

VC4 Guide— Managing GPON investments

How do you manage GPON investments to maximize efficiency and returns?

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Introduction: What is PON?

PON is an essential tool when it comes to maximizing fiber coverage and reaching the last mile. Of course, it's expensive to build out, which means you need to get it right. Not only do you need to plan effectively, but you also need to make sure you can manage and operate new fiber deployments, alongside your existing infrastructure and assets.

This demands a unified approach spanning, on the one hand, effective planning, while on the other extending to all legacy, current and future deployments as you light them up. Key to that is efficient registration of PON assets, into a single, unified inventory management solution that boosts operational performance while enabling effective planning.

So, what does this take? In this new briefing paper, we'll explore what you need, while highlighting what registering PON assets really takes in practice. Before we begin, though, let's go through a few basics – starting with a brief overview of some of the key technologies we should consider.

So, what is PON?

Well, it's the key to the last mile. PON simply stands for "Passive Optical Network". This means that, essentially, no power is required to drive delivery of the connectivity to the end-user site, simplifying deployment and driving down costs, so that fiber providers can reach more premises. While PON may be deployed in other network domains, it's primarily used for the last mile of Fiber to the Home (FTTH) connectivity and for connecting buildings or mobile sites.

In any PON deployment, there are several key bits of kit. The starting point is the OLT (Optical Line Terminal) or MSAN (Multi-Service Access Network) equipment, which is the device used to manage the connections to the customer ONTs (Optical Network Terminal, which can also be called ONUs - Optical Network Units).

It is essentially the breakout from the transport or metro network and requires power. From this point, PON signals can reach 20 km. Next, between the OLT and ONTs, there are multiple passive splitters, normally 2 or more. Each splitter has 1 or 2 "in" ports and multiple "out" ports. Often the first splitter (when seen from OLT) has 2 "in" ports for protection purposes. The downstream transmission (from OLT to ONT/ONU) and upstream (from ONT to OLT) are separated.

One OLT PON port sends the same signal to each ONT/ONU connected, but each ONT will send specific information back to the OLT. As a result, each ONT will have an allocated timeslot to send its information (in TDM - Time Division Multiplexing).

The upstream rate is less than the maximum because it is shared with other ONUs in a TDMA (Time Division Multiple Access) scheme. The OLT determines the distance and time delay of each subscriber and timeslot allocation for upstream data from each user is controlled by software.

The typical split of a single fiber is 1:32 or 1:64. This means each fiber can serve up to 32 or 64 subscribers, although split ratios of up to 1:128 are possible in some systems.

The different kinds of **Passive Optical Networks**

PON is a broad term, and you may encounter terms such as GPON, GEAPON, APON, BPON and 10G-PON (XG-PON). So, what's the difference?

GPON

GPON stands for Gigabit Passive Optical Network and is currently the most widely deployed version of PON. The ITU-T standard for GPON is G.984. This delivers 2.488 Gbit/s downstream and 1.244 Gbit/s upstream.

GPON uses one wavelength for downstream traffic (1490 nanometer (nm) wavelength) and another for upstream traffic (1310 nm wavelength) on a single mode fiber. If TV is being distributed, a wavelength of 1550 nm is used.

APON and BPON

APON stands for ATM Passive Optical Network and was specified in ITU-T G.983 and is an older PON variant based on ATM (Asynchronous Transfer Mode). Improvements to the original APON standard – as well as the gradual falling out of favor of ATM as a protocol – led to the final version of ITU-T G.983 often being referred to as “broadband PON”, or BPON. A typical APON/BPON provides 622 megabits per second (Mbit/s) (STM4/OC-12) downstream bandwidth and 155 Mbit/s (STM1/OC-3) of upstream traffic, although the standard can accommodate higher rates.

