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Integrated Science

River formation dynamics routing protocol for wireless mesh network

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ABSTRACT

Routing in WMNs is the very critical component because of its dynamic nature. The routing rules enlarged for WMNs and build it self -organized system. We have to find the smallest near path evaluation within a specified time. Thus, requiring some nature inspired approaches which provide "good enough" results in a reasonable computing time. Basically in this paper proposes a Cost Evaluation module for integrated cost measurement in terms of some parameters. These parameters comprises per node as well as per flow parameters. We apply River Formation Dynamics approach based on nature inspired computing to evaluate shortest distance near paths. RFD is executed using Network Simulator (NS2). The performance results of this approach are compared with the AODV and DSR. The conclusion reveals that RFD technique performs better than AODV and DSR.

Keywords: Integrated link cost, Nature inspired computing, NS2 Simulator, River formation Dynamics, Wireless Mesh Network

INTRODUCTION

Wireless mesh network are popular because of its flexibility, low cost consumption and simple to organize. They reduced wired infrastructure merged with bulky scale business.[1] WMN nodes are categorized into two parts that are wireless mesh routers and wireless mesh clients which are fixed and movable. These nodes have ability to link and generate a network within a radio range. WMN architecture comprised into three parts: (1) Infrastructure WMNs (2) Client WMNs and (3) Hybrid WMNs. Based on infrastructure WMNs, wireless mesh routers build an infrastructure for wireless clients. Based on client WMNs, it provides peer to peer networking and wireless mesh routers are not involved for client network. Hybrid based WMNs are the grouping of both infrastructure and client WMNs.[2]

Routing protocol work in a self-configuring and self-organizing mode provide some purpose i.e. offering management, reducing the ability of network and minimizing the packet delays.[3] Mobile Ad hoc Networks (MANETs) and WMNs both are familiar in many features. The routing protocol which is constructed for MANETs can generally be useful for WMNs. There are many performance parameters which basically used in wireless mesh networks can be classified into per flow, per node, per link and network wide parameters. Per flow consist of throughput, delay jitter, hop count and packet loss ratio. Per node consist of power efficiency. Per link consist of channel utilization and congestion where network wide parameters consist of QoS and total throughput.[4]

The routing strategies based on heuristics optimization provide a sub-optimal result in extremely dynamic WMNs. There are various soft computing techniques used for optimization especially swarm intelligence algorithm which is inspired by nature. These algorithms are proposed and applied for many optimization problems. A detailed clarification of different types of nature inspired meta- heuristic techniques comprised flower pollination,[5] dolphin echolocation,[6] firefly algorithm,[7] biogeography based optimization[8], river Formation dynamics,[9] Japanese tree frog calling,[10] black hole,[11] lion optimization algorithm,[12] cuckoo search[13] and many more. In this paper we determined river formation dynamics algorithm to evaluate the shortest distance and near path in a specified time. The proposed algorithm is stimulated in Network Simulator (NS2) and its routing performance is compared with existing techniques i.e. Ad hoc On-demand Distance vector (AODV)[14] and Dynamic Source Routing (DSR)[15] routing algorithms.

This paper is arranged into six sections. Section I signifies the inspiration for the current work as well as in brief explain of some nature inspired techniques based on soft computing is stated. In Section II shows cost evaluation module based on node architecture. Section III provides the RFD algorithm explanation. Illustrations of system model with its system properties areincluded in section IV. RFD is occupied to calculate the shortest distance and near path in the WMN in comparison with AODV and DSR in section V. Section VI concludes the paper.

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Highlights

1. Generate a WMN by inserting nodes within the radio range of network.
2. Generate some data from one node to its every neighbourhood nodes. Assume equal throughput, delay and residual energy at each and every node. Create the routing table (Cost).
3. Calculate the ILC based distance between the neighbourhood nodes.
4. Evaluate the shortest distance path for source and destination using the river formation dynamics (RFD) soft computing algorithm and then update the routing tables.

Node Architecture

The architecture of WMNs (where every node can also operate as a wireless router forwards the data packets to additional nodes) is considered. Every node there might be lots of inputs and lots of outputs. The Node Processing Unit (NPU) at a nodeconstruct and selecting the most complimentary link for specified information contain the restraint imposed by the network dynamics. This linkstate information is forward by NPU to Parameter Evaluation Module (PEM) to findsdifferent link parameters e.g. throughput, number of hopes, delay and residual energy of the node. After that information Cost Evaluation Module (CEM) finds the integrated link cost for the individual path.

