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Wireless Sensor Network Implementation to Prevent Railway Route Accident

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Abstract

A Wireless Area Network (WSN) routing protocol with excellent throughput, reliability, and energy efficiency is presented in this study. In order to lower energy consumption and lengthen network lifetime, multi-hop topology is used. It recommends choosing a parent node or forwarder by using a cost function. The parent node with the highest residual energy and closest proximity to the sink is selected using the suggested cost function. While the distance parameter guarantees successful packet delivery to the sink, the residual energy parameter balances the energy consumption among the sensor nodes. The simulation results show that the proposed protocol maximizes node uptime and network stability. Longer stability periods lead to higher packet delivery to sink, which is particularly desirable for continuous patient monitoring. The location of sensors, the architecture of base stations and sensor nodes, routing protocols, signal collecting and transmission, and the setup of an online monitoring system are all covered in this study's technological foundation. A realistic mesh sensing system has been used to study the evaluation of linear network topologies based on routing algorithms for train monitoring. According to the results, multi-hop topology performs better than conventional in terms of residual energy level, throughput, and end-to-end delay. The simulation results show that our protocol approach maximizes both network stability and node uptime. Higher packet delivery to sink is the result of longer stability durations, and this is highly desirable for ongoing patient monitoring.

Keywords

Routing Scheme, Wireless Sensor Network (WSN), Multi Hop, sensor node, cost function, Residual Energy, LEACH Protocol

1. Introduction

The number of collision-connected railway accidents shows worldwide an increasing tendency year by year. The ever-increasing operation velocities cause an increasing degree of grave consequences both in loss of human life and severe damage to the train and other railway equipment. In the technical literature very, few numbers of publications can be found that are dealing with investigations into the train collision processes to predict the level of forces and deformations realizing during accidental collisions/crashes [3]. The incredibly muddled character of the elements of train crashes can clarify the lack of literature. The paper takes endeavors to foster an iterative calculation technique for anticipating the elements of train impacts/crashes. An efficient railway communication system enables [4]. Communication among drivers and signalers at any time from any point of the station. All drivers in a specific region can convey through a transmission channel and be educated about any likely danger. The train's driver to speak with signalers and the control station in a crisis. Illuminate signalers about the training area on the track. Decrease the number of occurrences identifying with flagging issues and disappointments. Availability of timely and accurate information on train schedules to passengers. Driver to know the internal conditions of wagons attached to the locomotive. Provisioning of high security and reliability in all sectors of communications [5]. Over the past decades, trackside-monitoring techniques, such as infrared and acoustic monitoring, have been developed to monitor the rolling bearing in a freight train, but these techniques could not well be applied because of false positives and false frequently. On the other hand, onboard monitoring techniques cannot be used to freight train because the cars of a freight train are unattended, assembled frequently, and have no steady power supply.

2. Illustration of System

A systems model describes how processes interact and what operations these processes perform, but it does not go into details as to how these processes are implemented. The basic element of the systems model in this text is a block enclosing a transfer function.

2.1. Network Topology

The design of protocols for routing information of a WSN is closely related to the network topology considered. In this paper, Multi-Hop Network topology is presented to study the impact of reducing the number of hops in the overall performance of the network for train monitoring.

2.2. Multi-Hop Network Topology

Our model consists of 8 nodes (in our test area) distributed as illustrated in figure 1. along the train track, assumed that the distance between each node is 130m (Trial and Error) located on a straight line. The nodes classified into 5 clusters; each cluster has a different function. The nodes sense, continuously, a chosen parameter. Then, it sends data to the sink via multi-hop protocol. Consequently, the mesh network formed by the 8 nodes transfers data through gateway IEEE 802.15.4 standards for communication protocol to ensure low cost and low energy consumption. But it has low-data-rate monitor [6-7]. Sink node calculate the predicted required power for network to transmit to base destination via free space at frequency 868MHz as shown in Equation 1. using directional 6dBi antenna pointing to the sink.3.

