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Research on the Analysis of Operation and Governance in Interoperable Smart Cities

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ABSTRACT

Analyzing all public sector operations and services inside a smart city (SC) is considered to be a component of SC governance. Furthermore, it delves into the question of how existing models of public and social governance might be adapted to the virtual management of smart cities. Difficulties of digitalization, accessible distribution of essential services, different forms of engagement in decision-making and transparent governance are just a few of the numerous administrative problems that smart cities face. When it comes to running and managing an interoperable SC, there are several varieties of challenges to overcome. In this paper, the data was initially collected and then preprocessed. In addition, data analytic methods may be used to examine the SC's administration and functioning. The outcomes are then compared to methods already in use to accomplish this goal. The interoperability of smart cities may benefit from a new strategy with networking or telecommunication strategies in the future.

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1. INTRODUCTION

Several new countries that have developed during the last 20 years have had a significant impact on the way people live. One idea behind a "SC" is that when evaluating an urban area's efficiency, intellectual and social capital should be taken into account in addition to its physical resources. Furthermore, a council's economic growth is strengthened when human, social, and technological resources combine to make it a SC [1]. An urban area's economic growth results in higher standards of living and better services for its residents. Cell phones, telephones, financial services, and media platforms are just a few of the contemporary communication mechanisms that are being used to gather population input about the urban environment. Sensors are a convenient and affordable resource, which makes them an essential part of the infrastructure for smart cities. The use of sensors improves real-time feedback, such as city temperature, traffic flow, and carbon emissions measurement [2].

Additionally, a network of specialized sensors might be constructed with a centralized command and control centre to monitor certain city real-time events via regular communication networks like landlines. Huge data collections that need to be evaluated result from combining various geographically and temporally accessible data sets. Urban statistics have been quite scarce in recent decades. The creation of fresh urban data was a goal for statisticians and data scientists. With the advent of the Internet of Things, things have changed for the worse [3]. Numerous urban data genres are now widely available in a variety of formats and presentations. The continual flood of data rendered conventional data analysis methods ineffective. New software design and data analytics techniques are necessary to provide information that is actionable [4]. To organize this rapidly expanding urban data, a number of methods have been improved, including data warehousing, clustering, and also contemporary cloud-based data management. It is thought to be a difficult task to integrate all the data sets at one central repository to get the aggregated view because of their inflexible structure and historical standards [5].

