The Need for Implementation of Smart Cities

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Abstract

Smart cities are infrastructures that increase convenience, efficiency, safety, sustainability and optimal performance in a vast array of fields made possible by the Internet of Things (IoT), a trend of connecting as many smart devices as possible to computer-based networks. The purpose of this paper is to highlight relevant aspects for implementation. Hand-in-hand, with the endlessly imaginable benefits of IoT come threats to privacy, security and data. Through proper regulation and cohesion, threats can be minimized and even avoided. This paper reveals that, sustained through hubs, opportunities increase and problems can be solved and prevented to create a better, smarter future.

Keywords: smart cities, internet of things, sensors, hubs, cryptography, democratization

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Introduction

In South Korea, there is the Eco Delta Smart Village, a smart city experiment consisting of three tiers (Belcher, 2022). The primary tier is a smart mirror. It conducts all the same health measurements as a smartwatch and more, providing daily diet and exercise suggestions and daily news. This mirror doubles as a power bank for home information, storing everything from food expiration dates to daily energy consumption. Data fabricates this "thinking house," says Song-Lee, a village resident.

The purpose of smart cities is "to manage available resources more efficiently," along with "enhance knowledge and innovation, reduce costs and resource use, promote living and working environments, and increase communication between government and citizens" (*Statista*, 2023b). A smart city can be defined in many different ways, all relying on the "adoption of IoT communication technologies" (*Statista*, 2023b).

Economically, the formation of smart cities is "prompted as a strategy for retaining workforce and startups as well as attracting new businesses and talent" (Halegoua, 2020). Paving the path in both efficiency and economics, these cities provide "innovative solutions in various domains such as environment, economy, mobility, and safety with technology as enabler" (Lytras & Visvizi, 2019). They are designed to adhere to issues quickly by using information gathered from sensors constantly monitoring the environment (Halegoua, 2020). As the list of technological possibilities grows using sensors and other devices to solve issues, efficiency will also continue to rise (Statista, 2023).

Smart cities are increasing in popularity, however, along with all the benefits come threats to data, security and privacy. With the biggest hurdle to overcome being trust and

acceptance of these technologies, smart cities have a long way to go to mend broken trust due to abuse of power.

Being built and implemented all over the world using various methods, these cities will soon define all cities. Affecting every aspect of life from buildings to health care, IoT-driven cities will become common. The purpose of this paper is to spotlight the need for more sustainable, efficient and smarter cities becoming apparent. We are rapidly propelling toward smart city solutions.

Description

Breakdown of Implementation

Both public authorities and private companies have made this project a reality by developing approaches using IoT "hubs" as primary data collectors to provide an access point to a city's data infrastructure (Lea & Blackstock, 2014). With live sensed information and fixed inventories and assets, the contribution and crowdsourced data and other urban data collections can allow communities to meet the needs of individuals without government or commercial partner involvement. This access encompasses magnetic sensors and Wi-Fi scanners for the monitoring of key infrastructures.

Smart city technology focuses on communication and information. Transportation, building management, traffic control, pollution monitoring and energy monitoring are infrastructures of interest along with the IoTs paradigm for smart cities (Lea & Blackstock, 2014). Communication between subsystems is a key factor in consolidating outcomes. With IoT systems along with emerging subsystems and an open data access policy, links can be formed to maximize smart city services.

Seamless Integration

API proxy is a tool, offering a comprehensive API, or applications programming interface, of resources (Lea & Blackstock, 2014). This proxy has eradicated the dilemma of incompatibility between platforms, allowing for seamless integration and easy searching.

Catalog Explorer, another application that Lea and Blackstock (2014) mentioned is a hub-centric approach, allowing for simultaneous browsing through all hubs. Lea and Blackstock created "a diverse set of data sets and IoT resources available on a hub using a common catalog" (2014).

