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Practical Integration of Quantum Key Distribution with Next-Generation Networks

A. B. Price, A. Aguado, E. Hugues-Salas,
P. A. Haigh, P. Sibson, J. Marhuenda,
J. Kennard, J. G. Rarity, M. G. Thompson,
R. Nejabati, D. Simeonidou and C. Erven

Overview

 QKD Refresher

 Networks of the Future

 Emulating a Software Defined Network

 Time-Sharing QKD Systems

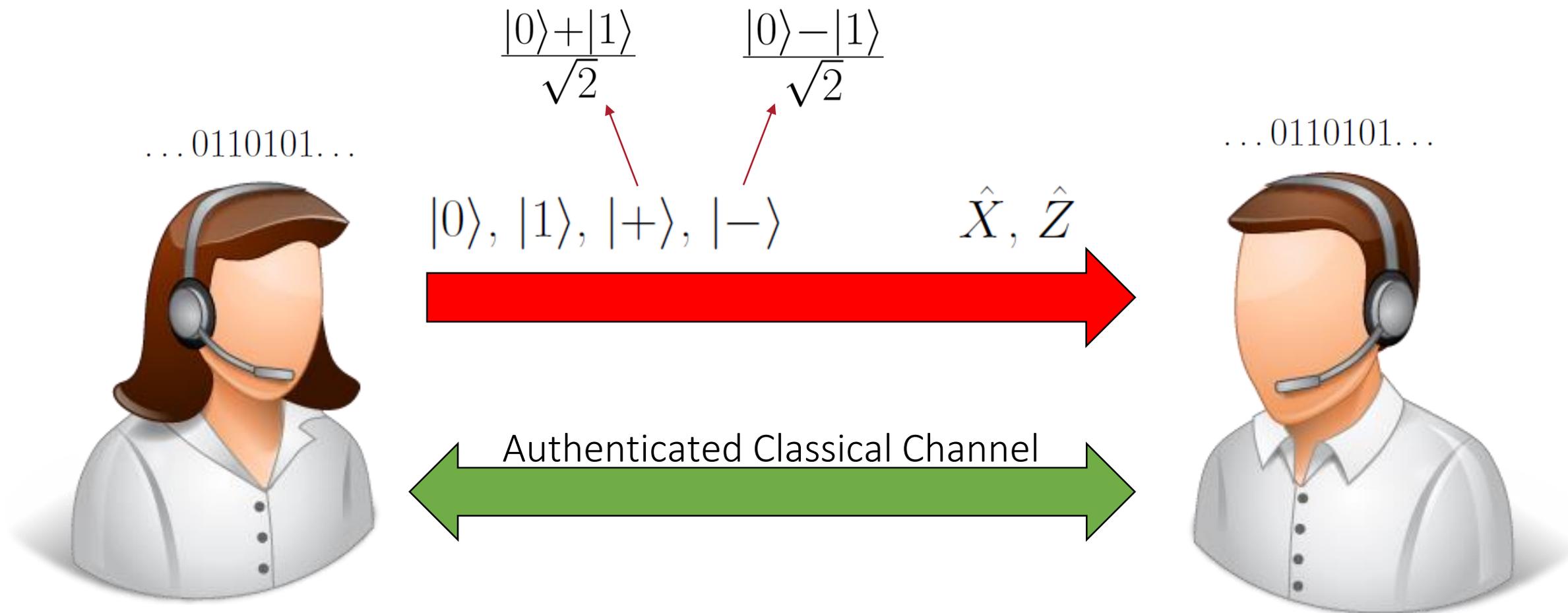
 Distributing Virtual Network Functions

 Next steps

QKD Refresher

-  Shor's algorithm can be used to attack conventional key distribution methods.
-  Grover's search strengthens brute force attacks.
-  Need a quantum-secure method of key distribution to use alongside conventional ciphers reinforced against Grover's.

