

Remote Patient Monitoring System Based Coap in Wireless Sensor Networks

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Abstract

Patient monitoring is a process of collecting medical parameters of a patient present at a remote location. To deal with this particular issue in a hospital or medical assistance centre, this paper proposes an alternative vision that includes support through internet based on wireless networks and also compatible with existing infrastructure. Most of the existing paper deals with monitoring through sophisticated hardware in a private network and each have its own overheads of switching to a new system model. This paper deals with the enhanced Constrained Application Protocol (CoAP) using multi hop flat topology, which makes the patients being monitored by a central system. It also provides secure communication among the patient nodes by using the public key algorithm. We aim to minimize as well improve implementation method more domestically and secure communication between client and server.

Keywords: Patient monitors; Constrained Application Protocol (CoAP); Internet of things; Sensor networks

Introduction

A wireless sensor network (WSN) of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a central coordinator. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, smart parking system, and so on. The Internet of Things is the network of physical objects accessed through the internet, as defined by technology analysts and visionaries. This patient monitoring system (Figure 1) is an integral part of health care that deals with medication and treatment to inaccessible areas. The current situation indicates the presence of bio telemetry where the hardware involved is complex and expensive. The proposed method is more domesticated where a particular patient can be monitored through mobile phone or computers by a concerned person or a doctor as long as each of them have access to internet and stay connected. It indicates the advantage of Implementing CoAP over existing technical resources. To understand the proposed model, consider a server-client model where it consists of one client and multiple servers. The client end serves as the monitoring mode where each and every server hosts a patient data indigenously. The server end hosts a page on the web that has a two way communication with the server only. The page contains data that are medical parameters in our case and also a set of options or buttons to serve the purpose of the application. The care takers or concerned persons who are relatives and friends of server (patient) are given access to view the parameters. The information palette can be designed or modified in their choice or knowledge. The hospital end (clients) will have more detailed information and can even control or adjust the equipment manually or through an automated algorithm by the connected actuators with the internet.

The goal of this work is to:

- Create a wireless topology with one client and multiple servers.
- Establish link between each server with client.
- Servers can be accessed via Copper Web Browser plugin through

which sensor data can be monitored.

- Each server is provided with separate URL; Client should be able to log onto the URL of particular server and enter his/her patient number and acquire necessary details from his platform.
- Sensors attached to the patient's body provides the information about the parameters in healthcare.
- As per the request from the client end, information is displayed.
- When implemented, the request by doctor, then information can also be displayed in his/her mobile devices, thus reducing the time spent for manual diagnosis.

The contributions in this paper are: A simulative evaluation of the proposed approach. The remainder of this paper is organized as follows. The next section discusses works related to CoAP (Figure 2) implementation in health care. Section 2 describes the proposed work of the paper and section 4 shows the evaluation methodology that is protocol to be used along with the simulated environment. The results are presented and discussed in Section 5. Section 6 concludes the paper.

Related Work

Internet of things made complicated functions very simple, leading to formation of more astute environment and smart appliances making a better and safe place to live in. Some previous works was based on an easy web interface that provides information about temperature, humidity and led status of sensors [1]. Other works is done on various applications like car parking which was implemented through COOJA simulator to offer parking facilities will get cars off the street and into parking spaces sooner thus contributing to congestion control in highly congested urban areas [2]. In order to develop a low power efficient

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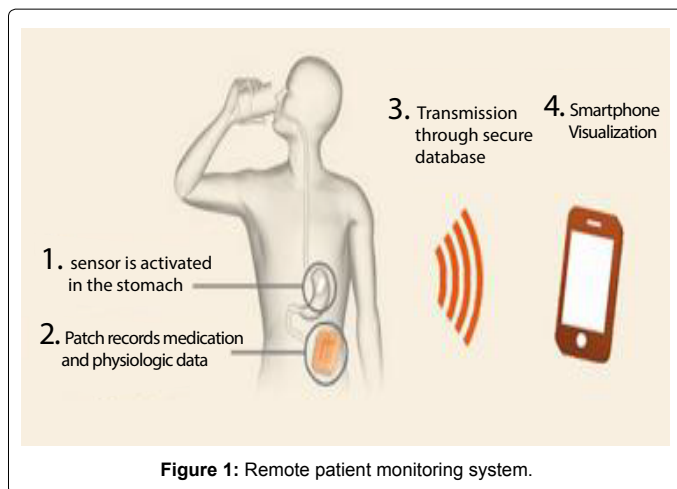


Figure 1: Remote patient monitoring system.

