Whitepaper

The impact of FTTH network architectures on the efficient use of active equipment

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Introduction:

I did touch this subject about 5 years ago but I felt the subject needed an update based on newer experiences but above all, price points mentioned in a previous version did evolve dramatically and it has an impact on the overall result. Read: prices of OLT cards have dropped so why would you still save on active equipment? Well today you might install GPON line cards whose prices have decreased over the last few years but tomorrow one might want to upgrade directly to the latest generation like NG-PON2 line cards which come at a higher price. So, a saving today will be a saving tomorrow and will repeat every few years as transmission equipment generations develop fast. It is not only about CAPEX on the first day, but also about the OPEX over the next 50 years. Let's not forget that the previous network based on copper wires lasted for a century, obviously with upgrades and the addition of fibre as a long stretched lifeline.

When deploying a passive optical network (PON), the FTTH network architecture chosen directly affects the cost of active equipment. Placement of optical splitters in the architecture plays a particularly important role. The size of the customer base served from the last splitter point influences the utilization rate of the optical line terminal (OLT) equipment in the central office or POP (Point of presence).

Most operators around the world use the term "take rate", as this is indeed the most important KPI to measure the return on investment (RoI). The more paying customers on the network, the faster the revenues cover the investment cost and creates profits. Take rate is the amount of paying customers ("homes connected"), divided by the number of potential customers that you build the network for ("Homes Passed").
To improve the ROI, I introduce an additional measure to validate how efficiently we use the active equipment in the network: "utilization rate". Utilization rate (UR) is the (average) percentage of active customers on an OLT port per total number of customers that could potentially be served from that OLT port.
Why is this important? OLT ports are expensive. Not using the equipment's maximum capacity drains CAPEX when take rates are low(er). Active equipment occupies expensive floor space and requires power and cooling even when not serving a revenue-generating customer**. Finally, active ports become obsolete every three to five years. When migrating to the latest generation of active equipment, unused capacity will be replaced with new unused capacity, further wasting CAPEX. This is an endless cycle that can be embedded in the network build by not taking the measure into account when planning a network build.

TAKE RATE = $\frac{\text{Number of homes connected}}{\text{Number of homes passed}}$ **%**

UTILIZATION RATE = $\frac{\text{Number of paying customers}}{\text{Number of OLT ports x 64*}}$ **%**

**Can be 32 in some constructions but generally it is 64*
***These expenses are operational expenses(OPEX). Paying OPEX for non paying customers, is a nightmare to each efficient operational dream.*

In general, FTTH network deployments with take rates between 25 and 40-percent are considered profitable. Many factors determine profitability, but it is mainly driven by the CAPEX spent to build the network, which in turn depends on factors such as:

- Population density
- SFU versus MDU
- Aerial versus buried infrastructure
- Distances from central office
- Ability to reuse existing infrastructure such as ducts and poles
- Required amount of new civil works and the related hourly labor rates
- Right of way costs
- Etcetera

When deploying a PON architecture, several active and paying customers will be grouped on a single fibre that is in turn connected to a fibre coming from the central office or POP. This is done by using passive splitters that separate traffic from the CO (downstream traffic) to individual connected customers and merge all upstream traffic from different customers into the single fibre leading back to the central office. All this traffic is managed through time domain multiplexing technology, whereby up and downstream time slots are dedicated to each customer. Most often, this can be managed dynamically. In the central office/POP site an OLT manages the traffic to and from the customers connected to this OLT port. Typically, these ports can manage data traffic for up to 64 customers. At the customer side, typically inside the premises, an ONT (Optical Network Terminal) receives the downstream traffic from and sends the upstream traffic to the OLT.

With this in mind, let's consider a term much less defined in literature and architecture descriptions—the Utilization Rate (UR) of the transmission equipment. The utilization rate can be defined as the number of active customers per number of OLT ports multiplied by the OLT's capacity to serve different customers from a single port (typically 64). This number can be influenced easily by altering the PON network architecture, but we will address that soon.
In most cases, utilization rate and take rate are not the same and, as a percentage, can be very close or far apart . This has a significant impact on the network's total cost of ownership.

