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An Efficient Minimum Path D-Equivalence CDS Construction for Wireless Adhoc Networks

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Abstract

Objective: The main intent of this research is to enhance the network capacity and compute the shortest path for reducing congestion in the wireless adhoc networks**. Methods**: In this manuscript, an innovative technique is introduced which is used to enhance the performance of α-MOC-CD based broadcasting and routing by using D equivalence classes of CDS. With that, we also apply minimum spanning tree for calculating the shortest path for avoiding the congestion to accomplish proficient broadcasting and routing in wireless networks. **Results:** The alpha-DEC-MOC-CDS (alpha-D-equivalence class-MOC-CDS) shows high network capacity when compared to the existing alpha-MOC-CDS. The proposed method improves the network capacity by using D equivalence classes and also the minimum spanning tree is used to recognize the shortest path. If the number of iterations is increased, the transmission capacity in alpha-DEC-MOC-CDS is 4.07, the medium, routing path length is 6.72 and the average routing path length is 5.73. The comparison result shows that the proposed method achieves better network capacity when compared to the existing system. **Conclusion**: The findings demonstrate that the alpha-D-equivalence class-MOC-CDS method is presented and suggested that this method high network capacity.

Keywords: Connected Dominating Set (CDS), D-Equivalence Classes, Minimum Routing Cost CDS (α-MOC-CDS), Minimum Support Tree, Shortest Path

1. Introduction

In wireless networks, topology control and routing are the necessary concerns. There are two phases of topology control in the broadcast wireless network. The first phase is to manage the power for diminishing the interference level. This decides which nodes are in the transmission range for a particular node and hence which potential links are present. The second phase is to choose the potential links for the transmission purpose. This link is called actual links. The topology control difficulty in a point-to-point network is appreciably different than that in a broadcast network. In a broadcast network, a node can create links with all of its potential neighbors.

In[1] the topology construction method is presented that aims to diminish the transmission range of all the nodes in the network. Different techniques are suggested in which the nodes assemble the information of their locations and also information about the neighbours[2-4]. The drawback in this method is highly difficult in the implementation process and high expensive. Another topology construction method is presented which is called as Connected Dominating Set (CDS). The main idea of this method is to improve the connectivity and coverage by using the redundant nodes instead of adjusting the transmission range of the nodes.

The construction of connected dominating set is accomplished by using the various techniques. This

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algorithm is categorized as maximal independent set (MIS) and also non-MIS based methods. The MIS is utilized to articulate the set of independent nodes. There are two phases in the MIS based method. In the first phase the MIS is generated and the second phase takes responsible for generating connected dominating set. The non-MIS based method uses the Rule-1 in[5] instead of creating MIS. Different MCDS approximation methods are suggested by Blum et. al in the wireless sensor networks and the mobile adhoc networks.

Alzoubi et al[7] suggested various distributed MCDS approximation techniques. In this method, there are two phases. The MIS is generated in the first phase and the CDS is created in the second phase. The message impediment is O (n log n) and the performance ratio is 8opt + 1. The are two phases in the[8]. According to the lowest level neighbour states, the dominator is selected. In the second phase, the gray node is selected which has highest dominant degree. This node is selected as the connector. The performance ratio is 8opt-2. There are two phases in this method. The first phase takes responsible for MIS generation and the second phase takes responsible for identification of identifiers. The performance ratio and time complexity are 192opt + 48 and O (n) and the message complexity of O (n).

