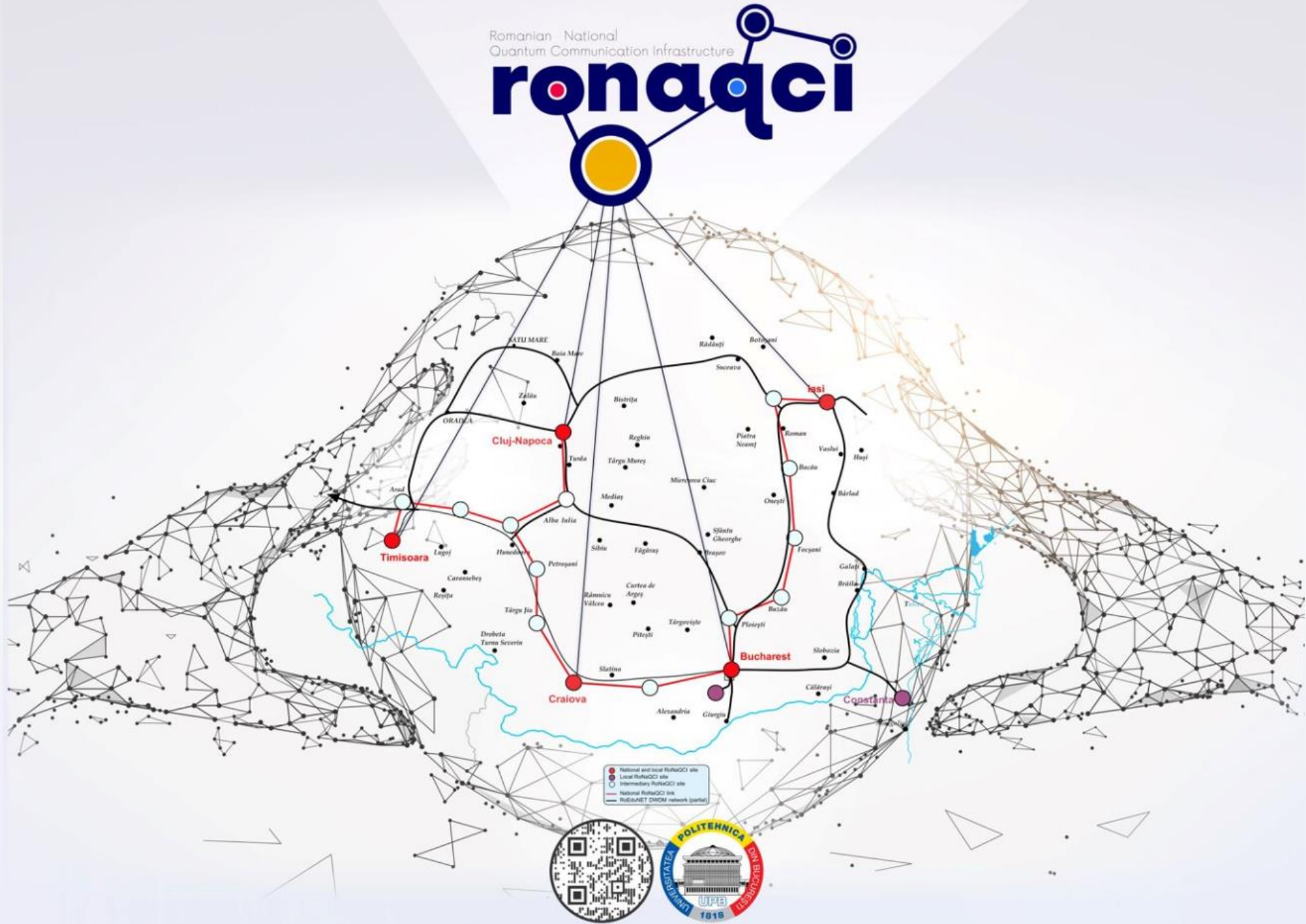


Romanian National  
Quantum Communication Infrastructure

# ronaqci





## **Current Status of RoNaQCI Project**

Mihai CARABAŞ / Valeriu VRACIU

UPB / RoEduNet

**NREN QKD Networks**

**25<sup>th</sup> of September 2024**

# EuroQCI: The European Quantum Communication Infrastructure (EuroQCI) Initiative

DECLARATION ON A  
**QUANTUM COMMUNICATION  
INFRASTRUCTURE**  
FOR THE EU

## All 27 EU Member States

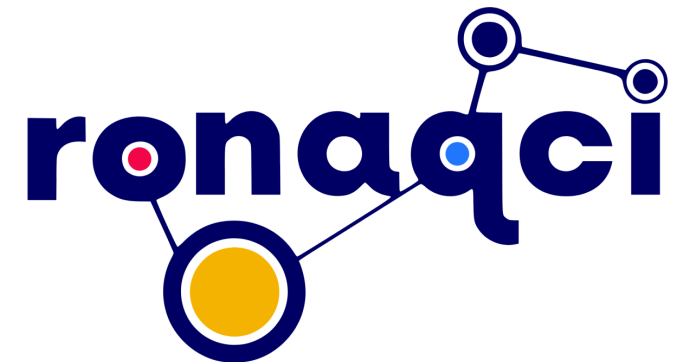
have signed a declaration agreeing to work together to explore how to build a quantum communication infrastructure (QCI) across Europe, boosting European capabilities in quantum technologies, cybersecurity and industrial competitiveness.

@FutureTechEU #EuroQCI



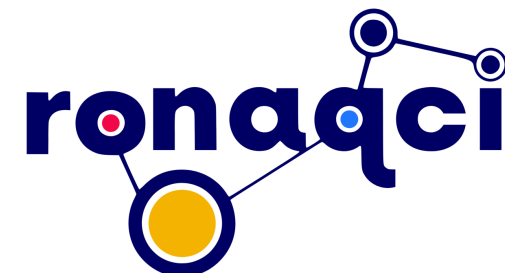
# EuroQCI: Romanian National QCI

- 30 partners, lead by University POLITEHNICA of Bucharest (UPB), joined forces and proposed RoNaQCI in 2022: UPB, RoEduNet, TUIasi, UAIC, UPT, UVT, UBB, UTC-N, UB, UCv, UGAL, ULB, UMC, IFIN-HH, INFLPR, ITIM Cluj, INCDFM, TRC, ICS, TSP, ROSA, ITA, METRA, ISS, IMT Bucharest, RNA, ClusterPower, IMAGO-MOL, CJDJ, PCv;
- RoNaQCI benefits from RoEduNET huge networks expertise



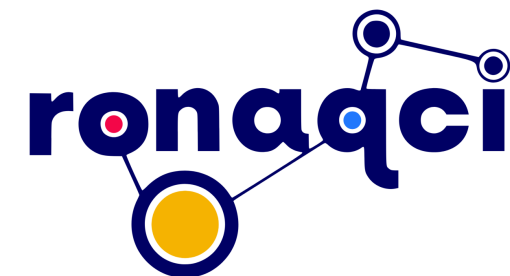
# RoNaQCI – in numbers

- Deployment of a 1500km+ QCI network including 6 metropolitan networks in the cities of Bucharest, Iasi, Cluj-Napoca, Timisoara, Craiova and Constanta
- 36 QKD links spanning Romania and connecting 10 universities, 5 research institutes, 5 public bodies, 3 data centers and a medical clinic, and with future links planned for quantum Internet interconnecting with neighbors



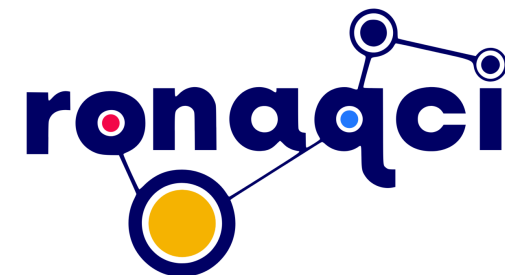
# RoNaQCI – in numbers

- Budget: 10 mil E
  - EC: 5 mil E
  - Romanian State: 5 mil E
- 30 partners
  - 24 full
  - 6 associates



