2. DB Modeling

- 2.1 Entity Relationship (ER) Model
  - Entities, Relationships, Constraints
- 2.2 Extended Entity Relationship (EER) Model
  - Specialization, Subtype, Supertype, Subtype Discriminator
- 2.3 Translation of EER Models to Relations

Module 2.1 – Entity Relationship (ER) Model

2. DB Modeling

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  - Specialization, Subtype, Supertype, Subtype Discriminator
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2.1 ER Model

Learning Outcomes

- Understand and explain ER modeling, including entities, relationships and their constraints
  - Relationship strength, degree, cardinalities, connectivity
- Understand various standards used in ER modeling
- Understand and use of Associative entities
- Create ER diagrams from user requirements
- Derive constraints represented by ERDs

Textbook Readings

- Chap 4

Testing*

*Main (but not the only ones) sections of the textbook used for testing are identified in parentheses

- Entity Relationship modeling (Chap 4)

Entity Relationship Modeling

- Entity–relationship modeling was developed for database design by Peter Chen in 1976
  ERD – Entity Relationship Diagram
- Variants for graphical representations
  - Chen, Crow's Foot, UML notation, …
- Enhanced (Extended) ER Modeling … in next module
  - Subclass, superclass (Is-a), specialization, generalization

Entity Relationship Modeling – Entities and Attributes

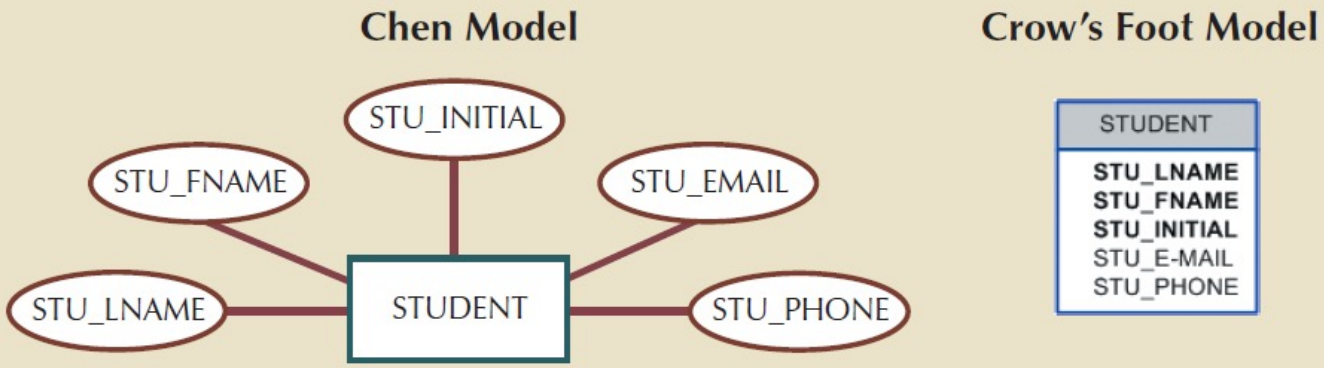
Entity Properties / Characteristics

- Noun for the name of an entity
- Required attribute: must have a value and cannot be left empty
- Optional attribute: does not require a value and can be left empty
- Domain: set of possible values for a given attribute
- Identifier: one or more attributes that uniquely identify each entity instance

Composite identifier: primary key composed of more than one attribute of more than one attribute

- Composite attribute: attribute that can be subdivided to yield additional attributes
- Simple attribute: attribute that cannot be subdivided
- Single-valued attribute: attribute that has only a single value
- Multivalued attributes: attributes that have many values

