

Optical Pluggables for Mobile Fronthaul in SKT

- For 5G and Beyond

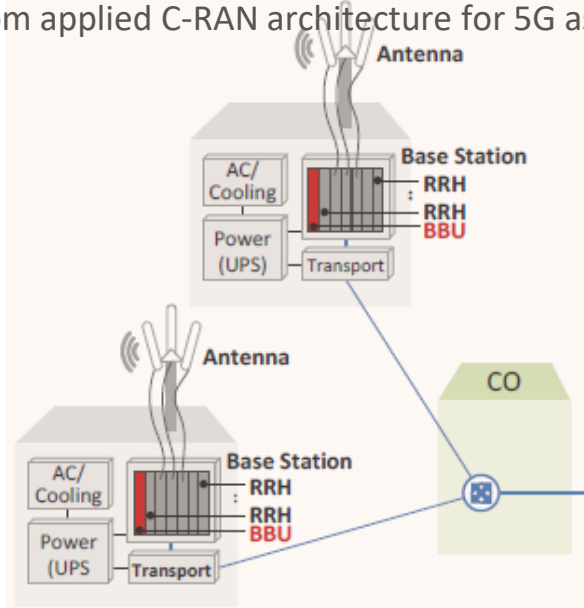
ECOC 2023 MOPA Workshop

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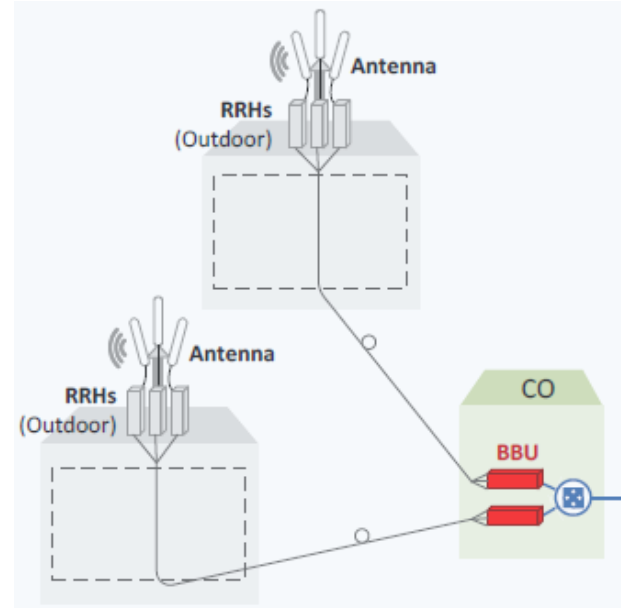
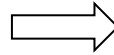
SK Telecom
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D-RAN vs. C-RAN & Fronthaul

- C-RAN: Extracting digital parts from e-Node B and placing them in CO
- Pros: Saving TCO (space rental, no air conditioning, less maintenance cost, more features etc.)
- Cons: Requires much higher bandwidth compared to original wireless data bandwidth
- SK Telecom applied C-RAN architecture for 5G as well as 4G



