Create a smart city using Internet of Things Architecture: Methods and Challenges

Student: Trac Duc Anh Luong - ID: 103488117

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1 Introduction

It is expected that the global population will continue to grow from 8 billion in 2022 to almost 10 billion by 2050 [1]. And by just 2030, the number of residents living in cities will rise to 5 billion [2]. This trend requires an immense technological upgrade to accommodate the most basic needs of the higher demands of people. As urbanization continues to occur, the density of inhabitants in cities will follow an upward trend, which requires thorough and insightful planning.

Some of the key elements that should be considered in the preparation phase to transform an urban area into a smart city include the physical well-being of citizens, transportation - making commutation more timely, productive, and more environmentally friendly, and other community services. With the development of IoT - the Internet of Things, the vision is gradually unearthed when integrates with good motivation, applicable modern architecture, and provision from the cities' councils and government officials. Several articles have been written to analyze the hurdle and propose different frameworks and solutions for smart cities. For the selected papers analyzed and cited in this document, the approach they used is mostly implementation-based. The researches mentioned in this paper are all-rounded, mentioning every aspect that relates to the architecture of a smart city with details, key insights, and reasonable planning.

However, challenges occur as it requires numerous resources in terms of physical IoT devices, network mapping and infrastructure, building servers and data warehouses to store the data collected, building and managing a system that processes the data in real-time, running a cloud-based machine learning server and train AI models that can make the decision and give insights from the data pool. Every component has to also be scalable and maintainable with a limited amount of resources and financial allocation. Also, the privacy of citizens needs to be taken into deep consideration as this topic has been worked on and debated over for the last decade.

This survey paper will cover different methodologies, evaluate the feasibility of application and identify key challenges to these approaches.

2 Current state of art

This section of the survey paper will discuss in detail what techniques and strategies are employed in the papers, important drawbacks, as well a comparison of the various techniques applied in the publications.

2.1 Methods and approaches

The approaches that the articles cited in this survey paper share some similarities in terms of motivation and coverage of the current drawbacks of urban areas and how smart cities' infrastructures tackle those obstacles. Given the limited and lesser resources that we have with location and space, portability, energy, etc., utilization of available assets is necessary. The articles used for this survey paper used an implementation-based approach.

In the first article, "An Information Framework of Creating a Smart City through the Internet of Things" [3], the authors gave a context of the current global overpopulation

issue, and technological breakthrough in recent years, specifically in the IoT segment with a crossover to data science, and what segments in the urban life can be tackled with the help from proposed technology as the motivation. The article then proposes the IoT infrastructure for smart cities through different layers, from the network, cloud, data analysis, application, and services to urban mapping. Each model of architecture is then graphed with detailed labels, mapping, and a table of comparison. The article explained what was shown in the respective figure, how each component of the framework functioned and their relation to one another. After that, the model was discussed on how its implementation could help solve dire existing issues in today's infrastructure. The quality of services was an instrumental meter to determine the requirement of the newly implemented system. Complex communication protocols, ranging from wired to wireless and a hybrid of both required a dynamic system built on the foundation of IoT, which differentiates itself from the standard homogeneous networks. Another keynote from the design of network architecture was that the construction would reuse various components from the current network solutions. This did not only minimize the number of resources needed to build a new system, but also reduce the waste that came from legacy technology. The proposed approach was proven to not be constrained by the existing new work structure and design, making it scalable and maintainable.

In the second article, "Security and Privacy in Smart City Applications: Challenges and Solutions" [4], the content shifted its focus to inspecting obstacles related to the privacy of urban citizens concerning the development of smart cities and how those problems could be tackled with holistic approaches. The purpose was to provide secured intelligent services to local citizens and visitors. The aspects covered are health care, energy, entertainment, and the environment. The backbones to build up a smart city were information and communication technology (I.C.T.), smart and clean energy, and smart in-door systems. The paper then proposed the smart city architecture for applications from the city's overall layout of how each segment can apply smart IoT systems. The system was then separated into the physical layer, the communication world, and the information world. The physical world contained portable devices, environmental sensors, and other smart sensing devices to later send the data collected to the communication layer, which reused heterogeneous systems and sent the data to the processing unit, which then the data could be accessed by the authorized units and served the purpose of decision making.

In the third article, "Current trends in Smart City initiatives: Some stylised facts", the method used was to take a sample of 70 international cities to analyze the various statistics and number of application domains where the cities have launched their renovation projects. The analysis conducted identified the key metrics to determine the ranking of every city's intelligent system the quality of life, and the figure of research institutes, technology analysts, and enterprises that contributed to smart cities projects. A table lists these measurements, their respective sources, and descriptive statistics for each. After inspection of different domains, the findings were that the cities in the sample report had the fewest efforts in the area of government. The inverse relationship shows that cities with investments in hard domains (public security, transport, mobility, logistics, etc.) are less likely to make significant investments in soft domains (economy, public administration, welfare, social inclusion, etc.), and conversely.