CoAP system works have been carried out as implementation for CONTIKI OS that leverages a generic radio duty cycling mechanism to achieve high energy efficiency [3]. The encryption technique between the client and server nodes provides secured data transfer between them [4].

In this paper [5], the implementation works in wireless sensor networks and not in mobile networks. The data transmitted and received during the process lacks security. So, Data can be accessed by irrelevant people. This method lacks privacy. This paper also gives an idea to establish communication between different motes. In this paper [6], the process works both in mobile networks as well as wireless sensor networks but lacks secure data transmission and communication between different servers or motes.

In this paper [2], the method can be implemented in mobile networks as well as wireless sensor networks but lacks data security and remote monitoring services. This paper establishes communication between various motes and it is implemented in CONTIKI OS. In this paper [3], the process is implemented without data security and remote monitoring services. From these above papers, the demerits of data insecurity and communication between motes can be rectified in order to implement the secured remote monitoring process.

This is done by improving the monitoring process to be carried in mobile networks and data security between client and server is established to provide privacy from others. The mobile monitoring is established by including CoAP protocol in browsers using COPPER plugin. The data security is established by using secure public key encryption technique to provide secured data transmission between different motes.

The already existing protocols such as REST, 6LoWPAN, and CoAP are implemented in the LINUX based CONTIKI environment with extended data security options that can readily be downloaded to commercially supported Contiki motes. These proposed features highlights the future possibility in a remote patient monitoring system. The achieved results showcases the easier implementation and simulations without involving specific hardware requirements [7]. They not only monitor the patient parameters but also provide effective indications and diagnostic solutions to the situation present

This work is done on Implementation of CoAP and its Application in Transport Logistics highlighting the use of the CoAP protocol for the retrieval of sensor data during land or sea transportation. Thus these early works are in interest for the betterment of environment.

Overview of CoAP

Constrained Application Protocol (CoAP)

It is a software protocol intended to be used in very simple electronics devices that allows them to communicate interactively over the Internet. It is particularly targeted for small low power sensors, switches, valves and similar components that need to be controlled or supervised remotely, through standard Internet networks [8]. Therefore, efficiency is very important. CoAP can run on most devices that support UDP or a UDP analogue.

Message types involved in CoAP are Confirmable, Non confirmable, Acknowledgement, Reset messages. Confirmable requires Acknowledgement whereas Non Confirmable doesn't require Acknowledgment. Reset message indicates missing of few contexts.

- GET: The GET method helps in retrieving information from that of server.
- POST: The POST method requests the server to provide data for the user.
- PUT: The PUT method helps in updating or creating the information in the corresponding URI.
- DELETE: The DELETE method helps in erasing the information stored.

The usage of CoAP in patient monitoring application is to form a client-server relationship, whereas Doctors use the browser as client and the server program runs in the GUI for updating the browser dynamically. Thus the Method definitions are used efficiently for remote monitoring application

Proposed Architecture for Remote Patient Monitoring Application

System architecture

As per Figure 3, Patient is monitored by the sensors mounted on them. Servers will host the information on the network. The server collects the data from the sensors. On the other side, Doctors are acting as clients. If doctors request server for data, the CoAP protocol helps to connect server with client to display the current status and check for variation of sensor values [9]. If there is any variation, Doctors can give medication indicating emergency situation for the patient. This medication is done in browser using CoAP Protocol. The data of patient is stored in some data storage device for future purposes.

In multi-hop flat wireless topology, there are one or more intermediate nodes along the path that receive and forward packets via wireless links. During transmission and reception in multi-hop networks, nodes communicate with each other using wireless channels and do not have the need for common infrastructure or centralized control.

