지능형 광 전달망에서의 on-demand 회선 생성 성능 분석 실험

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An Experiment on On-Demand Circuit Provisioning in SONET/SDH ASON Networks

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Abstract

In the SONET/SDH based ASON, one VC3 connection contains 21 VC12 calls. Hence, it can serve up to 21 VC12 calls. When a new VC12 call arrives, if there exists at least one available VC3 connection in the network, that VC12 call is severed immediately. However, if there is no available VC3 connection, that VC12 call has to wait a certain time, called setup latency, for the a new VC3 connection to be established. This is inconvenient for the customers. On the other hand, if there are more VC3 connections than the network requires, this can waste network resources. In this paper, we proposed the solution for these problems. In order to reduce the number of VC12 calls which have to wait, we setup a new VC3 before all VC12 time slots are occupied. Furthermore, to avoid the waste of the network resources, we do not establish all VC3 connections at the same time, but do establish step by step.

1. Introduction

In the SONET/SDH based ASON, a 10Gb trunk can accommodate up to 192 VC3 connections. In turn, each VC3 contains 21 VC12 time slots, hence, it can serve up to 21 VC12 calls. In current network architecture, when a first VC12 call arrives, we have to set up a new VC3 connection to serve it. When a second VC12 call arrives, it is served by the previously established VC3 connection. This process is continued until the 21nd VC12 call arrives. However, these actions lead to some problems when the 22nd VC12 call arrives. If there is no available VC3 connection at that time, we have to set up a new VC3 connection to serve that request. It takes a given time, called set up latency time, for that VC3 connection to be active and the 22nd VC12 call has to wait during that time. This latency time depends on the network devices, and we cannot reduce. This is inconvenient to the customers. On the other hand, if we already establish all VC3 connections in a 10Gb trunk, no VC 12 calls have to wait, but the network resource is wasted, because only a few VC3s are used at given time. Hence, the problem is how to minimize the percentage of VC12 calls which have to wait for a VC3 connection to be active while reducing the number of VC3 connections used at any time, or increasing the network utilization.

In this paper, we proposed a solution for the above problems. To avoid the number of VC12 calls which have to wait, we setup a new VC3 before all VC12 time slots in a given VC3 are occupied. Furthermore, to avoid the waste of network resource, we do not establish all VC3 connections at the same time, but do establish step by step. Whenever the total number of free VC12 time slots reaches a given value, we remove redundant VC3 connections. By simulation, we find the best combination values of when we setup a new VC3 connection and when we delete a redundant VC3 connection. With these values, the number of VC12 calls which have to wait is acceptable and the use of network resource, or the network utilization, is much higher compared with the case we setup all VC3 connections at the same time.

Our paper is organized as follow: in section 2, we present our proposed approach to solve the above problems. Section 3 shows our simulation results and finally, section 4 is our conclusion.

2. Proposed Approach

2.1 Minimizing the number of VC12 calls having to wait

It is certain that if we wait until all VC12 time slots in a VC3 are occupied, there will be no available VC12 time slot to serve the next VC12 call. As a result, that VC12 call has to wait. The solution for this problem is that we establish a new VC3 connection before all 21 VC12 time slots of that VC3 are occupied. But the question is when we set up a new VC3.

Let *TH* be the number of available VC12 time slots in a VC3 at which we establish a new VC3. *TH* is call threshold value. We have: $0 < TH \leqq 21$. Obviously, the larger the number value of *TH*, the smaller the number of VC12 calls having to wait. However, if *TH* is larger than the requirement of the network at given time, this also waste the network resources, or the network utilization is low. On the other hand, if *TH* is so small, the number of VC12 calls which have to wait is still so high. Therefore, the problem is how to find the best value of *TH* at which the number of VC12 calls have to wait and the utilization of the network is resonable.

In this paper, we find the best value of *TH* by simulation.

2.2 Increasing the network utilization

We also have to remove VC3 connections when the number of available VC12 time slots exceeds a certain value to keep network utilization as high as possible. This value is called as *TH_deletion* and we find it by simulation.

In this paper, we find the best values of both *TH* and *TH_deletion*. The objective is to optimize the network utilization and the number of VC12 calls which have to wait for a new VC3 connection to be established.

