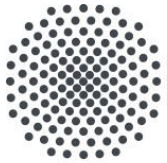
Wrap-Up



University of Stuttgart

Martin Beisel , Felix Gemeinhardt,
Marie Salm, Benjamin Weder

JOHANNES KEPLER UNIVERSITY LINZ

Tutorial Structure

- **Session 1 (09:00 - 10:30): An Introduction to Quantum Computing**
- Session 2 (11:00 - 12:30): Quantum Software Engineering
- Session 3 (14:00 - 15:30): Quantum Workflows
- Session 4 (16:00 - 17:30): Operation of Hybrid Quantum Applications

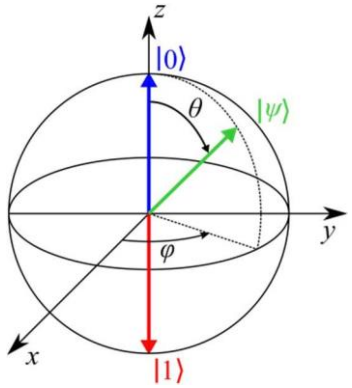
Introduction to Quantum Computing

1. Motivation and Overview

- Classical computing faces severe scaling issues
- QC is applicable to a variety of computational problems
- There are diverse approaches to quantum computing

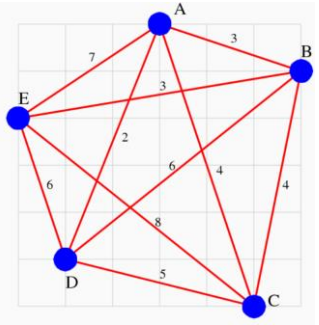
2. Basic Working Principles

- QC harnesses quantum mechanical phenomena
- Mathematically its linear algebra



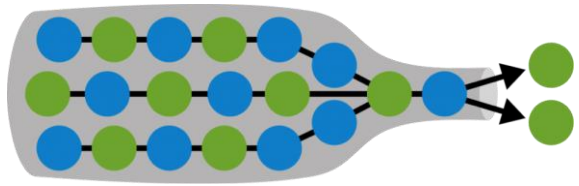
3. Near-term Applications are

- Quantum chemistry
- Quantum optimization
- Quantum machine learning



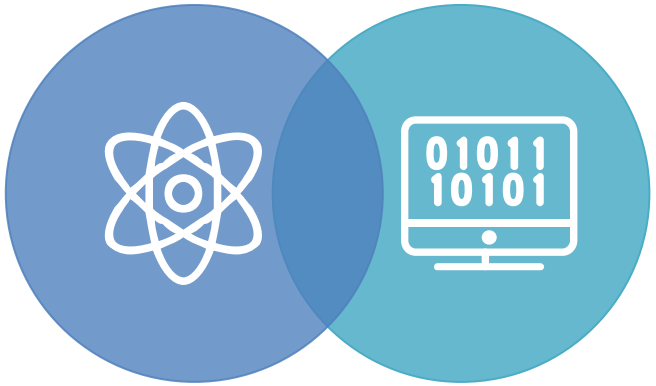
4. Challenges and Limitations

- Interesting challenges remain regarding quantum hardware, software, and their interaction
- Quantum computers will always be special purpose machines
- The potential is worth the effort



