★ Functional Dependency

1. **Tax_payer(Pan_number,name,Occupation type,DOB,address,Resident_no,gender)**

key: Pan_number
Fd_min set -

- Pan_number -> name
- Pan_number ->Occupation type
- Pan_number ->DOB
- Pan_number ->address
- Pan_number ->Resident_no
- Pan_number ->gender

Thus as **Pan_number** is super key in every above functional dependency so **Tax_payer** is in **BCNF.**

2. **Email_Tax_payer(email_id,pan_number)**

Key: Email_id
Fd_min set -

- Email_id -> pan_number

Thus as **Email_id** is super key in every above functional dependency so **Email_Tax_payer** is in **BCNF.**

3. **Tax_Payments(Payment_id,payment_amount,tax_year,payment_mode)**

Key: Payment_id
Fd_min set -

- Payment_id -> payment_amount
- Payment_id ->tax_year
- Payment_id -> payment_mode

Thus as **Payment_id** is super key in every above functional dependency so **Tax_payments** is in **BCNF**

4. **Tax_rate(rate_id,tax_type,tax_rate)**

Key: rate_id
Fd_min set -

- rate_id -> tax_type
- rate_id -> tax_rate

Thus as **Tax_rate** is super key in every above functional dependency, so **Tax_rate** is in **BCNF.**

5. **Tax_refunds(refund_id,refund_amount,refund_data, tax_year)**

Key: refund_id
Fd_min set -

- refund_id -> refund_amount
- refund_id ->refund_data
- refund_id -> tax_year

Thus as **refund_id** is super key in every above functional dependency, **Tax_refunds** is in **BCNF.**

6. **Tax_questions(question_id,description,status)**

Key: question_id
Fd_min set -

- question_id -> description
- question_id -> status

Thus as **question_id** is super key in every above functional dependency, **Tax_questions** is in **BCNF.**

7. **Tax_questions_asked(question_id,pan_number)**

Key : {question_id,pan_number}
Fd_min set -

As all attributes, this relation is part of key, so this above relation is in **BCNF**.

8. **Tax_Audits(Audit_id,Audit_date,Audit_description,Audit_result)**

Key: Audit_id
Fd_min set -

- Audit_id -> Audit_date
- Audit_id -> Audit_description
- Audit_id -> Audit_result

Thus as **Audit_id** is super key in every above functional dependency, **Tax_Audits** is in **BCNF.**

9. **Tax_prepares(Preparer_id,name,Email)**

Key : Preparer_id
Fd_min set -

- Preparer_id -> name
- Preparer_id -> Email

Thus as **Preparer_id** is super key in every above functional dependency, so **Tax_prepares** is in **BCNF.**

10. **prepares(preparer_id,pan_number)**

Key : {preparer_id,pan_number}
Fd_min set -

As all attributes of this relation are part of the key, this above relation is in **BCNF**.

11. **Income_Tax_Branches(Office_id,HOD, address)**

Key: Office_id
Fd_min set -

- Office_id -> HOD
- Office_id -> address

Thus as **Office_id** is super key in every above functional dependency so **Income_Tax_Branches** is in **BCNF.**

12. **Bank(Bank_name,account_no,Account_type)**

Key : {Bank_name,account_no}
Fd_min set -

- {Bank_name,account_no} -> Account_type

Thus as **{Bank_name,account_no}** is super key in every above functional dependency, **Bank** is in **BCNF.**

13. has_Account(Bank_nam,account_no,Pan_number)

Key : {Bank_nam,account_no,Pan_number}
Fd_min set -

As all attributes of this relation are part of the key, this above relation is in **BCNF**.

14. Assets(Asset_id,Acquisition_date,acquisition_cost, asset_description)

Key: Asset_id
Fd_min set -

- Asset_id -> Acquisition_date
- Asset_id -> Acquisition_cost
- Asset_id -> asset_description

Thus as **Asset_id** is super key in every above functional dependency so **Assets** is in **BCNF.**

15. Tax_documents(Doc_id,Doc_type, doc_date_generated)

Key: Doc_id
Fd_min set -

- Doc_id -> Doc_type
- Doc_id -> Doc_date_generated

Thus as **Doc_id** is super key in every above functional dependency so **Tax_documents** is in **BCNF.**

16. Income(pan_number,income_type,income_amount, income_date)

Key : {pan_number,income_type}
Fd_min set -

- {pan_number,income_type} -> income_amount
- {pan_number,income_type} -> income_date

Thus as**{pan_number,income_type}** is super key in every above functional dependency, so **Income** is in **BCNF.**

17. Tax_credits(credit_id -> credit_type, credit_amount,Tax_year)

Key: credit_id
Fd_min set -

- credit_id -> credit_type
- credit_id -> credit_amount
- credit_id -> Tax_year

Thus as **credit_id** is super key in every above functional dependency, **Tax_credits** is in **BCNF.**

