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# Optimized Segmentation based heuristic for Virtual Topology Design and its performance analysis

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***Abstract: This Paper presents Optimized Segmentation based heuristic as a solution to the design of a logical topology for a given physical topology. For a given physical topology in fiber optic network and Traffic pattern, the objective is to design a logical topology and routing algorithm so as to minimize both the average weighted number of hops and Congestion. Two constraints are considered namely, the number of wavelengths required to embed the resulting logical topology and the number of transceivers per node. Two new optimized segmentation based heuristic approaches i)Optimized Segmentation Based Left Top to Right Bottom Diagonal Heuristic (OSLTRBH), ii)Optimized Segmentation Based Left Bottom to Right Top Diagonal Heuristic (OSLBRTH) are proposed to design logical topology for a given traffic matrix to a physical topology in fiber optical network. The experimental results on 14 node NSFNET model obtained for the existing heuristics is better than proposed heuristic and their performances are compared for varying wavelengths and transceivers.***

***Keywords: Physical Topology, Logical Topology, Traffic Matrix, Average Weighted number of Hops Count, Transceivers, Congestion, Diameter, WDM Networks.***

## I. INTRODUCTION

Wavelength Division Multiplexing (WDM) offers the ability of building very large wide area networks with throughput of the order of terabits per second. These WDM networks, which provide very high data rates, low error rates, and low delay, can satisfy the emerging applications such as supercomputer visualization, medical imaging, and CPU interconnect [1]. A WDM network employing wavelength-routing consists of optical wavelength routing nodes interconnected by point-to-point fiber links in an arbitrary topology. End nodes with a limited number of optical transceivers are attached to the routing nodes.

A light path is an optical path established between two nodes in the network, created by the allocation of same wavelength throughout the path. The condition that the same wavelength be reserved on all links of a path is referred to as wavelength continuity constraint [1]. Two light paths can use the same fiber, if and only if they use different wavelengths. If two nodes are connected by a light path, a message can be sent from one node to the other in optical form without requiring any buffering and electro-optical conversion at the intermediated nodes. A set of light paths that are set up between end nodes forms the virtual topology. Thus, a virtual topology is a graph with nodes corresponding to the lightpaths. Physical topology is a graph in which each node in the network is a vertex, and each fiber optic link between two nodes is an arc [5]. The Heuristic Logical Topology Design [10] is based on Dijkstra's algorithm to find the shortest path between any two nodes in the networks; it selects the shortest path between every node pair depending on the availability of a free wavelength on the selected path and a free number of transmitters and receiver at the source and the destination nodes, respectively.

 

## II. RELATED WORK

In previous work [9] proposes two new segmentation based heuristics to design logical topology for a given physical topology traffic matrix and to find the average weighted number of hops and congestion.

### 2.1. SEGMENTATION BASED LEFT TOP TO RIGHT BOTTOM DIAGONAL HEURISTIC (SLTRBH)

The traffic demand matrix for the given physical topology is considered to have two partitions when divided along the major diagonal. Here the all major diagonal elements consist of zero values. Accordingly the heuristic is presented in two variations SLTRBH (L), SLTRBH (U).

### 2.2. SEGMENTATION BASED LEFT BOTTOM TO RIGHT TOP DIAGONAL HEURISTIC (SLBRTH)

The traffic demand matrix for the given physical topology is considered to have two partitions when divided along counter diagonal Here the all counter diagonal elements consists of non zero values. Accordingly the heuristic is presented in two variations. SLBRTH (L), SLBRTH (U).

## III. PARAMETERS

Listed below are the parameters used in the problem formulation

- Number of nodes in the network = N
- Number of wavelength per fiber = W
- Traffic matrix in source to destination = $T_{sd}$
- Number of hops in source to destination = $H_{sd}$
- Hop count values
- Average traffic from source to destination = t (sd)
- Average Weighted Hop count for the Topology(AWHT)
- Congestion=$T_{max}$

### 3.1 Traffic Matrix

A traffic matrix which specifies the average traffic of data flow between every pair of nodes in the physical topology. The traffic matrix T is a two-dimensional matrix with N rows and N columns. An entry $t^{sd}$ in T corresponds to the node pair<s,d> whose value is the average traffic flow from node s to node d.

### 3.2 Average Weighted Hop count

The average weighted number of (virtual) hops defined as the average number of lightpaths traversed by one unit. If $T^{sd}$ is the offered traffic between node s and node d and $H_{s,d}$ is the number of hops between s and d on the virtual topology, then the weighted number of hops required by this <s,d> pair is given by $T^{sd}*H_{sd}$.

Average Weighted Hop count for the Topology is given by

$$AWHT = \frac{\sum_{s,d} T_{ij}^{s,d} * H_{sd}}{\sum_{s,d} T_{sd}} \quad \text{………… (1)}$$

 

**3.3 Congestion**

Congestion is defined as the maximum virtual load among all the lightpaths due to all possible source to destination pairs in a virtual topology.

$$T_{max} = max_{ij} T_{ij} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

**3.4 Network Diameter:** A Virtual topologies in WDM networks is designed to minimize the network diameter. The network diameter specifies the number of hops o the longest shortest paths of all node pairs.

