Prison Database

by Norman Heinzmann

1. Introduction

This project is about designing a database to support all core operations of a prison. It tracks current inmates , their personal details, program enrollment, cell assignments, and criminal history, their contact information via phone numbers, and any work or educational activities they participate in. Staff members (guards and administrative staff) are also stored , but with separate subtype tables, and their assignments to cells or departments are recorded. By fully normalizing the schema to 4NF, the design prevents data redundancy and ensures that complex business rules, like unique cell occupancy or scheduling guards, can be enforced reliably through transactions.

2. Database Use Cases

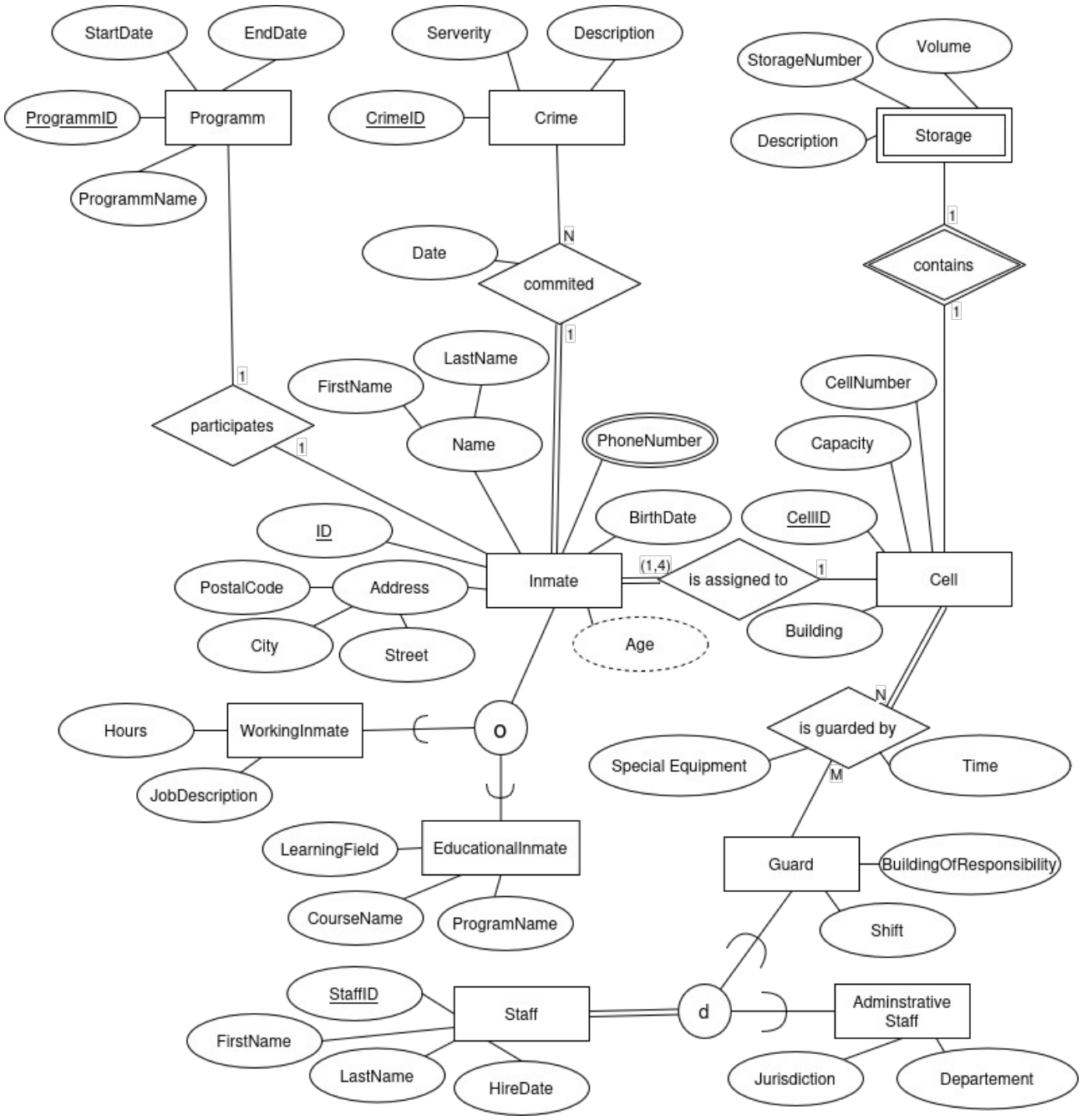
- **CRUD Operations:**
  - *Create:*
    - Add new prisoners along with their sentence records.
    - Insert new staff members (guards or administrative staff).
    - Create and assign cells (optionally with Storage).
  - *Read:*
    - Retrieve prisoner details and their sentence information.
    - Display staff guard shift information.
    - Query facility details including cell capacity or .
  - *Update:*
    - Modify prisoner records (sentence updates, adding program).
    - Change cell capacity
    - Adjust staff schedules
  - *Delete:*
    - Remove outdated or incorrect records while maintaining referential integrity
    - Remove inmate specialization
    - Remove attached storage

