An introduction to
Passive Optical Network (PON) technologies

NOKIA

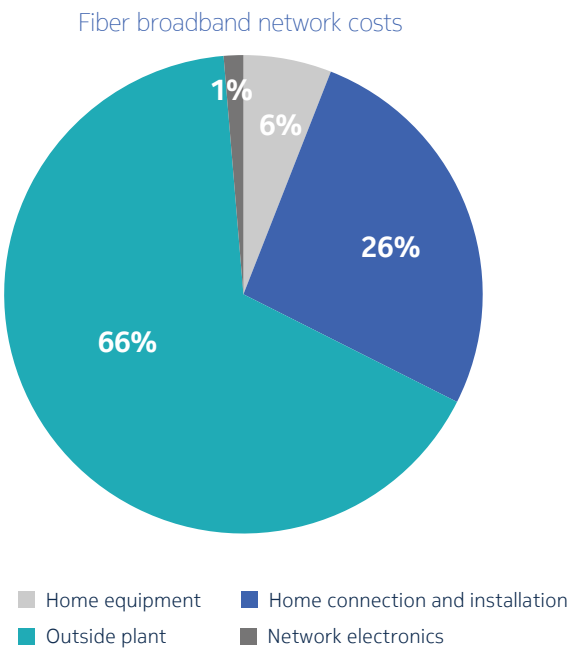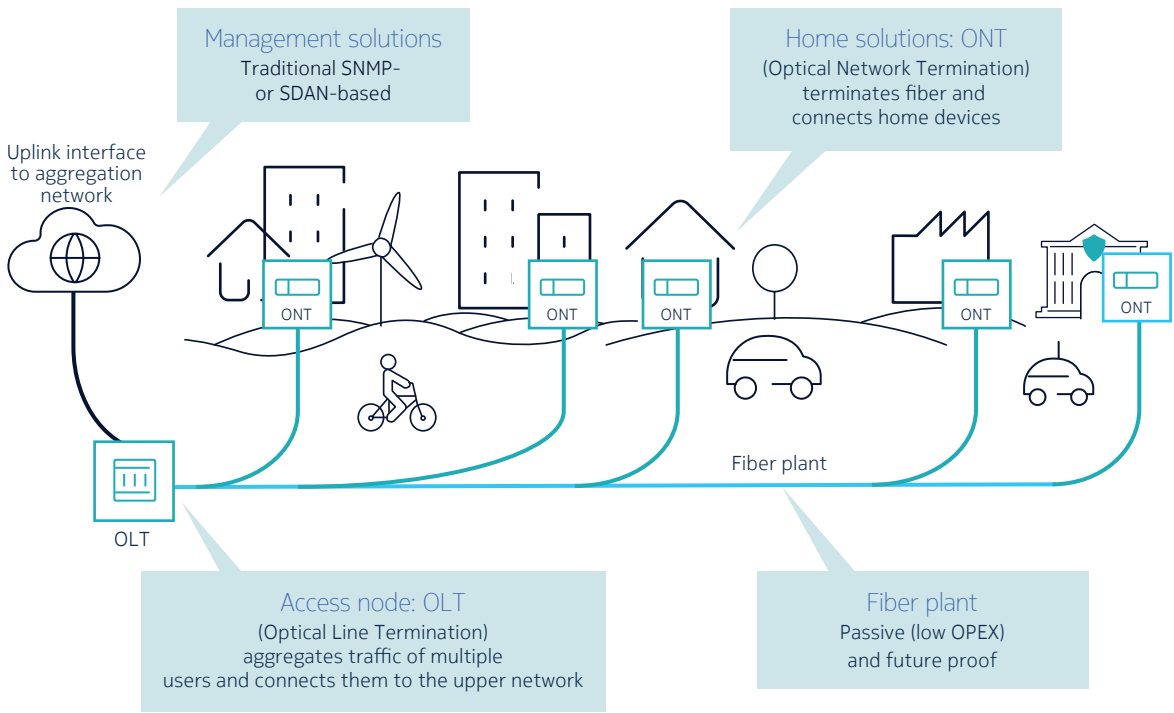# Contents