## IV. Proposed Work

This paper proposes two new optimized segmentation based heuristics to design logical topology for a given physical topology traffic matrix and to find the average weighted number of hops and congestion. Here Traffic demand matrix repeated values are eliminated.

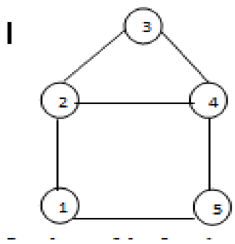


**Fig 1:** Physical Topology of the 5-node optical network

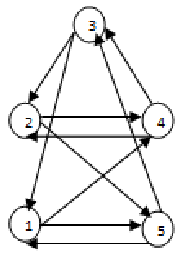


**Fig 2:** Virtual Topology of the 5-node optical

### 4.1 OPTIMIZED SEGMENTATION BASED LEFT TOP TO RIGHT BOTTOM DIAGONAL HEURISTIC (OSLTRBH)

The traffic demand matrix for the given physical topology is considered to have two partitions when divided along the major diagonal. Here the all major diagonal elements consist of zero values. Accordingly the heuristic is presented in two variations. OSLTRBH (L), OSLTRBH (U). Here two partitions are same equal parts of traffic demands matrix. The results are comparing same as OSLTRBH (L) and OSLTRBH (U).

#### 4.1.1. OSLTRBH (L) with lower portion of major diagonal to upper portion of major diagonal lightpath establishment

Establishment of lightpaths through optimized segmentation based heuristic commences by selecting from the lower portion of the traffic matrix along the major diagonal, selects the maximum traffic demand from source to destination node is followed by the lower portion diagonal part established the lightpath. If any repeated value in traffic matrix, the value is eliminated. Select the maximum traffic demand from source to destination node is followed by upper portion diagonal part established lightpath. If any repeated value in traffic matrix, the value is eliminated. This process will be continued to complete one cycle until all traffic matrix values become zero.

The same algorithm is implemented repeatedly it depends upon the number of transceivers fixed at each node. The heuristic proposed here is based on optimized segmentation to improve efficiency of AWHT.

Step 1: i) Number of nodes = N, node = Ni, i=1, 2… N

ii) Traffic matrix T= $(t_{ij})$

iii) Wavelength Wi, i=1, 2….k, (Number of wavelengths = k)

iv) Transceivers Ti, i=1, 2 …m, (Number of transceivers = m)

v) Physical topology PT= (V, E)

Step 2: i) select the lower diagonal matrix part

ii) Select the max value tij $_{(Max)}$ of lower diagonal

iii) If wavelength and transceivers are available from source to destination assign lightpath $L_{ij}$,

reset traffic matrix value tij $_{(Max)}$ = 0

Step 3: If any repeated values in Lower Diagonal matrix part that values are eliminated

Step 4: i) Select the traffic upper diagonal matrix part

ii) Select the max value tij $_{(Max)}$ of upper diagonal

iii) If wavelength and transceivers are available from source to destination assign lightpath Lij,

Reset traffic matrix value tij $_{(Max)}$ = 0

Step 5: If any repeated values in upper diagonal matrix part, the values are eliminated

Step 6: Repeat steps 2 to 4 until all traffic matrix values become zero or wavelength and transceivers are exhausted

Step 7: Establish logical topology with the lightpaths selected.

Step 8: Calculate the AWHT= Sum ($T_{sd}$*$H_{sd}$)/Sum ($T_{sd}$)

#### 4.1.2. OSLTRBH (U) with upper portion of major diagonal to lower portion of major diagonal lightpath establishment

Establishment of lightpath through segmentation heuristic approach starting from the upper diagonal portion of the traffic matrix along the major diagonal, followed by the lower diagonal portion of the traffic matrix. The procedure for finding lightpaths is similar to steps presented in section 5.1.1 except that the procedure starts from lower portion (traffic demands) of diagonal followed by upper portion ( traffic demands).

### 4.2. OPTIMIZED SEGMENTATION BASED LEFT BOTTOM TO RIGHT TOP DIAGONAL HEURISTICS (OSLBRTH)

The traffic demand matrix for the given physical topology is considered to have two partitions when divided along counter diagonal Here the all counter diagonal elements consists of non zero values. Accordingly the heuristic is presented in two variations. OSLBRTH (L) OSLBRTH (U. Here two partitions are not same equal parts of traffic demands matrix. OSLBRTH (L) is greater than OSBRTH (U) traffic matrix.

#### 4.2.1. OSLBRTH (L) with lower portion of counter diagonal to upper portion of counter diagonal lightpath establishment

Establishment of lightpaths through optimized segmentation based heuristic commences by selecting from the lower portion of the traffic matrix along the major diagonal, selects the maximum traffic demand from source to destination node is followed by the lower portion diagonal part established the lightpath. If any repeated value in traffic matrix, the value is eliminated. Select the maximum traffic demand from source to destination node is followed by upper portion diagonal part established lightpath. If any repeated value in traffic matrix, the value is eliminated. This process will be continued to complete one cycle until all traffic matrix values become zero. The same algorithm is implemented repeatedly it depends upon the number of transceivers fixed at each node. The heuristic proposed here is based on optimized segmentation to improve efficiency of AWHT.