EPON and GEAPON

EPON is Ethernet Passive Network, also known as GEAPON (Gigabit Ethernet Passive Network) and employs a single Layer 2 network that uses IP to carry data, voice and video. EPON delivers 1-Gbit/s or 2.5Gbit/s symmetrical bandwidth. EPON/GEAPON is more cost effective than GPON.

That's a lot of abbreviations and acronyms – but, this is hugely significant, because it means that, while in general terms you may be delivering “PON” or “GPON”, there may be considerable variation in the actual standard you are using for the different customers and communities you serve. What's more, you may need to revisit existing deployments and upgrade your customers to newer, higher speed packages...

10G-PON / XG-PON

10G-PON, also known as XG-PON, is the next generation ultra-fast capability for GPON providers, designed to coexist with installed GPON user equipment on the same network.

Asymmetric 10G-PON is specified as XG-PON1, yielding 10 Gbit/s downstream and 2.5 Gbit/s upstream (nominal line rate of 9.95328 Gbit/s downstream and 2.48832 Gbit/s upstream). Symmetric 10G-PON is also proposed (XG-PON2) with 10 Gbit/s upstream but this would require more expensive burst-mode lasers on optical network terminals (ONTs) to deliver this transmission speed. Another symmetric 10G-PON standard is XGS-PON (ITU-T G.9807.1).

Framing is “GPON like” but uses different wavelengths from GPON (using WDM to separate them) so that GPON subscribers can be upgraded to 10G-PON incrementally, while GPON users continue with the original OLT. The 10 Gigabit PON wavelengths (1577 nm down / 1270 nm up) differ from GPON and EPON (1490 nm down / 1310 nm up), allowing it to coexist on the same fiber with either of the Gigabit PONs.

From alphabet soup to practical steps

Phew. That’s a lot of abbreviations and acronyms – but, this is hugely significant, because it means that, while in general terms you may be delivering “PON” or “GPON”, there may be considerable variation in the actual standard you are using for the different customers and communities you serve. What’s more, you may need to revisit existing deployments and upgrade your customers to newer, higher speed packages – so, that should give a hint as to why registration is both so important and so challenging.

In turn, this tells us that we need a master database of all PON (regardless of generation or variant) equipment, where they are and how they relate to each other – after all, on one extreme, you may have two customers next door to each other, but each is using a different service.

Far more likely, you’ll want to be able to upgrade your customers when a newer technology is available, so you must plan the most effective routes and enable rapid activation once you’ve passed enough homes – customers won’t want delays when they take advantage of your offers!

...operators often forget to have a naming convention in place or forget to register important information. So, six months or a year after starting the network rollout, there is already a massive network data issue that is hard to resolve.

Why is correct registration of PON challenging?

The correct network inventory registration of PON networks is more complex than other types of networks. Why is that?

Well, while the technology is relatively simple, most operators are not able to manage their PON networks in an optimal manner. That's not because of the technology or network layers directly, but rather because correct registration of PON services needs a combination of:

- Active network registration
 - OLT
 - ONT/ONUs
- Passive networks registration
 - Splitters
 - ODFs, patch-panels
- Physical Network Inventory registration
 - Fiber, OSP, GIS
 - Physical equipment
 - Physical connections
- Logical Network Inventory registration
 - Logical connections
 - Customer services
- Relationship to other networks, such as:
 - MPLS (physical, logical, customer services)
 - Voice
 - WDM/OTN
- Telephone number management
- Network Auto Discovery and Reconciliation function
- Service Fulfillment

Why do problems often occur?

Not many OSS systems can handle all of this in a single system. Consequently, many operators struggle with multiple incomplete systems, which may not be synchronized with each other. To make matters worse, operators cannot just wait until they have the right systems in place. You must start somewhere, which can mean rolling out PON / FTTH networks with network drawings, like ACAD, and registering other information in Excel sheets or homegrown databases. And, once contracts have been put in place with contractors, the work starts, and proper registration is a secondary priority.

