Smart Cities as Identities

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1 Us and the City

From the moment we wake up in the morning to the time we go to bed at night, and even when we sleep, there so many little things that take place. We wake up, switch on the bathroom light, have a shower, wash our teeth. We then switch on the coffee maker, have a cup of coffee, wear our clothes, and get out of the building. We get into our vehicle, drive to work, wait at the traffic lights, get into elevators, make phone calls, use a computer maybe, submit an application to a municipal or governmental service ... and the list goes on and on.

All these actions, whether you realize it or not, at their core need two things to take place either implicitly or explicitly. You and a rule-based agreement. In other words, your personal identity and a set of rules that make sure, whatever you do can be attested somehow. Your national identity (national ID) is typically needed for the contract with the utilities which give you electricity, gas, water, phoneline. It is necessary when you go to the bank to transact, when you interact with governmental services. Aspects of it are needed to enter a place at work with a code, to log into your computer or a web service. Similarly, predefined rules dictate your benefits and obligations, your utilities will continue to serve you if you exchange your money for the equivalent value of the electricity you consumed, the value of which is set based on market rules, time of day, contractual agreement. Your application will be processed if you can prove your identity, your car will be filled up at a gas station if you pay for it and depending on your bank card or loyalty agreement you will probably get some loyalty points.

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Breaking it down to bare essentials, who *you* are dictates *what* or *how* rules apply to you, be it written or otherwise. Rules still apply to you, even if your identity is not explicitly required for an action. For instance, in the case of traffic lights, who *you* are will be punished if you do not respect the rules. Generally, we exist and interact peacefully within our cities because they are governed by rules, customs, codes of conduct, which *we* must abide by. These are necessary building blocks of our cities, in order to function efficiently, interact productively, and ensure the stability required moving towards our future.

1.1 Identity in the Foreground

When we talk about identity we must tread lightly. A regulated identity, typically a national ID and/or passport, is the one that identifies us and allows us to sign contracts with others and interact with governmental and other services. But a person is not defined unidimensionally. Consider personal data like age, gender, religion, sexual orientation, ethnicity, personal health data, and others. Let us not forget social roles like motherhood, teacher, nurse, and others, or social group participation. Sociologists distinguish between personal and social identity and while it is our regulated identity that is officially used on paper, it is with these two that we interact at every other level. Add our digital self and the myriads of interactions that can be attested to it in the digital realm, be it using social networks or digital services, and one can see how identity can be powerful, yet fragile.

In a city environment, individuals' identities must be placed front and centre as misuse can cause ripples in the social fabric. It can traumatize the relationship between individuals and the city, affect the ties of social groups, give rise to animosity and resentment. Conversely, if treated with trust and respect, they can be a city's greatest springboard for urban catalyzation as suggested by Dr. Ali Cheshmehzangi (2020) in his book *Identity of Cities and City of Identities*. A city's identity is but the sum of its citizens' identities, thus the manner in which it incorporates them into its processes can make all the difference.

1.2 Rules of Engagement

At the base of every interaction there are rules dictating how outputs are defined by inputs, and even if these rules are not predefined, there are other rules that dictate how the outcome must be treated. Let us illustrate this with two simple examples, one evident and another less so. When you visit the bank to open an account the bank asks for your national ID and other details that (a) identify you as an entity and (b) allow the bank to run a check on you called Know Your Customer (KYC) check. When everything checks out, the bank gives you a contract, which you are expected

to read carefully and then if you agree to the terms, sign it. The terms are the rules which dictate your relationship with the bank, your signature means that you have agreed and thus take full responsibility under the law to face the consequences if terms are not met. This relationship is transactional in nature, meaning that every time you transact with the bank or use your debit card, the transaction is logged and can be audited at any time. This is a purely rule-based relationship with predefined rules which most of the times will stop you from doing something outside its confines, e.g., overdraft, and in case this is not possible to audit you in the future.

The next example, however, is not that straight forward. You move to a nice neighbourhood with your family. Six months later a vibrant bar opens its doors, right next to your house. It respects quiet hours as dictated by law, but the rest of the day it is so loud and crowded that your family is affected, you cannot find a parking spot near your house and you start to feel resentful. To make matters worse, because of all the people coming in, the neighbourhood becomes a magnet for other similar businesses. Suddenly your choice to move there with your family becomes a nightmare and you are living in it. What rules govern this case? If the law is the only defining agent, then who serves the citizen's social identity?

Rules as previously stated can be explicit or implicit. With all aspects of identity being of equal importance, a city must uphold the rule of law but also address its citizen's needs. Rules are important not only at a daily transactional level, where it is easy to foresee and define, as well as at a forward-thinking level where a city can run simulations of itself growing, changing, and hopefully adapting.