Fiber broadband in a nutshell

In a PON access network there are two end-points with active (powered) electronic transmission equipment, connected by passive (non-powered) equipment known as outside fiber plant. At the subscriber premises, there is an Optical Network Termination (ONT) device that terminates fiber and connects home devices (TV, PCs etc). The second end point is Optical Line Termination (OLT), typically located in telecom central office. The role of OLT is to aggregate connections of multiple users and connect them to the core network. The biggest start-up cost is deploying the outside plant, followed by installing and connecting the ONTs.

Management solutions
Traditional SNMP- or SDAN-based

Uplink interface to aggregation network

Home solutions: ONT
(Optical Network Termination) terminates fiber and connects home devices

ONT

OLT

Fiber plant

Access node: OLT
(Optical Line Termination) aggregates traffic of multiple users and connects them to the upper network

Fiber plant
Passive (low OPEX) and future proof

Fiber broadband network costs

1%
6%
26%
66%

Home equipment   Home connection and installation
Outside plant   Network electronics

What is PON?

PON network uses point-to-multi-point topology. This means that a single transmission point in the OLT connects multiple end-points.

Optical splitters are used to split the signal into multiple branches. There could be several levels of splitters, which are separating the outside plant into different sections: fiber feeder, distribution, drop.

The outside plant components (splitters, cables, distribution frames etc) are completely passive an don't need power, making PON networks very power efficient.

Optical fiber distribution and drop

Optical fiber feeder

OLT

1:n passive splitter

ONT

ONT

ONT
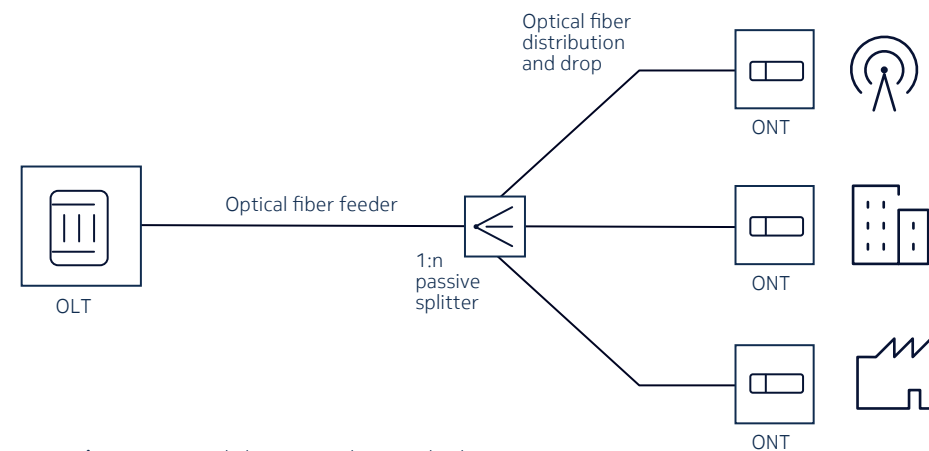
- **Passive**: No powered elements in the outside plant
- **Optical**: Using wavelengths of light to carry data in the fiber cables
- **Network**: Refers to broadband access network

How does PON work?

