Enabling Seamless Communication in IoT Network with Effective Routing Strategy

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Abstract

The integration of the Internet of Things (IoT) with data routing and its use in healthcare systems are examined in this article. The extension of the Internet through the addition of physical devices and the capacity to provide more intelligent services by utilizing the enormous amounts of data that are currently available are the two main forces behind the IoT. The research looks at how IoT principles can be applied to improve industries like green IT, logistics, and energy efficiency. It specifically looks into the data routing mechanism, which is essential for sending data from an IoT network's source to its sink. Using datasets from Kaggle and wustl.edu, two different networks with an emphasis on healthcare applications and diabetes were simulated for this research using the NetSim Simulator. A 6LoWPAN Gateway, a router, a server, and several sensor nodes—five in the first network and eight in the second—make up each network. The sensor nodes are set up to create and send data packets to the server via the 6LoWPAN Gateway on a regular basis. The findings demonstrate the potential advantages of IoT technology in enhancing healthcare data management and service delivery by highlighting the effectiveness of data transmission and routing in IoT healthcare contexts.

Keywords: IoT, RFID, IoBT, UAV

1 Introduction

The rapid growth of the Internet of Things (IoT) has resulted in a disruptive change across numerous industries, effortlessly integrating a wide range of physical objects to the digital ecosystem. This connectivity enables real-time data transmission, resulting in smarter, more efficient operations and informed decision-making. The IoT's ability to transform everyday devices into smart, connected systems has sparked significant advancements across numerous sectors, including energy efficiency, logistics, environmental monitoring, and healthcare. By collecting and analyzing data from an ever-growing number of devices, IoT systems are poised to enhance operational efficiency, improve safety, and enable more sustainable practices. However, as IoT networks expand, the complexity of managing communication between millions of interconnected devices poses significant challenges.
One of the key components of IoT systems is the effective routing of data between sensors (source nodes) and servers (sink nodes), ensuring that information is transmitted accurately and efficiently across the network. This routing process is critical for optimizing network performance, minimizing energy consumption, and ensuring that data is delivered within an acceptable time frame. As IoT networks often operate in resource-constrained environments with limited bandwidth, efficient routing strategies are essential to maintain a high level of performance and reliability.

This paper's remaining sections are arranged as follows: Section 2 summarizes existing research on routing strategies in IoT networks. Section 3 discusses the challenges and issues with IoT. Section 4 looks at several IoT applications. Sections 5 and 6 present the methods and simulation setup used in this investigation. Section 7 displays the simulation findings. Finally, Section 8 concludes the work with findings and recommendations for future research directions.

2 Literature Survey

In [1] authors developed a framework using an IoT-based methodology that uses sensors to detect vehicle accidents, with the information being stored and tracked on the Thingspeak cloud. An accelerometer, an ultrasonic sensor, and a GPS receiver work together to increase the warning anytime the vehicle is involved in an accident. The communication module transmits the real-time coordinates message. When the monitoring station realizes an accident has happened, it promptly dispatches emergency personnel to the hotspot. The integrated approach will be helpful because it will identify any vehicle malfunction and make it easier for the passengers to get emergency assistance. Any smart city will benefit from the proposed framework for saving human lives.

A novel Transmission Control Protocol/Internet Protocol green reliability technique for fog computing was proposed by the authors of [2]. Its foundation lies in utilizing the differences between User Datagram Protocol (UDP) and TCP protocol to send fewer packets over the network. The recommended method is made to ensure that slight packet loss in voice and online video applications doesn't materially affect the end result. Network noise is measured over time in order to optimize the dynamic switching between TCP and UDP. The authors evaluated the suggested method using several Quality of Service (QoS) parameters, including energy consumption, throughput, and latency.

In [3], the authors presented an energy-efficient routing technique for an IoT-driven smart city with restricted resources. The authors used "Sooty Tern Optimization Algorithm (STOA)" for cluster-based routing because it is rapid to convergence and has good exploration and exploitation capabilities. The primary objective of the authors' STOA was to find the optimal solution for the cluster head selection problem. The simulation analysis's findings showed that the suggested model will outperform the others in terms of network lifetime and stability duration.

An outline of the monitoring of water quality was given by the authors of [4]. An overview of the state-of-the-art for Internet-of-things-based smart water quality monitoring systems (IoT-WQMS) designed for residential applications was given by the authors through a survey. Through research and the use of a suggested empirical metric, this work aims to critically assess and validate modern IoT-WQMS. It investigates common water quality measures, safe drinking water thresholds, associated smart sensors, and makes recommendations for creating an efficient system.

The fundamental idea of the IoT is explained by the authors in [5] The architecture must meet the unique needs of such applications in order to implement Internet of Things solutions. Scalability, the transfer from closed to open platforms, and the creation of protocols for interaction at various levels are some of these requirements. The authors discussed IoT architectural problems and potential solutions. The writers also discussed the elements necessary for the creation of IoT-based apps and solutions. The writers examined several IoT difficulties and came up with solutions for them. The notions and applications connected to cognitive IoT analytics and its applications were elaborated by the authors.

The authors of [6] presented a method for monitoring water quality using IoT technology. They conducted an investigation of municipal water tanks and drinking water reservoirs. The pH levels were measured with an Arduino board, and messages were sent using a GSM module. An LED display was utilized to indicate the water parameters in real time, and the consumer was advised of the pH level.

The authors of [7] investigated effective routing in IoT. The authors demonstrated how the MQTT (*Message Queue Telemetry Transport*) protocol may be utilized to efficiently transmit data between a publisher and a subscriber via a central broker. The protocol was simulated using the MOSQUITTO open-source toolkit written in the Java programming language.

