

# Network Dimensioning Methodology in Packet-Optical Transport Network

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**Abstract—** Packet-Optical Transport Network (POTN) technologies and architectures integrate the functional switching capability of WDM wavelengths, Ethernet via various protocols, OTN/ODU as well as TDM. From a telecommunication service provider's view, it is a great advantage to replace various multiple-layer network equipment with the unified equipment using POTN technologies. On the other hand, it is a drawback to increase the complexity to operate highly-integrated equipment and to manage the network fluently. In this paper, we investigate considerations for dimensioning POTN and then we design the POTN Dimensioning System to reduce our operation and configuration complexities. Finally we suggest the result of network capacity in POTN through a test network dimensioning.

**Keywords—** Packet-Optic Transport Network (POTN); Network Dimensioning; Packet Transport Network (PTN); Optic Transport Network (OTN);

## I. INTRODUCTION

Recently wired or mobile broadband network has been spread all around the world and also the internet traffic using IPTV, smart TV or smart pad has been increased rapidly. However telecommunication service providers' sales have been tied up for a few years. Therefore telecommunication service providers have searched for the technologies to reduce network CAPEX (CAPital EXpenditure) or OPEX (OPERational EXpenditure). POTN is one of the technologies which telecommunication service providers have been searching for. Packet-Optical Transport Network (POTN) technologies and architectures integrate the functional switching capability of WDM wavelengths, Ethernet via various protocols, OTN (Optical Transport Network) as well as TDM. From a telecommunication service provider's view, it is a great advantage to replace various multiple-layer network equipment with the unified equipment using POTN technologies. Unifying network equipment means that we can lower OPEX such as network equipment's costs, network operators' personnel expenses, network operators' training costs and so on. Additionally POTN technologies enable more efficient transportation of the traffic using packet-based switching [1] or 2.5/1.25G-based optical switching [2]. On the other hand, it is a drawback to increase the complexity to operate highly-

integrated equipment and to manage the network fluently. For example, the current IP infra network consists of layer 3 routers, layer 2 switches or Ethernet equipment, layer 0/1 optical transport equipment etc. and therefore the current IP infra network operators can only manage a specific layer network equipment and they have less burden to acquire the technologies and operational knowledge. However if POTN equipment is introduced and it is integrated with function on the all packet/circuit/optic layers, POTN operators should learn all network information from Ethernet to optical transport layer and they should always consider all layers' situations to operate and manage the network. It makes more difficult for network operators to be experts than before. Additionally POTN technologies are just in market introduction stages and thus backbone network providers can have more risks in introducing the technologies than others. The backbone network providers usually use multi-vendor's products to construct their networks and it can guarantee higher stability of the network. But now it is not sure that POTN vendor's products are compatible with each other. In according to this situation, there is little research about network dimensioning methodology in POTN which can be applicable to a backbone network.

Network dimensioning process in POTN is as follows: First of all, we need to categorize the services to be accommodated in the target POTN. We can categorize the services according to a service type, service port, end-to-end service path, the end node etc. For example, they can be such as the Internet, TDM, IPTV channel, voice over IP. Secondly, we need to calculate the network capacities of each service. The network capacities must be predicted for the next specific time at which POTN will be in service. The prediction algorithm can refer to the services' growth patterns or the future traffic trends. Thirdly, we make two routing paths for the traffic transportation. The two routing paths will be the normal path and the protection path for the traffic. When we choose these paths, we should consider source node, end node, service's survivability level, physically separated two paths etc. Finally, we calculate network capacity according to the network dimensioning rules. The dimensioning rules include PTN or OTN mapping rules.

In this paper, we investigate considerations for dimensioning POTN and then we design the POTN Dimensioning System which can process four stages of the dimensioning automatically. Finally we suggest the POTN

dimensioning result using the system. Among four stages of the dimensioning process, the first and the second ones depend on the target network characteristics deeply. Therefore we will not refer to the first and second ones anymore and we will focus on the third and the fourth stages. For the simulation, we assume that end-to-end traffic is distributed randomly.

