

COMM1822

Term 2 2022

Introduction to Databases for Business Analytics

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Week 3 Relational Modelling

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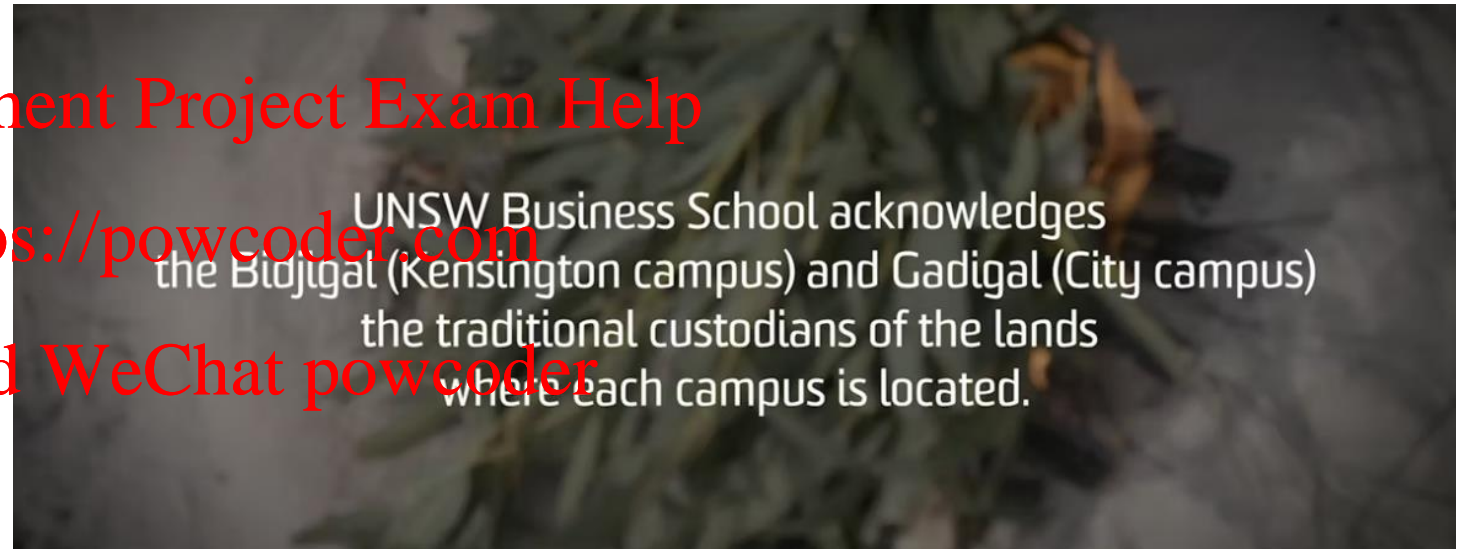
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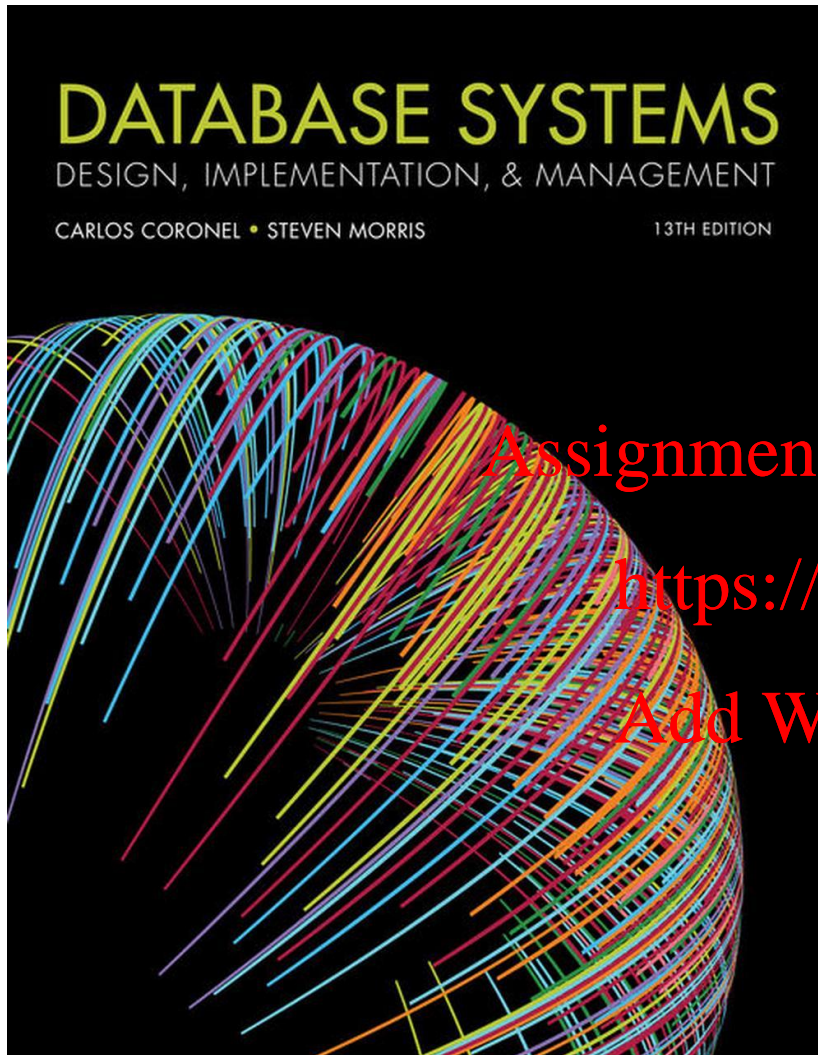
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Chapter 3

Relational Database Model

3-1 to 3-7

Agenda

Relational Database Modelling

- ❑ Definition **relational model**
- ❑ Relational model **integrity**
- ❑ From **ER diagram** to **relational model** (from entities to schema/tables)
- ❑ **Mapping ER relationships** in the relational model

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Database Design: Overview

When designing database for an organisation, the processes are:

- ❑ Gather business requirements.
- ❑ **Develop conceptual model using ER modelling technique (Weeks 1 and 2).**
- ❑ **Convert ER model to a set of relations in the relational model (Week 3).**
- ❑ Normalise the relations to remove any anomalies (Weeks 4 and 5).
- ❑ Implement the database by creating a table for each normalised relations.

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Relational Model

- ❑ “A **relational model** represents data in a two-dimensional table called a relation.”
- ❑ **Relational model** includes:
 - **Relations:** two-dimensional tables
 - **Attributes:** the **column headers** of a relation.
 - **Tuples:** the **rows** of a relation.
- ❑ The name of a **relation** (table) and its set of attributes (column headers) are called a **schema** for the relation.
- ❑ The **set of schemas** for **all relations** in a design is called a **database schema** (**metadata**).
- ❑ The **data dictionary** describes the database schema.
- ❑ Usually implemented in a **RDBMS** (relational database management system) such as **Oracle**.

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Example of a Relational Model

❑ Relational schema for the relation “MOVIE”

- MOVIE (TITLE, YEAR, LENGTH)

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❑ Relation

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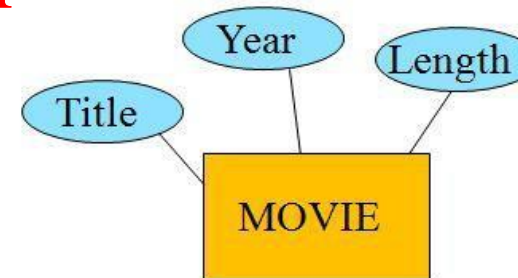
- Every relation has a **unique name**.
- Every attribute value is **atomic**.
- Every row is **unique**.
- **Attributes** in tables have **unique names**.
- The **order of the columns** is **irrelevant**.
- The **order of the rows** is **irrelevant**.

