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Multi Trajectory Particle Swarm Optimization towards Optimal Velocity Control against load balancing and band width controlling

Author :	**Dr.Gomathi.U**	Assistant Professor, Department of Computer Science, Hindustan College of Arts & Science, Coimbatore-28.

Abstract

The Multi Trajectory Particle Swarm Optimization has been employed to obtain the optimal velocity control of the load for effective channel management of the mobile AdHoc network. Node Architecture on aspect of node density is major design constraint in Mobile Ad Hoc Network. In order to effectively utilize the node density in terms of load balancing and bandwidth utilization, a novel optimal velocity control of nodes in cluster based MANET architecture has been proposed. Certain Trajectory of Node propagation with specific velocity has been computed. Computed trajectory nodes value will be scheduled using multi trajectory based particle swarm optimization. Many routing protocols have been developed during the last years to increase the lifetime of a channel and in turn the lifetime of the network.

Introduction

One of these developments is multipath routing protocols for dynamic channel allocation which is effective. Multipath routing protocols is modeled on basis of on demand routing structure which enables the source node to choose the best route among many routes during a single route discovery process. Multipath routing protocols [7] flood a route request to learn more than one path to the destination to forward packets through them This process in multipath routing will decrease the number of route discovery processes since there are backup routes already available and in case one route fails, it will reduce the end-to-end delay, energy consumption and the network lifetime of the network by establishing channel coordination.

1.1. On Demand Routing Protocol

An on-demand routing protocol(AOMDV) has its roots in the Ad hoc On-Demand Distance Vector (AODV), a popular single-path routing protocol. AOMDV creates a more extensive AODV by discovering, at every route discovery process, a multipath (i.e. several other paths) between the source and the destination. The multipath has a guarantee for being loop-free and link-disjoint[71]. AOMDV likewise offers two key services: route discovery and route maintenance. Since it greatly depends on the AODV route information, which is already available, AOMDV incurs less overhead than AODV through the discovery of multiple routes [72].

1.1.1. Link Life time

Link lifetime or link availability is defined as the probability that a link will be continuously available for a specified period of time. The link availability can be predicted accurately over a short period of time, by estimating the distance between two nodes. Let M_i represent the link, x_i be the connection, LT_{xi} the connection lifetime, N_{i-1} and N_i be the adjacent nodes, and B_{Ni} and B_{Ni-1} be the battery lifetime of the node N_i.

The connection lifetime (LT_{xi}) depends on the relative mobility and distance among the nodes N_{i-1} and N_i at time t. The link lifetime (LT_{Mi}) is estimated using the following expression:

$$LTMi=\min(LTxi,BNi-1,BNi)$$

Thus, the lifetime of route R is defined as the minimum value of the lifetime of both nodes and connections involved in route R.

1.1.2. Node Lifetime

The nodes may exist in two states such as active and inactive modes. The active mode node drains more energy that results in shorter lifetime than the inactive mode node. Therefore, the node lifetime routing depends upon the energy state of nodes such as residual energy and energy drain rate.

Let RE_i be the residual energy of the $N_{i,}$ ED_i be the energy depletion rate of N_i and T be the duration in seconds. The node lifetime is estimated using:

$$LTNi=REnTi/EDni,t\in[nT,(n+1)T]$$

1.1.3. Available Bandwidth of the Node

Available bandwidth of node for load scheduling of mobile adhoc network is computed using below form

$$ARij+\beta i=CiARij+\beta i=Ci$$

Where β be the available bandwidth and C be the link capacity associated with one-hop neighbor i and A_R is the cumulative assigned rates for all incoming and outgoing flows. Hence, the sum of the assigned incoming and outgoing flow rates and available bandwidth on the link should be equal to the capacity of the link i. The link capacity is measured and available bandwidth is defined by the following equation:

$$\beta j\Delta=\max\{0,Cj-ARij\}$$

It helps in simplifying the underlying routing paradigm by confining the major routing tasks to gateways.

