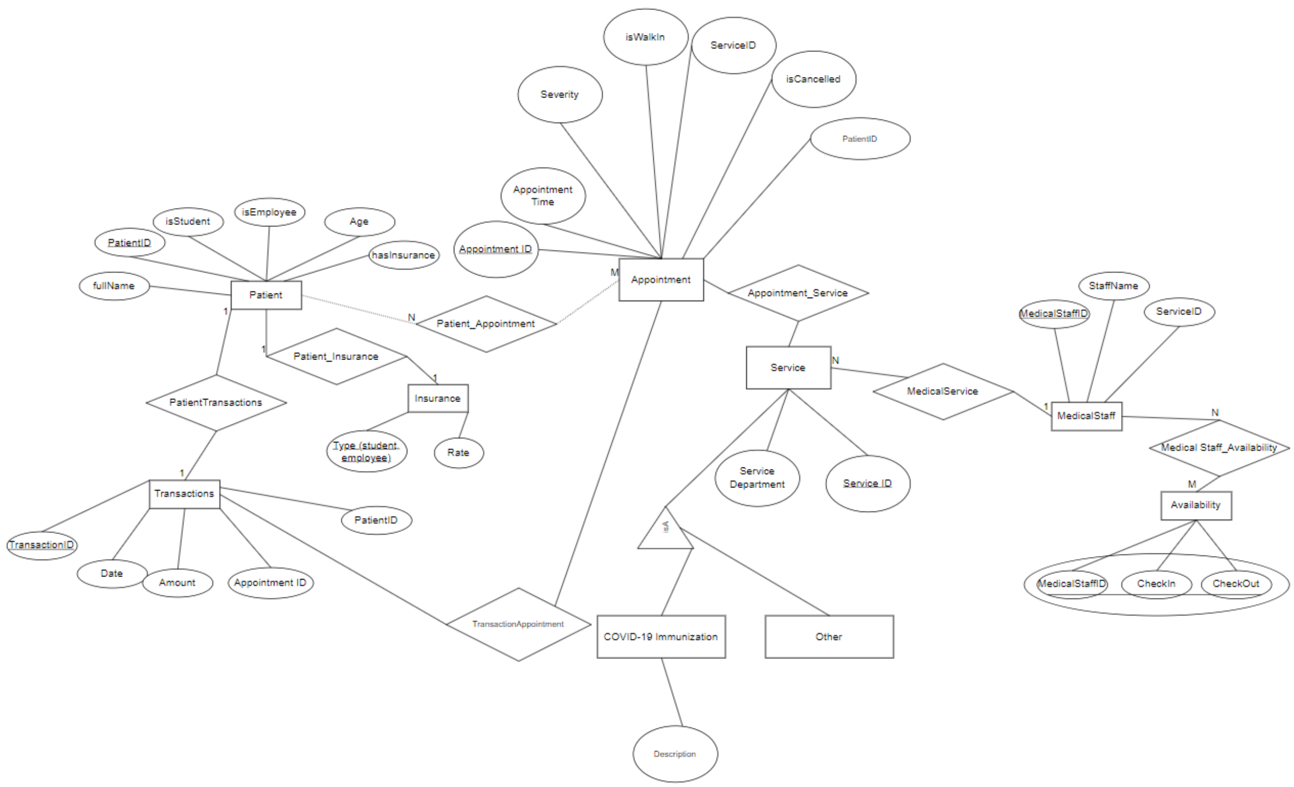
Program 4: Database Design

Gary Li, Liam Wilson, Fontaine Coutino, Raphaelle Guinanao

i. Conceptual Database Design:



[Diagram also attached as EER.drawio]
A Patient will have Insurance, some Appointments, and some Transactions. Each Appointment has a Patient, a Service and a Transaction. Medical staff will have an associated availability and service.
Service demonstrates Specialization as it allows for different service types: COVID 19-Immunization and other types denoted by a description. When implementing the EER into actual tables, I employed method 3 of the following source. As a table, we only created the superclass, service, with dose number as a description that may be null. A constraint is added onto service denoting that the service department must be one of the following: (General Medicine, CAPS, Laboratory and Testing, and Immunization)

ii. Logical Database Design:

Note: In **bold** are PKs, underlined are FKs
PATIENT:
PatientID Name isStudent isEmployee Age hasInsurance

TRANSACTIONS:
TransactionID PatientID AppointmentID Amount TransactionDate

APPOINTMENT:
AppointmentID PatientID ServiceID AppointmentTime Severity isWalkIn isCancelled

SERVICE:
ServiceID ServiceDept ServiceDesc CovidDesc

MEDICAL STAFF:
MedicalStaffID ServiceID StaffName

AVAILABILITY:
MedicalStaffID CheckIn CheckOut

INSURANCE:
Type Rate

iii. Normalization Analysis:

Patient (Liam):

Patient (Liam)- PID, isStudent, isEmployee, Age, hasInsurance

FDs:
PID determines every attribute as it is the primary key.
isStudent does not determine any other attribute, as any student may or may not be an employee, students may or may not be of the same age, and status as a student has no bearing on whether they have insurance or not.
isEmployee does not determine any other attribute, as while an employee has a mandatory insurance plan, not being an employee does not dictate insurance status. It does not determine isStudent as employees may or may not be students in a non-unique fashion, can be of any non-unique age, and there are likely many employees in the table (e.g. there is no direct relationship between isEmployee and PID).
Age does not determine any other attribute, as anyone in the table could be of the same age, and may or may not be a student, may or may not be an employee, and may or may not have insurance.
Known FDs: {PID-> isStudent, isEmployee, Age, hasInsurance}
FD closure: {PID, isStudent, isEmployee, Age, hasInsurance}

Minimal Cover:
PID-> isStudent, PID->isEmployee, PID->Age, PID->hasInsurance
(One FD in standard form).
Each value is atomic; hence table is in 1NF. Age, insurance, employee and student status are all independent of one another so the table is in 2NF. We have no transitive functional dependencies, so vacuously table must be in 3NF.
The only FDs that can exist are 1) trivial or 2) supersets of PID; hence table is in BCNF

Insurance (Fontaine)

FDs:
Type (T) → Rate (R)

Closure:

- Attributes: Type (T), Rate (R)

FD	$\{T^+\}$	temp
Empty	{T}	{T}
$T \rightarrow R$	$\{T, R\}$	$\{T, R\}$

Final FD Closure = $\{T, R\}$

Minimal Cover = $\{T \rightarrow R\}$

- Explanation: There is only one FD and it's in Standard Form.

BCNF Analysis: The only non trivial FD for the table MedicalStaff is $T \rightarrow R$ and it satisfies BCNF because T is a superkey in the FD.

Appointment (Raph)

A	B	C	D	E	F	G
Appointment ID (PK)	AppointmentTime	Severity	isWalkIn	isCancelled	ServiceID (FK)	PatientID (FK)

FDs:

- A -> BCDEFG // A is a PK, therefore it determines every other attribute

Non-FDs:

- AppointmentTime does not determine any other attributes as it has no direct relationship with the other attributes (ex. can not determine severity or if the appointment is a walk-in)
- Severity does not determine any other attributes, unless paired with isWalkIn (doesn't change Appointment Time, the service you're going in for, or the patient handled)
- isWalkIn does not determine any other attributes, unless paired with Severity (doesn't change Appointment Time, the service you're going in for, or the patient handled)
- While severity and walk-in can determine isCancelled (if both are true, then isCancelled is true) it may not always be the case. An appointment can still be canceled otherwise in the case of a no-show.
- ServiceID is a foreign key and does not determine the other attributes
- PatientID is a foreign key and does not determine the other attributes

Find closure of A (={A})

FD	$\{A^+\}$	temp
-	{A}	{A}
A ->BCDEFG	{ABCDEFG}	-

Final FD closure is: {ABCDEFG}

Find minimal cover of FDs:

1. Simplify right-hand side: A->B, A->C, A->D, A->E, A->F, A->G
2. Simplify left-hand side: N/A
3. Remove unnecessary FDs: N/A

Final minimal cover is: A->B, A->C, A->D, A->E, A->F, A->G

Normalization:
1NF: All values of our table can not be further divided into smaller parts, hence atomic.
2NF: Each attribute is also independent of one another according to the FDs we've produced, except for the primary key which is the exception.
3NF: No transitive FDs exist, so we also follow 3NF.
BCNF: The following table is in BCNF as all existing FDs are trivial or supersets of AppointmentID, our superkey.

Service (Raphaelle)

A	B	C	D

Service ID (PK)	ServiceDepartment	Service Description	Covid Desc

FDs:

- ServiceID -> ServiceDepartment, Service Description

Non-FDs:

- ServiceDepartment can only be one of the following: (General Medicine, CAPS, Lab & Testing, Immunization), but it may not always determine a service description. In the case of which two services share descriptions under different departments, it can not determine any other attribute.
- Service Description can not determine any other attribute

Find closure of A (={A})

FD	$\{A^+\}$	temp
-	{A}	{A}
A ->BC	{ABC}	-

Final FD closure is: {ABC}

Find minimal cover of FDs:

4. Simplify right-hand side: A->B, A->C
5. Simplify left-hand side: N/A
6. Remove unnecessary FDs: N/A

Final minimal cover is: A->B, A->C

Normalization:
1NF: All values of our table can not be further divided into smaller parts, hence atomic.
2NF: Each attribute is also independent of one another according to the FDs we've produced, except for the primary key which is the exception.
3NF: No transitive FDs exist, so we also follow 3NF.
BCNF: The following table is in BCNF as all existing FDs are trivial or supersets of Service ID, our superkey.

