UNIQORN

Affordable Quantum Communication for Everyone: Revolutionizing the Ecosystem from Fabrication to Application

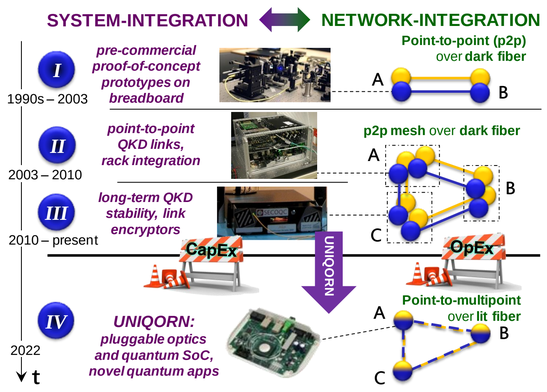
QUANTUM Communication

INTRODUCTION and CHALLENGE

1 Top-Level Aim:

Ubiquitous Quantum Communication

- ✓ **Quantum enhanced communication protocols**: information-theoretically secure key exchange, quantum random number generation and secure multiparty computation
- ✓ **High technological readiness** at the device level: Achieve cost-effectiveness through integrated, deployable quantum-photonic solutions

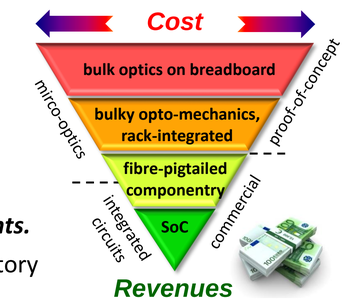


2 Roadblocks

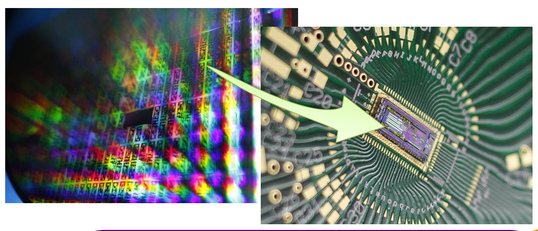
that spoil a practical introduction of quantum technology

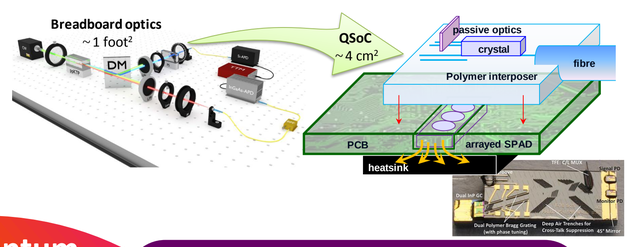
ICT infrastructure will not change to accommodate quantum functions.
Need to merge the striking benefits of quantum technology with highly advanced telecom technologies ("co-existence").

Powerful quantum applications need powerful yet cost-effective components.
The Second Quantum Revolution is only possible when it follows a success story such as that of microelectronics, which lead to the Information Age.



THIS IS WHERE UNIQORN COMES INTO PLAY...

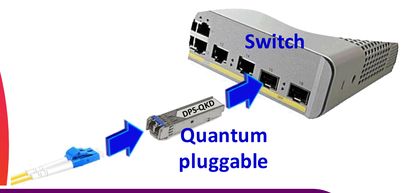




I. Develop value-added InP, CMOS and polymer quantum-optic communication components.

II. Shoehorning breadboards into chips – Develop a quantum System-on-Chip methodology.

III. Demonstrate the power of the technological food-chain: Realize feature-rich, scalable key sub-systems for quantum comms.



IV. Deployable system performance and novel network functionalities.

V. Demonstration of low-cost quantum links and novel end-user quantum applications beyond QKD in lab and field.

Quantum Fab · **Quantum App**

5 Objectives

that drive innovation along the value chain

4 Levels of quantum comms addressed,

covering the entire value chain

Components and qSoCs – quantum System-on-Chips

- Differential Phase Shift DV Transmitter
- Homo-/Heterodyne CV Receiver
- Quantum Random Number Generator
- Heralded and polarization / time-bin entangled pair sources
- 1550 nm up-conversion receiver
- Entangled squeezed light source

