Modified Radial Based Neural Network for Clustering and Routing Optimal Path in Wireless Network

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Abstract

Several methods have been developed for routing problem in MANETs wireless network, because it considered very important problem in this network ,we suggested proposed method based on modified radial basis function networks RBFN and Kmean++ algorithm. The modification in RBFN for routing operation in order to find the optimal path between source and destination in MANETs clusters. Modified Radial Based Neural Network is very simple, adaptable and efficient method to increase the life time of nodes, packet delivery ratio and the throughput of the network will increase and connection become more useful because the optimal path has the best parameters from other paths including the best bitrate and best life link with minimum delays. The results show how the proposed routing algorithm produces higher speed comparing with Dijkstra algorithm and finds the optimal path in addition to shortest path. Proposed routing algorithm depends on the group of factors and parameters to select the path between two points in the wireless network.

Keywords: ad hoc wireless network, MANET, Clustering, routing ,wireless network clustering, modified Radial based neural network, kmean++.

Introduction

An ad hoc network is a collection of wireless mobile nodes (or routers) dynamically forming a temporary network without the use of any existing network infra-structure or centralized administration.

The routers are free to move randomly and organize themselves arbitrarily; thus, the network wireless topology may change rapidly and unpredictably Multihop, mobility, large network size combined with device heterogeneity, bandwidth, and battery power constraints make the design of adequate routing protocols a major challenge. [1]

Mobiles Ad-Hoc Networks (MANETs) are self-organized networks, thus, ad hoc considers Self-configuring infrastructure-less network of mobile devices connected by wireless. Each device in a MANETs is free to move independently in any direction, and will therefore change its links to other devices frequently. This move will produce changing of its links to other devices considerably. Each must forward traffic unrelated to its own use, and therefore be a router hence, the major challenge of constructing MANET's is to continue keep the information collected for routing traffics.

MANETs possess certain characteristics like Bandwidth-constrained, variable capacity links, energy- constrained 0peration, limited physical security, dynamic network topology, frequent routing updates , an infrastructure less, self-organized and multi-hop network with rapidly changing topology causing the wireless links to be broken and re-established on-the-fly.[2]

The routing in network can be defineed as the process of choosing the paths in a network to convey network traffic. For this, the need to design routing protocol which seamlessly acclimatized with changing network topology that was unavoidable. As a consequence to the routing in this network became one of the most important challenging missions. [3]

Hence routing in MANETs became one of the most challenging tasks. Routing in networking is the process of selecting paths in a network to send network traffic. Therefore, the need to design a novel routing protocol which seamlessly adapt to chang network topology was inevitable. [4]

The clustering, is a method to gather nodes into group's. These groups are contained by the network and they are known as clusters. A cluster is basically a subset of nodes of the network that satisfies a certain property [5]. Hence, the Clustering can be defined as a way to rearrange all nodes into small groups are defined as Cluster head (CH) and cluster members that are determined with the same rule. Every clustering algorithm consists of two mechanisms: cluster formation and cluster maintenance.

2-Related work

Many researches in wireless network routing explored and suggested algorithm to find the optimal shortest path for nodes. In order to supply an overview of former work and to supply a basic theoretical understanding of the considered topic, some recent researches presented by different authors are reviewed and quote in this section Some of these researches were about the applying neural network to find optimal path in wireless network.

Heni Kaaniche and Farouk Kamoun , 2010 [6]reported that a recurrent neural network has been suggested here to estimate the stability of paths in a MANETs, this neural predictor is a three-layer network with feedback connections. Back propagation has been used to train the recurrent neural network. To exam the satisfactoriness of the predictor in mobility prediction, they have tested the neural predictor on time series describe sites of an Ad hoc mobile node, improving routing by reducing the overhead it is found the stable path and the number of connection interruptions.

Siddesh.G.K, et al. in 2011,[7] proposed a routing protocol in ad-hoc wireless network using software computing technique like neutral network, fuzzy logics and genetic algorithm. Performed simulation uses various existing protocols like power aware routing protocol, proactive, reactive and hybrid routing protocols. Authors in this paper use software computing's share to improving the protocol performance in very dramatic terms, establishing the link between the nodes in minimum time and find the optimal route to a large network.

