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shaping tomorrow with you

Perspectives of Post-400G PMD

September, 2016

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Background: Situation of the demands

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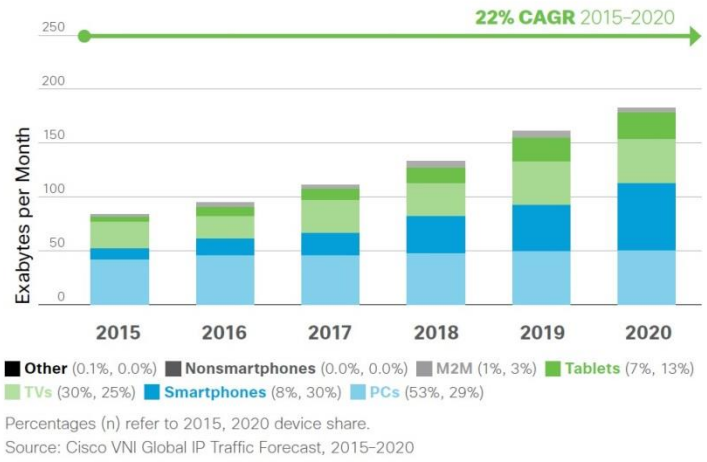
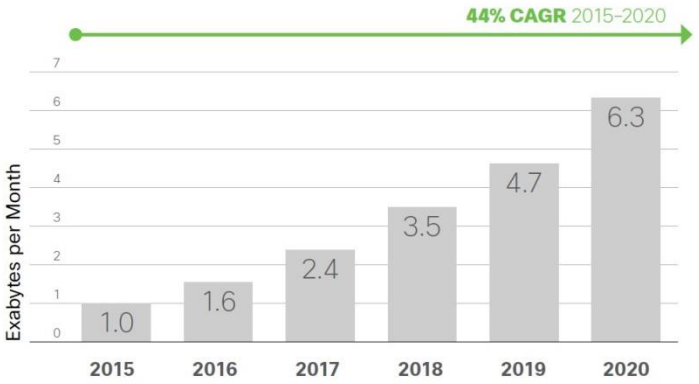
Global IP Traffic by Devices



Global M2M Traffic Growth: Exabytes per Month



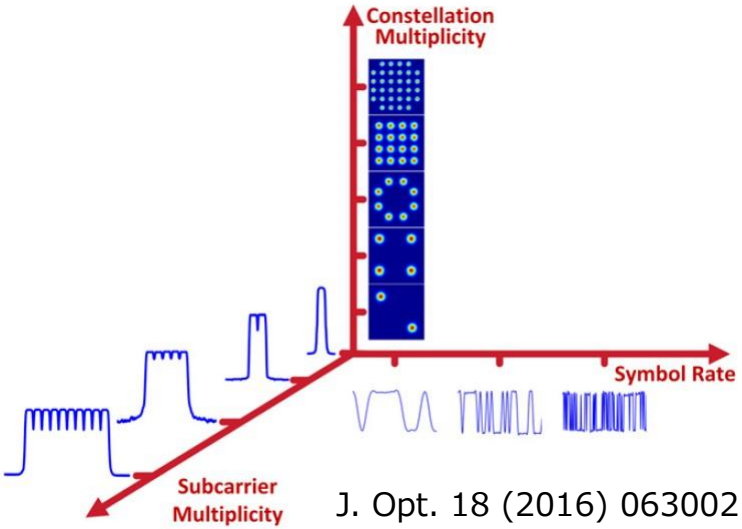
The Zettabyte Era: Trends and Analysis, July 2016

As everyone knows …
Global traffic is continuously growing up.

In this growth, Smartphone and Tablet are main stream.
Moreover CAGR of M2M is impressive, approximately 44 %.

Anyway we need to enhance the transmission speed continuously.

Dimensions of capacity evolution



J. Opt. 18 (2016) 063002

Improvement of bitrate is continuous important challenge.

