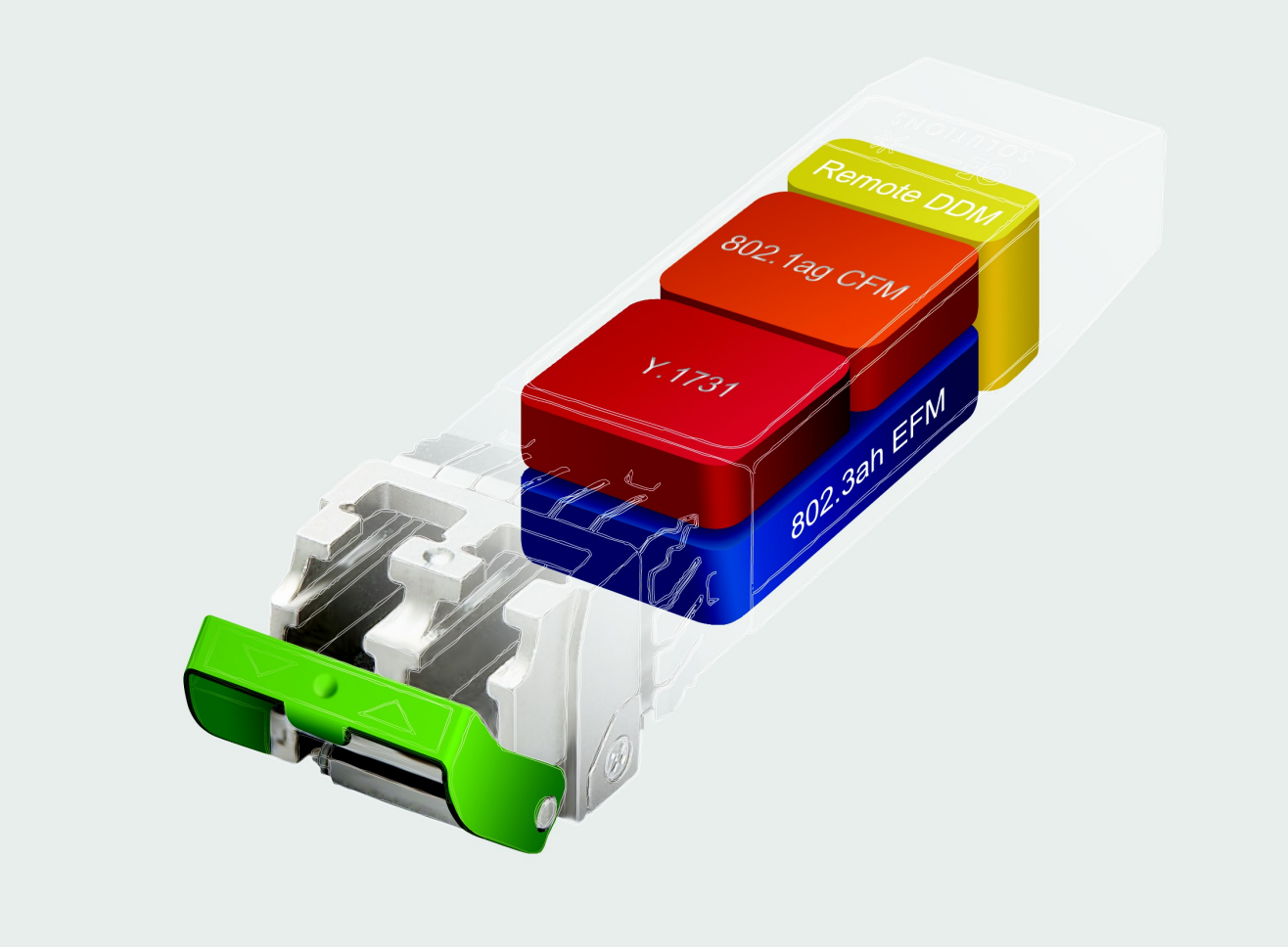
Smart SFP™ simplifies operations and maintenance for network operators



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1. Introduction

OE Solutions and AimValley introduce a new class of SFP module with integrated protocol processing and OAM functions. The Smart SFP™ enables operators and network providers to increase cost effectiveness in their access networks and to reduce operational costs. Fewer equipment is required at the network edge location, reducing installation time and power dissipation, which results in a lower carbon footprint.