Seyed Saeed Sadat Noori , et al.in 2012[8] proposed an efficacious protocol for disjoint path set and select backup in ad-hoc wireless networks. In this algorithm, the all trustworthy paths (among selected network nodes) can be found without needs in on demand routing algorithm to discover new paths. The new approach is using multi-layerperceptron (MLPs) neural networks to predict the probability of proper link. This MLP net updates its weights by using the back propagation error algorithm. For this reason, this type of neural network can be a perfect elect to predicting of the mobile nodes reliable links with best accuracy.

Parimal Kumar Giri in 2012 [9] suggested the neural network based approach for MANET. By using hopfield neural networks (HNNs) that made to solve or provide an convergent solution to the shortest path problem faster than would be possible with any algorithmic solution, relying on the neural networks (NNs) parallel architecture.

S. Gangwar, K. Kumar & M. Mittal in 2015 [10] have implemented ART1 neural network over the cluster head selection as a part of the routing technique which selects the cluster head depending on residual energy of the mobile node after the completion of every data transmission. After simulating the results showed that ART1 algorithm or simply ART1 has optimized the problem of cluster head selection and consequently optimized residual energy. And the network lifetime is increased up to 58% as compared to traditional routing techniques.

MANET

Mobiles ad-hoc Networks (MANETs) are typically kind of wireless ad hoc networks. MANET is the wireless ad hoc network in which all devices are free to move in any way independently. Mobile ad hoc networks are the self-configuring and infrastructure-less networks aim to support mobility of devices. Each device will be change links to other devices frequently resulting in distinct topology and a highly dynamic change. Each device plays the role of participant as well as router and/ or sender, receiver of the network [11]

Routing and Clustering

Routing in a network is the process of selecting paths to send network traffic. Routing can take place either in a flat structure or in a hierarchical structure. In a flat structure, all nodes in the network are in the same hierarchy level and thus have the same role. Although this approach is efficient for small networks, it does not allow the scalability when the number of nodes in the network increases. In large networks, the flat routing structure produces excessive information flow which can saturate the network. [12]

A routing algorithm can be considered as a part of the programs accomplished by the network layer and is accountable for conveying traffic packets from their sources to their destinations or can be defined as the set of software. In Ad-hoc networks, the routing algorithms have became a never-ending evolving matter.

The losing of communication is one of the important challenges of routing on ad-hoc networks. This phenomenon happened when they move out of covered regions or when terminals are turned off. So, one of earnest problems on networks itis Loss of communication [13]. To convey data from one node to another node, some types of routing protocols are used to do this transmits of data without any loss. Protocols are combination of regulations and rules that can be used in network communication. [14]

Radial Basis Function Networks

This type is distinctive kind in neural network and the radial basis function is activation function of this network. It very popular network and can be used for control and classification problems function approximation, time series prediction [15]. It has several distinctive features compared with other type of neural network: it is faster learning speed more compact topology and universal approximation, therefore, it is different from other neural networks. This network has been widely applied in many engineering fields and science [15]. Radial Basis Function Networks (RBFN) are comprised of three layers: input layer, hidden layer and output layer (as shown in figure 1)[16]. The input layer passes the input vector x = (x1, x2, . . . , xn) to the RBF layer. That later - which is a hidden layer of H RBF units - using transforms the input to new vector y = (y1, y2, . . . , yh) that is subsequently passed to the output layer using the linear transformation. Then the final result f = (f1, f2, . . . , fn) can be expressed as:

$$f_k(\mathbf{x}) = \sum_{j=1}^{h} w_{jk} y_j = \sum_{j=1}^{h} w_{jk} \phi\left(\frac{||\mathbf{x} - \mathbf{c_j}||}{b_j}\right) \quad (1)$$

where f_k is the output of the k_{th} unit of the output layer. [17]

The Proposed System

At the beginning in this section we described one of the proposed system goals to enhance the performance of Ad hoc and MANET wireless network because of their characters such as no preexisted infrastructure and high dynamic topology caused unpredictable change of their node as nodes enter and leave the network duo to broken routing links and packed lose, drop packed so it is needed recalculate their broken routing links information.

