OPTIME Managment and monitoring layer of optical network for time and frequency transfer

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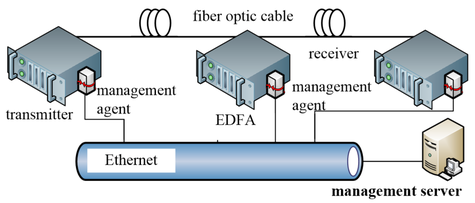
J. Kołodziej (jacek.kolodziej@agh.edu.pl), J.Stępień
AGH University of Science and Technology, Krakow, Poland

W. Bogacki (wojbor@man.poznan.pl), K. Turza
Poznan Supercomputing and Networking Center, PSNC,Poznan, Poland

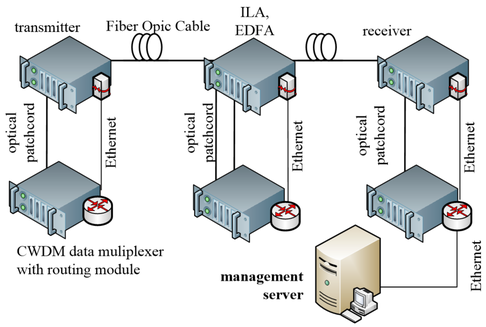
Optical Network Management

ONM for Time and Frequency Transfer



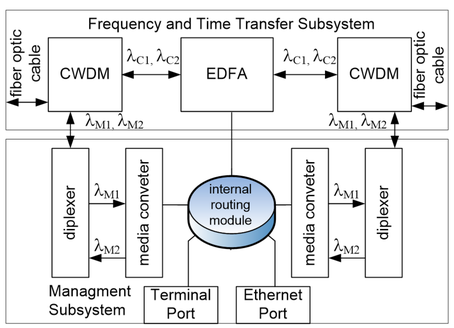
Reliable operation of ultra-precise time and frequency transmission **requires special monitoring, calibration and management procedures** to **ensure high functionality, safety, and quality** of the time and the frequency dissemination.

Functions of the ONMTFT:
- safe access to all active system nodes;
- reading the unit status (e.g.:name, programmable parameters);
- remote reprogramming the unit parameters (e.g.: gain)
- continues/real time and on demand monitoring node performance parameters (e.g.: temperature TEMP, input/output
- communication with end user (e.g.: sending information about system status).



In practical implementation of backbone network **is impossible to deliver dedicated Internet connection to all standalone nodes**. The GPRS access to network very often causes difficulties too, additionally for security reason some private network (e.g.: VLAN, VPN) is needed.
The **in-fiber techniques** solves mentioned problem, but requires additional components.

In-fiber management



An implementation of the ONMTFT management subsystems, requires additional elements:
- internal routing module (it is necessary to data exchanging between nodes and more flexible than programmable switches),
- Ethernet copper to fiber media converters
- optical CWDM filters
- optical diplexer.

In-fiber management methods multiplexes time signal and management data using only one fiber for two functions. Control and status data coming from dedicated EDFA are formatted into Ethernet packet and distributed according routing table by internal module to media converters or local external Ethernet port.
The CWDM filter combines two control links (with λ_{M1} and λ_{M2} wavelengths) with time transfer carrier (λ_{C1} and λ_{C2} wavelengths) in one common fiber.

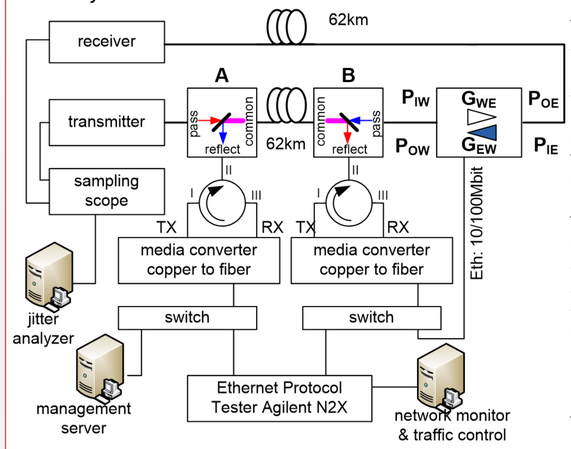
Tests and measurements

Problems to solve

1. Does a common transmission of precise time signal and management data in one optic fiber link degrade time accuracy?

2. Does logged data of each component in the time and frequency transfer link (EDFAs, endpoints) carry information about link behavior and could this information be useful to improve time stabilization?