FIGURE 4.1 THE ATTRIBUTES OF THE STUDENT ENTITY: CHEN AND CROW' FOOT

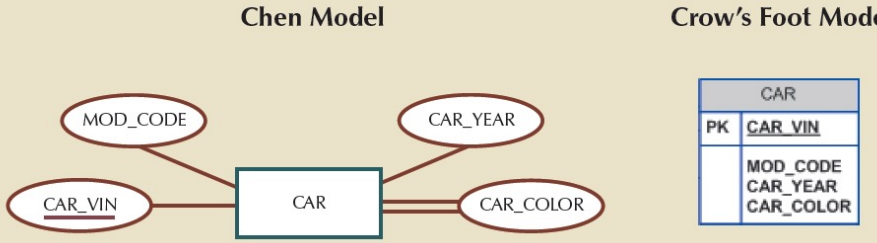


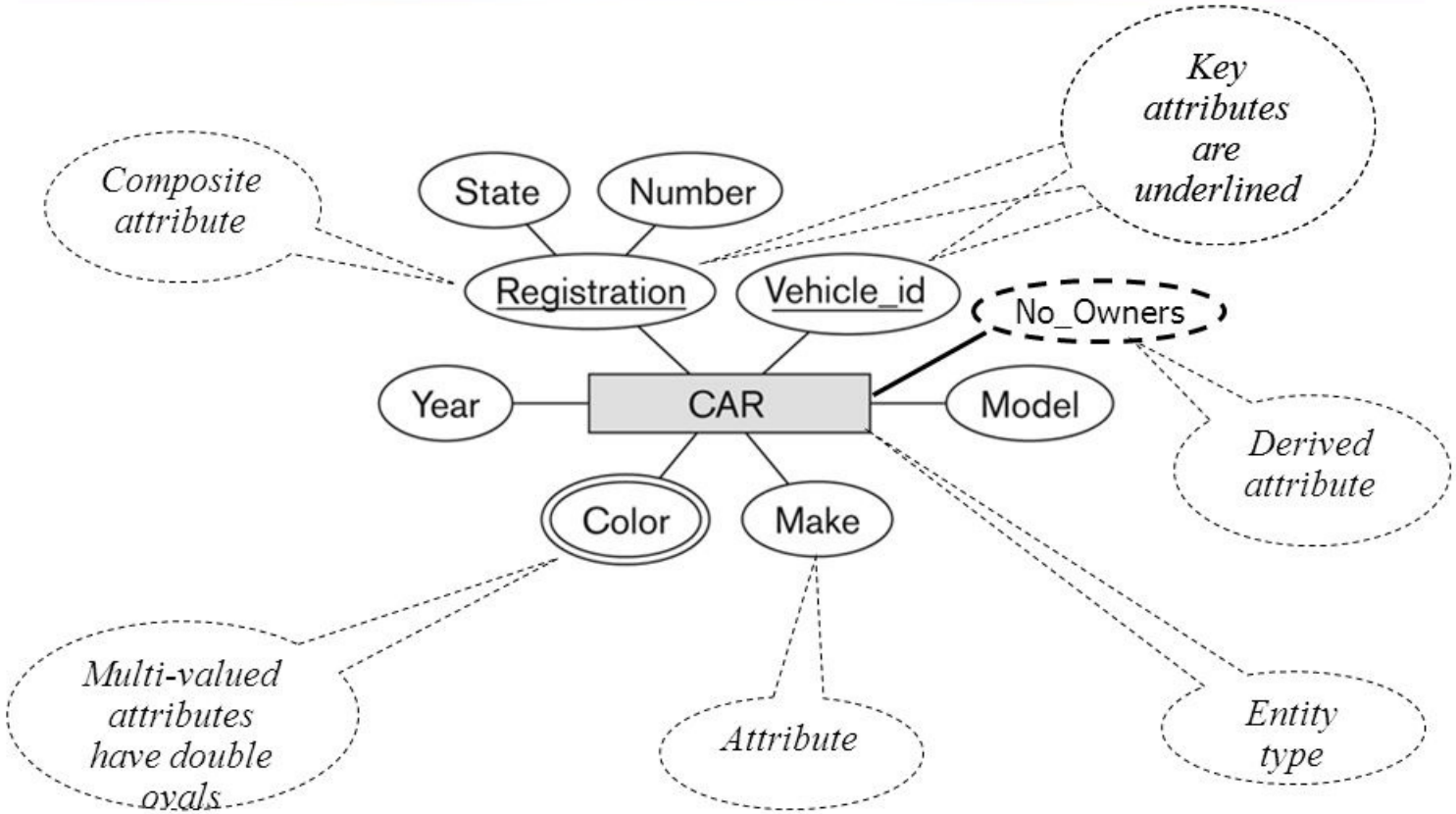
Entity Relationship Modeling – Entities and Attributes … continued

Attributes

- Multivalued
- Derived
- Composite

FIGURE 4.3 A MULTIVALUED ATTRIBUTE IN AN ENTITY





Relationships, Connectivity, and Cardinality

- Association (relationships) between entities that always operate in both directions
  - Participants: entities that participate in a relationship
- Connectivity: describes the relationship classification
  - Include 1:1, 1:M, and M:N
- Cardinality:
  - Express the minimum and maximum number of entity occurrences associated with one occurrence of related entity
    - Minimum cardinality … may be referred to alsoas optional or mandatory membership
  - In the ERD, cardinality is indicated by placing the appropriate numbers beside the entities, using the format (x, y)
- Existence
  - Independence - Entity may exist apart from all of its related entities
  - Dependence - Entity exists in the database only when it is associated with another related entity occurrence

Existence Dependence, Weak Entity, Identifying Relationship

- Existence Dependence
  - Dependence - Entity exists in the database only when it is associated with another related entity occurrence
- Weak Entity
  - Must be existence-dependent on its parent entity (strong entity)
  - Does not have an attribute that can serve as a primary key =>
    - Weak entity must inherit at least part of its primary key from its parent entity (Weak entity is connected to the strong entity via ***Identifying Relationship)***
- Identifying Relationship
  - ***Identifying Relationship*** … Primary key of the strong entity is a part of the primary key of the weak entity
    - In an identifying relationship, participation is mandatory
  - ***Non-identifying relationship*** … primary key of the parent entity is included in the child entity but not as part of the child entity's primary key

DB Design – ER Modeling Steps

Activities involved in building an ERD

- Create a detailed narrative of the organization's description of operations
- Identify business rules based on the descriptions
- Identify main entities and then relationships from the business rules
- Develop the initial ERD
- Identify attributes and primary keys that adequately describe entities
- Revise and review ERD