That caused consumes processing time, memory, Device power that introduce overhead traffic on the network and reduce network life time, Limited transmission range and, Limited coverage area.

Hence this proposed system was designed and implemented to avoidd some of these problems for these networks types by using method (clustering and adaptive routing neural network based) to get new adaptive routing algorithm for ad hoc and MANET wireless network (depending on the important role performance (routing delay, bandwidth, distance, no. of hops to reach the destination)).

Using neural network to overhead of the control messages and find optimal path from source to distention.

The Proposed Approach

1- **Modify** the RBFN for routing operation and using kmean++ for getting the optimal path for the wireless network (like MANETs). There are two stages:

2-**Clustering:** apply the use of k-mean++ to determine best cluster head and optimal number of cluster with their nodes.

3- Finding Optimal Path: applying the new proposed MRBFN network to find the optimal rout from source to destination. Figure 2 shows the flow chart of the proposed system

Modified Radial Based Neural Network (MRBFNN)

RBF network is fed forward neural network and using cluster, it is simpler to have three layer the training process is generally faster and the output result determined by hidden layer only so it is consider fast and give approximation value to desirable result, it is trained by hybrid learning algorithms by using by unsupervised learning supervised learning to reduce the error. MRBFNN is consider efficient method to increase network lifetime and find the optimal path in wireless network from source to destination. In this stage, the proposed modified RBFN is used to find the optimal shorts path. Algorithm (1) shows proposed modified RBFNN operation to find optimal path. In this algorithm, the proposed method depends on the information from the above stages like (number of CH, the path terminal points p1-p2, number of nodes, all paths information, network parameters and features).

In this modification, the hidden layers' weights to the outputs layer are adjusted and measured depending on the parallel "Moore-Penrose generalized pseudo-inverse".

The parallel moore-penrose pseudo inverse algorithm gaining some matter over general gradients algorithm such as stop criterions, learning rates, epochs number and local minima, has been useful for real time application because it is low trainings times and generalizations abilities due to it applied to all weights in parallel processing.

The modification of the Gaussian kernel is by adding some K-mean operations feature. The main factor of the K-mean clustering is the Euclidean distances among point and every center of cluster. The Euclidean distance between average distance for Euclidean distance points and each cluster center. The new basis's functions are taken to be modified Gaussian's:

$$\varphi(\|x - c_j\|) = exp\left\{-\frac{\|x-c_j\|^2+2Em_j}{2Em_j\,\sigma_i^2}\right\} \quad (2)$$

The variable sigma, σ, defines the width or radius of the bell-shape and is something that has to be determined empirically ,outputs from the hidden units are φ, cj The set centres of hidden units, x the inputs,where Em is the average Euclidean distance points closest to the cluster center for the (jth) hidden unit in the hidden layer.

Mostly, the activation functions center and distribution must have the same data characteristics. Here, the center and width of Gaussians are selected using K-means clustering features (like Euclidean distance).

The proposed modified RBFN network starts initializing of the neural parameters like number of nodes for the layers. In this proposed system, the modified RBFN input layer has size equal to all input information, hidden layer dynamic change depends on the errors of results until geting the optimal paths but initialize by 10 nodes, and the output layer has also dynamic size start with 30 nodes represent the number of nodes of the optimal path and change depending on the optimal path nodes.

The modified RBFN learned with the principles smallest Euclidean distance, optimized by other wireless nodes parameters (clusters size regions, packed size, (Dynamic or non-dynamic), link costs). The optimization will guide to get the optimal paths between two nodes in wireless network; not only on the distance between them.

Results and Discussion

There are many results that can be achieved from applying the proposed system based on the network cases and parameters distributions. The configuration of wireless network effect in the results of clustering and routing because these proposed algorithms depend on their parameters. So, the results of the proposed system will take effect changing the network parameters like (bitrate, link costs (hos no.), distances, dynamic and fixed topologies(mobility), network size, number of nodes, packed size, shape and size regions.

Many evaluation criteria were used to test the results of routing protocol, but in our proposed system the time will take as the main evaluation due to the virtually of the wireless network used in our tests .

