Database Design - Section 3

Instructor Guide
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Lesson Preparation

The previous section introduced entities and attributes. Relationships are the third component of a data model (the “R” in “ER modeling”). This section starts by identifying relationships between entities. Then it examines the characteristics of and rules regarding relationships.

What to Watch For

Have students go over each of the relationships shown in the Try It / Solve It activities, and change the business rules (example: any WAITER can take any ORDER from any table). Then have them restate the relationship with the revised cardinality and/or optionality.

Connections

We could use a familiar example here because it has many possibilities:

TEACHERS/COURSES/STUDENTS
Teachers may teach courses (part-time teachers may have the term off). Are all courses taught by teachers? What about online courses?
Students attend courses. Must students take a course to be considered a "student"? Can there be a course with no student?
What Will I Learn?

In this lesson, you will learn to:

- Interpret and describe relationship optionality.
- Interpret and describe relationship cardinality.
- Relate entities by applying the rules of cardinality and optionality.
Why Learn It?

Other discussion points for why it is important to understand relationships:

What is the relationship between student and library book? (What would you do if you received a fine for a book checked out by another student?)

- You would certainly protest because the student who checked out the book (this is the relationship) should also be responsible for any associated fines.
- This emphasizes the importance of clarifying relationships, especially in a business.

What is the relationship between you and your aunt, you and your uncle, your cousins, you and your grandmother, etc. (What would a society be like that did not categorize relatives as aunts, uncles, cousins, grandmother, and grandfather but only by their name? How could you tell someone that your friend was your cousin?)

- It would be a long and potentially confusing introduction, like “This is Jenny, who is the child of woman who has the same parents as my parent who is a woman,” as opposed to “This is Jenny, my mother’s sister’s child,” or “This is Jenny, my aunt’s child,” or the simplest one “This is Jenny, my cousin”. Notice that we still use a basic relationship in the longest introduction -- that of child to parent. Without that relationship it would be very difficult to introduce anyone beyond giving their name!
• Relationships are personal experiences, but they also help define roles in society (a parent is responsible for a child’s care), and they also form the basis of some laws (inheritance, marriage, etc.).
Tell Me / Show Me

Ask students: have you ever been scheduled for an airplane flight and heard the check-in desk attendant ask if anyone wanted to give up their seat because the plane was overbooked? Why does an airline sell one seat to two people? Is every seat sold to more than one person? Why does it happen sometimes and not all the time? Is it normal for a person to buy more than one seat for himself/herself on a plane?

Draw on the board SEAT, PASSENGER.

Ask the class to write out the relationship between the two entities based on the previous discussion.

Answer:

- Each SEAT may be sold to one or more PASSENGERS.
- Each passenger may purchase one SEAT.
- (No need to draw this relationship yet, just write it down in English).
- Note: At this point, you have not discussed cardinality and optionality, so they may not state the relationship exactly as above, other acceptable answers are:
- SEAT is sold to a PASSENGER (or PASSENGERS -- hence, overbooking).
• PASSENGER purchases or books a seat.

Some background info on airline systems to help the teacher look knowledgeable on the topic:

• Reference to an Airline Reservation Design Project that describes the components that must be in place for a reservation system.
• How Stuff Works website - "How Airlines Work"
• How Stuff Works website - "That's the Ticket"
Tell Me / Show Me

Point out that this statement describes the basic relationship between SONG and TYPE, but in order to fully capture the business rules, we need to revise the sentence to include optionality and cardinality.
Optionality (must or may?):

Encourage discussion about the business rules and how they affect optionality:

Must every SONG have a TYPE? Can you have a SONG that doesn’t fall under any one TYPE? Point out that in the diagram, all SONGs are classified by a TYPE.

How would you classify a religious hymn when you don’t have a type called “church” or “gospel” or “religious”? Would you leave it without a type or would you create a new type? That is a decision that is based on the business rules. In this particular business, ALL songs must have a type, so you would create a new type.