This white paper describes how the Smart SFP can be used in various network applications. The important protocols and features for access nodes are reviewed, and how operators and network providers will benefit from the use of the Smart SFP in these networks.

2. Carrier Class Ethernet in Access Networks

Ethernet has become a popular choice for carrier networks in the last few years. The definition of standardized OAM functions and broad availability of equipment gives network operators the confidence that Ethernet is a valuable protocol in their networks. The cost effectiveness of Ethernet products and broad support for service protocols accelerate deployments of new Ethernet networks in the field.

Especially at the edge of the operator network, in the metro and access domains, where cost effectiveness is critical, Ethernet has become a key technology. In many markets, business locations are now served with Ethernet based interface to the premises.

An even stronger push for Ethernet deployment occurs in the mobile backhaul networks. Operators see a continuing increase of capacity demand, that requires a migration from their overloaded transport networks to Ethernet. The introduction of femto and pico wireless base stations increases the amount of access locations that need to be connected to the backhaul network; the cost effectiveness, power consumption and size of the equipment all become critically important aspects of the solution.

To support these new applications, network operators demand Carrier Grade Ethernet solutions that provide these key attributes on products for the network edge:

- Full rate Gigabit Ethernet
- Carrier Class OAM tools: monitoring optical fiber, link layer and service layers
- Very low latency
- Low power, compact size and low cost
- Compatibility with Synchronous Ethernet and IEEE1588 Timing over Packet

2.1. Network Edge

At the edge of the Ethernet network the operator needs a demarcation point: a clearly defined point that separates the domain of the operator from the end user. This demarcation point resides physically in a telecom equipment room at the business customers' premises, or is part of the network interface equipment in the case of a wireless base station.

In many networks the demarcation point is implemented as a small Ethernet switch, supporting a network interface and one or more customer facing ports. These type of switches are generally known as Network Demarcation Device or Network Interface Device (NID) or similar. A NID often implements Ethernet OAM functions to assist the operator in monitoring, troubleshooting and fault localization.

The physical form factor of NID devices is often a 19” wide, 1 rack unit high box for high-end variants. Compact NIDs with a width of about 1/3 rack are also available. Although they are fairly small, they require dedicated equipment slots or rack space and power feeds in the telecom

equipment room. The power dissipation of a NID is in the range of 5 to 30 Watt depending on the configuration, and often fans are used to enable operation over a wide temperature range.

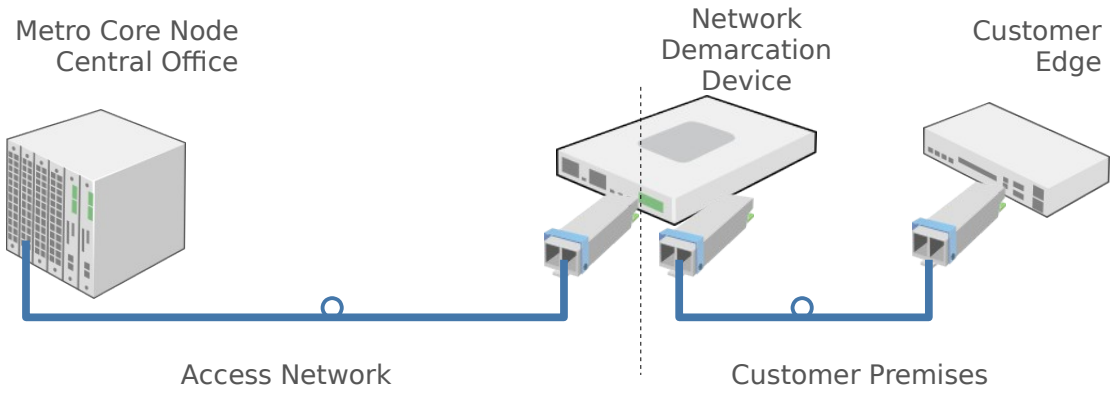

Figure 1: Access Network with NID demarcation

A common implementation of a Gigabit Ethernet based access link is depicted in figure 1. The fiber connection between the Metro Core Node and the business location can have a reach of several 10s km. At the Network edge, in the customer premises, a Network Interface Device (NID) is used as demarcation device. A second link is used between the NID and the Customer Edge equipment.