We conducted the experimental test of the proposed routing system and proposed clustering algorithms in ad hoc and MANET networks. The ad hoc wireless network has the following parameters as shown in table 1. The testing has two types of topology (fixed topology and mobile topology). The fixed topology is more simple from the mobile (dynamic) topology due the changing in the ad hoc nodes parameters like distance and nearness facility to the cluster centroid.

Algorithm 1: Modified RBFN to find optimal path

Start:P
Input: patterns nodes connection and paths, k: clusters number, number of intra path p1, inter path p2, number of CH all from Kmean++ algorithm
Output: find the optimal path
Note: Hidden layer: weight W j I =1,2, ... The neurons activated in this layer to find the short path that have smallest values E_{ij}.
Step1. Initialize RBFN network and initialize the parameter k = {k1, k2, ..., kn} of nodes.
Step2. Select the best Q that has the short path from all paths with minima E_{ij} using:
$Q = \min E_{ij}$ // in hidden layer
And have best other wireless nodes parameters (clusters size regions, packed size, dynamic or non-dynamic, link costs).
Step3. Initialize the weight vector wight kept as fixed while the hidden to output weights are learned with minimum distance and apply eqn. (3.1).
Step4. Select the minimum Euclidian's distances of B_{ij}

$$B_{ij} = Q \sum_{,i=1}^{m}\sum \|p1-p2\|$$

And optimized by other wireless nodes parameters (clusters size regions, packed size, (dynamic or non-dynamic), link costs).
Step5. Update the value of weight vector using Moore-Penrose pseudo-inverse as follows:
$(W)_{ij} = w_{ij}$, $(\Phi)_{pj} = \varphi(x_p)$, and $(T)_{pi} = \{t_{ip}\}$.
D= dimensional input vector xp = $\{x_p: i = 1, ..., D\}$
K1= dimensional target output tp = $\{t_p: i = 1, ..., K1\}$.
Widths $\{\sigma_j\}$ Wight w_{ij}
Step6. iteratively repeats step (2-5).
Step7. Neurons have smallest's values of E_{ij} is output. //outputs layers
End

As shown in table 1, the bitrate is random (between 1 Kbs to 1Mbs) for all links in the network. The routing protocol depends on the proposed approach. that uses the modified neural network (MRBFNN). Nodes links, and distances between nodes are randomly distributed. The network has size of 10, 50, and 100 nodes in the virtual region with maximum area 2km with random distribution. Figure 3 shows the asset of ad hoc network for examples 50 nodes with results of routing. Tables (2-10) show the routing results for 10 and 50 nodes with fixed and dynamic topology.

From the above routing tables, different times taken by MRBFNN for discovering the networks and other parameters like (bitrate, link costs, distances, dynamic and fixed topologies(mobility), network size, number of nodes, packed size, shape and size regions. The Dijkstra methods take big time comparing with the proposed methods. The mobility effect (in MANET) on the Dijkstra methodis more than the proposed methods. When comparing ratio time that taken of routing time (MRBFNN over Dijkstra) the result shows time between 150 to 300% speedup more that mean MRBFNN very speed.

Conclusions

MANETs one type of wireless networks and uses in many fields but this wireless network have many disadvantages such as bandwidth-constrained, limited translation range , energy- constrained operation, limited physical security, dynamic network topology packet lose and linked breakage hence finding optimal path in this network is big problem.

As shown from the results and ratios, the proposed routing algorithm has more speed and efficient than the Dijkstra method. In comparison with Dijkstra the proposed routing methods have less effect by increasing the ad hoc nodes and links. Due to the using of k mean++.Because the performance of selecting the optimal paths by using our proposed system, the throughput of the network will increase and the life time of nodes and connection become more useful. The packet delivered ratio is also increased because the optimal path has the best parameters from other paths including the best bitrate and best life link with minimum delays.

