Machine Learning for Human Intelligence
2026, Vol. 4, Issue 1

Research Article

Unveiling Insights from Massive IoT Data: A Framework for Real-Time Analytics

Saira Batool[1*] and Min Guo[1]

[1]Information and Communication Engineering, North University of China, Taiyuan, 030051 China; Email: sairabatool230@gmail.com; guomin_like@sina.com.cn
[*]Corresponding author: Saira Batool (sairabatool230@gmail.com)

Article History

Academic Editor:
Dr. Muhammad Sajid
Submitted: September 21, 2025
Revised: January 16, 2026
Accepted: March 1, 2026

Keywords:
Internet of Things, Sensors, Big Data, Contiki 2.7, Data management, Analytics

Abstract

A smart analytical environment must be adopted through ubiquitous or pervasive computing, enabled by the Internet of Things (IoT), significant technological advances, and the growing trend toward big data. Big Data refers to the enormous volume of data generated by a wide range of networked, interconnected sensors in a communication network. These networked devices require effective management and control over the communication network. Accordingly, a non-trivial analysis concern was raised about the effective collection, processing, and monitoring of large volumes of data from smart IoT-based sensors while consuming little energy. We have selected the smart office infrastructure for the study of sustainable and effective sensor data, despite the broader notion of the Internet of Things in the smart city. To enhance daily living, this article outlines the potential and promise of effective big data analytics in smart offices. To create positive and advantageous situations for their interaction and use, we have combined the features of the four most intriguing technologies, namely sensors, cloud computing, big data, and the Internet of Things (IoT). Through its real-time implementation, our proposed framework for managing sensor services would estimate each node's relative energy consumption in a smart communication network. Additionally, we have used their relevant throughput and energy usage to compare our suggested real-time solution with a typical system. Consequently, our projected real-time smart office solutions may guide us toward an effective smart workplace.

1 Introduction

The term "Internet of Things" (IoT) has brought about a significant transformation in the digital realm, driven by its early introduction alongside major advances in computer and communication technology [1]. Because of the interconnectivity of communication devices, independent work, cumulative results, and measurements, IoT-based interpretation has changed people's daily work activities by providing a smarter, more efficient environment [2]. Significantly, the Internet of Things is crucial to the monitoring and management of "Intelligence Office Management" [3]. The enormous amount of data (terabytes to hundreds of petabytes) generated by these networked devices is hereafter referred to as "big data" [4]. Microelectromechanical systems (MEMS), wireless networks, and digital electronics are converging rapidly, making it necessary for the Internet of Things to manage the massive volumes of data generated by businesses and individuals in the industrial sector [5]. This IoT boom significantly impacted the

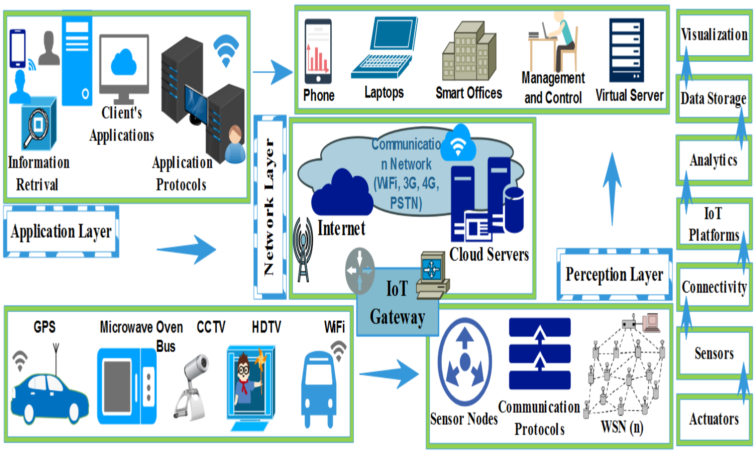

Figure 1: Smart Big IoT Architecture.

big data landscape. However, several opportunities are introduced to enable real-time analysis of the massive amounts of data generated by IoT sensors [6]. These opportunities include IoT applications for home, social, healthcare, and industrial use in pervasive or smart environments through wearable smart devices or in conjunction with remote monitoring devices; however, they are not discussed in terms of the energy consumption of smart offices [7]. Furthermore, as technology advanced, big data analytics became more difficult because data in the Internet of Things environment is collected and processed by a variety of sensors. Accordingly, the International Corporation research predicts that by 2019, the benefits of big data will drive the market to reach 125 billion US dollars [8]. IoT analytics describes the stages of analyzing a wide range of data from IoT sensors, including new insights, correlations, patterns, and trends that were not previously noticed [9]. Big data analysis may help with control and management for both individuals and businesses. Consequently, IoT-based Big Data is produced by combining these two unique technological worlds [10]. Moreover, Figure 1 presents the architecture of the smart massive IoT.

Wireless Sensor Networks (WSN) technology has been adopted to construct an IoT environment in support of this effort. Typically, it uses a small number of wirelessly connected sensing devices to communicate via the internet with limited resources [11]. These tiny devices, which are connected to other networks via routers and the internet, are also known as motes (Nodes) of wireless networks. Their purpose is to gather and send data and information. These Internet of Things (IoT) nodes, or motes, also provide continuous, simultaneous data streams from multiple endpoints, along with the benefits of real-time network failure detection and ease of installation and use [12, 13]. On the other hand, the primary source of power limitation for these sensory nodes is typically their separate batteries. Various energy-efficient initiatives, including smart grids for wind, water, and solar, have already been implemented to address this issue [14, 15].

However, data analytics is required to address this problem and provide efficient data services through a variety of sensors in an IoT environment. This can be done by determining how much energy each node consumes. According to [16], the need for real-time (efficient) analysis of this interconnectivity drives the development of significant data management solutions that address unique, beyond-the-scope requirements, such as the volume, velocity, and variety of the overall network's infrastructure and processing [17]. Thus, the goal of our research is to bring together all the aforementioned technologies to provide an effective solution that supports smart systems in an affordable, cozy, safe, hospitable, and scalable environment [18, 19]. Furthermore, this study will specifically focus on Intellectual Offices because there are numerous applications for managing IoT-related data, and some pertinent work is discussed in [20]. The main contributions of the proposed model are given below:

- Creating a smart, energy-efficient communication network that can gather and process large amounts of data from sensors while using little electricity is the primary purpose of this study.
- This research combined the four most interesting technologies, IoT, CC, Analytics, and BD, with

the important sensor visualization that foreshadows the predictive care mechanism.