- **Possible Transactions:**

  We want to add a new Inmate and give him his attributes, add his phone number to the Register, log his crimes and enroll him as a working- and educational-inmate. If one of these entries fail he can't make calls, is not registed in his work or can't participate in an educational course.
  Because of that we need Transactions.
  This example would look something like this:

```
BEGIN;

-- 1. Create the new inmate
INSERT INTO Inmate (Name, Address, ProgrammID, CellID)
     VALUES ('Carlos Rivera', '789 Cedar Lane', 2, 3)
  RETURNING InmateID INTO :new_inmate_id;

-- 2. Record a phone number for that inmate
INSERT INTO PhoneRegister (InmateID, PhoneNumber)
     VALUES (:new_inmate_id, '+15551234567');

-- 3. Log the crime they have committed
--    (assume CrimeID = 4 already exists)
INSERT INTO HasCommited (InmateID, CrimeID, CommitedDate)
     VALUES (:new_inmate_id, 4, CURRENT_DATE);

-- 4. Enroll them in a work assignment (e.g., Kitchen Helper)
INSERT INTO WorkingInmate (InmateID, JobName, Hours,
JobDescription)
     VALUES (:new_inmate_id, 'Kitchen Helper', 20.00, 'Assists in
meal prep');

-- 5. Enroll them in an educational course
INSERT INTO EducationalInmate (InmateID, CourseName,
LearningField)
     VALUES (:new_inmate_id, 'Basic Literacy', 'Reading');

COMMIT;
```