3. Simulation analysis

In this section, we will present our simulation analysis result. Our simulation is done under certain assumptions: (1) The arrival rate is assumed to follow Poisson distribution, (2) the service time is assumed to follow Exponential distribution, and (3) if a VC12 call arrives but no VC12 time slot in a VC3 is available, it will wait until one free VC12 time slot is available.

In our simulation, we have to change the values of arrival rate and service rate. In each pair of arrival rate and the service rate, we find the best value of *TH* and *TH_deletion*. Another parameter needs be considered is set up latency time. It depends on the network devices and we cannot reduce. In our simulation, we deal with three values of latency time: 1s, 2s, and 3s.

3.1 Finding the best value of TH

Because the range of *TH* is $0 < TH \leq 21$, by simulation, we run for this range and choose the best one.

3.2 Finding the best value of TH_deletion

The value of *TH_deletion* must satisfy the condition that if we delete one. VC3 connection, there should be enough free VC12 time slots not to trigger instant VC3 connection creation. It means *TH_deletion* must be greater than 21 + *TH*.

In our proposed approach, we set up and remove VC3 connections gradually. We call this 'dynamic case'. In the case that all VC3 connections are established at first time, we call this 'static case'. With each four-value of (*TH*, *TH_deletion*, arrival rate, service rate), we calculate the percentage of delayed VC12 calls. Further, we compare the network utilization of the dynamic case with that of static case. The following figures shows our simulation results.

From the simulation results, we see that: the best value of (*TH*; *TH_deletion*) pair is *TH* = 2 and *TH_deletion* = 26. Further, we have following notifications:

1. Optimal threshold condition (criterion : 99.9% of all VC12 calls are not delayed)
   * latency time 1, arrival rate 1, service rate 0.05 : TH_opt = 2, Utilization_Static = 38.9%, Utilization_Dynamic = 54.99% (*Fig 1, Fig 2*)
   * latency time 1, arrival rate 1, service rate 0.005 : TH_opt = 2, Utilization_Static = 75.9%, Utilization_Dynamic = 93.41% (*Fig 3, Fig 4*)
   * latency time 2, arrival rate 1, service rate 0.05 : TH_opt = 3, Utilization_Static = 34.1%, Utilization_Dynamic = 53% (*Fig 5, Fig 6*)
   * latency time 2, arrival rate 1, service rate 0.005 : TH_opt = 3, Utilization_Static = 76%, Utilization_Dynamic = 93.1% (*Fig 7, Fig 8*)
   * latency time 3, arrival rate 1, service rate 0.05 : TH_opt = 4, Utilization_Static = 32.6%, Utilization_Dynamic = 51.6% (*Fig 9, Fig 10*)
   * latency time 3, arrival rate 1, service rate 0.005 : TH_opt = 4, Utilization_Static = 75.4%, Utilization_Dynamic = 92.7% (*Fig 11, Fig 12*)
2. Optimal threshold value is almost independent of traffic load condition.
3. When traffic load increases, our simulation shows lower number of delayed calls. Is

it contradictory? No, that is because our simulation is to find optimal threshold values of *TH* and *TH_deletion* while minimizing the number of delayed calls, and maximizing network utilization. The number of delayed call is related with fluctuation of VC3 connections. Even though the traffic load is low, it can trigger frequent VC3 connection setups and removals, so it can cause a lot of delayed calls.

4. We have to find the *TH* value as small as possible to maximize network utilization. We can decrease the number of delayed calls when we increase *TH* value (tradeoff condition).
5. When we do not use dynamic VC3 setup method (static case), the network utilization gets worse about 15% ~ 20%.

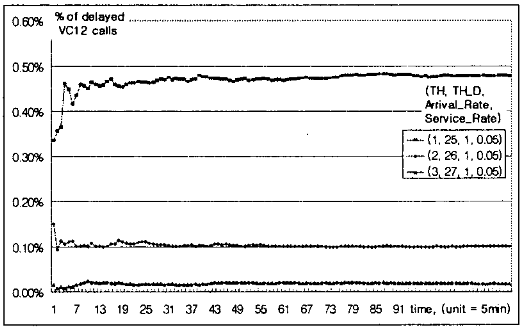

Fig 1. The percentage of delayed VC12 calls vs. time VC3 setup latency time = 1 sec, service_rate = 0.05

