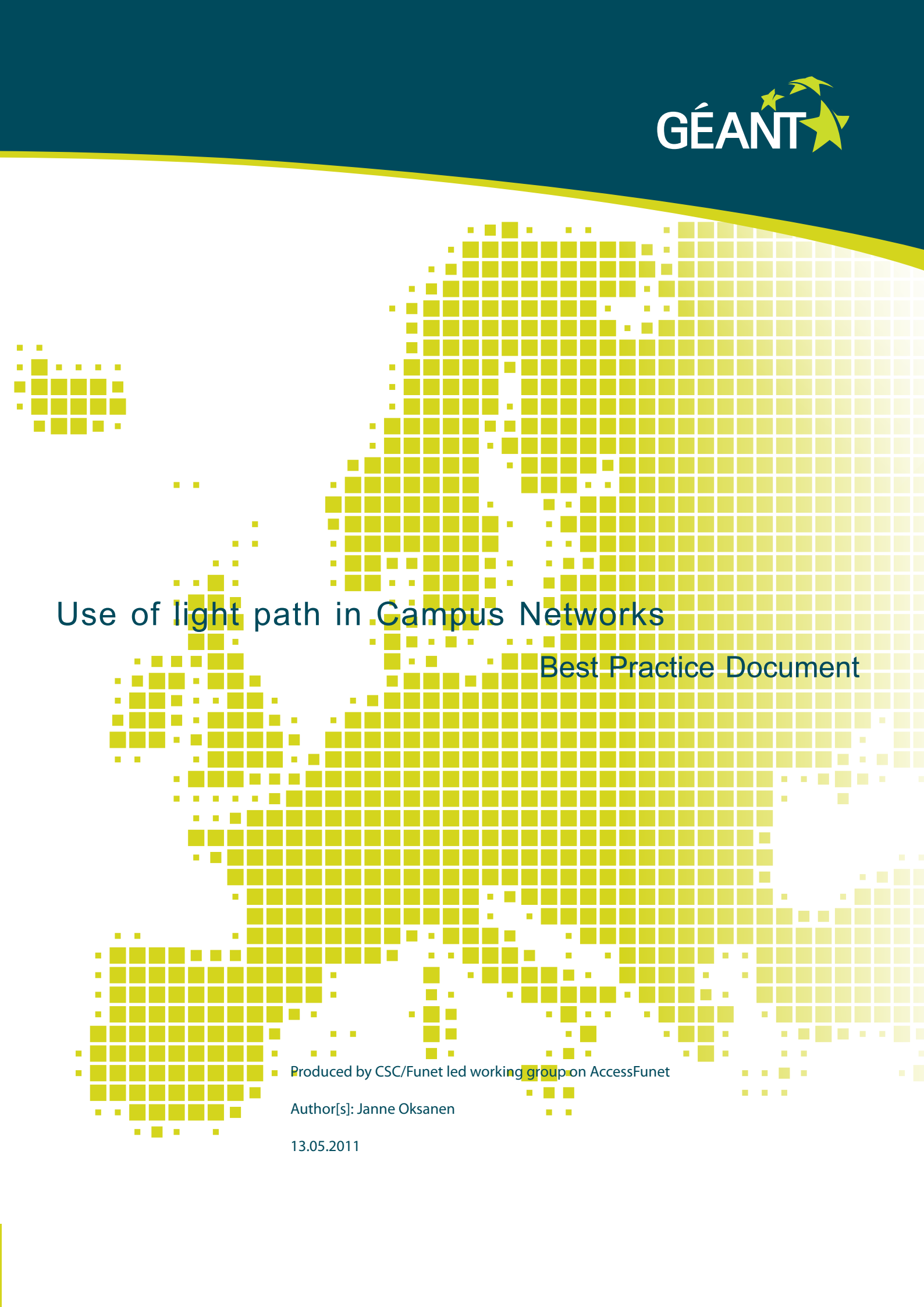

Use of light path in Campus Networks

Best Practice Document

Produced by CSC/Funet led working group on AccessFunet

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1. Light Paths

Light paths are separate, ultra-fast data communications connections, implemented at the optical level. The user of a light path has the use of the full data transfer capacity of the data communications connection in question. Data transfer speeds currently in use are 1 Gbps and 10 Gbps, depending on the required data transfer capacity.