Hubs

A hub is a base of activity that offers both an interface for IoT city infrastructure and an interoperability focal point to allow access to multiple hubs (Lea & Blackstock, 2014). "Applications accessing these hubs can use this data to adapt themselves to current or expected conditions, addressing needs in areas such as multi-modal transportation, environment waste management, and load management, driven by the needs of urban authorities, or by local entrepreneurs and citizen groups" (Lea & Blackstock, 2014).

Interoperability projects require hubs to develop in these stages: (1) leverage the web of things, (2) establish models and best practices, (3) hub representation and standardization, and (4) hub standard semantics to ensure the same quality throughout. By reaching agreements on these, a more in-depth application is possible (Lea & Blackstock, 2014).

The same authors mentioned two hub architecture focal points: (1) the Web of Things Tool Kit (WoTHit) and (2) an open-source system known as CKAN, which allows for effortless uploading and publishing to support the storage of all types of data through a single interface.

Managing sensor data, the WoTKit makes it easy for users to add to the IoT (Lea & Blackstock, 2014).

Creation Strategies

In today's world, most cities compromise on smart city initiatives, requiring a unique plan to adhere to its own priorities (Komninos et al., 2014). Komnions et al. (2014) propose top-down planning, a multiphase plan created without citizen collaboration and bottom-up regeneration for current cities with underlying problems. Both plans align citizens for the actualization of collective intelligence and the construction of an IoT environment. The bottom-up methodology consists of deciding what to focus on and aligning initiatives to meet goals, requiring more planning and difficulty in execution.

The IBM strategy proposal brought up by Komninos et al. (2014) states three crucial steps to smart city creation: "(1) instrumentation, allowing for greater data obtained through sensors, (2) interconnection, creating all types of links between data, people, and systems, and (3) intelligence, allowing predictive analytics to better the city."

Benefits to Society

Smart cities aid the cloud, analytics, mobile, social and security solutions, and they can change economic investments and employment opportunities (Amaba, 2014). "Ubiquitous connectivity and data-driven services are said to increase job opportunities for previously marginalized communities" (Halegoua, 2020).

IoT technologies have provided solutions for transportation, water management, energy management, citizen engagement and integration of social networks (Lea et al., 2014). According to Amaba (2014), governments, academics and industries are utilizing these systems to engineer optimal services in nuclear power, defense, aerospace and capital investment.

Systems of thinking, continuous engineering, and IoT aid in leveraging concepts and technologies in the development of smart cities (Amaba, 2014).

The System of Continuous Engineering focuses on "Identification of customer needs, Promoting engineering collaboration, Continuous validation and verification, Strategic knowledge reuse, and Systems governance throughout the life cycle" (Amaba, 2014). The Systems of Thinking is a collection of ideal practices for the System of Engineering. It benefits quality, safety, lowers costs of both development and delivery and improves predictability in delivery (Amaba, 2014).

Data collected throughout a smart city can aid in notifying authorities to combat issues in society (Stromire & Potoczny-Jones, 2018). Increased tracking and identification allow the police to better aid in crime investigations and Immigration and Customs Enforcement regulations (Green, 2019). Important factors include confidentiality, allowing for only authorized individuals to access data; data integrity, allowing for only authorized individuals to modify data; and authenticity, ensuring data authorship is true to its origins (Stromire & Potoczny-Jones, 2018).

Revenue

Statista (2023b) states that IoT technologies are utilized in all fields and services, and "revenue from smart city infrastructure is forecast to grow to more than 100 billion U.S. dollars by 2024." Cities, businesses and citizens are all anticipated to benefit financially. As shown in Figure 1, smart cities will have a predicted jump in revenue generated by companies in the next six years, expected to almost triple (Statista, 2023b).

Threats to Security

Even with an abundance of precautions, security breaches are on the rise. New advancements call for more data for companies to understand consequential interactions. Stromire and Potoczny-Jones (2018) mention that removing specific identifiable information does little to protect privacy. The authors state that zip code, date of birth, gender, pieces of public data and other information can be deciphered, stripping anonymization. Major worries include access control systems not shielding data during creation or transit (Stromire & Potoczny-Jones, 2018). Agreeing to the terms and conditions often gives companies the ability to sell user data for revenue. Many individuals are already apprehensive when it comes to data-collecting technologies.