Transmitted power = $Q(\frac{log\ _2(SF)}{\sqrt{2}}\frac{E_b}{N_0})$ Equation.1

,

No(dBi) = 10*log10(k*T*BW/1e-3) +NF+GN+GS.

Where, SF"Spreading Factor used in signals"=11.

K"Boltzmann Constant "= 1.38e-23 J. K^-

Node Gain = 6dBi.

Sink Gain = 10dBi.

T "Temperature" = 308Kelvin.

BW "Bandwidth" = 125KHz.

No "Minimum detectable signal for each node in dBi".

GN"Gain Node = 6dBi".

GS"Sink Node = 10dBi".

NF"Noise Figure".

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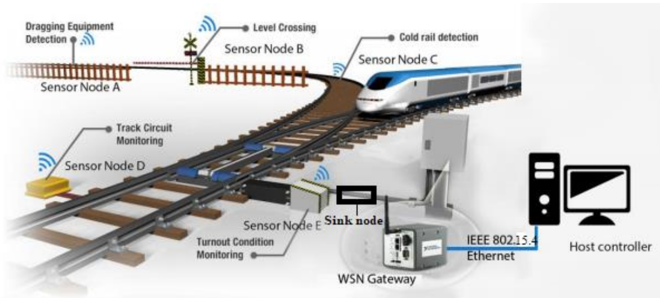

Fig.1: remote condition monitoring of the rail system [9].

3.1. Selection of next hop

In order to save energy and to enhance network throughput, we proposed a multi hop scheme for train track. In this section, we present selection criteria for a node to become parent node or forwarder. To balance energy consumption among sensor nodes and to trim down energy consumption of network, a proposed protocol elects new forwarder in each round. Sink node knows the ID, distance and residual energy status of the nodes. Sink computes the cost function of all nodes and transmit this cost function to all nodes. Based on this cost function, each node decides whether to become forwarder node or not. If i is number of nodes than cost function of i nodes is computed as follows in equation 2:

$$C.F(i) = \frac{d(i)}{R.E(i)} \quad \text{Equation.2}$$

- Where, di is the distance between the node i and sink, R.Ei is the residual energy of node i and is calculated by subtracting the current energy of node from initial total energy as shown in Figure 2. A node with minimum cost function is preferred as a forwarder. All the neighbor nodes stick together with forwarder node and transmit their data to forwarder. Forwarder node aggregates data and forward to sink. Forwarder node has maximum residual energy and minimum distance to sink; therefore, it consumes minimum energy to forward data to sink.
- Data aggregation is any process whereby data is gathered and expressed in a summary form. When data is aggregated, atomic data rows typically gathered from multiple sources are replaced with totals or summary statistics. Groups of observed aggregates are replaced with summary statistics based on those observations. ata aggregation can enable analysts to access and examine large amounts of data in a reasonable time frame. A row of aggregate data can represent hundreds, thousands, or even more atomic data records. When the data is aggregated, it can be queried quickly instead of requiring all the processing cycles to access each underlying atomic data row and aggregate it in real time when it is queried or accessed.

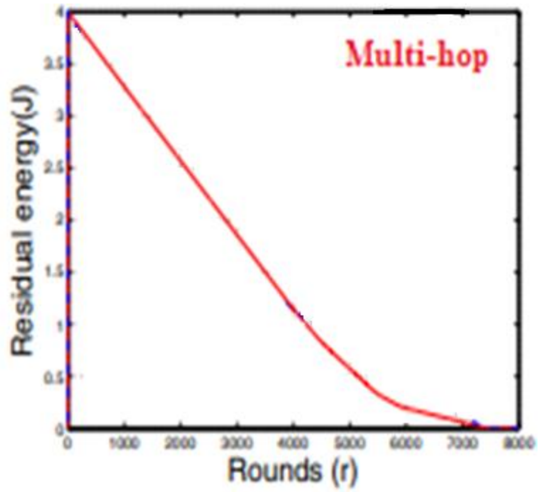

Fig.2: Analysis of residual energy.

