Putting quantum communications into action

Jörg-Peter Elbers, ADVA

NetSys 2021, ZdN - Advanced networking technologies

AGENDA

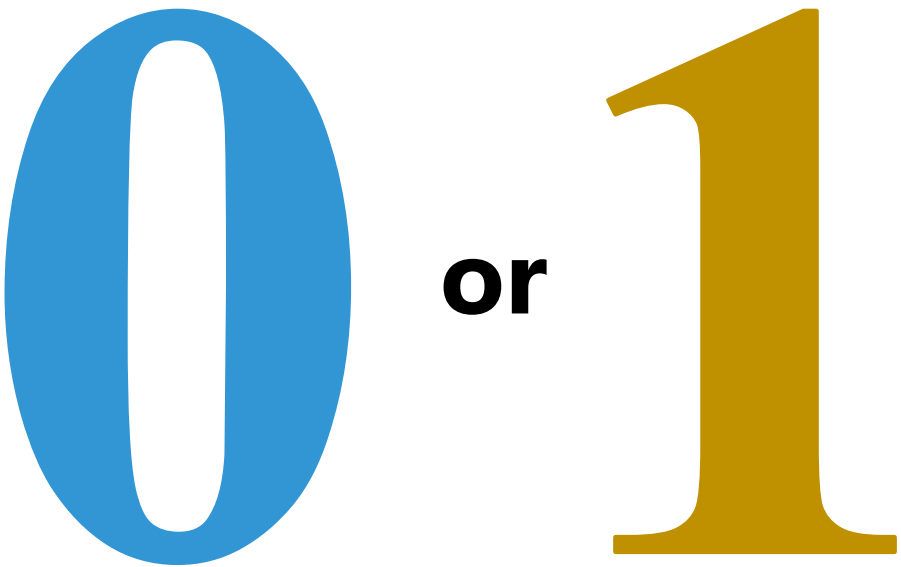
1. The wonderful quantum world
2. Quantum-safe communications
3. Quantum key distribution
4. Towards the Quantum Internet
5. Conclusions

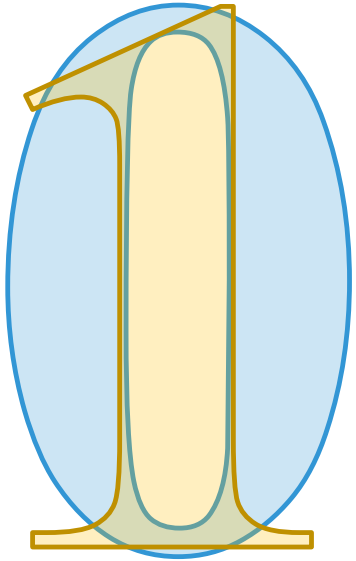
The wonderful quantum world

The power of quantum computing

Classical bit

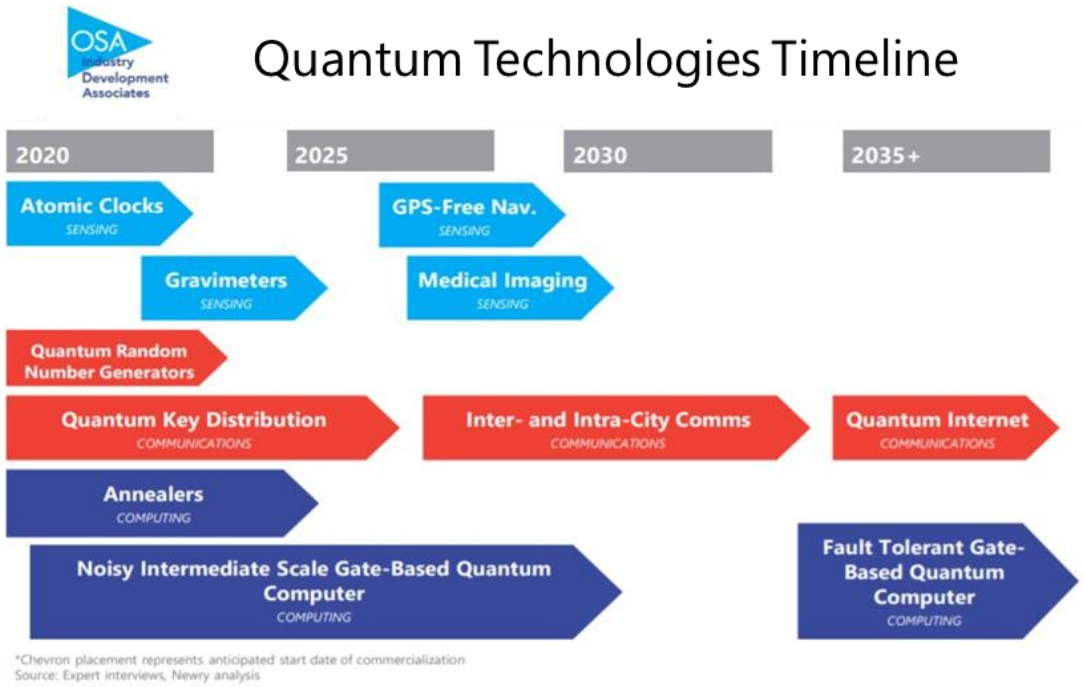
Quantum bit (qubit)



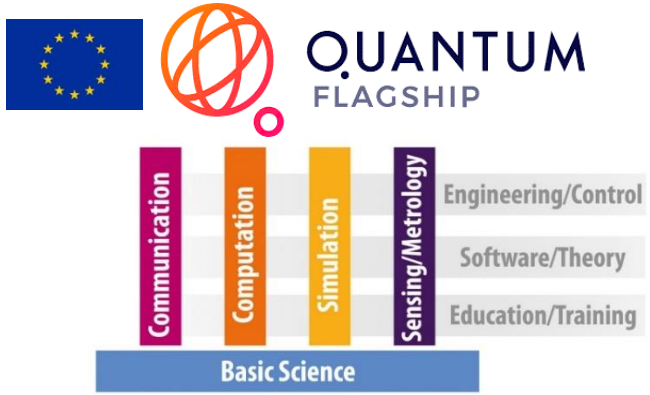


A quantum computer with 50 qubits can process 2^{50} = 1.125.899.906.842.624 states simultaneously

