Abujassar *J Wireless Com Network* (2024) 2024:46
https://doi.org/10.1186/s13638-024-02377-1

EURASIP Journal on Wireless
Communications and Networking

RESEARCH **Open Access**

A multi path routing protocol with efficient energy consumption in IoT applications real time traffic

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Abstract

The extensive utilization of IoT applications leads to the aggregation of a substantial volume of data, presenting a crucial challenge in terms of data routing within these networks. RPL intentionally surpasses the limitations sometimes observed in low-power and lossy networks, which are particularly prevalent in IoT networks. The RPL protocol is designed specifically for static networks that do not involve mobility or topological changes. The RPL protocol guarantees continuous connectivity between nodes and mitigates the risk of data loss in stationary IoT applications that do not involve mobility or alterations in network configuration. The article utilizes a mobility aid technology known as network performance stability using the intelligent routing protocol (nPSIR), which expands upon RPL. The Mobility Support Entity (nPSIR) facilitates the displacement of all nodes, with the exception of the root node, and ensures uninterrupted connection during mobility. Moreover, it deals with the situation where there is a physical barrier between two interconnected nodes in a changing environment. In order to achieve this objective, it employs a dynamic trickle timer that operates within two distinct ranges. Furthermore, it utilizes a neighbor link quality table, a mechanism for selecting the most beneficial parent node in the event of migration, a measure of confidence, the identification of crucial regions, and a blacklist. Multiple simulations validate that nPSIR effectively decreases hand-off delay and improves packet delivery, despite the minor drawbacks of increased signaling costs and power consumption. The delivery ratio decreases the quantity of lost data packets and surpasses both RPL as a responsive protocol and mRPL as a proactive protocol in relation to mobility.

Keywords: Network performance stability using the intelligent routing protocol (nPSIR), Internet of Things (IoT), HEAD nodes (HN), Request packets for creative and investigation (RPcI), WSN

1 Introduction

With the rise of the internet of things (IoT) and the increasing use of low-power and lossy network (LLN) applications, it is crucial to efficiently manage and guide the large amount of data generated by these networks.LLN which make up the majority of the internet of things (IoT), have specific limitations in terms of memory, energy, and processing capability. Furthermore, LLN networks also include links that are susceptible to data loss. The difficulties linked to data routing are substantial. Hence, a routing protocol that can seamlessly operate with diverse networks would be crucial. As a result, the IETF adopted the Routing Protocol for low-power and lossy networks (RPL) as described in the references [10] and [32]. The majority of the proposed solutions designed for multi-hop routing focus on addressing the limits of nodes in IoT networks, such as their energy constraints and the requirement for broader radio coverage, as depicted in Fig. 1. A multi-hop infrastructure-based routing system enables the transmission of data between sensors and the Internet. Hence, two main approaches were put forward: the initial approach proposes the transmission of data through ad-hoc networks until it reaches the Internet, employing techniques like AODV, DSR, and floods [2]. In contrast, the second approach argues that traditional routing protocols should be used to control traffic in IoT networks. The author presents a concise explanation of three fundamental methods for multi-hop routing: Data-centric protocols facilitate the transport of data by routing it through designated nodes. Geolocation protocols establish routing based on the geographic coordinates of the nodes. Hierarchical protocols implement a hierarchical arrangement of nodes within a specific region, wherein each node transmits its data to the central node for the purpose of routing [44]. The 6LoWPAN functions as an intermediary for communication between LLN devices and IP protocols. Various methods, such as CTP, Hydro, Hilow, and Dymo-low, have been developed by researchers to improve the compatibility of 6LoWPAN with low-power and lossy networks [8, 9].

The introduction of RPL was explicitly aimed at achieving this purpose, as stated in the references [15, 23]. Resource Public Key Infrastructure (RPL), which employs Internet Protocol version 6 (IPv6), is founded on the distance vector algorithm as described in the survey conducted by [31]. The IEEE has implemented a standardized framework for the physical (PHY) and media access control (MAC) layers of devices that utilize

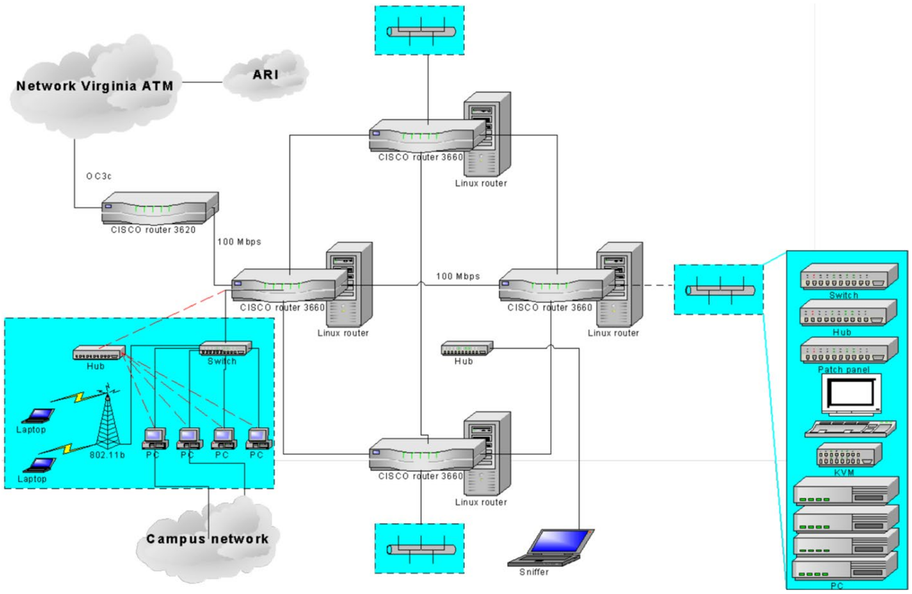

Fig. 1 IoT Networks LAN and Ad Hoc

LoWPAN technology. This framework is referred to as IEEE 802.15.4. The Internet Engineering Task Force (IEFT) introduced 6LoWPAN as an intermediary between the IEEE 802.15.4 standard and the IP protocols. LLN devices can connect to the Internet and send their IPv6 packets to lower layers using the IEEE 802.15.4 standard. The Routing Protocol for Low-Power and Lossy Networks (RPL) is responsible for implementing the 6LoWPAN protocol at the network layer. The transport layer employs the User Datagram Protocol (UDP), whereas the application layer utilizes the Constrained Application Protocol (CoAP) [14, 34]. The RPL protocol enhances the efficiency of network topologies that remain consistent and settings that do not change, demonstrating exceptional performance in these conditions. However, RPL is not capable of successfully managing the migration of nodes and alterations in network structure, which are common in many LLN applications. Consequently, nodes may experience disconnection, resulting in the loss of packets and depletion of energy. Moreover, additional cases of RPL defections in the mobile setting will be thoroughly investigated at a later time. Therefore, a routing protocol is necessary to allow the movement of nodes and adapt to changes in network architecture. Furthermore, the widespread use of the Internet of Mobile Things (IoMT) significantly impacts the implementation of e-health, building automation, and smart cities. The studies conducted by [11, 26] are being referenced. Scientists have suggested different approaches to improve the ability to navigate in RPL. However, the majority of them limit the movement exclusively to the leaf nodes, following the tree-like structure of RPL. Moreover, they often exhibit incompatibilities with the constraints of the LLN in various instances. The nPSIR protocol is utilized to introduce the Network Performance Stability protocol. The proposed protocol enables unrestricted mobility of any node inside the Directed Acyclic Graph (DAG), regardless of its location, as long as it remains within the boundaries of low-power and lossy networks [7]. Below, we have enumerated our contributions:

- Facilitating the mobility of all nodes except the source node (dynamic topology).
- Ensuring a seamless and uninterrupted connection during node movement.
- Improving the effectiveness of nPSIR in situations when there is an obstacle between two nodes in a dynamic environment;
- Implementing a dynamic routing mechanism for re-routing the traffic via alternative path with different node speed.

