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# Energy efficient node selection algorithm based on node performance index and random waypoint mobility model in internet of vehicles

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**Abstract** Internet of vehicles (IoV) is an improved version of internet of things to resolve a number of issues in urban traffic environment. In this paper IoV technology is used to select the best ambulance based on a novel node selection algorithm. The proposed IoT healthcare monitoring system consists of number of mobile doctors, patient and mobile ambulance. Performance rank (PR) index is calculated for each mobile ambulance based on the medical capacity (b) of the mobile ambulance, the number of patients currently using the mobile ambulance (n), and the Euclidean distance from a neighboring mobile ambulance. The minimum PR index is considered as best ambulance to provide a service to the patient. Random waypoint mobility model is used to simulate the proposed IoT based healthcare monitoring system. The proposed energy efficient node selection algorithm is compared with various node selection algorithms such as cluster based routing protocol, workload-aware channel assignment algorithm and scenario-based clustering algorithm for performance evaluation. The packet delivery fraction, normalized routing load and average end-to-end delay are calculated to evaluate the performance of the proposed energy efficient node selection algorithm. We have used NS-2 simulator for the node simulation to show the performance of the energy efficient node selection framework. Experimental results prove that the efficiency of the proposed energy efficient node selection algorithm in IoT healthcare environment.

**Keywords** Internet of things · Healthcare · Mobile ambulance · Euclidean distance · NS-2 simulator

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## 1 Introduction

Wearable devices play an essential role in continuous monitoring of patients' health, fitness and activities [1]. Data generated from this environment is continuously stored to provide various clinical services to the patients and public health. The continuous health data is also used to identify daily routine and physical examination [2,3]. Many IoT devices are developed to monitor the individual's body temperature, respiratory rate, blood pressure, heart rate, blood circulation level, blood glucose level and body pain. These IoT devices are fixed with human body to track the patient's health [4]. If the patients' health condition is worse, then the IoT devices sends the clinical value with alert message to the doctor to take necessary action. Hence, more number of mobile ambulances is used in the intelligent IoT based health monitoring system to provide the health care services to the patients. In recent years, more number of ambulances is used daily by more and more people. This would create more traffic and difficulties to choose best ambulance to provide clinical services. The best ambulance issue is considered as one of the key problems in IoT healthcare environment [5–8].

Vehicular ad hoc network (VANET) is originally developed from Mobile Ad-hoc Network (MANET). VANET is used Vehicle to Vehicle (V2V) and Vehicle to Roadside (V2R) communications to transfer the electronic signal between the source and destination vehicles. In order to improve the performance and connectivity of VANETs, and reduce the traffic and accidents on the roads, Internet of Vehicles (IoV) technology is identified from the Internet of Things (IoT) [9]. IoV is an improved version of Internet of Things to resolve a number of issues in urban traffic environment [10]. In addition, IoV environment is also used to offer network access and travel plan for drivers, passengers and individuals who are working in the traffic organization section [11]. In other words, IoV is an interconnection between a variety of road networks and wireless network technologies. This progression in Intelligent Transportation System (ITS) is used to develop the traffic monitoring system, to defend individuals from road accident, and to progress the travel comfort. In this paper IoV technology is used to select the best ambulance based on a novel node selection algorithm.

The existing node selection algorithms such as Cluster Based Routing Protocol (CBRP), Workload-Aware Channel Assignment (WACA) algorithm and Scenario-based clustering algorithm (SCAM) are used to compare the efficiency of the proposed energy efficient node selection algorithm. NS-2 simulator is used to calculate the Packet delivery fraction (PDF), Normalized routing load (NRL) and Average end-to-end delay (AED). These performance evolution parameters are used to evaluate the efficiency of the proposed energy efficient node selection algorithm. The structure of the paper is explained as follows: Sect. 1 describes the introduction to IoT based health monitoring system and Sect. 2 reviews the recent works done in IoT based healthcare systems. The background and proposed IoT based continuous health monitoring system are explained in Sects. 3 and 4 respectively. Result and discussion, and performance evaluation described in Sects. 5 and 6 respectively. Finally, Sect. 7 concludes the paper.

## 2 Related work

More commonly, relational database management systems are used to store the clinical data generated from IoT health monitoring system [12–14]. In recent years, the diversity and capacity of the IoT wearable devices are increased [15–18]. Hence, there is a need to develop a scalable data storage system to store such huge amount of data in distributed manner [19,20]. In addition, the existing data processing tools and methods are not used to store such huge amount of data generated by various IoT wearable devices [1,21–23]. To overcome this problem, scalable NOSQL (non structured query language) databases are used in the IoT based health monitoring system. In addition, more number of researchers has been using big data and NOSQL technologies in various IoT healthcare environments [24–27]. For example, Ning et al. have developed big data with cloud computing technologies to store the medical data generated by various IoT devices [28–31].

This proposed work focuses on storing continues healthcare data on heart rate, sweating, ECG, respiratory rate, skin temperature, blood pressure and heart sound. The IoT wearable devices used in this framework sends the patients' clinical data to the doctor in continues manner [32–34]. Whenever, the physiological parameters such as heart rate, ECG, respiratory rate, sweating, skin temperature, blood pressure and heart sound exceeds its normal value, and then the IoT devices send an alert message with clinical value to the other care holders and doctors. Harvard Sensor Network Lab researchers have identified the CodeBlue project to check the patients' health in uninterrupted manner [31,35,36]. In this framework the following sensors are used namely EMG, EKG, pulse oximeter, SpO2 sensor and Mica2 motes to sense the individuals' health prominence. The IoT devices used in this framework are fixed with the human body to transfer the health significance in continuous manner. The clinical data collected from the wearable devices are transfer to the end-user devices such as PDAs, laptops, and personal computers [37,38].

The health significance data stored in the data storage block are used to discover the high value insights. The significant results generated from the data store are used to create the decisions when the patients' health situation is inferior [14]. University of Virginia research team have identified the heterogeneous network architecture named Alarm-Net to examine the patient health in the assisted-living and home environment [39–41]. Alarm-net project consists of various environmental sensor devices and wearable sensor devices to examine any kind of health data. Three tier networks are followed in the Alaram-net to monitor the patient's health. Tier 1 consists of accelerometer, ECG and SpO2 to sense the individual physiological data. Tier 2 consists of dust, motion, temperature and light sensors to examine the ecological conditions. Tier 3 consists of internet protocol (IP)-based network with gateways to transmit the signal to the target with the help of wireless networks.

Ng et al. have developed UbiMon continuous health monitoring project that consists of wearable and implantable sensor devices based on the wireless ad hoc network [30]. The essential goal of UbiMon project is to discover the emergency situation of the patient and take better decision in near future [24,42,43]. Similarly, Chakravorty et al. (2006) have developed MobiCare project to offer continuous and timely monitoring of individual's physiological status. MobiCare project consist of various sensor devices to compute the individuals' health status it include wearable sensors such as SpO2, ECG and blood oxygen. MobiCare client uses HTTP POST protocol to transmit the individuals' health data to the sensor server. Medical staffs who are working in patient care department are also encourages to provide off line health care services using MobiCare project. In addition, personal ambient monitoring (PAM) project is initially developed by Blum et al. to observe the patient's psychological health [33]. Table 1 represents the recent node selection algorithms used in wireless networks. Table 2 represents the varieties of wearable sensors in IoT healthcare environment.