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Example of a Relational Model

TITLE	YEAR	LENGTH
Lord of the Rings	2001	178
Harry Potter	2006	150
Inception	2010	148

Relational Model



Conceptual Model

FIGURE 3.2 AN EXAMPLE OF A SIMPLE RELATIONAL DATABASE

Table name: **PRODUCT**
 Primary key: **PROD_CODE**
 Foreign key: **VEND_CODE**

Database name: Ch03_SaleCo

PROD_CODE	PROD_DESCRIPT	PROD_PRICE	PROD_ON_HAND	VEND_CODE
001278-AB	Claw hammer	12.95	23	232
123-21UUY	Houselite chain saw, 16-in. bar	189.99	4	235
QER-34256	Sledge hammer, 16-lb. head	18.63	6	231
SRE-657UG	Rat-tail file	2.99	15	232
ZZX/3245Q	Steel tape, 12-ft. length	6.79	8	235

Table name: **VENDOR**
 Primary key: **VEND_CODE**
 Foreign key: none

VEND_CODE	VEND_CONTACT	VEND_AREACODE	VEND_PHONE
230	Shelly K. Smithson	608	555-1234
231	James Johnson	615	123-4536
232	Anneise Crystal	608	224-2134
233	Candice Wallace	904	342-6567
234	Arthur Jones	615	123-3324
235	Nancy Orozco	615	809-3425

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Relational schema:

PRODUCT (Prod Code, Prod_Descript, Prod_Price, Prod_On_Hand, Vend_Code)

VENDOR (Vend Code, Vend_Contact, Vend_AreaCode, Vend_Phone)

TABLE 3.6

A SAMPLE DATA DICTIONARY

TABLE NAME	ATTRIBUTE NAME	CONTENTS	TYPE	FORMAT	RANGE	REQUIRED	PK OR FK	FK REFERENCED TABLE
CUSTOMER	CUS_CODE	Customer account code	CHAR(5)	99999	10000–99999	Y	PK	
	CUS_LNAME	Customer last name	VARCHAR(20)	Xxxxxxxx		Y		
	CUS_FNAME	Customer first name	VARCHAR(20)	Xxxxxxxx		Y		
	CUS_INITIAL	Customer initial	CHAR(1)	X				
	CUS_RENEW_DATE	Customer insurance renewal date	DATE	dd-mmm-yyyy				
	AGENT_CODE	Agent code	CHAR(3)	999			FK	AGENT
AGENT	AGENT_CODE	Agent code	CHAR(3)	999		Y	PK	
	AGENT_AREACODE	Agent area code	CHAR(3)	999		Y		
	AGENT_PHONE	Agent telephone number	CHAR(8)	999–9999		Y		
	AGENT_LNAME	Agent last name	VARCHAR(20)	Xxxxxxxx		Y		
	AGENT_YTD_SLS	Agent year-to-date sales	NUMBER(9,2)	9,999,999.99				

FK	= Foreign key
PK	= Primary key
CHAR	= Fixed character length data (1 – 255 characters)
VARCHAR	= Variable character length data (1 – 2,000 characters)
NUMBER	= Numeric data. NUMBER (9,2) is used to specify numbers with up to nine digits, including two digits to the right of the decimal place. Some RDBMS permit the use of a MONEY or CURRENCY data type.

ANSI/ISO SQL Data Types

Data Type	Description
CHAR	Fixed-length character strings
VARCHAR	Variable-length character strings
INTEGER	Integer numbers
BIT	Fixed-length bit string (bit array)
NUMERIC	Decimal numbers
FLOAT	Floating point numbers
DATE	Calendar date
TIME	Clock time
TIMESTAMP	Date and time

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Relational Database Keys

Example: STUDENT(zID, FName, LName, PassportNum)

e.g., zID, PassportNum, {zID, FName}, {zID, LName}, {zID, PassportNum}, ..., {zID, FName, LName, PassportNum} (as long as the attribute(s) can uniquely identifies each row)

TABLE 3.3

RELATIONAL DATABASE KEYS

KEY TYPE	DEFINITION
Superkey	An attribute or combination of attributes that uniquely identifies each row in a table
Candidate key e.g., zID or PassportNum	A <u>minimal (irreducible) superkey</u> : a superkey that does not contain a subset of attributes that is itself a superkey
Primary key e.g., zID	A <u>candidate</u> key selected to uniquely identify all other attribute values in any given row; cannot contain null entries
Foreign key	An attribute or combination of attributes in one table whose values <u>must either match the primary key in another table or be null</u>
Secondary key	An attribute or combination of attributes used strictly for data retrieval purposes

e.g., PassportNum

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Integrity

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Integrity Rules

Three basic types of **database integrity constraints**:

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- 1) **Entity integrity**: Requiring each row in a table to have a **different primary key** value. <https://powcoder.com>
 - 2) **Referential integrity**: Requiring the existence of a corresponding primary key in another table for any **foreign key** value. Add WeChat powcoder
 - 3) **Domain integrity**: Restricting data in a column to its **predefined data** types.

Integrity Rules

TABLE 3.4

INTEGRITY RULES

ENTITY INTEGRITY	DESCRIPTION
Requirement	All primary key entries are unique, and no part of a primary key may be null.
Purpose	Each row will have a unique identity, and foreign key values can properly reference primary key values.
Example	No invoice can have a duplicate number, nor can it be null; in short, all invoices are uniquely identified by their invoice number.
REFERENTIAL INTEGRITY	DESCRIPTION
Requirement	A foreign key may have either a null entry, as long as it is not a part of its table's primary key, or an entry that matches the primary key value in a table to which it is related; (every non-null foreign key value <i>must</i> reference an <i>existing</i> primary key value).
Purpose	It is possible for an attribute <i>not</i> to have a corresponding value, but it will be impossible to have an invalid entry; the enforcement of the referential integrity rule makes it impossible to delete a row in one table whose primary key has mandatory matching foreign key values in another table.
Example	A customer might not yet have an assigned sales representative (number), but it will be impossible to have an invalid sales representative (number).

Referential Integrity Example

FIGURE 3.3 AN ILLUSTRATION OF INTEGRITY RULES

Table name: CUSTOMER
Primary key: CUS_CODE
Foreign key: AGENT_CODE

Database name: Ch03_InsureCo

CUS_CODE	CUS_LNAME	CUS_FNAME	CUS_INITIAL	CUS_RENEW_DATE	AGENT_CODE
10010	Ramas	Alfred	A	05-Apr-2018	502
10011	Dunne	Leona	K	16-Jun-2018	501
10012	Smith	Kathy	W	29-Jan-2019	502
10013	O'Dwyer	Paul		04-Oct-2018	
10014	Orlando	Myron		28-Dec-2018	501
10015	O'Brian	Amy	B	22-Sep-2018	503
10016	Brown	James	G	25-Mar-2019	502
10017	Williams	George		17-Jul-2018	503
10018	Farriss	Anne	G	03-Dec-2018	501
10019	Smith	Olafte	K	14-Mar-2019	503

Table name: AGENT (only five selected fields are shown)
Primary key: AGENT_CODE
Foreign key: none

AGENT_CODE	AGENT_AREACODE	AGENT_PHONE	AGENT_LNAME	AGENT_YTD_SLS
501	713	228-1249	Alby	132735.75
502	615	882-1244	Hahn	138967.35
503	615	123-5589	Okon	127093.45

From Conceptual Model to Relational Model

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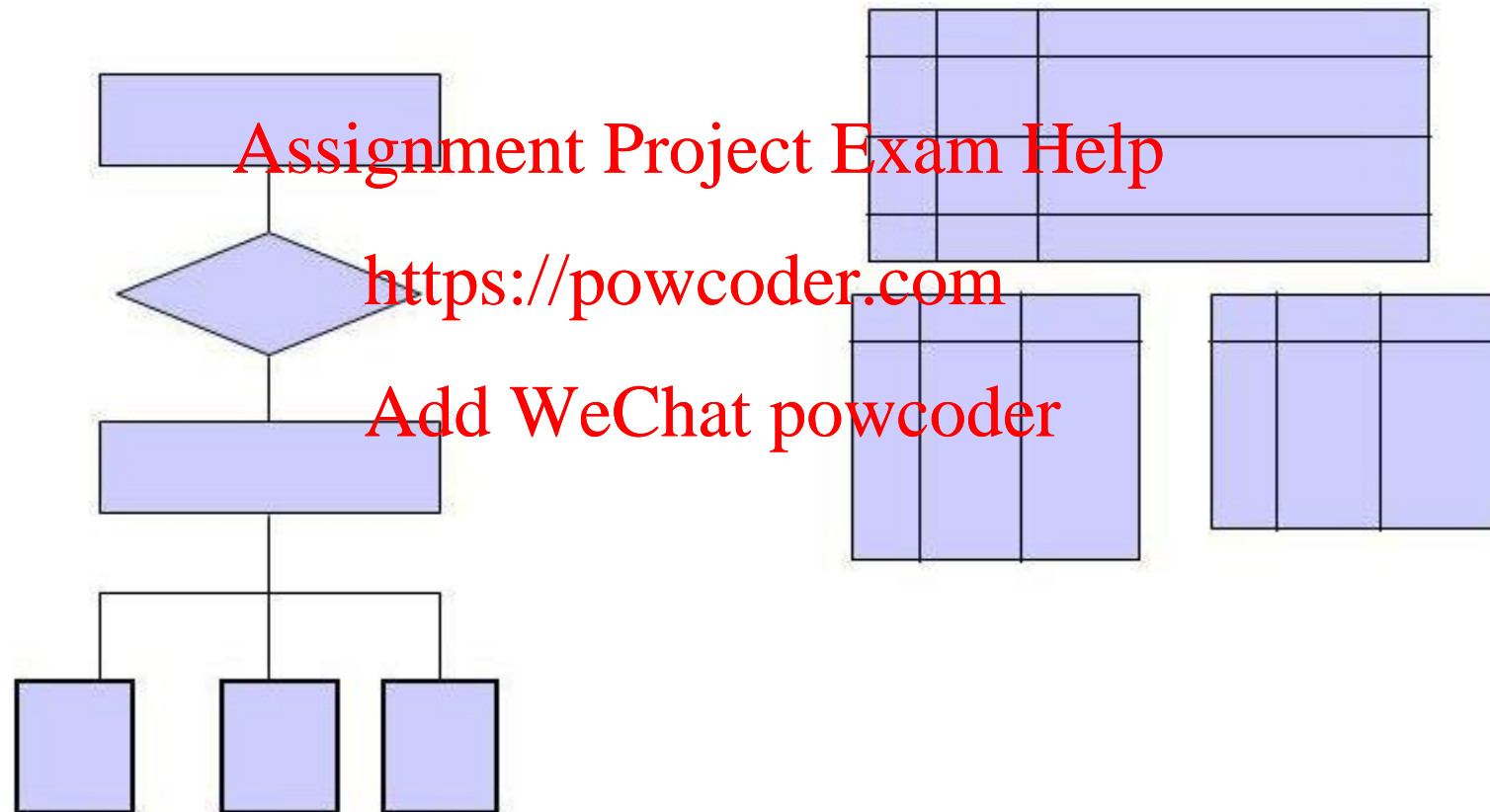
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Conceptual Model to Relational Model

