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Implementation of Dynamic Programming to Find All Pairs Shortest Path on Fibre Optics Networks Routing and to Formation of Virtual Topology Reconfiguration

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Abstract: Fiber optic networks- WDM technology - The formation of virtual topology on existing physical Network- Using Dynamic programming approach has been developed to produce different sets of traffic matrices for finding shortest path from each source to different destinations- Heuristic logical design Algorithm (HLDA) is implemented to find shortest path varying number of optical transceivers. A study on 4-node stage wise traffic matrices produced- and made formation of virtual topology reconfiguration done using dynamic programming - Comparative study on different object function on using dynamic programming virtual topology and reconfiguration of virtual topology

Keywords: Fibre Optics, Dynamic programming, Virtual Topology, All pair shortest path, Stages, Virtual topology Reconfiguration

I. INTRODUCTION

Internet traffic is quickly growing as a result of the arrival of latest styles of net access technologies, bandwidth-intensive network applications and large-volume transmission traffic [1-2]. In wavelength routed optical networks, a virtual topology is overlaid on a physical topology. The virtual topology is customarily acquired as a solution to a mixed integer linear programming (MILP) problem that minimizes the average hop distance in the network [3], the maximum flow (congestion) in a light path [4], [5], [6] or the total number of light paths [7].

Two types of constraints are specified for the MILP – multi commodity flow equations determined by the physical topology and the traffic matrix, and resource constraints to limit the number of light paths emerging and terminating at a node to less than the number of transmitters and receivers at the node. Related to virtual topology design is the predicament of reconfiguration.

The virtual topology may just need to be transformed due to the fact that of alterations in the traffic matrix and/or the physical topology. There is a cost related to reconfiguration because of disruption of carrier and reprogramming of the switches. The little literature that there's on reconfiguration considers minimizing the cost of one-time reconfiguration. Reconfigurations and we purpose to cut down the whole cost over all these reconfigurations. There are two motivations for this. Firstly, the short term cycle problem that arises from cyclical patterns in the traffic matrix like, for example, that seen in circuit switched telephone networks.

The physical topology [8] consists of optical WDM routers interconnected by point-to-point Fiber links and nodes in an arbitrary topology. In these types of networks, data transfer carried from one node to another node using light paths. A light path [9] is an all-optical path established between two nodes in the network by the allocation of same wavelength on all links of the path. A virtual topology [10] is a set of pre-established light paths established to provide all optical connectivity between nodes for a given traffic demand. The virtual topology is established logically through light paths, each identified by an independent wavelength, which provides end-to-end connectivity for transmission over the optical medium. The embedding of virtual topology over a physical topology results in minimizing the number of nodes that were actively involved in network transmission.

The Virtual Topology is a graph with nodes as routers in the physical network topology and edges corresponding to the light paths between them. A virtual topology is designed with an objective of minimizing certain objective function such as Average Weighted Hop Count of the Virtual Topology (AWHT), congestion, etc. The virtual topology designed initially for a particular traffic may not be Optimal for the changing traffic. The virtual topology designed over IP may need to be changed in response to changing traffic demands or due to failure of network elements.
Some light paths may be heavily loaded and hence new light paths to be set up to carry the additional traffic. Likewise, certain other light paths may have no traffic at all and such light paths to be deleted. This process of

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changing the current virtual topology to a new one to adapt the dynamic change of traffic or failure of network elements is called Virtual Topology Reconfiguration [10]. The dynamic reconfiguration of optical networks has been one of the hot topics among the communication research community Dynamic programming is both a mathematical optimization method and a computer programming method. In both contexts it refers to simplifying a complicated problem by breaking it down into simpler sub problems in a recursive manner.

While some Decision problems cannot be taken apart this way, decisions that span several points in time do often break apart recursively; Bellman called this the "Principle of Optimality". Likewise, in computer science, a problem that can be broken down recursively is said to have optimal substructure. If sub problems can be nested recursively inside larger problems, so that dynamic programming methods are applicable, then there is a relation between the value of the larger problem and the values of the sub problems.