3.2. Routing Protocol

Routing protocols in WSN are influenced by energy consumption constraint. The sensors use their energy for the purpose of data processing and transmission. The lifetime of a sensor depends mainly on its battery. Sensor node failure can change significantly the network topology and can impose a costly reorganization of the latter. In this work, we used two protocols LEACH Protocol, AODV Protocol. LEACH Multi-hop protocol is the extension of single hop method, which works in a way that maximum Cluster Heads (CHs) could send data to the BS. In addition, a single CH in this scheme shares data with the remaining CHs. The main feature for this protocol Saving energy. Saving energy is an extremely important factor in sensor networks. Thus, many routing algorithms aimed in efficient energy consumption have been developed such as LEACH protocol.

Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol [8] is a hierarchical protocol for minimizing the power consumption in order to increase the network lifetime.

- In LEACH, the nodes are organized into clusters, with one node acting as the leader (cluster-head). All non-leader's nodes should transmit their data to the cluster-head, while the cluster head must receive data from all the cluster members, perform functions of data processing (data aggregation), and transmit data to the base station. The LEACH works by rounds. In each round, leader nodes are exchanged to distribute the network energy consumption.

Two phases compose the rounds: clusters grouping, and communication phase. In the phase of clustering, the choice of leaders is performed through a distributed algorithm, and the source nodes choose to join the nearest cluster-head. In the communication stage, the transfer of data to the base station is made, including aggregation / data fusion by the leaders.

AODV (Adhoc on Demand Distance Vector) routing protocol is considered. AODV is a distance vector protocol [10]. It uses sequence numbers to avoid routing loops and to indicate the new paths to the destination node. An entry in the routing table contains essentially the address of the destination, the address of the next node, the distance in number of hops and the destination sequence number. AODV path discovery process begins when a node sends a RREQ message (Route request message) to AODV protocol, it sends a RREP message with the best destination. The routing tables of nodes are updated after each retransmission of the RREQ and RREP messages [11].

-Path loss must be taken in our calculation; it represents the signal attenuation and is measured in decibels (dB). Signal power is also degraded by Additive White Gaussian Noise (AWGN) [12]. Path loss is the difference between the transmitted power and received power whereas antenna gain may or may not be considered.

Path loss occurs due to the increasing surface area of propagating wave front. Transmitting antenna radiates power outward and any object between transmitter and receiver causes destruction of radiated signal. In Railway Tracks, different obstacles affect the transmitted signal. Path loss is related to the distance and frequency as shown in Equation 3 [13].

PLFree-space(dB) = 20log(f) + 20log(d) +32.44-GN-GS. Equation.3

$$PL_{Free\text{-}space}(dB) = 20\log(f) + 20\log(d) + 32.44 - G_N - G_S. \quad \text{Equation.3}$$

- -The Path Costs depend on BEP "Power needed to obtain total low BEP/BER" calculated from Equation 4 [14] (more accurate way is to use Linear CHIRP Time Division Modulation [15]).

$$P_{e,CSS} = Q\left(\frac{log_{12}(SF)}{\sqrt{2}}\frac{E_b}{N_0}\right) \qquad \text{Equation 4.}$$

Where, Eb = Pt*TB – PL

TB: Bit Duration.

Pt: Transmitted Power.

PL: Path Loss.

3.3. Results:

We used MATLAB as a simulator to analyze the behavior of the proposed routing protocol. Eight nodes are randomly distributed on the track and the sink node is placed in the front of the network. We studied the performance of the multi-hop protocol, reliability, power consumption, and high throughput routing protocol.

