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Implementation of Dynamic Programing to Find All Pairs Shortest Path on Fibre Optics Networks to Produced Optimized Routing and Virtual Topology

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ABSTRACT: Optical fibre has been the main choice of communication medium for long-haul networks because of its low transmission loss and high capacity of the data rate. A fibre cable can transmit many channels simultaneously using wavelength Division multiplexing (WDM) technology. This makes possible to establish many different virtual topologies on top of the physical topology. In this paper, dynamic programming model has been developed to produce different sets of traffic matrices for finding shortest path from each source to different destinations. On which existing Heuristic logical design Algorithm (HLDA) is implemented to find shortest path by varying number of optical transceivers. A study is made on stage wise 4-node, 7-node and 14-node NSFNET traffic matrices and comparative study has been done on utilisation of Average Weighted hops and Wavelength.

KEYWORDS: Fibre Optics, Dynamic programming, Virtual Topology, All pair shortest path, Stages, Minimum Congestion, Maximum Congestion.

I.INTRODUCTION

Optical networks using wavelength-division multiplexing (WDM) is seen as the technology of the future. With explosive growth of Internet and bandwidth-intensive applications such as video-on-demand and multimedia, conferencing the demand for bandwidth at lower costs is increasing every day. As such, a ration of research has been carried out in this area. A WDM optical network consists of wavelength routing nodes interconnected by point-to- point optical fibre links in a random topology. The WDM is a multiplexing technique that has led to efficient bandwidth utilizations up to few Tb/s. It is a method of transmitting data simultaneously at multiple carrier wavelengths over a fibre such that they do not interfere with each other

[1] Chlamtac, Ganz and Karmi [Chlamtac et al., 1992, 1993] introduced the concept of light path as an optical communication path (data channel) established between two nodes in the network, created by the sharing of the same wavelength throughout the path. A transmission between light path endpoints does not require processing or buffering at the intermediate nodes, and as such, light path communication weaken the bottleneck created at intermediate nodes. [2]Rama swami and Siva rajan [Rama swami et al., 1995] showed the routing and wavelength assignment (RWA) problem as an NP-hard problem and formulated it as an integer linear program (ILP). [3]Datta, Mitra, Ghose and Sengupta [Datta et al., 2004] proposed a polynomial time optimal RWA algorithm, which optimizes the assignment of a wavelength in terms of maximizing one-hop traffic in a tree topology. The virtual topology is the network topology in Which a link represents a light path that has been established between two physical nodes. The virtual topology is known as sometimes the optical connection graph or the logical topology. We will use the terms interchangeably. The virtual topologies can fall into two categories: Static, which is formed with the help of static light path establishment and reconfigurable, dynamic which is formed with the help of dynamic light path establishment. In dynamic light path establishment, the light paths are set up according to some connection requests at regular intervals and torn down after holding time elapses

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The virtual topology design problem can be formulated as a mixed-integer linear programming (MILP) problem [4] [Rama swami et al., 1996, and 1998]. It resembles the multi commodity flow problem, where a commodity corresponds to a light path and flow on an edge corresponds to traffic flow offered onto the edge. The objective is to design a virtual topology to optimize a certain metric subject to a set of constraints. The problem has been formulated as an optimization problem by [5] Mukherjee, Banerjee, Ramamurthy and Mukherjee [Mukherjee et al., 1996]. Some possible objective functions to minimize congestion, minimize average weighted hop count.

[6] [Banerjee et al., 2000], maximizing single hop traffic and minimizing message delay. Being an NP-hard problem, the virtual topology design is computationally intractable. It becomes almost impractical to solve when the network size becomes larger. Therefore, there is a need for good heuristic solutions that give reasonably good results close to the optimum one. A number of heuristic algorithms are given in the literature [Banerjee et al., 2000; Ozdaglar et al., 2003]. [7]Ghose, Kumar, Banerjee and Dutta [Ghose et al., 2005] compared the queuing delay in an optical network using both Poisson and self-similar traffic. They showed that the virtual topologies designed using self-similar traffic are more effective in handling present day brusty Internet traffic. In the static case the traffic in the network is known a priori with the help of a traffic matrix. The source-destination pair for setting up light path can be chosen in a particular order to establish an efficient virtual topology with the limited number of available wavelengths. Researchers have given various schemes to line up the connection requests while setting up the light paths for the static virtual topology [Chlamtac et al., 1992, 1996; Zhang et al., 1995; Ram swami et al., 1996]. The performances of these existing policies heavily depend upon the physical topology of the networks.

