



Module 2-7

Database Design

Objectives

- Database Design Exercise
- Database Definition Language
- Database Control Language

Database Design Exercise

Gallery Customer History Form

Customer Name

Jackson, Elizabeth
123 – 4th Avenue
Fonthill, ON
L3J 4S4

Phone (206) 284-6783

Purchases Made

Artist	Title	Purchase Date	Sales Price
03 - Carol Channing	Laugh with Teeth	09/17/2000	7000.00
15 - Dennis Frings	South toward Emerald Sea	05/11/2000	1800.00
03 - Carol Channing	At the Movies	02/14/2002	5550.00
15 - Dennis Frings	South toward Emerald Sea	07/15/2003	2200.00

The Gill Art Gallery wishes to maintain data on their customers, artists and paintings. They may have several paintings by each artist in the gallery at one time. Paintings may be bought and sold several times. In other words, the gallery may sell a painting, then buy it back at a later date and sell it to another customer.

Normal Forms

Before a single CREATE statement is run, the tables and their relationships need to be well thought out.

One design methodology commonly used is Boyce-Codd Normal Form (BCNF).

Normalization is the process of organizing a database to reduce data redundancy and improve data integrity.

Normal Forms: Before normalization

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	A	B	C	D	E
1	Name	Address	Phone	Purchases(ArtistId, ArtistName, ArtTitle, PurchaseDate, Price)	
	Jackson, Elizabeth	123 - 4th Avenue FonthillON	(206) 284-6783	03, Carol Channing, Laugh with Teeth, 9/17/2000, \$7000.00 15, Dennis Frings, South toward Emerald Sea, 5/11/2000, \$1800.00 03, Carol Channing, At the Movies, 2/14/2002, \$5550.00 15, Dennis Frings, South toward Emerald Sea, 7/15/2003, \$2200.00	
2					
3	Smith, John	123 Main StreetNew York, I	(123) 867-5309	02, Rick Steves, Travels through Europe, 9/01/2002, \$1050.00	
4					
5					
6					
7					
8					

Normal Forms: 1NF

- No table should contain duplicative columns that one could use to get other types of information.
- Every table should be organized in rows with primary keys that uniquely identify it.

CUSTOMERS							
CustomerID (PK)	Name	Address	Phone				
1	Jackson, Elizabeth	123 - 4th Avenue Fonthill	(206) 284-6783				
2	Smith, John	123 Main StreetNew York, NY	(123) 867-5309				
CUSTOMER PURCHASES							
CustomerID (PK, FK)	ArtCode (PK)	Purchase Date (PK)	ArtistId	ArtistName	Title	Price	
1	LWT	9/17/2000	3	Carol Channing	Laugh with Teeth	\$7,000.00	
1	STES	5/11/2000	15	Dennis Frings	South toward Emerald Sea	\$1,800.00	
1	ATM	2/14/2002	3	Carol Channing	At the Movies	\$5,550.00	
1	STES	7/15/2003	15	Dennis Frings	South toward Emerald Sea	\$2,200.00	
2	TTE	9/1/2002	2	Rick Steves	Travels through Europe	\$1,050.00	
1NF In 1st Normal Form, no table should contain duplicative columns (purchase 1, purchase 2, ... purchase n) that one could use to get other types of information. Every table is organized in rows with primary keys that uniquely identify it.							

