

# Optimized Deployment and Routing Strategies for QKD and DWDM Networks

10.05.2023, Mario Wenning

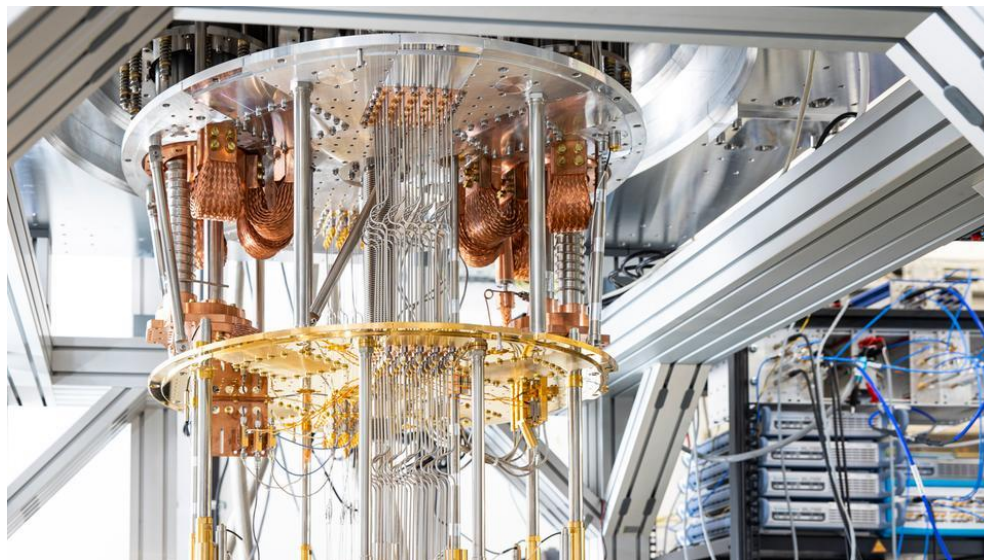
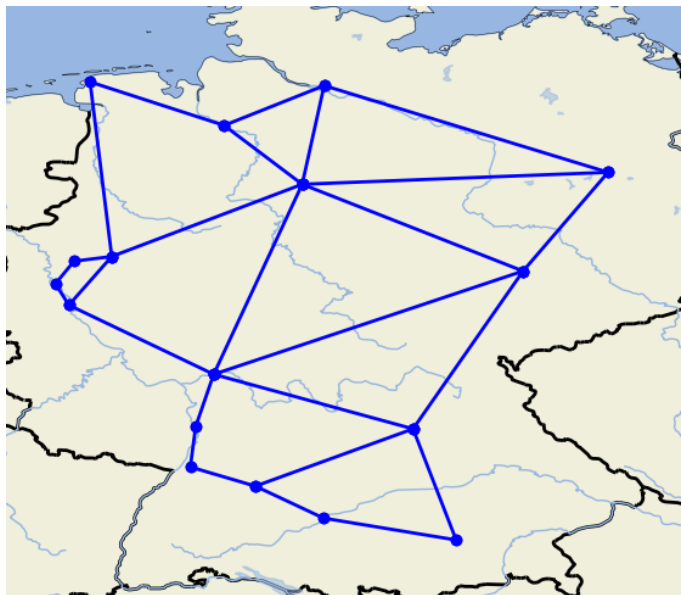


**QuNET<sup>+</sup>**  
*ML*

16KISQ066



# Post Quantum Security for DWDM Networks



<https://www.tagesschau.de/wissen/technologie/ibm-quantenprozessor-computer-101.html>

