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Congestion Aware WSN-IoT-Application Layer Protocols for Healthcare Services

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Abstract- In the healthcare industry, WSN-IoT networks can be used to gather patient data for statistical purposes. IoT-based application-level protocols do not take into account these facts while forwarding the data to the gateway or server, which may degrade the network performance if the data was collected from a patient with ordinary/critical health issues and the route was busy or congested. In this paper, we'll look at the performance of two application layer protocols (i.e. CoAP and MQTT) within the constraints of a scalable network by integrating a congestion-aware scheme with them.

Keywords- WSN-IoT, Sensors, Healthcare, IoT protocol.

I. INTRODUCTION

As shown in Figure 1, real-time data monitoring and analysis made possible by the automation of healthcare services can increase diagnostic precision and hasten the decision-making process. The healthcare industry can take advantage of a wide variety of WSN-IoT network services. It can be used to assess vital signs like blood sugar, blood pressure, and heart rate.

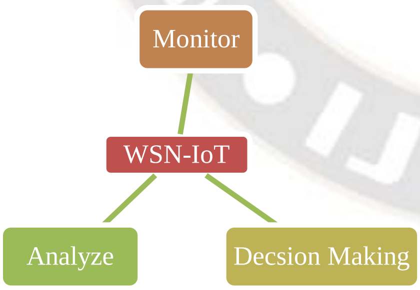

Figure: 1 WSN-IoT

Practitioners can recommend the diagnosis w.r.t. sensed data, as shown in Figure 2. Medical data can be categorized into different types as given below:

1. When we talk about "ordinary data," we're referring to information about non-emergency cases like fever, pain, and so on.
2. Critical patient data must be collected and analysed frequently in emergency situations to allow for prompt diagnosis and treatment.

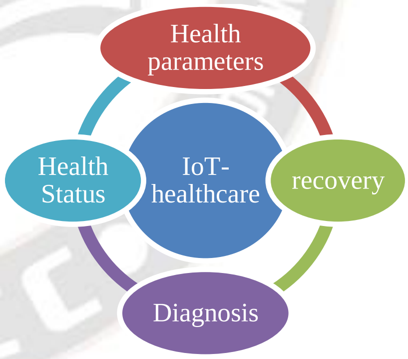

Figure 2: WSN-IoT-based healthcare

Challenges for WSN-IoT for the healthcare industry

- Different data formats, processing speeds, communication modes, etc., all add complexity to the process of integrating sensors with application protocols.
- The reliability of data collection is tied directly to the device's hardware. Designing precise devices to collect samples in real-time is essential in the healthcare industry.

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- The cost of diagnosis may rise if multiple sensors are needed to track various health indicators.
- In a heterogeneous environment, ensuring the safety of sensitive medical data exchanged over the internet by WSN-IoT networks can be challenging.

The benefits and drawbacks of healthcare that relies on WSN-IoT are as follows.

Merits:

- Illness data gathered in real-time
- Enhanced reliability of diagnoses
- Keeping tabs on the healing process
- Data management for medical charts
- Quick thinking and acting
- Help for the sick from a distance

Limitations:

- The cost of the necessary infrastructure is a limiting factor.
- The analysis of medical data still necessitates the oversight of specialists.
- Multiple medical sensors using incompatible hardware
- There are no universally accepted standards for the exchange or interpretation of data [1-5].

II. LITERATURE SURVEY

R. Dutta et al. [6] looked into the impact of IoT in the medical field. Patient health monitoring, recording, feedback, statistical analysis, disease progression, etc. are just some of the many services that healthcare automation provides, as shown in the study. The results of analytics can be used to create innovative Internet of Things (IoT)-based solutions for medical care.

Using cloud computing and the Internet of Things (IoT), W. N. Hussein et al. [7] created a framework for the medical field. Doctors and hospitals can use this system to share patient records in real time over an Internet of Things network, allowing for remote health monitoring and better treatment decisions. The results show that the data can be transmitted quickly using optimal network resources.

For Internet of Things networks that store individual patients' medical records, B. Kapoor et al. [8] developed a safety measure. It mandates a policy of using keys to access shared data across networks. Experiments show that it is more efficient and uses fewer resources than conventional cryptographic algorithms.

IoT (Internet of Things) based solution for real-time medical data management was developed by A. Asokan et al. [9]. Random patient data collection allows doctors to make more informed decisions more quickly. The results of the experiments prove that it is a viable energy-saving solution that can be put to use in times of medical emergency.

N. Taimoor [10] examined how IoT and AI could benefit the healthcare sector. Fast Internet of Things (IoT) networks were found to be capable of transmitting medical data, which artificial intelligence (AI) algorithms could then analyse for precise diagnosis and decision-making. Internet of Things sensors can be used for continuous patient monitoring. The results of this research can be applied to the creation of cutting-edge products in the medical industry.

T. Shaown et al. [11] gathered information about heart disease from patients by having them wear sensors connected to the internet. Real-time patient monitoring is supported, and the accuracy of diagnoses is boosted, as demonstrated by the experiments.

IoT-based healthcare applications that can enhance diagnosis, clinical decision-making, health record and medical test data management, patient monitoring, etc. were investigated by D. Tiwari et al. [12].

Patient data management solutions based on Internet of Things networks were presented by S. Lenka et al. [13]. RFID tags are used to keep tabs on each patient. Compared to other networks (based on 3G/4G), analysis shows that it can automate traditional healthcare and medical data collection methods.

Biosignals (electrocardiogram, electromyography, photoplethysmography) from patients can be collected with the help of an Internet of Things hardware interface, as presented by J. Yu et al. [14]. When it comes to life and death situations, it can quickly and accurately differentiate between signals. The results of the experiments demonstrate its efficiency, responsiveness, and low operational cost, among other benefits.

