Horizon 2020 & MIC funded SAFARI Project

Scalable and Flexible optical Architecture for Reconfigurable Infrastructure

Horizon 2020 EU-Japan coordinated R&D project on "Scalable And Flexible optical Architecture for Reconfigurable Infrastructure (SAFARI)"

6 Oct, 2016

NTT Network Innovation Laboratories

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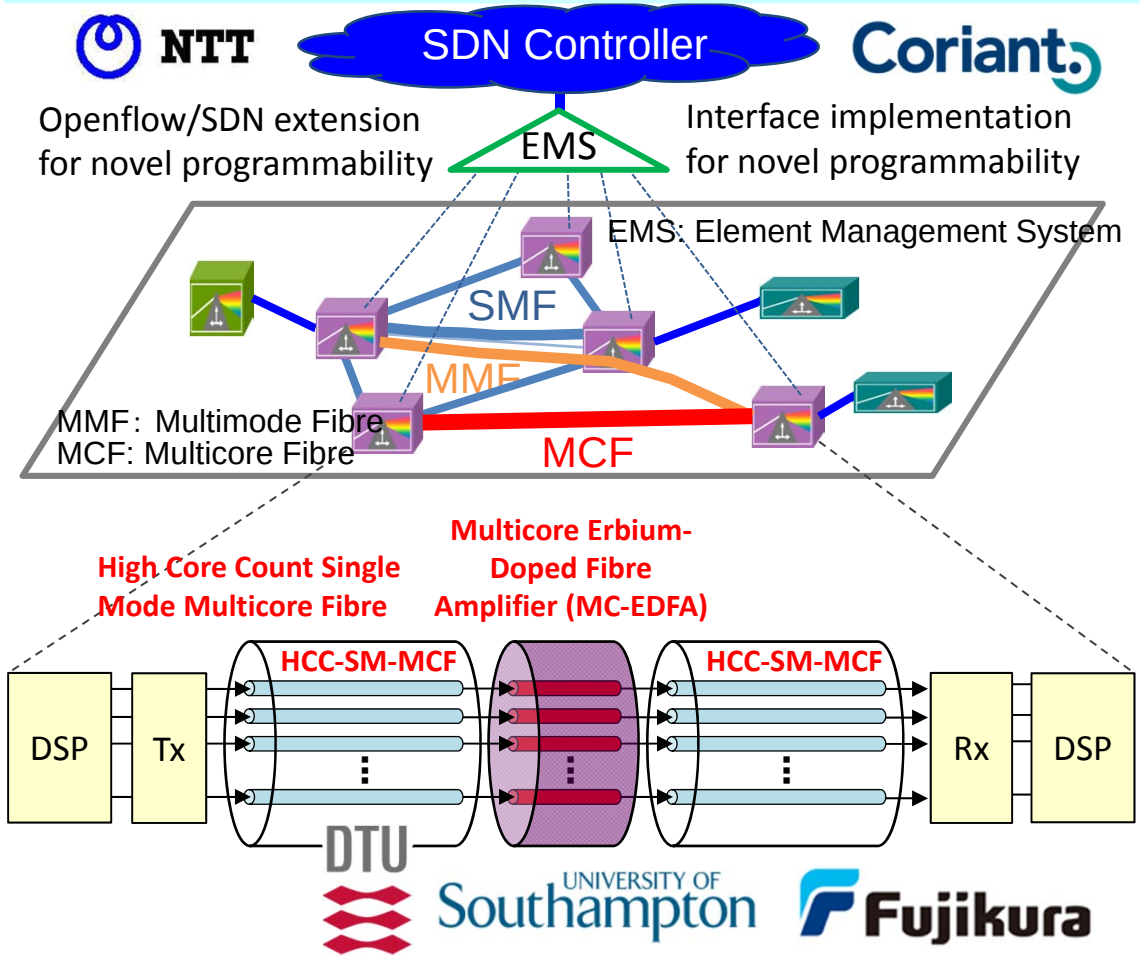
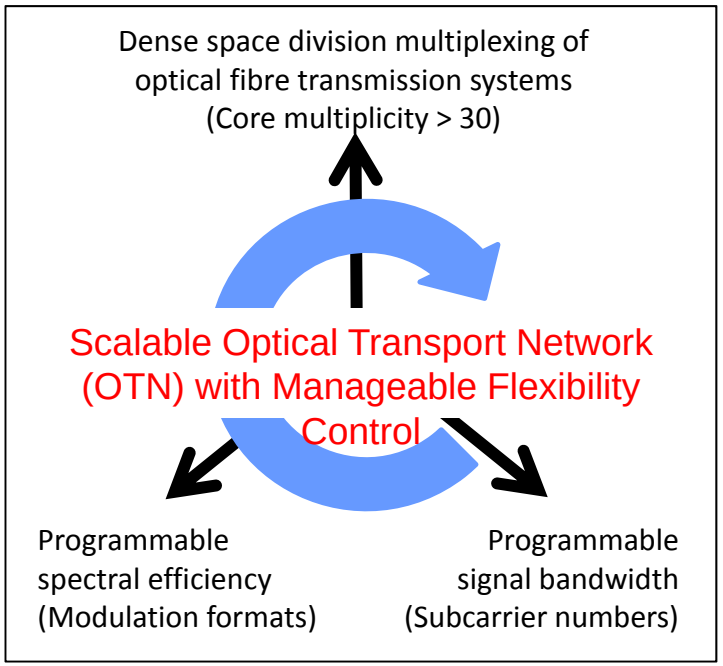
Overview and Target of SAFARI Project