Distributed RAN



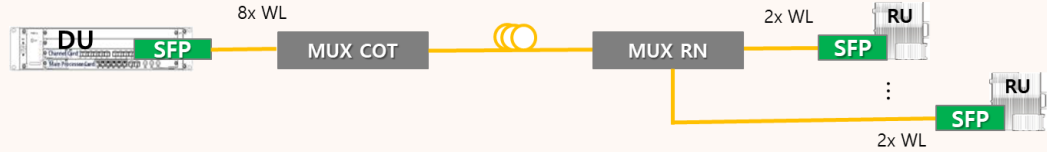
Centralized RAN

5G Fronthaul Solutions in SK Telecom

- Low Density Area

- 8 CWDM wavelengths

- No protection

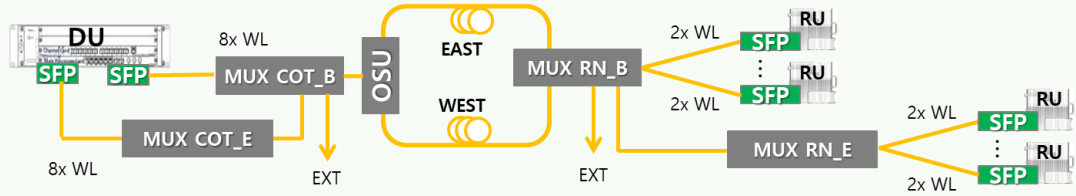


- Mid Density Area

- 16 WL in O-band

- Fixed DWDM SFP

- OSU optional

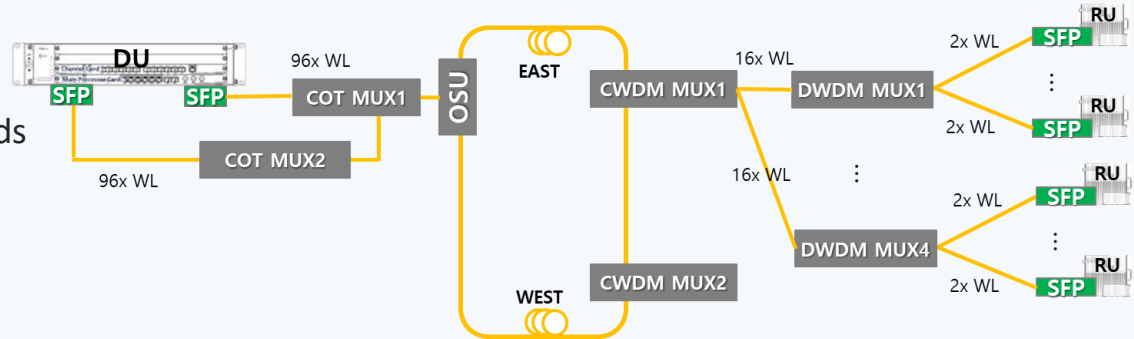


- High Density Area

- 192 wavelengths in 12 CWDM-bands

- Tunable DWDM SFP covering 4 WL

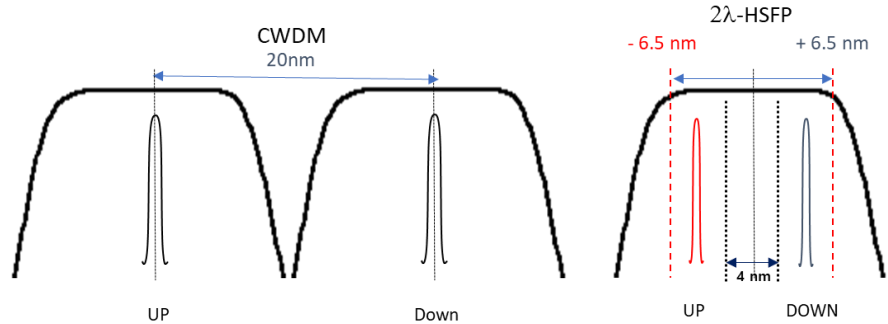
- OSU mandatory



Optical Pluggables for Mobile Fronthaul in SK Telecom

- High Density CWDM SFP

- Bi-Di SFP
- 2 Cooled lasers in 1 CWDM-band
- 3 or 6 Gbps, 20 km of SMF



- O-band DWDM SFP

- Duplex SFP
- 16 DWDM lasers in 1290 nm-band with 0.8 nm channel spacing
- 10 or 25 Gbps, 30 km of SMF

- Tunable DWDM SFP

- Duplex SFP covering 4 DWDM wavelengths in O/E/S/C-band , 0.8 nm spacing
- To reduce the inventory burden
- Two different version: with AMCC for automatic tuning/without AMCC for manual tuning

Optical Pluggables for Mobile Fronthaul in SK Telecom

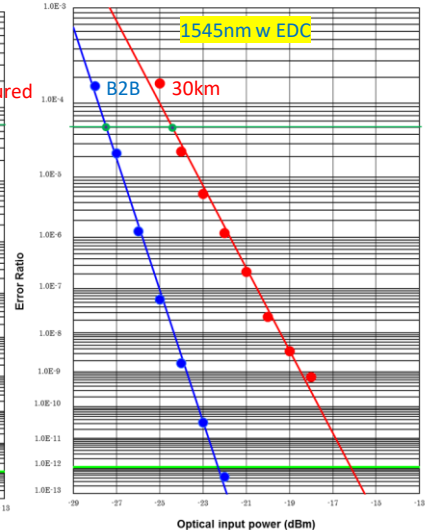
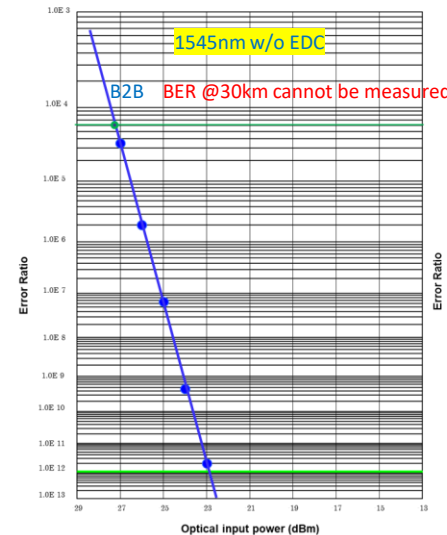
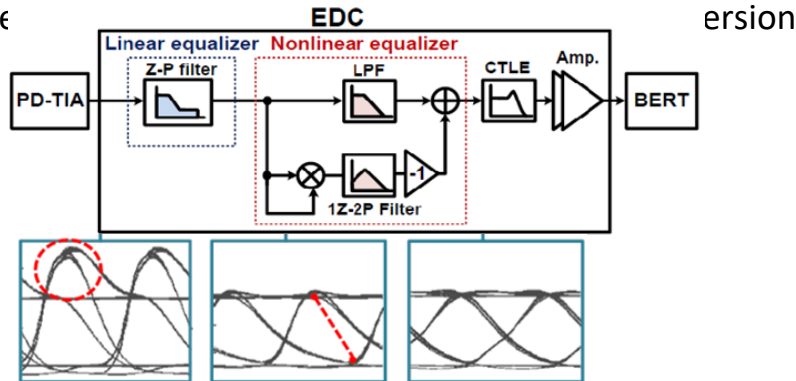
- 25 Gbps SFP with Electrical Dispersion Compensation