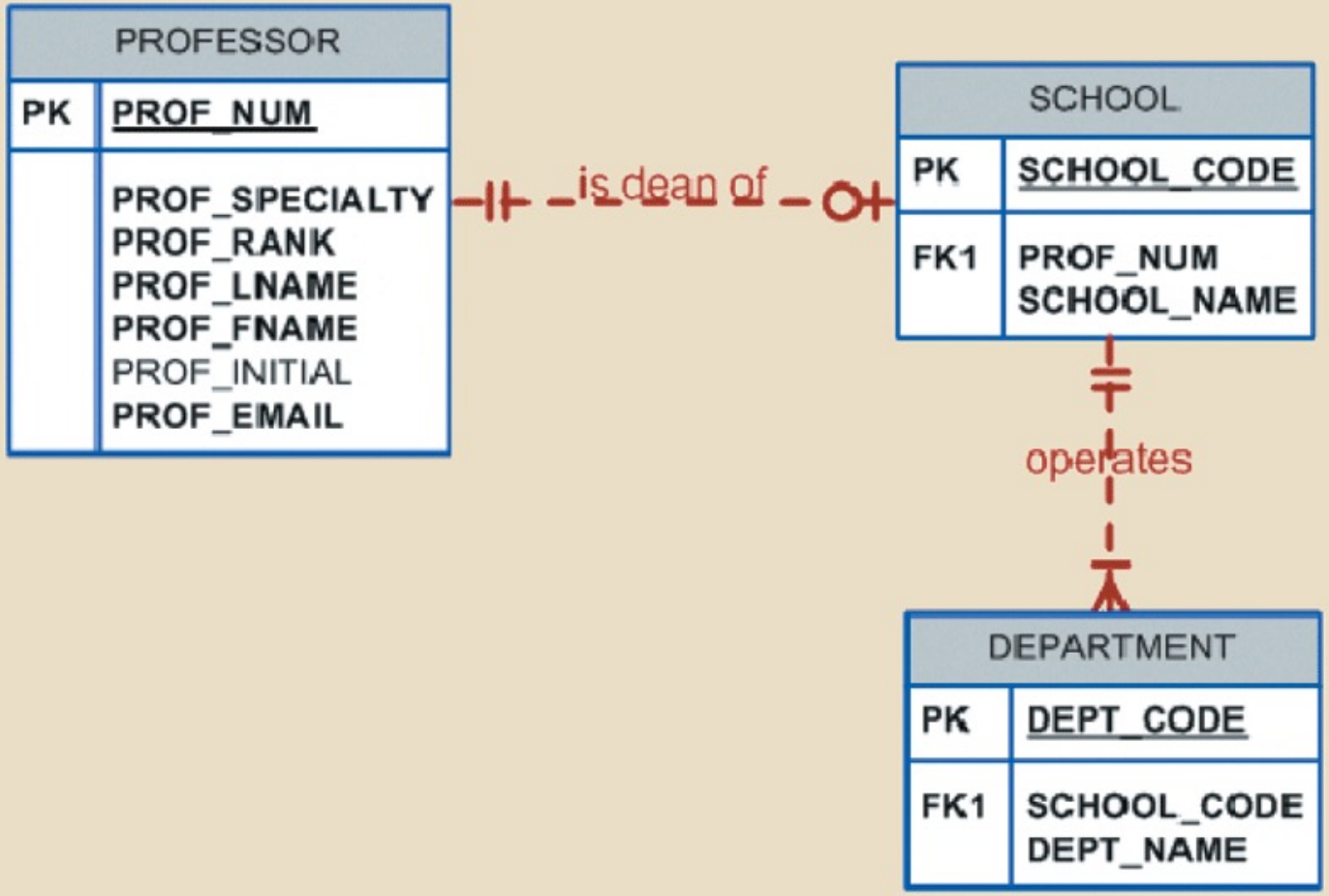
DB Design – ER Modeling Steps – Example: Tiny College

Concepts – Entities

- School
  - Professors
  - Departments
  - Courses
    - Classes (sections)

…

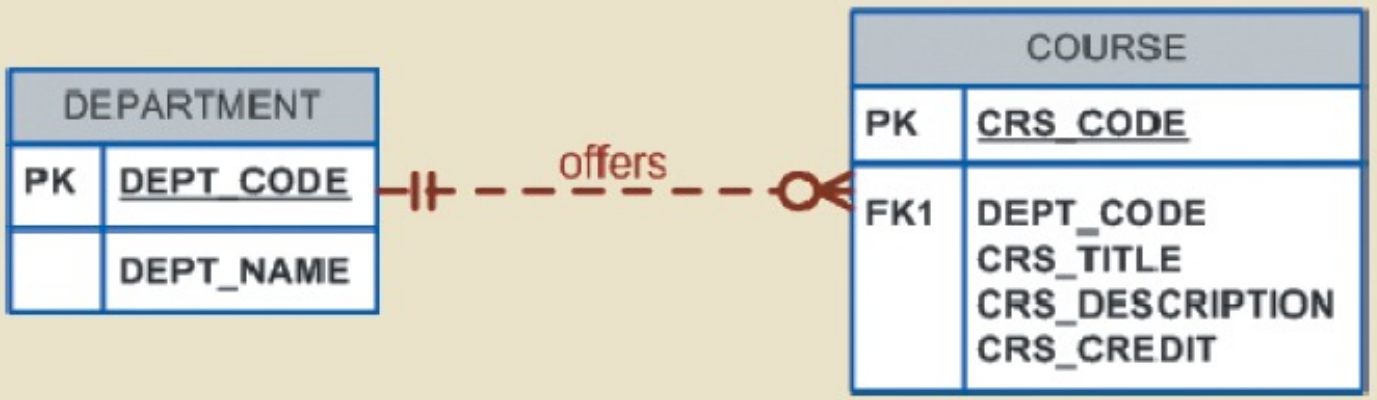
FIGURE 4.26 THE FIRST TINY COLLEGE ERD SEGMENT



