e-ISSN : 0976-5166
p-ISSN : 2231-3850

A cross-layer analytical model for optimization of performance in wireless sensor networks

[1]V Kiran Kumar *

Research Scholar,Department of CSE, VTU,
Belagavi.Karnataka,India
kiranmadhavv@gmail.com

[2]Dr.Shiva Murthy G

Associate Professor & Head,
Department of CSE,
VTUCPGS, Chikkaballapura,
Karnataka,India
kgshivam@gmail.com

Abstract

Objectives: To develop an analytical model to improve Qos in WSN. Method: Cross-layer protocol architecture is developed to improve energy consumption, delay, and packet delivery in a wireless sensor network. The Routing protocol to Cross layer Communication (RPTC) protocol was used for routing the packets through cross-layer interactions which helped to improve the QoS analytical results for common collector points (CCP) node selection, routing policies, and energy optimization. In the earlier study, a random routing policy was in place which did not take into account any proper mechanisms. Here, we define a policy for routing that takes into consideration Extended TDMA energy conservation techniques by choosing the shortest path with extended coverage. This will eliminate collisions, idle listening times, and entering inactive states until their allocated time slots. The extended TDMA helps reduce packet delays and guarantees reliable communication. The extension allows nodes with the largest one-hop neighbor to select multiple timeslots for themselves, which are scheduled in the MAC layer. We compared our analytical model based on delay, power consumption, and energy consumed in relation to simulation time. Findings: We found that the cross-layer analytical model achieves 20% less delay, power, and 30% less energy consumption when compared to existing cross-layer protocols such as the Hybrid Energy-Efficient Distributed Protocol (HEED), Co-ordinate Test Optimized Protocol (CTP), and Tree Cluster-Based Data Gathering Algorithm (TCBDGA). Novelty: WSNs need to be optimized across several protocol levels in order to achieve good interactions. QoS parameters are explored for this purpose and a cross-layer protocol called RPTC is analyzed using design parameters and resource levels based on the Poisson variate model (PVM). This helps improve network lifetime.

Keywords: **CCP, Extended TDMA, RPTC, MAC, PVM.**

1. Introduction

The specific features of WSN make it important for cross-layer optimization across several protocol levels. Quality of service (QoS) parameters is explored to improve the interactions between layers in WSN. The cross-layer protocol, called RPTC, has been studied using a set of design parameters and resource levels associated with a mathematical model known as the Poisson variate model (PVM). This helps obtain better network Wireless sensor networks (WSNs) are systems that use a lot of small sensors to monitor specific events. The main goal of using WSNs is to detect and understand event features from the data collected by all the nodes in the network. Nevertheless, the main challenge to achieving this goal is that wireless sensors have very limited energy and processing capabilities.

The collaborative sensing concept that is achieved through deploying networked sensors helps overcome the challenge of having limited resources in WSN. This has been done by developing networking protocols that are energy efficient.

One problem with using the parent node to forward packets is that it causes more delays, energy use, and packet delivery ratios. To address this issue, we develop a model to reduce these limitations.

In [1] proposed an energy-based random-repeat trust computation. The proposed method uses a fuzzy and heuristic simultaneous ACO to improve QoS. The HEACO RF QoS protocol has a couple of phases. In the first stage, the ant colony optimization is modified to identify candidate route deposits. Reliable fitness functions and heuristic factors are considered when selecting routes. In the second stage, each path is measured using a reliability technique, and the more reliable paths are evaluated by the agent using fuzzy logic. The proposed RF-HEACO technique yields a lower start-end delay and the lowest burst accident rate. The proposed technique provides better quality service and tolerates network system delays. In the future, work can be extended on the techniques for complying with privacy and security constraints.

In [2], the author presents a cluster head selection technique for WSNs based on grey wolf optimization. This approach considers different criteria, such as energy level and node level, to determine which relay nodes should be selected. The routing problem is tackled using a cost function that aims to select a QoS-aware relay node for efficient and reliable inter-cluster communication from the cluster head (CH) to the base station (BS). Additionally, this study includes mobile nodes in order to reduce computational complexity.

In [3] proposed a technique for enabling wireless sensor network-based Internet of Things applications in busy networks, the authors design an energy-efficient routing system. To choose the best course, the suggested methodology takes three criteria into account. The duration, dependability, and volume of traffic at the next hop node implementation of cluster-based routing protocols, the application of the proposed models to heterogeneous network environments using mobile nodes, and the redefinition of efficiency-constrained applications They suggest extending this work by applying evolutionary algorithms to optimize output of QoS parameters.

In [4] proposes a new imbalanced clustering protocol and import detection method for networks with quality of service (QoS) requirements such as capacity, robustness, and security. First, the model selects provisional cluster leaders based on three input parameters: residual power, distance to the base station (BS), and distance to neighbors. A detailed clustering algorithm using deep hierarchical observation is then used to create healthy services clusters. Finally, a strong intrusion detection system must be in place so that WSNs are safe from attack. CH is doing research to find ways to improve the DBN model's performance in the future. They are using a method called hyper parameter conversion which will allow them to set duration, time factor, and learning cost values correctly.

In [5], the author presents an energy-saving QoS asynchronous MAC protocol (AQSen), dubbed AQSen-MAC. AQSen-MAC examines various types of data packets and employs two novel strategies to increase power efficiency, packet delivery speed, and network throughput: self-regulation and scheduling. Furthermore, according to the protocol, the receiver adjusts its duty cycle based on the remaining energy to prolong the network operation. The AQSen-MAC protocol is extended for solar collector WSNs. The performance of real-world energy harvesting scenarios will be evaluated on a test bench using the grid.

In [6], the author presents a way to measure trust by combining authentication procedures with security measures. Furthermore, this work calculates three types of trust scores: direct, indirect, and general trust scores. This work also proposes a cluster-based secure routing technique that uses key-based security measures to improve communication security. The primary benefits of this suggested method are modifications in how clusters are formed based on QoS measurements and Trust Scores; increased malicious node detection accuracy; and malicious node eradication. Fuzzy rules will be used in future work to deal with uncertainty

In [7] present, an algorithm is developed that can optimally choose a route between two locations based on various network parameters and bandwidths. This method also determines the next best path for data packets when there are connections or node overload errors.

In [8] explored ways to improve communication between nodes by proposing an algorithm that can suggest the best parameters for each channel and the healthiest channel itself. This proposed approach can be used on any channel to automatically reduce the number of dimensions in data or choose features from a set of available features. This technique is further applied to recommend a single communication channel among all available channels based on the most appropriate characteristics selected for each channel.

