CSC 675 - Project Documentation

Spring 2024

Hospital Management System

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CSC675-02

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Checkpoint #	***Date Submitted***
Checkpoint 1	*2/20/2024*
Checkpoint 2	*05/03/2024*

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I. Project Description

The development of my hospital management database system is motivated by the urgent need to address several issues faced by healthcare institutions today. Key among these challenges are managing rapidly evolving medical information, overwhelming data reporting requirements, integrating burgeoning telehealth platforms, and navigating the complex logistics of vaccine distribution, this project seeks to address these multifaceted issues head-on. My project aims to tackle these problems, transforming the way hospitals manage and utilize their data to facilitate better public health responses, ensure continuity of care across various service delivery modes, and enhance infection control measures, all while supporting the well-being of healthcare workers and patients alike in a post-pandemic world.

At a high level, my database system is designed as a comprehensive, user-friendly platform that centralizes and simplifies the management of complex medical data. It is intended to serve as the backbone of a hospital's information system, facilitating seamless access to patient records, treatment histories, diagnostic information, and other critical data. The system will support real-time data updates and retrieval, ensuring that healthcare providers have instant access to the information they need to make informed decisions.

Unique features of my database system will include advanced data analytics capabilities, enabling hospitals to derive actionable insights from their data for improved patient outcomes and operational efficiencies. We will implement state-of-the-art security measures, including encryption and role-based access control, to protect sensitive patient information. My system will also feature robust interoperability solutions, allowing for seamless integration with existing software tools and healthcare systems, ensuring that hospitals can leverage their current technology investments. Additionally, the system will include scalable architecture to accommodate growing data volumes and a comprehensive disaster recovery plan to safeguard against data loss.

Two existing software tools that would greatly benefit from integrating with my database system are Electronic Health Records (EHR) systems and Laboratory Information Management Systems (LIMS). EHR systems, such as Epic or Cerner, would benefit from my advanced data analytics and interoperability features, enhancing their ability to provide comprehensive patient histories and support clinical decision-making. The seamless integration with my database would allow for more efficient data management and real-time updates, improving the quality of patient care. Laboratory Information Management Systems, like LabWare or STARLIMS, would benefit from my system's robust data integrity and real-time data access features. My database system would ensure accurate and timely sharing of laboratory results with clinicians, streamlining diagnoses and treatment planning while maintaining high standards of data security and privacy.

In summary, my hospital management database system project is poised to revolutionize the management of healthcare data, addressing critical issues faced by hospitals today and paving the way for a more integrated, efficient, and secure healthcare future.

II. Functional Database Requirements

For the Hospital Management System (HMS), functional database requirements are crucial to ensure that the system effectively meets the needs of its users, including patients, doctors, nurses, administrative staff, and other stakeholders. These requirements will cover a range of operations and relationships within the database, ensuring comprehensive coverage of hospital operations. Here's a detailed list, grouped by the entity that performs the action:

1. Hospital

a. A hospital shall have many patients.
b. A hospital shall have many employees.
c. A hospital shall have at least one department.

2. Department

a. A department shall belong to one hospital.
b. A department shall have at least one employee.
c. A department shall be managed by one employee.
d. A department shall have multiple pieces of equipment.

3. Employee

a. An employee in a hospital is a doctor, nurse, receptionist, pharmacy staff, or an inventory manager.
b. An employee shall belong to one and only one department.
c. An employee shall have only one work schedule.
d. An employee shall manage only one department.

4. Doctor

a. A doctor is an employee of a hospital.
b. A doctor shall manage multiple appointments.
c. A doctor belongs to one and only one department.
d. A doctor shall be able to manage multiple medical records.

5. Nurse

a. A nurse is an employee of a hospital.
b. A nurse shall take care of multiple patients.
c. A nurse can manage multiple appointments.

6. Patient

a. A patient shall manage multiple appointments.
b. A patient shall have at least one medical record.
c. A patient shall have multiple insurance records.
d. A patient shall have multiple insurance plans.
e. A patient shall be assigned to be taken care of by one nurse.