Moreover, any gateway node $Gi\in G$ should be able to communicate with gateway $Gj\in$, either directly or through a non-backbone node. As a consequence, the route finding search space is reduced to the path through the gateway nodes, which subsequently helps in minimising the control overhead related to routing. Therefore, the operating paradigm of the routing protocol will be faster and more efficient.

1.1.4: Deployment Conditions

It uses massive MIMO antenna and millimeter-wave communication technologies for the densification deployment of small cells. In this case, the wireless backhaul traffic has to be relayed to the given gateway by multihop links. As a consequence, distributed network architecture is a reasonable solution for 5G ultra-dense cellular networks[73]. It follows the centralized architecture. Deployment Model is configured based on Backhaul energy efficiency

$$\textbf{Backhaul energy efficiency } \boldsymbol{B} = \frac{\mathit{Backhaul\ Network\ Capacity}}{\mathbf{n}*(\textbf{small Cell BS BackHaul Energy Consumption})} \qquad \textbf{[Eq - 4.0]}$$

The backhaul energy efficiency first increases with the increase of the number of small cell BSs; then the backhaul energy efficiency decreases with the increase of the number of small cell BSs after the backhaul energy efficiency reaches the maximum threshold. The backhaul energy efficiency of ultra dense cellular networks achieves a stationary saturation value when the number of small cell BSs approaches infinity.

The deployment of femtocells is done in ad-hoc manner as per subscriber's requirements. The physical layer radio connectivity topology of femtocell networks is different from the wireless ad-hoc networks. Hence auto-configuration of radio parameters becomes a very important functionality for MANET networks. The auto configuration is an algorithmic approach which guarantees reconfiguration of networks with a tolerable disruption of the whole network.

1.3. Route discovery

Route discovery involve finding multiple routes from a source to a destination node. Multipath routing protocols can try to discover the link-disjoint, node disjoint or non-disjoint routes [74]. While link-disjoint routes have no common links, it may have nodes in common. Node-disjoint routes, which are also referred to as totally disjoint routes, do not have common nodes or links. Non-disjoint routes, on the other hand, can have both nodes and links that are in common.

Algorithm 1.1: Channel Assignment

Input = one-hop view of each node and total available colors

Output = k-hop clustered colored nodes such that any two nodes within two-hop distance are not assigned the same color

Process

- Initially Nodes are initialized to 0 as Assign Colour
    - Where node maintains information about available colors in the system
- If (R< TH)
- Node changes from IDLE to CH and Node broadcasts blurb message
- flag value to 1 and wait timer to t
- If (R>TH)
- Node changes from IDLE to NCHs
- Flag value to 0 and wait timer t2

Importance of discovering multiple routes during the process of route discovery is considered using the design of AOMDV. It is intended to serve highly dynamic ad-hoc networks that have frequent occurrences of link failure and route breaks. A new process of route discovery is necessary in the event that all paths to the destination break. It utilizes three control packets: the route request (RREQ); the route reply (RREP); and the route error (RERR). Initially, when a source node is required to transmit data packets to a specific destination, the source node broadcasts a RREQ [75].

The new weight vector w(l+1) to be used in round of iteration l+1 is then computed as a function g(d) of the normalized belief divergence d which is the distance between the sensor readings and the reputation vector $r^{(l)}$.

$$d = [d1, d2, d3 \ldots d_n]^T$$

$$d_i = \frac{1}{m} || x_i - r^{(l+1)} ||^2 \qquad \text{[Eq - 1.1]}$$

In this g(x) is called the discriminant function and it provides an inverse relationship of weights to distances d. Discriminant function was a reciprocal of the distance between sensor readings and the current computed reputation.

Reciprocal: $g(d) = d^{-k}$

Exponential : $g(d) = e^{-d}$;

Affine: $g(d) = 1 - k_1 d$ where $k_l > 0$ is chosen so that

$g(\max_i\{d_i^{(l)}\}) = 0$

A robust variance estimation method in the case of skewed sample mean is an essential part of secure aggregation of the sensed data towards planning the routing.Because the RREQs is a flooded network-wide, several copies of the very same RREQ may be received by a node.