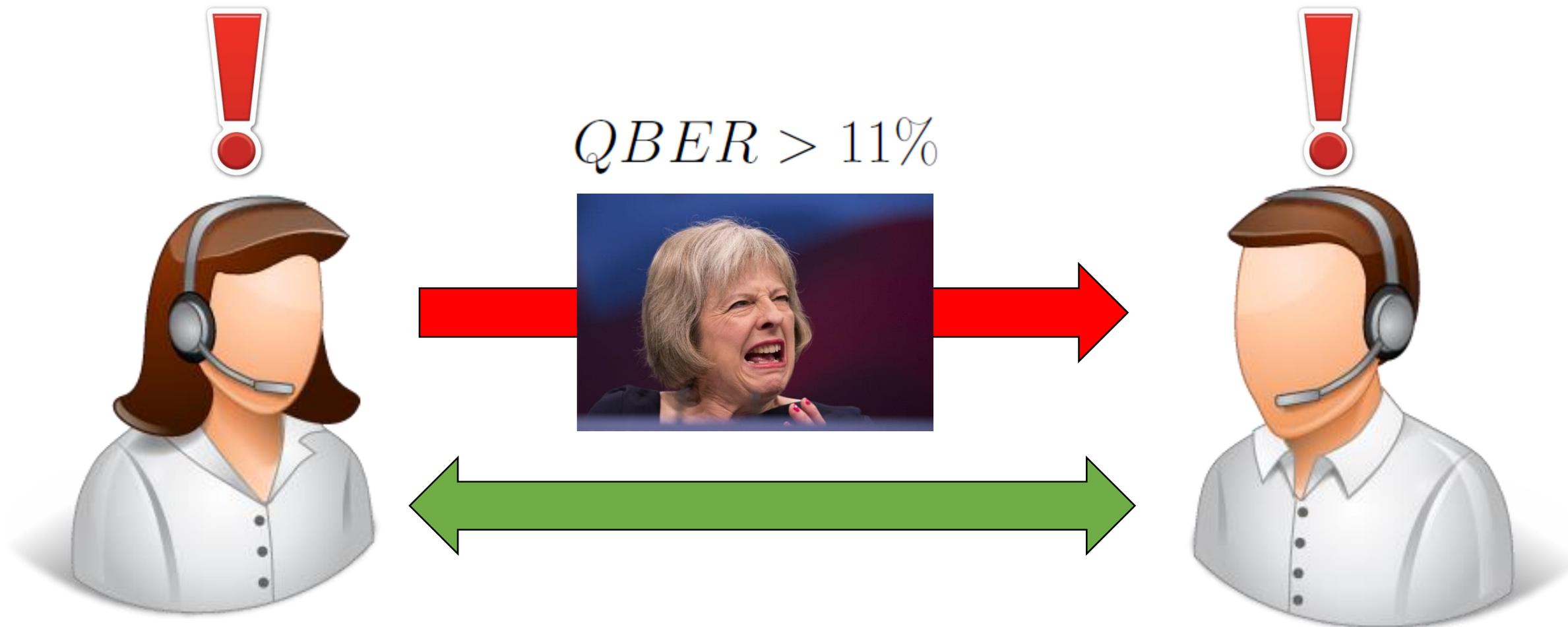
QKD Refresher



C. H. Bennett and G. Brassard, *Quantum cryptography: Public key distribution and coin tossing*, in Proceedings of IEEE International Conference on Computers, Systems and Signal Processing **175** (1984).

V. Scarani, A. Acin, G. Ribordy and N. Gisin, *Quantum Cryptography Protocols Robust against Photon Number Splitting Attacks for Weak Laser Pulse Implementations*, Phys. Rev. Lett. **92** (2004).