7. Medical Record

a. A medical record must belongs to one patient only.
b. A patient's medical record can be associated with at most an insurance record.
c. A medical record shall be managed by at most one doctor.
d. A medical record shall have many prescriptions.

8. Appointment

a. An appointment shall have a specific date, time, and doctor.
b. An appointment can be managed by a patient, doctor or a nurse.
c. An appointment can request multiple pieces of equipment.

9. Equipment

a. Equipment shall belong to at most one department.
b. Equipment shall be managed by an inventory manager.
c. Equipment shall be booked for at most appointment at a time.

10. Insurance record

a. An insurance record shall be associated with one and only one patient's medical record.
b. An insurance record shall be associated with at most one insurance plan.
c. An insurance record shall be associated with one and only one patient.

11. Insurance plan

a. An insurance plan can be bought by many patients.
b. An insurance plan shall be associated with at least one insurance record.
c. An insurance plan shall have the coverage date information.

12. Medication

a. A medication can be assigned to multiple prescriptions.
b. A medication can have one or more side effects.
c. A medication must have expiration date.

13. Prescription

a. A prescription is associated with one and only one a medical record.

b. A prescription shall have multiple medications.
c. A prescription must include a doctor and a patient.

14. Pharmacy Staff

a. A pharmacy staff is an employee in a hospital
b. A pharmacy staff shall manage multiple medications.
c. A pharmacy staff shall fulfill many prescriptions.

15. Receptionist

a. A receptionist is an employee of a hospital.
b. A receptionist shall be able to manage appointments.
c. A receptionist shall be able to check patients in and out.

16. Inventory Manager

a. An inventory manager is an employee of a hospital.
b. Inventory managers shall be able to manage many pieces of equipment.
c. Inventory managers shall be able to reorder supplies as needed.

This comprehensive set of functional database requirements is designed to ensure that the Hospital Management System is capable of managing complex relationships and operations, enhancing the efficiency and quality of healthcare services provided.

III. Non-functional Database Requirements

1. Performance

a. The HMS database shall support simultaneous access by multiple users without performance degradation.
b. Query response times shall not exceed 2 seconds under normal operation conditions.
c. The database should optimize data retrieval operations to minimize latency for frequently accessed data.
d. System performance metrics shall be continuously monitored to proactively address potential bottlenecks.

2. Security

a. All patient data shall be encrypted both at rest and in transit.
b. Access to sensitive data is restricted based on user roles and authenticated via multi-factor authentication.
c. The database system shall implement regular vulnerability assessments and patch management to protect against known threats.

d. Data input and output should be sanitized and validated to prevent SQL injection attacks and other forms of data tampering.

e. The system shall enforce automatic session timeouts and re-authentication for extended periods of inactivity to prevent unauthorized access.

3. Scalability

a. The database design shall support scaling to accommodate growing data volumes and user counts.

b. Allow individual components to scale independently based on demand.

c. The system can be deployed in a distributed environment to enhance load balancing and data redundancy.

d. Database architecture shall be flexible to support horizontal scaling, including the addition of new servers or clusters as needed.

e. Cloud-based storage solutions shall be evaluated for scalability and flexibility to support dynamic storage needs.

4. Coding Standards

a. Development of the HMS database shall adhere to industry best practices for coding and architecture, including the use of secure coding standards.

b. Code reviews and static code analysis tools shall be employed to ensure code quality and maintainability.

c. Documentation standards shall be established and followed to ensure that the database system is well-documented for developers and administrators.

d. Continuous integration/continuous deployment (CI/CD) pipelines shall be used to automate testing and deployment, ensuring coding standards is consistently applied.

e. Accessibility standards shall be incorporated into the development process to ensure the HMS is usable by all intended users, including those with disabilities.

