Optimization of Bandwidth for Dedicated Path Protection for SONET/SDH Networks

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Abstract* – Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) are Time-Division Multiplexing processes (TDMA) that are used to provide the bandwidth Services for the data users. In dedicated path protection, a real time network engine has been developed and implemented for the use of application for the SONET/SDH network. Dedicated path protection scheme has been investigated and implemented by real time network engine and performance matrices like blocking probability, Quality of services, accepted request and rejected request have been analyzed. The performance is evaluated for different values for the relative weight of dedicated path for the complete and minimum information scenarios. The number of accepted requests has been improved through the dedicated path protection algorithm. At alpha 0.1 the percentage of accepted number of requests are 86% and bandwidth utilization is 25%. At alpha 0.5 the percentage of number of accepted requests enhanced to 98% and bandwidth utilization up to 32%. The proposed algorithm yields better results as compared to previous work

Index Terms - **Dedicated protection, SONET/SDH, NP-completeness, Shared Risk Link Group (SRLG), Link, Trail.**

I. INTRODUCTION

When information is transmitted over a communication medium, a number of parameters are provided on the link, for framing of the data, error checking and managing the link. For optical communications, these functions have been standardized by the American National Standard Institute (ANSI) T1X1.5 committee for Synchronous Optical Networking (SONET) and by the International Telecommunication Union (ITU) for Synchronous Digital Hierarchy (SDH). Earlier the telephone calls were handled in the analog domain and long distance calls were routed over twisted pair, coaxial cable and analog microwave links between major switching offices. In 1962, AT&T installed DS-1 T-carrier services between long distance switching centers. Basically, these were channel bank-2 which took 24 analog telephone circuits, to convert to digital and to transmit over copper to the other switching center, where they were converted back to analog. It reduces the number of copper circuits required between switching centers and improved the quality of the telephone calls (less noise and crosstalk). The number of T-carrier circuits required between switching centers increased due to the enhancement of long distance communication. Additionally, DS-1C and DS-2 signals began to be used to increase the capacity of a circuit. In the late 1970’s, optical communications became feasible, allowing higher speed communications, which meant that one circuit could carry many more telephone calls, for example, one of the first commercial fiber circuits was installed in Chicago in 1977 and operated at 45 Mbps (DS-3 rate). The terminating multiplexers existed inside the switching offices, this point-to-point link is subject to failure and rings were used to provide backup (Fig. 1.1).The telephone companies found optical communications as a replacement for the older wire or microwave communications, they had been using for years, but later they realized a practical problem.

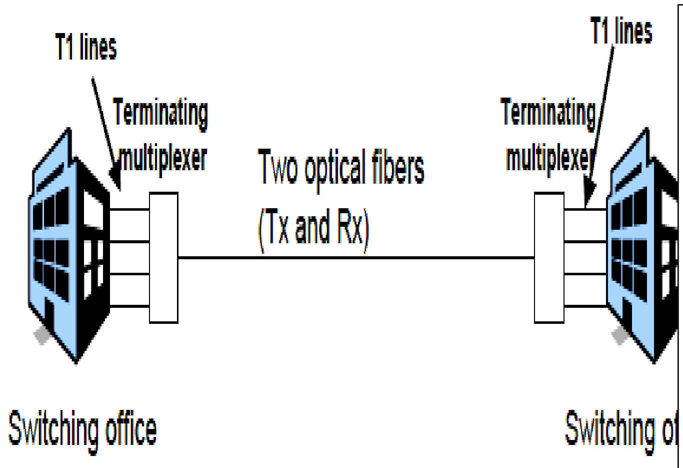


Fig 1.1 Early use of optical communications to replace DS-1 links between switching offices.

Vendors of optical communications equipment used their own framing techniques on the optical fiber. Once vendor is selected, it is required to struck with that vendor for all the equipment in that optical network. This raised the concept of standards in optical communications. It is extremely important to recognize that the first standards for optical communications were focused on handling voice circuits. At the time when these standards were developed, the tremendous volumesodata traffic had not appeared since there were few users and most people did not foresee it.

SONET offers cost-effective transport both in the access area and core of the network, for instance telephone or data switches rely on SONET transport for interconnection. The optical layer provides the foundation of transport services for both metro and long-haul applications. It also directly supports data services. The optical layer is now moving to next generation to provide the same level of sophistication that has been achieved with synchronous transmission, such as performance monitoring and network resilience .The SONET/SDH architecture has been shown in Fig1. 2. It consists of multiplexers at both the sender and receiver ends, regenerators for amplification of signal and add-drop multiplexers.