The above Figure 4 explains the Multi-hop topology with Border router, Client and server.

Server: A Restful server shows how to use the REST layer to develop server-side applications.

Border router: Border Router keeps radio turned on. Enabling of it helps in connection between that of client as well as server to that of CoAP web Address. Border-Router [10] has the same stack and fits into mote memory.

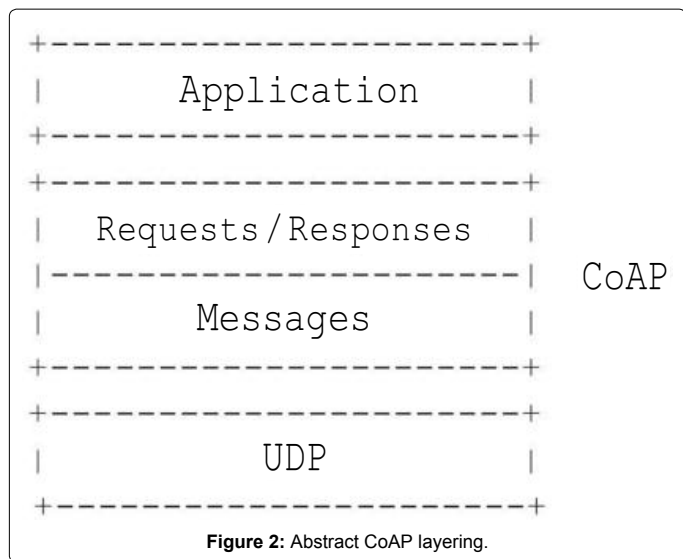


Figure 2: Abstract CoAP layering.

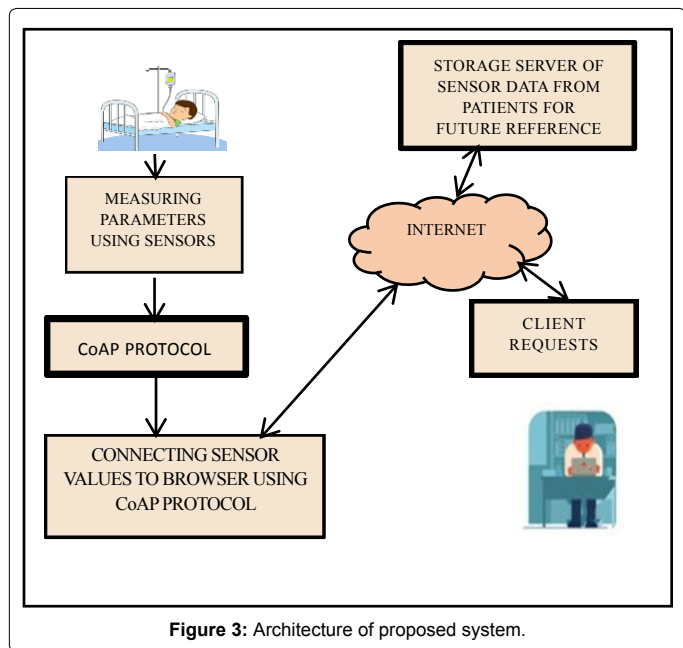


Figure 3: Architecture of proposed system.

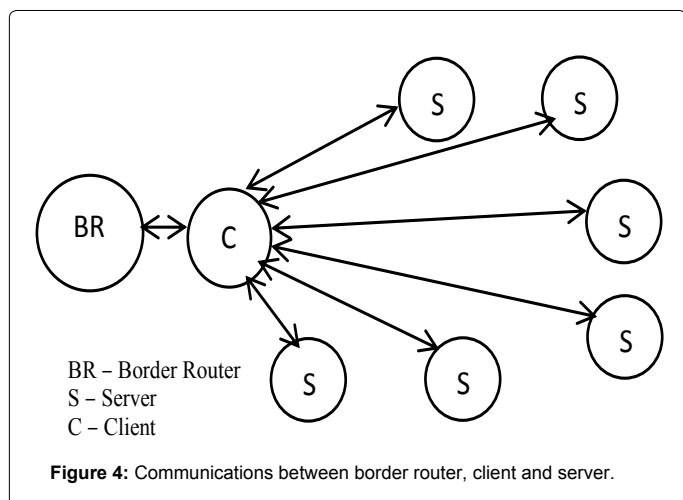


Figure 4: Communications between border router, client and server.

