Deep neural network with fuzzy algorithm to improve power and traffic-aware reliable reactive routing

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ABSTRACT

In wireless networks, link breaks, and restricted resources create fundamental challenges for maintaining network applications. Several wireless network routing techniques concentrate on power efficiency to expand the network lifetime, but the traffic and reliability parameters are not the primary concern. Though, these techniques are not capable of dealing with the wireless network. Hence, this paper proposes deep neural network (DNN) with a fuzzy algorithm to improve power and traffic-aware reliable reactive routing (PTAR) in wireless networks. The wireless network is formed by clustering by the node power and selects the cluster head (CH) based on a fuzzy algorithm. The wireless node power level, node buffer space, and node reliability to consider the input parameters of the fuzzy system. Then thefuzzy algorithm gives the output for CH round length. This selected CH improves the node reliability, power efficiency with minimized network congestion. Then we use a DNN algorithm to choose an optimal relay by applying an adaptive load balance factor in the network. DNN is a machine learning algorithm, and it provides high accuracy. From the simulation results, the PTAR approach improves the network performance, such as packet received ratio, delay, residual energy, and routing overhead.

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1. INTRODUCTION

Several applications and protocols used in wireless networks use connection quality estimations to improve the system's overall performance. However, accurately characterizing wireless connections in wireless networks is difficult since the links encounter regular channel changes and complicated interference patterns. But, it isessential to estimate the quality of the wireless connection to maximize the performance. In wireless networks, determining the quality of a link often involves evaluating the received signal intensity in addition to the error rates. Wireless networks have minimal access to resources, including energy, memory, and bandwidth. Because low-battery-powered nodes are often not capable of recharging, the amount of energy used by each node impacts not only the node's lifespan but also the network's lifetime as a whole. Therefore, energy is a vital resource. Since the path that uses the least amount of energy may differ from the path with the best performance. In most cases, a longer distance between the sender and the receiving node results in a longer delivery delay [1]. On the other hand, the nodes with the fewest total hops are the ones that use the least amount of energy, but this only sometimes equates to high performance. Additionally, the algorithm needs energy-efficient to increase the network's lifespan [2]. Congestion may have a significant effect on the performance of a wireless network. This manifests as a drastic fall in throughput and an increase in the energy used and the amount of time it takes for packets to be delivered. Congestion management is a vital topic in wireless networks [3]. Congestion might result in a buffer overflow since individual nodes have limited memory. As a consequence, this kind of buffer overflow issue may lead to the loss of essential information, which harms both the amount of time it takes and the amount of energy it uses [4]. As a result, considering buffer space while designing routing protocols is an absolute need [5]. The maximum power point tracking approach is widely used to enhance photovoltaic efficiency since it can produce maximum power under various weather conditions [6].

Problem formulation: using a wireless network makes it possible to ensure fast and reliable delivery of essential data. However, due to unreliable wireless connectivity and the fact that it is being implemented in hostile settings, the data transfer's dependability is reduced promptly. In that case, it may lead to the loss of essential data packets, an increase in energy wasted, and an extra delay. Thus, it is vital to cut down on packet loss to improve the network's performance. Accordingly, developing a routing method that can prioritize accurate data transmission is of the utmost importance. Table-driven routing methods use a lot of bandwidth and need a lot of storage space, reactive routing systems are intended to cut those costs. The dynamic path between a sender and a receiver may be constructed by these protocols using the on-demand applied processes. The power aware routing algorithm (PARA) objective is to enhance the routing established on the power level. This approach develops the details about routes to compute an essential power. It enhances the routing life. However, this approach increases the network traffic and can not provide reliable routing [7]. To solve these issues, deep neural network (DNN) with a fuzzy algorithm to improve power and traffic-aware reliable reactive routing (PTAR) is proposed.

Work contribution: the wireless node power level, node buffer space and node reliability to consider the input parameters of the fuzzy algorithm [8], [9]. The fuzzy algorithm gives the forecasted output like the round length for selecting the cluster head (CH). The main purpose of this paper is to propose a DNN algorithm for solving the optimal relay selection problem by applying the adaptative load balance (ALB) factor that reduces the computational cost. This approach improves node reliability, power efficiency with minimizes network congestion. The remaining parts of the article is structured as described below. DNN with a Fuzzy algorithm to improve PTAR is discussed in section 2. The results of the simulations are presented in section 3. Finally, the conclusion is presented in section 4.