Scalable and Flexible optical Architecture for Reconfigurable Infrastructure
(Oct.1, 2014 – Sep. 30th , 2017)

Realization of various programmable technology (modulation formats, subcarrier numbers, core multiplicity) for future Pb/s-class optical network (over 1000-km distance)

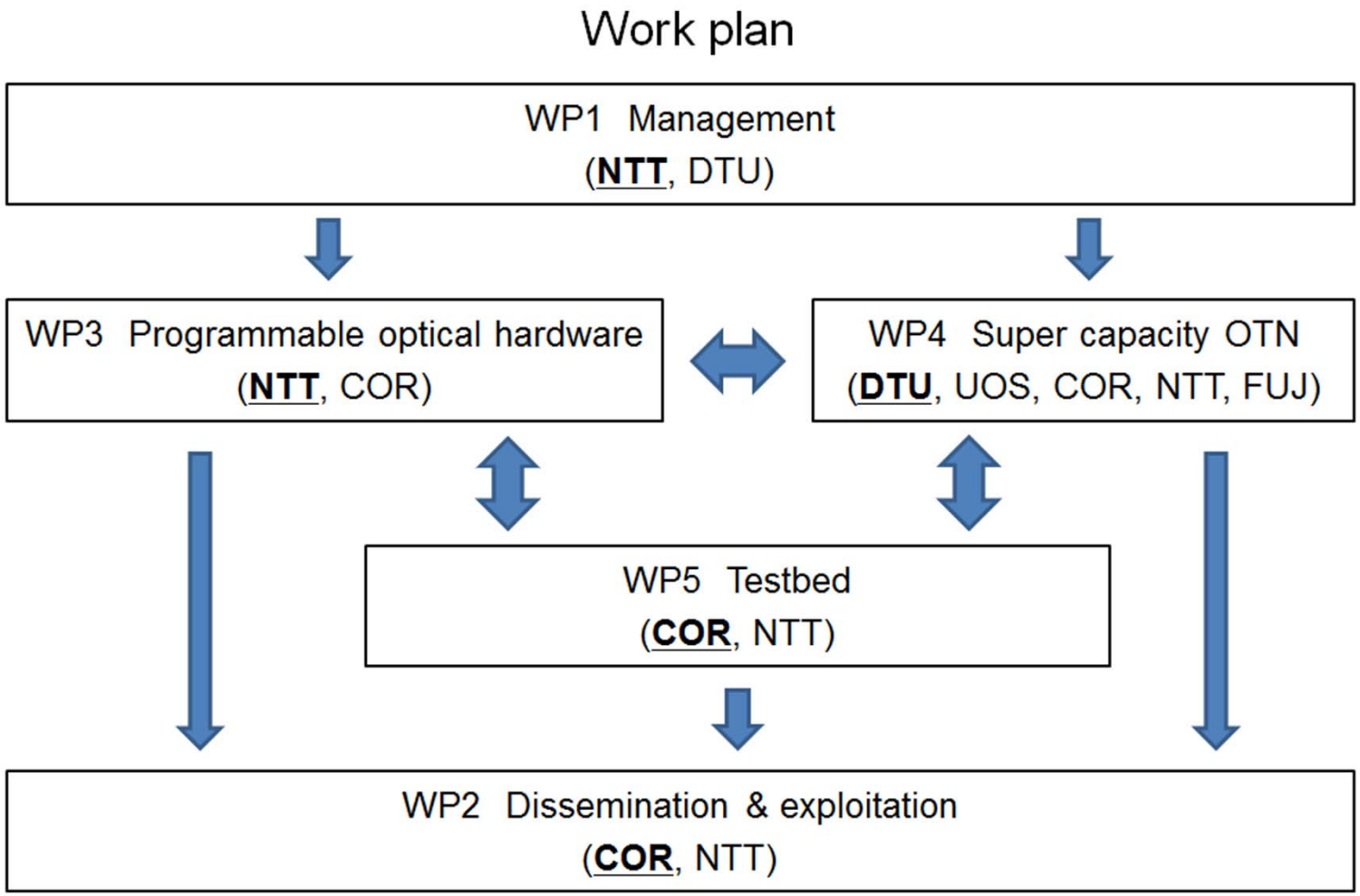




NTT
Coriant

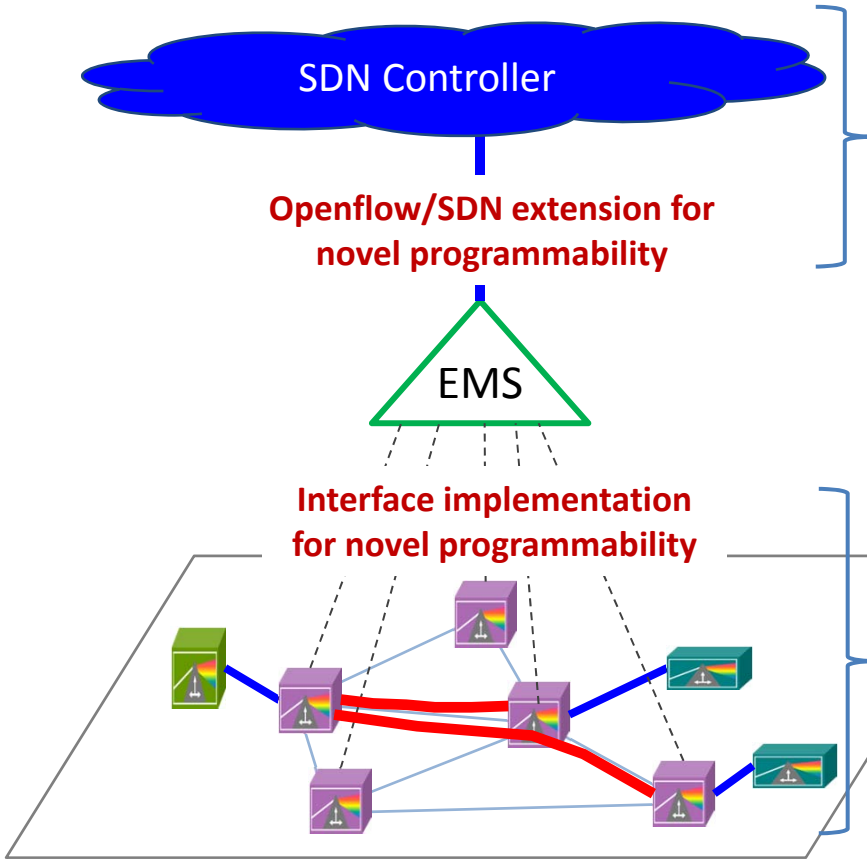
- **Control scheme for optical transport programmability beyond 400 Gb/s**
- **Joint testbed**