A blockchain-based, Internet-of-Things (IoT) healthcare solution was provided by U. Demirbaga et al. [15]. It can provide a variety of functions for medical professionals, including patient data collection, processing, secure transmission, analysis, and decision-making. The results show that it performs well compared to classic cryptographic algorithms in terms of efficiently using available resources.

M.L. Sahu et al. [16] created an Internet of Things (IoT) healthcare solution that transmits patient data to regional endpoints. Later, only the sensitive information is extracted and sent to the cloud storage. Data processing at the local level reduces routing overhead and resource consumption compared to other healthcare solutions.

D. Arora et al. [17] looked into the various Internet of Things (IoT) applications that can be used to enhance and broaden healthcare's reach. The study found that practitioners can remotely access this medical data by using cloud/big data platforms to transmit the data from wearable sensors that detect the various bio signals emanating from the patient's body. However, security and privacy risks may be associated with data transmission in an open environment.

Research by R. Marshal et al. [18] on end-user devices/sensors used to collect patient medical data found that data transmission in an open environment is vulnerable to interception by intruders, leading to a variety of security threats/attacks over WSN-IoT networks. Research shows that there are few security measures in place for such networks. Data analytics can then be applied to the problem of healthcare data security.

The ECG signals were detected using an IoT-based solution developed by R. Priyadarshini et al. [19]. The rate of battery drain is recorded and transmitted to the home base. Experiments show that it is an effective and efficient solution for the healthcare sector, with a sensing rate that varies with residual energy (to conserve resources).

S. Mohapatra et al. [20] proposed a solution that serves multiple purposes, such as collecting, processing, analysing, and predicting data in the medical field. Machine learning can be applied to medical data for accurate prognosis of health, recovery, etc. Medical professionals can use this answer to aid in diagnosis and treatment planning.

Support for IoT networks and web services was integrated by J. H. Jung et al. [21]. It employs a Restful API and the Constrained Application Protocol (CoAP) for information transfer. Data analysis demonstrates its superiority over conventional networks in terms of its ability to transfer data quickly and reliably despite mobility restrictions.

Medical records were processed by machine learning algorithms by A. A. Malibari et al. [22]. Sensing devices collect data from patients and transmit it to a central location, where medical records are analysed and classifications are made for use in developing prediction models. The experimental results demonstrate the efficacy of this strategy in enhancing disease detection and diagnosis.

An IoT-based strategy for genome sequencing was proposed by E. M. Onyema et al. [23]. In the end, a sequence alignment programme is used to map attributes to their corresponding nodes. The sequencing data can be used to diagnose various diseases, and the analysis demonstrates that it is a cost-effective healthcare option.

D. Verma et al. [24] suggested using Internet of Things (IoT) wearable sensors to compile various forms of health information. Information on patients' fitness levels, current medical statistics, and their health and recovery progress in relation to their treatment are all covered. The analysis demonstrates that medical professionals can benefit from utilising automated medical data collection.

Heart rate monitoring sensors were connected to a cloud platform by S. Bandyopadhyay et al. [25] to allow for continuous monitoring and real-time data analysis. Sensors can track a patient's heart rate and sound alarms if any warning signs are detected. According to the numbers, this is a cost-effective way to improve medical care delivery.

Using a wireless sensor network (WSN-IoT) for dynamic data collection, S. Singh et al. [26] created a healthcare solution. The quickest paths for sending data to clusters are determined. The analysis shows that it outperforms the conventional routing schemes regarding throughput, energy efficiency, and network lifetime.

The problems with collecting real-time patient medical data were studied by A. Sundas et al. [27], who then introduced a sensor-based Internet of Things (IoT) network that can collect samples related to various parameters (such as patient temperature, heart rate, oxygen level, etc.). Healthcare services and the management of patient's medical records and histories have been successfully automated in experiments.

According to Z Gupta et al., IoT-based applications.[28], can progress smart farming. However, the performance of IoT networks can be hindered by a variety of factors, such as the farm's coverage area, location, environmental conditions, etc. If maintaining a network in a variety of environments is resource intensive, it could reduce the lifespan of an IoT sensor. Using two distinct Internet of Things standards, this paper will introduce a method for energy-efficient smart farming and evaluate its performance based on several criteria.

Organizations committed to scientific study and research, according to Gupta, Z., and Bindal, A. [29], have established a promising technology using IoT to address issues in agriculture. Several different agricultural settings are analysed to determine how IoT is being used.

IoT can develop the performance of wireless sensor networks, as explained by Gupta A. et al. [30]. However, the WSN-IoT paradigm changes the focus of research and the end user's needs. This paper examines various related topics and their potential applications in the home, industry, healthcare, the environment, and surveillance, including data acquisition and aggregation, optimal energy consumption and harvesting for smart devices, scalable communication, etc.

Specifically, Bhatt V. et al. [31], IoT 4.0 impacts Industry 4.0 by enhancing connectivity, data security, human-machine interaction, usability, and seamless interactions in modern factories. It incorporates blockchain, big data, machine learning, and cloud computing for data processing and analysis.

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K. Goel et al. [32] [33], Smart agriculture offers numerous advantages over usual farming methods, including wireless sensor networks for monitoring soil moisture and temperature, microbial fuel cell membranes for accelerating sensor batteries, and hybrid network deployment and communication techniques. These advancements will improve farmers' economic and agricultural success, ultimately leading to enhanced financial prosperity.