5. Media Storage

a. The HMS database shall implement efficient storage solutions for large media files, such as medical images and videos, ensuring quick access and retrieval.

b. Media files shall be stored in a secure, encrypted format, with access controls to prevent unauthorized access.

c. The database shall support streaming of media content to authorized users without the need for full file downloads.

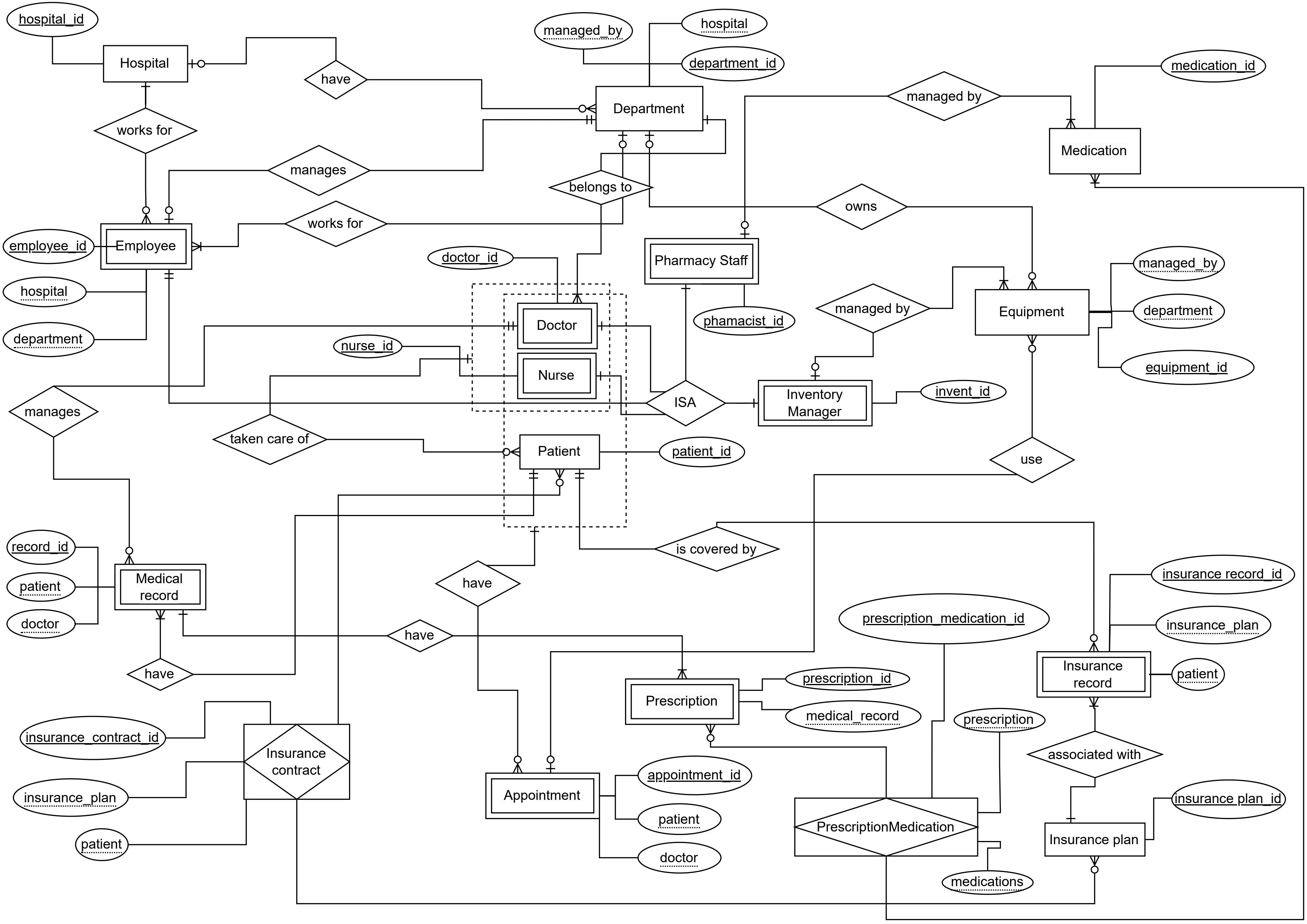
d. Redundancy mechanisms shall be in place for media storage to ensure data integrity and availability in case of system failure.

e. Media storage solutions shall be scalable to accommodate the growing volume of digital media in healthcare records.

