AnEfficient IoT Enabled Smart Ambulance Routing Appling LOADng Routing Protocol: Aiming to AchievesSustainable Development Goals

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Abstract: Despite, the fact, Internet of Things (IoT) has been applied in traffic detection and vehicle safety very few research shed light on how IoT-based smart transportation can achieve SDGs goals. Moreover, IoT inherits limitations from the power of the devices in the IoT infrastructure. Such limitations demand the need to have optimization research**.**To fill this gap,firstly this research applied LOADng-IoT protocol for the ambulance route system and secondly discussed how the system can be aimed to achieve SDGs goals. This research is significant, as traffic jam has become the main challenge in current metropolitan cities. Both in developed and developing nations, it is a concern for an ambulance to carry an emergency patient. Despite the fact, ambulance receives special traffic protocols, it is still challenging that the ambulance reaches the hospital on time. Lastly, the system is discussed under the lanes of the SDGs goals and pinpoints to the SDGs targets that can be achievable by this study.

Keywords: Smart Ambulance, LOADng-IoT Protocol, Raspberry Pi Microcontroller, Sensor, Fingerprint Scanner.

1. Introduction

The Internet of Things (IoT) is one of the most active and fascinating advancements in information and communications technology. Although networking technologies have grown more widely used throughout the last two decades, they were mostly used to link traditional end-user devices such as laptops, computers, mobiles, etc. The Internet of Things, or IoT, refers to billions of physical objects related to the internet, accumulating and replacing data all through the world (19). Any physical thing that can be linked to the internet and operated can be turned into an IoT device. Sensor-equipped devices and items are linked to an Internet of Things platform, which combines data from many sources. Devices and objects with built-in sensors are connected to an Internet of Things platform, which combines data from various devices and uses intelligence to distribute the most useful information with apps tailored to individual needs.

Several advanced protocols are available in IoT scenarios; however, the advanced protocols are rarely been used in life-saving situations. The situation is more significant in megacities where traffic jams delay life-saving situations, such as the ambulance transportation system. More specifically, in a city like Dhaka, the capital of Bangladesh, where there is no extra traffic lane for the ambulance, it is essential to use advanced IoT to improve ambulance transportation. In this paper, we will develop a model implementing the LOADng-IoT routing protocol to improve IoT performance (14). The improved model will be implemented in ambulance transportation. The paper is very important because the system introduced in this paper can provide a solution that can control the traffic signal, monitor the patient's health as well as send the status to the hospital using the LOADng-IoT protocol. LOADng-IoT is based mostly on three improvements to allow the nodes to discover Internet-associated nodes autonomously and dynamically, decreasing the manipulated message overhead required for the path construction, and lowering the shortage of data messages directed to the Internet (13).

To ensure the fast treatment provided to the patient we need to consider the factor of delay in the treatment of the patient in the hospital. The hospital will begin the preparation for treatment only after analyzing the health condition of the patient so the factor also plays an important role in saving the life of the patient. This system tries to solve the problem by increasing the chances of saving the patient by using an emerging technology Internet of Things that is connecting more devices exponentially to the internet. In this system, the ambulance is being connected with IoT and making it a smart ambulance that can monitor thehealth condition of the patient through sensors and forward the health status of the patient to the hospital with the help of the internet and LOADng-IoT protocol (9). It will give the ability to the doctors to know the condition of the patient whether it is critical or not before the patient arrives at the hospital. If the patient's condition is critical then the necessary arrangements for the treatment can be made sooner by the hospital that can help the doctor save the patient's life.

The United Nations (UN) has declared the Sustainable Development Goals (SDGs) to challenge some of the disadvantaged social and global challenges.SDGs aim togood health and well-being, industry, innovation and infrastructure,sustainable cities and communities,responsible consumption and production, and climate action.The Interdisciplinary, Multi-Disciplinary and Trans-disciplinary goals are a path for overcoming the most pressing

problems in the world. Therefore, the goal is the interplay between nature, society, sustainability, and technological transformation. In a careful review of the evidence, we suggest that technology has a direct or indirect link to the SDGs. In (20) it is claimed that sustainability research is linked to science and has as its main challenge to integrate knowledge and methods from different disciplines. To solve the most important sustainability problems, scientists must work closely with society.
However, goal 3- Good Health and Well-being, goal 9-Industry, Innovation, and Infrastructure, goal 11-Sustainable Cities and Communities, and lastly goal 12-Responsible Consumption and Production, goal 13-Climate Action have been subjects of study in this research under the lens of the Internet of Things (IoT) enabled smart ambulance routing.

2. Literature Review

As the research covers several important topics, the literature review is structured. Firstly, we will introduce ambulance transportation in Dhaka city to understand the critical situation. Then the literature review will proceed towards the routing protocols of IoT, especially the LOADng-IoT protocolsecondly IoT studies that attempted to achieve SDGs. However, the literature review is as below:

An ambulance is a vehicle for the shipping of a sick, injured, loss of a life-affected person from any vicinity to hospital. But in keeping with the latest examination, in the city, an ambulance is the least often accessed vehicle through sufferers in want of emergency medical services. A file with the aid of using The World Economic Forum (WEF), in collaboration with the University of Toronto, shows that the handiest 8% of sufferers accessed ambulances for the duration of a three-week study duration through researcher Justin Boutilier (11). The fundamental cause at the back of that is the site visitors' congestion. We can consider a scenario in which an ambulance with a loss of life-affected person or a pregnant mother who desires on the spot care of a doctor is status nevertheless due to a site visitors jam each second is maximum valuable to keep the lives of the ones. However, the ambulance playing on its horn continuously piercing the ears of passengers round it is far caught with all different vehicles in a traffic jam. It is a day-by-day scene on the roads of the city. This inspires us to layout an IoT-primarily based Smart Ambulance System with efficient routing.