The total available bandwidth on a PON is divided between all users that are connected to that PON, i.e. each user is allocated a portion of the total available bandwidth by traffic manager. PON has advanced security mechanisms in place to ensure that each end point ONLY receives the signal that is intended for them.
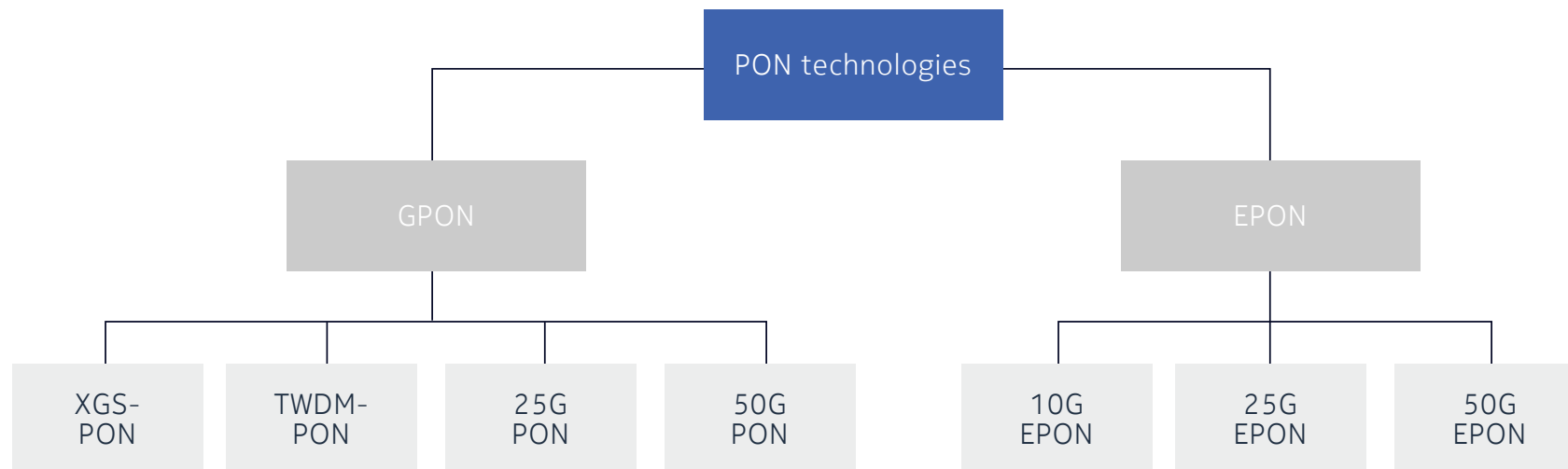
Here are some of the techniques used in PON networks:

- **Time Division Multiplexing** (TDM) enables each end-point to receive and transmit data in a given time slot. In upstream PON uses TDMA (Time Division multiple access) variant, which combines signals from multiple ONT transmitters into one OLT receiver.
- **Dynamic Bandwidth Allocation** (DBA) is a mechanism to dynamically distribute and manage upstream traffic from all users on a PON, based on demand, service priority and user profile.
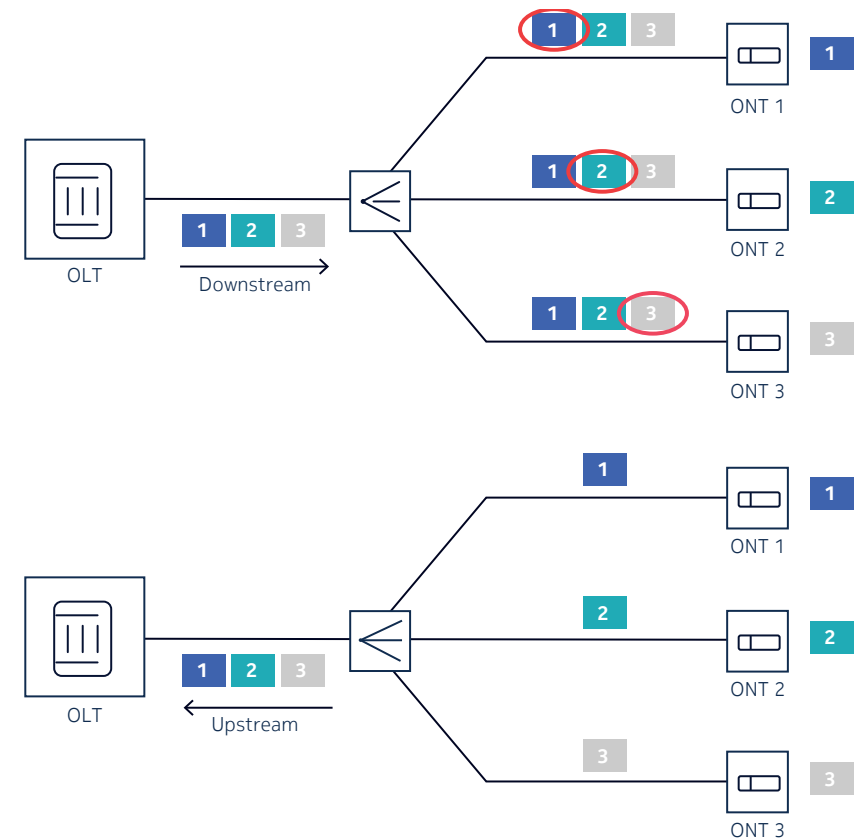
PON fiber access technologies