Additionally, operators often forget to have a naming convention in place or forget to register important information. So, six months or a year after starting the network rollout, there is already a massive network data issue that is hard to resolve.

But wait! There is a solution. VC4-IMS is a best-in-class PON network registration solution. It provides everything you need, in a single system – so you can ensure effective registration of all PON assets, right from the very beginning.

GPON Network Planning and Inventory in VC4-IMS

In this section, we provide a description of how PON networks can be registered in VC4-IMS. Since GPON is the most widely adopted form of PON network, the term GPON is used from this point onwards – but the descriptions below are applicable to any generation of PON network technology.

Registration of active network elements

Not only can the OLTs and ONT/ONUs be managed, VC4-IMS also covers MPLS/IP, Voice, WDM/OTN and other equipment that is connected to the GPON network. The basic details that are registered include:

- Equipment name
- Type of equipment
- Status of equipment
- Shelves / sub-racks
- Shelf type(s)
- Status per shelf
- Site/location where equipment has been installed
- Loopback address
- Management System
- Order details
- Hardware/Software version equipment and shelves
- Serial number equipment and shelves
- Barcode equipment and shelves
- UPS info
- General comments
- Physical graphical layout
- Slots per shelf, including slot numbering
- Cards per slot
- Sub cards (pluggables/SFP/XFPs) per sub slot within parent cards
- Port details such as:
 - Port name
 - Interface
 - IP address(es)
 - ODF position
 - Circuitname (connection on port)
 - Status of connection
 - Status of port
 - Type of port (bandwidth/speed)
 - Uni / bi-directional
 - Comment
 - Domain
 - Telephone number

Our network planning and inventory system can integrate with the GPON Network Management System (NMS) and/or Network Equipment (NE) to keep the active network in sync with the inventory data, through regular reconciliation procedures. For more information, see the sections on Auto-discovery and Network Reconciliation.

Registration of passive network elements

GPON networks consist of multiple types of passive equipment. To maintain the complete network inventory, VC4-IMS enables you to register:

- ODFs and patch panels, including positions
- Splitters, including in and out ports
- Splice boxes, including splice cassettes
- Fiber Distribution Terminals
- Outdoor cabinets
- Indoor cabinets / racks
- Any other passive equipment

Registration of fiber networks, Outside Plant (GIS)

The VC4-IMS Network Planning and Network Inventory system offers full GIS functionality to manage geographical data (location) and all fiber components. Examples of fiber equipment VC4-IMS manages include:

- Trenches, buried and aerial
- Poles
- Manholes, handholes
- Ducts
- Fiber cables
- Fibers
- Duct, cable, tube and fiber colors
- Splice boxes / enclosures
- Splices
- ODFs and Patch panels
- Fiber distribution terminals/outdoor racks
- Indoor and outdoor racks
- Splitters

With GIS capabilities, a host of functionality is unlocked, including:

- Positioning of the GPON network in a standard geographical background, such as:
 - OpenStreetMap
 - Google Maps / Satellite
 - Bing Maps
 - ESRI
 - Government / public background maps
- Zoom in/zoom out
- Create, modify and delete objects from the map,
 - with the possibility to create more objects in 1 action
- Create geographical connections, starting from the Trench layer, to register the difference between buried, aerial, drilling and other types
- Being able to change routing of such connection
- Auto route function
- Highlight connection on a map, physical and logical
- Import and export functionality, for example KML/KMZ, shape
- Add KML/KMZ files as a background layer on top of other background data.
- Turn on/off different object types on the map
- Show more (or less) information on the screen (e.g., icon details, capacity)
- API for Google, or other mapping solution, for obtaining address information automatically when creating new sites from the map
- Measure distances
- Search network item or site on map
- Search places on maps, like Google maps, Bing map search
- Highlight fiber cut location based on OTDR measurement
- Register over length (slack)
- Interactive Butterfly views
- Perform impact analysis from any object, click on an object (equipment or geo connection) and list all sub traffic up to the customer service level

Registration of logical network connections and parameters

The logical connections are essential in GPON network registration, because they provide the end-to-end relationship from OLT to customer ONT/ONU.