Power is an essential need for the network at all times. Because of this, one of the key performance objectives of such networks is to cut down as much as possible on the amount of power needed by each message. It extends the period during which a gadget powered by a battery can work before the infrastructure has to be maintained. Developing the channels' active time is necessary to convey a complete data package. This is because the amount of time the channels are active is limited. Power-saving routing (PSR) algorithm is designed to reduce the amount of power consumed by a network by routing packets more efficiently. This decision was taken after considering the actual channel characteristics, which included multipath fading, in terms of the minimum amount of power used. However, even though the extended PSR approach is suitable for ordinary network situations, it could be better for usage in conditions that include hybrid networks. This is because hybrid networks present unique challenges. The minimal power cooperative routing technique (MPCR) [10] is used to build a lesser power path, whichensures throughput via an optimal path. This is done even though the path may take longer. Nevertheless, one of the potential drawbacks of the MPCR is that there is a certain amount of time before the optimal path to a specific location will be available. This is likely the case because of problems along the way, such as the exhaustion of the available power supply.

An example of swarm intelligence algorithm to generate meaningful global behavior that cannot be done by each person working alone [11]. Richard Stallman is the one who invented the concept of "swarm intelligence". Ant colony optimization (ACO), is a process that imitates the actions of real-life ants as they search for food. It is an intriguing alternative for creating routing algorithms for wireless sensor networks (WSNs) since it has many helpful qualities. These characteristics include the following: To overcome difficulties with optimization, a significant number of research articles used ACO [12], [13]. This discovery has allowed these approaches to become more widely utilized. Particle swarm optimizer with crossover operation (PSOCO) [14] is an optimization approach that has been recommended because it employs not one but two different crossover processes. The ability of the PSOCO to pinpoint the most advantageous node is the source of its power. It considers the optimal route from various vantage points and angles. Power-aware cooperative routing (PACR) algorithm as a method for determining the most effective route from the origin to the destination. This approach takes into account the power constraints of the network. This approach considers the power level necessary for effective cooperative communication to maximize the likelihood of success in accomplishing its objectives. On the other hand, this was constructed without considering the requirements for a minimal lifetime for this path. Furthermore, the PACR uses the next hop as a metric in its search for the most effective path, yet this strategy needs to generate routes with the greatest potential throughput [15]. To characterize the fading influence of wireless networks in industrial contexts, a three-layer framework has been developed for the impulse response. Experiments that were carried out in a variety of different industrial settings showed that doing so significantly improved accuracy [16]. The Gilbert-Elliot two-state Markov model is used to carry out a study of the packet received rate (PRR). After that, thelink quality indicator (LQI) is converted into one of two distinct states according to the threshold established by the previous step. The Gibert-Elliot model, developed in line with the LQI [17], is utilized to measure the PRR.

Monitoring link quality in the routing protocol for low-power and lossy networks (RPL), also known as the RL probe, offers an accurate assessment of link quality with minimal wasted overhead and energy. The RL probe uses synchronous monitoring tactics and asynchronous monitoring strategies to preserve the information it gathers on the link quality up to date and swiftly adjusts to any unforeseen changes that may occur in the topology. An RL model drives monitoring operations and reduces the overhead [18]. An approach to determining the quality of connections that extensively uses support vector machines and employs several different classes. The received signal strength (RSS) and LQI are estimation parameters, and the connection quality is segmented in line with the PRR. The model can accurately assess the current connection quality [19] by using only a few probe packets. It is usual practice for hardware-based link quality estimator (LQE) algorithms to make use of characteristics like the received signal strength indication (RSSI), the LQI, and the signal-to-noise ratio (SNR) [20], [21] methods for estimating connection quality use the RSS and information acquired from data packets received to evaluate link quality [22]. Despite this, experiments [23] have shown that RSS is not sensitive to fluctuations in the quality of connections when used in its intended manner. The LQI would be used as a parameter once the connection quality was found to be of a high standard. On the other hand, the LQI values that were acquired via quick links show a much higher degree of fluctuation. The signal-to-noise ratio, often known as SNR [24]. The DNN algorithm can tackle various challenges because DNN can accurately estimate high nonlinear functions despite its relatively modest complexity, it has enabled various exciting applications in wireless communications [25]. The selection of the relay [26] and the assignment of the channel [27] are examples of some of these applications. Since relay selection has the potential to improve throughput [28], researchers have focused a significant amount of their attention on studying it over the past decade. A maximizing strategy is needed to choose the most appropriate relay selection, and accurate channel state information (CSI) is essential [29].

