Industrial IoT in the Quantum Age: Machine Learning and Cryptography for Secure Operations

Presenter: Esmot Ara Tuli

9Th Sep

Who AM I

Esmot Ara Tuli

Kumoh National Institute of Technology

Post Doctoral Researcher at ICT-Convergence Research Center

Metaverse, Quantum Machine Learning, Blockchain, Quantum Cryptography

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Introduction

- IIoT Security
- Basic ideal about QML and application in IIoT
- Quantum security in IIoT and others+

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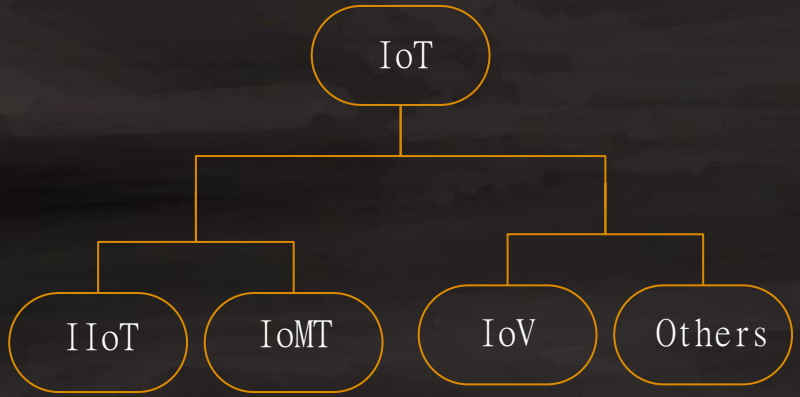
IIoT

Internet of Things (IoT)

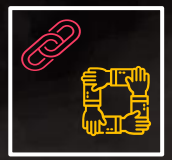


IIoT Requiremnt

1. Security
2. Reliability
3. Mission Critical
4. Organization Standard
5. And Others

IIoT Enabling Technologies


Cyber-physical system (CPS)


Blockchain


Cloud Computing


Internet of Things (IoT)


Machine-to-Machine Communication (M2M)


Artificial Intelligence(AI)


Big Data and Data Analytics


Digital-Twins

M. Alabadi, A. Habbal and X. Wei, "Industrial Internet of Things: Requirements, Architecture, Challenges, and Future Research Directions," in IEEE Access, vol. 10, pp. 66374-66400, 2022, doi: 10.1109/ACCESS.2022.3185049.

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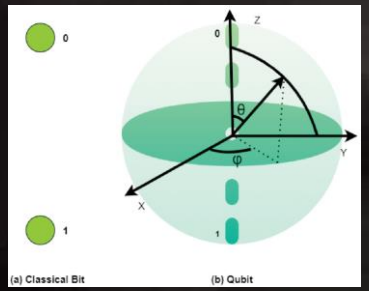
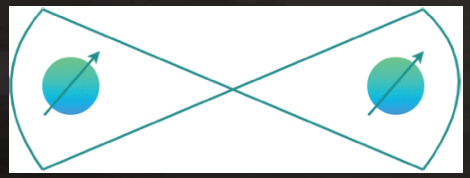
Quantum Computing

Quantum Bits(qubits)



Entanglement



Superposition

Quantum Computing Methods

Gate-Based: IBM, Google, Rigetti

Quantum Annealing: D-Wave

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Quantum ML

Quantum ML in IIoT

1. Cyber Security
2. Sensor Data Processing
3. Predictive Maintanance
4. Analytics and Decision-Making

Quantum ML

Quantum Neural Networks[1]