In[9] proposed the Energy Efficient Clustering Protocol for WSNs. The IBeeCup method, an extension of the Bee Cup method that finds the shortest path, was used to implement the new clustering-based route. This increased network life by 36%. Delay and Qos service parameters can be considered when evaluating protocol performance.

In [10] tries to use the clustering approach to introduce a new design routing model.The work done uses a layer-spanning mechanism across different layers (including physical and network layers). The Alpha Wolf-Assisted Whale Optimization Algorithm, which is a new type of algorithm, is used to choose the best cluster head. This makes sure that the shortest path is known and that the network will last a long time. A new optimization method called AW-WOA combines the theories of WOA Anglo. The optimal choice of CH was made in relation to many parameters. The proposed model was analyzed and tested for improved network resilience.

In [11], the author proposes three stages for creating a desired work environment. The first step is connecting different layers of an existing system. The second stage determines which wireless sensors are inaccurate and needs to be fixed. Finally, effective routing patterns need to be developed in order to control the activity of problematic nodes on a network.

In [12], the author proposes a cross-layer protocol that considers three main layers: application, network, and animal. To improve QoS, traffic management at the network layer and node table management in the MAC layer are used. This helps choose which forwarding nodes to use most effectively. Efforts should be made to integrate cross-layer design models with PHY switches so they can more efficiently utilize resources

In [13] the authors propose the QCM2R protocol. This sets up a path using random frequencies to distribute traffic and keep it manageable. It can also update wireless channels on-the-fly, which is helpful for reliable communication. The QCM2R protocol outperforms multi-REBTAM in terms of network life, reliability, latency end throughput

In [14] the author proposed a new routing protocol for energy efficiency, a hibernation method, and a low-electricity hardware layout. The number of sensor nodes that can be part of a WSN's tree cannot always be the same because WSNs need to adapt to constantly changing environments. The final module is designed so it can enhance the performance of AEB-AODV and sensor node hibernation by using an ARM Cortex microcontroller and transceiver units. A low-power ARM Cortex microcontroller is also used in conjunction with an algorithm called AADITHYA which flavors remaining energy in sensors after they are activated. There are many open ended systems that could be utilized, some components might even be integrated into functional devices, but one problem remains: how do we select sensors based on their residual energies? After being activated, the model creates different flavorings for each remaining bit of energy in sensors until there's none left.

In [15] a deep-learning, feature extraction based semi-supervised model was used to protect trust boundaries for IIoT networks. This method is unique and can learn quickly how attackers try to break into systems without requiring any manual effort.

In [16] hybrid edge-computing based machine learning model is proposed in consideration of the real world aspects of bike-sharing systems, such as traffic flow complexity, nonlinearity and uncertainty. The model performs better than previous approaches when it comes to prediction accuracy and generalizability. It's also possible to take into account Qos parameters like delay, energy and traffic when evaluating the model.

In [17] cross-layer optimization techniques are used to improve the performance of devices in industrial IoT systems. The first stage uses a state transition model to create a two-stage industrial hazardous gas tracking algorithm. A three-layer network of distributed edge computing is then developed using IIoT and tested for its ability to optimize other Qos parameters besides energy usage.we created a new model that takes into account the network and MAC layer's optimal layout. Our model focuses on the CEO-MAC routing model, cross-layer MAC model, cross-layer energy optimization models, and inter cluster/ intra cluster MAC operational models. The network and Mac layers' optimal layouts are taken into account by our model.

In [18] developed a novel model that is a cross-layered energy optimization-based Medium Access Control (CEO-MAC) protocol to overcome power and network monitoring issues. Its focus is on the CEO-MAC routing model, cross-layer MAC model, cross-layer energy optimization model, and inter cluster/intra cluster MAC operational model. The network and MAC layer's optimal layout are taken into account by our model. The CEO-MAC routing model, the cross-layer MAC model, the cross-layer energy optimization model, and the operational intercluster/intra cluster MAC model are the primary areas of focus. To evaluate the above protocol, energy, network lifetime, and delay can be taken into account.

In [19], an Energy Efficient Neuro-Fuzzy Cluster based Topology Construction with Meta heuristic Route Planning (EENFC-MRP) algorithm is created to plan routes for unmanned aerial vehicles. MRP is used to select the best possible route for intercluster communication, and techniques are designed to optimize data usage on the network.

In [20] the authors proposed a multipurpose localization service that would disseminate UAV positioning information to groups and estimate positions that are missed because of communication errors.

In [21] the author looks at a group of popular MANET routing protocols and compares their performance. They are evaluated under different conditions, such as how much traffic they can handle, how much jitter is there, and how long it takes to route packets. Other protocols that may be useful in analyzing this data include DSR, DSDV, LAR, and TORA.

A new approach called dynamic multiagent (DMA) is being proposed in [22] to help reduce the amount of duplicate information that gets transmitted between vehicles and roadside sensors. DMA has been found to be a successful method when it is used under highway conditions, and by filtering out unnecessary data, this will save time and

In [23] researchers studied the routing protocols for the Flying Ad-hoc Network (FANET). They described all of their strategies and methods in great detail, which is important as it will help improve future FANET networks. Additionally, they identified some practical requirements that have not been addressed yet by theoretical approaches. This will provide a better understanding of how to create successful FANET networks in the long term.

In [24] a perspective on FANETs is offered from the perspective of network communication challenges. By investigating various architectures that have been proposed for FANET networks, this paper provides a unique perspective on these challenging systems.

Research Gap: Despite the abundance of cross-layer protocols designed to improve QoS in WSNs, there are no agreed upon optimization techniques. We develop an analytical model that accurately captures how RPTC operates at the CCP level. In addition, we discuss grid formation and extended TDMA for scheduling nodes using this protocol. Finally, we identify which routing paths provide the best performance for a given scenario.
Most of the author's research has focused on improving network performance in lower layers, specifically for WSN. There is no standard protocol or toolkit to help with QoS issues in these networks.
In order to address the issues mentioned above, our work considers all three layers of a cross-layer optimization model. We use TDMA in the Mac layer, RPTC for routing in the Network layer, and find quality links in the Physical layer. The protocol designed in network layer schedules nodes based on an Extended TDMA schedule defined by Mac Layer. And availability of channels is decided at Phy level communicated to Mac Layer.
Following is the novel contributions in work

1) To improve traffic flow, the network is divided into grids. Routing information is then used to direct traffic between these different areas.
2)Policies are put in place to govern how people use this routing information, and it all happens at a layer above where computers send data packets back
3) In order to optimize link distortion and routing control, the Poisson variate model is used. This model helps determine how many links a page should have and where they should go on.

