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OLSR WITH OPTIMIZED HYBRID PARTICLE SWARM OPTIMIZATION AND INVASIVE WEED OPTIMIZATION

S. MEENAKSHI SUNDARAM[1] DR. S. PALANI[2] DR. A. RAMESH BABU[3]

[1] Professor and Head, Department of C.S.E., M.A.M. School of Engineering, Tiruchirappalli, India
[2] Professor & Dean, Department of E.C.E., Sudharsan Engineering College, Pudukkottai, India
[3] Professor & Head, Dept. of Computer Applications, Saranathan College of Engineering, Tiruchirappalli, India

E-mail: [1]smsresearch2k12@gmail.com, [2]keeranurdrspalani@gmail.com , arbbabu@yahoo.com

ABSTRACT

MANETs are multi-hop ad-hoc wireless networks where nodes move arbitrarily in topology. The network has no infrastructure and can be established easily in any environment. The Optimized Link State Routing (OLSR) protocol is a route management protocol which is used for such mobile ad hoc networks. The paper presents a hybrid algorithm based on Invasive Weed Optimization (IWO) and Particle Swarm Optimization (PSO), named IW-PSO. IWO is a relatively new numerical stochastic optimization algorithm. By incorporating the reproduction and spatial dispersal of IWO into the traditional PSO, exploration and exploitation of the PSO can be enhanced and well balanced to achieve better performance. In this paper, it is proposed to modify OLSR using Hybrid Particle Swarm Optimization Invasive Weed Optimization which reduces the end to end delay and also improves the throughput in the network.

Keywords: *Optimized Link State Routing (OLSR), Invasive Weed Optimization (IWO),Ad hoc Network, Particle Swarm Optimization (PSO)*

1. INTRODUCTION

Staying connected to a network is the aim of mobile technologies and MANETs are capable of providing a solution. In a MANET [1], all nodes are routers forwarding packets without infrastructure. Such a network is spontaneous, self-organized and self-maintained. Many routing protocols were developed for ad hoc networks and are classified based on varied criteria, the most important being by route discovery type which enables to separate routing protocols into proactive and reactive categories.

OLSR is an active link state, routing protocol for ad hoc networks where each node sends out HELLO / Topology Control (TC) messages periodically. It reduces flooding link state information overhead by requiring just Multi Point Relay (MPR) to forward TC messages. A routing table keeps next hop information for all destination nodes.

Link-state information is flooded throughout the network in a classic link-state algorithm. OLSR uses this method, but as the protocol runs in wireless multi-hop scenarios OLSR message flooding is optimized for bandwidth preservation. Optimization is based on a *Multi Point Relaying technique*. OLSR being table-driven, its operation includes updating and maintaining information in various tables. Table data is based on received control traffic, and the latter in turn is generated from information retrieved from tables. Route calculation is also table driven[2].OLSR defines 3 types of control messages:

Hello – Such messages are transmitted to neighbors and used for neighbor sensing and MPR calculation.

TC – *TC* messages are link state signaling by OLSR. This messaging is optimized by MPRs in many ways.

MID – Such messages are transmitted by nodes running OLSR on more than one interface. They list all nodes and IP addresses used.

Particle Swarm Optimization [3] is another derivative-free and flexible optimizer replicating bird flocking. PSO algorithm is promising for various optimization problems. It is effortless and easy to realize when compared to other computation intelligence techniques. It received attention from the field of evolution and is a research hot spot. Though PSO has high convergence speed, literature reveals that PSO finds it difficult to jump out of local optima, if it falls into minima. In literature, many approaches were introduced to improve PSO performance, by merging it with other evolutionary computation techniques. Hybrid PSO, (HPSO) technique merged a mutation operator and natural selection to solve

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premature convergence. By introducing roulette wheel selection based Cauchy mutation and evolutionary selection, HPSO greatly reduced probability of being trapped in local optimum.

Invasive Weed Optimization [4], a bio-inspired numerical stochastic optimization algorithm, simulates natural weed behavior in colonizing and finding place for growth / reproduction. Some properties of IWO when compared to other evolutionary algorithms are reproduction method, spatial dispersal, and competitive exclusion. IWO process starts with initializing a population [5]. A population of initial solutions is generated randomly in the solution space. Then population members produce seeds based on comparative fitness in the population. The seed number for each member varies linearly between Smin for worst member and Smax for best member. Seeds are randomly scattered in the search space by distributed random numbers with mean equal to zero and adaptive standard deviation.

