and routing overhead. In this work, further enhancement in the relay-based technique for fault recovery in the network is proposed.

4.1 Proposed Algorithm

The proposed algorithm for the E-OPR protocol for energy-efficient is shown in Algorithm 1.

4.2 Methodology

The wireless body area network is a kind of network that is used to sense body conditions. The sensors are deployed in such a manner that they can efficiently sense parameters of the body and then passed the data to the sink. Communication in the wireless body area network is multi-hop communication. In this type of communication, the source node establishes the shortest path to the destination. For that purpose, the source node can use some non-critical sensor nodes for transmitting their data further to the sink. These non-critical sensor nodes are those who sense some non-critical parameters like temperature, pressure, altitude, etc. Mostly they remain in the sleep mode; that's why they are forced to participate in the communication purpose. But in case these nodes get faulty, or battery of these nodes gets degraded, Fault may arise in the network. The relay-based technique uses the relay nodes for fault recovery. For the purpose of achieving better results, when link is failure during communication a Destination Sequenced Distance Vector (DSDV) and Enhancement in Ad-hoc On-demand Multipath Distance Vector (EAOMDV) (40) routing protocol is put forth to optimize a routing path for E-health application.

The proposed improvement is based on dynamic routing. In this routing, multiple paths are established from the source to the destination.

When the battery of any sensor node reduced to the threshold value, a new path will be automatically chosen for data transmission. Nodes transfer data through an intermediate node to the sink. The existing technique leads to a reduction in the network complexity, network delay, energy consumption, and hence increased the network throughput. Due to the fault, network performance degrades in terms of throughput, packet loss, delay, and energy. In the proposed technique, the enhancement is done by considering the predefined relay nodes. Three scenarios are depicted to prove the variation in the results by considering a different number of nodes each time.

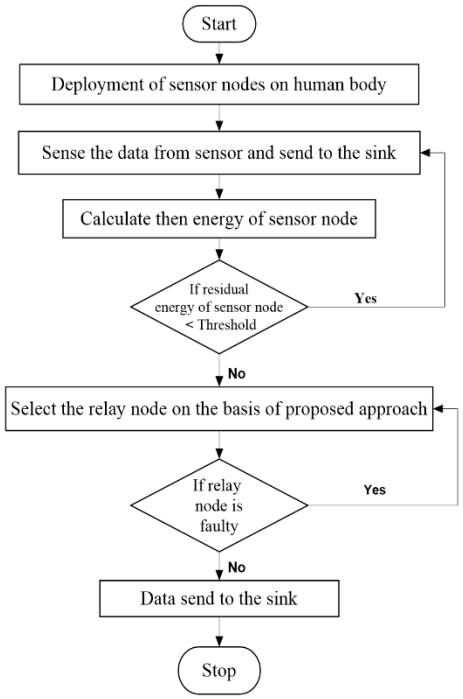

Fig. 3. Proposed approach of WBAN

4.3 Simulation Scenarios of Proposed Approach

In this simulation process, two scenarios have been evaluated on the basis of different parameters. In this methodology, 2 scenarios are implemented in the simulation tool. In simulation scenarios having sensor 1 is equipped with the functionality of measuring eating and smoking habits called as Tooth Sensor. Sensor 2 is the ECG Sensor here used for monitoring heart activity. Sensor 3 is the Health Patch that is placed at the chest and measures the parameters like heart-rate, heart-rate variability, temperature, body-posture, steps, and falls. Sensor 4 is the Limb sensor that monitors the movements of the legs of the human. Sensor 5 is equipped with the capability of tracking the wearer's steps, speed, foot landing technique, weight distribution, and altitude and known as the Smart Sock. Here, Sensor 6 is the Sink node capable of accepting packets from all other sensor nodes and hence forwards them to the base station. Also, it accepts the computed information from the base station and helps in responding to critical conditions. All this response is in the form of an action that will be done by the

actuator, which will inject medicine in the human body if required.

Algorithm 1. Proposed Algorithm for E-OPR

Begin
Input:
Step Set *X* Sensor Node's
Set *S* sender and R receiver
Node Routing = *DSDV*
Set Path
{If (path from *S* to *R* found)
{Check number of path;
If (path => 1) //means alternative path exist in network
{Find (energy of each path && energy > 20)
Select only 3 paths as a best path //shortest path
Send path acknowledge through all exist paths}
}
Else {path unreachable} } {
Source send (Ping message, adjacent nodes)
{
Adjacent nodes revert back to source which can recover path
Check (Node which has higher energy is path recover node)
{
Increment-*Q*;
Store incoming data;
} Receiver receives data from *I*
Node;
Send ACK to sender *S*;} } }
End-if
Repeat all the steps until all nodes becomes dead

Output:
Route← Shortest route from Source node to sink
End Begin

Scenario 1: No extra node is deployed, which acts as a relay node. All other sensor nodes are the same as that of the previous scenario. In this, six sensor nodes, along with one sink, is present.