6. Privacy

a. The HMS complies with healthcare regulations such as HIPAA for data privacy and security.
b. Patients have the right to access their data and request corrections.
c. The system shall implement the principle of least privilege; ensuring users have access only to the data necessary for their role.
d. Patients shall be informed of how their data is used and have the option to opt-out of data sharing that is not essential for their care.
e. When patient data is used for research, training, or statistical analysis, it shall be anonymized or de-identified to prevent the possibility of re-identification of individuals.

IV. Entity Relationship Diagram (ERD)


hospital_id
Hospital
have
managed_by
hospital
department_id
Department
medication_id
managed by
Medication
works for
manages
belongs to
owns
employee_id
Employee
works for
hospital
department
doctor_id
Doctor
nurse_id
Nurse
Pharmacy Staff
phamacist_id
managed by
Equipment
managed_by
department
equipment_id
ISA
Inventory Manager
invent_id
manages
taken care of
Patient
patient_id
use
is covered by
record_id
patient
doctor
Medical record
have
have
have
insurance record_id
insurance_plan
prescription_medication_id
Insurance record
patient
Prescription
prescription_id
medical_record
prescription
associated with
insurance_contract_id
Insurance contract
insurance_plan
patient
Appointment
appointment_id
patient
doctor
PrescriptionMedication
Insurance plan
insurance plan_id
medications

V. Entity Description

1. Hospital (Strong)

- hospital_id: key, numeric
- name: single value, alphanumeric
- location: composite, alphanumeric

2. Department (Strong)

- department_id: key, numeric
- name: single value, alphanumeric
- hospital_id: foreign key, numeric

3. Employee (Weak)

- employee_id: key, numeric
- name: composite, alphanumeric
- position: single value, alphanumeric

4. Doctor (Weak)

- employee_id: key, numeric
- specialization: single value, alphanumeric
- department_id: foreign key, numeric

5. Nurse (Weak)

- employee_id: key, numeric
- qualifications: multivalue, alphanumeric
- shifts: multivalue, timestamp

6. Patient (Strong)

- patient_id: key, numeric
- name: composite, alphanumeric
- dob: single value, timestamp

7. Medical Record (Strong)

- record_id: key, numeric
- patient_id: foreign key, numeric
- health_information: composite, alphanumeric

8. Appointment (Weak)

- appointment_id: key, numeric
- date_time: single value, timestamp
- patient_id: foreign key, numeric

- doctor_id: foreign key, numeric

9. Equipment (Strong)

- equipment_serial_number: key, numeric
- name: single value, alphanumeric
- status: single value, alphanumeric

10. Insurance Record (Strong)

- insurance_id: key, numeric
- patient_id: foreign key, numeric
- coverage_amount: composite, alphanumeric

11. Insurance Plan (Strong)

- insurance_plan_id: foreign key, numeric
- plan_name: single value, alphanumeric
- coverage_policy: composite, alphanumeric
- insurance_plan_detail: composite, alphanumeric

12. Insurance contract (Associative Entity-Weak)

- insurance_contract_id: key, numeric
- insurance_plan_id: foreign key, numeric
- patient_id: foreign key, numeric
- coverage_start_date: single value, timestamp
- coverage_end_date: single value, timestamp

13. Prescription (Weak)

- prescription_id: key, numeric
- medical_record_id: foreign key, numeric
- administered_by: foreign key, numeric

14. Medication (Strong)

- prescription_id: key, numeric
- name: single value, alphanumeric
- active_ingredient: single value, alphanumeric
- manufacturer: single value, alphanumeric
- expiration_date: single value, date