Quantum technologies are getting much attention



https://www.osa.org/en-us/industry/industry_intelligence/oidaroadmap/



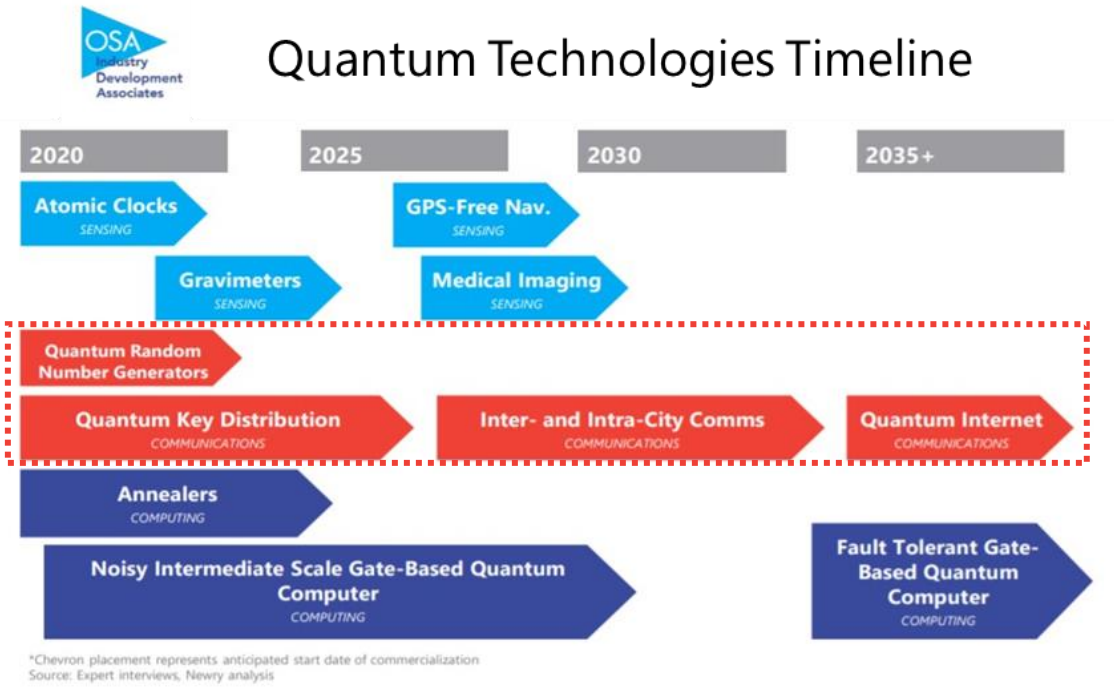
BEAUFTRAGT VOM

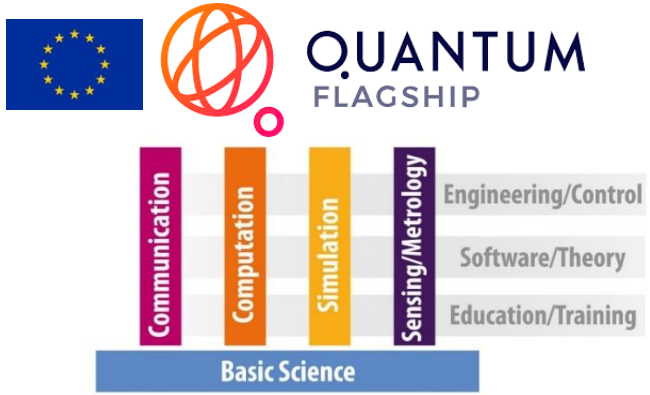
Bundesministerium für Bildung und Forschung