2. Motivation for cross-layer optimization

One reason designers don't use multilayer designs when communicating over wireless networks is because of the issues that come with using wireless links. These include things like how they can be used for opportunistic communication and the fact that they offer new ways to communicate not possible in a layered system. However, there are also many advantages to using wireless technology compared to traditional methods. One example is how changes in link quality allow for multiple packets being sent at once. This means that protocol parameters can be adjusted dynamically as needed based on current conditions. Wireless media also provide unique opportunities unavailable in strict layer systems- such as being able to have nodes work closely together without interference from other devices

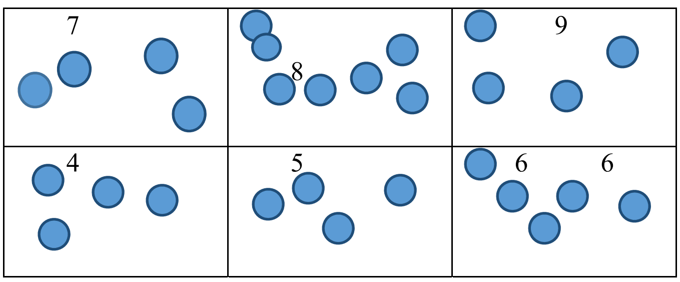
3. Methodology

3.1 *Cross-layer analytical model*

Consider a WSN and its source nodes. Each node in the network is responsible for collecting data from sources (BS) located at the field's edge, and sending that data to one of the other N-1 nodes as a common collector point. The number of hops needed to send data between any two points in the network depends on how far apart those points are Node N = 1 to N is deployed in A = (Rh x Rw), where Rh is height and Rw is width.

3.2 *Grid Formation*

When dividing a network into grids, the nodes are distributed equally across all of the grid squares. The center point is calculated by taking the sum of the left corner values and multiply it by the width of one square on that grid (width = 1). Then add this number to the right top corner value from another grid square. C = (h2-h1) + (w2-w1), where h1, w1 are the left corner values and h2, w2 are the right top corner values.



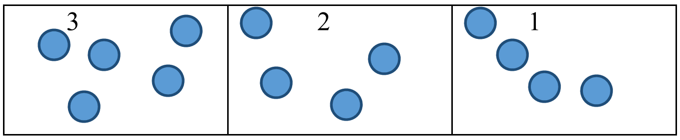


Fig 1: Grid Formation

So here, Col. M-1 is the column, and Row 0----- is the row. Row m-1 represents columns, and rows (QX, QY) and (Qxep, Qyep) represent the start and end of each cell.
QH stands for cell height, and QW stands for cell width. Where QH is the RH or HW zone height, Qw is the RW or HW zone width.

3.3 *Ccp Selection Phase*

We will choose the node that is closest to Network C's center because it has the best performance. This is done by taking into account how much energy each node has and calculating the average distance between them. The distance between each node and the network's centroid is determined.

$$GVi = asemblage(NEi + (1 / MDVi)) \quad (1)$$

NE represents the node's energy level, which will initially be constant for all nodes. Where MDV is the mean value of each individual node in that particular Cell as demonstrated in (7). The MDV, as illustrated in (3) and (4), is the separation between a node and every other node in the zone as well as from the zone's center. The centroid-based minimum value of MDV will raise the node's likelihood of being CCP.

$$dist(l,m) = \sqrt{(lx - mx)2 + (ly - my)2} \quad (2)$$

Where dist(l,m)a is a node distance from other nodes in its zone.

$$C(i,v) = \sqrt{(vx - ix)2 + (vy - iy)2} \quad (3)$$

C(i,v) is the distance of I nodes from centroid v.

Within the network, the base station will get the MDV of all nodes, which will be calculated once,

$$MDV = \partial * C(i,v) + \sum_{m=1}^{n} dist(l,m)\ , m \neq 1 \quad (4)$$

Where ∂ is the values given to cell and distance from other nodes.

3.4 *Extended TDMA for Scheduling nodes*

A extended TDMA schedule is developed in this stage. We assume that each CCP and the nodes it is connected to transmit data using a unique frequency. As a result, nodes travelling along various pathways can communicate simultaneously. Ready Receive Time (RRT) and Ready Transmit Time (RTT) are the two-time constants we suggest for each node (RTT). RTTi denotes the time window during which a node can transmit to its CCp while RRTi denotes the time window during which the CCp is prepared to receive from its nodes within grid for a node I. The period of time between [RRTi, RTTi] denotes the period of time in order for the node to transmit, its transceiver must be turned on and the node must be awake.

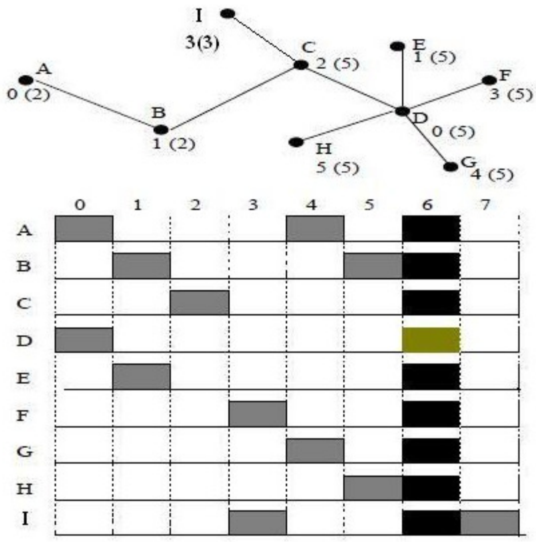


Fig 2 Timing slots in Extended TDMA

A sensor event occurs during time slot ts, and grid data is collected during this time slot, then for the normal node.
RRTi=ts (5)
RTTI and TRTi are used to calculate the final CCp. Eq. (5) is used to determine how long it will take for one data packet to be transferred. This calculation ensures that the CCp only stays awake while receiving input from its children; this prevents energy from being wasted by switching between the awake and sleep modes. Once all of the data packets have been received, the parent node sends them on to their Final CCp.
To calculate the RTT (round trip time) for a node, it sends out a probe packet with a time stamp. Each of its neighbors responds by echoing this timestamp back to the sending node. This way, the sending node can measure how long it takes for packets to travel from itself to each of its neighbors.
RTT is reduced by the number of sensor nodes in the Round trip path and the distance between them. Choose a minimum number of nodes to achieve this, which will reduce the RTT and create an RTP using groups of three sensors x1, x2, and x3.

$$RTD= x1+x2+x3. \quad (6)$$

When selecting RTPs in wireless networks, it is important to select only specific paths. These discrete RTPs are chosen by skipping two subsequent paths after each selected linear path. This equation is used to determine which RTPs will be selected in discreet steps of three.

$$TRTP=Q+C \text{ where } Q=|N/3| \quad (7)$$

If the number C (shown in parenthesis) is 0, then RTPs will be selected for every N sensor nodes in a wireless network. If C is not zero, then only RTPs with a remainder of 0 are chosen. This helps to reduce the amount of traffic that needs to be sent over the network.