Step 1: i) Number of nodes=N, node = Ni, i=1, 2… N

ii) Traffic matrix T= ($t_{ij}$),

iii) Wavelength Wi, i=1, 2….k, (Number of wavelength = k)

iv) Transceivers Ti, i=1, 2 …m, (Number of transceivers = m)

v) Physical topology PT= (V, E)

Step 2: i) select the lower diagonal matrix part

ii) Select the max value tij $_{(Max)}$ of lower diagonal

iii) If Wavelength and transceivers are available from source to destination assign lightpath Lij,

Reset traffic matrix value tij $_{(Max)}$ = 0

Step 3: If any repeated values in lower portion diagonal matrix part, the values are eliminated

Step 4: i) Select the traffic upper diagonal matrix part

ii) Select the max value tij $_{(Max)}$ of upper diagonal

iii) If wavelength and transceivers are available from source to destination assign lightpath $L_{ij}$,

reset traffic matrix value tij $_{(Max)}$ = 0

Step 5: If any repeated values in upper diagonal matrix part, the values are eliminated

Step 6: Repeat steps 2 to 4 until all traffic matrix values become zero or wavelength and transceivers are exhausted

Step 7: Establish logical topology with the lightpath selected.

Step 8: Calculate the AWHT=Sum ($T_{sd}$*$H_{sd}$)/Sum ($T_{sd}$)

**4.2.2. OSLBRTH (U) with upper portion of counter diagonal to lower portion of counter diagonal lightpath establishment**

Establishment of lightpaths through optimized segmentation based heuristic commences by selecting from the upper portion of the traffic matrix along the counter diagonal, selects the maximum traffic demand from a source to a destination followed by the lower diagonal portion of counter diagonal.

The heuristic proposed here is to improve the efficiency of AWHT. In this upper diagonal part the selection of one lightpath from source to destination is performed on the maximum total cost of destination node. If any repeated values are eliminated. The lower diagonal part selection next lightpath from source to destination based on next maximum total cost of destination node. If any repeated values are eliminated. This process will be continued to complete one cycle until all the destination node total cost are processed. The same procedure is implemented repeatedly it depends upon the number of transceivers fixed at each node. The procedure is presented as given below.

Step 1: i) Number of nodes=N, node = Ni, i=1, 2… N

ii) Traffic matrix T= ($t_{ij}$),

iii) Wavelength Wi, i=1, 2….k, (Number of wavelength = k)

iv) Transceivers Ti, i=1, 2 …m, (Number of transceivers = m)

v) Physical topology PT= (V, E)

Step 2: i) Select the upper diagonal matrix part

ii) Select the max value tij $_{(Max)}$ of upper diagonal

iii) If wavelength and transceivers are available from source to destination assign lightpath $L_{ij}$, reset traffic matrix value $tij_{(Max)} = 0$

Step 3: If any repeated values in upper diagonal matrix, the values are eliminated

Step 4: i) Select the traffic lower diagonal matrix part

ii) Select the max value $tij_{(Max)}$ of lower diagonal

iii) If wavelength and transceiver are available from source to destination assign lightpath $L_{ij}$,

reset traffic matrix value $tij_{(Max)} = 0$

Step 5: If any repeated values in lower diagonal matrix, the values are eliminated

Step 6: Repeat steps 2 to 4 until all traffic matrix values become zero or wavelength and transceivers are exhausted

Step 7: Establish logical topology with the lightpath selected.

Step 8: Calculate the AWHT=Sum ($T_{sd}$*$H_{sd}$)/Sum ($T_{sd}$)

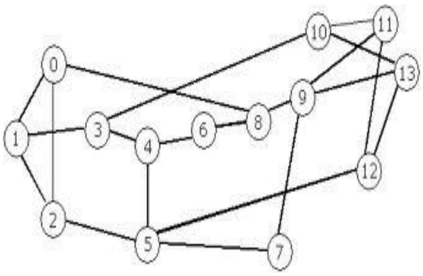


**Figure 3:** Physical Topology of the 14-node NSFNET optical network

**Table 1:** Traffic Demand Matrix for 5-node optical network

| | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **1** | 0 | 20 | 9 | 24 | 28 |
| **2** | 28 | 0 | 12 | 26 | 15 |
| **3** | 27 | 21 | 0 | 21 | 13 |
| **4** | 14 | 29 | 22 | 0 | 17 |
| **5** | 10 | 6 | 6 | 7 | 0 |