🔥 QKD Refresher



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QKD Refresher

One Time Pad

Mathematically secure

Infeasible for day-to-day communications

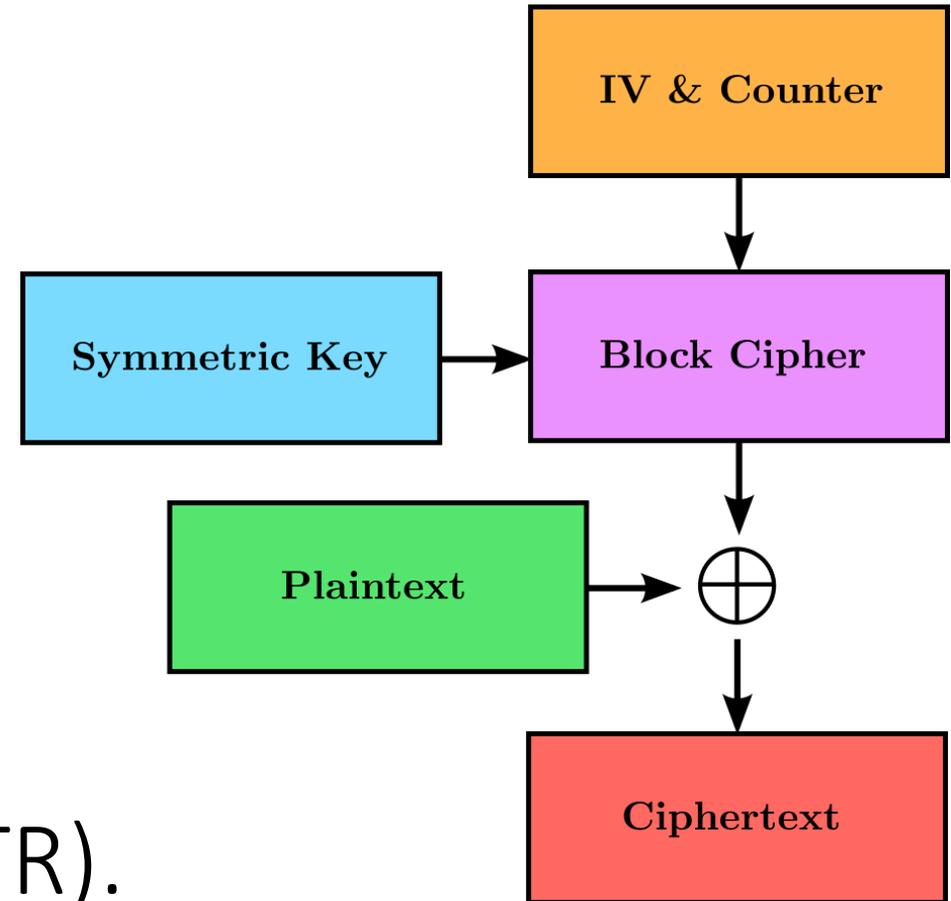
AES

Secure enough

Widely used in day-to-day communications