III. CONGESTION-AWARE APPLICATION PROTOCOLS OVER IOT NETWORKS

Step 1: initialize the WSN-IoT network

Step 2: Set the following parameters:

Link Flag Lf BUSY, IDLE,

Pay Load NORMAL, CONGESTED

Link capacity Lc

Health Message HMSG: CRITICAL ORDINARY

HMSG->priority: HIGH, LOW

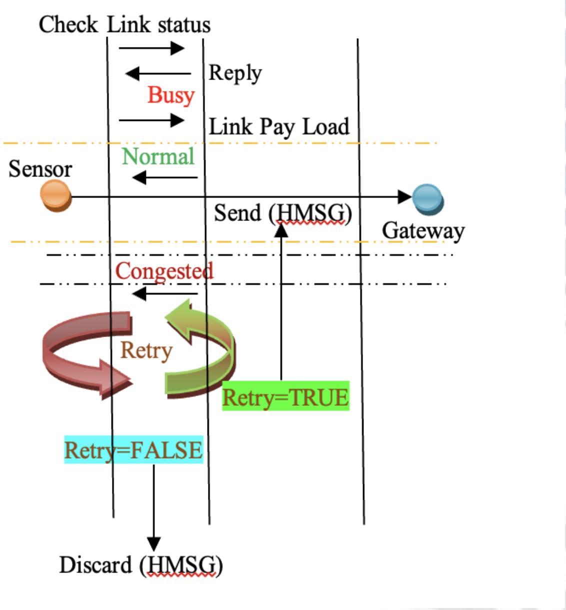

Figure: 3 Low-priority HMSG transmission at the sensor

Step 3: Estimate the number of engaged sensor w.r.t. gateway gw=∑n/2 > link capacity then *Lf= CONGESTED* engaged sensor w.r.t. gw=∑n/2 < link capacity then *Lf=NORMAL*

engaged sensor ∑n=0 then *Lf=IDLE*

engaged sensor ∑n> 1 then *Lf=BUSY*

//for high priority HMSG only

Step 1: Sense (HMSG)

Step 2: Check link status: sensor, gateway

If gateway->Link Flag: BUSY

If link payload: sensor, gateway, NORMAL

Send (HMSG, gateway)

Else link payload: sensor-> gateway, CONGESTED

retry(HMSG, gateway, interval)

if retry=FAIL, then discard (HMSG)

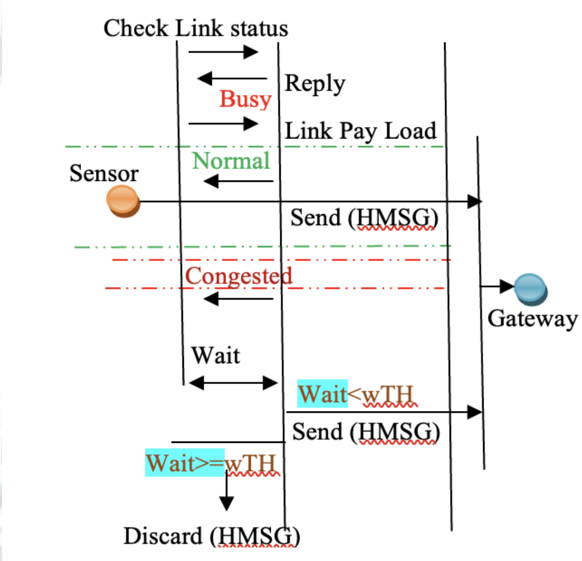

Figure: 4 High-priority HMSG transmission at the sensor

Step 1: If link payload: sensor, gateway, NORMAL

Send (HMSG, gateway)

Else link payload: sensor-> gateway, CONGESTED

wait++

Step 2: if sensor->wait> wTH then discard HMSG (ordinary)

else

send(HMSG, gateway)

//for gateway

Step 1: Check link load: gateway, server

Step 2: if link payload: gateway, server, NORMAL

Allocate slot for HMSG->HIGH priority

Send HMSG->HIGH priority: FIRST

Set ageing (HMSG->LOW priority, survival interval)

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Allocate slot for HMSG->LOW priority

Send HMSG->LOW priority: LAST

//if not expired

Else link payload: gateway, server,

CONGESTED

wait++

Step 4: if Gateway->wait> wTH then discard HMSG (ordinary)

else

send(HMSG, gateway)

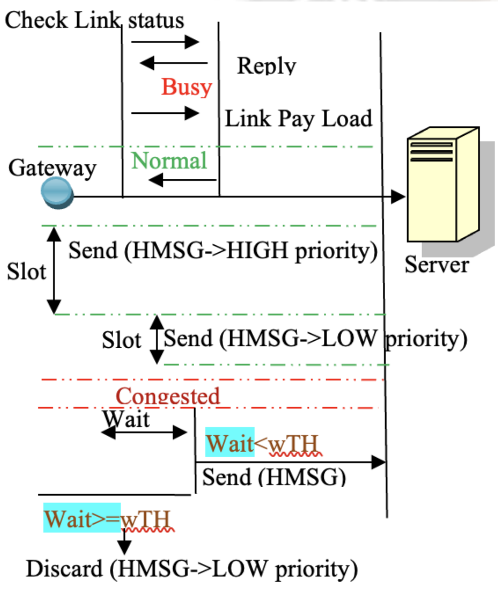

Figure: 5 Priority-wise HMSG transmission at the gateway

Medical data can be sensed directly from patients using sensors. This information has a lower priority than medical data relating to emergencies but is still considered medical information for non-emergency situations. Link status and payload over the current link are checked before the collected data, known as health messages, is sent to the gateway. If the gateway is not busy and the payload is normal, the sensor will send the information immediately to the gateway. If the link is busy and congested due to heavy payload, the sensor will attempt to send the information only once more before giving up (as shown in figure 4).

However, the sensor enters a wait state if the data is of high priority; if the link is still congested and the waiting interval is greater than the waiting threshold, the current data is discarded; otherwise, it is successfully transmitted to the gateway (as shown in figure 4). The gateway is responsible for estimating the health of the connection to the server. If everything is normal, a transmission slot is set aside for high-priority HMSGs only, and then the next slot is used to forward low-priority HMSGs. For low-priority HMSGs only, transmission is delayed for a waiting interval and the ageing factor in the event of a congested link defines the survival interval. If the timeout is less than the threshold, only low-priority HMSGs that are still alive are sent to the server; high-priority HMSGs that have expired are marked as such and discarded (as shown in Figure 5).