Working package structure



WP3 Programmable optical hardware

Verification and establishment of a control scheme for optical transport programmability beyond 400 Gb/s



Programmability utilization design for scalable network provisioning

Scalable control of carrier network with an optimum degree of programmability NTT

Interworking between SDN and Physical Layer

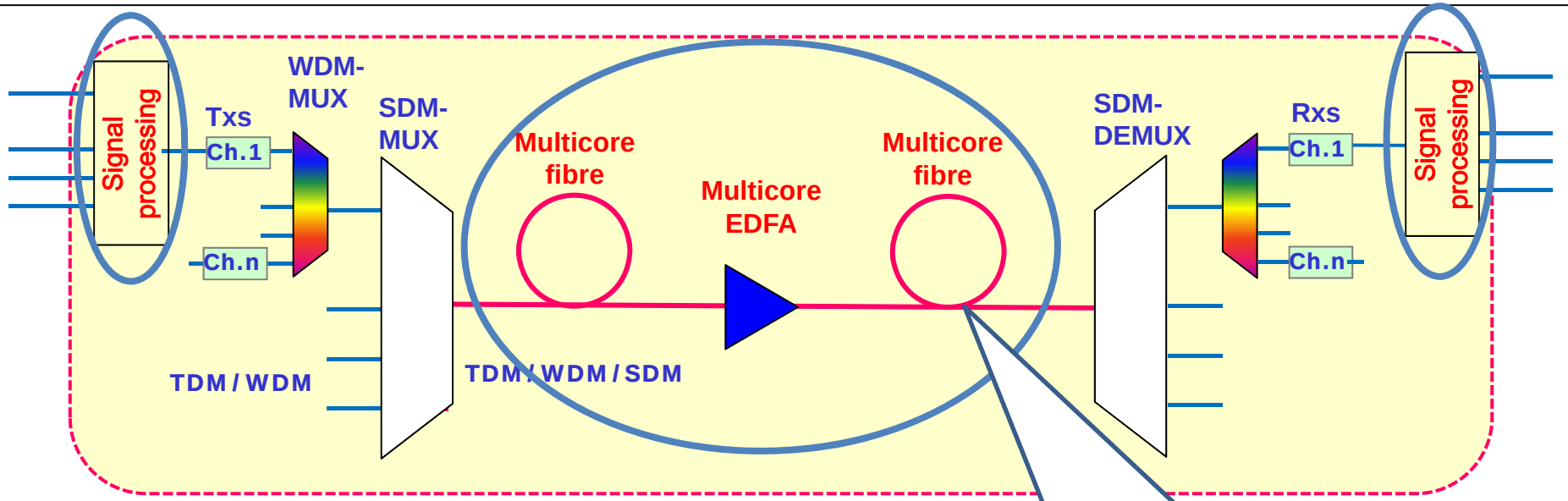
Abstraction of information from programmable elements and the fiber links and implementation of intermediate layer Coriant

Emerging programmable functions of L0/L1

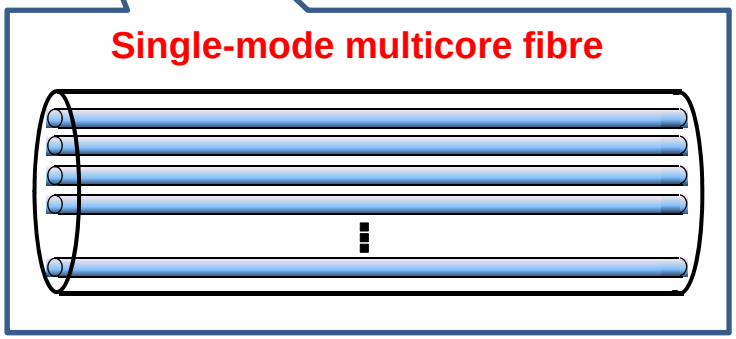
Develop and verify various flexible features of programmable optical hardware including carrier-number, modulation format etc. NTT

WP4 Super capacity optical transport networks

Investigation and development of MCF-based dense SDM (Space Division Multiplexing) with high core counts (≧30) toward super-capacity optical transport networks