AES

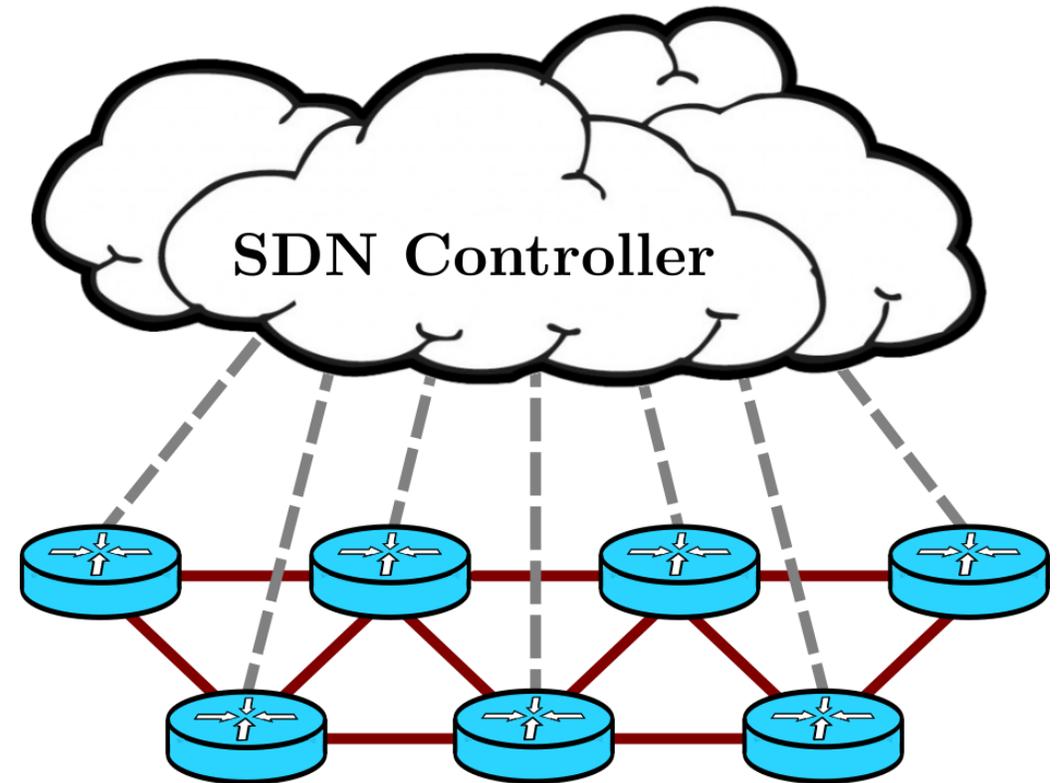
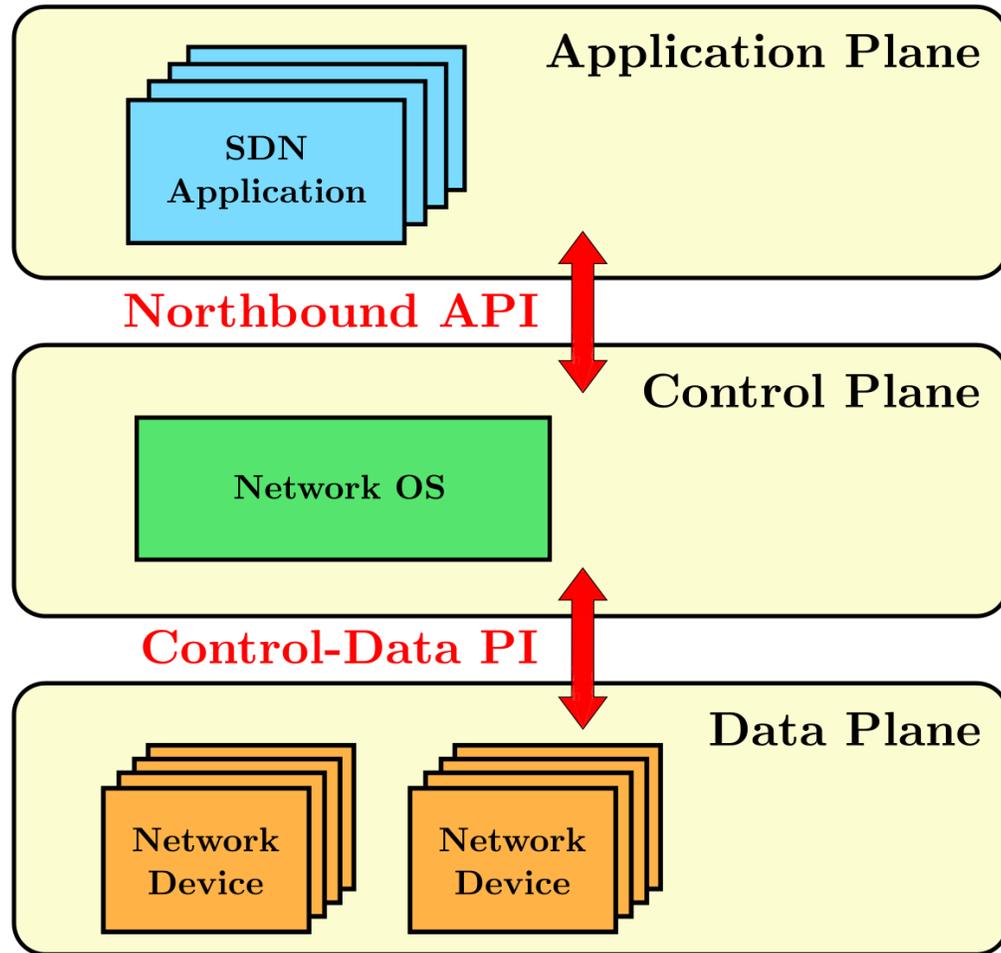
Enciphers and deciphers messages in 128-bit blocks with **256-bit** keys for post-quantum security. Can perform full encryption when operating in the correct mode (e.g. CTR).



