NIEDERSACHSEN QUANTUM COMMUNICATIONS TESTBED

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Abstract

Quantum key distribution (QKD) is a prominent technology for exchanging secure keys between two authenticated remote parties. The security in a QKD system is unconditionally ensured by the laws of quantum mechanics which guarantee that any eavesdropping attempts will be identified. The acceleration in the development of quantum computing demands imminent deployment of quantum-secure communication systems. Therefore, it is essential to provide experimental facilities for QKD providers and developers to test and verify the novel technologies, protocols, and different use cases. Although classical optical networks are widely available, exploiting these existing networks for QKD is challenging due to the excess noise generated by optical amplifiers and scattering of co-propagating classical channels. Consequently, establishing dedicated dark fiber testbeds is a prerequisite for the development of QKD technologies.

In this presentation, we will present the concept and structure of the Niedersachsen Quantum Link as a QKD testbed. The testbed consists of a 78 km long pair of dark fibers between the cities of Hannover and Braunschweig and is operated by Physikalisch-Technische Bundesanstalt. One of the dark fibers is reserved for “quantum” applications, while the second fiber is dedicated to the dissemination of time and frequency reference signals as well as classical communication between two sites. This combination of dark “quantum” fiber and integrated time-frequency infrastructure is a unique feature of the Niedersachsen Quantum Link testbed.

In the “classical” fiber, we have implemented both optical carrier frequency transfer, which offers frequency stability down to the 10^{-19} level, and time-frequency transfer based on modulated light, using a commercial system which provides standard 10 MHz and 1 PPS signals with picosecond-level stability and accuracy. We are also planning to deploy White Rabbit time synchronization technology, which can support sub-nanosecond accuracy that is well suited for time and latency sensitive quantum applications. Time and frequency dissemination and classical communication are all wavelength-multiplexed on the same fiber using standard wavelength division multiplexing devices.

Optical fiber links are susceptible to environmental perturbations such as acoustic noise and thermal variations which impose polarization fluctuations and cause optical path length variations, which lead to a timing drift and phase fluctuations. Polarization and phase fluctuations significantly degrade the QKD performance in polarization- and phase-sensitive QKD systems, respectively. Timing drift degrades the timing correlation between the two parties, and hence obscures the identification of the quantum time bins. Thus, a robust synchronization is crucial.

Therefore, we have thoroughly characterized the polarization, phase, and timing drift in our testbed. Moreover, we have conducted optical time reflectometry measurements of the deployed quantum link to investigate the loss and reflections profile of the testbed.

Finally, we have demonstrated successful operation of a commercial QKD system developed by Quantum Optics Jena GmbH. The system incorporates a proprietary clock synchronization algorithm and was initially operated without external clock. While it was able to generate encryption keys through the testbed, initial results indicate that it would benefit substantially from external synchronization, at least in a situation of relatively high link loss (around 28 dB in our testbed).