The VC4-IMS Network Planning and Inventory System supports the following logical connection types:

- Ethernet layer
 - The lowest logical layer that runs from OLT to ONT/ONU
 - Carried by a GPON connection
 - The system can generate end-to-end graphical views of this connection layer
 - The system can highlight the end-to-end path on the geographical map
 - The system can connect to the GPON NMS to automatically retrieve data from this connection layer from the live network (auto discovery and network reconciliation)
- V-LAN
 - Can run over multiple hops, like from MPLS node (see next paragraph) through the OLT to ONT/ONU
 - Can be carried by the GPON Ethernet connection or other VLAN (q-in-q)
 - The system can manage VLAN numbers
 - Can have a relation to physical port
 - Has VLAN parameters
 - The system can generate end-to-end graphical views of this connection layer.
 - The system can highlight the end-to-end path on the geographical map
 - The system can connect to GPON NMS and MPLS NE's/NMS to automatically retrieve data from this connection layer from the live network (auto discovery and network reconciliation)

Registration of Customer Services and parameters

And, last, but not least: the customer services you offer need to be stored and adequately managed. The VC4-IMS Network Planning and Inventory system keeps track of customer services and understands over which network layers they are routed/configured.

- Customer services
 - Register customer services end to end
 - Manage the customer details, name, address and more
 - Can be carried by the V-LAN connection
 - Have a relation to the actual customer (name and customer details)
 - Have customer service parameters
 - The system can highlight the end-to-end path on the geographical map
 - The system can manage the data services from customer site, via the GPON network, via MPLS & BNG to internet or interconnects
- The system can manage telephone numbers and relate these to customer and equipment ports
- The system can manage the voice service from customer site, via the GPON network, via MPLS to the Voice IMS (SBC – session board controller)
- VC4-IMS can connect to the GPON NMS's, MPLS/IP NEs/NMS and Voice IMS platform to automatically retrieve customer services from the live network (auto discovery and network reconciliation)

Relationships with **other networks**

Let's not forget that the GPON and fiber network is just part of the overall network, so of course the VC4-IMS Network Planning and Network Inventory system can manage all different kinds of networks, in the same application, with relationships between each network highlighted and understood.

Here are some examples of other networks that can be included in this single view and data model, but note that this is not an exhaustive list:

- MPLS/IP
- WDM/OTN
- Voice
- DSL/MSAN
- Fixed Wireless Access (4G & 5G)
- Mobile 2G, 3G, 4G, 5G - Core and Access
- Microwave
- SDH / SONET
- HFC
- Wi-Fi
- SDN / SD-WAN
- NFV

The VC4-IMS Network Planning and Inventory solution has integral work order management functionality, enabling you to easily manage all the tasks in the network rollout phase and beyond...

The VC4-IMS Network Planning and Inventory system includes all necessary capabilities to align these networks and to connect the different network platforms, enabling a complete, end-to-end view of the total network assets - and can also perform impact analysis.

Workflow and Order Management

Rolling out PON networks means much more than planning the infrastructure and matching that to customers and services.

It requires detailed management of internal and external teams, to ensure that everything is handled in the correct sequence.

The VC4-IMS Network Planning and Inventory solution has integral work order management functionality, enabling you to easily manage all the tasks in the network rollout phase and beyond, during the operational phase.

It covers the complete lifecycle for your GPON and other network investments.

To list a few of the system's workflow / order management functions:

- Define tasks
- Relate tasks to department queues
- Relate tasks (make the workflow)
- Assign (existing and customized) fields per task
- Automate tasks, where appropriate
- Create and adapt workflows
- Serial and parallel tasks
- Show workflow in a graphical view
- Support for decision points and loop back flows
- Support trouble ticket management
- Integrated with inventory module
- API functions to communicate with external systems

Reporting is key, so the VC4-IMS Network Planning and Network Inventory system includes rich reporting and dashboard features.

