Research Article

A Role of an Edge Computing Technologies for the Internet of Things in Smart Cities

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Abstract: Data-thorough analysis is the biggest contest in smart cities, due to the ubiquity of different types of devices, with the number of device explosions and the numeral of Internet of Things (IoT) rest area attached to smart cities. Using shrewd computing technology to create critical infrastructure and services for the city - including city administration, education, health, public safety, land, shipping and services - is smarter, more connected and efficient. In this paper, we explore the important technologies and structures already built in the literature to identify the right people for inclusion in smart cities for computing development.

Keywords: Internet of things, edge computing, smart city, fog, cloud.

1. Introduction

Implausible improvements in the daily consumption of automated infrastructure and software were leading to significant moves forward in communication networking and the introduction of the Internet of Things (IoT) concept. IoT is an evolving example of communication, in which devices can act as objects or "things" that can sense their environment, communicate, and share data over the Internet. By 2022, the IoT network will connect one trillion IP addresses or artifacts to the Internet. Recently, the IoT prototype used to create smart atmospheres with different application domains and associated services, also including smart cities and intelligent homes. The objective of creating such that the intelligent environment can make human life more constructive and convenient, addressing the living environment, carbon emissions and essential goods. The objective is directly expressed in the significant development across distinct networks of accessible IoT based services and apps. The Internet of Things is a physical device smart connectivity that drives huge gains in effectiveness, company development, and quality of life [4]. In this paper, the Internet of Things solicitations and contests explained in detail. Section II describes the literature review of Smart Cities Architecture. Section III gives IoT edge computing, fog computing, and cloud computing. Section III gives edge-computing models in brief. Section IV is about tools availability, and finally, section V presents the conclusion about this work.

2. Internet of Things

Internet of Things described as an environment where sensors and actuators interconnect and connect to the Internet. All objects related in the IoT system speak in the same language, understand, and acts without any human intervention. Originally, the word Internet of Things discovered in the presentation tile describing the Kevin Ashton. This explains about sensor tagging for products of large consumer company to make the supply chain management robust in 1999. Even the Internet of Things named very late, the concept of the connected system is not new, and there were many similar developments in progress. The coco-cola machine was connected to the internet during 1980 and monitored for availability, reducing unnecessary trips to the distributor. Sethi et al. [1], has reviewed the basic IoT system, Architecture, protocols available, and applications of IoT, and proposed taxonomies for further IoT are shown in the following figure 1.Tiwary A et al. [2], Tiwary has identified IoT features like Artificial Intelligence enablers, creates more linked systems, and an active interaction network, and also describes customer engagement, technology management, waste reduction and increased data collection are becoming more and more evident in the form of IoT features. In addition, security, privacy, complexity, flexibility and compliance are significant disadvantages of the Internet of Things.