Normal Forms: 2NF

- Must be in 1NF
- Any non-key attribute must be dependent on the primary key

A	B	C	D	E
CUSTOMERS				
CustomerID (PK)	Name	Address	Phone	
1	Jackson, Elizabeth	123 - 4th Avenue Fonthill	(206) 284-6783	
2	Smith, John	123 Main StreetNew York, NY	(123) 867-5309	
CUSTOMER PURCHASES				
CustomerID (PK, FK)	ArtCode (PK, FK)	Purchase Date (PK)	Price	
1	LWT	9/17/2000	\$7,000.00	
1	STES	5/11/2000	\$1,800.00	
1	ATM	2/14/2002	\$5,550.00	
1	STES	7/15/2003	\$2,200.00	
2	TTE	9/1/2002	\$1,050.00	
ART				
ArtCode (PK)	Title	ArtistID	ArtistName	
LWT	Laughing with Teeth	3	Carol Channing	
STES	South toward Emerald Sea	15	Dennis Frings	
ATM	At the Movies	3	Carol Channing	
TTE	Travels through Europe	2	Rick Steves	
2NF				
In 2nd Normal Form, the table must already be in 1NF.				
Any Non-key Attribute must be dependent on the primary key.				

Normal Forms: 3NF

- Must be in 2NF
- No transitive functional dependency – if column A is dependent on column B and column B is dependent on C, then column A is dependent on C

A	B	C	D	E	F	G
CUSTOMERS						
CustomerID (PK)	Name	Address	Phone			
1	Jackson, Elizabeth	123 - 4th Avenue Fonthill	ON (206) 284-6783			
CUSTOMER PURCHASES						
CustomerID (PK, FK)	ArtCode (PK, FK)	Purchase Date (PK)	Price			
1	LWT	9/17/2000	\$7,000.00			
1	STES	5/11/2000	\$1,800.00			
1	ATM	2/14/2002	\$5,550.00			
1	STES	7/15/2003	\$2,200.00			
2	TTE	9/1/2002	\$1,050.00			
ART						
ArtCode (PK)	Title	ArtistID (FK)				
LWT	Laughing with Teeth	3				
STES	South toward Emerald Sea	15				
ATM	At the Movies	3				
TTE	Travels through Europe	2				
ARTISTS						
ArtistID (PK)	First Name	Last Name				
2	Rick	Steves				
3	Carol	Channing				
15	Dennis	Frings				
3NF						
In 3rd Normal Form, the table must already be in 2NF.						
There cannot be any transitive dependency between columns (e.g. in 2NF Artist Name was dependent on Artist Id which was dependent on ArtCode)						

Normal Forms: 3NF

There are several levels above 3NF of “normal form” compliance, but generally the third normal form is good enough for 99% of all situations.

An informal intuitive definition of 3NF is as follows:



There are no fields in a table that are not directly determined by the values of the primary key.

Normal Forms: 3NF Example

Suppose we have the following table:

InvoiceNumber (PK)	InvoiceDate	Inventory ID	Inventory Description
1000	10/1/2019	45	Hammer
1001	10/3/2019	28	Nails
1002	10/3/2019	17	Screwdriver
1003	10/4/2019	45	Hammer

Some questions to consider:

- Is an invoice date directly related to an invoiceNumber?  Yes
- Is an inventory description directly related to an invoiceNumber?  No

Normal Forms: 3NF Example

Suppose we need a Spanish version of this database, and we need to value to show *Martillo* instead of Hammer. This would entail an UPDATE statement that targets 2 rows.

InvoiceNumber (PK)	InvoiceDate	Inventory ID	Inventory Description	
1000	10/1/2019	45	Martillo	
1001	10/3/2019	28	Nails	
1002	10/3/2019	17	Screwdriver	
1003	10/4/2019	45	Martillo	