There are two branches in the PON family tree: Gigabit PON (GPON) and Ethernet PON (EPON). And there have been many advances in each branch over the years, resulting in new flavors of PON with progressively better performance. GPON and XGS-PON are by far the most widely deployed PON technologies in the world today.

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                          ┌──────────────────────┐
                          │   PON technologies   │
                          └──────────────────────┘
              ┌──────────────────┘          └──────────────────┐
        ┌───────────┐                                    ┌───────────┐
        │   GPON    │                                    │   EPON    │
        └───────────┘                                    └───────────┘
   ┌──────┬────┴────┬──────┐                      ┌─────────┬───┴────┬─────────┐
┌──────┐┌──────┐┌──────┐┌──────┐              ┌──────┐ ┌──────┐ ┌──────┐
│ XGS- ││TWDM- ││ 25G  ││ 50G  │              │ 10G  │ │ 25G  │ │ 50G  │
│ PON  ││ PON  ││ PON  ││ PON  │              │ EPON │ │ EPON │ │ EPON │
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PON wavelengths

Each flavor of PON uses a different wavelength pair (one in upstream, one in downstream) to transmit data. The wavelengths are specified by international standards and stretch from 1260 to 1600 nm. Upstream traffic mostly uses the lower bands, because lasers operating in these bands are more cost-efficient, which is important for ONTs that are deployed in big volumes. Different PON technologies that use different wavelengths are able to coexist on the same fiber optical cable. This makes it simple to migrate from one generation of PON technology to the next.
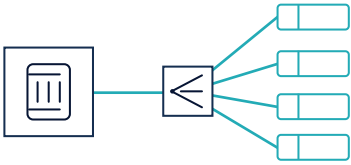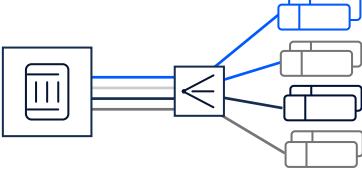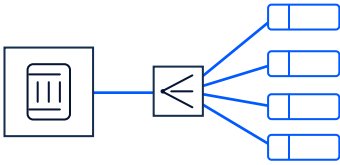

