CT511 Databases Design 1

Database Model For A Hospital System

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1. Background

The hospital has decided to convert from a paper-based system to an electronic based system for all records. This change is mandatory in order to comply with the Electronic Medical Records (EMR) as part of the Patient Protection and Affordable Care Act PPACA (2014). Database systems are efficient for the storage of vast quantities of data, including quick, reliable retrieval of information, therefore improving patient care and treatment efficiency and decreasing human error. An electronic database system is apt for application in medical information storage, simplifying the process of updating patient information, hastening patient information retrieval and thus in aiding prompt medical treatment. Medical record storage is better suited for electronic storage, as maintaining a paper based system for a rapidly growing population, with an average lifespan of eighty years is certainly no longer feasible. The electronic system will also comply with recent data protection regulation, offering improved security to patients. Accessibility to accurate patient information via the electronic system will decrease time and cost spent maintaining the non-electrical data system. Files can be backed up on a hard-drive rather than occupying an excess of physical space. Furthermore, electronic systems are conducive to a more environmental-friendly future.

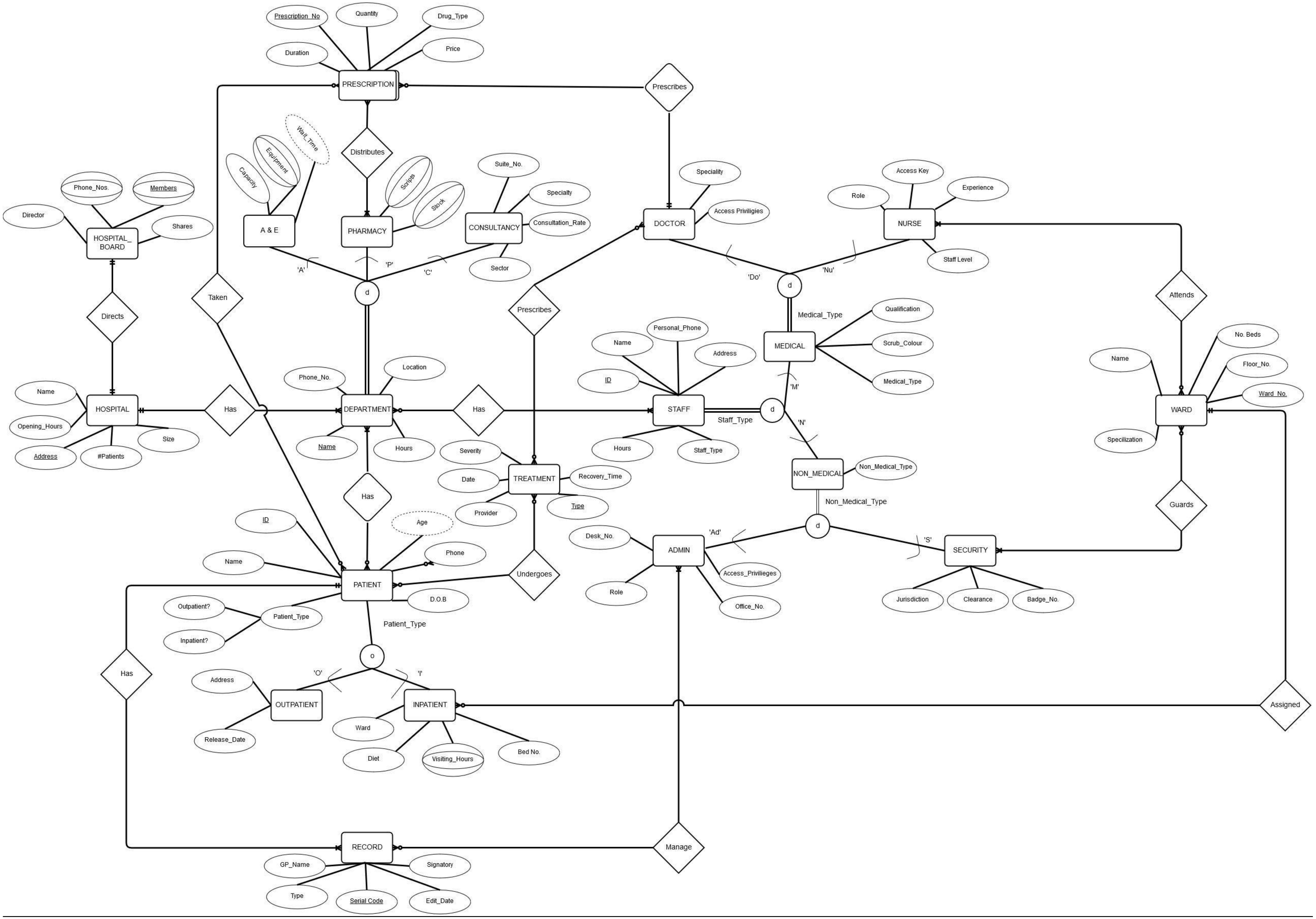
Overview of the system

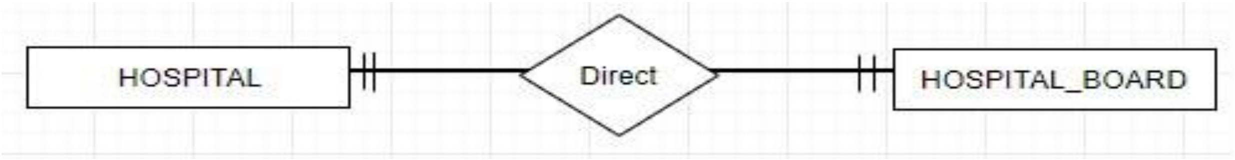
The following entities are included in the database as they were decided to be fundamental to the efficient running of a hospital: Hospital Board, Hospital, Department (A and E, Pharmacy, Consultancy), Staff (Medical, non-medical), Ward, Patient (Inpatient, Outpatient), Treatment, Prescription and Record.

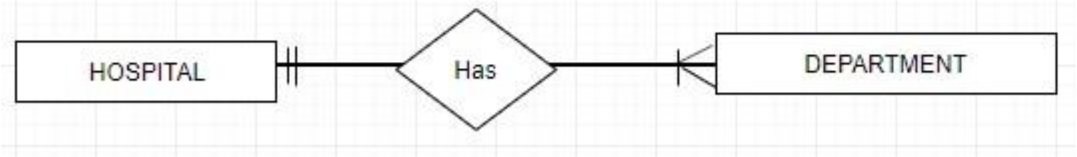
Medical-staff include Doctors and Nurses. Non-Medical Staff include Admin and Security.

The relationship between each entity is defined through and represented in the EERD. This includes the business rule relating the entities, and crow's foot notation is used to represent the number of interactions between entities.

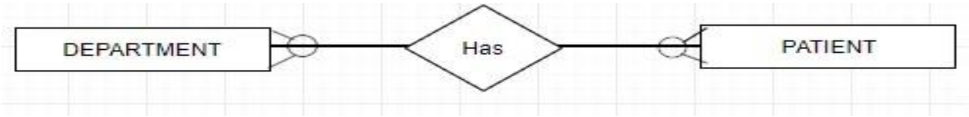
Sub-Entities are defined in the databases, and details on their specialization are shown.