Normal Forms: 3NF Example

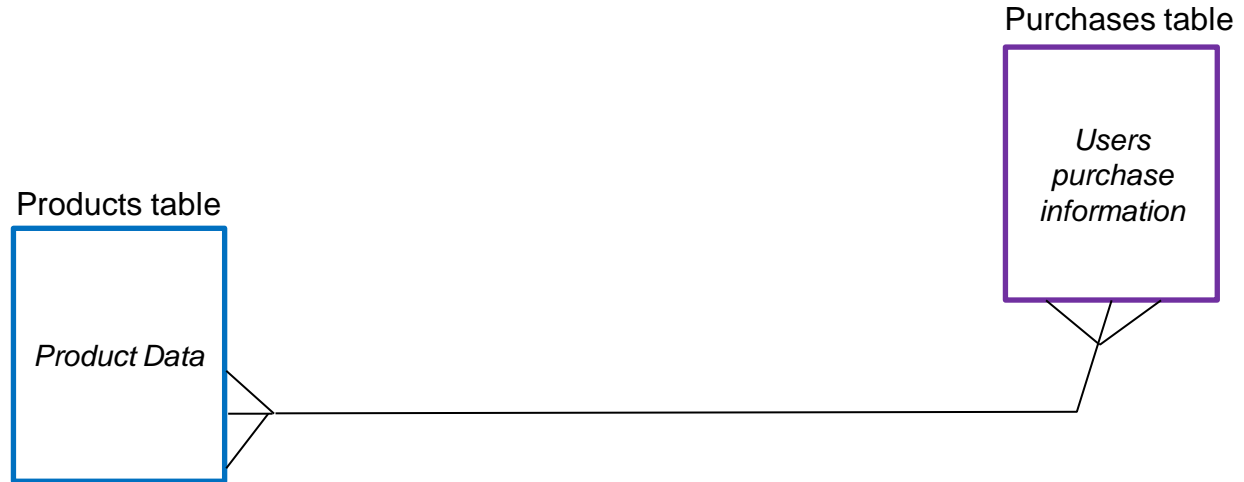
In this situation, we could have split up the data into 2 tables, thus we end up with a less risky query, affecting only 1 row:

InvoiceNumber (PK)	InvoiceDate	Inventory ID
1000	10/1/2019	45
1001	10/3/2019	28
1002	10/3/2019	17
1003	10/4/2019	45

Inventory ID (pk)	Description
28	Nails
17	Screwdriver
45	Martillo

Many to Many relationships

Generally speaking, when there are 2 entities for which there is a “many to many” relationship, we will end up with 3 tables when considering 3NF as part of our design.



Many to Many relationships Example

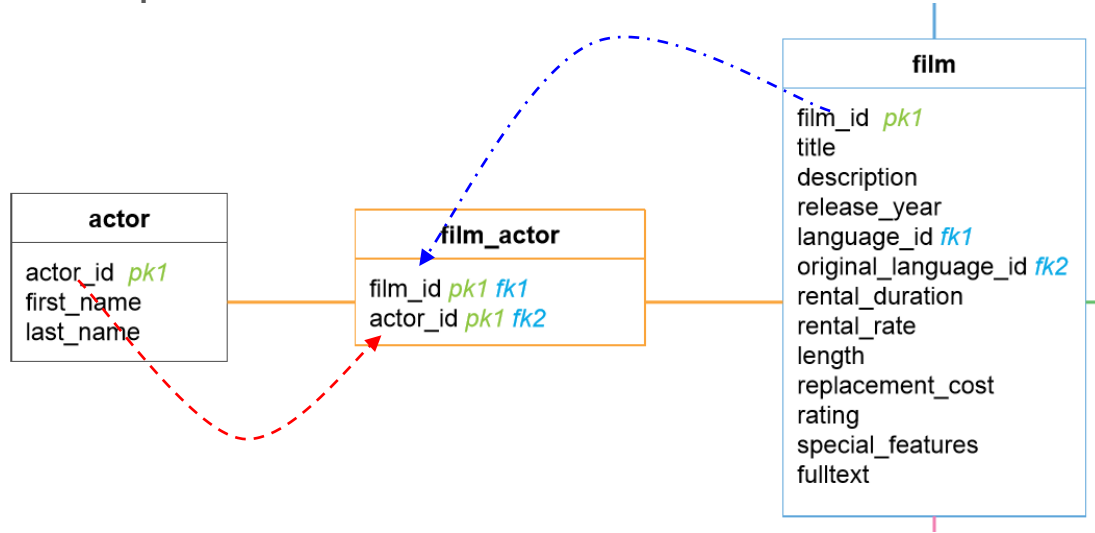
Consider the dvdstore example:

- An actor can be a cast member of several movies.
 - A movie can have several actors.