Currently, the per port cost of an OLT line card serving 64 customers per port is between $500 and $1000 (USD) when deployed in large volumes. The variation arises from the generation of transmission equipment (PON, GPON, XGPON, NG-PON2) used, the class of laser integrated, the services integrated to run over the network, the competitive landscape of the market space, etc. If the utilization rate is 100-percent, i.e. all customers connected to an OLT port are active/paying customers, the investment runs at the highest possible rate of return. This means that the operator invested CAPEX for the equipment of $8 to $16 (USD) per customer (the port price / 64). Same is valued for optimizing OPEX.

If the utilization rate is 10-percent, i.e. only 6 customers are active on an OLT port, the relative cost per customer will be eight times higher -- ranging between $64 and $128 (USD) per customer. This significantly impacts the total CAPEX spend per customer in a deployment. And for that reason, should more often be a topic for optimization. Though rarely considered, the payback times of the network deployment can be substantially influenced by low utilization rates.

It is tempting to blame low utilization rates on lower take rates – but the outside plant architecture, and in particular the placement of splitters in that network, actually drives the utilization rate of the electronics in central offices and POP locations. To better understand this, let us examine two extreme examples.

Example 1:

The example described here is one which is actually being built as this update is being written. In this architecture the operator decided to have the 1:32 splitter very close to the customer. The splitter serves on average 26 customers as 6 splitter ports are considered spare to serve future requirements of additional homes that could arise in the cluster. The cluster is defined as the amount of homes that are grouped together in the architecture. In this example, the splitter installed serves a cluster of 26 homes. Let's assume a take rate of 25% per cluster. This equals a rounded value of 7 paying customers per cluster of 26 homes passed.

The utilization rate achieved by this architecture and take rate is shown below. The only reason why take rate and utilization in this example rate are different is because of the spare capacity which is foreseen.

TR = 25%   UR = 7/32 = 22%

- Splitters close to customer reduce the UR
- Splitters close to the customer optimize fibre utilization (includes effects of digging distance, amount of splices)
- OLT port investment is a regularly recurring cost (replaced every 2 to 5 years)
- Splitters placed close to the customer resulting in
- Decreased utilization rate of active OLT ports in CO results in poor utilization of power, cooling and real estate