2. POWER AND TRAFFIC-AWARE RELIABLE REACTIVE ROUTING

The wireless network contains a number of wireless nodes and these nodes move freely in the network field. The block diagram of the PTRA mechanism is depicted in Figure 1. Initially, the wireless nodes build the clusters based on node power, and these nodes select the CH by applying a fuzzy algorithm.

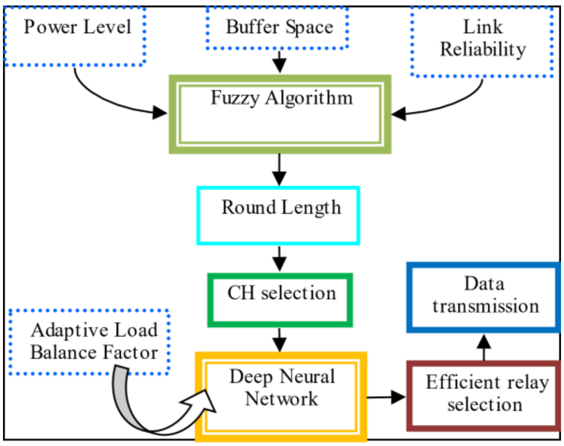

Figure 1. Block diagram of the PTRA approach

Every node updates channel state information like power level, buffer space, and link reliability. The fuzzy algorithm produces the round length (RL) output. Then we use the DNN algorithm to select the optimal relay based on adaptive load balance factor to enhance the routing efficiency.

Power level: absent of energy utilization management will affect the outcome of unbalanced residual energy allocation among wireless nodes, making origin holes in the receiver node region. Thus, power is essential since it minimizes energy expenditure and increases lifetime. The sender node checks the neighbor node's power level during route discovery based on the route request (RREQ) packet. The node power level (PL) computation is given (1). Where, IE designates an initial energy, the residual energy is depicted by RE, as well as TE refers the transmission energy.

$$PL = exp\left[\frac{1}{\frac{1+(IE-(RE-TE))}{IE}}\right] \tag{1}$$

Buffer space: in a wireless network, the node buffer size is restricted, and the buffer cannot extend size when presenting the highest data packet. For that reason, the node loses a particular amount of data packets; hence, it causes delay and packet retransmission. To avoid this issue, before data transmission, checks the buffer space. Normalized buffer space (NBS) denotes the ratio between the buffer's space and size. It evades the packets waiting for a long time in the queue. NBS computation is given (2).

$$NBS = \frac{Buffer\ Space}{Buffer\ Size} \tag{2}$$

Node reliability: node reliability (NR) is a significant component since time data forwarding suffers from disconnection of the link. It creates an additional delay, energy utilization and retransmits the data. Thus, link reliability-based data transmission to improve the routing efficiency. The NR computation is given (3).

$$NR = \frac{1}{FTR \times RTR} \tag{3}$$

FTR indicates the forward transmission ratio that represents the feasibility of a packet effectively recognized, and the reverse transmission ratio (RTR) that means the feasibility in which the Acknowledgement packet is effectively identified.

2.1. Fuzzy algorithm-based CH selection

The clustering concept is used to improve energy efficiency. Here, the CH nodes are chosen by the fuzzy algorithm based on node energy, NR, and node buffer size parameters. Here, NR and node energy and node buffer size values are specified as the input, giving the output is RL. The RL selection ratio calculation is specified (4).

$$RL = Highest(round\left[RL_{highest} * Fuzzy(NR, NB, NE)\right], 1) \tag{4}$$

Every node has informed the value of RL highest, and the highest RL value node is selected as a CH. The fuzzy set reports the node reliability input variables are very high, high, middle, low, and very low. The node energy input variables are very high, high, middle, low and very low. Furthermore, the buffer availability fuzzy input variables are very high, high, middle, low, and very low. The RL output variables are very high, high, middle, low, and very low.

