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Evaluation of Context Information for Intermittent Networks

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***Abstract*—**The context aware adaptive routing protocol is presented for unicast communication in intermittently connected mobile ad hoc networks (MANETs). The selection of the node is done by the Kalman filter prediction theory and it also makes use of utility functions. The context aware adaptive routing is defined by spray and wait technique, but the time consumption in delivering the message is too high and also the resource wastage is more. In this paper, we describe the spray and focus routing scheme for avoiding the existing problems.

***Keywords*—**Context aware adaptive routing, Kalman filter prediction, spray and wait, spray and focus, intermittent networks.

I. Introduction

DELAY Tolerant Networks have been used to send the routing messages in the partitioned networks [10], [42]. Ad Hoc Networks assume that a connected path exists between sender and receiver node at any point in time [12]. Context is the set of attributes related to the host. Adaptive routing is the capability of a system to change in condition [11]. Wang et al. confirmed that nodes which are not in the entrant list may also be helpful, as far as they snoop into the data packet and have confident geographical advancement on the way to the destination [25]. Boldrini et al. implemented an inherent context-aware middleware to conjecture possible mobility to assist routing packets in opportunistic networks [26]. A hypercube social feature extraction based routing is another kind of multipath routing used in networks [27].

Opportunistic Routing is a motivating development of the conventional MANET. The major supposition of the conventional mobile system is that the dispatcher and the recipient can be present concurrently [19]. If the dispatcher wants to broadcast data, but it cannot attach to the target throughout a multi-hop path, the data will be plunged [13]. However, the routing aims to swap the communication between disjointed nodes by persistently choosing some nodes to relocate data closer to the objective [14]. To maintain this objective, a quantity of innovative routing protocols should be re-modified inexorably. Essentially, the plan of routing protocol is a significant aspect of the opportunistic routing. Evaluated conventional routing protocol in MANETs [16], the innovative routing protocol has not attained a considerable dependable routing path among the sender and the receiver in opportunistic routing using Collaborative Watchdog with fuzzy logic approach [21]. Furthermore, requirement of the topological data restrain the construction of the efficient protocol. The main familiar method is the controlled overflow among the inadequate time to live (TTL). It can transmit the data to the target as soon as one node gets a forward link. Preoccupied from the technique of flood, multi-copy is a more proficient methodology [20]. Considering the nonexistence of the particular data, the alternate path in opportunistic routing is developed by using the dynamic clustering technique [22].

Spray and wait is based on the initial replication of a certain number of copies of the message. Then these copies are not replicated further and are only forwarded to the recipient of the message [39]. Context aware adaptive routing is used in the intermittent connected network [1]. Fuzzy based load balancing technique is used to find the best forwarded node in the network [15]. Context is any data that can be developed to illustrate the position of a node in the network [17]. Tree based network formation is the alteration for the context aware adaptive routing protocol [18].

To address the above issues, we present a protocol: Context-aware Opportunistic Routing (COR). COR allows all qualified nodes to participate in packet forwarding [23]. Energy based clustering formation using opportunistic routing [24] is presented for improving Quality of Service.

MANETs are categorized by dynamic node selection, incomplete bandwidth and restricted energy of their dynamic nodes. Bio/Nature-inspired routing algorithms (Swarm Intelligence) such as BeeAdHoc have been obtainable for developing routing algorithms for MANETs [34]. The dissimilar performances of this network are disseminated between the nodes and every other node will perform the responsibility of a router for the packets intended for the other nodes [36]. The system functionality of MANETs can change recurrently, since every node is intelligent to progress separately in several directions [35]. A Fuzzy set can include elements through only a biased quantity of membership. A membership function (MF) is a curvature that describes how every direct in the contribution space is mapped to a membership cost between 0 and 1. If-then rule declarations are employed to originate the provisional statements that encompass fuzzy logic [37]. The fuzzy methodology necessitates adequate expert information for the generation of the rule base, the permutation of the information and the defuzzification. In common, the affecting of fuzzy logic can be cooperative, for extremely composite procedures, when

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there is no straightforward mathematical representation, for extremely nonlinear procedures or if the procedure of expert knowledge is to be executed [38]. Stochastic routing is a method that can be utilized to find the next hop in a path concurrence to a probability allocation [40].

II. Related Work

The messages contained in the nodes are blindly stored and forwarded to the node that lies in the range of that particular node. It is based on the periodic pairwise connectivity of nodes. The advantage of this method is that it ensures high delivery rates and also because of limited buffer space, there may occur the dropping of messages and retransmissions [1]. A probabilistic metric is called delivery predictability for indicating the predicted path. Here the disadvantage is the problem of deciding and the distribution of messages to the number of nodes [2]. Securing Immutable Tracking system can be used to ensure the security in MANETs [3]. The Sparse MANETs are meant that they need the network partitions for a significant period of data delivery. Here the straight forward approach is followed [6]. In this approach, the data delivery rates are low and it has large delays [4]. The asynchronous communication for message delivery is used. Prediction of context information is utilized in the Kalman filter prediction technique and utility theory. Context Aware Routing performs respectable message delivery even without message replication [9]. The disadvantage of this methodology is that there is no acknowledgement mechanism in order to notify the sender about the correct delivery of messages [5]. Spray and wait has two phases; Spray phase: Source node spreads L copies of messages to other node. Here only the initial replication of a certain number of the messages will occur. Wait phase: The source node will wait until the message has been sent to the other node. The disadvantage is spraying the number of copies consumes much time and resources [7]. Context aware adaptive routing is meant for communication in intermittently connected networks. Here, Kalman filter and the multi-criteria decision theory are used. These predictions are then composed using multi-criteria decision theory. Here the spray and wait is indirectly used in asynchronous communication of message delivery [8]. Due to this, the transparency for finding novel route from source to destination may be elevated and additional wait for latest route discovery may be introduced and data broadcast becomes delayed [28], [29]. Scheduling algorithm may use the bandwidth delay aware protocol for improving the Quality of Service [30]. Energy efficiency is the prime factor for improving the network management [32], geographical approach can be implemented to improve the scalability [31], Dominating set cluster formation [33] is used to increase the network capacity. The Ad-Hoc broadcast protocol (AHBP) [41] creates multi-hop neighborhood information to choose the most competent subset of downstream nodes that should retransmit, so that all nodes in its multi-hop neighborhood are sheltered.

