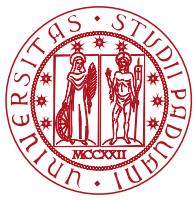

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Database Management Systems, A.Y. 2019/2020
Master Degree in Computer Engineering
Master Degree in Telecommunication Engineering

Homework 2 – Conceptual and Logical Design

Deadline: April 17, 2020

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Conceptual Design

Variations to the Requirement Analysis

We redefined the interaction between clinicians and patients. Now, a clinician creates a care plan for a patient. Within each care plan there is at least one visit prescribed and there can be different therapy sessions scheduled for the patient. Each visit can require multiple clinical tests and it presents the clinician's diagnosis about the patient. A patient can have multiple care plans, with different visits and therapies to follow depending on her condition. We also redefined the clinical case as a taxonomy, where clinical problems are categorized from general to specific (e.g., prostate cancer $\subset$ neoplasm). Additionally, the clinical report is made by a clinician after a set of visits and can be related to different clinical cases depending on the visits outcomes (diagnoses). The changes are reiterated through all the subsequent steps.

Entity-Relationship Schema

Figure 1 shows the entity-relationship schema.

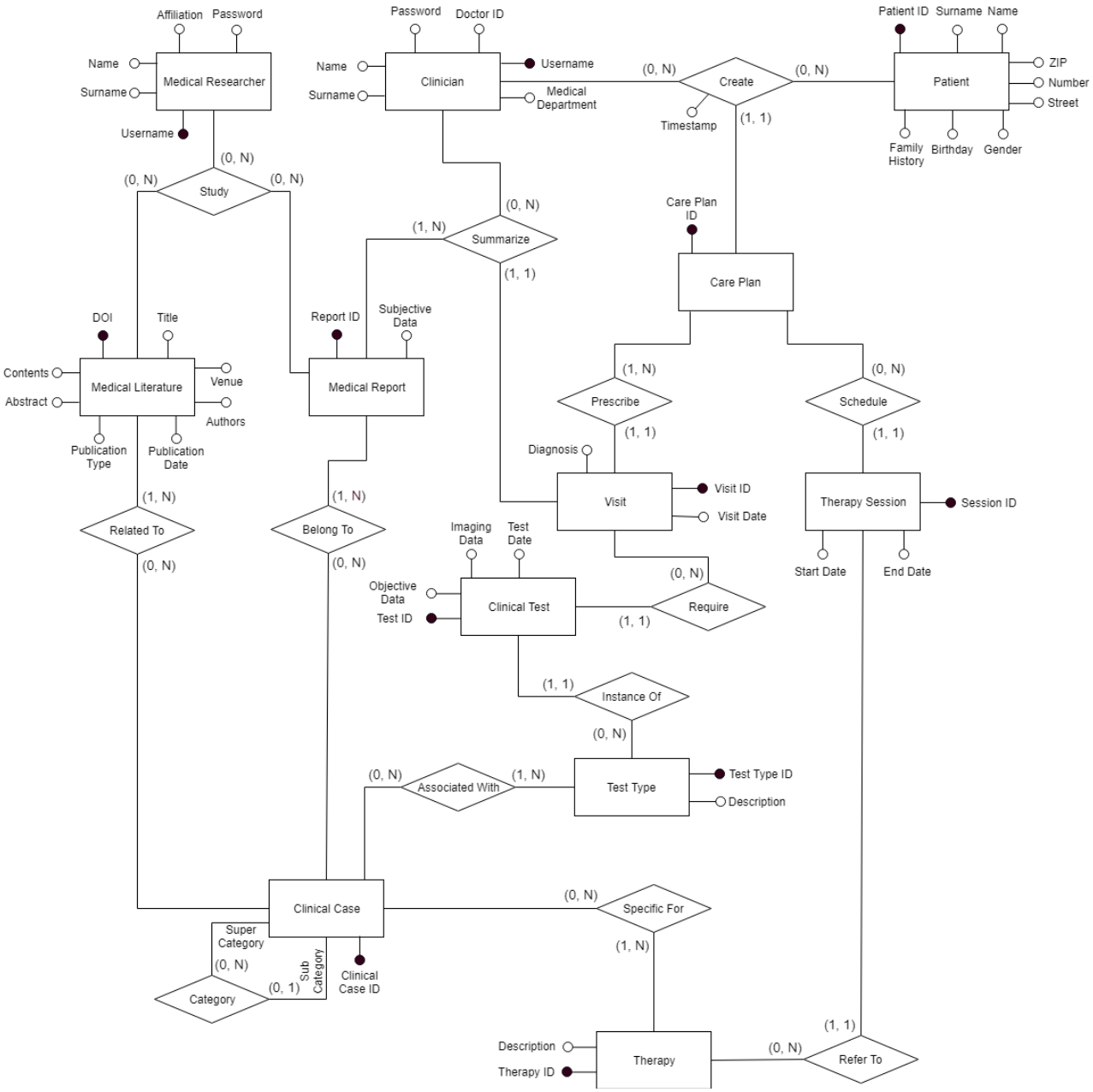

Figure 1: Entity-Relationship Schema

Data Dictionary

Entities Table

Entity	Description	Attributes	Identifier

Care Plan	Represents the patient's care path for a specific clinical case.	• Care Plan ID, identifier of the care plan, text.	Care Plan ID
Clinical Case	Represents a well-known medical problem studied both in medical literature and clinical routine.	• Clinical Case ID, identifier of the clinical case, text.	Clinical Case ID
Clinical Test	Represents the clinical test required by a clinician in a given visit.	• Test ID, identifier of the clinical test, text; • Test Date, test date and time, datetime; • Objective Data, objective data in the report, blob; • Imaging Data, images from the report, blob.	Test ID