5. Quantum Software Engineering

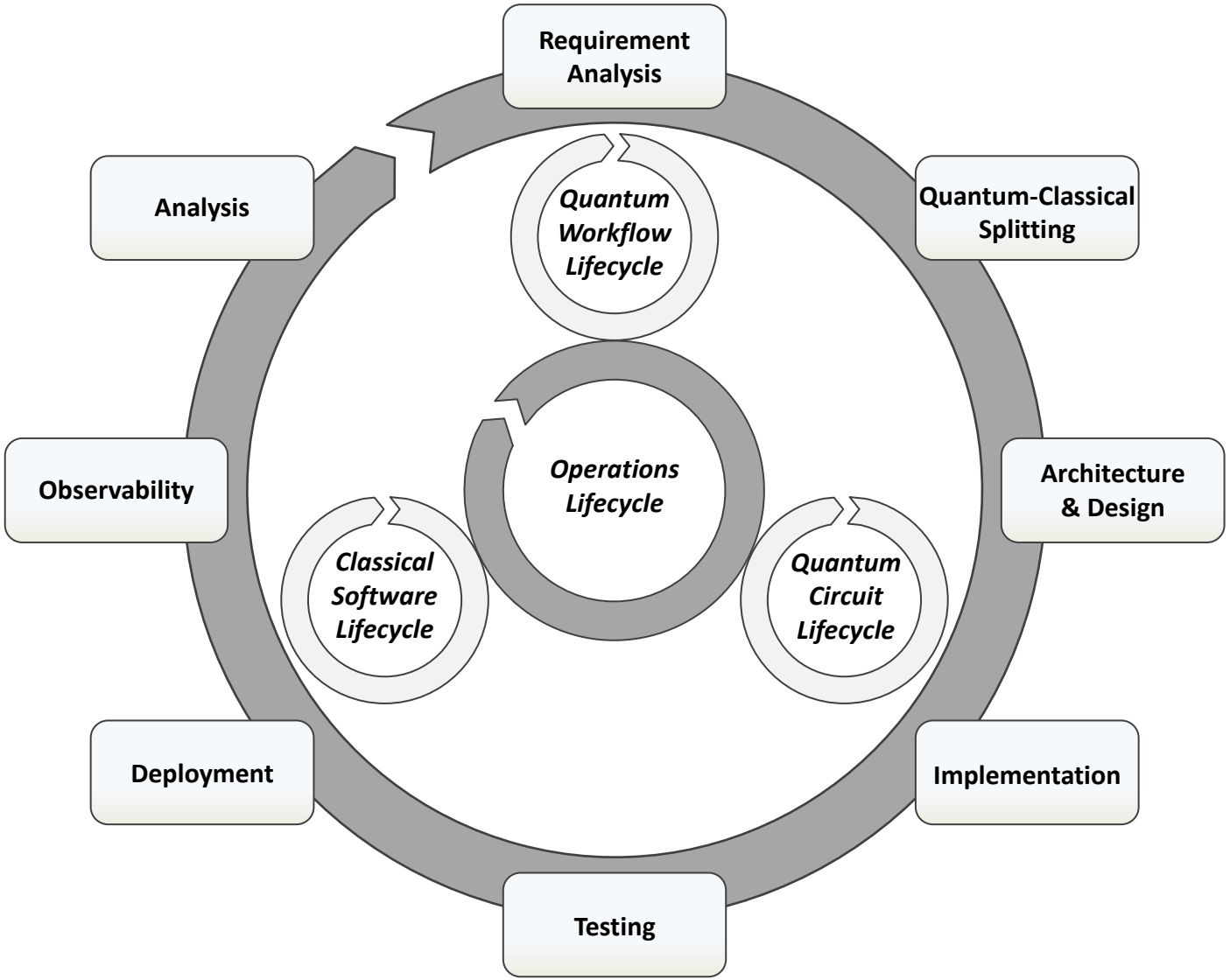
- Which concepts from classical SE can be applied to QC?
- What are sound SE principles for engineering quantum software?
- What are quantum-specific challenges and how to consider them?