- The analytical sensors' service management framework for the Internet of Things (IoT) layers of the smart office was given in this study.
- The throughput and energy consumption of each node were compared with a typical system in this study. This is the first effort to offer low-power, real-time estimation for the office's smart communication network.

1.1 Organization

The following divisions are included in the design of this article: We have covered the introduction and motivational standpoint in part 1. We have included a brief overview of the literature in Section 2, covering survey articles published in the IoT and big data analytics fields. The contribution is given in Section 3. Comparative analysis is carried out in Section 4. Section 5 discusses the criteria for an IoT network. The proposed service management structure for sensors is presented in Section 6. Sections 7 and 8: Contiki OS implementation is carried out, and the outcomes are assessed following the efficiency standards. Section 9: We offered an ideological outlook for future research as we wrapped up the entire report.

2 Related Work

IoT encompasses several novel trends and technologies to facilitate the integration of many current technologies, such as Bluetooth, Wi-Fi, RFID, Zigbee, and Wibree [21]. The industrialized nations with advanced technology have adopted IoT in practice to enable their citizens to stay connected and support the construction of their enterprises. Research scholars have generally surveyed and examined a wide range of big data analytics and Internet of Things (IoT) challenges, with a variety of applications, in the literature [22, 23]. Additionally, while various technologies are used to construct domain-specific smart environments, identifying and evaluating the effectiveness of communication networks remains a major challenge [24]. Even though there are several previous studies, we found that the effectiveness of smart and robust offices in real-time has not been explored before concerning IoT and analytics on big data. The main goal is to understand the various approaches used to manage and control sensor-generated data collection. An Integrated Information System (IIS) based on Big Data, Cloud Computing, the Internet of Things (IoT), and geoinformatics was proposed by [25] for environmental monitoring and management. Accordingly, a variety of embedded sensors and databases were employed in the data collection process. Furthermore, a highly accurate correlation among several environmental factors was observed, demonstrating the effectiveness of the proposed system [26, 27].

A survey conducted by [28] showed that a range of Internet of Things technologies are employed for monitoring. While the implementation is not provided, [29] proposes a technique to reduce energy harvesting in smart homes, along with a control strategy to monitor real-time occupancy status from sensors. Furthermore, we have included a real-time estimate of minimal energy usage. In [30], a proposal for an electrically supported real-time data-collecting system for e-bikes was presented. The e-bike system has several wireless sensors in addition to GPS units, which effectively give contextual data. Furthermore, the suggested model was tested over 30 cycles, yielding positive results for real-time data perception. As a result, IoT has been included to show the efficiency level in a cycling environment. A "track-stitching" technique was developed at Georgia Tech to identify and measure various smart-environment activities using pressure, optical, and radio-frequency identification (RFID) tags. Additionally, a pattern-matching technique was developed to identify various items and locations. Consequently, [31] suggests using a sequential learning model in the Mav project, coupled with Independent Lifestyle Assisting (ILA), to characterize the behavior of multiple patterns in a smart environment.

Additionally, the writers have included several industrial applications of this technology that enable effective surveillance [32]. Aside from the literature just mentioned, traditional service management systems are the focus of current research on smart offices. Efficient, sustainable, and intelligent interconnectivity among office objects is also necessary [33]. The majority of the work in the studies now available has focused on data processing in lab-based settings. Furthermore, to meet their scalability and applicability requirements, traditional RDBMS (Relational Database Management System) solutions were employed for constraints, processing, and storage [34, 35, 36]. Since there are no IoT establishments in Pakistan, this issue must be resolved by obtaining accurate measurements of the smart, networked workplace environment. As a result, leveraging the latest advances in big data analytics, we must investigate the development of a sensor-based, networked smart office with an effective, sustainable network connection [37]. The majority of smart office applications improperly describe and concentrate on sensor intercommunication and performance. How were the individual events determined? The majority of the bespoke protocols, such as Data Distribution Service (DDS) and Message Queue Telemetry Transport (MQTT), operate in the background of the topology and are unique to the sensor-equipped devices [38, 39]. To understand the insights from businesses in smart workplaces, it is imperative to learn how to properly collect and process sensor data. This data can be used in future research to examine and analyze important decisions and occurrences. Big data analytics is required for the office's evolutionary processes [40]. Therefore, our goal is to outline the promise and potential of big data analytics in smart offices to enhance day-to-day functioning.

This research used a cloud server to develop a method for collecting time series, or massive, continuous streams of data, from the movement of optical sensors. In this research project, the energy consumption of interconnected nodes was examined over various periods. Then, using efficient analytics and the many benefits of cloud computing, including increased storage capacity, efficiency, affordability, scalability, durability, reliability, and flexibility. This research examined the anomalies to enable a preventive care mechanism in smart offices [41, 42]. Furthermore, the relevance of each smart office node's energy consumption is not currently provided in the literature. Since every node in a communication network consumes significant energy, energy consumption is a significant problem [43]. Accordingly, a comparison between our suggested method and a standard communication system is provided. Our suggested solution thereby contributes to efficient service delivery and reduced energy use.

Table 1: Requirements for Experiments

Sr. #	Parameters
1	IoT Connections
2	Big data
3	Cloud Server for Storage and Virtualization
4	Big Data Management
5	Benchmarking Contiki OS
6	Low Power Consumption
7	Sustainability
8	Efficient Data Collection and Processing

3 Methodology

The Internet of Things is growing at an exponential rate, which means that data processing, administration, and storage must adapt to analyze sensor data. To manage the massive amounts of data generated by heterogeneous IoT devices (sensors), this study needs to identify the most promising use cases for real-time smart office deployment. Table 1 lists these specifications. To construct a smart office network, all of the aforementioned requirements must be met. These are the goals this study accomplished following the implementation's successful completion. The authors have chosen Contiki OS, which offers various low-power, affordable hardware options. Afterwards, several sensors are connected to each remote node; these sensors provide data over various time intervals. Furthermore, this study has developed various topologies that meet the specifications for a smart network. As shown in

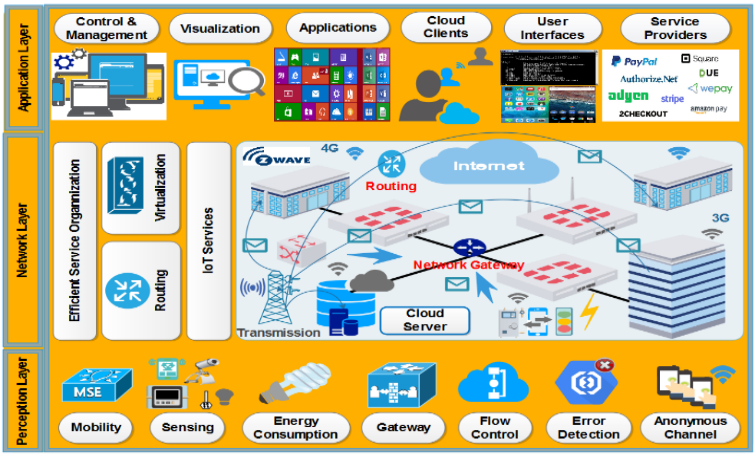

Figure 2: Framework of Smart Offices.

