

ARTICLE 1

Enhanced ER

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In this article, we will give a brief overview of Enhanced ER modeling. The term “enhanced ER (EER) modeling” refers to an expanded ER notation that depicts additional database modeling concepts beyond standard ER modeling. The most important EER addition to ER modeling are the concepts of a **superclass entity** and a **subclass entity**. In this article, we will illustrate this EER addition to ER modeling using several examples.

Superclass and Subclass Entities

The concepts of superclass and subclass entities are used in situations when, in addition to a set of attributes shared by all instances of the entity, certain groups of entity instances have additional attributes applicable only to those groups. The next three examples will illustrate the concept of superclass and subclass entities.

EER Example 1—Disjoint Subclasses, Total Specialization

Consider the following example:

- For each store, Company X keeps track of a store ID (unique) and zip code.
- Within Company X, certain stores are company owned. For such stores, Company X keeps track of their real-estate value.
- Within Company X, certain stores are rented. For such stores, Company X keeps track of their annual rent cost.

Figure 1 illustrates how this scenario would be modeled using the EER notation. In the figure, entity STORE represents a superclass, while entities COMPANystore and RENTEDSTORE represent the subclasses of the superclass STORE. All instances of a subclass inherit the attributes from its superclass. In this example, all company stores and all rented stores will have a StoreID value and a ZipCode value. In addition, all company stores will have a RealEstateValue value, while all rented stores will have an AnnualRent value.

In this notation,* the relationship between a superclass and its subclasses is marked by a circle to which the

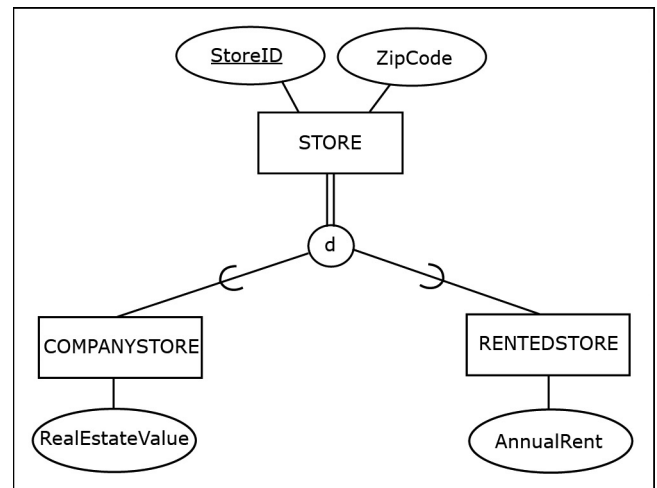


Figure 1 An example of a superclass and subclass for Company X.

* As we mentioned in Chapter 2, there is no one/single universally adopted standard ER notation. Likewise, there is no single universal EER notation. Depending on which EER notation is used, subclasses and superclasses can be represented differently but always have the same meaning.

subclass and superclass lines are connected. The relationship between a superclass and its subclasses is referred to as an IS-A relationship (in this case, indicating that a company store IS-A store and a rented store IS-A store). Subclasses are recognized by the semi-oval attached to the line connected to the subclass. The letter in the circle indicates whether subclasses are disjoint (letter *d*) or overlapping (letter *o*). In this case, subclasses COMPANYSTORE and RENTEDSTORE are **disjoint subclasses**, which means that an instance of subclass COMPANYSTORE cannot at the same time be an instance of the subclass RENTEDSTORE, and vice versa.

The double line connecting superclass STORE with the circle indicates **total specialization**. In the case of total specialization, every instance of a superclass must also be an instance of its subclass. In this example, total specialization means that there is no store that is neither a company store nor a rented store.

Within an EER diagram, both superclasses and subclasses can be involved in regular relationships with regular entities. This is illustrated by the expanded example shown in Figure 2, in which subclass RENTEDSTORE is involved in a binary 1:M relationship with a regular entity REALTYCO.