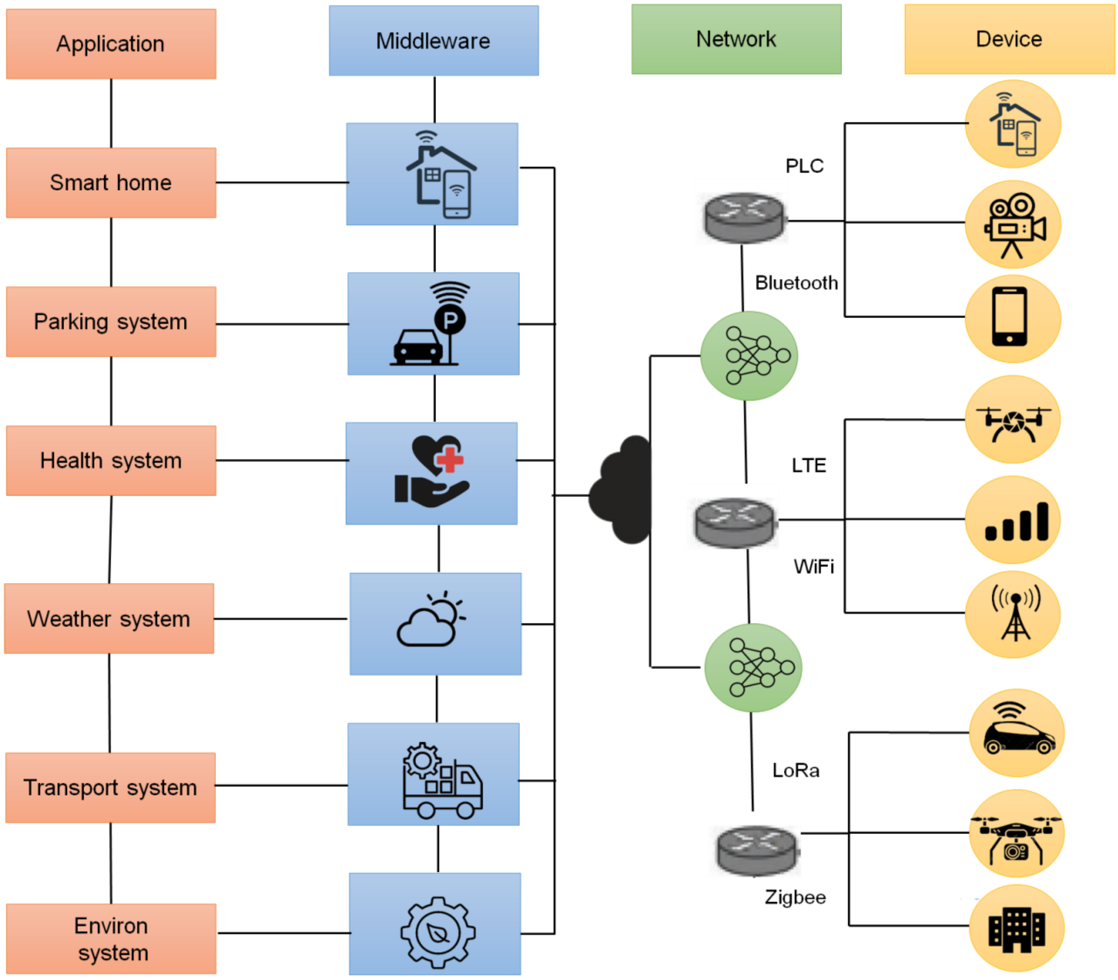

Figure 1. SC architecture with several layers

A SC includes four levels, including device, network, middleware, and application, with different components at each tier, as shown in Figure 1 [6]. The device layer covers a variety of heterogeneous devices utilized in many aspects of an SC, including drones, security cameras, smart automobiles, and smart meters. Power line communication, Bluetooth, wireless fidelity, long-term evolution, Zigbee, and long-range are only a few of the heterogeneous communication protocols utilized by diverse devices that are part of the network layer. The application layer, which is the last layer, encompasses services that are offered and used by different platforms in the SC. To achieve the SC, interoperability problems are caused by the variety at each layer. For instance, the majority of SC initiatives now employ their own standard-based devices created on various platforms and application programming interfaces, which are based on the many diverse standards that are already present in IoT contexts [7]. Thus, controlling and connecting multiple devices, integrating data and services across various network protocols, and managing system integration are the three most crucial components in resolving interoperability concerns in the SC. Interoperability has been emphasized in many initiatives and research, but since there are so many different standards, it is challenging for smart cities to serve as a foundation for true urban integration [8].

The suggested SC taxonomy, which specifies pertinent technological and legislative properties of SC services, is the paper's major contribution. The taxonomy is designed to study typical cases of actual SC services that have been selected as such, owing to their widespread usage in practice and/or intriguing technological features. A collection of regulatory suggestions for every function in the IoT value chain is one of the significant contributions. Stakeholders may find recommendations to be a useful tool as they plan and develop their SC initiatives. The service development cycles may be shortened if a stakeholder uses this advice to quickly define its roles and concentrate on key elements. Our objective is to provide recommendations and examples of best practices that may result in the broad adoption of SC technologies and successful replication.

The rest of the essay is formatted as follows. The related review of comparable frameworks is presented in Section 2, and the analysis of the need for interoperability in a SC environment is presented in

Section 3. Section 4 of the study summarizes and discusses the experimental findings, and Section 5 concludes the report and outlines further research.

2. LITERATURE REVIEW

An organization of the technical and legal parameters of IoT services for Smart Cities that are mapped to relevant positions in the IoT value chain. One of the main barriers to a larger uptake of SC services, according to their argument, is the absence of a legislative framework for Smart Cities. Such a framework should be supported by illustrations of best practices that emphasize the need to implement interoperable SC services [9]. There is a tremendous quantity of data from various forms and diverse sources that may be transferred due to the remarkable breadth and variety of applications that are developing in this setting. With respect to applications for smart cities, a strategy, a methodology, and a modular, scalable, multi-layered ICT platform are described. These are used to solve the issue of cross-domain interoperability [10]. A horizontal integration layer called the Open Standardized Urban Platform (OSUP) is used as part of the SC idea to connect several vertical domains. In terms of interoperability, a crucial idea in urban data platforms, there is still a gap in the use of open standards [11]. To make the idea of an SC easier to understand, a presentation of the popular SC guidelines will be presented. The implementation of smart cities may be compared using clear criteria. As standards and technology advance quickly, many cities must avoid being ensnared in a single vendor's integrated solutions because this makes it more challenging for them to exchange data with residents, developers, and other cities [12].