## II. CONSIDERATIONS FOR POTN DIMENSIONING

We need to consider many aspects to design POTN architecture including the expenses. In other words, we need to establish the dimensioning rules in consideration of both the expenses and the network management efficiency, operational convenience. For example, if we just focus on minimizing bandwidth, we design the network only in direction of increasing fill rate of the output interfaces and as a result, the total configuration of the network will be more complex. If there are two services and the first one is 5Gbps and the other is 3Gbps, we can assign one 10G interface for both of them. However if the first one will be increased to 8G after 6 months, we have better assign the whole 10G interface only for the first one, which can be useful for us to establish much more simple network. Now, we categorize three aspects to be considered as follows:

### A. Minimizing Network Bandwidth

The circuit network must use the whole output interface for a traffic although the traffic cannot be reached to the maximum volume of the interface. However we can share an interface with more than two type of traffic using PTN switching as a unit of packets or OTN switching as a unit of 2.5/1.25Gbps. Therefore we need to suggest the dimensioning rules to apply for PTN or OTN.

### B. Minimizing Switching Volume

POTN can enhance network efficiency using PTN or OTN switching. However it can be the reason of high introduction expenses. More specifically, WDM card is cheaper than PTN or OTN switching card and thus we need to check the traffic whether it will be better to be transported by WDM than to be transported by PTN or OTN. Additionally, PTN or OTN configurations are more complex than WDM configurations and thus, we need to be careful to choose the PTN/OTN assigning rules. We can refer to, for example, the future traffic trend, traffic volumes, the unit of output interface, basic PTN/OTN switching capability of the equipment etc.

### C. Considering of Management Efficiency

Because POTN is an integrated architecture with packet, circuit and optical network, as a natural consequence the operational complexity of POTN is very high. Therefore we also need to consider operational efficiency in dimensioning of POTN. It can be profitable for some traffic to assign to WDM instead of PTN or OTN switching. Moreover, we maybe need to separate the interfaces for traffics which should be adjusted for the different protection scheme or should be handled differently because of some operational issues.

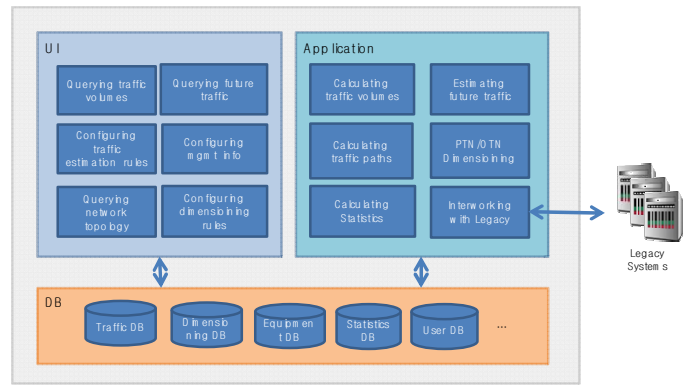


Fig. 1. POTN Dimensioning System Block Diagram

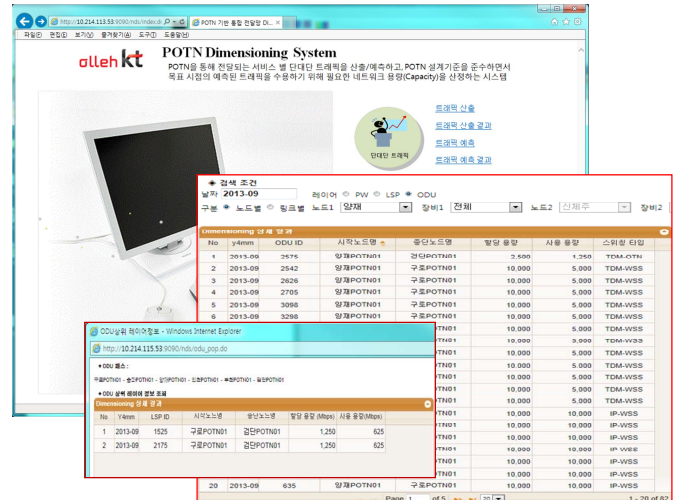


Fig. 2. POTN Dimensioning System UI

## III. POTN DIMENSIONING SYSTEM

To design a new network, we need a simulation tool to change some parameters automatically and compare their results. With this tool, we can reduce some expenses and mistakes in optimizing a new network. In this section, we design the architecture of POTN dimensioning system to simulate some parameters, for example, the equipment's functions (the support of ODU flex etc.), transportation paths for some services, a network topology (ring/mesh/complex) etc.