In WSNs, continuous-time PVM models are used to create a foundation for understanding link distortions, routing control and other cross-layer protocol design constraints. To evaluate how well the network is performing, we used a packetized data traffic model where PVM models use processes that generalize Poisson statistics. This allows us to generate queuing structures based on underlying network events. The count of packets using this approach is more accurate than methods that rely only on discrete space event descriptions (like Markov or Bayesian models).

The uninterrupted sensor data arrive at random $\partial_{0,}^{b}\partial_{1}^{b}.............\partial_{n}^{b}$ and their arrival times $\partial_{1}^{b}-\partial_{0}^{b},\partial_{2}^{b}-\partial_{1}^{b}..................\partial_{n+1}^{b}-\partial_{n}^{b}$ are independent.
In order to model multi-sensor detection, it is necessary to process data from at least S different sensors differently. Each form of sensed information will require a unique Quality of Service (QoS), which can be described in terms of protocol parameters and performance measures. Any S sensor type may be active during the mission thanks to PVM models, which demand various resources in order to maintain session quality. The processing completion times for sensor types = 1,...,S at node i and $\partial_{i,m}^{s}$ the corresponding sequence of inter-completion times may not always be valid $\partial_{i,1}^{s}-\partial_{i,0}^{s}..........$. A random variable with packetized data from other sensors' inter-completion time sequences will superposition these grids, suggesting that some overlap exists between them. Each grid

contains at least one intermediate processing node referred to as the Central Processing Unit (CCP). Any two or more sensors cannot form a renewal sequence if the service periods are not exponentially distributed.

3.5 *Energy-Efficient Routing*

The main thing that limits how connected a network can be is the available power at the nodes. A cross-layer routing scheme that meets the required quality of service (QoS) also needs to be optimized for energy efficiency. When all of CCP's nodes have enough battery capacity and link capacity, the path chosen by RPTC is the path with the lowest power. This can reduce relaying load on most nodes, extending their lifespan. However, to increase a node's lifespan Paths with high battery capacities and low link capacities must avoid nodes with less power in the batteries. CCp s path Pj at time t $\partial_{i,1}^{s} - \partial_{i,0}^{s}..........$ In the following $\partial_{i,1}^{s} - \partial_{i,0}^{s}..........$ is the node capacity at that time.

3.5.1 Policies for Routing

The source-to-BS data packet forwarding feature of the WSN routing protocol uses a random vector to decide which node should receive a particular packet., $T_{ij,t=}(T_{ij},_{1t} ....T_{i\,j},_{st})$ .The s'th When sensor data from node i is sent to node j, an event indicating that transmission has occurred is indicated by t.

Broadly speaking, when there are fewer resources available along the path or during processing changes, packets can be delayed. Random events are predictable functions and this affects how well the network flows. The forwarding ability of packets, correlation of data elements, and reference probability measure all influence how smoothly traffic moves through the system.

$$N \max xS \text{ Array } Tt = (T_{i\,j},_{st}; 0 \le i \le T_{\max}, 0 \le J \le T_{\max}, s = 1 ....S) \; t \in [0, T] \text{-------(8)}$$

There are a total of Tmax Nodes in the grid, which describe how connected each area is due to routing, reserving resources, and other interference. J may have more than one entry to simulate point-to-point, multipoint (like broadcast packets), and point-to-multipoint communications between nodes.

3.5.2 Protocol Parameters and QoS Metrics

The protocol layer parameters affect the quality of service metrics ($T_{i\,j},_{st}$). This determination is based on a number of factors, including throughput, packet transmission rate, SNR (signal-to-noise ratio), battery reserve, and connection status. The Bit Error Rate (BER) is the number of bits that go wrong in a transmission, divided by the total number of bytes transferred during the study period. For example: if there are 1000 errors in 100000 transfers, then the BER would be

$$BER = tnbe/tnbr \text{ ------ } (9)$$

When discussing the performance of any sensor network, PDR is defined as the ratio of how many packets were successfully received by all cluster heads to the number of packets that were generated. These two parameters are related to how well a sensor network can transfer information from one place to another. If BER performance improves on a certain network, then this improvement will also be reflected in an increase in PDR.

The signal loss can be measured in terms of how far the message is travel and how long it takes to reach its destination.

$$Sl = 10\log(4\pi de/\theta)2 \quad (10)$$

The strength of a radio signal decreases as the distance between the transmitter and receiver increases. This is because it becomes harder for antennas to pick up signals over longer distances, which results in lower quality audio or video transmission. To compensate for this, transmitters need to use higher power levels so that receivers can still receive data with acceptable accuracy. However, there are limits to how much power a transmitter can use without causing distortion or interference.

The SNR value that a receiver needs to receive a signal is determined by the BER (bits per second) of the signal. Once you know this, you can calculate the SNR required for your specific channel type using the given modulation scheme.

$$BER = 1/2erfc(\sqrt{Eb/N0}) \quad (11)$$

The BER (bits per second) value is nonlinear in relation to the energy per bit and the noise power density. To find this ratio, you can use the following equation:

$$Eb/N0 = [erfc - 1(2.BER)]2] \quad (12)$$

The equation shown above predicts how the bit error ratio (BER) changes depending on the energy per bit and noise power per hertz. It also predicts how BER changes depending on the signal-to-noise ratio (SNR). Because channel loss is based on SNR calculations, this relationship between BER and various factors is anticipated.
The relationship between the power being transmitted Pr and how clear it is at the receiver end can be found in equation (9), where A is a factor that includes antenna gain.

$$SNR_X = (Ps / N) * A \quad (13)$$

3.5.3 Minimizing the delay is part of the equation

ng ->Number of nodes in grid b=data flow

$$\sum_{ng}\sum_{b} de_{ngb} \text{ ---------------- } (14)$$

where ng > $\hat{\delta}$ in grid then de is less. where $\hat{\delta}$ is a low-density grid.