2 Digitalising Interactions

A city is facilitated by a sum of rules, supporting processes, which are in place to serve groups of identities, which in turn are constituting the interacting entities. With cities growing in size, so did complexity, and processes became incumbent, inefficient and counterproductive. Fast forward, the internet era brought enablers that allowed us to digitize some of them, make them faster and more efficient. Consider logging in to online services with your email and password, handling your taxes, tracking assets in a logistics chain, e-commerce payments, health data, online applications, and so on.

This led to the first digital transformation, largely based on the identity aspect, leading several processes to transit from slow paper based bureaucratic processes to digitally enabled and streamlined ones. However, major problems surfaced like security flaws, personal data vulnerability, mistrust of third parties and their use of our data, accountability of participating entities and auditing transactional activities among others, all of which slowed down this digital transformation over the last couple of years.

2.1 Enter Blockchains

One of these problems is *double spending*. It affects the digital cash system and underpins the issue of a digital currency being spent twice. This is typically a fraudulent attempt taking advantage of security flaws of financial institutions handling the transaction of digital cash, leading to digital information being reproduced. Well, someone or a group of people under the alias Satoshi Nakamoto (2008), came up with a brilliant idea. It was suggested a peer-to-peer network that would allow transacting entities to cryptographically perform a transaction directly without a financial third party acting as a mediator. The underlying mechanism would have to rely on many distributed computer nodes agreeing (mining) on the validity of a transaction through a consensus mechanism called Proof of Work. This would in turn create a public chain logging transaction in an immutable sequence open for auditing by virtually anyone. The Bitcoin cryptocurrency was born.

The idea was revolutionary. A distributed network, dependent to no one entity? Allowing disparate parties to transact financially without a third party necessary to provide trust? Talk about security and democracy in one go, right? Well, not exactly. It turns out Bitcoin even though it became popular soon after and it is still in the spotlight with over $600 billion in market capitalisation, the single biggest money event in history, has major shortcomings. It has inherent scalability issues, is subject to fear of consolidation of major mining farms, does not fulfil certain characteristics to allow adoption by financial systems and at the end of the day it is only a digital cash system that cannot integrate with anything else.

You would think that would be the end of that, but you would be wrong. In 2013, Vitalik Buterin proposed another blockchain framework called Ethereum (Buterin 2013). The underlying concept was, and I quote from the Ethereum Org whitepaper:

> a blockchain with a built-in Turing-complete programming language, allowing anyone to write smart contracts and decentralized applications where they can create their own arbitrary rules for ownership, transaction formats and state transition functions

So, in 2015 Ethereum framework was launched publicly and it supported the following three components (a) a cryptocurrency call ETH, (b) smart contracts, or simply put pieces of code, residing in the nodes to govern rule-based transactions, and (c) the ability to write decentralized applications, i.e., small pieces of software that could be integrated anywhere and facilitate access. All these characteristics under the prism of a trustful environment supporting any group of disparate parties and based on unbreakable cryptography. *This* was a true game changer. Applying rules under complete cryptographic principles fuelled a myriad of applications, inspired thousands of researchers, and large enterprises trying to position themselves in this new field. Blockchains or better yet Distributed Ledger Technologies (DLTs) were considered to be of the same magnitude of importance to the internet as cloud computing was, when it first came out, if not more so.

2.2 Enterprise Blockchain Frameworks

Following the introduction of Bitcoin and Ethereum several other cryptocurrencies were born. It seemed that the democratization of digital cash was on the rise. But cash, be it digital cash or otherwise, is a means to an end and not all processes are cash bound. Which brings us back to the two cornerstone ideas of identity and rules governing processes. Besides that, public blockchains have an inherent characteristic that does not necessarily fit most of real-world scenarios, and that is they are public by design, i.e., open and permissionless allowing anyone to participate and access the transactions' log. This led to a new wave of blockchain frameworks being proposed, which were designed with corporate activities at the heart of them, suggesting permissioned only or hybrid architectures more suited to corporate and governmental environments.

The Linux Foundation started hosting one of the first open-source (OS) community called Hyperledger, which quickly grew to one of the largest communities in the world developing enterprise-grade blockchain frameworks, libraries, and tools. Hyperledger frameworks widely used for research as well as currently deployed in the market are Fabric proposed by Digital Asset and IBM, Sawtooth proposed by Intel, Iroha and others called general purpose frameworks based on the concept that actors interact with other actors or assets, whilst Hyperledger Indy is focused on decentralized identity management. To support these frameworks there are libraries like Hyperledger Aries and Ursa and tools like Hyperledger Explorer and Cello open to the community to quickly implement solutions. These frameworks were built and are still evolving with a cross industry focus in mind, with major applications currently in value chains, healthcare, and governmental fields.

