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Welcome from the Conference Chair

Hi, I am Bill Buckles, the Conference Co-Chair for the 6th ICCCNT Conference held July13-15, 2015. I am very pleased to invite you each to Denton for the conference. Our conference consists of several key note addresses, papers, and tutorials that explore topics ranging from protocols, standard networking, security, image processing, computer architecture, LiDAR, wireless networks and many others. Together, with colleagues from all around the world, you will have opportunities to explore the technological achievements in various fields from mobile network, cognitive radio, image processing, pattern recognition to name a few. The 6thICCCNT is mainly categorized into three divisions, namely Computing, Communication and Networking Technologies.

We try to focus on two issues

(1)The gap between academic and industry research for which we discuss on how to narrow it

and

(2) Emerging applications. For the past decades, we see the computer, communication and networking technologies converging with many other technology such as bio-medical, video communication, remote sensing and many other applications providing e-mobility in this smart world. These are but a few of the various topics we entertain during the conference. Don't miss the opportunities to explore the latest computer, communication and networking technologies.

As a Conference Chair, I am delighted to be among the first to welcome you to Dallas for the next, the7th ICCCNT conference in 2016.

As an after note, allow me to inform you that we have also planned for online presentations (through Skype) by authors residing at locations at a distance from the conference venue of Denton and who are unable to physically attend. However, these authors should opt for this mode of presentation at the time of registration and should make their own arrangements for presentation at their end.

We wish all the delegates to the 6th ICCCNT 2015 a fruitful and memorable event!

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A New Opportunistic Routing Forwarders Selection Scheme to Enhance Throughput for Wireless Networks

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***Abstract*—The key goal of opportunistic routing is to deliver the packet to the destination in fewer hops. In the multihop networks, the intermediate nodes act as a helper node to deliver the packet to the destination and they are called forwarders in the opportunistic routing. The selection of these forwarders among the intermediate nodes is very crucial and has a great impact on the performance of the opportunistic routing. In this research, we analyze the equal/uniform distance network and on the basis of the analysis, propose a new algorithm to select the opportunistic routing forwarders. The main goal of this research is to show the impact of choosing forwarder on throughput and to improve the throughput by suggestive approach. We implemented the proposed scheme on ns2 and compare it with Ex-OR and random forwarder selection scheme. The proposed scheme performs better and it achieved significant throughput gains.**

I. INTRODUCTION

The main goal of the smart city is to improve the liveability. The smart city contains heterogeneous devices that ranges from sensors to the data centers. These devices interlink with each other using different communication technologies. The routing protocol comes into scene to establish connectivity and reliable delivery in lesser time.Therefore, the efficient routing protocol is essential to achieve this goal.

In traditional routing, the packets are delivered to the destination on the basis of preset intermediate nodes. The following hop selection algorithm can use shortest path algorithm or very complex algorithm that can take channel condition and link layer metric etc. in consideration. All the nodes within the range of sender transmission can overhear the transmission due to the inherent broadcast nature of wireless channel. The opportunistic routing (OR) [1-6] takes benefit of this by selecting intermediate nodes as a forwarder node to transmit data to the destination. The published work [3, 5, 7-9] has proven that OR enhances throughput in comparison of traditional routing in multi-hop wireless networks.

The OR aims to deliver the packet to the farthest node. The packet can be successfully received by several nodes; the forwarder closest to the destination should be the one to relay the packet successfully to the destination. In OR, multiple forwarders can be chosen among the intermediate nodes. The total number of forwarders is dependent on the routing protocol. In spite of that, by choosing too many forwarders incurs substantial cost penalty and collisions can become recurrent [5, 10]. In contrast, the small number of forwarders can reduce the potential cost of intra and inter-path collisions.

Routing protocol can be further split into three parts; route discovery, data forwarding and route maintenance. The selection of OR forwarders is the task of route discovery. The selection of right forwarders is very critical and performance of overall system highly depends on it. Further, in multi-hop it is much more devastating than the single hop transmission. The expected transmission count (ETX) [11] is the de facto method in several proposed schemes.

In this study, we focus on the forwarder selection method. We first analyze the equal distance chain topology and proposed new forwarder selection algorithm to enhance throughput on the basis of acquired intuition. We, then compared our proposed scheme with Ex-OR and random forwarder selection schemes.