$$Rl,t = Rij,t + Rji,t \forall l(i, j), \forall t(i, j) \text{ ---- } (15)$$

$$Rij,t = Rij,t + Rji, \forall t(i, j) \text{ ------------}(16)$$

$$Rij,t = \sum_{ne}\sum_{i,j=1}^{qij,ne} Rij,ne \text{ --------------}(17)$$

From equations 11,12, and 13, The l(i, j) occupies a specific slot. Pd is packet delivery; t is the product of data flow k and data packet q, which can range from 1 to a positive integer variable.

$$\sum_{t=1}^{S} Rij,t,ne,q = Tij,ne \forall ne, \forall q \in Pd \text{ ----- } (18)$$

This PVM model is established using the SNR (Signal to Noise Ratio) links provided in the routing algorithm. Links are established between CCpi, where i=2,4,6,8 nodes for data transmission. To resolve this, the resultant factor is defined.

$$r = \{Xr_{lx}, Yr_{ly}\} where X = 1.....z, Y = 1......y \quad (19)$$

$$SNR\alpha >= Qx, \sum_{x=1}^{X} X x \leq 1, \sum_{y=1}^{Y} Yy \leq 1 \text{ -------}(20)$$

Where,

Xrlx and Yrlx are the parameters denoting whether a link has χ a data rate with Y Qx is a threshold.

3.6 Algorithm and Framework

A cross-layer architecture for energy conservation is proposed. This framework uses QoS parameters to determine how data flows between different layers of the network. With a routing system that takes into account interactions between layers, this enables functionalities like connectivity and synchronization. The even grid CCP (connectivity coordination point) is chosen as the solution, and data is collected from MSC nodes based on distance using RPTC (Routing protocol to cross layer communication). An optimization process reduces energy consumption at lower levels by adjusting Protocols such as UDP (user Datagram protocol), TCP (transmission control protocol), and MAC layer modulation techniques.

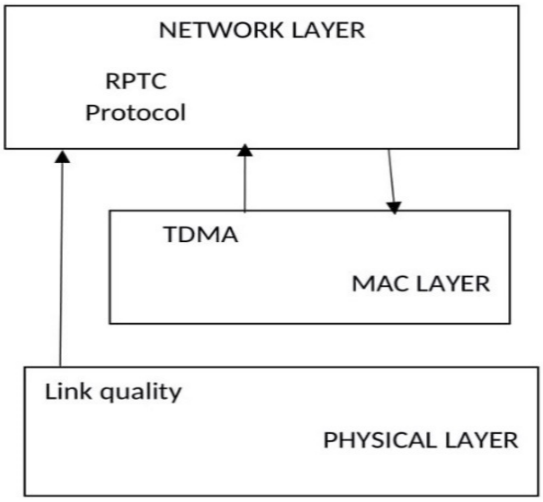


Fig 3 Framework for Cross layer

In the network, nodes are randomly distributed and each base station divides the network into grids with different numbers of nodes. Odd-numbered zones have fewer nodes (density), while even-numbered zones have more nodes (density). The centroid is calculated using a formula in those areas where there are more node densities.

To find the nodes that will be part of a new network in a given zone, all nearby nodes are selected as CCPs. These chosen CCPs are called Temporary CCPs (Temp CCPs). All nodes within the zone now send out announcements declaring their presence to other players. The node's position is then determined using its location information and compared to the locations of the TempCCPs. If they're closer than any TempCCP, they become a part of the new network.

$$DM = [\,[\,[\,[\,[\, d\mathrm{CCP}1,x1 \;\; d\mathrm{CCP}1,x2 \cdots d\mathrm{CCP}1,xn$$

$$d\mathrm{CCP}2,1 \;\; d\mathrm{CCP}2,x2 \cdots d\mathrm{CCP}2,xn \;. \;. \;. \;. \;. \;. \;. \;. \;. \;. \;. \;.$$

$$d\mathrm{CCP}m,x1 \;\; d\mathrm{CCP}m,x2 \;\; d\mathrm{CCP}m,x3 \;\; d\mathrm{CCP}m,xn \;]\,]\,]\,]\,] \qquad (21)$$

The value range for grid numbers 1-9 is from 1 to 9. The number of nodes in a cluster that falls within this range is indicated by the letter

Out of the temporary CCPs that are present in an Even number of grids, these nodes are designated as Final CCPs. The element located in the distance matrix between the CCP and node represents the distance between them. The column containing this value corresponds to Zone number of the corresponding node. For example, if 1 is found in first column, then this node belongs to grid with an odd number of nodes.

After BS has formed the zones, CCP receives messages from all nodes. Then, based on this data, CCP does some calculations to figure out how many CCPS (Communication Control Points) each zone should have. However, as the number of alive nodes decreases over time due to node death, fewer and fewer CCPS are needed in each zone. This causes problems because it means less communication is happening between the different parts of society

3.6.1 Algorithm

- **Setup Phase**

1. Deploy sensor nodes in the application area.
2. Set the initial values of the parameters:
3. The base station divides the network into grid zones in such a way that the Odd zone number contains nodes Nki with less density; NkjEven number contains nodes with more density.
4. Initially, every node will send a message to its neighboring node.
5. Each node I calculates the distance (di,j) from any arbitrary node j using Equation
$d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$-----(13)
6. After receiving the initial message, node j measures the distance djk from Centroid using formula
$dist=\sqrt{(x-x2)2+(y-y2)2}$—————————— (14) where (x, y) is centroid point of network (x2,y2) is the nodes point.
7. If the node is nearer to the centroid, that the node is selected as a Common collector point (CCP) termed as Temp CCPs in all zones.

8. Then based on density δ_X where X=2, 4, 6, 8 the CCPs are selected from the even grids $\delta_X = \frac{\gamma_X * N}{k_X}$ as final CCPs.

- **Steady Phase**

9. Nodes sense data and send it to CCPs in the Final CCP list.
10. The final CCP nodes collect data from different source nodes within the zone also from nodes that are present in TempCCPs another nearby zone.
11.Data are aggregated by Temp CCP nodes (in odd Zones) and Final CCPs aggregate data from its zone and Final CCP nodes communicate with the Temp CCPs nodes to send data to it.
12. Now, once the data is ready with Final ccps, it will be communicated to Msc to collect the data. Therefore, Msc travels only through the Final CCPs collected the data and submitted to the base station.
13. On traveling only through the Final CCPs, the distance covered by Msc will be less, also the energy of the network is saved since after transmitting the packets, the nodes go to sleep.

