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Photonics for next generation radio access network (RAN)

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The capacity of the optical communication infrastructure in backbone networks has increased a thousand-fold over the last twenty years. In addition to this rapid progress, Internet traffic is continuing to grow at an annual rate of 40%. This means that in twenty years, we will need Petabit/s or even Exabit/s optical communication. In addition, the traffic capacity of recent wireless communication systems is also increasing greatly as seen with 5G and 6G systems, where their peak rates reach as high as ~ 10 Gbit/s and ~ 100 Gbit/s, respectively. Therefore, there is an urgent need to incorporate advanced optical communication technology in the recently developed radio access network (RAN) as this will make it possible to realize a high-capacity and high-speed global communication network.

In this talk, I will first present recent challenges and efforts toward achieving a hardware paradigm shift to overcome the capacity limitation imposed by the current optical communication infrastructure. I will overview the latest advances on the three "multi" (3M) technologies, i.e., multi-level transmission with ultrahigh spectral efficiency, multi-core fibers for space division multiplexing, and multi-mode fibers for mode division multiplexing with multiple-input multiple-output (MIMO).

In the latter part, I will describe an optically and wirelessly linked fully coherent access system for next generation RAN that uses 3 M technology. I will highlight the importance of the fully coherent system and present in detail what we have been examining experimentally. In this system, we treat optical and wireless regions as one unified electromagnetic-wave transmission region although the IF carrier frequencies of the optical and wireless waves differ greatly. This method makes it possible to realize a simple and high performance mobile fronthaul (MFH) inexpensively by correcting the data errors that occur in the optical transmission region with a strong wireless forward error correction (FEC) scheme. That is, no FEC scheme was installed in the optical region. Since the present system operates by means of an analogue transmission between the wireless and optical regions, we can remove several A/D, D/A, and even common public radio interface (CPRI) framer/deframer devices.

To achieve such an interesting scheme, I will point out the important role played by an optical injection locking technique, which can achieve precise phase-locking between optical and local oscillator (LO) signals. I will show that the use of one laser diode (LD) makes it possible to phase-lock the LO and eventually achieve a 256 QAM MFH transmission. Lastly, I will present optical and electrical devices that can accelerate the development of a fully coherent MFH system including integrated optoelectronic devices.