18. Tax_withholdings(Withholding_id,employer_name,income_percentage)

Key: Withholding_id
Fd_min set -

- Withholding_id -> employer_name

- Withholding_id -> income_percentage

Thus as **Withholding_id** is super key in every above functional dependency, **Tax_withholdings** is in **BCNF.**

19. Tax_forms(form_id,form_type,form_status,form_due_date)

Key: form_id
Fd_min set -

- form_id -> form_type
- form_id -> form_status
- form_id -> form_due_date

Thus as **form_id** is super key in every above functional dependency, **Tax_forms** is in **BCNF.**

20. Tax_dependents(pan_number,Dependent_name,relation,DOB,gender)

Key : {pan_number,Dependent_name}
Fd_min set -

- {pan_number,Dependent_name} -> relation
- {pan_number,Dependent_name} -> DOB
- {pan_number,Dependent_name} -> gender

Thus as **{pan_number, Dependent_name}** is super key in every above functional dependency, **Tax_dependents** is in **BCNF.**

★ **DDL script**

```
CREATE TABLE Assets
(
 Asset_id          int NOT NULL,
 Pan_number        bigint NOT NULL,
 Acquisition_date  date NOT NULL,
 Acquisition_cost  bigint NOT NULL,
 Asset_description varchar(50) NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Asset_id ),
 CONSTRAINT FK_6 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer ( Pan_number
)
);
```

```
CREATE INDEX FK_2 ON Assets
(
 Pan_number
);
```

```
CREATE TABLE Bank
(
 Bank_name    varchar(50) NOT NULL,
 Account_no   bigint NOT NULL,
```

```
 Account_type varchar(50) NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Bank_name, Account_no )
);


CREATE TABLE Email_Tax_payer
(
 Email_id   varchar(50) NOT NULL,
 Pan_number bigint NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Email_id ),
 CONSTRAINT FK_17 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);

CREATE INDEX FK_2 ON Email_Tax_payer
(
 Pan_number
);


CREATE TABLE has_Account
(
 Bank_name  varchar(50) NOT NULL,
 Account_no bigint NOT NULL,
 Pan_number bigint NOT NULL,
 CONSTRAINT PK_2 PRIMARY KEY ( Bank_name, Account_no, Pan_number ),
 CONSTRAINT FK_12 FOREIGN KEY ( Bank_name, Account_no ) REFERENCES Bank (
Bank_name, Account_no ),
 CONSTRAINT FK_23_1 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);


CREATE INDEX FK_1 ON has_Account
(
 Bank_name,
 Account_no
);


CREATE INDEX FK_3 ON has_Account
(
 Pan_number
);
```

```
CREATE TABLE Income
(
 Income_type   varchar(50) NOT NULL,
 Pan_number    bigint NOT NULL,
 income_amount bigint NOT NULL,
 income_date   date NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Income_type, Pan_number ),
 CONSTRAINT FK_18 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);


CREATE INDEX FK_2 ON Income
(
 Pan_number
);



CREATE TABLE Income_Tax_Branches
(
 Office_id int NOT NULL,
 HOD       varchar(50) NOT NULL,
 pincode   bigint NOT NULL,
 city      varchar(50) NOT NULL,
 "state"     varchar(50) NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Office_id )
);



CREATE TABLE prepares
(
 preparer_id int NOT NULL,
 Pan_number  bigint NOT NULL,
 CONSTRAINT PK_2 PRIMARY KEY ( preparer_id, Pan_number ),
 CONSTRAINT FK_9 FOREIGN KEY ( preparer_id ) REFERENCES Tax_preparers (
preparer_id ),
 CONSTRAINT FK_10 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);
```

```
CREATE INDEX FK_1 ON prepares
(
 preparer_id
);



CREATE INDEX FK_3 ON prepares
(
 Pan_number
);



CREATE TABLE Tax_Audits
(
 Audit_id          int NOT NULL,
 Pan_number        bigint NOT NULL,
 Audit_date        date NOT NULL,
 Audit_description varchar(50) NOT NULL,
 Audit_result      varchar(50) NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Audit_id ),
 CONSTRAINT FK_11 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);







CREATE INDEX FK_2 ON Tax_Audits
(
 Pan_number
);



CREATE TABLE Tax_credits
(
 credit_id     int NOT NULL,
 credit_type   varchar(50) NOT NULL,
 Pan_number    bigint NOT NULL,
```

```
 credit_amount bigint NOT NULL,
 Tax_year      int NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( credit_id ),
 CONSTRAINT FK_22_1 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);



CREATE INDEX FK_2 ON Tax_credits
(
 Pan_number
);



CREATE TABLE Tax_dependents
(
 Dependent_name varchar(50) NOT NULL,
 Pan_number     bigint NOT NULL,
 relation       varchar(50) NOT NULL,
 DOB            date NOT NULL,
 gender         varchar(50) NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Dependent_name, Pan_number ),
