BCR Routing for Intermittently Connected Mobile Ad hoc Networks

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Abstract- The Wireless and the Mobile Networks appear to provide a wide range of applications. Following these, the Mobile Ad hoc Networks (MANET) aid in wide development of many applications. The achievement of the real world applications are attained through effective routing. The Intermittently Connected Mobile Ad hoc Network (ICMANET) is a sparse network where a full connectivity is never possible. ICMANET is a disconnected MANET and is also a Delay Tolerant Network (DTN) that sustains for higher delays. The routing in a disseminated network is a difficult task. A new routing scheme called Bee Colony Routing (BCR) is been proposed with a motto of achieving optimal result in delivering the data packet towards the destined node. BCR is proposed with the basis of Bee Colony Optimization technique (BCO). The routing in ICMNAET is done by means of Bee routing protocol. This paper enchants a novel routing methodology for data transmission in ICMANET.

Keywords — MANET, ICMANET, Delay Tolerant Network, BCO, BCR.

I. INTRODUCTION

A Mobile Ad hoc Network (MANET) is a collection of autonomous mobile nodes connected by means of Wireless medium. The nodes in this network are seemed to be organized in a decentralized manner. The nodes communicate with each other through links connecting the intermediate nodes available between the source and destination nodes. Connection through intermediate nodes is mainly due to the limitation of data transmission existing in the wireless environment.

In general, routing in a temporary network topology is a difficult task. Many traditional routing protocols viz., Distance Vector, Link State routing (LSR), Ad hoc Ondemand Distance Vector (AODV), Distance Source Routing (DSR), Opportunistic Adaptive Routing, Open Shortest Path First (OSPF) routing etc are been proposed since last decades. These routing protocols ensure effective data communication. MANET araise from mobile network and it leads to a disconnected network called the Intermittently Connected Mobile Ad hoc Network (ICMANET).

ICMANET is a typical Delay Tolerant Network (DTN), a network that incurs larger delays. It is designed to operate effectively over extreme distances such as those encountered in sparse communication or an interplanetary scale. The sparse or dense network of intermittent network is mainly due to high mobility of the nodes. The nodes stir within fractions of time and hence their topology changes in a dynamic way. Typical examples of intermittent network are wild life tracking, habitat monitoring sensor network, military network, nomadic community network and vehicular network etc. Due to typical distorted nature of the network, routing becomes an onerous task.

Many routing protocols are been proposed for communication in ICMANET since past years. The routing techniques are namely Flooding, Epidemic, Direction Based Routing, Adaptive Routing, Utility based Routing, Probabilistic Routing, Copy Case Routing, Spray and Wait Routing, LAROD-LoDiS etc. All the above mentioned routing protocols adopt a proficient mode for data communication.

In this paper, we propose a novel protocol for ICMANET using optimization techniques. The routing protocol is called BCR routing, with the basis of Bee routing protocol. This paper is organized as the following sections. Section II describes the Related Work for routing in ICMANET. The BCO description is discussed in Section III. Section IV describes the mechanism BCR routing. The performance evaluation is portrayed in Section V.

II. RELATED WORK

The Intermittently connected network is a new form of emerging network where routing data packets is seemed to be monotonous task. Many research works have proved the possibility of routing in ICMN. This section provides an overview of routing techniques applicable in the intermittent network. The routing techniques vary at a larger rate from the traditional routing protocols. The routing protocols of ICMN should include the main feature of tolerating higher delays as the connectivity is transient in nature. Some of the intermittent routing protocols are described as follows.

The traditional routing scheme that forms a basis for the routing schemes in ICMANET is the Flooding based routing. In this, one node sends packet to all other nodes in the network. Each node acts as both a transmitter and a receiver. Each node tries to forward every message to every one of its neighbors [15]. The result in every message eventually is delivered to all reachable parts of the network.

The Epidemic routing oeuvres on the basis of the traditional flooding based routing protocol, which states that periodic pair – wise connectivity is necessitate for message delivery [13]. The protocol banks on immediate dissemination of messages across the network. Routing occurs based on the node mobility of carriers that are within distinctive position of the network.