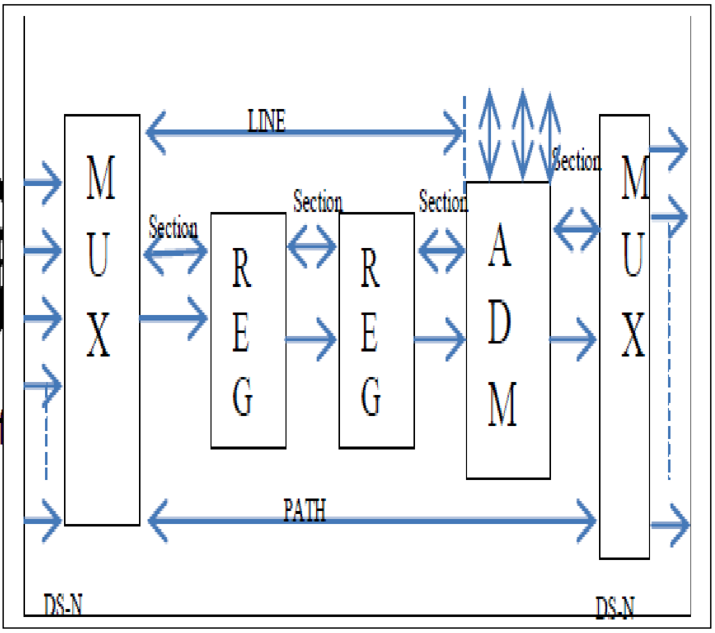


Fig 1.2 SONET/SDH architecture

The OC-N level signals and STS frames are analyzed, as the frame structure knowledge is important so it recognized as a standard for data communication. According to the SONET standards, the frame structures are available to communicate among the nodes of the communication elements (in this case the telecommunication hubs). The next section describes the analysis of STS frame structure and its various parts in detail.

II. Related Work

1. Asuman,E, Ozdaglar and Dimitri,P and Bertsekas, 2001 investigated and implemented RWA algorithm. In this work, the algorithm used to provide routes to the light path requests and links are assigned by different wavelengths. The author tried to enhance certain performance metric. The gap in this study is dependence of RWA on Integer linear programming (ILP) limits to provide some efficient solution for path provisioning.

2. Gangxiang,S,and Wayne,D, 2005 implemented a frame work for dynamic provisioning of surviable service based on the use of P-cycles to forma protecting working capacity envelope (PWCE).This technique simplified the provisioning technique. The author studied, analyzed and compared PWCE with SBPP. The technical feature of the PWCE is better than SBPP but the gap in this study is that there is still need of implementing PWCE experimentally. PWCE implementation is the area need to explore. The comparison with dedicated

path protection with PWCE mechanism still needs to investigated further.

3. Hu, J.Q. (2003) implemented two approaches for provisioning in SONET/SDH. This approach implemented over virtual concatenation which has tradeoff between resource over build and protection switching time. The author implemented protecting individual VCG member (PIVM) and provisioning fast restorable VCG.

4. Guo, Y., Kuipers ,F. and Mieghem, P.A(2003) suggest that there is good scope of research to find link/node disjoint path in multiple dimensions but this study faces conceptual problems. The author investigates the link/disjoint path and proposes a heuristic link/disjoint QOS algorithms DIMCRA (link disjoint multiple constraint routing algorithm). The scope of DIMCRA allows maximum disjoints path and simulating the performance.

5. Kuan Chou, L (2006) focused on design of mesh network that aggregate traffic at path level. The author implemented a shared, mixed protection algorithm for guaranteed survival of network after single link failure. There is still scope of research for multiple failure of links analysis using provided approach.

6. Shen, L., Yang, X. and Ramamurthy, B. (2005) analyzed various aspects of shared risk link group protection mechanism like dedicated and shared. The author worked with dedicated and revenue value. When the network unable to provision all the service request then the static provisioning problem is formulated as revenue maximaization problem whose objective is to maximize total revenue value. If there are sufficient resources, the problem becomes capacity maximization problem in which links are optimally enhanced for much better performance of network. Using ILP the author provided tabular search heuristic algorithm to solve the above problem. There is a scope of research to find solution of large scale network.

7. Canhui (Sam) Ou et (2004) linvestigated the dedicated path protection .For this, the author claimed that for dedicated path provisioning establishing a link under protection-at-connection(PAC)is NP complete. Author proposed heuristics for protection at line path to enhance efficiency.There is scope of rsearch for more than one link failure and optimization of network resources for such cases.

8. Guo, Y., Kuipers, F. and Mieghem, P.A(2003) provided an algorithm for the shortest pair of physically disjoint path between a given pair of nodes in the network. To enhance the reliability of network these disjoint path can be used .The amount of fiber usage and network cost can be well managed by optimizing the length of disjoint paths. There is research scope of validation of disjoint path algorithm for disjoint path algorithm for robust design of telecommunication network based on the concept of traffic of traffic flow over two-disjoint path for every pair of nodes in the network.

9. Rudra,D and George,N (2002) worked over defining the traffic grooming problem and provided a general formulation that provide solution to many problems of traffic grooming. There is research scope in minimization and maximization of cost function, optimization of rings of network, topologies with a special structure for different types of network issues, traffic pattern allocation and groming of multicast traffic.

10. Kodialam, M and Lakshman, T.V. (2000) worked on dynamic routing which means routing of incoming request that arrive one by one with no prior knowledge of future coming requests. This forces to implement online algorithm which can take instantaneous parameters to calculate the network resources to service any request .The best sharing process is achieved if the routing of every path in progress in network is known to routing algorithm. The author provides integer linear programming for this problem. The gap in this study is defining routing algorithm which is real time restorable with objectives that maximizes the number of incoming request.