Garey and Johnson presented a method in[20] that recognizes an MCDS is a complicated problem in the normal graphs by diminishing the set cover difficulty. In[11] Lund and Feige suggested a technique that shows for any permanent number $0 < \gamma < 1$, there is no polynomial time technique with a performance ratio= $(1-\gamma)\, H(\Delta)$ excluding $NP \subset DTIME\ [no\ (\log \log n)]$, that Δ represents the maximum degree of the input graph and H denotes the harmonic function. In[12] Baker suggested a method which is called as Polynomial Time Approximation (PTAS) technique for planar graphs. Different methods are suggested that intersects the communication form under Unit Disk Graph (UDG)[13]. This is a type of graph in which each node has the similar radius for the broadcasting process. If the two nodes are within transmission range, the two nodes are able to communicate. In[14] Clark given proof for the minimum dominating set (MDS) which is NP-hard problem. In[15,16] Cheng *et al.* and Hunt *et al.* presented the PTAS method for computing the MCDS in the UDG. Zhang et.al enhances a method into the Unit Ball Graph (UBG) which is a simplified UDG in the 3-dimensional space. Ambuhl[17] presented a constant-factor approximation method for the weighted CDS issue. In the network, every node has different weight and the main purpose is to classify a minimum weight CDS (MWCDS). Some works considered on deploying the new nodes in the original network [18].

The intent of this research is to find a CDS that covers a unit disk graph represents a MANET according to the local information. The problem of finding a minimum CDS is a NP-hard problem for both general graphs and also unit disk graphs. Wu and Lou presented an inclusive classification of new CDS methods in the mobile adhoc networks: global, quasiglobal, quasilocal, and local. In[19] Liu et.al suggested an iterative extension of Wu and Li's MP and rules 1 and 2 for the construction of CDS. In the MP, a node is considered as a dominator node if it has two neighbours which are not associated directly. Based on rule 1, a marked node adjusts back to unmarked node that has highest priority. A marked node neighbour set is enclosed consistently by two associated coverage nodes, a marked node is considered as unmarked node according to Rule 2. In the iterative expansion process, there are six rounds. The MP is used in round 1. Rule 1 is useful in round 1 with one priority and round 3 with another priority. At last, Rule 2 is used 4, 5 and 6 with different priority purposes. Furthermore, because of the disconnected lines the packet routing is degraded.

The main intention of this work is to augment the performance factor of network topology with lowest amount routing cost in wireless network and to accomplish proficient broadcasting and routing in wireless networks. The two concepts are called D equivalence classes of CDS and mini support tree. To enhance the performance of α-MOC-CD based broadcasting and routing, the D-equivalence class is used. In addition t that, minimum spanning tree is also used to evaluate the shortest path. By using this method, congestion is avoided for the routing in wireless networks.

In the proposed work there are two main contributions which are as follows,

1. First is the forward nodes are classified into the D equivalence classes based on the bandwidth, capacity and baud rate. Assume the network graphs have the similar ocd polynomial. G and H are the two graphs which is said to be ocd analogous, or basically D –equivalent.
2. Secondly, in order to find the shortest path for eliminating congestion, the Minimum spanning tree is applied.

3. By utilizing the methods of D equivalence classes, and Minimum spanning tree, the problems of topology control and routing cost constraint in the wireless networks are decided.

2. Connected Dominating Set

2.1 CDS Background

In the mobile adhoc network, the blind broadcast problem is a general problem. Blind broadcast is nothing but any node in the network will rebroadcast the whole received messages. If the similar copy of a message is received by one node from more than neighbors so that additional overhead is occurring. The broadcast overhead is reduced by using the connected dominating set. The reason for the overhead is some of the nodes broadcast the packets blindly. Due to the reduction in the redundancy, the bandwidth consumption is also reduced. The network overhead is diminished due to the utilization of Minimal Connected Dominating Set (MCDS). Let us consider a simple graph G=(V,E) in which V denotes the nodes and E denotes the edges. The node subset is represented as T so that the entire X in V-T there subsist Y relates to V, so that edge (x, y) relates to the edge E. This is the cover property of a CDS. The Connected Dominating Set (CDS) is denoted as T that is used to generate the connected graph. The CDS is represented in the Figure 1. In the Figure 1, black nodes 2 and 3 are correlated and wrap the entire network. The CDS and minimal CDS is created. CDS is previously minimum, so MCDS contains 2 and node 3 Figure: An example of MCDS is considered as a virtual backbone for the complete network.