DB Design – ER Modeling Steps – Example: Tiny College

Profs - Departments

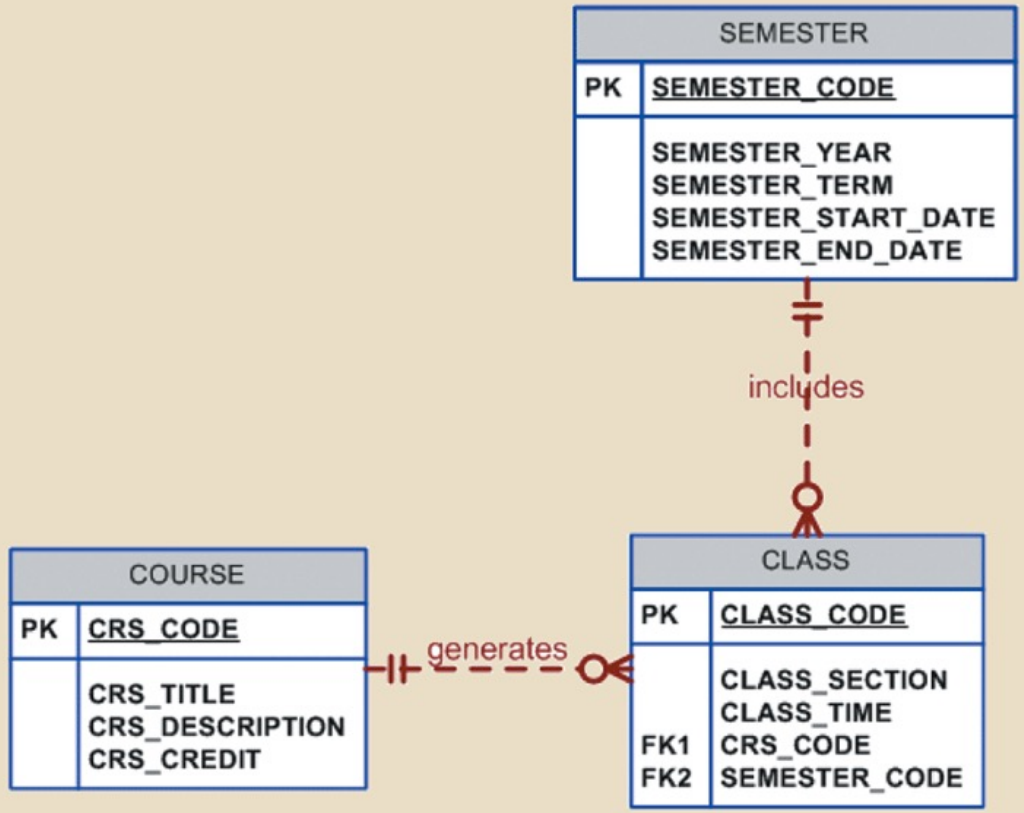
FIGURE 4.27 THE SECOND TINY COLLEGE ERD SEGMENT



DB Design – ER Modeling Steps – Example: Tiny College

Courses and Classes (Sections)

FIGURE 4.28 THE THIRD TINY COLLEGE ERD SEGMENT



DB Design – ER Modeling Steps – Example: Tiny College

Profs

Departments

Courses

Classes

FIGURE 4.29 THE FOURTH TINY COLLEGE ERD SEGMENT

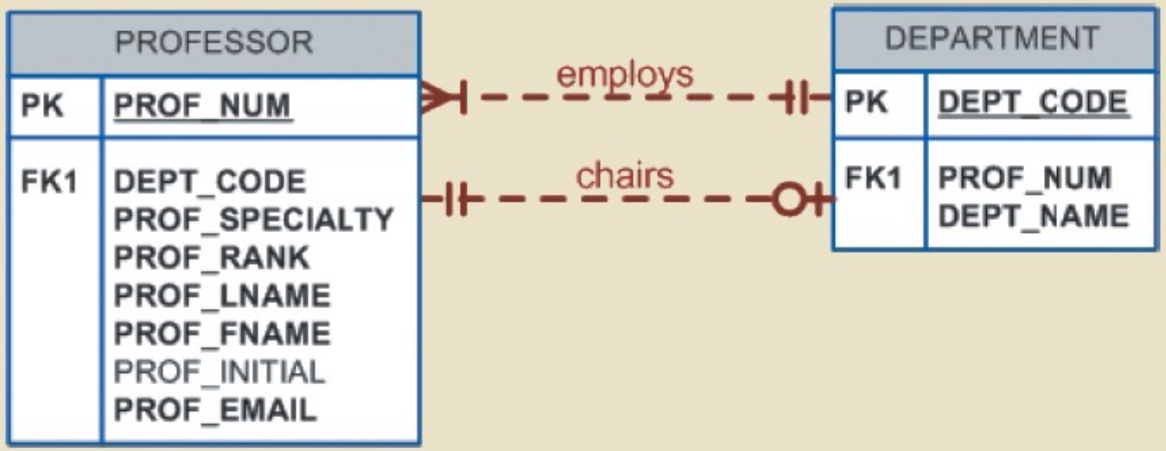
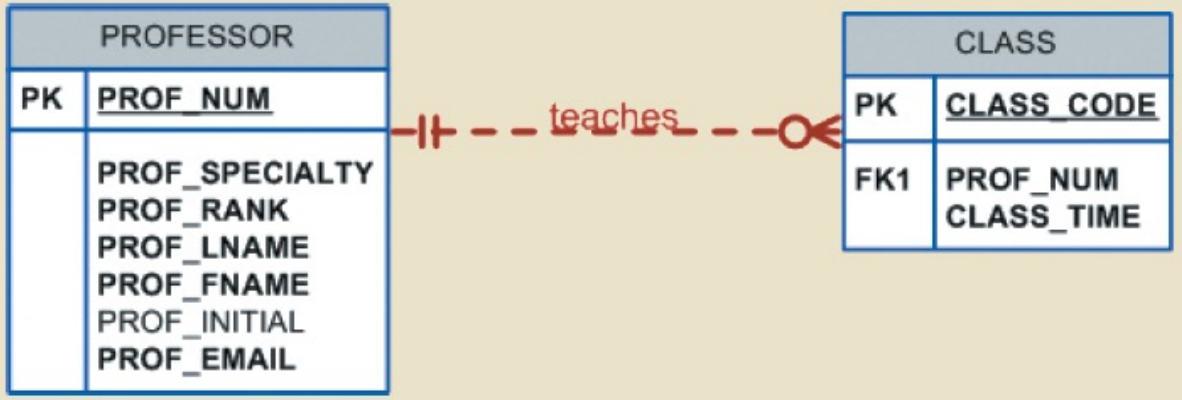
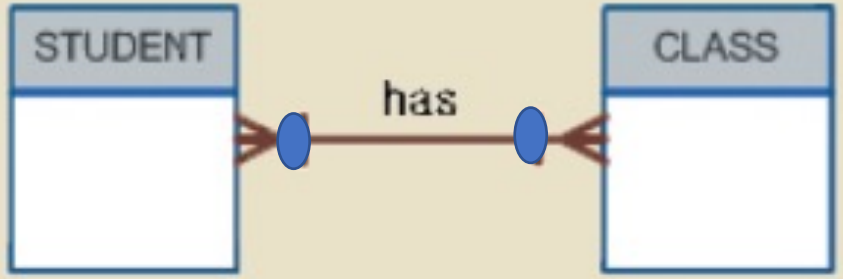


