Functional Dependency FD

Domain Range

a ----------> 1

b ----------> 2

c ----------> 3

4

```
y : square(x)
int square(int x)
{
    return x * x;
}
```

x	y
3	9
4	16
3	9
5	25
-3	9
1	1
0	0
-1	1
-3	9

If for every unique value of X I get the same value for Y then X functionally defines Y or Y is functionally dependent on X

$$X \longrightarrow Y$$

attributes

A	B	C	D	E
a1	b1	c1	d1	e1
a2	b1	C2	d2	e1
a3	b2	C1	d1	e1
a4	b2	C2	d2	e1
a5	b3	C3	d1	e1

rows / records

Table R

$C \longrightarrow D$ ✓

$D \longrightarrow C$ X

$B \longrightarrow E$ ✓

$A \longrightarrow B$ ✓

$B \longrightarrow A$ X

$BC \longrightarrow D$ ✓

$BC \longrightarrow A$ ✓

$CD \longrightarrow A$ X

Armstrong Axioms

1. If $B \subseteq A$ then
   $A \rightarrow B$
   Reflexivity
   $A \rightarrow A$

   name, age, address → age

2. If $A \rightarrow B$ then
   $AX \rightarrow BX$
   Augumentation

   name → sex
   name, age → sex, age

3. If $A \rightarrow B$ and $B \rightarrow C$ then
   $A \rightarrow C$
   Transitivity

   roll# → name
   name → sex
   roll# → sex

4. If $A \rightarrow B$ & $A \rightarrow C$ then
   $A \rightarrow BC$
   Union

   roll# → name
   roll# → address
   roll# → name, address

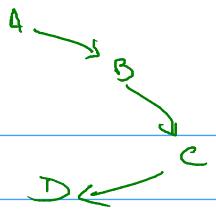
5. If $A \rightarrow B$ & $X \rightarrow Y$ then
   $AX \rightarrow BY$
   Composition

   roll# → s.name
   cid → t.name
   roll#, cid → s.name, t.name

6. If $AX \rightarrow BY$ then
   $AX \rightarrow B$ & $AX \rightarrow Y$
   Decomposition
   reverse of Union

   roll#, cid → s.name, t.name, grade
   roll#, cid → s.name
   roll, cid → t.name
   roll#, cid → grade

7. If $A \rightarrow B$ & $BC \rightarrow D$ then
   $AC \rightarrow D$
   Pseudo Transitivity



$R(A, B, C, D, E, F)$

$A \to B \quad B \to C \quad C \to D \quad E \to f \quad F \to E$

$A \to A$	Reflexivity	
$A \to B$	given	
$A \to C$	transitivity	$A \to B,\ B \to C$
$A \to D$	transitivity	$A \to B,\ B \to C,\ C \to D$
$A \to E$	not possible	

$AF \to E$

$A \to A$	Reflexivity
$F \to E$	Given
$AF \to AE$	Composition

Decomposition:
- $AF \to A$
- $AF \to E$

$AE \to ABCDEF$

A:
- $A \to A$ Reflexivity
- $A \to B$ Given
- $A \to C$ Given
- $A \to D$ Given

E:
- $E \to E$ Reflexivity
- $E \to F$ Given

Union:
- $A \to ABCD$
- $E \to EF$

$AE \to ABCDEF$ composition

Closure

R(A, B, C, D, E)

$A \to BC$ $C \to B$ $D \to E$ $E \to D$

① $A^+ \to ABC$

$B^+ \to B$

$C^+ \to CB$

$D^+ \to DE$

$E^+ \to ED$

② $AB^+ \to ABC$

AC^+

$AD^+ \to ADBCE$

$AE^+ \to AEBCD$

BC^+

$BD^+ \to BDE$

BE^+

CD^+

CE

DE^+

③ ABC^+

ABD^+

ABE^+

ACD^+

ACE^+

ADE^+

BCD^+

BCE^+

BDE^+

CDE^+

④ $ABCD^+$

$ABCE^+$

$ABDE^+$

$ACDE^+$

$BCDE^+$

⑤ $ABCDE^+ \to ABCDE$

# of possible combinations $= 2^n - 1$

Superkey : Set of attributes whose closure contain all attributes of Relation

HW-1

① R(A, B, C, D, E)