- SoC for EDC was integrated into SFP

- Linear equalizer to remove the energy overlap of level 0 and 1
- Nonlinear equalizer to take two different decision time for 0 and 1 based on internal eye scanner
- Supports CRPI and eCPRI both (different clock rate)

- Duplex SFP in E/S/C-band with SMF up to 30 km

- Power

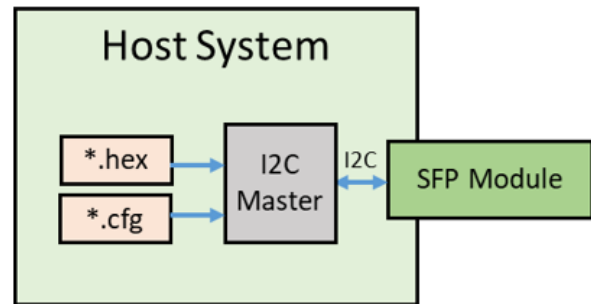


Remote Down-Loading the Firmware of Optical Pluggables

- Firmware of optical pluggables need to be updated.
 - Fixing Errors: not discovered in the system vendor certification testing but found after the deployment.
 - Implementing new user-required features
- Firmware update of optical pluggables in DU is relatively easy, but that in RU may consume much time and cost.
→ RDL for the firmware of optical pluggables can save Telco's operational cost
- Use case
 - Error 1: some of DDM information were not readable in host mobile system
 - Error 2: the rate selection of 10G/25G – the operator's requirement and the system vendor's implementation were different
 - Error 3: the center wavelength drift of DWDM pluggables due to the incompleteness of aging the laser
 - Extending the life cycle of optical pluggables by changing look-up table of TEC
 - Implementing the loop-back test function

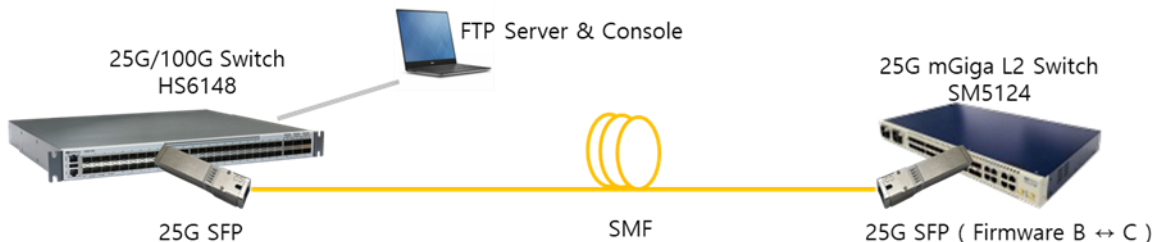
Remote Down-Loading the Firmware of Optical Pluggables

- Live Demo of Remote Down-loading the firmware of Optical pluggables
 - SK Broadband Stand-No. 805 in Hall3
 - Firmware update of SFP in remote side
 - L3 switch for CO side and L2 switch for remote side



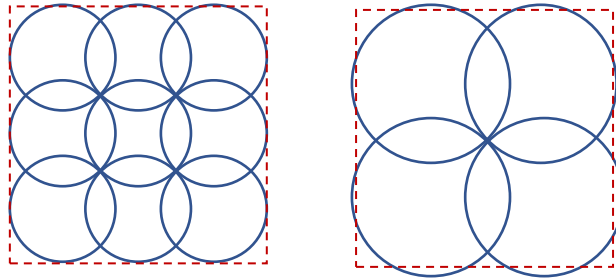
- RDL Operational Procedure

- The firmware image and the config file of optical pluggable are stored in FTP server.
- The files are transferred to the file system in remote host through data channel.
- Host systems download the files to the optical pluggable through I2C interface.
- The optical pluggables reboot and activate the new firmware.