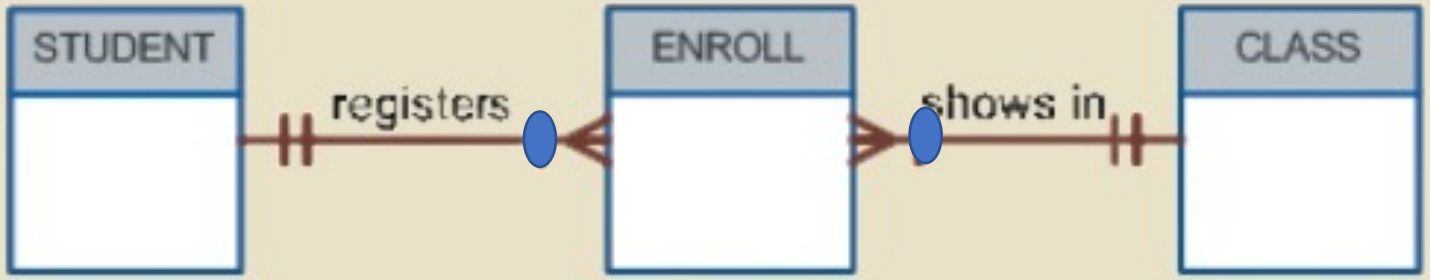
FIGURE 4.30 THE FIFTH TINY COLLEGE ERD SEGMENT



Changing a many-to-many relationship into two one-to-many relationships

3.26 CHANGING THE M:N RELATIONSHIPS TO TWO 1:M RELATIONSHIPS





DB Design – ER Modeling Steps – Example: Tiny College

Students

Classes

Departments

FIGURE 4.31 THE SIXTH TINY COLLEGE ERD SEGMENT

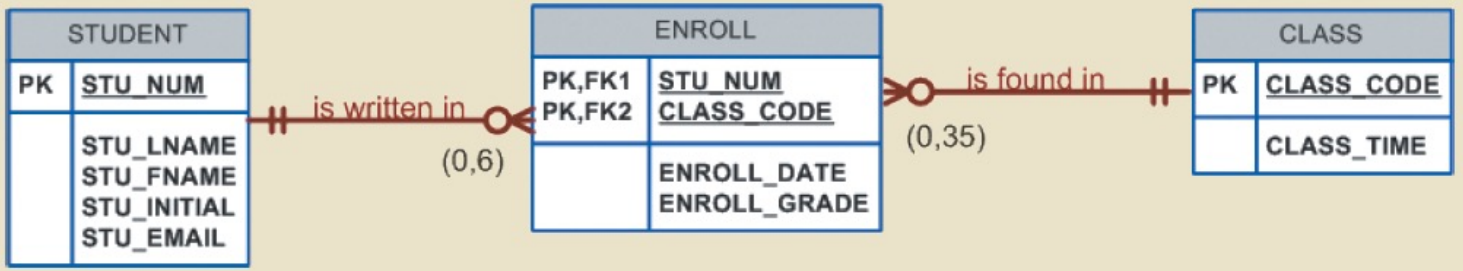
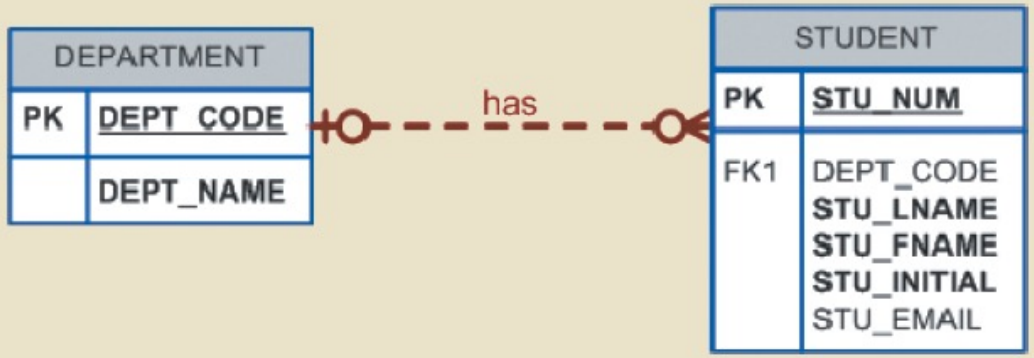