In this paper an Invasive Weed Optimization (IWO) / Particle Swarm Optimization (PSO) based hybrid algorithm (IW-PSO) is implemented. Incorporating IWO reproduction / spatial dispersal into traditional PSO, enhances the latter's exploration and exploitation in addition to being well balanced [6]. IW-PSO achieves better OLSR performance.

2 RELATED WORK

OLSR, a standard optimized link state routing introduces an interesting concept, Multi-Point Relays (MPRs), to lower message overhead during flooding. Malik et al[7] proposed a new MPR section algorithm to enhance OLSR performance using Particle Swarm Optimization sigmoid increasing inertia weight (PSOSIIW). The sigmoid increasing inertia weight greatly improves particle swarm optimization (PSO) regarding simplicity and quick convergence towards an optimum solution. PSOIIW's new fitness function, each node's packet delay and willingness degree are brought in to help MPRs selection in OLSR. The packet loss, throughput and end-to-end delay of the suggested method are examined through use of Network Simulator 2 (NS2). Overall results reveal good performance compared to standard OLSR and OLSR-PSO, specifically for throughput and end-to-end delay. Also, the proposed OLSR-PSOSIIW shows advantages in using PSO to optimize MPR selection algorithm's routing paths.

A numerical optimization technique for antenna configurations was introduced by Mallahzadeh et al [8]. The algorithm, inspired by colonizing weeds, was robust and adaptive to environment changes. Hence, their properties when captured would result in a powerful optimization algorithm. The proposed algorithm's feasibility, efficiency and effectiveness for optimization of antenna problems were examined by an antenna configurations set. The results were compared to PSO technique widely used in antenna optimization. Numerical results show good agreement between corresponding results.

Two evolutionary algorithms- Invasive Weed Optimization (IWO) based Power System Stabilizer (PSS) and Particle Swarm Optimization (PSO) based power system stabilizer were designed by Ahmed and Amin [9] to compare tuning performances of multi point power systems. IWO is a derivative-free real parameter optimization technique mimicking colonizing weeds ecological behavior. PSO again, is a derivative-free and flexible optimizer powered by bird flocking behavior. Eigen-value based objective function is used to tune PSSs to enhance electro-mechanical mode's system damping. The proposed system performance was tested /demonstrated under different disturbances in a 4 machine example power system. Eigen value analysis and non-linear time domain simulation results show that both IWO-based PSS and PSO-based design successfully damped out oscillations improving system stability.

Basak et al [10] suggested an improved variant of recently developed ecologically inspired meta-heuristic called IWO. It aimed to solve real parameter optimization issues regarding the plan of time modulated linear antenna arrays with ultra low Side Band Level (SBL), Side Lobe Level (SLL), and Main Lobe Beam Width (BWFN). Classical IWO improved by the introduction of 2 parallel populations and a more explorative routine of changing mutation step-size with iterations. Results indicate the proposed algorithm achieved better performance over design problem as compared to conventional Taylor Series, the only known Differential Evolution (DE) algorithm based meta-heuristic.

Invasive Weed Optimization is a population based meta-heuristic mimicking weed colonizing action. Sengupta et al [11] proposed improvements to this by introducing a constriction factor at seed dispersal stage. Temporal Difference Q-Learning was adapted to this parameter for various population members through successive generations. The proposed mimetic approach, Intelligent Invasive Weed Optimization (IIWO) was tested on a set of 15 benchmark functions and

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also real world Circular Antenna Array Design problem. Test results indicate the proposed approaches efficiency.