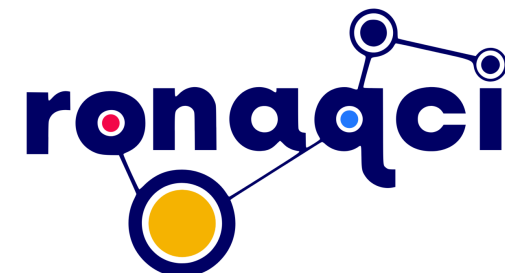
# RoNaQCI – objectives

- O1. Deploy advanced national quantum systems and networks (RoNaQCI)
- O2. Test, monitor and integrate RoNaQCI with classical communication infrastructure
- O3. Develop advanced use cases tailored around strategic interests in exploiting RoNaQCI, linking Public Authorities, Governmental entities, Universities, Research Institutes and Private Companies
- O4. Upskill to create a large number of trained users based on specific profile and particular interests
- O5. Participate in EU-wide design and development efforts anticipating the Quantum Internet



# RoEduNet in RoNaQCI

- RoEduNet is taking care of the WP2 and WP3 - National and Metropolitan networks
- Building the specs and the tenders together with UPB





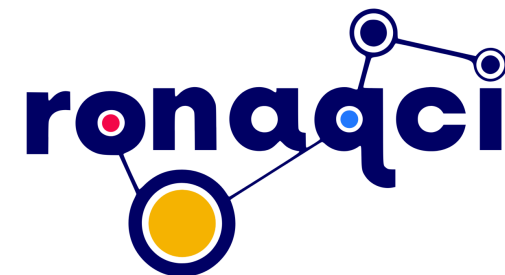


RoNaQCI –  
National QKD  
network



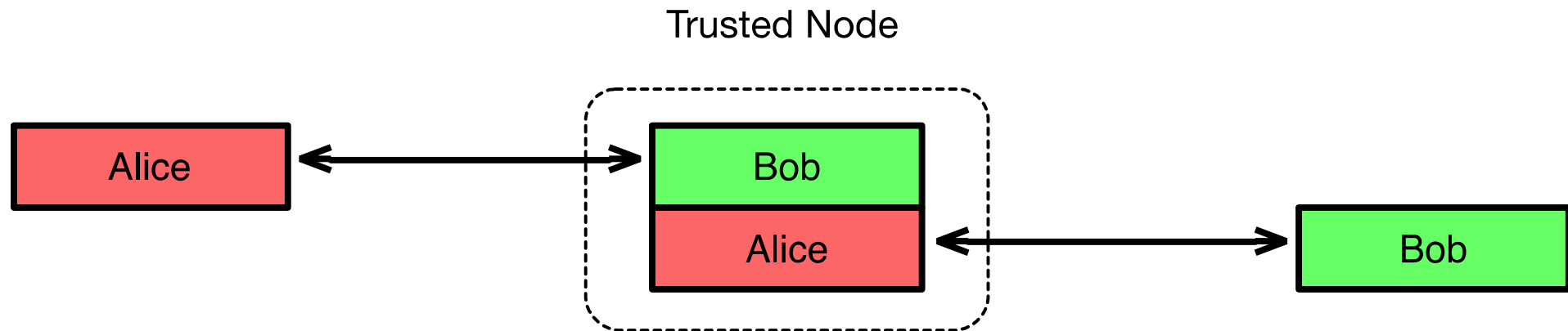
# RoNaQCI – National QKD network

- QKD - exchange encryption keys securely over different physical environments (e.g., fibre optics, free-space)
- RoNaQCI is concentrated on fibre optics transmission
- QKD communication - two endpoints:
  - Alice, as transmitter
  - Bob, as receiver (detector)

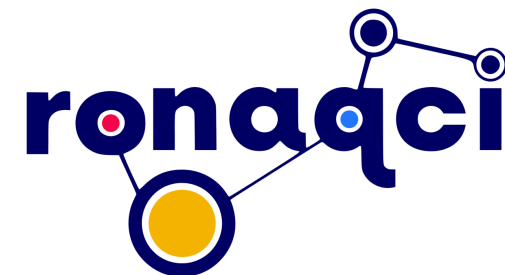
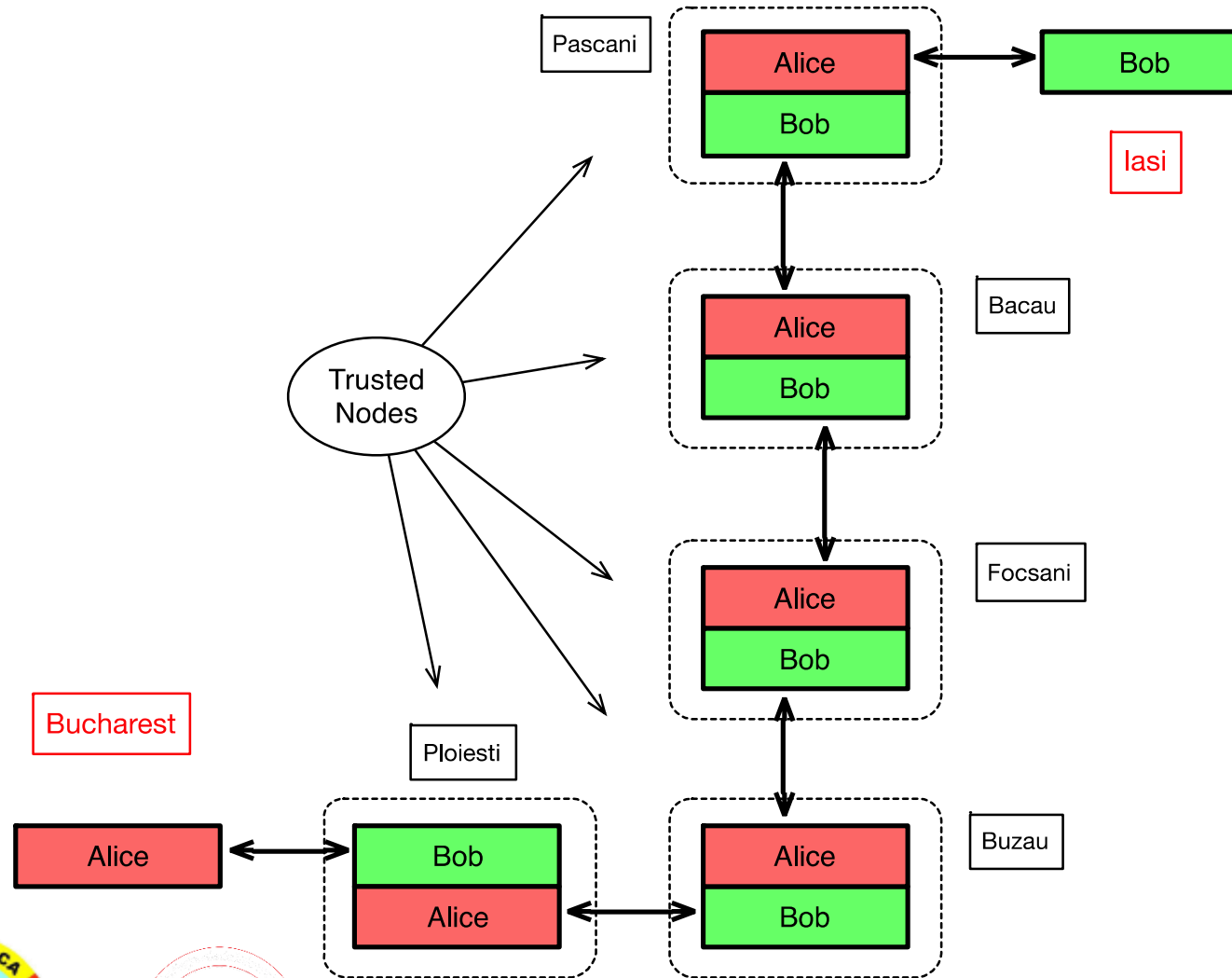