**Table 1** Recent node selection algorithms

| SNo | Node selection approach | Method | Network life time | Energy factor | Prediction |
|---|---|---|---|---|---|
| 1 | LEACH | Probability method/random selection | Yes | No | No |
| 2 | Extended HEED | Probability method/energy | Yes | Yes | No |
| 3 | ACW | Back-off method | Yes | No | No |
| 4 | HEED | Probability method/energy | Yes | Yes | No |
| 5 | CIPRA | ID based selection | Yes | No | No |
| 6 | EECHSSDA | Average energy | Yes | Yes | No |
| 7 | ERA | Probability method/random selection | Yes | Yes | No |
| 8 | LEACH-C | Average energy | Yes | Yes | No |
| 9 | HEF | Residual energy | Yes | Yes | Yes |

**Table 2** Varieties of wearable sensors in IoT healthcare environment

| SNO | Sensor name | Description | Sensor type | Measurement type |
|---|---|---|---|---|
| 1 | Accelerometer sensor | Human energy expenditure measurement | Wearable Body Sensor | Uninterrupted |
| 2 | Visual sensor | Motion; length; location; and area measurement | Wearable body sensor/surrounding | Uninterrupted/distinct |
| 3 | Temperature sensor | Body temperature measurement | Wearable body sensor | Distinct |
| 4 | Carbon dioxide sensor | Carbon dioxide level measurement | Wearable body sensor | Distinct |
| 5 | ECG/EEG/EMG sensor | Electrocardiograph signal measurement | Wearable body sensor | Uninterrupted |
| 6 | Pressure sensor | Pressure changes in foot measurement | Wearable body sensor/surrounding | Uninterrupted |
| 7 | Gyroscope sensor | Angular velocity measurement | Wearable body sensor | Uninterrupted |
| 8 | Blood oxygen saturation sensor | Percentage of oxygen saturation in blood measurement | Wearable body sensor | Distinct |
| 9 | Humidity sensor | Sweating rate measurement | Wearable body sensor | Distinct |
| 10 | Respiration sensor | Breathing measurement | Wearable body sensor | Uninterrupted |
| 11 | Blood-pressure sensor | Systolic and diastolic pressure measurement | Wearable body sensor | Distinct |

## 3 Classification of mobility models

Mobility model are classified based on the dependencies and restrictions. The major types of mobility models are listed below:

(i) *Random based mobility model* In random based mobility model does not follows any dependencies or restrictions. Random based mobility model is similar to RWP model.

(ii) *Temporal dependencies* In temporal dependencies based mobility model, movement of the past is used to influence the actual movement of a node

(iii) *Spatial dependencies* In spatial dependencies based mobility model, the neighboring nodes are used to model the movement of a node. Spatial dependencies based mobility model is similar to RPGM model

(iv) *Geographic restrictions* In geographic restrictions based mobility model, the area in which the node is allowed to move is restricted

(v) *Hybrid characteristics* Hybrid characteristics based mobility model consist of mixture of spatial dependencies, temporal dependencies, and geographic restrictions is realized

### 3.1 Internet of vehicles

Internet of Vehicles (IoV) is often used to make an interconnection between the things, vehicles and environments to transfer the data and information between the networks. The most important role of IoV is used to expand the human-vehicle-thing-environment with multiple vehicles, multiple things and various networks**.** In other words, IoV can be defined as the mixture of inter-vehicle network, an intra-vehicle network, and vehicular mobile Internet. IoV is used to supervise traffic, expand intelligent dynamic information communication between the vehicles, pollution and environmental protection, road accident prevention, road safety management and energy administration in intelligent transportation system. IoV is capable handling large amount of data in complex network. VANET is a part of IoV to build up an intelligent transportation system. Vehicle Telematics is the supplementary feature of IoV to transmit the messages and electronic information between the vehicles. In general, the following electronic data are transferred between the vehicles it include spatio-temporal location, geo position, navigation and remote monitoring information.

## 4. Proposed Framework

IoT wearable devices attached with the human body to collect the patients' clinical data in continuous manner. Whenever, the clinical measure of the individuals exceeds its normal value then the devices send an alert massage with clinical value to the doctor and care holder. The alert messages and clinical values are collected and stored into the database in continues manner.

Algorithm1 represents the IoT device initialization and continuous monitoring procedure. Whenever, an alert message send from patient or mobile ambulance or mobile doctor, the proposed energy efficient node selection algorithm is triggered to find the best mobile ambulance to prove the clinical service. Conceptual architecture and workflow of the proposed framework are represented in Figs. 1 and 2 respectively.

***Algorithm 1: IoT Device Initialization and Continuous Monitoring***

***Step1:*** *Fix the IoT medical devices in patients' body Start Device Initialization*
***Step2:*** *Start Device Initialization*
***Step3:*** *Continuously monitoring the patient health condition based on the following metrics*

```
1. if(Approximate Age==Newborn)
2. {
3. Respiratory Rate (RP)==30-50 && Heart rate (HR)==100-160&&Blood Pressure
   (BP):Systolic Range (SR)==75-100&&Blood Pressure (BP):Diastolic Range
   (DR)==50-70&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
4. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
5. }
6. elseif(Approximate Age==0-5 months)
7. {
8. Respiratory Rate (RP)== 25-40&& Heart rate (HR)== 90-150&&Blood Pressure
   (BP):Systolic Range (SR)==75-100&&Blood Pressure (BP):Diastolic Range
   (DR)==50-70&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
9. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
10. }
11. elseif(Approximate Age==6-12 months)
12. {
13. Respiratory Rate (RP)== 20-30&& Heart rate (HR)== 80-140&&Blood Pressure
   (BP):Systolic Range (SR)==75-100&&Blood Pressure (BP):Diastolic Range
   (DR)==50-70&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
14. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
15. }
16. elseif(Approximate Age==1-3 years)
17. {
18. Respiratory Rate (RP)== 20-30&& Heart rate (HR)== 80-130&&Blood Pressure
   (BP):Systolic Range (SR)== 80-110&&Blood Pressure (BP):Diastolic Range
   (DR)== 50-80&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
19. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
20. }
21. elseif(Approximate Age==3-5 years)
22. {
23. Respiratory Rate (RP)== 20-30&& Heart rate (HR)== 80-120&&Blood Pressure
   (BP):Systolic Range (SR)== 80-110&&Blood Pressure (BP):Diastolic Range
   (DR)== 50-80&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
24. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
25. }
26. elseif(Approximate Age==6-10 years)
27. {
28. Respiratory Rate (RP)== 15-30&& Heart rate (HR)== 70-110&&Blood Pressure
   (BP):Systolic Range (SR)== 85-120&&Blood Pressure (BP):Diastolic Range
   (DR)== 55-80&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
29. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
30. }
31. elseif(Approximate Age==11-34 years)
32. {
33. Respiratory Rate (RP)== 12-20&& Heart rate (HR)== 60-105&&Blood Pressure
   (BP):Systolic Range (SR)== 95-140&&Blood Pressure (BP):Diastolic Range
   (DR)== 60-90&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
34. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
35. }
36. elseif(Approximate Age==35-100 years)
37. {
38. Respiratory Rate (RP)== 12-30&& Heart rate (HR)== 60-100&&Blood Pressure
   (BP):Systolic Range (SR)== 95-140&&Blood Pressure (BP):Diastolic Range
   (DR)== 60-90&&Body Temperature (BT)==36.6 -37&&Blood Sugar (BS)
   :Fasting70-100&&Blood Sugar (BS):Post Meal==70-140
39. Send the RP, HR, BP, SR, BP, DR, BT, and BS values to the Amazon S3 data store
40. }
41. else
42. {
43. The health parameters is not regular
44. Send the voice alert "Patient is abnormal" with Clinical value the RP, HR, BP, SR,
   BP, DR, BT, and BS values to the Doctor as well as Amazon S3 data store
45. }
```