Employing temporal data analysis helps enhance comprehension of the diverse applications of the subject matter. Our surrounds are populated with numerous low-powered edge devices. These devices gather video or sensory data in a sequential manner over a specific duration. In order to derive meaningful patterns and valuable insights from past temporal data, it is possible to distribute data segments over multiple servers for processing, with the ultimate goal of subsequently merging the obtained outcomes. The available data sources include temperature, humidity, air pressure, fire alarms, security breaches, and CCTV footage collected in the days or weeks prior to the present instant. The increasing number of gadgets immediately intensifies internet congestion. When transmitting data for different applications inside the internet of things (IoT) and the 6LoWPAN network, several challenges may arise. If the chosen protocols and approaches fail to effectively manage congestion, there could be future consequences. There is a possibility of encountering network problems. The following items are as follows:

- Packet loss is the occurrence when one or more transmitted packets fail to reach their intended destination. This phenomenon, referred to as packet loss or packet drop, can be ascribed to network congestion or overload. [6].
- The end-to-end delay has experienced an escalation, resulting in a noticeable rise in latency, hence causing a delay in the arrival of packets at their intended destination. Network congestion can cause significant delays in network communication. In such situations, it is wise to choose the most beneficial course of action in order to achieve the desired outcome. Hence, the utilization of routing protocols is imperative for mitigating congestion, as affirmed by [4].
- Load Network balancing refers to the systematic distribution of packets across many channels within a network, with the aim of ensuring their reliable and efficient delivery to the desired destination. This strategy is evaluated and appraised as a means of achieving effective load balance. Failure to account for the possibility of choosing a route with minimal network traffic during the transmission of packets might lead to congestion. [46].
- Throughput is a crucial factor in mitigating congestion, as it quantifies the quantity of packets that are successfully transmitted from a source to a destination within a given timeframe. To effectively manage congestion, it is imperative to employ appropriate solutions. [33].
- The continuous transfer of data between internet of things (IoT) devices causes the ongoing activation of networking equipment, leading to a perpetual energy waste.

Therefore, in order to enhance the energy efficiency of devices, it is imperative to effectively manage congestion. Furthermore, the quality of the network is influenced by various factors, including the network's longevity, the strength of the connection, the level of control needed, the latency between different points in the network, and the presence of different devices within the network. The internet of things (IoT) is widely regarded as an essential element of the future internet, with significant implications for various fields. Nevertheless, the issue of resource allocation poses a significant obstacle to the future expansion of the internet of things (IoT), specifically with network congestion [24]. The 6LoWPAN network is widely acknowledged as a vital component of the internet of things (IoT). The presence of congestion in 6LoWPAN networks significantly impairs both performance and quality of service (QoS). This congestion is caused by limitations in memory, power, processor resources, bandwidth, and load balancing. In order to address these issues, it is imperative to implement congestion detection, avoidance, and control methodologies. Despite the extensive efforts made by standards bodies, corporations, coalitions, research institutes, and other stakeholders, the issue of network congestion persists without a solution. Therefore, it is imperative to prioritize the management of network congestion and the optimization of spectrum utilization. The subsequent framework encompasses the fundamental content of this article: In Sect. 2, we conducted a thorough analysis and comparison of the improved algorithm and the methodology used in other relevant studies. Nevertheless, we have incorporated the analysis of energy and power consumption, enabling us to assess the impact of power on each node in the network design. In Sect. 3, we analyzed the cited research that is pertinent to our topic.Furthermore, we have provided the equations utilized in the theoretical modeling, together with a segment of the code employed to execute the described protocol including multiple paths, in Sect. 4. In order to reduce latency in monitoring the connectivity between nodes in a grid internet of things (IoT) network, it is imperative to augment the frequency of transmitting RPcI signals for improved network performance monitoring and tracking. This article provides a concise overview of the relevant literature and research on enhancing node clustering in the internet of things (IoT) framework for smart cities. This inquiry will analyze via (nPSIR) protocols, including mRPL and RPL, that have been developed or improved. RPL is a routing protocol that functions in a multi-hop and hierarchical fashion. It is specifically tailored to meet the requirements of static IoT networks, while considering the constraints of LLN. The protocols have been developed or enhanced to establish a tree-like structure called the Directed Acyclic Graph (DAG), which enables hierarchical IPv6 routing to guide data between devices within a certain area. During typical routing settings, nodes send their packets to the sink node for transmission across the internet. Section 5 provides a comprehensive overview of the simulation parameters, along with a thorough exposition and analysis of the achieved outcomes. The overview and future work have been described in Sect. 6.

2 Methodology for the proposed nPSIR

The RPL routing protocol, specifically designed for LLNs in internet of things (IoT) applications, has limitations when used in high-density networks, especially with mobile nodes. The literature survey clearly indicates the widespread presence of mobile nodes in IoT networks and applications. Data transmission in these networks is commonly perceived as below standard and lacking in reliability. The sharing of data between mobile nodes, specifically in vehicle-to-everything (V2X) communications, which includes vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicular mobile network (V2C) communication, as well as users with access points and users with mobile connections, has led to a decline in the quality of service (QoS) when combined with network mobility performance. Moreover, achieving a high level of service quality (QoS) in a mobile environment is significantly more difficult. A Local Area Network (LAN), also referred to as an ad hoc network, comprises communication technology designed for both fixed and mobile situations. Static components, such as Roadside Units (RSUs) and Advanced Metering Infrastructure (AMIs), remain in a fixed position, while mobility nodes refer to cars that are in motion on the road. Hence, this research delves into these matters for the inaugural occasion, with a particular emphasis on the inadequate quality of service (QoS) associated with mobility. Therefore, we hereby propose the optimal strategy for achieving and sustaining optimal network performance in diverse scenarios. Firstly, we ascertain the exact attributes of the Quality of Service (QoS). In this study, we offer the mobility models utilized for a network including 10–220 nodes, with the potential for expansion up to 200. The main parameter in the primary approach of the suggested methodology can be summarized as follows:

- QoS Parameters: In this context, we focus on the expected transmission count (EXT), which represents the number of transmission packets required for effective delivery from the source to the destination. The value is discrete and calculated as follows:

  $$EXT = \frac{1}{Df * Dr} \tag{1}$$

  Df represents the likelihood of a sent packet being successfully received by the neighbor, whereas Dr represents the probability of successfully receiving the acknowledgment packet. A lower ETX number indicates higher reliability of links/protocol in the network. The value can be acquired from the collect view of NS2 Simulation for each experiment.
- PDR, or Packet Delivery Ratio, is the proportion of packets that have been successfully delivered to the intended destination out of the total number of packets that were sent to the destination. The calculation is as follows:

  $$PDR = \frac{\sum_{of\ all\ recieved\ packets}}{\sum_{of\ all\ sent\ packets}} * 100 \tag{2}$$

  Network performance improves when the PDR (Packet Delivery Ratio) increases. To get this value, one must gather the data on received and sent packets from the collect view of NS2 Simulation for each experiment.
- Traffic OverHead (ToH):Control messages are produced to establish and sustain Destination Oriented Directed Acyclic Graphs (DODAG). The four forms of control messages are Solicitation (DIS), DODAG Information Object (DIO), and Destination Advertisement Object (DAO). ToH represents the cumulative aggregate of these control messages. The ToH holds a lower position, while the protocol performance is enhanced. The value is discrete and calculated as:

  $$ToH = \sum_{x=1}^{m} DIO(x) + \sum_{x=1}^{n} DIO(x) + \sum_{x=1}^{o} DAO(x) \tag{3}$$

Given variables x and m, this value can be incorporated into all topologies for analysis of the data provided by NS2 simulation. The examination of the produced results will provide a summary of the overall number of sent packets and the total number of received packets.