Client: A CoAP client cycles through four resources on event detection such as GET, PUT, PUSH, and DELETE. It gets connected to the server via multihop topology.

The communication between server and clients are of multi hop fashion. The data from the motes are sent to that of Copper Web Browser which can be viewed by the user.

Flow chart of client operation in browser

From Figure 5, Flowchart explains the methodology to carry out this particular application. The address of the server is typed in the URL using a copper plugin which runs on top of the http. The hosted servers responds to the requests only after permission of access is granted.

The hosted webpage displays the status of the patient along with the sensor values that has been under operation. The obtained values can also be stored on the cloud or offline for future references. The collected values are compared with the standard or normal diagnostic values to compute an action. Then, a particular or a group of parameters can be modified to stimulate an action in order to bring the patient condition to normal or to the require state.

Data security

The conversation between sensors nodes and client can be eavesdropped by the adversary. The adversary can be aware of the conversation between the sensors and can forge the data. Security is the main pre concern to socialize this network for common usage. The goal of security services in WSNs is to protect the information and resources from attacks.

The security in sensor network will be employed by public.

Key cryptography because it is easy to distribute keys in public key cryptography than symmetric key cryptography.

This is because of the random deployment of the sensor nodes in the network.

Thus we purpose, Public key algorithm using Elliptic Curve Cryptography algorithm for preventing replay attack in sensor network as well as for data confidentiality and authentication between patient nodes and client.

Simulation Output

Constrained Application Protocol is simulated via COOJA simulator. COOJA simulator is a java based simulator and it is also called as "cross level simulator".

The simulation can be done via the terminal as follows,

- Open terminal to connect the client with server using the command, \$ Make connect-router-cooja.
- This command is included in the same border router environment to bridge the connection using CoAP protocol.

Figure 6 will give the bridging terminal window between client and server.

Figure 7 gives the idea of connection exhibiting between different servers of patients with client of doctor being at another mote. The motes arrangement can be viewed in COOJA simulation window.

Figure 8 gives the final output can be viewed in Browser with a Mozilla Firefox add-on called Copper. Patient is a resource added to the left side window of the browser in the address bar `coap://`

