PSNC

Poznan Supercomputing and Networking Center

61-139 Poznan
ul. Jana Pawła II 10
phone: (+48 61) 858-20-01
fax: (+48 61) 852-59-54
office@man.poznan.pl
www.psnc.pl

61-139 Poznan
ul. Jana Pawła II 10
phone: (+48 61) 858-20-01
fax: (+48 61) 852-59-54
office@man.poznan.pl
www.psnc.pl

Piotr Rydlichowski, Ivana Golub

Quantum Communication and Quantum Computing in NREN perspective – PSNC activities

Poznań Supercomputing and Networking Center

Center of e-Infrastructure

- National Research and Education Network PIONIER
- Research Metropolitan Area Network - POZMAN
- HPC Center
- Data repositories and Digital Libraries Federation

Center of Research & Development

- New Generation Networks
- HPC, Grids & Clouds
- Grand challenge applications
- New media and visualization technologies
- Knowledge Platforms
- Future Internet - Technology, Applications and Services for IS
- Cyber Security
- Quantum Communication and Computing – use cases, practical scenarios and connecting/building community
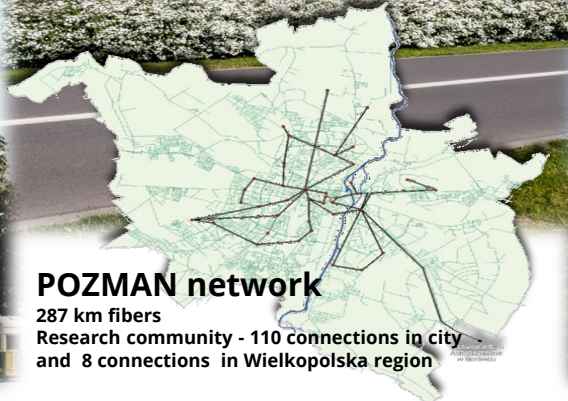
Poznań Supercomputing and Networking Center

PSNC LOCATIONS

Laboratories

PSNC HQ

Data Center

Living Labs
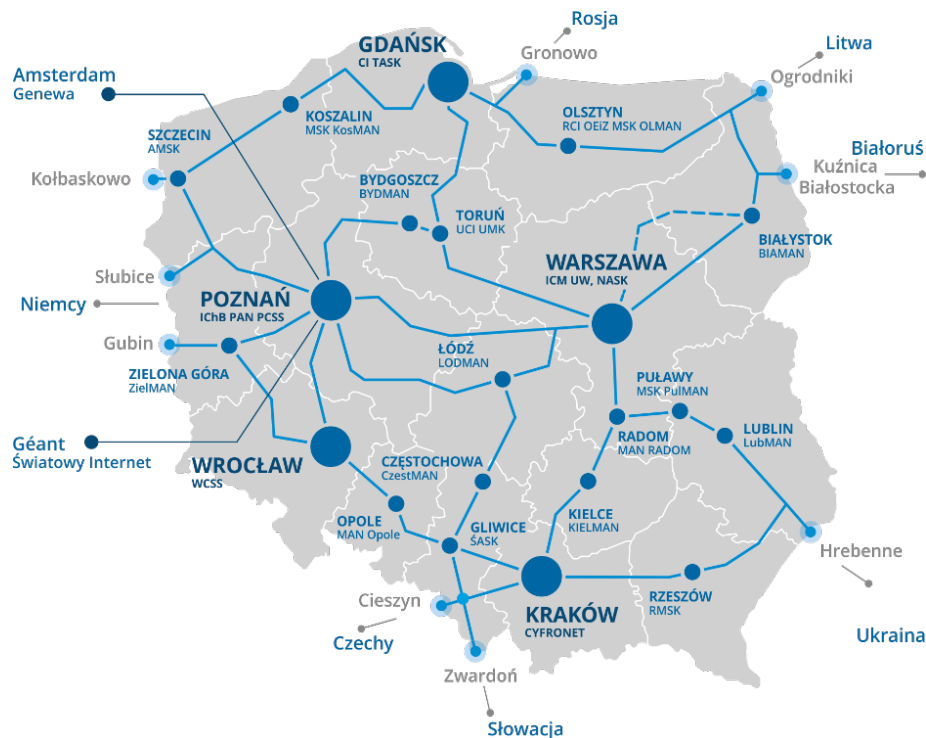Coworking space

POZMAN network
287 km fibers
Research community - 110 connections in city
and 8 connections in Wielkopolska region

Backup Data Center

Poznań Supercomputing and Networking Center

The PIONIER Consortium brings together 21 MAN Networks and 5 HPC Centers

Type of connected unit	Number of units
Research institutions	221
Universities	196
Post-secondary schools	21
High schools, secondary schools, primary schools and vocational schools	234
Healthcare	59
Public safety	27
Goverment administration	27
Provincial administration	59
District, municipality and city administration	73
Other administration	9
Court and public prosecutor's office	26
Cultural institutions	104
Other educational	27

Poznań Supercomputing and Networking Center

PIONIER NETWORK - EUROPE

Quantum Manifesto

- **Activities started by Quantum Manifesto and entry point for Quantum Flaghsip program.**

https://qt.eu/app/uploads/2018/04/93056_Quantum-Manifesto_WEB.pdf

Quantum Technologies Timeline

https://qt.eu/app/uploads/2018/04/93056_Quantum-Manifesto_WEB.pdf

QUANTUM FLAGSHIP

- Large-scale research and innovation initiative funded by the EC

- Started in October 2018 and will run for 10 years.