The rest of the paper is organized as follows. Section II presents the system modeling. In Section III, we describe our proposed scheme. Section IV provides the detail of the simulation environment and results. Finally, Section V concludes the paper.

II. SYSTEM MODELING

The Figure 1 shows the network topology. Our analysis assumes that network consists of N nodes. Node 0 acts as the source s and Node N act as destination d. The Node 1 to node N-1 are the intermediate nodes and are the potential forwarders f . The forwarder nodes help the source transmission to reach to the destination. In our analysis, we assume that the forwarder node can be single or multiple. All the nodes are equal distance from each other and distance is known.

Let us first consider the direct delivery from source to the destination. The s(x) is the packet success probability versus the distance between source and destination. The followings are the required mild assumptions and are reasonable. First,

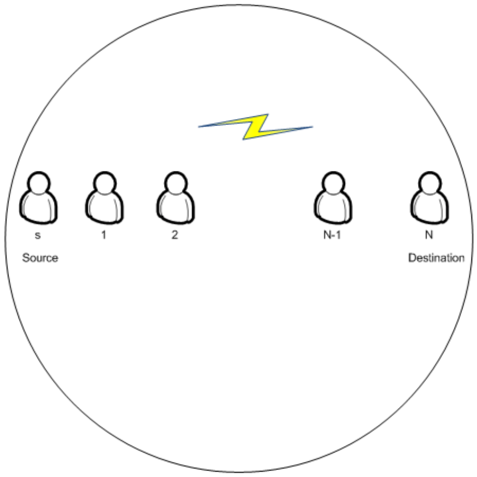

Fig. 1: Network Topology

s(x) is differentiable, and secondly, it is monotonically decreasing with x. Let DT(x) denote the average delivery time of an arbitrary packet from the source to the destination. If the packet is directly received by the destination, DT(x) is 1. Otherwise, the average delivery time of each packet DT(x) can be written as,

$$DT(x) = a + b(\frac{1}{s(D)} + \frac{1}{s(x-D)}) \tag{1}$$

where *a* represents the success probability and *b* represents the failure probability. The x is the distance between source and destination. The D is the distance between the source and the forwarder node. Taking the differentiation of DT(x) with respect to x Then, we can see DT(x) is minimized i.e. throughput is maximized at $\frac{N}{2}$ and the optimal forwarder is the node in the middle of the source and destination. The intuition, we acquired from this is, we can get maximum throughput whenever the forwarder is in the middle of source and destination node. When the source fails to deliver packet directly, forwarder(s) is used to deliver the packet to the destination and forwarders(s) act as a source for that transmission. Moreover, if the nodes, participating in the transmission, are in the middle of each other, we will achieve the maximum throughput.

The probability of a packet being directly received by the destination is given as s(N). So, we can see that

$$DT(x) = s(N).1 + (1 - s(N))(\frac{1}{s(i)} + \frac{1}{s(N-i)}) \tag{2}$$

We can define the throughput of the considered system as

$$Throughput = \frac{(NS)}{(X_1 + X_2 + \ldots + X_N)} \tag{3}$$

where, N is the number of transmitted packets, S is the size of each packet and X_i is the delivery time of i-th packet. We can further simplify the throughput equation by applying the law of large numbers [12] since X_i are independent and identically distributed (i.i.d) random variables.

$$\begin{aligned} Throughput &= \frac{(NS)}{(X_1 + X_2 + \ldots + X_N)} \\ &= \frac{S}{(\frac{(X_1+X_2+\ldots+X_N)}{N})} \\ &= \frac{S}{E[X]} \end{aligned} \tag{4}$$

Therefore, The throughput can be expressed using the following formula.

$$Throughput\, \alpha\, (Expected\, delivery\, time\, of\, each\, packet)^{(-1)} \tag{5}$$

The total delivery time of the packet is calculated from the delivery time from source to the forwarder (s→ f), and delivery time from forwarder to the destination (f→ d). For the later delivery time, we assume some forwarders have successfully received the packet. It can be written as

$$Expected\, delivery\, time\, of\, a\, packet = DT_{(s\to f)} + DT_{(f\to d)} \tag{6}$$

In our analysis, we assume that the expected delivery time of the each packet and the expectation are the same. Therefore, the expected delivery time of each packet can be deliberated as

$$\begin{aligned} &Expected\, delivery\, time\, of\, each\, packet = \\ &E[DT_(s\to f)] + E[DT_{(f\to d)}] \end{aligned} \tag{7}$$

We consider two cases. Case 1 is with one forwarded whereas case 2 is with two forwarders. Similarly, the analysis can be extended for more forwarders in the network.

