Part 2

A) Is the Schema in 1NF?

No it is not.

We want all the attributes to be atomic

Department Location is not atomic

If we want to access the city of a given employee we would need to parse the string of location

Solution:

Assuming location is only in Canada

Split Location into 4 attributes:

- `address_line`
  - Street names and numbers are complicated with different units and subunits so the culmination can be put here as as string
- `city`
- `province`
- `postalcode`
  - Although `province` can most likely be found using the `postalcode` it is not a guarantee
  - Assuming a string a length 6 without the dash

Start and End date are not atomic

Since we are ignoring dates this does not matter

Potential Solution

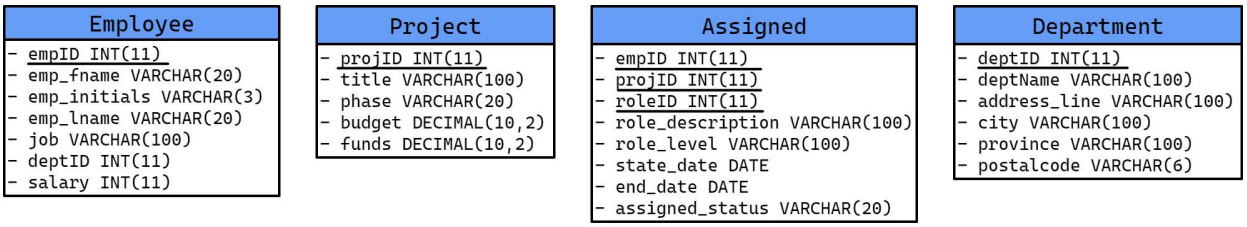
Split Dates into the following:

- `start_date` into
  - `start_date_year`
  - `start_date_month`
  - `start_date_day`
- `end_date` into
  - `end_date_year`
  - `end_date_month`
  - `end_date_day`

Splitting Role Level

Although role level can technically be split into L and then the level number, it does not reduce the complexity because L is always in front a a level number. If other first letters were possible such as M1 then we would split the `role_level` into 2 attributes

New Relational Schema Diagram



B1) Is the 1NF Schema in 3NF?

Checking 3NF

Functional Dependencies

Department $F = \{\text{deptID} \rightarrow \text{deptID, location}\}$
$= \{\text{deptID} \rightarrow \text{deptID, address\_line, city, province, postalcode}\}$

Project $F = \{\text{projID} \rightarrow \text{title, phase, budget, funds}\}$

Employee $F = \{\text{empID} \rightarrow \text{emp\_fname, emp\_initials, emp\_lname, job, deptID, salary}\}$

Assigned

$$F = \{\text{empID, projID, roleID} \rightarrow \text{role\_description, role\_level, start\_date, end\_date, assigned\_status,}$$
$$\text{roleID} \rightarrow \text{role\_description, role\_level} \}$$

Since Department Project and Employee FD all have their primary key on the left hand side. Thus these tables pass 3NF

For Assigned, `roleID` is not a super key because it cannot identify `start_date`, `end_date`, or `assigned_status` thus because of FD $\text{roleID} \rightarrow \text{role\_description, role\_level}$, Assigned is not in 3NF

3NF Decomposition

We need to decompose Assigned to be in 3NF

$R = (\text{empID, projID, roleID}$
$\text{role\_description, role\_level, start\_date, end\_date, assigned\_status})$

$$F = \{\text{empID, projID, roleID} \rightarrow \text{role\_description, role\_level, start\_date, end\_date, assigned\_status,}$$
$$\text{roleID} \rightarrow \text{role\_description, role\_level} \}$$

Finding Canonical Cover

Proving `role_description` and `role_level` is extraneous in:

$$\text{empID, projID, roleID} \rightarrow \text{role\_description, role\_level, start\_date, end\_date, assigned\_status}$$

Let:

$$F' = \{\text{empID, projID, roleID} \rightarrow \text{start\_date, end\_date, assigned\_status},\ \text{roleID} \rightarrow \text{role\_description, role\_level}\ \}$$

$$\begin{aligned}
\text{empID, projID, roleID} &\rightarrow \text{roleID} && \{\text{relexivity}\} && (1)\\
\text{roleID} &\rightarrow \text{role_description, role_level} && \{\text{given in } F'\} && (2)\\
\text{empID, projID, roleID} &\rightarrow \text{role_description, role_level} && \{\text{transitivity 1,2}\} && (3)\\
\text{empID, projID, roleID} &\rightarrow \text{start_date, end_date, assigned_status} && \{\text{given in } F'\} && (4)\\
\text{empID, projID, roleID} &\rightarrow \text{role_description, role_level, start_date, end_date, assigned_status} && \{\text{union 3,4}\} && (5)
\end{aligned}$$