- PSNC is active in the areas of quantum computing and quantum communication – applications, integration, use cases

- PSNC quantum communication activities are focused on early use cases and applications implementation and supporting research community

- PSNC quantum computing projects are focused on algorithms, uses cases and hardware evaluation

- These works and projects are in most cases carried out together under one umbrella project and initiative

- It provides potential foundations for future hybrid networks and quantum communication infrastructure that will potentially connect quantum computing infrastructure

Strategic Research Agenda

RESEARCH BASED

HORIZON 2020
2014-2020

HORIZON EUROPE

HORIZON EUROPE
2021-2027

INFRASTRUCTURES

QUANTERA

QUANTUM FLAGSHIP

Give **funding support** to **international research projects** in the field of Quantum Technologies

Bring quantum **technologies** from the **lab** to the **market** and consolidate European scientific **leadership** in quantum research

EUROPEAN QUANTUM SENSING AND METROLOGY INFRASTRUCTURE (EuroQSM)

Build and **deploy** dedicated **measurement services** for quantum devices and support the creation of **globally accepted standards**

DIGITAL EUROPE

QUANTUM COMMUNICATION INFRASTRUCTURE (EuroQCI)

Build and **deploy** in the next decade a certified secure pan-European end-to-end QCI for **cyber-security services**

QUANTUM COMPUTING AND SIMULATION INFRASTRUCTURE (EuroQCS)

Build and **deploy** an infrastructure for big data, artificial intelligence, high performance computing, among others

*European Quantum Support Activities*

PSNC

QUANTUM COMMUNICATION ACTIVITIES

PROJECTS

- PSNC takes part in several projects and activities connected with Quantum Communication and especially QKD technology as early use case:

  - **OPENQKD (HORIZON2020)**
  - **NLPQT (NCBiR)**
  - **QUAPITAL**
  - **GÉANT**
  - **EUROQCI**
  - **Supporting Quantum Internet Research Group QIRG (IETF)**
 - **Internal use cases focused on QKD integration in various sceanrios**

OPENQKD

- Construction of QKD testbeds in Europe and implementation of 40 different scenarios for services using QKD technology
- Project start - October 2019, end in 2023
- Poznań is one of the testbeds. Implementation and integration of QKD technology in the existing infrastructure and services of the POZMAN and PIONIER networks.
- Testing experimental QKD solutions in Poznań
- PSNC participates in works related to standardization activities and IPR
- PSNC develop data management and analysis software
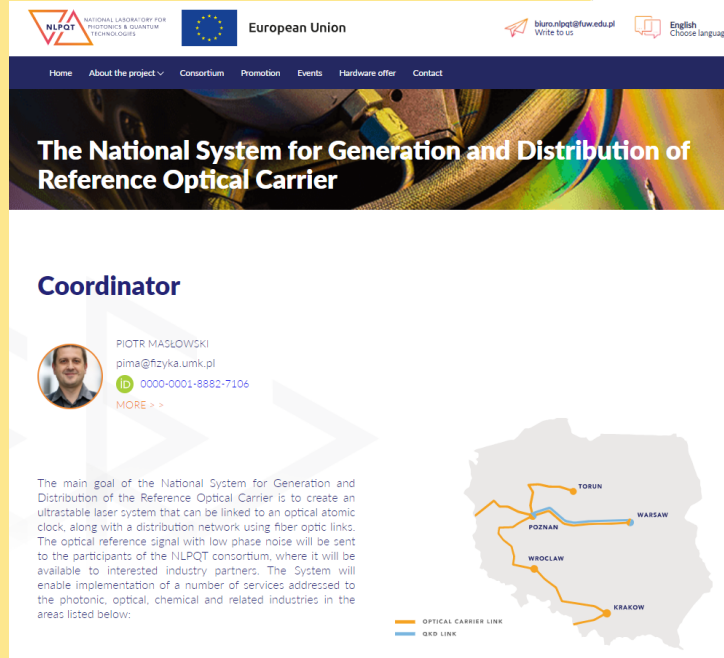- Testbeds currently running in Geneva, Madrid, Berlin (June 2021).
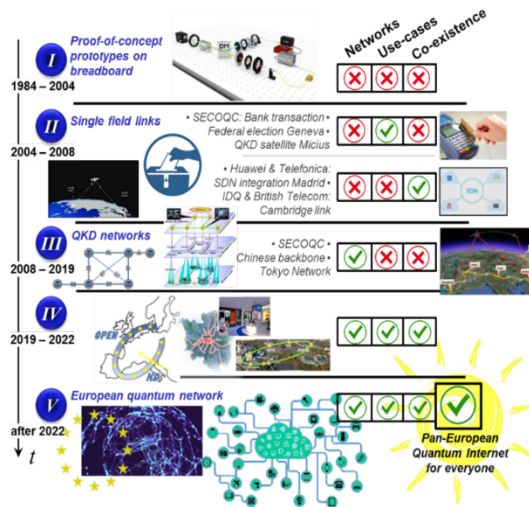
Testbed Poznań

- **Infrastructure in place as PSNC** is owner and operator of the infrastructure and network

- **Two QKD links installed and running** tests before the final deployment and use cases implementation

- **Various use cases are beeing prepared:** UC-06, UC-07, UC-08, UC-09, UC-10, UC-11 based on existing services and network. UC with VSB involves **QKD cross-border connection. Reference Time and frequency use case involves long distance connection.**

- **PSNC NOC** is working on implementing the monitoring and logging services for QKD infrastructure and services

- **SDN solutions currently analyzed**

- **Real world operational network** with shared infrastructure for quantum and classical communication and services. Connection point with other operators and several types and manufacturers of transmission equipment and encryptors

- **Direct connection with GEANT** node in Poland, network and services.

