Nordic T&F activities

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Recent T&F activities in the Nordic region

- 1st Nordic T&F workshop held in Copenhagen September 2019
  - NORDUnet and Nordic NRENs
  - National Time Labs (DK, FI, NO, SE)
  - IXPs (DK, SE) and regulators (FI, NO, SE)

- Situation vary in each country but was seen beneficial to work together
  - Enhancing sustainable support for official time keeping, critical infrastructures like 5G and smart power grids

- Knowledge sharing and working together when planning T&F transfer over optical systems
  - Do not “reinvent the wheel”
  - Interoperability between optical domains
T&F transfer FI-SE

• Had STM-64 based T&F link Espoo (FI) – Stockholm (SE) few years ago
  o Now decommissioned

• Migration to federated NORDUnet next-gen network
  o Use existing national optical systems and CBF links
  o New FI-SE links will be build Q1/2020, opportunity to build T&F support for bi-directional signals from day 1

• Funet and SUNET have similar requirements
  o Hybrid amplification (EDFA + RAMAN) to optimize OSNR
  o Mixing data and T&F in C-band not desired
  o OTDR (1650 nm) in use or planned
Bi-directional T&F challenges

• RAMAN amplifiers
  o No filters can be installed in front of the RAMAN amplifier
  o < ~ 1528 nm won't pass RAMAN amplifiers
  o ~ 2 dB insertion loss for > C-band signals
    o Except: extensive loss in ~ 1570 nm region
  o ~ 2-3 dB RAMAN gain in 1600 nm region
    o 2 dB gain measured for 1650 nm OTDR signals

• 1600 nm region between C-band and OTDR
  o Little bit higher loss per km in G.652 fibers
  o Higher chromatic dispersion

• Extra C-band loss to be avoided if possible
  o Daisy chaining different filters not an optimum solution
Joint planning for T&F links

- Extensive discussions and planning late 2019
  - Funet and SUNET
  - Netnod/RISE (SE) and VTT (FI)
  - ADVA

- **1610 +6.5 nm chosen for T&F**
  - Already tested in Finland and Sweden by using ADVA 1605/1615 nm optics and separate 1610 +6.5 nm filters
  - L-band DWDM optics available for ~1610 nm with required CD tolerance
  - EDFA noise filtered out so should not be an issue

- White Rabbit switches and low latency/jitter media converters
  - L-band optics will be tested by Netnod/RISE

- More optimization for filtering structure...
T&F filter

• Customized C-band (1525-1570 nm), T&F (1610 ±6,5 nm) and OTDR (1630-1670 nm) filter
  o 0,7 dB C-band loss (very important, similar with existing OTDR filter)
  o 1,0 dB T&F loss (very important on high loss links)
  o 1,2 dB OTDR loss (less important)
  o Fully bi-directional (no calibration needed)

• Customized optical circulator for high loss links (21+ dB)
  o 2 dB insertion loss

• Customized 1:2 optical splitter for low to medium loss links
  o 4 dB insertion loss

• Low CAPEX (fs.com)
  o < 70 EUR filter, < 10 EUR splitter, < 140 EUR circulator

Photos: CSC/Funet and Netnod
T&F filters in a node
T&F capability plans

- Espoo – Turku – Stockholm
  - Turku – Stockholm (when build)
  - Espoo – Turku (filter change)
- Vaasa – Umeå (readiness)
T&F readiness plans

- CBF to SUNET in Kalix
- CBF to UNINETT in Kilpisjärvi
- Kaareuvanto (EISCAT-3D site in Finland)
- Sodankylä (observatory)
- Kajaani (HPC site in Finland)
- Further links per needs (already build)
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