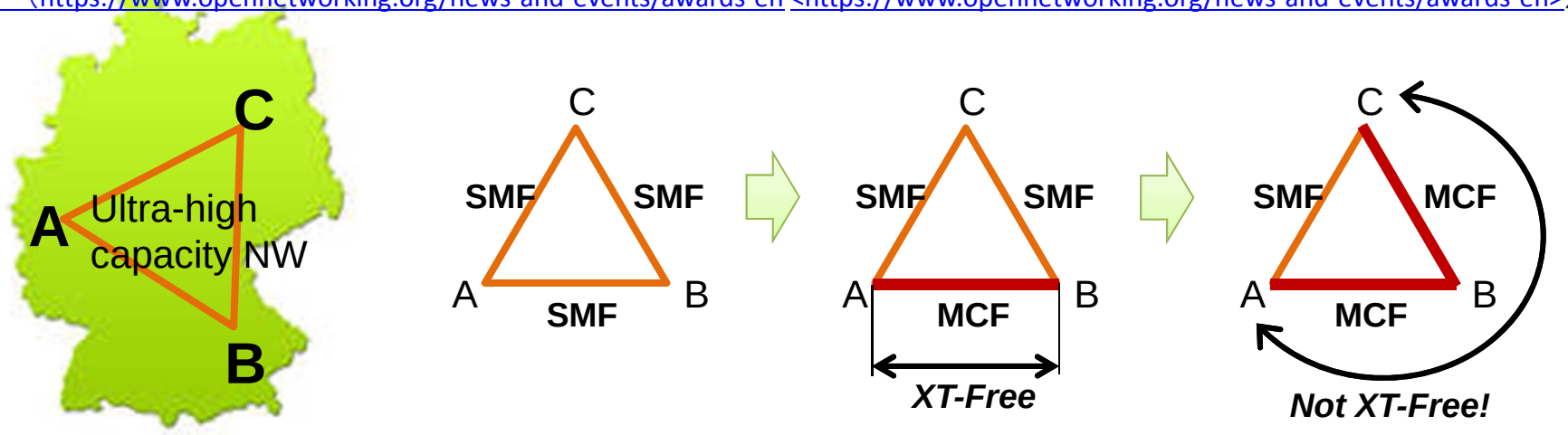
- *Multicore fibres*
- *Multicore EDFA*
- *Signal processing for SDM*



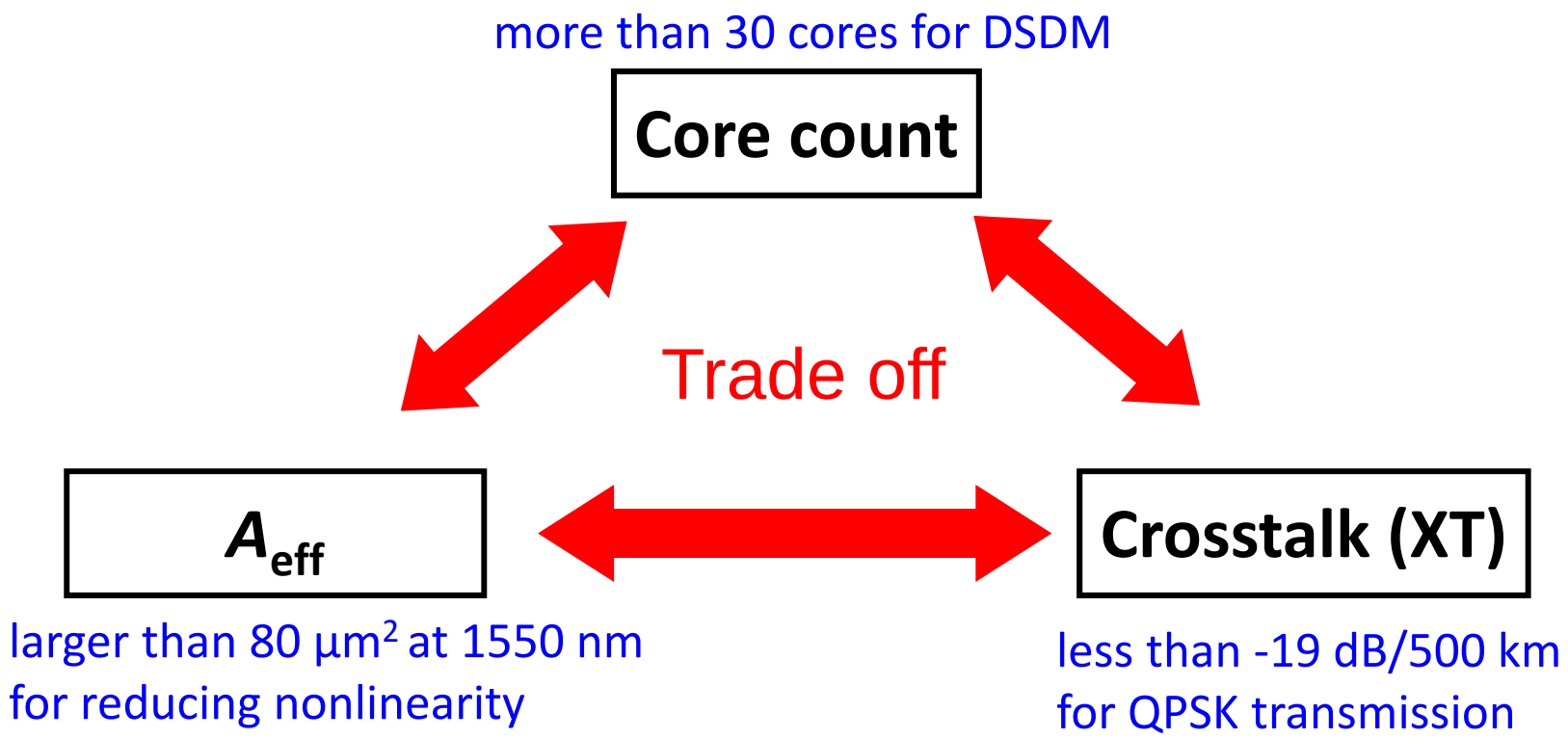
WP3: Use cases and MCF crosstalk issue

- We examined the control scheme of programmable optical hardware and investigated the use cases of the scalable and flexible optical networks.
- We clarified the impact of inter-core XT on network planning and control in an MCF deployment scenario.
- The use-case was adopted in ONF "Use-cases for Carrier Grade SDN" document in March, 2016.
- The contribution on "the carrier-grade SDN use case document with valuable and influential use case" was awarded as the outstanding contributor from ONF on Sept. 7th , 2016.

