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Enhanced Routing Protocol in Opportunistic Networks (ERON) for Improving Performance by Optimizing Social Information

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Abstract : The problem of overhead and intermittent connectivity between nodes are the issues in opportunistic networks. In enhanced routing protocol in opportunistic networks (ERON) we proposed a new routing algorithm that uses social information and Ant Colony optimization. The social information plays a decisive aspect in reducing the overhead because it rely upon the connectivity of nodes. The appropriate selection of forwarding node based on social information is critical for improving the efficiency of routing protocol in opportunistic networks. The frequent disconnection problem is overcome by optimizing the social information with Ant Colony Optimization method which depend on the topology of opportunistic network. The proposed protocol/ algorithm is evaluated thoroughly via analysis and simulation in order to assess their performance in analogy with other social based routing protocols in opportunistic network with respect to Throughput, Overhead Ratio and Average Buffer Time Occupancy under various parameters settings with consideration of scalability of network.

Keywords : Opportunistic networks; Social information; Routing Protocols; Ant colony optimization; Game Theory.

1. INTRODUCTION

Communication paradigms are being evolved rapidly, thus providing the world with better, faster and safer connectivity. Due to the advancements in communication technologies, communication is now made possible where building a reliable communication infrastructure is not feasible [1] [2]. Opportunistic networks are engaged in the suburbs where the probability of route formation is very low for message routing to take place [3]. In these networks the connectivity between the nodes do not exists all the times. The nodes in opportunistic networks are highly mobile, having limited power and short radio range. Due to advancements in wireless devices now the applications of opportunistic networks growing fast in different fields. Opportunistic network experience frequent changes in the topology of network due to node mobility [4]. The problem of intermittent connectivity, long delays, absence of end-to-end path, tends towards the poor performance of conventional routing schemes in opportunistic networks. To overcome problem of intermittent connectivity the mobility of nodes and buffering of messages plays an important role in message forwarding [5]. A node communicates on the basis of contact opportunity that arises when it came into contact with other nodes. The amount of data transferred in their contact times opportunistically determine the capacity of opportunistic networks. This contact opportunity forms the basis of social information. The nodes to which an individual is thus connected may become the social contacts of that individual. The individuals are called nodes, while the relations between nodes are called edges. Due to the inclusion of social contacts the opportunistic networks becomes part of social networks. A social network is a complex graph based network

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which consists of individuals termed as nodes and connected by some means of interdependency such as friendship, common interest etc. termed as edges [6]. The objective of social network study is to examine the relevance of a node in opportunistic network and to analyze the relations between nodes within the network. These relations become the key to forward the data in opportunistic networks [7].

The computation of Shapley value in case of opportunistic networks which are based on social information concept and then optimizing information with the help of Ant Colony optimization to forward data so that the data eventually reaches to destination without marginal loss and less delay by proposing an algorithm will be the main focus of our paper. We suggested a new routing protocol/algorithm (ERON) for determining relative importance of individual nodes using the concept of game theory and ant colony optimization. Section 2 describes the social context aware category of routing protocol in opportunistic networks under consideration are HiBop, Propicman and CAOR, and describe some other related work. The suggested algorithm is discussed in section 3. The results of suggested algorithm are analyzed with network throughput, overhead ratio and average buffer time in section 4 with respect to scalability of network and also compared with the previous routing protocols. Conclusion and futute scope is presented in section 5.