quanten technologien

Billions of Euros are being invested in a global quantum race

Quantum communication is one of the applications





BEAUFTRAGT VOM

Bundesministerium für Bildung und Forschung

quanten technologien

Near term market potential for QRNGs and QKD

ADVA

Quantum-safe communications

Encryption protects sensitive data …

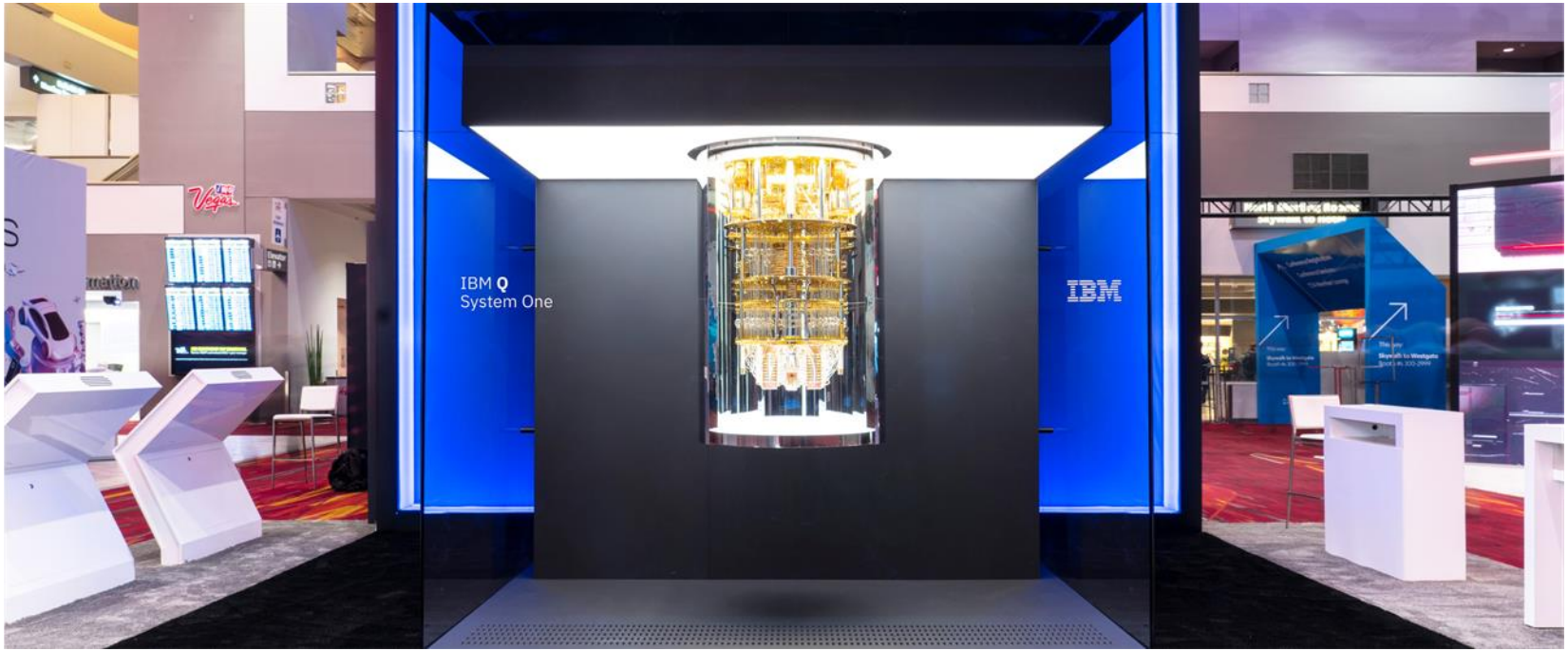
Freedom of the Press Foundation, Edward-Snowden-FOPF-2014, CC BY 4.0

Encryption works.

Properly implemented strong crypto systems are one of the few things that you can rely on.

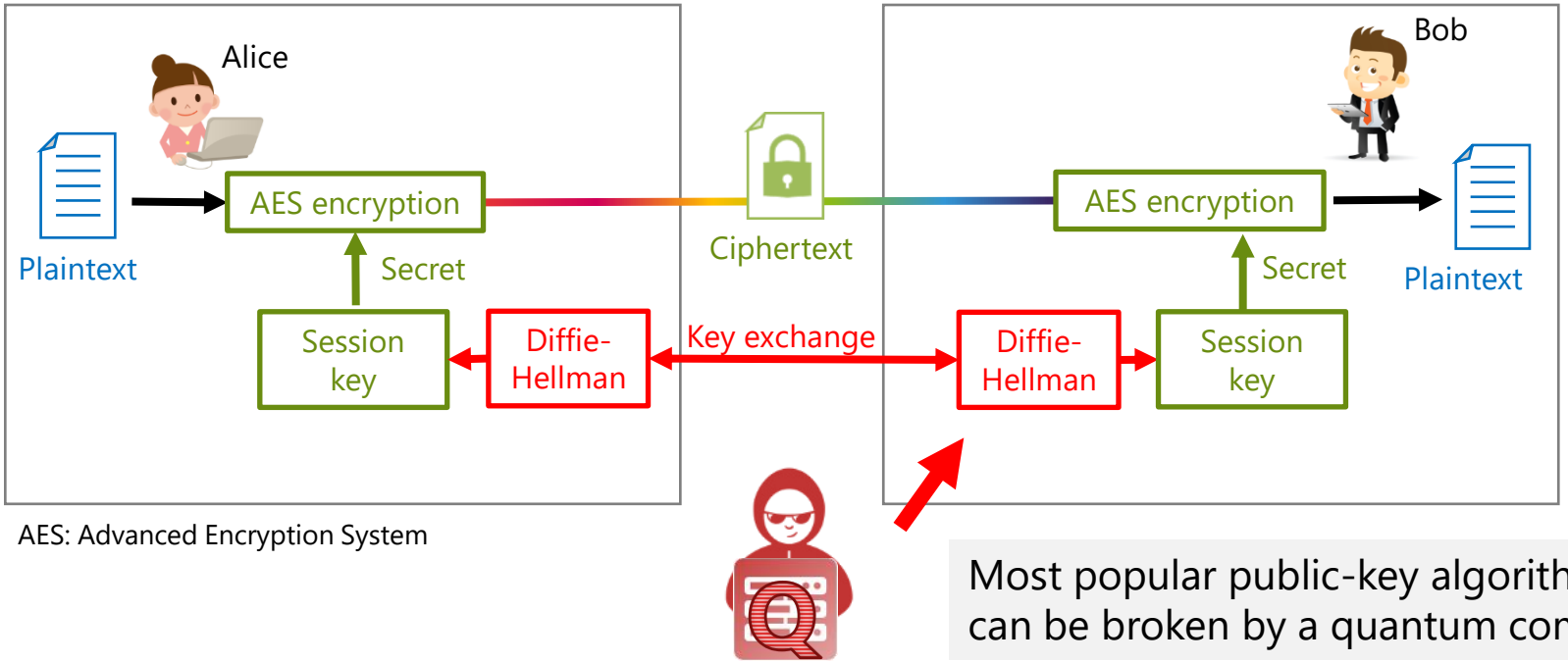
Edward Snowden

… but can be broken by large quantum computers



Attack scenario: Store now, decrypt later

The classical key exchange is the weak link



AES: Advanced Encryption System

Most popular public-key algorithms can be broken by a quantum computer

New quantum-safe solutions are needed

Quantum-safe key exchange methods

Two lines of defense

Post-quantum cryptography (PQC)	Quantum key distribution (QKD)
• Is based on hardened algorithms	• Is based on laws of quantum physics
• Works with any communication channel	• Needs optical fiber or free-space media
• Requires endpoint access on protocol level	• Requires access to physical infrastructure
• Is independent of optical link parameters	• Depends on optical link parameters