（https://www.opennetworking.org/news-and-events/awards-en <https://www.opennetworking.org/news-and-events/awards-en>）

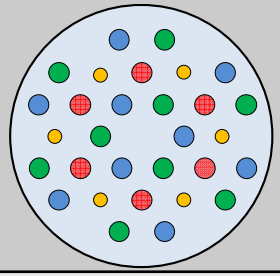
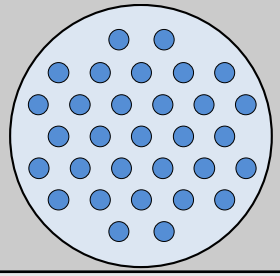
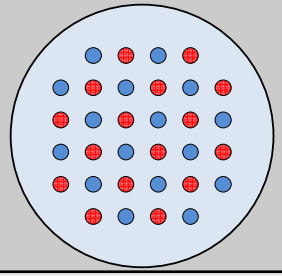


WP4: Requirements for designing SM-MCFs

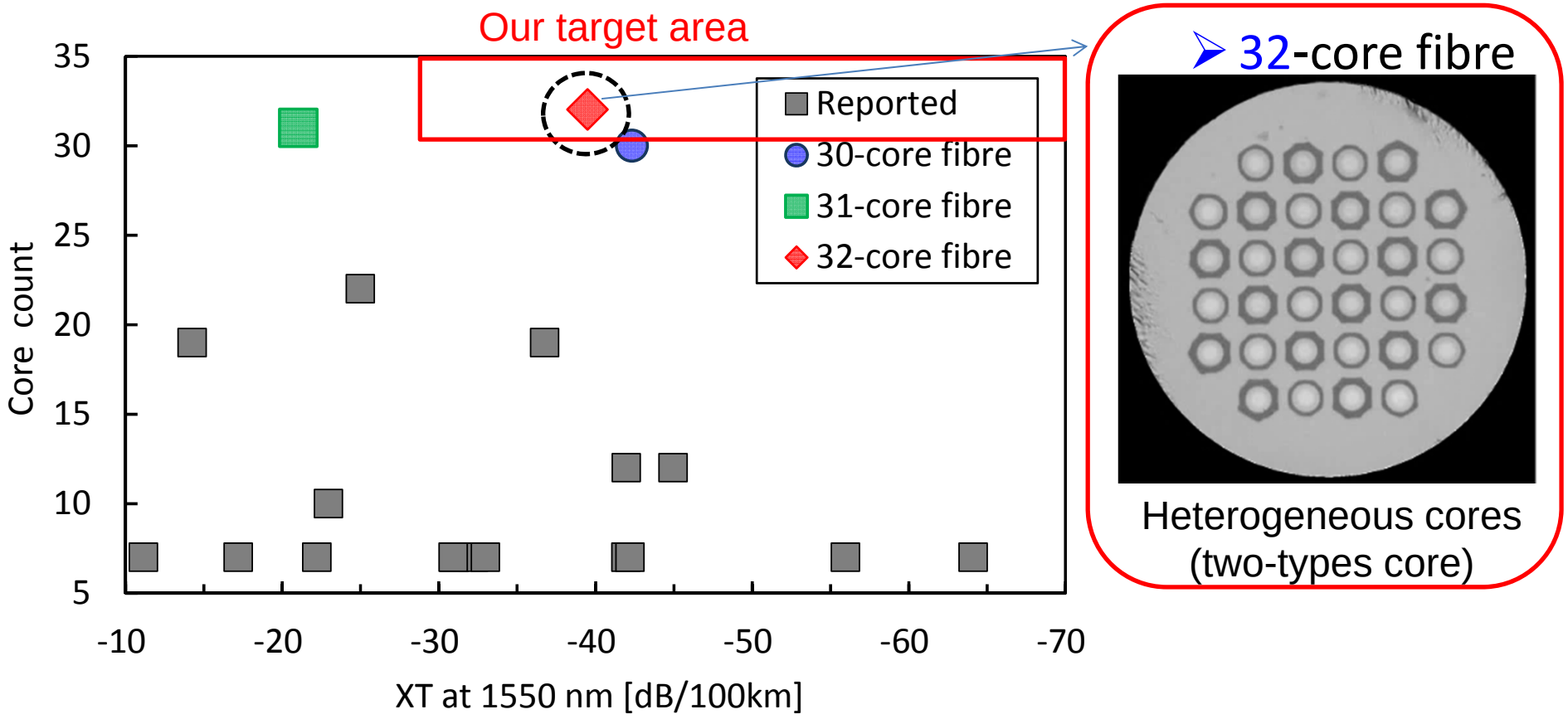


Cladding diameter of smaller than 250 μm is desirable from the point of mechanical reliability.