IV. RESULTS AND ANALYSIS

The proposed scheme is simulated using the NS-3 network simulator with two different IoT application protocols, namely Constrained application protocol (CoAP) and Message Queuing Telemetry Transport (MQTT), sensor density 100-600, initial energy 10J, and two different simulation scenarios, (a) no congestion aware scheme (NCA)-CoAP, (NCA)-MQTT, and (b) congestion aware scheme (CA)-CoAP/CA-MQTT.

Performance analysis of CoAP

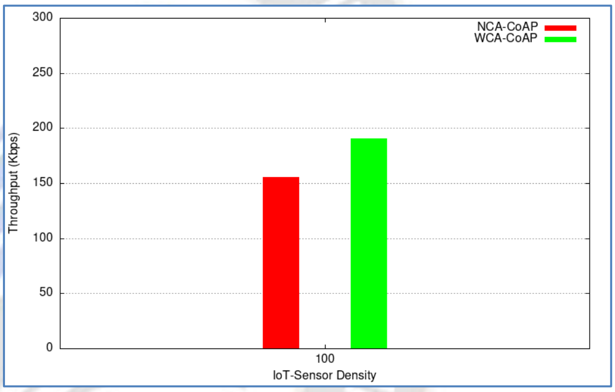

Figure: 6 Throughput-CoAP-IoT-sensors-100

Figure 6 shows the throughput of the CoAP protocol with two scenarios, i.e., NCA-CoAP and WCA-CoAP using 100 IoT sensors. It can be observed that NCA-CoAP delivered 155.80Kbps whereas it is 190.63 Kbps for WCA-CoAP.

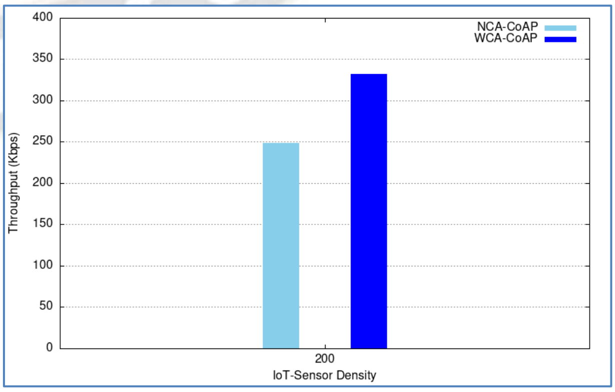

Figure: 7 Throughput-CoAP-IoT-sensors-200

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Figure 7 shows the throughput of CoAP protocol with two scenarios, i.e., NCA-CoAP and WCA-CoAP using 200 IoT sensors. It can be observed that NCA-CoAP delivered 248.83Kbps throughput whereas it is 332.19Kbps for WCA-CoAP.

Figure 8 shows the throughput of CoAP protocol with two different scenarios i.e. NCA-CoAP and WCA-CoAP using 400 IoT sensors. It can be observed that NCA-CoAP delivered 189.90Kbps throughput whereas it is 340.02Kbps for WCA-CoAP.

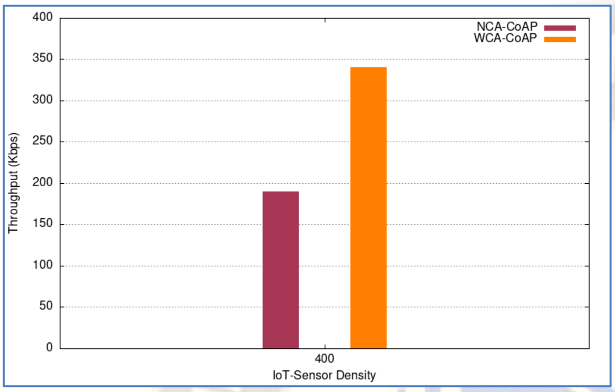

Figure: 8 Throughput-CoAP-IoT-sensors-400

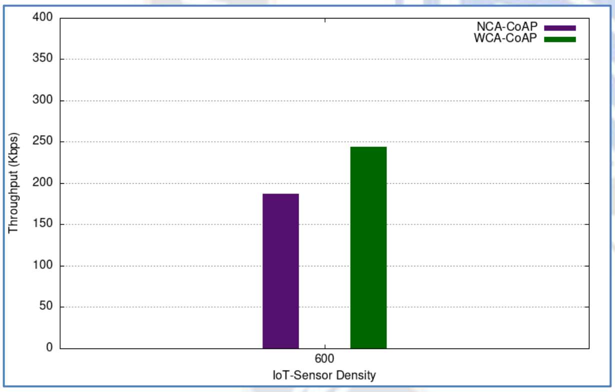

Figure: 9 Throughput-CoAP-IoT-sensors-600

Figure 9 shows the throughput of CoAP protocol with two scenarios, i.e., NCA-CoAP and WCA-CoAP using 600 IoT sensors. It can be observed that NCA-CoAP delivered 186.84Kbps throughput whereas it is 243.62Kbps for WCA-CoAP.

Figure 10 shows the throughput comparison of CoAP protocol w.r.t. IoT-sensors density (100-600). In the case of NCA-CoAP, it can be analyzed that there are a lot of variations in its value as the sensor density increases. It is highest with medium-level sensor density (200) and CoAP delivered average throughput with 100/400/600 sensors. WCA-CoAP enhanced its value under the constraints of scalable sensor density. It reaches up to its peak value using 400 sensors. However, with 600 sensors, it is marginally declined.