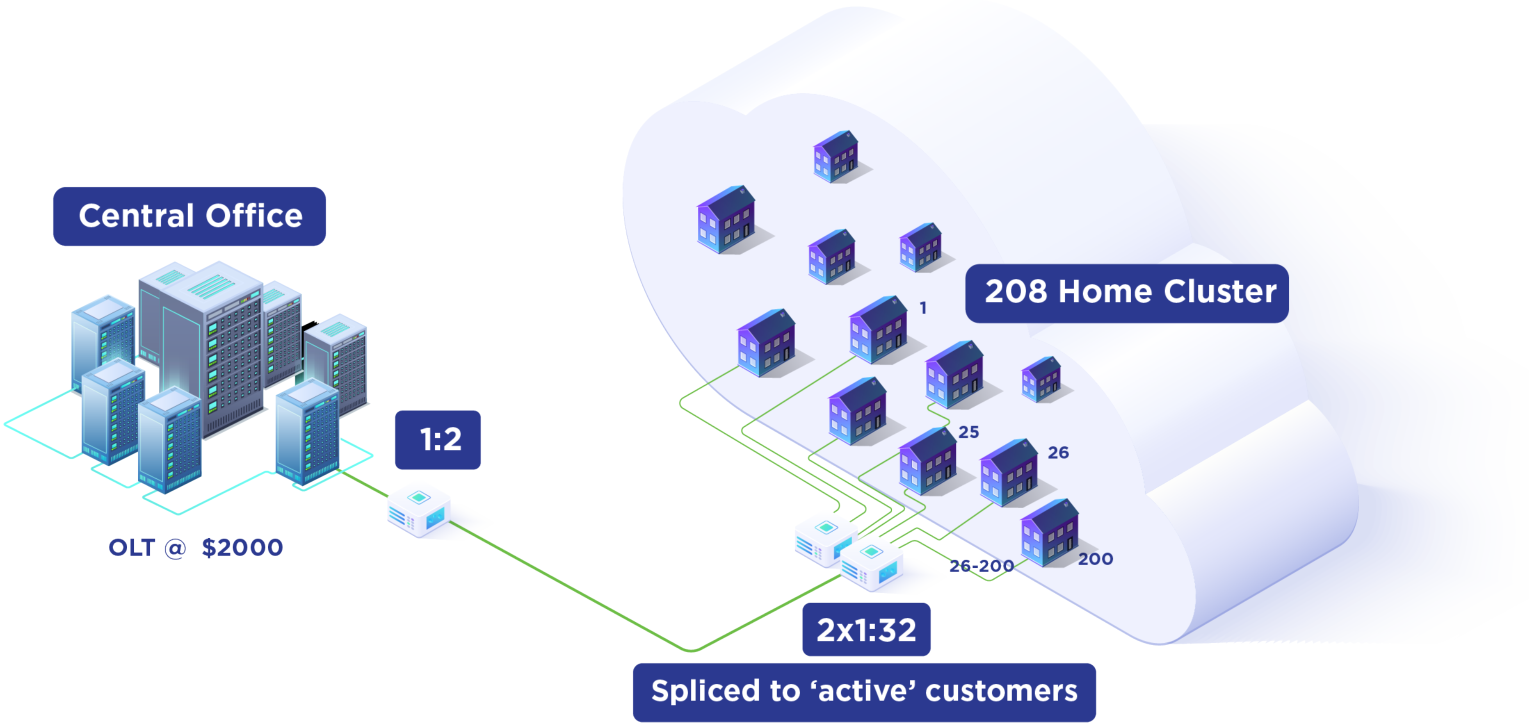
If for this example we assume a fixed TR of 25-percent; for every splitter closure including multiple 1:32 splitters, are spliced to multiple terminals that serve the cluster of 26. As all the terminal ports are spliced to the splitter ports, the utilization rate will always be linked to the take rate in the same dependence as calculated above. Now by fixed splicing of the splitter fibres to the customer ports in the terminals at construction of the network, it locks down the OLT port to these 26 potential customers from which seven only taking service. This means that 78% of the OLT capacity remains unused forever and can only be improved by increasing the take rate. Take rate however is linked to the commercial success, not to the efficiency of the network build.

When the network's take rate and utilization rate are almost the same, the effective OLT cost per customer is about 5 times higher than if the utilization rate would equal 100-percent. In this example, the real OLT cost per customer is not the 8-16 dollars expected but five-fold higher at 40 - 80 dollars per customer as 78% of the capacity is idle but paid for.

Example 2

Taking the same network cluster size and take rate as in Example 1, let's examine the results of changing how the splitters are connected to the terminal ports. By not having the splitters dedicated with a fixed splice to ports in the terminals, but by dedicating an activated splitter fibre (which means it is connected to an active OLT) only to the customers that take service on the network, one would remove a vast amount of OLT cards and ports. In reality if a more centralized splitter point is used that consolidates for example 8 clusters of example 1 in one single cluster of 208 homes passed.
As we consider the take rate and thus the commercial success as fixed, having a take rate of 25%, it would mean that 52 customers are paying customers in this enlarged cluster of 208 homes passed. As we would have to dedicate only 2 splitters, 32 ports each, to serve these 52 customers we would only need to fire up 2 OLT ports to serve all these 52 customers compared to 10 OLT ports in example 1. This results in a much better utilization of the OLT capacity. 52 customers served by a capacity of 64 drives up the utilization from 22% to 82%. So in the second example, we only waste 18% of OLT capacity compared to 78% capacity waste in the first example.

