QuantumCare - AI and Quantum Based Hospital System

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***Abstract*--Hospitals must coordinate limited resources such as intensive care unit (ICU) beds, doctors, nurses, operating rooms and ambulances. During emergencies, delays in identifying patient priority and assigning available resources may affect hospital operations. This paper proposes QuantumCare, a conceptual smart hospital resource scheduling and recommendation framework combining Artificial Intelligence (AI) with hybrid quantum-classical optimization. Classical computing is used for data processing, patient priority assessment and resource availability checking. AI-based modules are proposed for patient priority prediction, suitable hospital recommendation and ambulance arrival-time estimation. For resource allocation, the framework proposes the Quantum Approximate Optimization Algorithm (QAOA), in which a quantum circuit explores candidate solutions and a classical optimizer updates circuit parameters. The scheduling problem can be represented using binary decision variables and a quadratic objective with penalty terms for constraints such as resource capacity, availability and assignment conflicts. A validation stage checks whether the generated schedule satisfies defined requirements before it is presented to hospital staff. This paper describes the proposed architecture, workflow, optimization formulation, evaluation plan and limitations. It is a design proposal; no clinical deployment, measured performance improvement or experimental result is claimed.**

Keywords— Artificial Intelligence, Quantum Computing, Hospital Resource Scheduling, QAOA, ICU Bed Allocation, Doctor Scheduling, Ambulance Allocation, Healthcare Optimization.

I. INTRODUCTION

Hospitals operate in an environment where patient needs and resource availability can change quickly. Emergency departments may receive several patients at the same time, while the number of available ICU beds, doctors, nurses, ambulances and medical equipment is limited. Hospital staff must consider patient urgency, staff availability, resource capacity and operational constraints before making allocation decisions.

In many settings, these decisions depend on manual coordination or separate information systems. Information about beds, doctors and ambulances may not be available in one place or may not be updated at the same time. This can make it difficult to identify a suitable hospital or prepare a coordinated resource schedule. A decision-support system can help organize information and present possible allocation plans to authorized staff.

Artificial Intelligence can support tasks such as classifying patient priority from approved input data, identifying suitable hospitals based on available facilities and estimating ambulance arrival time. However, prediction and recommendation alone do not solve the allocation problem. When multiple patients compete for limited resources, the system must also consider combinations of assignments and constraints.

QuantumCare proposes a hybrid approach. Classical computing handles data preparation, priority assessment and availability checks. A quantum optimization component based on QAOA is proposed for exploring resource-allocation solutions. The system is intended to support—not replace—medical professionals and hospital administrators.

A. Problem Context

The central problem addressed by QuantumCare is the coordinated allocation of limited hospital resources under changing conditions. A suitable schedule should respect resource availability, staff capacity, patient priority and assignment rules. Hospital recommendations should explain which available facilities make a hospital suitable for a particular case. The quality of a schedule depends on accurate and up-to-date input information.

B. Research Objectives

- To propose an integrated framework for hospital resource scheduling and recommendation.
- To use AI-based methods for patient priority assessment, hospital recommendation and ambulance ETA estimation.
- To formulate ICU bed, doctor and ambulance allocation as an optimization problem.
- To explore QAOA as a hybrid quantum-classical method for generating candidate resource schedules.
- To validate generated schedules against availability, capacity and conflict constraints.
- To define an evaluation plan comparing the proposed approach with conventional scheduling methods.

II. RELATED WORK AND LITERATURE REVIEW

Research in quantum computing and healthcare optimization provides the background for the proposed framework. The selected studies cover foundational quantum computing, QAOA-based optimization, healthcare applications and transportation-related quantum computing. Their contributions are used as design motivation; they do not establish the performance of QuantumCare itself.

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A. Quantum Computing Fundamentals

Bhat et al. [1] discuss the fundamentals, implementations and applications of quantum computing. Concepts such as qubits, quantum gates and measurement provide the basic knowledge required to understand quantum algorithms. This work supports the quantum-computing component of the proposed framework.

B. Quantum-Assisted Optimization in Healthcare

Waseem, Epiphaniou and Maple [2] discuss a hybrid quantum-classical architecture for trustworthy AI-driven healthcare. Their work considers optimization and security-related healthcare applications and provides relevant background for combining classical processing with quantum optimization. QuantumCare adopts the general hybrid-computing idea for hospital resource scheduling; it does not claim to reproduce every method in that paper.

C. QAOA for Resource Allocation

Kołota [3] studies a QAOA-based approach to resource allocation in database systems. Although database allocation differs from hospital scheduling, both problems involve assigning limited resources while considering constraints. This work motivates investigating QAOA for a hospital scheduling formulation.

D. Quantum Computing in Transportation

Zhuang et al. [4] survey quantum computing applications in intelligent transportation systems. Transportation problems include routing and scheduling considerations. This area is relevant to ambulance allocation and route-related aspects of QuantumCare, although ambulance ETA estimation is treated as a separate prediction task.