The authors of [8] suggested an acceleration-based gait identification technique aimed at improving the functionality of wearable technology for senior citizens. The proposed method combines an arbitration-based score-level fusion matching technique with cycle- and fixed-length based template generation processes. A publicly available dataset of acceleration signals from 64 senior citizens, ages 50 to 79, was used to test the approach. When compared to conventional PCC-based single matching techniques, the testing findings showed a notable boost in recognition accuracy, with an average gain of 26.7%.

The authors of [10] proposed a "*Heterogeneous Transfer Learning for spliT Prediction System* (HTTPS)", which addresses privacy issues and improves model performance while providing a novel approach to big data predictions in the context of smart healthcare. Through the use of sparse networks and feature packing, the HTTPS framework not only enhances regularization through multi-task learning but also makes it easier to transfer knowledge across diverse datasets and prediction tasks. Ablation studies highlight HTTPS's exceptional transferability and the detrimental effect of diverse data on traditional models, while experimental results show that it performs better than benchmark systems. While maintaining general model applicability, the split learning approach allows privacy-conscious individuals to submit a restricted amount of personal information for correct predictions.

In [11], the authors discussed about IoT and IoMT and their applications. In IoMT networks, the *Epilepsy Seizure Detector-based Naive Bayes* (ESDNB) algorithm showed remarkable performance in detecting epileptic seizures, with accuracy ranging from 99.53% to 99.99%, whereas the *multimodal emotion recognition* (MEmoR) model achieved a minimum accuracy of 81.54% in predicting discrete emotions. The requirement for data standardization because different systems and devices have different formats, privacy and security issues with susceptible data transmissions, and the need to innovate data collection, transportation, and storage are some of the major obstacles that data fusion in IoMT must overcome.

3 Issues and Challenges in IoT

IoT is offering a wide range of applications. These applications have some issues related to them that are discussed below in brief:

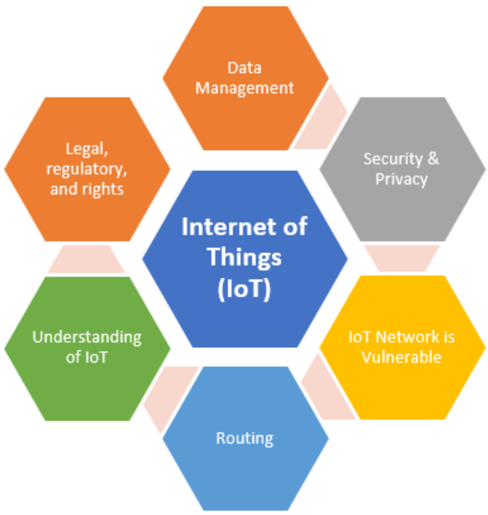

Fig. 1 Issues and Challenges in IoT

1. **Data management**: Data handling is one of the most significant IoT challenges. The growing applications of IoT are producing an enormous amount of data. Managing this data, filtering out the relevant data, deciding the lifetime of this data, etc. are some of the data management issues in IoT. Additionally, it is critical to guarantee that the data is of a high caliber because precise forecasting of future circumstances depends on it.
2. **Security**: By 2025, there will be 64 billion IoT devices worldwide, thanks to the IoT technology that is linking more and more gadgets every day. Both the benefits and threats of this growth are numerous. The rise in connected gadgets increases the entry points available to hackers and online criminals. As huge data flows over the network, this kind of data can be sensitive. Any tampering with sensitive data that relates to human health could endanger human life. IoT security and data management are therefore important problems. Data transport should not only be objective but also data transfer that is secure and free from threats and attacks of any kind. Making sure that unauthorized people cannot access the data the sensors have acquired is crucial.
3. **IoT Network is Vulnerable**: The IoT network is particularly open to threats and attacks. Due to its connection to the internet, if effective security management is not implemented, an attacker may occasionally find it simple to access the data in the IoT network. IoT gateways should use correct firewall methods to prevent any attacks.
4. **Routing**: The discrepancies between the various device types and the network topology are to blame for the routing issue in IoT. It is challenging for a single protocol to handle all of these characteristics because devices can be on a different network or in the same network, their connectivity can be constant or intermittent, their range may be limited, etc.
5. **Understanding of IoT**: Due to the rapid advancement of technology, it is crucial that a client is aware of cutting-edge technology and knows how to use IoT services. Work should be done to increase client IoT awareness.
6. **Legal, regulatory, and rights**: IoT device usage raises many new legal and regulatory challenges. The challenges' scope is enormous, and the policy, legal, and regulatory frameworks that go along with them frequently can't keep up with how quickly IoT technology is developing. Cross-border data flows provide a set of challenges because they arise when IoT devices gather personal data about individuals in one nation and transmit it to another for processing that has differing data protection regulations. Other legal issues pertaining to IoT devices include the conflict between civil rights and law enforcement monitoring, regulations for data storage and disposal, legal responsibility for unauthorized use, and security breaches.

The traffic patterns in conventional networks differ from those in Internet of Things communications. Periodically, constrained devices often communicate to report sensor measurements. Because there are so many devices connecting, network congestion may occur even in situations where individual devices produce little amounts of data. Traffic spikes brought on by events are another potential cause of congestion. Protocols like CoAP are made to fit IoT networks with congestion control mechanisms to lessen congestion to some level. Congestion control is seen as critical in both academic and commercial research due to a significant growth in network traffic.