The Beaconless routing protocol [12] is grounded on the hypothesis where there never exists an intervallic diffusion of beacons into the network. Routing primarily makes a choice of forwarding node in a dispersed modus amidst its neighbors, without any form of erudition about their location or prevalence.

The Context Aware Routing (CAR) [11] algorithm paves the forethought of asynchronous communication in ICMANET. The algorithm endows a basement of organizing the messages in the network. It addresses that the nodes are able to exploit the context information to make local decisions which imparts the good delivery ratios and latencies with less overhead. CAR is pain staked as a general framework to predict and evaluate context information for superior delivery of messages.

The Brownian Gossip [10] is an amalgamation of gossip and the random node mobility which provides a scalable geographical routing. In this routing, each node forwards the query related to other nodes information with certain values of probability. Gossiping is a resourceful approach for information dissemination and is done with a probability viz., Pgossip. The probability value makes certain that the query can reach the secondary nodes in the network with highest probability.

The Mobility Profile Based routing [9] addresses, a hub – level routing method and two versions of user – level routing methods [14].The routing involves a SOLAR–HUB (Sociological Orbit aware Location Approximation and Routing) which manipulates the user profiles that aids in hub – level routing.

The Direction Based Geographic Routing (DIG) [8] algorithm is grounded on geographic location of packets that are routed in an average approximate ideal path towards destination. The algorithm postulates that when two nodes encounter each other, the nodes exchange the knowledge of their current location, moving direction and the packets. The packets are forwarded to nodes whose distance and moving direction are closest to destination.

The Single Copy Case routing [7], from its nomenclature it postulates that only a single copy of message packet is carried to destination. The routing scheme includes direct transmission, randomized routing, utility based routing, seek and focus and Oracle based routing.

The Multiple Copy Case [6] scheme deals with the mechanism of spraying a few copies of message and then routing each copy in isolated manner to the destination. The algorithm that holds multiple copy case routing are Spray and Wait and Spray and Focus.

The Semi Probabilistic Routing (SPR) [5] algorithm considers that the network is partitioned into tiny portions that have a stable topology. The protocol upholds the information about host mobility and connectivity changes for more accurate message forwarding.

The Contention Based Routing postulates that the efficiency of routing can be achieved only by taking into account the contention and dead end [4].The Spray Select and Focus provides a better performance considering the contention and dead ends.

The Spray and Hop [3] is a routing protocol that holds two phases namely, Spray phase that sprays few copies of message into the network. Hop phase which occurs after the spraying phase, a node that was not able to find the destination, switches to the hop phase.

The Spray and Wait [2] is a scheme that sprays into the network a fewer number of message copies and waits until one of these nodes that holds the copies reaches the destination. It is simple to implement and can be optimized to achieve the depicted performance.

The LAROD-LoDiS [1] routing is a geographical routing that uses a Beaconless routing protocol and a Store Forward Carry technique. It also uses a database to communicate among them to achieve routing. It is done by Gossiping protocol. It provides constant overhead and higher delivery ratio.

In this paper we proposed a novel routing scheme called Bee Colony Routing (BCR) with fastest and reliable data transmission across the ICMANET.

III. BEE COLONY OPTIMIZATION

BCO [35] is an optimization technique under the swarm intelligence, a part of Artificial Intelligence which is based on the actions of individuals in various decentralized systems. The decentralized system is composed of individual systems that are capable to communicate, cooperate, collaborate and exchange information among them. BCO [35] is a “bottom-up” [36] approach. Artificial bees are created in BCO that acts as artificial agents inspired by the general behavior of natural bees aiding in the solution for optimization problems.

The natural bees operate in such a way described as follows. The bees perform a dancing ceremony called the waggle dance. The waggle dance [37] acts as the communication medium among bees notifying about the quantity of food collected and the closeness of the path. When a bee finds a source of food, on its return to the hive, the bees dance in a figure eight pattern [36]-[37]. The waggle dance is repeated for a few numbers of times. The dance informs the details about the distance and the angle towards the food source. Direction and distance are estimated by the angle of distance relative to sun position and the length of the straight waggle run respectively. With the general bee movement and behavior the BCO algorithm is formulated by experts as follows.

