Database Dependencies with Examples

1. Functional Dependencies (FD)

Basic Example - Employee Table

EmployeeID	Name	Email	DepartmentID
101	John Doe	john@company.com	5
102	Jane Smith	jane@company.com	3
103	Bob Wilson	bob@company.com	5

Functional Dependencies:

- EmployeeID → Name (Employee ID determines Name)
- EmployeeID → Email (Employee ID determines Email)
- Email → EmployeeID (Email determines Employee ID - assuming unique emails)

Types of Functional Dependencies

Trivial FD Example:

- EmployeeID, Name → EmployeeID (trivial because EmployeeID is part of both sides)
- Name, Email → Name (trivial because Name appears on both sides)

Non-trivial FD Example:

- EmployeeID → Name (non-trivial because Name is not part of EmployeeID)

Completely Non-trivial FD Example:

- EmployeeID → Email (completely non-trivial because EmployeeID and Email share no common attributes)

2. Partial Dependencies

Problem Example - Course Enrollment Table

StudentID	CourseID	StudentName	CourseName	Grade	Instructor
S001	C101	Alice Brown	Math 101	A	Dr. Smith
S001	C102	Alice Brown	Physics	B+	Dr. Jones
S002	C101	Bob Green	Math 101	B	Dr. Smith

Primary Key: (StudentID, CourseID)

Partial Dependencies (violations of 2NF):

- StudentID → StudentName (StudentName depends only on part of the key)
- CourseID → CourseName (CourseName depends only on part of the key)
- CourseID → Instructor (Instructor depends only on part of the key)

Full Dependencies:

- (StudentID, CourseID) → Grade (Grade depends on the complete key)

3. Full Functional Dependencies

Corrected Example - After 2NF Normalization

Students Table:

StudentID	StudentName
S001	Alice Brown
S002	Bob Green

Courses Table:

CourseID	CourseName	Instructor
C101	Math 101	Dr. Smith
C102	Physics	Dr. Jones

Enrollments Table:

StudentID	CourseID	Grade
S001	C101	A
S001	C102	B+
S002	C101	B

Now `(StudentID, CourseID) → Grade` is a full functional dependency.

4. Transitive Dependencies

Problem Example - Employee Department Table

EmployeeID	Name	DepartmentID	DepartmentName	ManagerName
101	John Doe	D001	Engineering	Sarah Wilson
102	Jane Smith	D002	Marketing	Mike Johnson
103	Bob Wilson	D001	Engineering	Sarah Wilson

Transitive Dependencies (violations of 3NF):

- EmployeeID → DepartmentID → DepartmentName
- EmployeeID → DepartmentID → ManagerName

Here, DepartmentName and ManagerName depend on DepartmentID, which depends on EmployeeID, creating transitive dependencies.

Solution - 3NF Normalization

Employees Table:

EmployeeID	Name	DepartmentID
101	John Doe	D001
102	Jane Smith	D002
103	Bob Wilson	D001

Departments Table:

DepartmentID	DepartmentName	ManagerName
D001	Engineering	Sarah Wilson
D002	Marketing	Mike Johnson

5. Multivalued Dependencies (MVD)

Example - Employee Skills and Projects

EmployeeID	Skill	Project
101	Java	ProjectA
101	Java	ProjectB
101	Python	ProjectA
101	Python	ProjectB
102	JavaScript	ProjectC
102	React	ProjectC

Multivalued Dependencies:

- EmployeeID →→ Skill (Employee 101 has skills Java and Python, independent of projects)
- EmployeeID →→ Project (Employee 101 works on ProjectA and ProjectB, independent of skills)

This creates redundancy because every combination of skills and projects must be stored.

Solution - 4NF Normalization

Employee_Skills Table:

EmployeeID	Skill
101	Java
101	Python
102	JavaScript
102	React

Employee_Projects Table:

EmployeeID	Project
101	ProjectA
101	ProjectB
102	ProjectC

6. Join Dependencies

Example - Supplier-Part-Project Relationship

Supplier	Part	Project
S1	P1	J1
S1	P2	J1
S2	P1	J2
S2	P2	J2

If this table can be decomposed into three binary relations without loss:

- Supplier-Part: {(S1,P1), (S1,P2), (S2,P1), (S2,P2)}
- Part-Project: {(P1,J1), (P2,J1), (P1,J2), (P2,J2)}
- Supplier-Project: {(S1,J1), (S2,J2)}

And these can be joined back to recreate the original table, then there's a join dependency.

7. Inclusion Dependencies

Example - Foreign Key Relationships

Orders Table:

OrderID	CustomerID	OrderDate
1001	C001	2024-01-15
1002	C002	2024-01-16
1003	C001	2024-01-17

Customers Table:

CustomerID	CustomerName	Email
C001	Alice Johnson	alice@email.com
C002	Bob Smith	bob@email.com

Inclusion Dependency: Orders[CustomerID] ⊆ Customers[CustomerID]

This means every CustomerID in the Orders table must exist in the Customers table.

8. Key Dependencies

Example - Student Course System

Students Table:

StudentID	Email	Name	Phone
S001	alice@email.com	Alice Brown	555-0101
S002	bob@email.com	Bob Green	555-0102

Key Dependencies:

- **Candidate Keys:**
  - StudentID (minimal set that uniquely identifies each row)
  - Email (assuming emails are unique)
- **Primary Key:** StudentID (chosen candidate key)
- **Alternate Key:** Email (candidate key not chosen as primary)

Course_Enrollment Table:

StudentID	CourseID	Grade
S001	C101	A
S002	C101	B

Foreign Key: StudentID references Students(StudentID)

Composite Key Example

OrderID	ProductID	Quantity	UnitPrice
1001	P001	2	25.00
1001	P002	1	50.00
1002	P001	3	25.00

Composite Primary Key: (OrderID, ProductID) **Foreign Keys:**

- OrderID references Orders(OrderID)
- ProductID references Products(ProductID)

Web link to artifact: https://claude.ai/public/artifacts/1ac1adcf-88f5-46d6-a9d9-c62f3bf6d27c