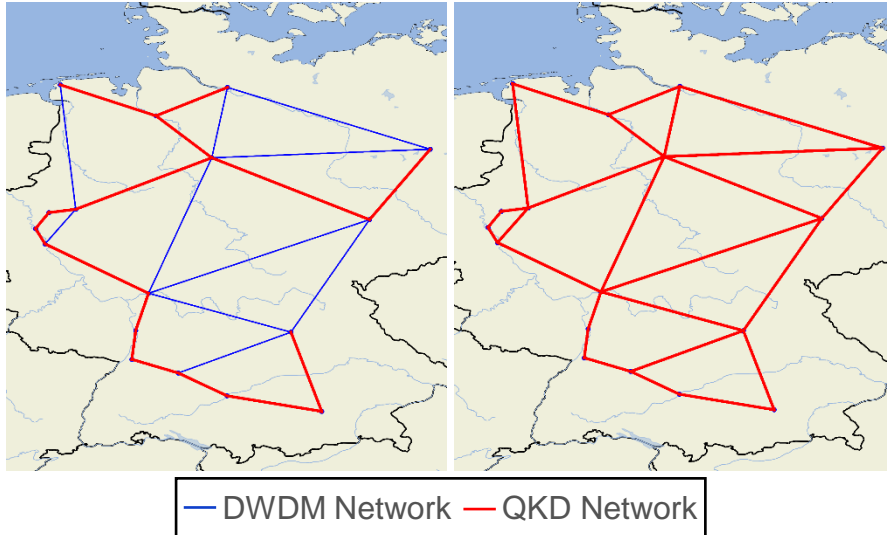
DWDM = Dense Wavelength-Division Multiplexing

QKD = Quantum Key Distribution

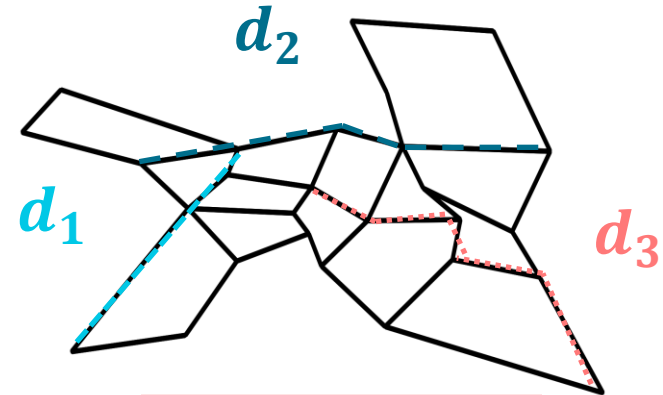
## How to secure long-haul DWDM networks by QKD?

# How to avoid secret keys bottlenecks?

## QKD Network Deployment Options



## Key Management Network Routing Options



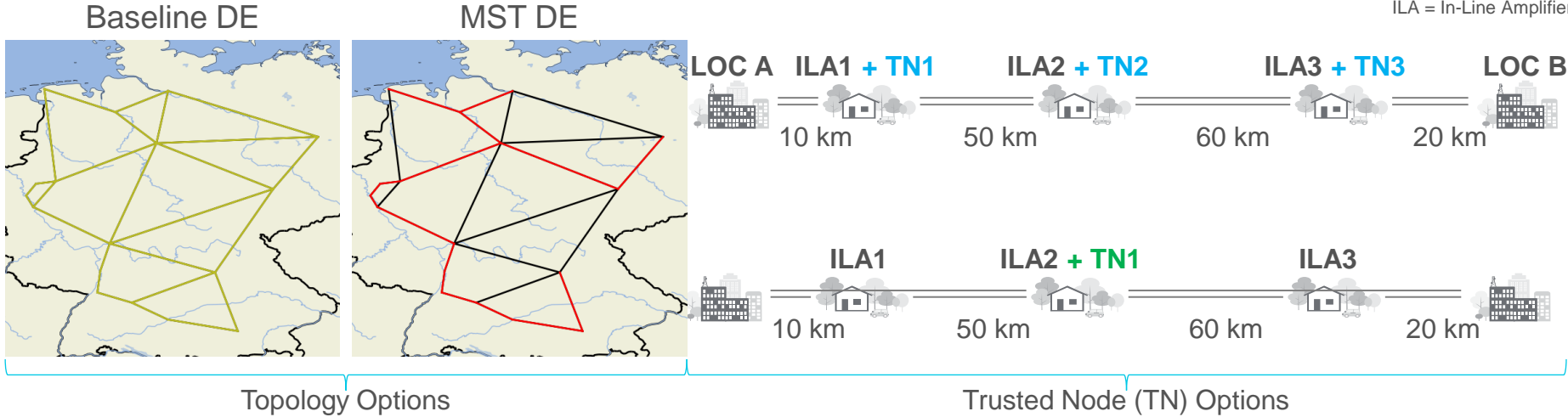
Heuristic-Based [1]