2. PREVIOUS WORK

In terms of network context, it is necessary to find out which nodes and which edges are more demanding than the others so as to effectively forward/route the data without delay and overhead. Importance of node determines its ability to forward the message based on its social information. This introduces the concept of centrality. The aim of centrality is to determine the influence of individual nodes and edges and it has been broadly studied [8] [9]. Practically, centrality analysis motive is to create persistent ranking of nodes in a network. There are various measures to compute centrality. Three of the most common measures are degree, closeness, and between-ness centrality [10]. All these centrality measures gauge the influence of a node by concentrating solely on the chore that a node perform by itself. But in real time practice such an assumption is not adequate due to coactions that may arise if we consider the working of nodes in group. Now to give importance to group of nodes, the concept of group centrality was introduced by [11]. The group centrality concept addresses the problem of conventional centrality measures but again it was not clear how to build up a persistent ranking of particular nodes among specific groups. The game theoretic network centrality (GTNC) measure addresses this issue, it finds out a way to compute the persistent ranking of particular nodes that allows alliance within feasible group of nodes [12] [13]. The key idea of GTNC is to describe a collegial game over a network structure in which agents are nodes, coalitions are group of nodes, and output of coalition are to defined so as to meet the requisites of a given application. The Shapley (1953) proposed a method to find individual marginal contribution among a group. Shapley demonstrated that his approach-known since then as a Shapley value must meet certain properties such as efficiency, symmetry, additivity and null players [14]. The Shapley value after that understood as a centrality measure as it represents the average marginal contribution made by every node to every group of other nodes. Once groups of nodes have been evaluated then it finds out persistent ranking of particular nodes.

One of the categories of routing protocols in opportunistic network is social context aware routing protocols [15]. There are various protocols under social context aware routing viz. HiBop, Propicman, CAOR etc. The HiBop uses social information based on past history and current context knowledge of a node [16]. The context knowledge is fully exploited to take routing decisions. Propicman [17] utilizes social information based on context knowledge, grant the sender to pick the next two hop neighbour (*s*), such that the message has the maximum probability to move to sink. Propicman uses probability of nodes to meet the destination. CAOR [18] uses the social information and forwarding is based on formation of community. These protocols exploit additional information about the context users to make the forwarding function more efficient. Apart from exploiting the information the HiBop and Propicman protocols do not include an explicit representation of the social network. CAOR is representing the social network based on forming communities. The existence of communities firmly affects the process of determining influential nodes. CAOR exploits the between-ness centrality metric of conventional centrality measure. But it fails to recognize the significance of nodes when presents in groups.

In all the social based routing protocols described previously, utilized the concept of social information. In many applications, it is not enough to only learn the relevance of every node as individual. Rather, the primary concern is to learn the significance of every node in terms of its efficacy when connected with rest of the nodes [19] [24]. The ability to include the contribution of all potential combinations of nodes in a group is missing in conventional centrality measures [12]. This serve as a drawback in many applications. The ranking is assigned to every node in a network in conventional centrality measures. But these measures fail to give scores to certain unique combination of nodes that can take down the entire network. This limitation has been overcome by GTNC [20]. The disconnection of nodes in opportunistic networks and data loss problem has been studied previously [18]. The main aim is to forward/route data efficiently in opportunistic scenario. Several works has been done in literature to forward/route data in opportunistic networks with reference to social context, but very few work has been done based on game theory. The proposed algorithm is first such study, which combines game theory concept with ant colony optimization. Next section briefly describes efficient use of social information of nodes in opportunistic networks and how that information is optimized using ant colony optimization method to forward data.

3. PROPOSED ROUTING METHODOLOGY

Practically users are prone to move everywhere in predictable or unpredictable manner. We can improve the routing protocol performance by making use of observations like that if a user has visited an area frequently, it is most probable that it can visit that area again or can choose a new area that has never visited before. To fulfil this each node must know the contact feasibility with further nodes currently reachable in the network. We used Shapley value concept to find out the social information of a node. The Shapley value shows the social information and position of particular node in the network. Here position means how much average connectivity is shown by a particular node. Shapley value is the new concept of game theoretic network centrality as it expresses the average marginal contribution made by every node to feasible group of other nodes [19] [23]. Game theory finds out the Shapley value effectively because it depends on the competitor steps and also on the other nodes position. When we deal with opportunistic network it relies on the motion of other nodes. So it resembles the game theory basic fundamental and we can use it to calculate the social information by game theory. Conversely Shapley value represents the contribution of nodes in the network. To accomplish this we are computing the Shapley value (ás) of every node and simultaneously computing shortest distance (ßd) using Dijkstra algorithm [20] in an opportunistic network. The detailed flow chart of proposed methodology is shown in Fig. 1. The computation of SV is given in Algorithm 1, Minimum Distance is computed using Algorithm 2 and Proposed Algorithm (ERON) in Algorithm 3.