3. ER Model


StartDate
EndDate
Programm
ProgrammID
ProgrammName
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Description
Crime
CrimeID
Date
commited
N
1
StorageNumber
Volume
Storage
Description
contains
1
1
participates
1
1
LastName
FirstName
Name
PhoneNumber
CellNumber
Capacity
ID
BirthDate
CellID
Inmate
(1,4)
is assigned to
1
Cell
PostalCode
Address
City
Street
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WorkingInmate
JobDescription
O
N
is guarded by
M
Special Equipment
Time
LearningField
EducationalInmate
CourseName
ProgramName
Guard
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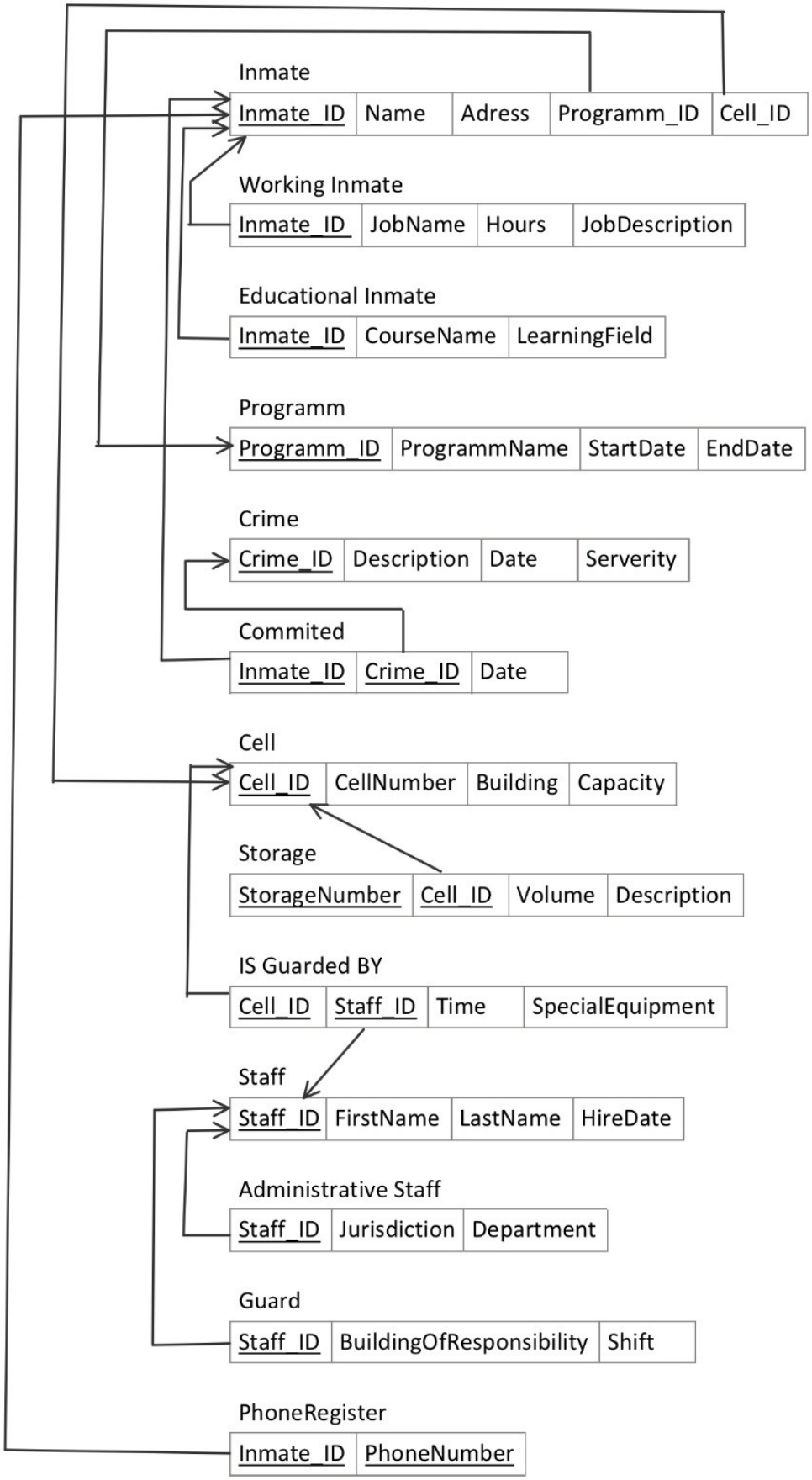
d
Adminstrative Staff
Jurisdiction
Departement

4. Relational Model



5. Normalization Steps

List of non-trivial dependencies

Inmate_ID ->	Name, Address, Programm_ID, Cell_ID
Inmate_ID →	JobName, Hours, JobDescription
Inmate_ID →	CourseName, LearningField
Crime_ID →	Description, Severity
(Inmate_ID, Crime_ID) →	Date
Cell_ID →	CellNumber, Building, Capacity
(Cell_ID, StorageNumber) →	Description, Volume
(Cell_ID, Staff_ID) →	Time, SpecialEquipment
Staff_ID →	FirstName, LastName, HireDate
Staff_ID →	Department, Jurisdiction
Staff_ID →	Shift, BuildingOfResponsibilty
Inmate_ID →	PhoneNumber
Programm_ID →	ProgrammName, StartDate, EndDate

The first normal form (**1NF**) is achieved by removing the multi-valued attribute PhoneNumber from the Inmate relation and placing it into its own lookup table—PhoneRegister(Inmate_ID, PhoneNumber). By doing so, every attribute in every relation is atomic, and there are no nested or repeating groups.