ILP-Based

ML-Based

# QKD Network Deployments

ILA = In-Line Amplifier



QKDN Deployment

Baseline Topology

Minimum Spanning Tree Topology (MST)

Minimal Deployment

Baseline Deployment

Minimal Deployment

Baseline Deployment

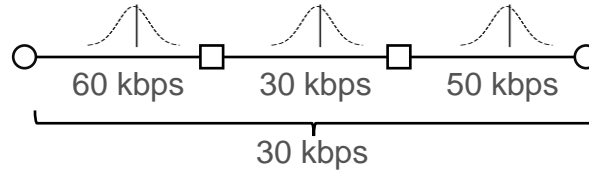
# Key Demand and Simulation Framework

## Key-Request and Security:

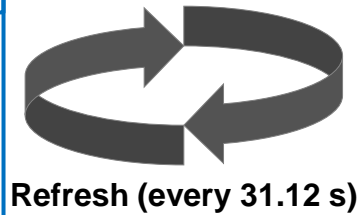
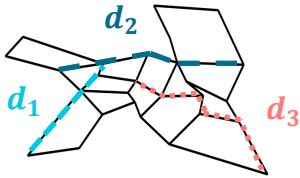
- Lightpaths (LP) with 100 Gbps needs every 31.12 seconds a new key of 256 Bits [2]
- 100 km maximum reach

## Simulation [3]:

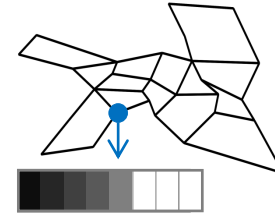
### Step 1: Secure Key Rate (SKR) Assignment