Algorithm 1: Compute Shapley Value (αs)

Input : Opportunistic Network Topology; Output: Shapley value of all nodes in Network Initialize the nodes by finding the Shapley value,

1. Begin
2. for each *v* V (G) do
3. Distance Vector (*d*) = Dijkstra (*v*, G)
4. ext. neighbour (*v*) = ø; ext_degree (*v*) = 0;2 dcut_off = 0;
5. for each *u* V (G) & $u \neq v$ do;
   if $d(u) \leq$ dcut_off ; then
6. ext_degree (*v*) ++;
7. end; end ;
8. return ext_degree (*v*) ++; end ;
9. for *v* V(G) do
10. $sv(v) = \dfrac{1}{1 + \text{ext dearee } (v);}$

11. for each uõext.neighbour (v) do
12. $sv(v) += \dfrac{1}{1 + \text{ext dearee } (v);}$
13. end for; end for;
14. return(sv); end;

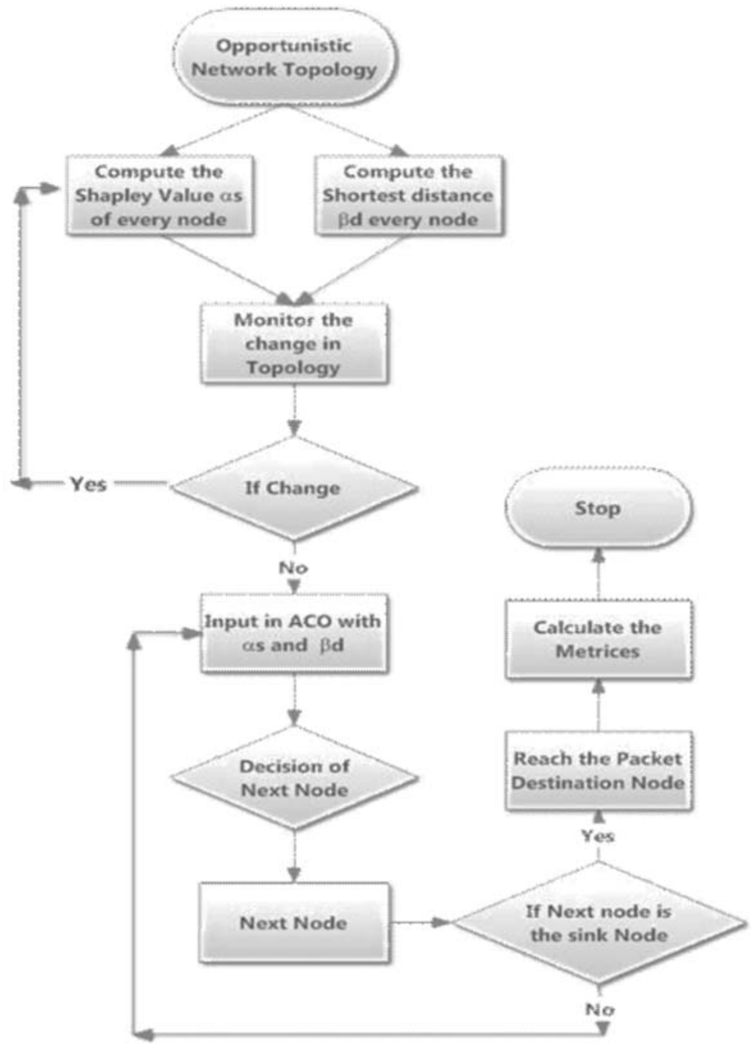

Fig. 1. Flow chart of proposed methodology.