In the AOMDV, all duplicate copies undergo an examination to determine the potential alternate reverse path. However, of all the resulting set of paths to the source, only the use of those copies, which preserve loop-freedom and disjointedness, get to form the reverse paths. In the event the intermediate nodes get a reverse path through a RREQ copy, it conducts a check to determine the number of valid forward paths (i.e. one or many) to the destination.

1.4. PSO Optimization – Swarm Based Metaheuristics Algorithm

PSO is a population based optimization technique, which follows the social behavior of species that exist in the form of swarms in nature. These swarms are capable of exchanging valuable information such as food locations in the environment. A basic variant of the PSO algorithm works by having a population (called a swarm) of candidate solutions (called particles). These particles are moved around in the search-space according to a few simple formulae

PSO optimization is an optimization technique employed to achieve load balancing efficiency in the multipath routing of the packets in the Mobile Adhoc Network using the energy or light intensity. It models the fitness function to control the data transmission on extracting the information of energy, distance, delay, and bandwidth of the proposed network. It helps the particles to move towards brighter and more attractive locations in order to obtain optimal solutions. All particles are characterized by their channel intensity associated with the objective function. Each velocity changes its position iteratively.

In addition additional factors have been consumed to model the fitness function which is as follows

- Load Balancing functions for each node
- The distance functions of the links connecting the neighboring nodes.
- Energy consumption of the nodes.
- Communication delay of the nodes

1.4.1. Optimal Node velocity Computation to Channel

Optimal Node Velocities to the channel is computed using particle Swarm optimization (PSO). The PSO algorithm[76] is a novel Metaheuristics, which is inspired by the behavior of particle which is considered as nodes in this model. The Model uses the particle and velocity to determine the optimal channel for nodes for data transmission on utilization of the fitness function. It provides the global best and local best information of the data to channel. Figure 1 represents the route selection using PSO optimization.

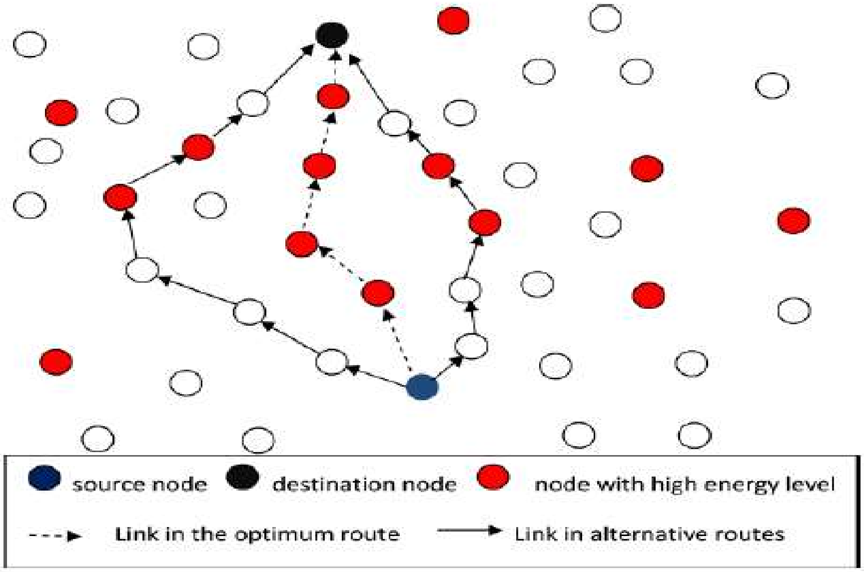

Figure 1.4: Optimum Channel Selection using PSO Optimization

The density of node is generated by a process of bioluminescence which energy of the nodes may serve as an element of courtship rituals or warning signals for data communication. The Metaheuristics constructed for the multipath routing is as follows

- All particles are unisex, and they will move towards more attractive and brighter ones. It provides the information about node's each energy level.
- The attractiveness of a particle is proportional to its brightness which decreases as the distance from the other velocity of the particle increases. If there is not a more attractive particle than a particular one, it will move randomly. It represents the distance of every route.
- The local best and global best of a particle is determined by the value of the fitness function on the basis of node factors in each process of route discovery. For maximization problems, the brightness is proportional to the value of the fitness function[77].