Faults in cryptography technology, including blockchain cryptography, are apparent. Inevitably, large data sets come with minimized efficiency, commonly breaking down to "integrity at the cost of confidentiality" (Stromire & Potoczny-Jones, 2018).

AutoSloit

The software AutoSloit allows hackers to easily hack into internet-based systems (Ainane et al., 2018). Hijacking devices is made simple using Au-to Sploit, a software that combines two tools, "Sho-dan.io, a search engine that can detect vulnerable connected objects, and Metasploit, a modular hacking platform used for security audits" (Ainane et al., 2018).

AutoSploit is simple to use. By indicating a keyword that refers to a particular system, the software retrieves a list of accessible devices and selects a series of attacks to obtain direct access (Ainane et al., 2018).

Targeting

"These smart city technologies have become covert tools for increasing surveillance, corporate profits and, at worst, social control" (Green, 2019). A lack of democracy gives power to the government and companies, and the data has the possibility to be easily found by other companies. The power this holds is immense, having the ability to "exclude people from credit, jobs, housing and health care in ways that circumvent anti-discrimination laws" (Green, 2019). Once installed, there will be virtually no place in the city to hide from these sensors.

In New York City, LinkNYC kiosks have been installed providing free wifi. While they do get some personal data, it all remains "anonymized," or so they say. The system "records a unique identifier for each device that connects," which can be utilized to track people's "movements and infer intimate details of their lives" (Green, 2019). Those who cannot afford a personal data plan will feel forced to use the Wi-Fi provided by the kiosks, giving up their privacy and opening possibilities for tracking.

This opens doors for more unjust targeting, surveillance and exploitation of minorities. Other major concerns consist of catering only to the upper class, lacking citizen investment and having over-stylized, under-planned technological designs (Halegoua, 2020). While wealthier households have little need, these kiosks are crucial for those not as fortunate. A worry of under-planned and over-stylized technology is also prevalent with many companies jumping to get ahead as this paradigm becomes a reality for many cities.

Solutions to Concerns

Smart Cities hold the responsibility to protect the data of their residents. A solution to privacy concerns is robust cryptography to protect data even through breaches (Stromire et al.

2018). Policy regulations from the city and companies for reductions in the retention of camera footage are ways to increase democratization (Green, 2019).

Lytras and Visvizi (2019) provide democratic procedure implementations in smart cities including "networking, decentralization, increased transparency and accountability, new modes of popular participation via the virtual agora, and hence collaborative democracy and citizens' empowerment."

Lytras and Visvizi (2019) also mentions how social networks hold the ability to boost civic participation, allowing citizens to stay up-to-date and increase democratization. Social media allows for the instantaneous spreading of information, encouraging citizens to have their voices heard and bringing necessary information to their fingertips efficiently and consistently.

The Utilization of Cryptography

Security protocols are composed of combining data collection and analysis techniques along with security, integrity and truthfulness to create trusted privacy-protecting software from the start. End-to-end cryptography offers protection while simultaneously allowing integration for city scale (Stromire & Potoczny-Jones, 2018).

End-to-end cryptography is the application of encryption during the transportation process of data to ensure safety and security while in transit, allowing the data itself to hold strong with its confidentiality, authenticity and integrity (Stromire & Potoczny-Jones, 2018). If hackers do manage to get their hands on data, it remains encrypted. Utilizing crypto libraries to store data, smart city adoption rates will increase as safety, privacy and trust in IoT technology grows (Stromire & Potoczny-Jones, 2018).

Blockchain is a newer technology system that completes the areas where data integrity and authenticity fall short (Stromire & Potoczny-Jones, 2018). It works by utilizing cryptography

to control write-only ledgers to form verified computation "chains." This blocks changes to data entirely, increasing integrity.