In many markets, even more equipment is needed at the customer premises or network edge: a first equipment owned by the access network provider, and a second equipment owned by the service provider. These independent roles are often required to comply with governmental or regional regulations. As a result, these providers need to install additional equipment at the edge of the network, resulting in higher power consumption, and additional operations costs for network deployments.

2.2. Smart SFP at the Network Edge

The Smart SFP integrates the key functions of a NID inside the SFP module: Gigabit Ethernet and Carrier Class OAM. This enables a major simplification and cost reduction at the Customer Edge location, see figure 2.

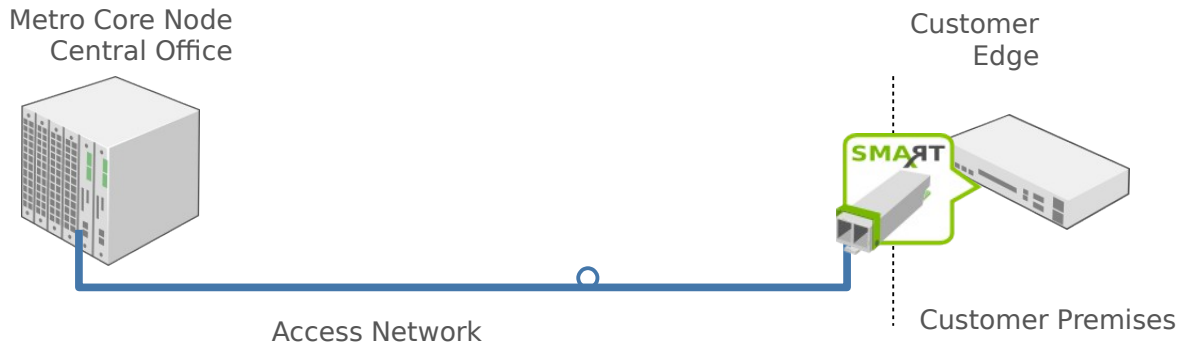

Figure 2: Access Network with Smart SFP

With the introduction of a Smart SFP in the access network link, the operator can build a very cost effective solution and simplify installation logistics: no need to install a NID demarcation system.

A further cost reduction is possible because 3 SFP modules at the customer premises can be replaced by a single Smart SFP module.

Due to its compact size and low power consumption, the Smart SFP can be deployed in various network scenarios, table 1 lists the main applications and key parameters.

Application	*Key parameters*
Mobile Backhaul	Full rate and low latency Gigabit compatible with Synchronous Ethernet
Femto cell feed	Very compact size and low power enable integration in femto networks
Telco wholesale - demarcation	Integrated NID functions such as Link OAM and CFM and Y.1731
CPE endpoints	Provide long haul fiber optics including single fiber and CWDM
Test and measurement	Integrated Link OAM and CFM tools enable Service Activation testing

Table 1: Application scenarios for Smart SFP

2.3. Optical interfaces

The key success factor for SFP modules is their flexibility of choice for physical interface type and signaling rate. In the case of optical Gigabit Ethernet SFP modules, there is a broad set of variants with a wide range of distance support from 100 m to more than 100 km, and a selection of dual fiber, single fiber, and WDM variants.

With the introduction of the Smart SFP module this demand for flexibility is not changed: the Smart SFP module typically is used at the edge of the network and a wide range of supported link distances or single/dual fiber types are key parameters for this application.

OE Solutions' portfolio of conventional optical Gigabit Ethernet SFP modules for a broad range of applications is now extended to the Smart SFP modules, supporting the wide range of fiber distances and single/dual fiber choices. CWDM and single wavelength bidirectional optical interfaces are provided as well.

2.4. Market drivers

Operators and service providers want to simplify their networks. They are faced with the challenges of integrating current and new networks and many different technologies that all need to interwork. At the same time their customers expect higher bandwidth and lower costs for their services.