Figure 2, we have developed an architecture of intelligent, massive IoT devices networked to facilitate the effective transfer of data from remote sensors. The Perception, Network, and Application layers of the Internet of Things comprise the framework's three divisions. Each tier of the framework performs the necessary operations for network communication [44]. First, the lowest layer of the framework is called the perception, sensing, or recognition layer [45]. This layer's primary job is to acquire data from sensors. To that end, it gathers useful information from the Internet of Things networked environment, including RFID, WSN, real-world items, heterogeneous devices, temperature, humidity, lighting, and so on. It then converts the actuator's data into a digital representation. Furthermore, it enables interconnectivity by providing a distinctive identity for real-world objects, gadgets, or things for communication via short-range technologies, such as RFID, Bluetooth, Low Power Personal Area Networks (6LoWPAN), Near Field Communication (NFC), and Bluetooth as a communication layer [46]. IoT devices are connected via a variety of communication technologies, which also facilitate data aggregation. Examples of these technologies include the Global Positioning System (GPS), bus, Wi-Fi, microwave ovens, RFID, ZigBee, HDTV actuators, and barcodes [47].

One of this layer's most important components is the nodes' ability to move around using routing table information and a gateway. It also evaluates the power usage of nodes along the anonymous channels' error detection path. This communication layer also establishes the flow of communication. Since it sits between the perception and network layers, the network, also known as the transmission layer, is referred to as the brain of this structure. According to [48], this layer performs the necessary processing and helps secure data transmission from sensors to applications and servers. This layer primarily provides gateway-based convergence between the Internet of Things and the wired or wireless communication network [49]. Furthermore, heterogeneous devices are linked together via a routing table for a cooperative network that stores data on cloud servers and conducts analytics to extract information from data across various IoT platforms. The enormous volume of Big Data generated by various types of sensors is managed by the proposed framework. Accordingly, the service managers of Internet of Things sensors effectively determine the optimal path for each communication. Every level of control and management has been integrated; the real-time simulation operates within this framework and provides insights into the reception and transmission of large data across a network of interconnected communication devices [50].

In Figure 2, however, a successful communication is shown. The forthcoming big data is examined on a cloud server and relayed to the necessary sensors following the findings. Three office branches are readily visible; routers connect them. This phenomenon is the result of the Internet Engineering Task Force (IETF) [51] imposing IPv6 or 6LoWPAN protocols across a variety of wired and wireless technologies, including fibre-optic, Wi-Fi, 3G, 4G, and the Public Switched Telephone Network (PSTN). Furthermore, to put this framework into practice, we created a network architecture with random positioning. This enables the creation of a smart office environment by facilitating effective, long-lasting communication among various nodes with higher throughput and lower power consumption. This framework's top layer helps users by providing access to the application and their customized services as needed. It is accountable for managing data and services generally and for transforming various applications or services that vary across the digital signal environments in which they are used. Then, it provides managers with computed high-level knowledge of applications, including weather forecasting, office management, smart grid systems, security alarms, mobility, health or disaster monitoring, fortune, control of the ecological and medical environment, and transportation with overall global management [52]. It offers consumers visuals and services following their needs, as well as facilities for all kinds of linked end users. The entire process will be put into practice to build a smart office that provides real-time data on sensors, power, and network throughput. An operating system called Con-

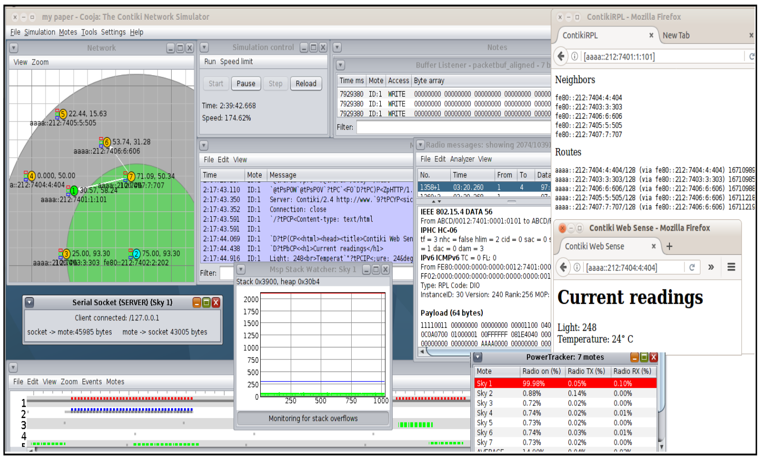

Figure 3: Simulation through the Cooja Emulator of Contiki OS.