The smart ambulance needs to keep a non-stop communication with the hospital to ship the facts of the patients' fitness conditions. There are many routing protocols to be had to apply in IoT. Among them, Routing Protocol for Low-energy and Lossy Networks (RPL) is a conventional IoT routing protocol. It helps point-to-point (P2P) communications (10). However, because of its unicast routing nature, the low scalability (in phrases of network length and multicast organization length), excessive propagation delay, and excessive strength intake at motes emerge as a large routing issue. Furthermore, in RPL, because of the provision of a single direction among the supply node and every other vacation spot node, communication reliability and safety will become the foremost demanding situations in communication. Stateless Multicast RPL Forwarding (SMRF) is some other routing protocol proposed through a researcher this is the extension of RPL functionality. In SMRF, motes most effective system the multicast packets which might be coming from their favored parents, therefore SMRF most effective permits the forwarding of multicast packets withinside the downward path withinside the RPL DODAG tree, therefore it's miles useful most effective withinside the cases, wherein the foundation node is performing because the supply mote for a multicast traffic flow, which isn't always constantly a case in realistic IoT networks. Recently, the authors proposed the Bidirectional Multicast RPL Forwarding (BMRF) protocol, which makes use of the capability of RPL's MOP three and it overcomes diverse risks of the SMRF protocol. In BMRF, whilst mote desires to ship a multicast message, it plays bidirectional forwarding. However, the BMRF additionally possesses a hard and fast of risks which includes better strength intake, latency, and decrease communique reliability. LOADng-IoT is an enhancement to the Lightweight On-call for Ad hoc Distance-vector Routing Protocol—Next Generation (LOADng) for IoT scenarios. It is primarily based totally on three upgrades a good way to permit the nodes to discover Internet-related nodes autonomously and dynamically, reducing the manipulated message overhead required for the direction construction, and decreasing the lack of facts messages directed to the Internet. LOADng-IoT has numerous blessings over different routing protocols utilized in IoT. That's cause we took into consideration this routing protocol for transferring data in our system.

The design of the smart ambulance is likewise a major subject in this report. The writer's interest in (1) is in the easy design of an interconnected smart device for the control and manipulate of the assisted traffic lighting fixtures,

unfolding over lengthy distances the usage of photoelectric sensors, each earlier than and after the traffic lighting fixtures. The huge subject is lowering reaction time and taking into consideration the efficient instruction and shipping of communications. It is primarily based totally on messages being exchanged or acquired from an IoT computer. Delay-Aware Accident Monitoring and Response System develops with the effective use of cell and fog computing functions to recommend and create less expensive and time-powerful applications (12). The authors diagnosed the feasibility of the usage of sensors to quantify traffic density. Traffic lighting fixtures manipulate records at the extraordinary traffic densities primarily based totally on data collected, specifically on the intersection, assisted via way of means of the traffic density calculated the usage of the RFID system. However, it isn't possible to discover the density of traffic past a sure distance the usage of this technique due to the fact it's far too costly. In adaptive traffic control, an associated method is used. The IoT-primarily based Traffic Signal Monitoring Strategy for Supporting Emergency Vehicles is recommended for progressed law of emergency vehicle traffic via way of means of the usage of the Internet of Things (IoT) (13). The counseled system encourages emergency vehicles to transmit a message to the traffic sign dispatcher on the traffic intersection wherein or greater lanes intersect to make certain that the traffic may be higher controlled. The person visiting with inside the ambulance holds the android phone with the apps deployed in it on this operation. To ship messages to the GSM module, the SMS (Short Messaging Service) to be had on users' cell phones is used. The writer proposed the synchronization manner and linked vehicle generation wherein every vehicle connects the other (15). In comparison with the modern traffic control system, this method indicates the results. This generation contains related cars, coordination of systems, smart transportation infrastructure, processing in real-time, and manipulation of intersections.

Research work (2) proposes a semi-automatic device that could manipulate and manipulate traffic for healthcare-associated emergencies. The GPS will display the shortest direction to the involved vacation spot and the stay region can be despatched to the hospital and traffic manipulate room. The traffic manipulate room will clean the traffic at the path and traffic sign control can be completed accordingly. This system can without difficulty be incorporated into the ambulance because it most effectively needs 12V, 1A strength for GSM SIM 900A, and 10V for Arduino UNO, which may be without difficulty supplied from the fuse board present this is in the ambulance. In this device, the driving force simply needs to click on the GPS display as soon as (16). There is a want to send the region of the ambulance as a message continuously. This has to be completed as soon as due to the fact the region this is despatched from the tool acts as a stay location. The proposed technique can deliver a way to one or more ambulances at an identical time. All though, the device is predicted to work properly on its base functionality, it suffers from hardware-associated limitations. The connections of the device ought to be made carefully. If there's a mistake in becoming a member of the connections the device will now no longer paintings properly. In Indian scenarios, the authors (3) constructed a developed ambulance pass-through caution mechanism (A2FAP). This thesis contains the modern-day generation together with the Internet of Things idea (IoT). The server-customer structure is the architecture used. Using an android program, the customer is a customer. The authors have additionally delivered an emergency car caution device primarily based totally on VANET. They additionally constructed an alert device for emergency vehicles that use inter-vehicle contact and additionally consists of roadside centers including visitors lighting. Other drivers are warned of an incoming emergency vehicle on this scheme and could gather unique information about the road. A well timed and enough reaction through different drivers is feasible primarily based totally on this knowledge. The microcontroller-primarily based RFID system, that is used to modify the traffic lighting on the visitor's mild junction upon arrival, changed into proposed. The tool produces an Android app that makes use of the cloud community to attach each ambulance and the traffic sign station. To introduce shrewd traffic sign control, this tool uses radiofrequency reputation technologies. The primary premise at the back of the proposed device is that RFID hooked up on the traffic sign tracks the RFID-tagged ambulance and sends the statistics to the cloud if the ambulance stops at the manner because of a traffic sign (17). The primary sign becomes Green for a while after the user's acknowledgment through the telephone app and after the ambulance passes through, it regains its unique go with the drift of the signaling chain, if this scheme is automated, it notices the visitors lighting are operated with the aid of using the ambulance region. During emergency times, this system monitors the traffic lighting and saves time. They have additionally counseled the usage of handheld structures for GSM, Arduino, and Android. The counseled device calls for emergency offerings to announce their arrival to the traffic sign controller on the traffic intersection so that traffic is controlled. This tool permits customers to fly in an emergency. This device calls for the customers to visit inside the emergency vehicle to sign the traffic controller hardware via the android utility deployed on their mobile phones.