Modern technological advancements include digitizing existing urban areas to provide data-driven services. According to this research, the current state of smart cities still presents technological, economic, and copyright implications that must be resolved in the next years despite the efforts and initiatives being made throughout the globe [13]. They examine how the paradigms for edge computing have changed. After that, they critically evaluate the most recent research that focuses on edge computing applications in smart cities. If action elements are interdependent, it might be challenging to divide them into portions for local execution and server implementation. This complicates partial offloading [14]. Interoperability is a feature that makes it easier for apps to integrate various devices and systems they utilize. Among the terms or approaches used to describe interoperability are integration, interoperability, middleware, and standardization. For applications that deal with crises or have special needs, the absence of compatibility also results in ineffectiveness, which is particularly undesirable. Interoperability is especially desired in diverse systems [15]. It provides information on the standardized framework for Smart Cities as planned by worldwide standards development organizations (SDOs). Furthermore, it is challenging to assess the successes of SC building owing to a lack of criteria [16]. They looked for a way to deal with the issue of preventing unlawful dumping in smart cities. They also discuss the prototype of an automatic visual identification and warning system in this regard. Due to the constraints presented by the tight schedule and the initial criteria of the issue, it is not taken into account in our model [17]. A linked and interoperable hospitality and tourist ecosystem is created via the use of value chain networks in smart hospitality. The macro-level information framework for smart hospitality is eventually provided by smart destinations and regional development, which integrates the whole ecosystem within the local economy. What is meant by "smart" and the ways in which organizations might become more intelligent are not widely agreed upon [18]. It introduces TASIS, a typology of architectural techniques for software-intensive systems interoperability. Thirty-three professionals from various countries with considerable expertise in integration projects helped us verify it as well. Numerous application sectors, including Industry 4.0, linked health, smart cities, and smart agriculture, to name a few, are progressively using complex and big software-intensive systems [19]. To examine, summarize, and debate the main issues facing the IoT middleware that is currently available. It also provides big data applications to the information environment of IoT middleware in order to obtain the appropriate level of services supporting sustainable cities. The middleware's functionality is limited, and processing huge data streams is not supported [20].

3. RESEARCH METHODOLOGY

Interaction standards, connectivity services, information system integration, analysis of data and sharing, and secured network technologies are all examples of technological interoperability. The interworking of data and the management of integration are crucial in smart cities for linking and regulating diverse tools and services. Everything from predictive maintenance and systems to hospitals, transportation, and trucking are all part of the smart cities. However, because of the absence of specific procedures, interoperability across devices in various areas is challenging. Hence, in this research, we evaluate the operation and governance in inter-operable smart cities. Figure 2 demonstrates the scenario and challenges of interoperability in SC contexts.