Clinician	Doctor with direct contact and responsibility for patients.	• Username, name used for log-in, text; • Password, password used for log-in, text; • Name, user name, text; • Surname, user surname, text. • Doctor ID, doctor identifier within the hospital, text; • Medical Department, department where clinician works in, text.	Username
Medical Literature	Represents the available medical literature related to clinical cases.	• DOI, digital object identifier, text; • Title, title of the article, blob; • Abstract, abstract of the article, blob; • Contents of the article, blob; • Publication Type, type of publication (e.g. journal publication), text; • Publication Date, date of the publication, date; • Authors, authors of the article, text; • Venue, name of the venue, text.	DOI
Medical Report	Medical report written by a clinician after a patient's visit.	• Report ID, the id of the medical report, text; • Subjective Data, subjective information in the report, blob.	Report ID
Medical Researcher	Doctor involved in theoretical	• Username, name	Username

	or laboratory studies.	used for log-in, text; • Password, password used for log-in, text; • Name, user name, text; • Surname, user surname, text. • Affiliation, the research institute the researcher belongs to, text.	
Patient	Patient following care plan(s) for a specific (set of) clinical case(s).	• Patient ID, patient identifier within the hospital, text; • Name, patient name, text; • Surname, patient surname, text; • Family History, information on patient's family clinical history, blob; • Gender, patient gender, text; • Birthday, patient birthday, date, • Address, patient address, text.	Patient ID
Test Type	The type of clinical test.	• Test Type ID, test type identifier, text; • Description, clinical test description, blob.	Test Type ID
Therapy	A therapy process to treat a clinical case-related problem.	• Therapy ID, therapy identifier, text; • Description, description of the therapy standard procedure, blob.	Therapy ID
Therapy Session	The therapy session scheduled within the care plan.	• Session ID, session identifier, text; • Start Date, starting date of the session therapy, date; • End Date, ending date of the session therapy, date.	Session ID
Visit	Represents a visit for the specific care plan of a patient.	• Visit ID, visit identifier, text ; • Visit Date, visit date and time, datetime.	Visit ID

