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論　文　内　容　要　旨

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学位論文題目	Study on All-Optical Modulation Format Conversion for Flexible Photonic Routing （柔軟なフォトニックルーティングのための全光処理による変調フォーマット変換に関する研究）		

内容要旨

In the past few decades, flexible optical network shows broad development with the exponential growth of information traffic. Because optical communication system is required to satisfy ultra-high speed, large capacity, and long reach related to next-generation information technology which are high definition video, Internet of things, artificial intelligence, and big data etc. This rate of data traffic growth is presenting big challenges that the ultimate capacity of conventional optical communication is already being approached as a result of the latest advances in the use of digital coherent transmission and the use of advanced modulation format signals. If such a traffic exponential growth continues as it is, current optical transmission technology using On-Off-Key (OOK) and direct detection (DD) cannot satisfy the required bandwidth demand. Because the spectral efficiency for the optical DWDM transmission system currently used is the most important parameter since the used interval of 95 nm of C or L bands depends on the amplifier factor. It means current DWDM system cannot use huge number of wavelengths due to the limited operation band of EDFA. One of way to increase optical transmission capacity is boost bit rate on every single channel of DWDM system. But when using limited spectral resource, the best solution is to use optical higher-order advanced modulation formats with higher spectral efficiency. The recommended spectral allocation of current DWDM transmission system following ITU-T standard G.694.1 is divided by 80 fixed grid with 50 GHz span. The total capacity can be increased by using higher-order modulation formats even in such DWDM transmission system.

Another major barrier in current optical communication system is electrical to optical or optical to electrical conversion, when subscriber data is transmitted over optical communication network. Because optical communication capability is limited by electrical digital signal processing unit in node of optical transmission network. This limitation is so-called ”electrical bottleneck”. All-optical signal processing is created to solve the mentioned limitation. But modulation format adaptation, which means deciding a modulation format exploited for the specific network depending on the desired transmission capacity and reach, is indispensable for flexible and efficient use of the fiber spectral resources. In such spectral efficient networks, flexible conversion between different levels of multi-level modulation formats will be important. Nowadays researchers are doing research on flexible optical modulation format conversion based on all-optical signal processing.

The flexible photonic networks use different modulation formats due to networking purpose, capacity, and level. When information stream is sent from backbone network to

access network, format conversion is needed in edge nodes of such network. Because backbone, metro, and access networks are using different modulation type depending on required capacity and optical reach. Some important function are needed to serve in all nodes of the flexible photonic network. There are routing and optical modulation format conversion. In this research, therefore, we consider solving the issue by converting to a symbol rate doubled single BPSK tributary from QPSK. As mentioned, every network chooses modulation format due to desired optical distance and required capacity in the optical communication system. Therefore, such networks using different modulation format need modulation format adaptation in joint or edge node of networks.

I would like to consider solving how to merge two separated BPSK tributaries. It is required that each of the spatially separated BPSK tributaries have once been temporally compressed to at least half of the pulse width and then de-interleaved each other to avoid inter symbol interference. To perform such pulse width compression, we utilize a single step comb-like profiled fiber (CPF). Since it uses a highly nonlinear fiber (HNLF) to perform pulse width compression, the signal quality in the format conversion is thought to be affected by the nonlinear distortion. Our modulation format conversion method has consisted of 3 subsections. There are orthogonal polarized dual pump four wave mixing (FWM) based phase conjugated idler generation, single step comb-like profiled fiber based optical pulse width compressor, 3dB coupler based I and Q component generation and de-interleaving with optical time delay.

We numerically evaluate the system performances by bit error rate (BER) and constellation diagram and discuss the influence on the signal quality to the location of the pulse width compressor. Potential applications of this method include all-optical redirection from QPSK-format to BPSK-format networks, flexible allocation of the signal for efficient use of the spectral resource as an elastic optical network, replacing a complex receiver with a simpler BPSK receiver, and serving as the phase regeneration in all-optical QPSK regenerators.