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Coherent One Way (COW) QKD Protocol

João António, Daniel Silva, Armando N. Pinto

Department of Electronics, Telecommunications and Informatics,
University of Aveiro, Aveiro, Portugal
Instituto de Telecomunicações, Aveiro, Portugal

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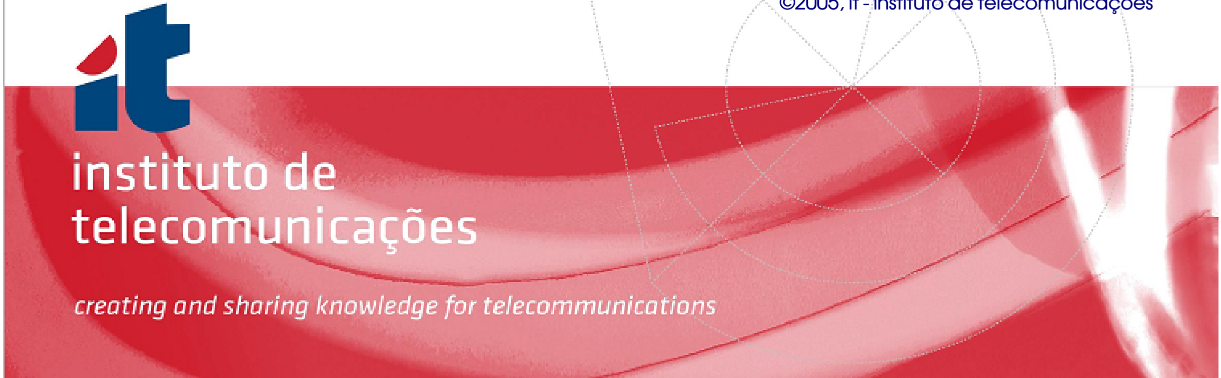


COW - Protocol

Step 1 Alice produces:

$$|0\rangle = |\alpha\rangle_{2k}|0\rangle_{2k+1},$$

$$|1\rangle = |0\rangle_{2k}|\alpha\rangle_{2k+1}.$$

$$|d\rangle = |\alpha\rangle_{2k}|\alpha\rangle_{2k+1}.$$

where $|0\rangle$ is teh vacuum state and $|\alpha\rangle$ is a coherent state of light with intensity $\mu = |\alpha|^2$.

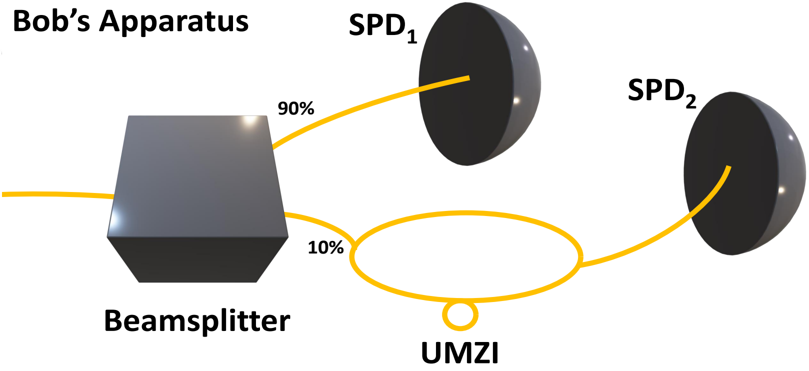
Alice produces $|d\rangle$ with probability f and the quantum signal cannot be divided bitwise (coherence of the laser).

$$|...0d10...\rangle = |... : 0\alpha : \alpha\alpha : \alpha 0 : 0\alpha ...\rangle$$

COW - Protocol

Step 2 Alice uses an attenuator to around 0.1 photons per pulse and then transmits through a quantum channel.

