IEEE802.3 HSSG

100GE – 10/40km Economic Feasibility – Network Provider View

Ralf-Peter Braun,

Deutsche Telekom AG

March 2007 – Plenary - Orlando

100GE – 10/40km Economic Feasibility – Network Provider View
## HSSG approved Objectives – Overview

HSSG approved objectives

#1   Support full-duplex operation only

#2   Preserve the 802.3/Ethernet frame format at the MAC Client service interface

#3   Preserve minimum and maximum Frame Size of current 802.3 Std

#4   Support a speed of 100 Gb/s at the MAC/PLS interface

#5   Support at least 10km on SMF

#6   Support at least 100m on OM3 MMF

#7   Support a BER better than or equal to 10-12 at the MAC/PLS

#8   Support at least 40 km on SMF

100GE – 10/40km Economic Feasibility – Network Provider View
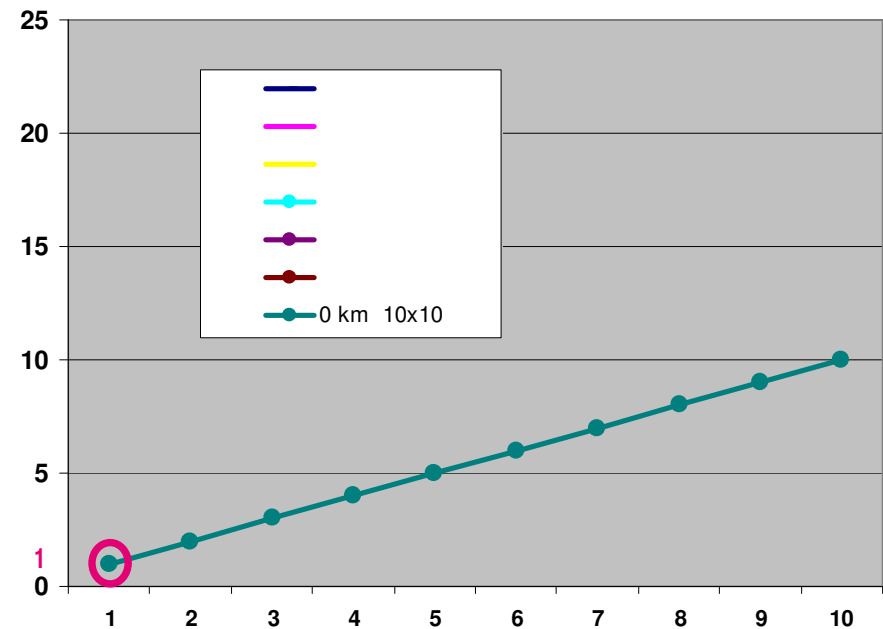## 10 Gbit/s – Reference Scenario

- **Basic Scenario: 10GE - SR**
  - Bitrate   1 x 10 Gbit/s
  - Fiber Length   0 km
  - Aspects   Connection with 2 Line cards and 2 XFPs (Short Reach), no end-switches
  - Cost Factor   **1** (basic 10GE-SR connection, 2 x XFP-card & 2 x XFP-SR)

1 x 10GE–SR connection, 0 km
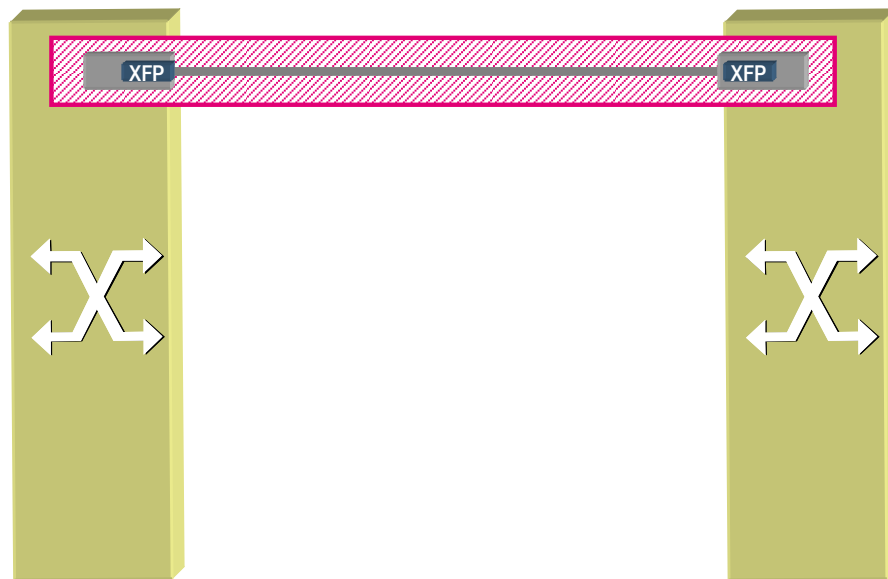
Cost Factor versus Number of 10GE Channels