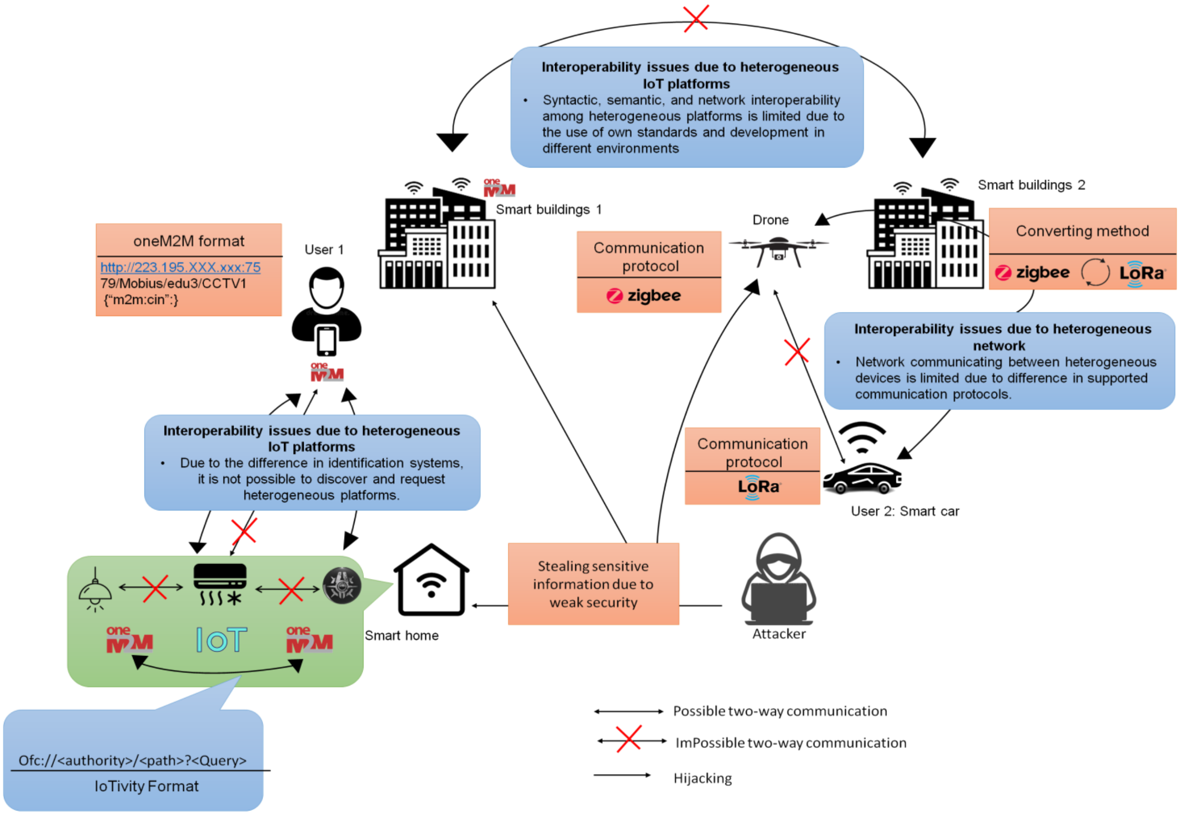

Figure 2. Scenario and challenges of interoperability in SC contexts

3.1. Conditions for interoperability in a SC

IoT (Internet of Things), big data (data analytics), artificial intelligence (AI), cloud computing (computing on a large scale), and other forms of sophisticated information and communication technology (ICT) are all components of the SC because they allow for the collection, storage, analysis, and application of information about urban areas. Furthermore, several initiatives for smart cities include the use of IoT platforms and protocols to create products and equipment. Furthermore, interoperability in a modern city is restricted because of the variety of network elements, and not every participant utilizes the same platforms.

3.1.1. Interoperability for Syntactic

The situation for syntactic comparability and associated problems in the modern city are as follows. One user sets up the IoT service with a variety of IoT systems running on different systems. User 1 uses a mobile app to make a service request for their Smart Device. The program is unavailable on this system, although no IoTivity equipment has been found to employ it. The IoTivity air conditioner and other products not dependent on this system are ineligible for usage. Problems with syntactic interoperability emerge due to the fact that each IoT platform has its own identifying scheme. The authorization system is a tool for discovering and obtaining new types of resources on any given platform. For instance, various IoT systems utilize a wide variety of distinct IDs to track individual services and gadgets. Concerns, such as self-development and regulations, plague the SC since IoT platforms rely on the information designation method and data format. However, if information is exchanged, they are useless since the formats of the various systems are incompatible. Thus, transferring the file formats across systems should be addressed to achieve syntactic interoperability in a modern city. Renovating information or operations via a standard interface and translating it into a standardized way might be addressed whenever it is challenging to transfer file formats across platforms. Device and service IDs should retain their individuality after being transformed into a standard format. For a SC's IoT devices and services to work together, they need to be uniquely identified.

3.1.2. Interoperability for Semantic

Syntactic interoperability situations and problems are comparable to data integration in a modern city. Utilizing a smartphone application built on oneM2M, User 1 seeks IoTivity air conditioner function in terms of Smart Home services. Unfortunately, the services could be deployed due to the lack of a way to logically differentiate between the service that oneM2M signifies and the service under IoTivity. In other terms, since every system uses a distinct representation format for identical content, there are problems with data integration. It is hard to comprehend the significance of information systems across different systems since the IoT application adheres to its specific criteria. Thus, it is important to take into account the transfer, processing, and incorporation of knowledge representation. The usage of distinctive identities must be accounted for while building such a standard centralized data structure.