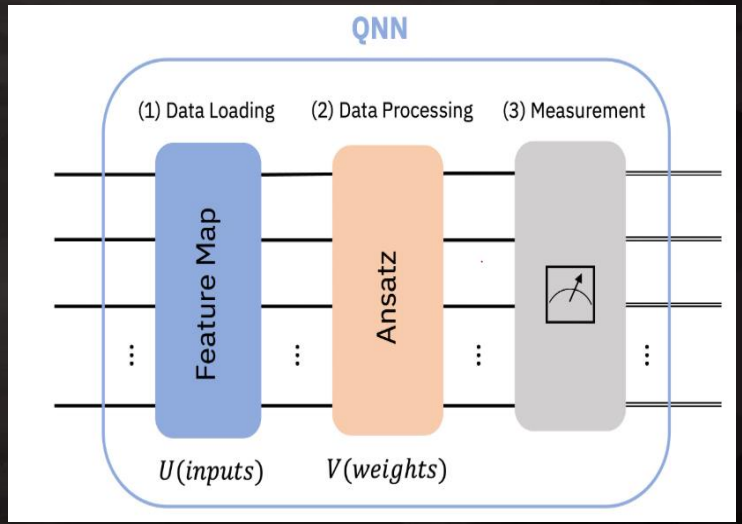
Quantum Neural Networks

Quantum Kernel Machine Learning

Quantum Generative Adversarial Network

Quantum Convolution Neural Network

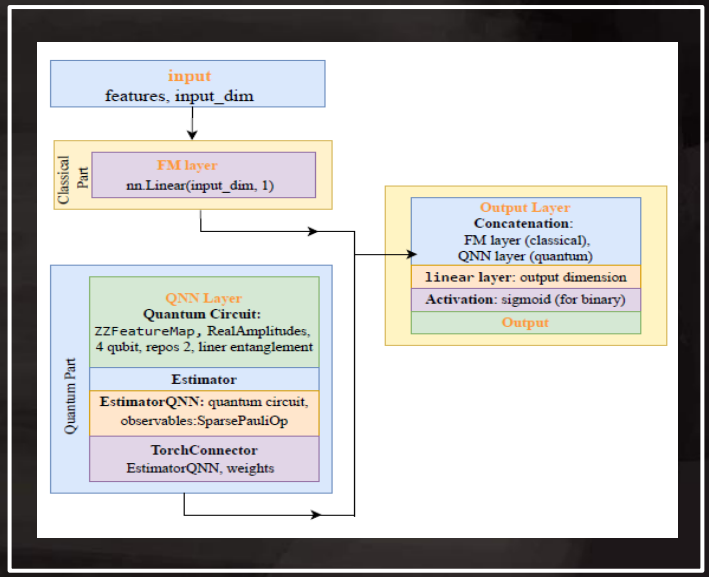
Hybrid QNN



1 https://qiskit-community.github.io/qiskit-machine-learning/tutorials/01_neural_networks.html

Hybrid Quantum Machine Learning

- Classical: factorization machine (FM) layers & Quantum: quantum neural networks (QNNs)
- TorchConnector used to concatenate



E. A. Tuli, M. Golam, M. M. H. Somrat, R. Khafagy, and D.-S. Kim,"Hybrid Quantum Machine Learning for Detecting GPS Spoofing Attacksin Military Mission", 2025, Cebu, Philippines.

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Cryptography

1. Substitution Cipher

2. Public Kay Cryptography (Rivest-shamir-Adleman)

3. Digital Signature Algorithm

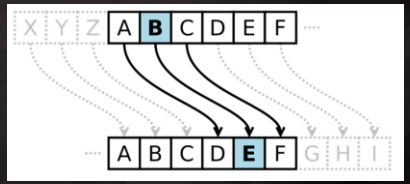

Fig: Simple substitution cipher

- Quantum Key Distribution (QKD: BB84, B92, E91)
- Quantum Digital Signatures (QDS)
- Quantum Secret Sharing (QSS)
- Quantum Multiparty Secret Computation (QMSC)