The Fig. 1 shows us the block diagram of POTN dimensioning system. The system consists of Application part, UI part and DB part. The application part are composed of the interworking part with legacy systems, the current traffic volume calculation part, the future traffic volume calculation part, the traffic path calculation part, the PTN/OTN dimensioning part, the statistics calculation part. The interworking part with legacy systems connects to the legacy systems related with the services' traffic and obtains the information to be used for calculation of current traffic volumes. The calculation parts of service traffic and future traffic volumes convert the traffic information obtained from the interworking part to the traffic information suitable for the POTN architecture. And then, they estimate future traffic volumes in a specific time which will be the start time of POTN service. The traffic path calculation part creates the

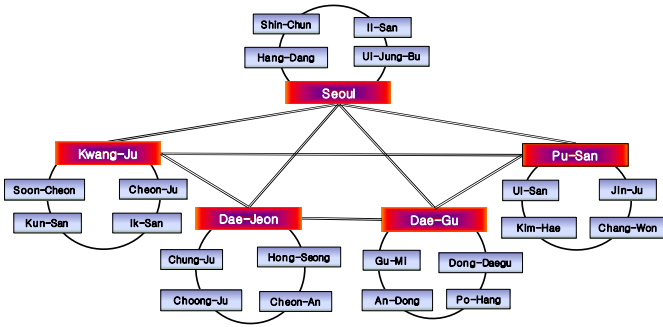


Fig. 3. Network Topology for Simulations

TABLE I. The Distribution of END-2-END Traffic

Volumes	Internet (number)	TDM (number)
1G~2.5G	617	596
2.5G~5G	603	675
5G~7.5G	585	592
7.5G~10G	645	587

services' working and protection paths using modified Dijkstra's algorithm which has two parameters, the distance of the nodes and hop counts. The modified Dijkstra's algorithm searches the separated two paths for the high survivability of the services. It means that the two paths never have any sharing node at all. For example, in the ring topology the algorithm chooses Dijkstra's shortest path for the working path and then it chooses the opposite direction of the path for the protection path. The dimensioning part of PTN/OTN makes PTN/OTN configurations for the traffic and calculates the total network capability. The statistics calculation part creates useful statistics for users. In UI part, there are many functions for users to query the estimated traffic's volumes, configurations of PTN/OTN layers and the total network capability. Fig. 2 shows the UI for querying specific OTN mapping information.

#### IV. SIMULATION

As I explained in the previous section, we can simulate the various network designs with the POTN dimensioning system. In this section, we will look into the simulation result of the network dimensioning according to the various POTN configurations and we also will guess the optimal dimensioning scheme.

The network topology for a simulation is as like the Fig. 3. In the topology, 5 big cities are connected to each other in shape of partially meshes and the 5 big cities have their own ring type of connection to four regional cities. And each of cities has two service edge nodes which are hidden in the figure. All users for services can be connected to the two service edges. The links of the regional ring are connected as a unit of 10Gbps and the links among the big cities are connected as a unit of 100Gbps.

The traffic between nodes is created randomly between 1Gbps and 10Gbps. If operators want to the special type of traffic

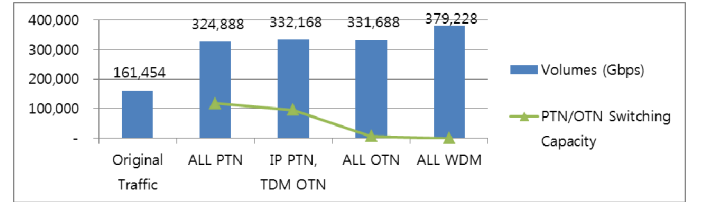


Fig. 4. POTN Dimensioning Results of Simulations

simulation such as Hub & Spoke type, you can use other special traffic generation function instead of random. We limit the services only to two types which are Internet and TDM. We maybe include IPTV channel service or voice over IP for the simulation. However IPTV or voice over IP service needs its service center and it can be the service provider's dependent data. And thus, we judge that it is inappropriate for this simulation. We assume that Internet and TDM End-to-End traffic will be randomly distributed for the simulation. The generated traffic is as like TABLE I. In this table, we can see that traffics are randomly distributed. The total number of the generated traffics including Internet and TDM is 4,900.