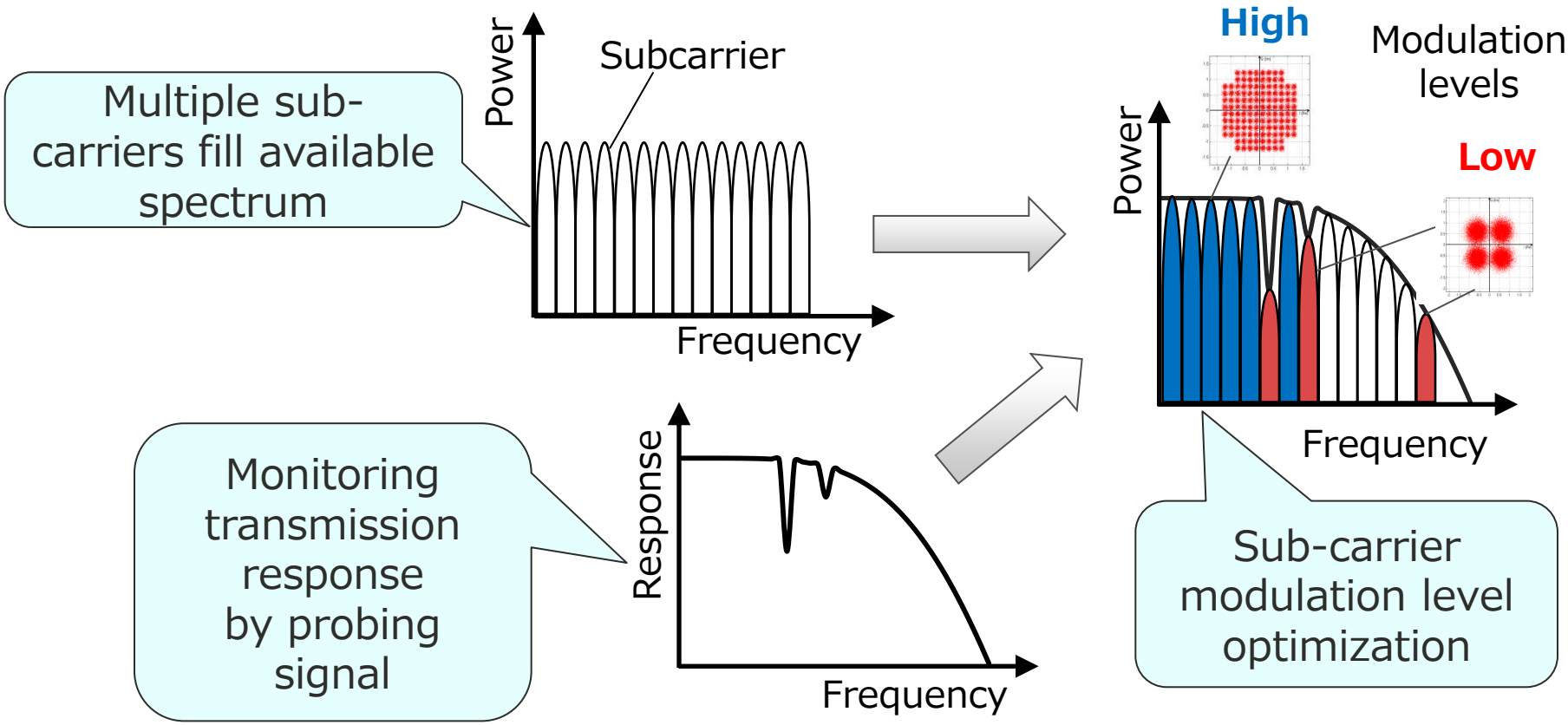
There are several ways for this issue.
- Constellation multiplicity
- Symbol rate
- Subcarrier multiplicity

From the point of cost efficiency, constellation multiplicity is first choice.

Therefore…

We are focusing on DMT.
DMT is one of the most efficient modulation format.

Discrete Multi-Tone



From the benefits of these features,
We can use unsophisticated components.

Technology roadmap in ITRS

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Year	2015	2017	2019	2021	2023	2025	2027	2029
System structure								
Data Rate/ Lane (Gbit/s)	25	25	50	50	50	100	100	200
Single Channel GBaud/s	25	25	100	200	200	400	400	800
Distance (km)	<2km	<2km	<10km	<80km	<80km	<80km	<80km	<80km
Number of Wavelengths	1	4	8	8	8	8	16	16
Number of Bits per symbol (HOM)	1	1	2	4	4	4	8	8
Additional link penalty due to HOM (dB)	0	0	5	8	8	8	11	11
Device Performance								
TX I/O loss (dB)	2.5	2.5	2	1.5	1.5	1.5	1	1
RX I/O loss (dB)	4	4	3.5	3	2.5	2	2	2
MUX IL (dB)	0	2	1.5	1.5	1.5	1.5	1.5	1.5
DEMUX IL (dB)	0	2	1.5	1.5	1.5	1.5	1.5	1.5
Target RX Sensitivity (dBm)	-12	-12	-12	-12	-12	-12	-15	-15
Noise Penalty at the receiver side (dB) (25G as reference)	0	0	1.5	3	4.5	6	7.5	9
Laser Output Power (dBm) [3]	13	14	16	16	16	16	16	16
Photo detector BW (GHz)	17.5	17.5	35	35	35	70	70	140
Modulator BW (GHz)	17.5	17.5	35	35	35	70	70	140