The Smart SFP enables operators to reduce costs in access and edge networks, allows for significant savings in rack space, and provides savings in maintenance of deployed systems via remote configuration, monitoring and troubleshooting. Furthermore, due to its very low power consumption, the Smart SFP can be an effective tool for operators that want to reduce their carbon footprint.

Benefit	*Background*
Lower CAPEX	Overall cost reduction at the demarcation or access node
Lower OPEX	Simplified installation and integrated monitoring and troubleshooting tools
Lower carbon footprint	Major energy savings possible by removing rack equipment
Operational flexibility	Support of Ethernet OAM and remote configuration
Gigabit capacity	Full rate bi-directional Gigabit Ethernet performance and very low latency

Table 2: Operational benefits with Smart SFP

3. Management and OAM protocols

3.1. Overview

The Smart SFP provides NID functionality integrated in an SFP module. The optical interface at the front of the module, and electrical interface at the system side both provide full rate Gigabit Ethernet. The Smart SFP is fully compatible with the MSA standard for SFPs, see [MSA] and [DDMI].

The electrical system interface supports the Gigabit Ethernet data signals, and out-of-band signals for Loss of Signal, Transmit Disable, Transmit Fault, Module present and 2-wire serial interface. The local host system can access the standard SFP inventory and Digital Diagnostics Monitoring via the 2-wire latter interface the host system.

The Smart SFP Protocol Processor supports Ethernet OAM protocols and Remote DDMI. An integrated database maintains the protocol and configuration parameters of the SFP module and restores these parameters during power up of the module.

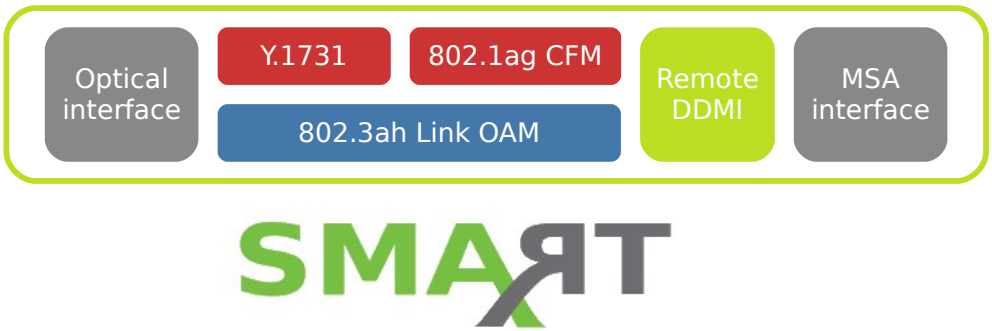

Figure 3: Smart SFP functions

3.2. Remote Management

Some functionality on the Smart SFP is available as instant-on: the module provides these functions without any configuration. An example of instant-on is the support for Link OAM. As soon as the Smart SFP is inserted in a system, the Link OAM protocol is automatically established with the remote equipment, without any configuration on the Smart SFP.

Other protocols must be configured or enabled on the Smart SFP before they can be applied in a network. As an example, the Maintenance Domain parameters for the CFM OAM protocol must be configured by the operator and aligned with other equipment in the same Domain. The Smart SFP module contains an integrated management function to allow retrieval and configuration of parameters from a central network operations center.

Access to the protocol parameters on the Smart SFP is enabled by Titan, a software module provided by AimValley. The Titan module allows system and product manufacturers to integrate Smart SFP management functions into their own systems. Titan can be added in an existing management framework, or integrated in the transport nodes in the network.