In the adhoc network, a virtual backbone structure[20] is utilized for supporting unicast, multicast and also broadcast communications. It also uses the fault-tolerant methods. But there is a difference between the virtual backbone and wired backbone network. The MCDS method conserves the carbon copy of the global topology of the network and defends the shortest path in the pair of the nodes.

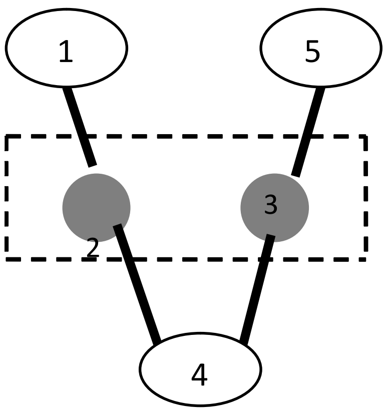

Figure 1. An Example of CDS.

2.2 Network Model and Assumptions

This section provides some postulations and also describes the network model. In addition to that, the association between hop distance and density of a network is also derived. In the wireless adhoc network, the nodes are disseminated in the region R. For a particular node, the communication range is r. To select the active node set, some of the node-scheduling methods are suggested. Because of this, some of the nodes are scheduled at a specific time. The interference is diminished due to the utilization of TDMA-scheduling. At each link in the network, the channel errors are occurred. In the network, the packets are created and send in the multi-hop manner to the sink node. In the wireless adhoc network, some of the routing protocols take responsibility to forward the data packets. Throughout the network, the following terminology is used.

R denotes the radius of the sensor field
R denotes the communication radius
N represents the number of nodes
X denotes the fraction of nodes with the receivers off
n represents the number of nodes with receiver turned on
n = N(1-X)
d denotes the average degree

$$D = \frac{N(1-X)}{\pi R^2} = \text{Average density}$$

F denotes the channel error rate
$\square_p$ denotes the packet generation frequency per node

2.3 Construction of CDS

The routing information is only kept so the searching time of the route and the communication cost is diminished. Connected Dominating Set (CDS) is an efficient method to hierarchical topology organization. A CDS construction is used to enhance the performance of the network. The network is considered as a bidirectional graph. This can be represented as G= (V, E) in which V represents the nodes and also E represents the edges. A subset S of V is a CDS if S meets two restrictions: 1). ∀u ∈ 2 V\S, ∃υ ∈ S having).(u, v) E, 2 The induced graph G [S] is linked.

Once the CDS is constructed, the nodes I the CDS forwards the data. The nodes distribute the data to other nodes in the network. The information associated to the routing is send to the CDS and forward to other nodes. The CDS construction affects the performance of the network. If the CDS size is huge, the number of nodes contained in the data forwarding is also large. The disadvantage is high redundancy and interference. So it takes high routing path when compared to the normal network. So, that there is high packet delivery ratio. Figure 2. Shows the construction of minimum CDS. The CDS is constructed by using the nodes (D, E, F). The path length between the node A and C is p_{AC}= {A, B, C} of length 2.

The routing path between A and C through a minimum CDS becomes p'_{AC} = {A,D, E, F,C} of length 4 that is twice as that of p_{AC}. If the CDS size is small, efficient routing and broadcasting is accomplished. The diameter is defined as to compute the length of the shortest path between the pair of nodes in the network. Another method is suggested by Kim et al called as Average Backbone Path Length (ABPL).

The CDS with shortest path is utilized called as MOCCDS. The CDS method is not able to achieve high tradeoff between the CDS size and cost for the routing process. Some modifications are done in the CDS and presented a new CDS called as α minimum routing Cost Connected Dominating Set (-MOC-CDS) for achieving effectual broadcasting and routing. There are some specialties in the α-MOC-CDS. That is there is minimum one path for any pair of nodes. All the intermediate nodes communicate to α-MOC-CDS and the number of intermediate nodes is smaller than α times so that the