tiki (Instant Contiki 2.7) is used for real-time data collection and processing. A. Dunkel investigated this existential approach to a smart environment, and to carry out the necessary real-time simulation, we built a smart office topology with numerous nodes (Motes in Contiki). An open-source operating system called Contiki provides a variety of applications to simulate a network environment and offer advantages such as data extraction, storage, collection, and transmission via a communication network [53]. It enables low-cost, low-power, massive-scale data collection by interconnecting small devices. The specified simulation and outcomes have been achieved by using one of its emulators, Cooja. Many sensors generate enormous amounts of data, which are sent from our current network in real time to a server. Additionally, as illustrated in Figure 3, the Cloud server effectively delivers the appropriate analysis, known as knowledge discovery, to multiple nodes simultaneously based on incoming data. A significant volume of data is produced by sensors and sent to the cloud server gateway [54]. To transfer information across devices, every node turned on the LED (Light Emitting Diode) lights. Multiple windows in Fig. 3 above display the corresponding simulation findings of a smart workplace. First, as shown in the window's upper-left corner, the network structure is designed to connect multiple sensor motes. Second, the following window gives us access to the simulation's control buttons, which include start, pause, stop, and reload, along with the simulation's total duration and speed [55]. Afterwards, the following box offers the option to record significant measurements for future reference. Thirdly, the output of each mote or node is displayed in the purple-backed window, along with the unique IDs assigned to each node based on the programming-based classification. We used the IPv6 protocol and the low-power Personal Area Network (6LoWPAN) to construct the topology of the smart environment. To obtain a PCAP file for the examination of transmitted networks, choose that option from the menu. All the information about communication between nodes, including the protocols used for intermediary communication, is available in the radio message pane. Additionally, because IPv6 Internet Control Message Protocol (ICMP) is used, all radio messages provide the entire payload data in bytes [56]. To display the mote's radio duty cycle, the power tracker for the simulated individual transmission (ITX) and individual receiving (IRX) along their radio service is shown in the window's bottom-right corner and in Table 2. The transmitted data's overall heap and stack flow are displayed in the stack pane. This Cooja emulation tool allows you to calculate the percentages of each mote,

Table 2: **Power Traces of each mote at different positions**

Network's Mote (Nodes)	Radio Service (%)	Radio Transmission (ITX) (%)	Radio Receiving (IRX) (%)
(Border Router) Sky 1	99.98%	0.05%	0.10%
Sky 2	0.88%	0.14%	0.00%
Sky 3	0.72%	0.02%	0.00%
Sky 4	0.74%	0.02%	0.01%
Sky 5	0.73%	0.02%	0.00%
Sky 6	0.74%	0.03%	0.01%
Sky 7	0.73%	0.02%	0.00%
Average	14.02%	0.05%	0.03%

both individually and collectively, including the average. The aforementioned Table 2 contains all these simulation measurements, along with the designated transmission and receiving percentages for each node. To simulate this network, we have chosen the sky-type mote, which features an 8 MHz MSP430 microcontroller with 48 KB of flash memory and 10 KB of RAM. These types of motes are equipped with additional features, such as a network transceiver with sensors that operate wirelessly and provide advantages such as 2.4 GHz, 250 Kbps, and IEEE 802.15.4 Chipcon for temperature, light, and humidity measurements, a battery indicator, and sensor power control. It allows the optional 6-pin SMA antenna to be expanded [57].

By inputting the IP address of the border router into the browser (Firefox), as indicated on the right side of the aforementioned Figure 3, an application of Contiki OS offers information about routers and neighbors of the communication protocol. Additionally, it gives information from other sensors, such as temperature (240 °C) and light (248), when the IPv6 address of any device is entered into the browser's search bar [58]. Furthermore, light sensors use the illuminance (LUX) unit to determine relative distance (Onasch and Spero 2018). Additionally, the last window with lines of various colours displays the chronology of all nodes, and the Serial Socket window shows the server-side connection and the number of bytes communicated over the network. Nevertheless, 6LoWPAN was selected because it enables low-power, radio-frequency communication with IPv6 at the physical layer [59]. We have included the border-router program with the sky mote to ensure the necessary outcomes. Furthermore, we have collected and accessed the majority of recent sensor-generated data using the sky-websense.c application. An integrated web server powers this real-time application. A utility tool called Tunslip6 is used to use Cooja to connect routers across a network to the outside world. All of the windows began receiving the necessary data as soon as the simulation was launched. Thus, power consumption analysis makes it simple to observe a communication network's efficiency [60].

4 Results and Discussion

The anticipated efficient transmission outcomes will be produced by the simulation. Our designed topology began operating on the web server as soon as we pressed the start button, and all the motes (sensors) in the network began producing real-time big data. This data travels over the cloud web server in the Cooja emulator built on Contiki. The ping information for the motes is provided in the experimental outcomes. The calculated outcomes are divided into two categories: power measurements and sensor measurements concerning smart network connectivity. The results corresponding to these categories are discussed below. As seen in Figure 4, the simulation distributes the sensors' real-time data over the networked integrated system within the predetermined "Time" and "Celsius." First, we have the average temperature of every node, which is 615.9 degrees Celsius at 100% humidity. For every node with low latency, the battery indicator is 1. We also have the results of the light and battery voltages used by the sensors during communication. Accordingly, each sensor has an LED attached that blinks whenever it receives data; the fluctuating light data is displayed over time. Furthermore, battery consumption over voltage ranges between 0.00 and 0.50, indicating very low battery voltage

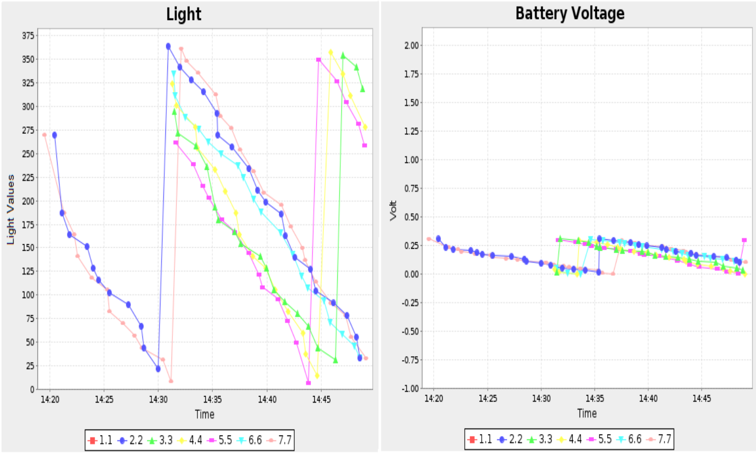

Figure 4: Result of Light and Battery Voltage.

usage for each node. Each node is represented by a color, and the overall graphical shape shows the back-and-forth fluctuations in the node's transmission.

$$TTX = TX1 = TX2 = TX3 = TX4 = TX5 = TX6 = TX7 \tag{1}$$

In Equation 1, TTX stands for Total Temperature Transmission, and TI is the temperature of node 1. This temperature is the same for all nodes when we view them all together to determine the average temperature of all the motes.

$$TBI = BI1 = BI2 = BI3 = BI4 = BI5 = BI6 = BI7 \tag{2}$$

In our given real-time simulation situation, TBI defines the Total Battery Indication as in Equation 2, which is the same for every node. B1 denotes the battery of node 1.