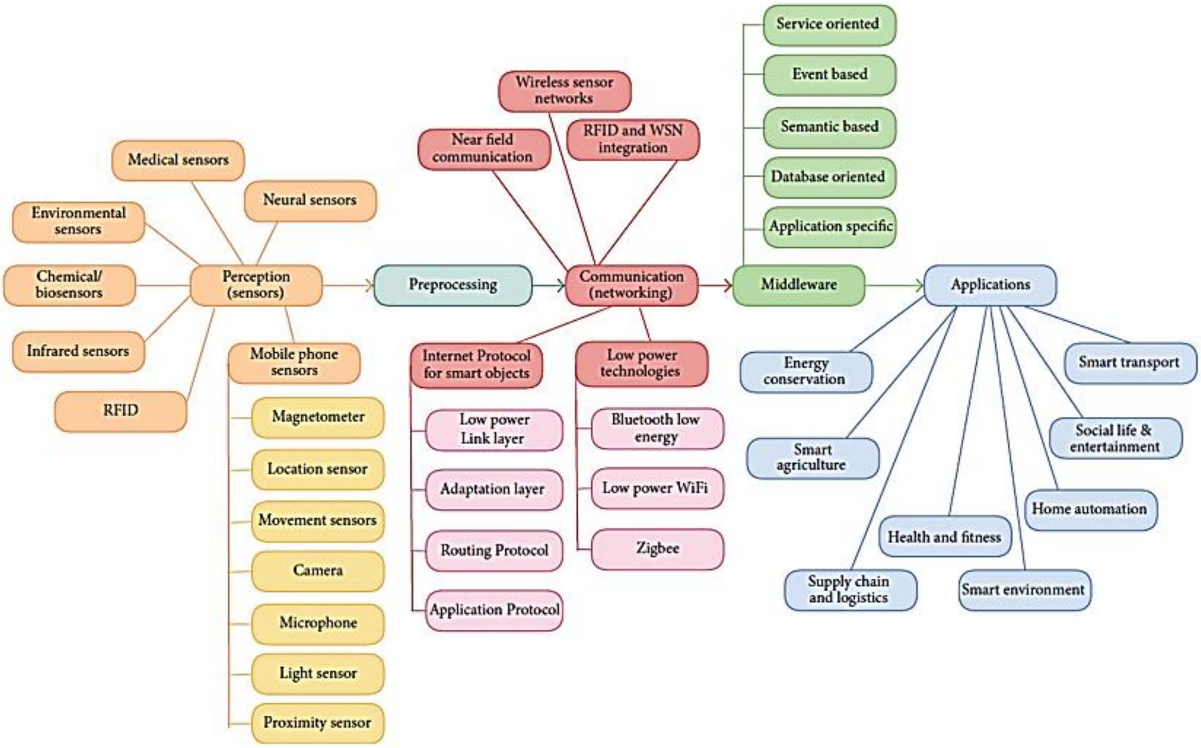

Figure 1: Taxonomy of Research in IoT Technologies

Sharma V et al. [3], has stated better security and surveillance, disability assistance, automated industrial control, smart agriculture, home, and building automation are the major applications of Internet of things, but this application of IoT is not limited, and currently smart city umbrella of all IoT applications and emerged as a critical field of study are shown in the following figure 2. Sarhan, Q.I. [4] had a detailed review of the experiments and focuses of the Internet of things. He has categorized the challenges in Global use, Standards and Protocols, Operational and Technical, and Data and Software. He stated, as privacy and security were the biggest challenges when IoT enabled for global use. Data integrity, Data Authentication, Data Confidentiality, and Trust and Governance affects the global use of the Internet of things. In addition, he detailed how interoperability, mobility, scaling, human-machine interaction, and dependability are the major operational and technical challenges of IoT are shown in the following figure (Fig.3).