III. Proposed System

In this work, we will use the Spray and Focus Routing Technique through the Kalman Filter and the Utility functions. Here it enters the spray phase first then enters the focusing phase. It sprays L copies to L relays and in the route each copy using a single copy utility based scheme.

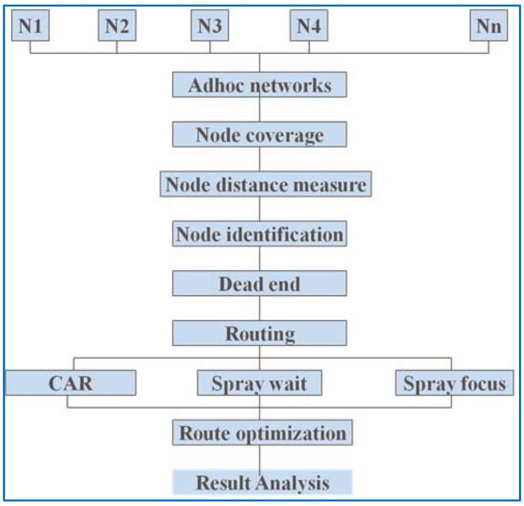

Fig. 1 Proposed Work

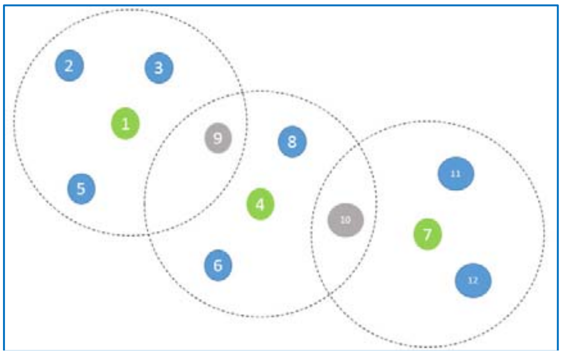

Fig. 2 Node Creation

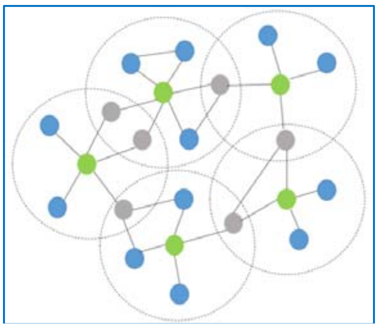

Fig. 3 Node Formation with Clusters

A. Node Arrangement

It allows mobile hosts to communicate with one another with no pre-existing communication infrastructure. In ad hoc networks, arbitrary mobile hosts can be recruited to “fill the gap” by serving as intermediate routes between two hosts that may otherwise not be in direct transmission range of one another. Random node arrangement is the process of the selected number of nodes which are randomly placed in the network.

B. Node Coverage

It defines the node's individual coverage capacity. In that range, the neighboring node can be interacted for the message transferring purposes. The coverage of each node will be generated which represents the transmission power (range) of each node.