However, node will adaptively decrease its maximum effective communication range when its own residual energy is lower than a threshold and becomes less and less, which is helpful to prolong the life time of the underwater sensor nodes. The coverage range can be computed as follows

$$\mathrm{R}=x=\frac{2\mathrm{R}}{\pi}\tan(\mathrm{p}) \qquad \text{[Eq - 1.2]}$$

Where p is E/E_o is percentage of residual energy

1.4.2. Distributed Multichannel and Mobility-Aware Cluster-Based MAC Protocol

Problems are identified such as predictability, fairness, low throughput, latency, and high collision rate, particularly in high-density networks. Therefore, a distributed multichannel and mobility-aware cluster-based MAC (DMMAC) protocol is proposed. Through channel scheduling and an adaptive learning mechanism integrated within the fuzzy-logic inference system (FIS), vehicles organize themselves into more stable and no overlapped clusters. Each cluster will use a different sub channel from its neighbors in a distributed manner to eliminate the hidden terminal problem[78].

Increasing the system's reliability, reducing the time delay for vehicular safety applications, and efficiently clustering sensor nodes in highly dynamic and dense networks in a distributed manner are the main contributions of the proposed MAC protocol. The reliability and connectivity of DMMAC are analyzed in terms of the average cluster size, the communication range within the cluster and between cluster heads (CHs), and the lifetime of a path. Simulation results show that the proposed protocol can support traffic safety and increase vehicular ad hoc networks' (ASN) efficiency, reliability, and stability of the cluster topology by increasing the CH's lifetime and the dwell time of its members.

Algorithm 1.2: Specified Channel Data Transmission

- Spatial Information of the node = S_I
- Temporal Information of the Node = T_i
- Distance between (x_{i-1} y_{i-1}) and (x_i y_i) = D_t
- If (D_t > Specified limit)
- Commit Data Transaction
    - Set fag Value =1
- Else
- Choose the best path for data Transmission
    - Set Flag Value = 2

This concludes that there is no effect of cluster radius over the number of messages flown per femtocell in the network.

Interference = N

Network Inference (Speed of the Node 1 at T_i - Speed of Node 1 at T_{i+1})

Reduce the traffic to the Node

1.5. PSO based Node Trajectory computation for Channel Selection

Node trajectories are treated separately on the basis of the channel conditions; the criteria for these channel selection are different. For each trajectory, the selection of channel points falls into the following two aspects. First, the node selected as selection points as it should be those with the most urgent needs of channel supplement [79]. Second, as the node constraints move over the selection points back and forth for data gatherings during a time interval, the length of each migration of channel is expected to be short so that the mobile node navigation can spend more time on data transmission.

To better enjoy the benefit of the energy supply provided by the proposed model against the nodes in the network, more selection points should be selected such that more cluster nodes can timely get determined based on the node factors. Let S be the source, D the destination and Px where x = 1,2,…,n be the possible multiple paths from S to D. Each link $(ni,) \in Px$ is defined by the weighted exponent vector of delay (wd), interference (wI)and route lifetime (wl), such that wd, wI, $wl > 0$.

$$wI(Pi)=\Sigma wI(ni,nj)(ni,nj\in Pi)>wI(Pi')=\Sigma wI(ni',nj') \qquad \text{[Eq - 1.3]}$$

Given wd, wI, and wl, the MCOR selection problem in DICR is to find the path $Pi \in Px$ such that,

$$wd(Pi)=\Sigma wd(ni,nj)(ni,nj\in Pi)>wd(Pi')=\Sigma wd(ni',nj') \qquad \text{[Eq - 1.4]}$$