BCO [38] is inspired by the natural behavior of bees and is a population-based algorithm. The basic idea behind BCO is to create a group of artificial bees. The artificial bees represent agents, each generating a new solution. The process is to generate an optimal solution. The BCO [38]-[39] algorithm consists of two phases namely the forward and backward phases respectively. The forward phase is a search phase during which artificial bees undergoes a predefined number of moves, constructing the solution and hence yielding a new solution. The new solution obtained is the partial solution. The artificial bees then start the backward phase, where they share information about their solution with each other. The information sharing is estimated by the objective value function.

The pseudocode for BCO [39]-[40] is portrayed in Figure 1 as follows.

```
Procedure BCO()
Initialize_Population()
    While stop criteria are not fulfilled do
        While all bees have not built a complete path do
            Observe_Dance()
            Forage_ByTransRule()
            Perform_Waggle_Dance()
        End While
    End While
End Procedure BCO
```

Figure 1 Pseudocode for BCO

The algorithm involves three steps namely performing the dance, estimating the path with the aid of dance and observing dance. The sequences of steps are repeated to find an optimal solution with all the partial solutions available from each artificial bee.

IV. BEE COLONY ROUTING PROTOCOL

In this section Bee Colony Routing (BCR) is proposed for routing in ICMANET. It ensures reliable data transmission by means of certain value called the objective value (OV).

Each node in the network acts as an artificial bee. Initially the bees (here bee refers to the node in the network) will be in the sleep mode and the OV is set to 0. The selections of the relay nodes are done with the help of Bee routing scheme using objective value (OV). Each node in the network acts as an artificial bee. Initially the bees (here ant refers to the node in the network) will be in the sleep mode and the OV is set to 0. As a data packet is generated at a node A, it searches the relay node in a random manner. The search of relay node is a step of forward phase. The efficiency of the relay node i.e. capability of the relay node to deliver data packet towards destination is determined using the OV estimated during the backward phase. With the successful delivery of data packet by the relay node, the OV value is incremented each time and the efficiency of the path is shared during the backward phase. The information share aids in estimating the path for future data transfers. Hence with this the destination can be reached by Bee routing. The pseudocode for BCR is shown in Figure 2 as follows.

```
Initialize
  OV=0;
Repeat
  For all nodes
    Bee_Route();
Until route found
Bee_Route()
  If no route found
    Fwd_phase() //search for relay nodes
  End if
  If route found
    Bwd_phase()//estimate  the path using OV
      OV+=1;
  End if
  For OV=max
    Deliver data packet
End Bee_Route()
```

Figure 2 Pseudocode for BCR

V. SIMULATION RESULTS

This section describes the simulation results of BCR for efficient and reliable routing in ICMANET. The BCR routing protocol has been evaluated using one simulator [21]. The ultimate motto of BCR is to provide a better routing. Hence BCR is compared with Epidemic Routing (ER), Spray and Wait (SNW). Since ER is the traditional routing and SNW has optimal performance results of ICMANET, they are compared with BCR to show off its better results. Section V-A clearly shows the scenario setup for the BCR. Subsequent to this in the Section V-B performance comparison of BCR in contrast to ER and SNW are shown.

A. Scenario Setup

The parameters set are the basic one simulator [22] environ parameters and are given in Table 1.

The one simulation [23-24] for BCR, in this paper, uses the pheromone mobility model. The nodes move in an area of 2000 x 2000 m with a speed limit within bounds 0.5 to 1.5 m/s. The radio range is set to 250 m. The efficiency of any routing protocol is determined by the node density i.e. the total number of nodes within the set network. The packets are generally generated with the initial setup of the simulation and holds through the overall simulation time. The Time To Live (TTL) or the packet life time is set as 600s initially that are varied lately on consideration to the performance criterion. When evaluating, the simulation is run for 3000s.