0 km 10x10
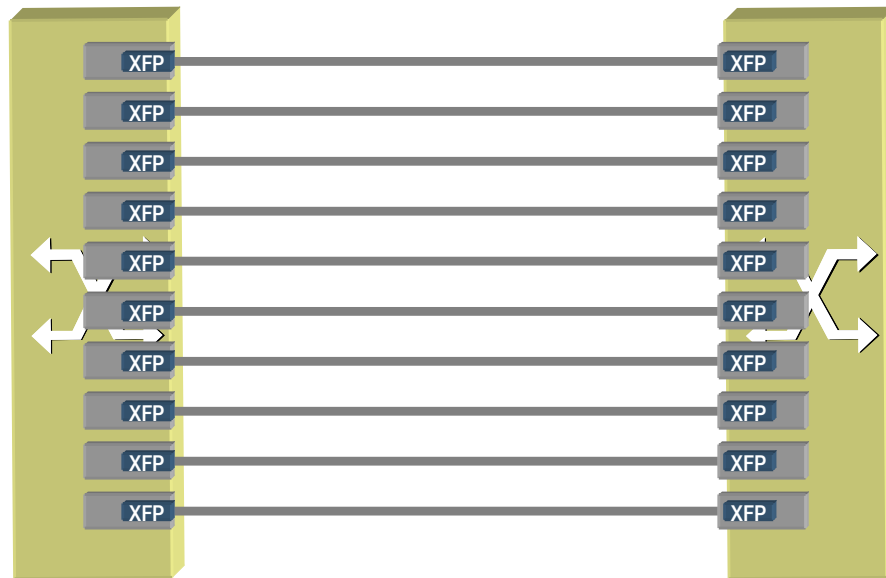
Deutsche Telekom · · T · · Systems

100GE – 10/40km Economic Feasibility – Network Provider View
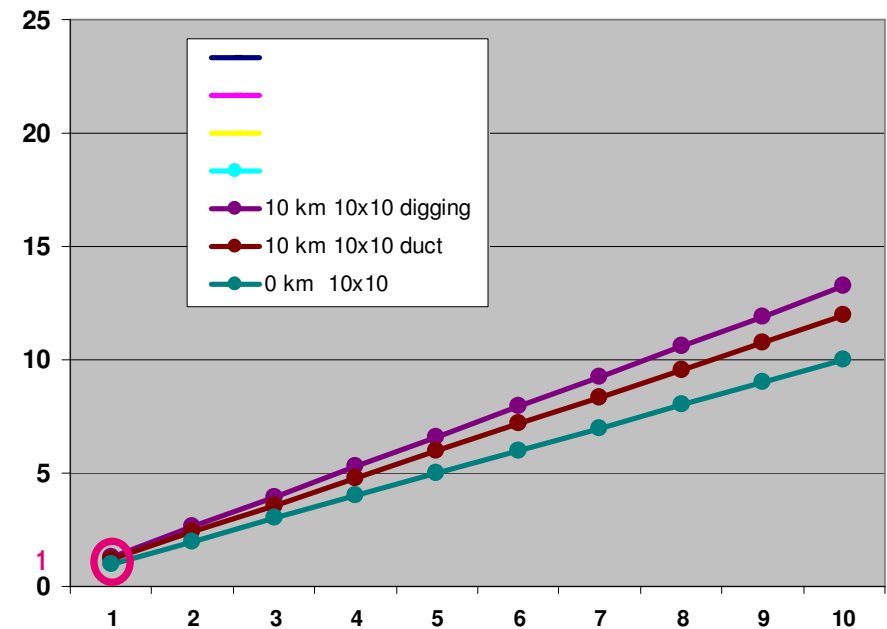## 100 Gbit/s – 10 km Scenarios: Multiple 10GE