Must every TYPE describe or classify a SONG? Can you have a TYPE with no SONGS under it? Point out that in the diagram, some TYPES are not used to classify any SONGs.

Why have type called “New Age” when you don’t have any songs that can be classified under it? Why would you have the type at all? Possible answer: to prepare for future songs, since New Age seems to be an increasingly popular category.
**Cardinality (how many?):**

Encourage discussion about the business rules and how they affect cardinality:

How many TYPES can a SONG belong to?

Point out that in the business scenario, it is stated that a SONG is classified under only one TYPE. That is the rule of this particular business. However, ask the class if it is possible for another business to classify a SONG under many TYPES. Answer: quite possibly. Tell them that this would change the cardinality of the relationship. It would now be, “Each SONG must be classified by one or more TYPES.”

How many SONGs can fall under one TYPE?

Again, the diagram and the business scenario indicate that a TYPE may be used to classify several SONGs. It’s a bit far-fetched to think of a business where a TYPE must apply to only one SONG, but ask the class if they can think of a scenario where this is possible. Encourage them to think of what is logically possible and what is probably unlikely.
Point out that this statement describes the basic relationship between ORDER and CUSTOMER, but in order to fully capture the business rules, we need to revise the sentence to include optionality and cardinality.
Tell Me / Show Me

**Optionality (must or may?):**

Encourage discussion about the business rules and how they affect optionality:

**Must a CUSTOMER place an ORDER?** Do you consider someone a CUSTOMER if he/she has not placed an ORDER? The diagram indicates that all customers have orders; therefore, someone who does not have an order is not a customer. Challenge the students to imagine another business where you could have a customer with no order. Possible answer: Some restaurants define a customer as anyone who enters the premises (uses the restroom, public phone, etc.). In this case, the optionality of the relationship will change to: Each CUSTOMER may place one or more ORDERs.

Discuss the other end of the relationship:

**Must an ORDER be placed by a CUSTOMER, or can you have an ORDER that is not placed by any CUSTOMER?** Can anyone in class think of a case where this could be true?
**Cardinality (how many?):**

How many ORDERs can one CUSTOMER place?

Again, have them think of the business. In the given scenario, a CUSTOMER can place many ORDERs. Is it likely that in another business a CUSTOMER is allowed only one ORDER? Probably not in the food business.

How many CUSTOMERs are responsible for a single ORDER?

The scenario states that only one CUSTOMER is responsible for an ORDER. However, ask the class if they’ve ever eaten at a restaurant where they asked the waiter to split the payment for the bill between two or more credit cards. This would mean a different cardinality for the relationship. Have them state it: Each ORDER must be placed by one or more CUSTOMERs.
Try It / Solve It

Assessment:
Each EMPLOYEE must have (or handle, or be responsible for) one or more jobs.
Each JOB may be the responsibility of (or assigned to) one and only one EMPLOYEE.
Try It / Solve It

Assessment:
Each WAITER may be assigned to (or handle, or take) one or more ORDERs. Each ORDER must be assigned to (or handled by, or taken by) one and only one WAITER.
Assessment:

Each PARENT may pick up one or more CHILDren.
Each CHILD must be picked up by one and only one PARENT.
Try It / Solve It

Assessment:

Each TEACHER may tutor one or more STUDENTs.
Each STUDENT may be tutored by one or more TEACHERs.
Try It / Solve It

Have the class go through this exercise only if there is extra time.
Verbalizing the diagram demonstrates understanding and creates a desire on the part of the student to think more deeply about what they are creating because they will be required to “share” later. If you do not have time to allow the “sharing,” you may want to collect the papers to observe the understanding of each student at this critical juncture. Presenting is much more public and easier to provide feedback on.
Lesson 2 - ER Diagramming Conventions

Lesson Preparation
No further lesson preparation information.

What to Watch For
Make sure students are naming both sides of the relationship and stating the optionality and cardinality. This will help students draw it in the next lesson. Get them accustomed to using “must/must be” or “may/may be” and “one and only one” or “one or more.”