Relationship Table

Relationship	Description	Component Entities	Attributes
Associated With	Relates Test Types to Clinical Cases.	• Clinical Case, (0, N); • Test Type, (1, N).	
Belong To	Associates each Medical Report to the Clinical Case it belongs.	• Medical Report, (1, 1); • Clinical Case, (0, N).	
Category	Defines Clinical Case as a taxonomy with direct sub and super categories.	• Clinical Case (Sub Category), (0, 1); • Clinical Case (Super Category), (0, N).	
Create	Creation of a Care Plan by a Clinician for a given Patient.	• Care Plan, (1, 1); • Patient, (0, N); • Clinician, (0, N).	• Timestamp, care plan creation date and time, datetime.
Instance Of	Associates each Clinical Test with its Test category.	• Clinical Test, (1, 1); • Test Type, (0, N).	
Prescribe	Associates a care plan with its visits.	• Visit, (1, 1); • Care Plan, (1, N).	
Refer To	Associate a Therapy Session with its Therapy category.	• Therapy Session (1, 1); • Therapy (0, N).	
Related To	Relates Medical Literature with Clinical Cases.	• Clinical Case, (0, N); • Medical Literature, (1, N).	
Require	Associates each Clinical Test with the Visit that requires it.	• Clinical Test, (1, 1); • Visit, (0, N).	
Schedule	Schedules a Therapy Session for a given Care Plan.	• Care Plan, (0, N); • Therapy Session, (1, 1).	
Specific For	Associates each Therapy with the Clinical Case it treats.	• Therapy, (1, 1); • Clinical Case, (0, N).	
Study	Connects Medical Researchers with Medical Literature and Reports	• Medical Literature, (0, N); • Medical Report, (0, N); • Medical Researcher, (0, N).	
Summarize	Summarizes the results of a number of Visits in a Medical Report written by a Clinician.	• Visit, (1, 1); • Medical Report, (1, N); • Clinician, (0, N).	

External Constraints on ER

1. A patient cannot have two Therapy Sessions that overlap (i.e., Start Date of second Therapy Session in between the Start-End dates of the first Therapy Session) if they refer to the same Therapy (i.e, same Therapy ID). This means that, after a Patient starts a Therapy Session and until its duration is not over, there cannot be a different Therapy Session ongoing with the same Therapy.
2. Only Clinicians can submit Patients-related information. This means that if a Clinician is also a Medical Researcher, she needs to log in with the Clinician user profile in order to submit Medical Reports, Care Plans, Visits or Therapies.

3. Clinicians can submit Medical Reports only after a (set of) Visit(s) has been performed (Visit Date) for a given Care Plan (and therefore for a given Patient).

Functional Requirements Satisfaction Check

In details, the DBMS has to:

- **Manage different user roles for clinicians and medical researchers:** the entity User stores Username and Password for each user, be it a Medical Researcher or a Clinician. Entities Clinician and Medical Researcher specify different information that allow to distinguish users and their roles.
- **Manage different user permissions for different roles:** external constraints 2. And 4. ensure the requirement is satisfied. The entity Clinician stores the Doctor ID, which enables to identify user roles for setting permissions.
- **Manage clinicians and medical researchers logs in and accesses to their personal pages:** the entity User stores Username and Password for each user, thus enabling to manage users logs in and accesses.
- **Allow medical researchers and clinicians to search the heterogenous data by patient's clinical history or by clinical case history:** the relationship Create provides access to all the care plans of a given Patient – and therefore to all her visits, clinical tests, therapy sessions and medical reports. Besides, each Medical Report is associated to a (set of) Clinical Case(s) through the relationship `Belong To' with cardinality (1, N). This relationship enables users to search for Patient's clinical history for a specific Clinical Case. Furthermore, the relationship `Refer To', between Therapy Session and Therapy, allows to look for all the Therapy Session a Patient has followed for a specific Therapy. Additionally, the entity Therapy is connected with cardinality (1, N) to the entity Clinical Case through the relationship `Specific For'. This enables a user to search for all the Therapy Sessions a Patient has followed given a Clinical Case of interest. The entity Clinical Case is also related to the entity Medical Literature and therefore a user can search for all the literature related to the Clinical Case of interest.
- **Store patients information:** the entity Patient stores all the information necessary to identify a specific patient, that is Patient ID, Name, Surname, Family History, Birthday, Gender and Address.
- **Store clinicians information:** the entity Clinician stores all the information necessary to identify a specific clinician, that is Doctor ID and Medical Department.
- **Store visits information:** the entity Visit stores the information required to identify a visit, that is Visit ID, Visit Date and diagnosis.
- **Collect and store all the medical reports related to each patient:** the entity Medical Report stores all the medical reports written by Clinicians. Besides, the connection with Visit through the relationship `Summarize' allows Medical Reports to be associated with a Care Plan – and therefore to a specific Patient.
- **Record the details related to each medical report:** the attributes Report ID (text) and Subjective Data (blob) of the entity Medical Report enable to store all the information contained within a medical report and to uniquely identify it (Report ID).
- **Check that within each care plan there is at least one visit prescribed:** the cardinality (1, N) of the entity Care Plan in the relationship `Prescribe' ensures that entity Care Plan is associated with at least one visit.
- **Collect and store medical literature related to each clinical case:** the entity Medical Literature stores medical articles, composed of DOI (text), Title (blob), Abstract (blob), Contents (blob), Authors (text), Venue (text), Publication Type (text) and Date (date).The relationship `Related To' associates each medical article to one or more (1, N) Clinical Cases.

Logical Design

Transformation of the Entity-Relationship Schema

1. Redundancy Analysis

Intensional redundancy: the schema does not contain any intensional redundancy.

Extensional redundancy: the schema does not contain any cycle of entities, but presents the derivative attribute Tests in the entity Visit. We report below the analysis of the database load to check whether keeping this derivative attribute or not.

2. Choice of Principal Identifiers

The schema does not contain external identification cycles and the main identifiers comply with the selection criteria.

Analysis of Database Load

In this section, we report the analysis of the database to justify the presence of redundancies in the entity relationship schema. Consider the following two example operations that involve the redundant attribute Objective Data:

- O1: store a new clinical test together with its visit;
- O2: print data about a visit, together with the number of tests each visit is associated to.

Table 1 reports the description of each operation, its frequency and type. Both O1 and O2 are online operations since clinical tests need to be stored right after they are performed and visits need to be retrieved on the fly.

Operation	Description	Frequency	Type
O1 Insert new test	store a new clinical test associated with a visit	4/week	Online
O2 Print visits of a care plan	print all data about a visit, together with the number of tests each visit is associated to	1/week	Online

Table 1 Frequency Table

Table 2 reports the access/volume data related to operation O1 with redundancy.

Concept	Construct	Access	Type	Average Access
Clinical Test	Entity	1	W	1 x 4 x 2 = 8
Require	Relationship	1	W	1 x 4 x 2 = 8
Visit	Entity	1	R	1 x 4 x 1 = 4
Visit	Entity	1	W	1 X 4 X 2 = 8
Total Access				28

Table 2 Access/Volume Table for Operation O1 with redundancy

Table 3 reports the access/volume data related to operation O1 without redundancy.

Concept	Construct	Access	Type	Average Access
Clinical Test	Entity	1	W	1 x 4 x 2 = 8
Require	Relationship	1	W	1 x 4 x 2 = 8
Total Access				16

Table 3 Access/Volume Table for Operation O1 without redundancy

The difference between Table 2 and 3 is the presence (or not) of the entity Visit.
Table 4 represents the access/volume data related to operation O2 with redundancy.

Concept	Construct	Access	Type	Average Access
Visit	Entity	1	R	1 x 1 x 1 = 1
Total Access				1

Table 4 Access/Volume Table for Operation O2 with redundancy

Table 5 represents the access/volume data related to operation O2 without redundancy.