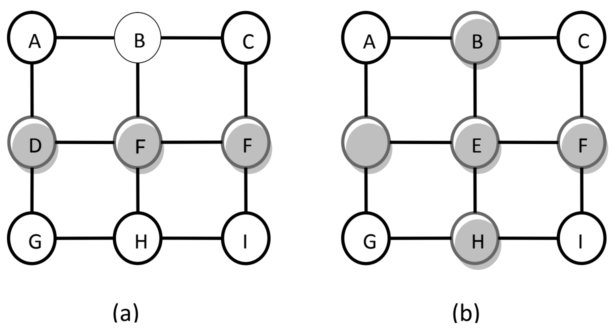

Figure 2. Regular CDS and MOC-CDS. (a) A Minimum regular CDS. (b) A Minimum 1-MOC-CDS.

shortest path is taken in the original network. Figure 2a represents the creation of 3-MOC-CDS. Figure 2b shows the example for the case α= 1. A minimum 1-MOC-CDS is generated. The shortest path length between A and C is 2 in the network. The routing path between A and C through the 1-MOC-CDS is still of length 2—{A; B;C]. In the Figure 2. Achieve the trade-off between CDS's size and routing hops. Another method called α- 2hop-DS is presented. The α-2hop-DS and α-MOC-CDS are corresponding to each other.

2.4 Dominating Set Reduction

A vertex is differentiated as T because it may be only relationship between its two neighbours in the method. Usually, there are two major dominant pruning regulations and that can be used to reduce the size of the CDS. Assume, if a vertex is included by more than one vertices the vertex V0 is uninterrupted. A vertex is eliminated only when it is encircled by vertices with superior id's. The priority is given to every id (v) of each vertex. In the network, the node is to be considered as gateway if it has high priority. Id uniqueness is not compulsory, but frequently ids will make more gateways.

Consider $N[v] = N[v] \cup \{v\}$ is a closed neighbor set of v the rules will be:

Rule 1: If N [v] ⊆ N [u] in G and id (v) < id (u), after that unmark v.
Rule 2: If N (v) ⊆ N (u) U N (w) in G and id(v) = min{id(v), id(u), id(w)}, after that unmark v.

2.5 Dominating Set Based Routing

For a given adhoc network, a CDS is determined. In the dominating set based broadcasting process, there are three steps:

i. The source node is not selected as gateway, the packets forwarded to the source gateway.
ii. If the node is chosen as a source gateway, the source gateway is selected as new source to transmit the packets in the graph create the connected dominating set.
iii. At last, the packet at a destination gateway is transmitted to the destination host.

Some of the reactive routing protocols are used in the routing process. The routing protocols such as DSR and AODV are used. In the routing process, the connected dominating set is utilized as a forward set node for transmitting the route request packets. In a given graph, a minimum size subset is identified so the sub graph followed by S is associated and S structures a dominating set in G. This problem is modeled as NP-hard[8]. A dominating set is one where each vertex is a dominating set or neighboring to dissimilar vertex in the dominating set. In the given graph, the shortest walk visiting a subset of vertices is recognized so that the vertex is either visited or atleast one of its neighbors visited.

2.6 Node Priority Rotation

There are determined ways to solve the node priority problem. The node priority is represented as a function p(v,i) of round number I and node ID v, where the IP address is used as ID. For each node, the initial priority is taken as integer values from {1 . . . n}. The hash function is utilized to map the IP address to an integer priority. If there is similar hash value, more local resolutions is considered for computing the node priority.

3. D-Equivalence Class and Minimum Spanning Tree

The performance of the network is computed by considering the attributes of the wireless network. The performance is computed in terms of broadcasting, scheduling of transmission and routing. There may be a network failure in the wireless network so that some of the links cannot accomplish effectual routing. Some of the techniques are suggested to diminish the class of useless topology information from a network which is called as topology organization. The topology control method is used to enhance the broadband utilization and also accomplish high packet delivery ratio.