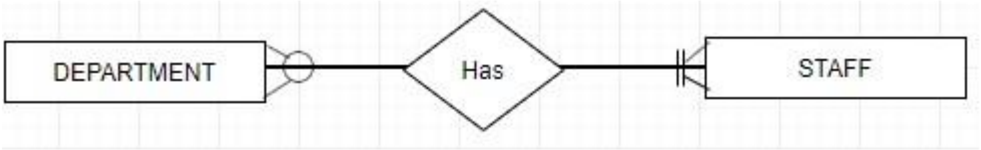

Prescription_No
Quantity
Drug_Type
Duration
Price
PRESCRIPTION
Prescribes
Distributes
Wait_Time
Equipment
Capacity
Scrips
Stock
Suite_No.
Specialty
Consultation_Rate
Sector
Speciality
Access Priviligies
Access Key
Experience
Role
Phone_Nos.
Members
Director
Shares
HOSPITAL_ BOARD
A & E
PHARMACY
CONSULTANCY
DOCTOR
NURSE
Staff Level
'A'
'P'
'C'
d
'Do'
'Nu'
d
Taken
Directs
Prescribes
Medical_Type
Qualification
MEDICAL
Scrub_Colour
Medical_Type
Personal_Phone
Name
Address
ID
Attends
No. Beds
Name
Floor_No.
Ward_No.
Specilization
WARD
'M'
Name
Opening_Hours
HOSPITAL
Address
#Patients
Size
Has
Phone_No.
Location
DEPARTMENT
Name
Hours
Has
STAFF
d
Staff_Type
'N'
Hours
Staff_Type
Severity
Date
TREATMENT
Recovery_Time
Provider
Type
NON_MEDICAL
Non_Medical_Type
Non_Medical_Type
Guards
Has
ID
Age
Phone
Name
PATIENT
Undergoes
D.O.B
Desk_No.
ADMIN
'Ad'
d
'S'
SECURITY
Role
Access_Privilieges
Office_No.
Jurisdiction
Clearance
Badge_No.
Outpatient?
Patient_Type
Inpatient?
Patient_Type
o
'O'
'I'
Has
Address
OUTPATIENT
INPATIENT
Assigned
Release_Date
Ward
Diet
Visiting_Hours
Bed No.
RECORD
Manage
GP_Name
Signatory
Type
Serial Code
Edit_Date

Entity	Attributes	Relationship	Entity
HOSPITAL	Name (Varchar) Opening _Hours (Int) Address (Varchar) Number_Patients (int) Size (Int)	Mandatory 1 to Many Rationale: A hospital has one Hospital Board	HOSPITAL BOARD
			
HOSPITAL BOARD	Address (Varchar) Opening_Hours (Int) Size (Int) Number_Patients (Int) Name (Varchar)	Mandatory 1 to Many Rationale: A hospital board has one hospital	HOSPITAL

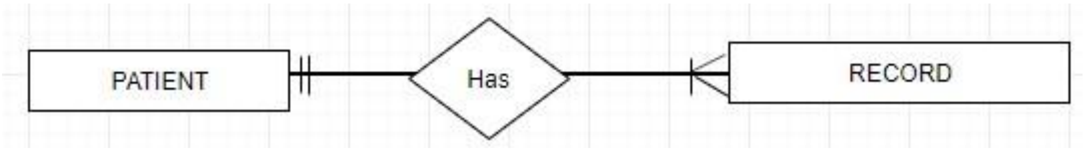
Entity	Attributes	Relationship	Entity
HOSPITAL	Name (Varchar) Opening_Hours (Int) Address (Varchar) Number_Patients (Int) Size (Int)	Mandatory one to many Rationale: one hospital has many departments	DEPARTMENT
			
	Name (Varchar) Location (Varchar)	Mandatory one	

DEPARTMENT	Phone_No. (Int)	Rationale: departments only have one hospital	HOSPITAL
	Hours (Int)		

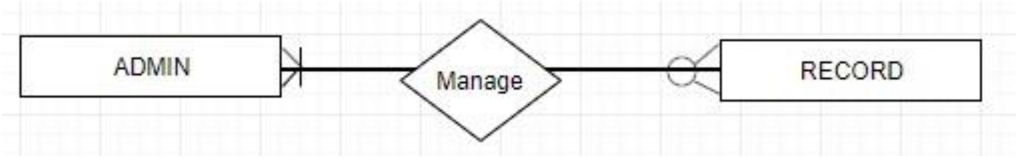
Entity	Attributes	Relationship	Entity
DEPARTMENT	Name (Varchar)	Optional zero to many	PATIENT
	Location (Varhcar)		
	Phone_Number (Int)		
	Hours (Int)	Rationale: Department can have no patients or many	
			
PATIENT	Name (Varchar)	Mandatory one to many	DEPARTMENT
	Id (Int)	Rationale: patient has at least one Department they are treated in	
	Patient_Type (Varchar)		
	D.O.B (Int)		
	Phone (Int)		
	Age (Int)		

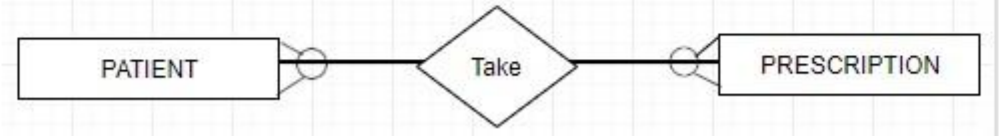
Entity	Attributes	Relationship	Entity
DEPARTMENT	Name (Varhcar)	Mandatory one to many	STAFF
	Location (Varchar)		
	Phone_Number (Int)		
	Hours (Int)	Rationale: a department can have one or many staff	
			