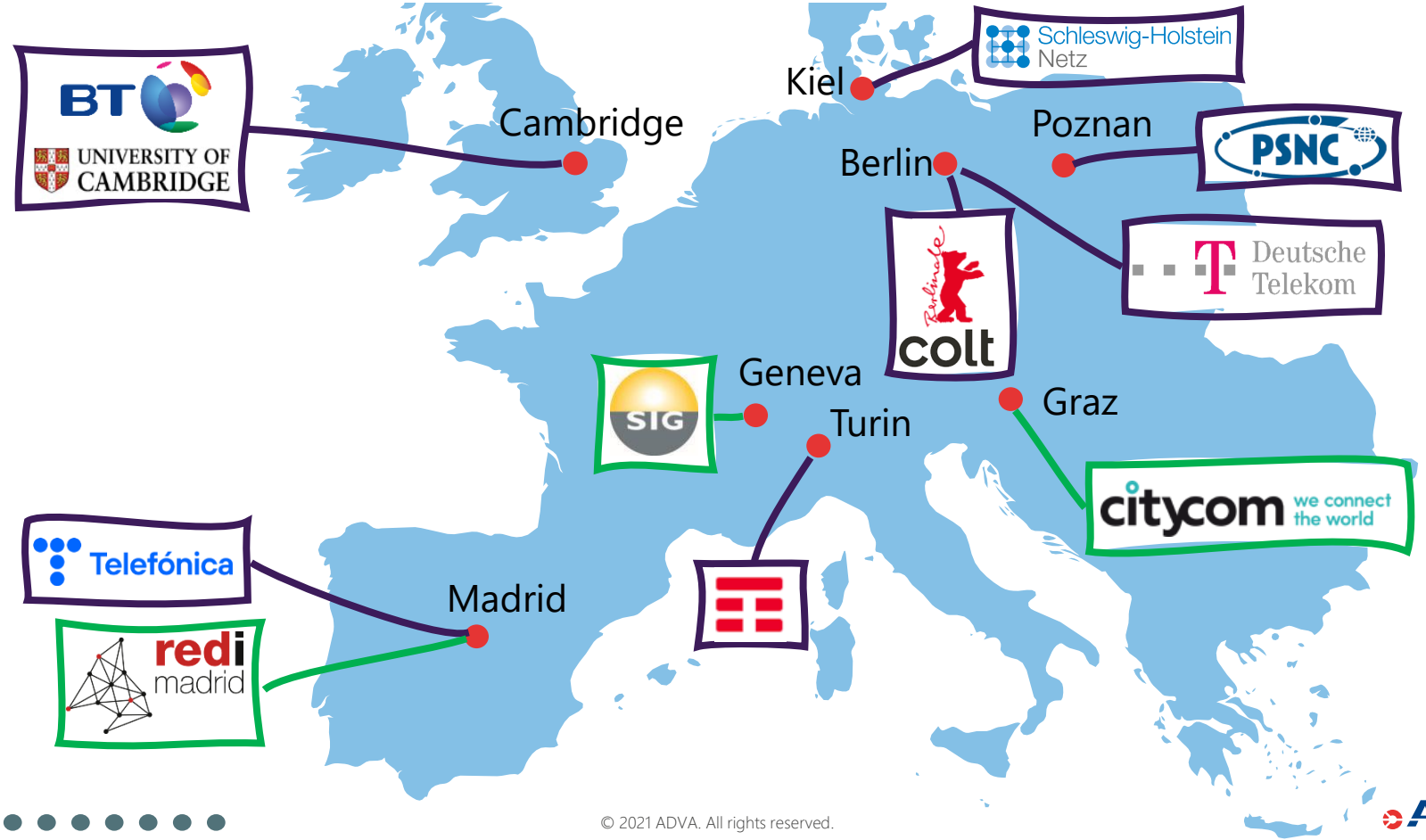
First line of defense

Additional protection

Quantum key distribution

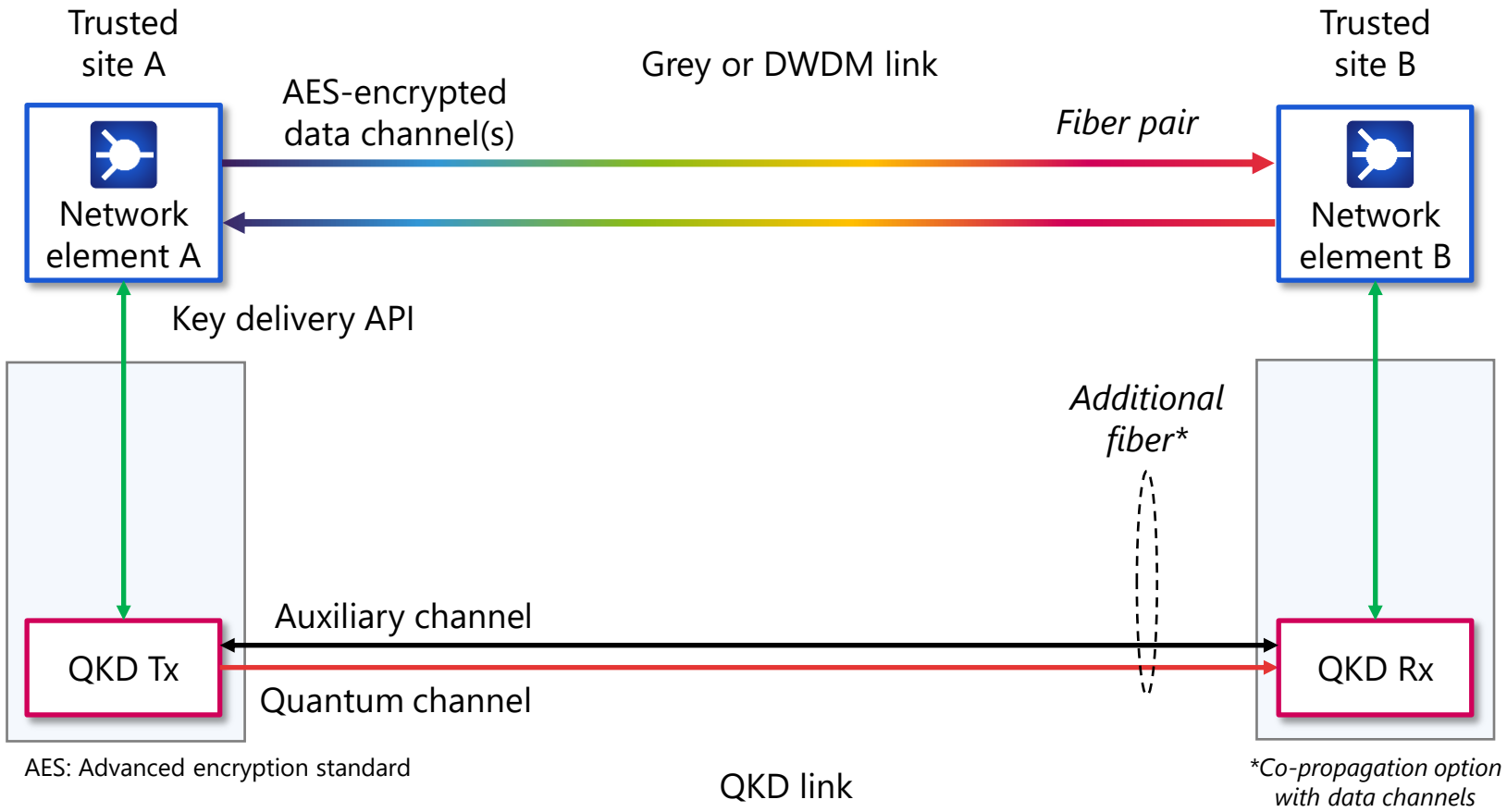
ADVA: Enabling QKD deployments