3. METHODOLOGY

A. WEIGHTED FAIR QUEUEING (WFQ)

It is based on a class of queue scheduling disciplines. When a packet completes transmission, the sent packet is one with the smallest value of F_i^{α} [12]. Finishing time is being calculated using equation 1 as given below:

$$F_i^{\alpha} = S_i^{\alpha} + \frac{P_i^{\alpha}}{\phi_{\alpha}} \quad (1)$$

$$S_i^{\alpha} = \max[F_{i-1}^{\alpha}, R(\tau_i^{\alpha})] \quad (2)$$

with Generalized Processor Sharing (GPS), a flow α is assigned a weight $\emptyset_{\alpha}$ that determines the number of bits transmitted from that queue in each round. Effective packet length is $1/\emptyset_{\alpha}$times true packet length. It can be seen that, at any given time, service rate gi for a non-empty flow i is calculated by using equation 3 as given below:

$$g_i = \frac{\phi_i}{\sum_j \phi_j} C \quad (3)$$

where the sum is taken over all active queues and C is outgoing link data rate. Maximum delay experienced by flow i, Di is bounded by equation 4 as indicated below:

$$D_i \le \frac{B_i}{R_i} \quad (4)$$

The flows set is defined by and limited to token bucket specification. Bi and Ri are bucket size and token rate respectively for flow i. Weight assigned to each flow equal token rate. Under WFQ, the first ten packets of flow 1 have processor share finish times smaller than packets on other connections and transmit these packets first.

B. PULSE CODE MODULATION (PCM)

Traffic characterizes PulseCode Modulation (PCM) using G.711 codec [13]. It compresses 16-bit linear PCM to 8-bit logarithmic data. The ITU-T Rec. G.711 presents two PCM audio codecs, A-law and U-law. In implementation, 16-bit samples are passed to coder input. For given input x, A-law encoding is as in (5):

$$F(x) = \operatorname{sgn}(x)\begin{cases} \dfrac{A|x|}{1+In(A)}, & |x| < \dfrac{1}{A} \\ \dfrac{1+In(A|x|)}{1+In(A)}, & \dfrac{1}{A} \le |x| \le 1 \end{cases} \quad (5)$$

where A is the compression parameter.

The μ-law algorithm for encoding is as given in equation (6) below:

$$F(x) = \operatorname{sgn}(x)\frac{In(1+\mu|x|)}{In(1+\mu)} \qquad -1 \le x \le 1 \quad (6)$$

Where μ=255 (8 bits).

C. PARTICLE SWARM OPTIMIZATION (PSO)

Particle Swarm Optimization (PSO) maximizes objectives to find parameters through exploring search space for a problem. This technique is from Swarm Intelligence and evolutionary computation [14]. Swarm Intelligence is based on swarming habits of birds / fish, and evolutionary computation locates a local / global maximum. PSO algorithm represents each solution as a 'bird' in the search space and calls it a 'particle'. Objective functions evaluate candidate solutions, operating on resultant fitness values. Candidate solution and estimated fitness / velocity give the particle's location. It remembers best fitness value it achieved during the algorithm's operation, referred to as individual best fitness, and candidate solution which achieved it being called individual best position 'pbest'. Best fitness value among all swarm particles is called global best fitness, and candidate solution which attained this fitness is called global best position/global best candidate solution 'gbest'. PSO algorithm includes 3 steps reiterated till stopping criteria is met [14]:

1. Evaluation of each particle's fitness.
2. Individual / global best fitness and positions updated
3. Velocity / position of each particle updated.

A directed graph G = (V, E) defines a communication graph, where V is a set of n nodes and E a set of m edges. Each edge has parameters of link quality, jitter and packet dropped. These functions can be formulated as follows for a path:

$$\begin{aligned} link\ \text{quality}(p_i) &\ge L & i &= 1,\dots,k \\ jitter(p_i) &\le J & i &= 1,\dots,k \\ Packet\_dropped(p_i) &\le PD & i &= 1,\dots,k \end{aligned}$$

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D. INVASIVE WEED OPTIMIZATION (IWO)

IWO algorithm is a numerical stochastic search algorithm mimicking natural weed colonizing behavior, finding a suitable place for growth / reproduction. Some IWO properties when compared to other EAs are reproduction way, spatial dispersal and competitive exclusion. There are 4 steps for the algorithm as described below [5]:

1) Initialization of a population: A number of weeds are randomly spread over the search space (*D* dimensional). Each generation's initial population is termed as $X = \{x1; x2,. . . ,xm\}$.

2) Reproduction: Each member of population *X* produces seeds in a specified region centered at own position. Number of seeds produced by $xi;\ i \in \{1, 2, . . ., m\}$, depends on relative fitness in the population regarding both, best and worst fitness.

3) Spatial Dispersal: Generated seeds are randomly distributed over d-dimensional search space through normally distributed random numbers with zero mean and variance σ2.