Reports and dashboards

Reporting is key, so the VC4-IMS Network Planning and Network Inventory system includes rich reporting and dashboard features.

These enable you to keep track of rollout projects, expenditure, network capacity, project lead times, trouble ticket lead times and all your other KPIs with VC4-IMS. Custom reports can be created easily by users.

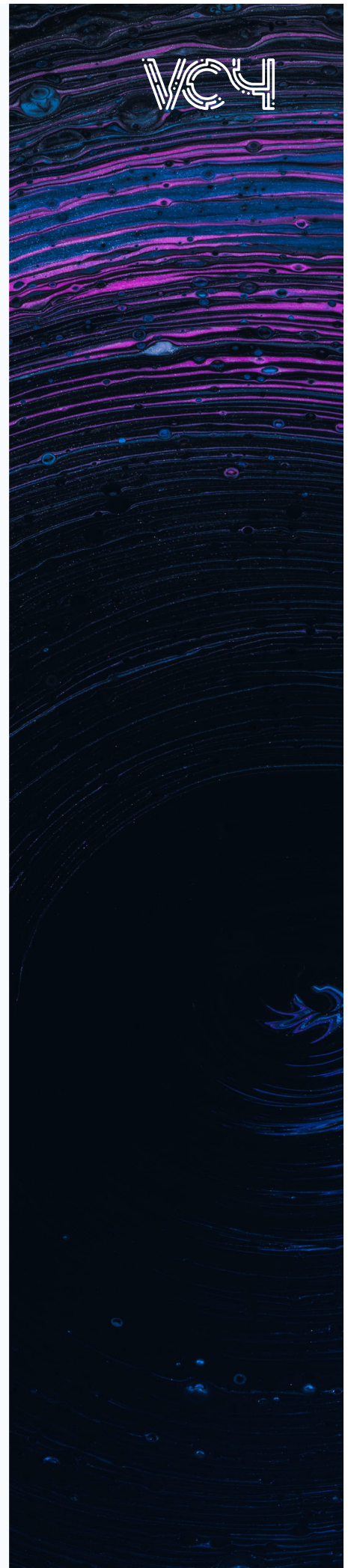
Reports can contain graphics from the inventory system, such as floorplans, splice views, cable routes, geographical network maps, so that the report function can be used for work packs to suppliers.

Bill of Materials

The VC4-IMS Network Planning and Inventory system can create 'Bill of Materials' for the planned FTTH / GPON network. It takes into consideration:

- Item prices in local or foreign currency
- Length prices in local or foreign currency
- It automatically calculates all totals:
 - Total number of materials per type
 - Total of material costs per type
 - Total length of materials per type, for example
 - Total length of DUCT, type XYZ
 - Total length of 144 fiber cable, type ZYX
- Total labor costs per type

The Bill of Materials can be presented in table format and can be included in (any) report.



Network Reconciliation

Data can rapidly become outdated, because not everybody follows the correct process at all times, and people can make mistakes. To minimize the risk of data pollution, an interface can be built to the network to retrieve actual network information.

After integration with all required systems, the VC4-IMS Network Planning and Network Inventory system will take a snapshot of the NMS/EMS and NE data and compare this data with the data in the VC4-IMS database. This data set is updated daily, according to scheduled reconciliation programs – ensuring that accuracy is maintained.

This section provides information regarding interfaces to:

- Network Management Systems (NMS)
- Element Management Systems (EMS), and
- Directly to the Network Elements (NEs)/Equipment

Types of Interfaces

The Network Planning system should support multiple types of NMS/EMS and NE interfaces. Some examples include:

- CORBA (Common Object Request Broker Architecture)
- RESTful based interfaces
- MTOSI
- TL1
- Interfaces based on XML (Extensible Markup Language)
- SNMP
- CLI/Telnet/SSH
- Flat files (txt, csv)
- Vendor proprietary interfaces
- Database to database interfaces

The VC4-IMS Network Planning and Network Inventory system supports all the above – and more.