Road transport is one of the primitive modes of transport in many parts of the world today. The number of vehicles using the road is increasing exponentially every day. Due to this reason, traffic congestion in urban areas is becoming unavoidable these days. Research (4) focuses on density-based traffic control with priority to emergency vehicles like ambulances and fire brigades. In this project, the researchers have successfully made the prototype for real-time image processing for smart automation of traffic signal systems for density estimation and emergency vehicle detection such as ambulance4. This model detects the ambulance by detecting its siren. This is achieved through image segmentation based on the red & blue colors of the siren. The traffic density on each lane is also estimated and the traffic signal is prioritized accordingly. The usage of the algorithm is also cost-effective.

A smart ambulance system is modern-day's demand for the increasing amount of traffic on the road. The manual method may be inefficient compared to the IoT-based city ambulance service. If the system can be monitored in a way that both the patient party and the ambulance driver can locate each other, then they will be able to meet in less time. The performance-based non-functional requirements should be the application may take only 100MB of the mobile's Android space. It needs to be lightweight both in the interface and system functions. The time taken for loading delay should be no more than 10 seconds or less than that. In paper (5), the users need to be signed in and then one QR scan-able code will help to connect both the patient and the driver. The driver will be continuously seeing the location of the patient. The Actors in the case will be the driver, registered citizen, administrators, Hospital management, and an ambulance officer. The performance of the system would be monitored after 3 months of interval. The system function also helps to give the direction of the shortest and traffic jam free-road to reach the patient and the dedicated hospital. An IoT-based controlling system is pre-installed in the ambulance to help guide the path and GPS for locating the position of the patient as well as the ambulance itself. The performance of this smart ambulance will get better if applicable in Service-Oriented Application (SOA).

In paper (6) authors proposed a method for determining traffic density on roads using image processing techniques and a model for controlling traffic signals based on information received from images of roads taken by a video camera. There are some other techniques available to determine the congestion of traffic on the roads and most of them calculate the congestion by counting the vehicles on a particular road. In this paper, the authors have pointed out this as a disadvantage since this technique can be faulty in certain scenarios. So rather than counting the vehicles, they proposed a version that calculates the whole quantity of pixels in a video frame which corresponds to the quantity of region occupied through vehicles on the road in preference to locating the variety of vehicles. They have set parameters as output which might be variable traffic cycle and weighted time for every road primarily based on on-site traffic density and manage traffic lighting fixtures sequentially. To extract the traffic information from the image, they have followed some processes which are the gradient magnitude and background subtraction method. The usage of these processes has been described briefly in this paper. As per the traffic control system concern, they have formulated an algorithm where traffic points are treated as independent locations. This algorithm takes the traffic densities of different roads at any certain time as input. Based on input it produces two outputs. One is Traffic Cycle (Tc) i.e., is the total time required for one complete rotation of the signal lights at any traffic point, and another one is Traffic Density (TD) (20). The denser the traffic, the longer is the traffic cycle. The authors believe that this model could be extended to incorporate a large number of interconnected traffic junctions and use their traffic density to adjust adjacent junction's time allocation.

The modern world is highly dependent on the transportation system. So, congestion-free transportation or smart vehicle systems are highly suggested for socio-economic reasons. Sometimes if the traffic is busy and it creates a problem for the special purpose vehicles like the ambulances to pass through signals with a significant delay then it can create life-threatening issues in the circumstances. So, these vehicles should be monitored thoroughly to help them reach their destination on time. There are a lot of system parameters working behind to implement the system like GSM to send health-related conditions to the dedicated hospitals and Radio Frequency Identification Tags to help the vehicles pass through the traffic signals without facing any red signals. Also, the ARM model microcontroller is needed to deal with the electromagnetic wave reception and emission from the system model of the vehicle (7). The system also generates the digital output of the heartbeat and temperature sensor readings with the help of an ADC. The major benefit is that it helps to make transportation and traffic control much efficient. The delay in the signal and management of the congestion in the traffic is way quicker than the conventional approach. Also, the update of blood pressure and body temperature guides to monitor the health condition of the patient which

has a huge effect on saving critical patients' lives. Therefore, faster transportation and continuous data sending by monitoring the health of the patient make both transportation and health sectors' performance more efficient.
In a paper (8), the authors believe that saving a life is auspicious as well as precious. In this paper, the idea is to provide an intelligent smart health system using some sensors and microcontrollers. The sensors' main task is to sense the condition of the body. After collecting the data, the system will send the data to the collaborated hospital's website. Then, an ambulance will be allotted to the patient's residence if the condition is critical. The driver will use google maps with the help of the website to reach the destination on time. In this system, integrated hardware is made using Arduino and sensors to avoid accidents and obstacles.

3. Research Gap

An IoT-based traffic signal control system for supporting emergency vehicles is introduced for improved traffic monitoring of emergency vehicles (3). This system allows emergency responders to transmit a warning about the arrival to a traffic signal controller stationed at a traffic intersection where two or more lanes cross, allowing traffic to be controlled accordingly. In this process, the user in the ambulance travels with an Android phone that has the app installed on it. The messages are sent to the GSM module through SMS, which is accessible on the users' mobile phones. There is a limitation in this system there may be cellular network problems in any place or the SMS module may be run out of service at any time or if any message delay may fail the system.

There is a sound sensor-based system that uses a siren detection method to identify an ambulance (1). In this system, a primary sensor is located 120 meters away from the traffic signal area and a secondary sensor is situated in the traffic signal area. After detecting any ambulance siren of 130db, the primary sensor sends a signal to the traffic area sensor to operate the traffic lane. The limitation of such a system is that there might be problems detecting the ambulance siren if there is excessive noise on the road.

An RFID-based image processing system catches the image of ambulance signal light by binary image processing of red and blue light beams (4). When an ambulance is detected, the current green lane will become red and the counter display will show an ambulance symbol. After a few seconds, the lane having the ambulance will be allowed. If there are two ambulances detected at the junction, the ambulance which is nearer to the signal gets the priority first. This system now has a limitation: some other vehicles with top red and blue lights accept ambulances. In this type of scenario, the system will fail to detect vehicles that need clear traffic lanes.