ER Model -> Relational Model -> Database



Conceptual Model to Relational Model

In general, **each entity will be converted to a relation**. The attributes of the entity become the attributes of relation.

- ❑ Eliminate **composite and multi-valued attributes**.
- ❑ Translate each **entity** into a **relation** (table).
- ❑ Translate appropriate **relationships** into a **relation** (others might just be a FK link).

Mapping Entities

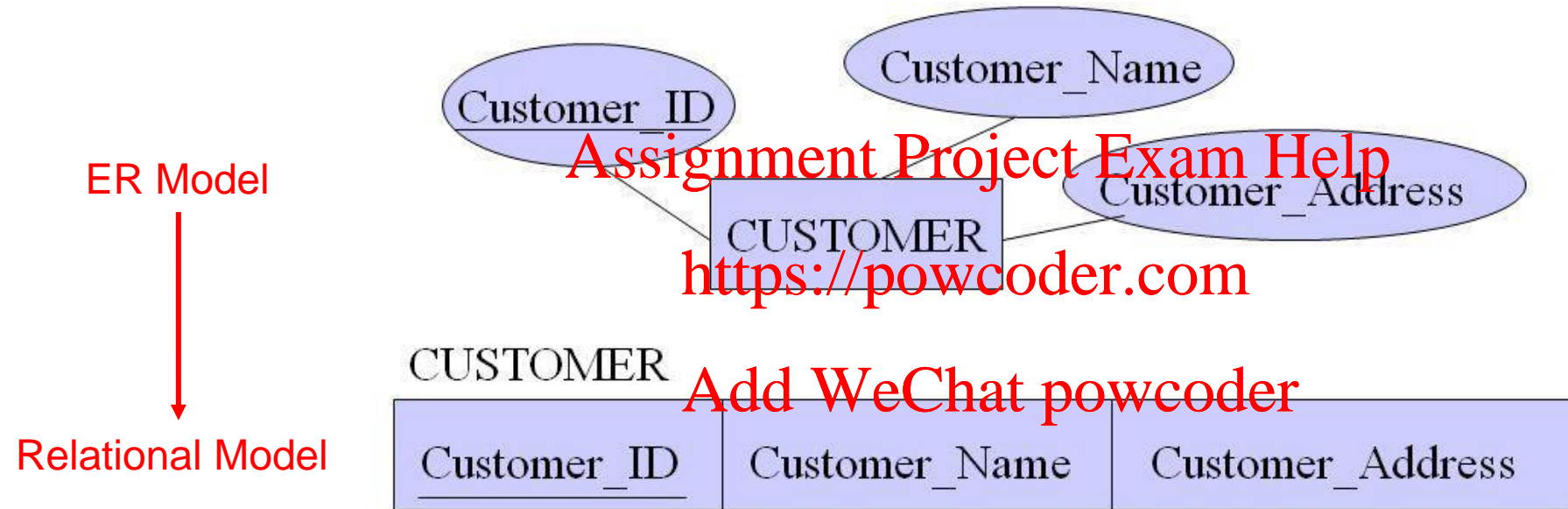
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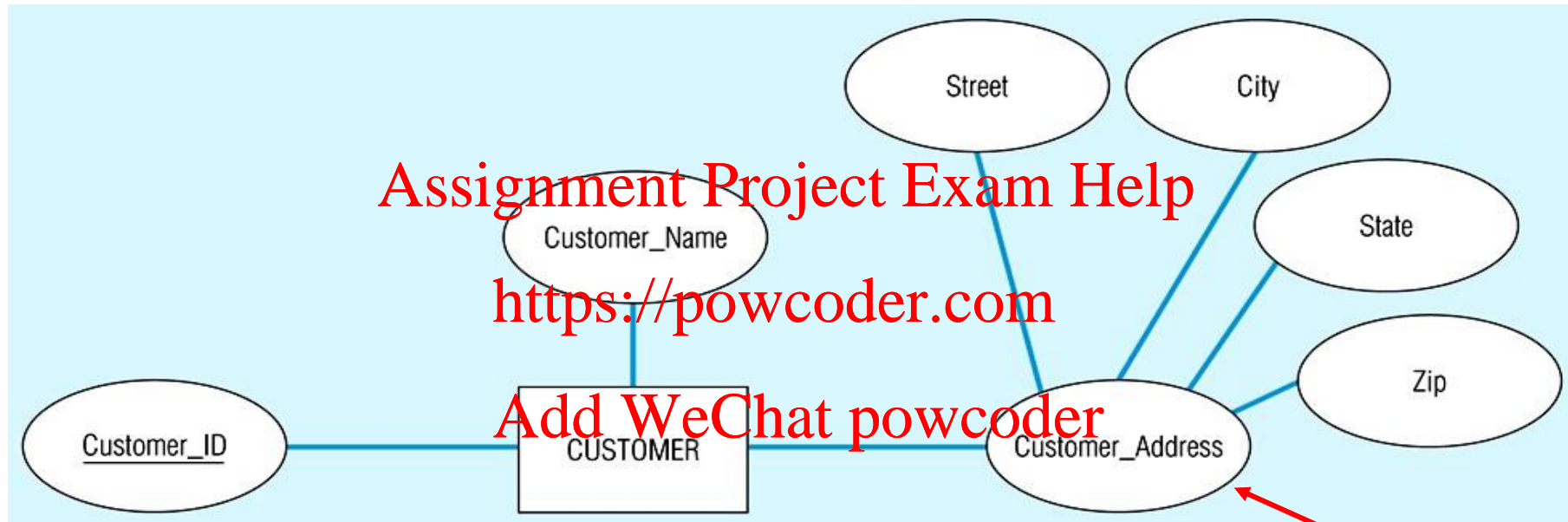