Thus:

$$F_C = \{\text{empID, projID, roleID} \rightarrow \text{start\_date, end\_date, assigned\_status},\ \text{roleID} \rightarrow \text{role\_description, role\_level}\ \}$$

Decomposition

So we can split the relation into

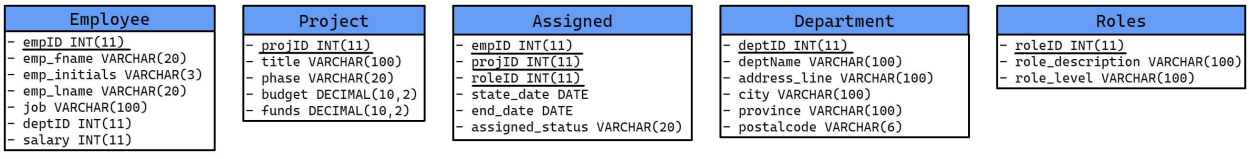
$$R_1 = (\text{empID, projID, roleID, start\_date, end\_date, assigned\_status})$$

$$R_2 = (\text{roleID, role\_description, role\_level})$$

Since both these relations only have super keys on the left of the FD they are both in 3NF

Let R_1 be named Assigned and R_2 be Roles

New Relational Schema Diagram



B2) Is the 1NF Schema in BCNF?

Checking BCNF

Functional Dependencies

Department $F = \{\text{deptID} \rightarrow \text{deptID, location}\}$
$= \{\text{deptID} \rightarrow \text{deptID, address\_line, city, province, postalcode}\}$

Project $F = \{\text{projID} \rightarrow \text{title, phase, budget, funds}\}$

Employee $F = \{\text{empID} \rightarrow \text{emp\_fname, emp\_initials, emp\_lname, job, deptID, salary}\}$

Assigned

$$F = \{\text{empID, projID, roleID} \rightarrow \text{role\_description, role\_level, start\_date, end\_date, assigned\_status,}$$
$$\text{roleID} \rightarrow \text{role\_description, role\_level} \quad \}$$

Since Department Project and Employee FD all have their primary key on the left hand side. Thus these tables pass BCNF

For Assigned, `roleID` is not a super key because it cannot identify `start_date`, `end_date` or `assigned_status` thus because of FD $\text{roleID} \rightarrow \text{role\_description, role\_level}$, Assigned is not in BCNF

BCNF Decomposition

$$R = (\text{empID, projID, roleID}$$
$$\text{role\_description, role\_level, start\_date, end\_date, assigned\_status})$$

$$F = \{\text{empID, projID, roleID} \rightarrow \text{role\_description, role\_level, start\_date, end\_date, assigned\_status,}$$
$$\text{roleID} \rightarrow \text{role\_description, role\_level} \quad \}$$

We already know that this relations is not in BCNF

The functional dependency:

$$\text{roleID} \rightarrow \text{role\_description, role\_level}$$

is a nontrivial FD that holds on R and `roleID` is not a super key for R since $(\text{roleID})^+ = \{\text{roleID, role\_description, role\_level}\}$

So we will split R into:

$R - \{\text{role\_description, role\_level}\} = R_1(\text{empID, projID, roleID, start\_date, end\_date, assigned\_status})$

$R_2(\text{roleID, role\_description, role\_level})$

Checking R_1 and R_2 for BCNF

R_1 is in BCNF since `empID`, `projID`, `roleID` is a super key for R_1

- $(\text{empID, projID, roleID})^+ = \{\text{empID, projID, roleID}$
  $\text{role\_description, role\_level, start\_date, end\_date, assigned\_status}\}$

R_2 is in BCNF since `roleID` is a super key for R_2

- $(\text{role})^+ = \{\text{roleID}, \text{role\_description}, \text{role\_level}\}$

Let R_1 be named Assigned and R_2 be Roles

New Relational Schema Diagram