In addition to speed, a light path is also secure. Unlike on the Internet, other network users are unable to intentionally or unintentionally disrupt the light path connections of others. There is also no need to use firewalls, if the parties at the ends of the light path connection trust each other. This saves time, effort and money from both the users and maintainers of the connection.

Light paths can be constructed on both short and long distances. Light paths can also be constructed via international research networks. The costs of international light paths are determined on a case-by-case basis.

2. DWDM Fibre Technology

Nationwide fibre networks commonly use the DWDM technology. The Dense Wavelength Division Multiplexing technology is also used in the Funet fibre network. In the DWDM technology, data from different sources is sent along the optic fibre at their own wavelengths. If necessary, DWDM equipment will automatically correct the optical signal into the correct shape and amplify or dampen it.

Currently, newly constructed fibre connections are terminated at the panels with LC connectors (Figure 1), but the most commonly used connector model is still SC (Figure 2). For the light path, it does not matter what kind of connector or fibre is used. The same rules apply to a light path as to any other optical connection with regard to physical connections.

Figure 1. LC connector

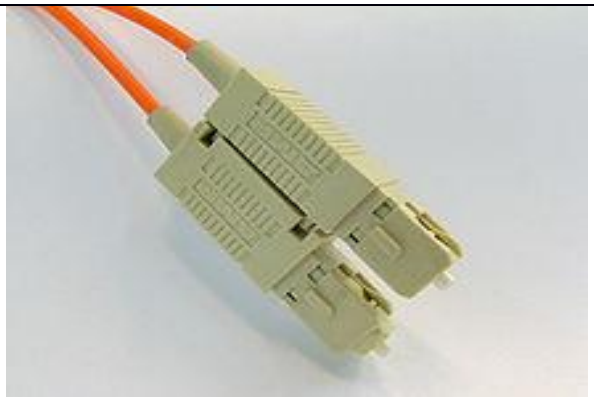

Figure 2. SC connector

3. CWDM

The DWDM technology is used in the Funet core network. At the network edges, on short (under 30 km) distances, the CWDM technology is used instead. The Coarse Wavelength Division Multiplexing technology also allows setting up several light paths in one fibre pair. Funet uses eight-channel CWDM-MUXes.

CWDM-MUX muxes and demuxes wavelengths from each other into their own wavelengths. In Funet, these wavelengths are 1470, 1490, 1510, 1530, 1550, 1570, 1590 and 1610nm. In addition to these, the so-called normal 1310 nm wavelength travels through the CWDM-MUX.

The CWDM-MUXes used by Funet (Figure 3) are passive and do not require electricity. The muxing and demuxing of wavelengths is done optically. For this reason, these devices are often also called 'prisms'.

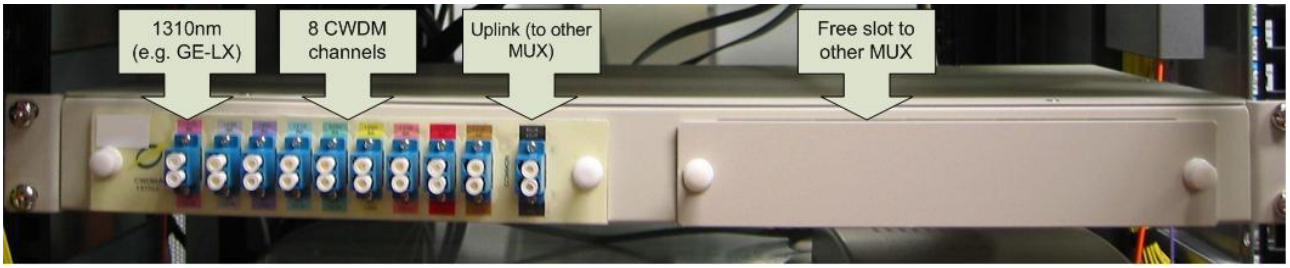

Figure 3. CWDM-MUX

4. Applications

Light paths can be used for different purposes. One of the most common and popular applications is connecting the remote offices of Funet members to the main campus network. As the light path is a secure end-to-end connection, the remote office can be connected to be part of the main campus intranet.

