

# Demonstration of Hybrid Probabilistic Geometric Shaping 64QAM Optical Fiber Transmission Using Optimized Constellation for MAP Detection with Hard Decision Decoding

Rachata Maneekut \*, Daniel J. Elson \*, Yuta Wakayama \*, Shohei Beppu \*, Hidenori Takahashi \*,  
Noboru Yoshikane \*, and Takehiro Tsuritani \*

*\*Photonic Transport Network Laboratory, KDDI Research Inc., 2-1-15 Ohara, Fujimino, Saitama, 356-8502, Japan.*

ra-maneekut@kddi-research.jp, da-elson@kddi-research.jp, yu-wakayama@kddi-research.jp,  
sh-beppu@kddi-research.jp, takahashi@kddi-research.jp, yoshikane@kddi-research.jp,  
tsuri@kddi-research.jp

**Abstract**— We propose the optimized HPGS-64QAM constellations for hard decision decoding and experimentally verify the performance with optical fiber transmission. The proposed HPGS-64QAM constellations outperform the regular PS-64QAM in all ranges of entropy.

**Keyword**— Geometric shaping, probabilistic shaping, coherent optical transmission

**Rachata Maneekut** received the B.E., M.E., and Ph.D from Microwave and Lightwave Communications Strategic Research Area with the Department of Electrical Engineering, Faculty of Engineering Chulalongkorn University, Thailand, in 2007, 2010, and 2018, respectively. He has been working with Photonic Transport Network Laboratory, KDDI Research Inc., Japan. His research interests include the advance modulation scheme over passive optical network, constellation shaping and digital signal processing for optical transmission systems. In 2015, he received the short-term research fellowship from the National Institute of Information and Communications Technology (NICT), Japan. In 2017 he also joined the internship program at the Photonic Transport Network Laboratory, KDDI Research, Japan.

**Daniel J. Elson** received a BSc and MSci from Imperial College, UK in 2012 in Physics. Started his Ph.D at University College London (UCL), UK in 2013 with the Optical Networks group focusing on nonlinear compensation techniques in experimental systems. In his final year had a 4-month internship at NICT (national institute of information communication and technology), Tokyo working on multicore fibre systems. He graduated from UCL in 2019 and moved to the Photonics Transport Network Laboratory, KDDI Research, Japan to focus on spatial division multiplexed systems.

**Yuta Wakayama** received the M.E. and Ph.D. degrees in information science and technology from Hokkaido University, Sapporo, Japan, in 2010 and 2013, respectively. After graduation, he joined KDDI Corporation, Tokyo, Japan. Since then, he has been with KDDI R&D Laboratories (currently KDDI Research) Inc., Saitama, Japan. His research interests include space-division-multiplexed optical fiber transmission systems. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan. He was the recipient of the IEICE Communications Society OCS Young Researcher's Award in 2015, the Best Paper Award of OECC 2016, and the Young Researcher's Award of IEICE in 2017.

**Shohei Beppu** received the B.E. and M.E. degrees in communication engineering from Tohoku University, Miyagi, Japan, in 2013 and 2015, respectively. He joined KDDI Corporation, Tokyo, Japan, in 2015. Since 2016, he has been working with KDDI R&D Laboratories Inc. (currently KDDI Research, Inc.), Saitama, Japan. His current research interests include signal processing for coherent optical communication systems and space-division-multiplexed optical transmission systems. He was the recipient of Outstanding Student Paper Competition Honorable Mention in OFC 2014 and the Young Researcher's Award of IEICE in 2014.

**Hidenori Takahashi** received the B.E. and M.E. degrees in electronic engineering from Tohoku University, Sendai, Japan, in 1998 and 2000, respectively, and the Ph.D. degree from Waseda University, Tokyo, Japan, in 2012. He joined KDD R&D Laboratories Inc. (currently KDDI Research, Inc.) in 2000. He was involved in the research and development of silica-based planar waveguide devices. From 2006 to 2007, he was a Visiting Researcher and a Fellow of the Advanced Study Program with the Massachusetts Institute of Technology, Cambridge, MA, USA. Since 2007, he has worked on highly spectrally efficient transmission systems with digital coherent optical OFDM technologies and high-capacity systems using multicore fiber. Since 2012, he has been a member of the Submarine Cable Planning and Engineering Section of KDDI Corporation. Since 2016, he has also been a member of the Photonic Transport Network Laboratory of KDDI Research Inc., to realize future high-capacity and long-distance optical fiber transmission systems. He was the recipient of the Best Paper Award from the 7th International Conference on Optical Internet.

**Noboru Yoshikane** joined Kokusai Denshin Denwa Company, Ltd., (now KDDI Corporation), Tokyo, Japan, in 1999, and since 2001, he has been working with the Research and Development Laboratories. He has been engaged in research on the design of submarine cable systems, highly spectrally efficient optical communication systems utilizing wavelength division multiplexing transmission and designing and modeling of photonic networks. He is a member of the IEICE.

**Takehiro Tsuritani** received the M.E. and Ph.D. degrees in electronics engineering from Tohoku University, Miyagi, Japan, in 1997 and 2006, respectively. He joined Kokusai Denshin Denwa (KDD) Company Limited (currently KDDI Corporation), Tokyo, Japan, in 1997. Since 1998, he has been with their Research and Development Laboratories (currently KDDI Research Inc.) and has been engaged in the research of high-capacity long-haul wavelength-division-multiplexed (WDM) transmission systems and dynamic photonic networking. He is currently a Senior Manager with the Photonic Transport Network Laboratory, KDDI Research Inc., and a senior member of the IEICE. He was the recipient of the Best Paper Award of OECC 2000.