# RoNaQCI – National QKD network

- How can amplify the signal in a QKD network?
- ***You cannot***

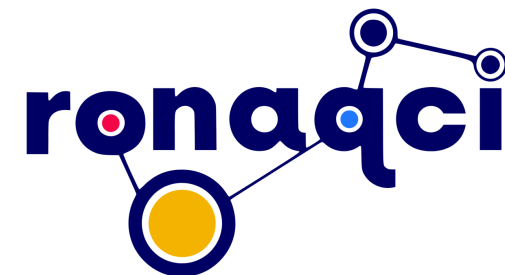
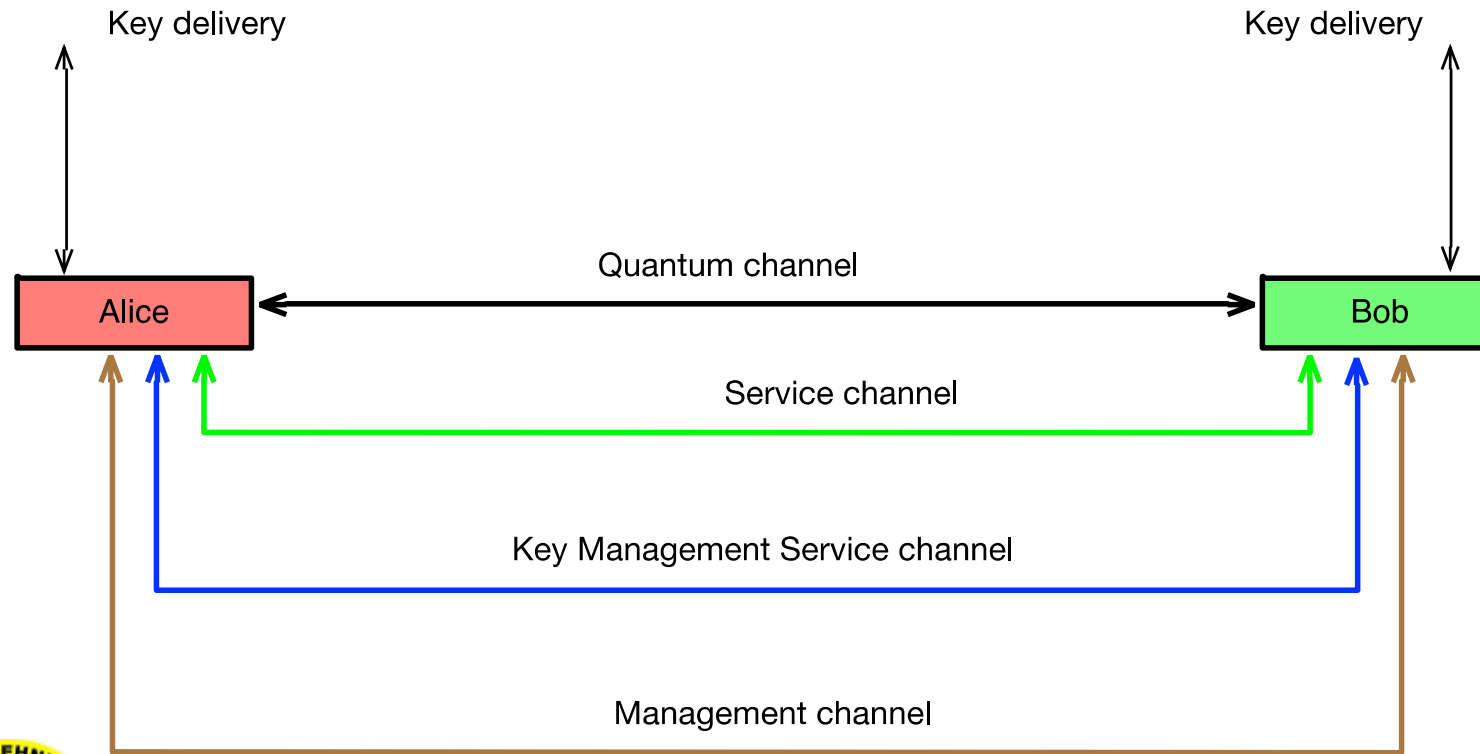


# RoNaQCI – National QKD network



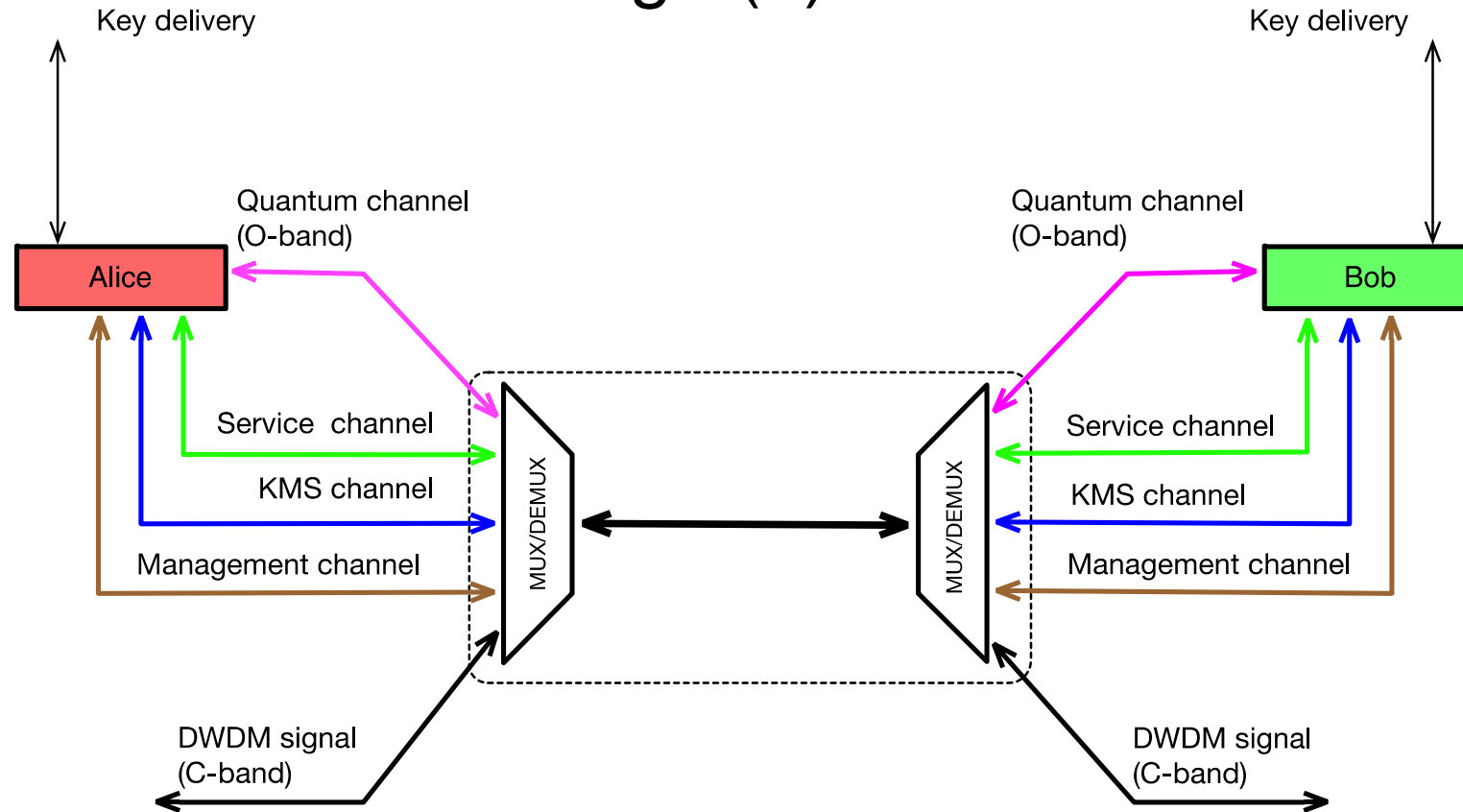
# RoNaQCI – National QKD network

- The two sides are using multiple channels to accomplish the secure generation, transmission and management of keys



