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National Institute of Information and Communications Technology
Fujikura Ltd.

Press Release

Demonstration of World Record: 159 Tb/s Transmission over 1045 km with 3-mode Fiber

【Summary】

The National Institute of Information and Communications Technology (NICT, President: Hideyuki Tokuda, Ph.D) Network System Research Institute and Fujikura Ltd. (Fujikura, President: Masahiko Ito) developed a 3-mode optical fiber, capable of wide-band wavelength multiplexing transmission with standard outer diameter (0.125 mm) that can be cabled with existing equipment. We have successfully demonstrated a transmission experiment over 1045 km with a data-rate of 159 Tb/s. Multimode fibers have different propagation delays between optical signals in different modes that makes it difficult to simultaneously satisfy large data-rates and long distance transmission. This achievement shows that such limitations may be overcome.

Converting the results to the product of data-rate and distance, which is a general indicator of transmission capability, results in 166 Pb/s×km. This is the world record in a standard outer diameter few-mode optical fiber and the largest data-rate over 1000 km for any kind of standard-diameter fiber. In order to achieve the transmission capacity of 159 Tb/s, mode multiplexing is used in combination with 16-QAM (quadrature-amplitude modulation), which is a practical high-density multilevel modulation optical signal, for all 348 wavelengths and MIMO (multiple-input and multiple-output) enables unscrambling of mixed modal signals even after transmission over more than 1000 km. This shows that standard outer diameter multimode fibers can be used for communication of high capacity optical backbone transmission systems.

The results of this demonstration were selected for presentation as a post-deadline paper at the 41st Optical Fiber Communication Conference and Exhibition (OFC2018).

【Background】

In order to cope with ever-increasing communication traffic, research on large-scale optical transmission using new types of optical fiber exceeding the limit of conventional optical fiber and its application is actively conducted all over the world. The main new types of optical fibers studied are multicore fibers in which multiple passages (cores) are arranged in an optical fiber and multimode fibers that support multiple propagation modes in a single core with a larger core diameter. Up to now, successful transmission experiments of large capacity and long distance have been reported for multicore fiber, but it was considered that transmission which satisfied both large capacity and long distance simultaneously was difficult in multimode fiber.

【Achievements】

In this work, NICT constructed a transmission system using an optical fiber developed by Fujikura and successfully transmitted over 1045 km with a data-rate of 159 Tb/s (Fig. 1). Converting the results to the product of transmission data-rate and distance, which is a general indicator of transmission capability, is 166 Pb/s×km. This is about twice the world record so far in the few-mode fibers.

The transmission system consists of the following element technologies.

- 3-mode optical fiber with standard outer diameter 0.125 mm
- 348 wavelength optical comb light source
- 16-QAM multi-level modulation technology equivalent to 4 bits / single polarization symbol
- Separation technology of multimode optical signals with different propagation speeds in fiber (MIMO processing)

We succeeded in transmitting over 1045 km using a standard 3-mode optical fiber. When laying of standard outer diameter optical fibers takes place, the existing equipment can be used and the practical use at an early stage is promising. Also, ultimate large-capacity transmission will become possible in the future if combined with multicore technology, which is researched by NICT in cooperation with industry, university and government in Japan.

【Future Prospects】

We will continue to research and develop future optical communication infrastructure technologies which can smoothly accommodate traffic such as big data and 5G network services.

The results of this work were presented as a post deadline paper on the prestigious 41st Optical Fiber Communication Conference and Exhibition (OFC2018), held in San Diego, USA from March 11, 2018 until March 15, 2018.

【Reference】

Georg Rademacher, Ruben S. Luis, Benjamin J. Puttnam, Tobias A. Eriksson, Erik Agrell, Ryo Maruyama, Kazuhiko Aikawa, Hideaki Furukawa,Yoshinari Awaji, and Naoya Wada, "**159 Tbit/s C+L Band Transmission over 1045 km 3-Mode Graded-Index Few-Mode Fiber**," in Proc. 41st Optical Fiber Communication Conference and Exhibition (OFC), March 2018, paper Th4C.4.