A. Single/One Forwarder

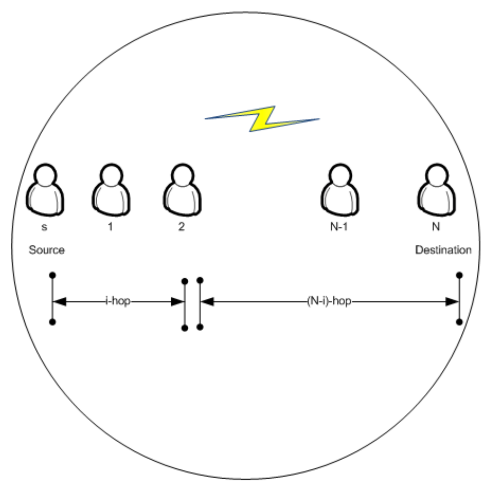

Fig. 2: Single Forwarder Network Topology

The Figure 2 depicts the single forwarder network topology. Let node i be designated as the forwarder. Therefore, delivery time from source to the forwarder i can be given as

$$E[DT_{(s\to f)}] = \frac{1}{DT(i)} \tag{8}$$

$$E[DT_{(s\to f)}] = \frac{1}{s(N) + (1 - s(N))(\frac{1}{(s(i))} + \frac{1}{(s(N-i))})} \quad (9)$$

The delivery time from forwarder to the destination can be written as

$$E[DT_{(f\to d)}] = \frac{1}{DT(N-i)} \quad (10)$$

Similarly, we can get E[$DT_{(f\to d)}$] using equation (10), E[$DT_{(f\to d)}$] =

$$\frac{1}{s(N) + (1 - s(N))(\frac{1}{s(N-i)} + \frac{1}{s(N-(N-i))})} \quad (11)$$

We can get the throughput using the equation (5) by replacing these values

$$Throughput\ \alpha\ (E[DT_{(s\to f)}] + E[DT_{(f\to d)}])^{(-1)} \quad (12)$$

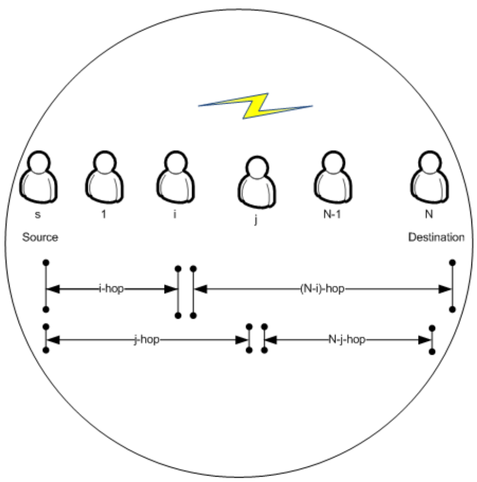

Fig. 3: Two Forwarder Network Topology

B. Two forwarders

The Figure 3 illustrates the two forwarder network topology. In this scenario, we select two intermediate nodes as a forwarder. Let node i and node j be designated as the forwarders. We can calculate expected delivery time from source s to forwarder f as

$$E[DT_{(s\to f)}] = \frac{1}{(1 - (1 - s(j))(1 - s(i)))} \quad (13)$$

Afterwards, we have to calculate the delivery time from forwarder f to destination d. However, we need to consider two cases. Here, we introduce the terminology of effective forwarder, i.e. who received the packet successfully.

Case I- The node j is the effective forwarder. The success probability s_x of node j is defined as

$$E[DT_{(f\to d)}] = \frac{s(j)}{[1 - (1 - s(j))(1 - s(i))]} \quad (14)$$

Conditional to $E[DT_{(f\to d)}] = \frac{1}{s(N-j)}$

Case II- The node i is the effective forwarder.

$$E[DT_{(f\to d)}] = \frac{(1 - s(j))s(i)}{[1 - (1 - s(j))(1 - s(i))]} \quad (15)$$

Conditional to $E[DT_{(f\to d)}] = \frac{1}{s(N-i)}$

Now, the cumulative delivery time from forwarder f to destination d

E[$DT_{(f\to d)}$] =

$$\frac{s(j)}{[1 - (1 - s(j))(1 - s(i))]s(N-j)} + \frac{(1 - s(j))s(i)}{[1 - (1 - s(j))(1 - s(i))]s(N-i)} \quad (16)$$

The expected delivery time from source to destination is given as

$$DT(x) = E[DT_{(s\to f)}] + E[DT_{(f\to d)}] \quad (17)$$

We can calculate throughput by putting equation (17) into equation (5) and we get

$$Throughput\ \alpha\ (DT(x))^{(-1)} \quad (18)$$

Similarly, we can calculate the throughput for N number of nodes.