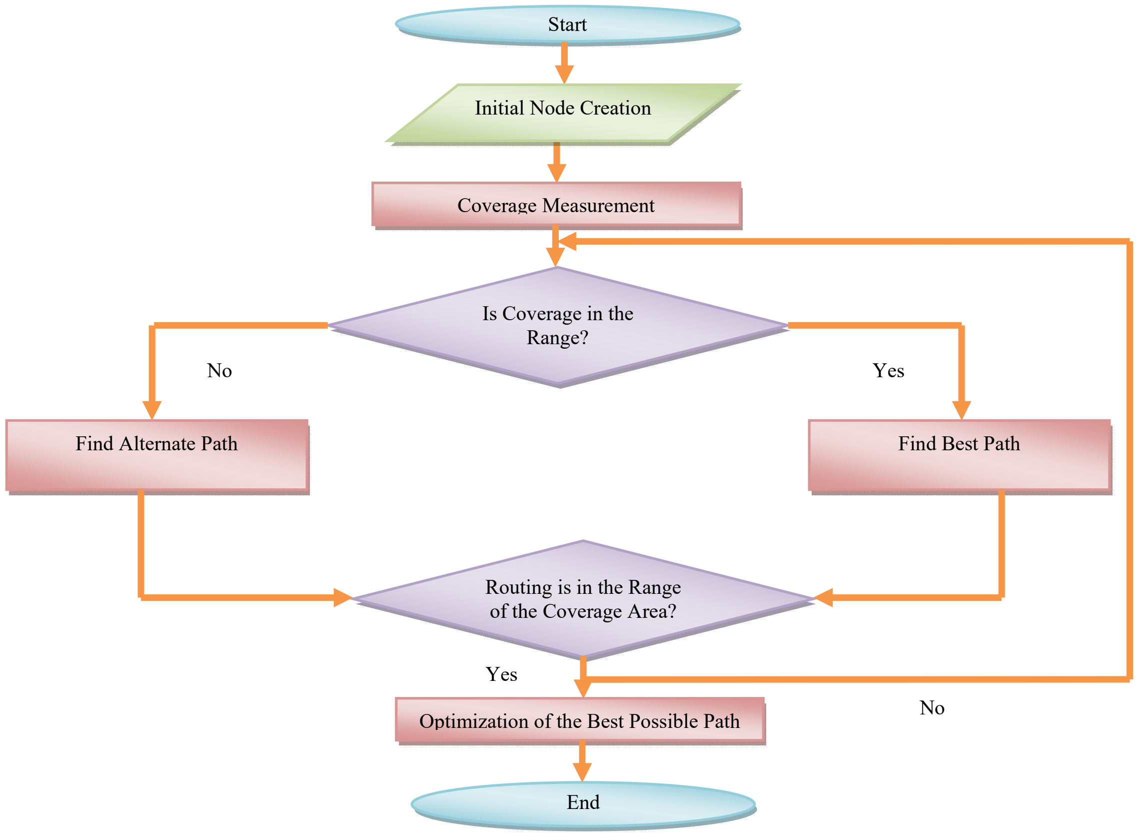

Fig. 4 Flowchart for the proposed scheme

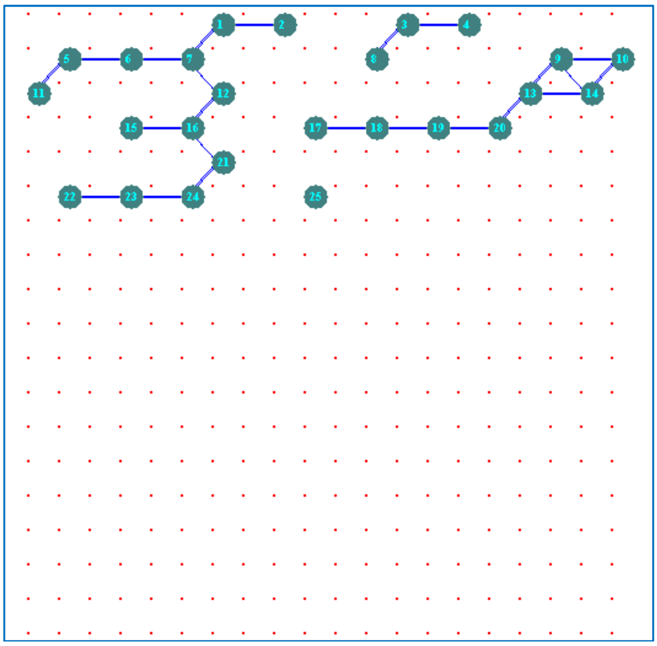

Fig. 5 Nodes Hop Distance

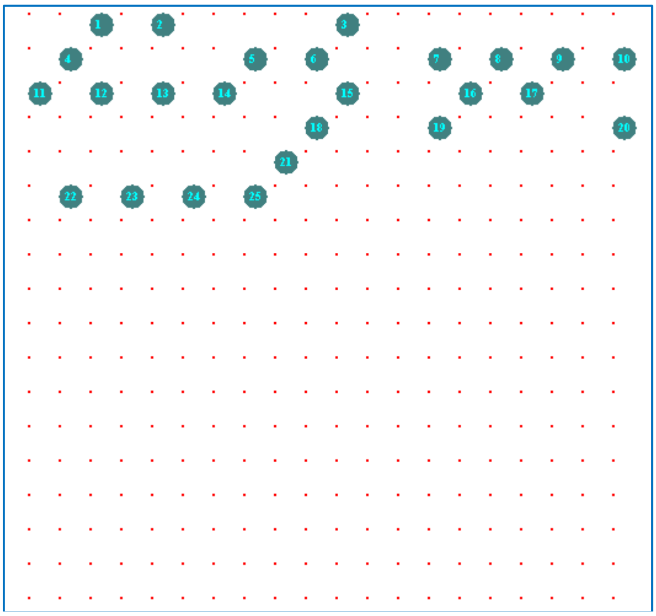

Fig. 6 Nodes Arrangement

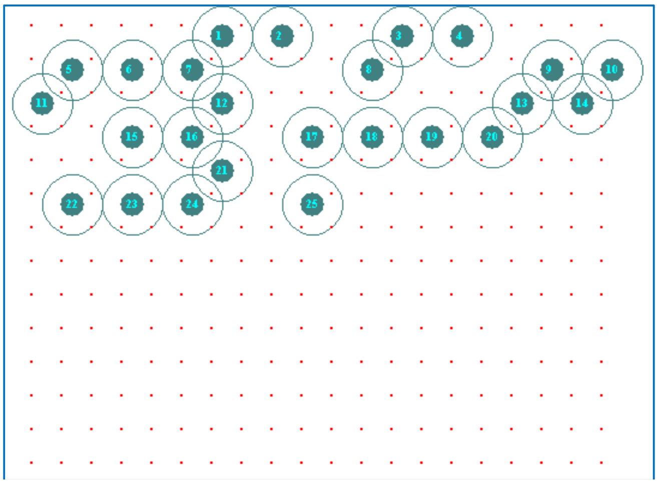

Fig. 7 Node Coverage

IV. Context Aware Adaptive Routing

Context aware adaptive routing is used for the delay tolerant unicast communication in intermittently connected MANETs. It uses prediction to allow the efficient routing of messages to the recipient. Context aware adaptive routing does not assume any previous knowledge of the routes of the hosts. It is based on a single copy of message in the system. Under context aware routing, we can use the following techniques:

- Spray and Wait
- Spray and Focus

The source and the destination node may lie on the same cloud or different clouds.

A. Node Performance

The performance of the node is considered by the change degree of connectivity and the past collocation of the nodes here these are fed as the input to the Kalman filter. The output of this filter is composed using multi-criteria decision theory to give the overall performance. The change of degree of connectivity is calculated as:

$$U_{cdc_h}(t)=\frac{\left|n(t-T)\cup n(t)\right|-\left|n(t-T)\cap n(t)\right|}{\left|n(t-T)\cup n(t)\right|} \quad (1)$$

$$Time_{Avg}(NR)=\sum_{i=1}^{n}\left(\frac{FwdN\left(\frac{n_i+1}{n_i}\right)}{n}\right) \quad (2)$$

where n is the hop distance number and FwdN is the Forward Node for broadcasting data packet, which is calculated as $n_i + 1$ by n_i.

$$Time_{Avg}(ER)=\sum_{i=1}^{N}\left(\frac{AdjN\left(\frac{n_i+1}{n_i}\right)}{N}\right) \quad (3)$$

where n is the hop distance number and AdjN is the Adjacent Node for broadcasting data packet, which is calculated as $n_i + 1$ by n_i.