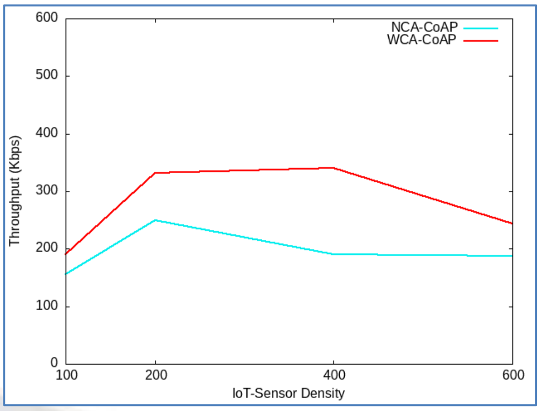

Figure: 10 Throughput- Comparison-CoAP-IoT-sensors

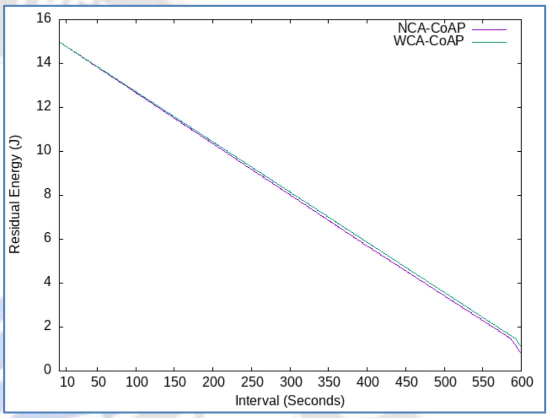

Figure: 11 Residual Energy-NCA-CoAP/WCA-CoAP-IoT-Sensor-100

Figure 11 shows the residual energy of NCA-CoAP and WCA-CoAP with 100 IoT sensors. It can be observed that there is a sharp decline in energy level, and it reaches its minimum level till the end of the simulation interval for both scenarios. However, WCA-CoAP retained its acceptable level in contrast of NCA-CoAP.

Figure 12 shows the residual energy of NCA-CoAP and WCA-CoAP with 200 IoT sensors. It can be observed that their energy level declined up to its minimum level using both scenarios.

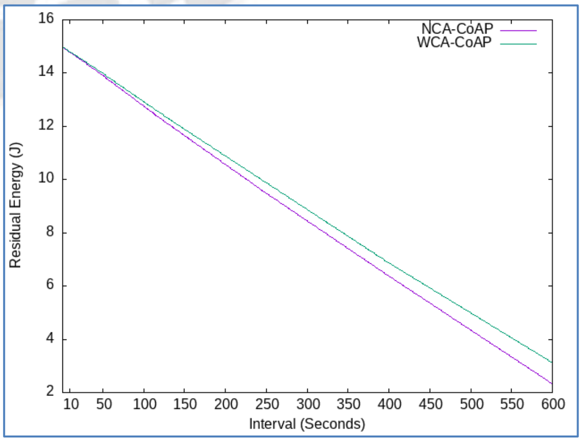

Figure: 12 Residual Energy-NCA-CoAP/WCA-CoAP-IoT-Sensor-200

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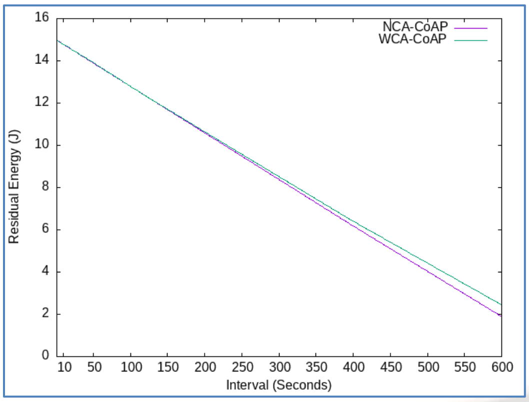

Figure: 13 Residual Energy-NCA-CoAP/WCA-CoAP-IoT-Sensor-400

Figure 13 shows the residual energy of NCA-CoAP and WCA-CoAP with 400 IoT sensors. It can be observed that there is a marginal difference between energy consumption using booth scenarios till the end of the simulation.

Figure 14 shows the residual energy of NCA-CoAP and WCA-CoAP with 600 IoT sensors. It can be observed that energy depletion is almost similar for NCA-CoAP and WCA-CoAP up to the end of the simulation with the highest sensor density.

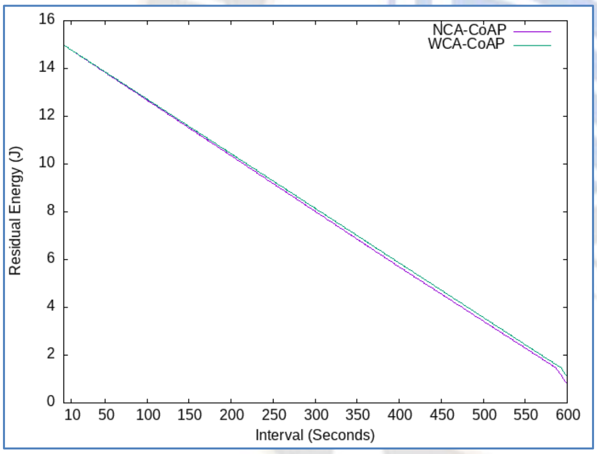

Figure 14 Residual Energy-NCA-CoAP/WCA-CoAP-IoT-Sensor-600

Figure: 15 compares residual energy using NCA-CoAP/WCA-CoAP with IoT-sensor density (100-600). It can be analyzed that more energy is consumed as the IoT-sensor density increases, thus resulting in the lowest residual energy level for NCA-CoAP and WCA-CoAP. Results indicate that WCA-CoAP optimized the resource consumption and maintained higher residual energy than NCA-CoAP w.r.t. IoT-Sensor density.