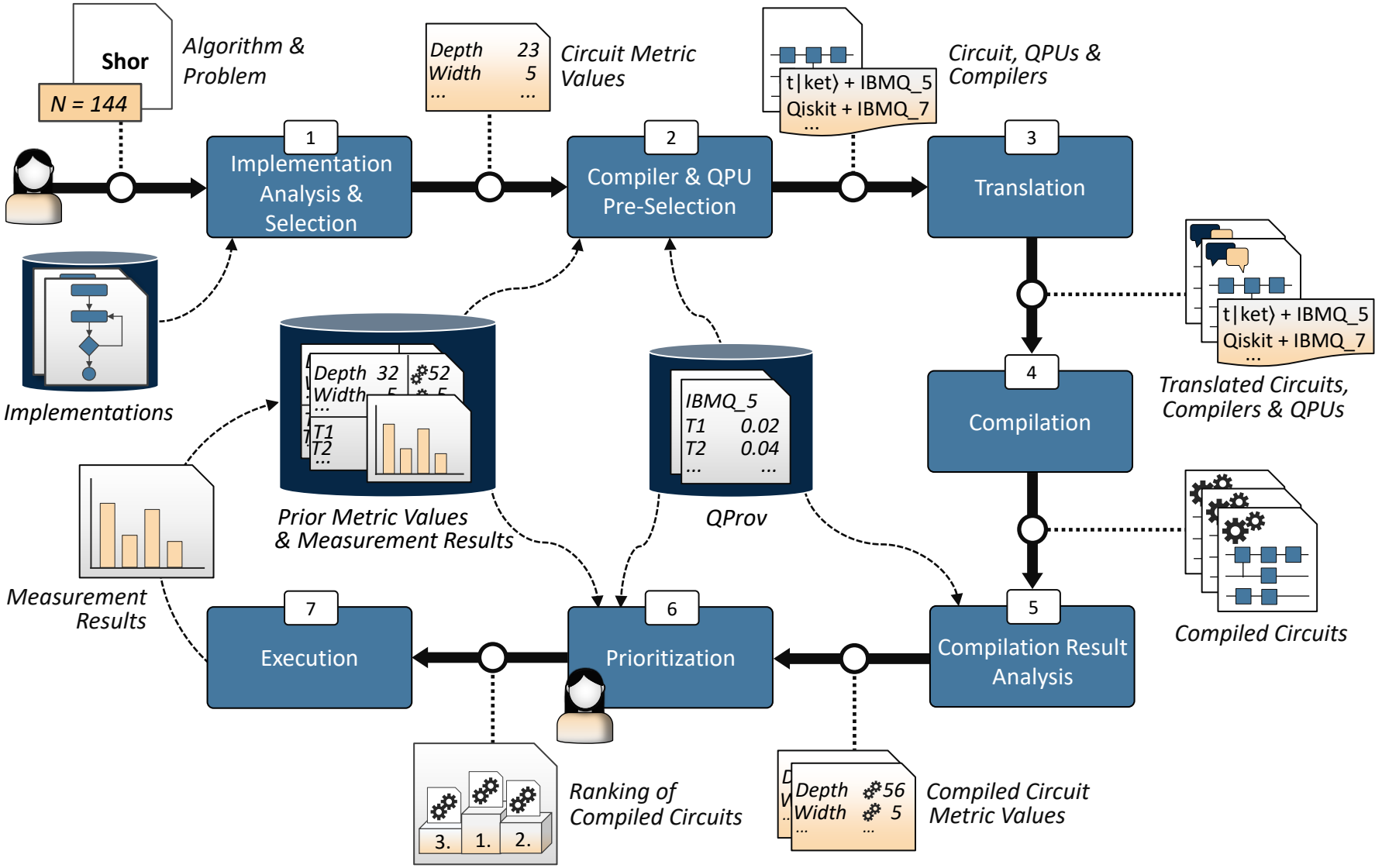
Tutorial Structure

- Session 1 (09:00 - 10:30): An Introduction to Quantum Computing
- **Session 2 (11:00 - 12:30): Quantum Software Engineering**
- Session 3 (14:00 - 15:30): Quantum Workflows
- Session 4 (16:00 - 17:30): Operation of Hybrid Quantum Applications