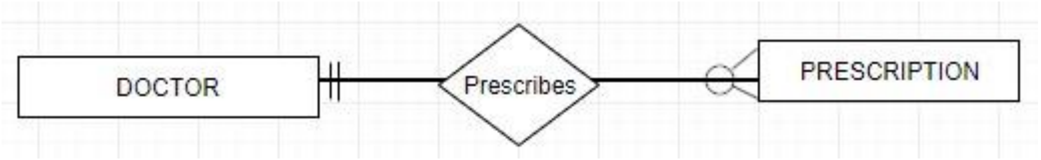
STAFF	Id (Int) Staff_type (Varchar) Name (Varchar) Personal_Phone (Int) Address (Varchar) Hours (Int)	Zero to many Rationale: staff can work independently of Department	DEPARTMENT

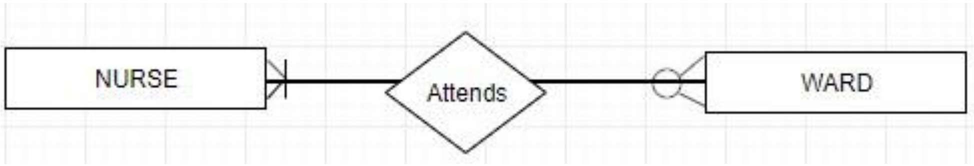
Entity	Attributes	Relationship	Entity
PATIENT	ID (Int) Name (Varchar) Patient_type (Varchar) D.O.B (Int) Phone (Int) Age (Int)	Mandatory one to many Rationale: A patient has to have a record	RECORD
			
RECORD	Serial_Code (Int) Type (Varchar) Gp_Name (Varchar) Signatory (Varchar) Edit_Date (Int)	Mandatory one A Record has one patient	PATIENT

Entity	Attributes	Relationship	Entity
RECORD	Serial_Code (Int) Type (Varchar)	Mandatory one to many	ADMIN

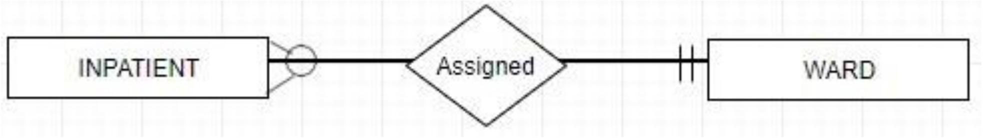
	Gp_Name (Varchar)		
	Signatory (Varchar)	Rationale: a record has at least one administrator	
	Edit_Date (Int)		
 			
ADMIN	Date_Number(Int)	Optional zero to many	RECORD
	Role (Varchar)		
	Access_Priveleges (Int)	Rationale: An administrator doesn’t	
	Office_Number (Int)		
		have to manage a record	

Entity	Attributes	Relationship	Entity
PATIENT	ID (Int)	Optional zero to many	PRESCRIPTION
	Name (Varchar)		
	D.O.B (Int)		
	Patient_Type (Varchar)	Rationale: patient doesn’t have to have a prescription	
	Phone (Int)		
	Age (Int)		
 			
PRESCRIPTION	Prescription_No (Int)	Optional zero to many	PATIENT
	Duration (Int)		
	Quantity (Int)		
	Drug_Type (Varchar)	Rationale: A prescription doesn’t have to be given to a patient	
	Price (Int)		

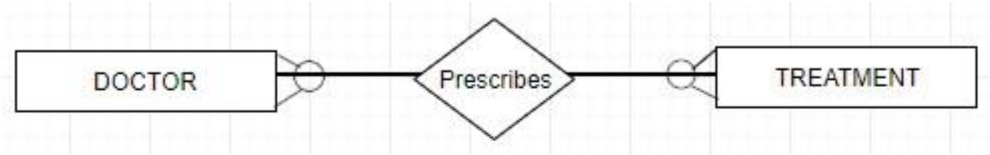
Entity	Attributes	Relationship	Entity
PRESCRIPTION	Prescription_no (Int) Duration (Int) Quantity(Int) Drug_Type (Varchar) Price (Int)	Mandatory one Rationale: a prescription must be prescribed by a Doctor	DOCTOR
			
DOCTOR	Speciality (Varchar) Access Privileges (Int)	Optional zero to many Rationale: Some Doctors don’t have to prescribe medicine	PRESCRIPTION