In the fourth article, "Internet of Things for Smart Cities" [5], the authors pointed out the assorted types of data collected by a current urban IoT system, which progressed the transparency of existing problems in the major cities and how smart systems tackled them. This was a critical factor to persuade local authorities, as well as raising the awareness of people about the status of the city they were residing in. That was also the goal of this paper, to discuss a generic reference framework for an urban IoT design. The research outlined the distinctive qualities of an urban IoT as well as the services that could encourage local governments to adopt it. A brief overview was given about the link layer technology that

could be used to interconnect various parts of the IoT design. The web service architecture for IoT services that the IETF standards for IoT support have been extensively described in the literature as a very promising and adaptable strategy. The authors suggest exploiting the Asynchronous JavaScript and XML functionalities of current web browsers to communicate between the browsers to IoT nodes, which could be explained as different standalone IoT devices.

In the fifth article, "Software-defined internet of things for smart urban sensing" [6], data focusing and cloud computing were the main topics. As data processing could happen throughout the whole system life cycle, from filtering noise data from the sensor nodes and encrypting data to analyzing the data acquired from the survey to make intelligent decisions. As of now, there are no holistic solutions to dynamically control the data flow from sensors, as they would continuously transmit data to remote servers, including undesired data, making the network bandwidth slower and wasted. The solution to this will be a considerate and resourceful mapping of cloud centers with quantitative analysis. On a smaller scale, the controller can assign each sensor to a maximum of one application to prevent conflicts.

2.2 Comparative Analysis

The methods used in the mentioned papers are implementation-based. The key analysis came from model building, framework proposal, data analysis, supervised testing, and observation. The inspections came from the third article which analyzed different major international cities around the world and was successful and engaging as the smart city infrastructure came from real data, together with statistics and data interpretations. Graphs and numbers have provided a detailed context to the reader. The models from other articles were detailed, and well-structured with visual aids, with an overview of how each segment could implement IoT cutting-edge technology how each element specifically worked, and how they could be integrated with information and communication technology, and cloud servers. Every layer of architecture was also given a background of the existing technology, its drawbacks, and how the newly implemented system can help solve these dire issues. The articles also provided insights on AI and machine learning, which played an instrumental role in making intelligent decisions to make a city truly smart and efficient with the given data and other existing resources that the new framework would be built on top of.

2.3 Key limitations

There are numerous concerns after consideration of applying a new large-scale architecture. Financially, a large amount of grants is needed from the state fund. The frameworks from these articles have to be financially feasible to a certain metric standard for government officials to consider the plans and apply them to a certain scale for observation, and modification and eventually apply them to a larger scale nationally and internationally. The financial statements seem to be lacking in the mentioned papers. The necessity of a budget plan is to give investors a convincing rationale of the amount of budget they need to allocate and how that investment will bring value to them in return. In our cases, it would be helpful to consider the proposed IoT approaches with some further monetary details with the given business model.

As we have mentioned previously that data is needed to be collected, stored, and processed. In this life cycle, the information we generated afterward is prone to errors and threats. Storing data required big and scalable data lakes, data warehouses, efficient servers to process the data, and cloud architectures to connect our components. In "Security and Privacy in Smart City Applications: Challenges and Solutions", the article pointed out that a key challenge was to defend this large quantity of data as it proved to be a valuable target for attackers. The requirements to defend data from unauthorized disclosure, interruption, alteration, inspection, and annihilation are ubiquitous and challenging. If this instrumental factor is secured, only then can the public be convinced and the infrastructure can be fueled with consented data from the cities' inhabitants.

As mentioned above, a limitation of the mentioned articles relates to privacy. The key to building a smart city relies heavily on data collection, processing, and making decisions. From collecting CCTV video to tracking traffic routes and keeping personal records of every citizen, the data collected gets deeper with more details. Due to this certain fact, a large sector of the population has dire concerns as they do not want privacy to be violated. Privacy leakage can result in it the person's identity being exposed, which leads to information about their location, email, phone number, passwords, and medical history being compromised by criminals and cyber attacks.

Another disadvantage is the usage of current resources, which has not been yet optimized. Introducing new technology is synonymous with using more resources. In terms of infrastructure, more IoT networks and devices will cost more energy to maintain, as well as costing more bandwidth to be consumed for these devices to send the data collected to the back-end server to be stored and processed. The use of more energy will cost more pollution, directly affecting the mass health and well-being. Another paramount factor that has to be considered is that the new framework of infrastructure has to be built on top of the previous one, as the population continues to grow, taking up the available space, which now is mostly used for sheltering or community services. Therefore, the challenge of renovating the cities' current design to be smarter but also greener and not degrade other quality-of-life criteria has not yet been solved with an optimized approach.

3 Conclusion

With the current situation of continuous overpopulation and other related appalling issues, it is now an urgent need to plan, develop, test, and apply new technologies to the current urban infrastructure to support its inhabitants. The quality of life of citizens around the world can be improved with support from smart city frameworks and intelligent systems.

The five articles mentioned in this paper have provided an insightful look into how each segment of life can be implemented with IoT technology. These market segments include healthcare, mobility, buildings, infrastructure, governance & education, security, and energy. The articles have provided the current context of urban planning, existing issues with the system, and their motivation to come up with an improved design to make the city smarter, which is synonymous with upgrading the welfare and well-being of residing citizens. The approaches are implementation-based, with a detailed explanation of their proposed new infrastructure. Key findings are outlined with comparisons to the present system, following the goal of making these changes with a minimum amount of resources. The new architectures were also required not to degrade the other resources, such as energy, network, and space.

Challenges exist regarding financial planning, privacy protection, the usage of data, etc. Therefore, further timely researches and findings are essential to make modern cities truly smart and desirable.

4 References

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