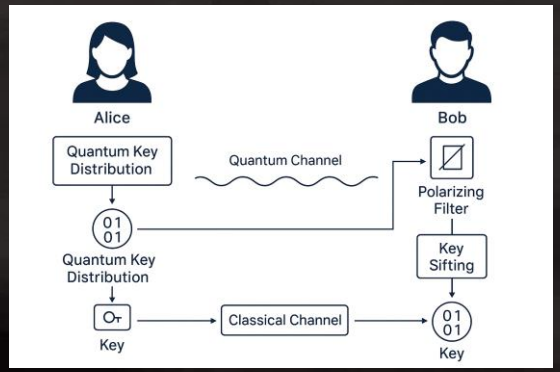

Fig: Quantum Key Distribution

Example

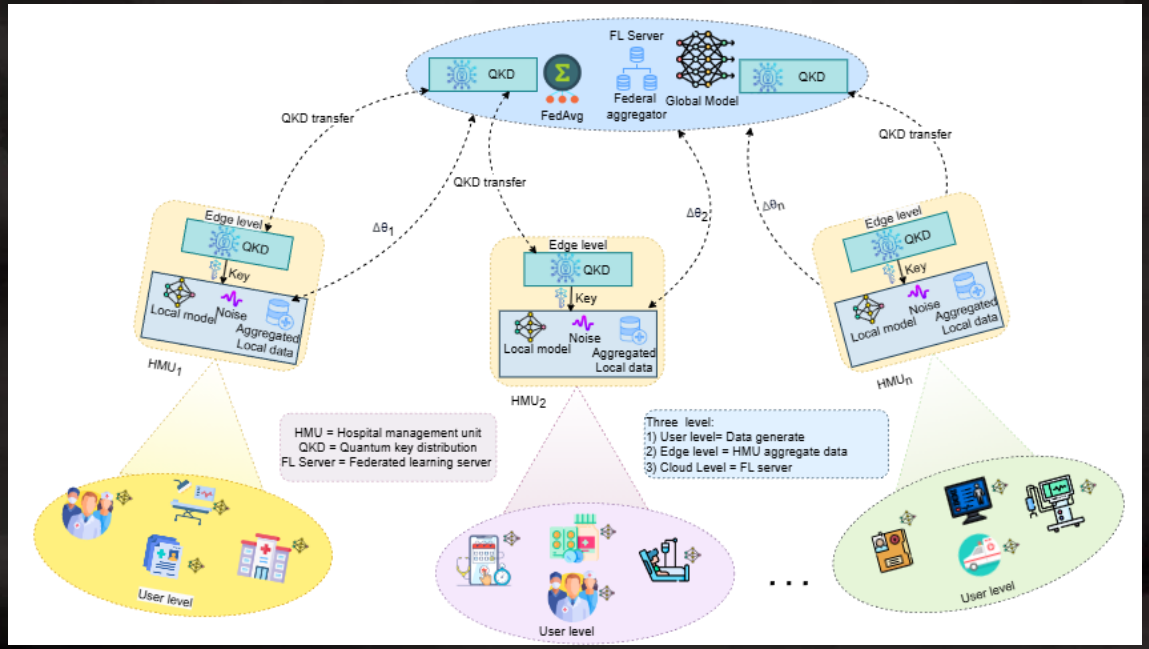

Fig: Framework of Proposed Federated Quantum Mechanism for Secure IoMT Ecosystem using QKD.

Example

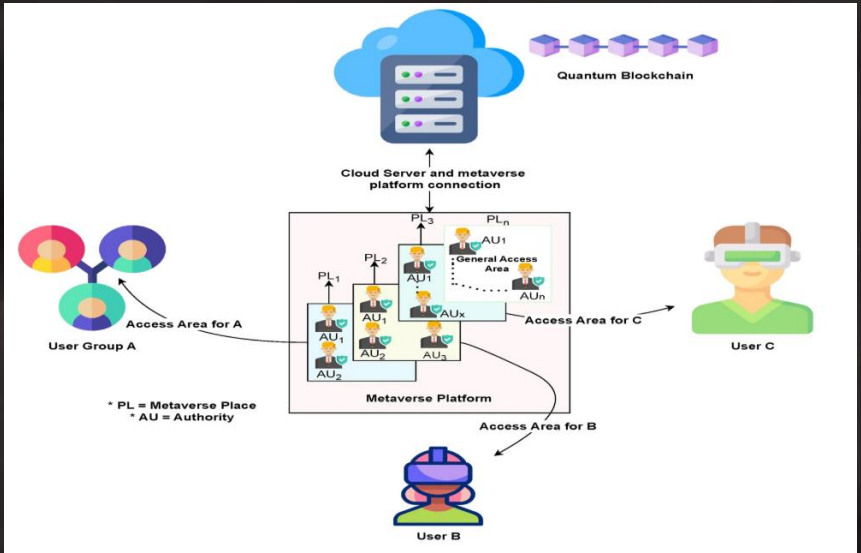

Fig: Overall system architecture for secure multiparty space sharing and authentication (MSSA) using Quantum Multiparty Secret Computation .

06 Research Direction

Research Direction

Security

For quantum and classical attack safe IIoT

Efficient Communication

Mission critical ultra reliable and THz Communication

Predictive Maintanance

Quantul ML, quantum sensor for noisy industrial data

Blockchain

Quantum cryptography enable secure blockchian

Digital Twin

For better decision in factory and supply chain, energy grids

Optimization

Accelerate scheduling, resource allocation, routing

Thank You for Listning

Q & A!

Mail Me:

tuli.cse.bd@gmail.com
or
esmot@kumoh.ac.kr