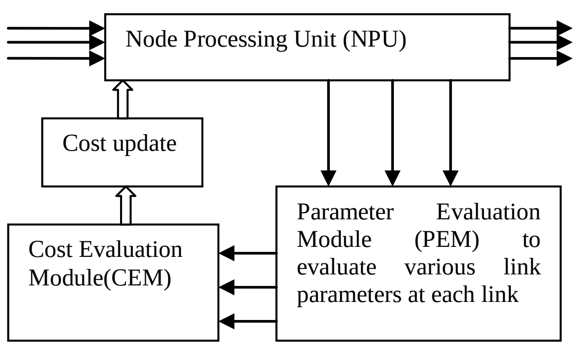

Figure 1. Node Architecture

River Formation Dynamics Algorithm

RFD is a heuristic optimization and subset of swarm intelligence (SI). This algorithm based on the thought that how drops of water unite to form river and then rivers come together to form sea by choosing shortest distance path. In river formation process, the drops of water are constantly flowing from top altitude location to lesser altitude locations. The drops of water flowing from upper locations to lower locations erode and deposited the obtain soil in the lower location. The altitude of the lesser location gets enhanced by placed the soil and from higher to lower location shortest distance path is created.[16]

Basic Pseudo codes for River Formation Dynamics:

```
begin
    /Initialization of WMN parameters/
Define Source Node, Destination node, Number
of Nodes , location of nodes, Number of paths

while(true/ Termination criteria not met)
fork = 1 : n /for all n nodes/
forl = 1 : n /for all n nodes/
ifdistance (k, l) < =Radio range of node
connectivity matrix(k, l)=1
Integrated_link cost (k, l) =f(Throughput,
Delay, No. of hops, Residual Energy)
endif
endfor k
endfor l
/Build path between source and destination/
move_Drops (k, l)
analyze_Paths (k. l)
erode_Path (k,l)
placed_Segments (k, l)
endwhile
Postprocess results and visualization
end
```

Figure 2. Pseudo code for RFD

Basic algorithm for RFD

RFD basically consists of two phases. First phase is initialization phase and second one is River formation phase. In initialization phase, there are three different locations named as Source also called drop producing location, Intermediate location and destination location. These locations have different altitude range. Source and intermediate location have positive altitude whereas destination location has zero value. The source location always produces drops of water. After that drops receive by intermediate locations forwards in the direction of the sea. In the second river formation phase, the river is generated between source locations and generating sea via iterative procedure comprising functions *choose_forward_location (k,l), move_drops (k,l),examine_path (k,l), erode_path (k,l)* and *deposit_segments (k,l).*The probability function indicate as *P(k,l)*shows that location k having probability to choose the location l for on warding drops[16].

$$P_t(k,l) = \begin{cases} \frac{G(k,l)}{sum.(d_l)^{\alpha}} & \text{for } j \in H_r(k) \\ \frac{\omega/|G(k,l)|}{sum.(d_l)^{\alpha}} & \text{for } j \in S_r(k) \\ \frac{\delta}{sum\ (d_l)^{\alpha}} & \text{for } j \in F_r(k) \end{cases} \quad (1)$$

Here, $H_r(k)$ is the collection of neighbours with positive gradient, $S_r(k)$ is the collection of neighbours with a negative gradient and $F_r(k)$ represents neighbours with a smooth gradient. Gradient G (k, l) is defined by variation between the altitudes of nodes and the ω and δ representas certain small values. Here, the sum is the whole weight of every neighbour from dissimilar collections and $d_k$specifies the length from node l and α represents a convergence tuning coefficient[17].

$$DG(k,l) = \frac{altitude\ (k) - altitude\ (k)}{distance\ (k,l)} \quad (2)$$

Here, DG (k, l) is decreasing gradient between node k and l. In the erode_Path(k, l), the paths are eroded accordance with movement of drop. If a drop goes from location S to location D then erode S and place that eroded soil to D using add_Sediments (k,l). The altitude of S location is decreased and altitude value of D location is enlarged. It is mainly depend on the gradient value between S and D. The altitude of the seais always equal to zerothroughout implementation. Finally, analyze_paths (k, l) generated by drops and stores the shortest distance nearest path[17].

System Model

Simulations were executed for various scenarios in NS2 v 2.35 to examine the performance of routing algorithm. To observe the performance of routing algorithm we take 10, 20, 50, 100 and 150 nodes. These nodes are placed within a three different area i.e. 500m x 500m, 1000m x1000m and 2000m x 2000m . Radio range of the nodes varied from 250 meters to 500 meters.The River Formation Dynamics(RFD) algorithm was executing in Network Simulator (NS2). Numerical outcomes were calculated and comparedwith two existing techniques i.e. AODV and DSR. Figure 3 show the graphical representation of WMN topology for 50 nodes.