$$TPX = TPR + TPL, \quad TPX = 1244 + 0 = 1244 \tag{3}$$

The total packets transmitted (TPX) in Equation 3 is equal to the total packets received plus the total packets lost along the communication network. Moreover, Equation 4 indicates that the Packet Delivery Ratio (PDR) is 100%.

$$PDR(\%) = TotalReceivedPackets/TotalTransmittedPackets \times 100 \tag{4}$$

Several methods are used to accomplish the overall power analysis. As Figure 5 illustrates, the power

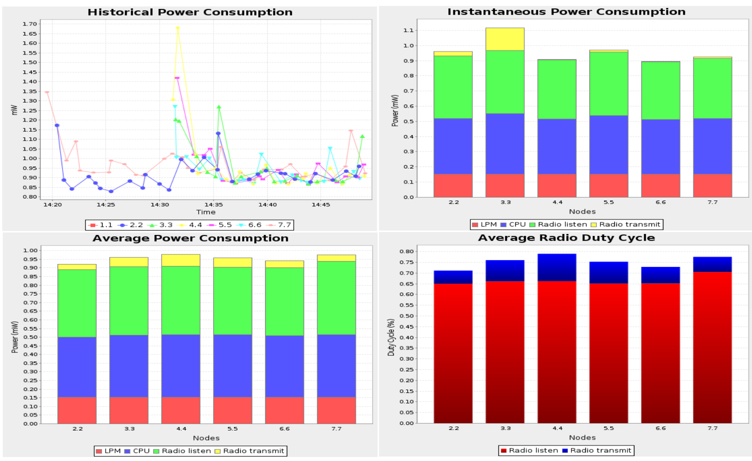

Figure 5: Result of Overall Power Consumption.

history graph provides a comprehensive view of power usage across all nodes, measured in megawatts.

It illustrates how much less is used overall when compared to slower systems. A variety of histograms are shown to illustrate the power utilization by various sensors [61]. These include the immediate power usage and the average power consumption for each node, along with its radio duty cycle. The sections on instantaneous and average power consumption illustrate the overall power consumption of many elements. For example, the yellow color represents radio transmission, the green color represents radio listening, the blue color represents the Control Processing Unit (CPU), and the red color represents the Longest Prefix Match (LPM). LPM, or low power consumption algorithms, allows IP addresses to be connected to their routing tables [62]. On the other hand, in the typical radio duty cycle, the blue portion represents the average time spent transmitting messages. In contrast, the red portion displays the ping information from nodes to listen to the messages.

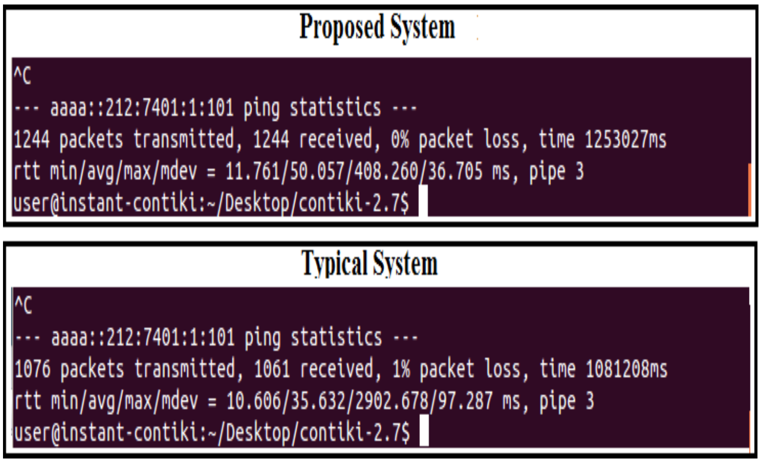

Figure 6: Comparison of Proposed and Typical System.

Furthermore, we have provided a real-time simulated comparison of two topologies for Internet of Things environments: the suggested system (the topology indicated above) and the basic topology, which represents a typical system. Furthermore, the typical system operates under the User Datagram Protocol specifically and has seven nodes [63]. Additionally, the two systems' protocols differ, which is reflected in the results. Several protocols have been employed to quantify the relative difference, indicating that 6LowPAN outperforms the conventional system. The relative differences in throughput and energy usage of the networked nodes are then displayed in this comparison. Accordingly, the period is the same for both topologies. As illustrated in Figure 6, the total number of packets sent and received, as well as packet loss, is readily apparent.

Different smart-environment topologies and architectures were examined for real-time implementation in earlier research. As Table 3 illustrates, we have differentiated the earlier research to provide a comparative analysis of the reviewed literature and their unique methodologies. The authors of [64] provided a localized framework for smart home data processing that is effective. Thus, creating localized sensors can represent the surrounding interdependencies of linked sensors effectively. Furthermore, this framework provides an optimal bandwidth-power consumption forecast based on the information. Using historical communication patterns, it provides real-time defect detection and tolerance for sensors in Internet of Things-based smart homes. Moreover, this real-time connection eliminates redundancies and gives information about usage patterns and power consumption. To understand security measures, the authors of [65] addressed the challenge of massive data management and collection in Internet of Things environments using cloud computing.

To efficiently deploy smart cities through IoT devices and real-world user interfaces such as RFIDs and smartphones, the authors addressed the convergent domain of IoT and Cloud Computing [42]. Furthermore, a cloud computing framework based on IoT is suggested. As a result, the smart building is designed and implemented using an intelligent and adaptable automated controller [11]. According to compliance, this suggested solution improves user experience by increasing energy efficiency, comfort, and safety. It then offers a fast plug-and-play installation situation for the automated smart building application. The authors of [34] discussed location-aware interior architecture as a way to improve visitors' experiences. To be more precise, the system's design offers cultural materials to verify the wearable device's ability to recognize images and perform localization. To publish environmental events on social networks in response to user demand, this proposed work archives multimedia materials on a cloud server. Moreover, singularity architecture is put forth in [66] to prototype science fiction-style scenarios to investigate the behavior of biological development. Accordingly, parametric digital manufacturing and modern technologies are combined with the morphogenetic design of intelligent buildings. Additionally, a morphogenetic framework is proposed to account for the implications of the design team's debate. In [43], urban planning is covered in the context of big data analysis in smart cities. A Hadoop framework is suggested to handle the four stages of data collection in smart cities. Furthermore, MapReduce has been integrated with Hadoop for data management. Based on Table 3, it is evident that many of the previously mentioned articles offer relevant work aimed at addressing the Quality of Service (QoS) issue. Similarly, the majority of writers discussed another matter about the effectiveness of smart monitoring in both localized and broader environments. Furthermore, only two papers addressed the security issue, while five addressed the transmission speed issue.