- Scenario: N x 10GE

  - Bitrate   N x 10 Gbit/s

  - Fiber Length   10 km

  - Aspects   Cable, duct, digging, parallel fibers, OPEX

  - Cost Factor   > 10 x basic 10GE-SR for 100GE
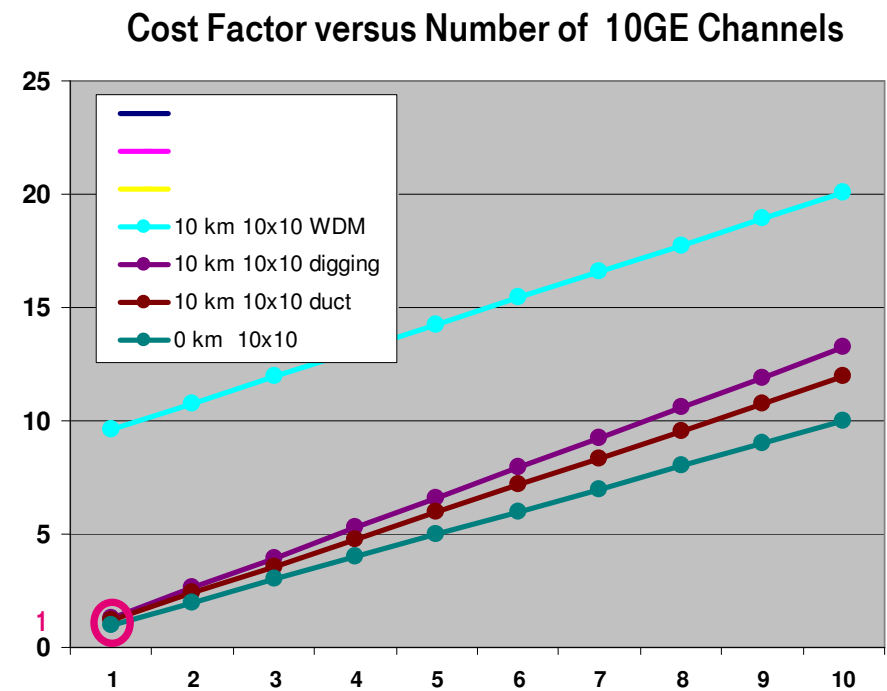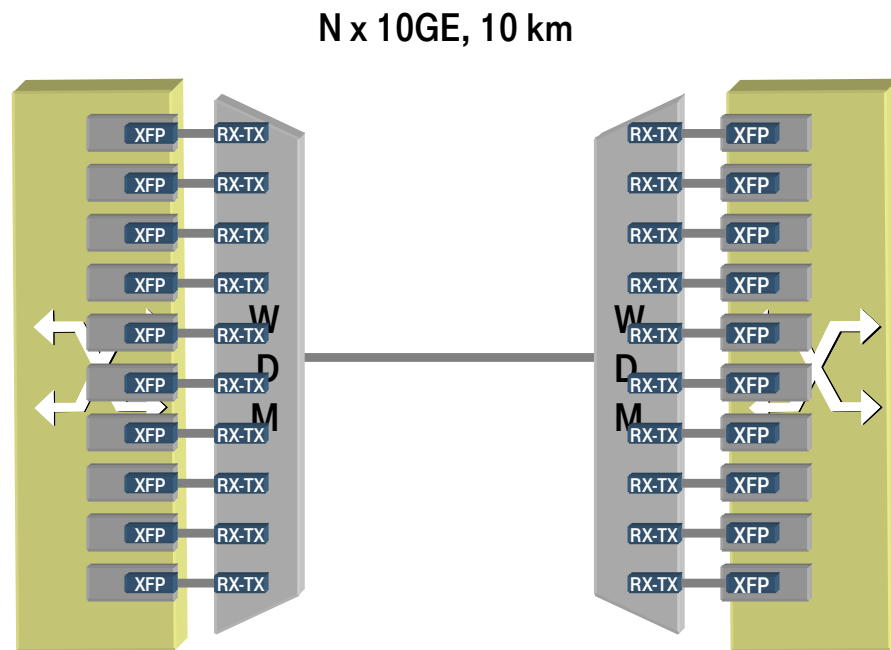
N x 10GE, 10 km