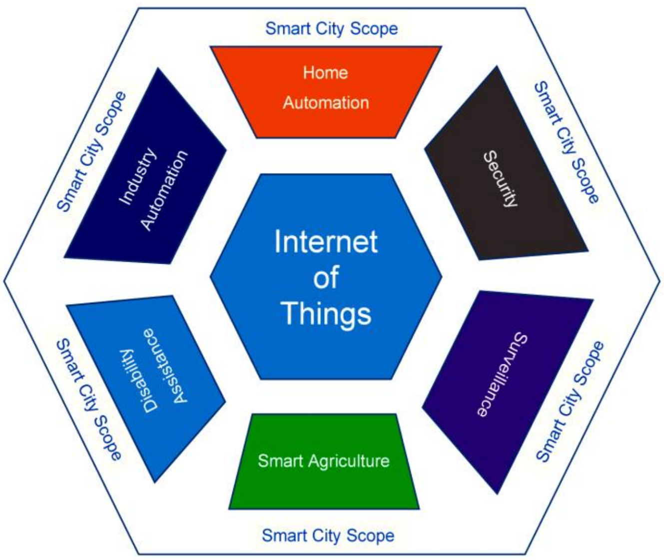

Figure 2: Applications of Internet of Things

3. Literature Review

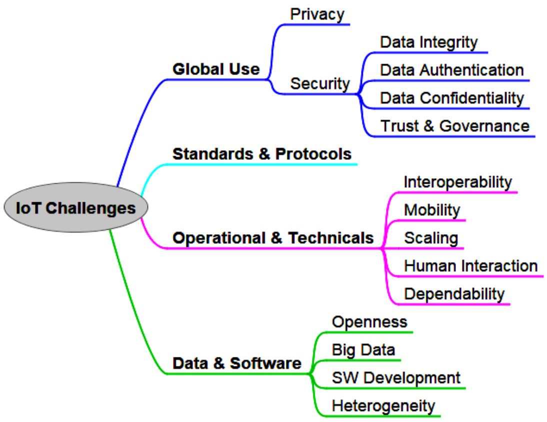

Figure 3: Challenges in Internet of Things

Gianni Pasolini et al. [5], presents about the smart city will be smarter when there is less or nil natural resource wastage, better transport, environmental carrying, better emergency supporting and, recently, the smart city concept emerged as a groundbreaking solution to solving the problems facing new urban areas. Rapid spread, the aging of buildings, the movement of vehicles, and the provision of energy, personal security and Data protection are some of the problems that have a major effect on the quality of life and health of people, and on the economic and environmental sustainability of human operations. This factor is certainly important because, by 2050 people living in urban areas are predicted to increase. IBM terms a clever city like "a city that makes use of all the mutual knowledge today to better understand and monitor its operations and maximize the use of limited resources.

3.1 Existing Research

3.1.1 Architecture

Initially, Jiong jin et al. [7], was one of the first researchers describes due to increasing population of a city The city challenges the challenges of using limited resources more efficiently meeting the needs of city dwellers, workers and visitors, and improve the length of smart cities' critical IoT building blocks, and their communications and policies and resolutions. Moreover, calculate the requirements and start the noise mapping work in conjunction with IoT City. Roozbeh Jalali et al. [8] had a detailed review of the city's population presents significant experiments, containing air toxic waste, movement crowding, health problems, vitality and discarded management. Solutions to these threats include the coordination of multiple ICTs into urban carvings. Aseel Alkhelaiwi et al. [9], introduce the aggregate of data to be shown to the cloud is very important and there are bandwidth, network and storage challenges. It provides a data reduction service and proposes lossless compression steps for congestion, accelerometer readings and single-precision floating-point data obtained from GPS coordinates. It proves floating-point compression to reduce the cost of transmitting large amounts of data. Federico Montori et al. [10], gives the architecture Sensquare can handle different data cradles from an exposed IoT stand and crowd sourcing battles, and demonstrate integrated entrance for customers. Paula Ta-Shma et al. [11] presented analysis of comprehensive historical data sets and seemly for real-time analysis, it is complex, to solve this issue proposed the hut architecture it uses open source components to optimize for Big Data applications. Jianhua He et al. [12] Introduces a new fog-computing model with specialized computing infrastructure and simple, functional modules that can reduce potential problems with slow cloud computing response. It has evolved to evaluate the FOG-based analytics service and the proposals for QoS management. Experimental findings show the analytics services' potential for influencing multitier fog and planned QoS schemes. Bo Tang et al. [13], Fog extends computing to the edge of computing networks, to rectify the challenge of data-intensive analysis in the smart cities. It introduces a Classified Distributed Fog Figuring Design for Big Data Enquiry in Smart Cities. Computational and storage networks require latency-sensitive applications at each layer as well as provide a fast control loop to help make sure data security elements are efficient.