OPEN QKD

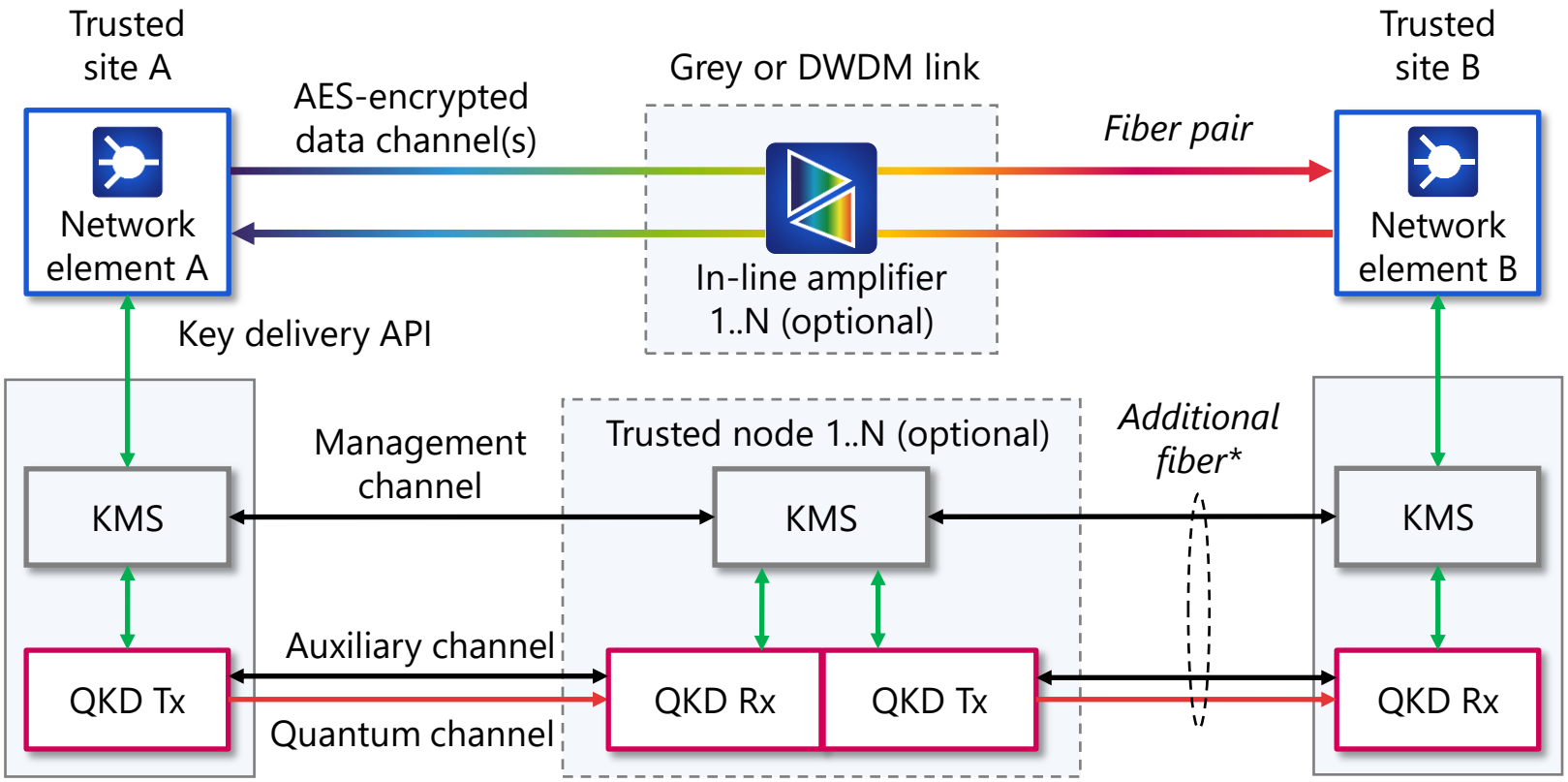


ADVA

QKD is part of a larger network encryption solution …



… and creates dependencies important to understand