Where, $i\neq i'$ and $Pi\cup Pi'=Px$

The path $Pi \in Px$ has maximum lifetime among all other paths $Pi' \in Px$, if it has a node $m\in Pi$ with optimal value of minimum lifetime. However, this would adversely prolong the migration trajectory and transmission time. Thus, there is an inherent tradeoff between the number of node to be selected from the cluster head and the trajectory length. The energy used by node ni to transmit unit information to nj is denoted by $eninj$

$$(ni)=\Sigma_{(eninj)}(If(ni,nj)) \qquad \text{[Eq - 1.5]}$$

The lifetime of node ni is the ratio of its residual energy to rate of energy depletion. In terms of rate of information flow, the energy depletion rate of node ni can be expressed as

$$[ni(t)]=REni\ \Sigma_{(eninj)}(If(ni,nj)) \qquad \text{[Eq - 1.6]}$$

Based on this observation, the node point selection problem for channel trajectory at a particular time interval k can be described as follows.

Given the up-to-date energy states of node obtained by the constrainst at the end of time interval k-1,

E_{k-1} = States of Nodes

In order determine the maximum number of selection points for channel trajectory at time interval k such that the node located at these selection points holds the least energy, and meanwhile by visiting these selection points, the trajectory length of the constraints[80] is no more than a threshold value.

Energy at each node = $(EA1, EA2, EA3)_{k-1}$

Trajectory Length >Threshold of node propagation

For Normal Node trajectory, the anchor points are selected based on the amount of data that can be collected. Based on the observation that the more residual energy on a node, the more data it can upload, the constraints are likely to be able to collect more data if the surrounding node have high transmission level.

$E_{residual} >$ Threshold

Allow Data Collection and Transmission

Thus the set of selection points can be selected based on the energy status of their neighbors, which also satisfies that the migration length does not exceed the threshold value.

Lagrangian Multiplier is to predict the Available route in iteration

Available Route for data Transmission through Mobiles node is given by

$R_M = \{R1, R2, R3, R4......R_n\}$

Path Selection for Data Transfer can be calculated using

$$\mathrm{R1} = \mathrm{T} + K\sum_{n=1}^{\infty}\left(\cos\frac{\mathrm{T}}{l} + \sin\frac{T}{l}\right) + \mathrm{R}(\left(\cos\frac{\mathrm{T}}{l} + \sin\frac{T}{l}\right) + B_d + R_m \quad [\text{Eq - 1.6}]$$

No of Route Request for R_M is given by

Mobile Sink Allocated to Route $A_R = \max \sum_{R=1}^{R=\infty} N$

The Spatial and Temporal information determines the optimal data rate for the data transfer by the mobile node and the flow routing algorithm finds the optimal routing path and flow rate on each link on eliminating the fast degrading nodes. Figure 1.2 represents the architecture of the proposed model. In addition, Geographic routing algorithm has been used along the Lagrangian multipliers [9] iteratively and passes to gather the node information by neighbor discovery principles.

The path prediction is performed to mark the neighbouring node as best node for transmission [8]. Hence it is termed as reliable routing path that provides fast data delivery. Lagrangian multipliers are used to maximize the node performance in specific condition and constraints on the attack propagating medium