III. New Opportunistic Routing Forwarders Selection scheme

In the following section, we explain our proposed mechanism to select the opportunistic routing forwarders.

Algorithm 1: When number of forwarders is 1

```
Get No of Forwarders
Get Distance
Get Total No of Nodes
Create Candidate_list
Get Position and id of candidates
if No_of_Forwarders = = 1
    Get the midway node
    for Look for the node id
      Get Matched candidate
        Use as a forwarder
    end for
end if
```

The Algorithm 1 shows the heuristic [13] based new opportunistic routing algorithm (NORF) to select opportunistic routing forwarder, if the number of forwarder is one. It is explained earlier that we know the end-to-end distance between source and destination and all intermediate nodes are equal distance from each other. The algorithm works as follows, First of all, get the distance between source and destination. After that, get total number of nodes in the network and create a candidate list by excluding source and destination. Next, get candidates identity and position. Afterwards, get the potential forwarder by getting half of the distance and then round it to make it integer number. After that, search the candidate list to match the distance and get the entity of the matched node. Now, choose this node as the forwarder node to transmit the packet from source to the destination. Our analysis shows that

Algorithm 2: When number of forwarders are more than 1

```
Get No of Forwarders
Get Distance
Get Total No of Nodes
Create Candidate_list
Get Position and id of candidates
    for Run till the no of forwarders
        Get The midway node
        for Search for the node id
            Get Matched Candidate
            Use this as a forwarder
        end for
    end for
```

if we pick the forwarder which is in the middle of the source and destination, it will get the best throughput.

The Algorithm 2 exhibits forwarder selection scheme when the number of forwarders is more than one. First, get the number of forwarders. Then, search and match potential forwarders with the help of distance. Afterwards, store in the forwarder list and use it to transmit the packet from source to destination.If we have to select more than one forwarders , our strategy is the same as described earlier i.e. , pick up the nodes which are approximately in the middle distance from each other.

IV. Performance Evaluation

To validate our proposed scheme, we conducted an extensive set of simulations in the network simulator ns-2.30 [14]. We use the network scenario depicted in Figure 1. It is multihop chain topology [15,16]. We focus on improving end-to-end throughput of network by selecting the best forwarding nodes. The throughput is considered for performance metric. The parameters used in our simulation is shown in Table I. There are 6 wireless nodes in our experimental setup. We run

TABLE I: Simulation Environment Specifications.

Channel Type	WirelessChannel
Radio Propagation Model	Shadowing
Network Interface type	WirelessPhy
MAC/Routing	Opportunistic
Interface Queue Type	PriQueue
Link Layer Type	LL
Antenna Model	OmniAntenna
Queue Size	50
Packet Size	1000 Byte
Topography Area	1000 m X 1000 m

the simulation by varying the number of forwarders from 1 to 3. We chose this to avoid the intra-path collisions which results in hidden terminal effect between on-path stations and to reduce collisions among the relayed and local traffic [5]. In addition, if the forwarders are less, it can restrict the likely penalty of intra- and inter-path collisions. If there are more number of forwarders, collision can become recurrent and the performance degraded than the single path routing strategies [17].