Table 3: Comparative analysis with state-of-the-art Techniques

Paper References	Communication Protocol	Observational Environment	Architecture	Transmission Speed	Fault Tolerance	Efficiency	QoS
[15]	-	Localized	✓	✓	✓	✓	✓
[42]	COAP	Localized	✓	✓	×	✓	✓
[28]	ZigBee	Localized & Generalized	✓	×	×	✓	✓
[11]	AIBSBAC	Localized & Generalized	✓	✓	×	×	✓
[10]	BTLE	Localized	×	✓	×	×	✓
[34]	SFP	Localized	✓	×	×	✓	×
[43]	ZigBee	Generalized	✓	✓	✓	✓	×

Using various communication protocols, we can see that the pertinent prior research has been carefully evaluated in this publication. This leads us to conclude that, while the Correspondence Protocol is a typical issue, the precise goals of each system type vary. In conclusion, we would suggest a new topology aligned with a smart office framework. This would aim to address key improvements, such as efficiency, low power consumption, big data management, increased throughput, low latency, and higher transmission speeds compared to a typical system. Furthermore, this real-time smart office implementation offers projections for its deployment in developing nations such as Pakistan. Big data from sensors is effectively gathered and processed with minimal energy consumption. Furthermore, as shown in the above-mentioned literature, the IPv6 6LowPAN (Low-Power Wireless Personal Area Network) protocol has been used in our real-time office application. Furthermore, whereas the current literature uses a variety of techniques to estimate power and efficiency across various applications, our approach uses Contiki OS.

5 Conclusion

Managing linked nodes effectively and efficiently has become more difficult due to big data. Accordingly, to combine their features and provide a better solution, we have surveyed the most promising communication technologies, such as sensors, cloud computing, big data, and the Internet of Things. Building on the IoT tiers, we have developed a unique architecture for managing sensors in a smart office installation. Furthermore, we have demonstrated that our proposed architecture can facilitate effective network communication by building a sensor network using the simulation findings described above, which correspond to a typical system. Furthermore, a list of requirements outlining their requirements for off-office real-time implementation has been provided. To that end, we have integrated the Internet of Things (IoT) into a network of interconnected sensors as part of a real-time communication system. It then effectively gathers and communicates temperature, humidity, light, and movement data that is useful for smart office management. Users can access and manage data following the distant network to take necessary action when needed. For example, if a remote user notices movement in the workplace after business hours, he can address it by taking appropriate action. Additionally, a comparative analysis is carried out by carefully reading the literature review, and we have integrated the smart office environment into a real-time simulation using Contiki OS's Cooja emulator to efficiently gather and transmit data wirelessly. The study of the data, which we compared with a typical system, validates the communication network's successful efficiency. With lower energy usage, our system offers improved efficiency in sensor data collection and administration.

Conflict of Interest

There are no conflicts of interest in this article.

Funding Statement

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

[1] Kryftis, Y.; Mastorakis, G.; Mavromoustakis, C. X.; Batalla, J. M.; Pallis, E. et al. (2016): Efficient entertainment services provision over a novel network architecture. IEEE, Wireless Communications, vol. 23, no. 1, pp. 14-21.

[2] Stergiou; Christos; Psannis, K. E. (2017): Algorithms for big data in advanced communication systems and cloud computing. IEEE 19th Conference on Business Informatics (CBI), vol. 1, pp. 196-201.

[3] Stergiou; Christos; Psannis, K. E. (2017): Efficient and secure big data delivery in cloud computing. Multimedia Tools and Applications, vol.76, no. 21, pp. 22803-22822.

[4] Stergiou; Christos; Psannis, K. E. (2017): Recent advances delivered by Mobile Cloud Computing and Internet of Things for Big Data applications: a survey. International Journal of Network Management, vol. 27, no. 3, pp. 1-12.

[5] Stergiou; Christos; Psannis; K. E.; Kim, B. G. et al. (2018): Secure integration of IoT and cloud computing. Future Generation Computer Systems, vol. 78, pp. 964-975.

[6] Chen, H.; Chiang, R. H.; Storey, V. C. (2012): Business intelligence and analytics: From big data to big impact. MIS Quarterly, vol. 36, no. 4, pp. 1165-1188.

[7] Ahn, H.; Lee, J. H.; Cho, H. J. (2019): Research of panoramic image generation using IoT device with camera for the cloud computing environment. Wireless Personal Communications, vol. 105, no. 2, pp. 619-634.

[8] Alberdi, A.; Aztiria, A.; Basarab, A.; Cook, D. J. (2018): Using smart offices to predict occupational stress. International Journal of Industrial Ergonomics, vol. 67, pp. 13-26.

[9] Alfarraj, O.; AlZubi, A. A. (2019): A novel approach for ranking customer reviews using a modified PSO-based aspect ranking algorithm. Cluster Computing, vol. 22, no. 2, pp. 1-7.

[10] Alletto, S.; Cucchiara, R.; Del Fiore G.; Mainetti L.; Mighali, V. et al. (2015): An indoor location-aware system for an IoT-based smart museum. IEEE Internet of Things Journal, vol. 3, no. 2, pp. 244-253.

[11] Basnayake, B. A. D. J. C. K.; Amarasinghe, Y. W. R.; Attalage, R. A.; Udayanga, T. D. I.; Jayasekara, A. G. B. P. (2015): Artificial intelligence based smart building automation controller for energy efficiency improvements in existing buildings. International Journal of Advanced Automation Science and Technology, vol. 40, no. 40, pp. 150-156.

[12] Bello, H.; Xiaoping, Z.; Nordin, R.; Xin, J. (2019): Advances and Opportunities in Passive Wake-Up Radios with Wireless Energy Harvesting for the Internet of Things Applications. Sensors, vol. 19, no. 14, p. 3078.

[13] Chen, M.; Mao, S.; Liu, Y. (2014): Big data: A survey. Mobile networks and applications, vol.19, no. 2, pp. 171-209.