P.K Sharma et al. [14], Represented the embedded system in the central network and at the edge servers. This relies on three technological advancements: Computing for Fog, SDN, and Block chain. This architecture supports full functionality, data package in proper time, high interoperability, preservation, explosiveness and low power consumption. It eliminates the end-to - end transmission delay between IoT systems, machine resources and existing network lateral load as compare to direct communication protocols. Moreover, loading files in the cloud is a more appropriate path. Pradeep Kumar Sharma and others. [15], with the potential for developing software-defined networking and block chain technology, Novel network architectures for smart cities reported. To achieve productivity and address existing limitations, Smart City Networks divided into two classes, Argon 2, for core network and edge networks, as well as securely distributed smart city networks using the block chain method. Implementation of work based (energy) scheme. Zaheer Khan et al. [16], has described sensible cities consumption a range of ICT solutions to touch upon tangible-world inner-city challenges. It includes environmental property, socioeconomic innovation, and democratic governance, higher public services, designing, and cooperative decision-making, and Converts application-specific knowledge into an assistive application of information and knowledge to facilitate urban formation and policymaking. Since the ICT angle, the prospect of identifying capitals is aided by smart hardware and software packages, e.g., IoT, RFID, sensible phones, detector nets, sensible house utilizations, and capability to accomplish and method giant-weighbridge knowledge exploitation cloud computing while not compromising data security and voters privacy. Zaheer Khan and others. [17] Through ICT, it is challenging to understand the smart cities that process integration data from a variety of sources and support the information provided by the services used by voters and public administration. Integrating large amounts of data, collecting data in multiple formats, correlating such information to the right issues and events, analyzing records to reduce expedient figures and visualization, and the perpetually increasing number of such Information Management. Solving these defies requires a multi-pronged slant that includes information architecture standardization, information integration processes, process processes and storage infrastructure. In the context of sensible cities, Karima Velaquez et al. [18] describes the quality could be a key demand that ought to be reconnoitered, permitting expedients and services to seizure info concerning the surroundings and act in the period. During this urban quality state of affairs, within the sensible town paradigm, The Fog Orchestrator surfaces foremost challenges, for case in point, the quality of cloud-based traffic sensing and resource management associated with travel designing services / applications. Part of the modeling orchestration is cloud readiness and the difficulty of managing surrounding tasks. Cloudlets deployed, bringing with them many new interesting programming challenges. Application classification and user quality are two key aspects of programming in providing fog and managing financial resources for their customers.

4. Edge Computing

The Edge Computing (EC) interface is the fresh from several functions. Thanks to its excellent performance capabilities Low running costs, easy operation, high speed and excessive quality of service (QoS) in having to deliver real-time data analysis. IoT has evolved significantly over the past two decades with pioneering advances in evidence and telecommunication equipment.

Mukesh Prasad and others [20] explained the increasing demand from consumers, except for the high internet value purely functional to trillions of gigabytes by edge systems. This cloud makes maximum use of dormancy problems and bandwidth. Because out-of-date cloud servers are unable to button this massive aggregate of data with their centralized network architecture, IoT applications require more streamlined computing management systems in real time. Therefore, EC is essential because it overcomes the barriers of centralized infrastructure, taking the computing capability to the edge of the link. Although the EC grasped as a good expertise, the work of the EC is stagnant at an early stage.

4.1 Edge Computing Introduction

Edge computing since the 1990s, Akamai has released its Content Delivery Network (CDN), which executes nodes purely nearer to end-user locations. In 1997, computer scientist Brian Noble proven how to expenditure edge figuring through mobile devices to understand voice. This routine also used to improve cell phone series life after two years. At the interval, this method called "imitation forges," which essentially runs the speech recognition services provided by Apple's Siri and Google.

4.2 What is Edge Computing?

According to Edge Computing, the aging company IDC is "a network of palmtop data centers that practice or store important data in the neighborhood and all the data collected in a footprint of less than 100 square feet. Transferred to a crucial data center." This commonly brings up to as IoT use gears where edge expedients collect data - often in large quantities - and send it to a cloud for dispensation. Edge attempts to compute data close by so that some of it can handle in the vicinity, sinking traffic from the backward to the principal depository [22].

4.3 Difference between Other Methods

The data processing in a computer, on the edge computing, or on the gateway computer near the sensor. Calculation and storage systems are located below the data generation unit, program, or component.

4.3.1 FOG Computing

In fog, computing, authority-computing events are transferred to processors connected to local area network or LAN hardware. Data in fog computing is processed in an IoT gateway or LAN within a fog node [23]. Fog computing, first introduced by Cisco, and has emerged as a new concept that can solve latency-sensitive computing problems. Defined as a postponement of the cloud. Fog functionality specified in Fog Servers (FS) and Foglet, where FENs and FS are hardware nodes and Foglet Middleware for data exchange. When Fog used as a platform for IoT, a FEN can be a neighboring smart object for complex contact and edge computing, so that knowing, controlling besides intake can quickly achieved in FEN. In contrast to FEN dealing with interactions between smart objects, FS focuses on the interaction stuck between FEN and the cloud. In this way, the FS reins, maintains, and matches the FEN at its one-hop contiguity.