3.1.3. Interoperability for Network

SC ideas and network interoperability challenges are as follows. User 2: The LoRaWAN network is supported by the smart car, and the Zigbee network is supported by the drone in the area. User 2: Smart Car then makes a service request to enable the use of the drone but is unable to do so since the Smart Car's permitted communication protocol is incompatible with the drones. Communication between User 2: A Smart Car and a Drone service that supports heterogeneous communication systems must occur through Smart Building 2, a gateway that translates communication systems. Simply put, the disparate usage of different networking protocols, transport methods, and access networks across devices is the root cause of networking interoperability problems in smart cities. A number of IoT devices may work together, utilising the same communication network to address this issue. Network intermediates are needed to facilitate communication between devices whose physical network components do not match. The need for a protocol converter arises when two devices have incompatible communication protocols. Some specifications for interoperability between networks are also necessary. Since the dynamism and real-time flow of data and services are crucial to a SC's functioning, network interoperability in such a setting is very sensitive to latency and QoS. The utilization of private information and services in a SC requires reliable and consistent interoperability across various network types. Maintaining stability is essential for meeting QoS and SLA requirements. Because of the diversity of wireless networking technologies, a network mechanism is required to assure the quality of service while delivering significant amounts of sensitive data to end-user devices. For heterogeneous wireless networks to effectively share data and services, load balancing and scalability are essential. The accessibility and fast response of the network transportation system may be improved with the help of a design that incorporates algorithms and solutions dealing with load balancing and scalability. In heterogeneous networks, many types of wireless communications may cause disruptions. That's why it's important to develop a brand-new theory and electron transport that can effectively investigate and control interference.

3.1.4. Interoperability for Middleware

There are a few different situations and problems that might arise from the interoperability of middleware in a SC. One Smart Design features oneM2M-based devices, while another uses FIWAER-based devices. Unfortunately, syntactic, semantic, and network interoperability are constrained between the two smart buildings since they were built in distinct contexts and adhere to separate standards. That is to say, the disparate methods of software creation across IoT platforms contribute to the difficulties of ensuring middleware compatibility in smart buildings. The development of each IoT platform occurs in a unique setting with its own set of standards. Integrating various data management tasks, such as data collection, storage, treatment, and analysis, is challenging. This means that you need to give some thought to how to construct a unified platform for data organization. Techniques of renovating data and services using a particular API, as well as joining an integrated ontology, are seen as an indication of how to establish an integrated platform. When developing such a unified system, it is important that the IDs of all linked devices and services remain distinct. Entities inside the scope of an operation must be assigned unique identifiers, and those identities must be consistent throughout the whole platform. As a result, ID allocation should be arranged such that each platform may assign its own unique IDs without encroaching on those of other platforms.

3.2. Services for smart cities

According to the public sector and the private sector, as well as the economy and the IT industry, many IoT applications are brought to use every day. Presently, the industry is dominated by sectoral, stand-alone IoT networks, which are limited to that environment and could be built across a particular IoT network. Since the same technology and data might be implemented by and integrated into certain services, many sectoral systems don't really exchange either technology or created data with one another. Consequently, in order to comprehend the technological and legal specifications of various solutions, it is important to group them according to their features. The achievement of technology support in the Safe City framework depends on their ability to meet the technical and legal specifications, which are eventually to really be established as legal responsibilities, and this segment identifies the legislative and operational attributes that need to be well-defined for this to happen. From this comprehensive study, we identify and categorize technological and regulatory aspects of SC services.

3.2.1. Technical features of SC services

Quality of Service (QoS), as well as other specifications directly pertaining to system technology and development, is the most prominent type of technological improvement of SC services. We differentiate between the qualities of a smart system and those of a fundamental service. The following are some of the fundamental features that pertain to the technological and QoS criteria shared by all advanced smart cities:

- Clients: the total sum of people who will actually make use of a product or service.
- The total amount of network gadgets being used, including all the sensors and devices.
- Quantity of information entails the total amount of data produced by each activity, which would, in turn, cause a rise in network congestion for IoT systems. The data volume created by most SC services is very small, but there are certain systems, such as surveillance videos, that have the ability to produce a substantial amount of information.
- Time-sensitive services, such as e-health facilities, need prompt responses to situations and necessitate real-time provisioning and fast data handling, for example, so that medical personnel may respond in a timely manner to patient demands.
- Destination services: if a program is dependent on a destination address, subsequently, it is important to plan ahead for this potential and determine if external or internal placement is required. The next step is to find a positioning technique that can provide enough accuracy for the planned services.
- Invoicing: certain services are completely free, while others need payment from individual consumers.
- Many cities run test programs on a lesser scale, to begin with; as a result, it's important to plan for growth in the number of network devices and end users while developing the software requirements.
- To facilitate the integration of IoT devices and the accompanying information handled by many digital products and services, IoT platforms must present consistent and easy endpoints. This may increase the likelihood of people adopting SC services by fostering an environment of services that work together across cities and make innovative use of existing open infrastructures. Because only interoperability IoT systems can readily be incorporated into unique creative cross-platform and cross-domain applications and services, cities, therefore, need requests for public and interoperable equipment and application systems from hardware and software manufacturers. The following are features of IoT gadgets:
- Interaction method: a city planner has to think about the interaction technology necessary to link IoT devices to the Internet whenever creating a city-wide strategy, as well as the unique physical features of a given location. Interaction protocols, either wireless or wired, must be sufficient. There are now a plethora of different methods and transmission methods on the market; going forward, at minimum, some of them must be recognized as standards.
- The capacity to compute is a game-changer for the structure and functioning of services. If a gadget has enough processing power, it may be able to conduct certain processes and basic computations locally, minimizing the need for it to communicate with a centralized computer or network. On the other hand, the cost of a gadget will rise, and it will need more juice to do its computational work. Hence, it is important to carefully consider if the processing would be performed in the cloud or at the edge of the network or if more processing capabilities must be employed on a gadget for a particular action.
- One of the most important aspects of an IoT device is how much energy it needs to function. The majority of gadgets in use presently are operated by batteries, and their lifetime has greatly enhanced as a result of both the increased performance of modern systems and the reduced power operating mode they use, in addition to the increased capacity of modern batteries. Nevertheless, because of their energy requirements, certain electronics must still be plugged into a wall outlet. In recent times, we've also seen the proliferation of power generation methods used in combination with reduced electronics. A device's electricity supply could be rechargeable batteries, conventional electricity, or some kind of power generation.
- For position-based services to work, it is necessary to be able to determine exactly where a gadget is, which usually necessitates the installation of a GPS chip in a working device. Some features of an IoT device's connections are:

- Bandwidth: depending on customer needs, it is vital to determine the pace at which data is transferred between such a gadget and an IoT platform.
- Delay time could not have major impact on most systems, but for a subset of those services, it could have a profound effect. Certain systems are particularly vulnerable to interruptions in transmitting information, such as real world applications like Smart Parking.
- Data loss: certain systems could be particularly vulnerable to data failure, necessitating the implementation of extra safeguards—such as retransmission to prevent their occurrence. Some systems, meanwhile, may continue to operate normally and even be built with loss of data in consideration.

3.2.2. Regulations of SC services

Regulations and ordinances that apply to SC services are referred to as legislative features. The governmental or EU regulations that apply to all EU member states have already been specified. The following qualities are those that make a solution most essential:

- Legal interception: In several nations, state provisions require the capability to intercept data transmission, which also extends to IoT communication.
- Reliability of the service: The capacity to prevent failures that become more serious and frequent than is tolerable.
- Personal information security is a key core human right that guarantees people's ability to safeguard their private information.
- Privacy: ideas and techniques for protecting online crimes at the stage of the services and the equipment.
- Operator's transition: The capacity to transfer between IoT providers, that is, any participant in the IoT supply chain.
- Wandering: applicable to controlled activities when multinational identifiers were included beyond the local network, i.e., IoT devices authorized in one system are employed in other systems.
- Compatibility and transparent data accessibility and programs: this, we feel, is not just a technological necessity as well as a legislative one, particularly for all social welfare SC services. It has a close connection to controller switching.

3.3. Statistical Analysis

Gathering data, making sound judgements, and presenting findings persuasively all rest on the statistical analysis. The use of statistics is essential for making innovations, sound evaluations, and precise forecasts. An effort to analyze the reliability of the evaluation is made using the Chi-square test and the ANOVA test.

3.3.1. Analysis of Variance (ANOVA) test

Analysis of variance (ANOVA) is a method of statistical analysis that categorizes the observed data variation into two categories: structured and arbitrary. Methodological considerations affect the displayed statistics, whereas unpredictability parameters have no effect. The analysis of variance (ANOVA) test is often used by investigators to investigate the impact of confounding variables on the precision of a predictive study. The ANOVA equation, which is used to conduct an analysis of variance, is a powerful measurement software often used to demonstrate the existence of statistically significant differences between a number of independent variables. With the help of the ANOVA complete form and how we generate ANOVA, we will be able to show how to conduct numerous analyses of distinct groups. As demonstrated by equation 1, the ANOVA equation is as follows.

$$F = \frac{Mean\ sum\ of\ squares\ due\ to\ treatment}{mean\ sum\ of\ squares\ due\ to\ error} \tag{1}$$