ALB: the greatest data flow is insufficient to the link's capability, creating a bottleneck. Hence packet loss occurs. So, we select the route that equates the load based on the ALB factor. The ALB factor calculation assists in minimizing the clustering network traffic and enhances the network performance. The ALB factor for each route calculation is given (5).

$$N_{ALB} = \left[C_{OH} + P_{OH} + \frac{TB}{DT}\right]\frac{1}{1-\beta_{TS}} \tag{5}$$

Where OH_C denotes the channel overhead, OH_P denotesthe protocol overhead, DT denotes the data transmission, TB represents the test frame bits and β_{TS} denotes the calculatingtime of transmission state. For example, Figure 2 explains source B selects the route based on the ALB factor. In this figure, node B is a source, D is a destination, and X, Y, and Z nodes are intermediate nodes.

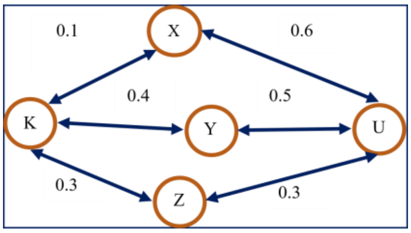

Figure 2. ALB factor illustration

The node K to U builds the routes are K→Y→U, B→X→U and K→Z→U and these route whole ALB factor loads are 0.9, 0.7 and 0.6. In route K→X→U in whichX→U is greater; accordingly, traffic will happen at node X, which makes the packet drop. Alternatively, the route K→Z→U load is uniform; as a result, the packet drop is minimized. The load balance threshold can be defined as in (6). Where, THALB represents the threshold of adaptative load balance and NALB(i) represents the route adaptative load balance.

$$TH_{ALB} = \frac{1}{m}\sum_{i=1}^{m}(N_{ALB}(i)) \quad (6)$$

2.2. DNN based relay selection

The DNN algorithm measures the weight, which can be intended as the function of mapping. The features of input rearrange as a vector that is specified in (7). Then it computes the weight based on the adaptive load balance factor. The DNN algorithm obtains the modified input weights and then computes the output for selecting the relay nodes and this output calculation is specified in (8).

$$X^{(m)} = [x_{PL}, x_{NBS}, x_{NR}] \quad (7)$$

$$Y = N_{ALB} > TH_{ALB} \quad (8)$$

Where, the Y value is introduced between 0 to 1 and the preset threshold value is 0.5. The DNN algorithm based relay selection to enhance the route dependability and and power level.

3. SIMULATION ANALYSIS

Here, the network simulator tool is used for evaluating the network performance. This section exists packet received ratio, routing overhead, delay, and residual energy parameters to demonstrate the achievable performance of the introduced PTAR approach. This research is performed by raising the wireless nodes from 20 to 100 nodes. Table 1 illustrates the simulation parameters of the PTAR approach.

Table 1. Simulation parameters of the PTAR approach

Parameters	values
Time for simulation	200 seconds
Channel	Wireless
Wireless nodes	100
MAC	802.11
Transmission range	180 meter
Range of transmission	150 meter
Simulation region	800×900 m^2
Size of the packet	1024 bytes
Bandwidth	11 Mbps
Rate of flow	128 kbps

Packet received ratio is the ratio between the number of packets effectively obtained by the receiver and the overall amount of data packets forwarded by the sender nodes. Routing overhead is defined as the ratio of control packets created to the number of effectively obtained data packets. The network is realistically congested because of the highest load and the reasonably high wireless nodes. Figure 3 illustrates the packet received ratio of PARA and PTAR approaches based on wireless node count. The routing overhead of the PARA and PTAR approaches is shown in Figure 4.