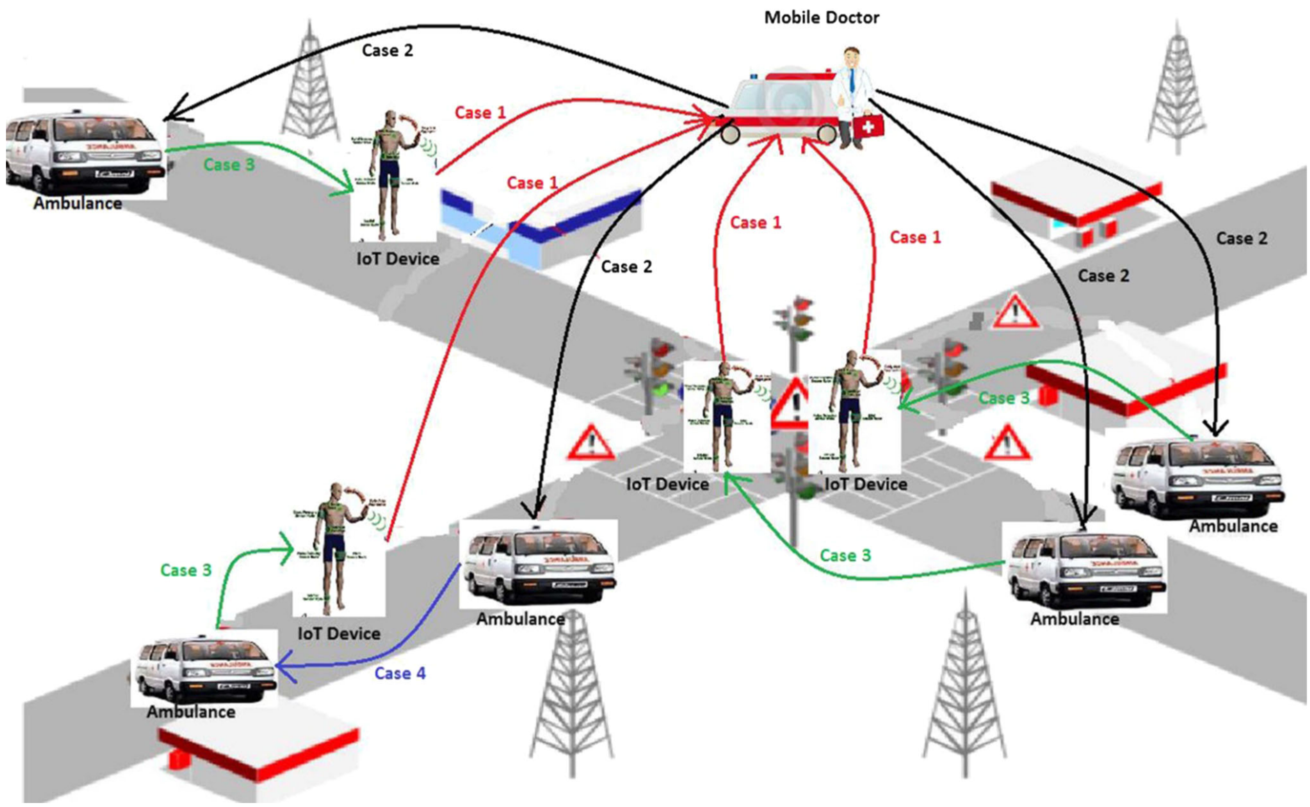



**Fig. 1** Conceptual architecture

## 4 Node selection algorithm

The proposed IoT healthcare monitoring system consists of number of mobile doctors, patient and mobile ambulance. In this paper the computations are based on the theory that the mobile doctors, patient and mobile ambulance do not leave the network coverage area but the mobile doctors, patient and mobile ambulance can travel around the duration of time the application is running. Time t is used to identify the location of the mobile doctors, patient and mobile ambulance. Random Waypoint Mobility Model is used to simulate the proposed IoT based healthcare monitoring system. Radom direction and speed are followed in the Random Waypoint Mobility Model. Predefined ranges are used to model the new speed and direction. A constant time t or constant distance d is used to simulate the node movements in the Random Waypoint Mobility Model.

The following equations are used to simulate the boundaries of the nodes at time t or distance d. Let us assume that ($a_0$, $b_0$) is the initial location of the mobile node. The movement of the node ($a_1$, $b_1$) is defined by,

$$a_1 = a_0 + v_1.t.cos\theta_1$$
$$b_1 = b_0 + v_1.t.sin\theta_1$$

where, t = travelled time, $\theta_1$ = travelling angle, $v_1$ = travelling velocity

The above calculation is a continuous process to simulate the movements of the mobile doctors, patient and mobile ambulance. It is assumed that the movements of the mobile doctors, patient and mobile ambulance after t time seconds, can be defined by,

$$a_n = a_{n-1} + v_n.t.cos\theta_n$$
$$b_n = b_{n-1} + v_n.t.sin\theta_n$$

### 4.1 Performance rank

Performance Rank (PR) index is calculated for each mobile ambulance based on the medical capacity (b) of the mobile ambulance, the number of patients currently using the mobile ambulance (n), and the Euclidean distance from a neighboring mobile ambulance (d), as:

$$t = b(n.d)$$

where, b = medical capacity of the mobile ambulance, n = a number of patients currently using the mobile ambulance, d = Euclidean distance from a neighboring mobile ambulance

Table 3 represents the assumptions on range of medical capacity in mobile ambulances.