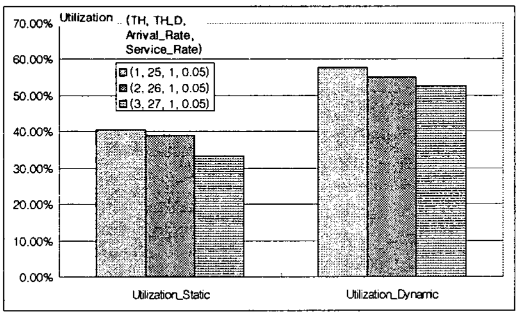

Fig 2. The network utilization VC3 setup latency time = 1 sec. service_rate = 0.05

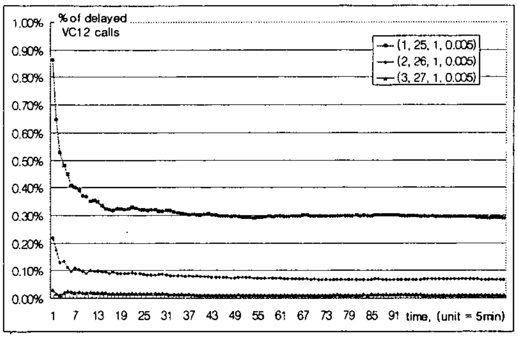

Fig 3. The percentage of delayed VC12 calls vs. time VC3 setup latency time = 1 sec, service_rate = 0.005

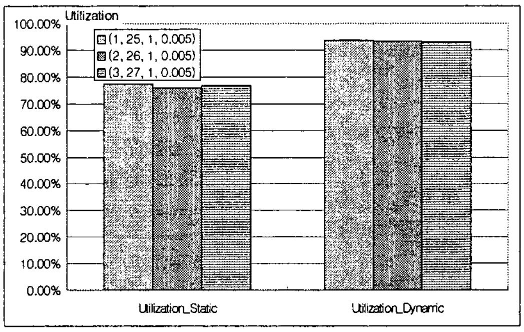

Fig 4. The network utilization VC3 setup latency time = 1 sec. service_rate = 0.005

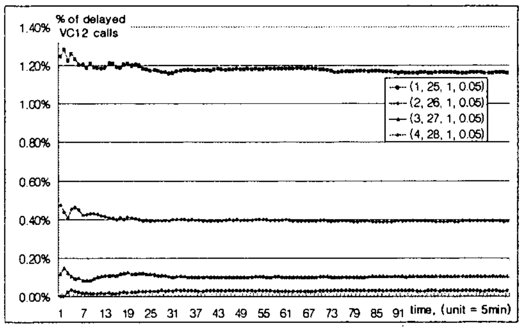

Fig 5. The percentage of delayed VC12 calls vs. time VC3 setup latency time = 2 sec, service_rate = 0.05

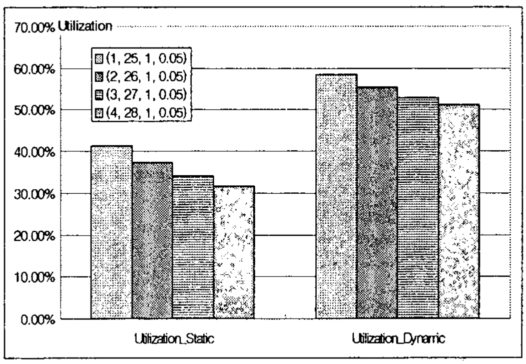

Fig 6. The network utilization VC3 setup latency time = 2 sec. service_rate = 0.05

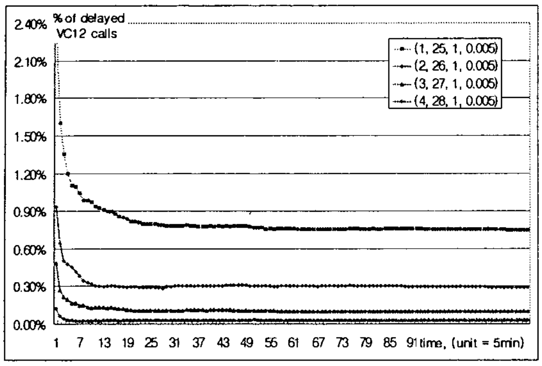

Fig 7. The percentage of delayed VC12 calls vs. time VC3 setup latency time = 2 sec, service_rate = 0.005