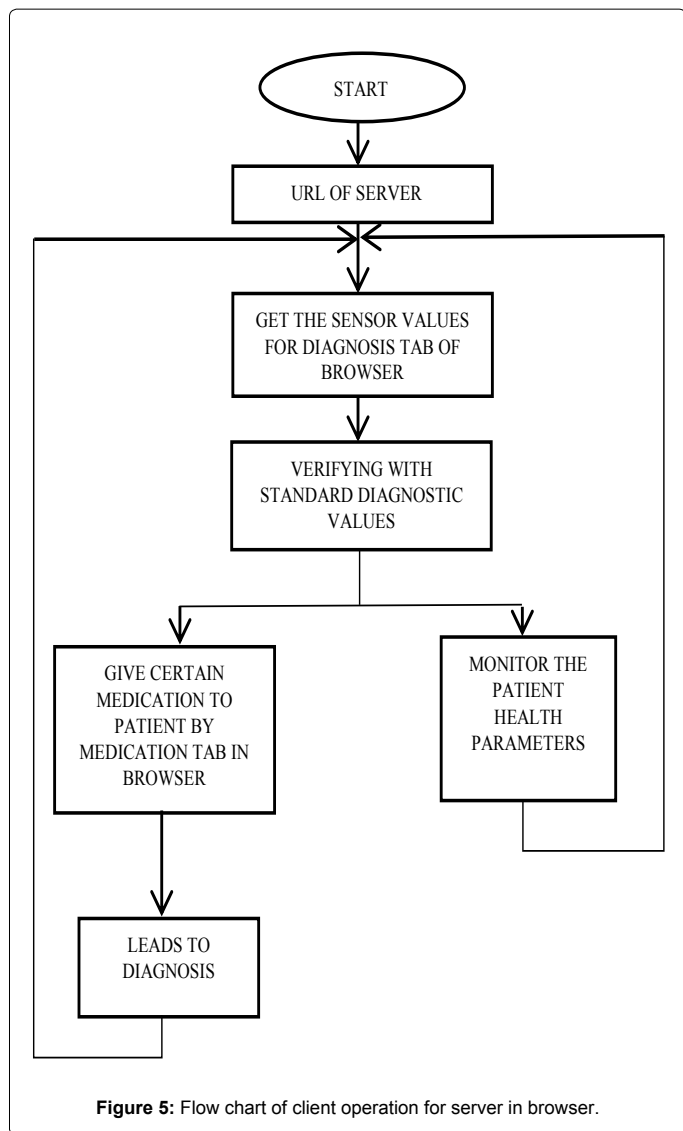


Figure 5: Flow chart of client operation for server in browser.

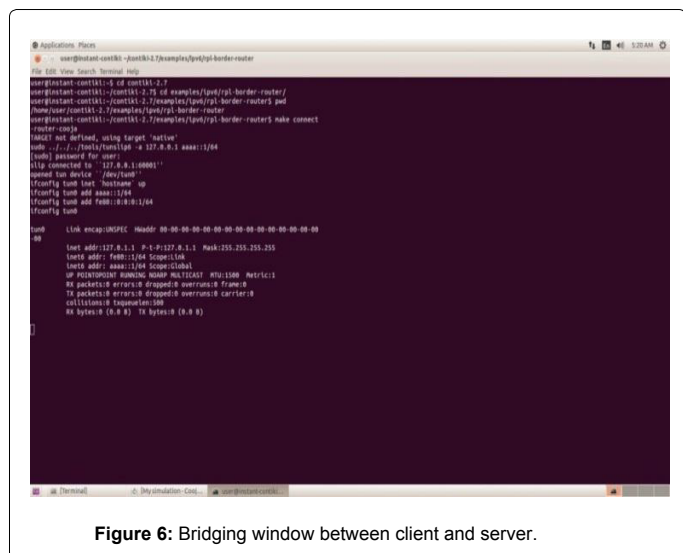


Figure 6: Bridging window between client and server.

[aaaa::212:7402:2:202]/connects client to the particular server [11].

This shows the process done in Mozilla Firefox browser:

- Discovery–calls the resources included in the server.
- Ping–Tab helps to check the connectivity of the server and client.
- GET, POST, PUT, DELETE are the Method definitions which gets in to effect only after Pinging.

From Figure 9, it shows the sub-resources added to the browser in order to perform varied operation in server end.

Diagnosis

The diagnosis function is performed, when client wants to read the sensors data from server. In this, client transmits command to the server to read the data from sensors.

On the other hand, server gathers the data from sensors and transmits it back to client. The transmission of command from client to server and reception of data from server to client is done using CoAP protocol. Depending on the data received, clients or doctors recommend medication to the patients.

Medication

Used to indicate the patient to go to nearest hospital by actuator.

This medication helps patient to identify some changes in their body conditions and corresponding remedial measures can be implemented by doctors in hospitals based on the sensor data received from the servers.

Figure 9 shows the browser screen indicating the Sensor Values,

Figure 10 indicates any change in standard diagnostic values leads medication to be done in order to prevent patient from detrimental effect of his/her health.

Figure 11 indicates change in patient’s body by the actuator signal, this is done to aware the patient that is parameters are not accurate. This is the indication to patient to move to hospital as early as possible.

Figure 12 shows that if every parameters are within range then the browser will indicate to the client that the patient is normal and further investigation of that particular patient is not required.