FIGURE 4.32 THE SEVENTH TINY COLLEGE ERD SEGMENT



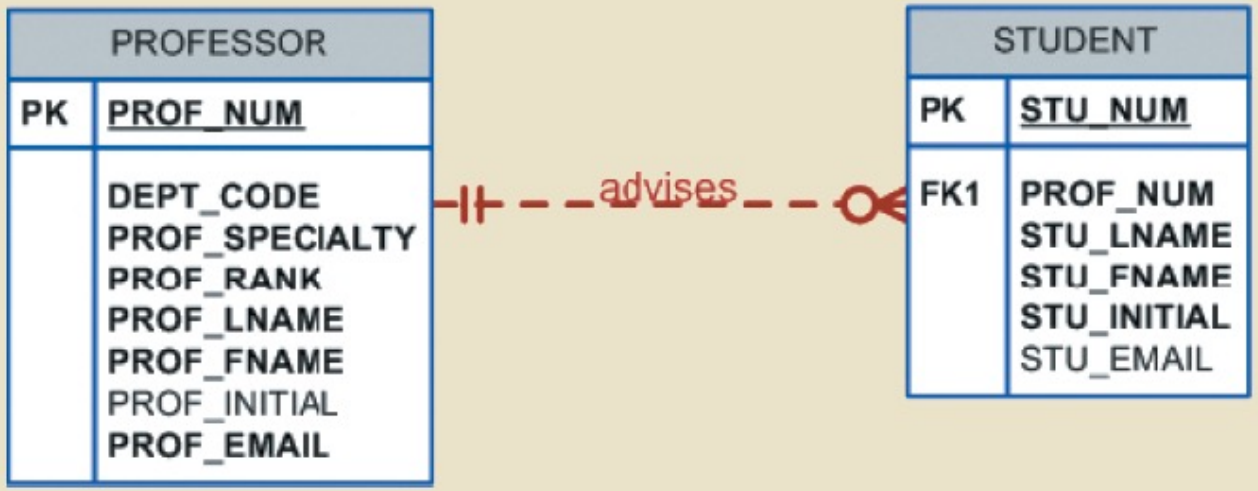
DB Design – ER Modeling Steps – Example: Tiny College

Students

Professors

Advising

FIGURE 4.33 THE EIGHT TINY COLLEGE ERD SEGMENT



DB Design – ER Modeling Steps – Example: Tiny College

Classes

Rooms

Buildings

FIGURE 4.34 THE NINTH TINY COLLEGE ERD SEGMENT

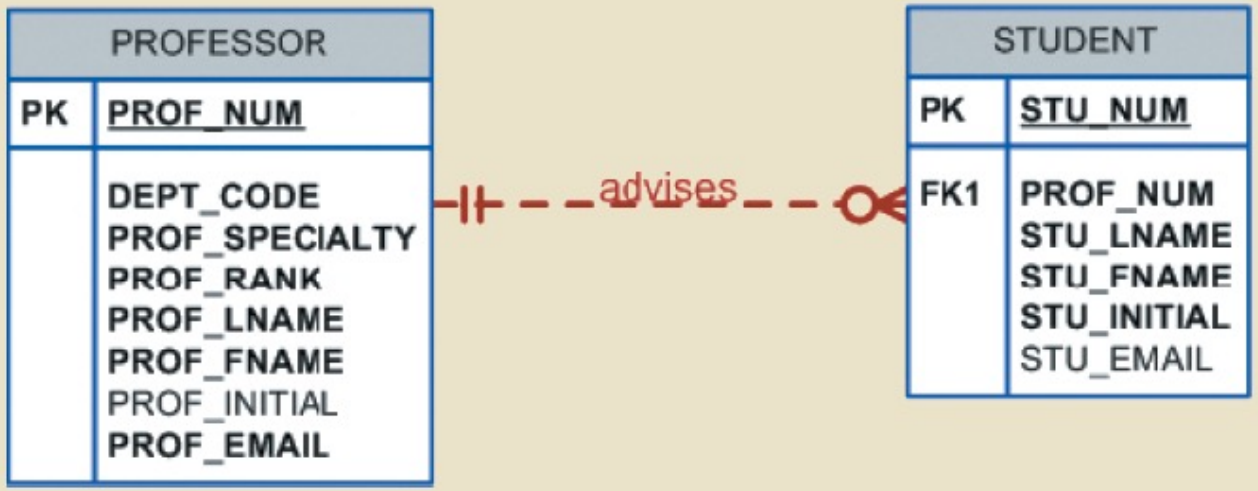
DB Design – ER Modeling Steps – Example: Tiny College

Classes

Classrooms

Locations

FIGURE 4.33 THE EIGHT TINY COLLEGE ERD SEGMENT



DB Design – ER Modeling Steps – Example: Tiny College

Table 4.4	Components of the ERM		
Entity	**Relationship**	**Connectivity**	**Entity**
SCHOOL	operates	1:M	DEPARTMENT
DEPARTMENT	has	1:M	STUDENT
DEPARTMENT	employs	1:M	PROFESSOR
DEPARTMENT	offers	1:M	COURSE
COURSE	generates	1:M	CLASS
SEMESTER	includes	1:M	CLASS
PROFESSOR	is dean of	1:1	SCHOOL
PROFESSOR	chairs	1:1	DEPARTMENT
PROFESSOR	teaches	1:M	CLASS
PROFESSOR	advises	1:M	STUDENT
STUDENT	enrolls in	M:N	CLASS
BUILDING	contains	1:M	ROOM
ROOM	is used for	1:M	CLASS
	Note: ENROLL is the composite entity that implements the M:N relationship “STUDENT enrolls in CLASS.”		