Scenario 2: Here, nodes are present along with predefined relay nodes and a single sink, which helps in forwarding packets to the sink by accepting from the relayed nodes if any of the intermediate nodes (sensor node used as a relay node if no such node is present in the network and in case if it is not sensing at that time) gets faulty or corrupted. These are helpful in emergency cases. These nodes are not the sensor nodes but just used for the relaying process. Throughput gives the best performance in this scenario. Variables of Simulation is given below in Table 1.

Table 1. Variables of Simulation for WBAN

Parameter	Values
Nodes	6
Simulation Area	800*800
Simulation-Time	8000 rounds
Type of Antenna	Omni-Directional
MAC- Layer	802.11e
Type of Channel	Wireless Channel
Routing –Protocol	DSDV
Physical –Medium	Wireless

5. Results Analysis

The execution of the proposed protocol is evaluated here, after analyzing the performance of the residual energy without relay by using numerous metrics like throughput, energy, network lifetime. Initially, the energy of all nodes is kept constant (1 J per node)

5.1 Throughput

Throughput is computed as the size of bits (total bits) divided into the simulation duration (duration). As illustrated in Fig. 4, the throughput of the opportunistic protocol is high as compare to the other scenario. By considering the relay nodes, throughput increased. As the relay nodes help in maintaining the network uniformity by allowing the packets to reach the sink, the packet drop ratio gets reduced.

Simulation duration = time End – time Begin

where, time Begin = time of the first line in the trace file time End= time of the last line in the trace file

5.2 Energy Consumption

It is the total consumed energy of each sensor node placed in the body(41). Fig. 4 shows the energy comparison between without relay mechanism and selection of relay mechanism of proposed schemes.

This kind of protocol ensures maximum energy in the nodes that resulting in the transmission of data from transmitter to receiver. It also increased the productivity of the network. In scenario 1, due fault in the network, packet-loss is increased at a steady rate.

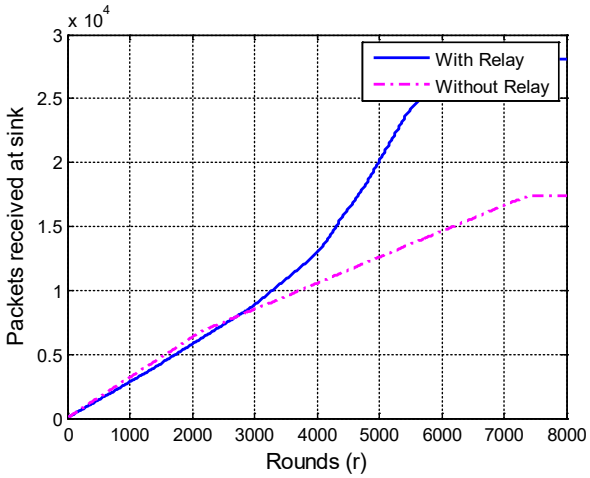

Fig. 4. Analysis of throughput with respect to rounds

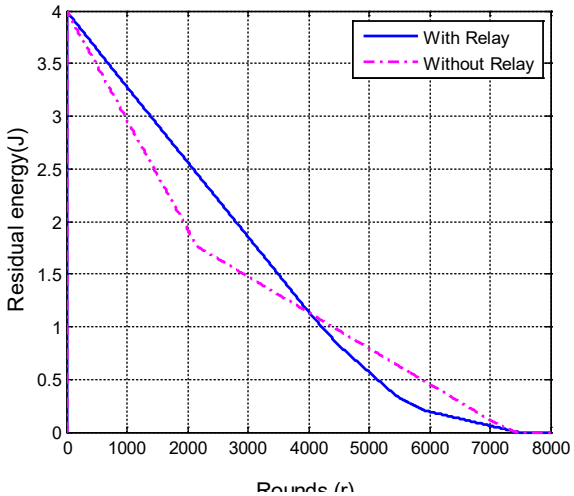

Fig. 5. Analysis of energy with respect to rounds

Hence, packing forwarding again and again due to the fault leads to more energy consumption. The proposed technique recovered the network fault and finally led to a reduction in the energy consumption of the network. Figure 5 shows minimum energy consumption.