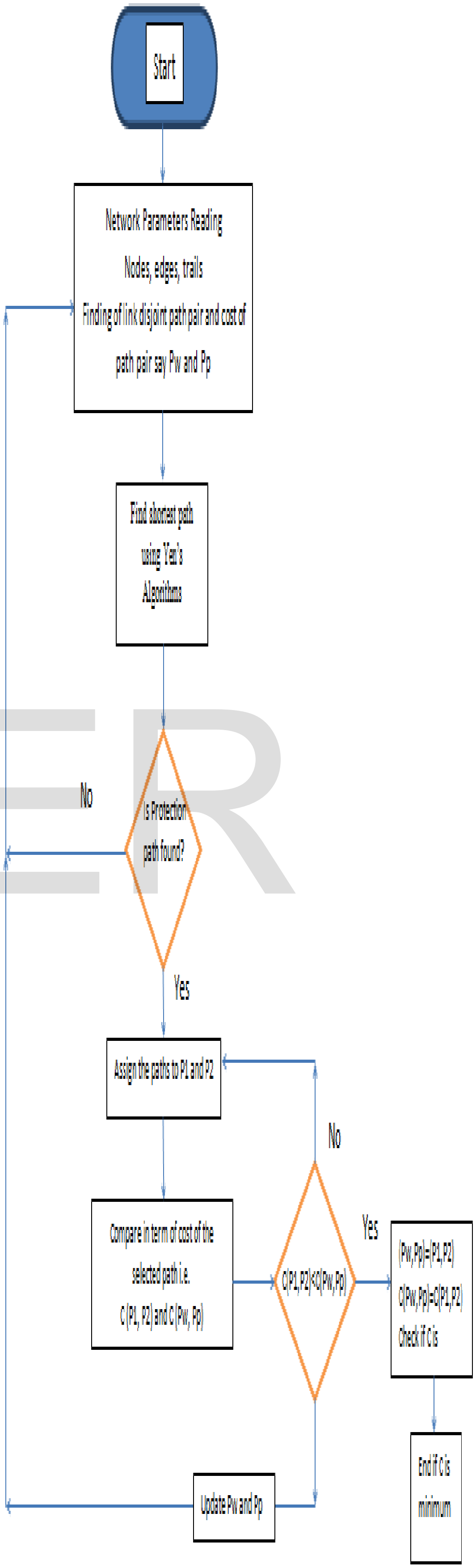
11. Madanagopal, R., Usha Rani, R. and Timothy, A.G. (2007) implemented heuristic algorithm for path protection for dedicated and shared protection. The algorithm is capable of online algorithm of incoming request with different services and parameters .The cost of network is first calculated and assigned to the links between two nodes and then the decision is taken to route the service request with desired parameters. Implementing the algorithm for SRLG-disjoint paths is still a problem which needs to investigate further.

12. Madanagopal, R., Usha Rani, N. and Gonsalves, T.A. (2010) implemented path computation algorithm .The special case in this work is that in spite of considering the network elements and integers the author matched the parameters with network hardware like multiplexers, switch etc. The

validation of results of this work is better because of consideration of multiplexed structure defined by SDH which imposes restriction on allocation of bandwidth.

III. Dedicated Protection

In dedicated-path protection, a protection path to protect a particular working path exclusively is provided, whereas in shared-path protection, a protection path can be shared by many working paths. In both cases, the constraint is that a working and its protection path have to be diversely routed so that at least one path can survive a single failure in the network. Protecting against multiple failures is more complex. Computation algorithms for SDH network has been worked, analyzed and investigated in this chapter. These algorithms are used to compute the path needed for the requested Quality of Service by calculating the associated shortest path and its relative cost factor considering all the bandwidth related information in the network. This chapter has analyzed and compared the path protection and computation algorithm. The investigated algorithms can be used in both Synchronous Digital Hierarchy and Synchronous Optical Network because of the same structure of multiplexing and de-multiplexing.