Figure 4 depicts the comparison of NORF, Ex-OR and random channel selection schemes. The x-axis shows the number of forwarders and y-axis represents throughput achieved. The random forwarder selection algorithm choose any intermediate node as a forwarder. Whereas, Ex-OR picks up the nodes closest to the destination. our suggested approach pick up

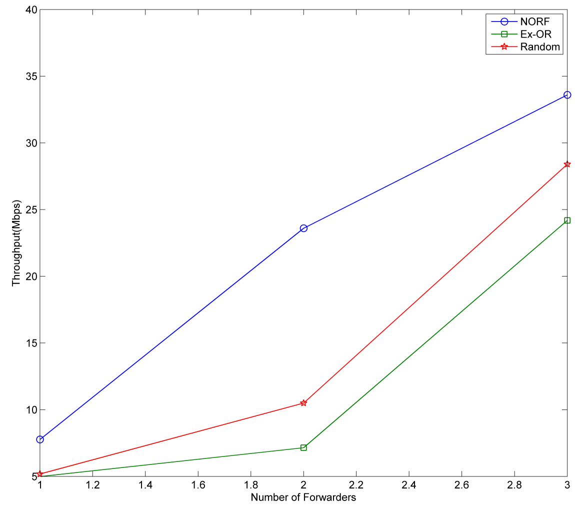

Fig. 4: Number of forwarders vs throughput

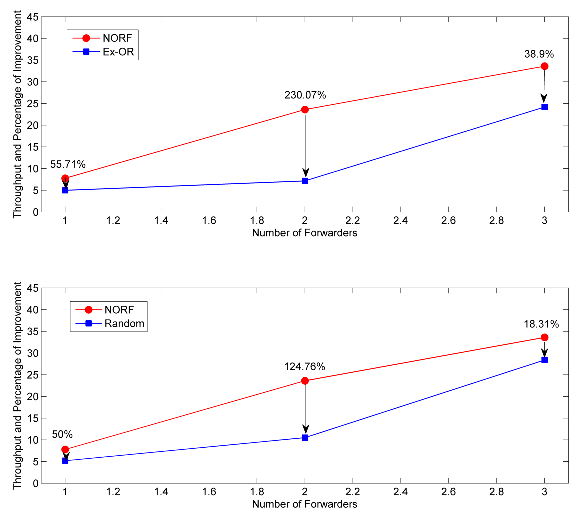

Fig. 5: Number of forwarders vs percentage throughput improvement

the forwarders on the basis of distance. The outcomes clearly show, NORF performs best and Ex-OR performs the worse. The random forwarder selection performs better because the nodes it chose as the forwarders turn out to give better throughput than Ex-OR.

Figure 5 shows the throughput improvement of NORF over Ex-OR and Random. It can be clearly seen that our proposed heuristic approach performed better than the other two schemes.

Figure 6 demonstrates the latency comparison of all the three schemes. The NORF delivers more data in less time with all cases of a number of forwarders. It is evident by seeing the result , increasing number of forwarders for all the schemes

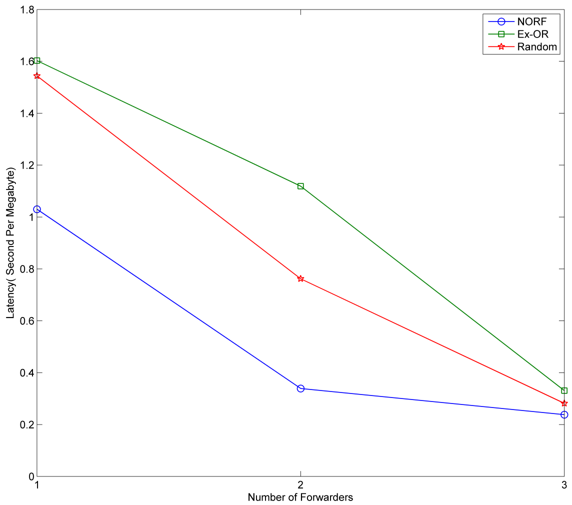

Fig. 6: Number of forwarders vs Latency

reduces the latency and in a longer run eventually it will merge. However, increasing number of forwarders severely increases the collisions. As a consequence throughput will decrease and subsequently latency will be higher.

V. Conclusions

We studied opportunistic routing forwarder selection scheme in wireless networks. Choosing the good forwarder among the intermediate nodes is a key factor in the overall performance of the opportunistic routing. The study on the impact of forwarder selection on throughput is still very limited. Numerous opportunistic routing protocols are proposed in the literature. The Ex-OR protocol is considered to be the pioneer and many further research is on top of it. We proposed new forwarder selection scheme for equal distance chain topology. We first analyzed it and on the basis of intuition, devise our algorithm to enhance throughput. We compare our proposed scheme with Ex-OR and random forwarder selection schemes. The experimental outcome shows improvement in throughput in comparison of other two schemes.

Acknowledgment

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