Mapping Entities



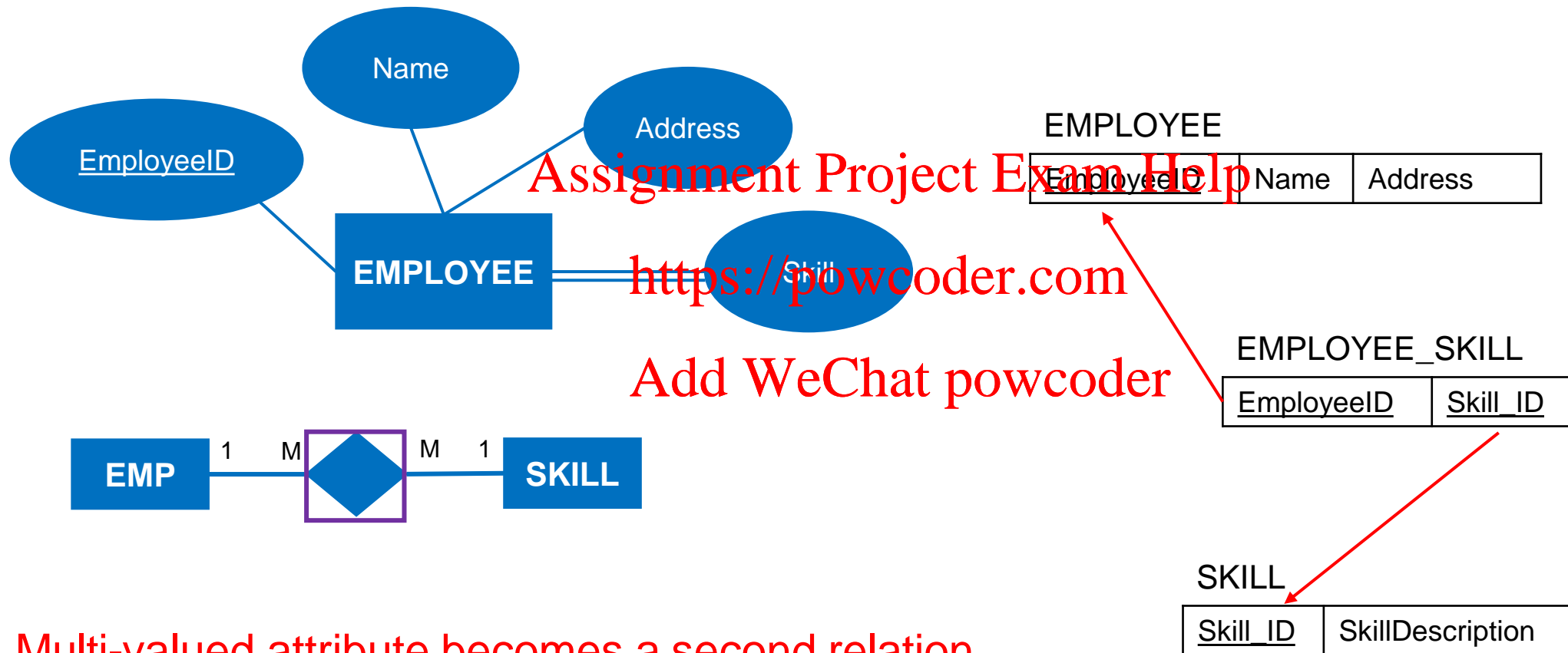
Map all regular entities to relations.

Mapping Composite Attributes



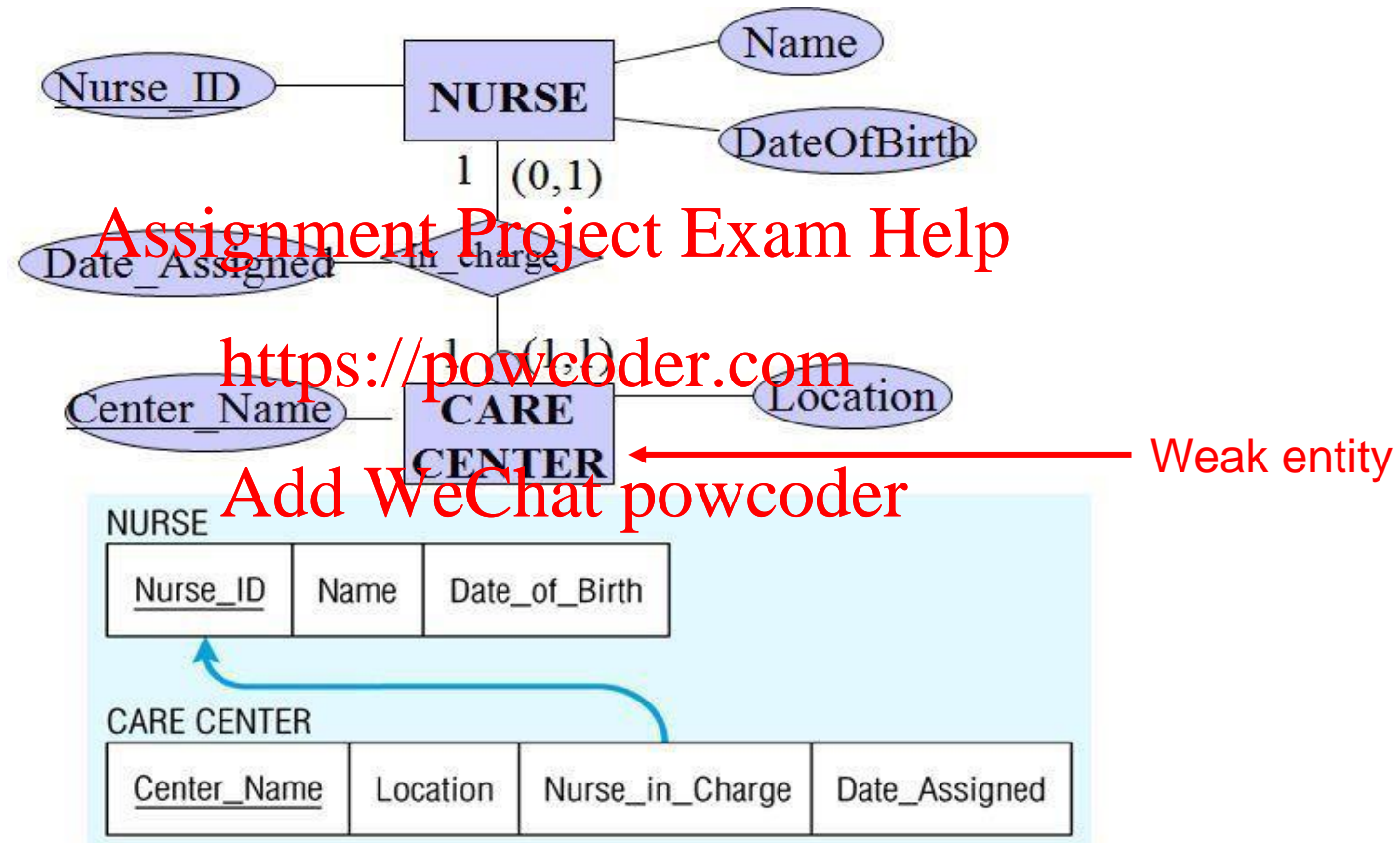
CUSTOMER					
<u>Customer_ID</u>	Customer_Name	Street	City	State	Zip

Mapping Multi-Valued Attributes



Multi-valued attribute becomes a second relation.

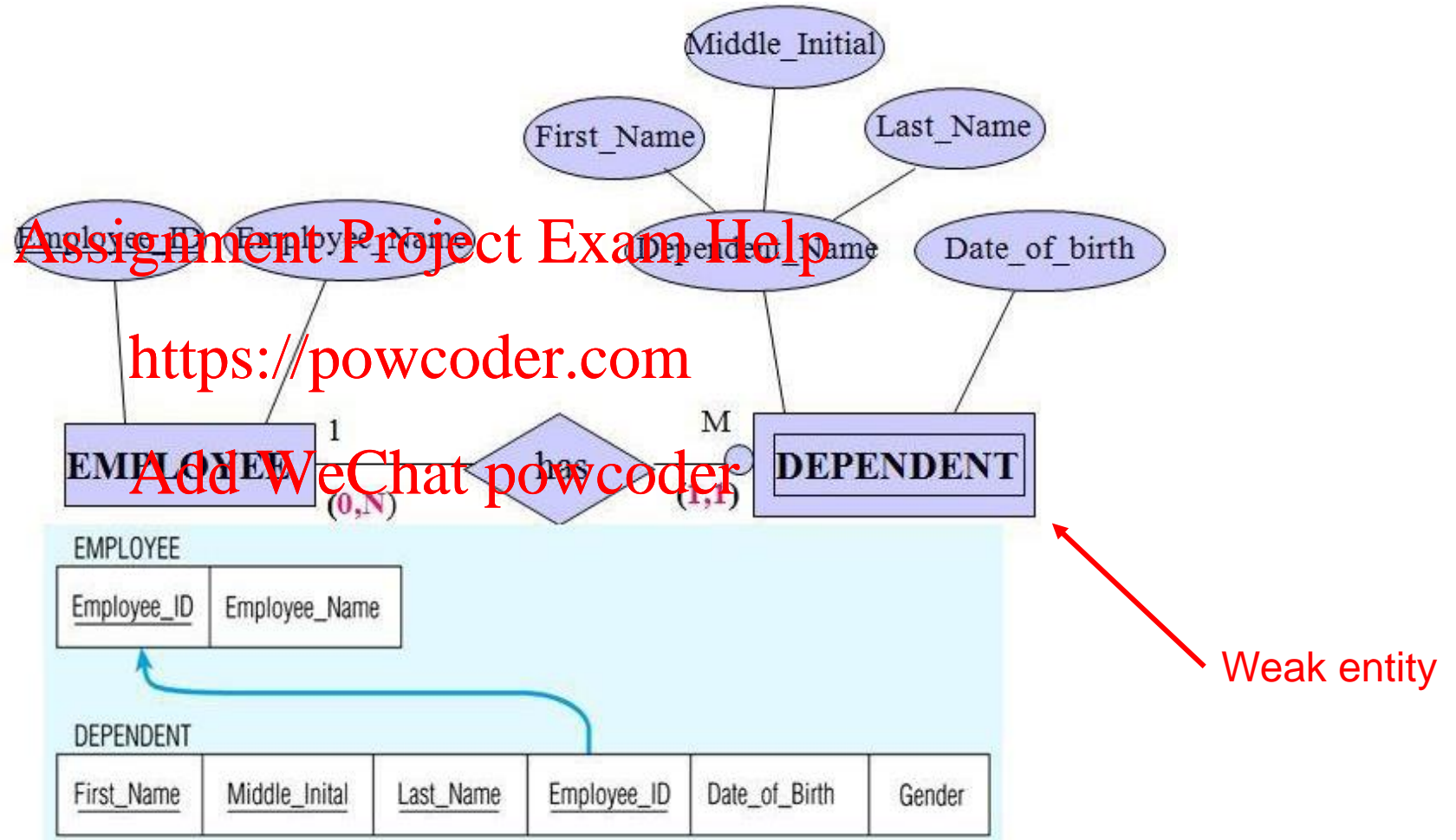
Mapping 1:1 Relationships



ER relationship is expressed through FK reference.

