A resource-effective QKD field-trial in Padua with the iPOGNAC encoder

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We test a QKD system based on the iPOGNAC encoder on the deployed urban fiber network in Padua. This new encoder guarantees stability and ease of alignment.

The iPOGNAC

- A polarization encoder based on a Sagnac interferometer on a polarization-maintaining (PM) fiber [1].
- Light enters the fiber in a balanced (w.r.t. the axes) polarization state, set by a half-waveplate (HWP) in free-space.
- In the fiber, the two components are separated by a polarization beam splitter (PBS) and travel in opposite directions, both on the slow axis.
- They encounter a phase modulator which sets the relative phase.
- They are mixed again at the PBS and directed to the output by a free-space beam splitter (BS).
- PM components guarantee stability and offer a definite polarization reference.

The field trial

This is the first test of the iPOGNAC outside of the laboratory [2]. We implement the efficient BB84 protocol with three transmitted states and two intensity levels [3]. The two terminals are connected via two 3.4 km-long deployed urban fibers: the qubits travel on one, whereas the other is for the classical post-processing. The transmitter includes a distributed feedback laser source at 1550 nm and 50 MHz of repetition rate, an intensity encoder for the decoy-states method, the iPOGNAC and various attenuation stages. At the receiver, a polarization decoder based on BSs and PBSs sends the qubits, separated in polarization, to four InGaAs single-photon avalanche diodes (SPADs) whose output is temporized by a time-tagger. The alignment of the measurement bases uses a pre-shared qubit sequence sent at the beginning of the acquisition, without additional optical signals. The Qubit SYNC algorithm synchronizes the two terminals without additional hardware, using only the expected times of arrival of the qubits. All components are commercial and off-the-shelf and we could fit the optical sections of both transmitter and receiver into portable 2U rack enclosures.

Results

During a one-hour long QKD run, we accumulated 2.7 × 10⁸ qubits. The average error rates (QBERs) in the key (K) and control (C) bases were 2.0% and 1.1% respectively. We attribute the change in QBER shown on the left to minor temperature variations at the receiver. After the post-processing, we measured a secret key rate (SKR) of 11.5 kbps. Using parameters extracted from the experiment, we simulated the performance that the system would have with different channel losses, and concluded that we would obtain a positive SKR with up to 23 dB attenuation, as shown on the right.

Conclusions

- We deployed our QKD system on the urban fiber network in Padua.
- We tested for the first time outside the laboratory the polarization encoder iPOGNAC.
- This encoder guarantees stability, ease of installation, and a fixed polarization reference.
- Our simple system does not need additional optical signals for polarization alignment nor for synchronization.
- We measured a QBER of 2.0% and 1.1% in the two bases and a SKR of 11.5 kbps.
- This field trial represents a step towards the deployment of resource-effective and practical QKD systems in urban fiber networks.

References