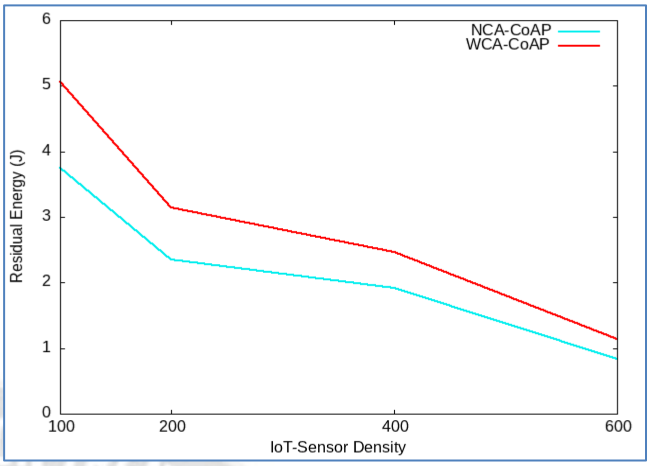

Figure: 15 Residual Energy-Comparison NCA-CoAP/WCA-CoAP

Performance analysis of MQTT

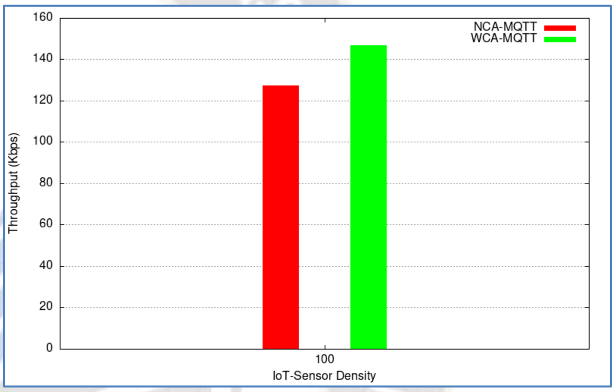

Figure: 16 Throughput-MQTT-IoT-sensors-100

Figure 16 shows the throughput of MQTT protocol with 100 IoT sensors using two different simulation scenarios i.e. NCA-MQTT and WCA-MQTT. In case of NCA-MQTT, it is 127.27Kbps with NCA-MQTT and 146.81Kbps with WCA-MQTT.

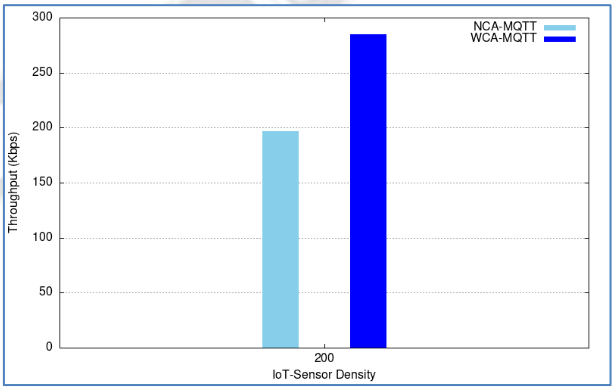

Figure: 17 Throughput-MQTT-IoT-sensors-200

Figure 17 shows the throughput of the MQTT protocol with 200 IoT sensors using two different simulation scenarios i.e. NCA-MQTT and WCA-MQTT. In the case of NCA-MQTT, it is

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196.56Kbps with NCA-MQTT and 248.65Kbps with WCA-MQTT.

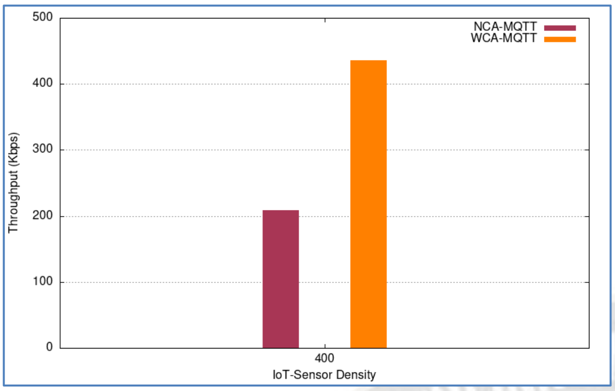

Figure: 18 Throughput-MQTT-IoT-sensors-400

Figure 18 shows the throughput of the MQTT protocol with 400 IoT sensors using two different simulation scenarios i.e. NCA-MQTT and WCA-MQTT. In the case of NCA-MQTT, it is 208.90Kbps with NCA-MQTT and 436.20Kbps with WCA-MQTT.

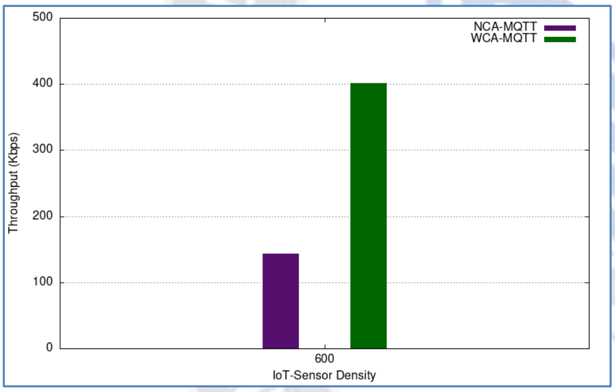

Figure: 19 Throughput-MQTT-IoT-sensors-600

Figure 19 shows the throughput of the MQTT protocol with 100 IoT sensors using two different simulation scenarios i.e. NCA-MQTT and WCA-MQTT. In the case of NCA-MQTT, it is 142.80Kbps with NCA-MQTT and 401.38Kbps with WCA-MQTT.

Figure 20 shows the throughput comparison of MQTT protocol w.r.t. IoT-sensors density (100-600) using different scenarios (NCA-MQTT/WCA-MQTT). In the case of NCA-MQTT, It can be observed that it is increased w.r.t. sensor density up to 400 sensors only. The highest sensor density (600) is slightly dropped, whereas WCA-MQTT improved its value significantly under the constraints of a scalable network.