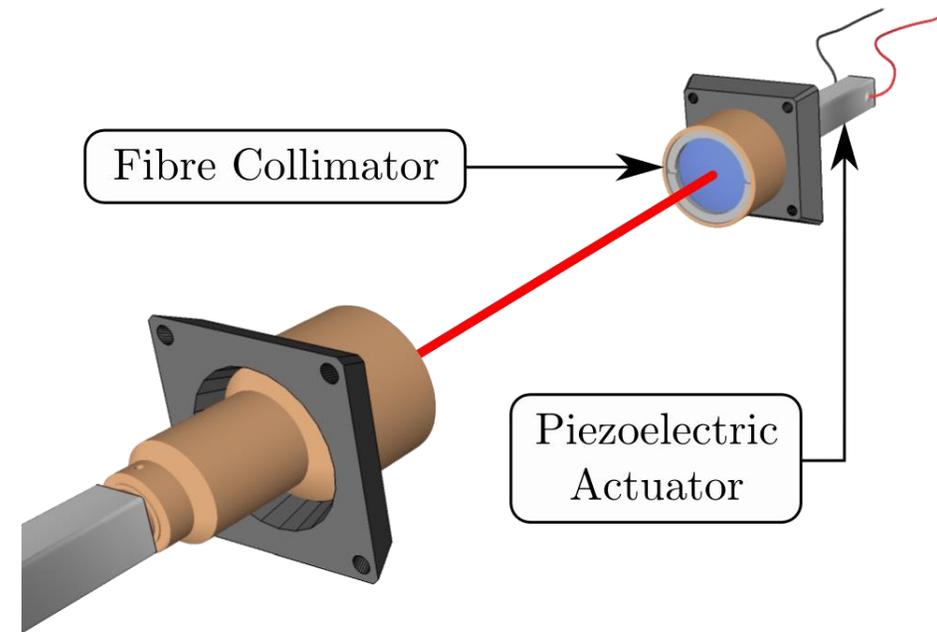
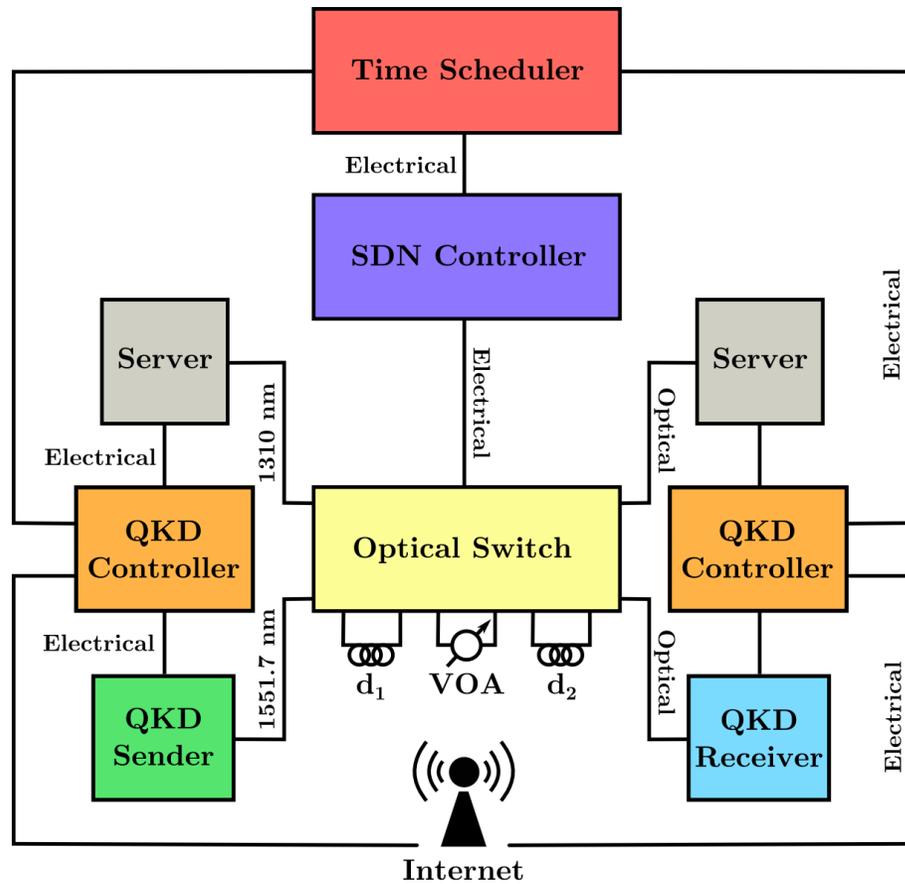
Networks of the Future