WP4: Characteristics of each fabricated fibre

	30 core	31 core	32 core
			
Techniques for reducing XT	Heterogeneous (trench and step index)	Homogeneous and Quasi-single mode	Heterogeneous and Relaxing cutoff condition
Core types	4	1	2
Manufacturability	Relatively bad	Good	Reasonable
Layout	Hexagonal-close-packed structure	Hexagonal-close-packed structure	Square lattice structure
1550 nm- A_{eff}	77.3 μm^2	75.1 μm^2	81.8 μm^2
1550 nm-total- XT	-35 dB/500km	-14 dB/500km	-33 dB/500km
Cladding diameter	229 µm	230 µm	242 µm
Fibre length	9.6 km	11.0 km	51.4 km

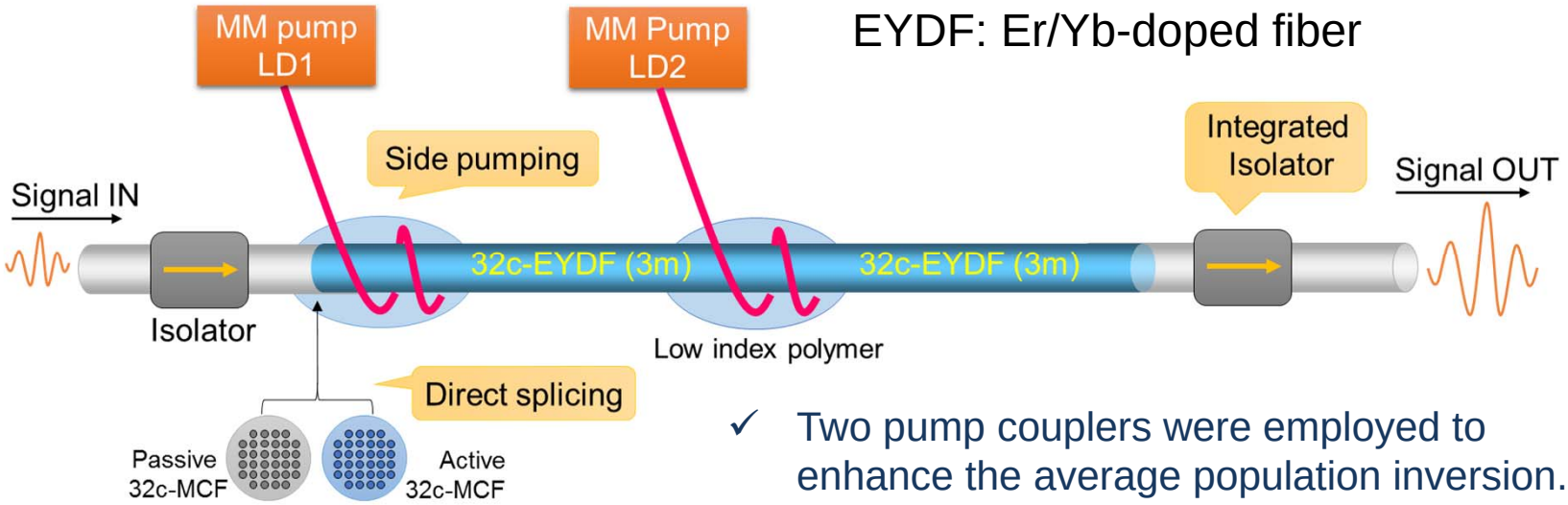
WP4: Comparison with reported SM-MCFs



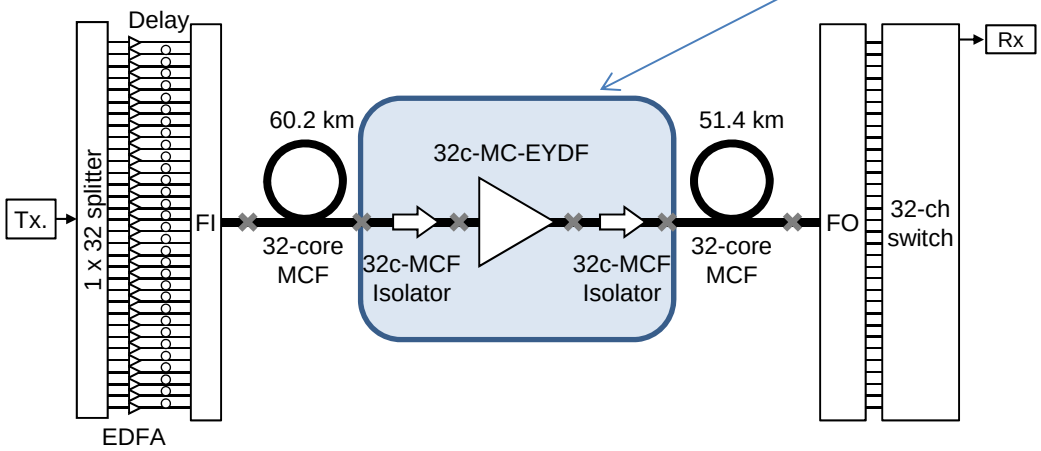
32-core fibre has realized the highest core count and low XT simultaneously.

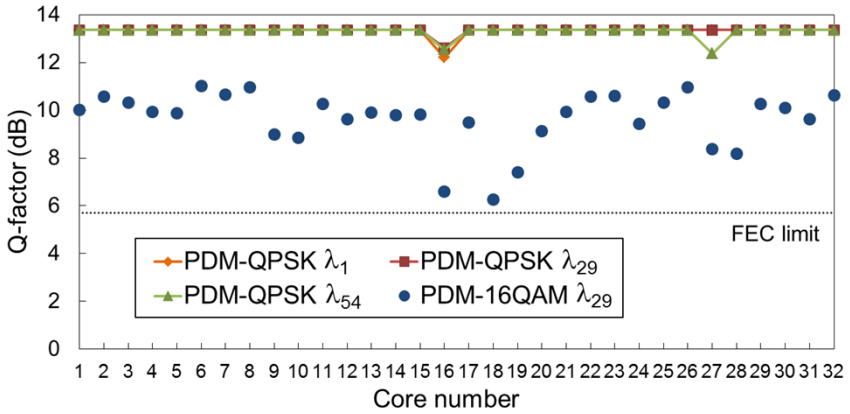
Y. Sasaki et al., ECOC 2016, paper W.2.B.2.