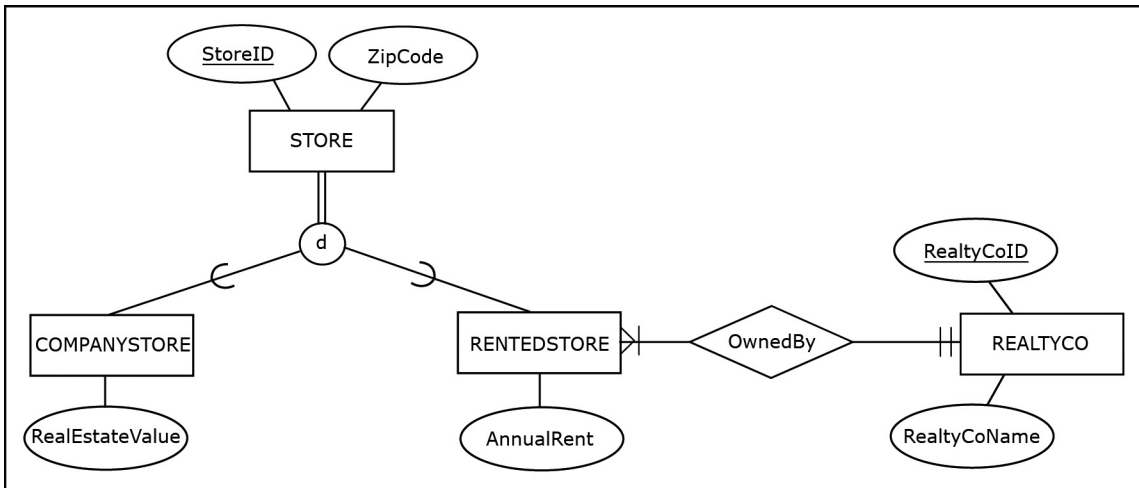


Figure 2 An example of an EER diagram for Company X.

When an EER diagram is mapped into a relational schema, an IS-A relationship between a superclass and its subclasses is mapped as a series of 1:1 relationships between the superclass and its subclasses. Figure 3 illustrates the mapping of the EER diagram in Figure 2 into a relational schema. Note that in relations COMPANYSTORE and RENTEDSTORE, column StoreID is both a primary key and a foreign key.

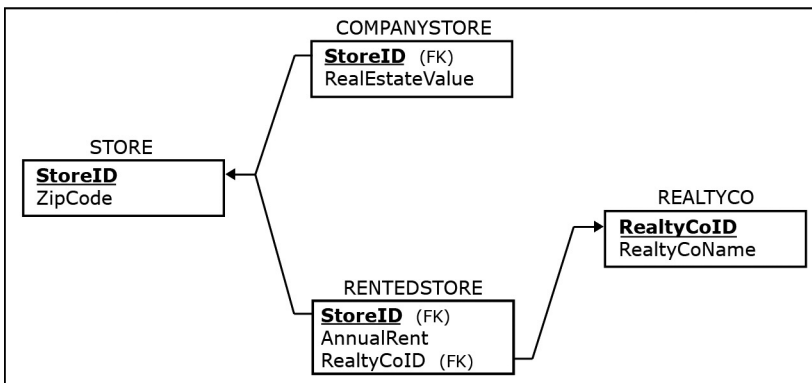


Figure 3 An EER diagram mapped into a relational schema for Company X.

Figure 4 illustrates a data sample in the Company X database resulting from the EER diagram in Figure 2.

Note that due to total specialization, every store is either a company store or a rented store. Also note that because subclasses are disjointed, no company store is at the same time a rented store, and no rented store is at the same time a company store.

EER Example 2—Overlapping Subclasses, Total Specialization

Consider the following example:

- For each book, Publisher X keeps track of a book ID (unique) and a book title.
- Within Publisher X, some books are printed books. For each such book, Publisher X keeps track of its number of printed copies (PBookCopies) and its printed copy price (PBookPrice).
- Within Publisher X, some books are ebooks. For each such book, Publisher X keeps track of its price (EBookPrice).
- Each ebook is available on a number of platforms (each platform has a unique PlatformID and a PlatformName). Each platform has a number of ebooks available on it.

STORE		COMPANY STORE	
StoreID	ZipCode	StoreID	RealEstateValue
S1	60600	S1	\$9,000,000
S2	60605	S2	\$11,000,000
S3	35400	S4	\$8,000,000
S4	60611		
S5	35405		
S6	35405		

RENTEDSTORE		REALTYCO	
StoreID	AnnualRent	RealtyCoID	RealtyCoName
S3	\$450,000	R1	Braun CR
S5	\$550,000	R2	Shea Prop
S6	\$400,000	R1	

Figure 4 Sample data for Company X.

Figure 5 illustrates how this scenario would be modeled using EER notation.

The letter *o* in the circle indicates that the subclasses PRINTEDBOOK and EBOOK are **overlapping subclasses**. The instance of subclass PRINTEDBOOK can be at the same time an instance of the subclass EBOOK, and vice versa. In other words, a book can be available at the same time as a printed book and an electronic book.