- Energy Consumption (EC):The EC refers to the total power or energy utilized by the nodes for the entire duration of the network's existence. The power consumption of the acknowledgment packet is lower. A lower ETX number indicates higher reliability of links/protocol in the network. The value can be acquired from the collect view of NS2 Simulation for each experiment.

$$EC = ((T * 19.5\,mA + L * 21.5\,mA + CPU* \\ 1.8\,mA + LPM * 0.00545\,mA) * 3\,V)/32768 \tag{4}$$

T denotes the transmission duration, L denotes the listening duration, CPU marks the period of maximum power consumption by the CPU, and LPM represents the time when the CPU operates in low power mode. The radio transmission time, indicated as T, and the radio reception time, identified as L, are both time-dependent variables in node communication. The values acquired from the collect view can be examined during simulation in NS2. The CPU is a statistic that quantifies the extent of computational activities executed by a node. In contrast, LPM denotes the energy usage of a node when it is not actively functioning. The collect view in NS2 enables the surveillance of CPU time and LPM time data during the trial. The total power consumed during the simulation is calculated by combining these four power categories. Introducing the idea of genetic fitness as a tactic to reduce energy use. Furthermore, the network expands its coverage. This section offers an extensive analysis of several components related to physical fitness. The main focus is on the straight-line distance (DD) to the base station (BS). The direct linear distance (DD) to the base station (BS) denotes the computation of the overall distance or separation between the sensing nodes and the base station, as specified by Eq. 5. The gap or distance is determined by a mathematical Eq. 6.

$$C = \sum_{i=1}^{k} d_{ih} + d_{hs} \tag{5}$$

$$DD = \sum_{i=1}^{m} \frac{d}{is} \tag{6}$$

In this specific context, we will denote the distance as d, the ith node as i, and the base station as S. This refers to the distance between two distinct nodes, namely node **i** and node **S**. In order to enhance the energy efficiency of nodes in bigger networks, it is imperative to limit energy loss by reducing the distance between them. In Eq. 6, the word "node distance" refers to the cumulative area encompassing the nodes from the node head to the base station node, along with the area covered by the nodes in the network topology. Equation 6 represents the membership of the C node in the K collection of nodes. The node distance is measured by the standard deviation (SD). To achieve a uniform and evenly distributed configuration of sensor nodes, it is crucial to limit the variability in the distances between the nodes. However, while spreading nodes in a random and non-uniform manner, it is essential to ensure that the distances between nodes are not the same. The calculation of node gaps and standard deviation, as denoted by Eqs. 7 and 8, is performed in the following manner:

$$SD = \sqrt{\sum_{i=1}^{h} (\mu - d_{nodes})^2} \tag{7}$$

$$\mu = \frac{\sum_{i=1}^{h} d_{topology}}{h} \tag{8}$$

The energy transfer (E) represents the amount of energy consumed in transmitting the entire message from the cluster head node to the BS node. The quantification of energy transfer within a network of interconnected nodes is determined by the number of K members. According to Eq. 9,

$$E = \sum_{j=1}^{k} E_{Tjh} + K + E_R + E_{ths} \tag{9}$$

Zigbee is a wireless communication system that operates within the 2.4 GHz or 2400 MHz frequency range. Therefore, the wavelength λ of Zigbee may be determined by applying the formula $\lambda = c/f$, where c denotes the velocity of light, around $3x10^8$ meters per second. The power received by the receiver, denoted in decibels (dB), diminishes proportionally as the distance (d) between the transmitter and receiver grows, as demonstrated by Eqs. 10 and 11. They provide data on the initial power received by the receiver (Pr) at a precise distance (d) of 1 m.

$$P_r = P_0 \div d^2 \tag{10}$$

- Latency: Latency refers to the overall delay experienced by a packet from the moment it is transmitted from the source until it is successfully received at the destination. A network's efficiency increases as latency decreases. The calculation is performed as follows 11:

$$Latency = \sum_{x=1}^{m} RT(x) - ST(x) \tag{11}$$

The value can be determined by evaluating the data generated after each experiment in NS2, where RT represents the receive time and ST represents the sending time for each node in the topology. The calculation involves variables x and m. Each communication is linked to a mote ID and timestamp, enabling us to determine the delay for a particular node by subtracting the transmitting timestamp from the receiving timestamp. The combined latency of all nodes is equivalent to the total latency of the network.

- Throughput: is the quotient obtained by dividing the total number of transmitted packets by the total duration of the simulation. The measurement is denoted in packets per second. The network's performance is contingent upon the amount of traffic it carries. The calculation is performed as follows in 12:

$$Throughput = \frac{Total\ of\ sent\ Packets}{Simulation\ Time} \tag{12}$$

An analysis reveals a high positive correlation between ToH and Throughput, as well as a large negative correlation between PDR and Power/EC. Power/EC and Total Latency exhibit a weak positive correlation, while PDR and Total Latency demonstrate a negative correlation. Consequently, we can deduce that the Time of Hold (ToH) is anticipated to rise in correlation with the augmentation of throughput. Similarly, there is an expected decrease in Power/EC as the PDR increases, and vice versa.

2.1 Proposed Solution by nPSIR

The main goal of this study is to improve the routing capabilities of the standard RPL protocol in order to effectively manage high-data-rate traffic, namely real-time traffic generated by internet of things (IoT) applications. To achieve this goal, we have established and implemented a novel protocol called nPSIR, which specifically operates at

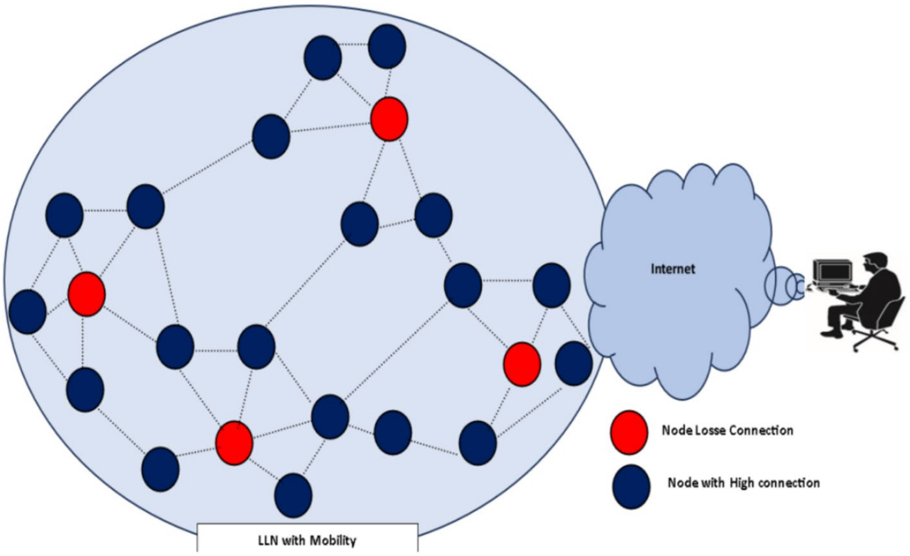

Fig. 2 System Model

the network layer, for the RPL multipath routing protocol version. The nPSIR functions as the core component of our strategy, facilitating the transmission of immediate traffic, such as UDP or any live streaming generated by IoT applications. Figure 2 depicts the primary elements of our system designed to enable encoding, transmission, and decoding in a low-power and lossy network-based wireless multimedia sensor network (WMSN). Additionally, it encompasses an evaluation of the current traffic conditions.

The proposed protocol is configured to run after the routing protocol uses a routing table to transmit data to each network node. After the routing protocol sends data to each node in the network using a routing table, the proposed protocol runs. The RcPI packets will broadcast between nodes, and when they receive signals from neighboring nodes, then this evidence that the routing table is complete, and the proposed protocol will adjust the topology and compute the multipath via the adjacent nodes. For the proactive or pre-active routing protocols use a routing database in every network node to create data transmission channels, which might take 15 s depending on node density [29, 40].

2.2 Multipath over nPSIR

The nPSIR protocol chooses multiple alternative paths to send packets while creating the DODAG. These pathways depend on the default route. The nPSIR protocol facilitates the generation of multiple routes by assigning a set of parent nodes to each node inside a network. Within this collection of parent nodes, there exists a distinct subset that is only utilized for transporting packets between the source and destination, as illustrated in Fig. 2.

RPcI packets will be solely forwarded to the nearest or neighboring node. If there are no surrounding nodes, all nodes will be unable to receive the packets. The routing table controls the actions of the main node and each individual node by storing essential information. This is the introduction to a unique platform that enables the connectivity of various devices inside an internet of things (IoT) network. The extent of network congestion increases as the number of networked devices grows. The routing system effectively monitors the traffic on each network line by evaluating the size and quantity of individual packets, enabling the calculation of the load on a specific connection. An effective approach to alleviate congestion involves modifying the transmission rate in accordance with the present state of the network. To immediately adjust the transmission rate based on changes in bandwidth and delay control. The routing information indicates the existence of an alternative route from the neighboring node to the destination, distinct from the main path. When a node seeks information about the existence of an alternative route to the destination from a neighboring node, it is attempting to determine whether or not those nodes are interconnected with other groups through additional nodes.