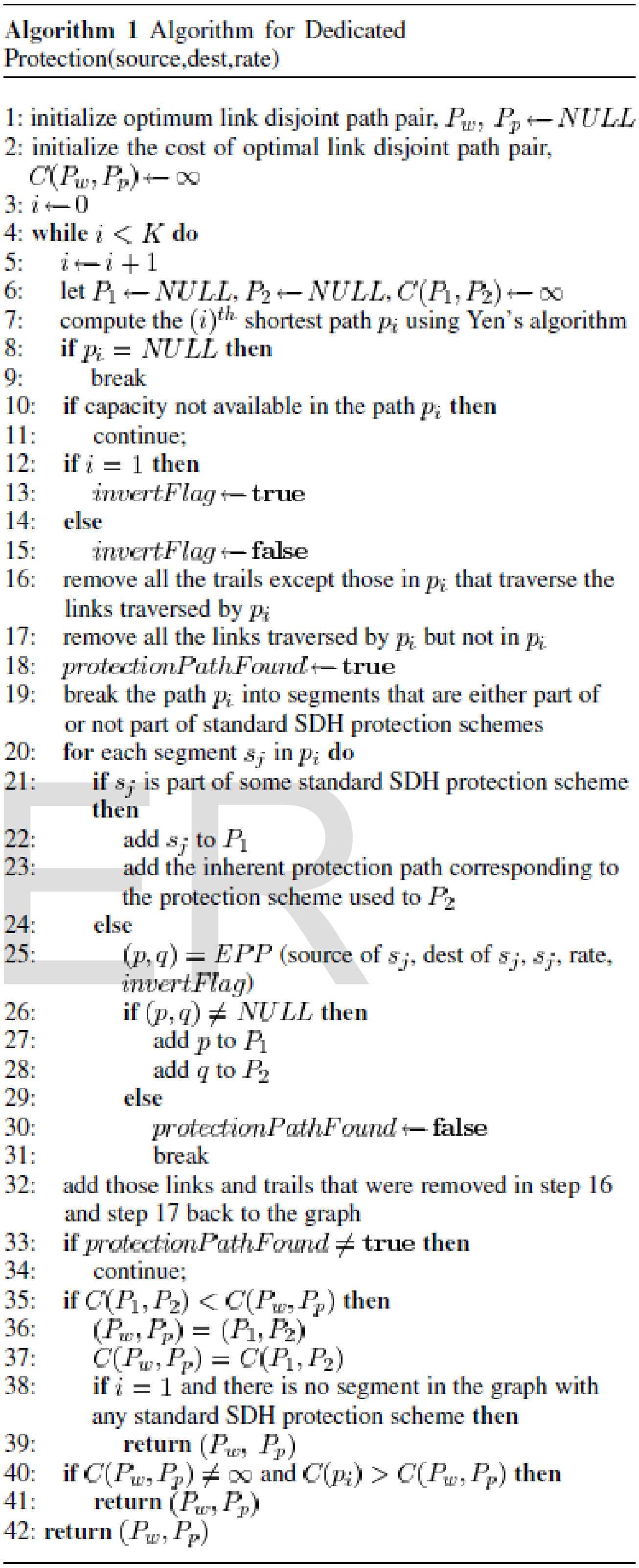

Start
Network Parameters Reading
Nodes, edges, trails
Finding of link disjoint path pair and cost of path pair say Pw and Pp
Find shortest path using Yen's Algorithms
No
Is Protection path found?
Yes
Assign the paths to P1 and P2
No
Compare in term of cost of the selected path i.e. C (P1, P2) and C (Pw, Pp)
C(P1,P2)<C(Pw,Pp)
Yes
(Pw,Pp)=(P1,P2)
C(Pw,Pp)=C(P1,P2)
Check if C is
End if C is minimum
Update Pw and Pp

The MATLAB is used for the application of the network and request generation. The output is analyzed with the help of MATLAB tool. The working engine is designed for the above said issues and a real time network virtually establish to check the real time issues like blocking probability and Quality of service. The network working engine is able to generate number of requests and able to generate the shortest path following the rules of the dedicated path protection. The Dedicated Path protection algorithm are implemented and measured on different strength of network. The networks are built by the engine and then different kind of the analysis on the base of the dynamic and static network conditions.

The issues which are covered by the engine are as follows:

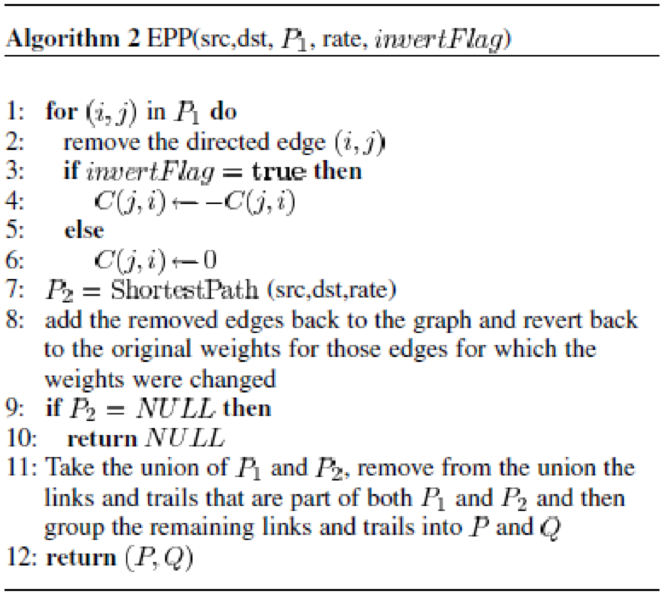
1. Simulation consist of two distinctive interactive Units:
    a. Network Play
    b. Request Play
2. Network Play
    a. This is a Network Engine which runs in backend
    b. It has 2 Major controls:
        i. Start/Pause/Resume Network
        ii. SONET/SDH State viewer
3. Request Play
    a. This is implemented in the frontend.
    b. It has all the controls to generate/process requests
    c. Key controls are:
        i. Posting a User request
        ii. Randomize request parameters
        iii. Randomize + Post request (for ease of analysis)
        iv. Auto – Request Generator

The simulations are based on the above points. Network interface provides the interface with the network which should be specially SONET/SDH network. The network engine runs at back end. It provides the virtual view of the network and the service requests and their bandwidth requirement can be changed at own choice. It helps to better analysis of the network. The number of the nodes and their links with weights can be assigned automatically or manually using network engine. The running network can be stopped for the analysis purpose and the network can be resumed again. The states of the network can be checked at any time. That how many number of requests handled or rejected by the network at any particular time. It can be checked using the state viewer of the network engine.



