 index fell 18 percent over the same period, which is considered a major decline for the stock market. One of the founders of the largest cryptocurrency exchange estimates that over 90 percent of NFTs will be worthless within five years[11]. Complaints regarding cryptocurrency to the Consumer Financial Protection Bureau went from 488 in 2019 to 979 in 2020, to more than 1,400 in 2021[12]. Crypto firms themselves project that thousands of cryptocurrencies will collapse or essentially be worthless [13]. Volatility of this kind is historically not uncommon in cryptocurrencies, and due to a lack of regulation or consumer protections in this space, little can be done to protect against or remediate fraud or losses.

Furthermore, as described in the Sustainability, Climate, and Resilience section, cryptocurrency mining requires a massive amount of power, and Texas is one of the leading locations for

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[8] Brookings Institute
[9] Washington Post
[10] Kansas City Fed
[11] Bloomberg
[12] American Banker
[13] CNBC

cryptocurrency miners in the world. In other states that have seen growing cryptocurrency mining, costs for expanding infrastructure to meet the overall increased power demand have been passed on to customers. In upstate New York, cryptocurrency mining is estimated to have increased all residential energy bills by $8 per month, and $12 per month for small businesses[14].

Anyone investing in cryptocurrencies should understand the risk of financial loss and lack of protection when engaging with these assets. Furthermore, the City should help educate BIPOC communities, which are increasingly the target of cryptocurrency marketing, about the risk, fraud, industry immaturity, and lack of protection that currently defines the space.

Sustainability, Resilience, and Climate

The environmental and climate change implications of cryptocurrency and blockchain technologies has been well documented, and are due to energy use. The amount of energy a blockchain requires is largely due to the type of consensus mechanism it relies on to cryptographically verify transactions (these verifications are rewarded with cryptocurrency, and are what is referred to as "mining"). For example, the Bitcoin blockchain uses a proof of work consensus mechanism, which becomes more complicated - and thus, more energy intensive to validate - as the chain grows. Computers validating transactions on Bitcoin's chain now use more electricity annually than the entirety of The Philippines, i.e. about 91 terawatts (70 times more energy than is used across Austin annually). Nearly all of this energy comes from fossil fuel sources which emit greenhouse gasses - an estimated 40 billion pounds of carbon emissions per year[15] - that increase the effects of climate change. While other industries use as much or more energy, most provide significantly more utility to society than cryptocurrency and blockchain applications currently do.

The two current largest blockchains - Bitcoin and Etherium - both use energy-intensive proof of work consensus mechanisms. Multiple smaller chains do as well, as well as the thousands of applications that are built on these chains. Etherium is proposing to convert to a much more efficient proof of stake consensus mechanism in September 2022, which would dramatically cut its energy requirements. It remains to be seen if this shift will occur.

In Texas and other oil and gas-producing states, cryptocurrency miners are locating near oil and gas wells to capture natural gas that would otherwise be flared off as waste and turn it into electricity that powers their mining equipment. While this does utilize natural gas that would otherwise be burned straight into the atmosphere, because it is dependent on the byproduct of oil and gas wells, it still creates emissions and increases the market for fossil fuels which undercuts the City's climate goals.

Cryptocurrency miners are locating near power generation stations of all types. The City of Denton, Texas struck a deal with a cryptocurrency mining company to locate in its natural gas

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[14] Upstate NY electricity cost increases
[15] Environmental impact of cryptocurrency

power plant in exchange for a projected $16M+ per year[16]. However, this project will double the amount of electricity used in Denton, a demand increase that will be met by power from the natural gas plant with its associated greenhouse gas emissions. Furthermore, the mining company's shares fell nearly 80% in 2022[17], calling into question the ROI projections cited in the deal. Though cryptocurrency mining projects often employ various types of carbon offsets, many of these are structured as creative accounting exercises, and the greenhouse gasses that mining produces are still released into the atmosphere where they contribute to climate change.

Finally, the proliferation and State-level support of cryptocurrency mining in Texas will further tax our power grid[18]. Texas has become a hotspot for cryptocurrency mining, with an estimated 25% of all U.S. cryptocurrency mining occurring in the state[19]. Currently, the Texas power grid has about 92 gigawatts of generation capacity in perfect operating conditions. In July 2022, demand hit an all-time high of 78 gigawatts, which seriously strained the grid and led to calls for conservation and talks of potential rolling blackouts. The cryptocurrency mining projects proposed for the next four years would add 27 gigawatts of demand to the grid. Even if the actual increased demand from crypto mining is closer to the more modest 5 gigawatt projection, this still exceeds the amount of demand that strained the grid to a near-maximum in 2022. It also doesn't take into account the population growth for the state (and its associated power demand), which is projected to continue[20]. To avoid grid collapse, we will have to build additional infrastructure, whose costs will almost certainly be passed on to electricity customers. Though many of these mines have agreed to shut down during power emergencies to help ease the load on the grid, there is no law that they must do so.

5.0 / Guidelines for Considering Blockchain-Based Solutions

Again, blockchains are simply distributed, immutable ledgers used to record transactions or events. Due to the amount of investment in the blockchain and cryptocurrency space, there are products which incorporate blockchain for nearly every sector and application, regardless of whether blockchain is the most efficient and effective technology to use in that particular case. City departments will need to make decisions on whether to adopt blockchain products and

16 Denton Crypto Mine
17 Core Scientific Stocks Fall
18 TX Power Grid Strain from Crypto
19 TX Share of Crypto Mining
20 University of Houston TX Population Projections

services not based on whether they *can* (there is almost certainly a product that exists for whichever application they're investigating), but rather whether they *should*.

Put another way, staff should consider whether a blockchain-based application is the best solution for what they are solving for, or if another solution or technology is more efficient ,adaptable, and sustainable.