3.1 Topology Formulation

There are two aspects in a network topology. One is network nodes and another one is connecting links. Generally, MANET can be plotted into a graph. The topology of a classical MANET is parameterized by some convenient constraints, which decide the subsistence of wireless links directly. Habitually, these parameters can be transmitted power and antenna directions, etc. There are two types of channels in a cooperative transmission. One is broadcast channel and multiple access channels. The channel time is categorized into two orthogonal successive slots to execute cooperative transmissions. The source node broadcasts the message to the relay and the destination node in the first time slot. Then, in the second time slot destination acquires the signals from the source and the relay via multiplexing technology. The topology control is to decide the subsistence of wireless links subject to network connectivity, the common topology control problem. In the MANETs, it is high difficult to gather the whole network information. Consequently, the centralized topology control should be resolved using a distributed algorithm, which usually necessitate sonly local knowledge, and the algorithm runs on every node separately.

3.2 D-Equivalence Class

The Non-isomorphic graphs may have the same ocd polynomial. The graphs G and H are said to be ocd ($\breve{D}$) equivalent or evidently $\breve{D}$ Equivalent, it is considered as G ~c H, if $\breve{D}$ (G, x) = $\breve{D}$ (H, x). It is observable that the relation ~ c of being D-equivalent is a correspondence relation on the family G of graphs and thus G is estranged into equivalence classes, called as the D-equivalence classes. For a given graph G ∊ G, let [G] = {H ∊ G: H ~c G}. The [G] is called as the equivalence class determined by G. A graph G is taken as a be outer connected dominating unique or simply D-unique, if] = {G}. In the equivalence classes, there are two motivating issues:

i. Inspect which graphs are D-unique?
ii. Determine the D-equivalence classes for some families of graphs.

Let us consider the graph G=(V,E) where V denotes the nodes in the network and E represents the edges between the nodes. A set S ⊆ V is determined as the dominating set where every vertex is neighbour to atleast one vertex in the connected graph. γ(H) is nothing but the domination number which is the small amount cardinality of a dominating set in H. An outer associated dominating set of the graph is represented as S ⊆ V (H), if S represents the dominating set of H and S = V (H) or V \S is a connected graph. The corona of two graphs H1 and H2 are denoted by Frucht and Harary; is the graph H = H1 0 H2 generated of H2, where the ith vertex of H1 is neighboring to every vertex in the ith copy of H2. The corona H 0 K1 is the created graph from a copy of H, where, for every vertex v ∊ V (H), a novel vertex v ' and a pendant edge vv ' are additionally added. The amalgamation of two graphs G1 and G2 are represented by H1 V H2, which is a graph with vertex set V (H1) ∪ V (H2) and edge set E(H1) ∪ E(H2) ∪ {uv|u ∈ V (H1) and v ∈ V (H2)}. Normally, the complete graph is represented as the cycle and the path of order n by Kn , Cn and Pn, uniformly. In addition, we call K1, and a star of order n + 1.

3.3 Efficient Data Aggregation for Sensor Networks with Connected Dominating Set

The information about the connected dominating set is considered. Some of the significant characteristics are: (1) Simple and easy in the formation process. (2) It is significant to create the dominating set and it is close to minimum for finding the shortest path. (3) The consequential dominating set should also comprise the complete intermediate nodes of any shortest path. By using this method, the shortest path is identified in the routing process. Let us consider a non-separable outer planar graph G=(V,E) in which G denotes the outer planar and it contains the simple cyclic of length |V|, so (G) (|V| + 2)/ 3.

Algorithm

- Firstly, the series of sorted edges are hobbled arbitrarily.
- Based on the hobbled succession of edges, a creation of spanning tree is accomplished.
- The edges are removed which are in previously created spanning trees and obtain the concentrated graph.
- This rule is sustained on the condensed graph and generate the spanning trees.
- Using the internal nodes the CDS is created. If the node has highest energy level, the CDS is selected as a root node.
- The rooted directed tree is bunged to the links from the leaf nodes to the neighbouring CDS in the directed graph.
- In each round, the data is collected and switch over to next disjoint in the spanning tree.
- The energy level of the nodes is computed and node with highest energy level is selected as a root node.