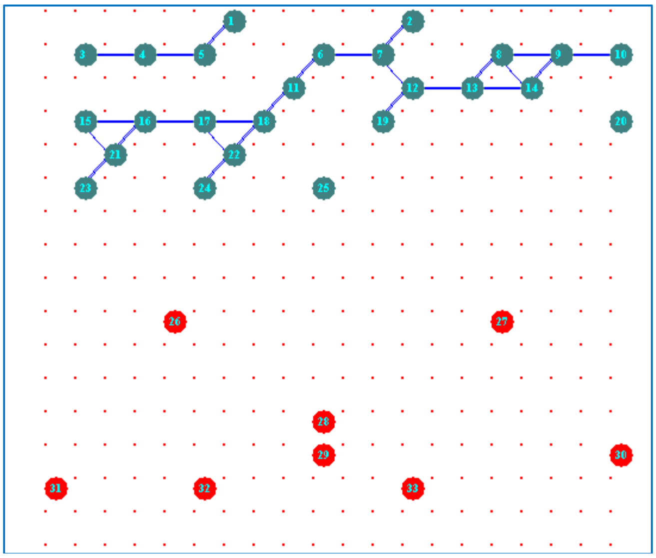

Fig. 8 Dead End Node

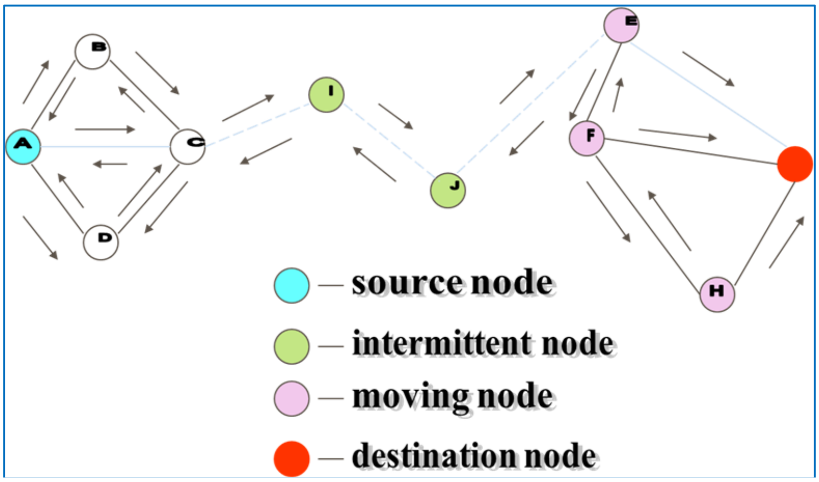

Fig. 9 Network Model

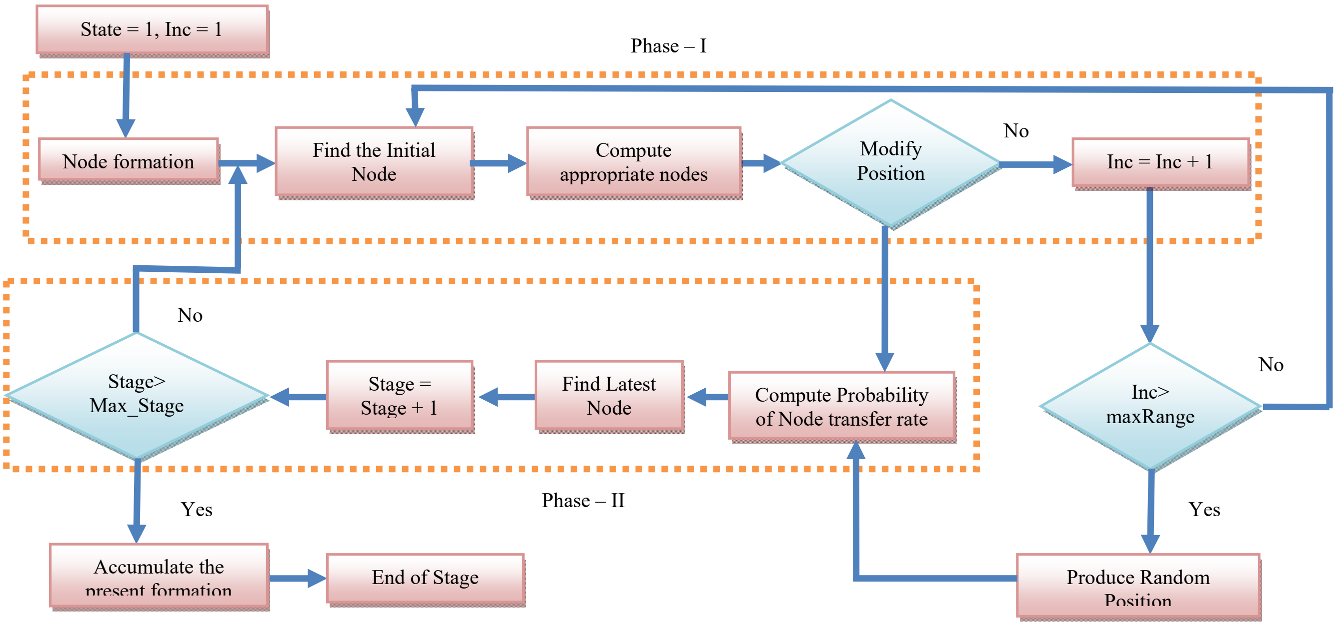

Fig. 10 Proposed Flowchart

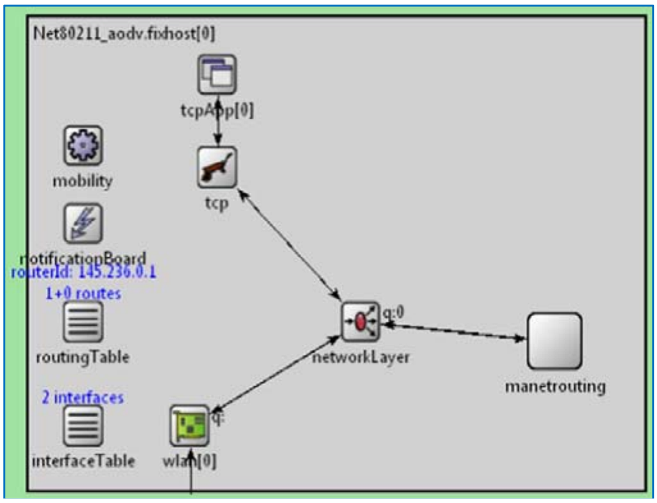

Fig. 11 Node Structure

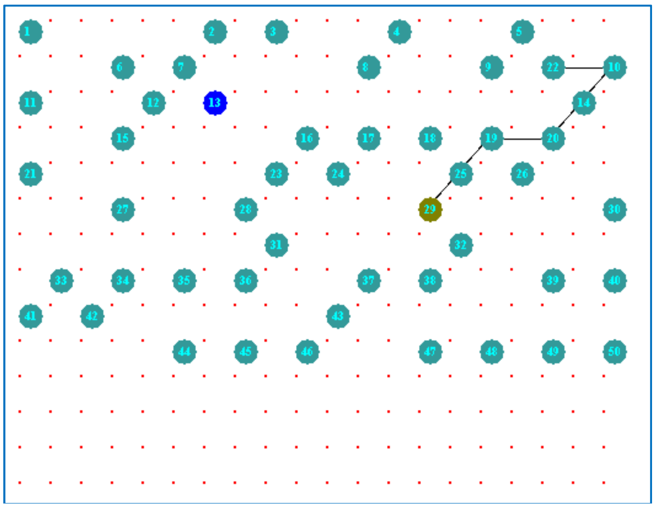

Fig. 13 Spray and Focus Routing

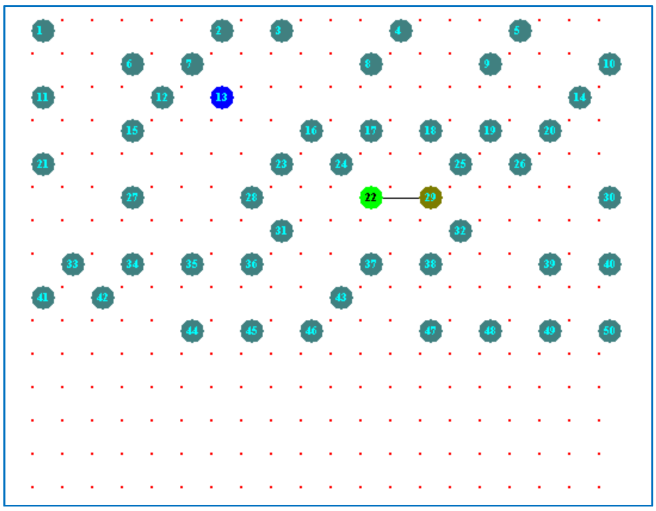

Fig. 12 Spray and Wait Routing

$$Indirect_{Trust}\,[Y/X] = \sum_{i=1}^{N}\left(\frac{Rec_{Trust}\left(\frac{Y}{n_i}\right)}{N}\right) \quad (4)$$

where $Rec_{Trust}\left(\frac{Y}{n_i}\right)$ demonstrates the recommended indirect trust value of the node Y by Adjacent Node for broadcasting data packet, which is calculated as $n_i + 1$ by n_i. N denotes the sum of all the total recommendations received by the node Y.

$$\text{Final}_{\text{Trust}}\left[\frac{Y}{X}\right] = \theta \text{ x Direct}_{\text{Trust}}\left[\frac{Y}{X}\right] + \vartheta \text{ x Indirect}_{\text{Trust}}\left[\frac{Y}{X}\right] \quad (5)$$

B. Algorithm

Procedure Location_Finding
Obtain location of (Xi, L) from N nodes;
Inside_Set = 0;
for every adjacent node Ai do

if point of adjacent node = TRUE then
Inside_Set = Inside_Set U A_i;
end if
end for
Estimated_Location= Center_of_Gravity(Inside_Set);
Obtain location of Sector boundary of (Xi, L) from N nodes
Obtain initial values:
(A_{min}, B_{min}, X_{max}, Y_{maz})
position the search area as the rectangle
(A_{min} - R, B_{min}- R, X_{max}+ R, Y_{maz} + R), where
R is the radio range.
Partition the search area into grids.
Foreverylocation received do
Increase the value of point by one if this point is within the segmentdistinct in this location.
end for
Estimated_Location= Center_of_Gravity(the highest value of points)
Transmit observed node and wait for radio adjacent node transmits
recognizevisualization_neighbors
Transmit_Receive Observations
if for revolution from synchronize
Transmit_Receiveobservations from another location
Calculate rotation
endif
Compute absolute revolution from synchronize
Update coordinate transformation service
endif
upon expiration of timer TA for p∈ A
do
A.remove(p);
ifp.Q ≥ Qmin then
if |S| < CS then
S.add(p);
else
q := minQ S;
ifq.Q<p.Q then
S.remove(q); S.add(p);
with Period TN do
for all p ∈ S in descending order do
ifp.Q ≥ Qmin then
if |N| < CN then
N.add(p); S.remove(p);
else
q :=
replacementCandidate(N, p);
if q _= null then
N.remove(q); N.add(p);
S.remove(p);
if U=D then
EXIT # U is the final destination of M. The routing has succeeded.
else
if U_= N then
Discard M – EXIT
U is not needed in the routing of M
else
U is the recipient of the packet, in charge of forwarding it to D.
ifexistPh(U,D) = true then
NextNode ← getNextNodePH(U,D)
There already exists a pheromonetrail to D
else
if ND(U)= N then
NextNode ← N st ||UD| − |ND|| = maxv∊ ND(U)||UD| − |vD||
else
Greedy mode fails, U launches the recovery mode.
NextNode ←Recovery(U,D)