Algorithm 1 Algorithm for Dedicated Protection(source,dest,rate)

```
1: initialize optimum link disjoint path pair, $P_w$, $P_p \leftarrow NULL$
2: initialize the cost of optimal link disjoint path pair,
   $C(P_w, P_p) \leftarrow \infty$
3: $i \leftarrow 0$
4: while $i < K$ do
5:     $i \leftarrow i + 1$
6:     let $P_1 \leftarrow NULL, P_2 \leftarrow NULL, C(P_1, P_2) \leftarrow \infty$
7:     compute the $(i)^{th}$ shortest path $p_i$ using Yen's algorithm
8:     if $p_i = NULL$ then
9:         break
10:    if capacity not available in the path $p_i$ then
11:        continue;
12:    if $i = 1$ then
13:        $invertFlag \leftarrow$ true
14:    else
15:        $invertFlag \leftarrow$ false
16:    remove all the trails except those in $p_i$ that traverse the
       links traversed by $p_i$
17:    remove all the links traversed by $p_i$ but not in $p_i$
18:    $protectionPathFound \leftarrow$ true
19:    break the path $p_i$ into segments that are either part of
       or not part of standard SDH protection schemes
20:    for each segment $s_j$ in $p_i$ do
21:        if $s_j$ is part of some standard SDH protection scheme
           then
22:            add $s_j$ to $P_1$
23:            add the inherent protection path corresponding to
               the protection scheme used to $P_2$
24:        else
25:            $(p, q) = EPP$ (source of $s_j$, dest of $s_j$, $s_j$, rate,
               $invertFlag$)
26:            if $(p, q) \neq NULL$ then
27:                add $p$ to $P_1$
28:                add $q$ to $P_2$
29:            else
30:                $protectionPathFound \leftarrow$ false
31:                break
32:    add those links and trails that were removed in step 16
       and step 17 back to the graph
33:    if $protectionPathFound \neq$ true then
34:        continue;
35:    if $C(P_1, P_2) < C(P_w, P_p)$ then
36:        $(P_w, P_p) = (P_1, P_2)$
37:        $C(P_w, P_p) = C(P_1, P_2)$
38:        if $i = 1$ and there is no segment in the graph with
           any standard SDH protection scheme then
39:            return $(P_w, P_p)$
40:    if $C(P_w, P_p) \neq \infty$ and $C(p_i) > C(P_w, P_p)$ then
41:        return $(P_w, P_p)$
42: return $(P_w, P_p)$
```



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Algorithm 2 EPP(src,dst, $P_1$, rate, $invertFlag$)