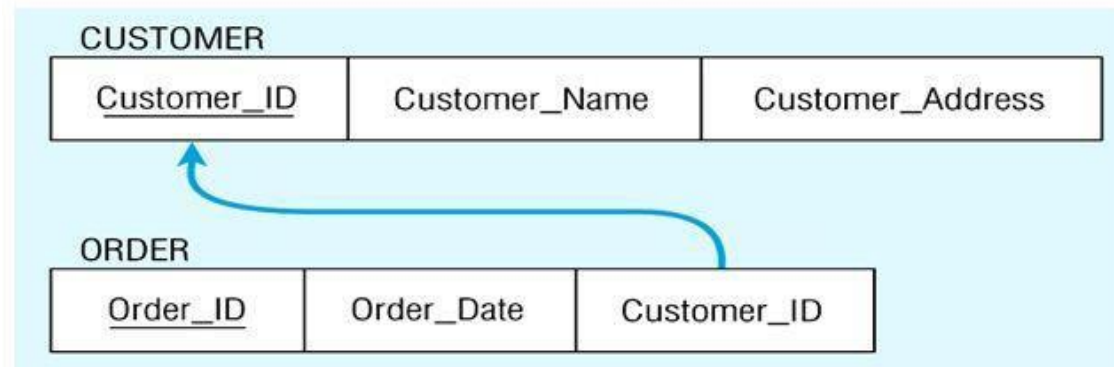
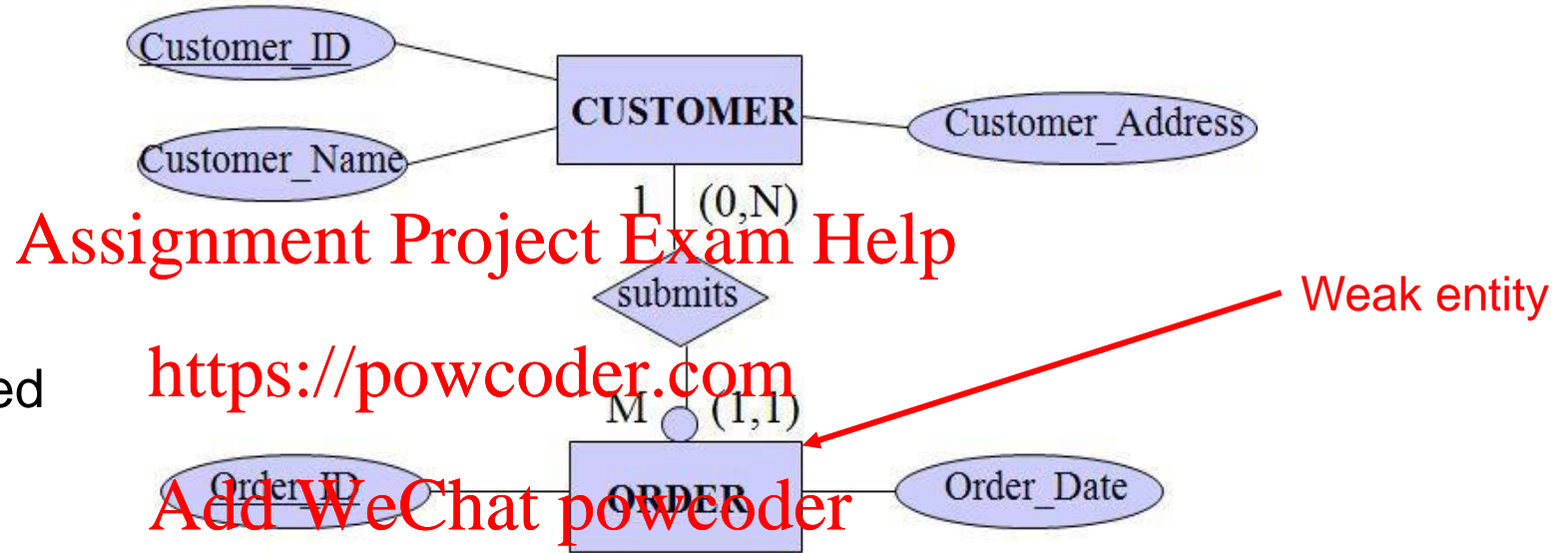
Mapping Weak Entities

ER relationship is expressed through FK reference (FK also a PK).



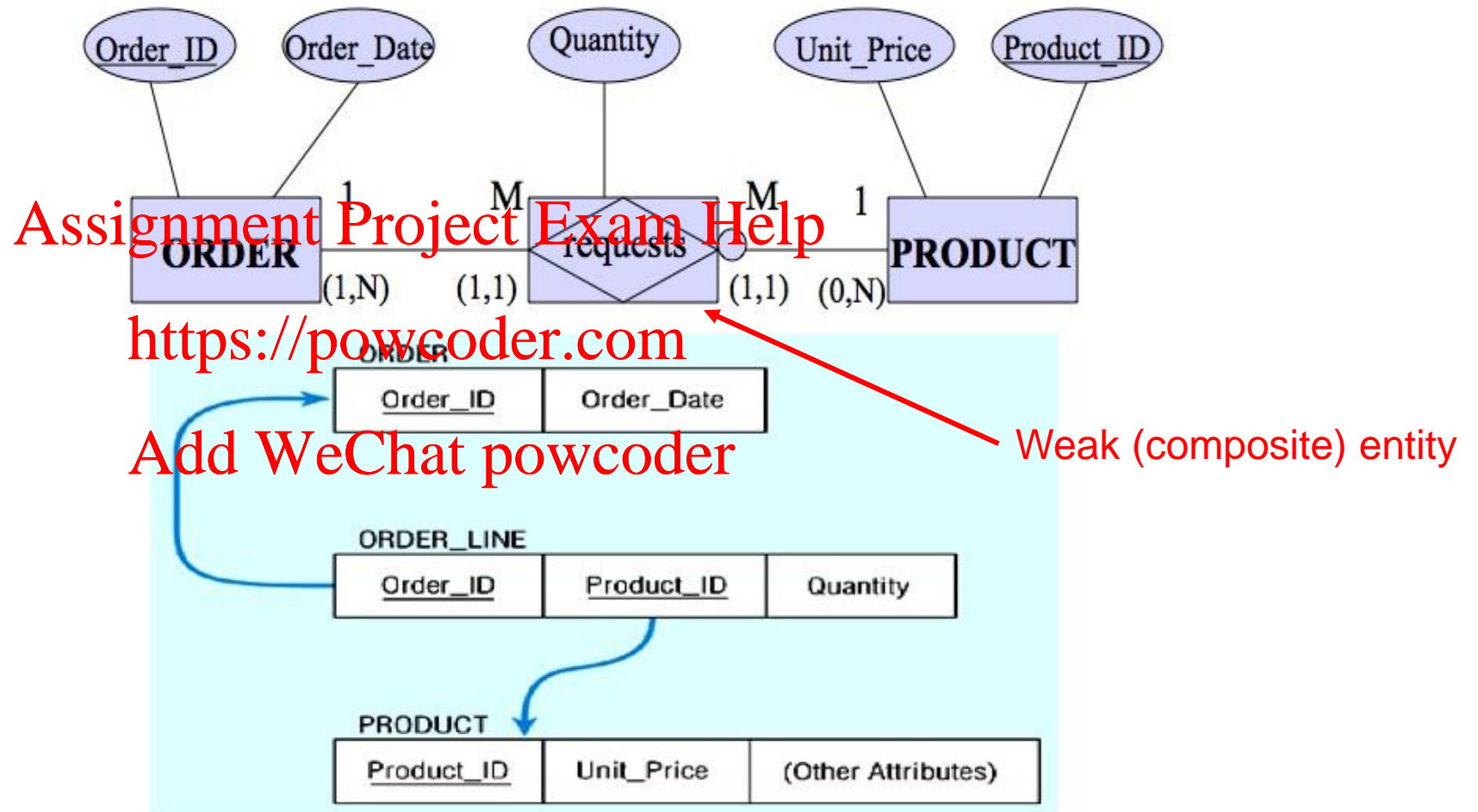
Mapping 1:M Relationships

ER relationship is expressed through FK reference.