end if
end if
Return NextNode
end if
end if
updateBRTable(U)
if |UD| < |KD| then
sendBant(K,D)
Node U allows a progress compared to the stuck node and can stop the recovery.
else
ifexistPh(U,D) = false then
initialisePh(U,D)
end if
NextNode ← getNextNodePH(U,D)
end if
Return NextNode
End Procedure
Procedure Mutation ()
t:=0,
tM := random(x,y);
Arbitrarily initialize node position Po(0)
memory Me(0)
do
evaluate node position Po(t) and memory Me(t)
best El(t1-1) from Po(t1-1)
substitute bad individual with Po(t) by the elite El(t1-1)
from Po(t1-1)
If changes strength
Po(ta) := recover suitable individuals from (Po(t1), Me(t1))
Else
Po(t) := Po(t1)
If t = t1 or changes position then
If t = t1then
B_p(t1) := recover good entity from (Po'(t1))
If changes position then
B_p(t1) := El(t1-1)
If any arbitrary point in memory then
restore a arbitrary point with B_p(t1)
else
If t > t1 then
If f (B_p(t1)) > fun (C_M(t1)) then
fun (C_M(t1)) := B_p(t1)
T_M := t1+rand(x,y)
Perform inherited operations
Po"(t1) := select for duplicate (Po(t1))
Cross_over(P0(t1))
Mutate (P0(t1); pm)
P0(t1 + 1) := P0'(t1)
End if
Until the stop condition is convene (t1 > t_{max})
End Procedure
Procedure Rep()
Input:
Re_S(i1) generates every neighbor
NS1.Level;
NS1.REP
M = total number of adjacent neighbors
Output:
OPT for every neighbor
Selected adjacent node_ID
Steps:
i=0;
REP=0;
For each Re_S(i)
Generate Re_S fields;

```
    Generate NS1.level;
    Generate NS1.REP;
        Apply rule base.
    Modify output based on rule base
    Compute Fk(x);
    Fk(x) =base(NS1.level-RS1.level);
    NS1.REP = base*RS.Battery+b2*Rs.Tot_D;
    NS1. Level = base*Tot_P+base*Tot_H+base*NS.REP;
Compute output;
    If output >NS1.REP then
    NS1.REP=Output
    Selected next_node=RS1.Node_ID
    End if
        i=i+1
    Next
    if my_Time > ITERATION_LENGTH then
    if my_State = transmitted then
    return Finish
    else if my_State = not_transmitted then
    wait for my neighbor heads to complete, then pick one as my
    transmitted_node
    return finish
    else if my_State = not_transmitted then
    find a arbitrary node to proceed as my alternative after it finishes
    wait for it to transmit, then return finish
    end if
    else if my_State = not_transmitted
    and num_Followers()< f_min(my_Time) then
    my_ID produce New Random_ID( )
    locally transmit (Find, my_ID)
    else if myState = New_node then
    best_Leader my_ID
    best_Follower_Count = num_Followers
    for all n where n is a probable new node do
    follower_Count = Poll For Num_Followers(n, my_ID)
    if follower_Count > best_Follower_Count then
    best_Leader = n
    best_Follower_Count > follower_Count
    end if
    end for
    if best_Leader is not my_ID then
    send(best_Leader, my_ID)
    wait for best_Leader to transmit it's latest communication
    nearby transmit (Global, my_ID)
    end if
    end if
End procedure
```