3.7 Cross-Layer Optimization

Cross-layer protocol optimization is defined in terms of WSN performance metrics, and it is the constrained optimization of a cost functional derived from PVM.

3.7.1 Optimization of Qos energy

To each U $\wp$, we have a equation for the form:

$$\mathrm{Cos}\,t(T_t) = \mathrm{Re}^T[\int_0 C_b(t,T)dt + \ell_r] \quad (22)$$

For each cost rate $C_b(t,T)$ t belongs [0,A] where A=0,1.......N. is a composite process, $C_b(t,T,(\phi),\phi) = (C_b.T)(t,\phi)$ --(16) and is F adapted for each sample path ($T,(\phi)$ path P, the space of values taken by the routing arrays, The function Cb is measurable with respect to t and continuous in the sample path values (($T,(\phi)$) $\forall \phi \in \exists$) . Function Cb is thus measured with respect to the Lagrange-algebras $(F, t \in [0,t]; F \in (FX\mathbb{F}))$, with left-continuous paths for each U□ $\wp$.

The cost of terminal ft is a non-nonnegative, F-measurable, and ϖ^u -integrable function for U□ $\wp$ Indicates the cost incurred at the end of the transmission. Metrics defined in 5.3 satisfy the assumptions.

The optimization problem is the determination of policies $U^{\square} \in \wp$ that satisfy.

$$C_b(U^{\square}) = \min_{U\in\wp}(C_b(U)) \quad (23)$$

Subject to the battery reserve constraints at nodes and along routes, If such a routing strategy exists, it is known as the ideal routing policy for the cross-layer protocol under energy constraints.

3.7.2 Power Control

Defining rate of error of packet with white Gaussian noise

$$\mu_{il,DC} = 1-(1/2e^{\alpha^{il}/2})^D \quad (24)$$

$\alpha_{il} = (p_{tc},_{sum},_i\, f_{tc} / p_{anp})x(N_b / Nr)$ is spectral power noise density ratio where $p_{tc},_{sum},_i$ is the transmitting a packet power that's aggregated at i, N_b is noise bandwidth and p_{tc} is of link (t, c) loss of path , p_{anp} is the noise power that's averaged. The consumption of power by a packet transmitted successfully is $p_{tc},_{sum},_i$ =(Pi)* p_{tc} ,i the occur of congestion in the WSNs, power transmitted is denoted by p_{tc} when there is no congestion, $P^{\square}i$ is rate of congestion at node is the noise to power ratio average is given by p(i)* $P^{\square}n$

where $P^{\square}n$ is an noise power average when there is n congestion, the maximum data link rate $Nr = pi * Nr^{\circ}$ where is Nr° in a ideal condition with max data link rate.

$$\alpha_{il} = (P_i) * p_{tc},_i, f_{tc} / p_i * P^{\square}n) * Nb / pi * Nr^{\circ} \text{ i.e. } (p_{tc},_i f_{tc} / pi * P^{\square}n) * (N_b / Nr^{\circ}) \quad (25)$$

We can conclude that α_{il} is smaller , $\mu_{il,DC}$ is bigger from a formula when there is increase in congestion rate The power, Congestion rate, when suitably regulated, limits the domain of validity by reducing packet error rate. Power is precisely distributed according to need, which can clearly demonstrate efficiency of power.

4. Results and discussion

In this section, we describe how to use a numerical model to assess the feasibility of using RPTC. We did this by creating a field with eighty randomly placed center points and set the distance between them to 20 meters. We also used 10–100 groups as backings for our simulation. The bundle viewpoint was 1024 pieces, and it took 400 milliseconds for it to run

Table 1. Simulation parameters

Sl.No.	Parameters	Values
1	Network size	100x100 m2
2	Initial energy of normal node	1J
4	Initial energy of Msc node	1.5 J
4	Number of Base stations	1
5	Number of nrounds(max)	100
6	Data aggregation energy	5Nj/bit
7	Routing protocol	RPTC
8	Performance parameters	Energy Consumption, Packet delivery ratio, Delay

Fig 4 shows that the RPTC calculation is generally lower when the delay of HEED, CTP, and TBGCA and LEACH is more. This suggests that limiting the delay to a specific degree might be necessary. However, there are different ways in which this can be done: using Msc to calculate distance travelled by even networks or EXTENDED TDMA for calculating distance voyaged. Checking this achieves better organization control and channel choice; the distance travelled is substantially less in the RPTC calculation than with all other cross-layer protocols. Delay is reduced by 20% compared to all other cross-layer protocols.

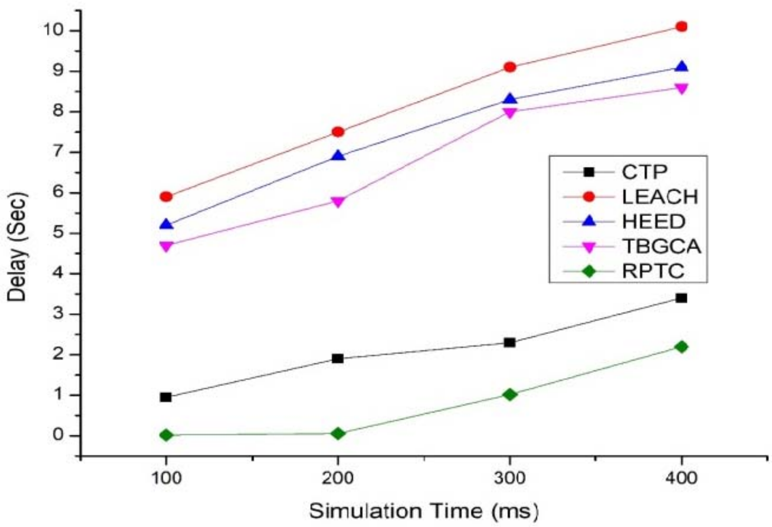


Fig 4 Delay comparison Heed,CTP,TBGCA and LEACH vs RPTC

Fig 5 shows that using RPTC results in a surprisingly high delivery rate for packets. The calculation performed with the different channel choice methods proves to be too complicated, causing congestion. Therefore, the bundle conveyance proportion is increased by 20%. Additionally, the CTP optimization calculation demonstrates failure of channel competition leading to congestion. Consequently, packet delivery is increased by 20% compared to all other cross layer protocols.