A → BC, C → B, D → E, E → D

② R(A B C D E)

A → B B → C D → C

Find closure of all possible combinations

also identify superkeys

R(V, W, X, Y, Z)

Sk = { ② VY, ② VZ, ③ VWY, ③ VWZ, ③ VXY, ③ VXZ, ④ VWYZ, ④ VWXZ, ⑤ VWXYZ }

CK = { VY, VZ }

Size of Superkey : # of attributes in the Sk

Default Superkey : set of all attributes of the relation

Candidate key : Superkeys with smallest size

Primary key : One of the candidate key

R(S T U V W)

S → T T → U U → V V → W W → S

S^+ → STUVW ✓

T^+ → TUVWS ✓

U^+ → UVWST ✓

V^+ → VWSTU ✓

W^+ → WSTUV ✓

Ck = { S, T, U, V, W}

R(A B C D E)

D → E , E → D

R(W X Y Z) $Z \to WXY$ $X \to W$

$W^+ \to W$

$X^+ \to XW$

$Y^+ \to Y$ $CK = \{Z\}$

$Z^+ \to ZWXY$ ✓

R(A B C D E) $A \to C$ $C \to B$ $B \to E$ $E \to D$ $D \to A$

$A^+ \to ACBED$ ✓

$B^+ \to BEDAC$ ✓

$C^+ \to CBEDA$ ✓ $CK = \{A, B, C, D, E\}$

$D^+ \to DACBE$ ✓

$E^+ \to EDACB$ ✓

R(A B C D E) $A \to C$ $E \to D$ $B \to C$

$ABE^+ \to ABECD$

$CK = \{ABE\}$

D	D
A	C
B	D
E	

R(V W X Y Z) $Z \to WXY$ $X \to W$ $Y \to Z$

$V^+ \to V$

$VW^+ \to VW$

$VX^+ \to VXW$

$VY^+ \to VYZWX$ ✓ $CK = \{VY, VZ\}$

$VZ^+ \to VZWXY$ ✓

D	D
V	W
	X
	Y
	Z

R(A B C D E) A→C C→B B→D D→E E→A

D	D
	A
	B
	C
	D
	E

$A^+ \rightarrow ACBDE$ ✓

$B^+ \rightarrow BDEAC$ ✓

$C^+ \rightarrow CBDEA$ ✓

$D^+ \rightarrow DEACB$ ✓

$E^+ \rightarrow EACBD$ ✓

CK = {A, B, C, D, E}

R(A B C D E F G H I J)

AB → EF A → C B → DGHI H → I AE → BDFGHI

L	B	R
A	B	C
J	E	D
	H	F
		G
		I

D	D
A	B
J	C
	D
	E
	F
	G
	H
	I

$A^+ \rightarrow AC$

$AB^+ \rightarrow ABCDGHIEF$ ✓

$AE^+ \rightarrow AECBDFGHI$ ✓

$AH^+ \rightarrow AHCI$

CK = {AB, AE}

Prime Attributes: Any attribute that appears in any CK

Non Prime Attributes: Any attribute which not a prime attribute

$AJ^+ \rightarrow AJC$ ✓

$AJB \rightarrow AJBCDGHIEF$ ✓

$AJE \rightarrow$ ✓

$AJH \rightarrow$

CK = {AJB, AJE}

PA = {A, J, B, E}

NPA = {C, D, F, G, H, I}

R(A, B, C, D, E, F, G, H)