Future networks will be software-defined, deploying data handling rules as software rather than hardcoding them in the firmware of devices, allowing global reconfigurability of the network from a single location as and when required.

Networks of the Future



🔥 Emulating a Software Defined Network



Emulating a Software Defined Network

possible switch configurations = $10^{10^{438}}$

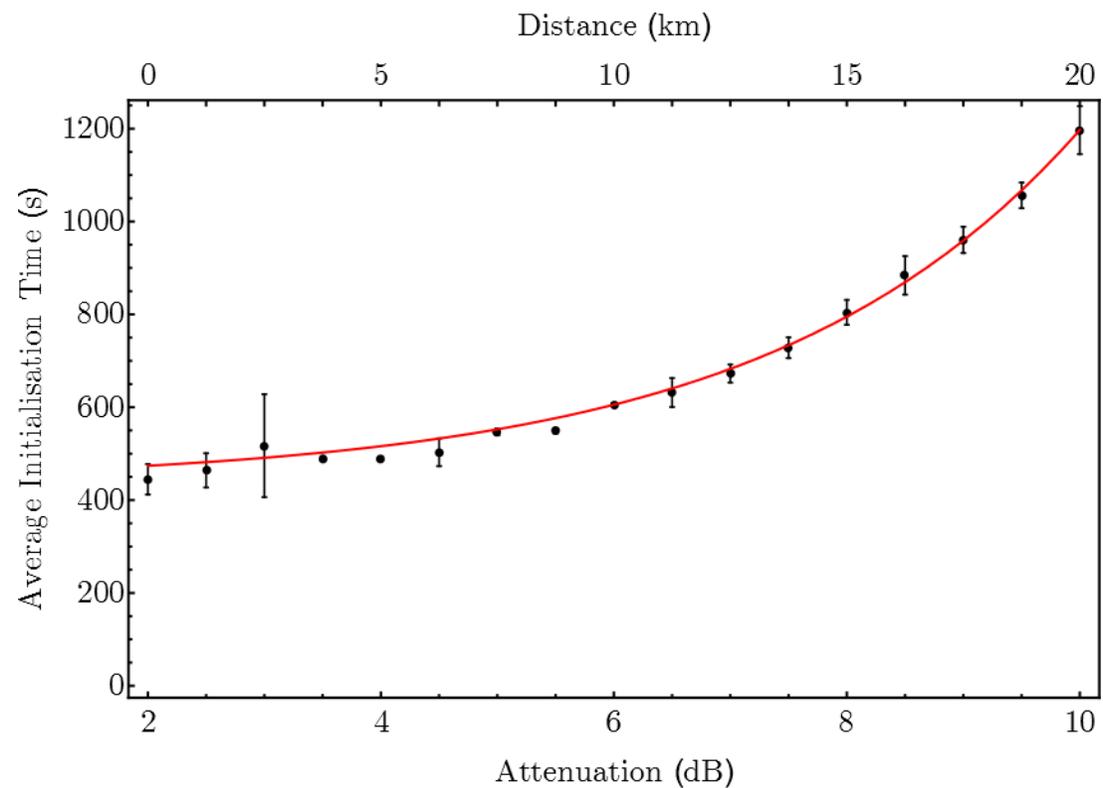
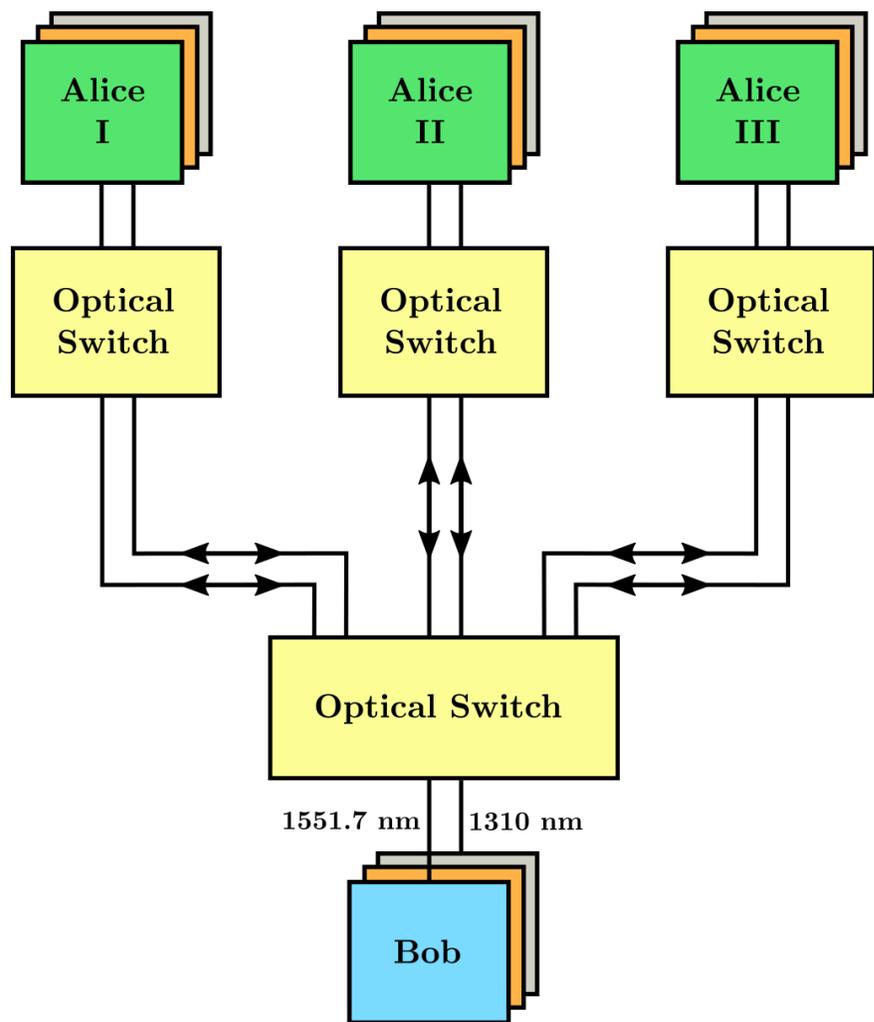
set wavelength