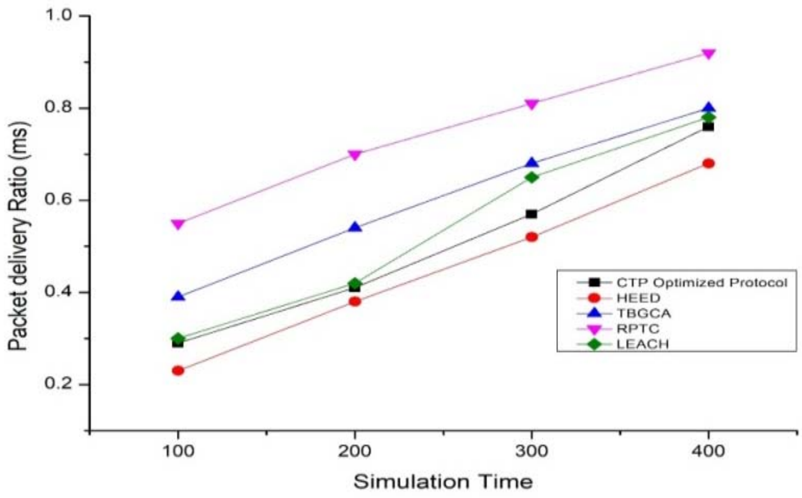


Fig 5 Packet delivery ratio comparison Heed,CTP,TBGCA and LEACH vs RPTC

From Fig 6, it can be seen that RPTC is the best option for reducing energy consumption. This method suggests that added up data makes traffic reduce, which could capably lower energy usage. Additionally, by choosing channels wisely, you can take advantage of power obliged to you. The other options are not as good as RPTC in this issue and will consume more energy than necessary

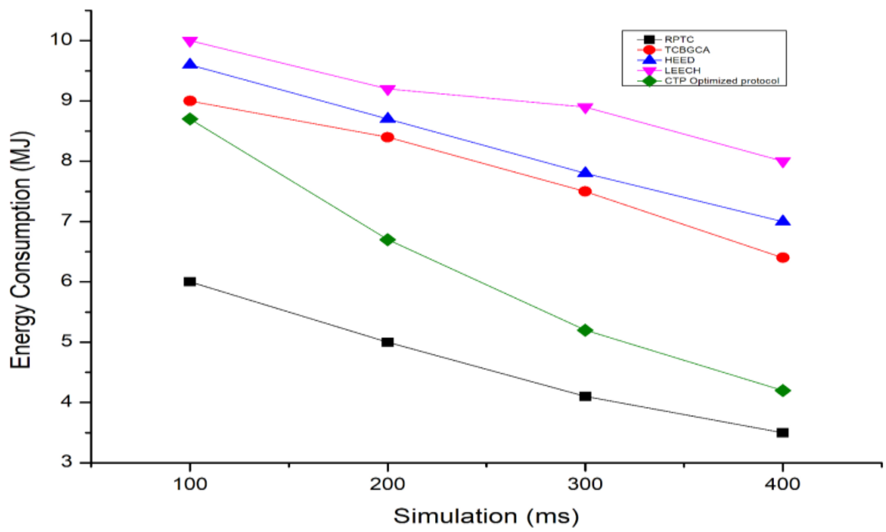


Fig 6. Energy consumed by RPTC vs Heed, CTP, TBGCA and LEACH

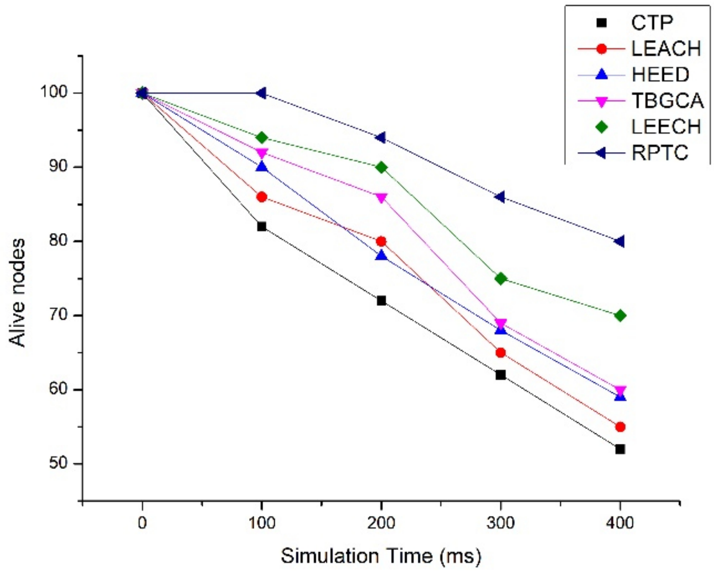


Fig 7. Graph showing Number of alive nodes by RPTC vs Heed, CTP, TBGCA and LEACH

From Fig 7, it can be seen that RPTC has the highest number of live nodes. This kind of method suggests that only during the data transmission the nodes will be awake and after that they go to sleep. So there will be a reduction in energy and an increase in their network lifespan. The other protocols are not as good when compared to RPTC with this issue. The number of nodes alive is 25 percent more than all the other protocols

A model is created that divides a network into grids with random distribution of nodes. The node at the center (CCP) is chosen based on its distance from the grid's center. it was highlighted how mobile nodes are used, our model only uses data collected by even-grid nodes and sends information to a base station. Also, compared to methods defined in [3][4][5], here we define a model that also defines routing policies which improve communication within the network. Additionally, PVM has been modeled to optimize energy usage and control power consumption. So, we have achieved better results than those previously described.

4. Conclusion

This paper proposes a cross-layer enhancement to extend TDMA booking for WSN networks. We use a PVM model to find the best path between grids, in order to minimize energy usage and delay. Our calculation outperforms competing conventions concerning delay and packet delivery ratios, as shown by simulation results. The goal of our enhancement is to improve network performance overall; by resolving issues with capability utilization and reducing idle time on devices.

Conflicts of Interest

The authors have no conflicts of interest to declare.

5. References

[1] K,Shakthi dasan (2021) Energy-based ased random repeat trust computation approach and Reliable Fuzzy and Heuristic Ant Colony mechanism for improving QoS in WSN, *Elsevier*.7:pp.7967–7976.