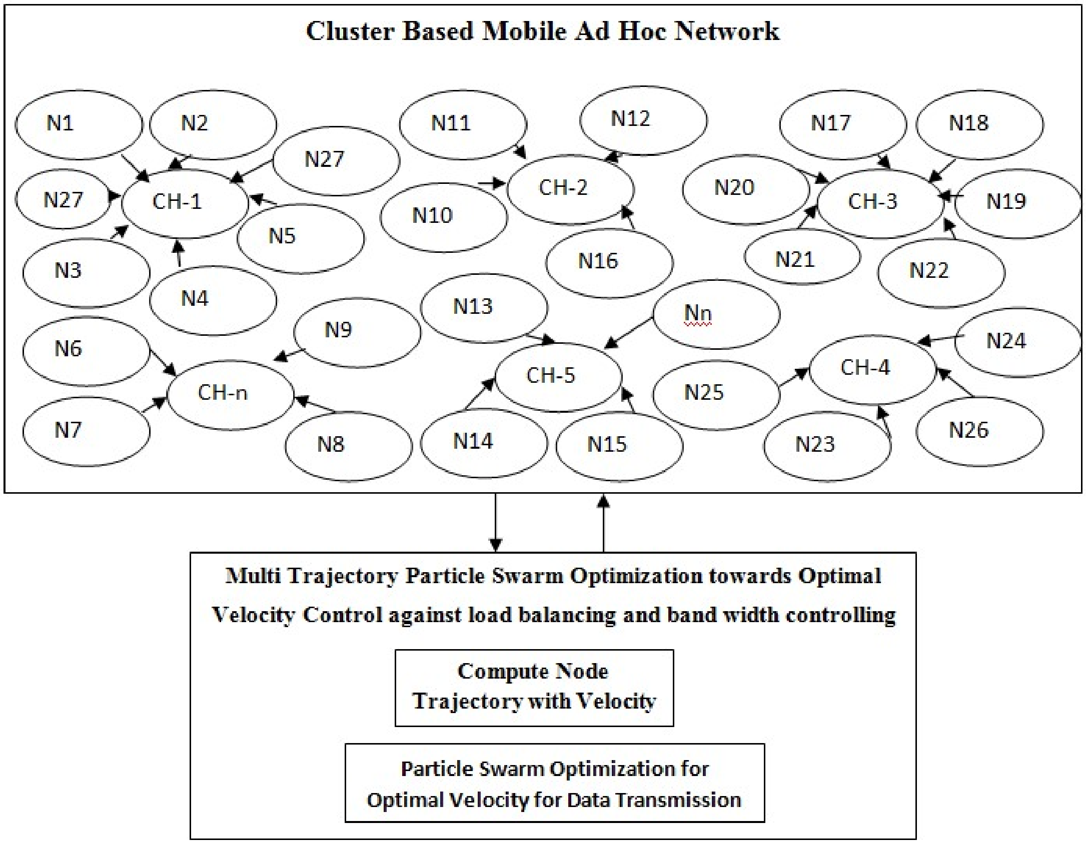

Figure 1.2: Architecture of the proposed MTPSO approach

. Excessive average energy consumption in the network is calculated for mitigating the node capabilities on cluster region and computation at node density is represented by μ_i^j. *The* network utility under the bandwidth constraints helps to determine the energy balance and link capacity while maintaining the perpetual operation of the network with maximum throughput achieved. The Constraints are as follow

- Optimal rate for a node to generate data should be more than specified node density
- Route sensing data under the constraints of energy and link capacity has to be more the alternate path
- Effective time period to collect data from nodes under the constraints of energy and load capacity has been in the value range for mitigating the retransmission.

On meeting the above constraints meets, each node can participate in data transmission to the mobile node in at most in any consecutive time slots by eliminating the data loses.