Dynamic programming is an inductive design technique, similar to 'greedy approach' and 'divide and conquer'. Dynamic programming divides a problem into a set of sub problems and founds a recursive relationship among the original problem and its sub problems. A sub problem that represents a small part of the original problem is solved for obtaining the optimal solution. Then the scope of this sub problem is enlarged to find the optimal solution of a new sub problem. This process of enlargement is repeated till the scope of the sub problem involves the whole original problem. Thereafter, solution for the whole problem is obtained by combining the optimal solutions of its sub problems.

II.RELATED WORK

Finding shortest paths is an important and fundamental problem in communication network and transportation networks, circuit design, graph analysis Internet node traffic, social networking, and graph analysis [8] (Girvan & New- man, 2002)—and is a sub-problem of many combinatorial problems, such as those that can be represented as a network flow problem The heuristic logical topology design algorithm (HLDA) is the main objective is to minimize the congestion in the congestion in the network.it efforts to control set of light paths in terms of their source and destination nodes .in given network the traffic matrix and physical topology are taken as the input and stage wise we can find out all pair shortest path.

[9] In a multistage graph G = <V, C> for given physical topology is taken is a directed graph where the vertices (nodes) are partitioned into $k \geq 2$, disjoint sets V_i, where $1 \leq i \leq n$. Every edge (links) connects two nodes from two partitions. Each edge is associated with an edge cost C (i, j). The initial node is called a source and the last node is called a sink. The multistage problem is a problem of finding the shortest path from the source to the destination. This problem is also called the 'stage coach problem'. The dynamic programming approach can be used to solve this problem

Given a directed graph G =(V,E) with n vertices V = {v1,v2,...,v n}and m edges E = {e1,e2,...,e m},the distance version of the algorithm work out the length of the shortest path from vi to v j for all (vi, v j) pairs. The full version also returns the actual paths in the form of an ancestor matrix.

III.SCOPE OF RESEARCH

In case of implementation of Dynamic Programming several components are involved which are discussed as follows**:**

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Stages: The given traffic matrix based on physical topology on the length of each node we can divide into number of sub problems, called stages.

Decision: In every stage, there can be multiple decisions out of which the best shortest path (least cost)

State: A state indicates the stages for which decision needs to be taken. The variables that are used to take a decision at every stage are called state variables.

Policy: A policy is a rule that determines the decision at each stage. A policy is called an optimal policy if it is globally optimal.

Principle of Optimality: It states that the optimal sequence of decisions in a multistage decision problem is feasible if and only if its sub-sequences are optimal.

The uses the dynamic programming approaches for finding the shortest path between any two given two nodes. The input for the algorithm is a network $G = <V, E>$, and a set of weights $w_{I\,j}$ for each (i, j) $\in E$. algorithm finds the shortest simple path from node s to node t. The input for the algorithm is an adjacency matrix of the graph G. The cost (i, j) is computed as follows

Initially, the matrix D (0) is initialized as cost (i, j). Then, in subsequent iterations, the next matrix D is computed. Now D (1) is computed with only one intermediate node {1}. D (2) is computed with only two intermediate nodes {1, 2}. In general, D (k) is computed from D (k−1) and there are only two possibilities for computing it, which are as follows:

1. The first possibility is that node k is not involved. Since the node is not part of the path, only nodes {1, 2, to$k$ − 1} are considered. Hence, $D_{ij}(k) = D_{ij}(k-1)$.
2. The second possibility is that node k is used as an intermediate node. In this case, one Can split the path as I->k and k+1->j. If the path I->j is the shortest path, then the paths

I->k and k + 1->j should be shortest paths as well.

The shortest pathbetween $i$and j is computed as follows

$$D_{ij}(k) = \min \{D_{ij}(k-1), D_{ik}(k-1) + D_{kJ}(k-1)\}$$

The algorithm proceeds subsequently as D (0), D (1), D (2), and D (n). It can be observed that D (n) entries represent the shortest path between any pairs of vertices

Step 1: Read weighted graph $G = <V, E>$.