set power

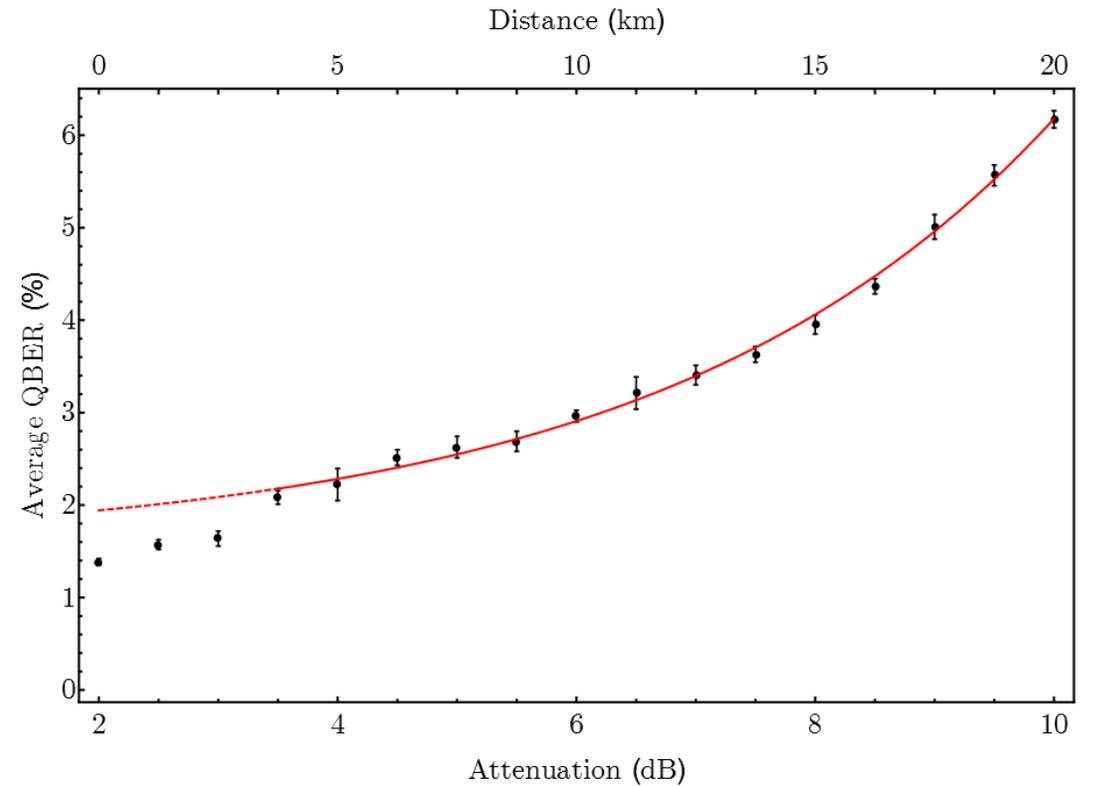
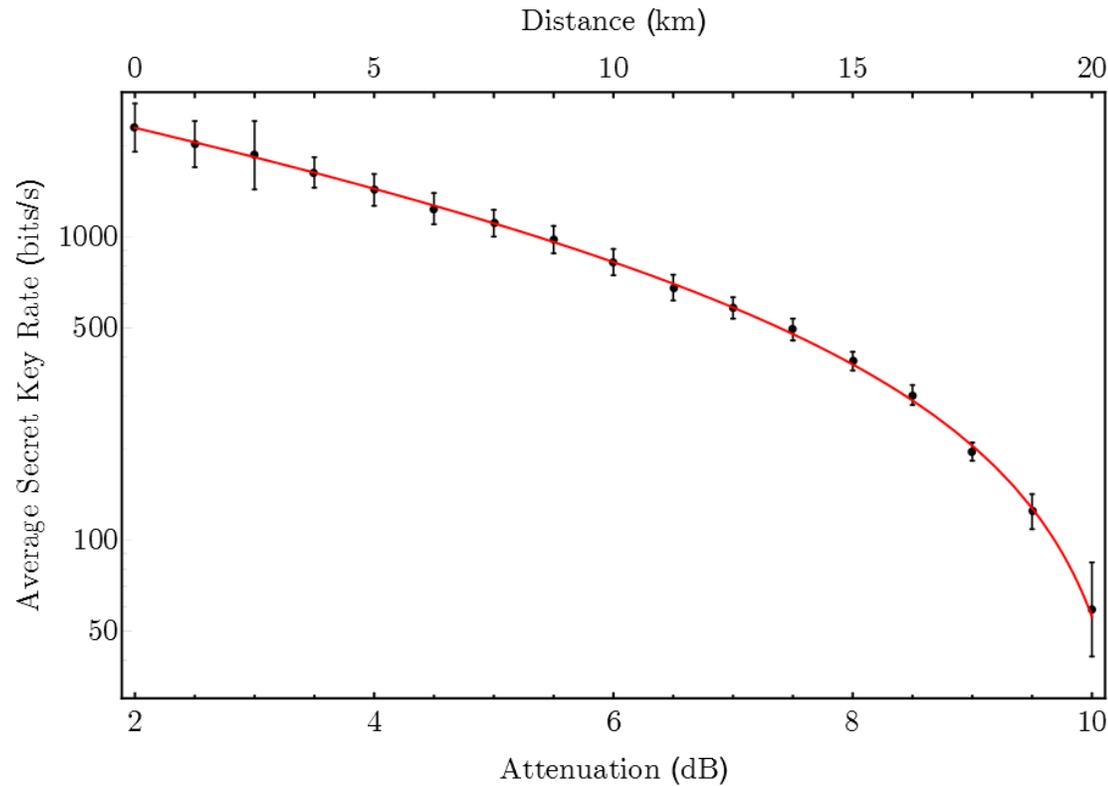
1 classical fibre
1 quantum fibre