Algorithm 1 *ConnectedPath* nPSIR algorithm with RPcI

```
$L\_p : List - number - of - head - nodes - or - parent - Ni(m \leqslant n)$
$m : isconsidermaultipathvianeighbour$
$N\_pp = Nodeparentarepreferdtobehead$
$N\_pp = \prod N\_pp \bigodot (N_H, V_i), (N_H, NH)$
$\Gamma(N_H)$ is checking to the next available node $V_i$.
$L_p = \phi and N_{pp} = 0$
while $N_{pp} \leqslant m$ do
  $Node_{pRout} = Find(neighbour\_LeadTo\_nexthop(v_i) \notin ondemandroutingtable \approx lessDistance)$
  $Check\_its\_Routing\_Table(neighbour\_Node)$
  if $Node\_has\_NieghbourLowDist\_BuildPath$ then
    $ADDthisneighbourtoAlternativeRoutingTable$
  end if
  $N_pToDest = ThefunctionHead- > V_iisequalto(V_{i+1}, D)$
  $V\_i\_Adjacent\_Labeled\_As\_Available = elementP_rout$
  $getNH\_i\_dfortheRPcINodes$
  $Time = R - S$
  if $rout[Source][NH_{id}] = adj\mathbf{and}rout[S][NH_{id}] \neq PrimaryAdj$ then
    $NextHop[v_i] = ara_rout[v_i][NH]$
    $i \leftarrow ID + 1$
    $FomringRoute[S][NextNeighbour] = rout[NextHop[NH\_i\_d]][neighbour]$
  end if
end while
$CountRPcIoutboundfromnode$
$AllNeighbourNodes \leftarrow RPcI \notin (SandNHinthemainrouting)$
while $RPcI \neg 0$ do
  $getNH\_i\_dfortheRPcINode$
  $T = T_R - T_S$
  if $min < Time$ then
    $min = T$
  end if
  if $rout[Source][NH_{v_i}] = NextNeighbour\mathbf{and}rout[S][NH_{v_i}] \neq NextNeighbour$ then
    $NextHop[S] = ara_rout[S][NH]$
    $i \leftarrow ID + 1$
    $FomringRoute[S][NH] = rout[NextHop[v_i]][NextNeighbour]$
  end if
end while
$retuen(all - neighbour - - as - new - RoutingTable[all - alternative - neighbour])$
```

The nPSIR-RPcI method demonstrates its approach to investing in the next node of each cluster, as described by the provided equations and explanation. This involves selecting an adjacent node, referred to as the HEAD, to operate in a condition of low power or reduced energy usage until it begins to receive the primary packets from its HEAD. Subsequently, the HEAD directs these packets to the ultimate destination, irrespective of its position within a separate topology.

2.3 Path constructed in theoretical modelling

The multi-hop pathways identified by nPSIR can be categorized as either node-disjoint, link-disjoint, or partially disjoint paths. For the purpose of this discussion, let us consider the following: Firstly, the nPSIR algorithm establishes a minimum of two pathways, denoted as PR_d and PR_a, connecting a node in the network to the sink node (DODAG root). Secondly, PR_d is one of these path routes.The variable PR_a is utilized to direct video traffic with high priority (or low priority) towards the sink.The nPSIR is employed to indicate the forwarding of video traffic with high priority, whereas PR_a is utilized to denote the forwarding of real time traffic with low priority towards the sink. Let $PRd = n_s, n_1, n_2, ...n_k, n_d$ and $PR_a = n_s, n_1, n_2, n_3, n_4, n_d$, where n_s and n_d are source node and sink node respectively, n_i and n_j (i=1..k, j=1...l) are intermediates nodes that belong to paths PR_d and PR_a, respectively.

- PR_d and PR_a are node-disjoint pathways, meaning that they do not share any connections or nodes, save for the source and sink nodes. This occurs when the primary preferred parent of each intermediate node n_i in the set PR_d is not present in the parent set Pa, and the second preferred parent of each intermediate node n_j in the set PR_a is not found in the set PR_d. The formulation of this case can be expressed as follows: $\forall i, \forall j$ such that $PPPR_{ni} \notin PR_a$ and $SPPR_{nj} \notin PR_d$ (i=1...k,j=1...l)
- PR_d and PR_a are link-disjoint pathways, meaning that they do not share any links but may have multiple common nodes. This scenario occurs when the secondary preferred parent of at least one intermediate node n, which is part of path PR_a, is the same as the primary preferred parent of an intermediate node n_i in path PR_d. This scenario can be represented by: $\exists j, \exists i$ such as $SPPR_{nj}$=$PPPR_{ni}$ (i=1...k,j=1...l).
- PR_d and PR_a are partially disjoint pathways, meaning that there may be some shared links or nodes between the two paths. These types of paths occur when the second highest-ranking parent of an intermediate node n_j in path PR_a is the same as the highest-ranking parent of an intermediate node n_i in path PR_d. Additionally, the common intermediate node N_c between PR_d and PR_a only has one parent. This means that all packets received by N_c are sent to its parent node through the same link, regardless of packet priority. Here we can articulate this case by $\exists j, \exists i$ such as $SPPR_{nj}$=$PPPR_{ni} = N_c and PPPR_{ni}$,(i=1...k,j=1...l).Regardless of the characteristics of the constructed pathways, they are consistently utilized simultaneously to ensure that the combined bandwidth meets the demands of multimedia applications.

3 Background and related work

RPL gained recognition in the research community as a solution for LLN difficulties. Since then, RPL has become the main focus of analysts and has attracted various scientists to suggest and analyze its improvements. However, there have been very few studies that have specifically focused on discussing RPL for IoT networks. This lack of research motivates us to do this study. In previous publications [28], researchers introduced a Context-Aware Objective Function (CAOF) and conducted a comparative analysis with the usual OF0. The objective was to mitigate power depletion by using the battery level as a variable. Their results, which were equivalent, demonstrated a significant improvement in the lifespan of the network. The authors in reference [28] propose a three-phase methodology. The initial stage is the phase of transmitting data. During this stage, if a parent node determines that the link quality is below a predetermined level, it detects the movement before disconnecting and proceeding to the next stage. In the second phase, the parent node asks the Mobile Node (MN) to send three Discovery (DIS) messages on a regular basis. It also asks other nodes in the Directed Acyclic Graph (DAG) to send the measured Received Signal Strength Indicator (ARSSI) of the MN DIS messages. In the third phase, the parent node chooses the node with the highest ARSSI and informs it to establish a connection with the MN. This approach exhibits reduced energy usage compared to the prior way, but both methods take into account the mobility constraints limited to the leaf node(s) in the Directed Acyclic Graph (DAG). Furthermore, they are unable to ascertain mobility when the packet rate is exceedingly low. In addition, they exhibit suboptimal performance when there is an obstruction between two nodes that are transferring data, resulting in the loss of data packets and the depletion of energy in the nodes. Furthermore, the majority of the aforementioned techniques alter the conventional structure of RPL-regulating messages proposed by the IETF [12]. Table 1 provides a concise overview of the aforementioned strategies and also demonstrates a comparison between them. However, the study did not evaluate Objective Function Zero (OF0), which is another standard and default Objective Function (OF) of RPL. Instead, they found that Minimum Rank with Hysteresis Objective Function (MRHOF) is believed to be superior to OF0 [25, 42]. In [17], other authors had also suggested scalable CAOF (SCAOF), which demonstrated enhancements in network longevity and energy efficiency. They performed simulations and real test-bed experiments, but only with a limited number of 30 nodes. This number is insufficient to thoroughly analyze the effectiveness of the suggested strategy in scenarios with varying levels of node density. As a result, our article has demonstrated the ability of the network to handle up to 220 nodes, with the potential for further expansion to accommodate a larger number of nodes, assuming there are no computational constraints. The authors of the research [13] assessed the network performance using four different combinations of single and multiple measures, considering both critical and periodic traffic. The simulation results depicted the graphical patterns for network convergence, packet delivery ratio (PDR), and latency. However, no other approach was suggested. In a similar manner, the work [47] presented the idea of grouping nodes into clusters and thereafter directing packets through the suggested OF. The experiment demonstrated an enhancement in PDR values, but it was limited to stationary nodes. This research addresses the aforementioned gap by also taking into account the dynamic and mobile environment. The authors of the research [6] highlighted the need for mitigating energy bottlenecks at nodes in order to enhance network longevity and routing stability. The researchers introduced a new metric for predicted lifetime, utilizing the residual energy of the node as a parameter. The findings of this approach showed promise. Nevertheless, the network's reliability experienced a decline, which presents a noteworthy avenue for future investigation by academics. In the study [4], a method for selecting energy-efficient paths was proposed to address the problem of node failure in RPL for stationary nodes, with the aim of enhancing Packet Delivery Ratio (PDR) and throughput.