Cost Factor versus Number of 10GE Channels

Legend:
- 10 km 10x10 digging
- 10 km 10x10 duct
- 0 km 10x10

100GE – 10/40km Economic Feasibility – Network Provider View
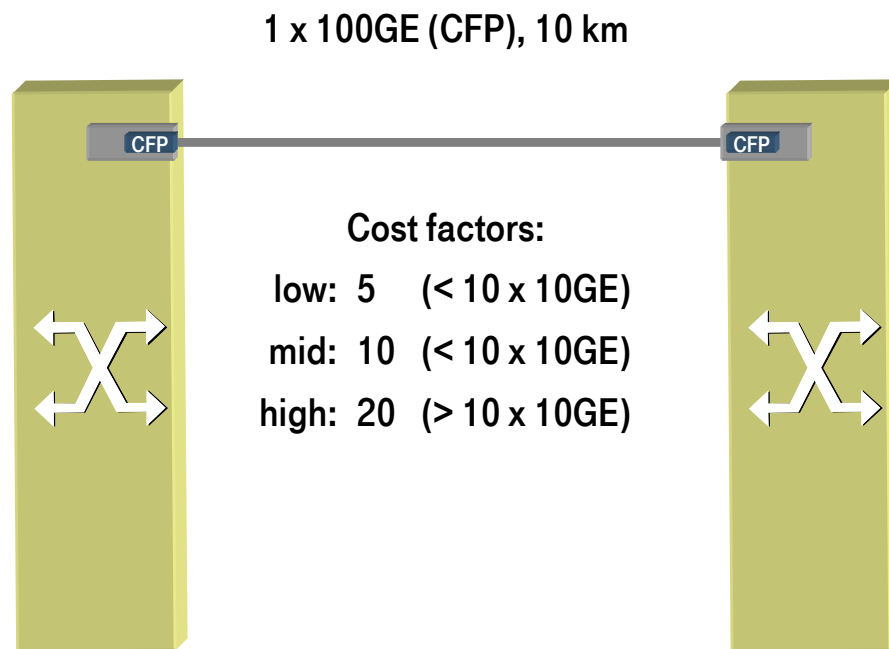## 100 Gbit/s – 10 km Scenarios: Multiple 10GE, WDM

- Scenario: N x 10GE

  - Bitrate   N x 10 Gbit/s

  - Fiber Length   10 km

  - Aspects   Cable, duct, OPEX, WDM

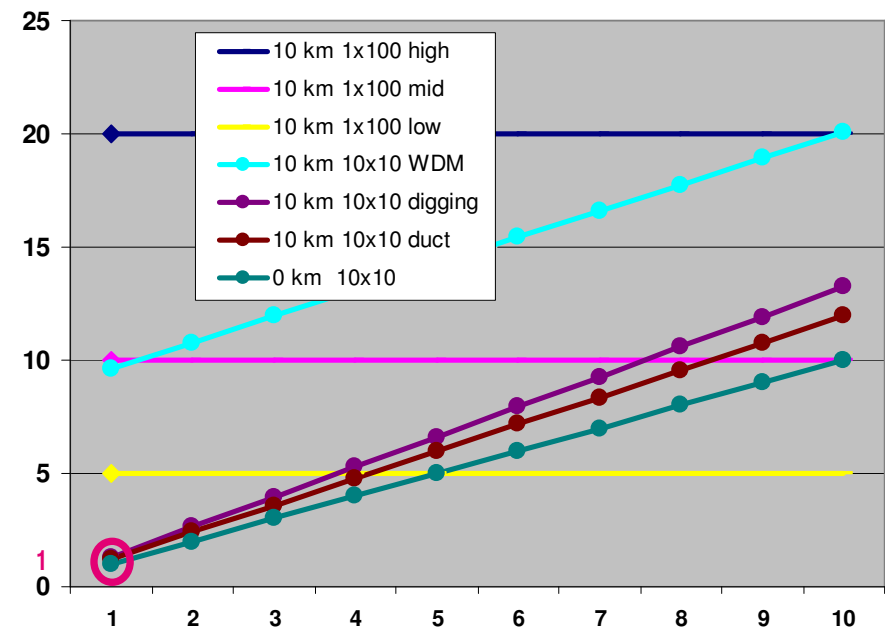 - Cost Factor   > 10 x basic 10GE-SR for 100GE