4 Applications of IoT

Following are some applications of IoT:

1. **Healthcare:** IoT widely spreads in the field of medical science because of its ease of use and advancements. Connecting healthcare devices over the Internet for the remote monitoring of patients – often termed as Internet of Medical Things (IOMT).

   This would help patients for remote treatment efficiently without the need to travel and wait for an appointment in a long queue. This would eventually save the time of the patient and get better treatment at home. IoT can be implemented in several ways to contribute to the smart hospital.

   (a) Wearables to fight with depression: In this competitive world, everyone wants to become rich and excel in their career. This hectic life ultimately results in mood swings and depression all around. IoT discovered a method to fight against sadness and melancholy life by introducing "Mood aware IoT devices" which collect data such as heart rate using a Heart rate monitor, and blood pressure with the help of a blood pressure monitor which can infer the patient's mental health. If the predicted value of the mental state reaches above the predefined value or falls below it will send the notification to the user.

   (b) Connected inhalers: People who are suffering from asthma and other respiratory system-related problems such as COPD. Inhalers with IoT capabilities assist patients by tracking their heart rates and attack frequency. Furthermore, they gather environmental information that aids medical professionals in determining the root causes of an attack. This could help to take preventive measures beforehand and allow the patient to be least prone to asthma attacks.

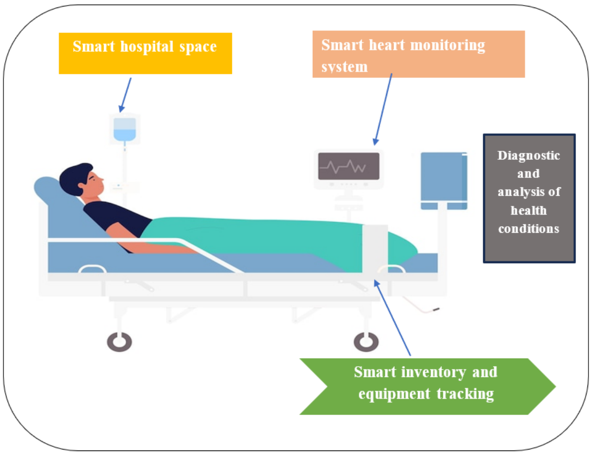

Fig. 2 IoT in Healthcare

2. **Water Quality Monitoring:** From now and then water is a basic necessity for humans as well as animals to survive but what if the water is not pure or safe to drink this could lead to several medical issues and even a high prone of death. For a healthy and safe one should drink healthy water and eat healthy food.

   By measuring the harmful contents in the water, we can determine the purity level this will ensure whether the water is safe to drink or not.

   To measure the safety level of water we can use sensors and other devices to check the pollutant level in the water. The parameters of water quality The concentration of hydrogen ions is measured by pH (power of hydrogen). The water's acidity or basicity is determined by the concentration of hydrogen ions.

   - If the pH < 7 the water is acidic.
   - If water has a pH level of 7 then it is considered as a neutral state.
   - If pH > 7 the water has more basic properties.

   Various sensors are being used by scientists to ensure the safety level of water.

   (a) Turbidity sensor: Turbidity is a metric that quantifies how hazy the water is, showing how much of its transparency has been lost. The light required for submerged aquatic plants is obstructed by turbidity.

   (b) Flow sensor: The flow sensor measures the flow of water. This sensor consists of a plastic valve body, a rotor, and a Hall Effect sensor. As water passes through the valve, the rotor's speed, which is proportionate to the flow rate, rises.

   (c) pH sensor: The solution's pH value indicates how acidic the mixture is. The scale is logarithmic, with a range of 0 to 14. It uses a 5V power supply to function, and interacting with the Arduino is simple.

   (d) Temperature sensor: The temperature sensor measures how hot or cold the water is. Thermocouples, RTDs, and thermistors are some of the temperature sensors used to detect the temperature of water.

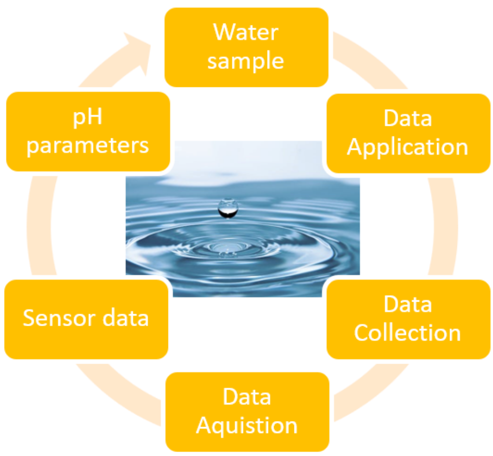

Fig. 3 Steps in Water Quality Monitoring

3. **Military:** Not only in the healthcare field, but IoT also finds its application in military applications such as real-time GPS monitoring and tracking the battlefield, displaying speed and motor status, overall engine times, and many more areas of defense.

   The embedded IoT devices with sensors in the scope of the military are often termed as Internet of Battlefield Things (IoBT).

   There are numerous IoT sensors or devices used by the army which includes wearables, hearable headsets, surveillance systems, electro, and optical infrared systems, reconnaissance (C4ISR) systems, communication and command control systems, satellites, and the army base infrastructure, etc. These widely used IoT devices cost much more than other sectors. A report estimates that USD439 billion in 2019 has been rising to USD486 billion and it is also predicting that it will grow to USD807 billion by 2025, at a CAGR of 11% over the year.