From these above simulation results, we can ensure that Patient’s diagnosis evaluation will go to its pinnacle point.

Conclusion and Future Work

We presented our low-power CoAP implementation for Contiki that leverages a generic radio duty cycling mechanism to achieve a high energy efficiency on a COOJA simulator. We experimentally evaluated our implementation in a multihop network and showed that the use of a duty cycle results in a low power consumption, at the cost of a higher latency. Our protocol-independent REST Engine provides an abstraction to create RESTful Web services. In future work, we plan to evaluate the possibilities and limitations of the RESTful approach towards the low cost microcontrollers such as Arduino family, MSP Launchpads and other ARM processors through construction of custom motes and bring in more features of contiki like how the IP-based IoT performs in terms of latency, reliability, and battery-lifetime.

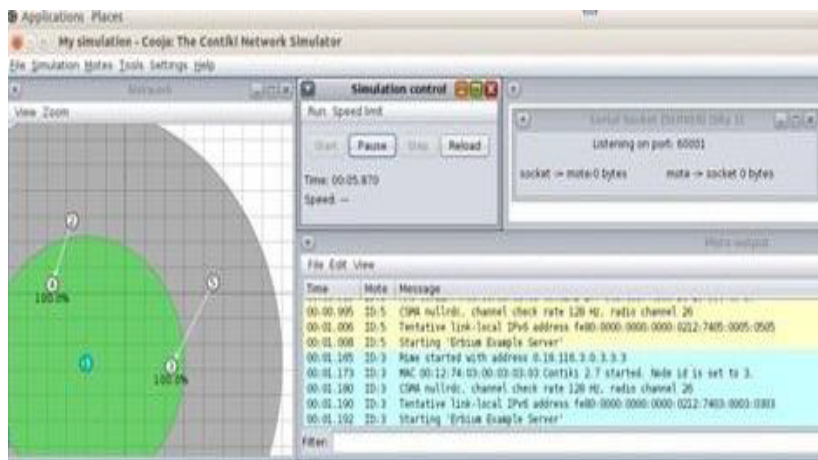


Figure 7: Notes connection representing server and client.

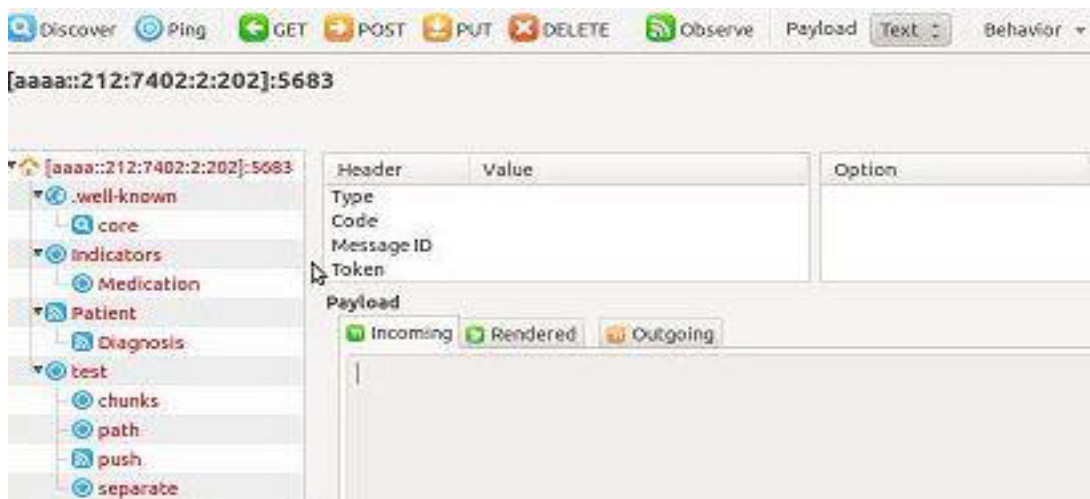


Figure 8: CoAP interface in browser.



Figure 9: Browser screen indicating the sensor values.