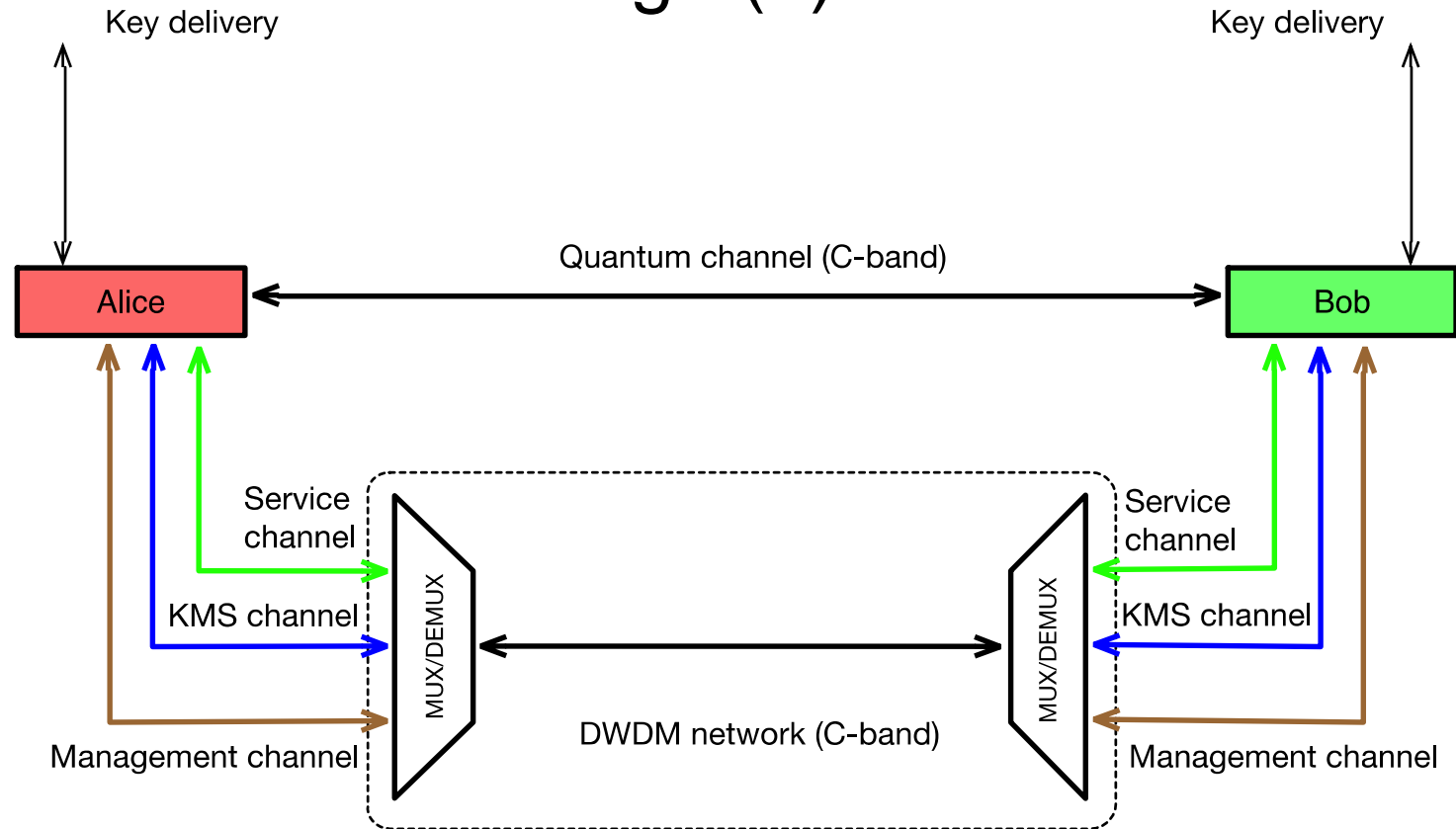
# RoNaQCI – National QKD network

- Optimizations of fiber usage (a):



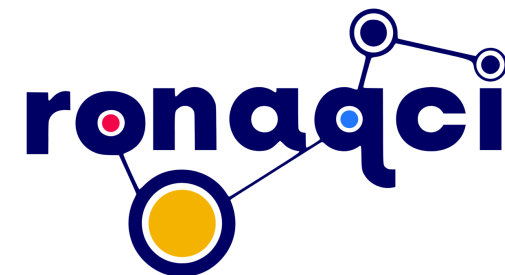
# RoNaQCI – National QKD network

- Optimizations of fiber usage (b):



# O-band (1310nm) vs C-band (1550nm)

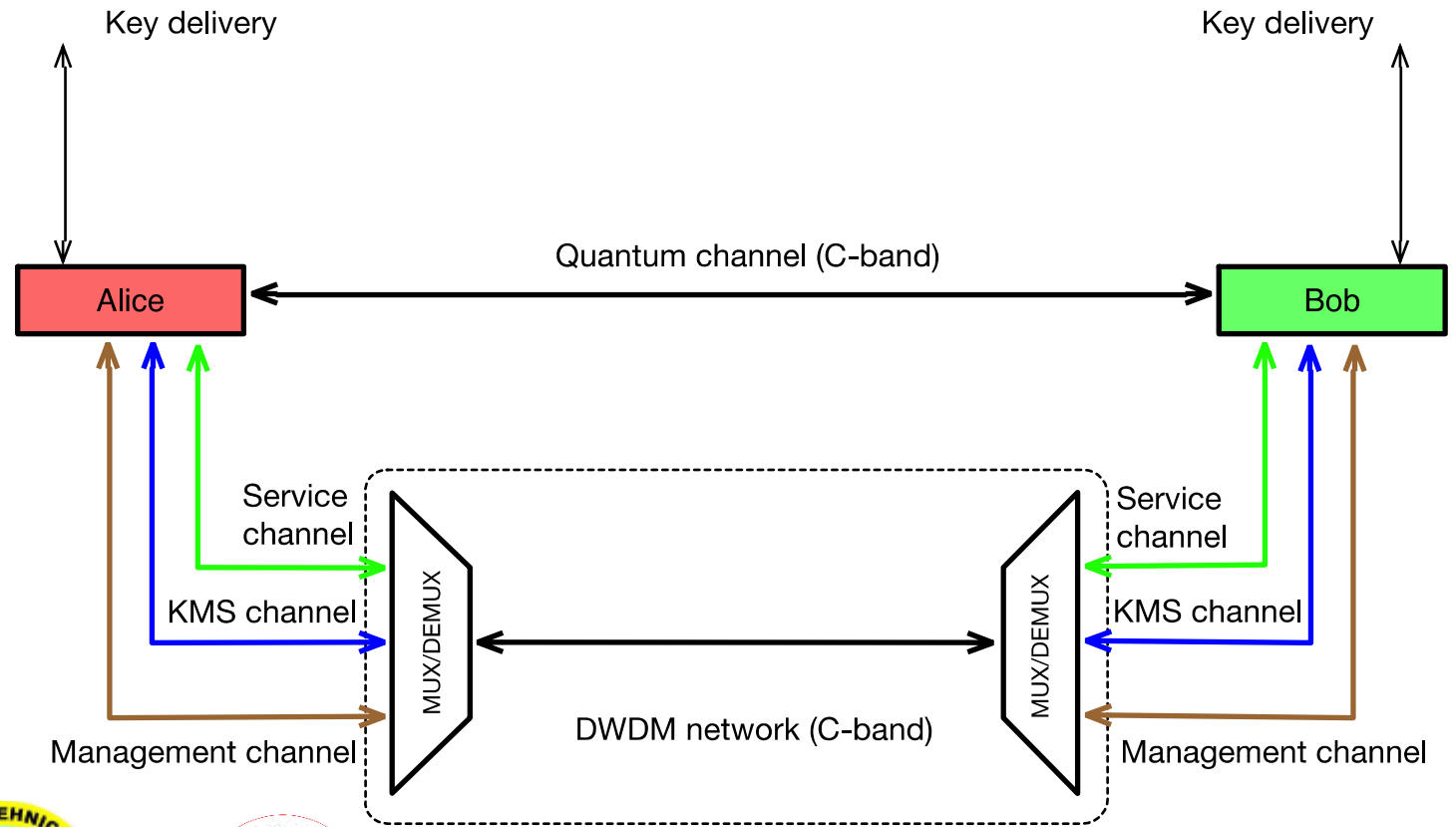
- In C-band there is a loss 0.25 db/km and in O-band is almost double
- Transceivers nowadays can work with a loss of 30db without amplifiers (in any technology)
- $30 / 0.25 \rightarrow 120\text{km}$  without amplifiers (in C-band!) and  $\sim 60\text{km}$  in O-band (because the loss is double)