Step 2: Initialize D [i, j] as follows

$$\text{Cost (i, j)} = \begin{cases} 0 & \text{if i=i, } 1\leq i\leq n \\ W_{ij} & \text{if} <i, j> \in E (G) \\ \infty & \text{If} <i, j> \notin E (G) \end{cases}$$

Input: A weighted graph, represented by its weights matrix

Output: produces the matrix distances [ ] [ ] of values representing the all pair shortest path

All pair shortest path (G)

For each u €V do

For each v €V do

Dist [u] [v] =∞

Pred [u] [v] = -1

Dist [u] [u] =0

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For each neighbour v of u do

Dist [u] [v] = weight of edge (u, v)

Pred [u] [v] =u

For each t € v do

For each u € v do

For each v € v do

New Len =dist [u] [t] + dist [t] [v]

If (new Len <dist [u] [v]) then

Dist [u] [v] = new Len

Pred [u] [v] = pred [t] [v]

End

0 8 ∞ 1	0 8 ∞ 1	0 8 ∞ 1	0 8 ∞ 1
∞ 0 1 ∞	∞ 0 1 ∞	∞ 0 1 ∞	∞ 0 1 ∞
4 ∞ 0 ∞	4 ∞ 0 ∞	4 ∞ 0 ∞	4 ∞ 0 ∞

Traffic matrix for 4- Nodesusing dynamic progrming to genarate all pair shortest path

(i) Traffic matrix (ii) stage2 (iii) stage3 (IV) stage4 (v) stage5.

IV.RESULTS AND ANALYSIS

Heuristic	nodes	trans	Light path	wavelength	physical hop	hop weight	totalhopweight	averageweightedhopcount	maximumcongestion	minimumcongestion
Stage1	4	1	3	0	3	21	21	1	3->2(9)	2->0(4)
	4	2	6	2	6	34	34	1	0->1(16)	1->2(1)
Stage2	4	1	3	1	5	22	46	2.091	3->2(9)	2->0(7)
	4	2	6	4	9	36	65	1.806	0->3(13)	1->2(1)
Stage3	4	1	2	1	6	21	63	3	0->3(11)	1->2(4
	4	2	5	4	10	37	84	2.227	0->3(16)	3->2(3)
Stage4	4	1	4	3	10	35	89	2.543	2->0(20)	0->3(6)
	4	2	8	9	16	56	127	2.268	2->0(32)	3->2(3)
Stage5	4	1	4	3	10	24	61	2.542	2->0(20)	0->3(6)
	4	2	8	8	16	40	87	2.175	2->0(30)	3->2(3)

Table-1: Heuristic Based 4-Nodes data

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Table-1 ison 4-node traffic matrix with different stages is showingresultson utilisation oftransceivers, light paths wavelengths, hop weight, total hop weight, average hop weight, maximum congestion and min congestion.