Algorithm 2: Compute Minimum Distance (β*d*)

Input : Opportunistic Network Topology
Output : Shortest distance β*d*

1. begin
2. Dsrc = 0;
3. Dsink = ∞, for src ≠ sink;
4. β*d* = V;
5. for sink = 0 to V = sink
6. find *vm* β*d* with minimum dm;
7. for each edge (*vm* , *vt*) with vsink βd
8. if ((dsink > *dm*) + length (*vm*, *vt*)) then dsink = *dm* + length (*vm* , *vt*);

9. end for;
10. $\beta d = \beta d - vm$;
11. end for ;
12. return βd ;
13. end for ;
14. end ;

Algorithm 3: Proposed Algorithm (ERON)

Input : α_s, β_d and random initialized path (D_l, d),

For each node v V do

1. Begin
2. Take Random initialized path *i. e.* (D_l, d) and decision on the basis of α_s and β_d ;
3. Randomly send the data $p_{xy}^{k} = \dfrac{(T_{xy}^{\alpha s})(\eta_{xy}^{\beta d})}{\sum_{Z \text{ allowed } X} (T_{xz}^{\alpha s})(\eta_{xz}^{\beta d})}$; eq1.
4. Update $T_{XY} = (1 - \rho)\, T_{XY} + \sum_k \Delta T_{xy}^{k}$; eq2.
5. $\Delta T_{xy}^{k} = \begin{cases} \alpha / L_k \text{ ; if one time uses } xy \text{ path} \\ 0 \text{ ; otherwise} \end{cases}$; eq3.
6. $L_k = \alpha s + \beta d$; eq3.
7. Extract information of destination, find the path according to step 2 to 5& find the deviation in social Information ΔT according to network domain;
8. Compute $\Delta_{v,d}$ (new path) and $\Delta_{l,d}$ (random path taken at starting);
9. If $\Delta_{v,d} < D_{l,d}$
10. Condition true then Let's v holds the message; else Let l holds the message;
11. end;

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4. PERFORMANCE ANALYSIS

This section discusses the work of our proposed algorithm (ERON) and compared with the existing social aware algorithms: HiBop, Propicman and CAOR. The scenario taken consists of dynamic set of mobile nodes. We are setting the number of nodes equal to 100,200,300,400,500. The time taken for simulation is 43200 sec. The TTLs are set 300 minutes. Simulation results are shown in Figures (2-4). The commonly used performance metrics are examined: Throughput, Overhead Ratio and Buffer Time Average occupancy. Simulation is carried using ONE (Opportunistic Network Environment) simulator [24]. In opportunistic networks node move in a certain transmission area/range. Network throughput is universally proportional to average delay between source and destination. Throughput gives the fraction of channel capacity used for useful transmission. Overhead ratio is defined as total number of copies to each generated message in the network [25]. The buffer time average describes the average time message stays in buffer.

Result shows that our proposed algorithm ERON outperforms Hibop, Propicman and CAOR. By increasing the scalability of network there is less significant change in throughput in our proposed algorithm but it is higher than HiBop, Propicman and CAOR. Fig. 2 shows variation of network throughput as scalability of network. The throughput of our proposed algorithm is higher and is consistent with little increase when number of node density increases. This is because of the fact that throughput depends on network configuration not on the node densities.

Fig 3 shows the variation of overhead ratio with number of nodes. The number of messages generated per packet to deliver to sink is less in ERON as compared to other protocols. The overhead is less in our proposed algorithm and it is nearly same when scalability of network increases (Shown in Table 1). From Table 1, it is clear that our proposed algorithm reduces the overhead ratio which is due to the precise use of social information by Shapley value and incorporation of ACO.