3.4 Finding Shortest Path Using Minimum Spanning Trees

The problem of Minimum Spanning Tree (MST) is a significant and normally occurrencing primal in the design and process of data and communication networks. The minimum spanning tree is the optimal routing tree in the adhoc networks for achieving the data aggregation. For finding the shortest path, an optimal algorithm is presented in the DAG in an effectual manner. Firstly, the DAG is sorted in a topological order after that the succession of edge relaxations is used in order to discover the shortest path.

Topology order is nothing but the linear ordering of the entire vertices in the DAG representation. In each vertex (x_i, x_j), the vertex x_i comes previous to x_j in the ordering. The edge relation process verifies whether the present best path to a vertex y can be improved by passing via dissimilar vertex x. The upper bound of the distance is denoted as δ [x] of vertex x. Each edge (x, y) in the network is said that x is the precursor of y denotes that x = π [y]. Adj [x] is denoted where a list that includes the whole vertices y that are neighboring to x, i.e., there endures an edge (x, y) ∈ E. The shortest path is computed starting from a given source.

Algorithm
DAG-SHORTEST-PATHS (G, s)

1. The vertices are arranged in a topological manner.
2. INITIALIZE-SINGLE-SOURCE(G, s)
3. In the graph, for every vertex taken in the topologically sorted order
4. do for every vertex y ∈ Adj [x]
5. do RELAX(x, y)

The Depth-first search algorithm is executed to perform the topological sorting. The succeeding line of the algorithm connects the initialization of a gathering of variables as shown next:

INITIALIZE-SINGLE-SOURCE (G, s)

1. For each vertex x ∈ V
2. do δ [x] ← ∞
3. π [x] ← NIL
4. δ[s] ← 0

This process rations of the order Θ(|V |). At last, the DAG-SHORTEST-PATHS (G, s) is utilized so that at each time the next step in the topological order is honored. The function RELAX(x, y) is used to given as next substantiates whether the current shortest path from s to y can be superior by passing through x.

RELAX (x, y)

1. if δ[y] > δ[x] + 1
2. then δ[y] ← δ[x] + 1
3. π[y] ← x

The joint scheduling and data rate controlling method are presented in the single hop networks. The main work is to diminish the necessary time for the complete transmitters to allocate their traffic persevere to their projected receivers. This difficulty is starts with a shortest path problem in a single source directed acyclic graph and a best graph-theoretic algorithm is use to choose this problem. After that, the original difficulty is mapped for a continual time corresponding and by restrictive the set of probable scheduling and rate control actions that can be preferential, eminent a more creative policy that distinguish a minimum-length schedule.

4. Performance Evaluation

In this section, the performance is evaluated for the proposed approach with the existing system. The performance evaluations of the approaches are done based on metrics such as network capacity per node with no of iterations and time.

4.1 Transmission Capacity

We analyze and compare the transmission capacity offered by alpha-MOC-CDS and alpha-DEC-MOC-CDS. Here if the no of iterations increased the transmission capacity also increased linearly while transmission. The transmission capacity of the proposed alpha-DEC-MOC-CDS method is high. The experimental result shows that the proposed method attains high transmission rate when evaluated to the existing method. The values are represented in the Table 1 and the graph shown below in Figure 3.

Table 1. Transmission capacity

S. No	No. of iterations	Alpha-MOC-CDS	Alpha-DEC-MOC-CDS
1	5	1.09	1.39
2	10	2.13	2.54
3	15	3.06	3.58
4	20	3.61	4.07

4.2 Medium Routing Path Length

The performance of the Medium Routing Path Length offered by alpha-MOC-CDS and alpha-DEC-MOC-CD is analyzed and compared. If the number of node size is increases, the medium routing path length is also increased. The result shows that the proposed method achieves better result when compared to the existing method. The values are represented in the Table 2. The graph results have shown in the Figure 4.

4.3 Average Routing Path Length

The performance of the average routing path length is evaluated. The performance of the alpha-MOC-CDS and alpha-DEC-MOC-CDS is analyzed and compared. If the number of node size is increases, the average routing path length is increased. The experimental results shows that the proposed method achieves better result than the other existing systems with higher rates. The values are represented in the Table 3. The graph results have shown in the Figure 5.