4) Competitive Exclusion: If a plant has no offspring then it becomes extinct; otherwise they can take over the world. Hence there should be some competition between plants to limit maximum plant numbers in a population. Initially, plants in a colony reproduce quickly, and all weeds are included in the colony, till the plants number reaches a maximum value of *pop max*

A meta-heuristic algorithm mimicking weed colonizing behavior is Invasive Weed Optimization (IWO) [15].

If sd_ max and *sd_* min are the maximum and minimum standard deviation and if *pow* is a real no. , then the standard deviation for a particular iteration may be given as follows:

$$sd_{ITER} = \left(\frac{iter_{\max} - iter}{iter_{\max}} \right)^{pow} (sd_{\max} - sd_{\min}) + sd_{\min}$$

This ensures that the probability of dropping a seed in a distant area decreases nonlinearly with iterations, resulting in grouping fitter plants and eliminating inappropriate plants. Hence, this is an IWO selection mechanism

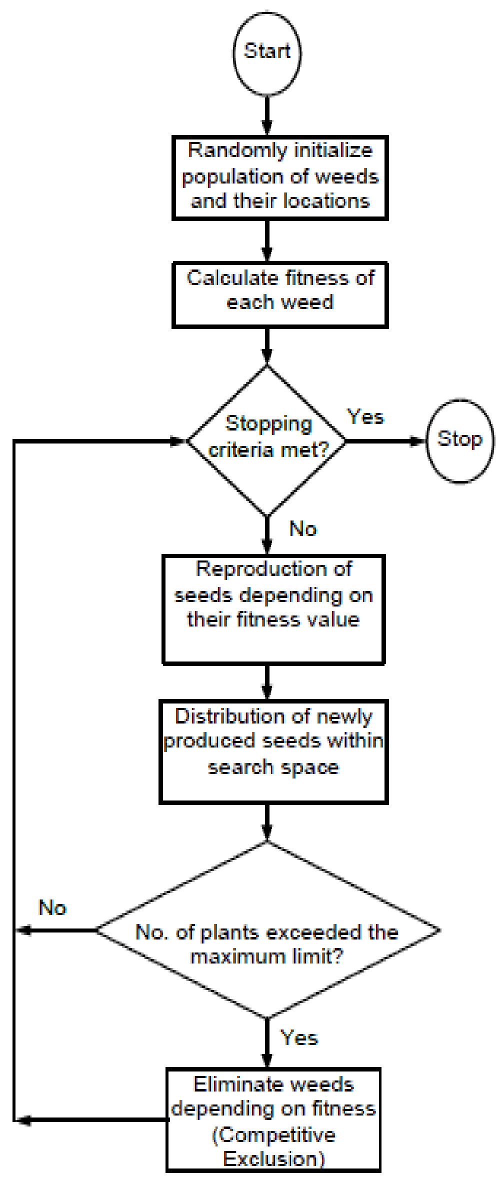

Figure 1 Invasive Weed Optimization Algorithm Flowchart

4. SIMULATION STUDY AND RESULTS

The simulation setup consists of 20 nodes. The nodes are spread over 2000 meter by 2000 meter with the trajectory of each node being random. Each node runs a multimedia application over UDP. The data rate of each node is 11 Mbps with a transmit power of 0.005 watts. The simulations are run for 400 sec. The parameters used in the OLSR [16] routing protocol is shown in Table 1 below:

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Hello interval in seconds	3
TC interval in seconds	7
Neighbor hold time in seconds	9
Topology hold time in seconds	21
Duplicate message hold time in seconds	30
Addressing mode	IPV4

Table 1: OLSR Parameters Used In The Simulation Study Setup

Table 2 below gives the details of the network layer packet prioritizing. A weighted queuing approach is adapted with the lowest priority for background traffic and very high priority for streaming traffic, to maintain the QoS of the network.

Individual Queue Limit for low priority data	32 Packets
Individual Queue Limit for low priority data	64 Packets
Weights assigned for streaming packet	50
Weights assigned for multimedia packets	30

Table 2 Packet Shaping in the Network Layer

Figure 2 below shows the average jitter for OLSR and modified OLSR. It is seen that the proposed modified protocol reduces the jitter when compared to the existing OLSR. The jitter is reduced in the range of 25% to 32% when compared to the classic OLSR. Though, the proposed optimization has very less impact on the jitter.