The study (20) was conducted as an attempt to find gaps, problems, and obstacles to achieving the SDG goal. The document's findings highlighted the importance of IoT in achieving the SDGs due to a result that shows 84% of respondents believe Green IoT / Green ICT technologies can be game-changing to achieve sustainable development and growth in a green economy. Areas, where technology can act as a major asset, include the productive and efficient use of raw materials, the conservation of natural resources, and the reduction of greenhouse gases and other waste.

4. The System Description

The previously mentioned system has used a siren detection method to identify an ambulance and for health monitoring GSM modem is used to send a patient's health status to the doctor through a text SMS. The limitation with such a system is that there might occur any problem to detecting the ambulance siren if there is excessive noise on the road. Moreover, in some systems SMS is used to send patients' health conditions to the doctor so it cannot ensure continuous health monitoring of the patient. In the proposed system for controlling the traffic signal, RFID technology is used and for health monitoring, some vital health parameters such as ECG, Heart rate, body temperatures are calculated. These data are sent to a PC in the ambulance and then finally it is sent to the hospital server with the help of the internet. The Smart Ambulance System is divided into three parts shown in Figure 1. These areas are below:

A. Mobile Application

The mobile application will store the data of the user, patient, and hospital. The user will input the details such as name, address, gender, date of birth, blood group, contact number, health problem or symptoms of the patient, etc.

Users can register themselves as a patient also. Hospital details such as name, type of hospital, facilities given by the hospital, location, and emergency contact number will be stored in the application. Users can see hospital details from the app and based on the complication of the patient, the user can find or choose a hospital and can send a request for an ambulance from the application.

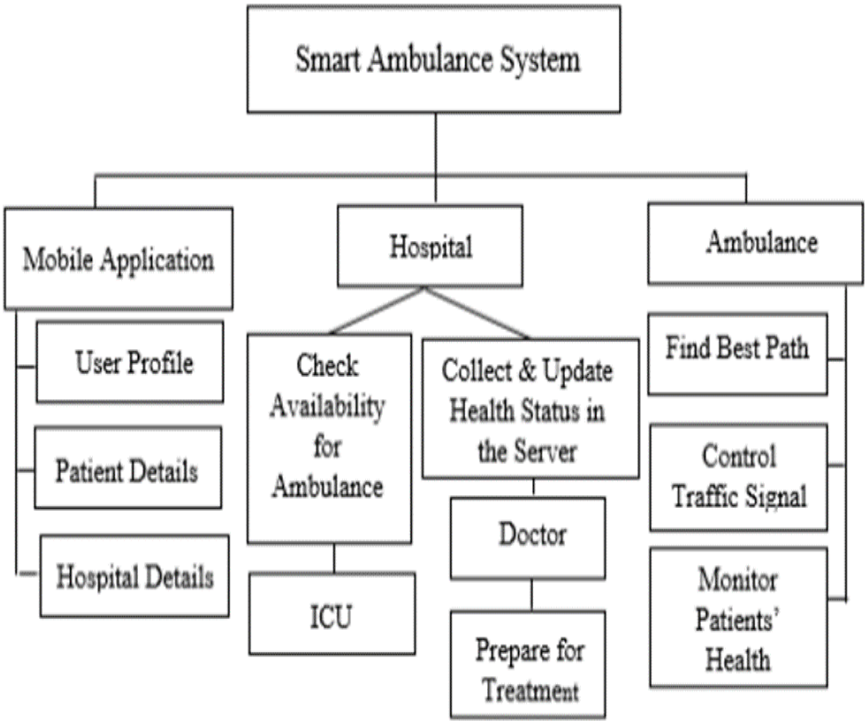

Fig. 1. Working Modules of the Smart Ambulance System.

B. Hospital

After a user sends a request for an ambulance it will check the availability for an ambulance. If there is any available ambulance, then it will assign the ambulance to the user/patient. After the ambulance receives the patient, it will collect the data on the patients' health and will inform the doctors about the patients' condition. Then, based on the data hospital will prepare an ICU and the doctors will take the necessary steps for the treatment.

C. Ambulance

The ambulance is the most important part of this system. Because it will perform several essential tasks at the same time. At first, when the ambulance receives a patient, it will find the best path using GPS so that it takes a minimum amount of time to reach the hospital. The ambulance can control the traffic signal. If a traffic jam occurs, then it will automatically transmit a signal that can change the red light to the green light. It will also monitor patients' health conditions and transmit the data to the hospital so that necessary arrangements can be taken before reaching the hospital. Some health parameters such as ECG, body temperature, heart rate can be measured with some biomedical sensors. There will also be a fingerprint sensor to scan the fingerprint of the patient / injured person.

5. Smart Ambulance System

Two systems are combined with this paper to design a smart ambulance system. They are, Traffic Controlling and Health Monitoring System. Both traffic controlling and health monitoring systems will work concurrently.

A. Traffic Controlling System

It is an intelligent traffic controlling system in which the ambulance can control the traffic signal using RFID technology. RFID is an acronym for "Radio-Frequency Identification". It refers to a technology whereby digital data encoded in RFID tags are captured by a reader via radio waves. A basic RFID system has mainly two parts. They are,

The Tag: The actual RFID component has two parts. For storing and processing information there is an integrated circuit and to receive and transmit a signal there is an antenna. The RFID tag has non-volatile memory storage that means it can store information when the power is off. A battery-assistive passive tag is used in the system that has a small onboard battery but is only activated when in the presence of an RFID reader. The ambulance will carry the RFID tag for storing ambulance information and transmitting the signal.

Reader: The RFID reader features a two-way radio transmitter-receiver which is also known as transceivers. Sometimes it is referred to as an interrogator. The transceiver passes a concealed radio signal to investigate the tag. The radio signal essentially triggers the tag. In turn, the tag transponder modifies the radio signal into usable power and replies to the reader. In the proposed system the traffic signal unit will have the RFID reader so that it can receive an RFID tag from the ambulance. After receiving the RFID tag the microcontroller will decode the RFID signal and the traffic signal will be turned green. Thus, it will ensure the free pathway for the ambulance.