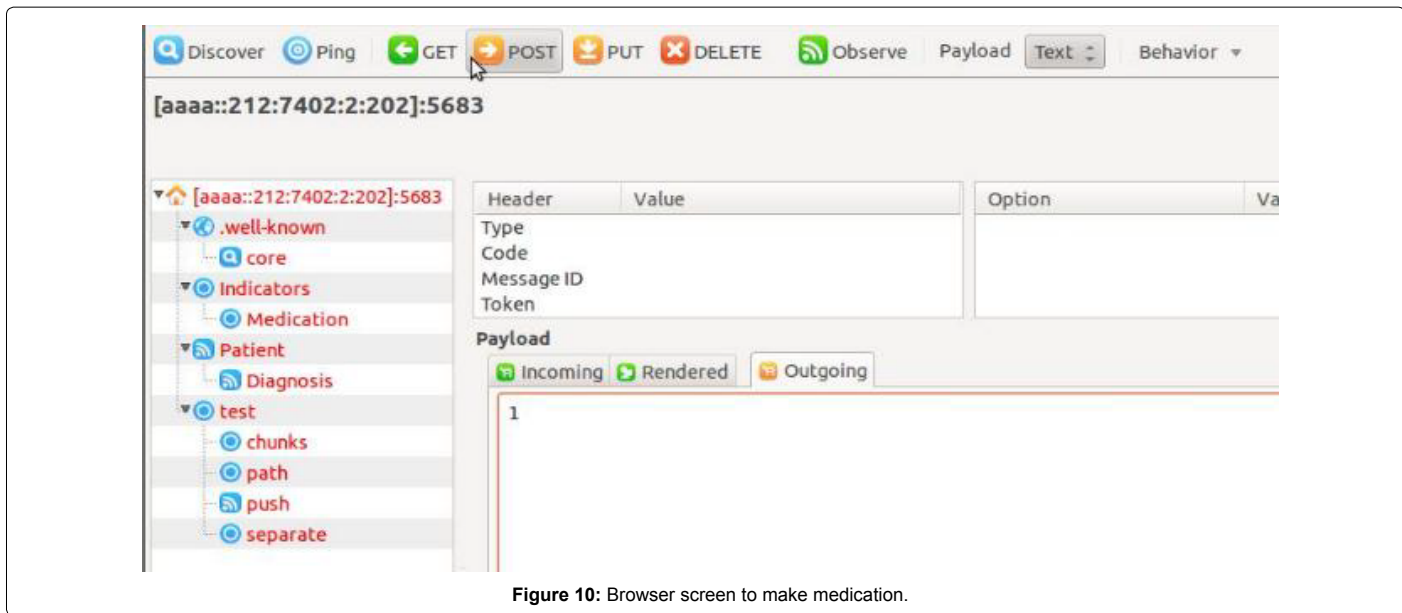


Figure 10: Browser screen to make medication.