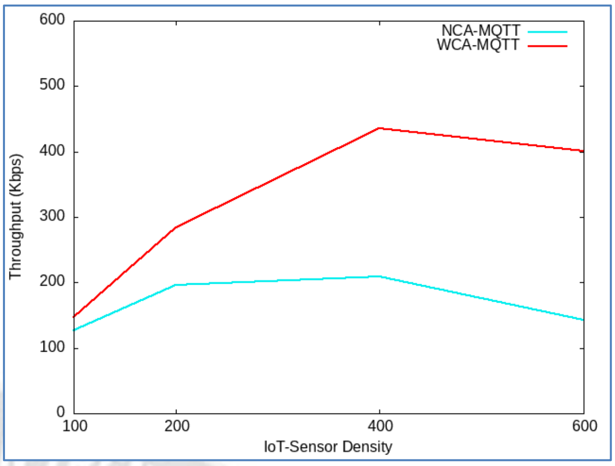

Figure: 20Throughput- comparison NCA-MQTT/WCA-MQTT

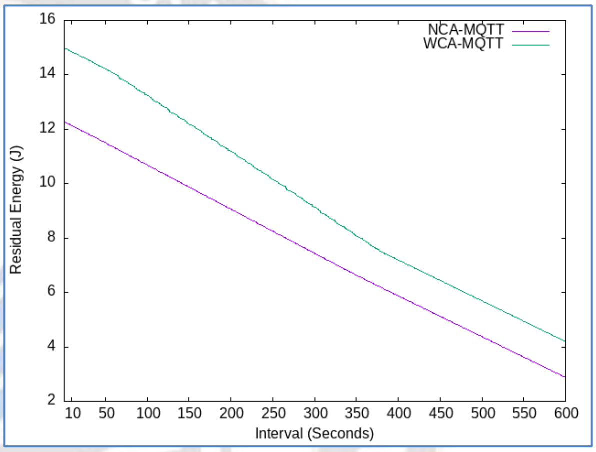

Figure: 21 Residual Energy-NCA- MQTT/WCA-MQTT-IoT-Sensor-100

Figure 21 shows the residual energy of NCA- MQTT and WCA-MQTT with 100 IoT Sensors. It can be analyzed that WCA-MQTT maintained higher residual energy than NCA-MQTT until the end of the simulation interval.

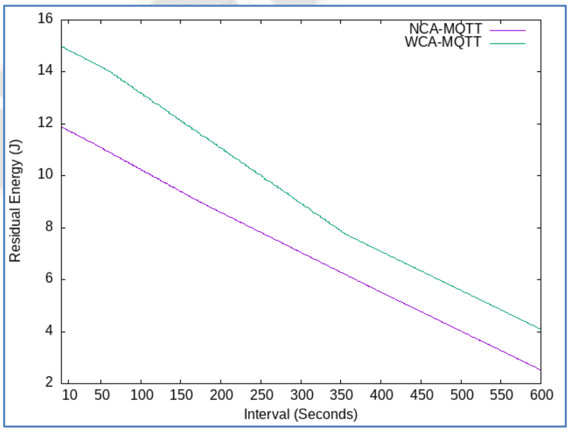

Figure: 22 Residual Energy-NCA- MQTT/WCA-MQTT-IoT-Sensor-200

Figure 22 shows the residual energy of NCA- MQTT and WCA-MQTT with 200 IoT Sensors. It can be analyzed that WCA-

MQTT maintained higher residual energy than NCA-MQTT until the end of the simulation interval.

Figure: 23 shows the residual energy of NCA- MQTT and WCA-MQTT with 400 IoT Sensors. It can be analyzed that there is a sharp decline in residual energy using NCA-MQTT, whereas it varies slightly using WCA-MQTT until the end of the simulation interval.

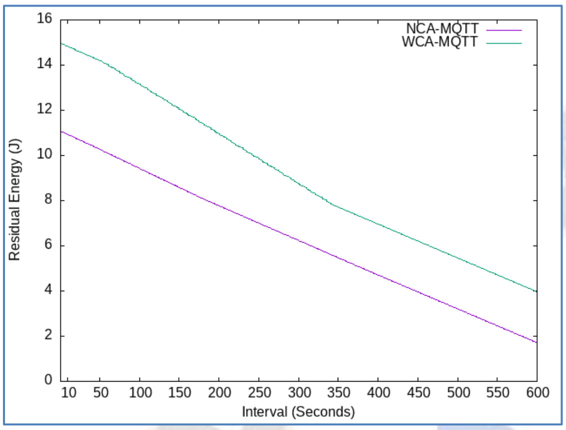

Figure: 23 Residual Energy-NCA- MQTT/WCA-MQTT-IoT-Sensor-400

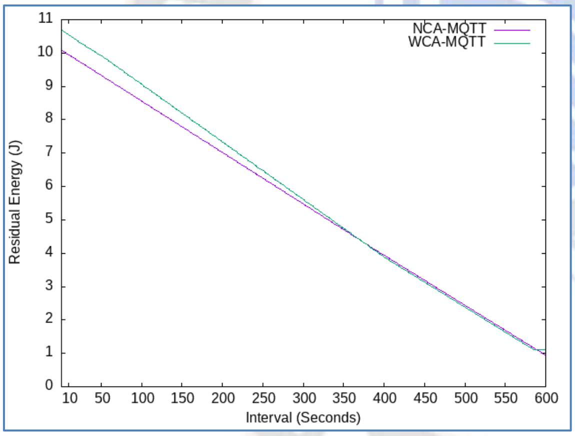

Figure: 24 Residual Energy-NCA- MQTT/WCA-MQTT-IoT-Sensor-600

Figure 24 shows the residual energy of NCA- MQTT and WCA-MQTT with 600 IoT Sensors. It can be analyzed that in starting the simulation, there is little difference between the residual energy level of NCA-MQTT and WCA-MQTT. Later on, it is almost similar for each scenario until the end of the simulation.

Figure 25 compares residual energy using NCA-MQTT/WCA-MQTT with IoT-sensor density (100-600). It can be analyzed NCA-MQTT consumed more energy w.r.t. IoT-sensor density (100-600) whereas WCA-MQTT consumed the energy optimally up to 100-400 sensor density and with the highest IoT sensor density (600), there is sharp depletion in its energy level. However, WCA-MQTT retained higher residual energy as compared to NCA-MQTT.