   Armed force soldiers can scan the battleground using unmanned aerial vehicles (UAV) that are fitted with cameras used to capture images of the battlefield and sensors collect data on suspicious and irrelevant activities the data collected by these devices will be sent to the command centers all thanks to IoT.

   Army base has been always undergone through unpredictable and complex situations they need to be alert 24X7 by virtue of which they are unable to sleep and eat properly on time, as we all know to rescue someone, we must be healthy and soldiers are our nation's saviour they must pay attention to their health but because of their rigorous duty they might ignore themselves so here IoT acts as saviour for our soldiers and finds the solution for them by keep monitoring of the army personnel on daily basis by analysing the speech patterns, pulse rate, body temperature, thermal distribution and sends the current status of their health to them.

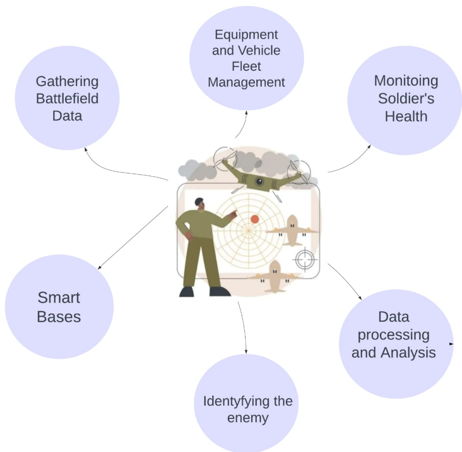

Fig. 4 Military applications of IoT

4. **Supply Chain Logistics:** IoT is being used in the supply chain process by many businesses nowadays. The IoT has the potential to enhance every step of the intricate supply chain process. Warehouse managers can keep track of their shipments and inventory with the aid of technology. Raw materials and completed goods are transported and stored as part of the supply and logistics business. The use of connected automobiles can help drivers and fuel efficiency.

   The main issue facing the logistics and supply chain sectors is delivery delay. This problem can be solved with IoT. Devices with IoT capabilities aid companies in tracking shipments. IoT sensors (such as motion sensors, GPS, etc.) can offer details on the condition of cargo.

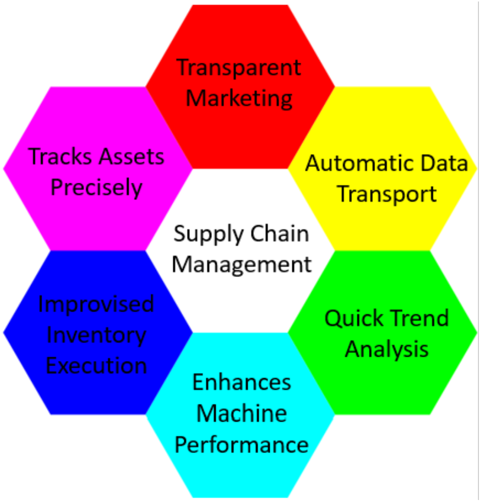

Fig. 5 Supply Chain Management

5. **Automotive Industry:** Fully autonomous vehicles are now being developed by automakers using IoT technology. Furthermore, the industry is embracing IoT use cases swiftly, especially those that could enhance automated traffic management, smart parking, and driverless vehicles. IoT-enabled solutions enable manufacturers to significantly improve vehicle efficiency and reduce the environmental impact of their products. Everyone, from makers of electric vehicles to ride-sharing businesses, shares the goal of maximizing travel distance while reducing consumption and pollution. By enabling automakers to assess usage data and install systems to make vehicles shared, more effective, and better drivers, the IoT is making a contribution.

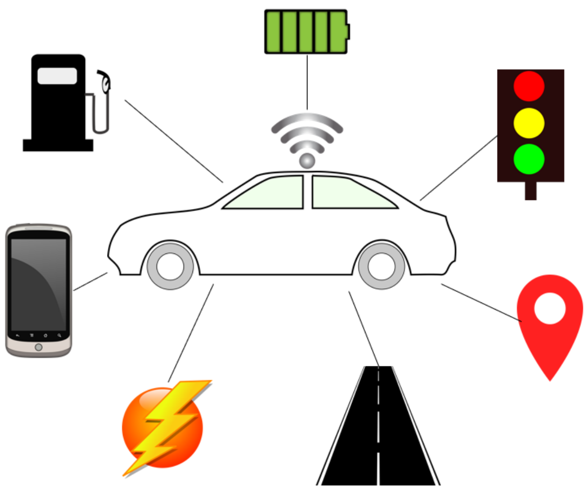

Fig. 6 Automotive IoT

6. **Smart Homes:** Homes can be equipped with IoT to become smart homes. Home security systems can now be controlled remotely from a smartphone thanks to IoT technology. IoT has the ability to enhance security in Smart Homes by reducing the constraints imposed by centralized infrastructure.

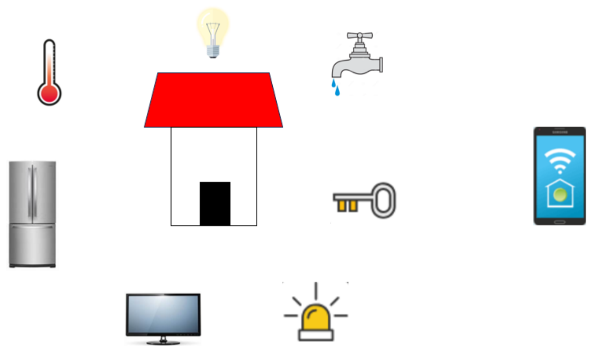

Fig. 7 Smart Homes

7. **Smart Cities:** Our cities put a tremendous amount of strain on the environment, with pollution, heating, cooling, and water use all posing environmental problems. Authorities are using IoT data to drive new initiatives to increase sustainability, minimize energy usage, reduce waste, and operate more efficiently. This is done by rethinking how smart city services are provided. The objective of smart cities is evaluated holistically using metrics like enhanced quality of life, but in practice, advancements are realized through enhancing every aspect of the urban environment.