Proposed work

The shortest path between i and j is computed as follows

Dij(k) = min {Dij(k−1), Dik(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

Dynamic Programming APSP (V, E, w):
for all vertices u
for all vertices v
if u = v
dist[u, v, 0] ←0
else
dist[u, v, 0] ←∞
or k ← 1 to V - 1
for all vertices u
  dist[u, u, k] ←0
for all vertices v ≠ u
dist[u, v, k] ← ∞
for all edges x→v
if dist[u, v, k] > dist[u, x, k - 1] + w(x→v)
dist[u, v, k] ←dist[u, x, k -1] + w(x→v)

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. [11]

4-Node traffic matrix is a directed graph cost is initialized randomly and represented in a traffic matrix. In these Network finds out the shortest path from individually source to different destination using Dynamic programming. Link connectivity networks in direct network cost are initialized randomly and represented in traffic matrix. To find out up to full pledged traffic matrix based on intermediate values that are stages.

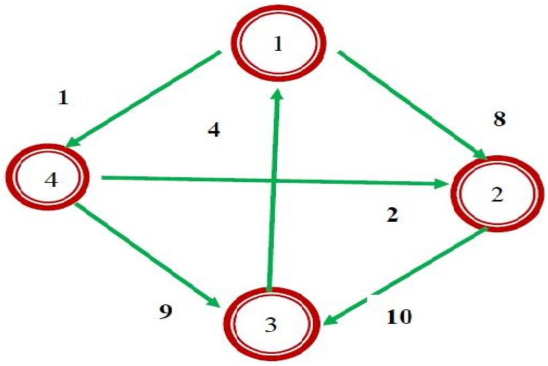

Fig 1: 4-node directed network

0	8	∞	1
∞	0	10	∞
4	∞	0	∞
∞	2	9	0

Stage-1

0	3	10	1
14	0	10	∞
4	12	0	5
13	2	9	0

(II) Stage-2

0	3	10	1
14	0	10	15
4	7	0	5
13	2	9	0

(III) Stage-3

The above Traffic matrices for 4- Node network using Dynamic programming to generate all pair shortest path (i) Traffic matrix or stage 1 (ii) stage2 (iii) stage3. Here stage-1 means it will check neighbours on supported physical network, referred to as stage-1. That means intermediate node is zero. stage-2 one intermediate node is added in all directions. Stage-3 two intermediate nodes is added in all directions

Stage-2	1->4->2	2->3->1	3->1->2
	1->4->3	3->1->2	3->1->4
Stage-3	2->3->1->4	3->1->4->2	

The Heuristic algorithm considered here attempts to minimize the maximum congestion in the network, for changing traffic conditions. Using dynamic programming

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reconfigure on 4-node directed network with stage wise traffic matrices

DP-H	trans	Light paths	Wave length	Phy-hops	Hop weight	Total hop	Avg hop wei	Maximum congestion	Minimum congestion
Stage 1	1	3	0	3	22	22	1	1 -> 2 (10)	2 ->0(4)
	2	6	2	6	43	43	1	0 -> 1 (16)	2 ->0(8)
Stage 2	1	3	1	6	36	72	2	2 -> 0 (21)	0 ->1(7)
	2	7	5	12	67	121	1.806	2 -> 0 (39)	0 ->1(10)
Stage 3	1	4	2	9	45	105	2.333	2 -> 0 (35)	0 ->1(7)
	2	8	7	15	76	155	2.039	2 -> 0 (54)	0 ->1(10)

Table1: Dynamic Programming Heuristic (DP-H) method on 4-node network

The above table Dynamic Programming Heuristic (DP-H) shows that utilisation of transceivers, light paths, wavelengths, hop weight, total hop weight, average hop weight, maximum congestion and min congestion on 4-node traffic matrix in all stages

$$\begin{Bmatrix} 0 & 2 & \infty & 1 \\ \infty & 0 & 10 & \infty \\ 4 & \infty & 0 & \infty \\ \infty & 8 & 9 & 0 \end{Bmatrix}$$

Stage-1

The above Traffic matrices for 4- Node network using Reconfiguration heuristics of dynamic programing to generate all pair shortest path (i) Traffic matrix or stage 1 (ii) stage2 (iii) stage3

$$\begin{Bmatrix} 0 & 2 & 10 & 1 \\ 14 & 0 & 10 & \infty \\ 4 & 12 & 0 & 5 \\ 13 & 3 & 9 & 0 \end{Bmatrix}$$

Stage-2

$$\begin{Bmatrix} 0 & 3 & 10 & 15 \\ 14 & 0 & 10 & 1 \\ 4 & 7 & 0 & 13 \\ 5 & 2 & 9 & 0 \end{Bmatrix}$$