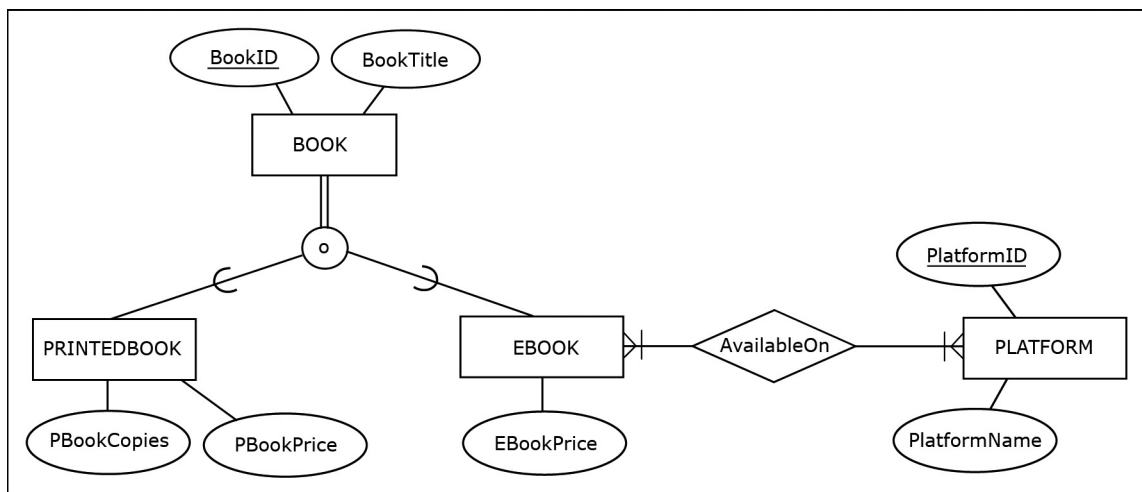


Figure 5 An example of an EER diagram for Publisher X.

Total specialization, represented by the double line connecting the superclass **BOOK** with the circle, states that there is no book that is neither a printed book nor an electronic book.

Figure 6 illustrates the mapping of the EER diagram in Figure 5 into a relational schema.

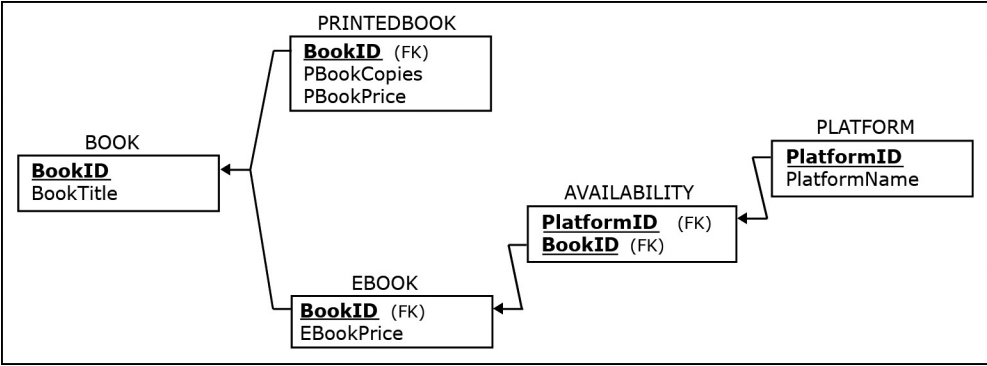


Figure 6 An EER diagram mapped into a relational schema for Publisher X.

Figure 7 illustrates a data sample in the Publisher X database resulting from the EER diagram.

BOOK	
BookID	BookTitle
B1	Winter Game
B2	Solitude
B3	Code Q
B4	Pam & Sue
B5	Arrival
B6	My Mind

PRINTEDBOOK		
BookID	PBookCopies	PBookPrice
B1	10,000	\$90
B2	20,000	\$70
B4	25,000	\$120

PLATFORM	
PlatformID	PlatformName
P1	Bimble
P2	EyeGlad

AVAILABILITY	
BookID	PlatformID
B2	P1
B3	P1
B3	P2
B4	P1
B4	P2
B5	P1
B6	P1

EBOOK	
BookID	EBookPrice
B2	\$60
B3	\$110
B4	\$55
B5	\$55
B6	\$70

Figure 7 Sample data for Publisher X.

Note that due to total specialization, there is no book that is neither a printed book nor an electronic book. Also note that because the subclasses are overlapping, some books are at the same time printed books and electronic books.