For controlling traffic signals ATmega32P microcontroller has been used. The microcontroller will be at the receiver side will process the received commands by the RFID reader and will switch the traffic light to a green signal immediately. The high-performance ATmega328P is an 8-bit AVR RISC-based microcontroller that combines 32KB ISP flash memory with read-while-write capabilities, 1024 EEPROM, 2KB SRAM, 23 general purposes I/O lines, 32 general-purpose working registers, three flexible timer/counters with comparative modes, internal and external interrupts, serial programmable USART, 2-wire serial interface with a byte-oriented, SPI serial port, a 6-channel 10-bit A/D converter (8 channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates from 1.8-5.5 volts. Because ATmega32P is reliable and can process a task very fast also the price is lower than other microcontrollers so it is used in the traffic controlling system.

In Fig.2, we can see that an ambulance is approaching the traffic signal. The ambulance is carrying an IR transmitter and RFID tag and the traffic control unit contains Microcontroller, IR receiver, and RF reader. We can also see that the current traffic signal is red.

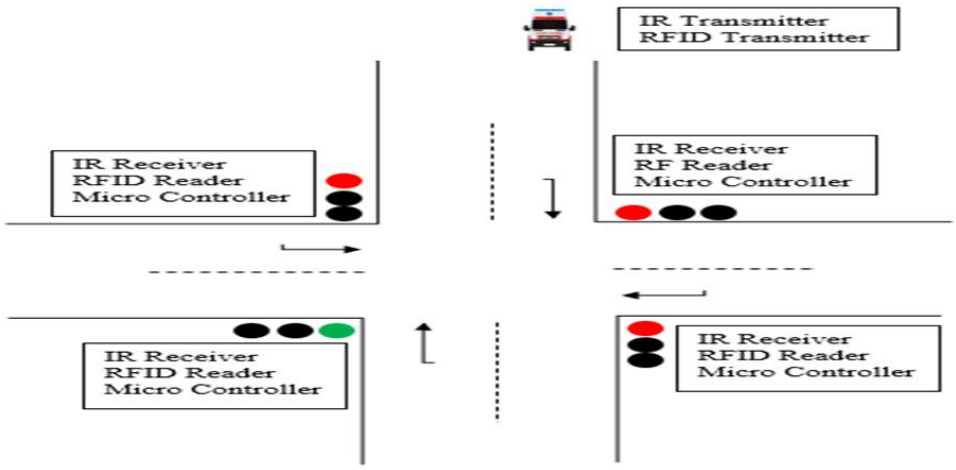

Fig. 2. Graphical View of Controlling Traffic Signal – 1.

Fig. 3 shows that when the ambulance is within the range of the RFID reader of the traffic signal which is approximately 500 meters, then the reader scans the RFID tag which is attached to the ambulance. After reading the RFID tag the microcontroller decodes the signal and turns the traffic light from red to green and makes all the traffic lights in the junction red.

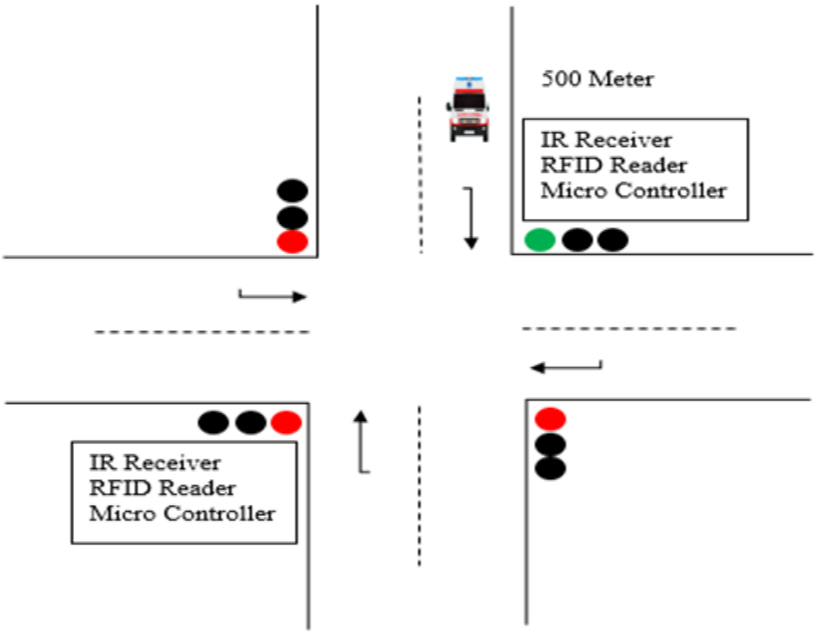

Fig. 3. Graphical View of Controlling Traffic Signal – 2.

In Fig. 4 we can see that when the ambulance passes the traffic signal the control unit again turns the green light to red light ensuring the safe and free pathway for the ambulance. In this system, the IR transmitter and IR receiver are used to increase the duration of the green light. While crossing the traffic signal if the signal is green, the ambulance will send an IR signal to the control unit. Then the control unit will receive the IR signal through the IR receiver and will keep the green light for some time until the ambulance passes the traffic signal. This is how the traffic controlling system works in the system.

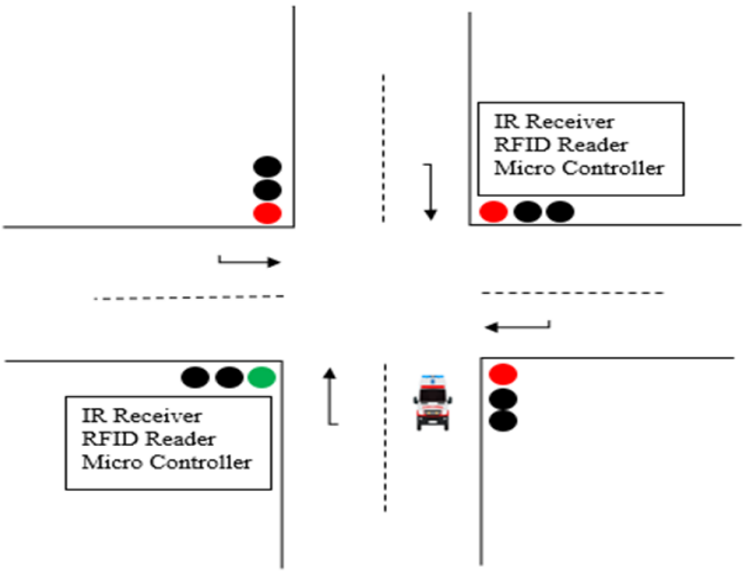

Fig. 4. Graphical View of Controlling Traffic Signal -3.