**Table 2:** Traffic Demand Matrix for the 14-node NSFNET optical network

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0.00 | 33.029 | 32.103 | 26.008 | 0.525 | 0.383 | 82.633 | 31.992 | 37.147 | 0.568 | 0.358 | 0.544 | 0.651 | 0.160 |
| **1** | 0.546 | 0.00 | 0.984 | 0.902 | 0.866 | 0.840 | 0.013 | 62.464 | 0.475 | 0.001 | 0.342 | 0.925 | 0.656 | 0.501 |
| **2** | 35.377 | 0.459 | 0.00 | 0.732 | 0.272 | 0.413 | 28.242 | 0.648 | 0.909 | 0.991 | 56.150 | 23.617 | 1.584 | 0.935 |
| **3** | 0.739 | 0.225 | 0.296 | 0.00 | 0.896 | 0.344 | 0.012 | 84.644 | 0.293 | 0.208 | 0.755 | 0.27 | 0.20 | 0.17 |
| **4** | 0.482 | 96.806 | 0.672 | 51.204 | 0.00 | 0.451 | 0.979 | 0.814 | 0.225 | 0.694 | 0.504 | 0.704 | 0.431 | 0.333 |
| **5** | 0.456 | 0.707 | 0.626 | 0.152 | 0.109 | 0.00 | 0.804 | 0.476 | 0.429 | 0.853 | 0.280 | 0.322 | 90.503 | 0.212 |
| **6** | 0.042 | 0.067 | 0.683 | 0.862 | 0.197 | 0.831 | 0.00 | 0.585 | 67.649 | 56.138 | 0.896 | 0.858 | 73.721 | 0.582 |
| **7** | 0.616 | 0.640 | 0.096 | 97.431 | 0.308 | 0.441 | 0.299 | 0.00 | 0.161 | 0.490 | 0.321 | 0.638 | 82.231 | 0.376 |
| **8** | 0.786 | 0.323 | 0.676 | 0.359 | 0.019 | 50.127 | 12.129 | 0.650 | 0.00 | 0.483 | 45.223 | 58.164 | 0.894 | 0.613 |
| **9** | 0.037 | 0.318 | 0.367 | 2.981 | 0.976 | 0.629 | 0.525 | 0.293 | 0.641 | 0.00 | 33.922 | 0.228 | 0.995 | 71.905 |
| **10** | 12.609 | 0.479 | 0.146 | 0.174 | 0.181 | 0.072 | 23.080 | 0.671 | 0.634 | 0.759 | 0.00 | 0.725 | 0.592 | 0.445 |
| **11** | 0.887 | 0.004 | 1.614 | 0.471 | 0.120 | 0.263 | 0.585 | 0.086 | 0.157 | 95.633 | 45.828 | 0.00 | 0.527 | 0.021 |
| **12** | 9.019 | 0.569 | 0.936 | 0.975 | 81.779 | 0.573 | 0.738 | 0.410 | 0.490 | 0.948 | 0.154 | 0.145 | 0.00 | 0.436 |
| **13** | 20.442 | 0.515 | 0.719 | 0.089 | 39.269 | 49.984 | 0.720 | 0.863 | 0.858 | 0.490 | 0.106 | 0.765 | 0.059 | 0.00 |

## V. RESULTS

**Table 3:** Comparison of AWHT values for SLTRBH and OSLTRBH 5-node Logical Topology

| Number of nodes | Number of Transceivers | Number of wavelengths | HLDA | SLTRBH-LTU | SLTRBH-UTL | OSLTRBH-LTU | OSLTRBH-UTL |
|---|---|---|---|---|---|---|---|
| 5 | 2 | 2 | 1.473239 | 1.473239 | 1.473239 | 1.414085 | 1.414085 |
| 5 | 3 | 2 | 1.250704 | 1.250704 | 1.191549 | 1.242254 | 1.182421 |

**Table 4:** Comparison of AWHT values for SLBRTH and OSLBRTH 5-node Logical Topology

| Number of Nodes | Number of Transceivers | Number of Wavelengths | SLBRTH-LTU | SLBRTH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|
| 5 | 2 | 2 | 1.459155 | 1.492958 | 1.408451 | 1.425352 |
| 5 | 3 | 2 | 1.20000 | 1.383099 | 1.19352 | 1.309859 |

**Table 5:** Comparison of AWHT values for SLTRBH and OSLTRBH the 14-node NSFNET Logical topology

| Number of Nodes | Number of Transceivers | Number of Wavelength | HLDA | SLTRBH-LTU | SLTRBH-UTL | OSLTRBH-LTU | OSLTRBH-UTL |
|---|---|---|---|---|---|---|---|
| NSFNET ( 14 Nodes) Logical Topology | 2 | 2 | 1.500643 | 1.500643 | 1.500643 | 1.481860 | 1.481860 |
| | 3 | 3 | 1.48632 | 1.48632 | 1.48632 | 1.46563 | 1.46563 |
| | 4 | 4 | 1.47134 | 1.47134 | 1.47134 | 1.45534 | 1.45534 |
| | 5 | 5 | 1.46937 | 1.46813 | 1.4672 | 1.144930 | 1.14468 |
| | 6 | 6 | 1.45342 | 1.45321 | 1.45332 | 1.43238 | 1.43221 |

 

**Table 6:** Comparison of AWHT values for SLBRTH and OSLBRTH the 14-node NSFNET Logical Topology

| Number of nodes | Number of Transceivers | Number of Wavelengths | SLBRTH-LTU | SLBRTH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|
| NSFNET ( 14 Nodes) Logical Topology | 2 | 2 | 1.498659 | 1.519206 | 1.479725 | 1.489531 |
| | 3 | 3 | 1.47963 | 1.48832 | 1.46003 | 1.47325 |
| | 4 | 4 | 1.47062 | 1.48102 | 1.44502 | 1.46728 |
| | 5 | 5 | 1.46019 | 1.47356 | 1.42320 | 1.45420 |
| | 6 | 6 | 1.4512 | 1.46892 | 1.43128 | 1.4383 |