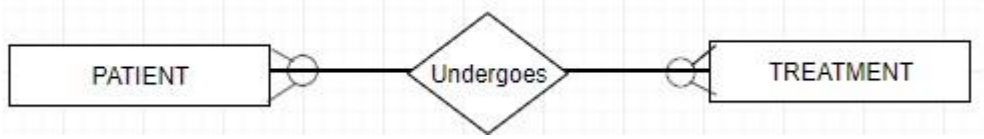
Entity	Attributes	Relationship	Entity
NURSE	Access Key (Int) Role (Varchar) Experience (Varchar) Staff level (Int)	Zero to many Rationale: a nurse doesn’t have to work in a ward	WARD
			
Ward	Ward_No (Int) Floor_No (Int) No. Beds (Int) Name (Varchar)	Mandatory one to many	NURSE

	Specialization (Varchar)	Rationale: A ward is attended by at least one Nurse	

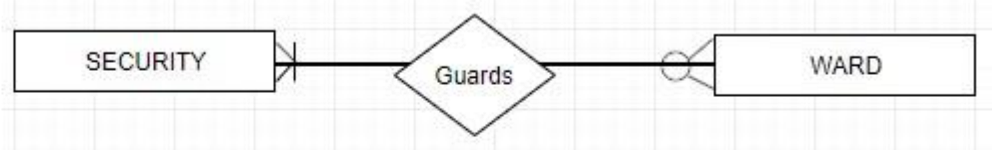
Entity	Attributes	Relationship	Entity
WARD	Ward_no	Optional zero to many	INPATIENT
	Floor_no (Int)		
	No. Beds (Int)		
	Name (Varchar)	Rationale: a ward can have zero patients or many	
	Specialization (Varchar)		
			
INPATIENT	Visiting _Hours (Int)	Mandatory one	WARD
	Diet (Var_Char)		
	Bed No. (Int)	Rationale: An inpatient must be assigned to a Ward	
	Ward (Int)		

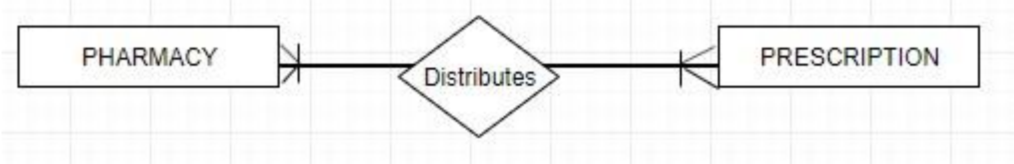
Entity	Attributes	Relationship	Entity
TREATMENT	Treatment_Type (Varchar)	Zero to many	DOCTOR
	Provider (Varchar)		
	Date_Of_Treatment (Int)		
	Recovery_Time (Int)	Rationale: Treatment may be provided by a non-doctor	
	Severity (Varchar)		

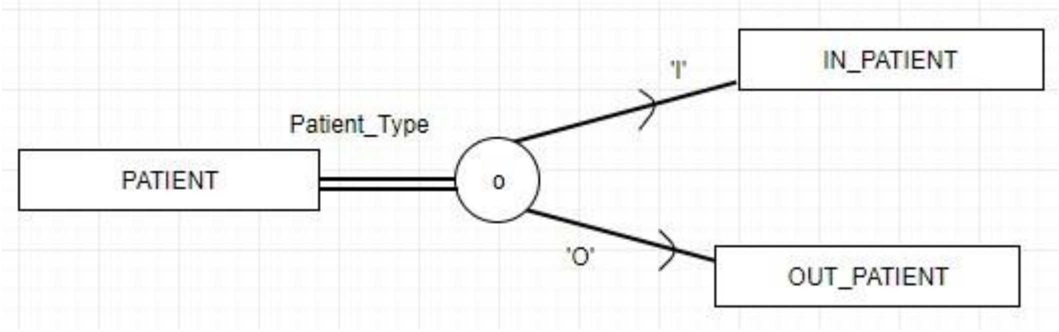
			
DOCTOR	Speciality (Varchar) Access Privileges (Int)	Zero to many Rationale: Doctors may not prescribe treatments, rather consult and refer.	TREATMENT

Entity	Attributes	Relationship	Entity
PATIENT	Patient_Id (Int) Dob (Int) Phone (Int) Name (Varchar) Patient_Type (Varchar)	Zero to many Rationale: a patient may have a consultation or checkup	TREATMENT
			
