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OPT: Ondemand Probabilistic Time Variant Approach for Dynamic Route Selection on Wireless Mesh Networks under Dynamic Traffic Conditions

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Abstract: The performance of wireless mesh networks is highly depending on route selection under high traffic conditions. The traffic conditions will be varying at all time frames due to the conditions of wireless nodes, which affect the throughput of the network. There exist various approaches to handle the route selection under dynamic conditions but suffers with quality of service parameters. The changing conditions of wireless mesh network makes difficult for the node to select traversal paths. In WSN all the nodes performs source routing, which lead to higher traffic at few nodes which also suffers the network. We propose a time variant approach which works on the probability of traffic conditions. The proposed method estimates the traffic at each time window and computes the probability of traffic could occur at next time window. Each node maintains traffic details of current time window and previous time window, specifies sequence number, source, destination addresses and time details. Using these details from traffic matrix, the proposed approach computes the time variant traffic estimate based on which the new route will be selected. The initial routing starts with single hop traffic condition and shortest routing scheme, whereas the later routing are based on probabilistic approach. The proposed route selection scheme has improved the performance of the network by 95% than earlier methodologies.

Key words: WMN · Source Routing · Dynamic Routing · Time variant approach · Probabilistic model

INTRODUCTION

Wireless mesh networks consist of large number of nodes and has many connections with the neighbor nodes. The routing in WMN is performed using source routing and the packet traverse through different nodes. The source node selects the path through which the packet has to be transmitted and selected based on shortest route scheme. The traffic conditions are always changing and cause traffic at certain nodes, where the intermediate node presents at a location which is short to reach different destination [1].

For example, from Figure 1: if the nodes A, H, M tends to transmit packet, then all the nodes select the path which passes through the nodes C and D. This increases the traffic condition at the nodes C and D. The source routing scheme always selects the shortest path and at traffic conditions, it chooses another shortest path and so on. This way of routing increases the rate of re-transmission and increases the packet drop ratio [2].

Various dynamic routing schemes have been proposed, where most of them select a path according to the traffic conditions present in the intermediate nodes. In dynamic routing schemes, the traffic conditions have to be exchanged to choose the shortest path or select a path according to the conditions or traffic present at the intermediate nodes. Exchanging traffic information and node status increase the overhead by sending control information's, which has to be reduced to improve the quality of service [3].

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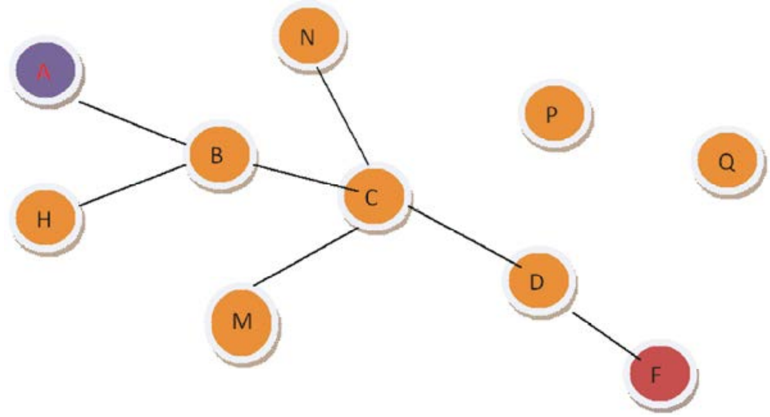

Fig. 1: Shows example topology.

The transition path between the same source and destination will get changed according to the network conditions, so that the path will get changed at all fraction of time window. The proposed methods depend on the traces generated at each time window, which is generated by each of the nodes of wireless mesh network. These traces could be used in identifying and predicting the upcoming traffic condition [4].

The probabilistic models work based on computed probability values on certain parameters. We propose such a model which computes probability of traffic could occur at certain nodes present in the transition path. The probability is computed using the earliest traces of traffics and estimation is done using these traces [5].

The quality of service in wireless mesh networks depends on different parameters of QoS like throughput, packet drop ratio, time and space complexity values by the routing protocols used. The protocol should produce less latency, packet drop ratio and higher throughput [6].

Related Works: Though there exists number of routing protocols for wireless mesh networks, we discuss few of them according to the problem statement [7].

Cluster based Routing Protocol for Cognitive Radio Wireless Mesh Networks [1], introducing a new concept called clustering, which includes both static and dynamic clustering for mesh routers and mesh clients. By using these clustering algorithms we can reduce the signaling messages, so the overall network performance will be increased. In [6], the author proposes a Fuzzy Logic based integrated cost measure in terms of delay, throughput and jitter. Based upon this distance (cost) between two adjacent nodes we evaluate minimal shortest path that updates routing tables. We apply two recent soft computing approaches namely Big Bang Big Crunch (BB-BC) and Biogeography Based Optimization (BBO) approaches to enumerate shortest or near short paths. BB-BC theory is related with the evolution of the universe whereas BBO is inspired by dynamical equilibrium in the number of species on an island. Both the algorithms have low computational time and high convergence speed.