E. AI and Quantum Approaches for Healthcare Resource Management

Damodaran et al. [5] discuss AI and quantum-computing approaches for healthcare resource allocation and emergency response. This topic is closely related to the motivation of QuantumCare. Complete bibliographic details for this reference must be checked against the original publication before submission.

F. Research Gap

The reviewed literature motivates AI for healthcare decision support and quantum optimization for constrained allocation problems. The proposed research direction is to bring patient-priority information, hospital suitability and resource scheduling into one conceptual workflow. The framework emphasizes validation and human review so that a generated schedule is not treated as an automatic medical decision. The integrated QuantumCare design remains a proposal and requires implementation and evaluation.

III. PROPOSED QUANTUMCARE FRAMEWORK

QuantumCare is designed as a modular decision-support framework. It receives patient and hospital information, processes the information through classical and AI-based components, formulates an allocation problem and sends the optimization model to a QAOA-based module. The output is checked against constraints and displayed to authorized users.

A. Main Functional Modules

Module	Main Function	Expected Output
Patient Information	Collect patient details and emergency information.	Structured patient record
AI Priority Assessment	Estimate urgency using a trained model and approved input features.	Priority category for staff review
Hospital Recommendation	Compare patient needs with hospital facilities and resources.	Suitable-hospital suggestions
Resource Availability	Check ICU beds, doctors, nurses and ambulances.	Availability information
QAOA Optimization	Explore candidate assignments for the scheduling objective.	Candidate allocation schedule
Validation and Dashboard	Check constraints and display results to authorized staff.	Validated schedule and status

Table. 1. Main functional modules of QuantumCare.

B. Hybrid Quantum-Classical Architecture

The architecture contains five logical layers. The user-interface layer allows authorized hospital users to enter information and view recommendations. The data-management layer stores resource and availability information. The classical processing layer validates inputs, performs AI-based assessment and prepares the optimization problem. The quantum optimization layer executes the QAOA circuit through a simulator or supported quantum platform. The validation and result layer checks the candidate schedule and presents it for human review.

- User Interface Layer: Receives patient and scheduling information and displays results.
- Data Management Layer: Maintains information about beds, doctors, nurses, operating rooms, equipment and ambulances.
- Classical Processing Layer: Performs input validation, AI-based assessment, resource checking and QUBO formulation.
- Quantum Optimization Layer: Uses QAOA to generate candidate solutions through a hybrid quantum-classical process.

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• Validation and Result Layer: Checks constraints, identifies conflicts and displays feasible schedules and reports.

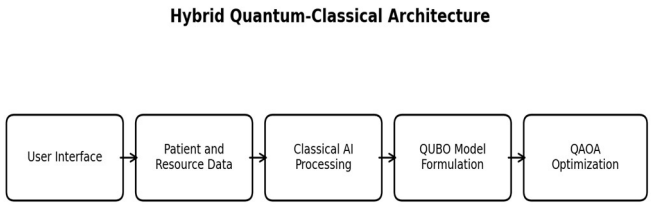


Fig. 1. Hybrid quantum-classical architecture of the proposed QuantumCare system.

C. Proposed Workflow

The workflow begins when patient information is entered into the system. The classical layer validates the information and the AI module estimates patient priority. The system checks hospital resources and prepares suitable hospital recommendations. Based on the selected hospital and current availability, the scheduling problem is formulated. QAOA generates candidate assignments for ICU beds, doctors and ambulances. A validation module checks the assignments against defined constraints. The final schedule is shown to authorized hospital staff, who can review and approve the decision.

- START: Patient registration and information entry
- Input validation and AI-based patient priority assessment
- Check hospital facilities and resource availability
- Recommend a suitable hospital
- Formulate the resource-allocation optimization problem
- Run QAOA and obtain candidate resource assignments
- Allocate ICU bed, doctor and ambulance subject to constraints
- Validate schedule and identify conflicts
- Display results and notify authorized hospital staff
- END

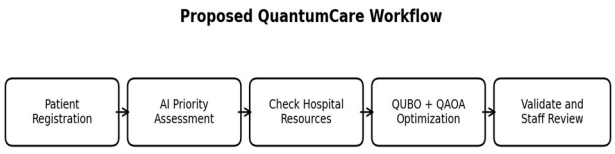


Fig. 2. Proposed workflow for patient assessment and resource allocation.

IV. QAOA-BASED RESOURCE OPTIMIZATION

The Quantum Approximate Optimization Algorithm (QAOA) is a hybrid quantum-classical algorithm designed to find approximate solutions to combinatorial optimization problems. It uses a parameterized quantum circuit and a classical optimizer in an iterative process. QuantumCare proposes QAOA for the allocation stage because hospital scheduling can involve many possible assignments and constraints.

A. Optimization Variables

A scheduling model can define binary decision variables. For example, a variable may indicate whether patient i is assigned to ICU bed j, doctor k or ambulance m. A value of 1 represents a selected assignment and 0 represents no assignment. The model must include only assignments allowed by current resource and operational information.