Body Temperature: A temperature sensor is used to quantify the temperature in blood vessels and to estimate the cardiac output. IC lm35 sensor is used to measure the body temperature.

In this system, the latest model of Raspberry Pi which is the Raspberry Pi 4 microcontroller is used for health monitoring. To obtain the health parameters of the patient, the sensors are interfaced with the Raspberry Pi. The speed and performance of the new Raspberry Pi 4 are a step up from earlier models. The energy-efficient Raspberry Pi uses far less power than other computers and runs silently. Raspberry Pi 4 has upgraded USB capacity, along with two USB 2 ports there are two USB 3 ports, which can transfer data up to ten times faster. Depending on how much RAM is needed, different variants of the Raspberry Pi 4 are available. Raspberry Pi can handle multitasking and run more complex functionality because it is faster and powerful.

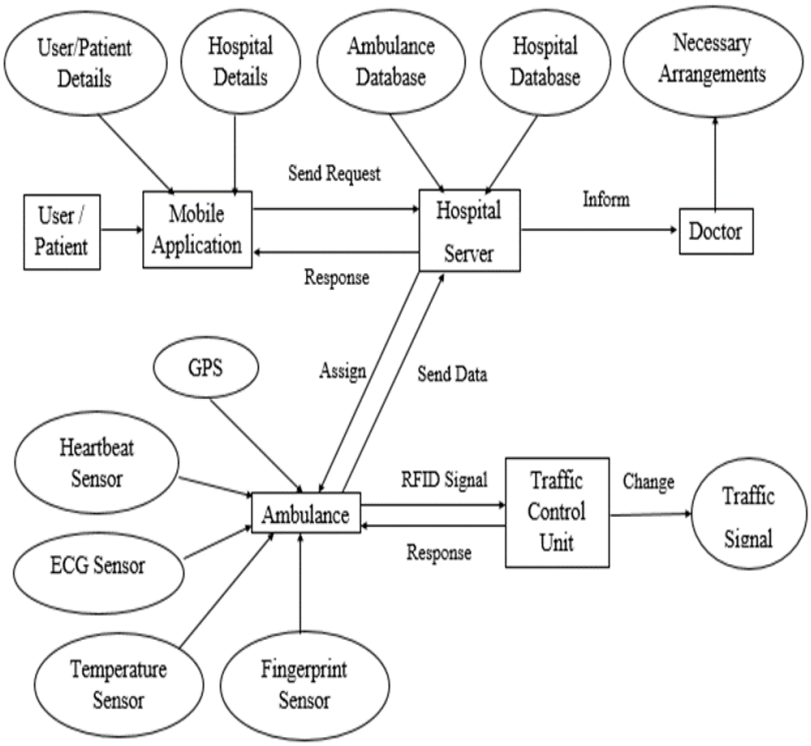

Fig. 5. Block Diagram of the Smart Ambulance System.

B. Block Diagram of the Smart Ambulance System

Fig. 5 mentioned below shows the complete block diagram of the smart ambulance system. In this system at first, the user will create a profile in the mobile application with the necessary information. Users can register themselves as a patient also. The mobile application will store user information, patient details, and hospital information. From the application, the user can send a request for an ambulance. Then the hospital server will check that if there is any available ambulance or not. If there is an available ambulance, the server will assign an ambulance for the user and will send the information of the ambulance to the user. In the ambulance, there is GPS, ECG sensor, Heartbeat sensor, and Temperature sensor. After receiving the patient, the ambulance will find the best path towards the hospital using GPS and it will monitor the patient's health using these sensors. Then it will send the data to the hospital server so that it can ensure continuous monitoring of the patients' health condition. Based on the data the hospital authority or the doctors can make necessary arrangements before the patient reaches the hospital. The ambulance can also control traffic signals using RFID technology. If a traffic jam occurs and the ambulance reaches

within the range of the RFID reader, then the ambulance will send an RFID tag to the traffic control unit. The traffic control unit will receive the signal using an RFID reader. After receiving the signal, the microprocessor decodes the signal and turns the red light to the green light. If the signal is green when the ambulance reaches within the range of the RFID reader then the IR transmitter will transmit the IR signal from the ambulance. Then traffic control unit will receive the IR signal using an IR receiver and will tell the microcontroller to keep the green signal for some time. When the ambulance passes the traffic signal, the green light will automatically turn into red light. The system ensures an easy and free pathway for the ambulance. There is also a fingerprint sensor in the ambulance. If the ambulance receives any injured person whose identity is unknown then the fingerprint sensor can help to identify the persons' identity. After receiving the unknown injured person the fingerprint sensor will scan the fingerprint of the injured person and send the data to the hospital server. If the persons' information is stored in the server then the server will inform the injured persons' family members about the condition and the person will get proper treatment. As a result, we can see that with the help of this smart ambulance system patients will get proper treatment in a minimum amount of time.

C. IoT Based Smart Ambulance System with Efficient Routing for Performance Environment

In this concept of the work, two different portions are going to be analyzed for implementation together to facilitate efficiency and better advantage from the Ambulance service. As it can be seen that the aim for both of the portions is the same. Both are being as a system for the Internet of Things (IoT) which are sensor-based. An efficient Routing Protocol should be followed for better performance of the system where the ambulance can get to the destination or hospital in the smallest possible time. Both the time and money will be saved by following an Efficient Routing Protocol on the system. The routing protocol is IoT sensor oriented named the LOADng-IoT routing protocol.

LOADng-IoT and Smart Ambulance System Overview: The things which both the routing protocol of LOADng-IoT and the Smart Ambulance System have been demonstrated in Table I below.