The VC4-IMS Network Planning and Network Inventory system also includes helpful OSS functions that facilitate the management of GPON FTTH and other networks

Network Reconciliation and Auto-Discovery process

The steps below describe the network auto discovery and reconciliation process employed by the VC4-IMS Network Planning and Network Inventory system:

1. Each night the system collects the data from NMS/EMS and/or NEs
2. The network data is stored in separate 'reconcile' table in the database
3. Each element (e.g., equipment, connection) has a unique link ID to NMS/EMS/NE
4. Connections running over multiple platforms have different NMS/EMS/NE IDs, so the system determines exactly which part of connections should be synchronized
5. The VC4-IMS Network Inventory Management system queries and compares the data in 'reconcile' table with the 'normal' IMS

If differences between the NMS / EMS / NE and VC4-IMS are found, there are two options:

1. The auto-discovery process corrects the data automatically in the database
2. The system has a specific screen to present the discrepancies in a logical way. For example, to show the discrepancies per type in different tab pages, such as:
 - Equipment type differences
 - Connections with a different routing
 - Connections on different ports
 - Card differences
 - Cards that are deleted in NMS, but still 'in service' in IMS

Other OSS functions

The VC4-IMS Network Planning and Network Inventory system also includes helpful OSS functions that facilitate the management of GPON FTTH and other networks:

Bulk loaders

Since data may come from different systems, so it can be necessary to be able to upload from Excel or .csv into the VC4-IMS Network Planning and Inventory system. In VC4-IMS we call this 'bulk loader' functionality.

Warehouse – Stocks & Spares

To manage the complete life cycle of materials, from ordering from your equipment vendors until implementation in the network, as well as fault handling and decommissioning processes, it is helpful to be able to do all of this in a single tool. With VC4-IMS, the serial numbers can be tracked end to end, without the need for any additional integration.

IP Management

GPON network elements and ports have IP addresses related. Without accurate IP address management functionality in the Network Planning and Inventory tool, duplication and other mistakes may happen. The VC4-IMS Network Planning and Network Inventory system supports IPv4 and IPv6, with the capability to create sub ranges, and to assign IP addresses to different types of objects.

Financials

To support the Bill of Materials and manage the costs for rolling out the network, functions are available to manage prices per material and labor costs. Some other helpful VC4-IMS Network Planning and Network Inventory system financial management functionality includes:

- Purchase orders
- Invoices
- Payments
- Contract management
- APIs for integration to financial systems

We are telecom experts working in the IT industry – we help you plan and manage your network investments efficiently and effectively, providing a solution that spans all your infrastructure and grows with your business.

How VC4 can help you

First, let us introduce ourselves to you! We are VC4. We are telecom experts working in the IT industry – we help you plan and manage your network investments efficiently and effectively, providing a solution that spans all your infrastructure and grows with your business.

In the last 20 years or so, we've developed a complete OSS suite with all functionalities available in a single application.

We're based in the Netherlands, but our international teams are everywhere. VC4 is a rapidly growing company – because our customers know we care for them and that we understand their businesses. And, of course, we have a fantastic solution.

Besides implementing and maintaining our software application we also provide the following services:

- Integration to live networks
- Integration to other systems
- Data migration
- Data cleansing
- Training

VC4-IMS

All the functionality listed in this document are available in our VC4-IMS Network Planning and Network Inventory system. We bring active & passive, physical & logical, and geographical & graphical together in a single system.

We deliver results, in the fastest possible time, giving you complete visibility of your inventory and the relationships between all the assets. So, if you want the best GPON network planning and inventory solution, please contact us and discuss how we can help your business - and grow together.

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