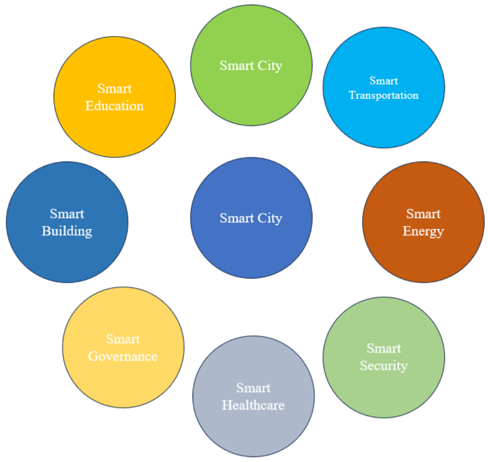

Fig. 8 Smart Cities

8. **Agriculture:** Utilizing IoT technologies in agriculture can help produce enough food to meet demand and improve agricultural production processes. A plethora of useful data on crops can be obtained and utilized for yield monitoring and early diagnosis of illnesses that could have a big influence on crop output. Monitoring soil and nutrient levels would improve agricultural production methods and save water, both of which are beneficial in some regions. Agritech solutions that are IoT-enabled can reduce excessive fertilizer use or pave the way for more ecologically friendly farming. The application of IoT technology in the agricultural sector may lead to innovations that fundamentally change the way agricultural production is carried out at the moment.

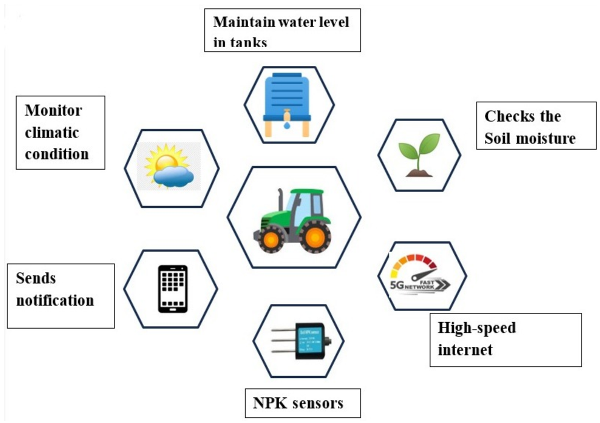

Fig. 9 Smart Agriculture

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5 Methodology Adopted

The primary objective was to transfer the data, collected by sensors, from source to destination securely and compare the throughput and packet transmission rate. To achieve this various network simulators were explored and finally found that the NetSim simulator was best for secure routing.

5.1 Dataset Description

The datasets used for testing purposes have been obtained from Kaggle [8] and wustl.edu [9]. The datasets of Diabetes_Prediction and Biometric_data , collected using IoT sensors, have been utilized to create two virtual networks corresponding to these datasets.

The Diabetes_Prediction.csv dataset file (Figure: 10) contains the report of patients. This dataset file includes the details of patients like *Glucose, Blood_Pressure, Insulin, BMI, DiabetesPDFunction*. The Biometric_data.csv dataset file (Figure: 11) contains patient's biometric data . The dataset file contains the report of *Temperature in degrees Celsius, SpO2 (Blood oxygen), PulseRate (Pulse Rate in BPM), SYS (SYStolic blood pressure), DIA (DIAstolic blood pressure), HeartRate, RespRate (Respiration Rate in BPM) and ST (Electrically neutral area between ventricular depolarization (QRS complex) and repolarization (T wave) in millivolts (mv))*.

1	Id	Glucose	BloodPressure	Insulin	BMI	DiabetesPedigreeFunction	Age
2	1	148	72	0	33.6	0.627	50
3	2	85	66	0	26.6	0.351	31
4	3	183	64	0	23.3	0.672	32
5	4	89	66	94	28.1	0.167	21
6	5	137	40	168	43.1	2.288	33
7	6	116	74	0	25.6	0.201	30
8	7	78	50	88	31	0.248	26
9	8	115	0	0	35.3	0.134	29
10	9	197	70	543	30.5	0.158	53
11	10	125	96	0	0	0.232	54
12	11	110	92	0	37.6	0.191	30
13	12	168	74	0	38	0.537	34
14	13	139	80	0	27.1	1.441	57
15	14	189	60	846	30.1	0.398	59
16	15	166	72	175	25.8	0.587	51
17	16	100	0	0	30	0.484	32
18	17	118	84	230	45.8	0.551	31
19	18	107	74	0	29.6	0.254	31
20	19	103	30	83	43.3	0.183	33
21	20	115	70	96	34.6	0.529	32
22	21	126	88	235	39.3	0.704	27
23	22	99	84	0	35.4	0.388	50
24	23	196	90	0	39.8	0.451	41
25	24	119	80	0	29	0.263	29
26	25	143	94	146	36.6	0.254	51
27	26	125	70	115	31.1	0.205	41
28	27	147	76	0	39.4	0.257	43
29	28	97	66	140	23.2	0.487	22