[14] Chen, S.; Xu, H.; Liu, D.; Hu, B.; Wang, H. (2014): A vision of IoT: Applications, challenges, and opportunities with China perspective. IEEE Internet of Things Journal, vol.1, no. 4, pp. 349-359.

[15] Choubey, P. K.; Pateria, S.; Saxena, A.; SB, V. P. C.; Jha, K. K. et al. (2015): Power efficient, bandwidth optimized and fault tolerant sensor management for IoT in Smart Home. IEEE International Advance Computing Conference (IACC), pp. 366-370.

[16] Da Xu, Li; He, W.; Li, S. (2014): Internet of things in industries: A survey. IEEE Transactions on Industrial Informatics, vol. 10, no. 4, pp. 2233-2243.

[17] de Matos; Everton; Amaral, L. A.; Tiburski, R. T.; Schenfeld, M. C. et al. (2017): A sensing-as-a-service context-aware system for the Internet of Things environments. 14th IEEE Annual Consumer Communications & Networking Conference (CCNC), pp. 724-727.

[18] Deering S.; Hinden R. (2017): Internet protocol, (IPv6) specification, version 6.

[19] Dehwah, A. H.; Shamma, J. S.; Claudel, C. G. (2017): A distributed routing scheme for energy management in solar-powered sensor networks. Ad Hoc Networks, vol. 67, pp. 11-23.

[20] Fang, S.; Xu, L.; Zhu, Y.; Liu, Y.; Liu, Z. et al. (2015): An integrated information system for snowmelt flood early-warning based on the Internet of things. Information Systems Frontiers, vol.17, no. 2, pp. 321-335.

[21] Kiefer; Chris; Behrendt, F. (2016): Smart e-bike monitoring system: real-time open source and open hardware GPS assistance and sensor data for electrically-assisted bicycles. IET Intelligent Transport Systems, vol. 10, no. 2, pp. 79-88.

[22] Klievink, B.; Romijn, B. J.; Cunningham, S.; de Bruijn, H. (2017): Big data in the public sector: Uncertainties and readiness. Information Systems Frontiers, vol. 19, no. 2, pp. 267-283.

[23] Gantz, J.; Reinsel, D. (2011): Extracting value from chaos. IDC view, vol. 1142, pp. 1-12.

[24] Golchha, N. (2015): Big data-the information revolution. IJAR, vol. 1, no. 12, pp. 791-794.

[25] Grover, V.; Chiang, R. H.; Liang, T. P.; Zhang, D. (2018): Creating strategic business value from big data analytics: A research framework. Journal of Management Information Systems, vol. 35, no. 2, pp. 388-423.

[26] Gubbi, J.; Buyya, R.; Marusic, S.; Palaniswami, M. (2013): Internet of Things (IoT): A vision, architectural elements, and future directions. Future generation computer systems, vol. 29, no. 7, pp. 1645-1660.

[27] Hui, T. K.; Sherratt, R. S.; Sánchez, D. D. (2017): Major requirements for building Smart Homes in Smart Cities based on Internet of Things technologies. Future Generation Computer Systems, vol. 76, pp. 358-369.

[28] Kaur, M. J.; Maheshwari, P. (2016): Building smart cities applications using IoT and cloud-based architectures. International Conference on Industrial Informatics and Computer Systems (CIICS), pp. 1-5.

[29] Kaur, R.; Kinger, S. (2014): Analysis of security algorithms in cloud computing. International Journal of Application or Innovation in Engineering & Management (IJAIEM), vol. 3, no. 3, pp. 171-176.

[30] Kokkonis, G.; Psannis, K. E.; Roumeliotis, M.; Schonfeld, D. (2017): Real-time wireless multi-sensory smart surveillance with 3D-HEVC streams for internet-of-things (IoT). The Journal of Supercomputing, vol. 73, no. 3, pp. 1044-1062.

[31] Lee; I.; Lee, K. (2015): The Internet of Things (IoT): Applications, investments, and challenges for enterprises. Business Horizons, vol. 58, no. 4, pp. 431- 440.

[32] Lin, J.; Yu, W.; Zhang, N.; Yang, X.; Zhang, H. et al. (2017): A survey on Internet of things: Architecture, enabling technologies, security and privacy, and applications. IEEE, Internet of Things Journal, vol. 4, no. 5, pp. 1125-1142.

[33] Manogaran, G.; Varatharajan, R.; Lopez, D.; Kumar, P. M.; Sundarasekar, R. et al. (2018): A new architecture of Internet of Things and big data ecosystem for secured smart healthcare monitoring and alerting system. Future Generation Computer Systems, vol. 82, pp. 375-387.

[34] McGinley, T. (2015): A morphogenetic architecture for intelligent buildings. Intelligent Buildings International, vol. 7, no.1, pp. 4-15.

[35] Mital, R.; Coughlin, J.; Canaday, M. (2015): Using big data technologies and analytics to predict sensor anomalies. Advanced Maui Optical and Space Surveillance Technologies Conference.

[36] Nicolalde, F. C.; Silva, F.; Herrera, B.; Pereira, A. (2018): Big Data Analytics in IoT: Challenges, Open Research Issues, and Tools. World Conference on Information Systems and Technologies, Springer, vol. 746, pp. 775-788.

[37] Onasch; T.; Spero, D. J. (2018): Light measurement using an autonomous vehicle, U.S. Patent App. 15/705,106.

[38] Osterlind, F.; Dunkels, A.; Eriksson, J.; Finne, N.; Voigt, T. (2006): Demo abstract: Cross-level simulation in cooja. In Proceedings of the First IEEE International Workshop on Practical Issues in Building Sensor Network Applications.

[39] Pavlo, A.; Paulson, E.; Rasin, A.; Abadi, D. J.; DeWitt, D. J. et al. (2009): A Comparison of Approaches to Large-Scale Analysis. Proceedings of the ACM SIGMOD International Conference on Management of Data. pp. 165-178.

[40] Pfarr, F.; Buckel, T.; Winkelmann, A. (2014): Cloud Computing Data Protection-A Literature Review and Analysis. System Sciences (HICSS), 47th Hawaii International Conference, IEEE, pp. 5018-5027.

[41] Plageras, A. P.; Psannis, K. E.; Stergiou, C.; Wang, H.; Gupta, B. B. (2018): Efficient IoT-based sensor BIG Data collection–processing and analysis in smart buildings. Future Generation Computer Systems, vol. 82, pp. 349-357.