Recursive (Unary) Relationships

- Relationship can exist between occurrences of the same entity set
  - Naturally, such a condition is found within a unary relationship
    - Common in manufacturing industries

- One common pitfall when working with unary relationships is to confuse participation with referential integrity
  - Similar because they are both implemented through constraints on the same set of attributes

Recursive Relationship … continued

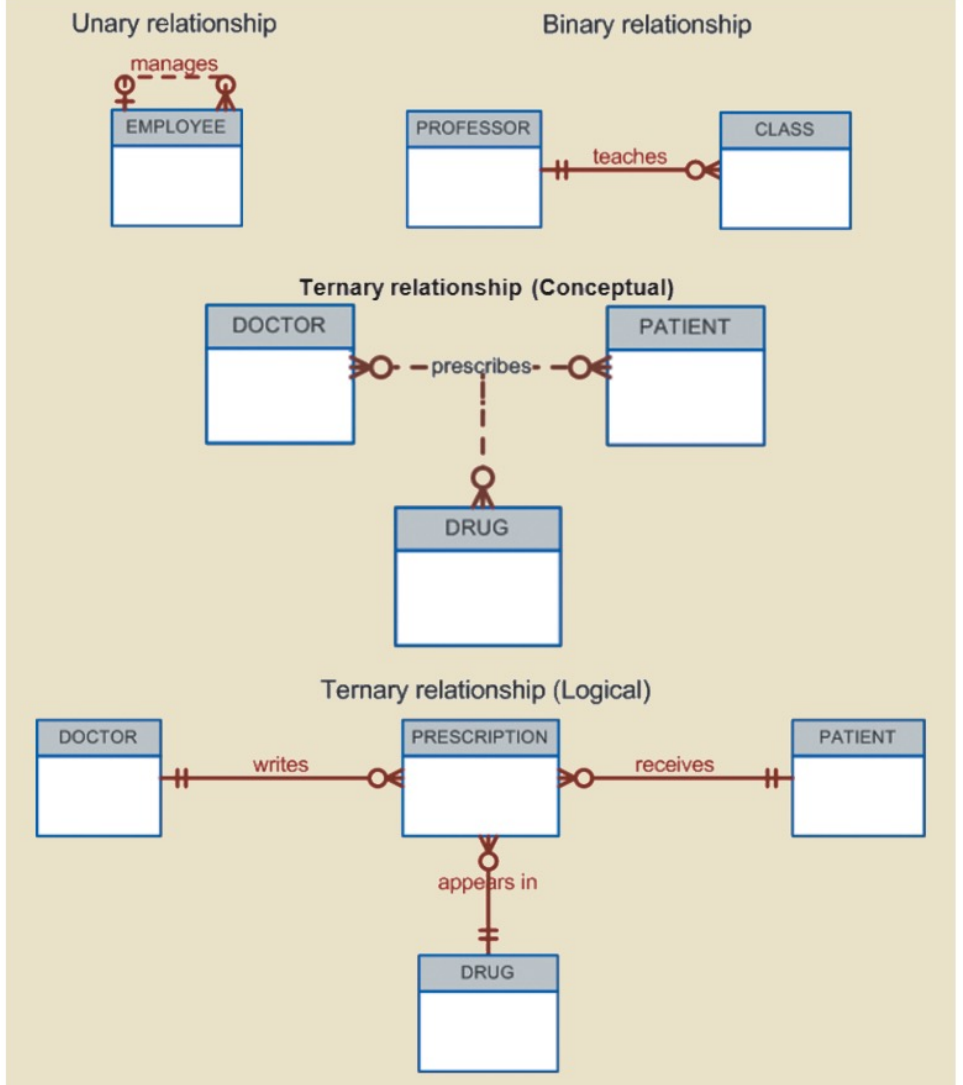
FIGURE 4.17 AN ER REPRESENTATION OF RECURSIVE RELATIONSHIPS

Higher Degree Relationship

- Indicates the number of entities or participants associated with a relationship
  - Unary relationship: association is maintained within a single entity
    - also called Recursive relationship
  - Binary relationship: two entities are associated
  - Ternary relationship: three entities are associated