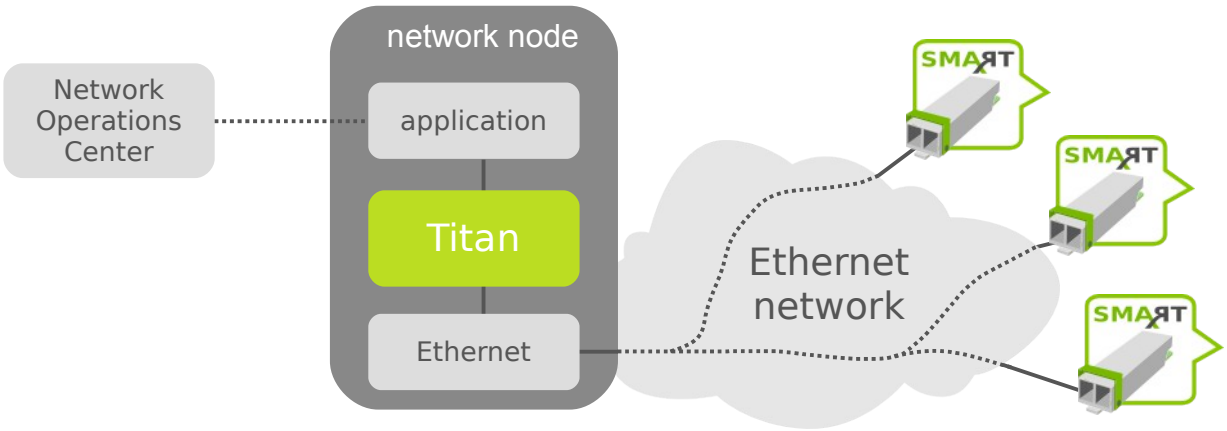

Figure 4: Titan software module for access to Smart SFPs in a network

With the Titan software, the Smart SFP behaves as a plug-and-play device on the network: when a device is inserted for the first time with factory default settings, it is automatically detected on the network and can be configured for service from a central network operations center. This reduces the installation effort, and enable remote monitoring and troubleshooting of Smart SFPs at the edge of the network.

The Titan software module that acts as a device driver for Smart SFPs. In the typical usage scenario Titan is integrated in one of the transport or switching nodes on the network, see figure 4. The Titan software in the network node acts as a proxy or gateway between the Smart Devices and a network management system. The Titan module provides the access to devices on the network, while the application software provides an interface to the Network Operations Center.

3.3. OAM protocols

To address various applications and requirements set forth by operators and network providers, Ethernet OAM is defined at several network layers. Each layer in the network uses a dedicated OAM protocol. The network provider, the operator and the end-customer deploy their specific protocol to monitor network performance at their level of the hierarchy. These different OAM layers operate in parallel on the network.

Layer	*Protocol*	*Function*	*Description*
Physical Layer	DDM	Digital Diagnostics	Monitor receive and transmit power, temperature and voltage levels
Link Level	Link OAM	Discovery	Monitor communication between the devices on the link
		Critical Events	Report link failures and dying gasp
		Latching Loopback	Enable link testing with measurement equipment
		Event Notifications	Report link level code errors and frame errors
Service Level	CFM	Connectivity	Monitor path between devices across a network
		Loopback	Discover remote devices
	Y.1731	LM	Supports measurement of frame loss and frame loss ratios
		DM	Supports measurement of frame delay

Table 3: OAM at multiple layers

3.4. Link OAM

The Smart SFP supports Link OAM as an instant-on functionality. Upon insertion into a system, the Smart SFP provides Link OAM in passive mode, without any configuration. The Smart SFP implements discovery, critical event reporting, event notification PDUs and loopback. If the equipment at the other side of the link enables active mode Link OAM, the protocol is automatically established without any configuration at the Smart SFP.

A typical use case is during installation and service activation of a new access link. The Smart SFP is installed at the customer edge of the network. The service personnel of the access network provider can use standard measurement equipment at the network center and perform extensive link monitoring and performance testing, using the Smart SFP as an active remote loopback device.

After service turn-up, during normal service operation, the Link OAM function remains enabled, and operates on the fiber link between the Smart SFP and the Edge Switch of the network provider. The access link is continuously monitored by the Edge Switch, and link level alarms and performance monitoring reports are collected and reported to the Network Operations Center of the provider.