Then you get frameworks like Ripple a brainchild of Ripple Labs focused on financial transactions like settlements and remittances. Corda span out of R3's research, open sourced soon after and initially focused on legal contracts but is currently fast taking its place as a cross industry framework. Quorum is another example that was designed by J.P.Morgan for the financial field, acquired by Consensys and subsequently open sourced and opened to other application fields.

These are some of the examples of blockchain frameworks out there, which is just a family of DLTs. The one common theme is the fact that they are all exploring the OS route to standardization and the market. The wider community is jumping at the opportunity to contribute to them and use them for market or research applications. Similarly, the big IT warehouses like IBM, Microsoft, Amazon Web Services, and others are exploiting the field with Blockchain-as-a-Service offerings and services. They are actively pulling their weight to roll-out large real-world applications working with financial institutions, value chain behemoths, the manufacturing industry, healthcare systems, and governments. Governments and institutions though latecomers in this field are also actively investing and exploring the opportunities that lie in adding this enabling technology in their arsenal.

2.3 Shortcomings and Limitations

As any technology in its infancy blockchain is not without shortcomings. In a comparison of open blockchains and DLTs conducted (Dinh et al. 2017) against several benchmarks the core issue is scalability. Fostering millions of transactions per second, whilst maintaining a secure-by-design architecture is a major roadblock. Granted not all applications have real-time significance but then again, a large enough number does. How long would waiting for an application approval be too much?

The main consensus mechanisms require high processing power making them resource intensive. Some frameworks, like Hyperledger Sawtooth, have adapted to allow pluggable on-the-go consensus algorithms, which means that as a blockchain based system scales, consensus algorithms can be adapted for speed and efficiency. This however may compromise the inherent characteristics of security. Another factor leading to security concerns is the 51% attack, which means that in a public blockchain whoever owns 51% of the nodes, basically owns the network. Interoperability is one other limitation, as most frameworks do not work well with each other, thus leading to siloed and disjointed implementations. Quantum resilience is also an issue for most blockchains, which are not ready to handle the advances of processing capabilities quantum technology will entail. Subsequently an already complex and resource intensive technology may need to become even more complex and resource intensive to compensate.

However, limitations are faced by any new technology out there. The effort put into overcoming them is directly proportional to (a) the application field and (b) the intrinsic value it has to offer. The first blockchain was proposed in 2008, and now, almost 13 years later, the momentum for adoption and diversification is stronger than it ever was.

3 Blockchains and the Real World

Cryptocurrencies were the first application of blockchain technology. Bitcoin, Ethereum, Cardano, Litecoin, and many others sprang out were crowdfunded, via so-called Initial Coin Offerings (ICOs), raising as much as Telegram's Open Network $1.7 billion, and some of them are still traded at crypto exchanges. But digital cash as explained is just one side of the proverbial coin. With enterprise-grade frameworks available, many more applications were implemented and are being researched, some of them already hitting the market supporting various industries and their processes.

3.1 Applications of Blockchain

Let us go through a few sectors where blockchain technology is leveraged or considered so far.

Logistics & Transport: In 2018, Maersk along IBM and GTD Solutions launched TradeLens. TradeLens is an open blockchain powered ecosystem for supply chain management as well as tracking of vehicles, containers, and assets. It allows disparate parties to share information across supply chains, reducing friction in global trade. Similarly, in 2019 the United Parcel Service (UPS) joint forces with Inxeption to launch Zippy, a B2B blockchain powered marketplace facilitating logistics and tracking for e-commerce businesses. And the list goes on with household names like British Airways, FedEx down to innovative startups.

Mobility: Mass mobility is also benefiting from the application of blockchain. Apart from major industry players like Accenture and Ernst & Young positioning themselves in the field, several startups are also bringing forward innovative solutions. The mobility space lends itself to a multitude of applications from ticketing and connected cars, to vehicle-to-infrastructure and dynamic insurance. Every year at MOVE in London, a mobility focused conference, a parade of implementations leveraging blockchain are presented to the public. Moreover, the Mobility Open Blockchain Initiative (MOBI) has formed to address the potential of blockchains in mobility, supported by major Automakers, Governments, Insurance companies, Academia, Cities, Startups, and many more.