Stage-3

RDP-H	trans	Light paths	Wave length	Phy-hops	Hop weight	Total hop wei	Avg hop wei	Maximum congestion	Minimum congestion
Stage 1	1	4	0	4	23	23	1	1 -> 2 (10)	0 ->3(1)
	2	6	1	6	34	34	1	1 -> 2 (10)	0 ->3(1)
Stage 2	1	3	1	6	36	72	2	2 -> 0 (20)	0 ->1(6)
	2	8	5	13	68	122	1.794	2 -> 0 (38)	3 ->1(3)
Stage 3	1	4	1	6	45	66	1.467	2 -> 0 (21)	0 ->1(7)
	2	8	5	13	76	125	1.645	2 -> 0 (53)	3 ->1(2)

Table2: Reconfiguration Dynamic Programming Heuristic (DP-H) method on 4-node network

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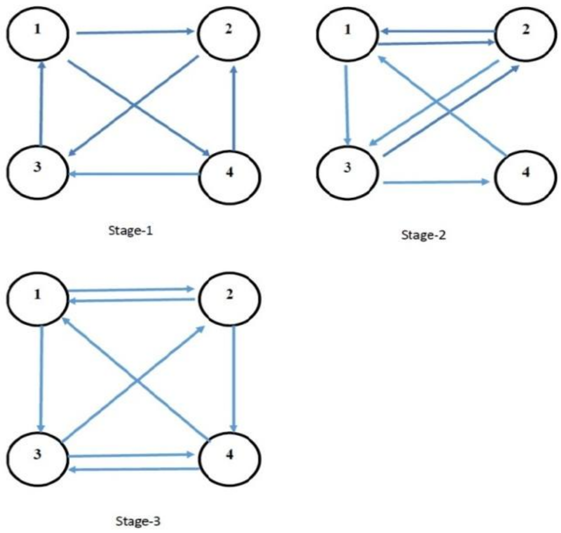

Fig 2: 4-node network formation of virtual topology on stages (DP-H)

The above figure the formation of virtual topology using Dynamic Programing Heuristic (DP-H) stage-1 to Stage-3

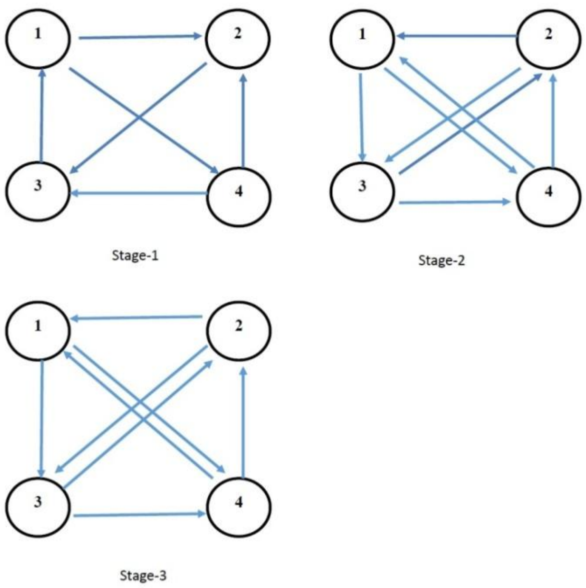

Fig 3: 4-node network formation of Reconfiguration virtual topology on stages (RDP-H)

The above figure the formation of virtual topology using Reconfigure Dynamic Programing Heuristic (RDP-H) stage-1 to Stage-3 In comparison takes place between utilisation of light paths Vs Stages with usage up to 2 transceivers. As the traffic is gradually increased Reconfiguration of Dynamic Programming Heuristic (RDP-H) on 4-node network