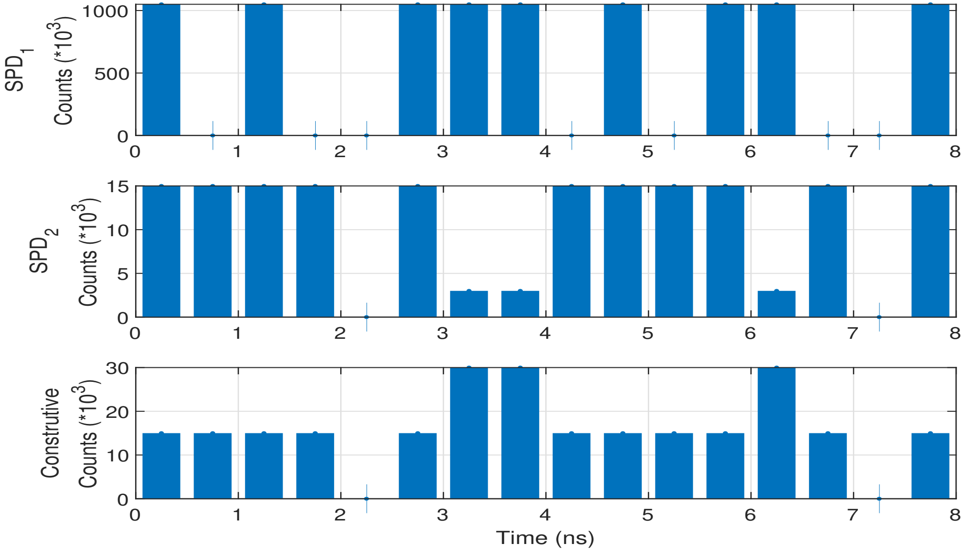
Step 3 Bob uses a 90:10 beamsplitter making 90% of the photons into the SPD1 to arrival time measurements, the remaining 10% are used to measure phase coherence.



COW - Protocol

In the UMZI (Mach-Zehnder Interferometer) the delayed half of each pulse is recombined in the non-delayed half the next pulse.

For example, the key $|0\rangle|0\rangle|1\rangle|d\rangle|1\rangle|1\rangle|0\rangle|1\rangle$



COW - Protocol - Attacks

Step 4 Alice informs Bob when she sent a decoy pulse.

Step 5 They calculate the visibility (V) and the QBER (Q) of the key.

$$V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

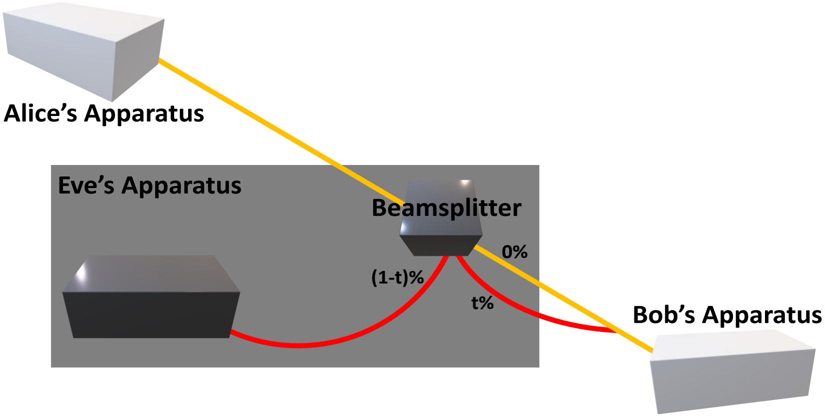
where the I_{max} and I_{min} are the average pulse intensities for constructive and destructive interference respectively.

They also share a small part of the key in a public channel, to see if there are errors in the message.

A loss of coherence and therefore a reduction of the visibility reveal the presence of an eavesdropper, in which case the key is simply discarded

COW - Protocol - Attacks

- Beam-splitting attack - Eve removes a small part from the intensity of the original message and send the rest to bob in a no-losses channel (symbolized by a red line). Eve introduces additional errors in order to make her information equal to the Bob information.
- Active beam-splitting attack - Eve removes smaller intensities of the message and can make individual measurements and block some of it.



COW - Protocol

- Unambiguous state discrimination (USD) - Alice and Bob only check for coherence in two successive pulses. d So if Eve attacks while they don't check the coherence, she can do an unnoticed attack. But if systematically, they notice that no decoy is detected.

Name	Discriminating
USD3	$\|0\rangle\|\alpha\rangle\|0\rangle$
USD4a	$\|0\rangle\|\alpha\rangle : \|\alpha\rangle\|0\rangle$
USD4b	$\|0\rangle : \|\alpha\rangle\|\alpha\rangle : \|0\rangle$

E-mail: joaoantonio@ua.pt