**Table 7:** Comparison of Congestion values for SLTRBH and OSLTRBH 5-node Logical Topology

| Number of Nodes | Number of Transceivers | Number of Wavelengths | HLDA | SLTRBH-LTU | SLTRBH-UTL | OSLTRBH-LTU | OSLTRBH-UTL |
|---|---|---|---|---|---|---|---|
| 5 | 2 | 2 | 6 | 6 | 6 | 5 | 5 |
| 5 | 3 | 3 | 5 | 5 | 6 | 4 | 5 |

**Table 8:** Comparison of Congestion values for SLBRTH and OSLBRTH 5-node Logical Topology

| Number of Nodes | Number of Transceivers | Number of Wavelengths | SLBRTH-LTU | SLBRTH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|
| 5 | 2 | 2 | 5 | 6 | 4 | 6 |
| 5 | 3 | 3 | 5 | 5 | 4 | 5 |

**Table 9:** Comparison of Congestion values for SLTRBH and OSLTRBH the 14-node NSFNET Logical Topology

| Number of Nodes | Number of Transceivers | Number of Wavelengths | HLDA | SLTRBH-LTU | SLTRBH-UTL | OSLTRBH-LTU | OSLTRBH-UTL |
|---|---|---|---|---|---|---|---|
| NSFNET (14Nodes) Logical Topology | 2 | 2 | 19 | 19 | 19 | 17 | 17 |
| | 3 | 3 | 18 | 18 | 18 | 16 | 16 |
| | 4 | 4 | 17 | 17 | 17 | 15 | 15 |
| | 5 | 5 | 16 | 16 | 16 | 14 | 14 |
| | 6 | 6 | 15 | 15 | 15 | 13 | 13 |

**Table 10:** Comparison of Congestion values for SLBRTH and OSLBRTH the 14-node NSFNET Logical Topology

| Number of nodes | Number of Transceivers | Number of Wavelengths | SLBRTH-LTU | SLBRTH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|
| NSFNET (14Nodes) Logical Topology | 2 | 2 | 18 | 20 | 17 | 18 |
| | 3 | 3 | 17 | 19 | 16 | 17 |
| | 4 | 4 | 17 | 18 | 15 | 16 |
| | 5 | 5 | 16 | 17 | 13 | 15 |
| | 6 | 6 | 14 | 16 | 12 | 14 |

To determine the new Optimized Segmentation based heuristic approach for virtual topology design is implemented in C++ language for 14 node NSFNET topology shown in fig 1. In our algorithm we have presented four variations of improved segmentation based heuristics are (i) OSLTRBH(L) (ii) OSLTRBH(U) (iii) OSLBRTH(L) (iv) OSLBRTH(U). The experimental results shown in form Table 1 Table 3 and Table 4. It is oberserved that for 5-node network, the AWHT is best for the proposed improved segmentation based heuristic than existing segmentation based heuristic algorithm. The results obtained 14-node network, we are shown in Table 2 Table 5 and Table 6 in which is observed results pertaining to AWHT the proposed heuristic perform better that the existing segmentation based heuristic algorithm and other heuristics OSLTRBH(L), OSLTRBH (U), OSLBRTH(U) also observed the results are consisists that when number of transceivers are increased. In case of maximum congestion value $T_{max}$ from Table 9 and Table 10 it is formed the similarly on comparison with the results of congestion it is formed the proposed heuristic and Segmentation based heuristic gives same performance as the number of transceivers increases.

**Table 11:** Comparison of hop count values for HLDA, SLTRBH and SLBRTH 5-node Logical Topology

| Number of Nodes | No. of Hops | Number of Transceivers | Number of Wavelengths | HLDA | SLTRBH-LTU | SLTRBH-UTL | SLBRTH-LTU | SLBRTH-UTL |
|---|---|---|---|---|---|---|---|---|
| 5 | 1 | 2 | 2 | 9 | 9 | 9 | 10 | 10 |
| 5 | 2 | 2 | 2 | 9 | 9 | 9 | 10 | 9 |
| 5 | 3 | 2 | 2 | 2 | 2 | 2 | 0 | 0 |

**Table 12:** Comparison of hop count values for HLDA, SLTRBH and SLBRTH 5-node Logical Topology

| Number of Nodes | No. of Hops | Number of Transceivers | Number of Wavelengths | HLDA | SLTRBH-LTU | SLTRBH-UTL | SLBRTH-LTU | SLBRTH-UTL |
|---|---|---|---|---|---|---|---|---|
| 5 | 1 | 3 | 3 | 13 | 13 | 13 | 12 | 10 |
| 5 | 2 | 3 | 3 | 7 | 7 | 7 | 7 | 9 |
| 5 | 3 | 3 | 3 | 0 | 0 | 0 | 1 | 1 |