The authors in [12] examined strategies to alleviate the impact of the most severe parent attack in RPL. The paper [38] provided successful outcomes by focusing on reducing

Table 1 Comparison among mentioned methods towards mobility

Method	Description	Strengths	Weaknesses
Co-RPL [27]	Provide a routing solution using the corona mechanism.	Minimize the latency of transferring data across nodes and optimize the speed at which the parent node is switched	Does not identify or recognize failures or disconnections.
Momoro [17]	Layer of support and fuzzy estimator	Identifies the movement and changes the primary nodes	Failure to detect objects above the head.
MobiRPL [28]	Employ adaptive probing and proactive discovery techniques.	Identify the occurrence of a disconnection after a specific period of time.	Does not mitigate or anticipate failure
mRPL [35]	Define smart hop	Identifies the movement prior to the absence of signals.	Generate significant overhead with substantial energy usage.
EMA-RPL [20]	Triple phase refers to a concept that addresses the issue of mobility.	Identifies the movement prior to signal loss and mitigates packet loss, resulting in reduced overhead and energy usage.	Let's assume that movement is restricted to the leaf node. Insufficient data packets may hinder the detection of motion.
ARMOR [13]	Time to reside refers to the duration that an object or entity remains in a particular location or state before moving or changing.	Establish a durable and extended pathway to provide a more extended connection.	Necessitates the use of specialized gear, such as GPS, in order to acquire location information.
GI-RPL [30]	Transmission in Communication zone, refers where communication signals or networks are established	Minimize the level of disconnection experienced by mobile nodes.	Not consistent with LLN
Proposed nPSIR	Transmission in Communication zone, with detecting failure and make alternative path	Reroute the traffic in-case of disconnection and No additional overhead with supporting UDP live streaming traffic	Need more Improvement for the high speed

latency and improving packet delivery ratios to enhance quality of service (QoS). Researchers achieved this by introducing new OpenFlow (OF) techniques and comparing their performance with traditional OF methods. Several authors [1] have suggested the use of objective functions (OFs) that rely on fuzzy logic and context awareness. The purpose of these OFs is to enhance data transfer and network performance for tactical nodes in vehicle settings. This article achieves the dynamic nature that they were lacking in the network. Furthermore, the authors of the research [45] not only addressed the security and privacy concerns of RPL but also proposed a self-collected RADAR dataset and a technique called DETONER for identifying routing attacks in RPL specifically for static nodes. The data set can be examined for privacy and security concerns, as well as quality of service (QoS), although it does not take into consideration mobile nodes. The paper [25] suggested employing a fault-tolerant routing method for the smart grid architecture specifically designed for stationary nodes. Later studies, like the ones [21, 37], and [19], have suggested that dynamic nodes should be used in the evaluation of OF. However, previous studies [3, 13] have examined mobility in RPL exclusively within the context of IoT networks. Authors in their publication [17] introduced a routing metric called REFER, which considers the mobility of nodes. The main objectives of this metric are to optimize energy usage and enhance the resilience of the network. Nevertheless, this study does not analyze any potential applications for integration into the internet of things (IoT). The article [19] introduced a novel retransmission strategy known as IM-RPL. This technique took into account the movement of nodes in order to enhance data communication in the network. This article, however, does not address the quality of service (QoS) factors. In their publication [15], the authors introduced a content-centric optical flow (OF) approach, which included supplementary mobility capabilities. Their findings demonstrated enhancements in both the ratio of successfully received packets from end to end and the delay in transmitting data, compared to the standard Open Flow protocol. However, these benefits came at the expense of a decreased lifespan for the network. The authors in [43] also suggested including mobile nodes by implementing a mobile design in their study. They focused on facilitating routing and forwarding decisions at mobile nodes for mobility scenarios. In a similar vein, the authors of [47] focused on minimizing network overhead and energy consumption in mobile nodes with the introduction of a novel routing algorithm. Their simulation results demonstrated enhancements, although at the expense of packet delivery ratio (PDR) and end-to-end delay. Our study addresses and resolves these limitations. Paper [18] examined both environments for analyzing the malicious node. However, the dynamic environment considered in the previous study was limited to random mobility. In contrast, this study tests both environments for three configurations: QoS parameters (6 parameters) and network scalability (10–220 nodes). In their publication [30], the authors introduced a new routing metric called ARMOR, which takes into account mobility and aims to balance dependability and PDR. However, it is important to emphasize that ARMOR is specifically designed for IoT devices. In addition, the authors of the publication [36] introduced a protocol specifically designed to decrease the packet delivery ratio (PDR) for mobile ad-hoc networks based on the internet of things (IoT). The article[16] proposed utilizing swarm optimization techniques to enhance the performance of RPL through evolutionary processes.

4 Multipath routing over view

Extensive research has been conducted to create a multipath routing version for RPL with the aim of addressing issues associated with LLNs, including stability, congestion avoidance, load balancing, and quality of service (QoS) enhancement. The authors in [5] introduced M-RPL, an extension of RPL designed to address congestion. M-RPL identifies congestion on a certain routing path primarily by analyzing the buffer size and packet delivery rate at the relaying nodes. It subsequently offers temporary multipath routing as a solution to this issue by picking multiple temporary parents to divide traffic flow across partially separate pathways. This aids in alleviating congestion on the very trafficked parent node. The simulation findings comparing M-RPL with RPL show that M-RPL effectively mitigates congestion and improves the total network throughput. In their study, researchers [39] introduced a congestion avoidance-RPL (CA-RPL) technique with the objective of enhancing network dependability and reducing latency. To accomplish this objective, the CA-RPL technique allocates data to parents who are already awake, instead of waiting for the desired parent to wake up. The CA-RPL protocol incorporates a novel routing metric called DELAY ROOT, which relies on the ContikiMAC duty cycling mechanism. However, this new metric presupposes that all the nodes possess an identical wake-up interval, which may not hold true for all cases in wireless sensor networks (WSNs). The simulation examination of the proposal versus RPL shows that CA-RPL effectively alleviates congestion and improves network throughput. In order to extend the lifespan of the network, researchers in [41] have suggested an energy-balancing routing method. This scheme ensures that all paths in the network consume an equal amount of energy while also avoiding the use of bottleneck nodes. This is achieved by assessing the expected lifetime (ELT) of nodes and utilizing multiple parents. In order to maintain network stability, the authors also recommended implementing the multipath technique to restrict parental exchanges. The evaluation using simulation demonstrated improved routing dependability and an increase in the network's lifespan while reducing the frequency of parent modifications. The goal is to enhance the durability of the network while reducing the frequency of changes to the parent. This paper presents the introduction of LeapFrog Collaboration (LFC), a system that integrates MAC and routing layers to improve reliability and minimize jitter in RPL-based industrial networks. The LFC algorithm is a method of routing that increases the number of available paths by replicating each data packet on an alternative route. It authorizes each node to receive only the first instance of each data packet and removes all subsequent duplicates. The results indicate that LFC exhibits superior performance compared to the single-path routing strategy utilizing RPL and TSCH. The authors cited in reference [18] have proposed an augmentation of the multipath LFC. The alternative way of selecting parents relies on the interplay between the child, parent, and grandmother. This method involves increased computational costs and greater data input and output procedures (DIOs). Prior studies have examined various enhancements to RPL, but none of them have particularly examined a framework for enabling RPL to support multimedia applications via multipath routing. Therefore, a unique and tailored solution explicitly created for Internet of Medical Things (IoMT)-based Wireless Multimedia Sensor Network (WMSN) applications is crucial. A proposed solution is to implement a multipath routing version of RPL in order to meet the specific requirements of multimedia applications, including quality of service (QoS) and quality of experience (QoE). Furthermore, our system utilizes a lightweight codec specifically designed for constrained Wireless Multimedia Sensor Networks (WMSNs) to encode and decode video data. This differs from the resource-intensive H.264 codec used in [22].