Concept	Construct	Access	Type	Average Access
Clinical Test	Entity	1	R	1 x 1 x 1 = 1
Require	Relationship	4	R	4 x 1 x 1 = 4
Total Access			5	

Table 5 Access/Volume Table for Operation O2 without redundancy

Finally, Table 6 reports the summary of the total accesses per week, showing that the redundancy increase the number of accesses from 21 accesses to 29 accesses. This does not represent a gain. Therefore, the introduction of the derived attribute does not help.

Operation	With Redundancy	Without Redundancy
O1	28	16
O2	1	5
Total Access/Week	29	21

Table 6 Comparison of the Number of Accesses for each Operation

Relational Schema

Figure 6 shows the relational schema. The entity Clinical Case was the only entity to participate in a one-to-many relationship, i.e. Category, with optional participation, that is with cardinality (0,1) for the Sub Category role. This relationship is mapped to a different relation (Category) to avoid systematic NULL values due to the many root/leaves categories present within the taxonomy. All the other relationships do not present any type of choice and are transformed straightforwardly

Data Dictionary

Relation	Attribute	Description	Domain	Constraints
Associated With	Test Type ID	Test type identifier	Text	Foreign key to Test Type, Not NULL, primary key with Clinical Case ID
	Clinical Case ID	Identifier of the clinical case	Text	Foreign key to Clinical Case, Not NULL, primary key with Test Type ID
Belong To	Report ID	ID of the medical report	Text	Foreign key to Medical Report, Not NULL, primary key with Clinical Case ID
	Clinical Case ID	Identifier of the clinical case	Text	Foreign key to Clinical Case, Not NULL, primary key with Report ID
Care Plan	Care Plan ID	Identifier of the care plan	Text	Primary
Category	Super Category	Identifier of the clinical case	Text	Foreign key to Clinical Case, Not NULL

	Sub Category	Identifier of the clinical case	Text	Foreign key to Clinical Case, Not NULL, Primary key
Clinical Case	Clinical Case ID	Identifier of the clinical case	Text	Primary key
Clinical Test	Test ID	Identifier of the clinical test	Text	Primary key
	Test Date	Test date and time	Datetime	Not NULL
	Objective Data	Laboratory test results and images	Blob	Not NULL
Clinician	Username	Name used for log-in	Text	Primary key
	Password	Password used for log-in	Text	Not NULL
	Doctor ID	Doctor identifier within the hospital	Text	Not NULL
	Medical Department	Department where clinician works in	Text	Not NULL
	Name	User name	Text	Not NULL
	Surname	User surname	Text	Not NULL
Create	Username	Name used for log-in	Text	Foreign key to clinician, Not NULL, primary key with Patient ID and Care Plan ID
	Patient ID	Patient identifier within the hospital	Text	Foreign key to patient, Not NULL, primary key with Username and Care Plan ID
	Care Plan ID	Identifier of the care plan	Text	Foreign key to care plan, Not NULL, primary key with Username and Patient ID
	Timestamp	Care plan creation date and time	Datetime	Not NULL
Medical Literature	DOI	Digital object identifier	Text	Primary key
	Title	Title of the article	Blob	Not NULL
	Abstract	Abstract of the article	Blob	Not NULL
	Contents	Contents of the article	Blob	Not NULL
	Publication Type	Type of publication (e.g. journal)	Text	Not NULL
	Publication Date	Date of publication	Date	Not NULL
	Authors	Authors of the article	Text	Not NULL
	Venue	Name of the venue	Text	Not NULL
Medical Report	Report ID	ID of the medical report	Text	Primary key
	Subjective Data	Subjective information written by a clinician within the report	Blob	Not NULL
Medical Researcher	Username	Name used for log-in	Text	Primary key
	Password	Password used for	Text	Not NULL

		log-in		
	Affiliation	The research institute the researcher belongs to	Text	Not NULL
	Name	User name	Text	Not NULL
	Surname	User surname	Text	Not NULL
Patient	Patient ID	Patient identifier within the hospital	Text	Primary key
	Name	Patient name	Text	Not NULL
	Surname	Patient surname	Text	Not NULL
	Family History	Information on patient's family clinical history	Blob	Not NULL
	Gender	Patient gender	Text	Not NULL
	Birthday	Patient birthday	date	Not NULL
	ZIP	Postal Code	Int	Not NULL
	Number	Street's number	Int	Not NULL
	Street	Street	Text	Not NULL
…	…	…	…	…