TREATMENT	Treatment_Type (Varchar) Provider (Varchar) Date_Of_Treatment (Int) Recovery_Time (Int) Severity (Varchar)	Zero one to many Rationale: A treatment type may not be provided at a given time (refferals)	PATIENT

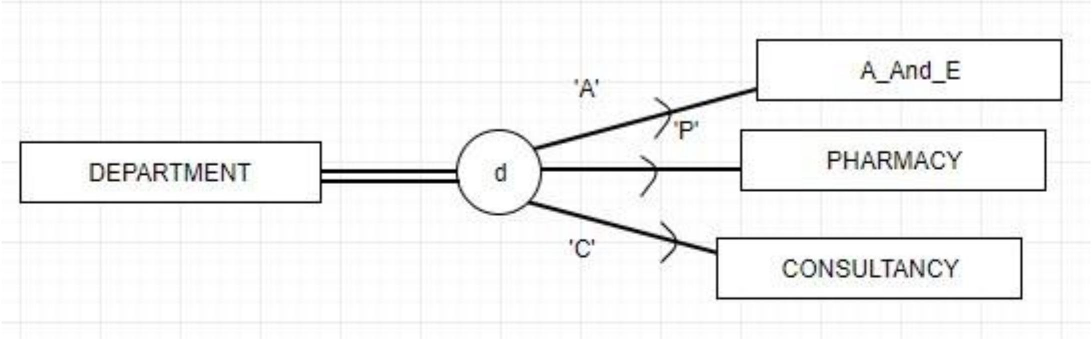
Entity	Attributes	Relationship	Entity
SECURITY	Jurisdiction (Varchar) Clearance (Varchar) Badge_Number (Int)	Zero to many	WARD

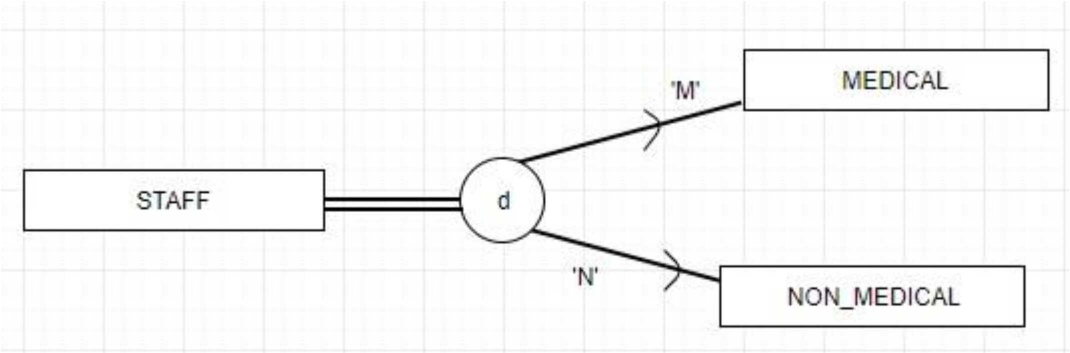
		Rationale: A security guard may work in a morgue or parking lot	
			
WARD	Ward_Number (Int) Number_Beds (Int) Name (Varchar) Ward_Number (Int) Specialization (Varchar) Floor_Number (Int)	Mandatory 1 to many Rationale: At least one security guard must work on every ward.	SECURITY

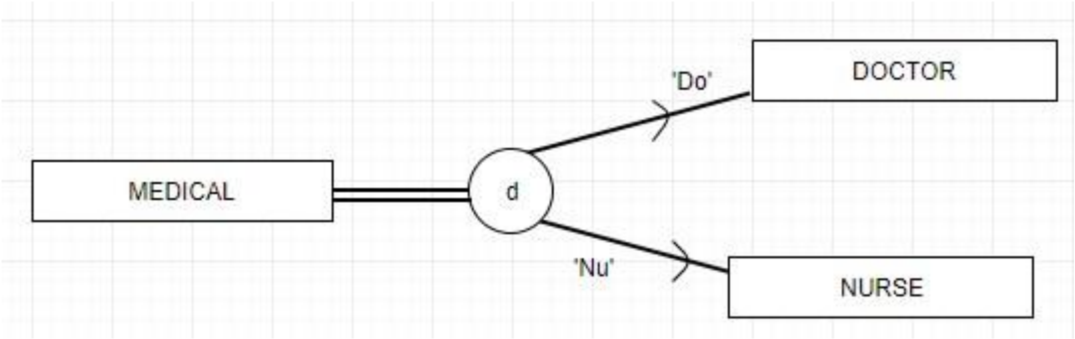
Entity	Attributes	Relationship	Entity
PHARMACY	Scripts (Int) Stock (Varchar)	Mandatory one to Many Rationale: Pharmacy distributes all prescriptions	PRESCRIPTION
			