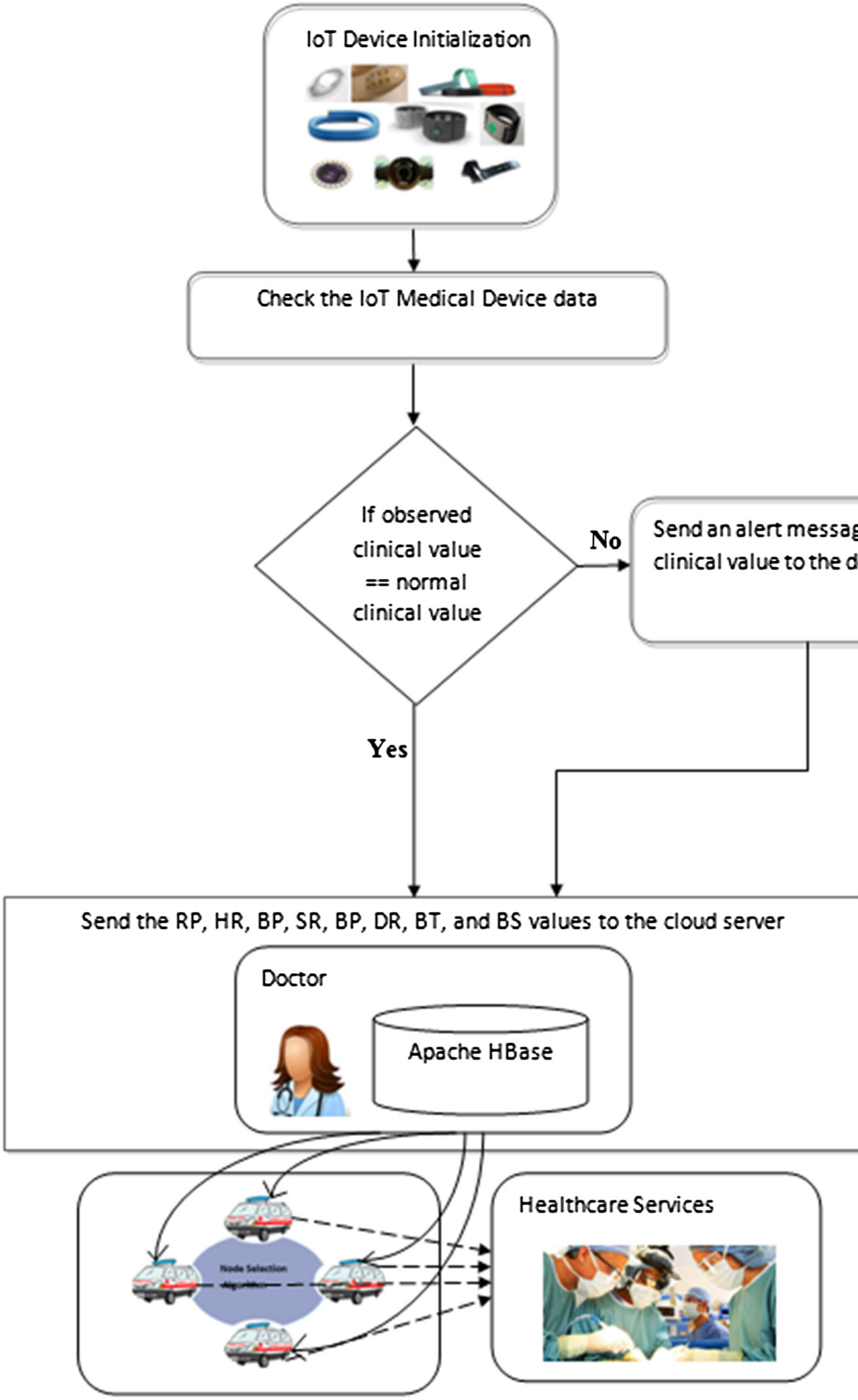



**Fig. 2** Workflow of the proposed framework

**Table 3** Range of medical capacity

| S. no | Value | Range of medical capacity |
|---|---|---|
| 1 | 1 | Remaining medical capacity is >80% of total capacity |
| 2 | 2 | Remaining medical capacity is within 61–79% |
| 3 | 3 | Remaining medical capacity is within 31–60% |
| 4 | −1 | Remaining medical capacity is <31% |

***Algorithm 2: Node Selection Algorithm***

***Step1:*** *Fix the IoT medical devices in patients' body Start Device Initialization*
***Step2:*** *Continuously monitoring the patient health condition*
***Step3:*** *for each node type = "Mobile Ambulance"{*
***Step4:*** *if new node registered then update {*
*b=remaining medical capacity*
*n=number of registered node*
*d=distance of each mobile ambulance from a service mobile doctor/patient*
*Performance Rank PR=b(n+d)}}*
***Step5:*** *if (node entry= "Patient") then {*
*Search for a clinical service*
*if more than one Mobile Ambulance found within the range,*
*then { find Mobile Ambulance with minimum positive Performance Rank PR*
*and register with it } }*
***Step6:*** *if (node entry= "Mobile Doctor") then {*
*receive multicast message from mobile ambulance to find the best ambulance with*
*minimum Performance Rank PR and register with it } }*
***Step7:*** *if (node exit= "Mobile Ambulance") then {*
*Search for alternative*
*if more than one Mobile Ambulance found within the range,*
*then { find Mobile Ambulance with minimum positive Performance Rank PR*
*and register with it } }*

### 4.2 Scenario 1

If patients' health condition is abnormal then the IoT device sends a request to the energy efficient node selection framework to find the best ambulance to provide the clinical service. If more than one Mobile Ambulance found within the range, then it finds the mobile ambulance with minimum positive Performance Rank (PR) value. Figure 3 represents this scenario in a graphical manner.

### 4.3 Scenario 2

If patients' health condition is abnormal in offline mode, then the mobile doctor sends a request to the energy efficient node selection framework to receive multicast message from every