The inter national technology roadmap for semiconductor 2.0:2015

Simulation of the DMT

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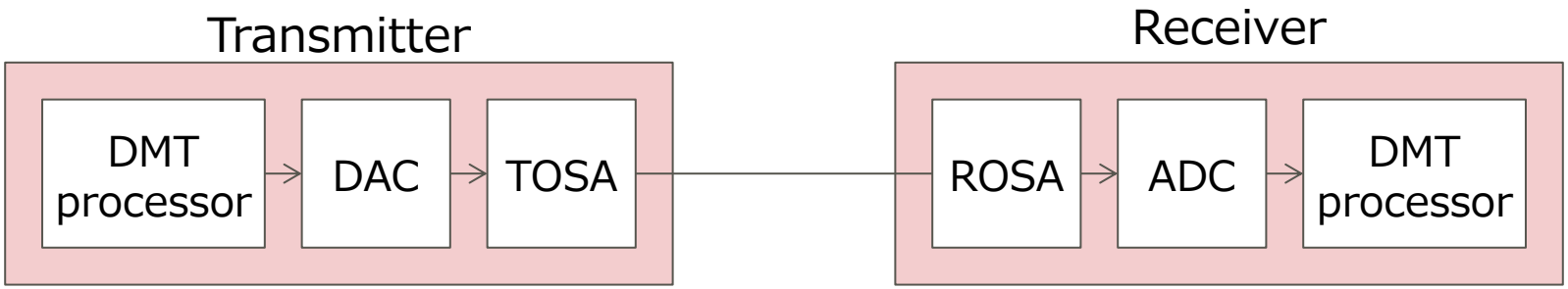
Simulation model



Simulation parameter

Parameter	Value
Target BER	4.5 e-3
Subcarrier number	256
Cyclic prefix	16
Sampling rate	100 Gsample/s
Clipping ratio	3.16
Filter model	Bessel4th

Simulation result of DMT

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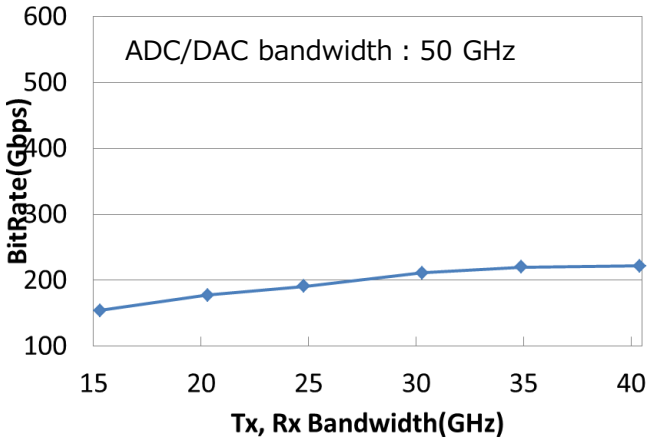
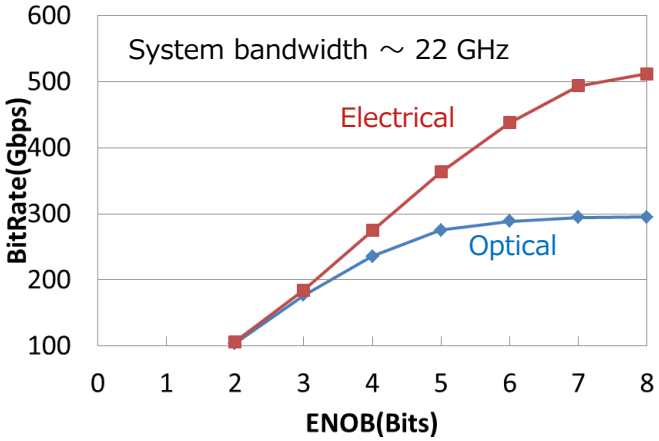
Improvement of system bandwidth



Improvement of system ENOB



Experimental result of high speed DMT

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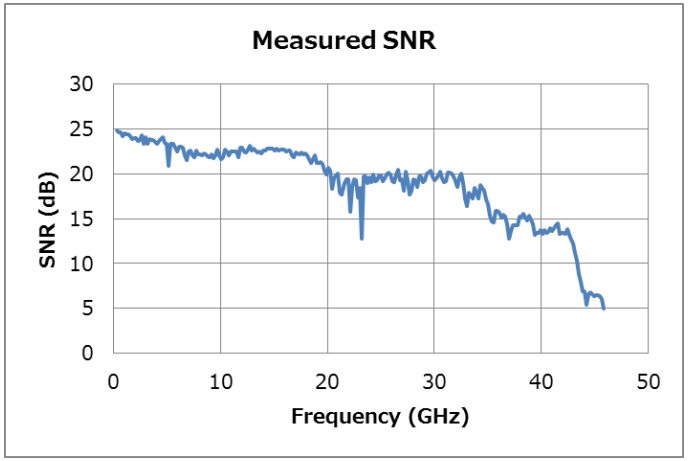
Off-line processing