Test system architecture



The fibers deployed in optical cable and located in the field running along the motorway near Krakow and being the part of the TP S.A. telecommunication infrastructure, was used.

The fibers were looped-back, thus both ends of each line were accessible in the AGH Optical Network Laboratory.

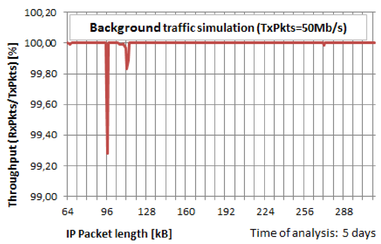
In whole line SC/APC mechanical connectors were used.

Experiments EDFA amplifier, was continuously control and data was recorded to the server.

Managed amplifier was inserted between two 62 km long fiber spans (referred as B) with total attenuation equal 19.2 dB and 19.5 dB respectively.
The copper to fiber media converter with the SFP module of 1510 nm (λ_{M1},λ_{M1}) and link budget 20 dB was applied.

The optical circulator separate TX and RX signal and optic filter to split (λ_{M1},λ_{M1}) and time transfer carrier (λ_{C1},λ_{C2} wavelengths close to 1497ns) .

Management data traffic simulation

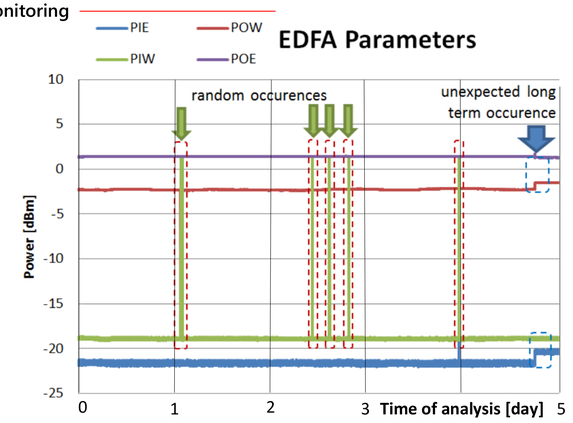


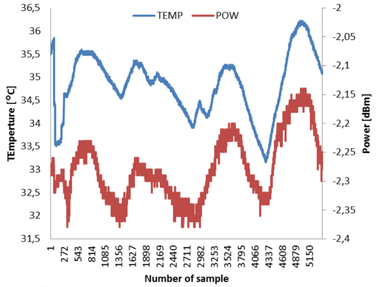
The ILA remote pooling was executing concurrently with simulation of background 50Mbit/s network traffic, generated and measured by AGILENT N2X Network Protocol Analyzer. The maximum measured throughput between point A and B was 80Mbit/s, and this boundary is consequence of switches limitations.

Conclusions

Continues EDFA monitoring

A short random occurrence of PIW fluctuation and changes of POW and PIE was observed, but it **doesn't influent to time stability**.

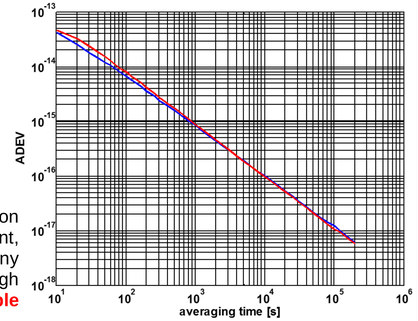




The **strong correlation between temperature and output power can be observed**, however previouse* analyzes suggest that it is possible to compensate influence of temperature variance to output power. This discovery should be better investigated in future, because is related to transmitted time stability. This discovery should be better investigated, because is connected with transmitted time stability.

Time transfer accuracy

Time and frequency stability with (red line) and without (blue line) management, measured by the Allan deviation (ADEV) **gives similar results**.



Summary

The Time and Frequency dissemination system requires additional management, because the link is spread over many kilometers and keeping it on its high accuracy of time transfer **is impossible without reliable management system**.

Presented out of band in-fiber solution **fulfill operator expectation** and could be developed in the future. The management system **doesn't change Allan deviation of transmitted clock** and allows provide additional analysis to improve performances of time transfer.

* Ł. Śliwczyński, J. Kołodziej, "Bidirectional Optical Amplification in Long-Distance Two-Way Fiber-Optic Time and Frequency Transfer Systems" IEEE Trans. Instr. Meas., vol. 62, pp. 253-262, 2013.