AB → C AC → B AD → E B → D BC → A E → G

11. R(A B C D)

$AB \to C$ $AB \to D$ $C \to A$ $D \to B$

L	B	R
	A	
	B	
	C	
	D	

$A^+ \to A$

$B^+ \to B$

$C^+ \to CA$

$D^+ \to DB$

$AB^+ \to ABCD$ ✓

$AC^+ \to AC$

$AD^+ \to ADBC$ ✓

$BC^+ \to BCAD$ ✓

$BD^+ \to BD$

$CD^+ \to CDAB$ ✓

CK = {AB, AD, BC, CD}

P.A = {A, B, C, D}

N.P.A = {}

Item	Color	Price	Tax	Qty
T-Shirt	Red, Blue	12.00	0.60	5, 3
Polo	Red, Yellow	15.00	0.60	8, 2
T-Shirt	Red, Black	12.00	0.60	5, 9
Sweatshirt	Blue, Black	25.00	1.25	12, 2

Database Design Guidelines

1. Table should have relevent data
2. Avoid redundency — anomalies — insert, update, delete
3. Avoid NULL values
4. Avoid generation of spurious records (when using natural join)

Normalization

0 - Normal Form (0NF)

You should have table with data

1st Normal Form (1-NF)

Data must be in 0-NF

AND

no complex or multivalued data in the table

OR

-table should have FDs

OR

table should have PK

2nd Normal Form

Table must be in 1-NF

AND

All non prime attributes must be fully functionally dependent on whole primary key

OR

No partial dependency between Non prime attributes and portions of PK

3rd Normal Form

Table must be in 2nd Normal Form

AND

All non-prime attributes must be directly functionally dependent on the primary key

OR

No transitive dependency is allowed in the table b/w non-prime attributes and the PK.

Item	Color	Price	Tax	Qty
T-Shirt	Red, Blue	12.00	0.60	5, 3
Polo	Red, Yellow	15.00	0.60	8, 2
T-Shirt	Red, Black	12.00	0.60	5, 9
Sweatshirt	Blue, Black	25.00	1.25	12, 2

Item	Color	Price	Tax	Qty
T.shirt	Red	12.00	0.60	5
T.shirt	Blue	12.00	0.60	3
Polo	Red	15.00	0.60	8
Polo	Yellow	15.00	0.60	2
~~Tshirt~~	~~Red~~	~~12.00~~	~~0.60~~	~~5~~
T.shirt	Black	12.00	0.60	9
S.Shirt	Blue	25.00	1.25	12
S.shirt	Black	25.00	1.25	2

Item → Price
Price → Tax
Item, Color → Qty

$(Item, Color)^+ \rightarrow$ Item, Color, Price, Tax, Qty

L	B	R
Item	Price	Tax
Color		Qty

$CK = \{(Item, Color)\}$
$PK = (item, color)$

R1 (item, color, price, tax, qty) R1 is in 1NF

ABC
A
B
C
AB
AC
BC

Prime attributes : {item, color}
Non Prime Attr : {~~price~~, ~~tax~~, qty}

$item^+ \rightarrow$ item price, tax
$color^+ \rightarrow$ color

R2 (item, price, tax)
R3 (item, color, qty)

R2 & R3 are in 2NF

$A \to x$ $B \to Y$ $C \to W$ $AB \to Z$ $BC \to V$

PK = ABC

R1(A, B, C, V, W, X, Y, Z)

P.A : {A, B, C}

NPA : {V, W, X, Y, Z}

$A^+ \to AX$

$B^+ \to BY$

$C^+ \to CW$

$AB^+ \to ABXYZ$

$AC^+ \to ACXW$

$BC^+ \to BCYWV$

R2(A, X)

R3(B, Y)

R4(C, W)

R5(A, B, Z)

R6(B, C, V)

R7(A, B, C)

R2 (item, price, tax)

R3 (item, color, qty)

R4 (item, price)

R5 (price, tax)

R3, R4 & R5 are in 3NF

R4

item	price
T.shirt	12.00
Polo	15.00
S.shirt	25.00

R5

price	tax
12.00	0.60
15.00	0.60
25.00	1.25

R3

item	color	qty
T.shirt	Red	5
T.shirt	Blue	3
Polo	Red	8
Polo	Yellow	2
T.shirt	Black	9
S.shirt	Blue	12
S.shirt	Black	2