Essentially, the ANOVA test will allow us to investigate more than two groups at once to see whether there is a connection between them. The ANOVA statistic, often known as the F-ratio or the F statistic, is the solution to the equation used to determine the ANOVA statistics. The F - -statistics is useful for analyzing data sets with a high degree of repetition, allowing us to measure the degree of variation among and within individual occurrences. Results from the ANOVA equation for the F-ratio statistic will be consistently near 1 or range from 0 to 1 in all analyses when there is no substantial difference among the categories being evaluated for analysis (analysis of variance example). Number 2 denotes the ANOVA equations, which account for both inter and intra-group differences in the data.

$$F = \frac{\sum_{j=1}^{k}\sum_{j=1}^{l}(\overline{x_J}-x_j)^2}{df_\omega} \quad (2)$$

Here, x stands for observations, x_j for the mean, and df_ω for the number of possible observations.

3.3.2. Chi-square test

The chi-square test is a kind of statistical analysis that uses measurements from a wide range of variables (symbolized as 2). In most circumstances, it entails conflicting and evaluating two sets of quantitative data. The goal of this assessment was to investigate and distribute data on categorical data. As a consequence, the test became known as the Pearson's chi-squared test. The chi-square test is used to estimate the chance that the findings would be as reported under the assumption that the default assumptions are valid. An assumption is a chance that a given set of criteria or a specific claim is true, which we may then test. This probability may be represented as a percentage. The application of a sum of the squared errors throughout the statistical distribution is often used in the creation of chi-squared analyses. In order to discover whether or not both the predicted value and the actual value vary in any fashion, the chi-squared test is performed. Chi-square may also be expressed explicitly, as in equation 3, which is acceptable.

$$X^2 = \sum \frac{(\text{Observed value} - \text{Expected value})^2}{\text{Expected value}} \quad (3)$$

As a synonym for potential value, the phrase "P-value" is often used. It is defined as the probability of experiencing an effect that is either stronger than or similar to the actual outcomes. It's feasible to arrive at any of these two conclusions. P-values, or degrees of peripheral importance, are statistics measures used in hypothesis testing to establish the likelihood of a certain outcome. The P-value represents the significance level where the null hypothesis would be abandoned rather than the rejecting point. This is done so that no misunderstandings occur about the actual meaning of the phrase "rejecting point." There is more data to back up the null hypothesis when the P-value is as little as feasible. The p-value is a number that may range from 0 to 1. The researcher is in charge of setting a threshold for significance. The significance level of 0.05 is often used. In Equation 4, we get the formula for calculating the P-value.

$$Z = \frac{\hat{P} - P^0}{\sqrt{\frac{P^0(1-P^0)}{n}}} \quad (4)$$

4. PERFORMANCE ANALYSIS

The analysis's findings were determined by averaging each criterion's scores together. The five criteria, precision, credibility, dependability, security, and versatility, are each depicted separately to explain the process and to demonstrate the function in reality. According to the Cities in Motion Index (CIMI), a SC is a method of municipal government that upholds residents' quality of life and future sustainability while also creating commercial prospects for public-private sector cooperation. A SC is one that has generated proactive interest in itself from inhabitants throughout the globe in the digital sphere, according to the Digital City Index (DCI). According to the Global E-Government Survey (GEGS), the two pillars of digital governance are the provision of public services and citizen involvement in government. According to the Innovation Cities Index (ICI), an SC is a process of innovation and is thus concerned with idea development, execution, and communication. According to SC Governments (SCG), an SC is a method of city governance that makes use of investments in digital solutions, identifies and interacts with population groups that are most vulnerable and transforms the city into a place that is prepared for the future and focused on its residents. According to the SC Index (SCI), an SC is an urban area where technology is used to improve urbanization's advantages and mitigate its drawbacks for local residents.

Figure 3 displays the precision of SC indexes. The evaluation was validated by the fact that all indices had consistent rankings with at least one control group city. With just one stable ranking among the four chosen cities, the Global E-Government Survey and the SC Index received the lowest score. According to its city recruitment process, GEGS only included Shanghai and Berlin, which is appropriate. Due to SCI's findings representing local residents' subjective opinions rather than objective official statistics, the poor consistency may indicate that residents' perceptions may not always correspond to actual city performance. Since all cities had consistent rankings, the Innovation Cities Index and SC Governments received the full score in precision.