- **QKD equipment installed at PSNC DC nodes** and under preparation for use cases

- **QKD equipment installed on Ostrava – Cieszyn crossborder line for HPC use cases with VSB**

- **Joint activities with National project NLPQT – National Laboratory for Photonic and Quantum Technologies**

Poznań Testbed
Operational and R&D network
Poznań area

▲ PSNC DCs and main QKD nodes

● QKD and UC nodes
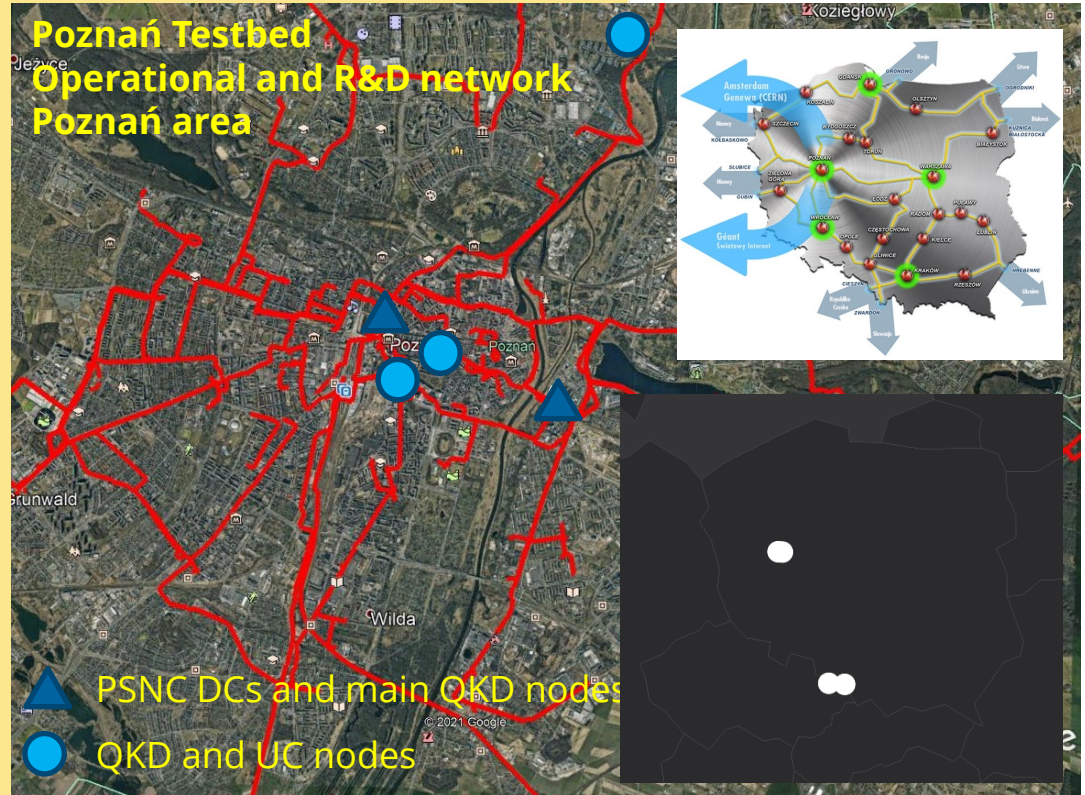
Testbed Poznań

- Testbed has one IDQ system deployed between PSNC primary and backup data centers in Poznań

- TOSHIBA O-band system for different metro use cases

- First use cases focused on HPC applications, medical services and reference time and frequency transmission

# PSNC – VSB crossborder testbed

OPEN QKD

TRIAL PREPARATION

- First intercity and international trial in CZ
- Ostrava Cieszyn line – fibre itself 75km, 16 dB
- QKD channel in 1550 nm band, will be disturbed by parallel traffic
- Line is very close to maximum system performance
- QKD system „fibre hungry", service OOK channel will consume 2 additional optical channels
- Offer for aditional fibre pair uncompetitive
- All data (incl. QKD service channel) moved into bidi DWDM

Management and use case node

DWDM system interconnection

QKD node
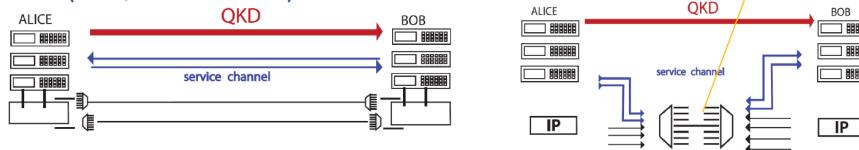
SPIE. DIGITAL LIBRARY

CONFERENCE PROCEEDINGS

PAPERS   PRESENTATIONS   JOURNALS   EBOOKS

▶ Presentation + Paper

4 October 2022

First cross-border trial of quantum key distribution sharing fiber line with data and accurate time transmissions