Availability (Liam)

Availability (Liam)- Medical Staff ID, CheckIn, CheckOut
FDs:
Composite primary key {MedicalStaffID, CheckIn, CheckOut} determines every attribute as 1) it is trivially a result of self-determination and 2) it is a primary key.
MedicalStaffID does not determine any other attribute as a staff member will likely have multiple times they are available.

CheckIn does not determine any other attribute as multiple staff members may check in at the same time, and has no bearing on when a shift may end.
WLOG CheckOut does not determine any other attribute.

Hence -
Known FDs: {(MedicalStaffID, CheckIn, CheckOut)->MedicalStaffID, CheckIn,CheckOut}
FD Closure: {MedicalStaffID, CheckIn,CheckOut}
Minimal Cover: {(MedicalStaffID, CheckIn, CheckOut)->MedicalStaffID, (MedicalStaffID, CheckIn, CheckOut)->CheckIn,(MedicalStaffID, CheckIn, CheckOut)->CheckOut}

Table is in 1NF as each value is atomic. Table is in 2NF as all of our attributes are part of the primary key so there are no non-prime attributes. Table is in 3NF as there are no transitive FDs. The only FDs that exist are trivial, hence the table is in BCNF.

MedicalStaff (Gary) - Medical Staff ID, Service ID (FK), StaffName

FDs:
Medical Staff ID (M) → Service ID (S), StaffName (N)
Medical Staff ID (M) → Service ID (S)
Medical Staff ID (M) → StaffName (N)

Closure:

- Attributes: Medical Staff ID (M), Service ID (S), StaffName (N)

FD	$\{M^+\}$	temp
-	{M}	{M}
$M \rightarrow S$,N	$\{M, S, N\}$	-

Final FD closure is: {M,S,N}

Find minimal cover of FDs:

7. Simplify right-hand side: M->S, M->N, A->D, A->E, A->F, A->G
8. Simplify left-hand side: N/A
9. Remove unnecessary FDs: N/A

Final minimal cover is: M->S, M->N

Normalization:
1NF: The medical staff relation has no set-valued attributes. Each attribute can only have one value which makes it 1NF.

2NF: The attributes ServiceID and StaffName are fully functionally dependent on the primary key Medical Staff ID. There are no other candidate keys so the medical staff relation is in 2NF.
3NF: Medical Staff ID is superkey for the 2 FD relations $M \rightarrow S$ and $M \rightarrow N$ so the medical staff relation is in 3NF.
BCNF: The only 2 non trivial FDs for the table MedicalStaff are $M \rightarrow S$ and $M \rightarrow N$. They both satisfy BCNF because Medical Staff ID is a superkey in the FD.

Transactions (Gary) - TransactionID (T),PatientID(P),AppointmentID(I) ,Amount (A), TransactionDate (D)
FDs:

- T -> PDIA // T is a PK, therefore it determines every other attribute
- I -> PDTA // I is a CK, therefore it determines every other attribute

Closure:

- Attributes: TransactionID (T), PatientID (P), Amount (A), TransactionDate (D), AppointmentID(I)

FD	$\{T^+\}$	temp
-	{T}	{T}
$T \rightarrow PDAI$	$\{T, P, D, A, I\}$	-

Final FD Closure = $\{T, P, D, A, I\}$

Find minimal cover of FDs:

10. Simplify right-hand side: T->P, T->D, T->A, T->I, I->P, I->D, I->A, I->T
11. Simplify left-hand side: N/A
12. Remove unnecessary FDs: N/A

Final minimal cover is: T->P, T->D, T->A, T->I, I->P, I->D, I->A, I->T

Normalization:
1NF: The transaction relation has no set-valued attributes. Each attribute can only have one value which makes it 1NF.
2NF: All attributes are fully functionally dependent on the primary key TransactionID and candidate key AppointmentID so the relation is in 2NF.
3NF: All non-trivial FDs for the transactions satisfy 3NF because TransactionID and AppointmentID are superkeys of every FD.

BCNF: All non-trivial FDs for the transactions satisfy BCNF because TransactionID and AppointmentID are superkeys of every FD. There are no prime attributes so the relation satisfies BCNF

iv. Query Description:

Our self-designed query outputs what transactions occurred in the Immunizations department on a given date. This would allow medical staff to determine what immunizations had occurred, canceled or not, on a particular date. Perhaps to check if further immunizations must be scheduled or just to ensure that the patient had been properly charged.