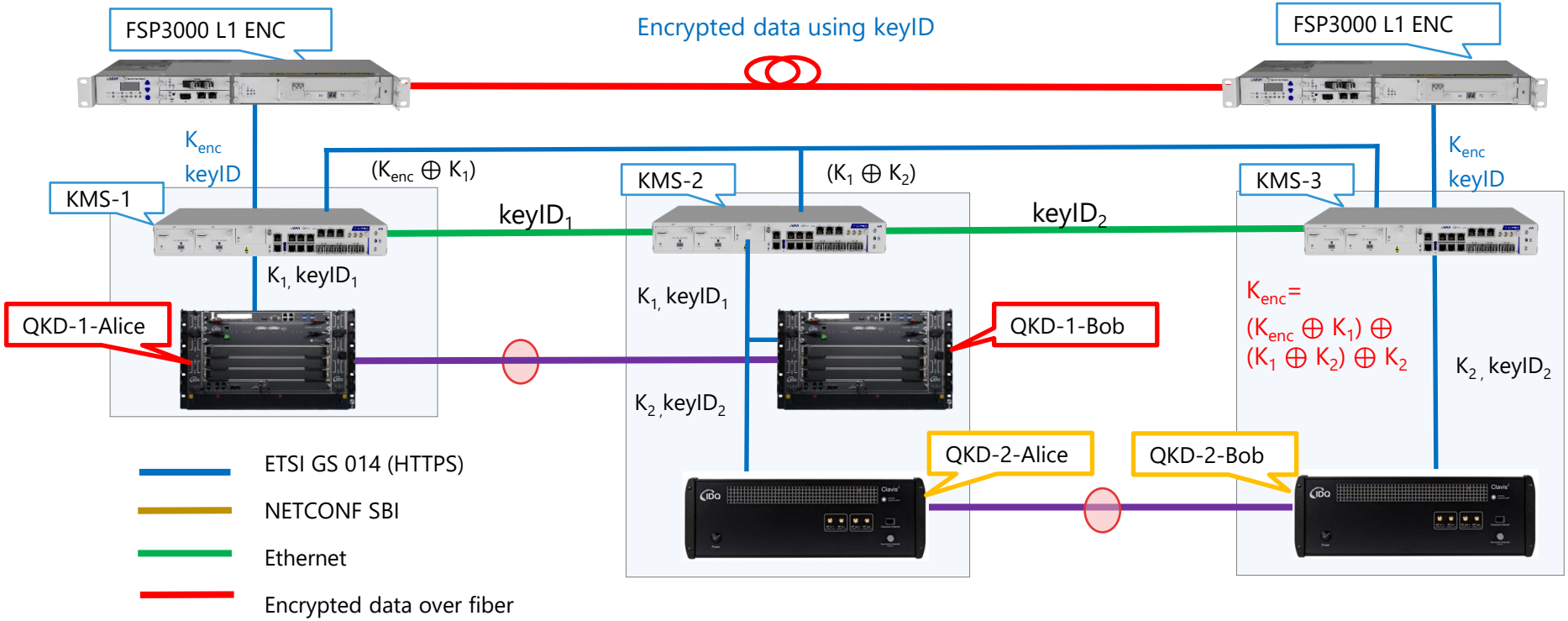


AES: Advanced encryption standard

KMS: Key management system

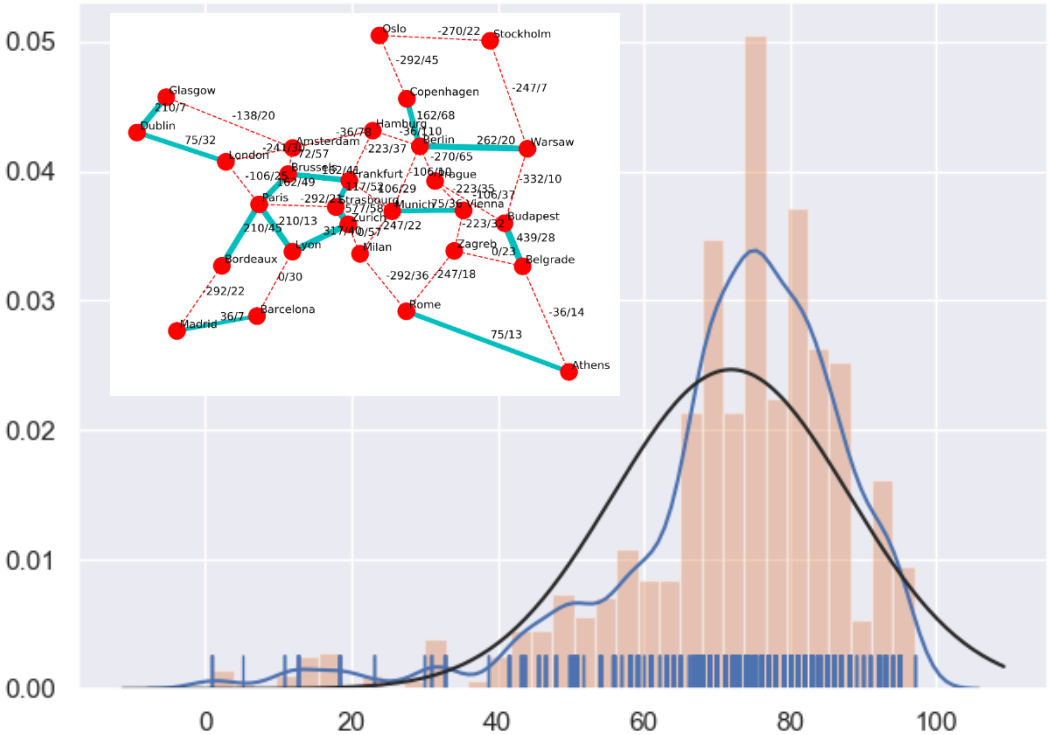
*Co-propagation option with data channels