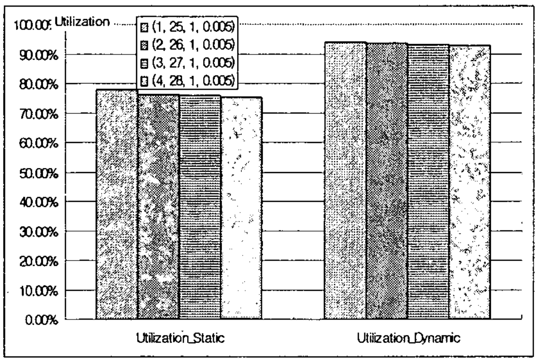

Fig 8. The network utilization VC3 setup latency time = 2 sec. service_rate = 0.005

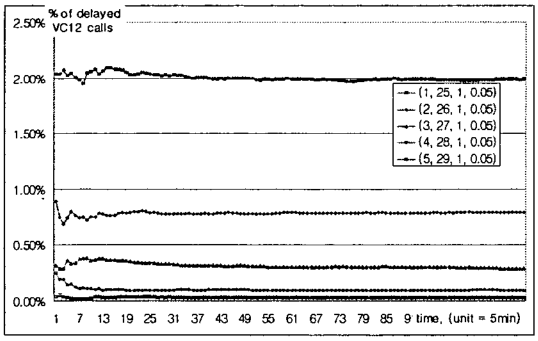

Fig 9. The percentage of delayed VC12 calls vs. time VC3 setup latency time = 3 sec, service_rate = 0.05

4. Conclusion

The problem in the real network is that the number of VC12 calls which have to wait for a new VC3 connection is quite high. In addition, in the case that all VC3 connections are established at the first time, the utilization of the network is very low. In this paper, we propose a solution to reduce the number of delayed VC12 calls. Further, we also propose a

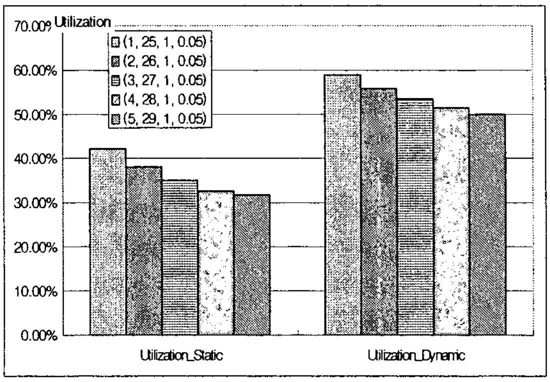

Fig 10. The network utilization VC3 setup latency time = 3 sec. service_rate = 0.05

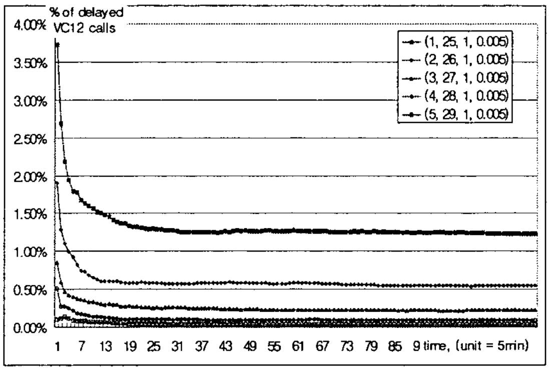

Fig 11. The percentage of delayed VC12 calls vs. time VC3 setup latency time = 3 sec, service_rate = 0.005

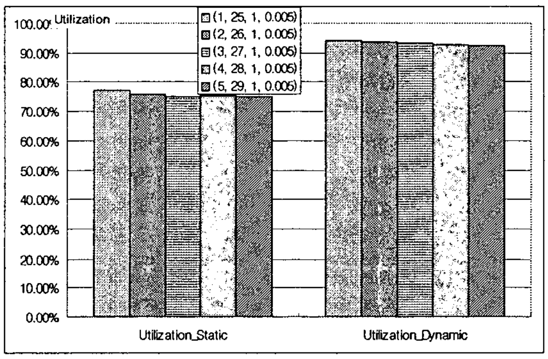

Fig 12.. The network utilization VC3 setup latency time = 3 sec. service_rate = 0.005

solution to improve the network utilization. Finally, by simulation, we find the best value of *TH* and *TH_deletion* considering the number of delayed VC12 calls and the network utilization.