Table 1. Demonstration of Smart Ambulance and LOADng-IoT Protocol

Smart Ambulance	**LOADng-IoT**
Sensor-based system for authenticating and ambulance place detecting.	Sensor-oriented Efficient P2P reactive routing Protocol.
Traffic Lights turn green if it reaches a specific point of the road or path for a certain amount of time for the ambulance.	Routing Protocol that works on routing path discovery by sending the notification internally from the source to the destination.

The Key Concern of the Routing Protocol LOADng-IoT: LOADng-IoT is a sensor-based IoT applicable routing protocol. It is a reactive routing system that works through point-to-point (P2P) system communication for data passage. [10] The routing is done ensuring the destination node discovery process of intercommunication of the network. The reason behind this routing should be implemented is that the system wants to have the shortest possible pathfinding routing protocol which would be best for the ambulances' distance coverage. Also, it makes the traffic less congestion-free for the ambulance by the perfect and effective use of this efficient routing. The energy consumption and the amount of power dissipation are also less which makes this routing protocol quite usable for the smart ambulance system.

Working Procedure of LOADng-IoT in Smart Ambulance: When a smart ambulance wants to go to a specific destination of the patient's targeted hospital. The LOADng-IoT routing gives the best possible path to the hospital. Initially, it sends a notification to the sensor in the destination node which is the hospital will get the RREQ signal from the place of the ambulance. Then the node in the hospital will be sending an RREP reply message to the ambulance or the source. As the connection is established in the IoT sensor network through message passing, an

efficient path is calculated by the routing protocol for the sake of the ambulance. If in case any error or miscommunication occurs the driver in the ambulance node will be notified by LOADng-IoT's RERR message. As this process will help all possible nodes in between the path of the ambulance (source) and the Hospital (destination) the best covering path and the fastest route to the hospital will be shown or become visible in all the intermediary sensor nodes of the path. Thus, the LOADng-IoT routing protocol helps the smart ambulance system to avoid congestion and decrease the path cost.

The Efficient Route to the Destination: Let's assume the ambulance, the hospitals, and all the possible path checkpoints are the sensor nodes. Now the internet nodes and the simple nodes are different in their operations. The internet nodes in the network will help to pass the patient's condition through the internet to the targeted hospital. But the all possible routes will be compared by the LOADng-IoT routing and direct the best possible route to the hospital from the point of pickup of the patient. Thus a congestion-free route to the hospital may be directed by the LOADng-IoT routing. The routing signal from the source to destination will be passed and all the intermediary nodes will be aware of it. It can also help to get to the fastest way possible for the patient. Thus the message passing and routing around the sensor networks through the internet and normal nodes will be less delay prone and the latency of both ends will be reduced by using this protocol. All it is needed to assign all the possible nodes (ambulance, patients, checkpoints & hospitals) in the network. The shortest route will beneficial for this type of low network power service.

Performance Advantages and Benefits of Using LOAdng-IoT**:** LOAdng-IoT is for low power networks in IoT so the energy consumption is less. Hence, it would be beneficial in terms of energy efficiency and cost-effectiveness. The routing may help the patient to reach the hospital faster as this routing protocol is less delay prone in a specific IoT network. The end-to-end latency in terms of communication nodes is very less. So it can be faster to ensure P2P communication in this reactive routing system. The amount of communication data overhead will be less leading to a quality enhancement of efficiency for the service. As the ratio of delivery in LOADng-IoT is less for its point-to-point communication and collision detection mechanism in terms of failure (by generating RERR), the throughput of the system will get increased by implementing the routing protocol in the system. The smart ambulance network would be implementable in both dense and sparse networks.

6. Discussion

Generally, traffic signals have a fixed time to switch the signals. There are no changes for the ambulance. Without a smart ambulance system, if an ambulance wants to cross a certain junction with a traffic signal, it has to wait for several minutes until the red signal turns green. The aim is to design an ambulance system that has a traffic signal controlling system and a patient health monitoring system. The system will monitor the continuous medical condition of a patient and send this data to the hospital as well as it can identify an anonymous injured person who is the victim of road accidents. Sometimes it happens that after a patient reaches the hospital the hospital authority fails to give proper treatment or the hospital doesn't provide the treatment at all for the specific problem that the patient is suffering with. So there is a high chance to lose the patients' life. In the proposed system user can see the details of the hospitals as well as the location. So, it will help the user to find or choose the right hospital based on the symptoms of the patient. The smart ambulance system uses RFID technology to control the traffic signal. The RFID transmitter can send the RFID signal approximately 500 meters which is hardly half a kilometer. At times heavy traffic jams can occur that can block one or two kilometers from the traffic signal. Then the system will face the problem to read the RFID tag from the RFID transmitter. To overcome this problem a high gain antenna can be used to read the RFID tags from much further away. But it will lead to some privacy problems.

Figure 6 shown below is the probable routing path from the source to destination. The LOADng-IoT routing helps in the efficient message routing in the IoT scenario for lightweight network communication. This kind of routing can be both used in message propagation and the probable direction assistance from the system. Here, the "+" sign nodes, are the internet nodes, and the "." signed nodes are the simple nodes in the wireless IoT network. The source node is the point node of the location where the ambulance is. The destination is the hospital. Here are 4 intermediate nodes from the source to destination. Node A, B, C, and D all will be getting the message from the source that where it wants to go or what is the destination for the source. So all the nodes are well aware of the final destination and the system provides the best possible way by the situation. The probable paths like A->B->C->D, A->B->D and A->D the shortest path is the last one. It will both reduce the time and the amount of path covered by the vehicle saving both the fuel consumption and amount of energy dissipated from the sensors for covering the shortest

path possible. The "red dotted" line is the shortest path shown among all the intermediate's possible paths. As a result, it may help in locating the ambulance and help it to optimize a congestion-free way to get to the hospital as fast as possible to save the lives of the patients.