To verify second normal form (**2NF**), one must ensure there are no partial dependencies—no non-key attribute should depend on only a part of a composite primary key. Examining each relationship with a composite key—namely (Inmate_ID, Crime_ID), (Cell_ID, StorageNumber), and (Cell_ID, Staff_ID)—reveals that neither Inmate_ID nor Crime_ID alone can determine Date, nor can Cell_ID alone determine Description and Volume, nor can Cell_ID alone determine Time and SpecialEquipment. Because no attribute in any of those composite relationships depends solely on a subset of the key, the schema already conforms to 2NF.

For third normal form (**3NF**), we must check for transitive dependencies: a situation where a non-key attribute depends on another non-key attribute that in turn depends on a key. The only dependency that connects to another entity is Inmate_ID → Name, Address, Programm_ID, Cell_ID. Since Programm_ID and Cell_ID are foreign keys referencing other tables, we need to ensure that neither Name nor Address is transitively determined by Programm_ID or Cell_ID. A review of the non-trivial dependency list shows that neither Name nor Address appears on the left side of any dependency; thus, no transitive dependency exists and the schema satisfies 3NF.

To confirm Boyce–Codd normal form (**BCNF**), every non-trivial functional dependency must have a determinant that is a superkey. Scanning the list of dependencies, we see that Inmate_ID, Crime_ID, Cell_ID, Staff_ID, and Programm_ID are all primary keys or components thereof, and composite keys such as (Inmate_ID, Crime_ID), (Cell_ID, StorageNumber), and (Cell_ID, Staff_ID) are also primary keys for their respective relations. Each of these determinants is therefore a superkey, and no functional dependency violates the BCNF condition. As a result, the entire schema is already in BCNF.

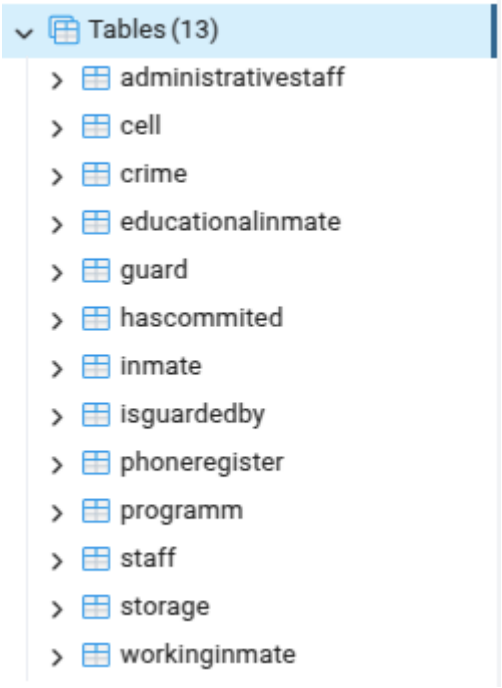
Finally, fourth normal form (**4NF**) prohibits the presence of non-trivial multivalued dependencies (MVDs) in a relation. Since all multi-valued attributes—such as PhoneNumber—have been relocated to separate relations, and because no remaining relation has an attribute that can take on multiple independent values of another non-key attribute, there are no MVDs present. Consequently, the schema complies with 4NF.

In conclusion, after minor adjustments—specifically relocating PhoneNumber into its own lookup table—the relational model is in full compliance with 1NF, 2NF, 3NF, BCNF, and 4NF. It exhibits no partial or transitive dependencies, no determinant outside of a superkey, and no non-trivial multivalued dependencies, thereby fulfilling the highest standards of normalization.

6. Highlights

In the following I want to underline some features of the database, which makes usefull.
One of its standout features is the use of role-based subtyping for staff management. By separating general staff information into a main “`Staff″` table and using subtypes like “`Guard″` and “`AdministrativeStaff″`, the database avoids data duplication while allowing detailed role-specific attributes. This design provides flexibility and clarity in managing different categories of personnel.
The schema is fully normalized up to the Fourth Normal Form, which ensures high data quality by eliminating redundancy and preventing update, insert, and delete anomalies. Multivalued attributes, such as phone numbers, are handled properly using lookup tables like “`PhoneRegister″`, further contributing to the clean and structured design.
Another key feature is the database’s support for complex relationships and atomic transactions. Tables such as “`HasCommited″` and “`IsGuardedBy″` are modeled with composite primary keys and enforce meaningful connections between inmates, crimes, cells, and guards.
The system also provides a strong foundation for both operational and analytical use. Daily activities like inmate tracking, staff scheduling, and program participation can be managed efficiently.