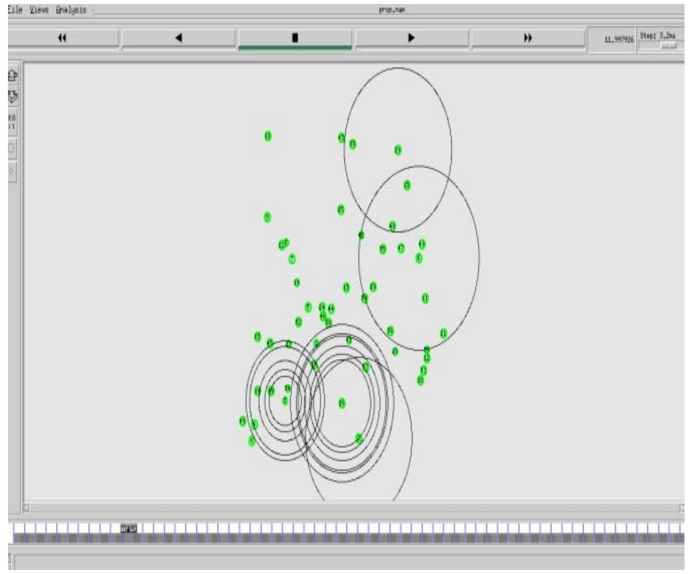

Figure 3. Graphical Representation of Network topology

In Table 1, the radio range of nodes is varied from 250 meters to 500 meters. The node density was varied in the range of [10,150]. The general architecture details of WMN is tabulated in Table.2 and 2, 4, 8, 16 and 25 fixed wireless mesh routers are placed to maximize the optimal network connectivity for 10, 20, 50, 100 and 150 node WMN respectively.

Table 1. The system properties thoseare compatible with WMN.

PARAMETERS	VALUES
Channel Type	Wireless Channel
phyType	Phy/WirelessPhy
Interface queue type	Queue/Drop Tail/PriQueue
Mac Type	Mac/802_11
Link Layer type	LL
Antenna Model	Omni directional
Time of simulation	70 s
Routing Protocol	Dynamic Routing
MIMO	5 I/P & 5 O/P
Radio Propagation	250m - 500m

Table 2. Architecture Details of WMNs

No. of Nodes	Area (m X m)	No. of Routers
10	500 x 500	2
20	500 x 500	4
50	1000 x 1000	8
100	2000 x 2000	16
150	2000 x 2000	25

RFD algorithm compared with the results of AODV and DSR techniques. The results of AODV and DSR are based on some parameters i.e. Delay, Throughput and Residual Energy.

Results and Discussion

Table 3 shows the results of RFD algorithm for varying number of nodes. The corresponding values of throughput, delay and residual energy with varying number of nodes is tabulated in Table 4.

The variation between Throughput and number of nodes is shown in Fig.4. When number of nodes from 10 to 150 increases then the values of throughput also increases. Fig.5. shows the variation of Delay with Number of nodes 10, 20, 50, 100 and 150. As the number of nodes increases delay also increases. Fig.6. shows the variation between residual energy and number of nodes respectively.

Table 3. Results of RFD algorithm

No. of nodes	Cost of path	Shortest path
10	2.0601	0-9-6-2-1
20	3.2234	0-10-8-3-1
50	5.8734	0-49-38-45-47-25-6-1
100	2.9331	0-5-75-3-13-42-39-64-94-28-11-1
150	3.5210	0-32-13-79-85-3-10-126-137-14-15-104-1

Table 4. Throughput, delay and residual energy analysis for varying number of nodes

Nodes	Throughput	Delay	Residual Energy
	RFD		
10	0.99	5.78	68.9456
20	1.04	5.68	56.8235
50	1.06	5.66	48.1624
100	1.07	17.62	41.5436
150	1.09	21.05	29.0978
	AODV		
10	0.92	5.78	58.5520
20	0.94	5.88	51.5148
50	0.97	28.25	41.8345
100	1.02	31.05	33.8734
150	1.05	66.05	22.1781
	DSR		
10	0.82	12.66	46.1117
20	0.85	10.81	37.7267
50	0.94	31.98	29.3112
100	0.97	48.44	20.6769
150	1.03	85.05	16.5508