for $(i, j)$ in $P_1$ do
    remove the directed edge $(i, j)$
    if $invertFlag$ = true then
        $C(j, i) \leftarrow -C(j, i)$
    else
        $C(j, i) \leftarrow 0$
$P_2$ = ShortestPath (src,dst,rate)
add the removed edges back to the graph and revert back
to the original weights for those edges for which the
weights were changed
if $P_2 = NULL$ then
    return $NULL$
Take the union of $P_1$ and $P_2$, remove from the union the
links and trails that are part of both $P_1$ and $P_2$ and then
group the remaining links and trails into $P$ and $Q$
return $(P, Q)$
```

IV. Implementation

Following are the motive of the implementation of dedicated path protection algorithm:

1) To improve bandwidth consumption as per requests.

2) Allows multiple requests to be generated to decrease wastage as in transport networks which have fixed leased lines and hence wastage of available resources.

There are some of the prerequisites which are as follows to develop the dedicated path protection.

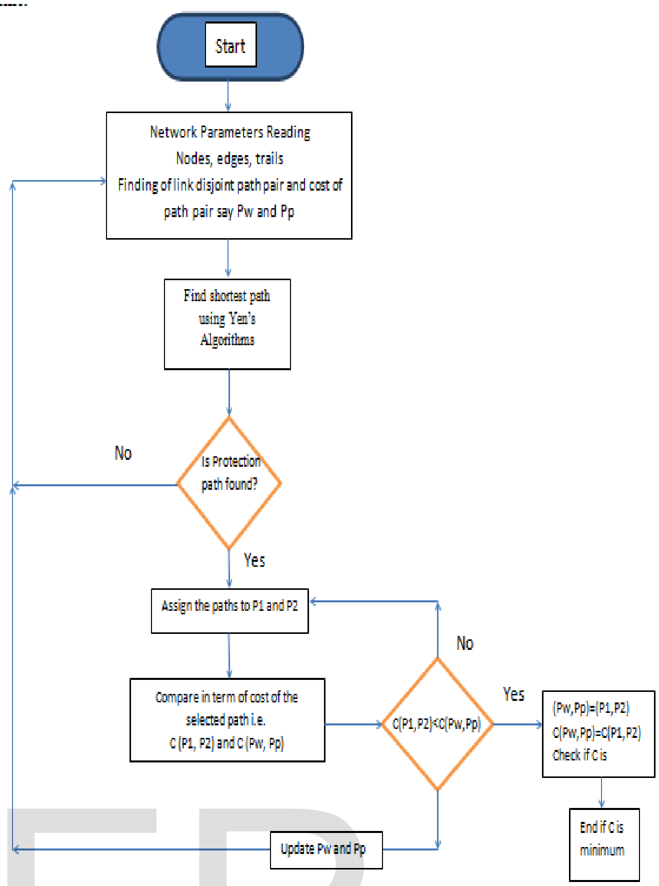
- If the network is considered as a simple graph of nodes and edges (Physical links and Logical trails) than the weight associated with each trail can be shown as following equation where is the weight associated with the trail , is the weight associated with the link , is set of links on the path through which the trail is established, is some value between 0 and 1, and * denotes multiplication.

$$w(t)=\alpha * \sum_{l\in L} w(l)$$

- For dynamic weight adjustment:

where is a number between 0 and 1 such that the weight of the trail is reduced when there is no need to break high rate containers.

$$w(t)=\beta * \alpha * \sum_{l\in L} w(l)$$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Assign the paths to P1 and P2
Compare in term of cost of the selected path i.e. C (P1, P2) and C (Pw, Pp)
C(P1,P2)<C(Pw,Pp)
No
Yes
(Pw,Pp)=(P1,P2)
C(Pw,Pp)=C(P1,P2)
Check if C is
End if C is minimum
Update Pw and Pp

4.2.1 Real time Network

Requests or calls originated and completed follows a random fashion, which would be difficult to predict before it actually occurs. Thus, in the given situation, there is a compulsory need for a real time network engine, which could process the calls/requests as per the present conditions. These conditions are discussed in upcoming sections.

The study of behavior of SONET/SDH in a standard network which uses 50 nodes (users) and 175 links (logical) connections were performed. A network operating Engine is designed which implements the call requests on real time basis. It can allow or reject or could keep in queue the coming requests at an instance.

4.2.2 Request generating system

Request generating system, created here is a key to initiate any request. This system helps in putting the call requests into the Engine. For simplification purpose of request generation, certain parameters were kept constant and predefined accordingly. However, on alpha basis, it allows to generate a request from any one node to any other node within the network limits. The request Source, Destination and the

Relative weight (Alpha) can only be varied within permissible ranges to be selected.

4.2.3 Analytic System

Analytics is one of the multi-dimensional disciplines. The insights from data are used to recommend action or to guide decision making. Thus, analytics is not so much concerned with individual analyses or analysis steps, but with the entire methodology, there is a pronounced tendency to use the term analytics in business settings e.g. text analytics vs. the more generic text mining to emphasize this broader perspective. There is an increase use of the term advanced analytics, typically used to describe the technical aspects of analytics, especially predictive modeling, machine learning techniques, and neural networks. Analytic system helps in judging current situation of the network. It works on many factors like: QoS, accepted and rejected no. Of requests, NOR generated v/s alpha, nor rejected v/s alpha, QoS v/s time, NOR generated v/s time, nor rejected v/s time, blocking probability v/s time (blocking probability is defined in terms of offered load and call arrival time), (NOR is number of requests).

4.2.4 Alpha (α)

Alpha is the relative weight assigned for a Virtual channel (VC) allotted for a particular voice or data communication. This value gives the amount of bandwidth to be used for creating a mutually independent channel within the SONET fiber.

4.2.5 Blocking Probability