Quantum Software Lifecycle – Interwoven Lifecycle



Approach of the NISQ Analyzer



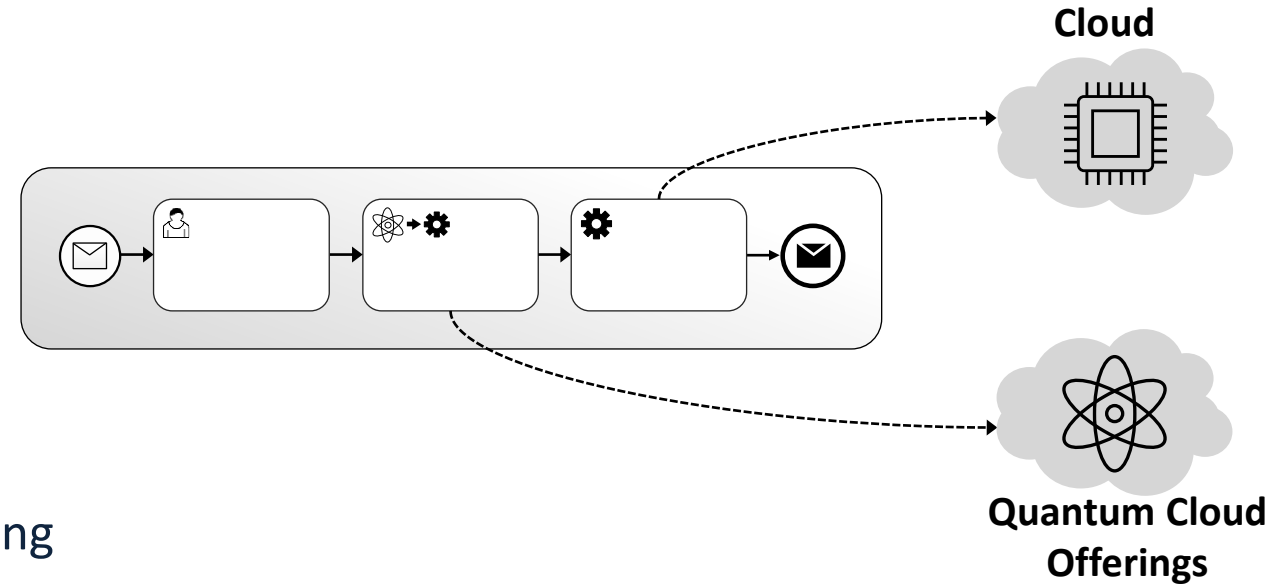
Tutorial Structure

- Session 1 (09:00 - 10:30): An Introduction to Quantum Computing
- Session 2 (11:00 - 12:30): Quantum Software Engineering
- **Session 3 (14:00 - 15:30): Quantum Workflows**
- Session 4 (16:00 - 17:30): Operation of Hybrid Quantum Applications

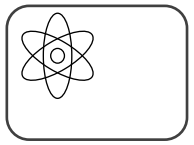
Workflows for Quantum Computing

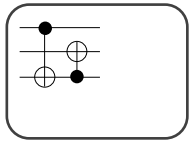
- Workflows enable orchestration and integration of heterogeneous applications
  - Definition of activities, control flow, and data flow

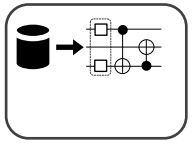
- Advantages:
  - Scalability
  - Robustness
  - Monitoring
  - Advanced Exception Handling
  - Portability via standardized languages (BPMN, BPEL)

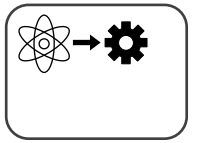


Quantum Modeling Extension (QuantME)