Josef Vojtech, Rudolf Vohnout, Ondřej Havliš, Petr Pospíšil, Martin Šlapák, Radek Velc, Lada Altmannová, Tomáš Horváth, Jan Kundrát, Michal Hažlinský, Elisabeth Andriantsarazo, Piotr Ridlichowski
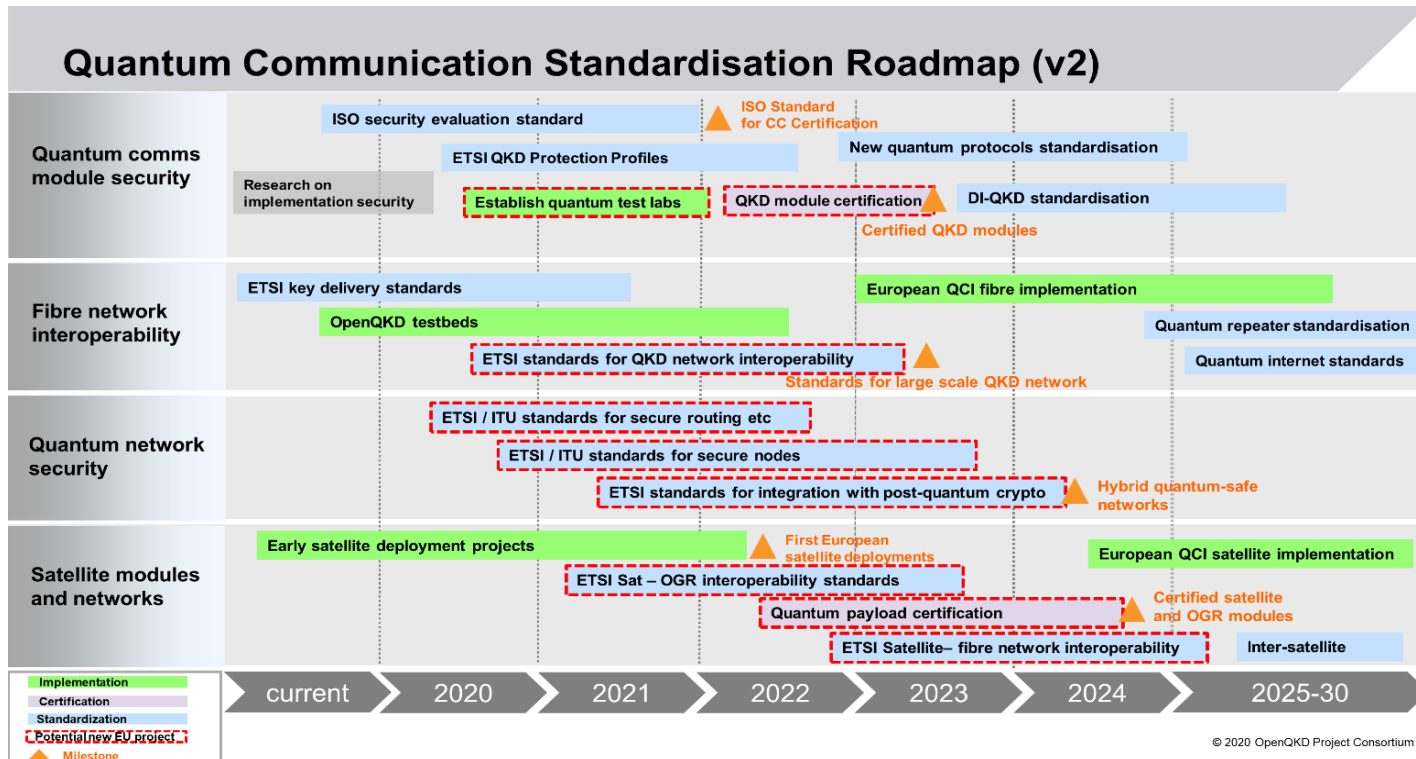
Author Affiliations +

ARTICLE   CITED BY ▾

Abstract

This contribution focuses on experimental verification of the QKD system deployment in a multi-domain network environment managed by Czech and Polish National Research and Educational Network (NREN) operators. We demonstrate full functionality of such a solution for transmission of secret keys in boundary conditions, and with this we open up new possibilities for further use of extremely secure communication between two neighboring network entities, and the services built upon it. Moreover, we have shared the cross-border link among strong QKD service channels, accurate time, and classical data channels together with weak quantum channel to reduce the total number of optical fibers needed for transmission. To our

STANDARDIZATION AND CERTIFICATION

Quantum Communication Standardisation Roadmap (v2)

Quantum comms module security
- ISO security evaluation standard
- ISO Standard for CC Certification
- ETSI QKD Protection Profiles
- New quantum protocols standardisation
- Research on implementation security
- Establish quantum test labs
- QKD module certification
- DI-QKD standardisation
- Certified QKD modules

Fibre network interoperability
- ETSI key delivery standards
- European QCI fibre implementation
- OpenQKD testbeds
- Quantum repeater standardisation
- ETSI standards for QKD network interoperability
- Quantum internet standards
- Standards for large scale QKD network

Quantum network security
- ETSI / ITU standards for secure routing etc
- ETSI / ITU standards for secure nodes
- ETSI standards for integration with post-quantum crypto
- Hybrid quantum-safe networks

Satellite modules and networks
- Early satellite deployment projects
- First European satellite deployments
- European QCI satellite implementation
- ETSI Sat – OGR interoperability standards
- Quantum payload certification
- Certified satellite and OGR modules
- ETSI Satellite– fibre network interoperability
- Inter-satellite