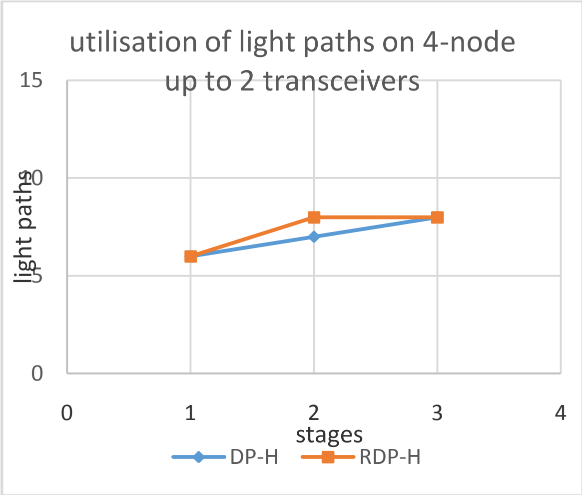

Fig 4:4-Nodes up to 2 transceivers light paths on different stages

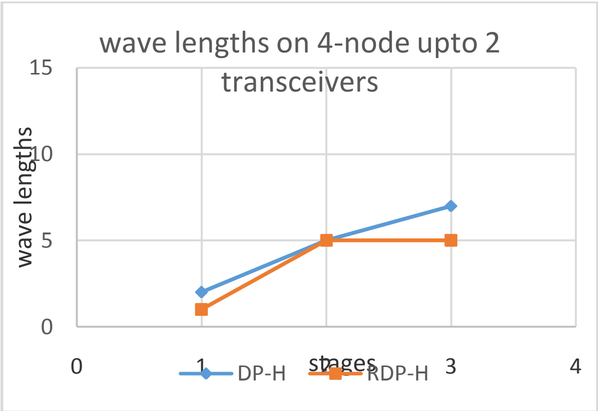

Fig 5:4-Nodes up to 2 transceivers wave lengths on different stages

In comparison takes place between utilisation of wavelengths Vs Stages with usage of up to 2 transceivers. As the traffic is gradually increased reconfiguration of Dynamic Programming Heuristic (DP-H) on 4-node network

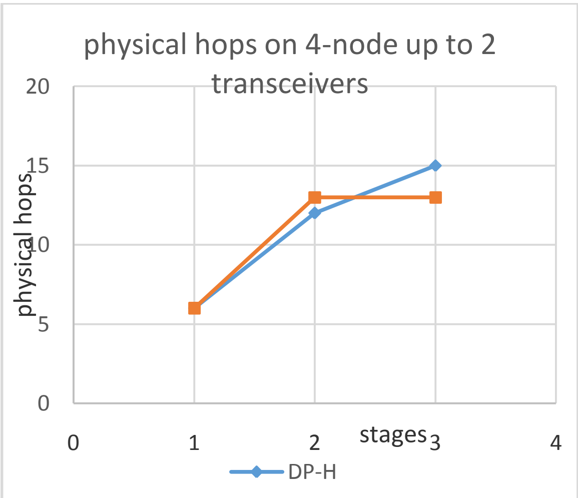

Fig 6:4-Nodes up to 2 transceivers physical hops on different stages

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In comparison takes place between utilisation of physical hops Vs Stages with usage of up to 2 transceivers. As the traffic is gradually increased reconfiguration of Dynamic Programing Heuristic (DP-H) on 4-node network

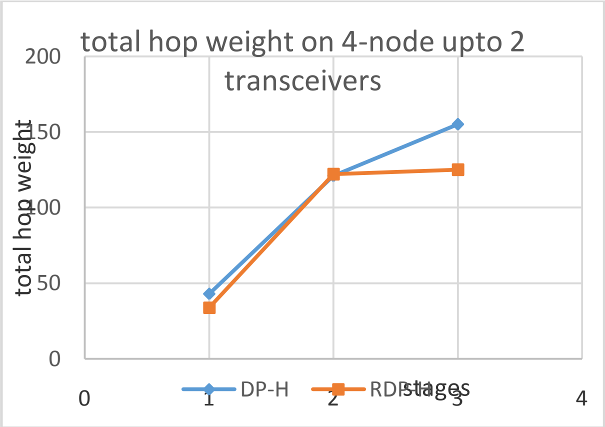

Fig 7:4-Nodes up to 2 transceivers total hop weight on different stages

In comparison takes place between utilisation of total hop weight Vs Stages with usage of up to 2 transceivers. As the traffic is gradually increased reconfiguration of Dynamic Programing Heuristic (DP-H) on 4-node network

CONCLUSION

Virtual Topology Reconfiguration with the Dynamic Programming Heuristic on 4-node Network with 2 transceivers producing all pair shortest path at each stage. A Source node may be chosen among all the nodes and formed a full pledged traffic matrix to the given network in step by step process.

In this paper, focus is on stage wise reconfiguration of existing traffic matrix by implementing Dynamic Program Heuristic (DP-H). The utilisation of light paths, wave lengths, physical hops and usage of total hop weight is graphically represented in the figures from 4 to 7. The effective utilisation is observed because of forming of shortest path with reconfiguration on Virtual Topology.

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BIOGRAPHIES

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