To prevent security breaches, companies run pen tests, or cybersecurity tests, on their own company to identify any vulnerabilities (Stromire & Potoczny-Jones, 2018). Another security-checking method mentioned by Stromire and Potoczny-Jones (2018) uses role-based access control with systems and individuals assigned roles (e.g. bystander, operator, supervisor) corresponding with a set of allowed associated actions.

Cryptographies in use, including Transport Layer Security (TLS) and full disk encryption (FDE), are the main security walls backing many personal devices that use internet communications and data storage (Pokharel & Sharif, 2022).

Smart city safety precautions come in two forms: common protocols such as Bluetooth and wifi and specialized protocols including Insteon, a "home automation system that uses both existing electrical wiring and wireless radio frequency (RF) to communicate," Z-Wave, a "wireless home automation technology that allows you to control household appliances and lighting making your home a connected and intelligent smart home" and many other adaptive applications (Ainane et al., 2018).

Implementing Guidelines

The Creators of the previously referred to Eco Delta Smart Village, acknowledge hesitation from individuals worldwide with privacy concerns. In response to these worries, the city has put together a committee that's "drafting policy guidelines and all of the info is encrypted," says Mr. Min, a member of the committee (Belcher, 2022).

Examples of IoT Devices

Smart buildings are revolutionizing how we go about our daily lives indoors. According to Ainane et al. (2018), smart buildings are structures utilizing automated processes for automatic control of the building's operations “including heating, ventilation, air conditioning, lighting, security and other systems.” In addition to conserving energy, smart buildings will save money.

New technologies are paving the way for affordability, accessibility and better population health. By promoting walking and cycling, tracking technology data can “be applied in initiatives and tools to align the interests of stakeholders and the interests of individuals towards cycling and walking choices” (Barretto et al., 2016).

Barreto et al. (2016) suggest a Cycle-to-Shop application to “increase bicycle usage in a city by rewarding citizens and, at the same time, to provide urban planners with mobility traces of such users.” As bikers inform shops about their arrival via bike, shops will provide benefits. A 5-20% cycling increase is expected. More citizens will utilize biking. Beginning in order to get shop rewards and facilitate a healthier, more efficient and greener lifestyle, the Cycle-to-Shop application will change overall public health and exercise.

Smart retail is a system to make shopping better, faster and safer (Ainane et al., 2018). From smart dressers assisting with outfit combinations to smart check-outs, this system revolutionizes and accelerates the retail industry.

Smart Health Care is an umbrella term coining any technology to elevate diagnostics, treatments, and overall life quality, a common example being eHealth, allowing our current hospital systems to better their quality of care and treatment while minimizing overall costs (Ainane et al., 2018).

The UK's Technology Strategy Board's initiative funded eight industry-led projects for the delivery of IoT clusters through a variety of hubs with an extra focus on the highway maintenance sector. By collecting data on the UK's regional and national road network about traffic flow, accidents, road work, floods and rain, interoperability between hubs was formed, helping to cut costs and vendor lock-ins that make customers dependent on one vendor (Lea & Blackstock, 2014).

Smart Cities Utilizing IoT Devices Examples

Busan's Eco Delta Smart City is an extreme approach. The limited land and overpopulation crisis South Korea is facing accentuate demands for smart cities like these (Belcher, 2022). They aim to create a smart city blueprint for future replication, starting from the ground up.

The overall goal of this experiment is sustainability. "Though it will remain part of the city of Busan, it will have its own sewage treatment, water treatment and electricity through solar and hydropower" (Belcher, 2022). Systems implemented to recycle sewage water, treat water for drinking, drones to maintain clean streets and derive electricity from solar and hydrothermal energy will be implemented to maintain minimal environmental and financial impacts.

Major cities including New York City have implemented LinkNYC kiosks that provide free Wi-Fi, domestic phone calls and USB charging. Accompanying these, these kiosks comprise cameras and sensors (Green, 2019).

Barcelona, Spain is a pioneering city, restructuring policies to optimize democratization and doing their part to engage the public (Green, 2019). This is the beginning of increasing public trust in smart city technologies.