Legend:
- Implementation
- Certification
- Standardization
- Potential new EU project
- Milestone

Timeline: current | 2020 | 2021 | 2022 | 2023 | 2024 | 2025-30

© 2020 OpenQKD Project Consortium

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform/29227

NATIONAL LABORATORY FOR PHOTONICS AND QUANTUM TECHNOLOGIES (NLPQT)

- **Metro QKD research and operational infrastructure in Poznań, integration of QKD solutions**
  - QKD infrastructure (operational and R&D QKD devices, encoders and quantum random number generators)

- **Construction of the QKD Poznań - Warsaw link – June 2022**
  - experiments related to quantum communication between University of Warsaw nodes and PSNC in Warsaw.
  - Experiments related to sources and detectors of single photons
  - Integration of the infrastructure with the optical carrier infrastructure
  - Next generation QKD prototypes testing (based on enatnglement)
  - 380 km and 5 trusted nodes

QUANTUM COMMUNICATION ACTIVITIES

QUAPITAL

- Project related to QKD technology and quantum communication
- Focus also on providing infrastructure, especially cross border
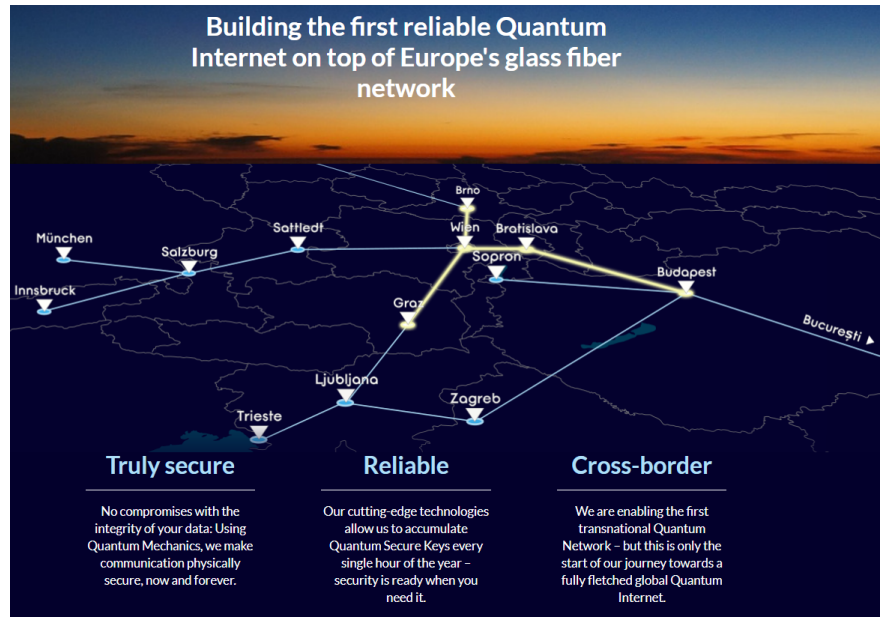
Quantum Key Distribution (QKD) Subtask

Network Technology Evolution (WP6 T1) Subtask

Objectives:

- Identify the R&E network community interest and needs
- Involve GÉANT and NREN community in the QKD technology.
- Establish a cooperation with commercial QKD vendors
- Make the NRENs 'quantum aware' and increase the 'knowledge capital'
- Investigate QKD technology, solutions and use cases for the community

Participating organisations:

- CESNET, DFN, GÉANT, KIFU, PSNC, RENATER

GÉANT

Quantum Activities in the QKD Subtask

Survey among EU NRENs on awareness and involvement in Quantum-related projects

- filled in by 70% NRENs
- 68% aware of QKD
- 21% participate in some Quantum-related project
- 61% welcome future training on QT

Activities:

- Quantum Technologies Status Overview White Paper
- Knowledge sharing - infoshares
- Quantum Simulators
- Long-haul PoC project
- Open Quantum Group Meeting
- Quantum Internet Hackathon 2022 co-organisation with RIPE NCC
- QKD Wiki

19-01-2021

Quantum Technologies Status Overview

www.geant.org

Dissemination Activities - GÉANT Infoshares

Previous infoshares (links with presentations and video recordings):

- [Quantum Technologies - Principles, Challenges and Applications](#)
- [Quantum Key Distribution - Practical Implementations, Challenges, R&E Use Cases and Standardisation outlook](#)
- [Quantum Key Distribution (QKD) Simulation](#)
- [Quantum Key Distribution (QKD) Physical implementation and testbed](#)

Forthcoming Infoshare: 25 November 13:30 - 16:00 CET

Quantum Key Distribution deployments
Registrations: https://events.geant.org/event/1304/

GÉANT

Quantum Key Distribution (QKD) Wiki

Gathering and presenting information about

- Quantum Technologies

- The results of the GÉANT project's QKD NETDEV subtask

- Upcoming events

News

GÉANT Infoshare Nov 25, 2022

Quantum Key Distribution Deployments

This infoshare will present a feedback on the QKD deployment and the lab test performance results. *Read more...*

Information

Quantum Fundamentals

Quantum Keys

QKD Protocols

Quantum Simulators

Demo

Events

Further Readings

Join us on our discussion list:

quantum-discuss@lists.geant.org

More information:

https://wiki.geant.org/display/NETDEV/QKD

Quantum Internet Hackathon 2022

1-2 December 2022

Amsterdam, Dublin, Padua, Poznan, Tashkent, Sarajevo - and online!