Fig. 10 Screenshot of Diabetes_Prediction.csv dataset

1	Patient_num	Temp	SpO2	Pulse_Rate	SYS	DIA	Heart_rate	Resp_Rate	ST
2	1	28.9	0	0	0	0	0	0	0
3	2	28.9	0	0	0	0	78	17	0.4
4	3	28.9	89	104	0	0	78	17	0.4
5	4	28.9	89	104	0	0	79	17	0.4
6	5	28.9	89	101	0	0	79	17	0.4
7	6	28.9	91	103	0	0	79	17	0.4
8	7	28.9	91	103	0	0	82	17	0.4
9	8	28.9	91	97	0	0	82	17	0.4
10	9	28.9	91	97	0	0	91	10	0.3
11	10	28.9	91	92	0	0	91	10	0.3
12	11	28.8	91	92	0	0	91	10	0.3
13	12	28.8	91	92	0	0	100	10	0.3
14	13	28.8	92	89	0	0	100	10	0.3
15	14	28.9	92	89	0	0	100	10	0.3
16	15	28.9	91	90	0	0	100	10	0.3
17	16	28.9	91	90	0	0	100	13	0.3
18	17	28.9	92	90	0	0	100	13	0.3
19	18	28.9	92	90	0	0	96	13	0.32
20	19	28.9	93	91	0	0	96	13	0.32
21	20	28.9	94	88	0	0	96	13	0.32
22	21	28.9	94	88	0	0	89	13	0.32
23	22	28.9	94	88	0	0	87	13	0.32
24	23	28.9	94	88	0	0	86	13	0.26
25	24	28.9	94	88	0	0	88	13	0.26
26	25	28.9	95	93	0	0	88	13	0.26
27	26	28.9	95	93	0	0	91	13	0.3
28	27	28.9	96	94	0	0	91	13	0.3
29	28	28.9	96	94	0	0	95	13	0.3

Fig. 11 Screenshot of Biometric_data.csv dataset

5.2 Cleaning of Dataset

Steps to clean the dataset

1. Install Anaconda3 2022.10 (Python 3.9.13)
2. Open Jupyter 6.4.12
3. Import libraries
4. Read csv file and see the top 5 instances of the data
   df = pd.read_csv('C:/Users/sonam/Downloads/Routing_using_NetSim/data.csv')
   df.head()
5. Identify how many and what type of missing values are in the dataset
   df.isnull().sum()
6. Replace blanks with NaN in the dataset
7. Perform Mean & Median & Mode Imputation

Algorithm: Sensor – Server Communication

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1. **Notation**
2. Sn – Sensor Node where Sn=1 to 6
3. Sr – Server
4. LG – LOWPAN Gateway

5. *Rtr* – Router
6. *R*– Rank
7. *LQ* – Link Quality
8. *p* - Received power(dBm)
9. *rs* - Receiver sensitivity (dBm)
10. *Pckt* – Packet
11. *NR* – Not Reachable
12. *DAG* - Directed Acyclic Graph
13. *DODAG*– Destination-Oriented DAG
14. *DODAGID* - DODAG ID
15. *DIOM* – DODAG Information Object Message
16. *NDODAG* – New DODAG
17. *PDODAG* – Parents to the DODAG root
18. *DIS* – DODAG Information Solicitation

```
19. Trigger: Nodes transmit the packet
20. LG ← EstablishConnection(Sn)
21. IsConnectionUp(Sn,LG)
22. if(EstablishConnection==True)
23. {
24.         Sn ← send(LG,DIOM)
25.         Sn ← listen(DIOM)
26.         Sn ← join(NDODAG)
27.                 if(Rtr falls(OTR) LG)
28.                 {
29.                         Rtr ← send(LG, DIS)
30.                         Sn ← broadcast(Rtr, DIS)
31.                 }
32.                 else
33.                 {
34.                         goto step 8
35.                 }
36.         Sn ← calculate(R & LQ)
37.         invoke rank()
38.         invoke link_quality()
39.         Sn ← select(PDODAG)
40.         Sn ← send(LG, Pckt)
41. else
42. {
43.         print("Connection could not be established")
44. }
45. rank()
46. {
47.         R= (Max_increament - Min_increament) × (1 – LQ) + Min_increament
```

```
}
link_quality()
{
        LQ = (1 − (p/rs)
        LQ = (Sending Link Quality + Receiving Link Quality) / 2
}
if(Sr==NR)
LG ← Drop(Pckt)
ConnectionEnd(Sn, LG)
```