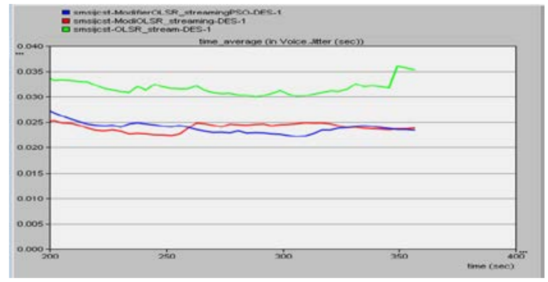

Fig 2: Average Jitter For The Proposed OLSR And Classic OLSR

The modified OLSR Routing Protocol performance of data dropped and end to end delay is shown below in Figure 3 and Figure 4 respectively.

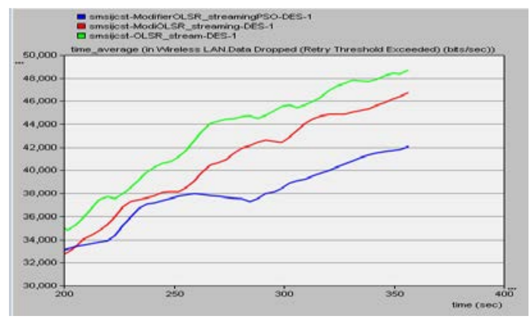

Fig 3: Data Dropped

The performance in terms of packet data dropped improves considerably with the use of proposed optimized OLSR. It is evident from the graph that with the increase in time the proposed optimized OLSR drastically reduces the number of packets dropped when compared to both OLSR and modified OLSR.

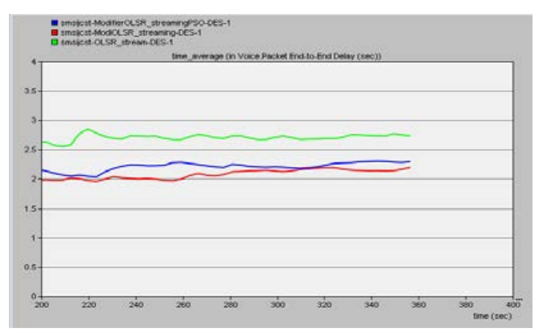

Fig 4: End To End Delay

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The performance of the proposed optimized OLSR is better than the OLSR when compared to end to end delay.Fig 4 shows that Modified OLSR performs the best. Throughput is shown in Figure 5, and the proposed OLSR achieves better throughput when compared to the traditional OLSR.The proposed optimization's performance is better with time, and the throughput is improved by more than 3% with respect to OLSR and modified OLSR

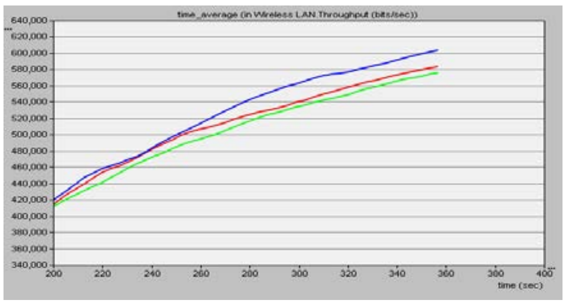

Fig 5: Throughput For Various OLSR

5. CONCLUSION

In OLSR, link state information is generated only by nodes elected as MPRs. Thus, a second optimization is achieved by minimizing the number of control messages flooded in the network. As a third optimization, an MPR node may chose to report only links between itself and its MPR selectors. Hence, as contrary to the classic link state algorithm, partial link state information is distributed in the network. This information is then used for route calculation. OLSR provides optimal routes (in terms of number of hops). The proposed modified protocol reduces the jitter when compared to the existing OLSR. The jitter is reduced in the range of 25% to 32% when compared to the classic OLSR. Though, the proposed optimization has very less impact on the jitter. The performance in terms of packet data dropped improves considerably with the use of proposed optimized OLSR. With the increase in time the proposed optimized OLSR drastically reduces the number of packets dropped when compared to both OLSR and modified OLSR. The proposed OLSR achieves better throughput when compared to the traditional OLSR and modified OLSR. It is also noticed that the proposed optimization performs better with time, improving the throughput by more than 3% w.r.t OLSR and modified OLSR.

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