Initiated by RIPE NCC as a follow-up of QIH2019

10 participating organisations, including **PSNC and GÉANT**

6 places + online, including **PSNC in Poznan**

Goals:

- Sharing existing software and protocols, receiving feedback
- Developing new / improving existing software and tools
- Producing documentation and other materials
- Forging connections between participants and nodes
- Learning about Quantum Networking, monitoring and management

Participating Organisations

- GÉANT
- INHA University of Uzbekistan
- Poznan Supercomputing and Networking Center (PSNC)
- QuTech
- RIPE NCC
- SURF
- The Quantum Internet Alliance
- Trinity College Dublin
- University of Padova
- University of Sarajevo

https://labs.ripe.net/author/karla-white/take-part-in-the-quantum-internet-hackathon-2022/

www.geant.org

GÉANT

QUANTUM COMMUNICATION ACTIVITIES

Post Quantum and QKD demo - TNC18 conference
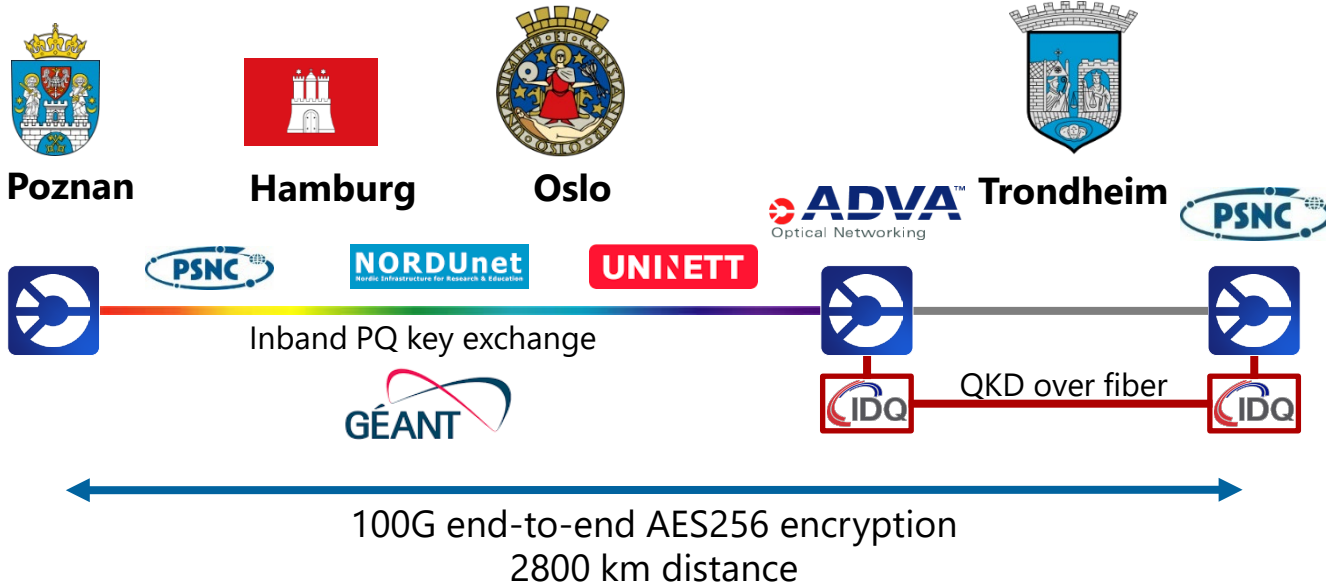
Poznan   Hamburg   Oslo   Trondheim

Inband PQ key exchange

QKD over fiber

100G end-to-end AES256 encryption
2800 km distance

POST-QUANTUM CRYPTOGRAPHY

Current state and quantum mitigation

MAY 2021, v2

QIRG

- Document "Applications and Use Cases for the Quantum Internet" (draft-wang-qirg-quantum-internet-use-cases-06) during the last revision (end of May 2020).

- The document "Architectural Principles for a Quantum Internet" (draft-irtf-qirg-principles-03)

- The GÉANT WP6 T1 QKD Group submits its comments

- Abstract: "The Quantum Internet has the potential to improve Internet application functionality by incorporating quantum information technology into the infrastructure of the overall Internet. In this document, we provide an overview of some applications expected to be used on the Quantum Internet, and then categorize them using various classification schemes. Some general requirements for the Quantum Internet are also discussed. The intent of this document is to provide a common understanding and framework of applications and use cases for the Quantum Internet. "

QUANTUM COMMUNICATION ACTIVITIES

QUNATUM NETWORKS SIMULATORS

- QuISP, Keio/WIDE
- SimulaQron, TU Delft http://www.simulaqron.org/
- NetSquid, Dahlberg, TU Delft https://netsquid.org/
- SeQueNCe, Suchara, Argonne https://cpb-us-w2.wpmucdn.com/voices.uchicago.edu/dist/0/2327/files/2019/11/SeQUeNCe.pdf
- SQUANCH, Bartlett https://pypi.org/project/SQUANCH/
- https://arxiv.org/abs/1808.07047
- QuNetSim, DiAdamo https://arxiv.org/abs/2003.06397
- QKD simulator in ns-3, including routing, Mehic et al https://ieeexplore.ieee.org/document/8935373 https://www.qkdnetsim.info/ https://twitter.com/mickeyze2
- Physical-layer, online calculator for SPDC http://spdcalc.org/
- QuISP - Quantum Internet Simulation Package https://aqua.sfc.wide.ad.jp/quisp_website/