Best case: Negligible cross-talk
Worst case: 49.1×10^3 counts/s

Time-Sharing QKD Systems



Distributing Virtual Network Functions



10 km data centre: Secret key rate = 825 bits/s, QBER = 2.96 %

🔥 Distributing Virtual Network Functions

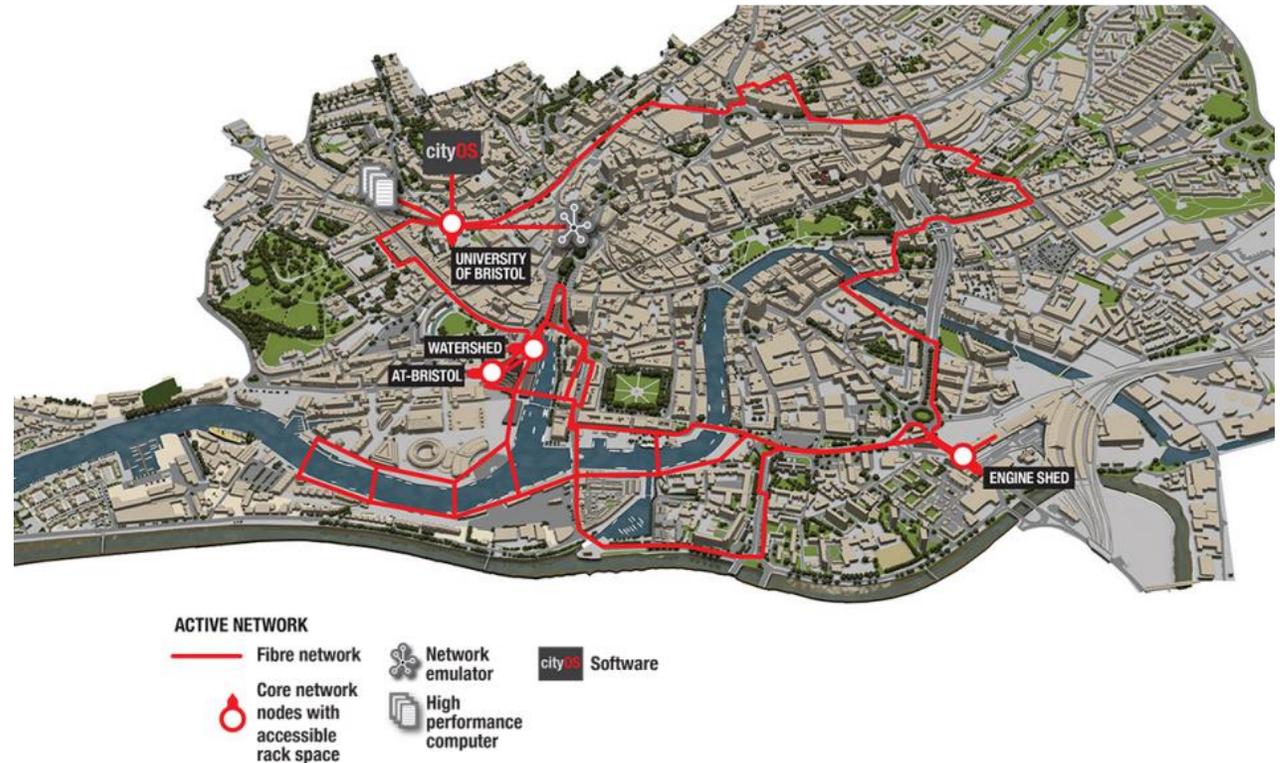
- 🔥 Transmitted AES-encrypted Windows VM (**14.831 GiB**), Ubuntu VM (**0.178 GiB**) and CentOS OVS_LC (**0.716 GiB**).
- 🔥 AES GCM encrypts \leq **64 GiB** per key/IV pair.
- 🔥 **606 \pm 2 s** to generate each **223 \pm 1 kbit** set of VNF keys allows **79** Alices per Bob in 10G networks.

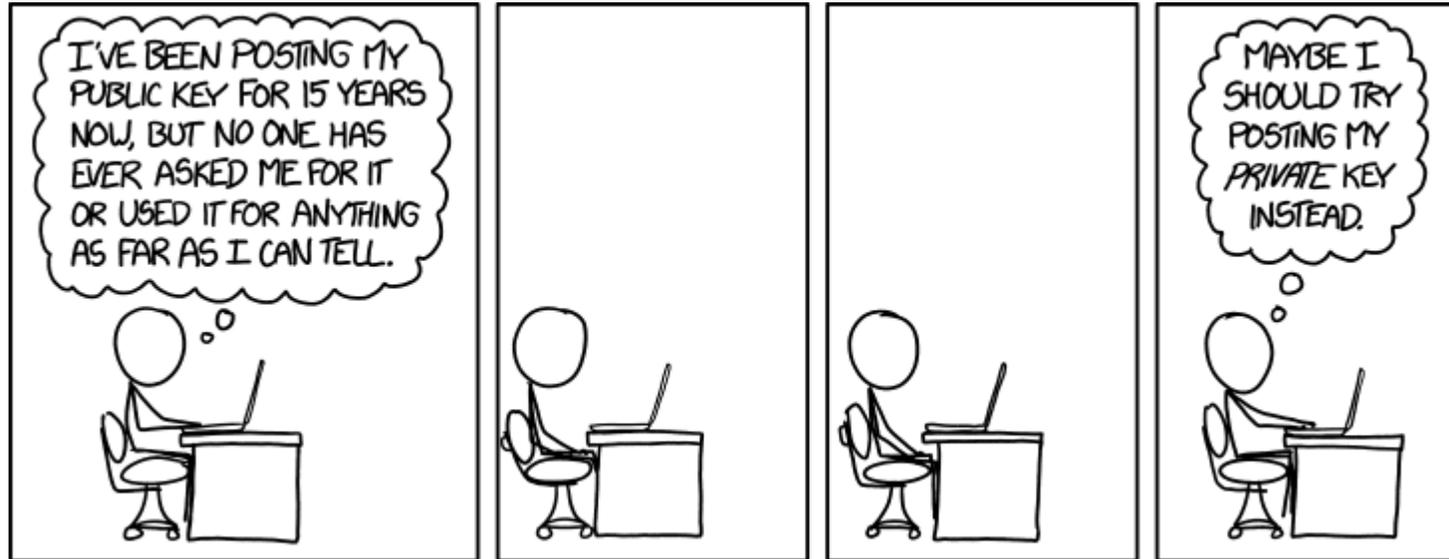
Summary and Next Steps

-  Demonstrated compatibility of QKD with the software defined networking paradigm.
-  Utilised the SDN framework to time-share commercial QKD systems.
-  Secured the transfer of virtual network functions using quantum keys.

Summary and Next Steps

The Bristol is Open metropolitan-scale SDN relies on VNF distribution to maintain a versatile infrastructure.





<https://xkcd.com/1553/>