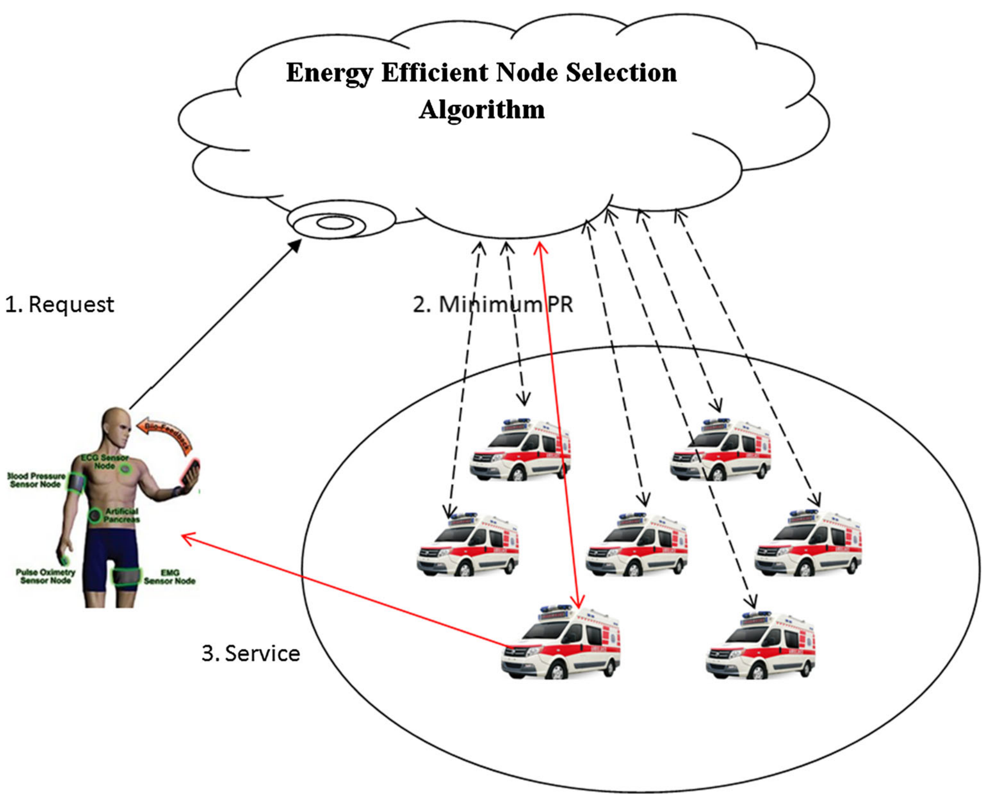



**Fig. 3** Scenario 1

**Fig. 4** Scenario 2

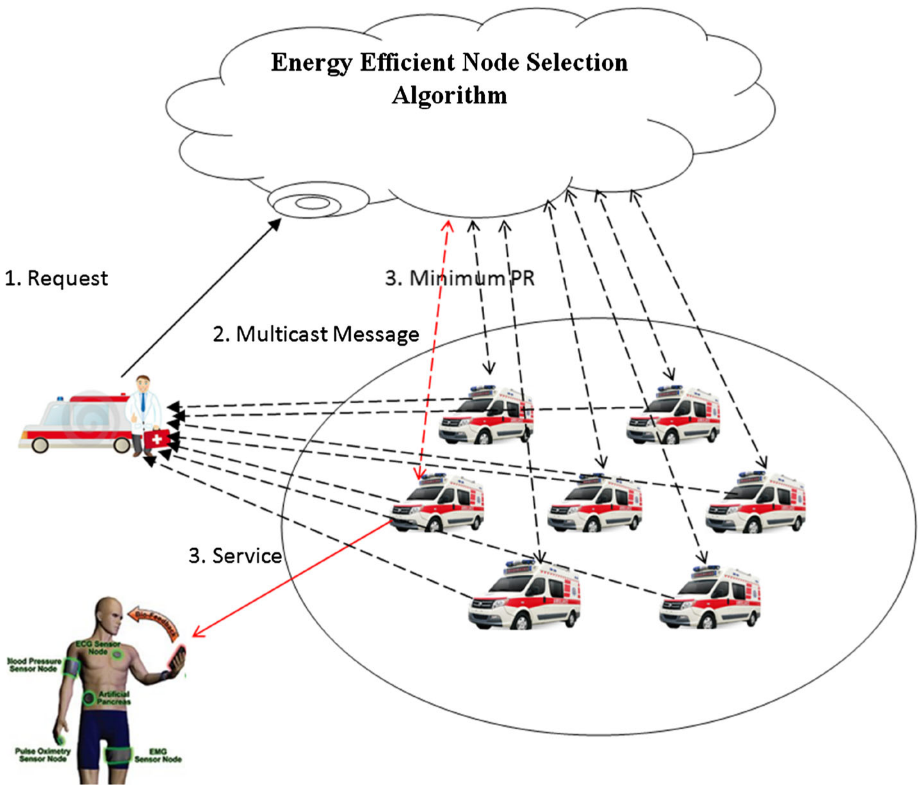
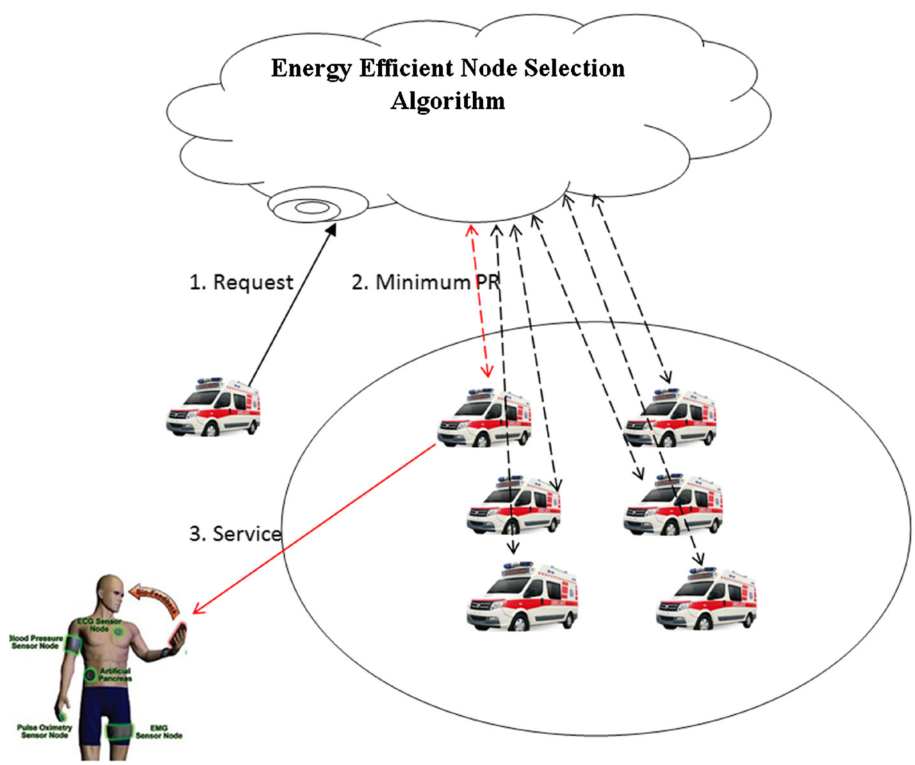



**Fig. 5** Scenario 3



mobile ambulance. This multicast message is used to find the best ambulance with minimum Performance Rank (PR) value. Figure 4 represents this scenario in a graphical manner.

### 4.4 Scenario 3

If medical capacity of the mobile ambulance is finished during the healthcare service, then the mobile ambulance sends a request to the energy efficient node selection framework to search for alternative mobile ambulance. If more than one mobile ambulance found within the range, then the proposed framework finds a mobile ambulance with minimum positive Performance Rank PR value. Figure 5 represents this scenario in a graphical manner.

## 5 Simulation results

This paper uses NS-2 simulator for the simulation to show the performance of the energy efficient node selection framework. Tables 4 and 5 depicts the parameter values used in this study. The parameters are number of nodes, network size, max speed, packet size, pause time, transmission area, hello packet interval, and simulation time. The proposed method is compared with various node selection algorithms such as Cluster Based Routing Protocol (CBRP), Workload-Aware Channel Assignment (WACA) algorithm and Scenario-based clustering algorithm (SCAM) for performance evaluation.