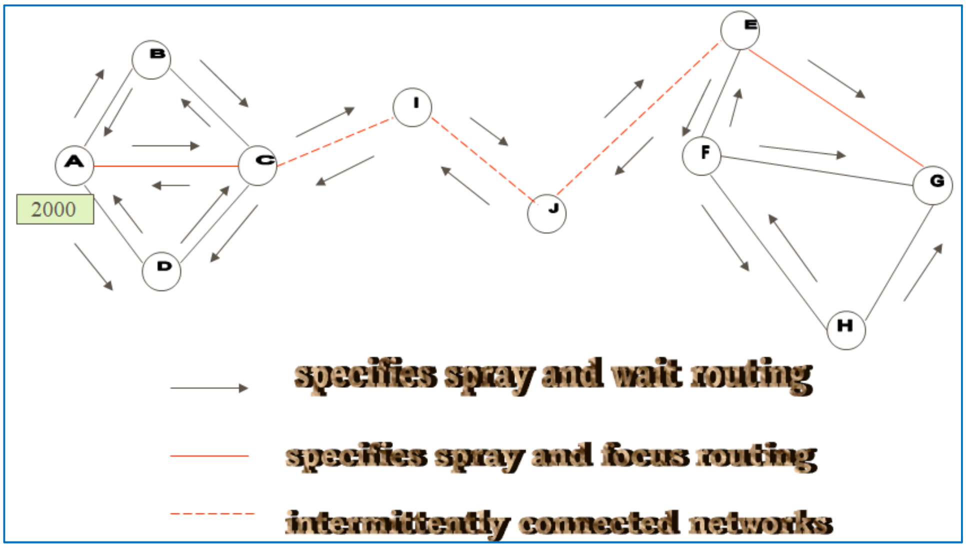

Fig. 14 Network Connectivity

V. Performance Evaluation

TABLE I
NODE TRAVERSING PARAMETERS

Nodes	Distance	Time	Nodes	Distance	Time
A-B	2	0.02	J-I	2	0.02
A-C	3	0.03	J-E	3	0.03
A-D	4	0.04	E-J	3	0.0399
B-A	2	0.0266	E-F	4	0.0532
B-C	2	0.0266	E-H	2	0.0266
D-A	4	0.0532	F-E	4	0.04
D-C	3	0.0399	F-H	4	0.04
C-A	3	0.03	F-G	3	0.03
C-B	2	0.02	H-E	2	0.02
C-D	3	0.03	H-F	4	0.04
I-C	4	0.0532	H-G	2	0.02
I-J	2	0.0266	G-F	3	0.0399
			G-H	2	0.0266

TABLE II
NODE MOBILITY

Node	Mobility
A	0.99
B	0.66
C	0.99
D	0.66
I	0.66
J	0.99
E	0.66
F	0.99
G	0.66
H	0.99

A. Local Evaluation of Context Information

$$U(x_1, x_2, \ldots\ldots, x_n) = \sum_{i=1}^{n} U_i(x_i)$$

Packet size = 2000

- Consider the host A,(0.66+0.99+0.66) * 2000 = 4620
- Consider the host B,(0.99+0.99) * 2000 = 3960
- Consider the host C,(0.99+0.66+0.66) * 2000 = 5940
- Consider the host D,(0.99+0.99) * 2000 = 3960
- Consider the host E,(0.99+0.99+0.99) * 2000 = 5940
- Consider the host F,(0.66+0.99+0.66) * 2000 = 4620
- Consider the host G,(0.99+0.99) * 2000 = 3960
- Consider the host H,(0.66+0.99+0.66) * 2000 = 4620
- Consider the host I, (0.99+0.99) * 2000 = 3960
- Consider the host J, (0.66+0.66) * 2000 = 2640

B. Automatic Adaptation of Utility Functions:

$$a_i(x_i) = a_{range_i}(x_i) \,.\, a_{predictability_i}(x_i) \;\;.\;\; a_{availabiltiy_i}(x_i)$$

In Spray and Wait,

$f(U(x_i))$ = 3*4620+ 2*3960 + 3*5960 + 2*3960 + 2*3960 + 2*2640 + 3*5964 + 3*4620 + 3*4620 + 2*3960= 1,14,180