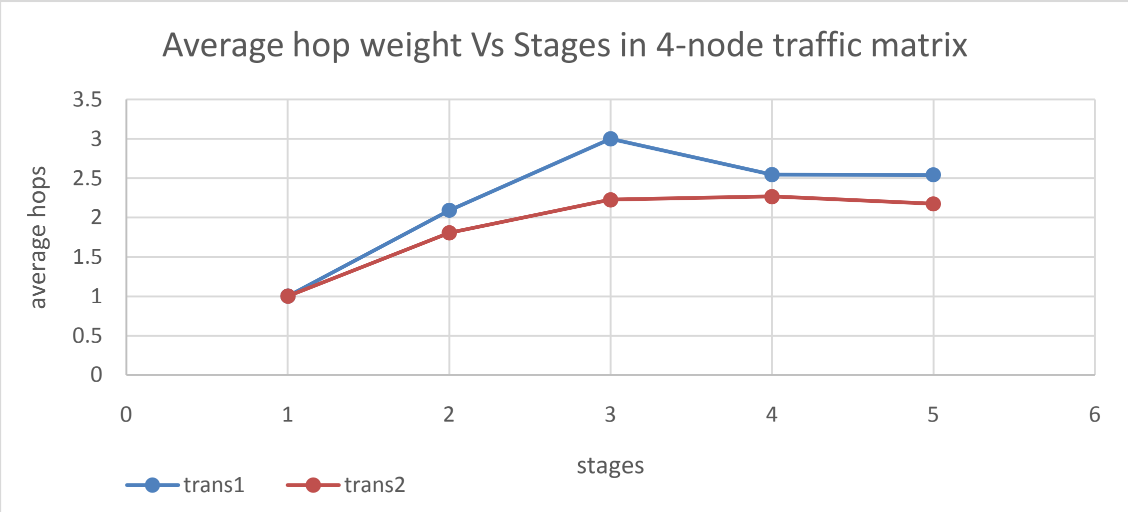

Fig1:4-Nodes 2-Transceivers Average hop weight hops on different stages

In Fig-1, comparison takes place between Average hop Weight Vs Stages with usage 1 & 2 transceivers. As the traffic is increased and the usage of 2- transceivers, average hop weight is gradually increased on 4-Node Traffic Matrix.

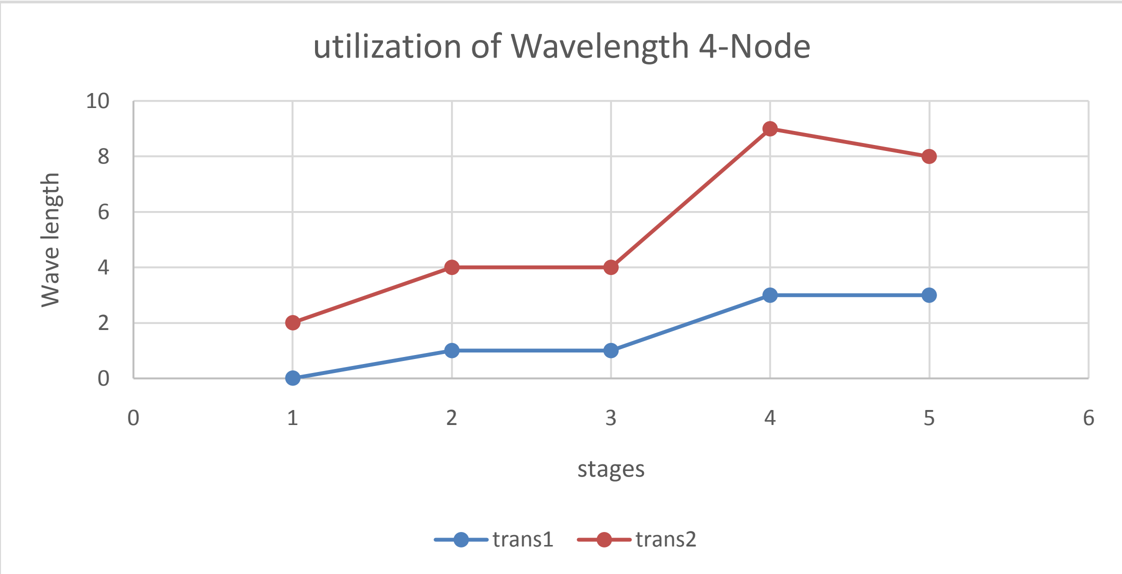

Fig-2:4-Nodes 2-Transceivers Utilization of Wave Lengths on different stages

In Fig-2 represents the utilisation of wavelengths on 4-node Traffic matrix with different stages with1 & 2 transceivers. The Utilisation is effective when traffic matrix grows and as well as with 2-transceivers.

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0 2 ∞ 1 ∞ ∞ ∞
∞ 0 ∞ 3 10 ∞ ∞
4 ∞ 0 ∞ ∞∞ ∞
∞ ∞2 0 2 8 4
∞ ∞∞ ∞ 0 ∞ 6
∞ ∞5 ∞ ∞ 0 ∞
∞ ∞∞ ∞ ∞ 1 0