Also point out that an attribute may be mandatory or optional depending on the business and its rules. Give an example: an EMPLOYEE’s eye color may be optional in a restaurant business, but may be mandatory in a security organization. When naming attributes, also mention their data types (number, date, character, etc.)

Connections
No connections for this lesson.
In this lesson, you will learn to:

- Construct an ER diagram that represents entities, attributes, and relationships according to diagramming conventions.
Why Learn It?

People speak different languages throughout the world, but some signs are understood globally.

Guess the meaning of these signs.
Tell Me / Show Me

After viewing the graphic and guessing the meaning of each sign, you can also use another example -- international sign language.

It’s another way for people to communicate without even talking out loud!
Tell Me / Show Me

Tell Me / Show Me

It is efficient to communicate information in a way that can be easily understood by many people.

ER diagramming is like that -- you may verbalize things differently because of the way you speak, your accent, and so on, but everyone diagrams according to the same conventions.
Tell Me / Show Me

DJs on Demand: Clients, Events, and Types

"Our client list is growing. We have a lot of repeat business -- customers who like what we've done who ask us to work their other events. We have some very busy customers who can have more than one event going on at the same time! Each partner has some specialty or expertise -- so when it's appropriate, we like to classify our events by theme to help us assign the right person (partner) to the job. An event theme can be a beach party, medieval, carnival, retro, sixties or seventies, etc. We keep adding event themes as we go."
Tell Me / Show Me

Section 3
Lesson 2 - ER Diagramming Conventions

Tell Me / Show Me

Drawing Conventions

Entities are represented by "softboxes.
Entity names go in the softboxes.
Entity names are always singular and written with all capital letters.

CLIENT

EVENT

THEME
Tell Me / Show Me

Drawing Conventions

Attributes are listed under the entity names.
Mandatory attributes are marked with "***
Optional attributes are marked with "**
Unique identifiers are marked with "#"

CLIENT
- # number
- * first name
- * last name
- * phone number
- * email address

EVENT
- # id
- * name
- * date
- * cost
- * description

THEME
- # code
- * description

Tell Me / Show Me

Mention that any attribute that is part of the UID is always mandatory.
So it is also acceptable to draw it with "#" and "*" before the name.
Tell Me / Show Me

When viewing the graphic that shows the relationships, just talk through it but tell students that you will discuss the rules of how to draw relationships in more detail in the next lesson.
Try It / Solve It

In some cases, there could be discussion about whether an attribute is mandatory or optional. Encourage this discussion and tell students that if it is not clear in the business scenario, they need to make assumptions. These assumptions should be documented so you can go back to the client later and confirm them.

A HAIRSTYLIST may work on one or more CLIENTs.
A CLIENT must be assigned to one and only one HAIRSTYLIST.
Try It / Solve It

In some cases, there could be discussion about whether an attribute is mandatory or optional. Encourage this discussion and tell students that if it is not clear in the business scenario, they need to make assumptions. These assumptions should be documented so you can go back to the client later and confirm them.

Why not have hourly rate as an attribute for a band? Answer: because it can be derived from the hourly rates of the members.

Each BAND must be composed of one or more MUSICIANs. Each MUSICIAN may belong to one and only one BAND.
The Challenge Exercise: TEACHER, COURSE, and CLASS deals with three entities. It is a bit more complicated but can be worthwhile for the faster students. Have them do this if there is time.

Each TEACHER may be assigned one or more CLASSes.
Each CLASS must be assigned to one and only one TEACHER.
A COURSE may be offered through one or more CLASSes.
Each CLASS must be an offering for one and only one COURSE.
Lesson 3 - Drawing Relationships and Speaking ERDish

Lesson Preparation

No further lesson preparation for this lesson.
What to Watch For

Make sure students understand that more than one relationship can exist between entities. Example: different relationships between person and class (attend, teach, write). Also watch out for the crow’s feet pointing the wrong way. It’s a common mistake that should be corrected early. You can also mention that ideally you’d like to draw the relationships so that the “crows fly south and east,” but that this is not a strict requirement.

