Consideration on chromatic dispersion from telecom's realistic deployment of optical cables

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Background

- Chromatic dispersion parameters or zero dispersion wavelength (ZDW) ranges play an critical role in 802.3dj‘s 2km and 10km IMDD specifications.
- The relevant discussions using a statistic method have been proposed and ongoing as the spec’s progress
  - cole_3dj_optx_01_230427, liu_3dj_01a_2307, and johnson_3dj_2307
  - castro_3dj_optx_01_240222, rodes_3dj_optx_01a_240222,
  - parsons_3dj_01b_2403, castro_3dj_01a_2403
- Here we present the realistic deployment scenario of telecom’s optical cables, and give some suggestions on consideration of chromaitc dispersion parameters.

2km and 10km PMDs are widely used in CMCC's nework

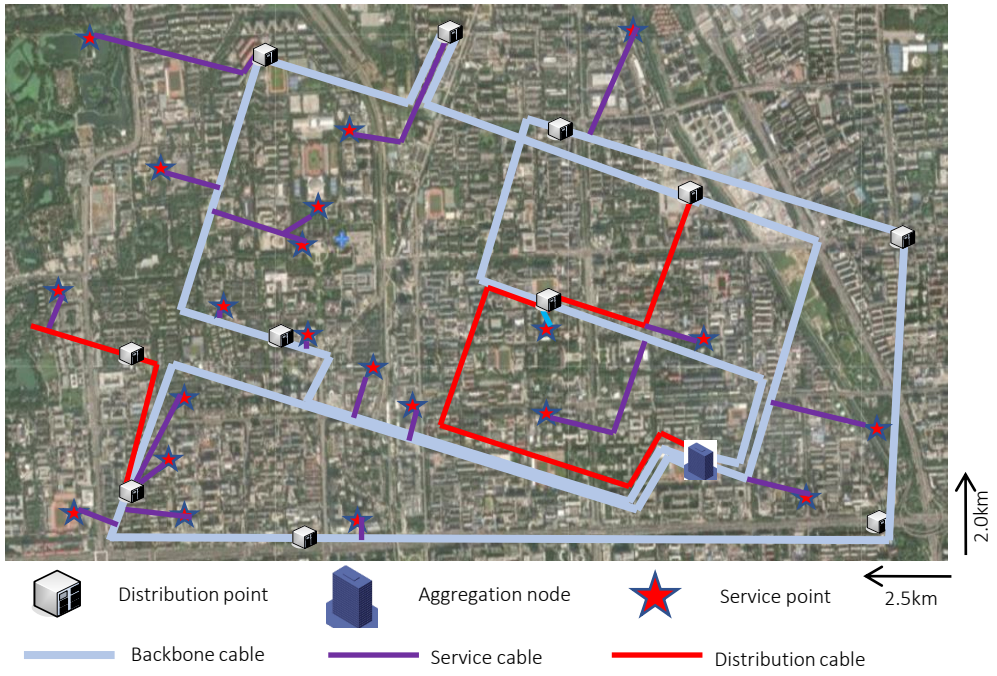
- As a service provider of telecom and cloud, CMCC uses a wide range of 2km and 10km PMD technologies in IP network and data center network
  - In the IP network, 2km optical PMDs of one pair SMF are used to interconnect between IP routers and optical transport devices in the same buliding; 10km optical PMDs are used in devices distributed different bulidings.
  - In the date center network, especially for AI infrastructures, CMCC also adds 2km PMDs for spine and leaf switches on the same floor, and 10km PMDs for different floors or buildings.
- For this moment, 2km and 10km PMDs are both connected through single-mode optical fibers or cables

Deployment of telecom’s optical cables

The optical cables in China Mobile's current IP network are distributed with huge complexity and diversity, with significant differences among different areas or cities

- Different areas in the city
  - Urban areas: optical cables are mainly set or buried along roads, underground pipelines, rivers, greenbelts, etc. At the crossing, optical distribution boxes are extensively used for the interconnection of fibers.
  - Non-urban area: such as forests and mountains, optical cables are overhead or exposed outside,which suffer from harsh environmental changes.
- Different cities or provinces
  - The layout of optical cables in different cities or provinces are also different. Eg. Inner Mongolia province’s geographic region is long and narrow, and there are relatively longer fiber sections and aerial optical cables.