Healthcare: There are but a few sectors where the application of blockchain can be more fitting than the healthcare sector. Health data security, sharing thereof, concept management are cornerstone in the field and there are many efforts attempting to address this. United States startup, SimplyVital Health is one such example creating blockchain powered open-source database for healthcare providers. Robomed, a Russian company partnered with Taipei Medical University Hospital to secure patients' medical records. At institutional level, the Centres for Disease Control and Prevention (CDC) in the USA is working with IBM on data collection solutions. European startups are not lagging behind in the race, but most importantly research through Horizon 2020 framework projects like *My Health My Data* are paving the way forward for patient data privacy, security as well as transferability across healthcare systems. Similarly, *Pharmaledger* a project sponsored by the Innovative Medicines Initiative (IMI) and the European Federation of Pharmaceutical Industries and Associations (EFPIA) under the Horizon 2020 framework programme is looking at blockchain scalability and governance to address major roadblocks of the pharma industry today like clinical trial data privacy and drug counterfeiting, among others.

Energy: Another promising sector primed for disruption is energy. The sector comprises of production, distribution, pricing, charging of Electric Vehicles (EVs), and other activities, all of which are fundamentally rule based. Apart from research projects active in demand response, microgrids and other subjects several companies are rolling out peer-2-peer energy sharing marketplaces like American startup LO3

Energy, whilst others like Israeli startup Greeneum, which incentivizes consumers to save energy, are looking to turning consumers to prosumers. Big companies are also active. IBM's Energy Blockchain Labs, for example, facilitates emissions trading, whilst Accenture is focused on procure-to-pay processes in the Oil and Gas market.

These are but a few examples of applications currently hitting the market, and we have not even touched the financial sector. The buzz is high, investments are monumental from both private capital firms and institutions. If nothing else, it proves that blockchain has the potential to facilitate viable solutions, although more must be accomplished for the technology to leave up to its promise.

3.2 Governments and Institutions

While businesses are taking care of business, institutions are also examining the use of blockchain technologies. As in any race, you get frontrunners and latecomers, and in the case of institutions like governmental and civil services you would expect the timescale of change to span across decades. However, as blockchains stand to offer several obvious benefits, some governments hurried up to experiment with the new technology even though it came out in a global recessionary period. Some of the top-level benefits that could be leveraged are

- Securing citizens' and businesses' data, with secure and cryptographic storage.
- Cutting down on bureaucracy and costs by automating processes.
- Limiting the opportunities for corruption and fraud, through traceability and immutability of records.
- Reinventing identity and support consent-based sharing of personal data.

Estonia was among the first nations to fully digitize processes like e-governance, e-tax, digital identities, e-voting, e-health, so it came as no surprise when as early as 2012 it designed the Keyless Signature Infrastructure (KSI) blockchain to serve its Justice Department, then expanded its use in Healthcare, Land Registry, and other services. Such was the success of the KSI blockchain that is currently used by NATO and the U.S. Department of Defence.

Estonia is not alone in this. The Netherlands has deployed the Pension Infrastructure which is a blockchain powered pension administration back-office. The Swedish Mapping, Cadaster and Land Registration Authority in 2016 launched a blockchain based land registry. Malta is putting educational credentials and transcripts on the blockchain, whilst also rolled out a favourable regulatory framework for blockchain businesses and cryptocurrencies. The list continues with more nations piloting blockchain solutions and implementing them day by day and they are not without support. The European Union, for example, has dedicated millions in research in the field, has setup the EU Blockchain Observatory and Forum, has launched the European Blockchain Services Infrastructure (EBSI) to provide institutional backing in the efforts to reach standardization, setting up distributed nodes across EU member states that will facilitate public services.

3.3 Cities in the Loop

Cities in this respect are smaller scale counterparts. Blockchain solutions built by governments affect cities in a big way as they have local civil services and part of national infrastructures. But they also have a closer connection to local businesses, communities, schools, healthcare facilities, citizens, and a number of other actors, not to mention the municipal infrastructure. Thus, research and the market are working hard on providing their input and solutions in identifying the right applications of blockchains within a smart city framework.

Research: Researchers are working hard on identifying the place for blockchain technologies in future smart cities. The underlying characteristics of the technology are thoroughly examined (Hakak et al. 2020) (Salha et al. 2019) to identify potential benefits that can be efficiently exploited. Other research work is focused on specific challenges, like how Internet of Things (IoT) implementations can be secured (Rahman et al. 2019) (Gong et al. 2019) at the edge, and how cities can extract infrastructural data in a trusted way.

Another strong focus of researchers is identifying exploitable synergies between enabling technologies. The convergence of blockchain technology and artificial intelligence in IoT networks (Singh et al. 2020) is one of the examples of research activity taking place. Sharma and Park (2018) examined the feasibility and performance of a hybrid software defined network with blockchain implementations. They researched how edge and core network elements can take advantage of these underlying enablers to support a wider smart city infrastructure.