### Step 3: Demand Routing and Key Consumption

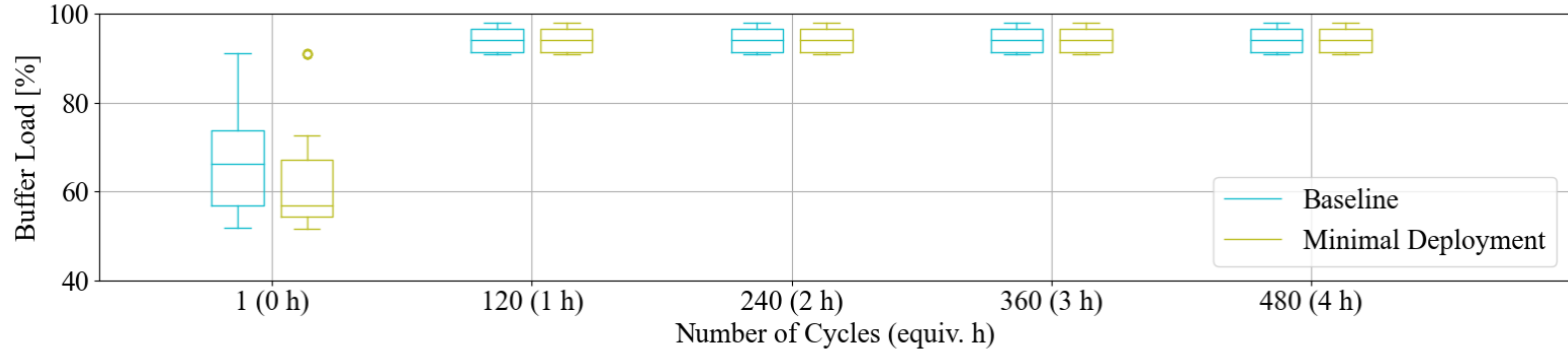


### Step 2: Fill buffer



# Uniformly Distributed Demands

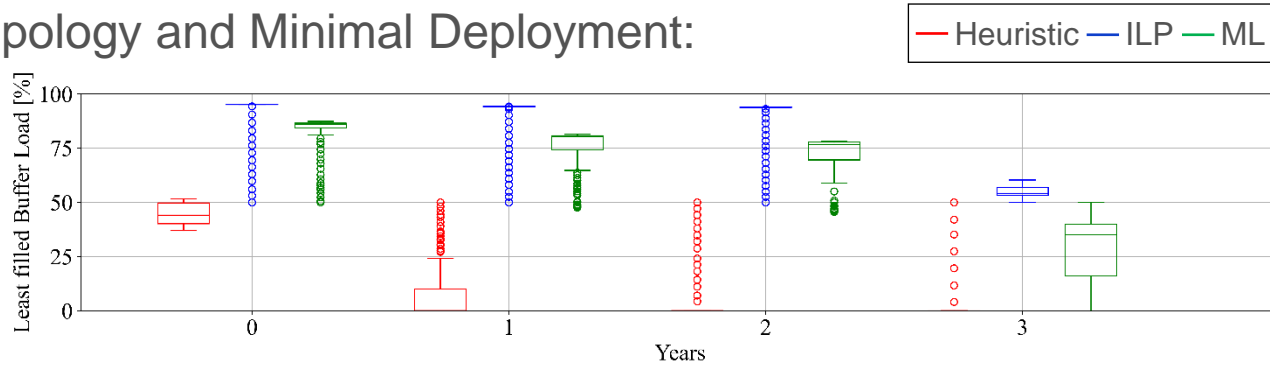
Minimum Spanning Tree Topology:



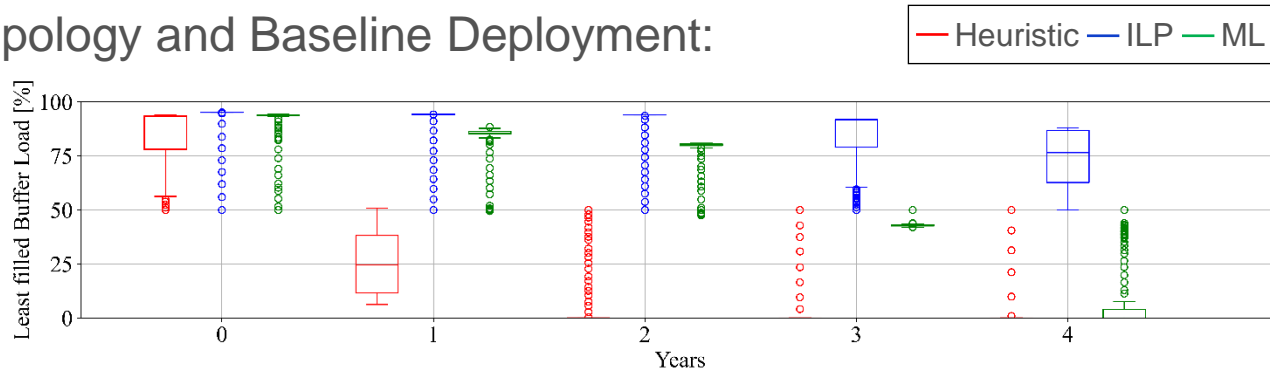
One encrypted lightpath with 100 Gbps between any pair of nodes supported.

# Multi-Year QKD Network Planning [4]

## Baseline Topology and Minimal Deployment:



## Baseline Topology and Baseline Deployment:



# Conclusion and Outlook

## Summary:

- Minimal services supported with minimum spanning tree
- 18% Reduction of QKD devices by optimized operation
- Step-wise deployment achieves optimized utilization
- QKD can scale with forecasted traffic for the next four years

## Outlook:

- Software architecture for dynamic online planning needs to be evaluated
- Verification of the scalability of SDN-based country-wide QKD networks



# References

- [1] M. A. Ojewale et al., “Routing heuristics for load-balanced transmission in TSN-based networks,” SIGBED Rev., vol. 16, no. 4, pp. 20–25, Jan. 2020, doi: 10.1145/3378408.3378411.
- [2] A. Luykx et al., “Limits on authenticated encryption use in TLS,” Aug. 2017.
- [3] M. Wenning et al., “Towards Optimized Demand Routing in QKD Networks,” Optical Fiber Communication Conference, Optica Publishing Group, 2023.
- [4] S.K. Patri et al., “Multi-Band Transparent Optical Network Planning Strategies for 6G-Ready European Networks,” Journal of Optical Fiber Technology, 2023.

# Thank you!

SPONSORED BY THE



Federal Ministry  
of Education  
and Research

**QuNET<sup>+</sup>**  
**ML**

16KISQ066