**Table 13**: Comparison of hop count values for HLDA, OSLTRBH and OSLBRTH 5-node Logical Topology

| Number of Nodes | No. of Hops | Number of Transceivers | Number of Wavelengths | HLDA | OSLTRBH-LTU | OSLTRBH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|---|---|
| 5 | 1 | 2 | 2 | 10 | 10 | 10 | 11 | 10 |
| 5 | 2 | 2 | 2 | 10 | 10 | 10 | 9 | 10 |
| 5 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |

**Table 14:** Comparison of hop count values for HLDA, OSLTRBH and OSLBRTH 5-node Logical Topology

| Number of Nodes | No. of Hops | Number of Transceivers | Number of Wavelengths | HLDA | OSLTRBH-LTU | OSLTRBH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|---|---|
| 5 | 1 | 3 | 3 | 14 | 10 | 10 | 12 | 14 |
| 5 | 2 | 3 | 3 | 6 | 10 | 8 | 8 | 6 |
| 5 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |

The experimental results shown in form Table 11 Table 12 Table 13 and Table 14. It is observed transceivers 2 and wavelengths 2 that for 5-node network, the hop count values is best for the optimized improved segmentation based heuristic than existing segmentation based heuristic algorithm. Similarly transceivers3 and wavelengths 3 a slight difference to the existing work compare to transceivers 2 and wavelengths 2 the proposed optimized segmentation hop count values are increased.

**Table 15:** Comparison of hops count values for HLDA, SLTRBH and SLTRBH 14-node NSFNET Logical Topology

| Number of Nodes | Transceivers and wavelengths | No. of Hops | HLDA | SLTRBH-LTU | SLTRBH-UTL | OSLTRBH-LTU | OSLTRBH-UTL |
|---|---|---|---|---|---|---|---|
| NSFNET (14Nodes) Logical Topology | Transceivers =2 and Wavelengths=2 | 1 | 28 | 28 | 28 | 27 | 27 |
| | | 2 | 40 | 40 | 40 | 38 | 38 |
| | | 3 | 45 | 45 | 45 | 44 | 44 |
| | | 4 | 39 | 39 | 39 | 40 | 40 |
| | | 5 | 20 | 20 | 20 | 20 | 20 |
| | | 6 | 8 | 8 | 8 | 10 | 10 |
| | | 7 | 2 | 2 | 2 | 3 | 3 |
| | | 8 | 0 | 0 | 0 | 0 | 0 |

**Table 16:** Comparison of hops count values for HLDA, SLTRBH and SLTRBH Transceivers 3, 14-node NSFNET Logical Topology

| Number of Nodes | Transceivers and wavelengths | No. of Hops | HLDA | SLTRBH-LTU | SLTRBH-UTL | OSLTRBH-LTU | OSLTRBH-UTL |
|---|---|---|---|---|---|---|---|
| NSFNET (14Nodes) Logical Topology | Transceivers =3 and Wavelengths=3 | 1 | 30 | 30 | 30 | 30 | 30 |
| | | 2 | 42 | 42 | 42 | 40 | 42 |
| | | 3 | 43 | 43 | 43 | 42 | 42 |
| | | 4 | 41 | 41 | 41 | 42 | 42 |
| | | 5 | 18 | 18 | 18 | 18 | 18 |
| | | 6 | 10 | 10 | 10 | 10 | 10 |
| | | 7 | 2 | 2 | 2 | 2 | 2 |
| | | 8 | 0 | 0 | 0 | 0 | 0 |

**Table 17**: Comparison of hops count values for HLDA, OSLTRBH and OSLTRBH Transceivers 2, 14-node NSFNET Logical Topology

| Number of Nodes | Transceivers and wavelengths | No. of Hops | SLBRTH-LTU | SLBRTH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|
| NSFNET (14Nodes) Logical Topology | Transceivers =2 and Wavelengths=2 | 1 | 28 | 28 | 28 | 28 |
| | | 2 | 42 | 40 | 44 | 44 |
| | | 3 | 46 | 43 | 47 | 49 |
| | | 4 | 37 | 35 | 35 | 34 |
| | | 5 | 20 | 21 | 18 | 18 |
| | | 6 | 7 | 11 | 6 | 6 |
| | | 7 | 2 | 2 | 2 | 2 |
| | | 8 | 0 | 1 | 0 | 0 |

**Table 18:** Comparison of hops count values for HLDA, OSLTRBH and OSLTRBH Transceivers 2, 14-node NSFNET Logical Topology

| Number of Nodes | Transceivers and wavelengths | No. of Hops | SLTRBH-LTU | SLTRBH-UTL | OSLBRTH-LTU | OSLBRTH-UTL |
|---|---|---|---|---|---|---|
| NSFNET (14Nodes) Logical Topology | Transceivers =3 and Wavelengths=3 | 1 | 32 | 30 | 30 | 30 |
| | | 2 | 40 | 40 | 42 | 44 |
| | | 3 | 43 | 42 | 40 | 38 |
| | | 4 | 40 | 40 | 38 | 32 |
| | | 5 | 16 | 18 | 20 | 20 |
| | | 6 | 10 | 10 | 10 | 10 |
| | | 7 | 2 | 2 | 2 | 2 |
| | | 8 | 0 | 1 | 0 | 0 |

The experimental results shown in form Table 15, 16,17 and 18 It is observed transceivers 2, 3, 4 and wavelengths 2, 3, 4 that for 14-node network, the hop count values is best for the optimized improved segmentation based heuristic than existing segmentation based heuristic algorithm. Similarly transceivers3,4 and wavelengths 3,4 a slight difference to the existing work compare to transceivers 2 and wavelengths 2 the proposed optimized segmentation hop count values are increased.