Pilot Project

A pilot project brought up by Komninos et al. (2014) depicts a smart commercial district in Thermi, Greece intending to propel this city's uptake of systems for the creation of an IoT ecosystem. They began by conducting in-depth research on the environment, identifying issues such as high congestion levels in main market areas that lead to decreased business for small businesses, pollution and minimal parking (Komninos et al., 2014).

The researchers then decide which technologies, applications and solutions to implement to aid mobility, urban information management and e-commerce, congruent with specific issues they aim to address. Both hardware and software installations were implemented to "create a layer of smart city services" to meet their goal (Komninos et al., 2014). They created mobile applications and services using advanced web and open-source technologies (Komninos et al., 2014).

After deciding what needed to be replaced, they had to figure out how to get the money. Project partners agreed on two protocols: (1) to "distribute the applications under an open source license and (2) to follow a web 2.0 approach in data acquisition and update, taking the majority of data either from sensors or from users" (Komninos et al., 2014), minimizing maintenance and overall costs in the long run.

Conclusion

The Internet of Things turns the idea of a smart city into a reality. By connecting data from sensors and cameras, smart cities can enhance productivity, health, safety, profitability and quality of life while reducing negative environmental impacts.

With major cities battling overpopulation, lacking sustainability and simply not being as efficient as possible, there is a need for the implementation of smart cities. Smart cities were

invented to improve sustainability, and quality of life in cities and to create a more efficient Internet of Things ecosystem (Ainane et al., 2018). “By measuring elements like pollution, water and energy use, waste accumulation, and environmental factors,” smart cities make cities more resourceful, ecological and accommodating to change “safely and cost-effectively” (Halegoua, 2020). With the help of sensors and other IoT devices, smart cities have achieved economic benefits, improved safety and more efficient infrastructures.

Necessary data is in the hands of citizens. A mix of multimedia, human factors and user-centered methodology systems comprise a smart city (Amaba, 2014). Key factors for building a smart city include a sustainability focus, monitoring and evaluation of processes, crowdsourcing, community engagement, and focusing on clearly known issues (Komninos et al., 2014).

The implementation and construction of smart cities has proven to be successful in its goals. Each smart city has a different set of goals. Cities that follow a guideline or roadmap for facilitation are likely to succeed. Pilot experiments such as Barcelona, Spain and a district in Thermi, Greece, provide guidance for future cities to follow. With top-down methodologies for constructing a smart city in place, replication is made simpler.

Major concerns and hesitations arise when measuring trustworthiness. A severe lack of trust in IoT technologies implemented in these smart cities is skepticized. While the data collected can be used for good by minimizing traffic, bettering infrastructure, conserving energy, increasing small business exposure and profitability and increasing opportunities and safety, the probability of it being a threat seems to be at the forefront of people’s minds (Statista, 2023).

The numerous benefits that provide a vast array of urban infrastructures cannot pacify all concerns evoked. Major threats brought upon by smart cities, specifically IoT technologies,

pertain to privacy, safety, data security and trust are issues debilitating the increase in popularity of smart cities. Excluding worries deriving from abuse and theft of personal data, fears of being tracked are becoming more common as IoT technologies encompass more devices and services throughout cities.

Along with major privacy worries, equality is questioned. Smart cities create vulnerabilities for struggling demographics, seem to cater to the upper class and provide opportunities for discrimination and abuse of power. To combat and prevent these threats, data protection services can be utilized, restriction protocols can be passed by each city and government considering implementation, and precautions can be taken to ensure citizen safety, data integrity and privacy through all IoT services.

These up-and-coming technologies will define “the social contract of the future” (Green, 2019). Even with hesitations, with proper precautions taken, new milestones can be reached, efficiency in all aspects will be optimized, cities can be made safer and overall health can benefit, so we may as well embrace our inevitable future.

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Figure 1

*Projected Revenue Generated by Companies in the Global Smart City from 2020 to 2028**