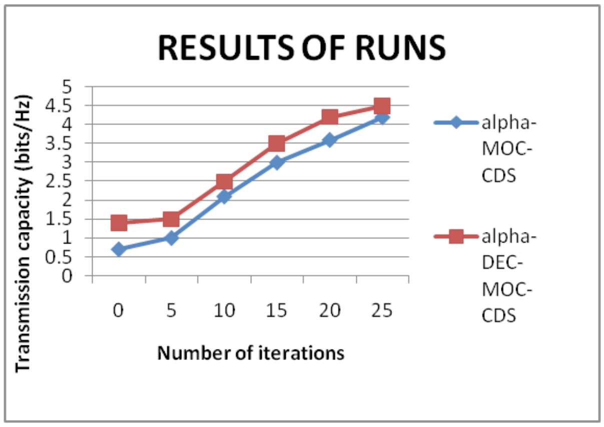

Figure 3. Transmission capacity.

Table 2. Medium routing path length

S.NO	No.of nodes	Alpha-MOC-CDS	Alpha-DEC-MOC-CDS
1	10	1.29	2.15
2	20	3.1	3.9
3	30	4.75	5.65
4	40	5.25	6.21
5	50	5.45	6.34
6	60	5.59	6.56
7	70	5.67	6.72

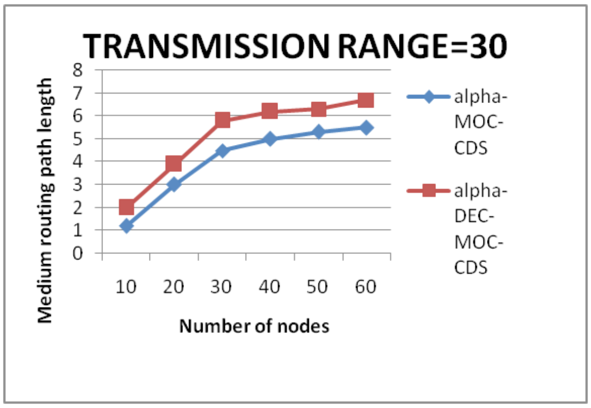

Figure 4. Medium routing path length.

Table 3. Average routing path length

S.NO	Number of nodes	alpha-MOC -CDS	Alpha-DEC -MOC
1	10	1.29	2.15
2	20	2.56	3.56
3	30	3.65	4.64
4	40	4.25	5.23
5	50	4.45	5.35
6	60	4.59	5.57
7	70	4.67	5.73

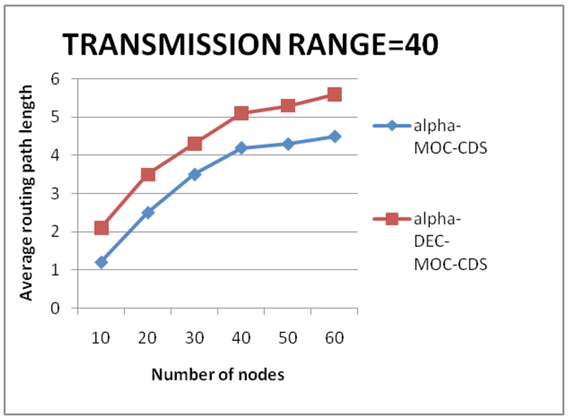

Figure 5. Average routing path length.

5. Conclusion

Topology Control and routing problem are solved by using the techniques separation of d equivalence classes, and Minimum spanning tree is for calculating the shortest path for avoiding the congestion. The routing can be efficiently succeeded through α-DEC-MOC-DCS (α-D Equivalence Minimum routing Cost CDS) with a minimum spanning tree which is to find the shortest path. Through the results we can provide the low cost and efficient routing strategy through these concepts. For future work, the greedy backup routing protocol (GBRP) is utilized that use the many paths from the source and destination. Suppose if the intermediate node gets failed, the alternate path is to be identified in the backup route cache. If the issue is not permanent, the error message is transmitted in the reverse path until to find the alternative route.

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