Fully integrated cladding-pumped 32core-EYDFA inline amplifier with two pump couplers



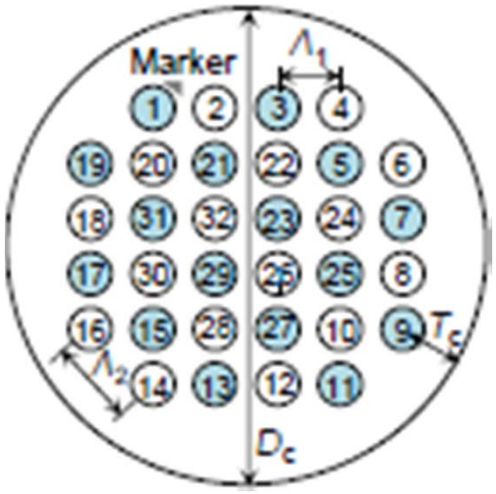
✓ Two pump couplers were employed to enhance the average population inversion.





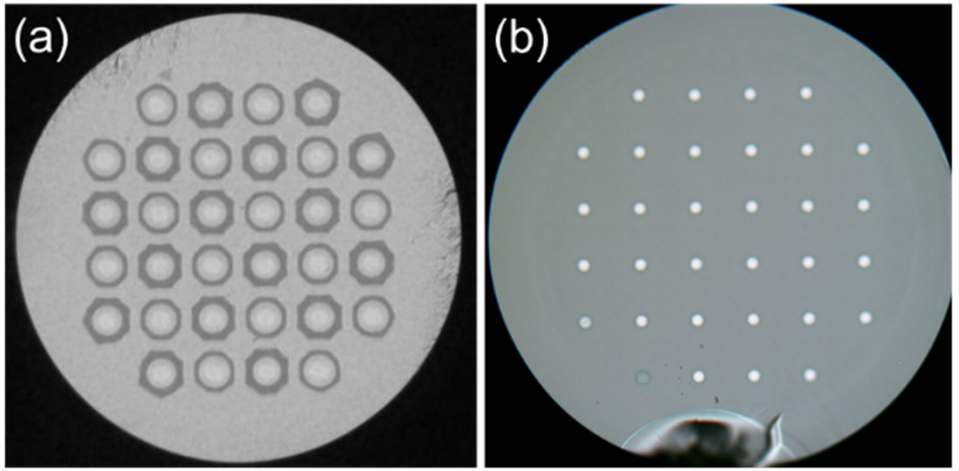
J. Saurabh et al., ECOC 2016, Postdeadline paper Th.3.A.1

Comparison between passive- and active fiber



Passive MCF

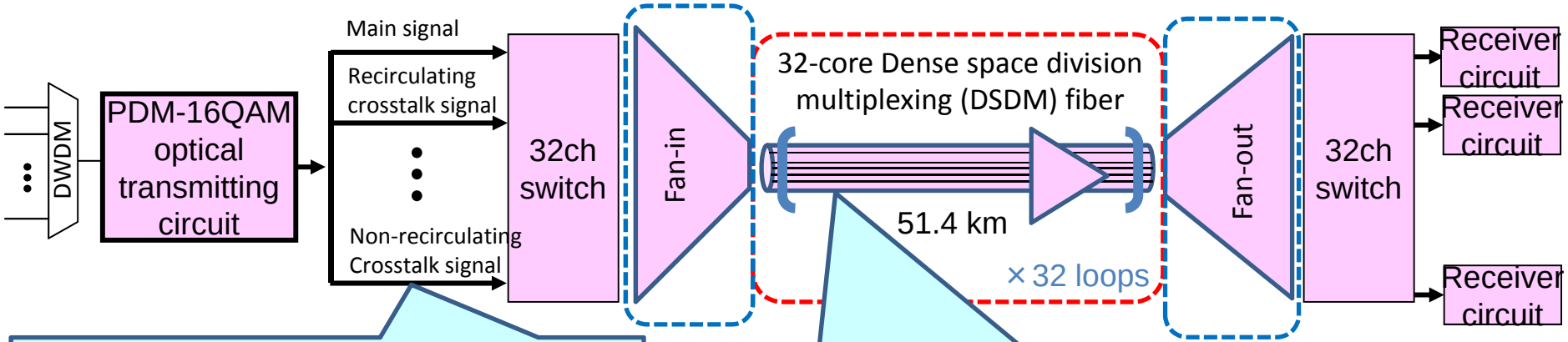
Active MC-EYDF



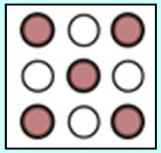
	MCF	MC-EYDF
Avg. Pitch[μm]	28.8	28.85
Max./min.[μm]	29.1/28.4	29.15/28.45
SD. [μm]	0.2	0.16
Cladding[μm]	241.2	242
MFD[μm]	9.9	5.6
Loss/abs.	0.235dB/km @1550nm	18dB/m @975nm
Splice Loss with MCF	<0.5 dB	1±0.25 dB