Blocking probability (Madangopal et al.,2007) describes the probability of call losses for a group of identical parallel resources (telephone lines, circuits, traffic channels, or equivalent), sometimes referred to as an M/M/c/c queue. It is, for example, used to dimension a network's links. It describes a probability in a queuing system (albeit a special case with a number of servers but no queuing space for incoming calls to wait for a free server). Hence, the formula is also used in certain inventory systems with lost sales.

The formula applies under the condition that an unsuccessful call, because the line is busy, is not queued or retried, but instead really vanishes forever. It has been assumed that call attempts arrive following a Poisson process, so call arrival instants are independent. Further, it is assumed that the message lengths (holding times) are exponentially distributed (Markovian system), although the formula turns out to apply under general holding time distributions.

The Erlang B formula assumes an infinite population of sources (such as telephone subscribers), which jointly offer traffic to *N* servers (such as telephone lines). The rate expressing the frequency at that new calls arrive, λ, (birth rate, traffic intensity, etc.) is constant, and does not depend on the number of active sources. The total number of sources is assumed to be infinite. The Erlang B formula calculates the blocking probability of a buffer-less loss system, where a request that is not served immediately is aborted, causing that no requests become queued. Blocking occurs when a new request arrives at a time where all available servers are currently busy. The formula also assumes that blocked traffic is cleared and does not return.

The formula provides the GoS (grade of service) which is the probability P_b that a new call arriving to the resources group is rejected because all resources (servers, lines, circuits) are busy: $B(E, m)$ where E is the total offered traffic in Erlang, offered to m identical parallel resources (servers, communication channels, traffic lanes).

$$P_b = B(E,M) = \frac{\frac{E^m}{m!}}{\sum_{i=0}^{m}\frac{E^2}{i!}}$$

(1)

where:

- $P_b$is the probability of blocking
- m is the number of identical parallel resources such as servers, telephone lines, etc.
- E=λhis the normalised ingress load (offered traffic stated in Erlang).

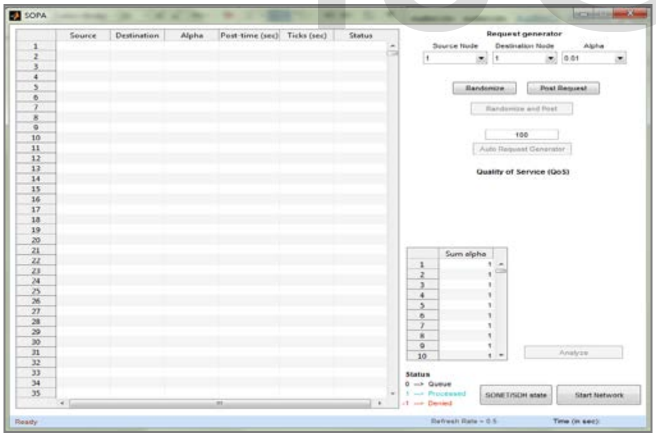
4.2.6 Quality of Service

Quality of service (QOS) (Mounir and Ouvry, 2005) is the overall performance of a network, particularly the performance seen by the users of the network. To quantitatively measure quality of service, several related aspects of the network service are often considered, such as error rates, bandwidth, throughput, transmission delay, availability, jitter, etc. Quality of service is particularly important for the transport of traffic with special requirements. In particular, much technology has been developed to allow computer networks to become as useful as telephone networks for audio conversations, as well as supporting new applications with even stricter service demands. Quality of service comprises requirements on all the aspects of a connection, such as service response time, loss, signal-to-noise ratio, crosstalk, echo, interrupts, frequency response, loudness levels, and so on. A subset of telephony QOS is grade of service (GOS) requirements, which comprises aspects of a connection relating to capacity and coverage of a network, for example guaranteed maximum blocking probability and outage probability.

In the field of computer networking and other packet switched telecommunication networks, the traffic engineering term refers to resource reservation control mechanisms rather than the achieved service quality. Quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. For example, a required bit rate, delay, jitter, packet dropping probability and/or bit error rate may be guaranteed. Quality of service guarantees are important if the network capacity is insufficient, especially for real-time streaming multimedia applications such as voice over IP, online games and IP-TV, since these often require fixed bit rate and are delay sensitive, and in networks where the capacity is a limited resource, for example in cellular data communication.

A network or protocol that supports QOS may agree on a traffic contract with the application software and reserve capacity in the network nodes, for example during a session establishment phase. During the session it may monitor the achieved level of performance, for example the data rate and delay, and dynamically control scheduling priorities in the network nodes. It may release the reserved capacity during a tear down phase.

A best-effort network or service does not support QoS. An alternative to complex QoS control mechanisms is to provide high quality communication over a best-effort network by over-provisioning the capacity so that it is sufficient for the expected peak traffic load. The resulting absence of network congestion eliminates the need for QOS mechanisms.