A hybrid multi-path routing algorithm for industrial wireless mesh networks [7], adopts the enhanced Dijkstra's algorithm for searching the shortest route from the gateway to each end node for first route setup. A virtual pheromone distinct from the regular pheromone is introduced to realize pheromone diffusion and updating. In this way, multiple routes are searched based on the ant colony optimization algorithm. The routes used for data transmission are selected based on their regular pheromone values, facilitating the delivery of data through better routes. Link failures are then handled using route maintenance mechanism.

An opportunistic multicast routing protocol for wireless mesh networks [8], proposes an opportunistic multicast routing protocol. The protocol addresses the problem of selection and prioritization of relay candidates to reduce the overall number of transmissions. It also addresses the problem of reducing protocol overheads. MAP [9], studies any path routing subject to multiple constraints. First they prove that the problem is NP-hard when the number of constraints is larger than one. We then present a polynomial time K-approximation algorithm MAP (Multi-constrained Any Path, where K denotes the number of constraints. In [10], the author provide an improved FPTAS for multi objective shortest paths, a fundamental (NP-hard) problem in multi objective optimization, along with a new generic method for obtaining FPTAS to any multi objective optimization problem with non-linear objectives [11].

Hop-by-Hop Routing in Wireless Mesh Networks with Bandwidth Guarantees [12], study the problem of identifying the maximum available bandwidth path, a fundamental issue in supporting quality-of-service in WMNs. Due to interference among links, bandwidth, a well-known bottleneck metric in wired networks, is neither concave nor additive in wireless networks. We propose a new path weight which captures the available path bandwidth information. We formally prove that our hop-by-hop routing protocol based on the new path weight satisfies the consistency and loop-freeness requirements. The consistency property guarantees that each node makes a proper packet forwarding decision, so that a data packet does traverse over the intended path.

Cross-Layer Metrics for Reliable Routing in Wireless Mesh Networks [13], proposes a novel routing metric, Expected Forwarded Counter (EFW) and two further variants, to cope with the problem of selfish behavior (i.e., packet dropping) of mesh routers in a WMN. EFW combines, in a cross-layer fashion, routing-layer observations of forwarding behavior with MAC-layer measurements of wireless link quality to select the most reliable and high-performance path.

Interference Aware Routing in Multi-Radio Wireless Mesh Networks [14] e present a new interference aware routing metric iAWARE that aids in finding paths that are better in terms of reduced inter-flow and intra-flow interference. We incorporate this metric and new support for multi-radio networks in the well known AODV routing protocol to design an enhanced AODV-MR routing protocol. We study the performance of our new routing metric by implementing it in our wireless test bed consisting of 12 mesh nodes. We show that iAWARE tracks changes in interfering traffic far better than existing well known link metrics such as ETT and IRU. We also demonstrate that our AODV-MR protocol delivers increased throughput in single radio and two radio mesh networks compared to similar protocol with WCETT and MIC routing metrics.

A Multipath Routing Algorithm Based on Traffic Prediction in Wireless Mesh Networks [15], consists of three modules including an algorithm on multipath routing built, a congestion discovery mechanism based on wavelet-neural network and a load balancing algorithm via multipath. Simulation results show that MRATP has some characteristics, such as better scalability, flexibility and robustness. Compared with the current algorithms, MRATP has higher success ratio, lower end to end delay and overhead. So MRATP can guarantee the end to end QoS of WMNs.

All the above mentioned routing protocols has the problem of route selection where the traffic conditions changes dynamically with short time.

Proposed Method: The proposed time variant dynamic route selection approach has following steps: Traffic log generation, Traffic Pattern generation, Route computation and selection. At the first phase the traffic logs are generated and maintained by each node and at the second stage traffic pattern are generated. Route computation process utilizes the output of pattern generated and finally a set of routes will be identified to select the traversal path.

Traffic Log Generation: Each node in the WSN performs both transmission and reception of packets. Whenever a node receives a packet whether it belongs to that or not, it generates a log into its memory. The log generated contains following information's like source address, destination address, hop addresses, time and ttl values. Each node maintains only latest logs generated, due to the memory restrictions of wireless sensor nodes. Each node maintains only least number of logs and removes the oldest logs generated at early time.

