Wroclaw Quantum Network – QKD deployment in a metropolitan network

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Abstract

We summarize research results preceding currently ongoing deployment of the QKD experimental systems in a real network environment of optical fiber metropolitan backbone network in the city of Wroclaw, Poland. Experimental and even early commercial QKD implementations are very susceptible to technical conditionings of the transmitting media (i.e. optical fiber infrastructure and associated alignment of the quantum optics) [1,2], therefore deployment of QKD systems in real metropolitan optical fiber infrastructure network poses a challenge. The optical infrastructure is determined by the city telecommunication canalization layout. Dark fibers connecting two, even not very distant metropolitan locations physically sharing an industry-standard telecom line with many parallel fibers (constituting the initial P2P topology and medium for QKD network) are divided in a series of thermally welded interconnections and junctions at telecom canalization crossings, which are main reason for decoherence and quantum signal losses, resulting with increased QBER and with infeasibility of key distribution in practical scenarios (this is specifically addressed to dark fiber infrastructure of metropolitan backbone telecom networks with multiple interconnections of telecommunication optical lines, which are implemented by thermal weldings – a connection between two locations separated by ca. 4-5 km distance, is usually divided by even several fiber weldings). Research on QKD deployment in practical telecommunication network environments resulted in evaluation of boundary conditions for QKD feasibility versus quantum channel and transmission parameters and a successful resolution of channel quality problem by proper alignment of experimental QKD setups. The fiber optics line of the SMF28 standard has been used to test different connection and welding configurations for two R&D QKD approaches based on the IdQuantique Clavis2 setup (non-entanglement QKD, encoding qubits on interfering phase shifts of laser impulses in Mach-Zehnder interferometers) and the AIT Quelle setup (entanglement QKD, encoding qubits on polarizations of entangled photon pairs generated in non-linear PDC process in a BBO crystal). The main optics fiber line (single mode SMF28 standard) has been subsequently modified in laboratory test runs by welded or interconnected F3000/APC and FC/PC adapters. The interconnectors resulted with high QBER increases, thus favoring thermal welding which in proper proximity distribution were characterized by ca. 10 times lower loss induction than interconnectors (ca. 0.01 dB per welding, depending on the proximities). Next the industry standard telecom fiber optics line tests has been carried out towards welding and interconnections configuration optimizing in regard to QBER and conditioning of the metropolitan network deployment. Primary focus was directed towards the non-entanglement based setup which turned out to be operating properly with an acceptable raw key exchange rate (RKER) generating targeted amount of distilled secret bits (DSB) under laboratory simulation of real optic fiber backbone metropolitan network configuration with required optimization of interconnections and welding infrastructure. The entanglement based QKD has been tested for the first time in a real telecom network environment and proved to be also feasible but within a very narrow gap of optical elements alignment and poor (unpractical) values of QBER and RKER with high additional instability of operation parameters. This research allowed for the current deployment of the QKD metropolitan network in Wroclaw.

References

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