TABLE 1
BASIC SIMULATION PARAMETERS

PARAMETERS	One Simulator
Area	2000 x 2000 m
Mobility Model	Pheromone
Node Density	200 nodes
Node Speed	1.5 m/s
Radio Range	250 m
Packet Life Time	600 s

B. Performance Comparison of BCR with ER and SNW

To show the pro of BCR, we compared the simulated result of BCR with ER and SNW. In order to mark the performance of BCR, a comparative analysis is made between the above mentioned three protocols.

We have made the comparison using various metrics as follows:

i. Performance with respect to Delivery Ratio
ii. Performance with respect to Overhead
iii. Performance with respect to Delivery Latency

Performance with respect to Delivery Ratio

Comparing the delivery ratio i.e. the probability to deliver the message, BCR shows a maximum delivery rate in contrast to ER and SNW. The comparative results are shown in Figure 3 and Figure 4 varying the number of nodes and the transmission range respectively.

ER incurs minimum delivery rate when compared to SNW and BCR whereas delivery rate is at a maximum rate in BCR. The ratio of delivery rate is lesser in ER and SNW when compared to BCR is mainly due to the non effective usage of intermediate nodes. In ER the forwarding of data is by means of pair-wise connectivity between nodes.

As the probability of connecting nodes pair-wise is less, its delivery rate is low. Whereas SNW forwards through node mobility through spraying mechanism resulting the probability to reach destination varies. Hence has lesser delivery rate than BCR. BCR uses the immediate intermediate nodes that it encounters during node mobility hence has higher delivery rate than ER and SNW. It is mainly due to the fact that BCR has higher probability of reaching the destination than ER and SNW.

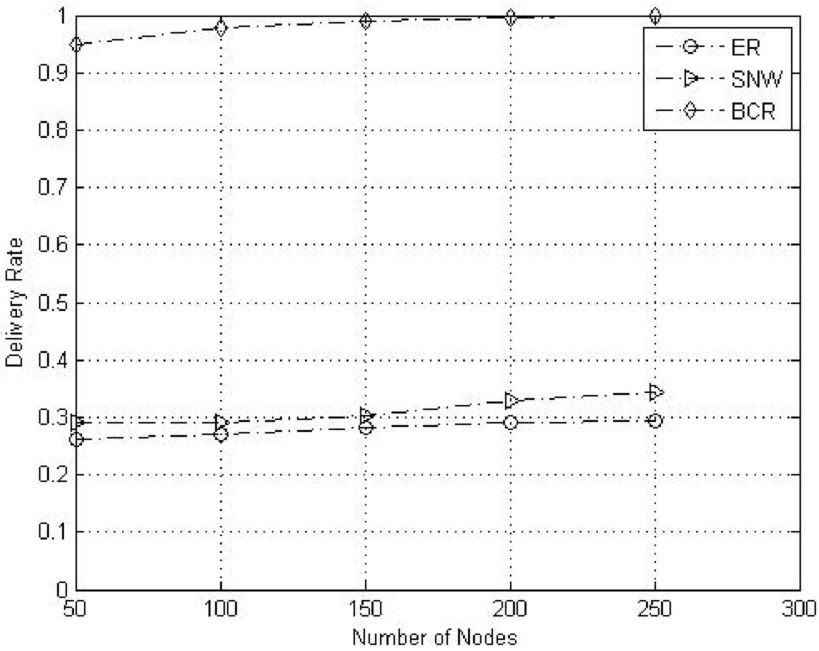

Figure 3 Delivery Ratio for various numbers of nodes

Performance with respect to Overhead

The overhead remains a major network parameter need to be considered to evaluate the performance. BCR has a constant overhead at all conditions. Figure 5 and Figure 6 shows the variation of BCR, ER and ER with respect to number of nodes and transmission range respectively.