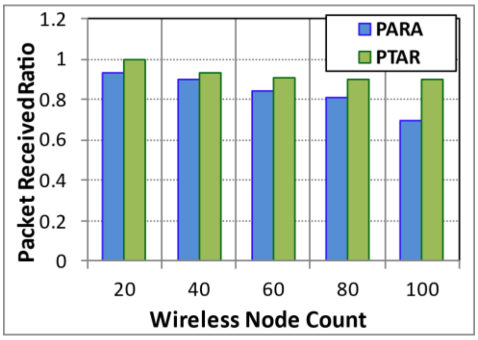

Figure 3. Packet received ratio of PARA and PTAR approaches

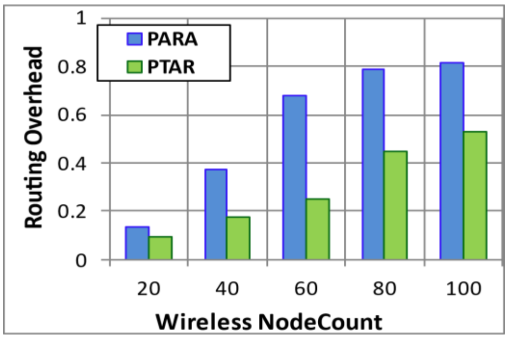

Figure 4. Routing overhead of PARA and PTAR approaches

From Figure 3, when the wireless node count increases, the packet received ratio of the PARA approach is highly decreased; however, the PTAR approach is slightly reduced since the proposed mechanism chooses the best relay node by node reliability, node power level, and node buffer space. From Figure 4, the fuzzy algorithm-based CH selection is minimized the network load. The DNN algorithm predicts the relay is minimized the network traffic since it selects the relay by the ALB factor. As a result, the PTAR approach minimized the routing overhead. But, the PARA approach only concentrates on energy efficiency. The delay metric is a significant since it minimizes network congestion. Figure 5 explains the simulation result of the delay with various wireless nodes, and it is measured by the millisecond. Figure 6 displays the residual power level of PARA and PTAR mechanisms versus the wireless node count.

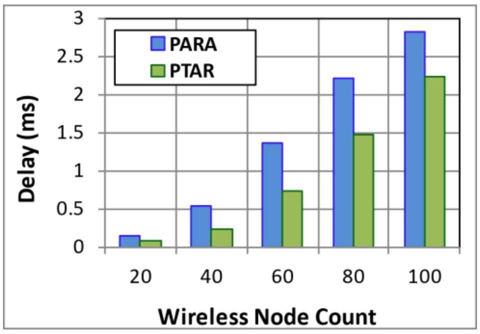

Figure 5. Delay of PARA and PTAR approaches

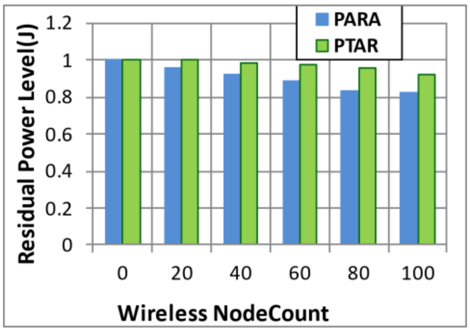

Figure 6. Residual power level of PARA and PTAR approaches

Here, raising the wireless nodes initiating from 20 to 100 nodes. The Figure 5, illustrates that the PARA approach delay rises when the wireless node count increases. Although the PTAR mechanism minimized the packet delay than a PARA mechanismsince the PTAR mechanism utilizes a DNN machine learning algorithm to select the relay, fuzzy-based CH selection reduces the delay in the network. The amount of power residual in the present time is known as the residual power level. From Figure 6, the wireless node count rises from 20 to 100 nodes; the PARA and PTAR approach minimizes the power level. Figure 6 obliviously demonstrates that the PTAR approach increases the power levelthan a PARA mechanism because the DNN algorithm picked out the relay based on the power level. Furthermore, the clustering concept minimizes the utilization of power level. Hence, the PTAR approach increases the power level in the network.

4. CONCLUSION

Several issues, for example, power-aware routing, traffic-aware routing, and reliability-aware routing, cause vast challenges in maintaining routing in wireless networks. DNN-based evaluator to solve the optimal relay selection issues by rapidly arriving at the optimal solution. In this article, we introduced PTAR using the DNN algorithm to improve the routing efficiency. The main aim of the DNN methodis to select the best relay and minimize the computational cost based on the adaptive load balancing factor. The fuzzy algorithm gives the input for choosing the CH by applying parameters like power level, buffer space, and node-link reliability that compute the fuzzy output, such as round length. The highest round length node is selected as a CH; as a result, it minimizes the utilized power. The simulation results demonstrate that the proposed PTAR approach increased the packet received ratio and enhanced the power level. Moreover, it reduced both the network delay and the routing overhead. The wireless network is heavily attacked due to wireless is unreliable. So, we will identify several types of attacks in the future.

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BIOGRAPHIES OF AUTHORS

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