Success in test of ultra-high-speed optical transmission up to distances of 10,000km

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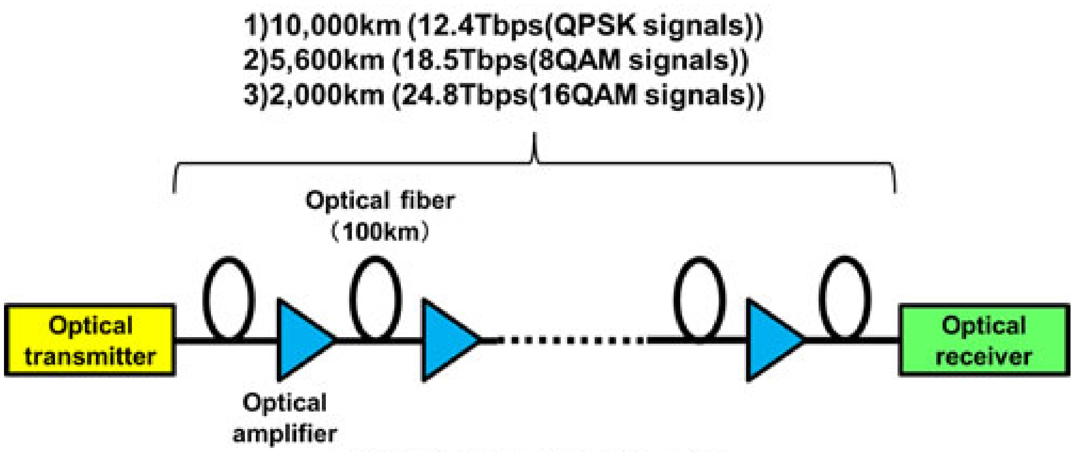

Figure1 Experimental setup

Fujitsu Limited, NTT Corporation, and NEC Corporation today announced that they have achieved a successful transmission test of the world's top-level, 400Gbps/channel-class digital coherent optical transmissions technology, marking a step toward commercialization. The test, with 400Gbps-class signals multiplexed up to 62 channels, verified fiber-optic transmissions of 12.4-24.8Tbps wavelength division multiplexed signals having different capacities for each modulation method at distances ranging from several thousand kilometers up to 10,000km.

By implementing this technology in an optical transceiver, a quadrupling of optical transmissions was achieved while using existing optical fiber, enabling the construction of the world's top-level core network, with the ability to handle transmissions of ultra-high-definition videos and the widespread expansion of machine-to-machine (M2M) communications. Building on these results, the companies will accelerate efforts to commercialize 400Gbps-class optical transmission technology. This R&D initiative was commissioned and is sponsored by Japan's Ministry of Internal Affairs and Communications (MIC) as part of its "Research and Development Project for the Ultra-high Speed and Green Photonic Networks" program.

Background

To accommodate the explosive growth in data communications traffic stemming from the widespread use of smartphones and fiber to the home, progress is now being made in the market to increase 100Gbps-class optical transmission systems that use digital coherent technology. Fujitsu, NTT, and NEC have pursued R&D on 100Gbps-class digital coherent optical communication technology as part of the MIC's "Research and Development on High Speed Optical Transport System Technologies" program (fiscal 2009) and "Research and Development on Ultra-high Speed Optical Edge Node Technologies" program (fiscal 2010-2011). The achievements of these development initiatives are currently being deployed by each company as part of a global roll-out to optical networks throughout the world. In addition, the coherent DSP that was employed in these programs currently holds the world's top market share. However, the arrival of a truly big data-based society and surging M2M communications has not just led to increased data volume, but further data diversification, and has necessitated next-generation, optical core networks that are able to transmit ultra-high-speed, high-capacity data both flexibly and economically. Accordingly, Fujitsu, NTT, and NEC in fiscal 2012 undertook the "Research and

Development Project for the Ultra-high Speed and Green Photonic Networks," a research program sponsored by MIC, and have been moving forward on joint R&D that brings the world's top level 400Gbps/channel class digital coherent optical transmissions technology to commercialization.

Results

The key technologies that enabled ultra-high speed optical transmission of 400Gbps-class/channel are as follows.

Extremely flexible 400Gbps-class adaptive modulation/demodulation technology

In addition to Quadrature Phase Shift Keying (QPSK), which is used in existing 100Gbps transmissions and which superimposes information on the phase of the light, an 8 Quadrature Amplitude Modulation (QAM) and a 16 QAM were used, superimposing information on both the phase and amplitude of the optical waves to expand data volume, and combined with sub-carrier multiplexing enabled by spectral compression technology called Nyquist filtering. By use of these technologies, an ultra-high speed optical transmission of the world's top-level 400Gbps-class was achieved, allowing for a much higher volume of information to be transmitted compared to that of conventional methods. In particular, in response to the characteristics of the optical transmission links, by selecting a modulation format appropriate for the quality of the link, in regards to the adaptive modulation/demodulation technology that enables the application of efficient optical network resources, the companies developed the world's first algorithm that can be implemented in an electronic circuit including an 8 QAM. Transmission ranges of 500 km to 1500km for capacities of 10 - 20Tbps per each core of optical fiber were successfully covered, which was not possible up until now, even with QPSK and 16 QAM. Therefore, the same hardware can support various modulation/demodulation formats in response to the conditions of the transmission line, such as transmission distance, enabling a highly adaptable and flexible network.

Compensation function using digital backward propagation signal processing, enabling long-distance transmissions

To achieve 400Gbps-class, ultra-high-speed optical transmissions over long distances, it is necessary to compensate for complex waveform distortions caused by nonlinear optical effects, which are generated with the optical fiber's refractive index changes in accordance with the intensity of the optical signal as high-power optical signals enter the optical fiber. These distortions would otherwise limit the power of incoming optical signals into the optical fiber. Up until now, however, compensating for the nonlinear optical effects of multi-level modulation signals within the optical fiber was difficult because the extremely large scale of the circuit made circuit implementation difficult. Therefore, it has been the primary limiting factor standing in the way of extending the distance of transmissions. To overcome this problem, the companies developed digital backward propagation signal processing, which, through refinements to the algorithm and circuit designs that dramatically reduced the volume of calculations, enabled circuit implementation and compensation of the nonlinear optical effects. They also developed chromatic dispersion estimation technology enabling estimations, for 10,000km of optical fiber, of the values of chromatic dispersion, which is a phenomenon in which the propagation lag times differ for each wavelength in an optical fiber. Moreover, a high-performance MSSC-LDPC error-correction code was used to enable a further extension of transmission distances. As a result of these technologies, the amount of equipment needed for long-haul transmission can be reduced, leading to expectations that the network would also consume less electricity. By combining these technologies, Fujitsu, NTT, and NEC, and successfully performed straight-line transmission tests for optically repeatered transmissions of up to 10,000km over a set-up emulating a submarine cable transmission link and optically repeatered transmissions of up to 3,000km over a set-up emulating a terrestrial transmission link. They also confirmed the viability of functions required for the practical implementation of algorithms enabling circuit implementation. These transmission tests were based on joint research with Japan's National Institute of Information and Communications Technology (NICT), and were performed using NICT's testing equipment.

Based on these results, the companies will move forward on development work to quickly put 400Gbps-class optical transmission technology into commercialization with the goal of creating the world's top-level optical network that delivers flexibility along with ultra-high speeds and low power consumption. In addition, they will collaborate with institutions inside and outside Japan in an aim to deploy their achievements on a global scale.

Provided by Fujitsu