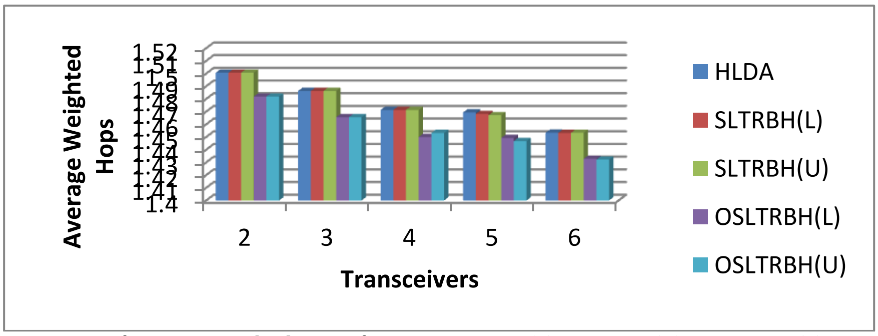


**Figure 4:** Comparison of Average Weighted Hops of HLDA, SLTRBH (L), SLTRBH (U), OSLTRBH (L), OSLTRBH (U)

 

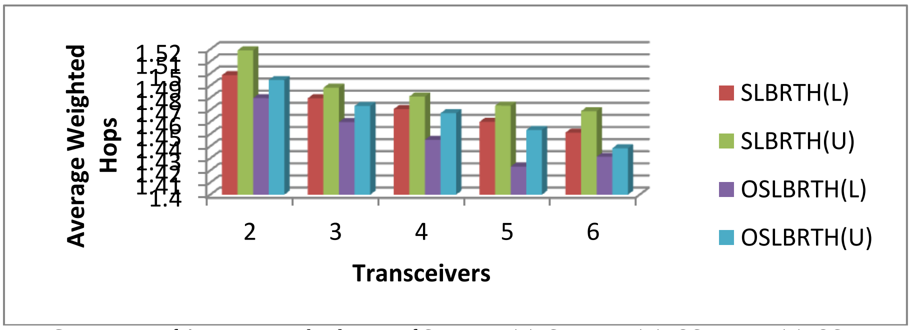


**Figure 5:** Comparison of Average Weighted Hops of SLBRTH (L), SLBRTH (U), OSLBRTH (L), OSLBRTH (U)

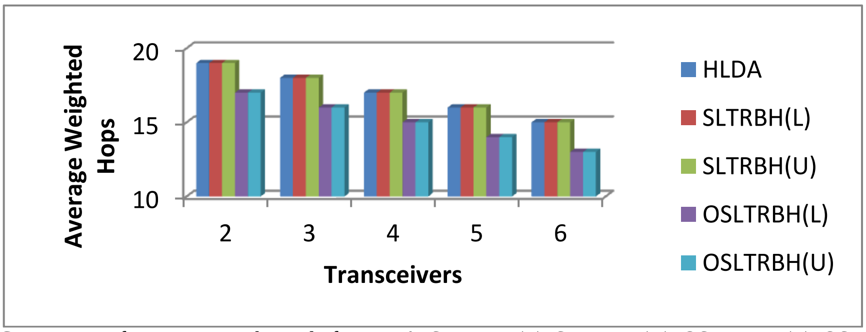


**Figure 6:** Comparison of Maximum Link Load of HLDA, SLTRBH (L), SLTRBH (U), OSLBRTH (L), OSLBRTH (U)

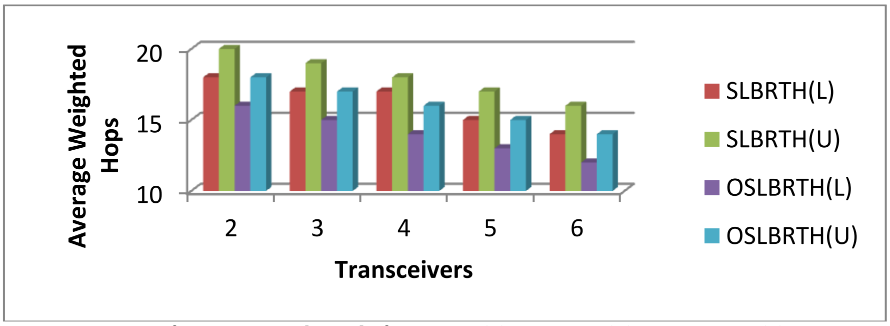


**Figure 7:** Comparison of Maximum Link Load of SLTRBH (L), SLTRBH (U), OSLBRTH (L), OSLBRTH (U)

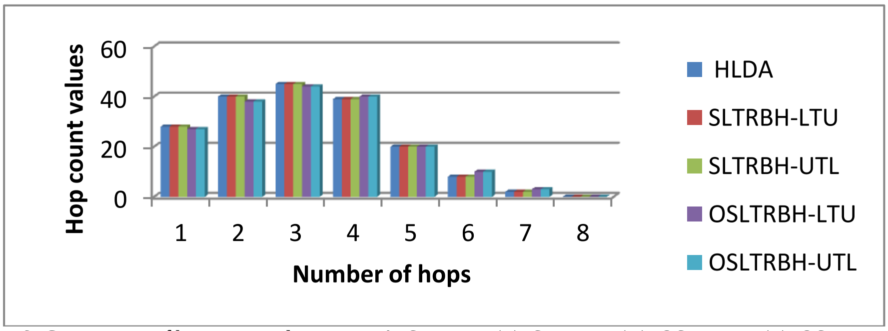


**Figure 6:** Comparison of hop count values HLDA, SLTRBH (L), SLTRBH (U), OSLBRTH (L), OSLBRTH (U)

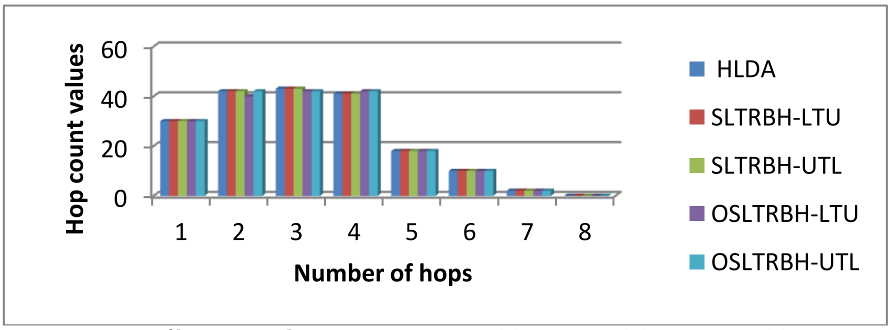


**Figure 7:** Comparison of hop count values HLDA, SLTRBH (L), SLTRBH (U), OSLBRTH (L), OSLBRTH (U)

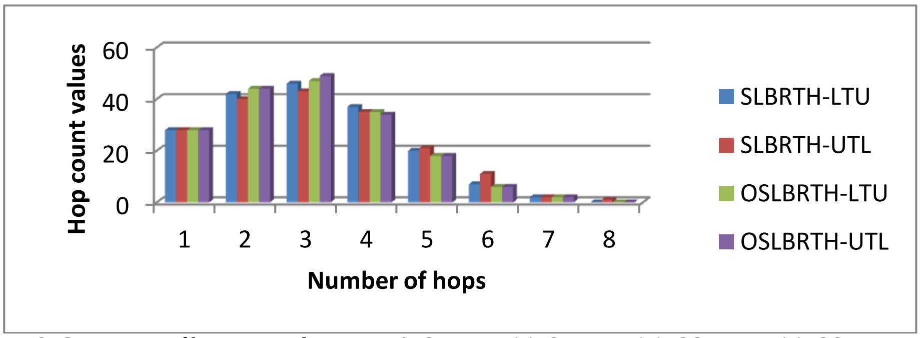


**Figure 8:** Comparison of hop count values HLDA, SLTRBH (L), SLTRBH (U), OSLBRTH (L), OSLBRTH (U)

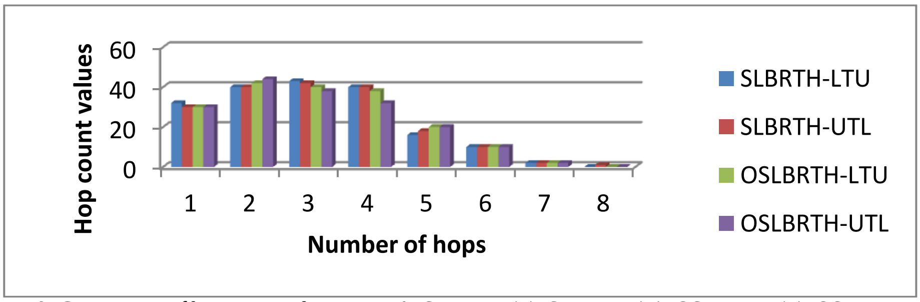


**Figure 9:** Comparison of hop count values HLDA, SLTRBH (L), SLTRBH (U), OSLBRTH (L), OSLBRTH (U)

## VI. CONCLUSION

In this paper presents Optimized Segmentation based heuristic as a solution to the design of logical topology for a given physical topology. The objective is to find a logical topology and routing algorithm so as to minimize both the average weighted number of hops, congestion and diameter. We have presented the analysis of performance of different metrics like of the NSFNET logical topology for varying number of the transceivers at each node, and the number of wavelengths in the fiber optic media and average weighted number of hops. The obtained experimental results show that the new segmentation based heuristic approach achieves better performance in terms of Average Weighted Number of Hops (AWHT) and Congestion ($T_{max}$) than the existing HLDA as the numbers of transceivers are increased with fixed number of wavelengths.

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