High performance field trials of QKD over a metropolitan network

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Abstract We report on two field trials of Quantum key distibution in Cambridge, the first showing robust performance with long term secure key rates of 2.5Mb/s. The second demonstrates reliable coexistance of QKD and 2x100Gb/s classical data over a 66km installed fibre with 16dB loss.

Introduction

In order to optimise the use of QKD secured data networks a test-bed has been created within Cambridge, which links through other fibre connections to other research centres in the UK.

The Cambridge Quantum Network has four nodes within the city, three at University locations and a fourth at Toshiba Research Europe labs (TREL). These nodes are separated by distances between 4 and 10km. In addition, The University hosts an end-point for the Janet Aurora 2 fibre network (UK Quantum Network) which connects the University with UK other institutions, in London, Southampton and Bristol

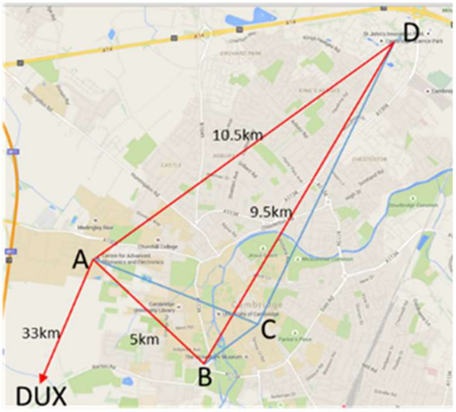

Fig.1. The Cambridge Fibre network, with A, the Electrical Engineering building, B, the Engineering Dept., C the University central network facility and D, Toshiba Research Cambridge Laboratory. Also shown is the Aurora2 dark fibre link to Duxford (DUX)

Previous works over similar distances feature low secure key rates. For example the Swiss Quantum Network between three sites displayed secure bit rates of the order kbps [1]. This paper describes initial field trials carried out on the Cambridge Quantum Network with resulting Mbps secure bit rates. We also report on the first part of the UK Quantum Network, a length of 66km.

Figure 1 shows the topology of the current Cambridge Quantum network, with nodes at A – The Electrical Engineering building, B – the main Engineering Department building, C – The University central networking facility and D – TREL.

Field Trials

The first field trial has been running for several months with QKD [2] systems from TREL deployed on links AB, DB and DA, lengths of 5.0, 9.65 and 10.4 km with losses of 1.2, 3.3 and 3.4 dB respectively. The QKD systems from TREL uses a decoyed-BB84 type protocol, termed “T12” with efficient basis selection to elevate the key rate, at a clock rate of 1GHz. The effect of finite key size is mitigated with a resulting key failure probability, $\varepsilon = 10^{-10}$ [3]. Figure 2 shows the QBERs on these links over a period of 2 months, demonstrating an average QBER 2.6±0.4%, 2.2±0.5%, 3.0±0.2% respectively. Figure 3 shows the resulting average secure key rates of 3.2±0.3, 3.2±0.3, 2.5±0.2 Mb/s achieved over the same period.

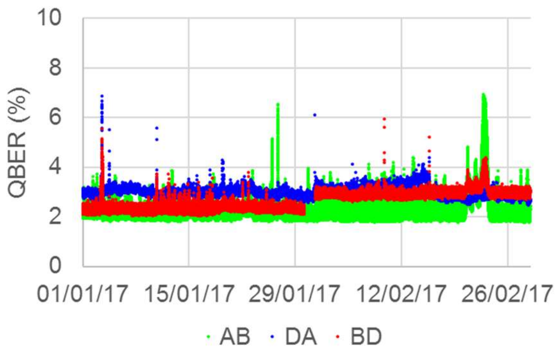

Fig. 2. Quantum bit error rate for the three links within the Cambridge network

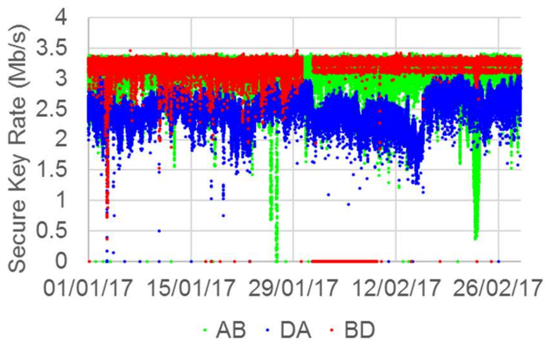

Fig. 3. Secure key rates for the Cambridge Network

In addition to the field trial of QKD transmission within the Cambridge Quantum Network a field trial has been performed over the first part of the UK Quantum Network, with signal being transmitted from the Electrical Engineering building to the first intermediate node on the UKQN at Duxford and looped back to the Electrical Engineering building. This is a distance of 66km, with a loss of 16dB.

In this extended reach field trial the QKD system coexisted with two classical polarisation multiplexed quadrature phase shift keyed data signals, each of 100 Gb/s data rate within the C band at around 1530nm with a launch power of -0.5dBm. These classical signals, from an ADVA FSP3000 transmission system, were encrypted using AES256 keys, provided by the QKD system running over the same fibre at a wavelength of 1550 nm. The classical channels ran error free using forward error correction, with a pre-FEC bit error rate of $4\text{x}10^{-5.}$

The QBER of the co-propagating QKD system is shown in figure 4, with a mean QBER of 6.6% and standard deviation of 0.5%. Figure 5 shows the secure key rate on the QKD link, with a mean of 80kb/s and standard deviation of 28kb/s.

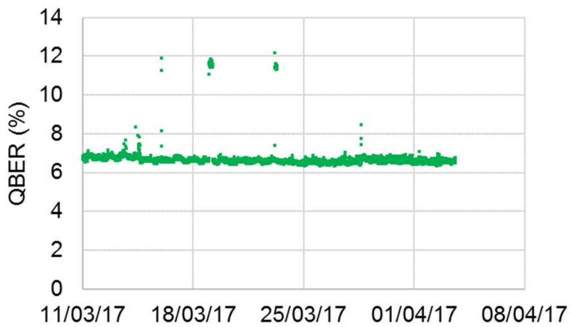

Fig.4. Quantum bit error rate for the loop back field trial coexisting with 2x100 Gb/s classical data channels.

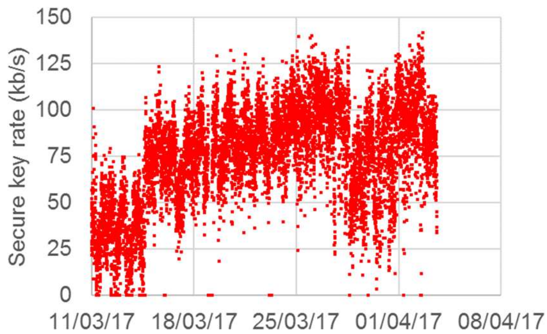

Fig. 5. Secure key rate for the loop back field trial coexisting with 2x100 Gb/s classical data channels

This is a significantly longer distance and duration field trial than has previously been undertaken using QKD equipment from TREL [4]. The aggregate bandwidth of the coexisting classical data has been increased from 40 to 200Gb/s. This field trial will soon be extended to encompass both the UKQN and also the Cambridge Quantum Network.

Conclusions

We show initial field trials of QKD traffic within the Cambridge Quantum Network, achieving the highest long term secure key rates ever demonstrated. Also a long distance field trial of coexisting QKD and multiple 100Gb/s classical data encrypted with AES256 keys derived from the QKD traffic is reported showing its long term stability. It is intended to extend both of these trials and present further results at the conference

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