Optical cable distribution at Daxinganling’s partial area



Current status of deployed optical cables

- Having been laid for a long period of time
  - The G.652 fiber cables procured by CMCC are required to have a service life of 15 to 20 years
  - Most latest cables of the access network were laid around 2017 for the construction of 5G networks
- Deteriorated performance over time
  - Muliple fusion-splice points may exist at one fiber segment due to the accidental cut off during municipal construction, effectively eating into link margin
  - The backbone optical cables buried underground are difficult to be replaced in the short term, where the aging process is inevitable.

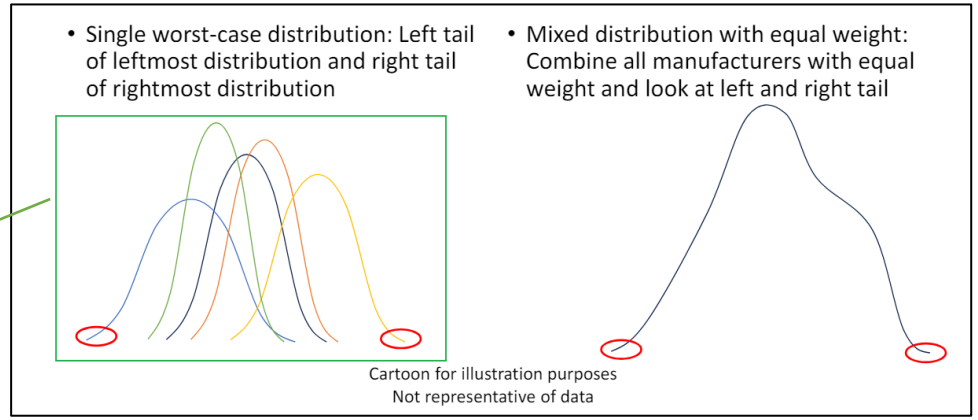
Impacts of link down on metro network

- For the super-cities like Beijing and Shanghai, its metro network generally covers very large density of population.
  - Average density of users in urban areas: 2000 to 4000 per square kilometer.
  - Number of users serviced by one service router: 3000 to 4000.
  - Coverage area of one service router: 0.75 to 2 km^2.
- Service routers are typically connected to metro core routers through a 2km or 10km link. On condition that the devices are located at different buildings, the links between them are usually necessary to utilize the already laid trunk optical cables.
- Any abrupt link down or signaling loss that occured at the trunk link could affect tens of thousands of users.

Inputs to the current discussion on dispersion model (1)

- Overall procurement of optical cables from multiple vendors by comparison and selection
- Due to the procurement and construction by stage, the fiber and cable may stem from multiple venders in CMCC's overall network. Some individual links are typically built using optical cables from one vendor.
- Therefore, it is suggested to consider some individual vendor distribution when performing statistical analysis.
  - Noting the quite diversed distribution of different vendors data
  - Preventing truncation of some vendors' due to the lump-sum consideration of a much bigger data set

✓ **Preferred methodology**



parsons_3dj_optx_01_240627

Inputs to the current discussion on dispersion model (2)

- Conservative is always safe
  - High requirements of reliability in metro and backbone network: no more than two times within one quarter and four times within one year; Once occuring such accident, huge economic losses will be caused to network operators
  - Given the gradually aging optical cables, relaxing the constraints on dispersion parameters may lead to intolerant link faults.
- Suggested direction for defining the CD model of 802.3dj optical PMDs
  - Considering distributions of individual vendors separately, based on the fiber cable deployment model
  - Consider a confidence level of at least 99.99%, noting the large impact of decreasing one decimal point raises risks for tens of thousands of our users.

Summary

- Distribution of telecom’s optical cables is relatively complex, and required a service life of 15 to 20 years. Hence, the transmitter specifications being developed should take into account the performance of aging optical cables.
- Narrowing the dispersion parameter range in excess will lower the requirement of transmitter performance, which may lead to intolerant link faults.