In Spray and Focus,

f(U(xi))=(0.99+0.99+0.66+0.99+0.66+0.99) * 2000 = 10,560

C. Change of Degree of Connectivity

Let n(t) = 1,

$$\frac{(\;|(1-0.02)+1\,|-|(1-0.02)*1\,|\;)}{(\;|(1-0.02)+1\,|\;)} = \frac{(1.98-0.98)}{(1.98)} = 0.5050$$

$$\frac{(\;|(1-0.03)+1\,|-|(1-0.03)*1\,|\;)}{(\;|(1-0.03)+1\,|\;)} = \frac{(1.97-0.97)}{(1.97)} = 0.5076$$

$$\frac{(\;|(1-0.04)+1\,|-|(1-0.04)*1\,|\;)}{(\;|(1-0.04)+1\,|\;)} = \frac{(1.96-0.96)}{(1.96)} = 0.5102$$

$$\frac{(\;|(1-0.0266)+1\,|-|(1-0.0266)*1\,|\;)}{(\;|(1-0.0266)+1\,|\;)} = 0.5067$$

$$\frac{(\;|(1-0.0532)+1\,|-|(1-0.0532)*1\,|\;)}{(\;|(1-0.0532)+1\,|\;)} = 0.5136$$

$$\frac{(\;|(1-0.0399)+1\,|-|(1-0.0399)*1\,|\;)}{(\;|(1-0.0399)+1\,|\;)} = 0.5101$$

$$\frac{(\;|(1-0.0399)+1\,|-|(1-0.0399)*1\,|\;)}{(\;|(1-0.0399)+1\,|\;)} = 0.5101$$

- Consider A= 0.5050+0.5076+0.5102= 1.5228
- Consider B = 0.5050+0.5050= 1.0134
- Consider C = 0.5050+0.5076+0.5076+0.5102= 2.0304

Similarly for,

- D=1.0237
- I=1.0203
- J=1.0126
- E=1.5304
- F=1.528
- H=1.5202
- G=1.0168

In spray and wait,

3*1.5228 + 2*1.0134 + 4*2.0304 +2*1.0237 +2*1.0203+ 2*1.0126+ 3*1.5304 +3*1.528 +3*1.5202 +2*1.0168 = 36.5994

In spray and focus,

0.5076+0.5102+0.5067+0.5076+0.5067= 2.5388

D. Analysis Result

TABLE III
ANALYSIS RESULT

Contents	Spray And Wait	Spray And Focus
RESOURCES	1,14,180	10,560
TIME (sec)	36.5994	2.5388

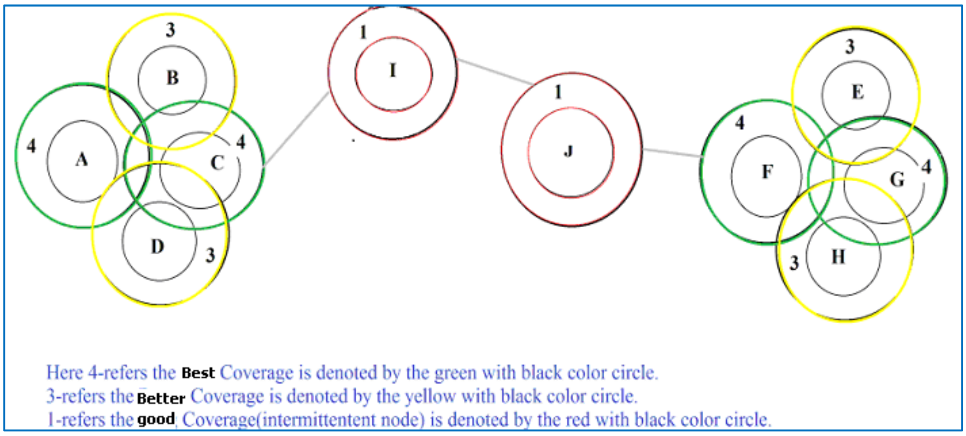

Fig. 15 Networks Coverage

TABLE IV
PERFORMANCE UNDER TRANSMISSION RANGE

Nodes	Range(mm)	Delivery Rate (%)	Baseline Rate	Avg Latency(ms)	Max Latency(ms)	Avg Hops	Max Hops
Node A	200	100	98.2	0.5	1	2.8	10
Node B	150	75	40	15.5	180	10	21
Node C	200	100	98.2	0.5	1	2.8	10
Node D	150	75	40	15.5	180	10	21
Node I	50	25	0	200	400	3	9
Node J	50	25	0	200	400	10	21
Node E	150	75	40	15.5	180	10	21
Node F	200	100	98.2	0.5	1	2.8	10
Node G	200	100	98.2	0.5	1	2.8	10
Node H	150	75	40	15.5	180	10	21

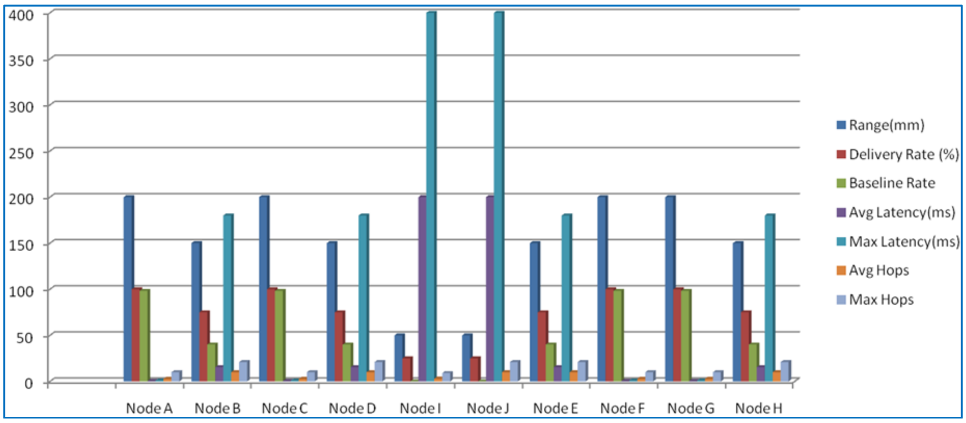

Fig. 16 Performance under Transmission range

TABLE V
RESOURCE CONSUMPTION CHARACTERISTICS

Nodes	Buffer size	Delivery Rate (%)	Avg Latency(ms)
Live Node A	500	100	80
Live Node B	666.67	75	160
Live Node C	500	100	80
Live Node D	666.67	75	160
Live Node E	666.67	75	160
Live Node F	500	100	80
Live Node G	500	100	80
Live Node H	666.67	75	160
Intermittent Node I	2000	25	300
Intermittent Node J	2000	25	300