7 -Nodes traffic matrix

Heuristic	node	Transmitter	light path	WaVel Length	Phy hop	Hop Weight	Tot Hop Weight	Avg Hop Weight	Max congestion	Min congestion
Stage1	7	1	6	0	6	35	35	1	1 -> 4 (10)	0 ->1(2)
	7	2	11	2	11	49	49	1	1 -> 4 (10)	0 ->3(1)
	7	3	15	4	15	68	68	1	1 -> 4 (20)	0 ->3(1)
	7	4	18	6	18	74	74	1	1 -> 4 (20)	0 ->3(1)
Stage2	7	1	6	1	11	41	76	1.854	5 -> 2 (15)	0 ->3(3)
	7	2	12	5	20	80	137	1.712	2 -> 0 (26)	3 ->4(2)
	7	3	16	10	27	101	175	1.733	2 -> 0 (30)	3 ->4(2)
	7	4	21	16	35	127	218	1.717	2 -> 0 (39)	3 ->4(5)
stage3	7	1	6	2	16	53	148	2.792	5 -> 2 (33)	3 ->4(3)
	7	2	13	9	34	105	286	2.724	2 -> 0 (64)	3 ->5(8)
	7	3	19	18	44	139	346	2.489	2 -> 0 (79)	3 ->4(12
	7	4	25	29	53	169	394	2.331	2 -> 0 (90)	3 ->4(12
stage4	7	1	6	3	19	60	214	3.567	2 -> 0 (52)	3 ->4(3)
	7	2	13	12	41	127	432	3.402	2->0 (101)	3 ->4(15
	7	3	20	24	56	172	547	3.18	2->0 (129)	3 ->5(18)
	7	4	27	39	70	217	641	2.954	2->0 (151)	3 ->4(24)
stage5	7	1	6	4	22	67	274	4.09	2 -> 0 (65	3 ->5(10)
	7	2	14	14	44	135	514	3.807	2->0 (122)	3 ->5(18)
	7	3	20	28	62	193	702	3.637	2->0 (167)	3 ->5(24)
	7	4	28	46	82	255	862	3.38	2->0 (201)	3 ->5(29)

Table2:7-Nodes heuristic data table

Table-2 is on 7-node traffic matrix with different stages is showing results on utilisation of transceivers, light paths wavelengths, hop weight, total hop weight, average hop weight, maximum congestion and min congestion.

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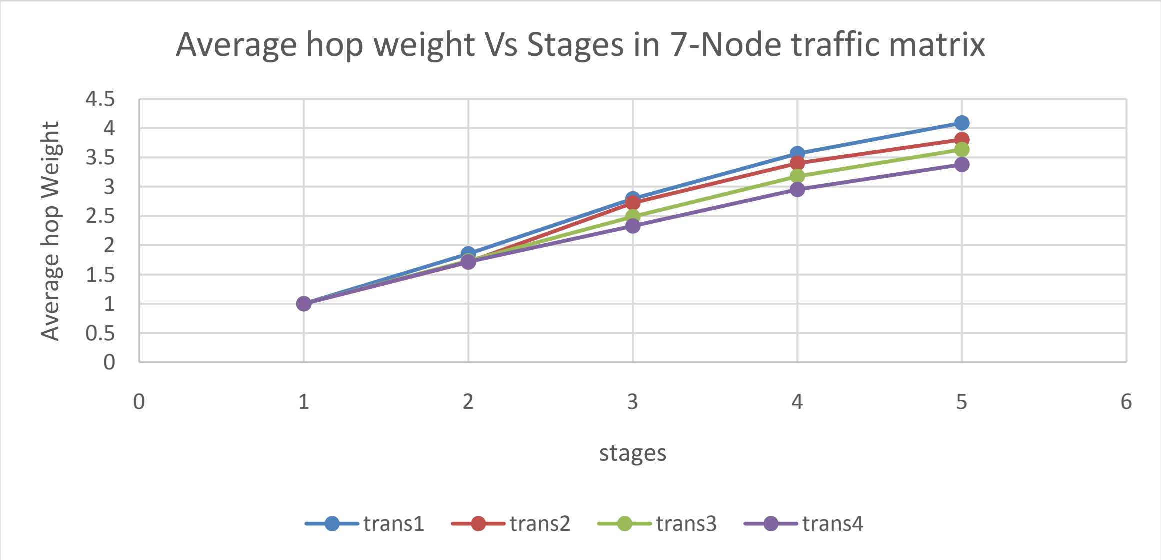

Fig3:7-Nodes, 4-Transceivers on stage wise Average hop Weight

In Fig-3, comparison takes place between Average hop Weight Vs. Stages with 4 transceivers. As the traffic is increased and usage of 2,3,4 transceivers, the average hop weight is gradually increased on 7-Node Traffic Matrix