15. PrescriptionMedication (Associative Entity-Weak)

- prescription_medication_id: key, numeric
- prescription_id: foreign key, numeric

- medication_id: foreign key, numeric
- dosage: single value, alphanumeric
- frequency: single value, alphanumeric

16. Pharmacy Staff (Weak)

- pharmacy_staff_id: key, numeric
- license_number: single value, alphanumeric
- specialization: single value, alphanumeric

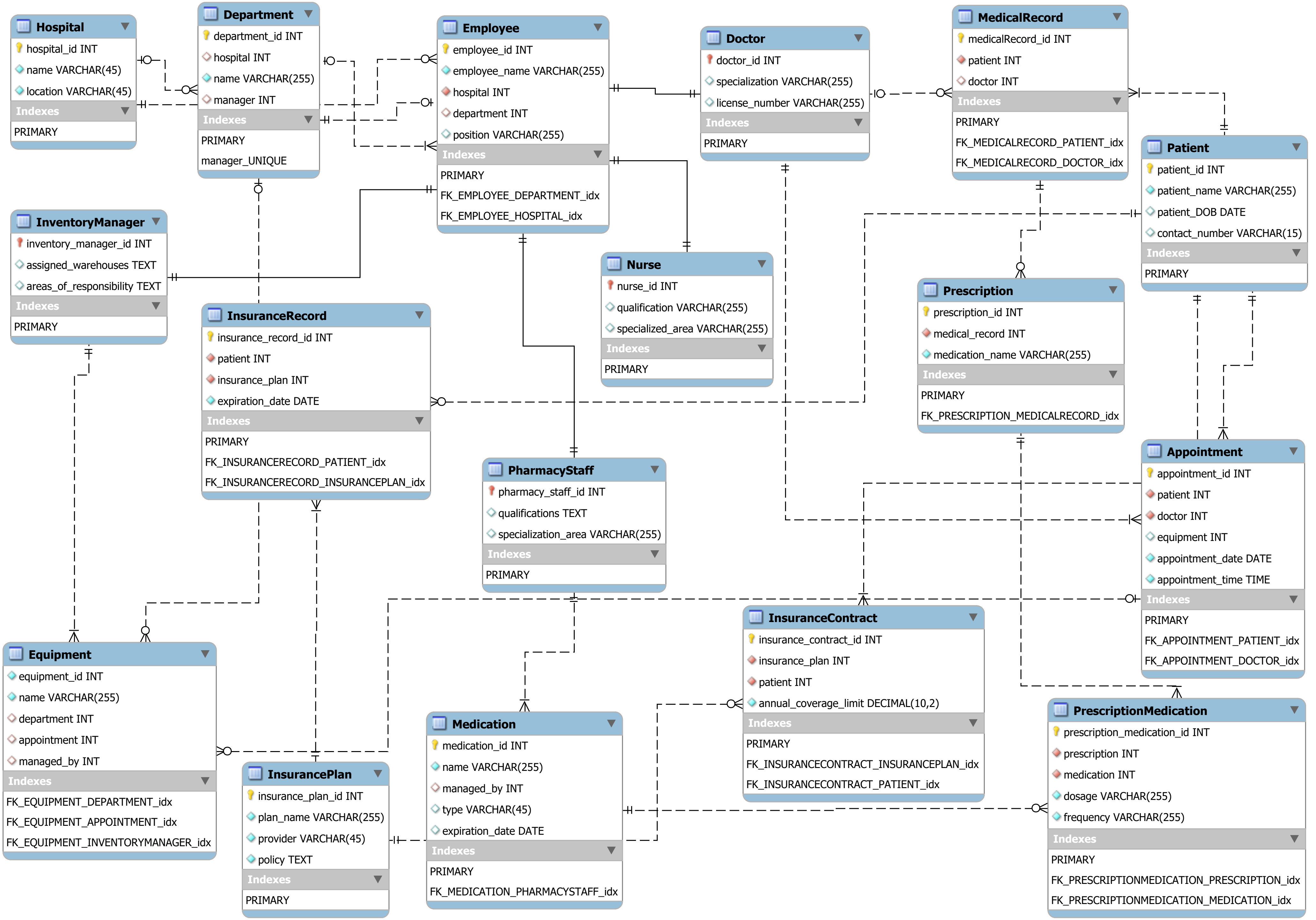
17. Receptionist (Weak)