Trusted node QKD demo

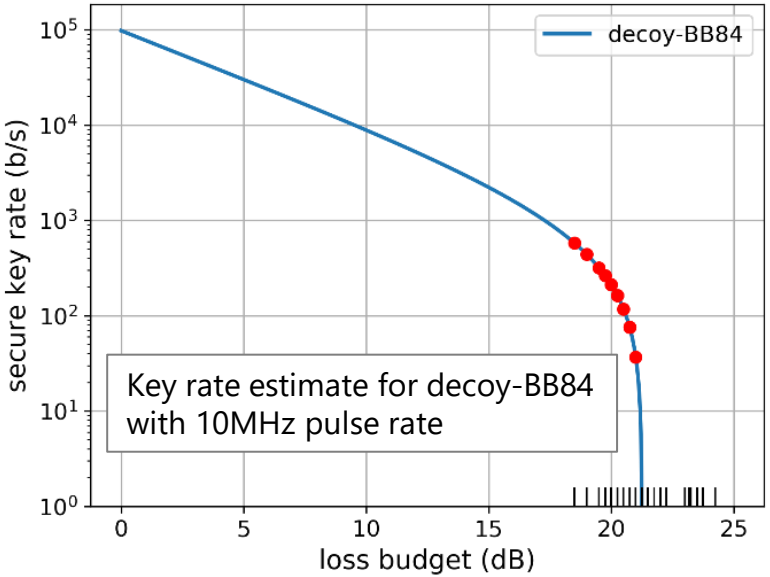


Towards the Quantum Internet

From p2p QKD-links to an EU-wide deployment



Span length (km) distribution EU-28

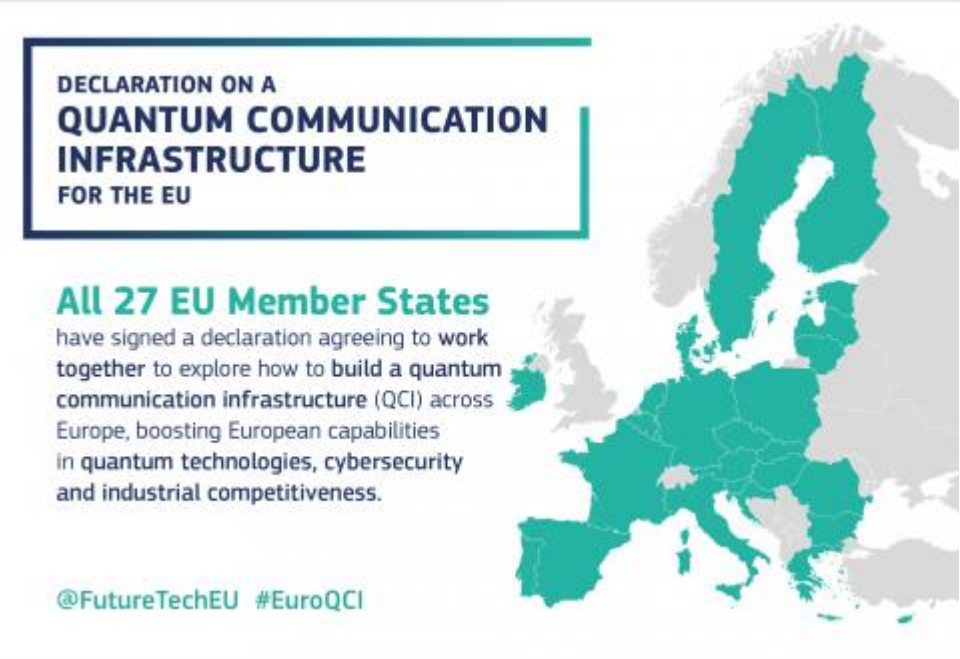


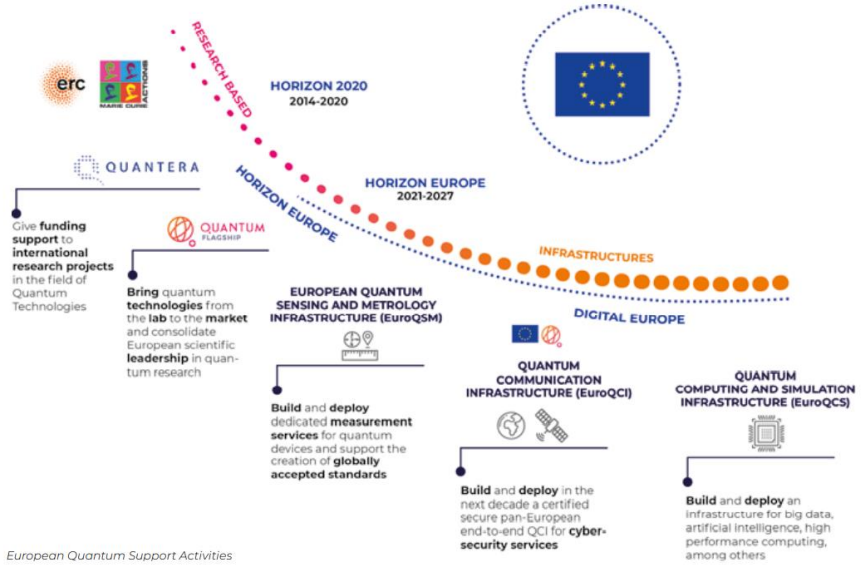
Key rate estimate for decoy-BB84 with 10MHz pulse rate

Nobel network model with typical span length distribution and 0.25dB/km. Ref:

T. Szymanski, "Maximum Flow Minimum Energy Routing in Exascale Cloud Computing Systems," 2013

Euro-QCI as stepping stone to the Quantum Internet



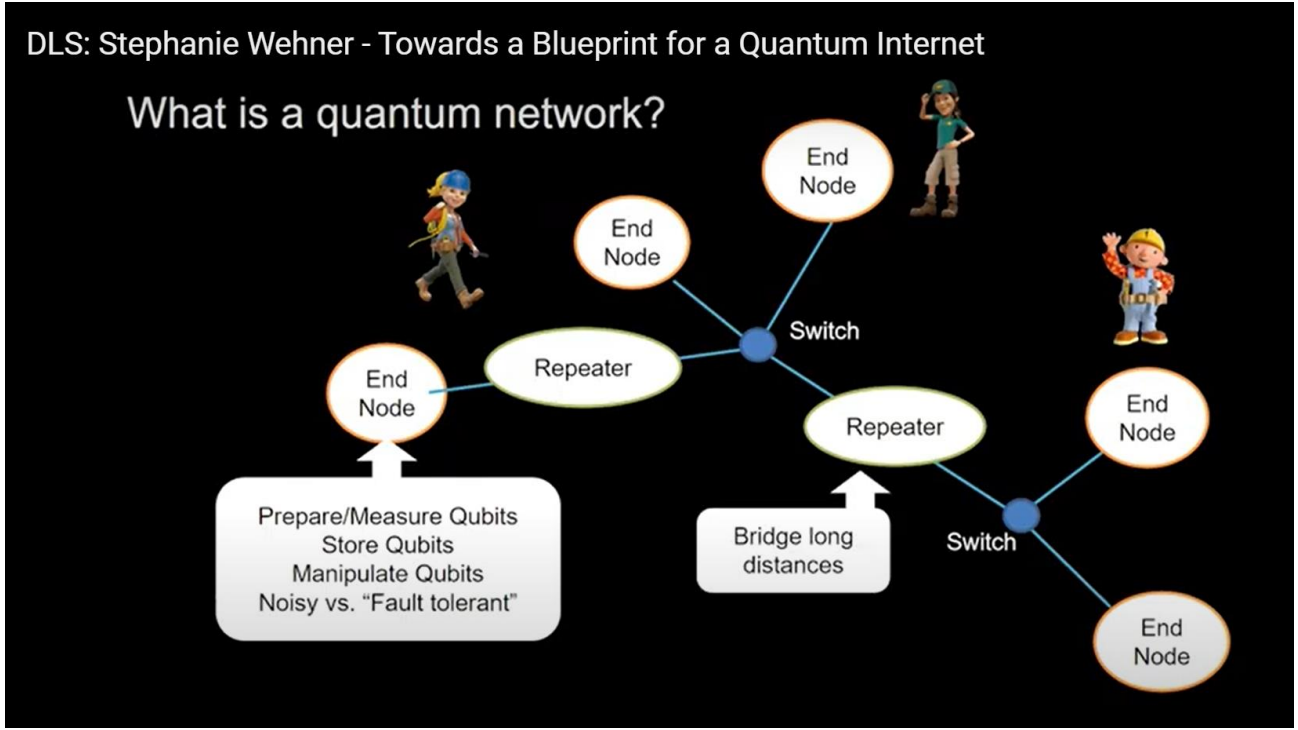


European Quantum Support Activities

https://qt.eu//app/uploads/2020/04/Strategic_Research-_Agenda_d_FINAL.pdf

Euro-QCI is planned to be fully operational by 2027

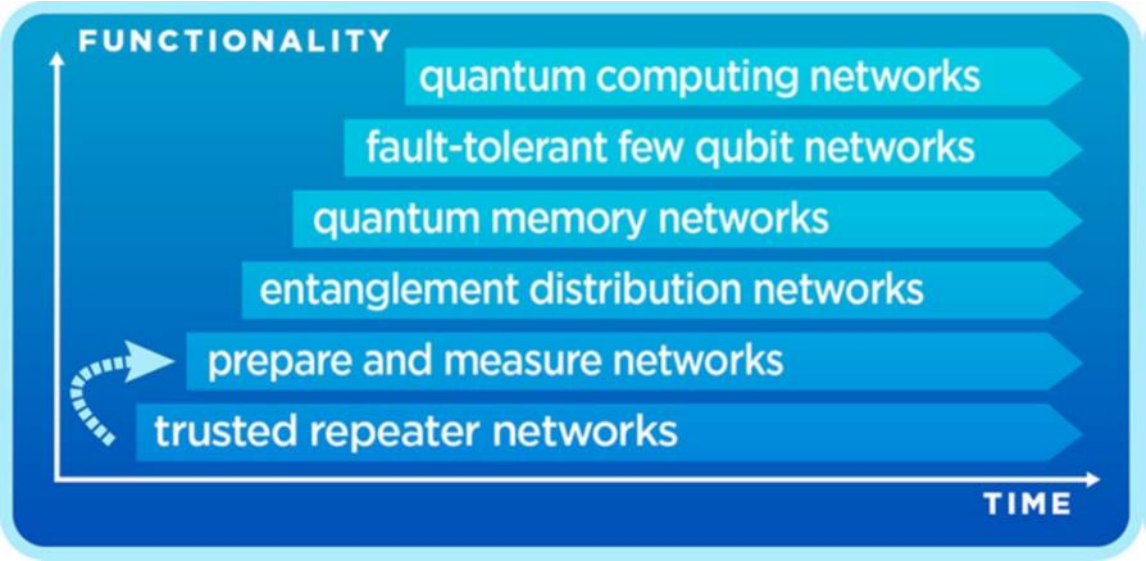
The Quantum Internet vision



https://www.youtube.com/watch?v=ig6TqDChnWI

Enabling worldwide quantum communication via fiber or satellite

Stages of the Quantum Internet



S. Wehner et al., Science 362, eaam9288 (2018). DOI: 10.1126/science.aam9288

Quantum repeaters are necessary for end-to-end Qubit transmission

Conclusions

Take-away messages

- Quantum communication facilitates secure exchange of quantum information
- It requires an underlying optical fiber or free space infrastructure
- It needs classical communication for management & control
- It is an area of early research and requires a multi-disciplinary approach
- Quantum key distribution is the practical, near term application
- Complementing cryptography, it enables quantum-safe encrypted communication
- It is a stepping stone towards the vision of a future Quantum Internet

Thank you

info@adva.com