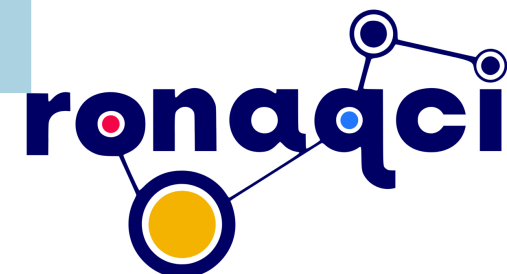
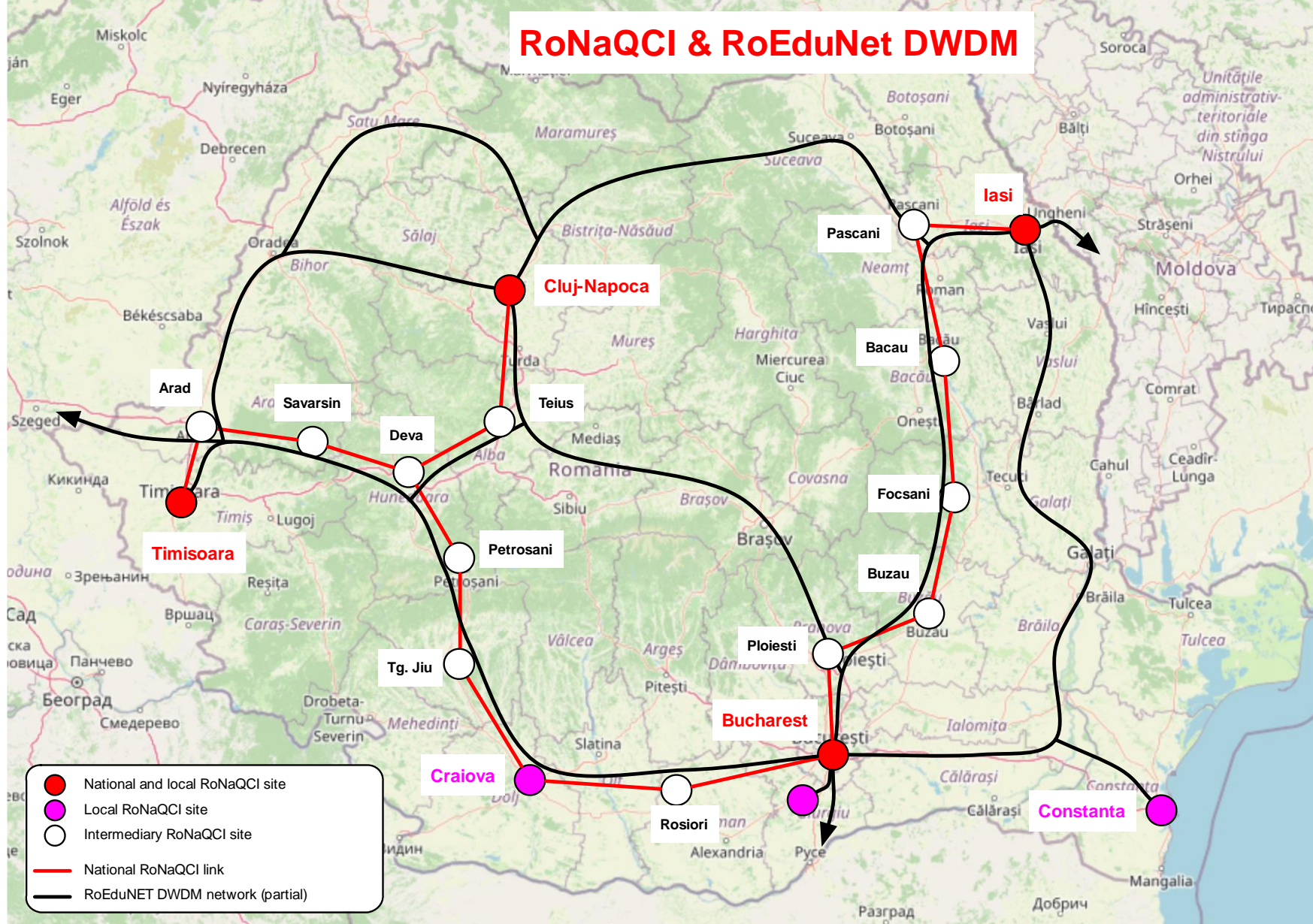


# O-band (1310nm) vs C-band (1550nm)

- We need to use a different fiber for the quantum channel

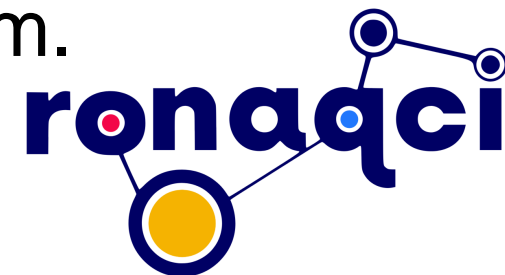


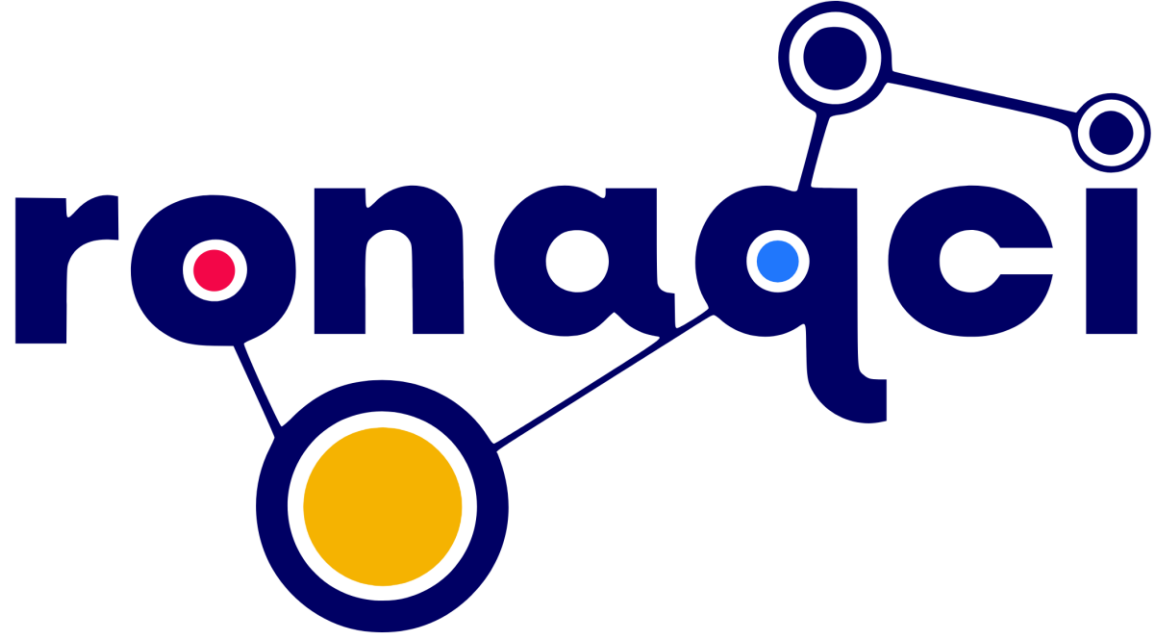
# RoNaQCI & RoEduNet DWDM



# RoNaQCI – National QKD network

- Bucharest - Iasi: 5 amplifier points and 497 km total length, resulting in 6 QKD pairs.
- Bucharest - Deva – Timisoara: 7 amplifier points and 698 km total length, resulting in 8 QKD pairs.
- Deva – Cluj-Napoca: 1 amplifier point and 194 km total length resulting in 2 QKD pairs.
- 16 QKD pairs (links) and a fibre length of 1389 km.