This is a “many to many” relationship.

Many to Many relationships Example

Consequently we end up with three tables to describe this relationship:



For this relationship to work we have defined two foreign keys in the **film_actor** table, the primary keys of each of the other two tables.

DML vs DDL vs TCL

The SQL statements we have seen so far fall into a number of different categories:

- Data Manipulation Language (**DML**): SELECT, INSERT, UPDATE, DELETE
- Data Definition Language (**DDL**): CREATE, ALTER, DROP
- Transaction Control Language (TCL): BEGIN, TRANSACTION, COMMIT
- Data Control Language (DCL): GRANT, REVOKE

The focus of this lecture will be DDL statements with appropriate constraints.

Creating Tables Example

We are now ready to evaluate the syntax for table creation and alteration. This is the Create table syntax for all 3 of the previous tables:

```
CREATE TABLE actor (  
  actor_id serial NOT NULL,  
  first_name varchar(45) NOT NULL,  
  last_name varchar(45) NOT NULL,  
  CONSTRAINT pk_actor_actor_id PRIMARY  
  KEY (actor_id)  
);
```

In film_actor are actor_id and film_id foreign keys yet?

No!

```
CREATE TABLE film_actor (  
  actor_id integer NOT NULL,  
  film_id integer NOT NULL,  
  CONSTRAINT pk_film_actor_actor_id_film_id PRIMARY KEY (actor_id, film_id)  
);
```

```
CREATE TABLE film (  
  film_id serial NOT NULL,  
  title varchar(255) NOT NULL,  
  description varchar(512),  
  release_year smallint,  
  language_id integer NOT NULL,  
  original_language_id integer,  
  rental_duration smallint DEFAULT 3 NOT NULL,  
  rental_rate numeric(4,2) DEFAULT 4.99 NOT NULL,  
  length smallint,  
  replacement_cost numeric(5,2) DEFAULT 19.99 NOT NULL,  
  rating varchar(5) DEFAULT 'G',  
  CONSTRAINT pk_film_film_id PRIMARY KEY (film_id),  
  CONSTRAINT ck_film_rating CHECK (rating IN ('G', 'PG', 'PG-13', 'R', 'NC-17'))  
);
```

Creating Tables Example

We finish by specifying that actor_id and film_id are actually foreign keys. The DBMS does not assume this just because it has the same name, we must use the ALTER command:

```
ALTER TABLE film_actor  
ADD FOREIGN KEY(film_id)  
REFERENCES film(film_id);
```

```
ALTER TABLE film_actor  
ADD FOREIGN KEY(actor_id)  
REFERENCES actor(actor_id);
```

CREATE/DROP syntax

```
CREATE DATABASE database_name;
```

```
DROP DATABASE database_name;
```

```
CREATE TABLE table_name  
(  
    column_name1 data_type(size),  
    column_name2 data_type(size) NOT NULL,  
    column_name3 data_type(size),  
    CONSTRAINT pk_column_1 PRIMARY KEY (column_name1),  
    CONSTRAINT fk_column_2 FOREIGN KEY (column_name2)  
        REFERENCES table_name(column_1)  
);
```

ALTER syntax

```
ALTER TABLE table_name  
    ADD CONSTRAINT pk_constraint_name  
    PRIMARY KEY (column_name(s));
```

```
ALTER TABLE table_name  
    ADD CONSTRAINT fk_constraint_name  
    FOREIGN KEY (column_name) REFERENCES  
    table(column_name);
```

```
ALTER TABLE table_name  
    ADD CONSTRAINT chk_constraint_name  
    CHECK (column_name = 'value' OR  
    column_name IN (values));
```