Connections

Go back to the entities drawn in the previous lesson:
1. HAIRSTYLIST and CLIENT
2. BAND and MUSICIAN
3. TEACHER, COURSE, and CLASS

Draw the relationships that represent the ERDish.

1. 

2. 

3.
What Will I Learn?

In this lesson, you will learn to:

- Analyze disparate pieces of data and articulate the relationship(s) between them.
- Illustrate relationships between entities using appropriate conventions for entity relationship diagrams.
- Interpret and name entity relationships.
Why Learn It?

Most businesses have a unique terminology that people speak in order to communicate information.

Data modeling also has a unique terminology as well, which we call ERDish for the purposes of this class. Learning how to create ERDs and speak ERDish gives you a common terminology with your clients and with DBAs who will implement your design.

Give examples of languages that end with “ish” -- English, Swedish (ask for other examples from the class -- Finnish, Yiddish, etc.).

Encourage students to think abstractly. Suggest “languages” such as "SCHOOLish" that would include such words as credits, TAs (teaching assistants), terms, primary, and secondary (include words specific to your institution).
Tell Me / Show Me

Tell Me / Show Me

Play the animation once, and then feel free to run it again, this time pausing at certain points for discussion.

For example:

When the waiter gives the chef the list of orders -- pause and ask the class, “Do you see a problem here?” (the waiter doesn’t really specify which food items go on which orders). Then continue playing and point out that now the waiter is confused as well, because he didn’t organize his food items according to orders either.
**Tell Me / Show Me**

When building the ERDish -- it helps to draw a standard relationship on the board. You can use ORDER and ORDER ITEM to relate it to the animation, or whatever you are comfortable with.

As you go through the six components of ERDish, highlight it on the diagram. If you can use six different colors, that would drive home the point visually. Point out the single toe or crow’s feet, and how it’s drawn at the opposite end, at the other entity (the feet connect to the "child" entity). Start by reading your diagram on the board from left to right, pointing out the ERDish components or highlighting them in a different color.
Tell Me / Show Me

The components of ERDish:

1. EACH
2. Entity A
3. OPTIONALLITY (must be/may be)
4. RELATIONSHIP NAME
5. CARDINALITY (one and only one or one or more)
6. Entity B

Now we read the relationship from right to left.

1. EACH
2. DEPARTMENT (entity B)
3. MAY BE (optionality, dotted line)
4. THE COST CENTER FOR (relationship name)
5. ONE OR MORE (cardinality, crow’s foot)
6. EMPLOYEE (entity B)

Tell Me / Show Me

Read your diagram on the board from right to left, pointing out the ERDish components or highlighting them in a different color.
Tell Me / Show Me

Breaking Down ERDish

The components of ERDish:
1. EACH
2. Entity A
3. OPTIONALITY (must be/may be)
4. RELATIONSHIP NAME
5. CARDINALITY (one and only one or one or more)
6. Entity B

Now we bring it together:

1. EACH
2. EMPLOYEE (entity A)
3. MUST BE (optional, solid line)
4. WORKING IN (relationship name)
5. ONE (cardinality, single line)
6. DEPARTMENT (entity B)

1. EACH
2. DEPARTMENT (entity B)
3. MAY BE (optional, dotted line)
4. THE COST CENTER FOR (relationship name)
5. ONE OR MORE (cardinality, crow's foot)
6. EMPLOYEE (entity B)

Tell Me / Show Me

Read your diagram on the board from left to right, and then right to left, pointing out the ERDish components or highlighting them in a different color.
Activity: Reading

The goal of this practice is to read a relationship.
Which text corresponds to the diagram?

A  Each EMPLOYEE may be assigned to one or more DEPARTMENTs.
    Each DEPARTMENT must be responsible for one or more EMPLOYEES.