PRESCRIPTION	Prescription no (Int) Duration (Int) Drug_type (Varchar) Price (Float) Quantity (Int)	Mandatory one to many Rationale: A prescription is distributed by at least one Pharmacy	PHARMACY

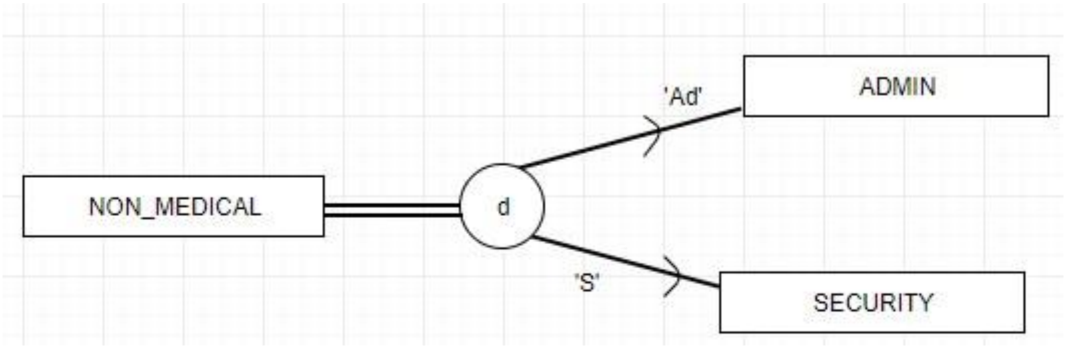
Parent Entity	Attributes	Relationship	Child Entity
PATIENT	ID (Int) Age (Int) Phone (Int) D.O.B (Int) Patient_type (Varchar) Name (Varchar)	Overlap: Rationale: outpatient and inpatient share entities	OUTPATIENT INPATIENT
 IN_PATIENT 'I' Patient_Type PATIENT o 'O' OUT_PATIENT			
OUTPATIENT	Address (Varchar) Release_Date (Int)		
INPATIENT	Visiting_Hours (Int) Bed_No. (Int) Diet (Varchar) Ward (Int)		

Parent Entity	Attributes	Relationship	Child Entity
	Name	Distinct	

Department	Hours (Int) Location (Varchar) Phone_No (Int)	Rationale: there is no shared entities between the departments they can only be one of the three types	A&E PHARMACY CONSULTANCY
			
A&E	Wait_Time (Int) Equipment (Varchar) Capacity (Int)		
PHARMACY	Scripts (Int) Stock (Int)		
CONSULTANCY	Suite no. (Int) Specialty (Varchar) Consultation_Rate (Float) Sector (Varchar)		

Parent Entity	Attributes	Relationship	Child Entity
STAFF	ID Name (Varchar) Personal_Phone (Int) Address (Varchar) Hours (Int) Staff_Type (Varchar)	Distinct Rationale: professionals cannot be medical and non-medical	MEDICAL NON-MEDICAL
			
MEDICAL	Qualification (Varchar) Scrub colour (Varchar) Medical_type (Varchar)		
NON-MEDICAL	Non-medical-type (Varchar)		

<table>
<tr><th>Parent Entity</th><th>Attributes</th><th>Relationship</th><th>Child Entity</th></tr>
<tr><td>MEDICAL</td><td>Qualification (Varchar)
Scrub_Colour (Varchar)
Medical_Type (Varchar)</td><td>Distinct
Rationale: Doctors cant become nurses and nurses cant be doctors</td><td>DOCTOR
NURSE</td></tr>
<tr><td colspan="4">
</td></tr>
<tr><td>DOCTOR</td><td>Specialty (Varchar)
Access privileges (Int)</td><td></td><td></td></tr>
<tr><td>NURSE</td><td>Role (Varchar)
Experience (Int)
Access key (Int)
Staff level (Int)</td><td></td><td></td></tr>
</table>