N x 10GE, 10 km

Cost Factor versus Number of 10GE Channels

Legend:
- 10 km 10x10 WDM
- 10 km 10x10 digging
- 10 km 10x10 duct
- 0 km 10x10

Deutsche Telekom · · · T· Systems

100GE – 10/40km Economic Feasibility – Network Provider View
100 Gbit/s – 10 km Scenarios: 100GE Cost Factors

- Scenario: 1 x 100GE

  - Bitrate   1 x 100 Gbit/s
  - Fiber Length   10 km
  - Aspects   100GE cost factors
  - Cost Factor   > 10 x basic 10GE-SR for 100GE

1 x 100GE (CFP), 10 km

100GE Cost Factors versus 10 x 10 GE scenarios

Cost factors:

low: 5   (< 10 x 10GE)

mid: 10   (< 10 x 10GE)

high: 20   (> 10 x 10GE)

Legend:
- 10 km 1x100 high
- 10 km 1x100 mid
- 10 km 1x100 low
- 10 km 10x10 WDM
- 10 km 10x10 digging
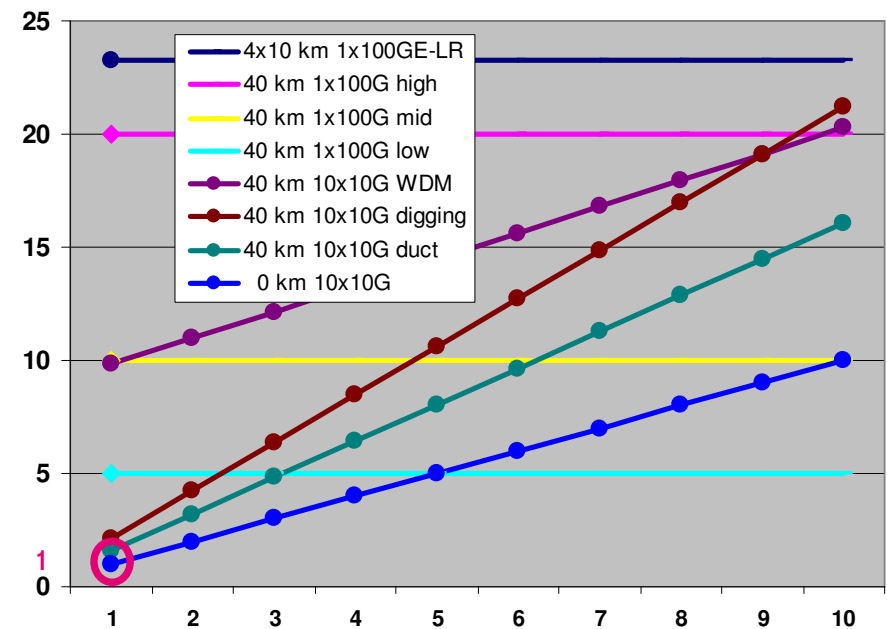- 10 km 10x10 duct
- 0 km 10x10

100GE – 10/40km Economic Feasibility – Network Provider View
100 Gbit/s – 40 km Scenarios: 100GE Cost Factors

- Scenario: 1 x 100GE

  - Bitrate   1 x 100 Gbit/s
  - Fiber Length   40 km
  - Aspects   Cable, duct, digging, OPEX, WDM, 100GE cost factors, 10GE-ER vs. 100GE-LR only
  - Cost Factor   > 10 x basic 10GE-SR for 100GE