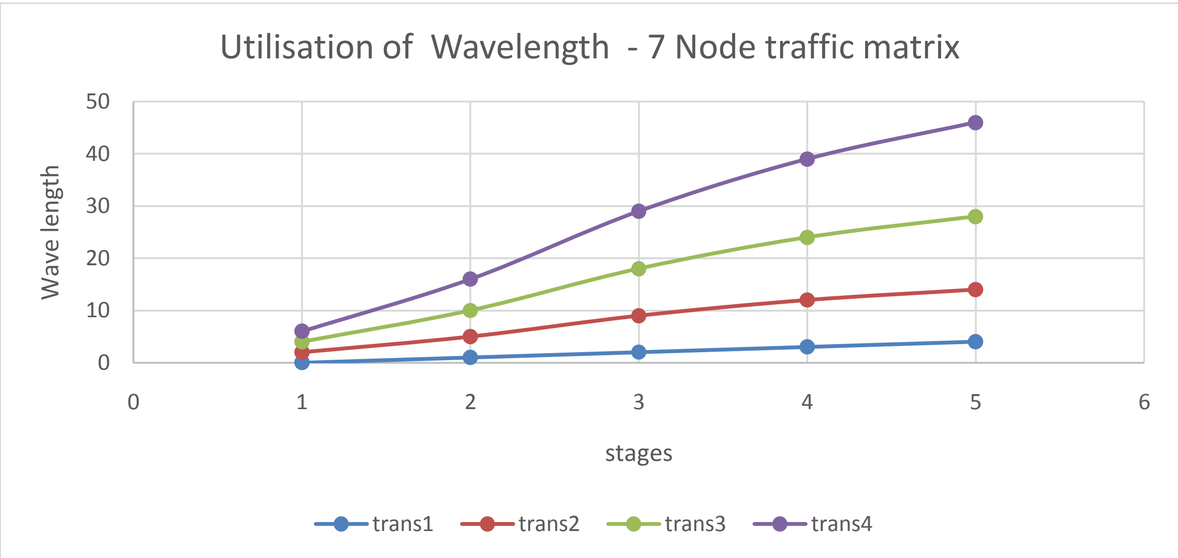

Fig 4: 7-Nodes, 4- Transceivers comparison different stages Utilization of Wave lengths

In Fig-4 represents the utilisation of wavelengths on 7-node Traffic matrix with different stages with 4 transceivers. The Utilisation is effective when traffic matrix grows and as well as usage of 2-4transceivers

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0 93 96 ∞ ∞ ∞ ∞ ∞ ∞ ∞ ∞ ∞ ∞ ∞
39 0 ∞ 14 77 ∞ ∞∞ ∞ ∞ 44 ∞ ∞ ∞
78 ∞ 0 ∞ ∞ 39 ∞ ∞ ∞ ∞ ∞ 88 98 ∞
∞ 5 ∞ 0 ∞ ∞ 39 ∞ 25 ∞ ∞ ∞ ∞ ∞
∞ 26 ∞ ∞ 0 ∞ ∞ 28 ∞ 23 ∞ ∞ ∞ ∞
∞ ∞ 7 ∞ ∞ 0 ∞ 97 40 ∞∞ ∞ ∞ ∞
∞ ∞ ∞ 61 ∞ ∞ 0 ∞ ∞ 36 ∞ ∞ ∞ 42
∞ ∞ ∞ ∞ 61 49 ∞ 0∞ 17 ∞ ∞ ∞ ∞
∞ ∞ ∞ 12 ∞ 57 ∞ ∞ 0 ∞ ∞ ∞ ∞ ∞
∞ ∞ ∞ ∞ 42 ∞ 97 47 ∞ 0 ∞ ∞ ∞ ∞
∞ 29 ∞ ∞ ∞ ∞ ∞ ∞ ∞ ∞ 0 41 28 0
∞ ∞ 54 ∞ ∞ ∞ ∞ ∞ ∞ ∞ 67 0 ∞ 87
∞ ∞ 26 ∞ ∞ ∞ ∞ ∞ ∞ ∞ 81 ∞ 0 3
∞ ∞ ∞ ∞ ∞ ∞ 53 ∞ ∞ ∞ ∞ 4 58 0