B  Each EMPLOYEE may be assigned to one and only one DEPARTMENT.
    Each DEPARTMENT may be responsible for one or more EMPLOYEES.

C  Each EMPLOYEE must be assigned to exactly one DEPARTMENT.
    Each DEPARTMENT may be responsible for exactly one EMPLOYEE.

Assessment:
Option B is the correct reading.
• Each person must be born in one or more towns.
• Each town may be birthplace of exactly one person.
• Comment: Both sides seem to be of the wrong degree.
• Each person must be living in one or more towns.
• Each town may be the home town of one or more persons.
• Comment: The first certainly has a wrong degree. The optionality seems wrong as well.
• Each person may be visitor of one or more towns.
• Each town must be visited by one or more persons.
• Comment: The optionality of the second seems very likely, but is probably wrong, depending on the definition of town. (Is it possible that a town could be visited by 0 persons? What if the town was formed yesterday by the government? Would they have visitors yet? No.
• Each person may be mayor of exactly one town.
• Each town may be governed by (as mayor) exactly one person.
• **Comment:** Both seem fine, except that if you need to keep historical information, then both sides of the relationship must be “many.” Historical information is that which is tracked as it changes over time. In this case, a person may be mayor of one town this year, then of another town the next year. Although a town can have only one mayor at one time, it has different mayors over the years.
Lesson Preparation

No further lesson preparation information.

What to Watch For

Nothing further to watch out for in this lesson.

Connections

No connections for this lesson.
What Will I Learn?

In this lesson, you will learn to:

- Distinguish between data and information and provide examples of each.
- Describe and give an example of how data becomes information.
Why Learn It?

If you work in the information-technology industry, it is essential to understand how data is modeled and stored in a database.

If you work in any other industry, you will most likely have to work with data stored somewhere on a computer and probably be required to use data in your job to create reports and/or make decisions.

Data Compared to Information

Data: Lunch Room Data

This report will tell us what our best-selling lunch items are.

Information:
Ask students to think about how an auto mechanic, taxi driver, or landscape gardener might use a database?

Possible answers include:

- Mechanic: looking up service records on a car; pricing a part carried by a supplier.
- Taxi driver: searching a website such as Yahoo to get driving directions.
- Landscape gardener: looking up information on plants or pesticides.

It is useful to understand the data requirements of the business you work in.
Tell Me / Show Me

Lead discussion with students on this topic: Ask students why they think this is possible?
Currently in some department stores, you can return items without receipts if you wrote a
check or charged it on a credit card. The clerk simply types in your checking-account or credit-
card number and up pops a list of every item you purchased using that payment type. That’s an
e example of getting information from a database!
Tell Me / Show Me

Tell Me / Show Me

Data vs. Information

The words "data" and "information" are often used as if they are synonyms. Nevertheless, they have different meanings.

Data: Raw material, from which you can draw conclusions. Facts from which you can infer new facts.

Information: Knowledge, intelligence, a particular piece of data with a special meaning or function. Information is often the result of combining, comparing, and performing calculations on data.

Another example to illustrate the difference between data and information:
Data: telephone directory (names, addresses, and phone numbers)
Information: names and phone numbers of florists in your neighborhood
Try It / Solve It

Ask students to name specific data that the school collects for each student. List the data items on the board. From the list of data items, ask students what information can be gleaned from this data.

Assessment:
Possible responses for data include: name, address, phone number, names of parents or guardian, age, sex, nationality, parking place, discipline history, academic history or attendance history, grades, test scores, ethnic background. Possible responses for information include: The ethnic groups represented in the school, what percentage of students drive a car to school, how many students have grade-point averages greater than 3.0 (information), performance of different ethnic groups on standardized tests, diversity of the school population, possible locations for new schools, etc.
Alternative activity:

Students use their driver's permit, license, student ID, or military ID to list the data it contains: last name, middle name, first name, age, street address, city, state, country, zip, postal code, height, eye color, weight, organ donor, gender, issue date, birth date, expiration date, not 21 until, lens correction, commercial driver’s license, signature, photo ID, medical-alert information. Information it contains: physical appearance, how old someone is, sex, glasses, married, what they can drive, where you live, police record, whether 21, jewelry, have parents in the military, etc.
Try It / Solve It