5 Results and discussion

This section presents the precise specifications and configuration details for the previously discussed approach. This study utilizes three instruments for its implementation. The study use the NS2 simulator as its main instrument.The system provides a simulated environment for the motes to encounter and control network connections. To carry out this research, we have set a limit of 220 nodes due to limitations in computational resources. Within this set of nodes, one node operates as the recipient, while the rest of the nodes operate as senders. The simulation is thoroughly documented in Table2. The nPSIR protocol enhances resource consumption and capitalizes on the benefits of merging resource management and traffic management tactics. Queuing Theory states that when the pace of data packet arrival at the destination exceeds the rate of processing, the source will observe an increase in throughput as a result of enhanced reception of data packets. This scenario arises when the influx of entities to the destination exceeds the rate at which they are being attended to.The primary node continually utilizes the RPcI to systematically examine the network for any newly acquired data. Upon detection of the primary table's construction, the source node will transmit an RPcI message. This communication will contain information that is in close proximity to its intended receiver. Upon receiving the RPcI message, a neighboring or descendant node initially utilizes the nPSIR method to select a parent node that is not excessively populated, hence implementing the resource control approach. Afterwards, it sends packets through the chosen parent. The nPSIR rating is derived by aggregating the outcomes of three metrics.To ascertain the value accurately, we choose the candidate whose rank is nearest to the highest rank as the alternative option for calculation. We employ a mathematical equation to determine the optimal distance between a parent and its offspring, in order to evaluate the importance of these observations. The source node computes the optimal distance.The nPSIR-RPcI protocol demonstrates its approach to investing in the following node of each cluster, as described by the provided equations and explanation. This involves selecting an adjacent node, referred to as the HEAD, to operate at a reduced power level or with less energy usage until it begins to receive the primary

Table 2 Simulation Details

Setup	Parameters
Propagation Model	DGM with Distance Loss
Start-up Mode Delay	65 s
Random Seed	123,456
Number of nodes	10 up to 220
TX Range	45 m
INT Range	90 m
TX Ratio	100

packets from its HEAD. Subsequently, the HEAD forwards these packets to the ultimate destination, irrespective of its position in a separate topology.

Additionally, the outcomes are divided into two distinct categories:

- Evaluation of nPSIR performance in both stationary and mobile settings
- Evaluation of nPSIR performance with mobility models

Through the examination of the limitations imposed by computational factors. The findings derived from these segments will aid us in delivering a thorough analysis of the evolution of the internet of things (IoT) network. Every simulation lasted for a total of three minutes and ten seconds. The experiment consisted of 10 unique repetitions, and the average value of each iteration was then computed. The experiment imposed a restriction on the packet size, setting it at 1024 bytes, and adjusted the bit rate to 2 megabits per second (MB/s). The packet had a size of 512 bytes. A network with an ad hoc setup allows its members to share the wireless connection, a feature that is generally acknowledged and endorsed. Regarding the number of nodes in each topology, the source nodes and destination nodes consistently maintained a traffic rate of 512 kilobits per second (kb/s) throughout the simulation. The subsequent section showcases the simulation results through accurately presented line graphs. The Table 3 presents the parameters that determine the visual attributes of these graphs. The packet loss ratio is the ratio of lost packets to the total number of transmitted packets. A statistical metric quantifies the mean duration required for a data packet to be transmitted and received, hence establishing the mean end-to-end latency. The average latency is measured in seconds.

The Fig. 3 displays the Total Latency Quality of Service (QoS) for the mPRL, Mobi-RPL, Gi-RPL, and nPSIR mobility models. The data presented in the graphic illustrates a direct relationship between latency and network size. The delay of the network is directly correlated with the quantity of packets that are transmitted. A higher volume of packets is transmitted, leading to an increased probability of packet collisions, network congestion, and other associated problems. Minimizing latency in the network will enhance network efficiency. However, while comparing the three models, it is clear that other suggested works have the shortest delay, whereas nPSIR exhibits the longest

Table 3 Simulation Parameter

Parameter	Value
Simulation Time	300 sec
Wireless Channel	Unit Disk Graph Medium (UDGM)
Max. range	250 m
Roaming area	1000 X 800 m^2
Pause Time	0,10,30,60,90 s
Min. Speed	0 m/s
Max. Speed	55 m/s
Mobility model	Random WayPoint
Clustering Range	10 m
Threshold Value	1Mbps

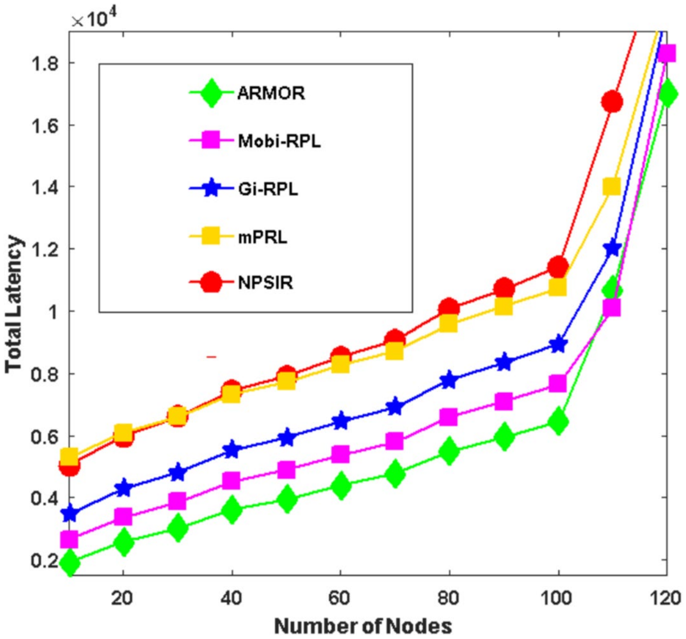

Fig. 3 Total Latency QoS for scalable network

latency. This indicates that nodes encounter more latency in the all-mobility paradigm in comparison to nPSIR. Consequently, nPSIR exhibits exceptional performance by reducing delay and optimizing network effectiveness.

The primary performance metrics employed in the simulation experiment include throughput, packet delivery rate (PDR), and end-to-end delay (E2ED). These demonstrate the extent to which the proposed routing protocol facilitates quality of service (QoS). In addition, the inclusion of the nPSIR protocol in the route management procedure necessitates a thorough analysis of the route control overhead, particularly the routing overhead ratio (ROR). Figure 4 demonstrates the correlation between the speed of the nodes and the packet delivery ratio. As the velocity of the node increases from 0 to 220 m/s, the transmission rate of packets for the three routing protocols falls. The ARMOR decreases from 65.24 to 30.49%, mPRL decreases from 92.04 to 48.68%, Mobi-RPL decreases from 70.09 to 39.24%, GI-RPL decreases from 85.45 to 40.53%, and nPSIR decreases from 92.5 to 45.6%. However, the nPSIR regularly demonstrates a higher packet delivery ratio compared to the other four routing protocols, especially in situations when nodes move quickly. The nPSIR protocol achieves a high packet delivery rate by utilizing its link interrupt prediction technique. This approach enables the protocol to dynamically change routes or divert traffic before a connection interruption happens, hence reducing the necessity for retransmitting packets.