14-Nodes traffic matrix

Heuristic	node	TrAnScEiVers	Light Path	Wavelenth	Phy Hop Weight	Hop Weight	Total Hop weight	Average Hop weight	Maximum congestion	Min congestion
Stage1	14	1	13	0	13	860	860	1	2 -> 12 (98)	7 ->9(17)
	14	2	27	1	27	1567	1567	1	2 -> 12 (98)	8 ->3(12)
	14	3	40	3	40	2025	2025	1	8 -> 5 (114)	12 ->13(3)
	14	4	53	5	53	2601	2601	1	0 -> 2 (192)	13 ->11(4)
stage2	14	1	13	2	33	1572	4178	2.658	1 -> 10 (314)	4 ->1(70)
	14	2	27	6	66	3033	8102	2.671	3 -> 1 (506)	11 ->2(58
	14	3	40	12	94	4272	10754	2.517	10- 12 (645)	1 ->0(68)
	14	4	53	18	120	5284	12742	2.411	1 -> 10 (773)	12 ->10(81)
stage3	14	1	14	2	40	1627	4998	3.072	1 -> 4 (371)	1 ->0(56)
	14	2	27	7	79	3258	9910	3.042	6 -> 9 (621)	2 ->11(95)
	14	3	41	13	117	4813	14741	3.063	2 -> 5 (797)	12 ->10(81)
	14	4	55	22	152	6184	18278	2.956	1 -> 10 (992)	12 ->10(81)
stage4	14	1	14	2	42	1648	5359	3.252	2 -> 5 (427)	1 ->0(56)
	14	2	28	8	87	3282	11063	3.371	2 -> 5 (862)	1 ->0(68)
	14	3	42	16	122	4763	15097	3.17	2 -> 5 (1108)	2 ->0(136)
	14	4	56	25	159	6251	19155	3.064	2 -> 5 (1244)	7 ->4(129)
stage5	14	1	14	2	42	1648	5359	3.252	2 -> 5 (427)	1 ->0(56)
	14	2	28	8	87	3282	11063	3.371	2 -> 5 (862)	1 ->0(68)
	14	3	42	16	122	4763	15097	3.17	2 -> 5 (1108)	2 ->0(136)
	14	4	56	25	159	6251	19155	3.064	2 -> 5 (1244)	7 ->4(129)

Table3: 14 Node (NSFNET) heuristic data table

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Table-3 is on 14-node(NSFNET) traffic matrix with different stages is showing results on utilisation of transceivers, light paths wavelengths, hop weight, total hop weight, average hop weight, maximum congestion and min congestion.