**Table 4** Simulation 1 parameters

| S. no | Parameters | Value |
|---|---|---|
| 1 | MAC protocol | IEEE 802.11 |
| 2 | Network size | 700 × 700 |
| 3 | Number of nodes | 20, 50, 80, 100 |
| 4 | Hello packet interval | 3 s |
| 5 | Transmission range | 20–200 m |
| 6 | Pause time | 0 s |
| 7 | Maximum node speed | 15 m/s |
| 9 | Simulation time | 420 s |
| 10 | Packet size | 512 byte |
| 11 | Mobility model | Random waypoint |
| 12 | Protocols | CBRP, WACA, SCAM and proposed energy efficient node selection algorithm |
| 13 | Distribution of nodes | 2 in each 10 groups |
| 14 | Probability of group change | 0.05 |
| 15 | Traffic type | CBR (constant bit rate) |
| 16 | Minimum node speed | 1 m/s |
| 17 | Connection rate | 20 pkts/s |
| 18 | Number of connections | 5 |

**Table 5** Simulation 2 parameters

| S. no | Parameters | Value |
|---|---|---|
| 1 | MAC protocol | IEEE 802.11 |
| 2 | Network size | 700 × 700 |
| 3 | Number of nodes | 80 |
| 4 | Hello packet interval | 3 s |
| 5 | Transmission range | 20–200 m |
| 6 | Pause time | 0 s |
| 7 | Maximum node speed | 15 m/s |
| 9 | Simulation time | 420 s |
| 10 | Packet size | 512 byte |
| 11 | Mobility model | Random waypoint |
| 12 | Protocols | CBRP, WACA, SCAM and proposed energy efficient node selection algorithm |
| 13 | Distribution of nodes | 2 in each 10 groups |
| 14 | Probability of group change | 0.05 |
| 15 | Traffic type | CBR (constant bit rate) |
| 16 | Minimum node speed | 1 m/s |
| 17 | Connection rate | 20–30–40–50 pkts/s |
| 18 | Number of connections | 5 |

Figure 6 represents the clinical data (blood pressure, blood sugar, heart rate and body temperature) collected from various sensors. Figure 7 represents the inter arrival time for various sensor measure. In general, sensors send its observation every 10 min whereas some other sensors send data in every hour. Hence, there is no fixed data arrival time is available in the IoT health monitoring system. In order to overcome this issue, the proposed health monitoring system uses timestamp values to calculate the inter arrival time for the sensor data over a duration of 10 min. Then, the inter arrival time values are listed in the bucket corresponding to 5, 10 and 15 ms. The maximum probability of inter arrival time is calculated based on hyper-exponential distribution and the results are depicted in Fig. 7.

## 6 Performance evaluation

The proposed energy efficient node selection algorithm is compared with various node selection algorithms such as Cluster Based Routing Protocol (CBRP), Workload-Aware Channel Assignment (WACA) algorithm and Scenario-based clustering algorithm (SCAM) for performance evaluation. The Packet delivery fraction (PDF), Normalized routing load (NRL) and Average end-to-end delay (AED) are calculated to evaluate the performance of the proposed energy efficient node selection algorithm.

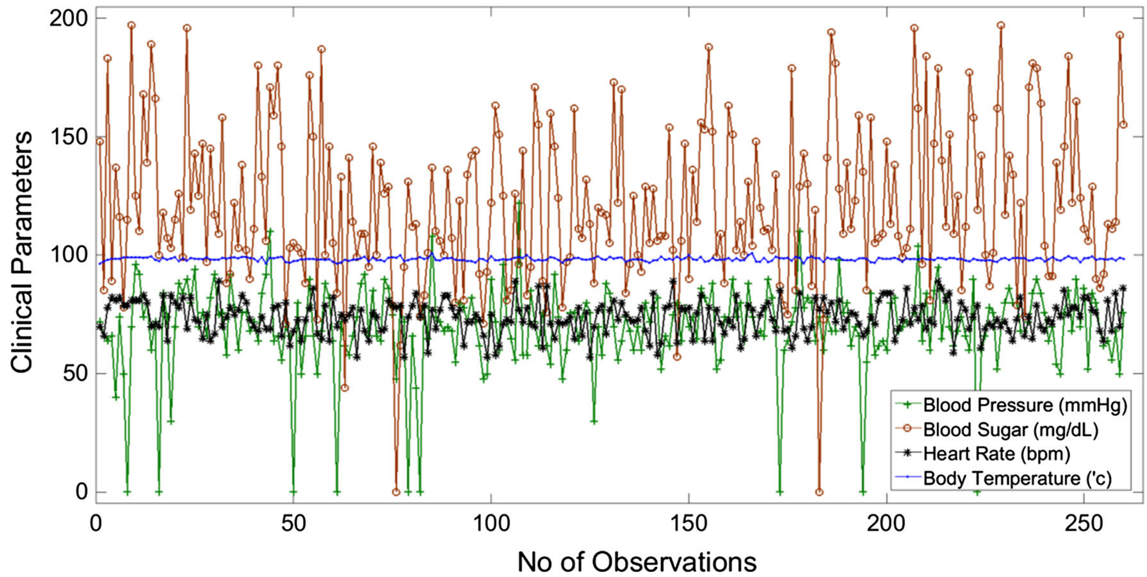



**Fig. 6** IoT wearable sensor data

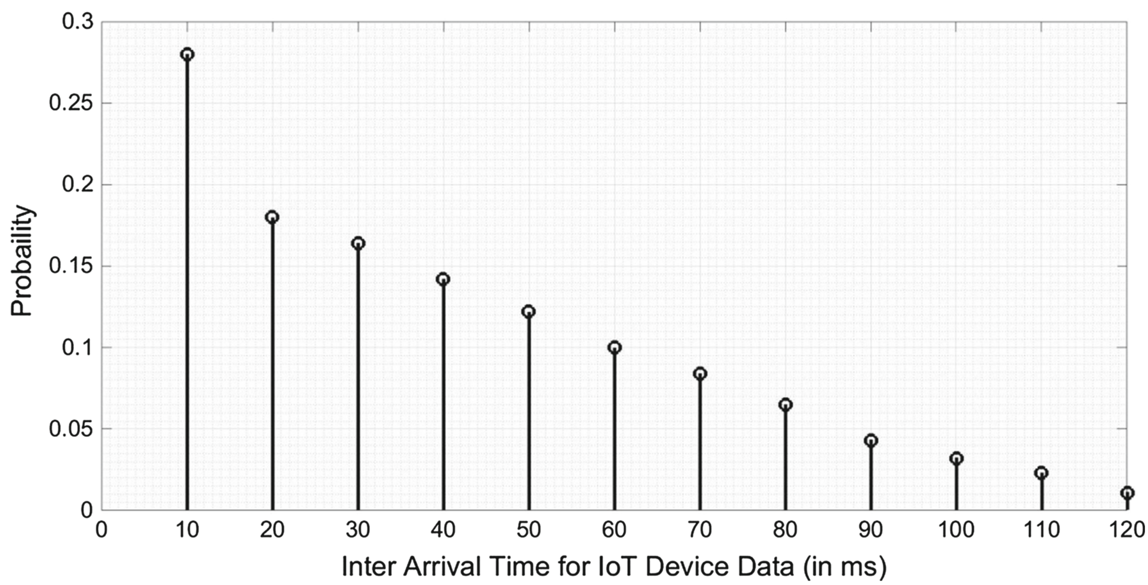



**Fig. 7** Inter arrival time

### 6.1 Packet delivery fraction (PDF)

Packet delivery fraction (PDF) is calculated to evaluate how successful the protocol is in delivering packets to the application layer. The PDF is calculated by,

$$PDF = \frac{\text{Number of received packets}}{\text{Number of sent packets}}$$