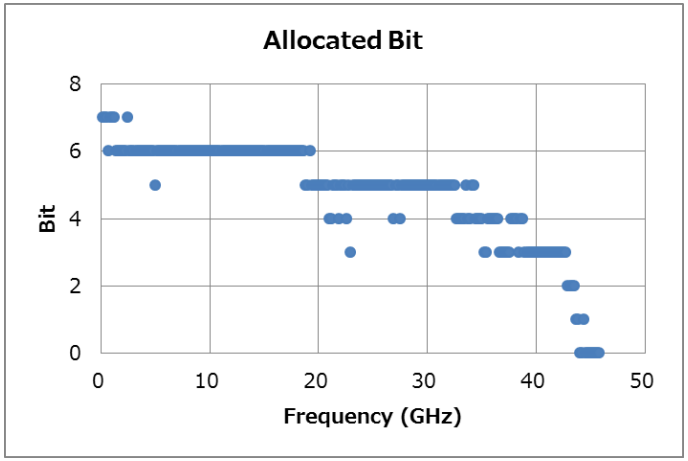
DMT Decoding

DMT Encoding

92 GS/s AWG

160 GS/s DSO



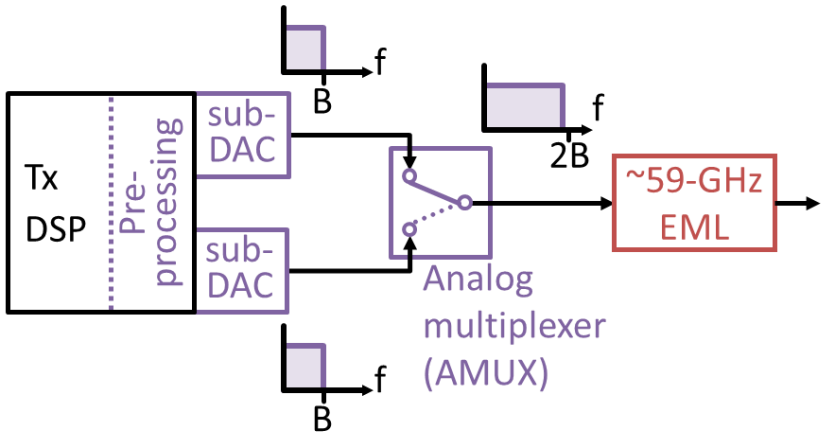


212.4 Gbps was achieved.

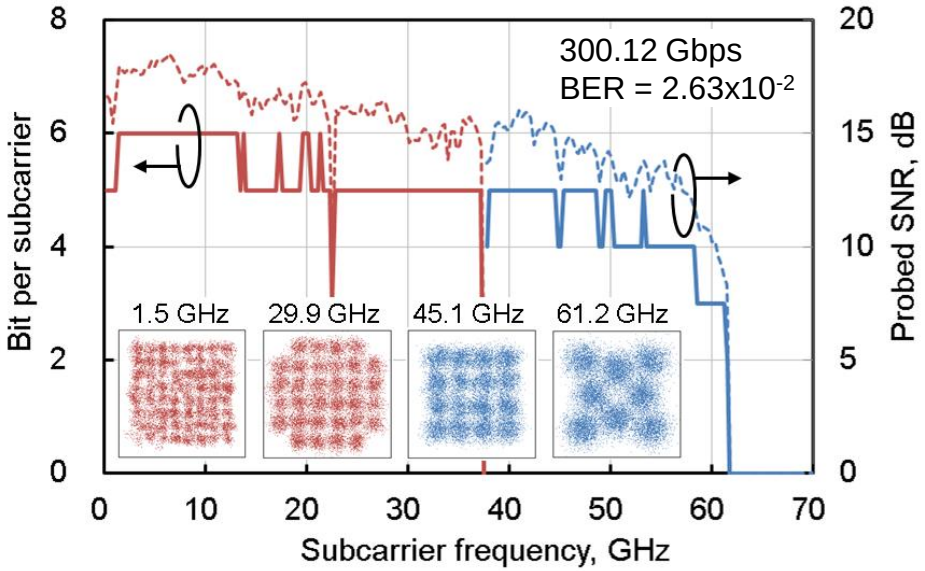
Latest experimental results

The 1st single-pol.
IMDD transmission at net data rate of 250 Gbps

Transmitter setup



Transmission results (SMF 10km, O-band)



H. Yamazaki et al., ECOC'16, Th.3.B.4

200 Gbps/λ is possible!!