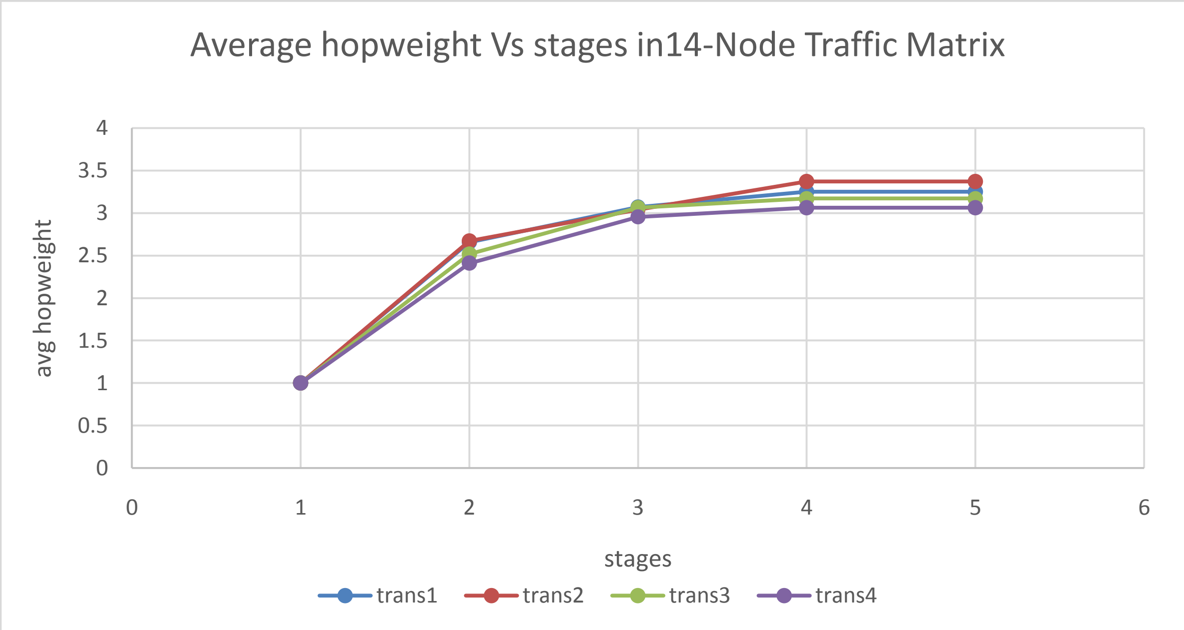

Fig5:14-Nodes 4-Transceivers different stages on average hop weight

In Fig-5, comparison takes place between Average hop Weight vs. Stages with 4 transceivers. As the traffic is increased and usage of 2-4 transceivers the average hop weight is gradually increased on 14-Node (NSFNET) Traffic Matrix

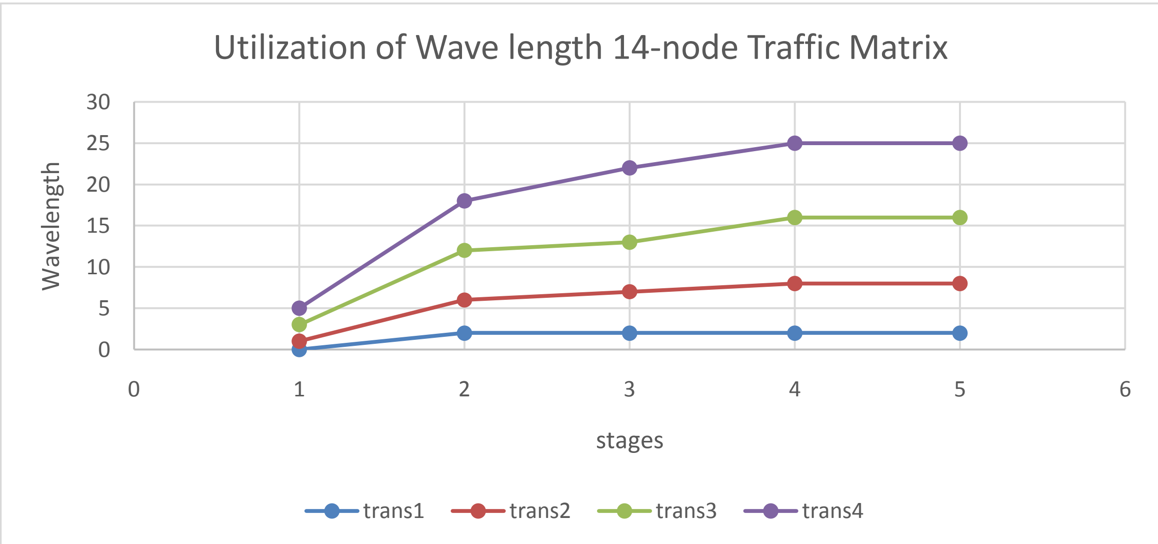

Fig6:14-Nodes 4- Transceivers different stages on Utilization of Wave lengths

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In Fig-6 represents the utilisation of wavelengths on 14-node (NSFNET) Traffic matrix with different stages with 4 transceivers. The Utilisation is effective when traffic matrix grows and as well as usage of 2-4 transceivers

V.CONCLUSION

In this paper the main emphasis of this work to find all pair shortest path by using dynamic programing on virtual topology. All the nodes are chosen as sources in step by step to produce the fulfilled traffic to the given network, the existing physical topology to topology is not linked to the all nodes.

By taking the existing traffic matrix and applying dynamic programing as said above the stage wise traffic matrices are developed. And each stage the Heuristic Logical Design Algorithm was applied and observed the results. The method was implemented 4nodes, 7nodes and 14 NSFNET.

When compared average weighted hops in Fig-(1) for 2-transcievers the solution is optimum in all stages. In case of Fig-(3) & (5) the average weighted hops are gradually increasing as the number of Transceivers are increasing and as well as traffic is increasing.

Utilization of wave length in Fig-(2) gradually increasing in 4-node traffic .in Fig-(4) and (6) utilization of wave lengths is also increased as the traffic is going in stage wise. Hence it is concluded that when the demand of a traffic is enhanced the average weighted hops and utilization of wave lengths is also increased gradually.

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