The utilization rate achieved by this architecture and take rate is shown below:



Overall cluster size = 208 1:32 splitter per sub-cluster TR = 25% → UR = 81%

- Splitters serving larger clusters of customers, and connecting the splitter to the customer on activation reduces the amount of activated OLT ports.
- Improves OLT port investment as a regularly recurring cost (replaced every 2 to 5 years)
- The biggest drawback to implement the improved utilization rate is that the splitter needs to be connected to the customer fibre on the activation of the customer. This comes with increased truck rolls and related costs that need to be balanced with the benefits.

Compared to Example 1, the utilization of active equipment improves by a factor of almost four (370-percent to be accurate). Therefore, the real cost of electronics per customer drops from a range between $40 and $80 USD, to $10 to $20 USD. Of course, in this architecture, more splice work is required and balances the savings on the active equipment.

These examples clearly demonstrate that the OSP architecture significantly influences central office costs and in the initial planning phases of PON deployments, operators should balance both costs carefully. Obviously the take rate is critical in the overall business case of a network deployment as this will determine the overall revenue stream generated, but optimizing the utilization rate will reduce CAPEX, OPEX and improve payback time.

Optimizing the utilization rate means optimizing the location of the splitters in a defined cluster size. Take rate targets are important for an overall business case, but market success, indicated by take rate, should not be fixed in a physical architecture. The architecture must be flexible enough to readily adapt to new technologies, new services and customer churn. We recommend a fully loaded OLT port at a take rate of 10- to 20-percent only. When the take rate grows above this level, a second group of OLTs are introduced to serve the next group of active customers.

In the examples above I used 1:32 splitters but in many predominantly European FTTH deployments, distributed splitter architectures are used. For example, in Spain most deployment have a distributed split architecture combining 1x4 splitters with 1x16 splitters. The same type of utilization rate challenges are valid for both centralized and decentralized architectures.

In the US some large deployments use a centralized splitter which resides inside a street cabinet. By using plug and play splitters that can be patched without splicing the mandatory connect-on-activation is limited to patching the first available and active splitter port into the patch panel position matching the new to be connected customer. This comes at a passive connectivity cost (the cabinet) but allows a full optimization of the OLT ports.

As demonstrated, the FTTH OSP architecture has a significant influence on the utilization rate and drives the amount of electronics in the CO/POP. Costs in the CO/POP are driven by more than the initial price of the equipment.

- Transmission equipment has an average lifetime of 2.5 to 5 years before it needs replacement and should be regarded as a recurring cost. The lower the utilization rate, the less that equipment is used efficiently – and the lower the return on the initial investment. By improving the network architecture and increasing the take rate by perhaps 4 times, the operator can save as much as 400-percent at each active equipment upgrade. As a result of careful architecture planning at the start, the savings made on Day 1 will be recurring savings in the future.

- Central office and POP space is expensive. Typically, the cost of floor space for each rack is around $1000 (depending, of course, on the location). By maximizing the use of active equipment, operators can reduce the amount of space required for passive equipment racks that are used to connect active ports to outside plant ports. This reduces the cost and complexity of these interconnection sites.

- Less active equipment results in lower power and cooling requirements. Relatively speaking, equipment running at medium load consumes more energy than equipment running at full load. As power costs continuously increase, additional costs are avoided. There is also the green aspect of power consumption and the related CO2 emissions. For example, all data centers in the US consume energy of thirty-four 500-megawatt power plants – and that number is growing rapidly (to 51 by 2020). While today's fibre networks' power consumption represents a small fraction of the total power consumption, seen as part of the same food chain, the communications industry as a whole comes under increasingly negative attention as "data centers are the new polluters." It appears that about one third of the equipment in the data center does not even add value in the network. As explained in the examples above, a similarly low rate of efficiency is seen in many FTTH network deployments today - with a resulting low return on investment and recurring wasted energy costs. The outside plant fibre network architecture has an important impact on the total cost of the deployment. This paper focused on the impact on the central office and POP sites. Utilizing transmission equipment efficiently lowers initial capital investment and minimizes operational expenses that keep the network running. Further, it reduces upgrade costs. Communications networks grow dynamically through increasing take rates. Careful initial planning of the architecture and anticipating the future growth, will provide a competitive advantage and bring better long-term profitability.

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