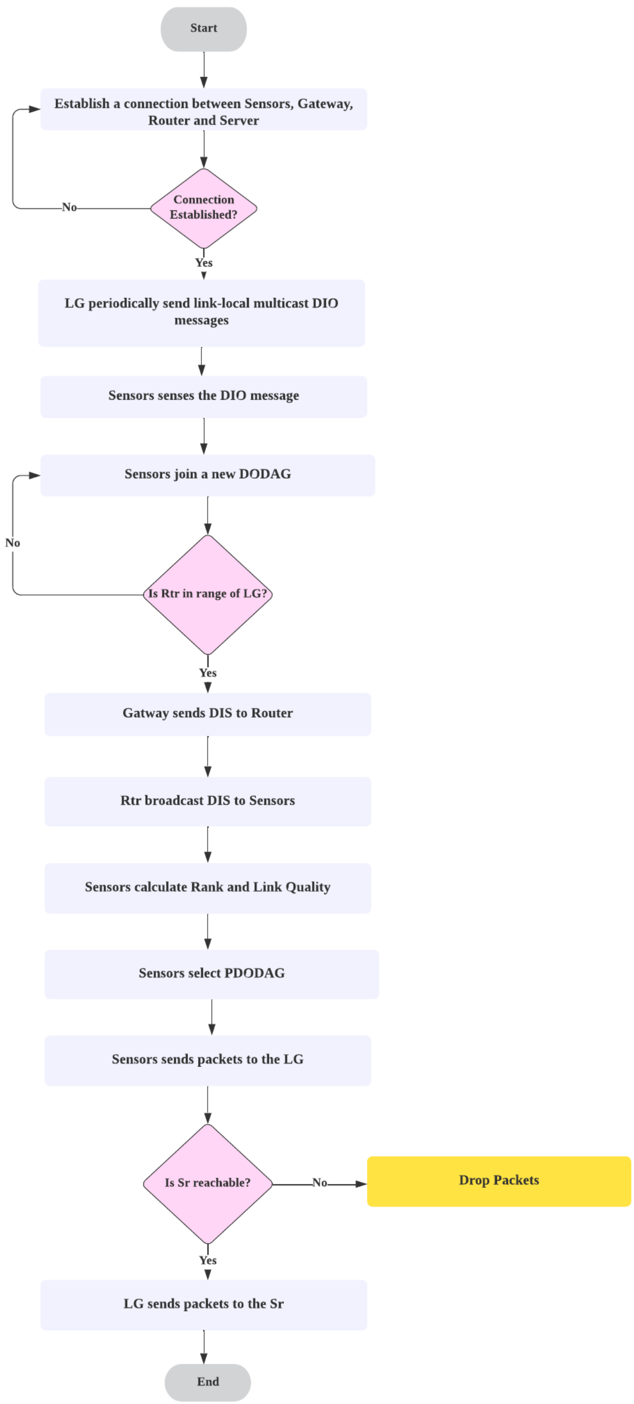

Fig. 12 Flowchart of routing between Sensors and Server

6 Experiment Setup

6.1 Software

The NetSim (Network Simulator) Standard v13.3.12 was used to comprehend and evaluate the network in real time. This network simulator simulates a network with devices, links, applications, sensors, and more, allowing users to examine its behavior and performance [15].

To simulate a network in NetSim, the following steps must be undertaken:

1. Network Setup: Create a virtual network by selecting and putting necessary devices, links, and components.
2. Customize the properties of devices, protocols, connections, and other network aspects to meet simulation needs.
3. Set Traffic Flows: Set traffic patterns, applications, and data flows to mimic real-world network behavior.
4. Open Visual Studio: Launch Visual Studio to alter and adjust the simulation code as needed.
5. Rebuild the Code: Compile the new code to check it is compatible with the network setup.
6. Run the Simulation: Start the simulation to see the network's real-time performance and interactions.
7. Visualize the Simulation: Use built-in capabilities to visualize network activity, traffic flow, and device behavior.
8. Analyze Results: Examine the simulation results, evaluate performance indicators, and draw conclusions to improve network architecture or resolve potential concerns.

7 Result

Two different networks were created using the IoT module in the NetSim simulator. The first network (Figure 13) comprises 5 sensors such as Glucose, Blood_Pressure, Insulin, BMI, DiabetesPDFunction connected to a 6LowPAN gateway followed by a router and this router sends data to the Server node. All the packets generated by these sensors follow the TCP protocol. The second network (Figure 14) comprises 8 sensors such as *Temperature in degrees Celsius, SpO2 (Blood oxygen), PulseRate (Pulse Rate in BPM), SYS (SYStolic blood pressure), DIA (DIAstolic blood pressure), HeartRate, RespRate (Respiration Rate in BPM) and ST (Electrically neutral area between ventricular depolarization (QRS complex) and repolarization (T wave) in millivolts (mv))* connected to a 6LowPAN gateway followed by a router and this router sends data to the server node. The performance of networks has been evaluated based on different metrics. The simulation results of both networks provide the numbers of packets generated, packets received, and packets collided.