WP4: 32-core Dense Space Division Multiplexing (DSDM) Long-distance Transmission over 1644.8 km

- Demonstration of 32-core dense space division multiplexing (DSDM), long-haul transmission over 1644.8 km
- World first demonstration of long-haul DSDM transmission exceeding 1000 km achieved in SAFARI project

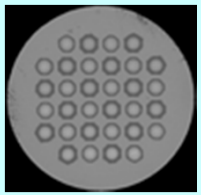


② Novel partial recirculating loop system



- Loop system configured to input recirculating signals into adjacent cores with larger crosstalk and non-recirculating signals into all other cores

① Multicore fiber design and fabrication technology

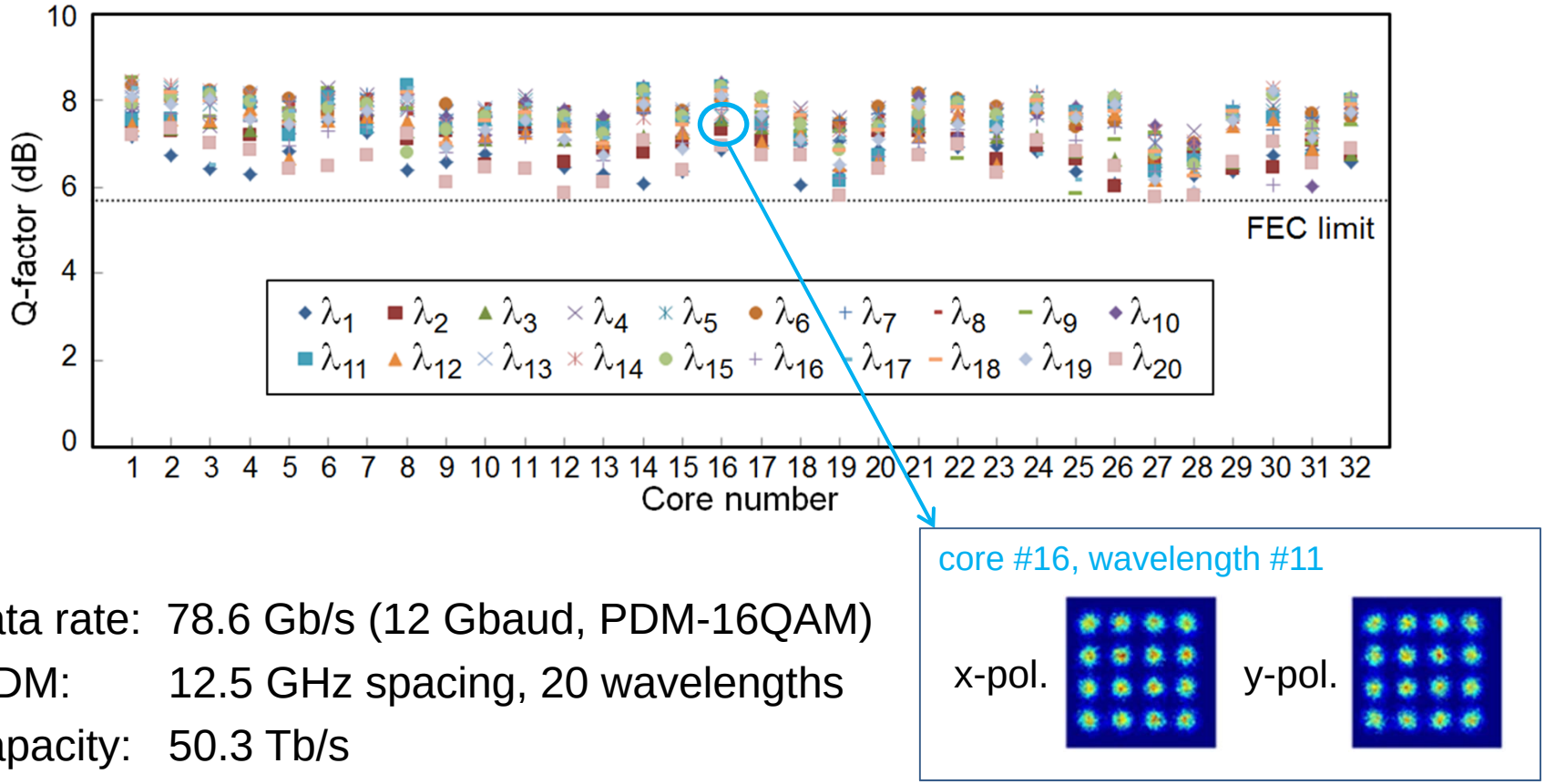


- Heterogeneous, square lattice structure
- Three times larger number of cores within typical 243 μm cladding diameter
- Low-crosstalk suitable for PDM-16QAM signal transmission exceeding 1000 km distance

T. Mizuno et al., OFC 2016, Postdeadline paper Th5C.3

WP4: 32-core dense SDM transmission experiment over 1000 km

Measured Q-factors of all 640 channels (32 DSDM x 20 DWDM) after 1644.8 km (=32 loops) transmission exceeded the FEC limit of 5.7 dB



- Data rate: 78.6 Gb/s (12 Gbaud, PDM-16QAM)
- WDM: 12.5 GHz spacing, 20 wavelengths
- Capacity: 50.3 Tb/s

T. Mizuno et al., OFC 2016, Postdeadline paper Th5C.3

Summary

- SAFARI PJ overview
- WP3: Proposal of MCF-based network use cases
- WP4: High count SM-MCF
- WP4: High count EYDFA
- WP4: 32-core transmission experiment