### 6.2 Normalized routing load (NRL)

Normalized routing load (NRL) is calculated the level of routing information being updated in the protocol. The NRL is calculated by,

$$NRL = \frac{\text{Number of routing packets sent}}{\text{Number of data packets received}}$$

### 6.3 Average end-to-end delay (AED)

Average end-to-end delay (AED) is calculated the average delay in transmission of a packet between two nodes. The AED is calculated by,

$$NRL = \sum_{i=0}^{n} \frac{(\text{time packet received}_i - \text{time packet sent}_i)}{\text{total number of packets received}}$$

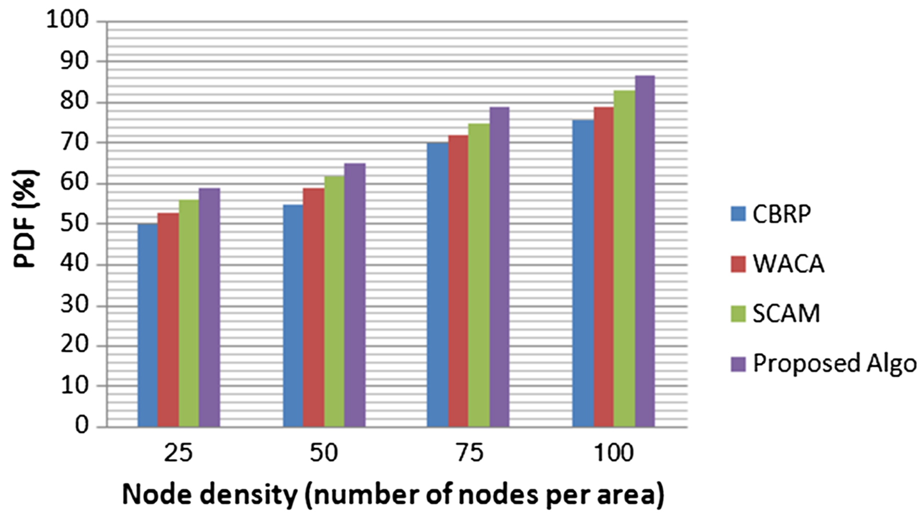



**Fig. 8** Packet delivery fraction versus node density

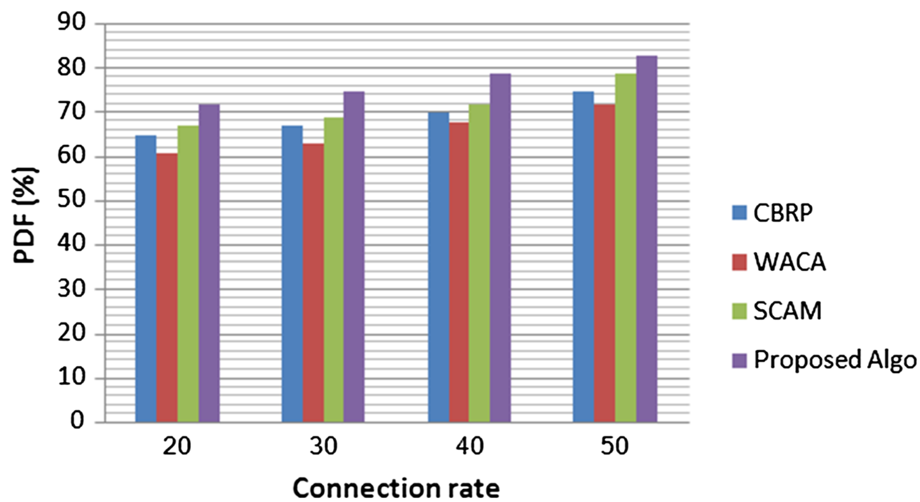



**Fig. 9** Packet delivery fraction versus connection rate

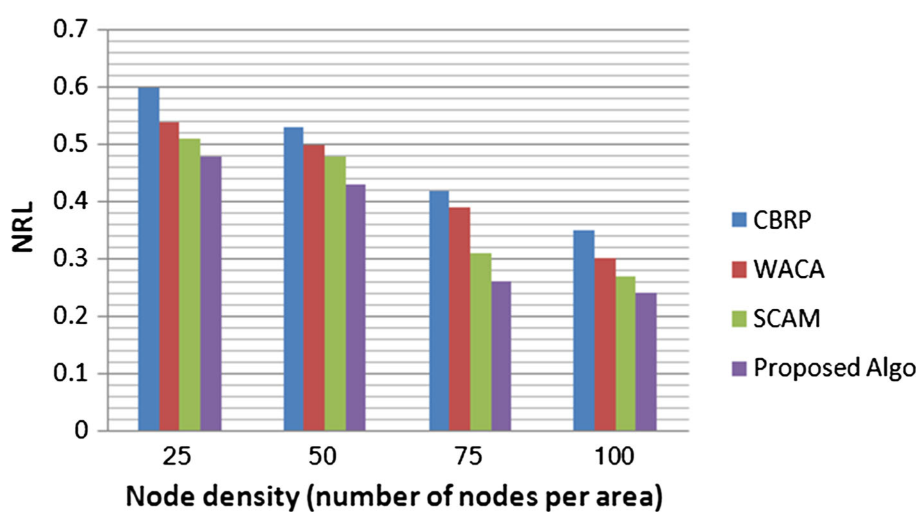



**Fig. 10** Normalized routing load (NRL) versus node density

**Fig. 11** Normalized routing load (NRL) versus connection rate

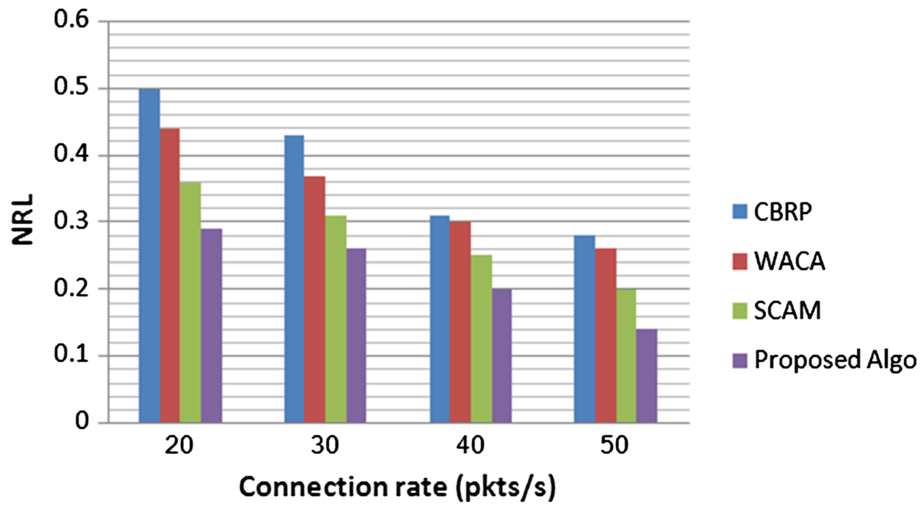



**Fig. 12** Average end-to-end delay (AED) versus node density

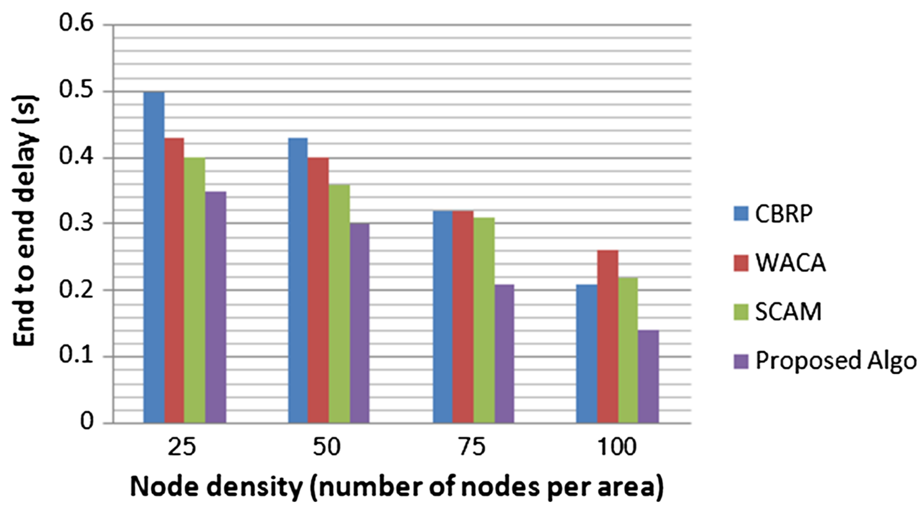
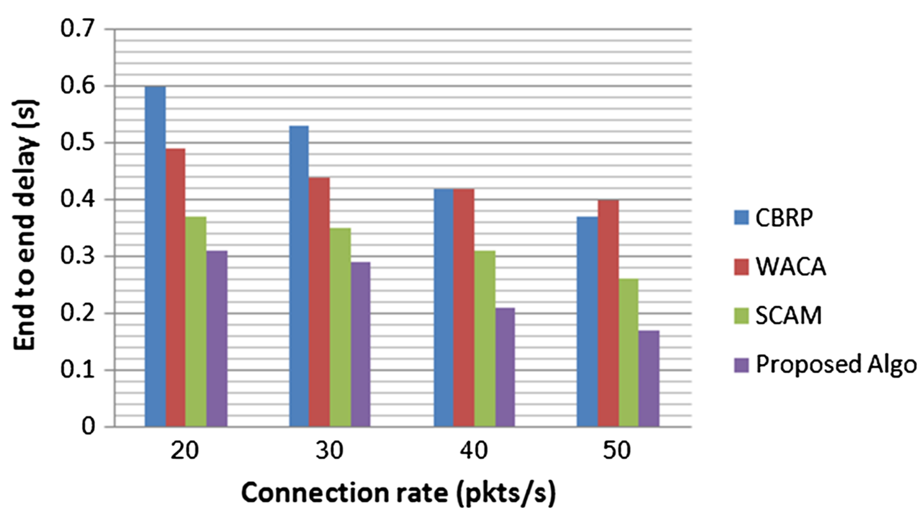



**Fig. 13** Average end-to-end delay (AED) versus connection rate



The Packet delivery fraction (PDF) is calculated for the proposed energy efficient node selection algorithm and compared with various node selection algorithms such as Cluster Based Routing Protocol (CBRP), Workload-Aware Channel Assignment (WACA) algorithm and Scenario-based clustering algorithm (SCAM) for performance evaluation. Figures 8 and 9 represents the Packet delivery fraction (PDF) based on Node density and Connection rate respectively.

The Normalized routing load (NRL) is calculated for the proposed energy efficient node selection algorithm and compared with various node selection algorithms such as Cluster Based Routing Protocol (CBRP), Workload-Aware Channel Assignment (WACA) algorithm and Scenario-based clustering algorithm (SCAM) for performance evaluation. Figures 10 and 11 represents the Normalized routing load (NRL) based on Node density and Connection rate respectively.