At the same time, Fog compromises annoyed-stage capabilities of resource observing, connectivity management. Overall, Fog provides a cloud-to-things continuum for networking services, and facilitates collaboration between IoT components.

4.3.2 Cloud Computing

Cloud computing acts like a standard server, responsible for all the activities in the system. Data management, required task response, data processing, etc. are all in the cloud storage. NIST (National Institute of Standards and Technology) provides cloud as per schedule. Cloud computing is an exemplary that allows everywhere, easy, Service on access to a common pool of universal computing resources which can be quickly distributed and published with marginal maintenance strength or interaction. In service providers, IoT cloud provided with the Cloud Platform, Platform provided by the service provider as a hosting service that facilitates the development of software submissions without the costs and hassle of obtaining and organization the underlying components provided by the hardware and software. A novel concept of service provider hosting offered as a hosting service, which enables the underlying hardware and software layer to disrupt the model intended to improve the information community, promote and optimize software applications' operation without cost and hassle. Refined services by building, exiting and developing built-in (physical and virtual) objects, providing end-to-end statistics and communiqué technologies with universal, fast, on-demand network accessible configuration properties (e.g., network, server). Extensive storage, software and amenities with marginal maintenance power or profitable outworker interactions can be easily distributed and issued Edge computing can be associated with the same data processing (or part of the data) at the endpoint (usually a computer such as an ATM system, gateway device, mobile, etc.) or more commonly known as an 'edge'. Initially, this 'Edge Analysis' collects streaming data, which used to shut down the wrong ATM system or perform a task or core focuses on dividing data processing work between edge computing and cloud-computing services to simplify IT workload and load sharing, improve the operational capabilities of the system, and create an efficient ecosystem .for business [24]. In this table 1 the comparison of Edge, Fog and Cloud and with future with IoT is listed. Calculation operation such as currency theft or fatigue on its delivery device. Smart phones use this computing method when making payments through the device; Edge Computing handles traffic lights, manufacturing like lot of activities performed by edge computing.

4.4 Edge Role in Smart City

This paper describes the Edge Computing Structure [25] for situational responsiveness in an IoT-based smart city. IoT is an edge-computing framework for processing locations in a smart city, which helps decision makers understand the situation and provide relevant services to city dwellers. Bin Cheng et al. [26] describes a regular-dedicated slant to designing and implementing a hazardous fog computing-dedicated structure for fog-flow, i.e. fog-flow, for IoT considered city stages. Limitations of the Fog Flow Programming Model IoT Real Estate Developers can conveniently program the cloud and edges to facilitate elastic IoT stay.

In addition, it re-uses the standard interfaces of climate and reference data for housing to identify atmospheric liveliness use in real-time - anomaly detection. The edge knob used to observer the process on or after all operations. Once a strange case perceived on the edge, the ordinance relating to the node is resolved, and the incident detected to process information in the cloud recorded. The system operator handles the information through the dashboard and the structure operator can enthusiastically update the detection statute.

Table 1 Comparison of Edge, Fog, and Cloud Computing and Future IoT

Requirements	Edge	Fog	Cloud	Future with IoT, Edge, Fog, Cloud
Latency	No delay in data processing	Low Latency	High Latency	New Deployment options
Responsiveness	Real Time Data Analysis	Better Data Control	Downtime	Smart Analytics
Security	Low Network Traffic	Flexible Storage System	Security	Better Security
Structure	Reduced Operating Costs	Connecting Centralized and Decentralized Storage	Privacy	Inter Device Interactions
Analysis	Short Term	Short-term	Long Term	Capable in Computing
Number of Nodes	Moderate	Very Large	Few	Based on the Requirement
Architecture	Distributed	Distributed	Centralized/ Hierarchical	Distributed and centralized
Data load	Small and intermittent	Small	Large and Continuous	Large
Service Scope	Limited	Limited	Global	Global
Data Enroute Attacks	Very Low probability	Low Probability	High Probability	High End Probability

4.5 Edge Computing in Smart City

Zhao, N., Leung et al. [27] proposes incipient perspicacious city architecture that integrates software-defined interacting, accumulating, and computing to ameliorate the routine of the perspicacious city applications. This paper additionally solves resource allocation, optimization, and quandary utilizing novel, immensely colossal data and deep reinforcement learning approach. Giordano, Andrea et al. [28] describes Rainbow middleware architecture, which discusses three-layer architecture to providing astuteness in fog computing with Multi-agent systems along with virtual objects to connect the authentic world sensors or physical methods.