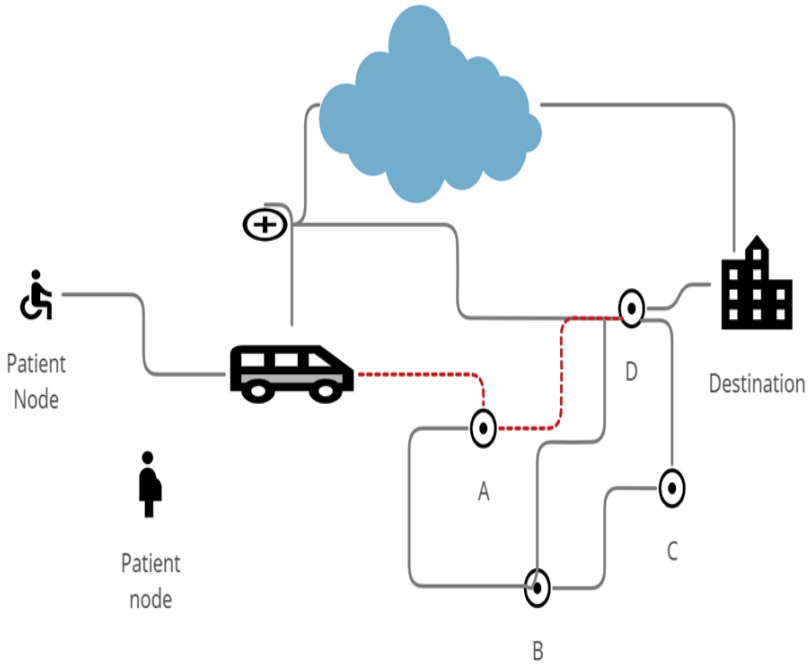

Fig. 6. Graphical View of LOADng-IoT Working Procedure.

A Careful review suggests that technology and science are directly or indirectly related to the SDGs.It is agreed that the problems that sustainability science needs to solve are defined by society, not by scientists, so the stakeholders in society must be involved in solving the problems.However, goal 3- Good Health and Well-being, goal 9-Industry, Innovation, and Infrastructure, goal 11-Sustainable Cities and Communities, and lastly goal 12-Responsible Consumption and Production, goal 13- Climate Action have been subjects of study in this research under the lens of Internet of Things (IoT) enabled smart ambulance routing.

However, the smart ambulance routing presented in the document is expected to deliver the following SDGs:

- 3.6 Halve the number of global deaths and injuries from road traffic accidents.
- 9.2 Promote inclusive and sustainable industrialization.
- 9.4 Greater adoption of clean and environmentally sound technologies and industrial processes.
- 9.5 Upgrade the technological capabilities of industrial sectors
- 11.2 Improving road safety
- 12.2 Sustainable management and efficient use of natural resources.
- 13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in the least developed countries, including focusing on women, youth, and local and marginalized communities.

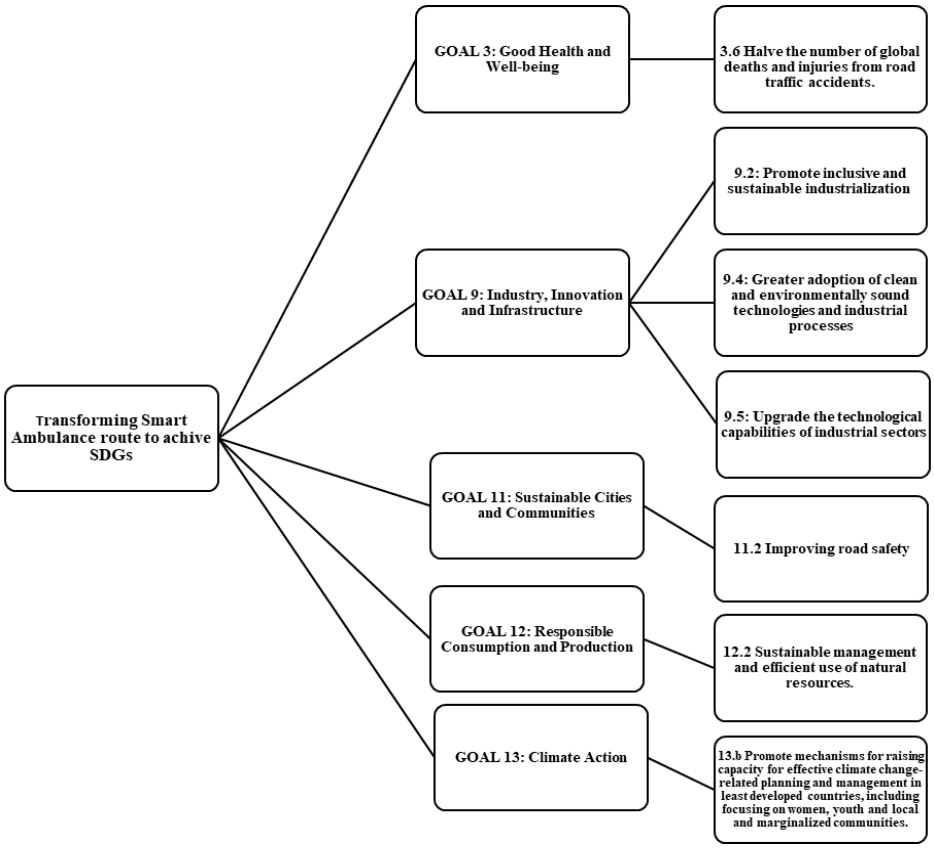

Fig.7. Block Diagram of Transforming Smart Ambulance Route to achieve Sustainable Development Goals.

7. Conclusion

The proposed smart ambulance system is designed based on a traffic control system and health monitoring systemand relates it with the SDGs'achievable goals. Using this application, the ambulance will be able to reach the hospital without facing the trouble of traffic jams will help in optimization of the time taken by the ambulance. Moreover, with the help of LOADng-IoT protocol in the health monitoring system, it is possible to send the current health status of the patient to the hospitals. So that the doctor can take necessary steps based on the data before, the patient reaches the hospital. This smart ambulance system may lead to saving one precious life. Future work will focus on improving the existing systems' architecture. There are many high-priority vehicles on the road such as fire engines, police vehicles that requires to reach the destination in minimum delay. The traffic controlling system proposed in this report can be extended to these high-priority vehicles also. Another future work is to retrieve NID details by using the fingerprint sensor. So that it will be possible to collect the details of the injured person using a fingerprint if he/she is a citizen of this country.

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