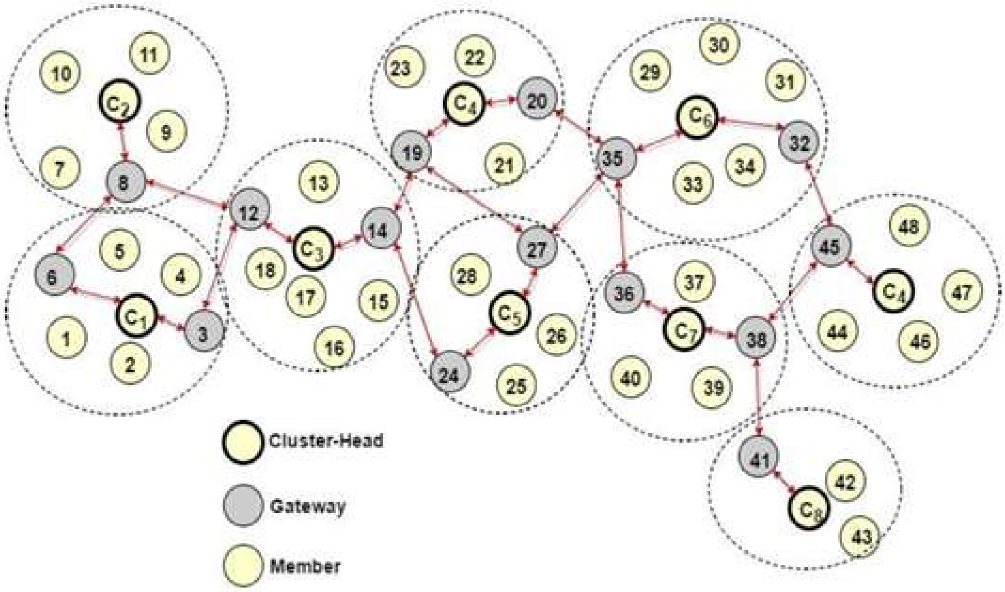

Figure 1.3: Cluster Connected Mobile Adhoc Network

Each mobile node computes the energy requirement of all registered nodes in time slots of the current time interval through unsupervised learning model, the mobile node compares the cluster head with the maximum transmission on the available path in the specified time slots, The comparison results makes the allocation decisions suing the cache information collected using the routing table [83].

- **Margin Adaptation**

It is generally considered to be crucial for energy-efficient scheduling especially for battery limited hand-held devices. The energy-efficient operation is for the UE while fulfilling some stringent QoS levels (e.g., rate, delay and delay jitter) and some degrees of fairness among different users (or different traffic classes) with scarce spectral resources over time and frequency-varying channels.

- **Rate Adaptation**

It is used to increase the bits-per-joule metric. It seems to be bilateral and used distinctly on resource allocations problems. It’s associated with conflicting constraints from one side and the limited availability of spectral resources from the other side

1.5.1. Packet transmission through cluster

In this M= ($N^n{}_s$, $N^n{}_D$), where $N^n{}_s$ is the set of deployable node for data communication , $N^n{}_D$ is the deployed node in the Movable and Deployable Resource Units which uses IEEE interface with carrier sense multiple access with collision avoidance protocol[84]. The nodes are equipped with multiinterfaces that transmit packets through multichannel and generate much less interference where nodes are equipped with a single Wifi interface, we assume that each node is equipped with a single Wifi interface in order to deal with a more difficult problem.

MDRU is a cluster or repository of the utilized and unutilized service nodes for data communication in the disaster period, it invokes and returns set of nodes based on the node density on bounded region also data communication is carried out between source and destination through queuing condition, channel condition and mobility.

We use R_i and $R_i^{|}$ to denote the packet transmission range and transmission interference range of node N, respectively. We use dij to denote the distance between nodes n_i and n_j. A packet transmission from n_i to n_j is successful if both conditions below are satisfied 1) dij< R_i and 2) any node n_k satisfying dkj < $R_i^{|}$, k is not transmitting packets, where 0 < k < N. Table 1 lists the symbols used in this paper for reference.

Table 1.1: Notation of the Symbols used

Notation	Description
$N^n{}_s$	set of deployable node for data communication
$N^n{}_D$	the deployed node in the Movable and Deployable Resource Units
R_i	Transmission range of node N
$R_i^{|}$	Inference range of node N
D_d	Deadline of the data
S_p	Packet size
T_w	Queuing delay

1.5.2. Path Reliability Estimation

The Path Reliability estimation denotes the packet reception ratio of link relaying node to the sender Node. It indicates the probability of delivery of packet over the path. If it discovers one or more repeated data transmission to the particular channel, it can revoke the particular nodes from utilizing the channel in the network with an authenticated revocation message. While conceptually simple, this approach suffers from several drawbacks inherent in a centralized system[85].

First, the node becomes a single point of failure. Any compromise of the communication channel around the node will render this protocol useless. Furthermore, the nodes closest to the channel will receive the brunt of the routing load and will become attractive targets for the node. The channel detection is carried out in the distributed region either splitting it into different zones or using entire region for data analysis.