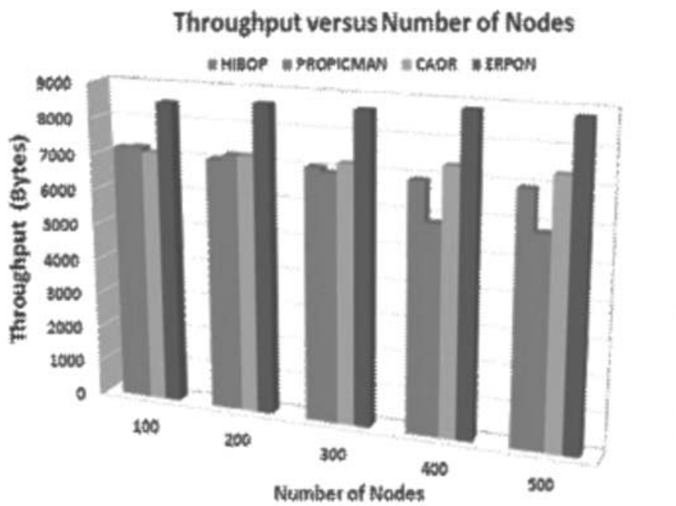

Fig. 2. Throughput

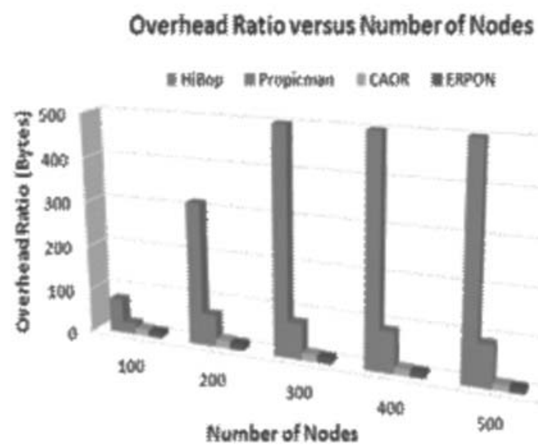

Fig. 3. Overhead Ratio

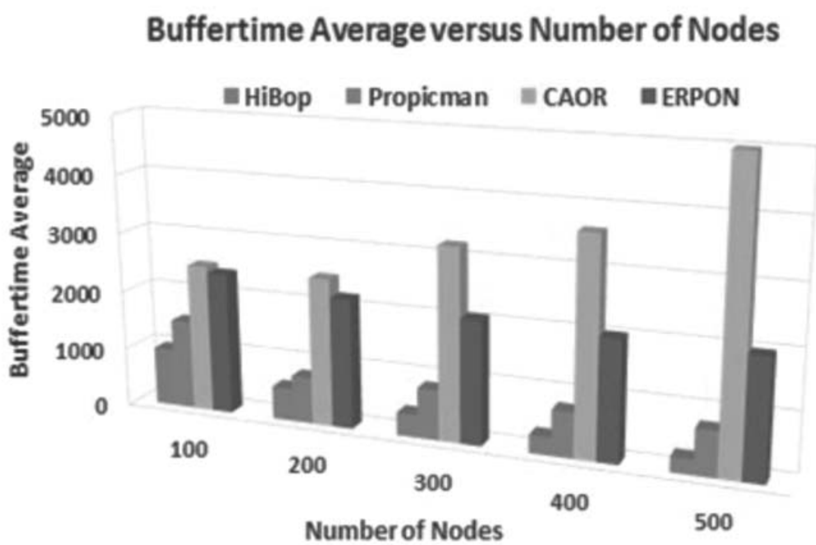

Fig. 4. Buffertime Average

Table 1. Values of Overhead Ratio

Nodes	*HiBop (Overhead Ratio)*	*Propicman (Overhead Ratio)*	*CAOR (Overhead Ratio)*	*ERON (Overhead Ratio)*
100	76.8467	24.3512	14.8531	11.8525
200	316.8277	71.1767	17.3378	13.8702
300	702.3324	80.1326	15.922	12.7376
400	1183.746	90.3642	14.4477	11.5582
500	1735.945	92.4216	12.9632	10.3705

Fig. 4 shows the buffer time average in seconds. The average buffer time in ERON is less as compared to CAOR but it is high as compared to HiBop and Propicman. The ERON results in low overhead by restraining the number of copies result in better delivery of messages. The win-win situation is maintained in terms of throughput, overhead ratio and buffer time average. Overall, ERON is prominent than other routing protocols.

5. CONCLUSION AND FUTURE SCOPE

In this paper, we have suggested an algorithm ERON and examined its performance over a range of parameter in analogy with HiBop, Propicman and CAOR routings. Our proposed algorithm is capable to accommodate the challenges of other routing strategies of opportunistic network particularly throughput and overhead by utilizing social information more effectively using the Shapley value and by integrating it with ant colony optimization. Apart from this, there exist a number of directions in proposed algorithm which can be investigated further by incorporating buffer management strategies to improve average buffer occupancy. For future work the proposed algorithm can be extended by use of other means of finding the shortest path which will give true optimal solution.

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