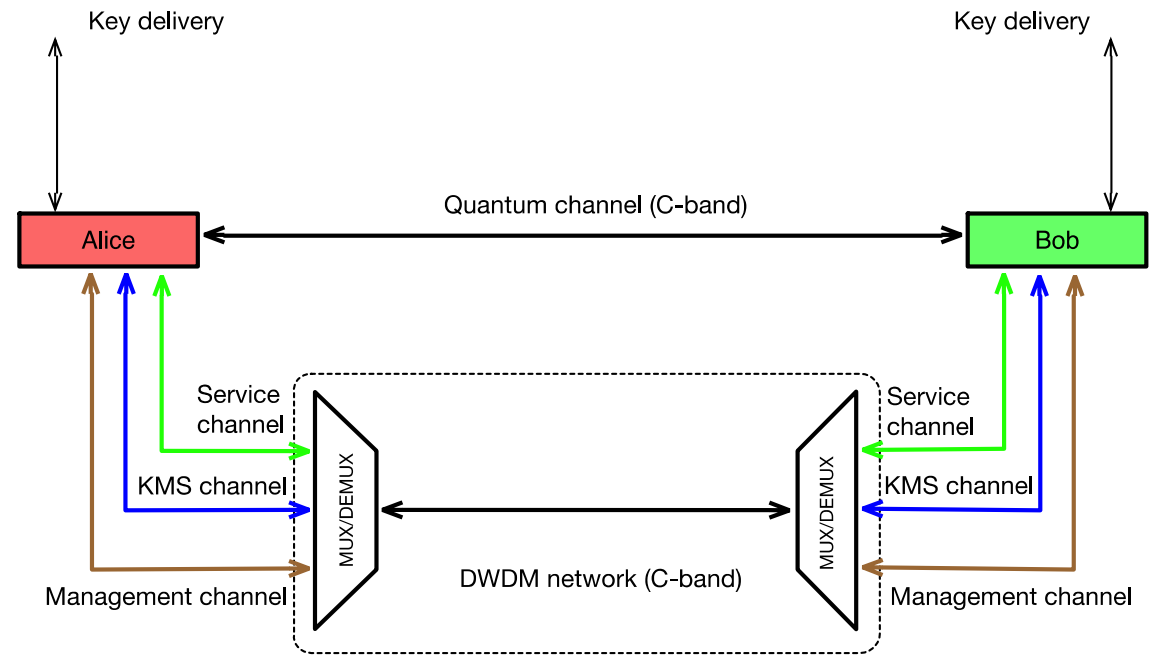
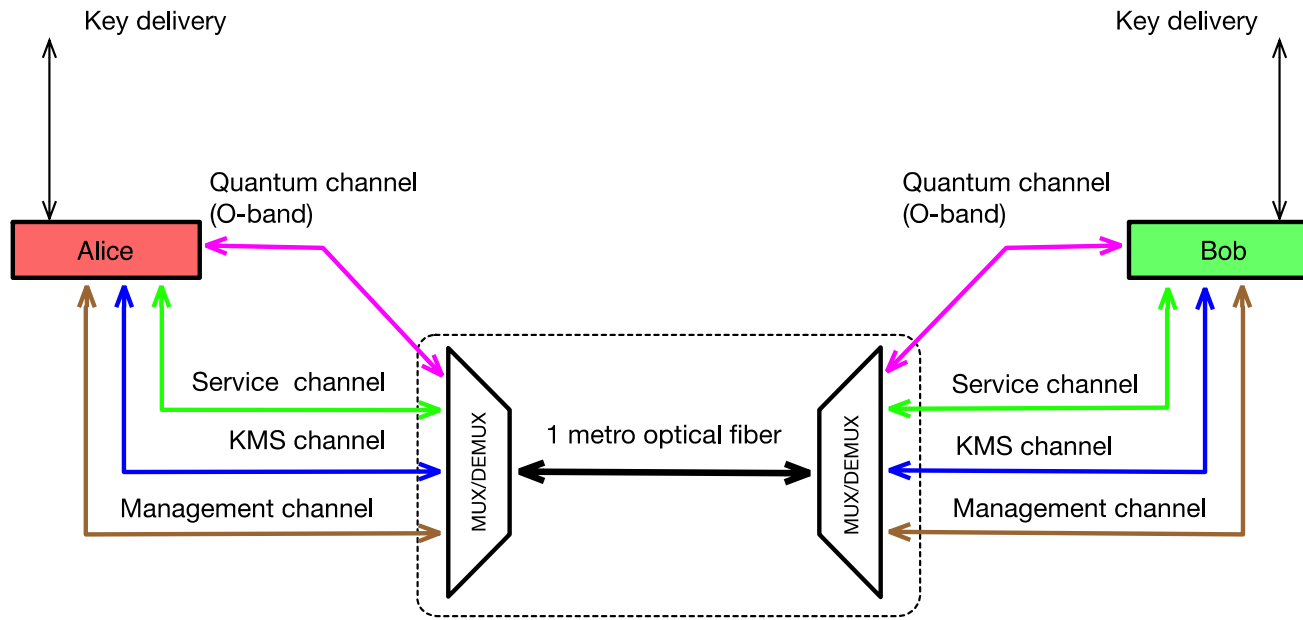