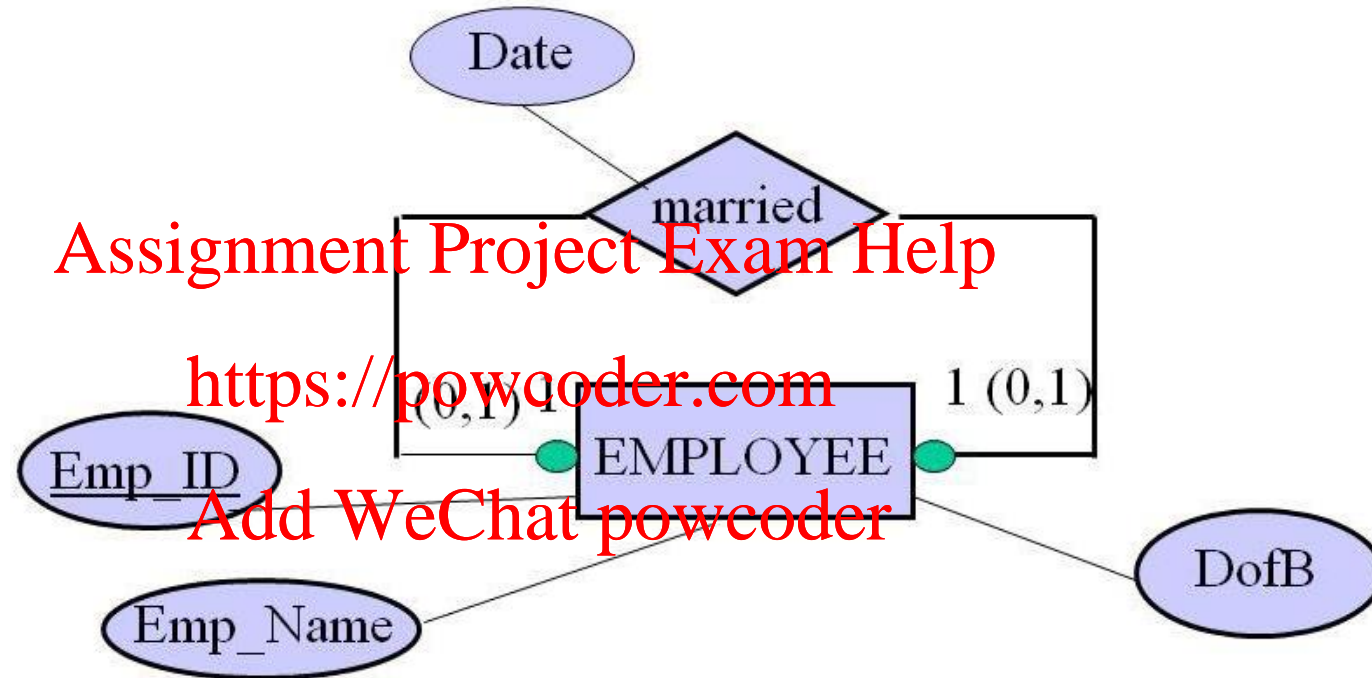
Mapping an M:N Relationship

ER relationship forms a relation in itself.



Mapping 1:1 Recursive Relationships

ER relationship forms a relation in itself.

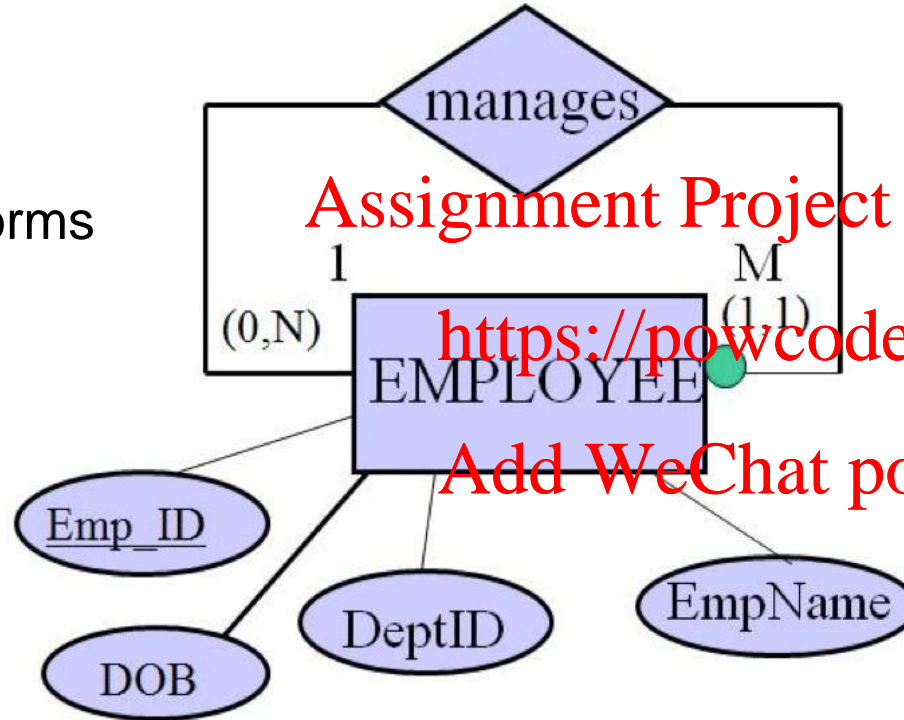


MARRIAGE (Emp_ID1, Emp_ID2, Date)

EMPLOYEE (Emp_ID, Emp_Name, DofB, ...)

Mapping 1:M Recursive Relationships

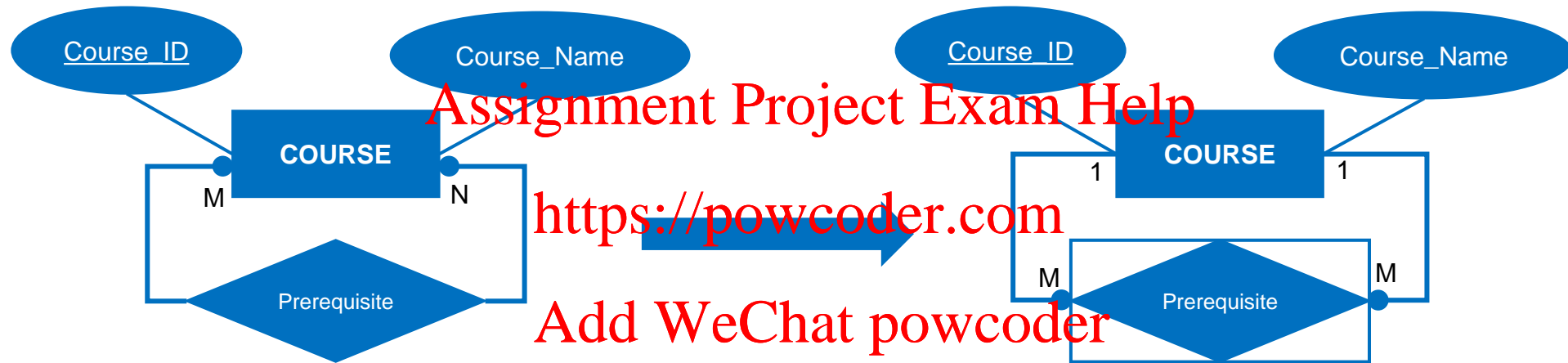
ER relationship forms a relation in itself.



- ❑ A **recursive FK** is a foreign key in a relation that references the primary key values of the same relation.
- ❑ In the example, for some employees the Manager_ID will be "NULL" because they do not have a manager.