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1. Transmission system developed this time

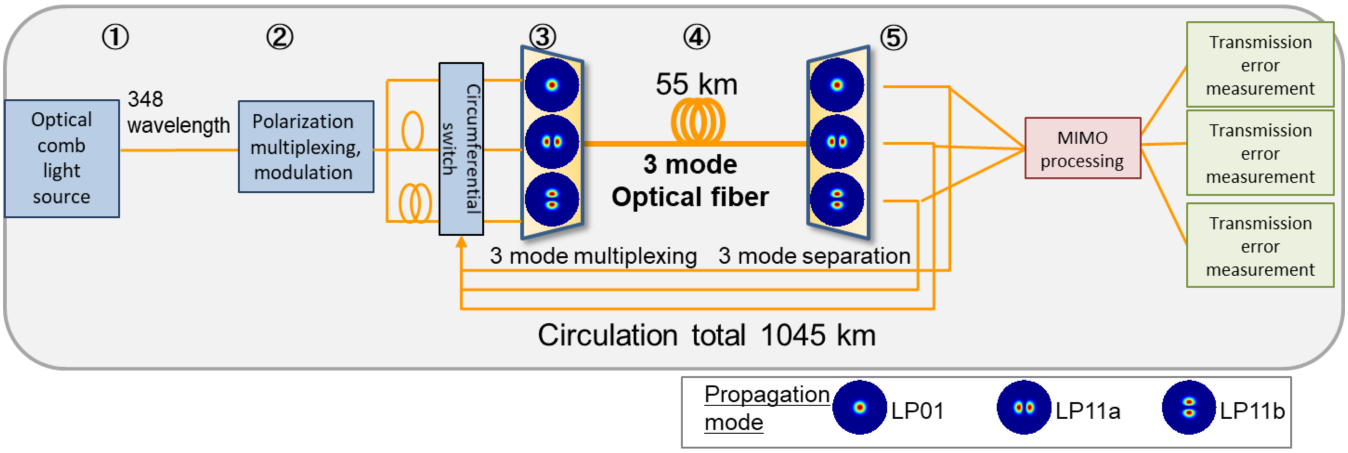

Fig.1: Schematic diagram of the transmission system

Fig. 1 shows a schematic diagram of the mode-division multiplexed transmission system.

① Laser lines at 348 different wavelengths generated simultaneously.

② Polarization multiplexing 16 QAM modulation is performed on the output light of the optical comb light source, and a delay difference is added to emulate multiple different signals.

③ Each signal sequence transmitted over the 3-mode optical fiber as a different propagation mode (LP01, LP11a, LP11b).

④ After propagating through the 3-mode optical fiber with a length of 55 km, it is introduced again into the 3-mode optical fiber via the circular switch. By repeating this loop transmission, the final transmission distance reached is 1045 km.

⑤ Each mode signal was optically separated, the signal was separated by performing MIMO signal processing of 6×6 scale, and the transmission error was measured.

2. Experimental results

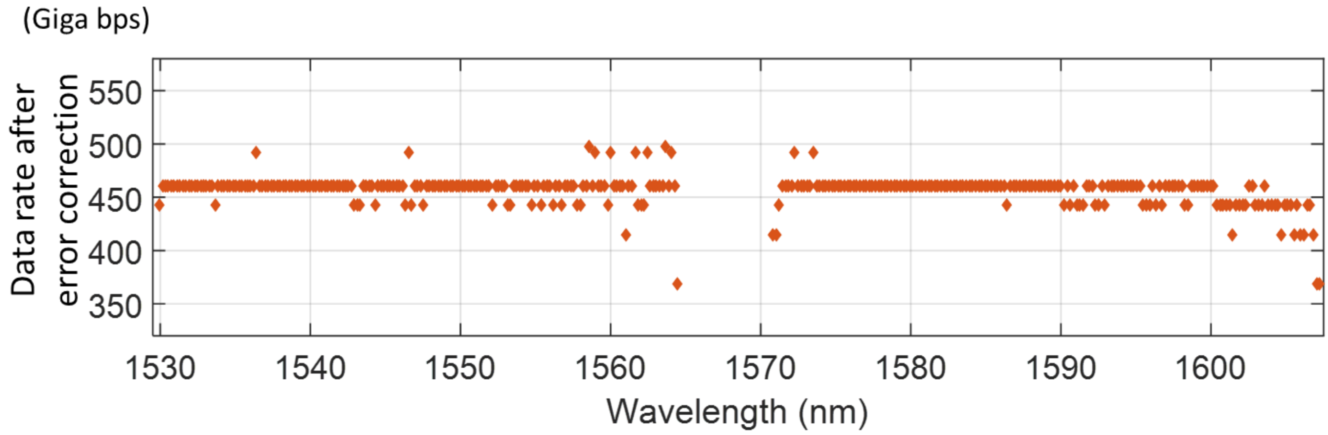

Fig.2: Experimental results

In the experimental system shown in Fig. 1, verification was carried out to maximize the transmission capability (data rate) of the system by applying various coding such as error correction processing at the time of transmission and reception.

The graph of the experimental results in Fig. 2 shows the application of error correcting codes to optimize total throughput. Although many have uniform coding rate, individual channels can use optimal error correction codes to achieve a total data throughput of 159 Terabits per second.