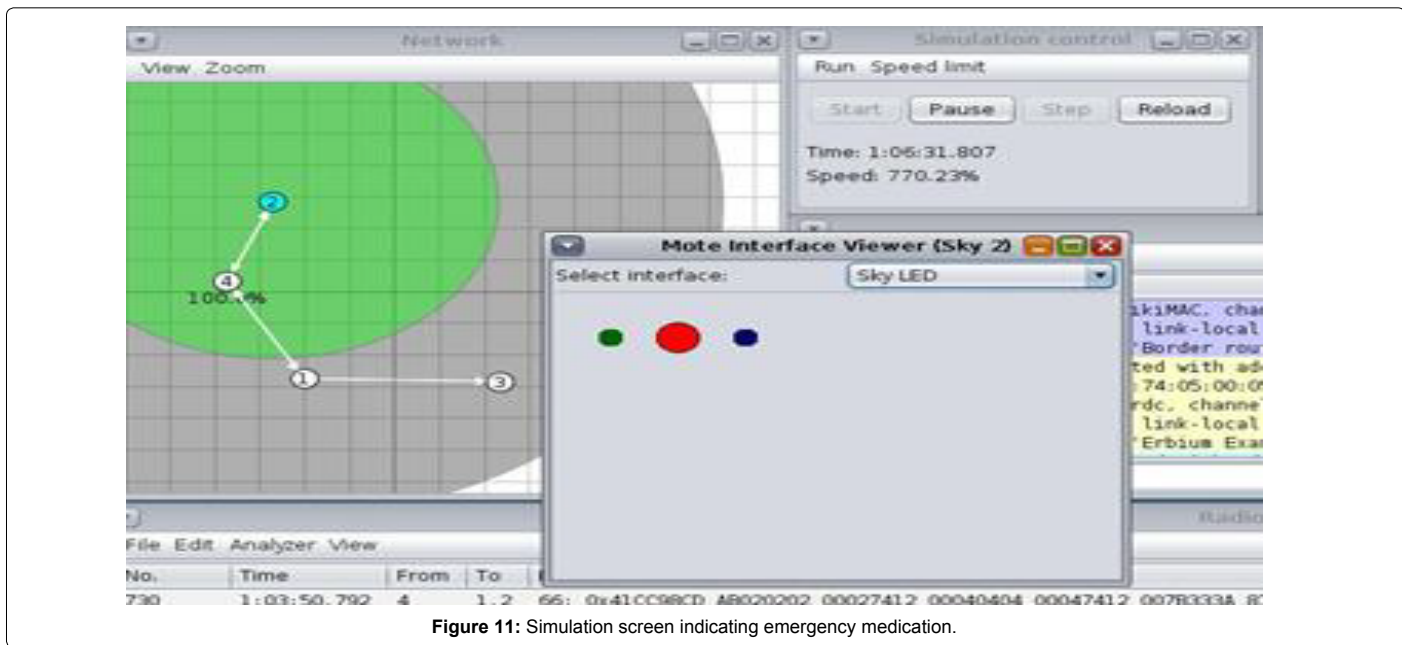


Figure 11: Simulation screen indicating emergency medication.

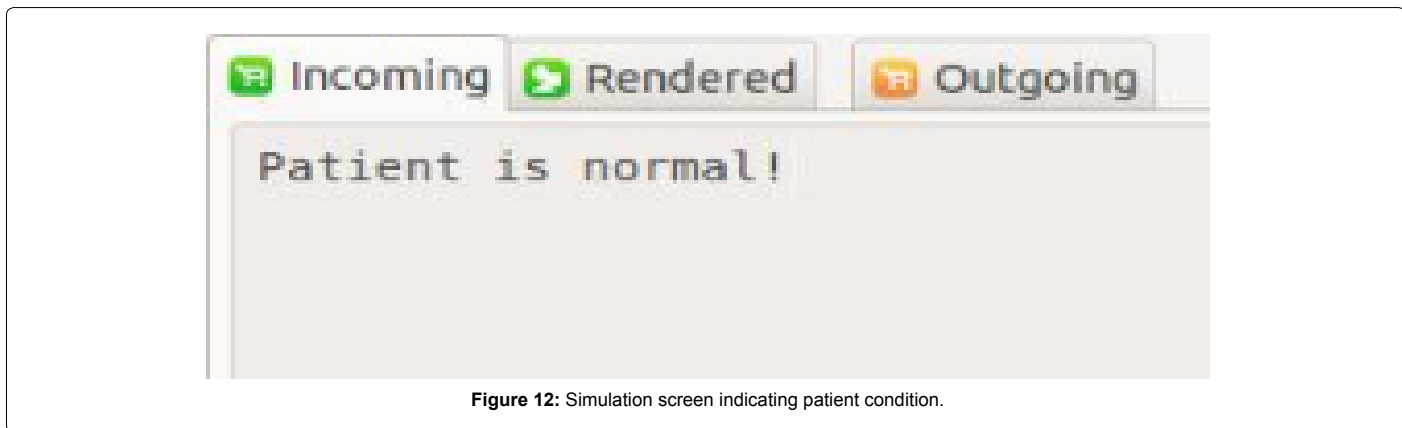


Figure 12: Simulation screen indicating patient condition.

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