Figure 5 illustrates the relationship between the average end-to-end latency of packets and the speed of the nodes. As the node speed increases within the range of 0–55 m/s, there is an increase in the end-to-end delay. Under conditions of low speed, the end-to-end latency indicators of the three routing protocols exhibit a high degree of similarity. As the speed of the node grows within the range of 0–55 m/s, the end-to-end delay likewise experiences a corresponding increase. Within this specific speed range, the delay time of the suggested approach exhibited a significant and

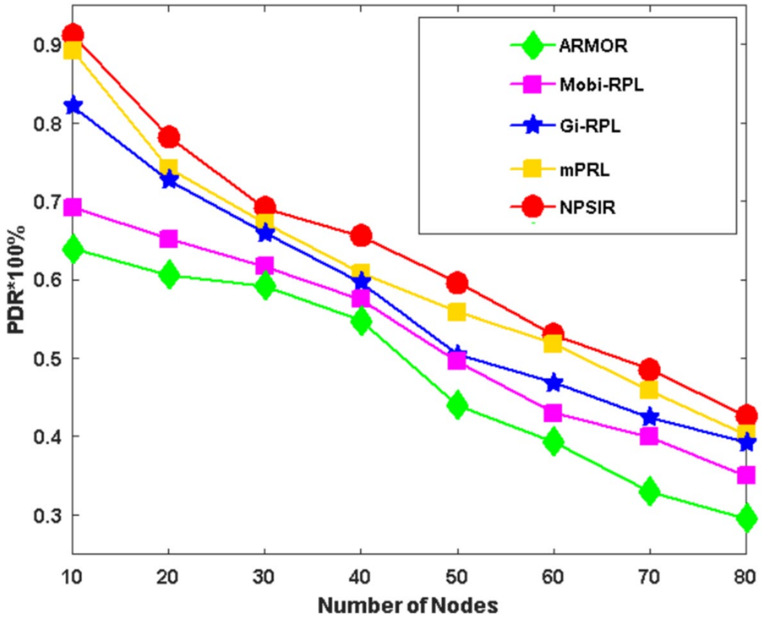

Fig. 4 Packet Over All Ratio Received

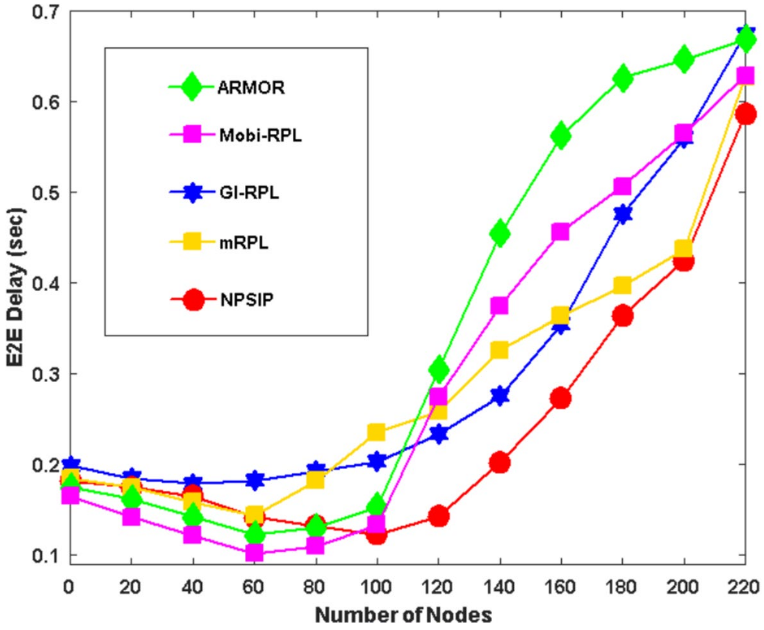

Fig. 5 End to End Delay

rapid rise, escalating from 0.25 to 70 s. The primary cause of this occurrence is the configuration of the abnormal state feedback threshold. When the node speed falls within the range of 0–55 m/s, there is a higher likelihood of initiating nPSIR packet transmission, which in turn leads to an increase in delay. During situations with low speeds, the frequent changes in network topology cause interruptions in the alternate paths of multipath routing protocols. If these alternate paths fail, it will lead to an

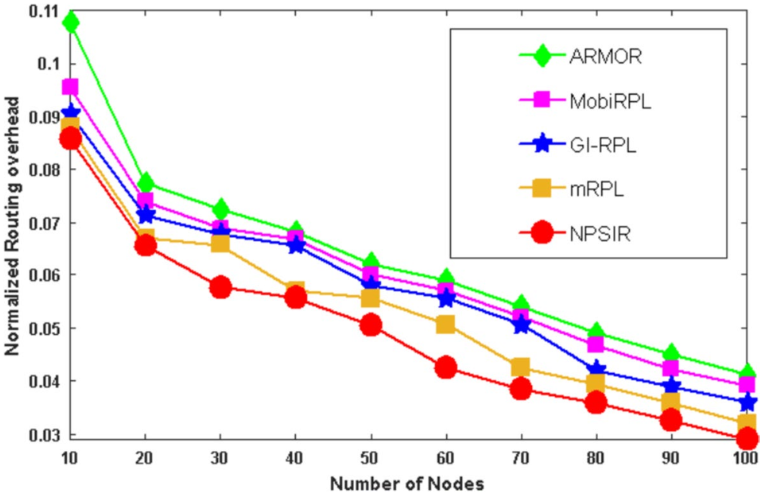

Fig. 6 Normalized Routing Overhead

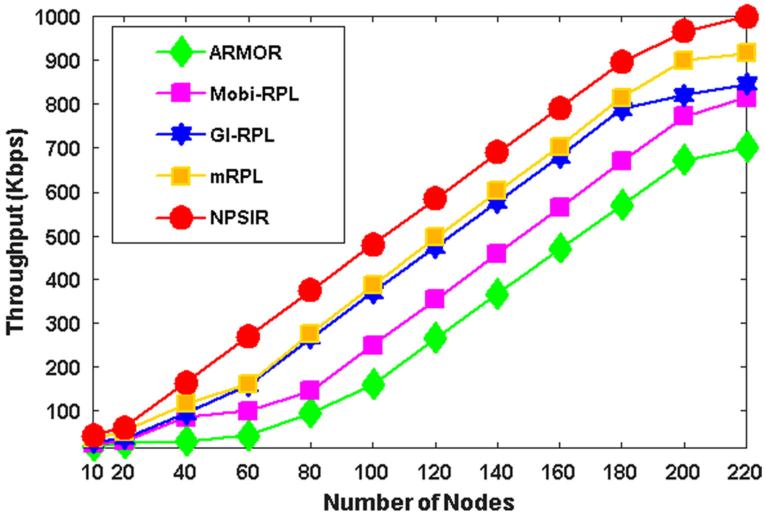

Fig. 7 Continuity of Receiving Data Packets

increase in end-to-end delay for rerouting or retransmitting data. The figure clearly demonstrates that nPSIR exhibits a reduced end-to-end delay. The stable path prediction mechanism in nPSIR was created so that it can effectively track any changes in the network topology and quickly switch or reroute the channel before it gets interrupted. The proactive approach of implementing the stable path prediction mechanism in nPSIR significantly mitigates the end-to-end latency caused by the need for packet retransmission.

Figure 7 illustrates the relationship between the average packet throughput and the mobility and stability of the nodes. The diagram illustrates the fluctuations in throughput, allowing for the assessment of performance over two separate time periods. As the velocity of the node increases from 0 to 55 m/s, the throughput of nPSIR drops when the nodes are moving at a speed of 0–55 m/s or lower. Out of the algorithms that were analyzed, nPSIR demonstrated the highest level of performance within this particular speed range, whereas mPLR, GI-RPL, and Mobi-RPL were ranked in declining order. In contrast, ARMOR exhibits the most unfavorable performance. As the node starts moving, the throughput of nPSIR deviates from a linear trend and starts decreasing. Hence, nPSIR exhibits optimal efficiency while functioning within the velocity range of 0–55 m/s. The performance of nPSIR is influenced by the increase in UDP data rate, namely in the region of 100–120 kbps. It demonstrates exceptional performance in comparison to mPLR, GI-RPL, Mobi-RPL, and ARMOR.

Figure 6 illustrates the impact of varying node quantities on the NRO (Network Reliability Optimization). With a rise in the number of nodes in the range of 10–100, the NRO (Network Routing Overhead) of nPSIR drops from 9.69 to 3.81%. Similarly, the routing overhead of the other four routing protocols is also lower. The primary cause of the reduction in routing overhead is the increased number of nodes, which facilitates the source node's ability to locate a path. As the number of nodes increases within the range of 10–100, the routing overhead of the five routing protocols exhibits minimal variation.

Once the destination node successfully receives a packet, all nodes collectively consume energy, hence contributing to the overall average energy consumption in this context. This performance metric accurately measures the network's energy efficiency. The graph depicted in Fig. 8 illustrates the average energy consumption (AEC) of the five routing algorithms at different node velocities. The application of nPSIR, mPLR, GI-RPL, Mobi-RPL, and ARMOR algorithms can efficiently reduce energy consumption resulting from retransmission by considering network path stability, quality of service, and link dependability aspects. When the speed exceeds 20 m/s, the proposed protocol demonstrates a reduced average energy usage in comparison to the other four routing protocols.

