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Review of Particle Swarm Optimization for Energy Management in Mobile Ad Hoc Networks

A. Karmel
Shool of Computing Science and Engineering, VIT University, 600127 Chennai, Tamil Nadu, India

Abstract: This study presents the requirement of an efficient optimization algorithm based on particle swarm optimization named with the target of optimizing (minimal in this case) the energy consumption when routing data packets form source to destination in mobile ad hoc network. The particle swarm optimization algorithm computes the particles position and velocity and minimizes the energy consumption. Particle swarm optimization algorithm formulates the fitness function purely based on the energy factor. The stopping criterion for the optimization run is computed based on the residual energy of the mobile node in the network. Energy consumption is one of the important metric to be considered when maximizing life time of the network.

Key words: Particle swarm optimization, fitness function, energy, velocity, termination criterion, India

INTRODUCTION

Mobile Ad Hoc Network (MANET) is a constantly self-designing gathering of portable nodes that can be vivaciously set up whenever and anyplace with no settled framework.

It is a self-ruling framework and the versatile hosts associated by remote connections are allowed to move haphazardly. The topology of such system is likely exceedingly dynamic in light of the fact that every system node can openly move and no preinstalled base station exist.

Because of the restricted remote transmission scope of every node, information packets might be sent along multi-hops. Route development must be finished with at least overhead and bandwidth capacity utilization. Energy-efficient routing algorithms (Jinhua and Xin, 2011) are trying to plan as execution debases with the development of number of nodes in the environment and an extensive ad hoc system is hard to oversee.

PSO is a populace based stochastic optimization system concocted by Kennedy and Eberhart (1995) and Shi and Eberhart (1998) was initially planned for simulating social conduct (Kennedy, 1997) as a copy representation of the development of living beings in a feathered creature rush (Fig. 1) or fish school (Fig. 2). An expansive review of PSO applications was made by Poli (2007, 2008).

PSO is a meta-heuristic as it makes few or no suspicions about the issue being upgraded and can look huge spaces of candidate solutions. PSO can be utilized on optimization issues that are mostly sporadic, loud, change after some time and so forth.

PSO works by initializing a population of random size possessing candidate solutions. Here, the population indicates the swarms and the candidate solution indicates the particles. These particles take a random movement in the defined hyperspace funneled by the particles individual best known solution and the whole swarm's best known solution.The process is iterated until a best optimal (minimal) solution is discovered.

Literature review

Binary Particle Swarm Optimization [BPSO] algorithm: BPSO (Rezaei *et al*., 2012) is an optimization algorithm to improve the highly adaptive reactive routing protocol TORA for mobile ad hoc network. The routing issues arise due to the limited battery capacity and dynamic topology. The actual PSO algorithm optimizes the problems only if the candidate solutions are continuous real values. But the particle cannot take continuous movement in a discrete valued hyperspace (Izakian *et al*., 2010).

In BPSO each particle position takes the binary value either 0 or 1.The Binary value '1' indicated that the particle is "included" and binary value '0' indicates that the particle is "excluded" in the defined hyperspace. The social acceleration co-efficient c_2 is zero and therefore, the global best solution of the entire swarm is ignored. The Fitness function is defined in terms of energy factor and distance factor:

$$\text{Fitnees}(p_i) = w_1\left(\frac{\text{energy}(p_i)}{\text{Max\_energy}}\right) + w_2\left(\frac{\text{max\_hopcount}}{\text{hopcount}(p_i)}\right)$$

w_1 and w_2 are the weight of energy and distance factor, respectively.

Each particle can transform its position from 0 to 1 and vice versa. Rezaei *et al*. (2012) also proposed an IMP-TORA and justified with the simulation results that IMP-TORA outperforms than TORA in terms of total data delivered and network life time.

MATERIALS AND METHODS

Hybrid routing intelligent model: PSO hybrid with ACO was proposed (Nancharaiah and Mohan, 2014) to improve the important MANET metrics such as power consumption End-to-end delay and communication cost. Ant Colony Optimization (ACO) inspire mobile nodes as ants and determines the best optimal path in a network and PSO, a meta-heuristic approach in swarm intelligence inspires mobile nodes as particles and computes the position and velocity of the particles in terms of local best and global best in the search-space. This hybrid algorithm is devised in such a way that it invokes the ACO algorithm to determine the best optimal solution.

If the optimal solution is not computed, then PSO algorithm is invoked by initializing particle position and velocity to compute the best optimal (minimal) solution. The fitness function is framed in terms of delay, distance, capacity, power and communication cost. Simulation results shows that the hybrid routing intelligent algorithm has better performance that ACO in terms MANET metrics.

RESULTS AND DISCUSSION

Improved Adaptive Particle Swarm Optimization [IAPSO]: A Joint Opportunistic Power and Rate Allocation (JOPRA) algorithm (Guo *et al*., 2011) was devised based on an Improved Adaptive Particle Swarm Optimization (IAPSO) to minimize power allocation in wireless ad hoc networks.

Particle swarm optimization is implemented in such a way that the exploration of particles was avoided by considering the PSO parameter by limiting maximum velocity, selection of inertia weight, cognitive and social coefficient. The stopping criterion is defined based on quick sort algorithm to terminate the optimization run. The IAPSO for JOPRA algorithm operates based on the following procedure:

- Initialize swarm population
- Overhaul the position and speed of the swarm
- Computation of inertia weight and acceleration coefficients
- Compute the optimal solution
- Update local and global bets solutions
- Terminate the optimization run based on the stopping criteria

JOPRA algorithm fast converges to the optimal solution with less power consumption.

PSO multicast routing: Multicast routing mechanism in light of particle swarm optimization was proposed (Nasab *et al*., 2012) to improve network performance and efficiency. An extended sequence and topologyencoding is implemented for particle encoding. Prim's algorithm is used to construct the spanning tree that includes all nodes in a given network.

The particle encoding is proceeded by constructing two array of some size. The first array holds the index of the node and the second array holds the index of the parent of each node in the first array. The fitness function is framed based on the energy and delay metrics. Simulation results show that the proposed mechanism outperforms that the multicast routing mechanism based on genetic algorithm.

Priority scheduler with PSO: A priority scheduler with PSO (Huang *et al*., 2009) is incorporated into the multicast routing mechanism for scheduling decisions in order to avoid packet loss rate. The priority index is defined based in the speed of the node that moves fastest, hop count left end-to end deadline time and the packet delivery ratio. The packet with low end-to-end deadline target time is given high priority.

Multi-Objective Particle Swarm Optimization (MOPSO): A Multi-Objective Particle Swarm Optimization (MOPSO) algorithm (Ali *et al*., 2012) was proposed to advance the quantity of clusters where the traffic is handled by cluster head and energy dissemination in nodes in order to give an energy effective solution which is accomplished through Pareto front. The simulation results were compared with other clustering techniques like WCA and CLPSO using the MANET metrics: level of nodes, transmission power and battery power utilization.

CONCLUSION

Thought particle swarm optimization is implemented for efficient multi-casting mechanism, efficient clustering mechanism and so on, still designing an efficient energy optimization algorithm based on PSO is an open challenge. The proposed algorithm is expected to give better performance compared to the other energy efficient mechanisms since the fitness function is formulated based only on the energy factor.

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