The Average end-to-end delay (AED) is calculated for the proposed energy efficient node selection algorithm and compared with various node selection algorithms such as Cluster Based Routing Protocol (CBRP), Workload-Aware Channel Assignment (WACA) algorithm and Scenario-based clustering algorithm (SCAM) for performance evaluation. Figures 12 and 13 represents the Average end-to-end delay (AED) based on Node density and Connection rate respectively.

## 7 Conclusion

Nowadays, many IoT devices are developed to monitor the individual's body temperature, respiratory rate, blood pressure, heart rate, blood circulation level, blood glucose level and body pain**.** In this paper, node selection algorithm is presented in IoV environment. Internet of Vehicles (IoV) is used to resolve a number of issues in urban traffic environment. The proposed IoT based healthcare monitoring system consists of number of mobile doctors, patient and mobile ambulance. Various performance metrics such as the medical capacity (b) of the mobile ambulance, the number of patients currently using the mobile ambulance (n), and the Euclidean distance from a neighboring mobile ambulance are calculated to choose the best mobile ambulance to provide a service. The computations of this paper are based on the theory that the mobile doctors, patient and mobile ambulance do not leave the network coverage area but the mobile doctors, patient and mobile ambulance can travel around the duration of time the application is running. Time t is used to identify the location of the mobile doctors, patient and mobile ambulance. Random Waypoint Mobility Model is used to simulate the proposed IoT based healthcare monitoring system. Radom direction and speed are followed in the Random Waypoint Mobility Model. Predefined ranges are used to model the new speed and direction. A constant time t or constant distance d is used to simulate the node movements in the Random Waypoint Mobility Model. The existing node selection algorithms such as Cluster Based Routing Protocol (CBRP), Workload-Aware Channel Assignment (WACA) algorithm and Scenario-based clustering algorithm (SCAM) are used to compare the efficiency of the proposed energy efficient node selection algorithm. NS-2 simulator is used to calculate the Packet delivery fraction (PDF), Normalized routing load (NRL) and Average end-to-end delay (AED). These performance evolution parameters are used to evaluate the efficiency of the proposed energy efficient node selection algorithm.

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