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100 Gigabit Ethernet in Data Centers

The increase in traffic within data centers is creating a need for new family of 100 Gigabit Ethernet pluggable optical transceivers, targeting the 2 km optical reach over single-mode fiber. Current 10 and 40 Gigabit Ethernet interfaces cannot keep up with emerging traffic needs, both in terms of data rate and line card density. Also, currently available 100G products are typically not suitable for data-center applications (either because they are expensive, e.g. the 10-km 100GBase-LR4, or are inadequate for the shorter 2-km spans, e.g., 100G over multimode fiber).

Two main approaches are driving the development of this new family of 100G transceivers. The first relies on 4 wavelengths at a rate of 25G (i.e., 4x25G) and the second on 10x10G. The 4x25G is expected to be more expensive and power hungry (because of the use of 25 Gbps components), but less complex than the 10x10G approach.

The two approaches are still unsettled and different 100G multisource agreements (MSAs) are competing in terms of which would be the most cost-effective transceiver solution for data centers.

Meanwhile, new technological solutions based on silicon photonics (SiPh) are rapidly emerging. Many suppliers believe that next generation of SiPh-based pluggable optical transceivers products will resolve the multiple challenges of higher bandwidth requirement, adequate distances, and low power consumption. First promising solutions have been recently presented at the OFC 2014 Exhibition. A lot of effort is on-going to industrialize cost-effective 100G transceivers.

Space Division Multiplexing

A combination of Space division multiplexing (SDM) and multi-core multi-mode fiber deployment is offering attractive solutions to increase the transmission efficiency of fiber-optic systems. Amongst the latest results reported in this regards an impressive record of spectral efficiency that close to 250 b/s/Hz. This has been recently demonstrated by NTT over a 40-km multi-core fiber system [1]. SDM is also considered for long-haul scenarios. For example, a 30 Tb/s transmission, comprising 7-core fiber, over more than 6000 km has been successfully demonstrated by KDDI.

[1] T. Mizuno et al., "12-core x 3-mode Dense Space Division Multiplexed Transmission over 40km employing Multi-Carrier Signals with parallel MIMO Equalization", OFC 2014

For an introduction to SDM, we recommend:

[2] D. J. Richardson, J. M. Fini and L. E. Nelson "Space-division multiplexing in optical fibres", Nature Photonics, April 2013.

Future Metro Networks

The increase in end-user bandwidth from few Megabits to one Gigabit per second is paving the way for significant changes in metro networks.

Thousands of IP network terminals plus one, or more, data center(s) are anticipated per network. Wireless-wireline convergence will also be required and must be taken into consideration.

To address these developments, future metro networks will have to support programmable switch matrices and efficiently exploit a combination of technologies such as wavelength switches/ROADM, OTN switches, and Ethernet switches. This combination will have to guarantee the dynamic connectivity management required by IP services while maintaining transparency to changes in bandwidth demands. Furthermore, programmability via standard system interfaces will be the key to providing such connectivity management at different scales for different signal levels.

More information can be found in:

[3] Q Liu, "Metro Transport Network Architectures for the Future", OFC 2014.

Cloud Radio Access Network (C-RAN)

Cloud radio access network (C-RAN) is gaining momentum as effective distributed base station architecture that is expected to enable CAPEX and OPEX savings in comparison to traditional wireless access technologies.

In traditional architectures, the base station is a system unit composed of different co-located entities, including the radio remote head (RRH) and the baseband unit (BBU).

In C-RAN, a centralized point is responsible for all of the BBU processing tasks, as in a cloud system. At the cell site, RRH still performs radio signal transceiving, amplification of signal power, and analog-to-digital conversion.

Thanks to the processing offload, cell sites need less hardware complexity and energy consumption, thus lowering their price. Moreover, C-RAN targets the adoption of resource virtualization and vendor-independent hardware of RRH and BBU entities.

The most relevant open issue in C-RAN is to make cost-effective the transport architecture and interface (called Common public radio interface - CPRI) between RRH and BBU modules, where stringent requirements in terms of high bandwidth (tens of Gbps), low latency, and jitter have to be guaranteed.

For further details, please see:

[4] http://www.fiercewireless.com/tech/special-reports/c-ran-plotting-next-generation-wireless-inside-base-station-hotel

[5] M. Hadzialic et al, "Cloud-RAN: Innovative radio access network architecture," ELMAR Symposium, Sept. 2013

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