Edge computing offers better worth of accommodation in terms of delays, power ingesting and concentrated data traffic in the cyber world. The core feature of Edge Computing is strengthening applications that involve low latency, location knowledge, and mobility. Ng Zhang, Hong, Zhu Zhang and others, [29] The proposed framework eliminates difficult tracking conditions due to such closure, turning, and distortion and intensely improves tracing accuracy. The proposed algorithm (region proposal correlation filter predicated on BACF) in constrained recollection profile and provides more precise and robust tracking even in arduous tracking conditions such as deformation, cluttering. Badidi Elarbi, et al. [30] describes a conceptual data integrative framework with the heterogeneity of systems at different caliber, including data models, data semantics, accommodation implementation, and interfaces. The architectural design to deal with issues above with edge computing, semantic integration, and data analytics.

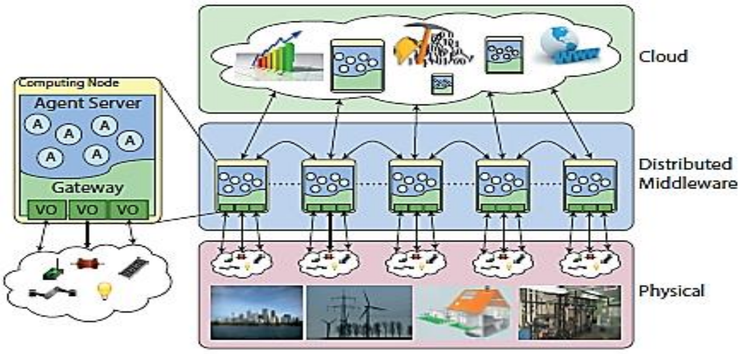

Figure 4: Rainbow Architecture

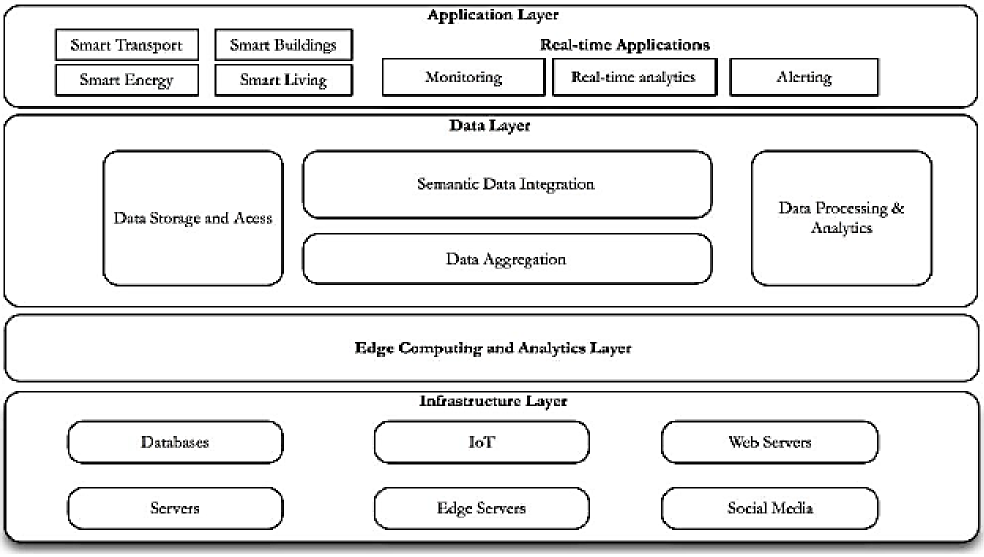

Figure 5: Architecture for Data Integration

4.6 Challenges Addressed with Edge Computing

4.6.1. Network Bandwidth

When more information shared at the edge and further evaluation begins at the edge, the network's bandwidth is modified. Companies traditionally allocate high bandwidth in data centers and reduce endpoint bandwidth. Now, the edge computing challenge is the need to balance more network-wide bandwidth.