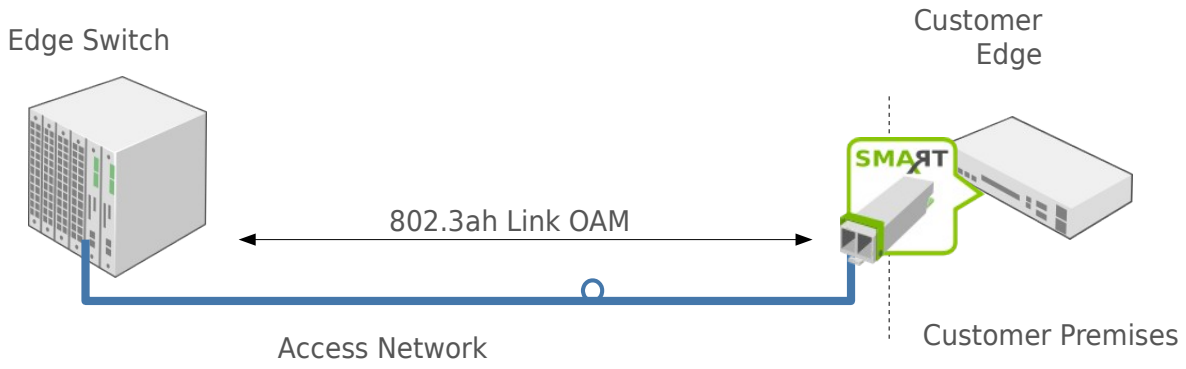

Figure 5: Link OAM

3.5. CFM and Y.1731

These protocols offer network monitoring tools that operate at the service layer. CFM OAM can be used at multiple levels, supporting monitoring of the access portion of the network, but also allows end-customers to monitor their connection end-to-end across multiple networks or operator domains. The Smart SFP can be configured to support specific maintenance levels and maintenance domains.

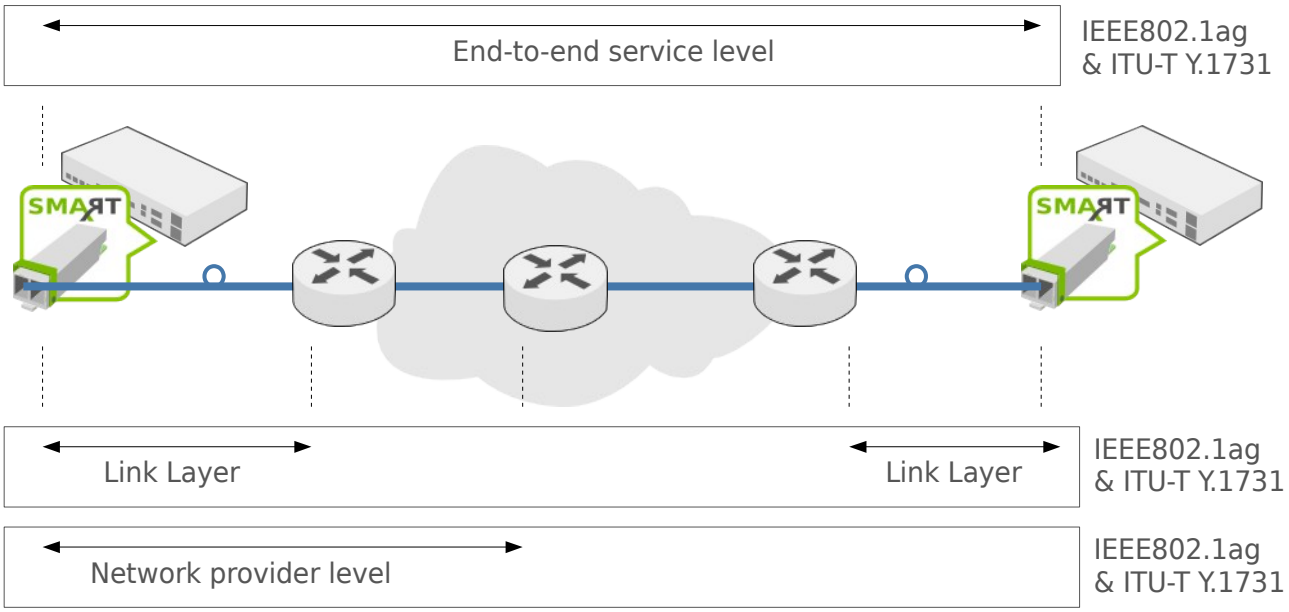

Figure 6: CFM at multiple layers

A typical application for end-customers is to deploy Smart SFP modules at their customer premises. Using service OAM at their maintenance level (level 6 or 7), the customer can monitor their service connections, and verify that they obtain the services that were agreed in the SLA contract with their provider.