EER Example 3—Disjoint Subclasses, Partial Specialization
Consider the following example:

- For each employee, Airline X keeps track of employee ID (unique) and employee name.
- Certain employees of Airline X are pilots. For each pilot, Airline X keeps track of his or her number of flight hours (NoFHours).
- Certain employees of Airline X are mechanics. For each mechanic, Airline X keeps track of his or her mechanic type (MeType).

- Certain employees of Airline X are flight attendants. For each flight attendant, Airline X keeps track of his or her flight attendant level (FALevel).
- There are other employees in Airline X who are not pilots, flight attendants, or mechanics. For such employees, Airline X does not keep any additional data besides the employee ID and employee name.

Figure 8 illustrates how this scenario would be modeled using EER notation.

Partial specialization is represented by the single line connecting the superclass EMPLOYEE with the circle. In this case, partial specialization states that some employees are not pilots, mechanics, or flight attendants.

The letter *d* in the circle indicates that the subclasses PILOT, MECHANIC, and FLIGHTATTENDANT are disjoint.

Figure 9 illustrates the mapping of the EER diagram in Figure 8 into a relational schema.

Figure 10 illustrates a data sample in the Airline X database resulting from the EER diagram.

Note that due to partial specialization, not every employee is a pilot, mechanic, or flight attendant. Some employees (Luc and Stu) are just generic employees. Also note that because subclasses are disjoint, there are no employees that are both pilots and mechanics, or pilots and flight attendants, or mechanics and flight attendants at the same time.

The superclass and its subclasses can be sorted into one of the following four categories:

- disjoint subclasses, total specialization
- overlapping subclasses, total specialization
- disjoint subclasses, partial specialization
- overlapping subclasses, partial specialization

The first three categories in this list are illustrated by the three previous examples (EER Example 1, EER Example 2, and EER Example 3.) As an exercise, you can create an example that illustrates the overlapping subclasses, partial specialization case.

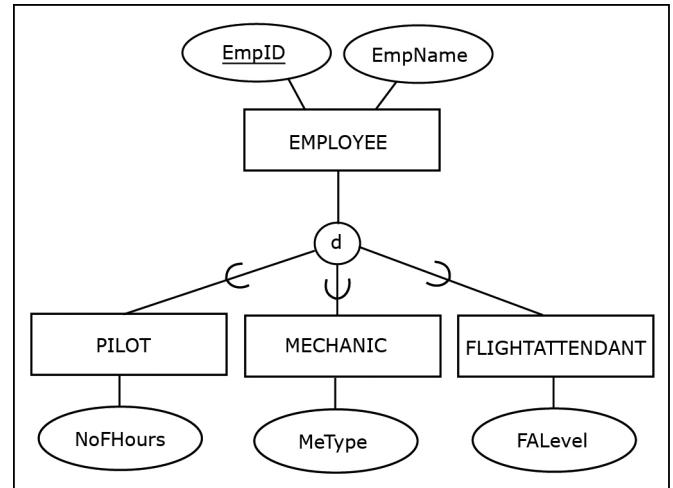


Figure 8 An example of an EER diagram for Airline X.

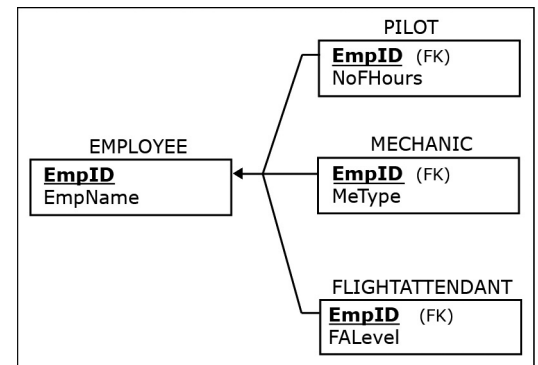


Figure 9 An EER diagram mapped into a relational schema for Airline X.

EMPLOYEE		PILOT	
<u>EmpID</u>	EmpName	<u>EmpID</u>	NoFHours
E1	Joe	E1	17000
E2	Sue	E2	20000
E3	Pat		
E4	Lee		
E5	Pam		
E6	Bob		
E7	Luc		
E8	Stu		

MECHANIC		FLIGHTATTENDANT	
<u>EmpID</u>	MeType	<u>EmpID</u>	FALevel
E3	Engine	E5	Level 1
E4	Wing	E6	Level 2

Figure 10 Sample data for Airline X.