7. Actual usage and implementation of the Database



7.1 Creating every table, with the “Create Table” Command.

```
CREATE TABLE Inmate (
    InmateID       SERIAL PRIMARY KEY,
    Name           VARCHAR(100),
    Address        TEXT,
    ProgrammID     INTEGER,
    CellID         INTEGER
);
```

7.2 Second step is to insert our data with the “Insert Into” statement.

```
INSERT INTO WorkingInmate (InmateID, JobName,
Hours, JobDescription) VALUES
(1, 'Kitchen Helper', 20.0, 'Assists in
kitchen'),
(2, 'Laundry Staff', 15.5, 'Manages washing'),
(3, 'Library Assistant', 10.0, 'Organizes books'),
(4, 'Janitor', 25.0, 'Cleans floors'),
(5, 'Workshop Assistant', 18.5, 'Helps in repair tasks');
```

7.3 After that we can create some Views to make the database easily useful for each usergroup:

7.3.1 View all cells

```
CREATE VIEW View_Cell_Occupancy AS
SELECT
    c.CellID,
    c.CellNumber,
    c.Building,
    c.Capacity,
    COUNT(i.InmateID) AS OccupiedSlots,
    ARRAY_AGG(i.Name ORDER BY i.InmateID) AS InmateNames
FROM Cell c
LEFT JOIN Inmate i
    ON c.CellID = i.CellID
GROUP BY
    c.CellID,
    c.CellNumber,
    c.Building,
    c.Capacity;
```

Now we can see each cell together with the inmates living there.

7.3.2 View all guards

```
CREATE VIEW View_Guard_Shifts AS
SELECT
   g.StaffID,
    s.FirstName || ' ' || s.LastName AS GuardName,
    igb.ShiftTime,
    igb.SpecialEquipment,
    igb.CellID,
    c.CellNumber,
    c.Building AS CellBuilding
FROM Guard g
JOIN Staff s
    ON g.StaffID = s.StaffID
LEFT JOIN IsGuardedBy igb
    ON g.StaffID = igb.StaffID
LEFT JOIN Cell c
    ON igb.CellID = c.CellID
ORDER BY
    igb.ShiftTime;
```

This would be very helpful for somebody controlling or scheduling the guards.

With this view you get the current guard assignment and their shifts.
An output would look like this:

	staffid integer	guardname text	shifttime timestamp without time zone	specialequipment text	cellid integer	cellnumber character varying (10)	cellbuilding character varying (50)
1	1	Robert Miller	2025-06-01 08:00:00	Taser	1	A101	North Wing
2	3	Sam Wilson	2025-06-01 08:00:00	[null]	3	C303	South Wing
3	5	Greg Anderson	2025-06-01 08:00:00	Shield	5	E505	Isolation Block
4	2	Laura Jones	2025-06-01 20:00:00	Helmet	2	B202	East Wing
5	4	Nancy Taylor	2025-06-01 20:00:00	Pepper Spray	4	D404	West Wing

8. Summary

The creation of this prison database was a structured journey through the stages of professional relational design. We began by analyzing the real-world environment of a prison, identifying key entities such as inmates, staff, crimes, and cells. These were modeled using an EER diagram to capture all necessary relationships and complexities.

Next, we transformed the conceptual model into a relational schema, applying normalization rules up to 4NF to ensured data integrity, minimized redundancy, and supported efficient querying.

We implemented the database for realuse cases in postgresql and improved usability by creating SQL views tailored for different user roles, such as monitoring cell occupancy or organizing guard shifts. The result is a clean, flexible, and well-structured system that reflects the operational needs of a modern prison.