Figures 9 and 10 depicts the AEC of five routing techniques, each with a different number of nodes. For node counts below 40, the average energy consumption (AEC) of

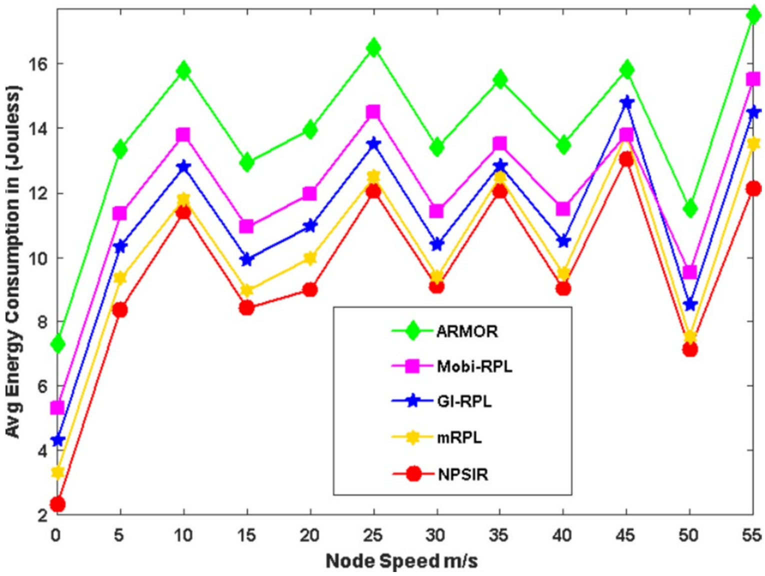

Fig. 8 Average energy consumption against Real Time Traffic

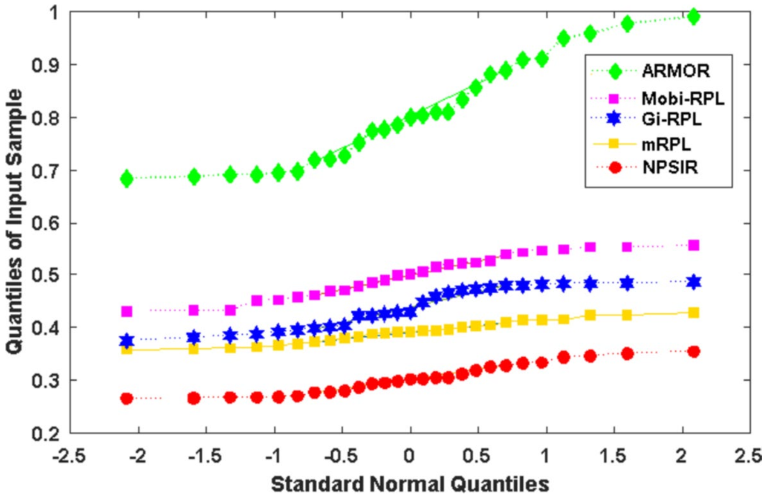

Fig. 9 Standard Normal Quantiles

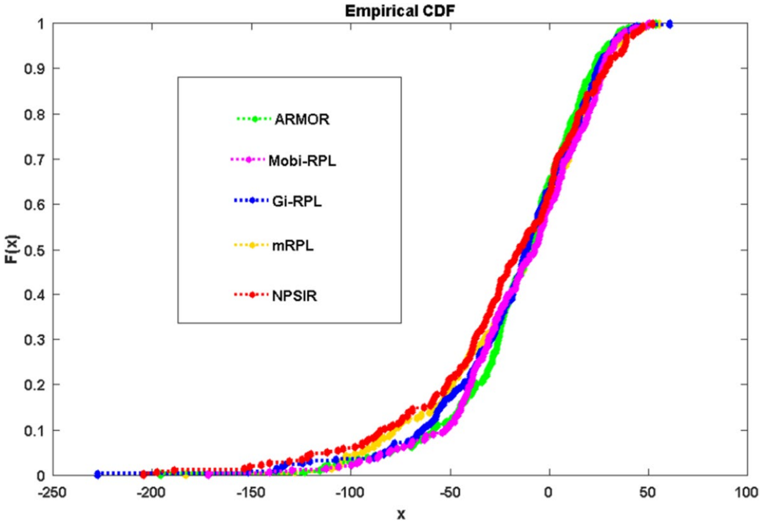

Fig. 10 Cumulative Frequency Distributed

the five routing protocols is almost indistinguishable. The image illustrates the amplitude and frequency domains of the five protocols, revealing their close resemblance. The nPSIR protocol demonstrates superior performance in energy conservation compared to other protocols. It achieves this by enabling selective node activation and is exclusively employed during emergency scenarios.

Figure 10 illustrates the cumulative distribution function (CDF) for the combined data. The time between contacts and the percentiles of the cumulative distribution function (CDF) are calculated for all device pairs in the simulation of all routing protocols. It is evident that, at any one time, a majority of the node pairs are observed. Determine the cumulative distribution function (CDF) for the inter-contact duration in a sufficiently The cumulative distribution function (CDF) exhibits a limited range of values in its vicinity.

Furthermore, we give five separate cumulative distribution functions (CDFs) for each routing protocol, which reveal certain variations that may not be apparent when considering the overall perspective. After analyzing the difference between the overall cumulative distribution function (CDF) and the average of individual CDFs, we found that the former provides a minimum value for the latter. However, the disparity between them was not significantly significant. Although the nPSIR protocol exhibited a lower probability compared to other protocols, our findings indicate that all protocols have equivalent semantics in terms of energy conservation for network nodes.

6 Conclusion

QoS routing methods that can dynamically adjust to sudden changes in network topology would enhance the efficiency of network applications in high-speed MANET, specifically in the context of a vehicular ad hoc network (VANET). This paper presents a novel method for ensuring network performance stability by employing an intelligent routing protocol known as nPSIR. The primary goal of this protocol is to guarantee reliable data transmission by establishing a coherent pathway. To evaluate the effectiveness of the proposed procedure, we run a comparison analysis using mPLR, GI-RPL, Mobi-RPL, and ARMOR, employing NS2 for this purpose. The simulation findings demonstrate that the nPSIR protocol outperforms the other four protocols in terms of packet delivery ratio, end-to-end delay, and throughput across all scenarios, encompassing node speed, data rate, and number of nodes. During the high-speed scene, where the nodes were moving at a velocity above 55 m/s, nPSIR demonstrated a higher packet delivery ratio (PDR) compared to mPLR, GI-RPL, Mobi-RPL, and ARMOR. To be more specific, the nPSIR PDR surpassed the mPLR, GI-RPL, Mobi-RPL, and ARMOR by 5.97%, 10.7%, and 7.79%, respectively. Furthermore, nPSIR demonstrated a reduced end-to-end delay (E2ED) compared to the other protocols. More precisely, the End-to-End Delay (E2ED) of nPSIR was 48.9%, 53.05%, and 51.5% lower compared to mPLR, GI-RPL, Mobi-RPL, and ARMOR, respectively. Furthermore, nPSIR demonstrated superior throughput, surpassing mPLR, GI-RPL, Mobi-RPL, and ARMOR by 13.1%, 9.28%, and 22.5% respectively. The author plans to conduct further study on the progress of routing protocols in high-speed settings, with a specific focus on the evaluation of both path stability and node density. The authors intend to create a heuristic routing system that enables nodes to deduce changes in topology by analyzing parameter variations, with the purpose of managing high-speed scenarios.

Abbreviations

NH	Next hop
NNH	Next next hop
ADJ	Adjacent node
Dest	Destination
alt	Alternative node
S	Source
RPcI	Request packets for creative and investigation (RPcI)
nPSIR	Network performance stability using the intelligent routing protocol

Author Contributions

All paper has been done by the corresponding author.

Funding
No funding available.

Availability of data and materials
Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Declarations
Some journals require declarations to be submitted in a standardised format. Please check the Instructions for Authors of the journal to which you are submitting to see if you need to complete this section. If yes, your manuscript must contain the following sections under the heading 'Declarations':

Conflict of interest/Conflict of interest
I confirm there is no Conflict of interest in this work

Ethics approval
I have approved there is no Conflict of interest for this study and not publish any where before.

Consent to participate
Consent to participate NOT Applicable

Code availability
Code availability available upon request

Received: 19 December 2023 Accepted: 3 June 2024

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Publisher's Note

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