[42] Plageras, A. P.; Stergiou, C.; Kokkonis, G.; Psannis, K. E.; Ishibashi, Y. et al. (2017): Efficient large-scale medical data (eHealth big data) analytics in the Internet of things. IEEE 19th Conference on Business Informatics (CBI), vol. 2, pp. 21-27.

[43] Rathore, M. M.; Ahmad, A.; Paul, A.; Rho, S. (2016): Urban planning and building smart cities based on the Internet of things using big data analytics. Computer Networks, vol.101, pp. 63-80.

[44] Suo, H.; Wan, J.; Zou, C.; Liu, J. (2012): Security in the Internet of Things: a review. In International Conference on Computer Science and Electronics Engineering (ICCSEE), IEEE, vol. 3, pp. 648-651.

[45] Rathore, M. M.; Paul, A.; Hong, W. H.; Seo, H.; Awan, I. et al. (2018): Exploiting IoT and big data analytics: Defining smart digital city using real-time urban data. Sustainable cities and society, vol. 40, pp. 600-610.

[46] Yassine; Abdulsalam; Singh, S.; Hossain, M. S.; Muhammad, G. (2019): IoT big data analytics for smart homes with fog and cloud computing. Future Generation Computer Systems, vol. 91, pp. 563-573.

[47] Sahu; Sunita; Dhote, Y. (2016): A Study on Big Data: Issues, Challenges, and Applications. International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE), vol. 4, no. 6, pp. 10611-10616.

[48] Silva, B. N.; Khan, M.; Han, K. (2018): Internet of things: A comprehensive review of enabling technologies, architecture, and challenges. IETE Technical Review, vol. 35, no. 2, pp. 205-220.

[49] Suciu, G.; Vulpe, A.; Halunga, S.; Fratu, O.; Todoran, G. et al. (2013): Smart cities built on resilient cloud computing and secure Internet of things. 19th International Conference on Control Systems and Computer Science, IEEE, pp. 513-518.

[50] Tomtsis, D.; Kontogiannis, S.; Kokkonis, G.; Kazanidis, I.; Valsamidis, S. (2015): Proposed cloud infrastructure of wearable and ubiquitous medical services. Fifth International Conference on Digital Information Processing and Communications (ICDIPC), IEEE, pp. 213-218.

[51] Wilde, O. (2018): The Power of UDA in Product and Service Development. Unstructured Data Analytics: How to Improve Customer Acquisition, Customer Retention, and Fraud Detection and Prevention. p. 267.

[52] Yau, C. W.; Kwok, T. T. O.; Lei, C. U.; Kwok, Y. K. (2018): Energy harvesting in the Internet of Things. Internet of Everything, Springer, pp. 35-79.

[53] Sajid, M., Malik, K. R., Khan, A. H., Iqbal, S., Alaulamie, A. A., & Ilyas, Q. M. (2025). Next-generation diabetes diagnosis and personalized diet-activity management: A hybrid ensemble paradigm. PloS one, 20(1), e0307718.

[54] Sajid, M., Khan, A. H., Malik, K. R., Khan, J. A., & Alwadain, A. (2025). A new approach of anomaly detection in shopping center surveillance videos for theft prevention based on RLCNN model. PeerJ Computer Science, 11, e2944.

[55] Malik, K. R., Sajid, M., Almogren, A., Malik, T. S., Khan, A. H., Altameem, A., ... & Hussen, S. (2025). A hybrid steganography framework using DCT and GAN for secure data communication in the big data era. Scientific Reports, 15(1), 19630.

[56] Sajid, M., Aslam, N., Abid, M. K., & Fuzail, M. (2022). RDED: recommendation of diet and exercise for diabetes patients using restricted Boltzmann machine. VFAST Transactions on Software Engineering, 10(4), 37-55.

[57] Sajid, M., Malik, K. R., Jabbar, S., Raza, U., & Habib, M. A. (2025). Secure 3D data hiding through cryptographic steganalysis resistance: reducing geometric inconsistency vulnerabilities. PeerJ Computer Science, 11, e3370.

[58] Khan, A. H., Sajid, M., Malik, K. R., Afzal, A., & Li, J. (2026). Meta-Learning Meets Transformers: A Novel Approach to Enterprise Network Intrusion Detection. Expert Systems with Applications, 131859.

[59] Imran, A., Malik, K. R., Khan, A. H., Sajid, M., & Arslan, M. (2024). Methodology for Ensuring Secure Disease Prediction using Machine Learning Techniques. Journal of Computing & Biomedical Informatics, 7(01), 15-25.

[60] Ahmad, H., Sajid, M., Mazhar, F., & Fuzail, M. (2025). Mapping Unseen Connections: Graph Clustering to Expose User Interaction Patterns. Journal of Future Artificial Intelligence and Technologies, 1(4), 474-496.

[61] Mushtaq, S., Malik, K. R., Ahmad, Z., & Sajid, M. (2023). A Deep Learning Based Approach to Enhance Object Edge Detection for Office Surveillance System. Journal of Computing & Biomedical Informatics, 6(01), 270-286.

[62] Sajid, M., Malik, K. R., Khan, A. H., Bilal, A., Alqazzaz, A., & Darem, A. A. (2025). Advanced multilayer security framework: integrating AES and LSB for enhanced data protection: M. Sajid et al. The Journal of Supercomputing, 81(17), 1607.

[63] Ahmad, M., Khan, A. U., & Sajid, M. (2023). A diet recommendation system for persons with special dietary requirements. Journal of Computing & Biomedical Informatics, 5(01), 153-164.

[64] Mazhar, F., Akbar, W., Sajid, M., Aslam, N., Imran, M., & Ahmad, H. (2024). Boosting early diabetes detection: an ensemble learning approach with XGBoost and LightGBM. Journal of Computing & Biomedical Informatics, 6(02), 127-138.

[65] Ullah, S., Iqbal, N., Khan, A. H., Sajid, M., Ahmad, Z., Ahmad, H., & Hussain, M. (2023). Empowering agriculture: a green revolution with internet of energy-driven farm energy management for sustainable and eco-friendly practices. Journal of Population Therapeutics and Clinical Pharmacology, 30(19), 975-992.

[66] Imran, S., Naqvi, R. A., Sajid, M., Malik, T. S., Ullah, S., Moqurrab, S. A., & Yon, D. K. (2023). Artistic style recognition: Combining deep and shallow neural networks for painting classification. Mathematics, 11(22), 4564.