quantum computation task

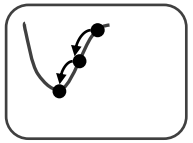

quantum circuit loading task

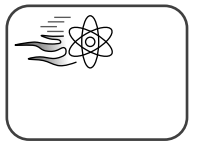

data preparation task

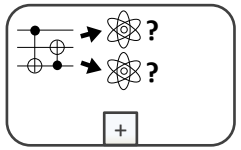

quantum circuit execution task

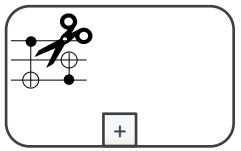

readout error mitigation task

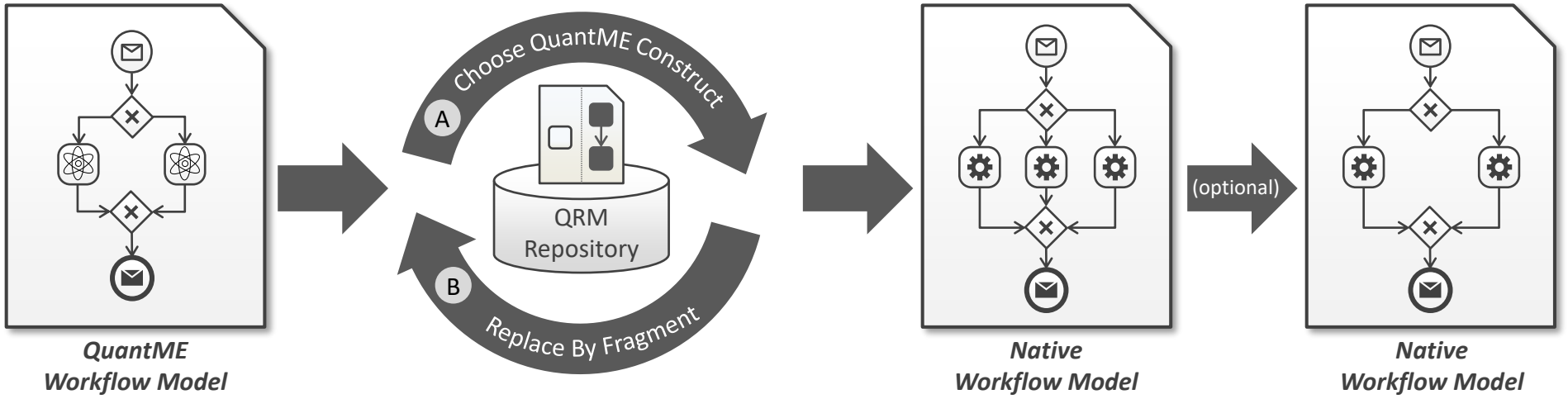

result evaluation task


optimization task

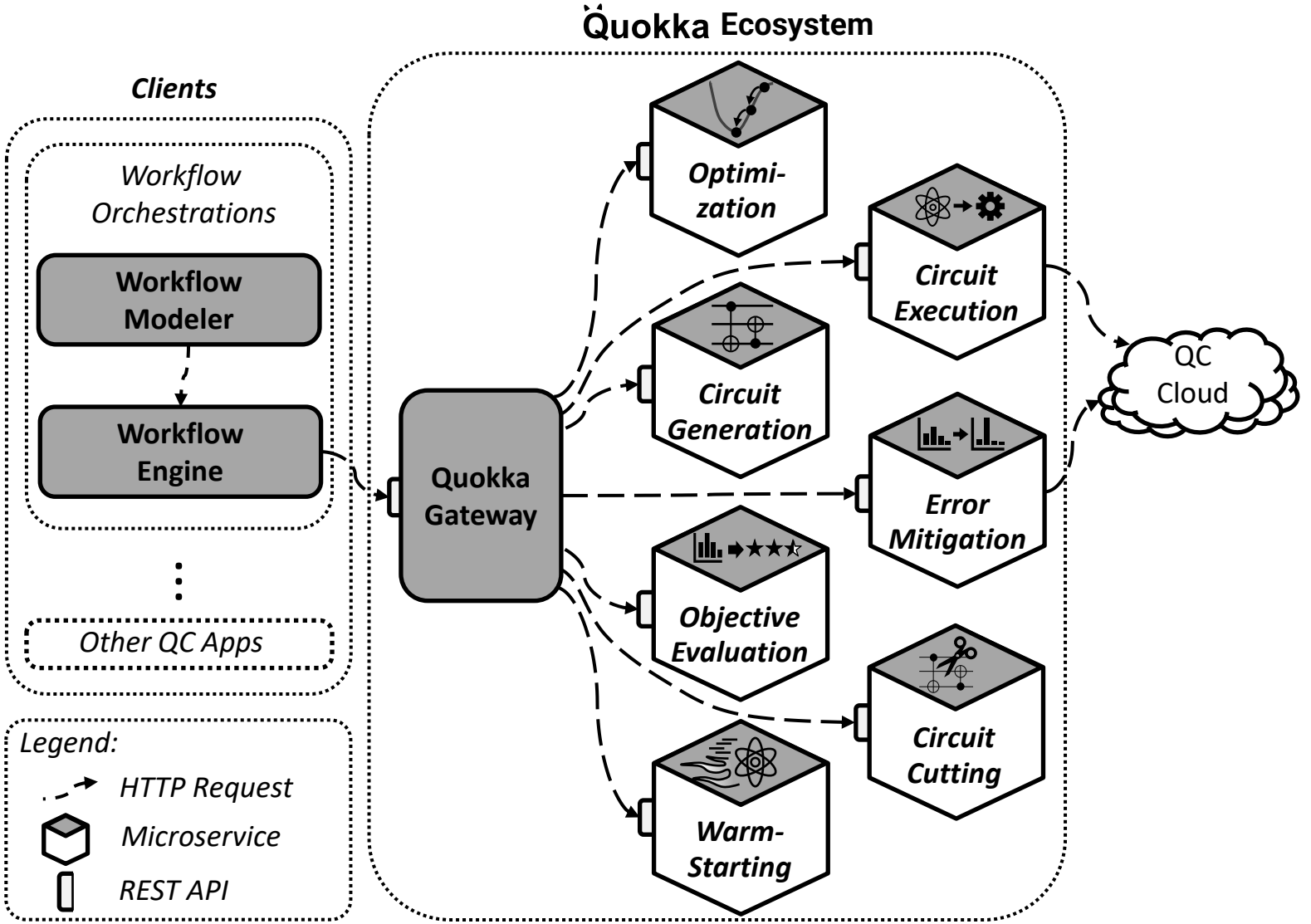

warm-starting task


quantum hardware selection sub-process


circuit cutting sub-process



Quantum Service Ecosystem

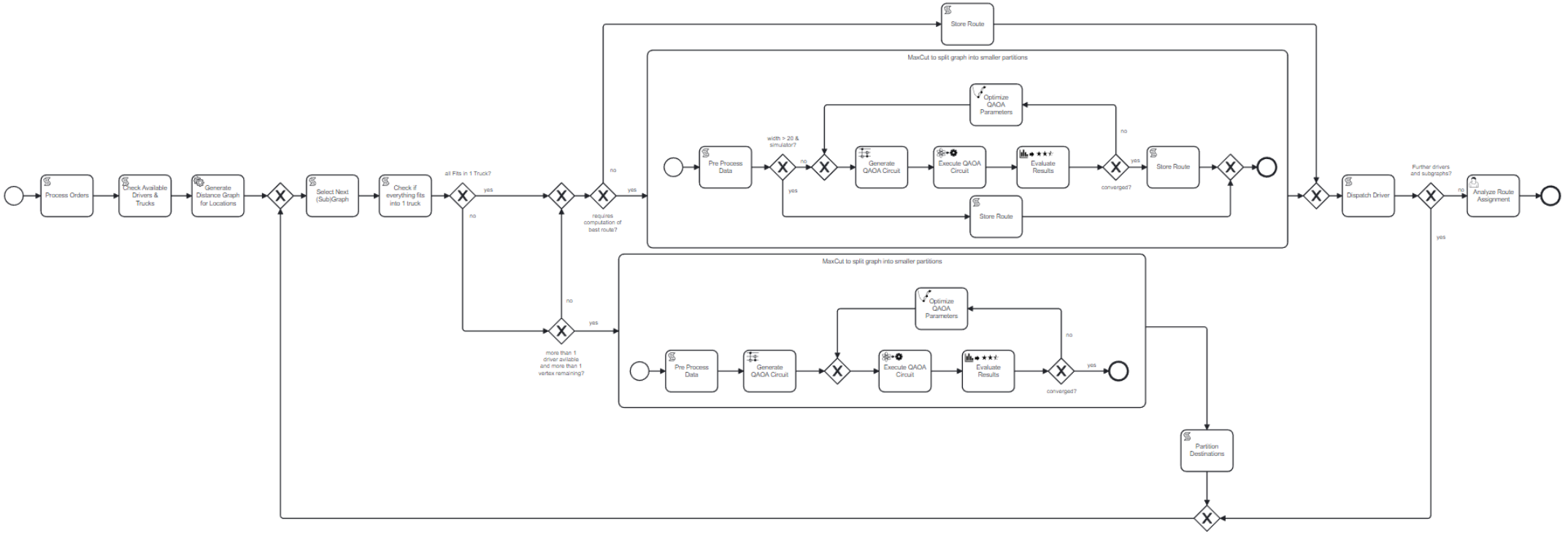


Tutorial Structure

- Session 1 (09:00 - 10:30): An Introduction to Quantum Computing
- Session 2 (11:00 - 12:30): Quantum Software Engineering
- Session 3 (14:00 - 15:30): Quantum Workflows
- **Session 4 (16:00 - 17:30): Operation of Hybrid Quantum Applications**

Hands-On Session: Route Planning for Package Delivery Drivers

- Hybrid Quantum Application:
  - MaxCut and TSP solved using variational quantum algorithms
  - Additional classical pre- and post-processing steps



Hands-On Session: Route Planning for Package Delivery Drivers

- Resulting routes for 3 drivers and 10 destinations:

Thanks for your participation!