 CONSTRAINT FK_16 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);







CREATE INDEX FK_2 ON Tax_dependents
(
 Pan_number
);



CREATE TABLE Tax_documents
(
 Doc_id             bigint NOT NULL,
 Pan_number         bigint NOT NULL,
 Doc_type           varchar(50) NOT NULL,
```

```
 Doc_date_generated date NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Doc_id ),
 CONSTRAINT FK_19 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);



CREATE INDEX FK_2 ON Tax_documents
(
 Pan_number
);



CREATE TABLE Tax_forms
(
 form_id       bigint NOT NULL,
 Pan_number    bigint NOT NULL,
 form_type     varchar(50) NOT NULL,
 form_status   varchar(50) NOT NULL,
 form_due_date date NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( form_id ),
 CONSTRAINT FK_22 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);









CREATE INDEX FK_2 ON Tax_forms
(
 Pan_number
);



CREATE TABLE Tax_payer
(
 Pan_number      bigint NOT NULL,
 "First name"      varchar(50) NOT NULL,
 Office_id       int NOT NULL,
```

```
 "Last name"       varchar(50) NOT NULL,
 "Occupation Type" varchar(50) NOT NULL,
 DOB               date NOT NULL,
 pincode           varchar(50) NOT NULL,
 city              varchar(50) NOT NULL,
 "state"           varchar(50) NOT NULL,
 Resident_no       int NOT NULL,
 gender            varchar NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( Pan_number ),
 CONSTRAINT FK_22_2 FOREIGN KEY ( Office_id ) REFERENCES Income_Tax_Branches (
Office_id )
);


CREATE INDEX FK_2 ON Tax_payer
(
 Office_id
);


CREATE TABLE Tax_Payments
(
 payment_id      int NOT NULL,
 pan_number      bigint NOT NULL,
 Payment_Amount bigint NOT NULL,
 Tax_year        int NULL,
 Payment_mode    varchar(50) NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( payment_id ),
 CONSTRAINT FK_3 FOREIGN KEY ( pan_number ) REFERENCES Tax_payer ( Pan_number
)
);


CREATE INDEX FK_2 ON Tax_Payments
(
 pan_number
);


CREATE TABLE Tax_preparers
(
 preparer_id int NOT NULL,
 Office_id   int NOT NULL,
 name        varchar(50) NOT NULL,
```

```
 email       varchar NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( preparer_id ),
 CONSTRAINT FK_8 FOREIGN KEY ( Office_id ) REFERENCES Income_Tax_Branches (
Office_id )
);


CREATE INDEX FK_2 ON Tax_preparers
(
 Office_id
);


CREATE TABLE Tax_questions
(
 question_id int NOT NULL,
 description varchar(50) NOT NULL,
 status      varchar(50) NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( question_id )
);

CREATE TABLE Tax_questions_asked
(
 question_id int NOT NULL,
 Pan_number  bigint NOT NULL,
 CONSTRAINT PK_3 PRIMARY KEY ( question_id ),
 CONSTRAINT FK_1 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer ( Pan_number
),
 CONSTRAINT FK_2 FOREIGN KEY ( question_id ) REFERENCES Tax_questions (
question_id )
);


CREATE INDEX FK_1 ON Tax_questions_asked
(
 Pan_number
);

CREATE INDEX FK_2 ON Tax_questions_asked
(
 question_id
);

 CREATE TABLE Tax_rate
```

```
(
 rate_id  int NOT NULL,
 Tax_type varchar(50) NOT NULL,
 Tax_rate decimal NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( rate_id )
);



CREATE TABLE Tax_refunds
(
 refund_id     int NOT NULL,
 Pan_number    bigint NOT NULL,
 refund_amount bigint NOT NULL,
 refund_date   date NOT NULL,
 Tax_year      int NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( refund_id ),
 CONSTRAINT FK_7 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer ( Pan_number
)
);




CREATE INDEX FK_2 ON Tax_refunds
(
 Pan_number
);

CREATE TABLE Tax_withholdings
(
 withholding_id    int NOT NULL,
 Pan_number        bigint NOT NULL,
 employer_name     varchar(50) NOT NULL,
 Income_percentage int NOT NULL,
 CONSTRAINT PK_1 PRIMARY KEY ( withholding_id, Pan_number ),
 CONSTRAINT FK_23 FOREIGN KEY ( Pan_number ) REFERENCES Tax_payer (
Pan_number )
);

CREATE INDEX FK_2 ON Tax_withholdings
(
 Pan_number
);
```

Some changes that we have made in ER diagram:-

1) We have removed some relationships, such as between Tax_Audits and Tax_documents, Tax_withholdings, and Income,Tax_forms and Income_tax_department,Tax_Documnets and Income_tax_department.
2) We have removed some attributes from Income_tax_department, Tax_payer, and Tax_withholdings.
3) We have changed some cardinality constraints in some relationships such as posses(between Tax_payer and assets), Audited to(Tax_payer and Tax_audits) and eligible for(Tax_payer and Tax_credits).