[2] Kavita Jaiswal, Veena Anand(2021). A Grey-Wolf based Optimized Clustering approach to improve QoS in wireless sensor networks for IoT applications, *Peer-to-Peer networking and Applications*,14:pp.1943–1962

[3] Kavita Jaiswal,Veena Anand(2020) EOMR: An Energy-Efficient Optimal Multi-path Routing Protocol to Improve QoS in Wireless Sensor Network for IoT Applications, *Wireless Personal Communications*,111:pp.2493–2515.

[4] M. Maheswari ,R. A. Karthika.(2021) A Novel QoS Based Secure Unequal Clustering Protocol with Intrusion Detection System in Wireless Sensor Networks, *Wireless Personal Communications*,118:pp.1535–1557.

[5] Sohail Sarang(2020). Energy-Efficient Asynchronous QoS MAC Protocol for Wireless Sensor Networks, *Wireless Communications and Mobile Computing*, 2020:pp.1-13.

[6] Thangaramya Kalidoss(2020) . QoS Aware Trust Based Routing Algorithm for Wireless Sensor Networks, *Wireless Personal Communications*,110:1637–1658.

[7] Turki Ali Alghamdi(2020). Route optimization to improve QoS in multi-hop wireless sensor networks, *Wireless networks*;

[8] Vivek Deshpande, Vladimir Poulkov(2020) . Model to Improve Quality of Service in Wireless Sensor Network. *Advances in Intelligent Systems and Computing book series,1016*

[9] Shankar Dattatray Chavan, Anju VijayKumar Kulkarni(2019), Improved Bio Inspired Energy Efficient Clustering Algorithm to Enhance QoS of WSNs, Wireless Personal Communications,109:pp.1897–1910.

[10] Shivaji R. Lahane (2021) .A Novel Cross-Layer Cross-Domain Routing Model and It's Optimization for Cluster-Based Dense WSN, Wireless Personal Communications volume 118:pp.2765–2784.

[11] R. Elavarasan,Chitra Krishnan(2020). An efficient fuzziness based contiguous node refining scheme with cross-layer routing path in WSN, Peer-to-Peer Networking and Applications, pp.2099–2111,
[12] Kummathi Chenna Reddy, Geetha D. Devanagavi1 , and Thippeswamy M. N(2019). CL-mWSNs: Cross Layer Model-Based QoS Centric Routing Protocol for Mission-Critical Cooperative Communication in Mobile WSNs, Journal of Telecommunications and InformationTechnology; pp.53—63 .
[13] Waqas Rehan,Stefen Fischer,Maaz rehan,Yasser mawad,Shazad saleem(2020). QCM2R: A QoS-aware cross-layered multichannel multisink routing protocol for stream based wireless sensor networks,Journal of Network and Computer Applications,156.
[14] Urmila patil, Anju V. Kulkarni, Radhika Menon ,Mithra Venkatesan(2021). A Novel AEB-AODV -Based AADITHYA," Cross Layer Design Hibernation Algorithm for Energy Optimization in WSN, Wireless Personal Communications, 117:1419–1439.
[15] M. M. Hassan, S. Huda, S. Sharmeen, J. Abawajy, and G. Fortino.(2021) An adaptive trust boundary protection for IIoT networks using deep-learning feature-extraction-based semi supervised model, IEEE Transaction on Industrial Informatics, 2021; 17(4): pp.2860-2870.
[16] T. Xu, G. Han, X. Qi, J. Du, C. Lin and L. Shu(2020) , A hybrid machine learning model for demand prediction of edge-computing-based bike-sharing system using Internet of Things" IEEE Internet Things Journals.,2020;7(8):7345-7356.
[17] Z Lv, J Wu, Y Li, H Song(2022) .Cross-Layer Optimization for Industrial Internet of Things in Real Scene Digital Twins, IEEE Internet of things Journal,2022;9(17): pp.15618-15629
[18] N Ajmi,A Msolli, Abdelhamid Helali, Pascal Lorenz, Ridha Mghaieth(2021) Cross-layered energy optimization with MAC protocol based routing protocol in clustered wireless sensor network in internet of things applications,International Journal of Computing Systems,2021
[19] Pustokhina, I.V.; Pustokhin, D.A.; Lydia, E.L.; Elhoseny, M.; Shankar, K.(2021) Energy Efficient Neuro-Fuzzy Cluster based Topology Construction with Meta heuristic Route Planning Algorithm for Unmanned Aerial Vehicles. Computer Networks.;(196): 108214.
[20] Pignaton de Freitas, E.; da Costa, L.A.L.F.; Felipe Emygdio de Melo, C.; Basso, M.; Rodrigues Vizzotto, M.; Schein CavalheiroCorrêa, M.; Dapper e Silva, T. (2020) Design, Implementation and Validation of a Multipurpose Localization Service for Cooperative Multi-UAV Systems. In: Proceedings of the International Conference on Unmanned Aircraft Systems.2020.
[21] B AL-Hasani, B Waheed.(2022) Comparative study and performance investigation of MANET routing protocols, International journal of non linear analysis and applications,pp.1953-1964,
[22] Mohammed I. Habelalmateen, A. H. Abbas, L. Audah, N. A. M. Alduais.(2020) Dynamic multiagent method to avoid duplicated information at intersections in VANETs. Telecommunication Computing Electronic Control. 2020; 18:pp.613–622
[23] Kakamoukas, G.A.; Sarigiannidis, P.G(2022). Economides, A.A. FANETs in Agriculture—A routing protocol survey. Internet of Things,
[24] Chriki, A.; Touati, H.; Snoussi, H.; Kamoun, F.(2019) FANET: Communication, mobility models and security issues. Computer Networks. 2019; 163:106877.
[25] Liu, J.; Wang, Q.; He, C.; Jaffrès-Runser, K.; Xu, Y.; Li, Z.; Xu, Y. (2020) QMR:Q-learning based Multi-objective optimization Routing protocol for Flying Ad Hoc Networks. Computer Communication Networks. 150:pp.304–316.

Authors Profile

V Kiran Kumar was born in october at Vijayapura near devanahalli. He s an M.Tech graduate pursuing his Phd under VTU. He s lifetime member of IEI,MISTE,Currently working as an Assistant professor in Dept.of ISE,SJBIT has published 13 paper in International journal and conferences.His area of interest are computer networks,Wsn,IOT.

Dr.ShivaMurthy G was born in Shivamoga, Karnataka.He Obtained his PhD degree from NITK Surathkal in the year 2013, M.E from Bangalore University. Currently he's working as Associate professor in Department of CSE, Chikkaballapur. He's a lifetime member of IEI, ISTE. His areas of interests are IOT and wsn. He has 26 publications in Scopus and Web of science.