ER has higher overhead as it involves pair-wise connectivity for routing. Since the connectivity between same nodes is possibly frequent, the ratio of overhead is higher. SNW shows a constant overhead upto a certain range and it slightly increases as the load and radio range gets increased. It is mainly due to the fact that during wait phase SNW has to wait indefinitely to meet up with the destination node. In BCR the overhead is constant for all varying load and radio range of a node. Since in BCR the transmissions are bound to the packets generated at each node, overhead remains constant. With this BCR assures secure communication.

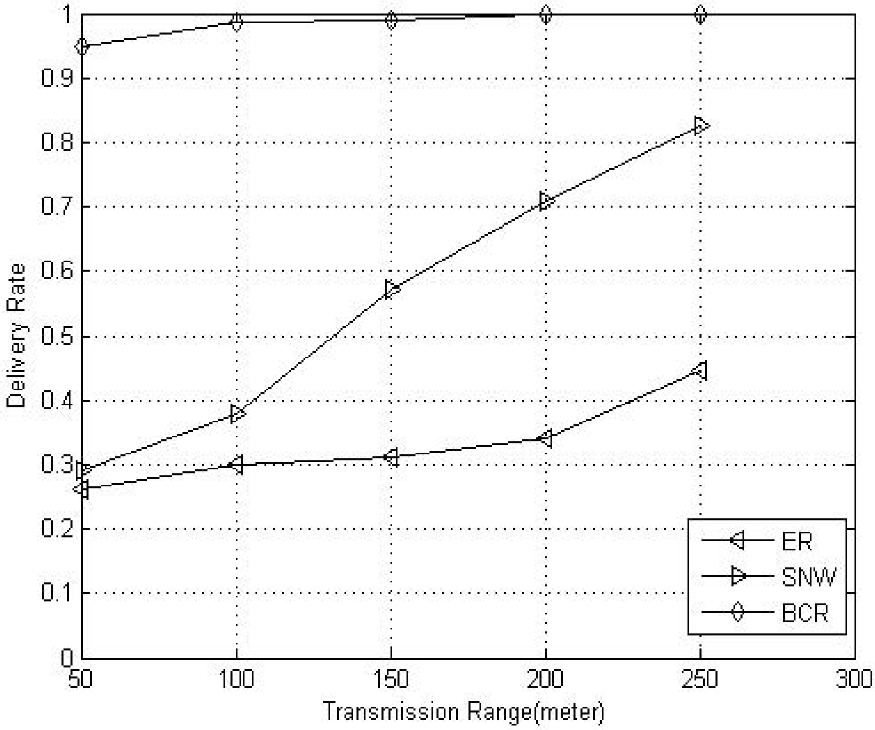

Figure 4 Delivery Ratio by varying transmission range

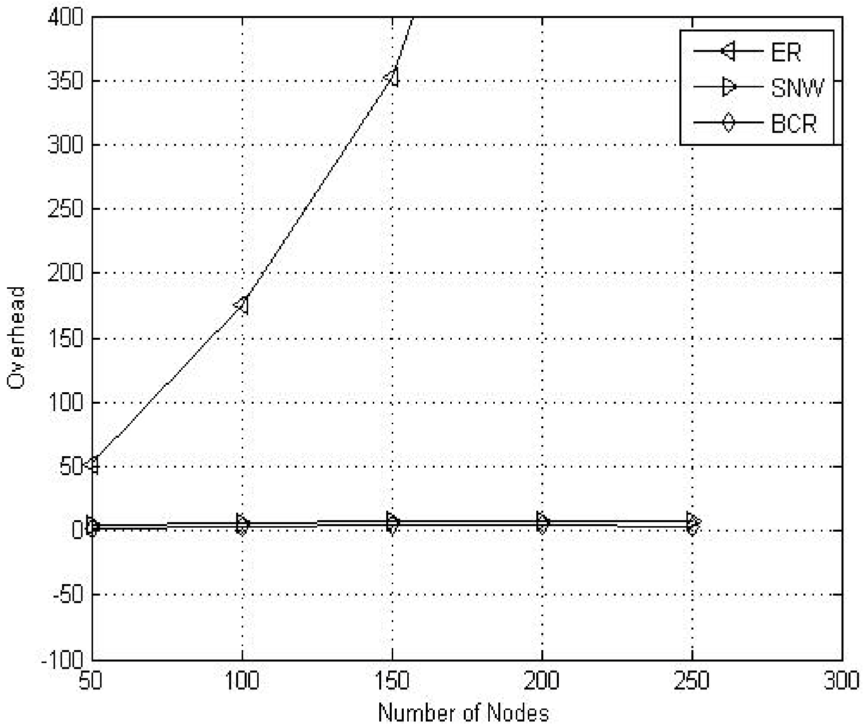

Figure 5 Overhead for assorted number of nodes.

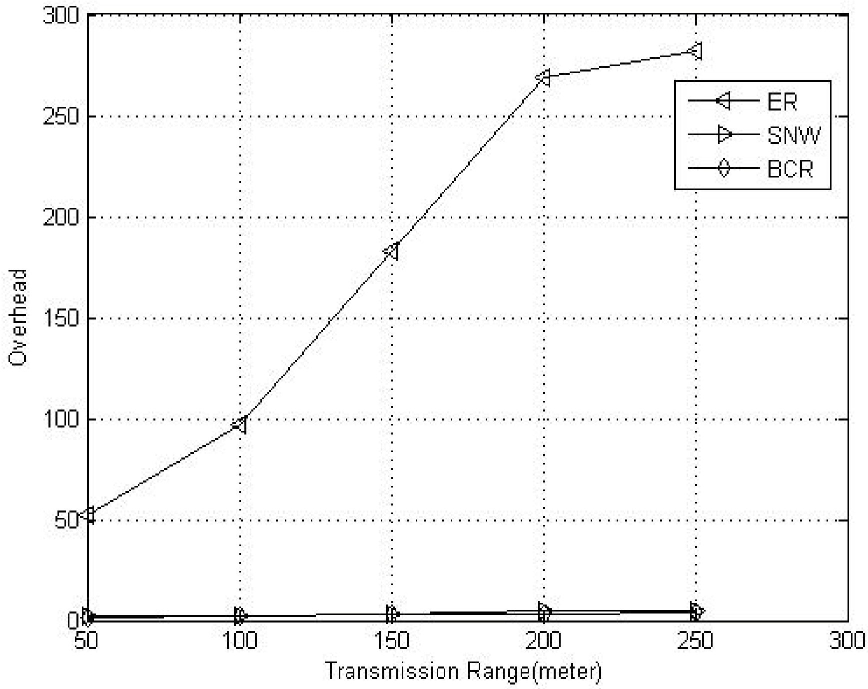

Figure 6 Overhead for different transmission range

Performance with respect to Delivery Latency

The time criteria once again stand forth as an important aspect during the measure of latency. The delay in delivering the data packets towards the destined node is lesser in BCR. Figure 7 and Figure 8 shows the variation of BCR, ER and ER with respect to number of nodes and transmission range respectively.

The delay in delivering the data packets towards the destination is larger when compared to SNW and BCR. The pair-wise connectivity between nodes in the network does not ascertain higher probability to reach the destination in minimum time period. SNW has an optimal delay; it is mainly due to the imprecise time by a node to reach the destination. BCR incurs minimum delay as the nodes are capable of reaching the destination through location services. The nodes are not in need to wait for any beacons and any node is destined to reach the destination. Hence the delay is lesser with secure data transmission.