TABLE VI
PERFORMANCE ANALYSIS IN VARIOUS PARAMETERS

Mobility Model (speed)	Delivery Rate of spray and wait (%)	Delivery Rate of spray and focus (%)	Delay in spray and wait (ms)	Delay in spray and focus (ms)
Random Waypoint (0-50 mm/ms)	65.4	90.2	25069	5069
Limited Random Waypoint (0-50 mm/ms)	53.2	86.4	38060	8060
Area Base (0-50 mm/ms)	46.3	76.3	49432	9432
Random Waypoint (0-25 mm/ms)	63.1	89.9	25162	5162
Limited Random Waypoint (0-25 mm/ms)	49.8	83.4	38164	8164
Area Base (0-25 mm/ms)	42.1	71.0	49498	9498

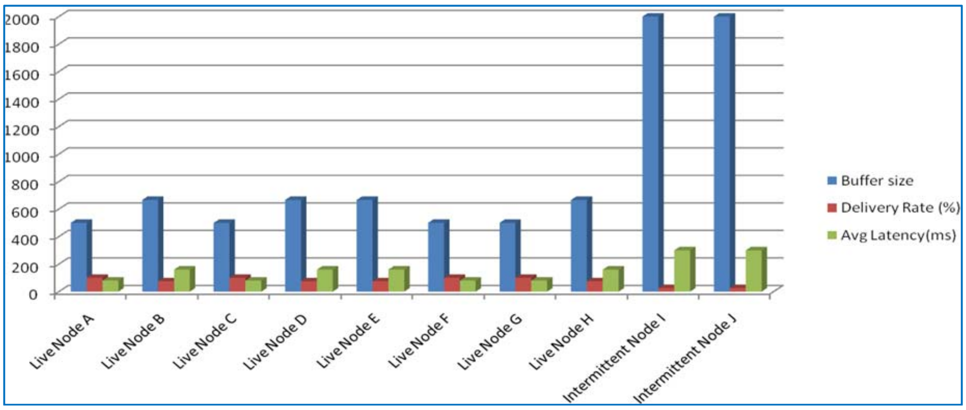

Fig. 17 Resource consumption

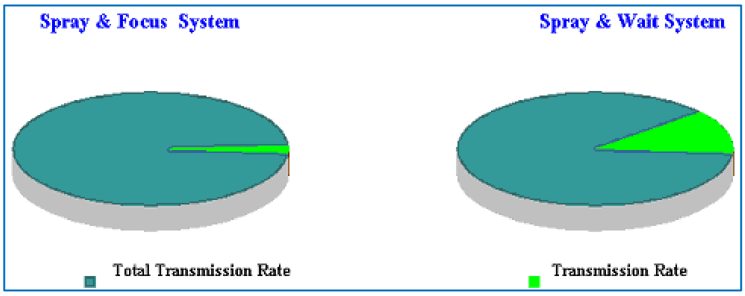

Fig. 18 Transmission Rate

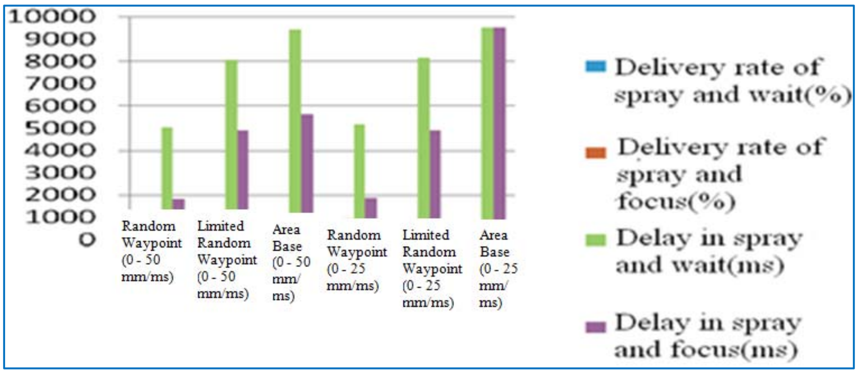

Fig. 19 Performance Analysis

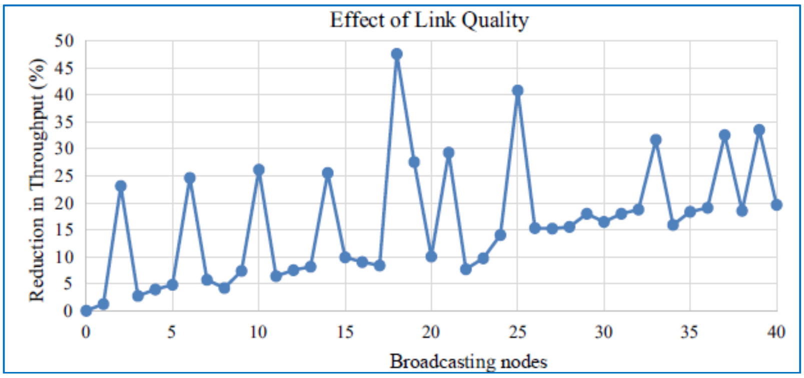

Fig. 20 Link Quality

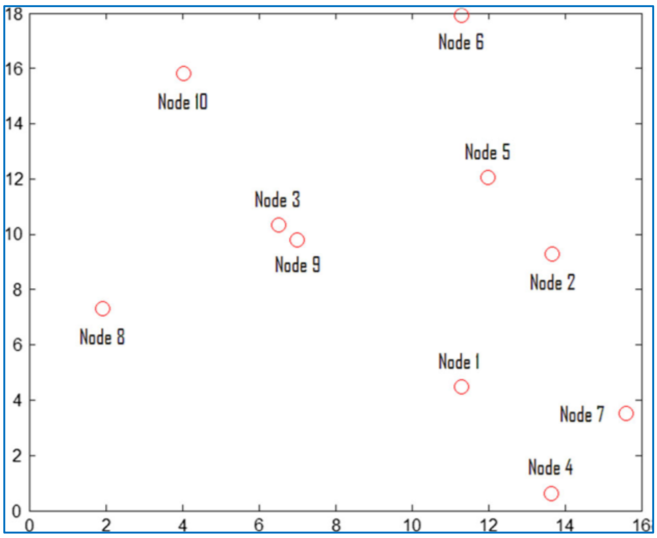

Fig. 21 Communication in Iteration

VI. Conclusion & Future Work

The spray and focus routing for communication between the intermittent networks was done with minimal time consumption and resource wastage. In future, this paper can be improved by means of considering the Quality of service in delivering the messages. Quality of service (QoS) refers to resource reservation control mechanisms rather than the achieved service quality. Also we can find the path stability before choosing a particular path. So that it will improve the route optimization.

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