1 x 100GE (CFP), 40 km

CFP ────────────── CFP

Cost factors:

low: 5   (< 10 x 10GE)

mid: 10   (< 10 x 10GE)

high: 20   (≈ 10 x 10GE)

high: 20   (< 100GE-LR only)
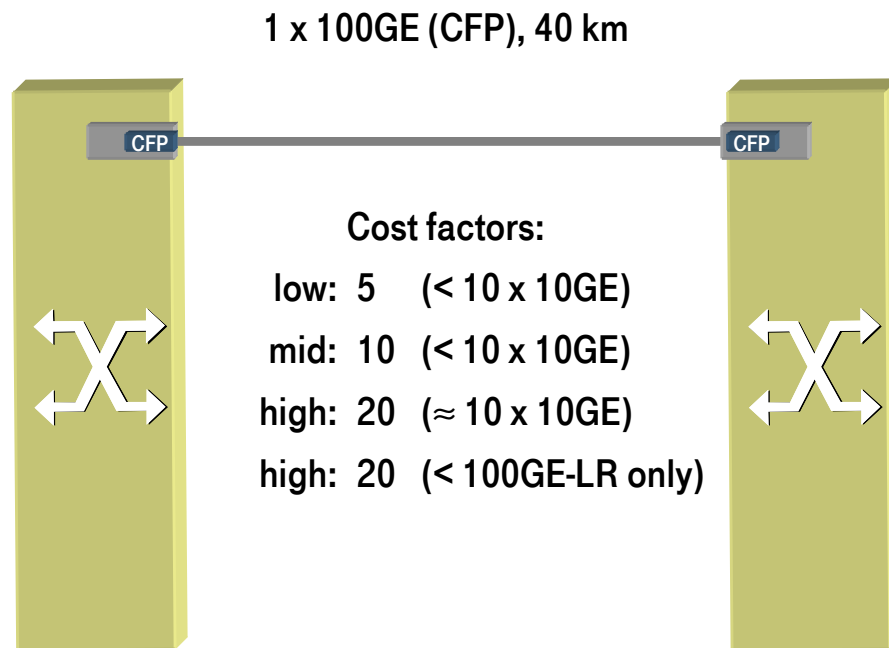
100GE Cost Factors versus 10x10 & 1x100GE scenarios

Legend:
- 4x10 km 1x100GE-LR
- 40 km 1x100G high
- 40 km 1x100G mid
- 40 km 1x100G low
- 40 km 10x10G WDM
- 40 km 10x10G digging
- 40 km 10x10G duct
- 0 km 10x10G

Deutsche Telekom · · · T · · Systems

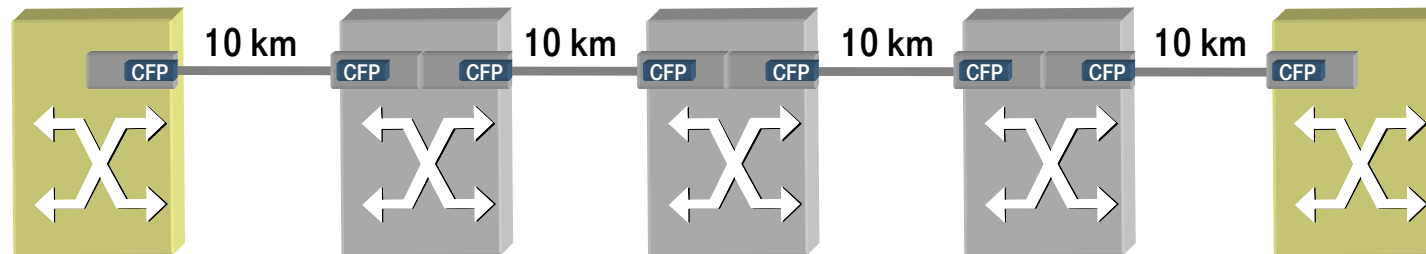# 100GE – 10/40km Economic Feasibility – Network Provider View
100 Gbit/s – 40 km Migration Scenario: 4 x 10 km, 100GE-LR only

- Scenario: Installed 10GE–ER connection via 40 km (1 x 40 km) to be migrated to 1 x 100GE connection using the already installed fiber infrastructure

  - Bitrate   1 x 100 Gbit/s

  - Aspects   Fiber Length 40 km, 100GE cost factors, 10GE–ER vs. 100GE-LR only

  - Cost Factor   > 20 x basic 10GE-SR for 100GE would be cost effective for 40 km transmission