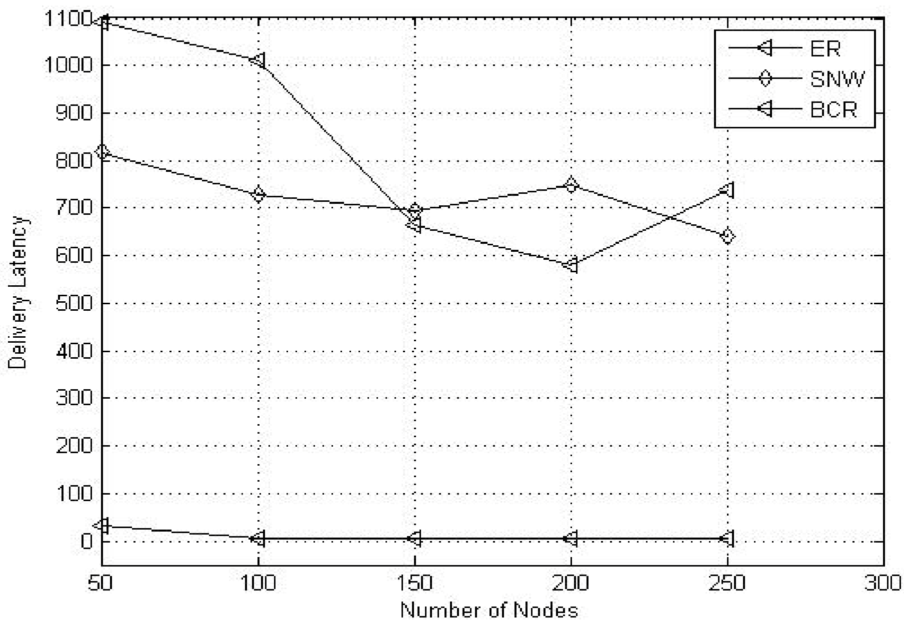

Figure 7 Delivery Latency for assorted number of nodes.

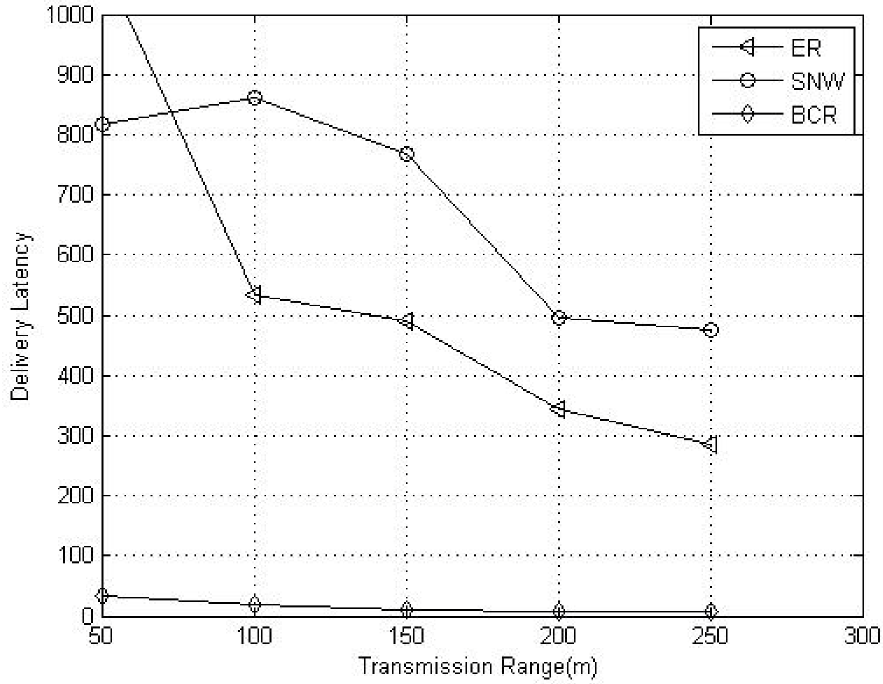

Figure 8 Delivery Latency with varying transmission range.

CONCLUSION AND FUTURE WORK

In this paper, we have demonstrated the means of efficient data transmission across ICMANET. The proposed routing BCR enables efficient and reliable routing with highest delivery ratio, constant overhead and minimum delay. A comparative analytic and simulative result of BCR with ER and SNW are roofed in this paper. As an enhancement, a mode of secure communication by means of agent technology with cryptographic algorithms will be proposed in the nearest future. It ensures a reliable and secure data transmission across ICMANET.

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