5.3 Network Lifetime

The network stability period is the duration of time in which network operations are performed until the nodes die (42). As far as the medial applications are concerned, the network should be optimized for lifetime. Most of the wireless sensor networks utilize various energy-efficient protocols for communication among the nodes and base stations. The proposed protocol has more stability period. It plays vital role for balancing the energy consumption and increase the network lifetime. The network should be operated for as long as it is required for measuring the body parameters.

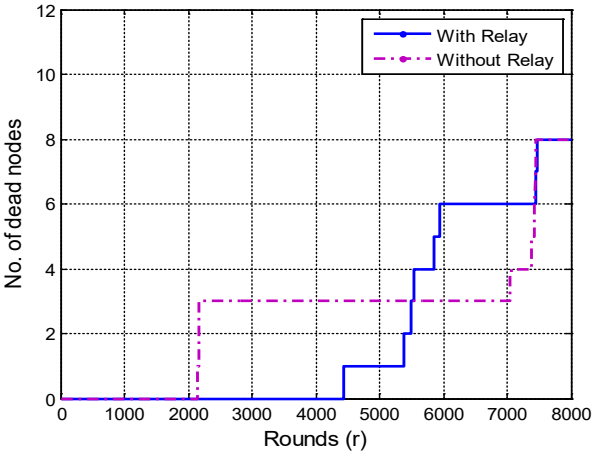

Fig. 6. Analysis of network lifetime with respect to rounds

Hence, Energy degradation leads to a halt in the network operational time (43).In Fig. 6, the network lifetime is increased due to fault recovery in the network by using relay nodes.

5.4 Path loss

Path loss is defined as the reduction in power for propagation while transmission of the data from sensor node to the sink. During propagation, sometimes the signals are diverted from the destination and split in the no. of fragmentation. The diversion of the signal is known as Path loss. Basically, it is loss of power density. This term is mostly used in the wireless network for transmission of data over the network. Basically, it is loss of power density.

The overall results comparison of scenario 1 and scenario 2 with different parameters is given in Table 2.

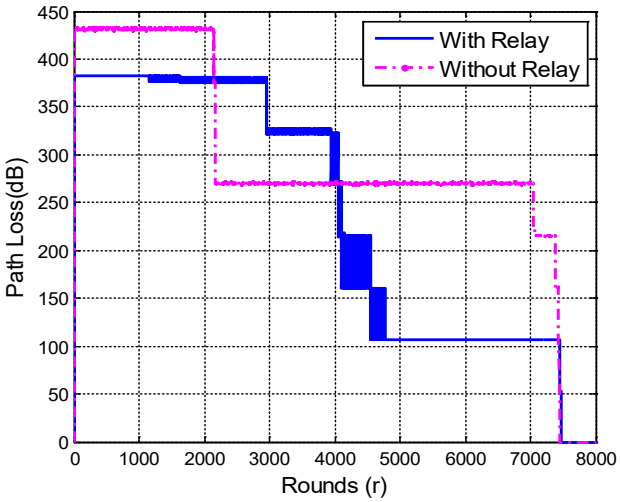

Fig. 7. Analysis of path loss with respect to rounds

Table 2. Result analysis of scenario 1 and scenario 2 with different parameters

Scenarios / Parameters		Scenario: 1 (Without Relay)	Scenario: 2 (With Relay)
No of rounds at which first sensor node dies		215 0	437 0
No of rounds at which last sensor node dies		723 5	725 5
Packets received		175 52	280 11
Residual Energy (J)	At 1000 rounds	3.01	3.30
	At 2000 rounds	1.90	2.60
	At 3000 rounds	1.50	1.90
	At 4000 rounds	1.21	1.24
	At 5000 rounds	0.73	0.80
	At 6000 rounds	0.51	0.52
	At 7000 rounds	0.23	0.24
	At 8000 rounds	0	0
Path-Loss (dB)	At 2000 rounds	43 7	38 1
	At 4000 rounds	27 5	27 5
	At 6000 rounds	27 5	11 0
	At 8000 rounds	0	0

6. Conclusion and Future work

In WBAN, there are numerous sensors and relay nodes for monitoring body parameters and data transmission, respectively. The relay nodes play a significant role as an inter-mediator. Due to the wrong selection of the relay node, there are always chances of the failure in the transmission of data from the sensor node toward the sink. For that purpose, relay nodes are there for packet forwarding toward the sink. The relay-nodes are selected from the nearest neighborhood along with considering maximum energy. An attempt is made on the selection of the relay node so that the failure may not occur, and hence data will be transferred to the sink without delay. The proposed technique is based on energy and resources in terms of buffer size. In future proposed technique will be applied hybrid MAC protocols for channel sensing and further enhancements can be done for the dynamic adjustments of the sensor nodes in WBAN and it can be used in the field of diagnosis of kidney dialysis, diabetes and other general prevention.

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