System Integration

- Low-Cost DPS QKD
- Quantum FPGA
- Programmable EPR Node
- Quantum ROADM

Network Integration

- Co-Existence:
  - Exploit the spectrally clean O-band
  - Electrically duplexed quantum signals
  - Machine-learning assisted allocations
  - Isolation through spatial multiplexing
- Quantum Networking:
  - Reconfigurable quantum overlay: the Quantum Whitebox
  - Quantum-aware SDN platform
  - Programmable EPR

Quantum Protocols and Applications

- One-Time Programs for cloud-based quantum processing
- Oblivious Transfer securing data base access
- QRNG as seed for NIC-integrated randomness engine
- Quantum-Secured IoT for Smart City and 5G

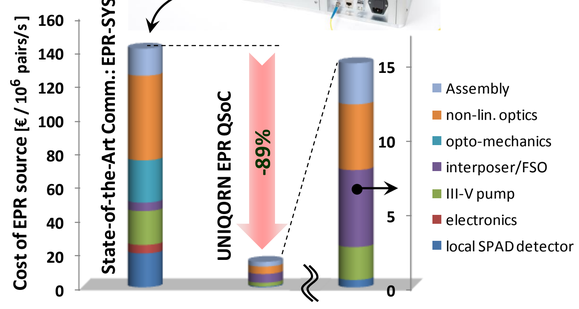
EFFICIENCY TRAITS

Components: *quantum revolution through technological evolution*

- merge the striking benefits of quantum technology with highly advanced telecom technologies
- tailor technology according to the application requirements, in the extremely diverse realm of quantum communications where there is no "one-size-fits-all" solution
- enable an aggressive reduction in terms of size and cost by dismissing free-space optics as the most instable and irreproducible element in a quantum-optic assembly
- Specific output:
  - Quantum-grade InP technology, leveraged by low-noise CMOS amplification to mitigate performance brick-walls for CV signal reception for up to 10 GHz
  - cutting cost per Si SPAD down to $^1/_{20}$ while enabling room-temperature operation
  - blending specialized quantum-optic components on low-cost industry-qualified planar polymer lightwave circuits serving as flexible integration bench

Quantum System-on-Chips: *demonstrating feature-rich and scalable quantum circuits following the same paradigm of microelectronics during the late 20th century.*

- space-saving heterogeneous integration of best-of-breed quantum components on sub-€ quantum-optic interposer
  - EPR source: massive overall $^1/_{70}$ reduction in size
- independent technology upgrades avoid the re-launch of innovation cycles for the entire QSoC since functional dies can be gracefully exchanged
  - high yield in excess of 90% due to the use of reliable, preselected dies
- efficient and low-loss (0.2 dB) interposer-to-fibre interfaces greatly reduces the packaging cost:
  - dismissal of active fiber alignment: 10-fold reduction in pigtailing cost
  - packaging cost that amounts to less than 10% of the overall system cost
  - EPR source: cost reduction of 89%



Systems: *addressing the needs of mice*

- compliance to form-factors that are widely used for communication modules
- secure key rate of >1 kb/s provisioned through pluggables / ¼-pizza-box quantum optics

Networks:

- software-defined networking and asset provisioning for impairment-mitigated and cost-optimized operation at reduced OpEx (no dark fibers)
- creating the first Quantum Whitebox ROADM, allowing the disaggregation of functionalities within the quantum network
- co-existence of quantum with classical channels through new dimensions of multiplexing
- backing of activities through network- and system-level simulation capabilities

Applications:

- accurate end-to-end validation of quantum communication applications in real-life environments through overall orchestration of cryptographic tools

17 Consortium Partners

that bring multi-disciplinarity as a key to success

- Quantum engineers with strong roots in theory & experiment
- RTOs turning basic science into applicable technology for years
- Photonic and electronic design of integrated circuits
- Design automation and simulation
- Assembly and Packaging
- Telecom system integration
- Industrial End-User perspective

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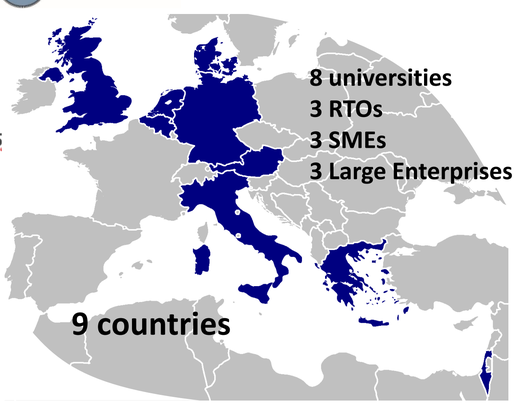

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