External Constraints on Relational

The schema should satisfy the following external constraints:

1. A patient cannot have two Therapy Sessions that overlap (i.e., Start Date of second Therapy Session in between the Start-End dates of the first Therapy Session) if they refer to the same Therapy (i.e, same Therapy ID). This means that, after a Patient starts a Therapy Session and until its duration is not over, there cannot be a different Therapy Session ongoing with the same Therapy. Thus, every time we insert a new tuple within Therapy Session, we need to check that there not exist a therapy session with the same Therapy ID and overlapping dates.
2. Only Clinicians can submit Patients-related information. This means that if a Clinician is also a Medical Researcher, she needs to log in with the Clinician user profile in order to submit Medical Reports, Care Plans, Visits or Therapies. Removed through the use of different relations to identify clinicians and medical researchers.
3. Clinicians can submit Medical Reports only after a (set of) Visit(s) has been performed (Visit Date) for a given Care Plan (and therefore for a given Patient). Therefore before inserting a new tuple within Medical Report, we need to check that the target patient has done a (set of) Visit(s) through the relations Visit (to get Visit ID and Care Plan ID) and Create (to get Patient ID).

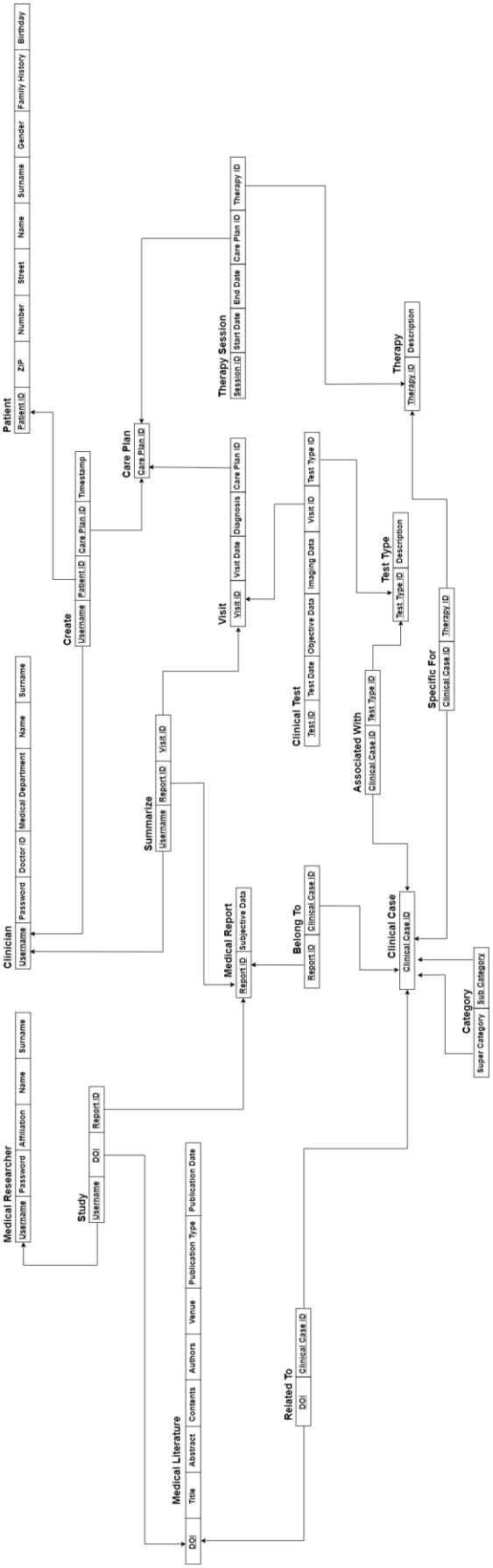

Figure 1 Relational Schema