Parent Entity	Attributes	Relationship	Child Entity
NON-MEDICAL	Non_medical_type (Varchar)	Distinct	ADMIN SECURITY
		Rationale: admin and security share no entities	
			
ADMIN	Desk_no (Int)		
	Role (varchar)		
	Access_priveleges (Int)		
	Office_no. (Int)		
SECURITY	Jurisdiction (Varchar)		
	Clearence (Int)		
	Badge no. (Int)		

5. Database rationale conceptual model

Databases are a fundamental component of any healthcare system. Database design consists of four key phases:

- Determination of user requirements
- Conceptual design
- Logical design
- Physical design

Data modelling is the method of generating a data model for the data to be stored in the database. This data model is a conceptual illustration of: Data objects, the associations/relationships between different data objects, and the rules.

The conceptual design takes the user requirements for the database and transfers this to a detailed graphical model. An Entity Relationship Diagram (ERD) is the most commonly used modelling technique for relational database design. The ERD characterizes entities, attributes and relationships. The ERD serves as an easy to comprehend focal point for discussing requirements and determining whether the database designer fully comprehends the stakeholder's needs. The conceptual model helps in the graphic representation of data and implements business rules, government procedures on the data and regulatory compliance. The data model ensures uniformity in naming conventions, semantics, default values, security and quality of data. The conceptual model emphasises what data is needed and how it should be organised instead of what the data is used for or what operations need to be performed on the data. It offers organisation wide coverage of the business concepts. It is designed and developed for a business audience. The model is developed independently of hardware specifications such as location, storage capacity or specific DBMS software. Its entire focus is to represent data as a user would see it in real life.

The fundamental component of the ERD is the entity which represents the objects of concern and significance to which the database is to be designed. Attributes then describe the entities and are the specific data types for which data is stored. Entities are connected by links which establish the relationship between two or more entities. Within an ERD there are cardinalities which describe the maximum and minimum of entities that may be related to a second entity. For example, a doctor could be related to a minimum of no patients and a maximum of many patients.

The conceptual data model is a combined view of all data in an organisation and helps to bridge the gap between the data organisation as viewed by the DBMS and individual user applications. The conceptual design is used to effectively validate the design by allowing easier communication between domain experts without having detailed knowledge about databases. This feedback from domain experts is critical when developing the database within the hospital system as the data can be complex and have varying types of data elements (Johnson *et al.* 1992*).*

Conceptual database modelling is the foundation of constructing a data warehouse application of significant value to the stakeholders. Effective modelling results in transforming data into a business information asset that is current, consistent and comprehensive. The relational model helps to reduce data redundancy and ensures data integrity (Sherman, 2014).

Rational breakdown

- Data objects represented accurately
- Helps stakeholders/businesses to easily communicate within and across an organisation
- Helps recognise accurate sources of data to populate model and database execution
- Produces an enhanced description of data to be stored
- Defines data structure, its elements and relationships between them

The conceptual EERD has been used to create our collection of tables which represent the contents of the database. The primary keys allow the entity type and relationship type to be expressed homogeneously as tables. For each relationship and entity, a unique table is created.

6. Business Rules

- Doctor has to be assigned to a department
- Staff must be either medical or non-medical
- All doctors are available for A+E
- Pharmacy can only dispense medicine/drugs for a registered patient at the hospital
- Each doctor must submit his own record of each patient
- Admin allocates patients to ward and assigns bed
- Nurse must be assigned to a ward
- Nurse must adhere/follow doctors treatment/instruction
- Doctor and Nurse can only access assigned patient records
- Doctor must detail treatment/instruction for each patient
- Assigned doctor or nurse only allowed access test results
- Admin must update ward list/patient list
- Doctors must issue prescription for pharmacy if required
- Admin must process doctors outpatient appointment follow up care
- Admin must book outpatient appointment

References.

Sherman, R., 2014. *Business intelligence guidebook: From data integration to analytics*. Newnes.

Johnson, S., Friedman, C., Cimino, J.J., Clark, T., Hripcsak, G. and Clayton, P.D., 1991. Conceptual data model for a central patient database. In *Proceedings of the Annual Symposium on Computer Application in Medical Care* (p. 381). American Medical Informatics Association.