Verticals are also researched in terms of how blockchain can provide and support value added services for a smart city environment. Treiblmaier et al. (2020) examined the various application fields that blockchain technologies could affect within a smart city framework. More specifically Rehman et al. (2020) addressed the vehicular infrastructure proposing a purpose-built network architecture, whilst Nam et al. (2019) focused on tourism, digging deeper into the potential of the technology and how it can disrupt the industry. Boulos et al. (2018) worked on the geospatial significance of securing healthcare systems and patient data, whilst other studies are focused on securing medical devices (Paliokas et al. 2019) addressing the connection between healthcare and a smart city framework.

The list of research activity is long, and it keeps expanding to multiple directions. Digging deeper into the technologies and frameworks available, addressing limitations as well as exploring promises, focusing on application areas and making the connection with a smart city environment more enticing and achievable.

Markets: Considering research backing and the number of people working in this field since 2012, especially following the launch of the Ethereum framework, market ready solutions soon surfaced addressing various applications fields within a city framework. Cities work with large IT powerhouses and integrators, like the prominent example of Dubai working with IBM and others, are trying out solutions developed internally like the Swiss city of Zug which decided to accept some municipal fees to be paid with cryptocurrencies, and they are also working closely

with startups and SMEs developing innovative blockchain based solutions in a range of application scenarios.

Agora, for example, is offering a voting system powered by blockchain technology, which secures the voting process and is highly dependent on identity. Solutions like Agora, BallotChain, and others allow citizens to vote from anywhere, help cities reduce time and related costs and safeguard against compromise of local elections bringing real-time transparency to one of our most democratic processes. Penta is a research company creating solutions based on blockchain addressing supply chains, healthcare, fintech, and even smart city focused applications like fractional real estate ownership, paving the way to faster processes, rethinking ownership, and expanding access to real estate investments. Paradox Engineering is integrating blockchain to secure city scale IoT infrastructures supporting from parking spaces and streetlights to waste collection and management. The Suez Group has developed the CircularChain leveraging a more circular approach to waste management.

Other companies are looking more into future applications, like Greyp a mobility tech startup from Croatia, which partnered with slock.it, part of Blockchains, LLC, to develop automatic payments for mobility solutions. Similarly, Chorus Mobility is working on how blockchain can be the underlying enabler for future mobility under a peer-to-peer outlook where vehicles are communally owned, self-driven and interact with a smart infrastructure, whilst Iomob *Powers Open Mobility Marketplaces* in support of shared mobility business models. Other efforts are also gaining ground working on peer-to-peer energy exchange, like the example of the Brooklyn Microgrid supported by LO3 Energy. ClearTrace is focused on emissions' tracking, which could easily scale down from institutional level, to city, business even neighbourhood or home level and support a new emissions trading economy maybe fractional, and maybe lead to a greener future.

4 The Long Road Ahead

When one talks about smart cities, it is almost a utopian vision of a city able to understand its citizens' needs and provide for them at all levels. Adapt and safeguard its infrastructural integrity and efficiency, and work towards its own positioning in the grander scheme of things. This vision is based on identities and their fractal tangents, it is based on rules and governance, but most importantly it is based on the understanding of a better future.

Rules do not enforce communal mentality, they do not ensure that innovation happens, they cannot give rise to creativity and art. In fact, Bettencourt and West (2010) two theoretical physicists turned urban theorists, came up with a set of simple yet powerful mathematical equations that can fully characterize a city from its sewage system length to its number of violent crimes. Moreover, these equations bring the defining patterns that can lead to a city's future into the light. However, when superimposing that to historian Lewis Mumford's famous quote on the rise of the megalopolis described as *the last stage in the classical cycle of civilization*, to

which West agrees, one is left with questions about how future can be defined and how sustainability can be achieved without compromising the unique characteristics that a make up a city.

Blockchain is just an enabler, and when integrated with powerful technologies like Artificial Intelligence, Big Data, IoT, and others, they will eventually make our cities … cleverer. Turning our cities into smart cities will take much more than that, though. It will require deeper understanding of how processes and data dictate results and reactions. How individuality and entrepreneurship affect a city in real time. How cities as part of global communities and economies can position themselves, be complementary to each other, support value exchange systems within as well as outside their limits. How they can tap into their internal potential to instigate uniqueness as well as create opportunities for a better future across the board.

Today we keep things simple, take small, calculated steps to achieve efficiency at scale, sustainability, build trust in sharing. But if our cities are to become smart, then they need to be able to define their *own* identity.

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