US: Upstream
UW: Upstream wavelength
DS: Downstream
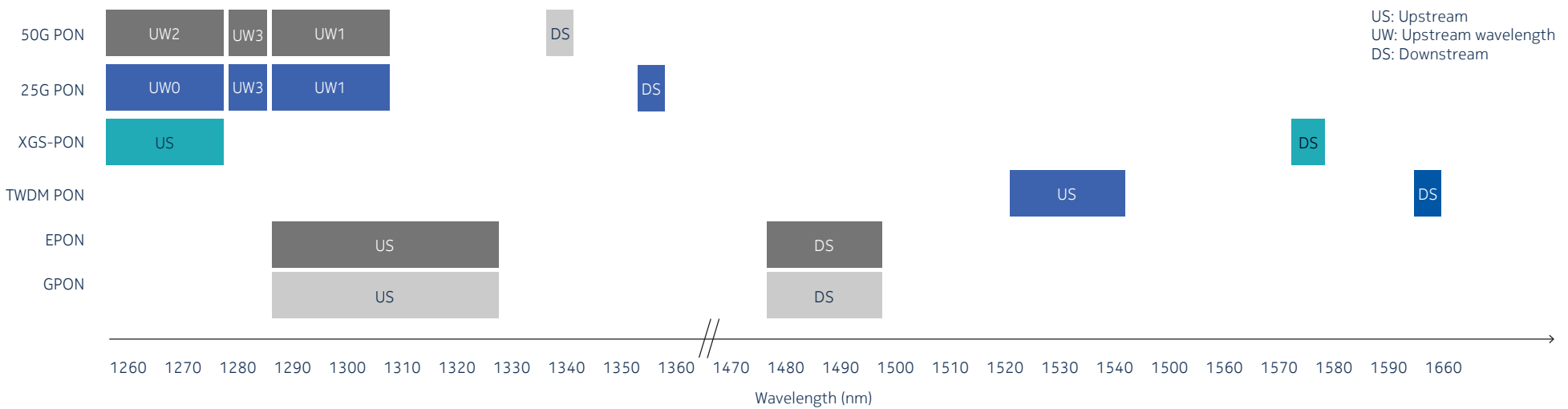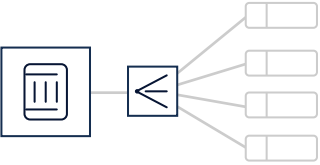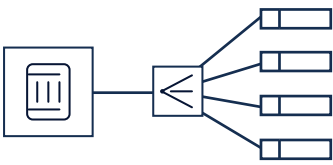
PON wavelengths

50G PON	UW2	1260 to 1280
	UW1	1290 to 1310
	DS	1340 to 1344
25G PON	UW0	1260 to 1280
	UW1	1290 to 1310
	UW3	1284 to 1288
	DS	1356 to 1360
XGS-PON	US	1260 to 1280
	DS	1575 to 1580
TWDM PON	US	1524 to 1544
	DS	1596 to 1602
GPON	US	1290 to 1330
	DS	1480 to 1500
EPON	US	1290 to 1330
	DS	1480 to 1500

Characteristics of PON

GPON	XGS-PON	TWDM-PON	25G PON	50G PON
Gigabit PON	10G symmetrical PON	Time wavelength division multiplexing PON	25G symmetrical PON	50G PON
2.5 Gb/s 1.2 Gb/s	10 Gb/s 2.5 or 10 Gb/s	4 x 10 Gb/s 4 x 10 Gb/s	25 Gb/s 10/25 Gb/s	50 Gb/s 25 Gb/s
Enabler of Gigabit broadband.	Dual rates: symmetrical or asymmetrical. Co-exists with GPON, TWDM-PON, 25G PON	Uses 4 wavelength pairs (4 in upstream, 4 in downstream). Multiple users share a wavelength pair.	Dual rates: symmetrical or asymmetrical. Co-exists with GPON, XGS-PON, TWDM-PON, 50G	Asymmetrical. Co-exists with GPON, XGS-PON, TWDM-PON, 25G PON
The widest deployed PON technology worldwide since 2007.	Now the main PON flavor being installed today, worldwide.	Limited deployments	Trials and pilots, some deployments started.	Research, prototypes.

Fiber is very robust and resistant to outside factors (water, corrosion). That means, once fiber broadband infrastructure is deployed, it can be used for 50+ years.

With 25G PON now commercially available, future 50G and 100G PON technologies already successfully demonstrated and standardization in the works, PON continues to be the future-proof technology we need.

At Nokia, we create technology that helps the world act together.

As a B2B technology innovation leader, we are pioneering the future where networks meet cloud to realize the full potential of digital in every industry.

Through networks that sense, think and act, we work with our customers and partners to create the digital services and applications of the future.