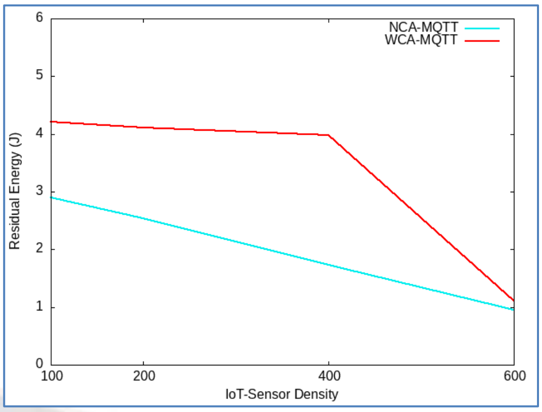

Figure: 25 Residual Energy-comparison- NCA- MQTT/WCA-MQTT

Comparison of CoAP and MQTT protocols

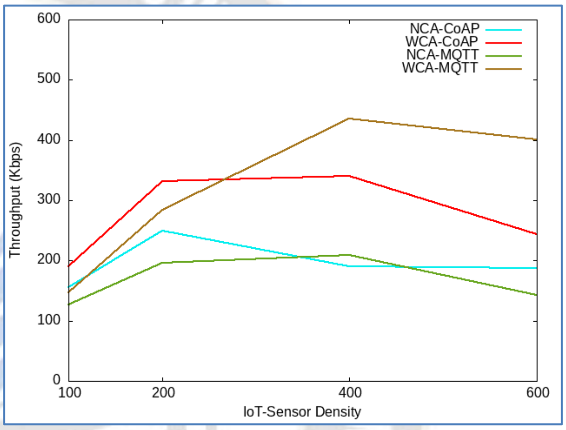

Figure: 26 Throughput- Comparison-CoAP and MQTT protocols

Figure 26 compares the throughput of two protocols, i.e., CoAP and MQTT, using NCA and WCA simulation scenarios. In the case of NCA-CoAP, with IoT sensor density 100-200, throughput is increasing and with 400-600 IoT sensors is degraded, whereas WCA-CoAP enhanced it under the constraints of IoT sensor density 100-400 only and with the peak IoT sensor density, it is marginally degraded. In the case of NCA-MQTT, throughput is increasing up to 100-400 IoT sensor density only. WCA-MQTT improved it further under the IoT sensor density 100-600.

Figure 27 compares the residual energy of CoAP and MQTT protocols using the proposed scheme. In the case of NCA-CoAP, with 100 IoT sensors, it is minimal and there are little variations as the IoT sensor density varies up to 600 IoT sensors. Using WCA-CoAP, it is maintained up to its highest level with 100 IoT sensor density and there is a smooth decline in its value and it could not retain up to a significant level w.r.t. peak IoT sensor density. In the case of NCA-MQTT, for the sensor density 100-200, there is a marginal decline in its value, which is minimal for 400-600 IoT sensor density. In the case of WCA-MQTT, it is stable up to 200 IoT sensors and has declined w.r.t. higher IoT sensor density (400-600).

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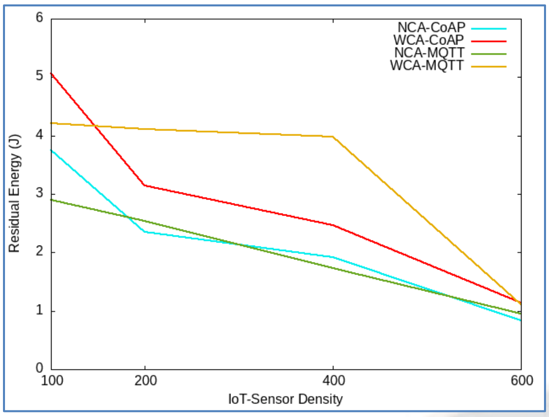

Figure 27 Residual Energy- Comparison-CoAP and MQTT protocols.

V. CONCLUSION

This paper presents a congestion-aware method for medical care delivery. Different IoT application layer protocols, such as CoAP and MQTT, were used to evaluate its efficiency within the limits of a scalable IoT network, residual energy, energy consumption, and so on.

We can see that the throughput of NCA-CoAP varies with the number of connected devices, peaking in the middle of the IoT sensor density spectrum and gradually degrading as it reaches its maximum value. WCA- CoAP was only able to maintain its value up to a sensor density of 400 IoT devices, but it was no longer effective with 600 IoT devices. In terms of the number of connected devices, NCA-MQTT provided lower throughput than NCA-CoAP.

WCA-MQTT offers slightly better value than WCA-CoAP up to 200 IoT sensor density, and its throughput was satisfactory for densities of 400-600 IoT sensors.

Based on the results of the analysis, the throughput of a scalable IoT network increases for both scenarios up to a density of 400 IoT sensors, after which it decreases for both scenarios. When it came to the maximum density of Internet of Things sensors, however, WCA-MQTT offered superior throughput to WCA-CoAP.

Using NCA-CoAP and NCA-MQTT, the residual energy decreases with increasing densities of Internet of Things sensors, reaching a minimum at the highest density. WCA-CoAP keeps it steady at its maximum before gradually decreasing it. However, it is also possible to determine that WCA-MQTT provided more reliable residual energy support up to 400 IoT sensor density than WCA-CoAP.

As a result, the proposed scheme is concluded to be more CoAP-compatible, have a higher throughput, and an optimal residual energy level than the MQTT protocol (WCA-MQTT) (WCA-CoAP). It is currently only compatible with application layer protocols used in the Internet of Things. In the future, its functionality will be enhanced so that it can operate in a wider variety of network settings, and its performance will be evaluated employing a wider range of Internet of Things (IoT) protocols (application/routing protocols, etc.).

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