EMPLOYEE (Emp_ID, EmpName, DeptID, DOB, Manager_ID)

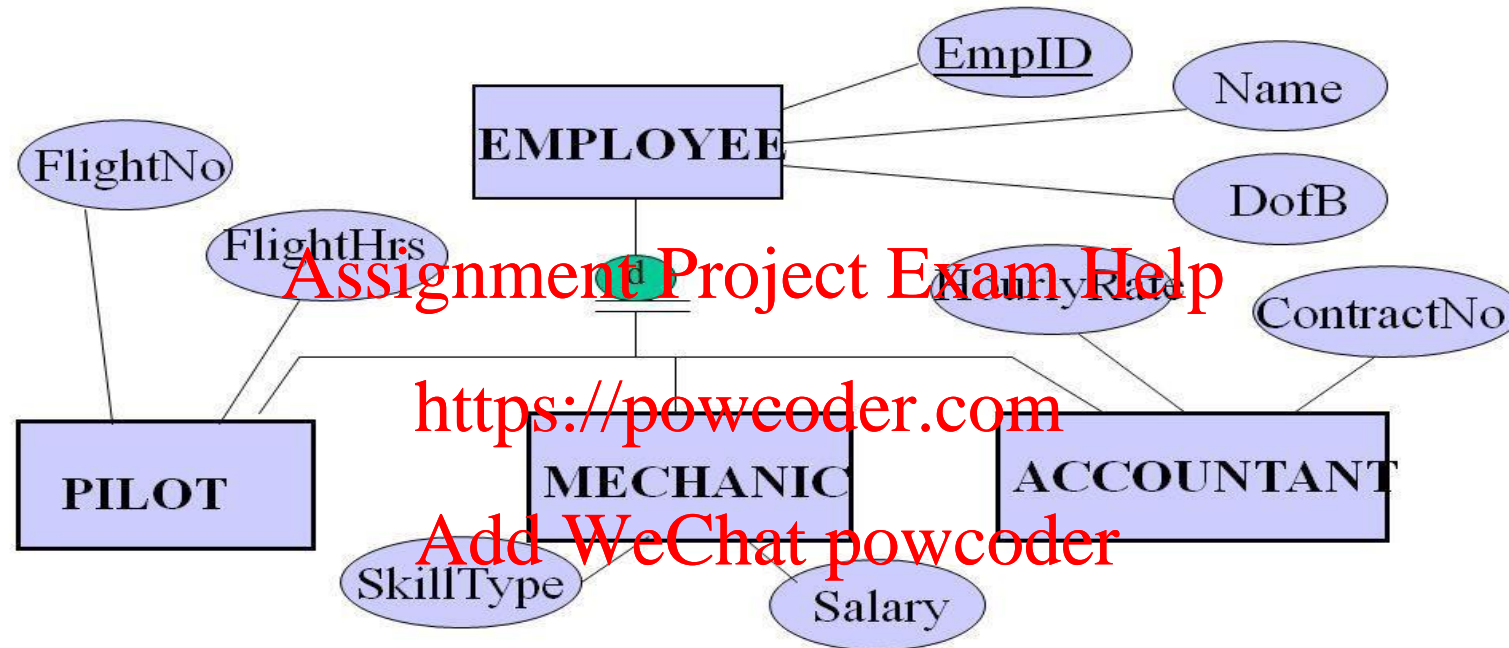
Mapping M:N Recursive Relationships



COURSE (Course_ID, Course_Name, ...)
PREREQUISITE (Course_ID, PrerequisiteCourse_ID, ...)

ER relationship forms a relation in itself.

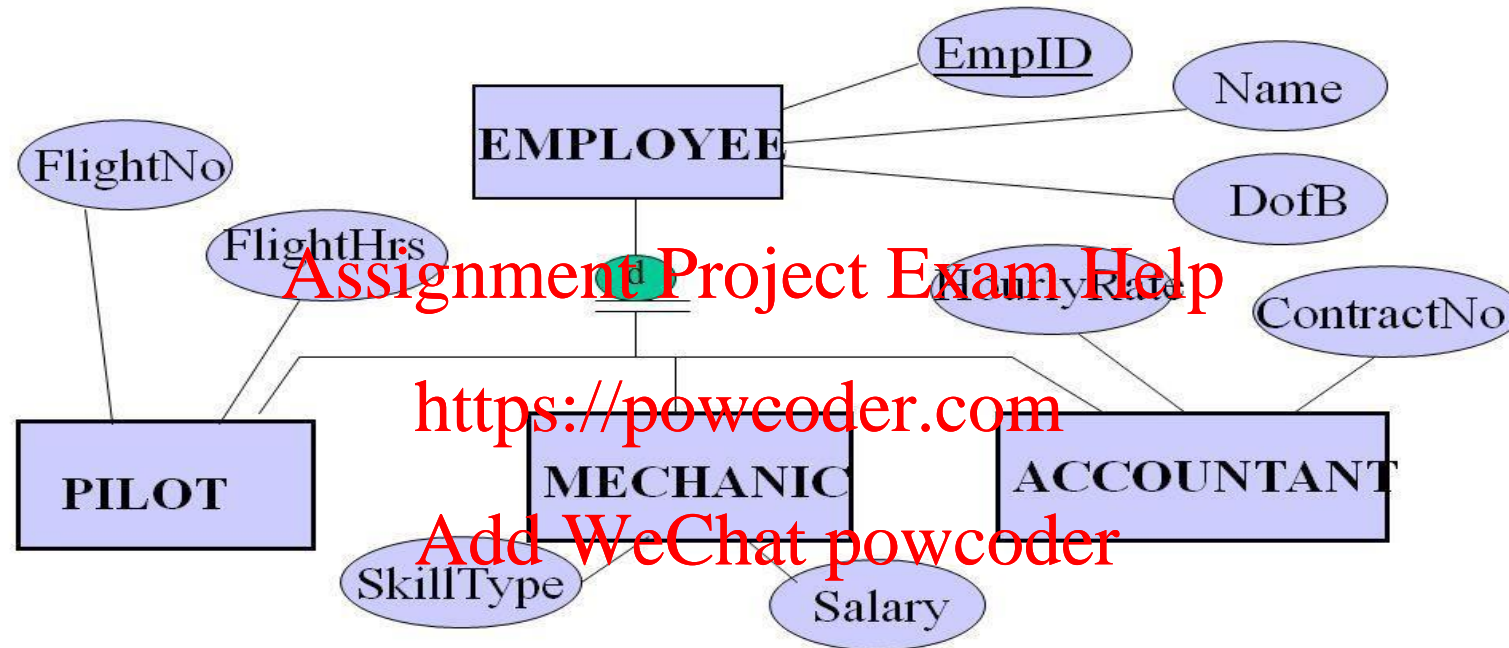
Mapping Super/Subtype Relations (1)



EMPLOYEE (EmpID, Name, DofB, FlightNo, FlightHrs, SkillType, Salary, HourlyRate, ContractNo)

Create only one relation (for the supertype). Or...

Mapping Super/Subtype Relations (2)

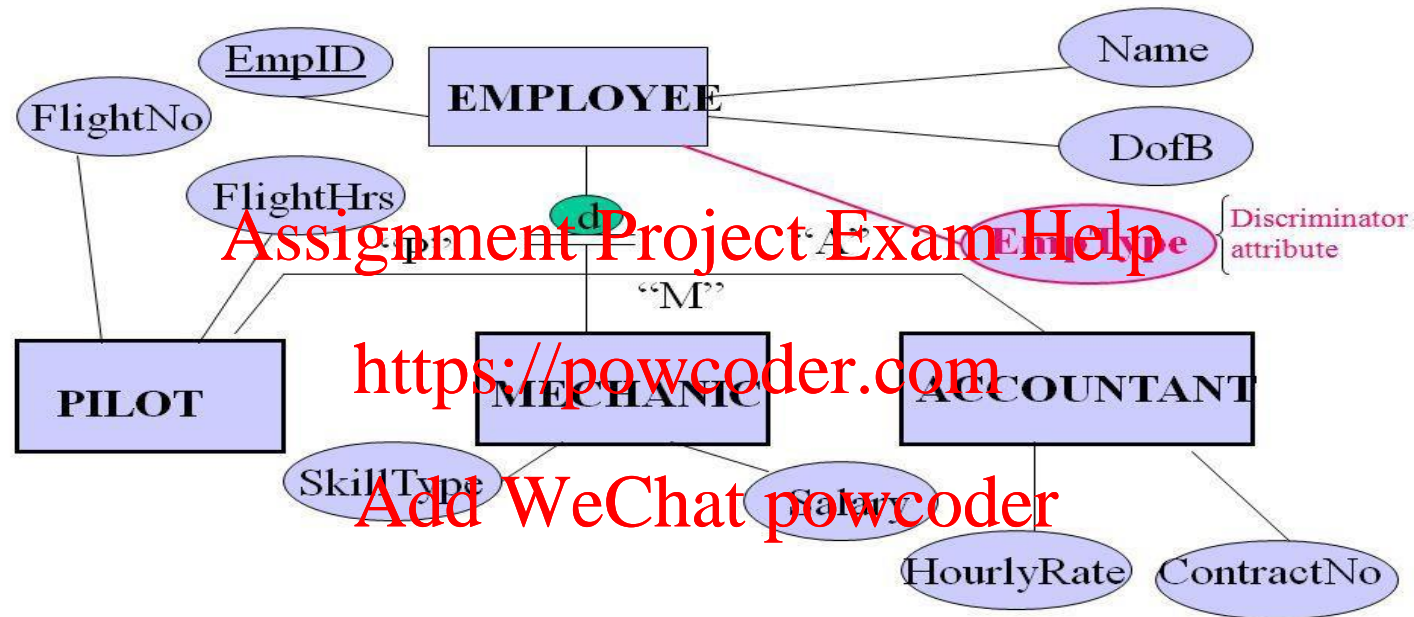


PILOT (P_EmpID, Name, DofB, FlightNo, FlightHrs)

MECHANIC (M_EmpID, Name, DofB, SkillType, Salary)

ACCOUNTANT (A_Emp_ID, Name, DofB, HourlyRate, ContractNo)

Mapping Super/Subtype Relations (3)



EMPLOYEE (EmpID, Name, DofB, **EmpType**)

PILOT (P_EmpID, FlightNo, FlightHrs)

MECHANIC (M_EmpID, SkillType, Salary)

ACCOUNTANT (A_EmpID, HourlyRate, ContractNo)

Create separate relations for each subtype and the supertype.

