Normal Forms

Functional Dependencies

For a table `[x,y]` y is functionally dependent on x if, when $t_1(x) = t_2(x)$, $t_1(y) = t_2(y)$

Here, x is called `determinant` and y is called `dependent`

First Normal Form 1NF

1. Each attribute must be atomic (ie should not be divisible any further)
    1. Composite attributes get separated to their own distinct attributes
    2. Multi Valued attributes get their own tuple or row
2. A attribute should contain values of the same type
3. attributes must have unique names
4. No order towards the rows should affect the database

- By default if a ER diagram is converted into a relational schema, it is in 1NF

Second Normal Form 2NF

1. Should be in 1NF
2. No Partial Dependency must be present in the table

Partial Dependency

- Partial Dependency is when A proper subset of the candidate key will determine a non prime attribute
- Prime attributes are ones that are part of Candidate key

R(A, B, C, D)
F.D: {AB → CD, C → A, D → B}

taking closure of entire set,

$ABCD^+ = \{A\ B\ C\ D\}$; now remove the dependents.
$\Rightarrow AB^+ = \{A\ B\ C\ D\}$; AB is a super key

now check if super key's subset are super keys
$A^+ = A$ only
$B^+ = B$ only

as its subsets aren't super keys, AB is a candidate key

To check for more candidate keys, "if a prime attribute is the dependent of any other attribute, there will be another C_k"

R As both A, B are dependent on C, D respectively
we will replace them and repeat check for candidate key

$CB^+ = \{A\ B\ C\ D\}$
$C^+ = \{C, A\}$
$B^+ = \{B\}$
} ✓ is a C_k

$AD^+ = \{A\ B\ C\ D\}$
$A^+ = \{A\}$
$D^+ = \{B, D\}$
} ✓ is a C_k

Total prime Attributes
A, B, C, D

Third Normal Form 3NF

1. Should be in 2NF
2. There shouldn't be any Transitive Dependency for Non Prime Attributes

> A table is in 3NF if and only if for each of its non trivial functional dependencies, atleast one of the following conditions holds
>
> 1. LHS is Super Key
> 2. RHS is Prime Attribute

Boyce Codd Normal Form BCNF

1. Should be in 3NF
2. For each Non trivial Functional dependency, the Determinant must be a super key

Rules of Inference

1. Reflexivity Rule
    1. If $Y \subseteq X$, then $X \rightarrow Y$
    2. If Y is a subset of X , X functionally determines Y
    3. Ex : $X = {A,B}$ then ${A,B} \rightarrow {A}$ and ${AB} \rightarrow {B}$
2. Augmentation Rule
    1. If $X \rightarrow Y$ then $XZ \rightarrow YZ$ for every Z
    2. If X determines Y, then X combined with any other attribute Z will determine Y combined with Z
3. Transitivity Rule
    1. $X \rightarrow Y$ and $Y \rightarrow Z$ then $X \rightarrow Z$
    2. If X determines Y and Y Determines Z, then X will Determine Z
4. Union Rule
    1. if $X \rightarrow Y$ and $X \rightarrow Z$ then, $X \rightarrow YZ$
    2. Allows you to combine the results of separate FDs with the same Determinant
5. Decomposition Rule
    1. if $X \rightarrow YZ$, then $X \rightarrow Y$ and $X \rightarrow Z$
    2. If X Determines a composite set of Attributes YZ, it indivisually Determines Both or all subsets of the Composite Set
6. Psudo Transitivity Rule
    1. if $X \rightarrow Y$ and $WY \rightarrow Z$, then $WX \rightarrow Z$
    2. If X determines Y and WY determines Z, then combining X with W will determine Z
7. Identity Rule
    1. $X \rightarrow X$
    2. Any set of attributes are functionally dependent on itself