RoNaQCI –  
Metropolitan  
QKD network

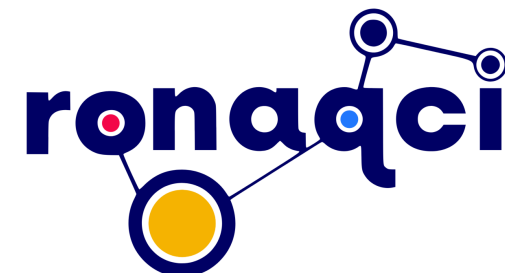


# QKD channels

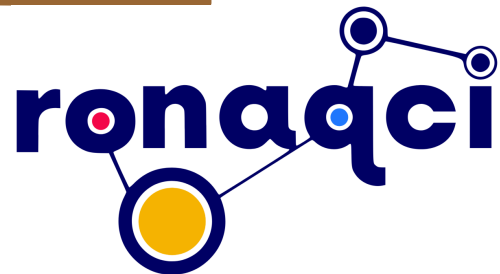
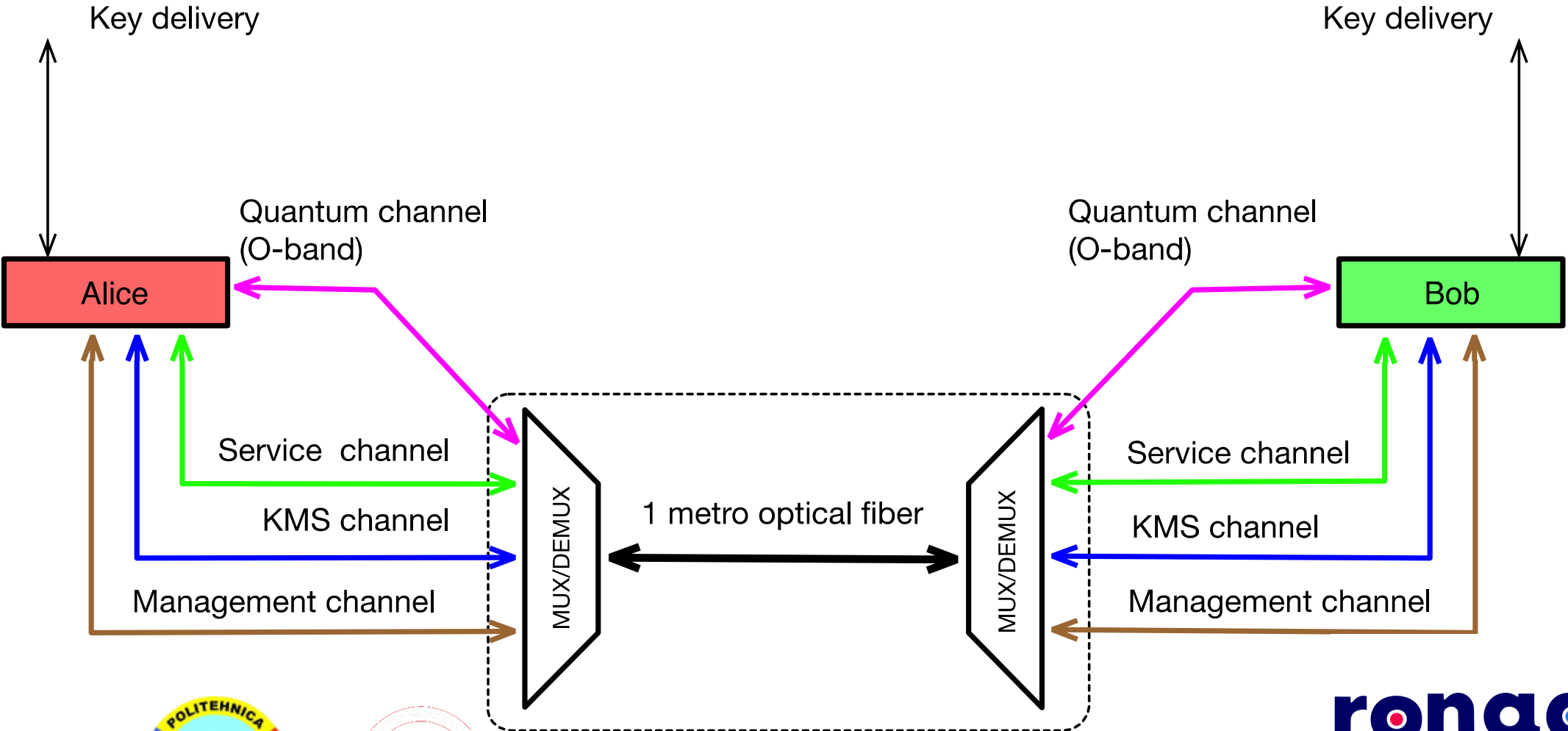


# Metropolitan Networks Particularities

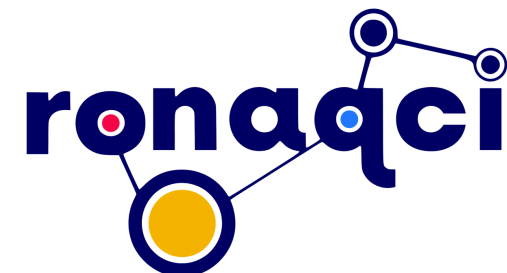
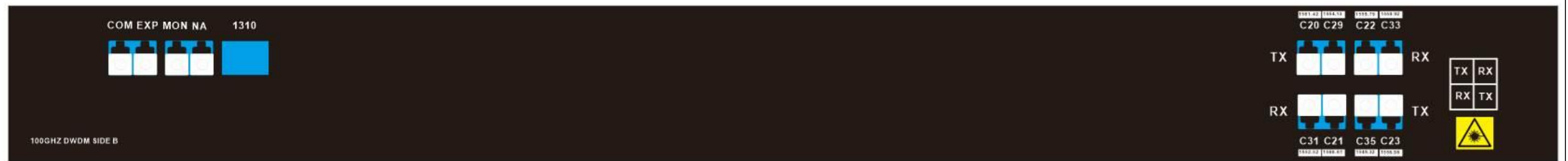
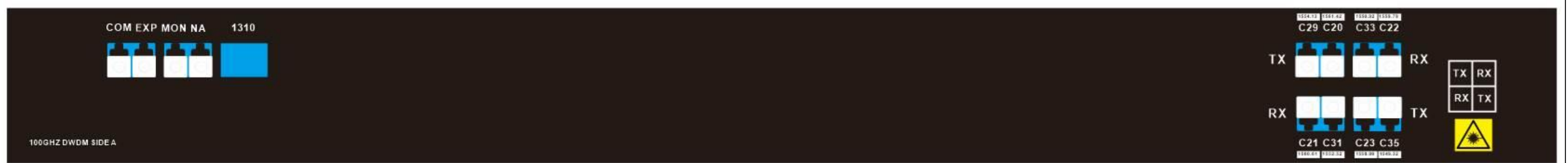
- Short distances (usual  $<10\text{km}$ , 1-2 exception  $\sim 20\text{km}$ )
- Dark fiber availabilities – more providers but all the ducts are almost occupied
- No DWDM available on the metropolitan networks in the cities



# Metropolitan Network Channel Transport

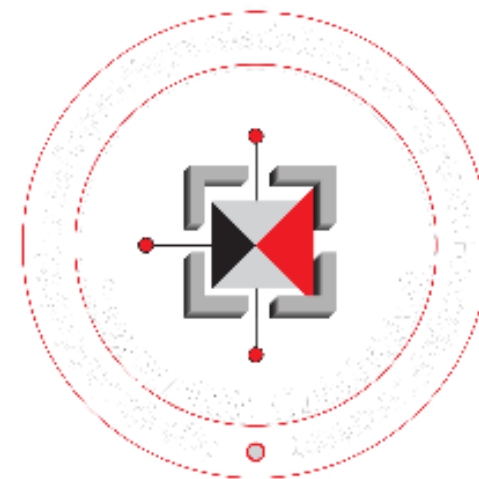
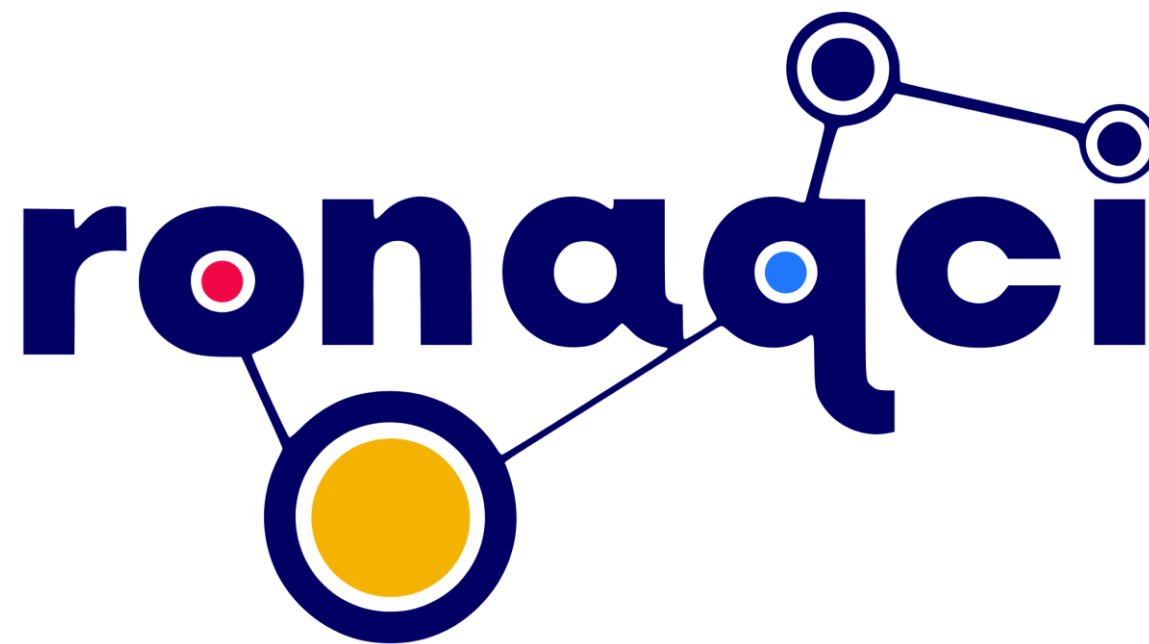