City staff should use the following questions when evaluating a blockchain-based solution. They may also seek additional decision criteria that are broader or more specific in scope, depending on the initiative in question [e.g. 21]. In general, if the answer to one or more of the following questions is "no", a different type of product or technology is likely a better fit.

1. Are you searching for a solution for a process which involves recording transactions or events that are relatively small in size from a data standpoint? (Large amounts of data are very expensive to store on blockchains.)
2. Does your information need to be recorded on an immutable ledger which can never be changed (even in the case of an error), only appended?
3. Does the information need infrequent (or no) updating, changes, or deletions?
4. Is (or should) the information be available and viewable to anyone, forever? (If no, a solution using a private blockchain may be viable, but see the section on private blockchains.)
5. Are the transactions or events you need to record relatively low in number?
6. Does the blockchain product you're considering rely on a consensus mechanism that is energy efficient? (For example, the proof-of-work consensus mechanism is highly *in*efficient.)
7. Is there a regulation or network-wide practice that requires your information to be recorded in a certain place, and/or by a specific entity? (If so, a blockchain solution will be redundant unless you can also change the regulation and/or network-wide infrastructure.)
8. Is there little to no exposure to volatile cryptocurrency markets for the City organization and residents?

If the answer to all of the above questions is yes, a blockchain-based solution may be a good fit. Please consider the questions carefully; very few use cases meet all the criteria. The blockchain and Web 3.0 ecosystem of products, services, and companies are still very early in their development cycle, and in many cases are still unstable and vulnerable to dramatic swings in cryptocurrency markets, technological advancements, or broader business trends.

Furthermore, the federal government is researching cryptocurrency under an executive order from the Biden Administration[22], and will likely enact legislation that sets up a regulatory

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[21] Stanford Social Innovation Review Web3 and the Trap of 'For Good'
[22] White House Executive Order on Ensuring Responsible Development of Digital Assets

framework for those markets and assets. This will affect other areas and products of the blockchain and Web 3.0 world due to the interconnections with cryptocurrency. Other states and municipalities are piloting cryptocurrency and blockchain applications and use cases[23,24,25,26,27,28] which in many cases exhibit heavy volatility, but may ultimately help stabilize the landscape.

6.0 / Alternative Technologies

There are other technologies that offer data recording, storage, and transaction capabilities that should be considered alongside blockchain solutions. We encourage you to work with the Communications and Technology Management Department (CTM) or other technologists to understand the nuances of your requirements and use case, and how these or other options compare to blockchain-based applications. Alternatives to blockchain technology include (but are not limited to):

- **Centralized databases** - traditional databases that can be high-performing and secure based on their design. Useful in instances that require large amounts of data storage or fast processing, and that do not necessarily need a distributed network architecture.
- **Distributed databases** - databases distributed across multiple nodes but appear to the user as a single database. Different nodes work in tandem to address database queries. This is proven technology that uses data replication, duplication, and data structures like Merkle Trees to ensure integrity. Slower with more overhead than centralized databases, but less vulnerable to attacks.
- **Other types of distributed ledgers** - proven technology that can be used for trusted distributed applications. Many rely on the Directed Acyclic Graphs (DAGs) architecture, which has been used in applications for decades. These technologies can write to their ledgers quickly, but validation can be slow. Peer-to-peer architectures also exist, and multiple examples now enable smart contract functionality.
- **Centralized ledgers** - shared databases designed for ledger-like applications which can provide transparency, immutability, and scalability when a distributed network architecture is not required. Blockchains may be preferable in cases that involve untrusted parties transacting, or where vulnerability to attack is very high or security resources are inefficient.

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[23] Blockchain in California: A Roadmap
[24] Colorado Cryptocurrency for Tax Payments
[25] Miami Cryptocurrency and City Coin
[26] Fort Worth Cryptocurrency Mining in City Hall
[27] Denton Cryptocurrency Mining
[28] City of Reno's Blockchain

- **Decentralized storage** - these solutions encrypt data and distribute it across multiple nodes in a network for storage. Useful in situations where a single storage point may be vulnerable to attack or untrustworthy.
- **Cloud storage** - proven, traditional solutions such as Dropbox, Google Drive, or Amazon S3 that allow users to store data using cloud (offsite) servers. Security and accessibility features are sufficient for many use cases.

7.0 / Potential Applications for City Government

For most use cases it is important to consider blockchain applications in conjunction with other technologies. For instance, a solution might use a database to store documents, a blockchain-based application to validate them, and another technology to share or view them. Understanding the potential of these types of combinations greatly expands the landscape when designing solutions. It also helps evaluate complex offerings whose components are in part, but not completely, blockchain-related.

In the developing Web 3.0 landscape it is also important to understand if a new blockchain-based solution is compatible with current regulations, requirements, or operating norms. During research and development of the LifeFiles platform, there were instances (such as automating certain types of ID document transactions) that were technically possible using blockchain technology, but were not viable because they did not conform with current regulations or network-wide infrastructure. It is necessary to consider such hurdles in any development project, but especially those which involve emerging technologies like blockchain.

Given the information above, these are the primary areas which have the most potential for blockchain applications for municipal government at this time:

- Digital identity and document validation
- Records validation and management
- Smart contracts for service administration and eligibility verification
- Asset ownership and transfer tracking
- Supply chain validation and management
- Transparency in accounting, vendor, and contract management

Until the blockchain, Web 3.0, and cryptocurrency ecosystems mature, federal regulations are finalized, the industry settles on more energy efficient consensus mechanisms, and consumer protections are in place, we recommend investigating other types of proven technologies alongside blockchain solutions that could meet the City organization's needs and adhere to its core values of equity, innovation, sustainability, and resilience.