- receptionist_id: key, numeric
- name: single value, alphanumeric
- contact_number: single value, alphanumeric

18. Inventory Manager (Weak)

- inventory_manager_id: key, numeric
- name: single value, alphanumeric
- contact_email: single value, alphanumeric

VI. Entity Establishment Relationship Diagram (EER)


Hospital
hospital_id INT
name VARCHAR(45)
location VARCHAR(45)
Indexes
PRIMARY
Department
department_id INT
hospital INT
name VARCHAR(255)
manager INT
Indexes
PRIMARY
manager_UNIQUE
Employee
employee_id INT
employee_name VARCHAR(255)
hospital INT
department INT
position VARCHAR(255)
Indexes
PRIMARY
FK_EMPLOYEE_DEPARTMENT_idx
FK_EMPLOYEE_HOSPITAL_idx
Doctor
doctor_id INT
specialization VARCHAR(255)
license_number VARCHAR(255)
Indexes
PRIMARY
MedicalRecord
medicalRecord_id INT
patient INT
doctor INT
Indexes
PRIMARY
FK_MEDICALRECORD_PATIENT_idx
FK_MEDICALRECORD_DOCTOR_idx
Patient
patient_id INT
patient_name VARCHAR(255)
patient_DOB DATE
contact_number VARCHAR(15)
Indexes
PRIMARY
InventoryManager
inventory_manager_id INT
assigned_warehouses TEXT
areas_of_responsibility TEXT
Indexes
PRIMARY
Nurse
nurse_id INT
qualification VARCHAR(255)
specialized_area VARCHAR(255)
Indexes
PRIMARY
Prescription
prescription_id INT
medical_record INT
medication_name VARCHAR(255)
Indexes
PRIMARY
FK_PRESCRIPTION_MEDICALRECORD_idx
InsuranceRecord
insurance_record_id INT
patient INT
insurance_plan INT
expiration_date DATE
Indexes
PRIMARY
FK_INSURANCERECORD_PATIENT_idx
FK_INSURANCERECORD_INSURANCEPLAN_idx
PharmacyStaff
pharmacy_staff_id INT
qualifications TEXT
specialization_area VARCHAR(255)
Indexes
PRIMARY
Appointment
appointment_id INT
patient INT
doctor INT
equipment INT
appointment_date DATE
appointment_time TIME
Indexes
PRIMARY
FK_APPOINTMENT_PATIENT_idx
FK_APPOINTMENT_DOCTOR_idx
InsuranceContract
insurance_contract_id INT
insurance_plan INT
patient INT
annual_coverage_limit DECIMAL(10,2)
Indexes
PRIMARY
FK_INSURANCECONTRACT_INSURANCEPLAN_idx
FK_INSURANCECONTRACT_PATIENT_idx
Equipment
equipment_id INT
name VARCHAR(255)
department INT
appointment INT
managed_by INT
Indexes
FK_EQUIPMENT_DEPARTMENT_idx
FK_EQUIPMENT_APPOINTMENT_idx
FK_EQUIPMENT_INVENTORYMANAGER_idx
Medication
medication_id INT
name VARCHAR(255)
managed_by INT
type VARCHAR(45)
expiration_date DATE
Indexes
PRIMARY
FK_MEDICATION_PHARMACYSTAFF_idx
InsurancePlan
insurance_plan_id INT
plan_name VARCHAR(255)
provider VARCHAR(45)
policy TEXT
Indexes
PRIMARY
PrescriptionMedication
prescription_medication_id INT
prescription INT
medication INT
dosage VARCHAR(255)
frequency VARCHAR(255)
Indexes
PRIMARY
FK_PRESCRIPTIONMEDICATION_PRESCRIPTION_idx
FK_PRESCRIPTIONMEDICATION_MEDICATION_idx