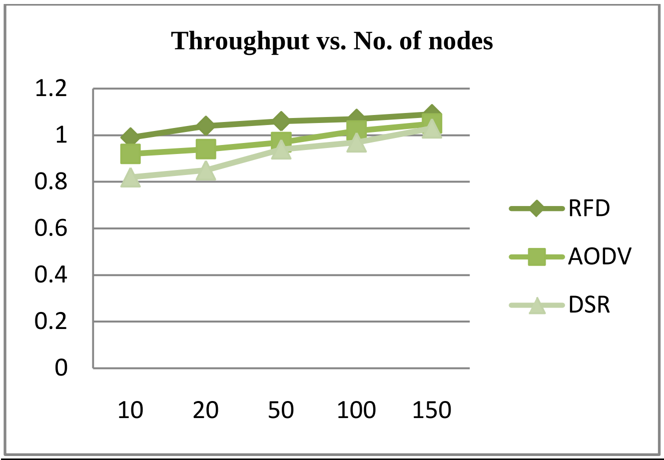

Figure 4. Throughput vs. Number of Nodes

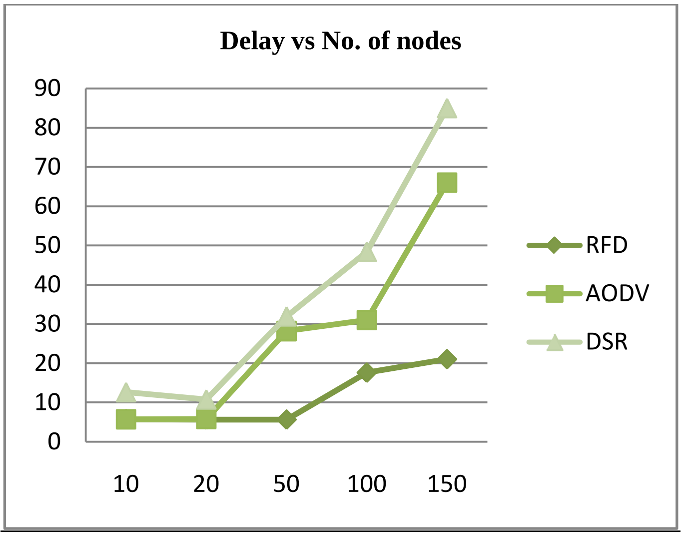

Figure 5. Delay vs. Number of Nodes

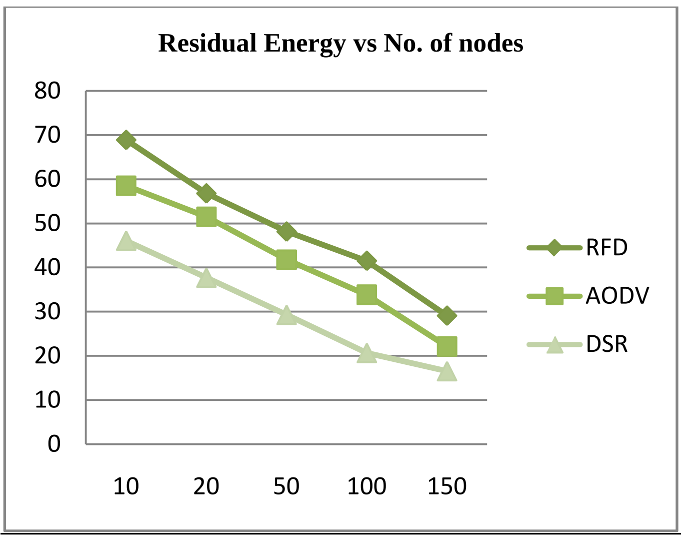

Figure 6. Residual energy vs. Number of Nodes

Conclusion

This paper stimulates the RFD algorithm in NS2 atmosphere and comparing the performance of RFD with AODV and DSR. This comparison is based on some parameters i.e. residual energy, end to end delay, and throughput. It is examined that RFD executes superior than AODV and DSR for the most part of the analysis depictedby outcomes. Further, results demonstrated that the parameters like end-to-end delay, residual energy and throughput proved best performance in RFD than AODV and DSR. Interms of throughput with huge number of nodes, RFD performs better than others. Upcoming improvements w.r.t RFD can be completed to recover the protocol by modification of the control packet overhead and create it appropriate for IoT(Internet of Things) applications. Furthermore RFD algorithm can beextended by matching the other bio-inspiredalgorithm for achieving the learning approaches.

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