Multiplexing QKD systems in Conventional Optical Networks

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Despite that QKD systems are maturing quickly [1], QKD networks are mostly following the model of a separated infrastructure consisting on a collection of dedicated point-to-point QKD links. The cost of dark fibre makes such an approach prohibitively expensive, except for niche applications, hindering the market growth of QKD technology. The objective of this communication is to demonstrate the feasibility of having ~64 addressable quantum channels and the associated QKD classical *service* signals sharing one dark fibre in a realistic, technologically and cost-wise, alternative based on the integration with existing infrastructure using telecom standards components and Wavelength Division Multiplexing (WDM) technology.

Modern telecom networks are moving towards the use of passive components and WDM as the multiplexing technology [2]. Therefore, a direct optical path between two points can be established, and thus a quantum channel. Ideally, QKD systems would simply use one of these wavelengths in the WDM ITU grid, but the power difference between quantum and classical signals (70-100 dB) would limit the number of QKD systems to just a few. Instead, in our WDM scheme, we multiplex only the quantum channels and the classical service signals needed to stabilize each quantum channel. Quantum signals use the O band of the spectrum (1260-1360 nm), and the classical ones use the C band (1530-1565 nm). This allows that: (i) standard telecom components can be used for the classical signals; (ii) the noise is strongly reduced due to the 200 nm separation; and (iii) keeping them in separated groups eases their manipulation, allowing for addressing schemes. On the other hand, although fibre absorption in the O band increases ~0.1 dB/km compared to the C band, this is a minor concern in Metropolitan Area Networks (MAN), since the overall losses stem primarily from wavelength independent device components and splices.

Fig. 1 shows the design of a QKD-MAN using our QKD network model. The network is divided into WDM-PON access networks, where QKD systems are connected, and a DWDM backbone network, which connects all access networks. Each access network has assigned a quantum O-subband and the corresponding, AWG-periodic, C-subband for the associated service channel. The structure matches a real telecom MAN allowing the use of as much existing commercial components as possible. Dotted rectangles mark the network devices that we have modified according to our WDM scheme. In particular, backbone nodes route quantum and classical subbands to the corresponding access network using band-pass filters and circulators, and access networks use optical switches and the periodicity of the AWGs to ensure all-to-all connectivity in the network. QKD devices select the destination by just choosing the wavelength and setting the port in the switch connected to the nearest AWG. The losses of each path are kept within the loss budget of modern QKD systems (~30 dB) [3].

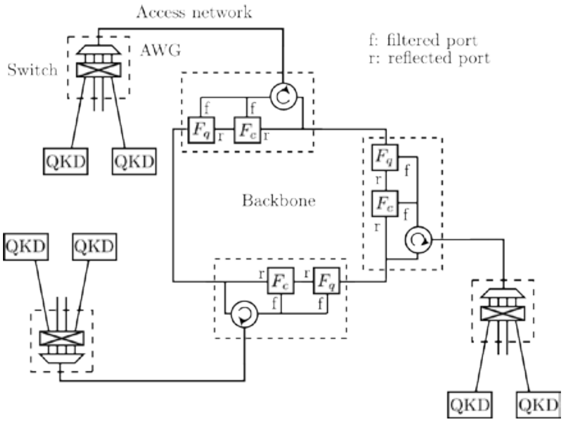

Fig. 1 QKD-MAN

Preliminary experiments with a worst-case scenario indicate that this QKD-MAN is able to multiplex at least 64 QKD systems in a single fibre, i.e., 64 quantum signals and 64 service signals, without reducing the total power of the classical signals (~0 dBm).

References:

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