B. Objective Function and Constraints

A possible objective is to minimize a weighted scheduling cost. The cost may include waiting time, mismatch between patient needs and resource capabilities, unnecessary resource use and assignment conflicts. Penalty terms can be added for violations of hard constraints. Examples include assigning one bed to more than one patient at the same time, assigning an unavailable doctor, or allocating an ambulance that is already occupied.

A simplified QUBO form is:

Minimize $E(x) = x^T Qx$ + penalty terms

Here, x is a vector of binary decision variables and Q represents objective coefficients. Penalty terms discourage invalid assignments.

C. Working Steps of QAOA

Convert the scheduling problem into a binary optimization model.

- Encode the objective and constraints into a cost Hamiltonian.
- Prepare an initial quantum state and apply parameterized cost and mixer operations.
- Measure the quantum circuit to obtain candidate binary solutions.
- Evaluate candidate solutions using the classical objective function.
- Update circuit parameters using a classical optimizer and repeat the process.
- Select a candidate that satisfies the constraints and validate it before presentation.

QAOA does not automatically guarantee the globally optimal schedule, and quantum computing is not faster for every problem. Its usefulness must be tested for the selected scheduling model and compared with suitable classical optimization methods.

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V. AI COMPONENTS

A. Patient Priority Assessment

The patient priority module is intended to analyze selected patient information and estimate an urgency category. Categories may be defined by the hospital, for example emergency, urgent and normal. The model must be trained and evaluated using suitable, authorized and representative data. Its output should support clinical staff and must not replace medical diagnosis or professional triage.

B. Hospital Recommendation

The hospital recommendation module compares patient requirements with available hospital facilities and resources. Factors may include required specialty, ICU availability, equipment availability, distance and current capacity. The system can present suitable options with reasons for each recommendation.

C. Ambulance ETA Estimation

The ambulance ETA module estimates expected arrival time using available information such as current location, destination and route conditions, where such data is available. The estimate may change because of traffic, road closures or other events. Therefore, ETA should be displayed as an estimate and updated when new information becomes available.

VI. EVALUATION PLAN

The proposed framework has not yet been experimentally validated in this paper. A future evaluation should use realistic or appropriately anonymized hospital scheduling data and compare the proposed approach with a conventional scheduling baseline. The evaluation should report the dataset, assumptions, constraints, hardware or simulator configuration, QAOA parameters and baseline methods.

Evaluation Parameter	**Purpose**
Resource utilization	Measures how effectively available resources are assigned.
Patient waiting time	Measures time between request and resource assignment.
Schedule feasibility	Checks whether generated schedules satisfy all constraints.
Allocation conflicts	Counts conflicting or invalid resource assignments.
Optimization runtime	Measures time required to generate a candidate schedule.
Solution quality	Compares objective values with classical baseline methods.
ETA error	Measures the difference between estimated and observed ambulance arrival time, if records are available.

Table. 2. Proposed evaluation parameters.

VII. IMPLEMENTATION CONSIDERATIONS

A possible implementation may use React.js for the user interface, Python with FastAPI for backend services, PostgreSQL for structured data storage and Scikit-learn for selected machine-learning models. Qiskit may be used to build and test QAOA circuits on a simulator or supported quantum service. GPS and a maps service may support location display and route information. These technologies are proposed options; the final paper should identify which components have actually been implemented and tested.

The system should protect patient information through access control, secure communication, data minimization and appropriate audit records. Access to sensitive patient information must be limited to authorized users. The system should also handle missing, outdated or conflicting resource data safely and clearly show when a recommendation cannot be generated reliably.

VIII. LIMITATIONS AND ETHICAL CONSIDERATIONS

The proposed framework depends on accurate and updated hospital data. Incorrect bed status, incomplete patient information or unavailable staff records may lead to unsuitable recommendations. AI predictions may contain bias if training data are not representative. Quantum optimization results depend on how the scheduling problem is formulated, the selected parameters and the available quantum simulator or hardware. Small-scale simulation results, if later obtained, should not be presented as proof of clinical benefit.

QuantumCare is intended as a decision-support system. Medical triage, patient treatment and final resource assignment must remain under the responsibility of qualified hospital professionals. Any future clinical use would require appropriate validation, privacy safeguards, regulatory review and approval from relevant institutions.

IX. CONCLUSION AND FUTURE WORK

This paper proposed QuantumCare, a conceptual framework that combines AI-based patient assessment and hospital recommendation with QAOA-based resource optimization. Classical computing is used for data processing, availability checking and preparation of the optimization problem, while the quantum-classical component explores candidate assignments for ICU beds, doctors and ambulances.

The proposed framework is motivated by research on quantum computing, QAOA, healthcare optimization and intelligent transportation. Its contribution is an integrated design proposal for hospital resource scheduling and recommendation, rather than a claim of a new quantum algorithm or a clinically validated product. Future work will include defining the exact

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optimization model, preparing suitable datasets, implementing the AI and QAOA modules, testing on a quantum simulator, comparing against classical methods and evaluating the system with domain experts.

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