In this simulation, we compare the differences of network capability and network switching volumes about four scenarios of network dimensioning. They are as follows: The first scenario is that all services are assigned to PTN, the second scenario is that Internet is assigned to PTN and TDM is assigned to OTN, the third scenario is that all services are assigned to OTN and the last scenario is that all services are assigned to WDM. The first one uses the most amounts of PTN switching capability among the four scenarios and it can expect high efficiency of the network bandwidth. The second one separates network dimensioning scheme for each of the services and it can expect high management efficiency; for example, in the second scenario, we can apply different protection schemes or routing schemes for INTERNET and TDM. The third scenario needs the most amounts of OTN switching capability among the four scenarios and it will be good solutions in case that most of the services' traffic volumes are bigger than 2.5/1.25Gbps and PTN module is more expensive than OTN module. The last scenario uses no PTN and OTN switching and it will be good solution in case that the services' volumes are big enough to fill the unit of interface. With the above four scenario, we obtained the result as like Fig. 4.

We can reach four conclusions from the Fig. 4. First, we can see that the first, the second and the third scenarios have an effect of saving 30% bandwidths. The WDM cannot use the network bandwidth effectively and it will need more network capability for building a same size of network. However the last scenario do not need PTN/OTN costs and thus, the total network cost should be considered with the PTN/PTN switching module introduction costs and the network bandwidth costs. Second, although the bandwidth differences of the first, second and third scenarios are too small to be compared, we can see that the second scenario needs the most amount of network bandwidth among the four scenarios. It will be explained that the simulation traffic data is below 10Gbps

and unit of output interface is 10Gbps and thus unifying the dimensioning scheme of Internet and TDM service have advantage to fill the output interface up to 10Gbps. If we use different type of traffic pattern for a simulation such as over 10Gbps traffic for simulation or more Internet traffic than TDM, we will see different results of dimensioning. Therefore, we can conclude that we need to choose an appropriate dimensioning method in according to the traffic patterns and volumes. Third, we can see that PTN/OTN switching capability is in inverse proportion to total network bandwidth. It means that PTN/OTN switching helps enhancing the efficiency of the network resource management. Both the first scenario and the third scenario use the least network bandwidth among four. In this result, the third scenario shows more reduction of switch capacity than the first scenario. It is because the PTN's unit of treatment is different from that of OTN. PTN treats a packet as a unit of transportation and it means that even more 9Giga traffic can be treated on PTN layer. However, OTN treats 2.5/1.25Giga traffic as a unit of transport and then more 8.25Giga traffic should be treated on WDM layer. As a result, the third scenario needs too less switching capacity than the first scenario. Lastly, there is no big difference of bandwidth between the first and the third scenarios. In the theory, PTN treats traffic as a unit of packet and thus PTN usually can be more efficient way of treating network resources than OTN. However in this simulation, there are too little difference between the first and the third scenarios and it seems a little strange. It can be explained that the simulation data is generated between 1G and 10G and the data makes PTN

switching effect weak. If there are more simulation data under 1G, the result will show that the first scenario need absolutely less network bandwidth than the first one.

This simulation results shows us that the dimensioning is too much complicated work and we need to consider many aspects for building a successful optimized network. The real network is more complicated and thus, we need to apply various routing schemes, designing rules when dimensioning.

## V. CONCLUSION

In this paper, we investigated considerations for POTN dimensioning and then we designed POTN dimensioning system to reduce our operation/configuration complexity. Additionally, we simulated four scenarios of POTN network using the POTN dimensioning system. The simulation results show that we should need to consider data patterns, network topology and designing rules when dimensioning a new network. In the future research, we need to research more items for optimizing network dimensioning and need to enhance the simulation functions of POTN dimensioning system for more various simulations.

## REFERENCES

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