Other typical applications include connecting a research device producing a lot of data to a centre located elsewhere, where the data is stored and refined further, for example through computation. Various computational science GRID projects and research projects using them are heavy users of light paths. Other similar applications include the connections between computer rooms at different offices, where a lot of data is transferred.

5. Implementing a Light Path

See below for a checklist on implementing a light path.

- Initial data: The light path's purpose of use, required capacity and endpoints.

- On a campus: is there fibre for the entire distance from Funet's DWDM node? At distances under 300 m, use multi-mode fibre, otherwise single-mode.
- Check that the edge device to which the light path is terminated does it supports CWDM technology and that it has suitable ports available.
- Choose which IP addresses will be used for the light path connection.
- Contact Funet at noc(@)funet.fi
- Funet will investigate the implementation alternatives in cooperation with the customer.
- If fibre is missing between Funet's DWDM node and the endpoint/campus, the availability of fibre is investigated.
- So-called dark fibre is usually rented from an operator. If no dark fibre is available, a 1 GE or 10 GE data transfer capacity connection is rented. If necessary, new fibre is laid, if the cost makes sense. Funet will assist in the acquisition of the fibre.
- If several light paths travel in the same fibre pair, the CWDM technology will be used. In such a case, Funet will inform the customer on which CWDM channel or wavelength is used.
- Once there is fibre all the way between the endpoints, the fibres are connected and Funet will make provision the DWDM equipment for the light path and provide instructions on to which DWDM device ports the connection will be connected. During this phase at the latest, the optics (LX, SX, LR, SR, CWDM) used in the edge devices are checked.
- Once the right kind of optics and fibres have been connected, the light path can be taken into use. It does not matter to the light path what addresses or protocols are used in the edge devices, or whether, for example, VLANs are available.
- The fibres must be correctly connected (Tx and Rx).
- When making fibre connections, the connectors must always be cleaned.
- Once the light path has been taken into use, Funet turns on monitoring for the light path, after which the DWDM management system will automatically alert Funet NOC if there are disruptions or outages in the connection.
- The customer adds the terminal devices of the light paths under its own monitoring.

6. Fault Management and Monitoring

The most common faults in light paths are caused by fibre cut by an outside party or a malfunction in the edge device. The risk of a cut fibre is at its highest when earthwork is being done, for example during road repairs. The danger then is that an excavator will gouge the fibre apart. We try to prevent such situations through precise documentation and expert visits at the work sites, showing the cable locations to the excavator operator.

Typical repair time for cut fibre varies between 8 to 24 hours. A light path can be duplexed by laying another, parallel path going a different route. The route selection is made in the customer's terminal devices.

The fibre connections of the Funet network have SLAs defining the fault correction times. Funet is prepared for equipment malfunctions by having a stock of spare parts, allowing the quick replacement of malfunctioning components. In addition to the spare parts stock, we have drawn

up instructions on how to act during fault situations. Funet has also entered into an agreement with a contractor that does the actual repairs.

Recommendation: We recommend the user of a light path to also monitor the operation of the light path by adding the edge devices at the ends of the light path under monitoring in their own monitoring system.

7. Costs

A light path will incur the following costs to a party ordering a light path:

- Depending on the transfer capacity of the light path (1 GE or 10 GE), there is a fixed annual price for the light path, charged in connection with the Funet connection invoice. The Ministry of Education and Culture in Finland subsidises half of the annual price for universities and polytechnics (see the Funet price list). The prices are confirmed annually.
- If fibre must be rented from an operator or laid between offices, these costs, which typically comprise of a monthly fee, are usually the responsibility of the customer. But if the fibre connection is part of the Funet trunk network, Funet will cover the fibre costs.
- The customer will cover the costs possibly incurred by the acquisition of suitable optics (LX, SX, CWDM) for the edge device to which the light path is terminated.
- If CWDM technology is used in the implementation of the light path, Funet will supply the required CWDM-MUXes. The customer does not need to acquire them.

Glossary

CWDM	Coarse Wavelength Division Multiplexing
DWDM	Dense Wavelength Division Multiplexing
GRID	Global Resource Information Database
NOC	Network Operation Center
SLA	Service Level Agreement