For access network providers, especially in the wireless backhaul domain, the Smart SFP allows them to continuously monitor the throughput, frame loss and delay parameters that are critically important for their customers: the mobile operators.

In all network scenarios the Smart SFP simplifies the service activation procedure: once the Smart SFPs are installed on the service monitoring points, the user can discover the devices on the network, configure the CFM and Y.1731 parameters from a Network Operations Center and then verify connectivity between network nodes, measure performance and subsequently, after activation testing, enable the network for operational service.

During the operational service phase, the Smart SFP supports alarm reporting and assists in fault localization, on-demand performance tests, and continuous pro-active measurement of throughput, frame loss and frame delay.

4. Conclusion and summary

The Smart SFP is a revolutionary new class of SFP which integrates intelligent and innovative system functions into an SFP module. Operations, Administration and Maintenance (OAM) tools are essential for service turn-up and Service Level Assurance in Carrier Ethernet networks. The Smart SFP provides operators with these tools for monitoring and troubleshooting Ethernet services by simply replacing a conventional SFP with a Smart SFP.

This solution reduces system and network complexity, and offers lower power and carbon footprint while generating CAPEX and OPEX savings. The Smart SFP enables green initiatives for service providers and allows them to optimize their carbon footprint in multiple ways: reduce the amount of equipment, lower power dissipation and reduction in air conditioning costs.

The Smart SFP modules provide customers easy solutions for monitoring and troubleshooting using standardized protocols at various operational layers:

- physical layer monitoring via remote digital diagnostics retrieval,
- link layer monitoring via instant-on support for Link OAM according IEEE 802.3ah,
- service layer OAM using Connectivity Fault Management according IEEE 802.1ag and ITU-T Y.1731.

These new capabilities are complemented with Gigabit Ethernet wire speed and very low latency. The Smart SFP serves a wide range of optical and reach applications: duplex fiber, single fiber bidirectional, and single wavelength bidirectional, including CWDM with reaches up to 80 km at industrial temperature range.

Bringing intelligence into SFPs simplifies operations and maintenance for network operators and service assurance applications. Ethernet products equipped with a Smart SFP provides operators service visibility at the network edge or demarcation in applications like Mobile Backhaul, Business Ethernet and Carrier wholesale, essential for rapid Service commissioning and manage revenue generating SLAs.

5. Acronyms

CCM	Continuity Check Message
CFM	Connectivity Fault Management (IEEE 802.1ag)
CPE	Customer Premises Equipment
CWDM	Coarse Wave Division Multiplexing
DDM	Digital Diagnostics Monitoring
EFM	Ethernet in the First Mile (IEEE 802.3ah)
IEEE	Institute of Electrical and Electronics Engineers
NID	Network Interface Device
OAM	Operations, Administration and Maintenance
SFP	Small Form-factor Pluggable transceiver
SLA	Service Level Agreement
WDM	Wave Division Multiplexing

6. References

[CFM] IEEE802.1Q-2011 Clauses 18 .. 22, Connectivity Fault Management (formerly IEEE802.1ag-2007)
[L-OAM] Link OAM, IEEE802.3-2008 Clause 57 (formerly IEEE802.3ah-2004)
[MSA] INF-8074i Specification for SFP (Small Formfactor Pluggable) Transceiver, Rev 1.0, May 12, 2001
[DDMI] SFF-8472 Specification for Diagnostic Monitoring Interface for Optical Transceivers, Rev 11.0, September 14, 2010

7. Contact

Smart SFP™ is a Trademark of OE Solutions and an intelligent transceiver product family developed jointly by OE Solutions (www.oesolution.com) and AimValley (www.aimvalley.com). You can find more information on our Smart Transceivers on www.smartsfp.com.

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