Header – Details Relationship

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Referential Integrity May Bring in Cascading Integrity

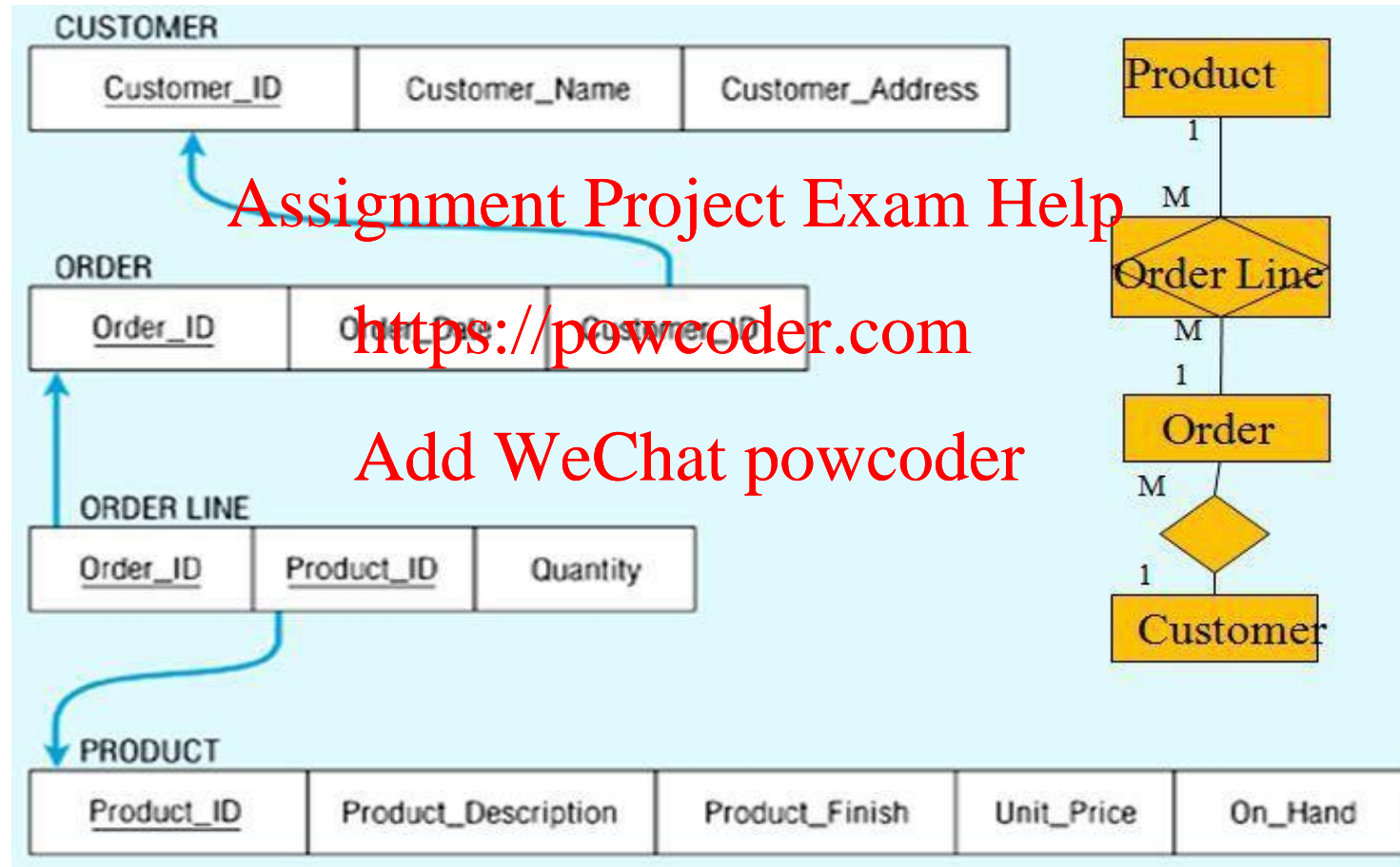


FIGURE 3.29 A SMALL INVOICING SYSTEM

Table name: CUSTOMER

Primary key: CUS_CODE

Foreign key: none

CUS_CODE	CUS_LNAME	CUS_FNAME	CUS_INITIAL	CUS_AREACODE	CUS_PHONE
10010	Ramas	Alfred	A	615	844-2573
10011	Dunne	Leona	K	713	894-1238
10012	Smith	Kathy	vW	615	894-2285
10013	Olowski	Paul	F	615	894-2180
10014	Orlando	Myron		615	222-1672
10015	O'Brian	Amy	B	713	442-3381
10016	Brown	James	G	615	297-1228
10017	Williams	George		615	290-2556
10018	Farriss	Anne	G	713	382-7185
10019	Smith	Olette	K	615	297-3809

Database name: Ch03_SaleCo

Table name: INVOICE

Primary key: INV_NUMBER

Foreign key: CUS_CODE

INV_NUMBER	CUS_CODE	INV_DATE
1001	10014	08-Mar-18
1002	10011	08-Mar-18
1003	10012	08-Mar-18
1004	10011	09-Mar-18

Table name: LINE

Primary key: INV_NUMBER + LINE_NUMBER

Foreign key: INV_NUMBER, PROD_CODE

INV_NUMBER	LINE_NUMBER	PROD_CODE	LINE_UNITS	LINE_PRICE
1001	1	123-21UUY	1	189.99
1001	2	SRE-657UG	3	2.99
1002	1	QER-34256	2	18.63
1003	1	ZZX/3245Q	1	6.79
1003	2	SRE-657UG	1	2.99
1003	3	001278-AB	1	12.95
1004	1	001278-AB	1	12.95
1004	2	SRE-657UG	2	2.99

Table name: PRODUCT

Primary key: PROD_CODE

Foreign key: none

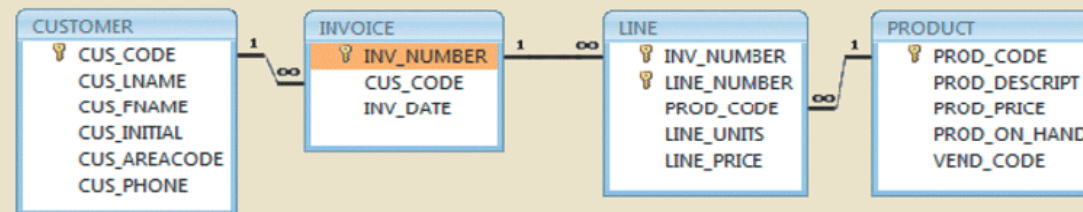
PROD_CODE	PROD_DESCRIPTOR	PROD_PRICE	PROD_ON_HAND	VEND_CODE
001278-AB	Claw hammer	12.95	2	235
123-21UUY	Housetite chain saw, 16-in. bar	189.99	4	235
QER-34256	Sledge hammer, 16-lb. head	18.63	6	231
SRE-657UG	Rat-tail file	2.99	15	232
ZZX/3245Q	Steel tape, 12-ft. length	6.79	8	235

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FIGURE 3.30 THE RELATIONAL DIAGRAM FOR THE INVOICING SYSTEM



Summary of Most Important Rules

- ❑ ER **entity types** become relational **schemata** (relations).
- ❑ ER **relationships** become relational **schemata** OR **references with FKs** in the schemata/tables.
- ❑ ER **attributes** of an entity type become **attribute column headers** in the schemata.
- ❑ **Entity instances** are the **rows** (tuples, relational instances) in the actual tables.
- ❑ **Connectivity** and **cardinality** are indirectly expressed through existence of schema, references with FKs, **number of rows** going into any particular relation, settings such as NOT NULL for the FK columns in the data dictionary, etc.

Recap: W3 Learnings

❑ Relational Database Modelling

- Definition **relational model**.
- Relational model **integrity**.
- From **ER diagram to relational model** (from entity types and entity instances to schemata and tables).
- **Mapping** specific ER relationships to a relational model.

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Questions



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