In order to facilitate the data communication with energy efficiency can be achievable by cooperative jamming detection mechanism in the collaborative clustering routing of the Mobile Adhoc network. The node cooperation and channel cooperation is carried out in parallel using collaborative clustering scheme which can potentially be utilized for data communication[86].

In the post deployment stage, coverage holes are created in the network due to predicable or unpredictable failure of the nodes such as power exhaustion or explosion. In our protocol, it is considered that the immediate one-hop neighbours of a dead node know the location of the holes in the network based on the location of the dead nodes. In such a deployment scenario, the node density of the network can be non-uniform as density of the nodes in the large overlapping area must be higher than the density of the nodes in the sparse region.

- **Switching strategy**

The switching strategy (NS), which adaptively switches on or off some low-power nodes based on the instantaneous load of the system has been considered. It is compatible with the microcells' load balancing feature and can be easily implemented on the basis of existing LTE-A specifications[87]. Moreover, an analytical model for analyzing the performance of system energy consumption, block rate, throughput, and energy efficiency has been analysed. The performance of NS is evaluated by comparison with existing strategies. Theoretical analysis and simulation results show that NS not only has a low block rate, but also achieves high energy efficiency.

1.5.3. Functionalities of Three-Hop Relay Algorithm.

During a timeslot, for each cell with at least two nodes:

1) If there exists a S-D pair in the cell, randomly select such a pair uniformly over all possible pairs within the cell. If the source has a new packet intended for the destination, transmit it and then delete it from its buffer. Else remain idle.

2) If there is no S-D pair within the cell, randomly designate a node in the cell as sender. Then for such a cell.

i) Broadcast transmission. If it is a popular cell and the designated sender has packets, transmit all the packets in its buffer to all other nodes in the cell with the assistance of AP. If a packet is received by its destination successfully, delete the packet from the buffers of all nodes holding it. Else remain idle.

ii) If it is not a popular cell, independently choose another node as receiver among the remaining nodes in the cell. With equal probability, randomly choose from the two options:

- Source-to-relay transmission. If the sender has a new packet which has never been transmitted before, relay the packet to the designated receiver. Else remain idle.
- Relay-to-destination transmission. If the sender has a packet destined for the designated receiver, transmit. Once the destination has received it, the packet will be dropped from the buffers of all nodes holding it. Else remain idle. Note that the algorithm schedules the single-hop S-D transmissions whenever possible, while S-R, R-D and broadcast transmissions happen independently.

1.5.4 Transmission Analysis using Redundancy measures

In location-based scenarios, delay can be further improved by allowing multi-user reception in popular cells, which are defined as transmission redundancy[88]. Here relay redundancy refers to the redundancy put forward in previous works, which could happen in any cell having at least two nodes. In transmission redundancy, a packet can be received by all other nodes in the same cell in a timeslot through broadcasting. The crucial difference is that, once transmission redundancy of a packet incurs, it will generate multiple duplicate-carrying relays for the packet. And to obtain the same number of duplicates, each packet is required to be retransmitted multiple times to different relays by relay redundancy since relay redundancy generates at most one duplicate each time. Note that rich node resource in popular cells enables transmission redundancy, which thus may not work in uniform scenarios.

The minimum delay of the network without relay redundancy has been considered as an important factor. Specifically, we consider an ideal situation where the network is empty and a source sends a single packet to its destination.

- We adopt a scheme without considering relay (i.e., non-redundancy scheme) since relaying packets cannot help improve delay.
- We explore the minimum delay of the network when implementing transmission redundancy

1.6 Result and discussion

In this work, we designed a multi adaptive particle swarm optimization for optimal velocity estimation for load balancing in the channels of the MANET. It is considered to be effective against dynamic load. The minimum delay of the network without relay redundancy has been considered as important factor. Specifically, we consider an ideal situation where the network is empty and a source sends a single packet to its destination. Further it utilizes the bandwidth and energy of the nodes on proper utilization of the channels.

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