VII. Constraints Description

Table	FK	ON UPDATE	ON DELETE	Comment
Department	hospital	CASCADE	SET NULL	If a hospital is deleted, the department that references to that hospital can still exist by itself.
Department	manager	CASCADE	SET NULL	If an employee who is a manager of a department is deleted, that department can still exist by itself without the need of having a manager.
Employee	department	CASCADE	SET NULL	An employee can still exist by itself without the need of belonging to any department.
Employee	hospital	CASCADE	CASCADE	If a hospital is deleted, all employees who work for that hospital are deleted, too.
Doctor	doctor_id	RESTRICT	CASCADE	Since a PK typically do not change, RESTRICT prevents the update of an employee_id in the Employee table if there is a corresponding doctor_id in the Doctor table.
Nurse	nurse_id	RESTRICT	CASCADE	Since a PK typically do not change, RESTRICT prevents the update of an employee_id in the Employee table if there is a corresponding nurse_id in the Nurse table.
PharmacyStaff	pharmacy_staff_id	RESTRICT	CASCADE	Since a PK typically do not change, RESTRICT prevents the update of an employee_id in the Employee table if there is a corresponding in pharmacy_staff_id the PharmacyStaff table.
InventoryManager	inventory_manager_id	RESTRICT	CASCADE	Since a PK typically do not change, RESTRICT prevents the update of an employee_id in the Employee table if there is a corresponding in inventory_manager_id the InventoryManager table.
Prescription	medical_record	CASCADE	CASCADE	If a medical record is updated or deleted, all the prescriptions that belong to that record will also be altered in the same way.
MedicalRecord	patient	CASCADE	CASCADE	If a patient entry is updated or deleted, all the medical records that belong to that patient will also be altered in the same way.
MedicalRecord	doctor	CASCADE	RESTRICT	If a doctor entry is deleted, all the medical records that reference to that doctor will still stay.
Appointment	patient	CASCADE	CASCADE	If a patient entry is updated or deleted, all the appointments that belong to that patient will also be altered in the same way because an appointment has to be made between a patient and a doctor.
Appointment	doctor	CASCADE	CASCADE	If a doctor entry is deleted, all the appointments that reference to that doctor will also be altered in the same way because an appointment has to be made between a patient and a doctor.
Equipment	department	CASCADE	SET NULL	Equipment can still exist by itself without the need of belonging to any department.

Equipment	appointment	CASCADE	SET NULL	If an appointment is deleted, that equipment still exists and may be assigned to another appointment later.
Equipment	managed_by	CASCADE	SET NULL	If an inventory manager is deleted, that equipment still exists and may be assigned to another manager later.
InsuranceRecord	patient	CASCADE	CASCADE	If a patient entry is updated or deleted, all the insurance records that belong to that patient will also be altered in the same way.
InsuranceRecord	insurance_plan	CASCADE	CASCADE	If an insurance plan is updated or deleted, all the insurance records that reference to that plan will also be altered in the same way.
InsuranceContract	patient	CASCADE	CASCADE	If a patient entry is updated or deleted, all the insurance contracts that belong to that patient will also be altered in the same way.
InsuranceContract	insurance_plan	CASCADE	CASCADE	If an insurance plan is updated or deleted, all the insurance contracts that reference to that plan will also be altered in the same way.
PrescriptionMedication	prescription	CASCADE	CASCADE	If a prescription is updated or deleted, all the prescription medications that reference to that prescription will also be altered in the same way.
PrescriptionMedication	medication	CASCADE	NO ACTION	If a medication is deleted, prescription medications that reference to that prescription will stay.