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Table(1) the network

Parameter	Description
Routing Protocols	(CBRP +neural net.) or neural net.
Size of Region	2 km
Shape of Region	Random
Number of Nodes	10, 50, and 100
Packet Size	20-64kb (random, and fixed)
Cluster Head	2,3 and 5
Simulation Environment	Dynamic, fixed
Channel Type	Wireless Channel
Network Type	Ad hoc and mobile ad hoc
Connection protocol	UDP (User Datagram Protocol)
Node Distance	Different
Node Link Cost	Different
Node Link Bitrate	Random

Table (2): the proposed system routing results for 10 nodes (fixed topology)

Samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	0.41328sec	0.09211sec	1-100	1-10	1-10	All
Net2	0.41677sec	0.09321sec	1-800	1-10	1-10	all
Net3	0.41638sec	0.09406sec	1-1000	1-10	1-10	all
Net4	0.41767sec	0.09425sec	1-1000	1-10	1-10	all

Table (3): The proposed system routing results for 10 nodes (one-two nodes mobile)

Samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	0.60893sec	0.11089sec	1-100	1-14	1-12	all
Net2	0.61071sec	0.11107sec	1-800	1-14	1-12	all
Net3	0.61189sec	0.11110sec	1-1000	1-14	1-12	All
Net4	0.62839sec	0.11119sec	1-1000	1-14	1-12	All

Table(4): The proposed system routing results for 10 nodes (three nodes mobile).

Samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	0.92111sec	0.32319sec	1-100	1-16	1-15	All
Net2	0.92201sec	0.32440sec	1-800	1-16	1-15	All
Net3	0.92288sec	0.32474sec	1-1000	1-16	1-15	All
Net4	0.92376sec	0.32489sec	1-1000	1-16	1-15	All

Table(5): The proposed system routing results for 10 nodes (five nodes mobile).

Samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	1.52985sec	0.50897sec	1-100	1-19	1-17	all
Net2	1.54453sec	0.50991sec	1-800	1-19	1-17	all
Net3	1.55190sec	0.51072sec	1-1000	1-19	1-17	all
Net4	1.57340sec	0.51098sec	1-1000	1-19	1-17	all

Table (6): The proposed system routing results for 50 nodes (fixed topology)

samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	1.15421sec	0.27451sec	1-100	1-10	1-60	All
Net2	1.15488sec	0.27478sec	1-800	1-10	1-60	All
Net3	1.15520sec	0.27498sec	1-1000	1-10	1-60	All
Net4	1.15531sec	0.27506sec	1-1000	1-10	1-60	All

Table (7): The proposed system routing results for 50 nodes (one-two nodes mobile).

samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	1.24782sec	0.32100sec	1-100	1-15	1-70	All
Net2	1.24883sec	0.32160sec	1-800	1-15	1-70	All
Net3	1.24982sec	0.32171sec	1-1000	1-15	1-70	All
Net4	1.24990sec	0.32201sec	1-1000	1-15	1-70	All

Table(8): The proposed system routing results for 50 nodes (three nodes mobile)

samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	1.53261sec	0.67821sec	1-100	1-20	1-75	all
Net2	1.53290sec	0.67860sec	1-800	1-20	1-75	all
Net3	1.53299sec	0.67930sec	1-1000	1-20	1-75	all
Net4	1.53310sec	0.67940sec	1-1000	1-20	1-75	all

Table (9): The proposed system routing results for 50 nodes (five nodes mobile)

samples	Dijkstra Time(avg.)	MRBFNN time(avg.)	Avg. bitrate(kbs)	Avg. links costs	Avg. Distance	Cover nodes
Net1	2.23675sec	0.89345sec	1-100	1-23	1-80	all
Net2	2.23690sec	0.89370sec	1-800	1-23	1-80	all
Net3	2.23734sec	0.89387sec	1-1000	1-23	1-80	all
Net4	2.23780sec	0.89398sec	1-1000	1-23	1-80	all

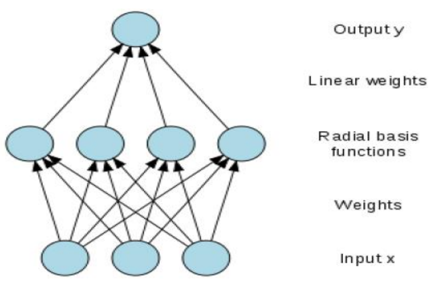


Figure (1): RBF network.