Challenges on B5G/6G Fronthaul – 1

- Challenge: Fronthaul Distance & Latency
- It is beneficial for mobile operator to have the longer distance of fronthaul network.
 - Smaller number of BBU hotels to cover the same area
 - Saving the operational cost (renting the space, providing air-conditioning/UPS)



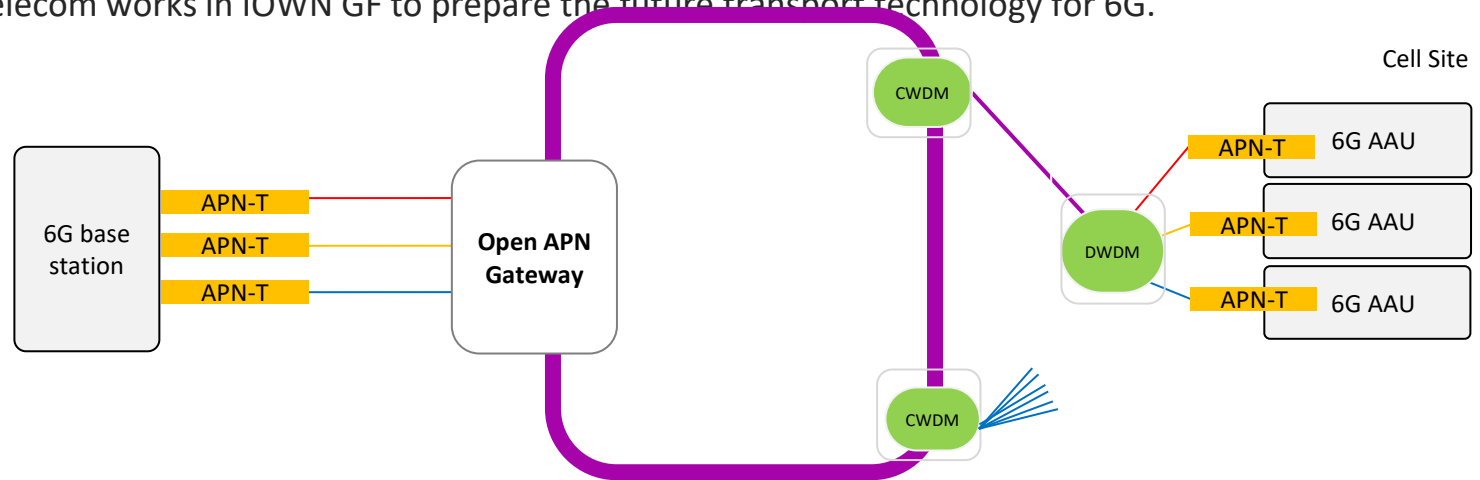
- Mobile systems tend to support the longer fronthaul distance.
 - The round-trip delay is not 3GPP requirements anymore but implementation issue
 - SK Telecom consistently asked for mobile system vendors to enlarge fronthaul distance.
 - 30 km fronthaul: Vendor A is ready in HW and SW, vendor B and C is ready in HW but not in SW
 - 40 km fronthaul: Long-term project. The side-effect on cell throughput need to be considered.

Challenges on B5G/6G Fronthaul – 2

- Challenge: Higher Line Rate of Fronthaul Interface
- Mobile systems will need higher fronthaul line rates to support more bandwidth and antennas.
- History
 - LTE : 2.5 Gbps/3.1 Gbps
 - 5G : 10 Gbps → 25 Gbps
- Considering points of higher line rates
 - High order modulation to get less impact from the fiber dispersion penalty → PAM4, Coherent
 - Package size & interface pin map to support 50/100 Gbps → staying with SFP or migrating to QSFP
 - Link budget need to be maintained regardless of the speed of fronthaul → Optical amplifier, Coherent
- Issues for 100G Digital Coherent Optics
 - cost : competitive to 100G PAM4 (100GBASE-ER)
 - power consumption : ~ 14 watt → 5 watt

Challenges on B5G/6G Fronthaul – 3

- Challenge: Dynamic Reconfiguration of fronthaul path
- Use case
 - Reduction of mobile system power consumption with elastic load balancing,
 - Network recovery against vDU failure
- SK Telecom works in IOWN GF to prepare the future transport technology for 6G.



APN-T : Open APN Transceiver