Assessment:

Possible answers: to keep a historical record of immigration into a country, laws passed, etc. Choose a website (perhaps one listed here) and ask students to find 10 data items and list 5 pieces of information. Have students share their data and information with each other. You can make this into a game with the students competing to see who has unique data and information. One student reads his/her list of data aloud. If someone else in class has that piece of data or information, no one gets a point for it. If only that student has the data/info on his/her list, that student gets a point. Go through all data/info items and have students report their points. Reward the highest score!
Lesson Preparation
The matrix diagram is a quick topic.
This activity should take no more than 10 minutes, leaving 20 minutes for the quiz and 10 minutes for assessment.

What to Watch For
Nothing further to watch for in this lesson.

Connections
Go Over Activity: Photography
Ask these questions of the class:
• Are the films developed in the same lab or in different labs?
• Does the photographer develop any of his/her films?
• Is a roll of film used on only one subject or on different subjects?
• Are all the pictures on a roll of film taken under the same conditions or do they vary?
Although students may not know how to model the answers at this point, just tell them that these are examples of business rules that they will learn how to represent in the ERD.
What Will I Learn?

In this lesson, you will learn to:

- Identify and construct relationships using the matrix diagram
- Demonstrate drawing the ERDs
- Label relationships using ERDish terminology
- Demonstrate 70% mastery for data modelling Quiz 1
Why Learn It?

Sometimes when you have a lot of entities, it’s hard to know where to start defining relationships. What if you miss something? How do you make sure that you haven’t missed some combination of entities? Maybe there’s a relationship you’ve missed!

We are going to learn another useful way for identifying relationships.
Tell Me / Show Me

Tell Me / Show Me

Business Scenario:

"I work for a travel agency. I keep a record of the countries that our customers have visited and the landmarks they've seen in each country. It helps us customize tours for them."

We can use the matrix diagram to uncover relationships.

Tell Me / Show Me

Demonstrate how to draw a matrix diagram by creating a grid with a diagonal line running across it and filling top rows and left columns with the names of the entities -- in this case, TRAVELER, COUNTRY, and LANDMARK.
Tell Me / Show Me

Point out that after using the matrix diagram, you should draw the relationships on the ERD to specify optionality and cardinality. Read the ERDish in the completed ERD and match it with what was listed in the matrix diagram.

Note that there is an M:M relationship between traveler and country. Tell them that this is a valid relationship, but it will be discussed more later.

Discuss with students the answers to the Review Sheet, as you will be administering the quiz right after the Photography activity.
Try It / Solve It

Try It / Solve It

Activity: Photography

Read the business scenario and examine the ERD. Make up two or more possible relationships between PHOTOGRAPH and the other entities that make sense for the business.

"I'm an amateur photographer. I own several cameras and am always taking pictures of different subjects. I'm trying to keep track of which camera and type of film perform best under certain conditions -- indoor light, outdoor light, etc. So when I have my films developed, I note down which camera I used. When the pictures come back, I note the subject and conditions. Each picture always features one subject. A subject could be a view, a person, or group of persons, or an object or group of objects."

Matrix Diagram

Try It / Solve It

Spend 15 minutes total on the activity including the assessment. Get students into the habit of really naming the relationships and not using the entity name or "is related to." This helps them really think in terms of the business function.

Photography Assessment
Try It / Solve It

Allow 20 minutes for the quiz and 10 minutes for assessment/discussion afterward.

Assessment:

You may want to encourage students to retake the quiz until they achieve a passing score. Or you may prefer to allow only one attempt at the quiz.

Have students work in small groups to review what they missed on the quiz. Based on what types of questions they missed, have students write out the rules -- for example, rules for subtypes. Have a member from each group present a summary back to the class about what areas their group can improve.