A. Throughput

Throughput is the successful packet received at the sink. As the Sink node has critical and important data of train tracks, so it requires a protocol that has minimum packet drop and maximum successful data received at the sink. The multi-hop protocol achieves high throughput, as shown in figure 3. The number of packets sends to the sink depends on the number of alive nodes. More alive nodes send more packets to the sink which increases the throughput of the network. Hence, the Leach Multi-Hop Protocol Network in Chirp modulation Scheme [16] achieves high throughput due to a longer stability period.

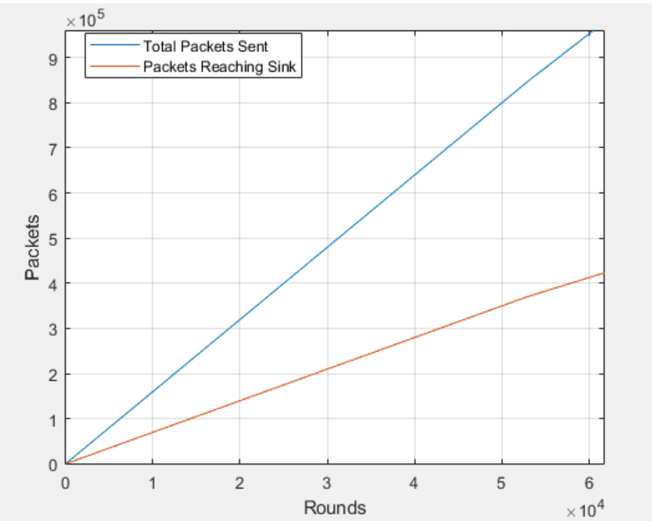

Fig.3: Analysis of Throughput.

B. Residual energy

the network's average power consumption in each round shown in figure 4. The suggested model employs a multi-hop topology, in which the data from each distant node is sent through a forwarder node to the sink. The sink node calculates the predicted required power to transmit for the network. Forwarder node is elected using a cost function. The selection of an appropriate forwarder in each round contributes to saving energy. To transfer packets to sink, our multi-hop topology uses different forwarder nodes in each round, this restricts overloading of a particular node. Simulation results show that leach multihop protocol consumes minimum energy till 70% of simulation time. It means, instability period, more nodes have enough energy, and they transmit more data packets to sink. It also improves the network's throughput.

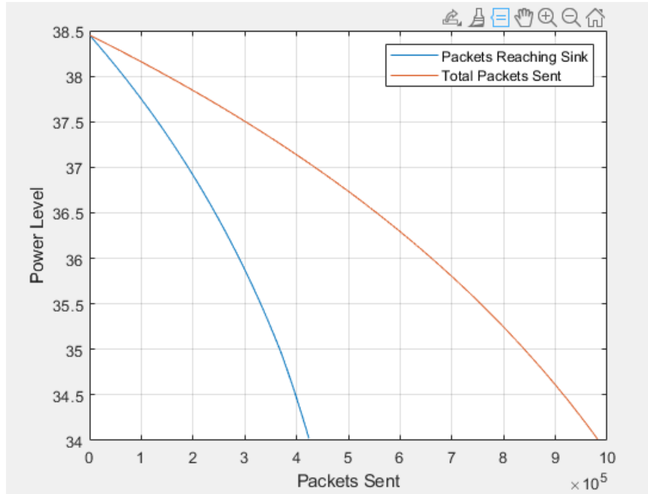

Fig.4: Total Power level over Total Packet sent.

Conclusion:

A method for routing data in railway tracks is presented in this paper. The proposed scheme uses a cost function to select an appropriate route to sink. The cost function is calculated based on the residual energy of nodes and their distance from the sink. Nodes with less value of cost function are elected as the parent nodes. Other nodes become the children of that parent node and forward their data to the parent node. Our simulation results show that the proposed routing scheme enhances the network stability time and packet delivered to the sink. Path loss is also investigated in this protocol. The results show that the proposed routing algorithm has less energy consumption and more reliable in sense of packet delivery. in future work, other routing protocol techniques will be investigated when mobile nodes are present in the mesh network to get maximum network lifetime.

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