PSNC

QUANTUM COMMUNICATION ACTIVITIES
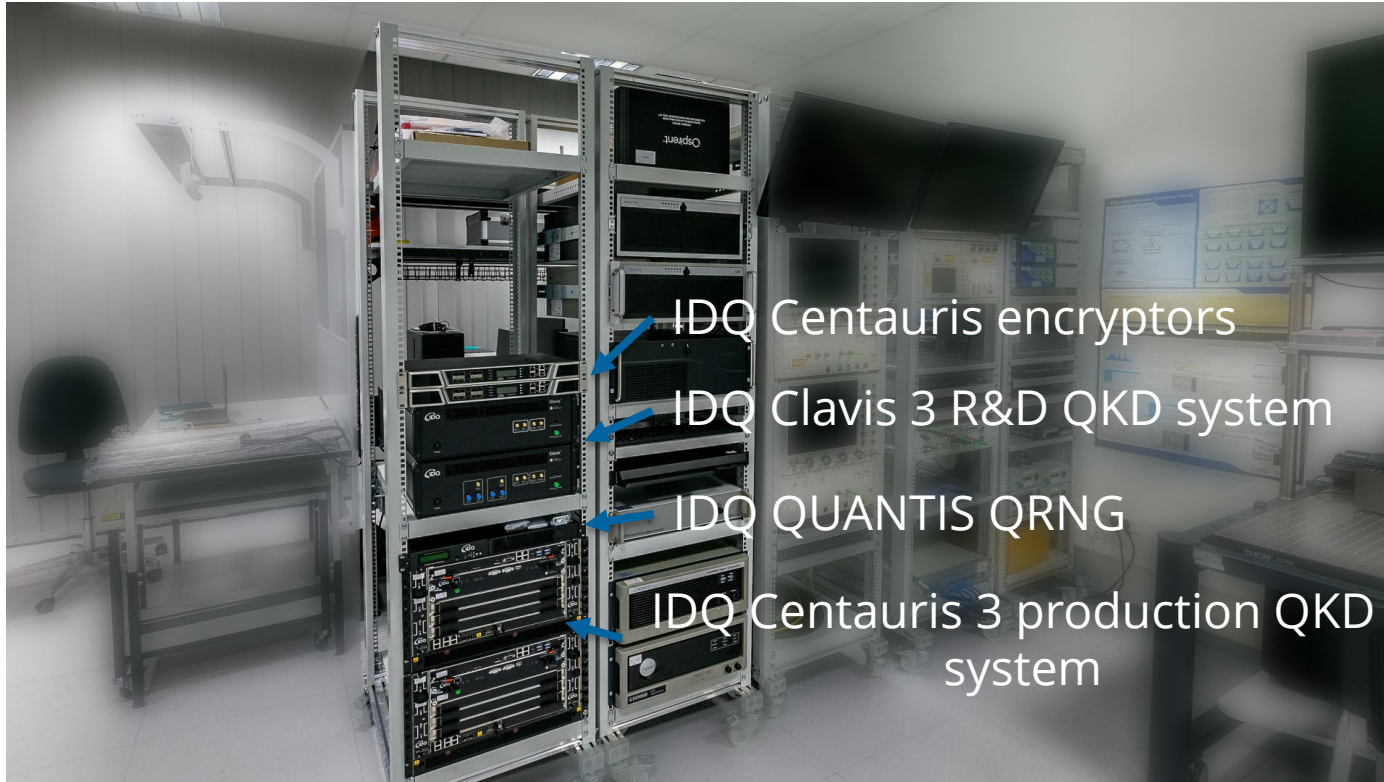
IDQ Centauris encryptors

IDQ Clavis 3 R&D QKD system

IDQ QUANTIS QRNG

IDQ Centauris 3 production QKD system

QUANTUM COMMUNICATION ACTIVITIES

TNC21 conference demo – Secure Key Management for Multi Vendor Interoperable Quantum Key Distribution Network

Key Relay using ADVA FSP150

Encryptor-Alice

KeyID

Encryptor-Bob

$(K_{enc} \oplus K_1)$

KMA-MID FSP150

$(K_1 \oplus K_2)$

KMA-INIT FSP150

K_{enc}

KMA-DEST FSP150

K_{enc}

$keyID_1$

$keyID_2$

QKD-1-Alice

K_1

QKD-1-Bob

$K_{enc} = (K_{enc} \oplus K_1) \oplus (K_1 \oplus K_2) \oplus K_2$

QKD-2-Alice

QKD-2-Bob

K_2

— ETSI GS 014 (HTTPS)
— Ethernet
— Encrypted data over fiber

ADVA   PSNC   IDQ

TNC22 conference demo

Machine·Learning·based·Optical·and·QKD·Network· Monitoring

ADVA·and·PSNC
[1]ADVA·Optical·Networking,·Fraunhoferstrasse·9a,·Martinsried,·Germany,·82152
[2]Christian-Albrechts-Universität·zu·Kiel,·Kaiserstr.·2,·Kiel,·Germany,·24143
[3]PSNC,·Wieniawskiego·17/19,·61-704,·Poznań,·Poland
mwenning@adva.com

Abstract:·We·demonstrate·a·fiber·network·monitoring·system·based·on·machine·learning·which· can·detect·and·diagnose·fiber·faults·and·hardware·failures·in·an·optical·network.·Our·system·also· has·the·capability·of·monitoring·the·performance·of·QKD·links.