4.6.2 Distribution Information

Companies need to accept location as an additional dimension of computing. Integrated models of computing being destroyed; Computing should now include networking as one of the main features of East-West transportation.

4.6.3 Latency

By applying the edge to the calculation, where the proximity to the measured data is, the delay in the application decreases with the decision delay. Moving from edge to center less and moving forward means faster responses and faster interference and with center and edge-based calculations, application data crosses the network in every direction, exchanging data and facing access rights. This means that data transfer is no longer a straightforward method.

4.6.4 Security

Computing resources and software clustered in the data center so companies can standardize both digital security and physical security. The wall can built around the capital to facilitate protection. However, Edge Computing requires companies to implement the same network security model with more remote servers and physical security parameters. The safety footprint issue and traffic policies are all over the city.

4.6.5 Backup

Edge computing usually needed because large amounts of data can collect from different areas. Organizations need an overlay scheme for data security that can cover this data. Because network backup does not make sense, properties for network capacity are required for storage capacity when deciding how to store such assets.

4.6.6. Data Accumulation

Data is an important business asset, and storing it sideways brings new problems. This could create liability if it does not comply with current data management law. Data collection and access are required, and data must be included as part of the life cycle. As more information shared at the edge, and more assessment starts at the edge, the bandwidth of the network will modify. Companies traditionally allocate higher bandwidth to data centers, and reduced endpoints bandwidth.

Now, an edge computing challenge is the need to balance more network-wide bandwidth. In this section, illustrate that the Edge computing Challenges in the table and denoted the possible solution for these identified problems and each methods for each challenge in respectively.

Table 2 Challenges of an Edge Computing based IoT

Challenges	Problem	Methods
Data Transmission	During data transmission some significant traffic generated	Software Define Networking(SDN) Detection: Intrusion Detection System(IDS) Protection : Traffic Isolation and prioritization
Storage	Lose Data Packets Data Leakage Data Reliability	Homomorphic encryption Random Mask Technique Network coding (laborious program)
Computation	Security Software verification Malicious Intrusion detection Privacy	Verifiable Computing Bottom-up and simple method for software stack security testing in IoT (BUFS) HoneyBot Proactive, reactive, predictive defense techniques
Manage Resources	Action Based Optimization	Action Schemes: allocate service fair and unbiased way. Increasing promise and complements auction schemes.
Privacy	Easy and down-to - earth system for IoT protection testing Movement of services across global and local scales Malicious Behavior	Privacy preservative mechanisms Local discrepancy privacy Discrepancy privacy with high utility
Security	Authenticate gateways	Smart meters

5. Conclusion and Future Work

In this paper, we have presented insight on the Internet of Things and smart city scope, various Architectures from the initial period until the current period, details about various computing architectures, and how Edge computing is going to plan a more significant role in smart city deployment. In addition, we have listed the challenges in smart city deployment, and a couple of smart city architectures analyzed and discussed their key problem and solution. However, most of the current research kinds of literature are respect to one domain or specific problem and does not address all the critical challenges together. Finally, based on this analysis, we plan to begin our future work.

a. Introducing Smart Middleware for Edge Computing used for any application domain with the Interoperable Data Conversion Manager.

b. Can develop integrated collaborative middleware architecture for designing smart middleware for edge computing architecture.

c. Plan to implement the design specifically for the use of edge, fog and cloud computing for the development and operation of smart city applications.

d. Configuring Geospatial Maps for Sensors with Conversion Schema using Public Shareable Parameters and Private Parameters.

e. To verify the efficiency of this design, we plan to develop an algorithm that supports Smart City applications using an Edge Computing.

In the future, IoT is the smart city to start a novel period in smart city development. It aims to broaden the competences of IoT and generate a common model in the design of applications for smart city architecture for edge computing, as it intentions to completely transform the budget, civilization and our way of life.

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