	Sum alpha
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1

Status
0 —> Queue
1 —> Processed
-1 —> Denied

Refresh Rate = 0.5
Time (in sec):

Fig. 3: MATLAB Network Engine for Dedicated path protection

Figure 3, shows a view for the working platform to apply the Network issues for the Dedicated Path protection and provisioning. At backend the network is created with automatic weight assignment which is based on the bandwidth and distances from the node and applied through dedicated path protection. The distance between the nodes also plays important role for the weight assignment and are implemented in the algorithm for dedicated path protection.

The Engine can be analyzed using the posting the requests and run the requests over the defined network. This point provides flexibility to check the processed requests and generation of requests. The Engine can directly implement on the real time network. The engine is providing good results for the advanced system design for networking of SONET/SDH Networks. The Network engine can be enhanced further using other implications for the Network design issues which effects the Network.

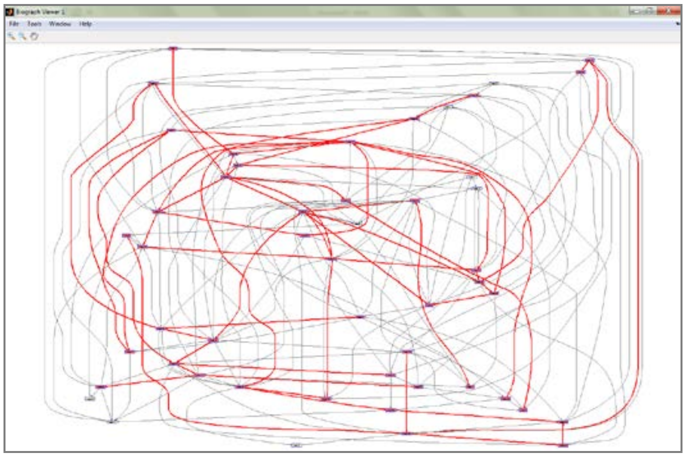


Fig. 4: A simple Network with connected and unconnected nodes using dedicated path protection

In Fig. 4, a network with 120 nodes has been shows with about 70 requests at a time. A Really important Backend parameter **"Refresh Rate"** is also available for view only to the system administrator, to check out the frequency or timeout of each request acceptance/denial.

IV. Results and Performance Analysis

In this paper, the algorithms have been proposed and implemented for dedicated path protection. The proposed algorithms are providing better throughput, blocking probability and optimization of bandwidth than other existing algorithms. Blocking probability is 0.2 for 10 nodes with 10 Erlangs traffic intensity and 0.3 for 60 nodes with 10 Erlang traffic intensity. Bandwidth Utilization is 75% for 10 nodes and 55% for 60 nodes at full load condition. Throughput is 1.4 x 10^{-5}Sec for 60 nodes and 0.6 x 10^{-5}Sec for 25 nodes.

A. Data Computation

1. Number of requests ***Accepted*** *and* ***Rejected*** *vs* ***Alpha***

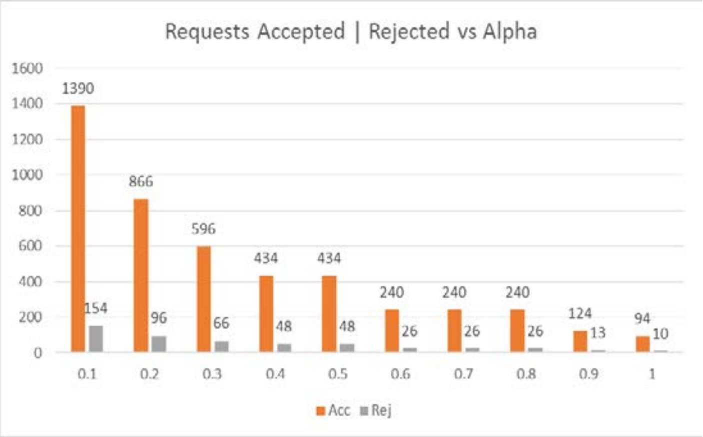


Fig. 5: Accepted and Rejected Requests Vs Alpha

2. ***Blocking Probability** vs **Time***

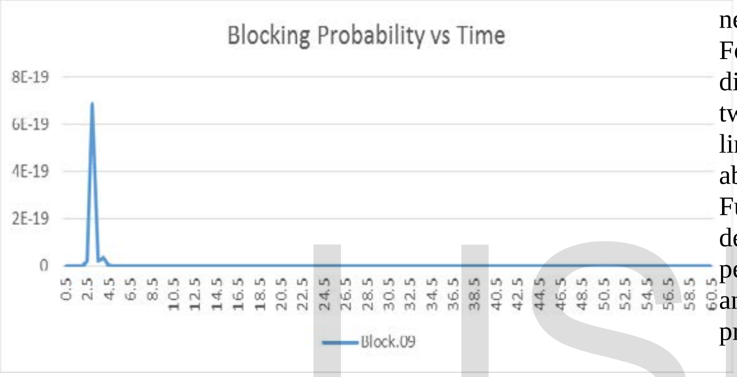


Fig. 6: Blocking Prob. Vs Time

3. ***QoS** vs **Time***

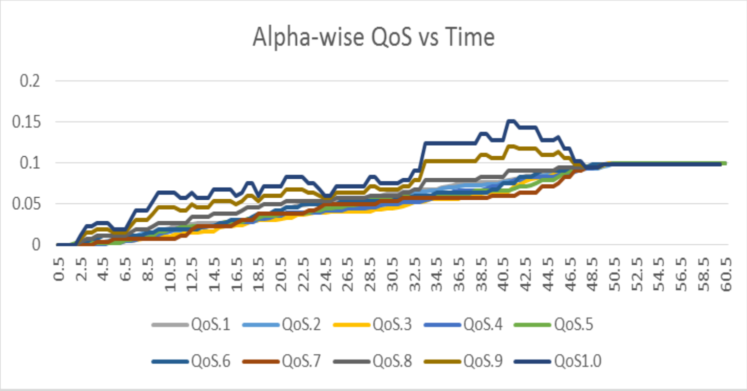


Fig. 7: QoS Vs Time

The number of accepted requests have been improved through our dedicated and shared algorithm. At alpha 0.1 the percentage of accepted number of request are 86% and bandwidth utilization is 25%. At alpha 0.5 the percentage of number of accepted request enhanced to 98% and bandwidth utilization is 32%. At last when alpha is 1 the percentage of number of accepted request enhanced to 95% and bandwidth utilization is 33%. Although in this fact the bandwidth utilization is not too much enhanced but no. of requests accepted provides a good Figure. Blocking probability with the presentalgorithm for shared protection is very nominal. The algorithm design suits for optical network completed with enhance factors and parameters discussed above.

V. Conclusion

The necessary features of advanced SONET that would overcome current limitation are discussed. The key point to realize traffic engineering and to incorporate smart functions such as dynamic bandwidth allocation and high bandwidth utilization are main points of effective path management. The scheme is to provide bandwidth guaranteed path and on disjoint path in order to guarantee, QoS as well as to balance network resource utilization. For this purpose reduced aware shared path protection was proposed based on sequential and parallel algorithms which would minimize the resource consumption is by choosing the shortest path and balance the network load by selecting the lightly loaded links. Bellman-Ford algorithm is modified by sequential algorithm to find two disjoint shortest paths one by one. The parallel algorithm finds two disjoint paths by expanding candidate paths to incident links with sufficient bandwidth. Simulation results verify the above algorithms function in normal as well as busy period. Further for dedicated path protection network engine is designed for optimization of bandwidth, QoS, and other performance parameters .The study is by far the first one to analyze the dynamic QoS path computation as well as protection for advanced SONET.

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