Installed scenario: 10GE–ER (XFP) connection via 40 km (1 x 40 km)
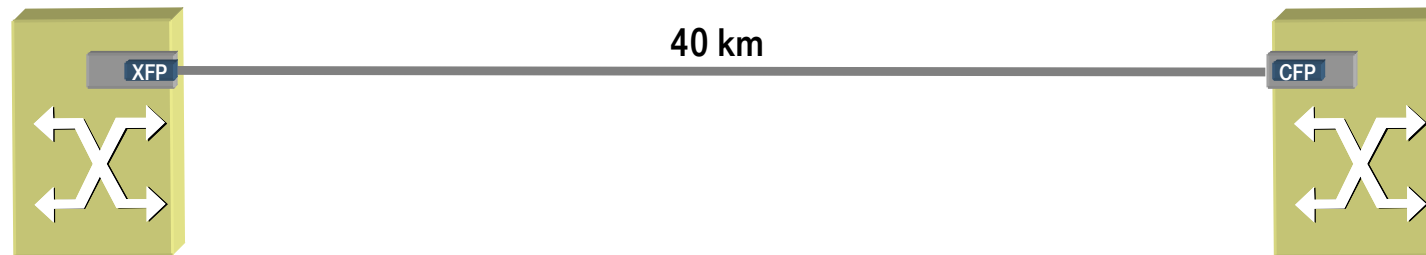
Migration scenario: 100GE–LR (CFP) only via 40 km (4 x 10 km)

100GE – 10/40km Economic Feasibility – Network Provider View
100 Gbit/s – Conclusion

- Comparison based on 10GE–SR connections including 2xXFP-cards and 2xXFPs (cost factor 1)
  - Ratio between 10GE-SR connection and single 10GE-XFP-SR is 14 :1
- Economic feasibility and related cost factors for 100GE transmission depends on
  - 10km or 40km reach, the fiber infrastructure, and used technology (e.g. WDM)
- A 10GE–ER interface including 40 km reach has been standardized
  - If no 100GE–ER with 40 km reach objective would be supported
    - the cost factor would be much higher than 20
      using 1 x 100 GE–LR (10 km reach interfaces)
      due to additional interim switches and housing
    - the cost factor for a 10 x 10GE WDM solution would be about 20

Scenario	Reach	100GE Cost Factor	Remarks
10 x 10GE	0 km	10.0	10GE–SR connection, Reference Scenario
10 x 10GE	10 km	12.0	10GE–LR, shared cable, duct, OPEX
10 x 10GE	10 km	13.2	10GE–LR, shared cable, digging, OPEX
10 x 10GE	10 km	20.1	10GE–SR, WDM, shared cable, duct, OPEX
10 x 10GE	40 km	16.1	10GE–LR, shared cable, duct, OPEX
10 x 10GE	40 km	21.2	10GE–LR, shared cable, digging, OPEX
10 x 10GE	40 km	20.3	10GE–SR, WDM, shared cable, duct, OPEX

100GE – 10/40km Economic Feasibility – Network Provider View
100 Gbit/s – Economic Feasibility and Cost Factor

- Basis for the Cost factors (e.g. 10GE-SR connection including 2 x XFP-cards and 2 x XFP-SR (cost factor 1))

- Degree of economic feasibility may differ for same cost factors for 10km and 40km reach interfaces

SMF	10km 1310nm	40km 1310nm	10km 1550nm	40km 1550nm
10x10G DML	mid	mid	low ≈ 5	mid ≈ 10
10x10G EML	mid	mid	mid ≈ 10	mid ≈ 10
5x20G / 4x25G DML	low ≈ 5	mid ≈ 10	low ≈ 5	not feasible
5x20G / 4x25G EML	mid ≈ 10	mid ≈ 10	mid ≈ 10	not economically feasible (RX DC)
2x50G DQPSK ML	high ≈ 20	not economically feasible (RX DC)	not economically feasible (RX DC)	not economically feasible (RX DC)
1x100G TDM ML	high (RX DC?) ≈ 20	not economically feasible (RX DC)	not economically feasible (RX DC)	not economically feasible (RX DC)

Green shading designates alternatives under detailed study by Fiber Optic Ad Hoc contributors.

Thank you

Ralf-Peter.Braun@T-Systems.com