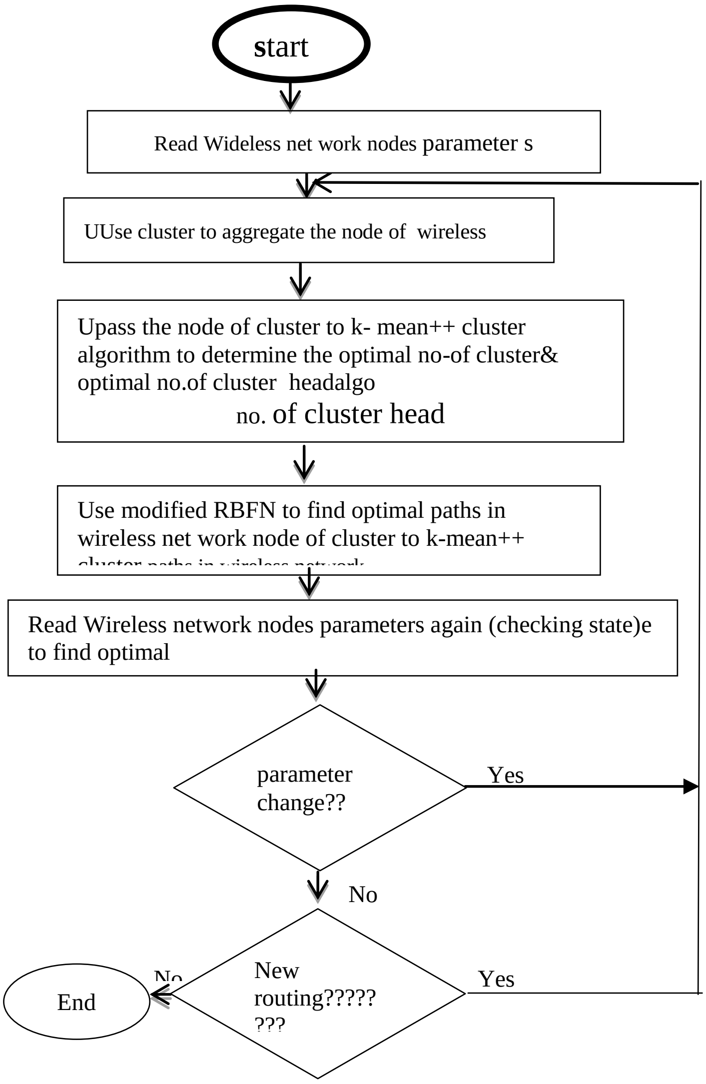
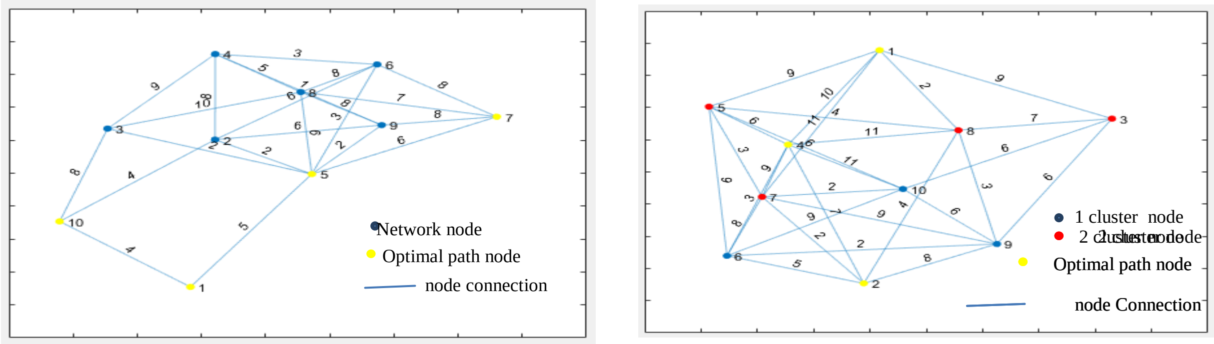
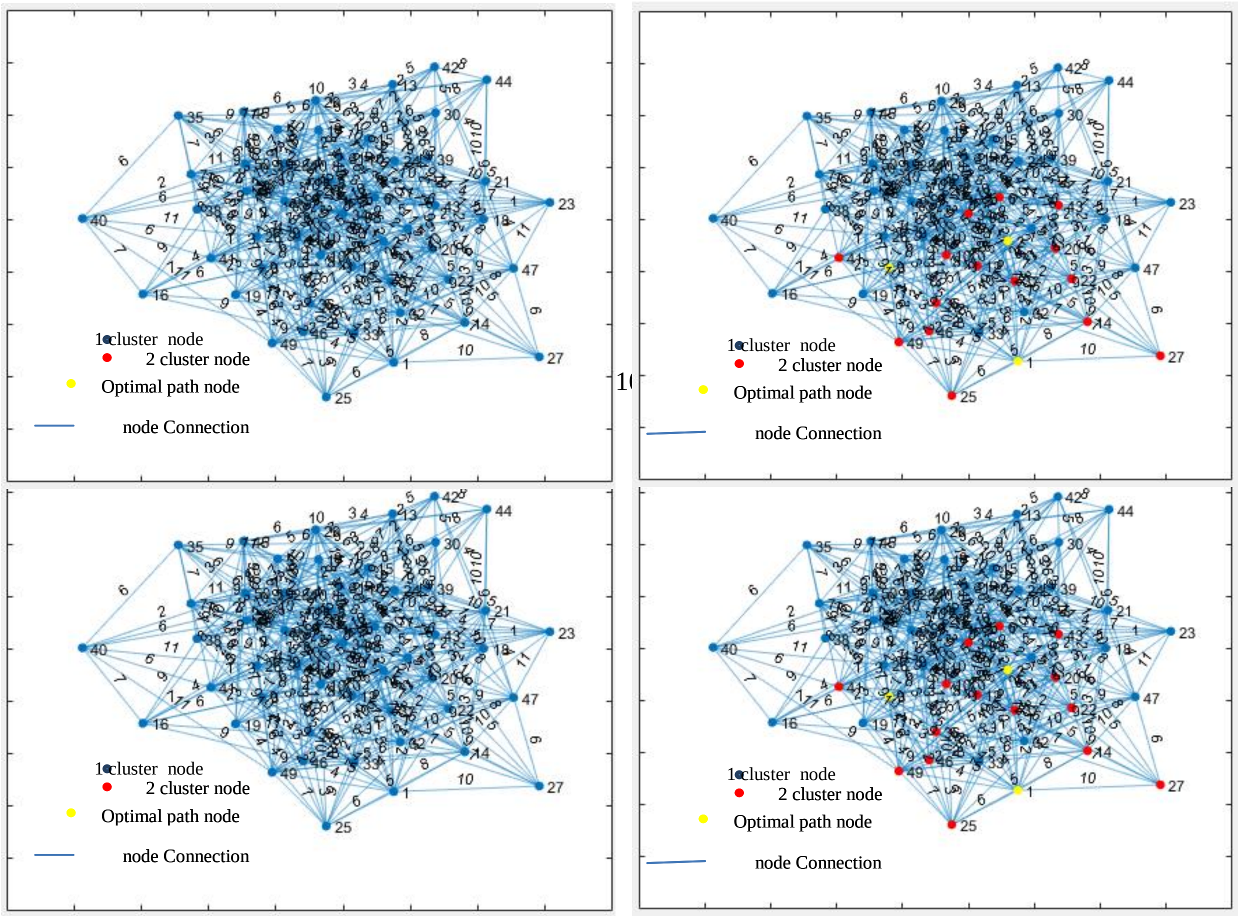


Figure (2): Flow Chart of the Proposed System



a: Sample network (10 nodes): Optimal path between (7-10) nodes b: Optimal path between (1-2) nodes



c: Sample network (50 nodes) d: Routing Result path between (1-2) nodes

Figure(3).a Sample network (10 nodes): Optimal path between (7-10) nodes. Figure 3.b optimal path between (1-2) node. Figure 3.c: Sample network (50 nodes). Figure (3). d: Routing Result path between (1-2) nodes