Figure 3. Precision

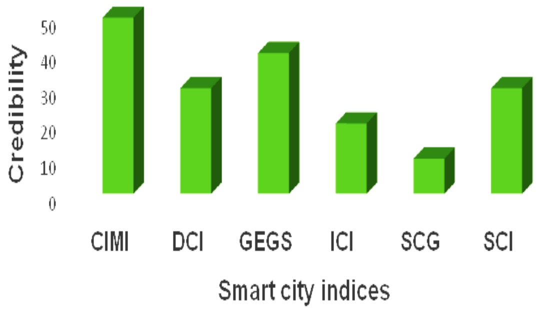

Figure 4. Credibility

Figure 5. Reliability

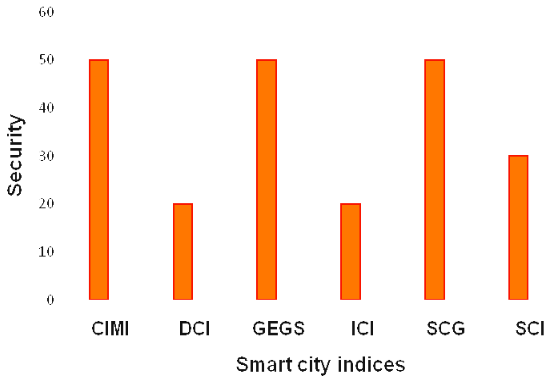

Figure 6: Security

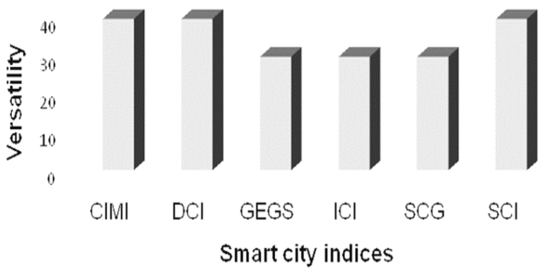

Figure 7. Versatility

The credibility of SC indices is shown in Figure 4. Universities with research-based employment are given greater credit, while SC Governments get the lowest credit, making the Cities in Motion Index the only one to receive complete marks in this category. With a leading performance in Credibility, the University of Navarra parent CIMI's organization benefits from a respectably high ranking in the World University Rankings. According to the number of fake followers, the Eden Strategy Institute, the parent company of SCG, does not have a good reputation as an institution.

The reliability of SC indices is seen in Figure 5. The majority of indices perform well in the reliability category, with the exception of the Digital City Index, which has never been cited by any municipality and has only seldom been mentioned in academic journals and the news. Another index, SC Governments, has a lower score since no governments have ever cited it. In particular, the three indexes with complete scores have received the most attention from scholarly journals and the media (CIMI, ICI, SCI). They have all been discussed in worldwide public media and mentioned more than five times in academic journals.

The Security of SC metrics are shown in Figure 6. All forms of interoperability in smart cities are subject to security concerns. Access control and vulnerability analysis are crucial since they deal with sensitive information (long-term remote illness treatment, telesurgery, smart grids, real-time traffic, etc.). As a result, systems like user identification and authorization that maintain the availability of services and access restrictions should be taken into account.

The versatility of SC indicators is seen in Figure 7. All indices perform above average for the versatility criteria. Apart from SC Governments and the SC Index, each index had a distinct rating for each continent, which was used to gauge how sensitive each index was to the regional environment. Moreover, all indexes included at least three aspects of smart cities, and three of them (CIMI, ICI, and SCI) even did so for all six, demonstrating their suitably broad applicability. With the exception of the Innovation Cities Index, all indices were constituted mostly of unique and important indicators when it came to the investigation of vital excellence of indicators. The majority of the indicators seemed to have no bearing on the SC, despite the fact that ICI declared to be tracking cities more broadly than the other indices in order to identify prospective changes in cities before the others.

5. CONCLUSION

Data interoperability and the methodical management of incorporation are crucial in the connected and contained way of a modern city. The compatibility of gadgets in multiple domains, which itself is challenging owing to the absence of standardization, is a feature of the SC, which incorporates IoT devices in numerous domains, including intelligent control, power generation, medical services, commodities, and transportation. In addition, there are many forms of cooperation in the IoT context, and it is important to understand that every type of interoperability requires. In order to show the different interoperable kinds and their shared protection, we first analyzed the need for interoperability in the modern city. We gathered and examined the relevant research examining interoperability in the homogenous system in order to determine the criteria for compatibility in an SC. The fundamental security needs for each form of compatibility and data processing were stated at the end.

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