Picosecond Accuracy Time Synchronisation for Quantum Communication Networks

Research Theme: Quantum Technologies

UCL Lead department: Electronic and Electrical Engineering (EEE)

Department Website

Lead Supervisor: Kari Clark

Project Summary:

The Research Challenge

The measurement of the quantum state at receivers in quantum protocols such as continuous-variable quantum key distribution (CV-QKD) must be co-ordinated to picosecond accuracy. This necessitates that clock signals, distributed separately to the quantum signals, synchronise all nodes in a quantum network to picosecond accuracy, which could all be spatially located away from each other by up to 100 km of optical fibre. Current state-of-the-art synchronisation protocols used in optical networks, such as White Rabbit, are limited to nanosecond accuracies by uncompensated differences – asymmetries – in time-of-flight through both the optical fibre and electronics in the transmitters and receivers. Quantifying, minimising and compensating these asymmetries to picosecond accuracy is a substantial challenge requiring experimental research.

The Research Project

The successful candidate will perform research with Dr Kari Clark and his colleagues in the Optical Networks Group to design, simulate and test new methods of achieving the picosecond synchronisation accuracies required for quantum communication networks. This will be achieved by exploring the minimisation and/or compensation of optical and electronic asymmetries that currently limit the achievable time synchronisation accuracy in optical networks.

Practically, the project's main emphasis will be on experimental research in the Optical Network Group's world-leading optical communications laboratory, involving a combination of digital circuit design using state-of-the-art field programmable gate arrays (FPGAs), optical communications prototype construction as well as experimental measurement and characterisation. Although the main emphasis of this project will be on experimental research, the student will also be strongly encouraged to perform analytical modelling to develop theoretical understanding based on their experimental results.

There is also extensive scope for collaborative experiments with BT Research, and for performing experiments through a real deployed optical dark fibre network using the National Dark Fibre Facility (NDFF), which has an access point in our department at UCL.

Who we are looking for and who we are

This project suits a talented and ambitious student with an interest and passion for experimental research, preferably someone with previous research experience in timing, optical communications and/or digital design.

The Optical Networks Group (ONG) is world renowned in the field of optical communications, as well as very well-resourced with extensive collaborative links with leading industry and research groups around the world. For some of the most recent examples of our research into clock synchronisation and timing see Nature Electronics 6, 694-702 (2023), JOCN 16, A89-A97 (2024), as well as our UKRI clock synchronisation research project with BT and Menhir Photonics, USYNC.