QUANTUM COMMUNICATION ACTIVITIES

EuroQCI and Digitial Europe – PSNC is the coordinator of Polish QCI proposal.

QUANTUM COMMUNICATION ACTIVITIES

PIONIER-Q

- QCI call proposal

- Interconnection between 5 HPC centers in Poland

- Number of use cases and associated activities

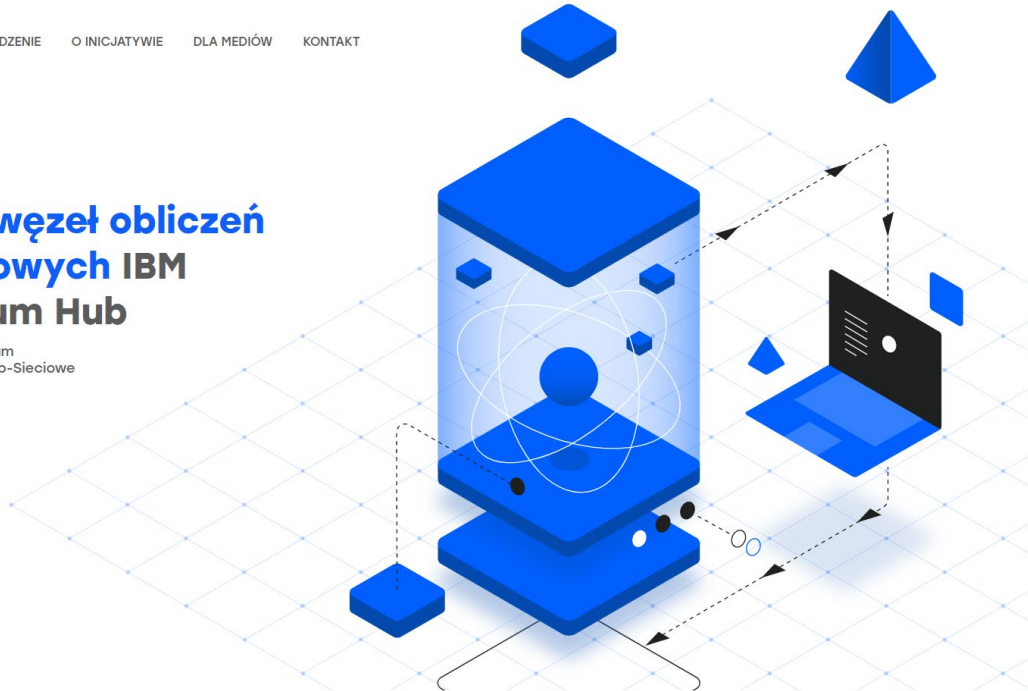- Based on PIONIER fiber infrastructure

QUANTUM COMPUTING ACTIVITIES

PSNC Quantum Hub - 02.2022 – PSNC joins IBM Quantum Network and Polish Quantum Hub is established

**Polski węzeł obliczeń kwantowych IBM Quantum Hub**

Poznańskie Centrum
Superkomputerowo-Sieciowe

PSNC is Hosting a Quantum Machine as a part of EuroHPC

Selection of six sites to host the first European quantum computers

The European High Performance Computing Joint Undertaking (EuroHPC JU) has selected six sites across the European Union (EU) to host and operate the first EuroHPC quantum computers: Czechia, Germany, Spain, France, Italy, and Poland.

The EuroHPC JU has selected six sites across the European Union to host and operate the first EuroHPC quantum computers in:

- 🇨🇿 Czechia
- 🇫🇷 France
- 🇩🇪 Germany
- 🇮🇹 Italy
- 🇵🇱 Poland
- 🇪🇸 Spain
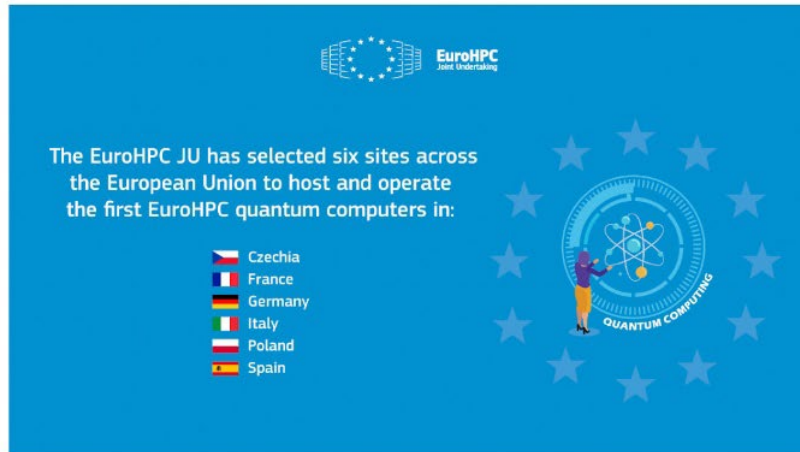
- R&D Purpose
- Available to EU users in scientific communities, industry and the public sector
- To help develop Q applications

https://eurohpc-ju.europa.eu/selection-six-sites-host-first-european-quantum-computers-2022-10-04_en

SUMMARY

- PSNC projects are focused mainly on the implementation an integration aspects

- Support for the whole NREN and GEANT community in Europe

- Possible support for QCI and QCS initiative

- Cooperation with vendors and R&D partners

- Integrating and supporting communities

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office@man.poznan.pl
www.psnc.pl