# DWDM MUX/DEMUX 4 channels and 1310nm port





RoNaQCI –  
Quantum  
Training and  
Education HUB



# RoNaQCI WP6. D6.1 Training materials – The Book

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# RoNaQCI WP6. D6.2 Examination certification

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- 4. Gates
- 3. Multiple Qubits and Universality
  - 1. Systems with multiple qubits
  - 2. Universal gates
- 4. Entanglement and Quantum Teleportation
  - 1. Entanglement
  - 2. Partial measurement in quantum mechanics
  - 3. Generation of the Bell states
  - 4. The Einstein - Podolsky - Rosen paradox
  - 5. The Bell inequality
  - 6. Quantum teleportation
- 5. Quantum Cryptography
  - 1. The Quantum Gift: both threat and blessing
  - 2. QKD
  - 3. The BB84 protocol
  - 4. The E91 protocol
  - 5. The B92 protocol
  - 6. Real-world application and technologies
  - 7. Post-Quantum Cryptography



Certification exam

✓ Done: View

To do: Receive a grade

To do: Receive a passing grade



Certificate

Mark as done



Not available unless: The activity **Certification exam** is complete and passed



<https://cnq.ronaqci.upb.ro/certificari/>




# RoNaQCI WP6. T6.4-T6.6 Training for Academia, Public Authorities and Industry M11-M30

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▼ Chapter 1. Introduction, Qubit and Single Qubit Gates - 19 dec 2023 Mark as done

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 Chapter 1. Introduction, Qubit and Single Qubit Gates Done

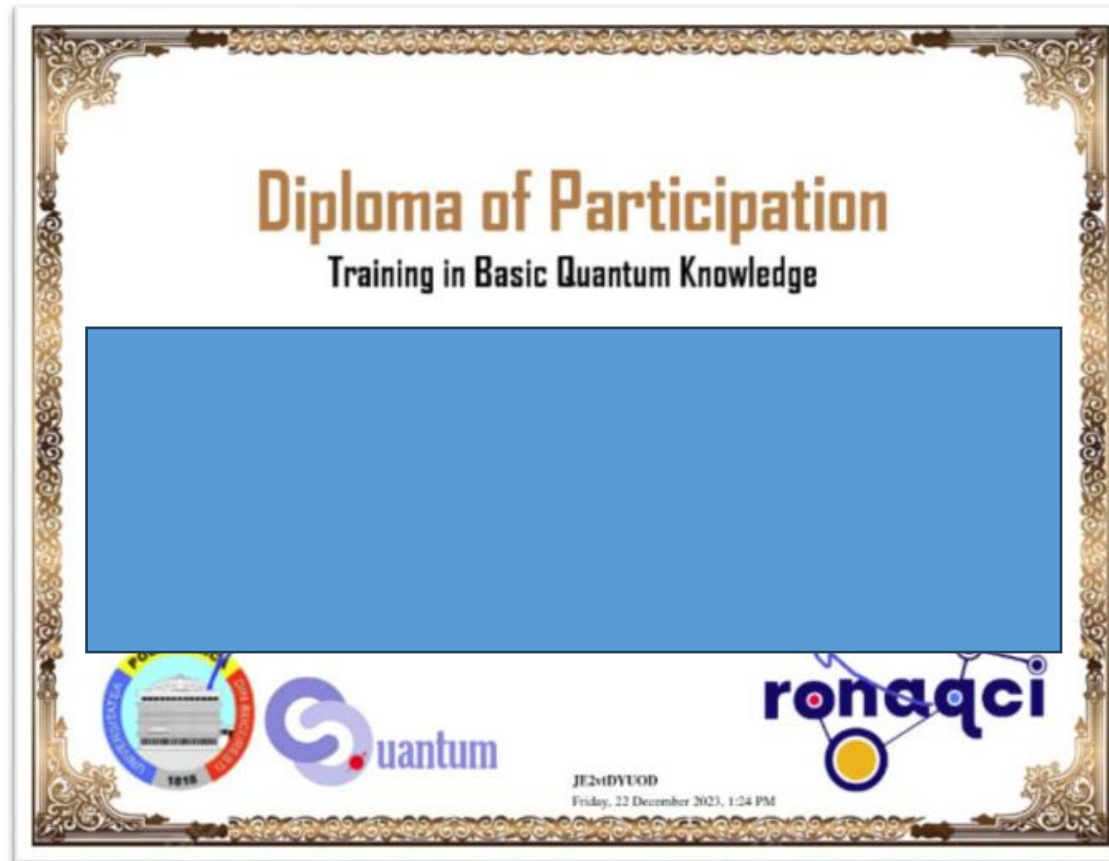
▼ Chapter 2. Multiple Qubits and Universality - 20 dec 2023 Mark as done

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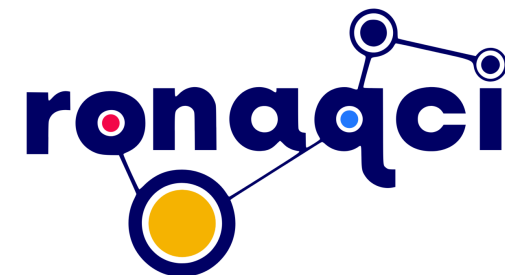
▼ Chapter 3. Entanglement and Quantum Teleportation - 21 dec 2023 Highlighted Mark as done

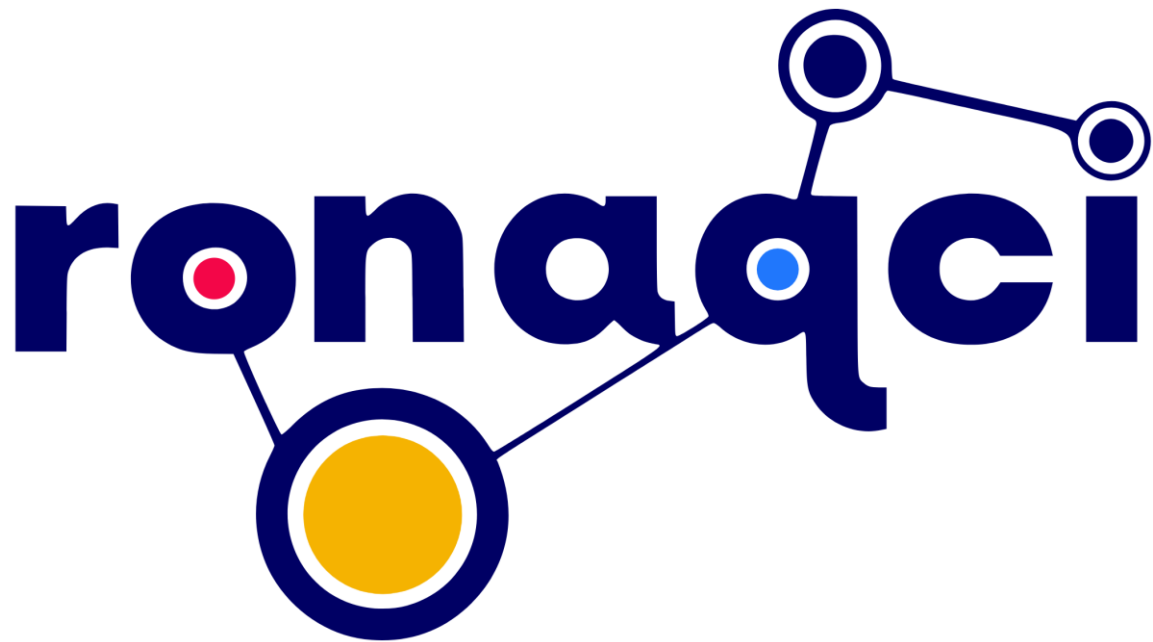
[Click here to join "Chapter 3. Entanglement and Quantum Teleportation" online.](#)



# QKD Quantum Hubs

- **Establishment of 17 Quantum Hubs**
- Covering all regions of Romania and the cooperation of all involved partners
- Trainings are in progress (Bucharest / Constanta done, Craiova / Cluj to come)





RoNaQCI –  
Advanced Use-  
Cases



# QKD Basic Use-Cases – WIP!

- File Transfer using OTP (One Time Pad)
- VPN using PQC

