Industry 4.0/5.0-Compliant Quantum LAN (qLAN) – Proposal Document

# 1. Introduction

This proposal outlines the architecture and design of a Quantum LAN (qLAN) system tailored for Industry 4.0/5.0 environments. The system integrates quantum and classical computing resources, enabling secure, scalable, and efficient execution of workloads across enterprise campuses, research labs, and cyber-physical systems.

# 2. Architecture Overview

The qLAN is designed to support real-time hybrid execution across zones, providing a backbone for quantum experimentation, industrial optimization, edge analytics, and AI integration. The architecture is modular, scalable, and compliant with NIST security frameworks and Industry 4.0/5.0 standards.

# 3. Text-Based Architecture Block Diagram

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 INDUSTRY 4.0/5.0 COMPLIANT QUANTUM LAN (qLAN)  
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1. USER INTERACTION ZONE  
 - Users: Business Analysts | Scientists | Engineers | Managers  
 - Interfaces: Dashboards | QaaS Portals | Experiment Consoles | APIs  
 - Tools: React.js | Grafana | Streamlit | REST APIs  
 - Output: Workload Definitions | Role-based Queries | Visualizations  
  
2. HYBRID WORKLOAD ROUTER & QPU SCHEDULER  
 - Functions: Parse workloads, schedule jobs, enforce access/security  
 - Tools: Kubernetes | Qiskit Runtime | FastAPI  
 - Input/Output: Workload definitions → Routed jobs and metadata  
 - Metrics: Scheduler latency, job queue length  
  
3. QPU EXECUTION & DISTRIBUTED LAYER  
 - Subsystems: On-prem QPUs, Emulators, Cloud QPU connectors  
 - Tools: Qiskit | Cirq | Braket | NetSquid  
 - Metrics: QPU utilization, error rate, fidelity  
  
4. CLASSICAL-CONTROL & MONITORING BUS  
 - Tools: SDN Controller | MQTT | Prometheus  
 - Function: Route control commands, monitor I/O and interfaces  
  
5. CYBER-PHYSICAL SYSTEMS (CPS) ZONE  
 - Integration: IoT Devices, Edge ML, Time Sensors  
 - Tools: OPC-UA | ROS 2 | TwinMaker  
 - Metrics: Latency, feedback loop efficiency  
  
6. SECURITY, IDENTITY & PRIVACY LAYER  
 - Frameworks: NIST PQC, BB84, TLS 1.3, SP 800-207  
 - Tools: Role-based ZTA | Session Key Management  
  
7. STORAGE, METRICS & KNOWLEDGE REPOSITORY  
 - Storage: Classical DB | Quantum logs | Datasets  
 - Tools: PostgreSQL | MLflow | MinIO  
 - Metrics: Reproducibility, data integrity

# 4. Python-Based qLAN Workload Simulator

Below is a Python-based simulator for executing workloads across zones using dummy SDKs, designed for Colab:

# qLAN Simulator  
users = { "Alice": {...}, ... }  
workloads = [ {"name": "VQE\_Molecule", "type": "quantum", ...}, ... ]  
  
def dispatch\_workload(workload):  
 ...  
def execute\_quantum\_job(zone): ...  
def execute\_classical\_job(zone): ...  
def log\_result(...): ...  
  
for workload in workloads:  
 dispatch\_workload(workload)

# 5. Expected Outcomes

- Real-time quantum-classical co-processing for industrial use cases.  
- Secure experimentation environment for quantum optimization and simulation.  
- Interoperable, compliant, and scalable LAN system for R&D and production.  
- Role-based access for multi-stakeholder collaboration.  
- Continuous metrics collection for performance and security assurance.