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Algorithm:
Step1: start
Step2: initialize traffic log Tl, Neighbor list Nl.
Step3: receive incoming packet P.
Step4: if P.NodeId = Node.NodeId then
    Else
        If Node.ID ϵ Nl Then
                Forward packet to its Neighbor.
        Else
         Extract P.Src, P.Dest, P.Hlist, Time from P.
                P.src – source address.
                P.Dest – destination address.
```

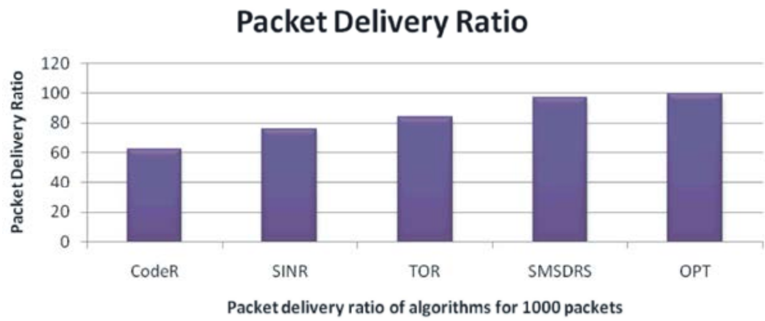
Hlist – Set of hops traversed.
Time – Time arrived.
Construct log Tlr = Σ{*P. src, P. Dest, Hlist, time*}
Clear most earlier log Tl = Tl□(Tl×Tl(Time-Th))
Th = Time threshold.
Tl = Σ *Tl + Tlr.*
End.
End
Step5: stop.

Traffic Pattern Generation: Each node maintains its own traffic log and from the traffic log the pattern is computed as follows. First, a subset of packets traversed towards the destination is generated from the traffic log Tl. From the subset computed we extract the following details like source, destination addresses and hop lists. With the extracted details, a pattern is constructed as a transaction pattern. The computed pattern will be given for route computation and selection processes.

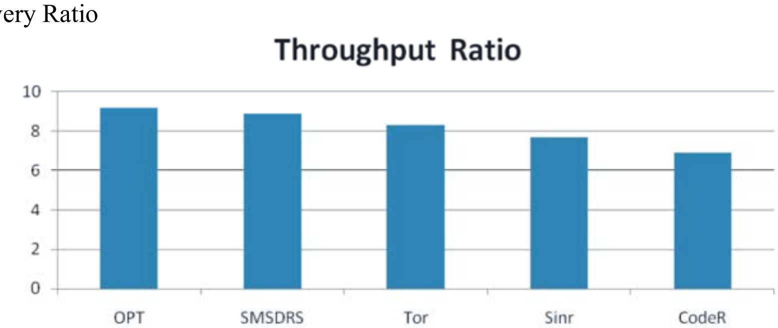
Algorithm:
Step1: start
Step2: read traffic log Tl.
Step3: initialize pattern set ps.
Step4: for each time window Tw_i of Tw
Extract logs belong to the particular time window Tl_i.
$Tl_{tw} = \Omega(Tl \times Tw)$.
for each traffic log Tl_i from Tl_{tw}
Extract the following details.
{Src,Dest, Hlist} = Tl_i(Src,Dest,Hlist).
Construct pattern P_i = {Src,Dest,$Hlist_{1...N}$}.
Add pattern P_i to P.
P = Σ *P + pi.*
End.
Step5: stop.

Route Selection: The route selection algorithm selects a specific route to forward the packet based on many metrics. First from computed pattern set, we compute the frequent item set based on number of times a packet traversed through a particular node. From computed frequent set, we identify the common node which is participate in most of the transmission is identified. Now we compute the available paths and using both available path set and frequent set, a non overlapping set is identified. The non overlapping set shows the path, through which there is no transmission occurred. From the non overlapping set we identify a shortest path to forward the packet towards destination.

Algorithm:
Step1: start
Step2: read pattern set Ps, Neighbor list Nl.
Step3: Compute available Routes AR.
$AR = \int_1^{Nl} P.NodeId \in N.Nl$
Step4: compute frequent pattern $Fp = \int_1^{N} Max(P)$
Step5: Identify Common node Cn = σ×(Fp)
Step6: Non overlapping path $NP = \int Cn \nexists AR$
Step7: compute shortest path from Np.
Step8: forward packet.
Step9: stop.



Graph 1: Packet Delivery Ratio



Graph 2: Throughput ratio of different algorithms.

Table 1: Shows the simulation parameters used

Property	Value
Number of nodes	50
Transmission Range	50 mts.
Power	50 Hz.

RESULTS AND DISCUSSION

The proposed method has been implemented in Network simulator Ns2 and it has produced efficient results. The proposed methodology has reduces the packet drop ratio and reduces the frequency of retransmission. The shared memory scheme has good impact on routing in wireless mesh networks and it has produced efficient results.

The Table 1 shows the simulation set up used to evaluate the proposed method. We have assumed all the nodes with same transmission range and power constraints.

The Graph 1 shows the packet delivery ratio of different algorithms. it shows that the proposed OPT has more delivery ratio than previous algorithms.

The Graph 2 shows that the proposed methodology has more throughput ratio than other algorithms.

CONCLUSION

In this paper, we proposed OPT- On demand Probabilistic Time variant approach, a co-operative routing scheme to maximize the lifetime and throughput of the sensor nodes. The proposed method has designed towards achieving robust performance under traffic information uncertainty. To elaborate, the proposed scheme optimizes the worst-case performance for a range of traffic conditions. The proposed scheme works under the whole spectrum of traffic information uncertainty from perfect traffic information to no traffic information. The performance of OPT adapts to the granularity of the traffic information available. The more accurate the information is, the better the performance will be. We show that OPT achieves optimal worst-case performance, as well as good average performance. The performance of OPT is robust under traffic dynamics, or even false traffic information.

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