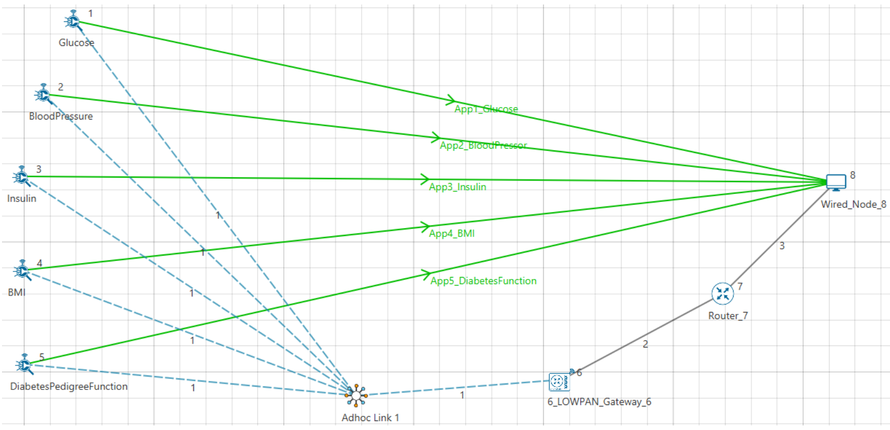

Fig. 13 IoT Network of Diabetes_Prediction dataset

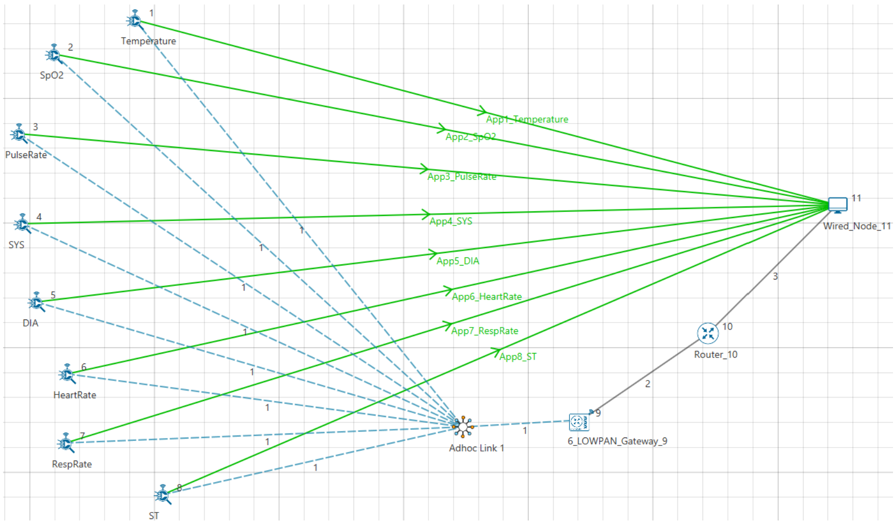

Fig. 14 IoT network of Biometric_data dataset

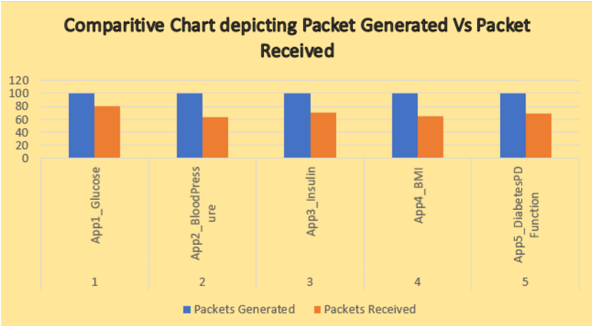

Fig. 15 Comparative chart depicting packet generated vs packet received of Diabetes_Prediction dataset

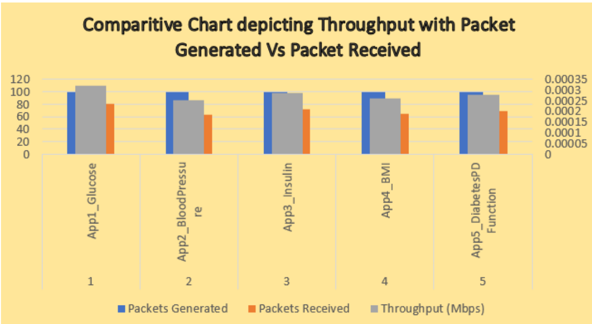

Fig. 16 Comparative chart depicting throughput with packet generated vs packet received Diabetes_Prediction dataset

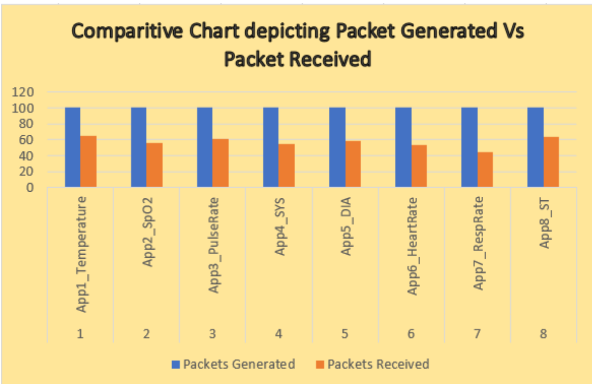

Fig. 17 Comparative chart depicting packet generated vs packet received of Biometric_data dataset

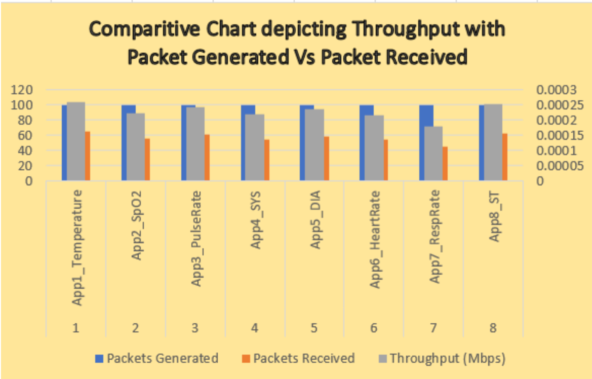

Fig. 18 Comparative chart depicting throughput with packet generated vs packet received Biometric_data dataset

8 Conclusion

In a number of industries, including healthcare, agriculture, and military applications, the IoT has shown itself to be a game-changing technology. In this study, we used NetSim Simulation to simulate two IoT-based networks in order to investigate the potential of IoT in healthcare. IoT devices were used to monitor and communicate vital health data from two different datasets: Diabetes_Prediction and Biometric_data, which were obtained from Kaggle and wustl.edu, respectively.

Five sensor nodes, a gateway, a router, and a server made up the first simulated network, whereas eight sensor nodes and comparable network components made up the second. These sensor nodes created an effective communication loop by continuously gathering and sending data to the server through the gateway. An easy-to-understand illustration of the network's performance was supplied by the simulation's informative results, which were displayed as an animation or result window.

Both networks produced very positive results. The networks effectively handled the health data produced by the sensor nodes, and the data transfer was flawless. The encouraging results highlight how well IoT works in healthcare applications, especially when it comes to continuously monitoring patients' vital signs and other biometric data, which makes it possible to manage healthcare more proactively and individually.

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