Higher Degree Relationship … continued

FIGURE 4.15 THREE TYPES OF RELATIONSHIP DEGREE

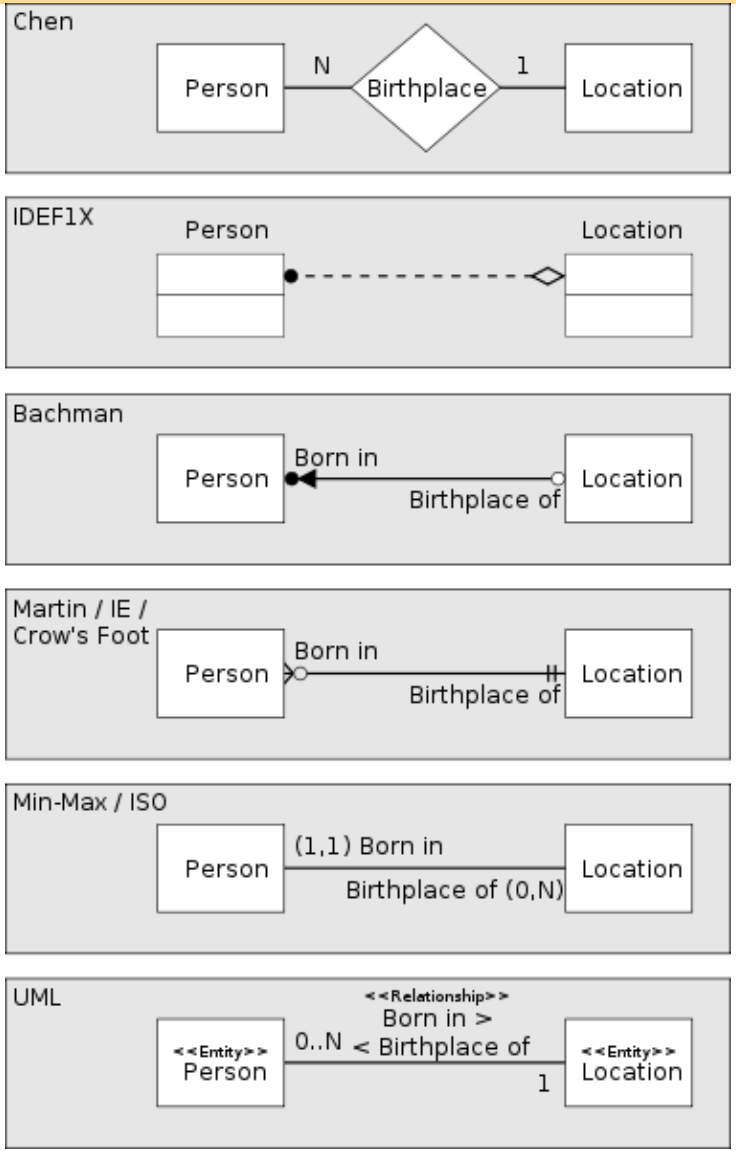


ER - Notations

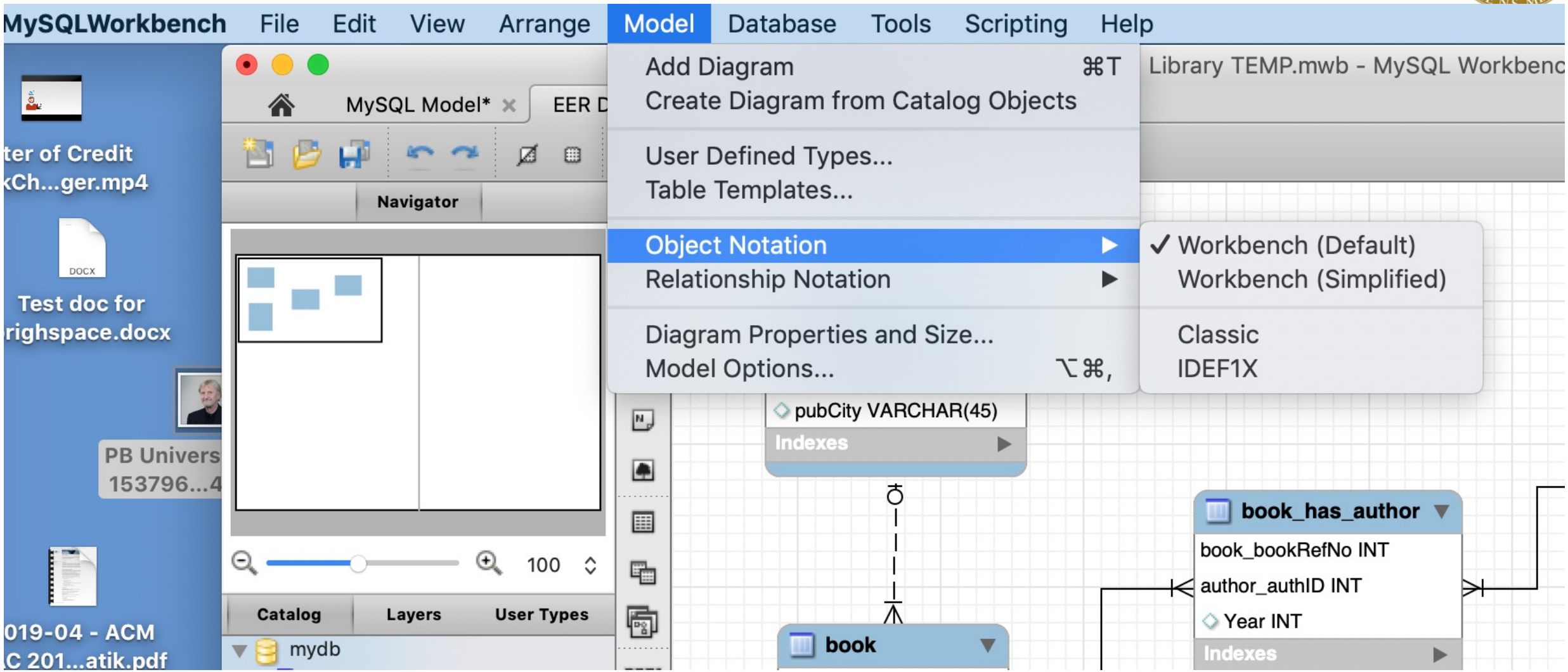
From Wikipedia:

ER diagram standards

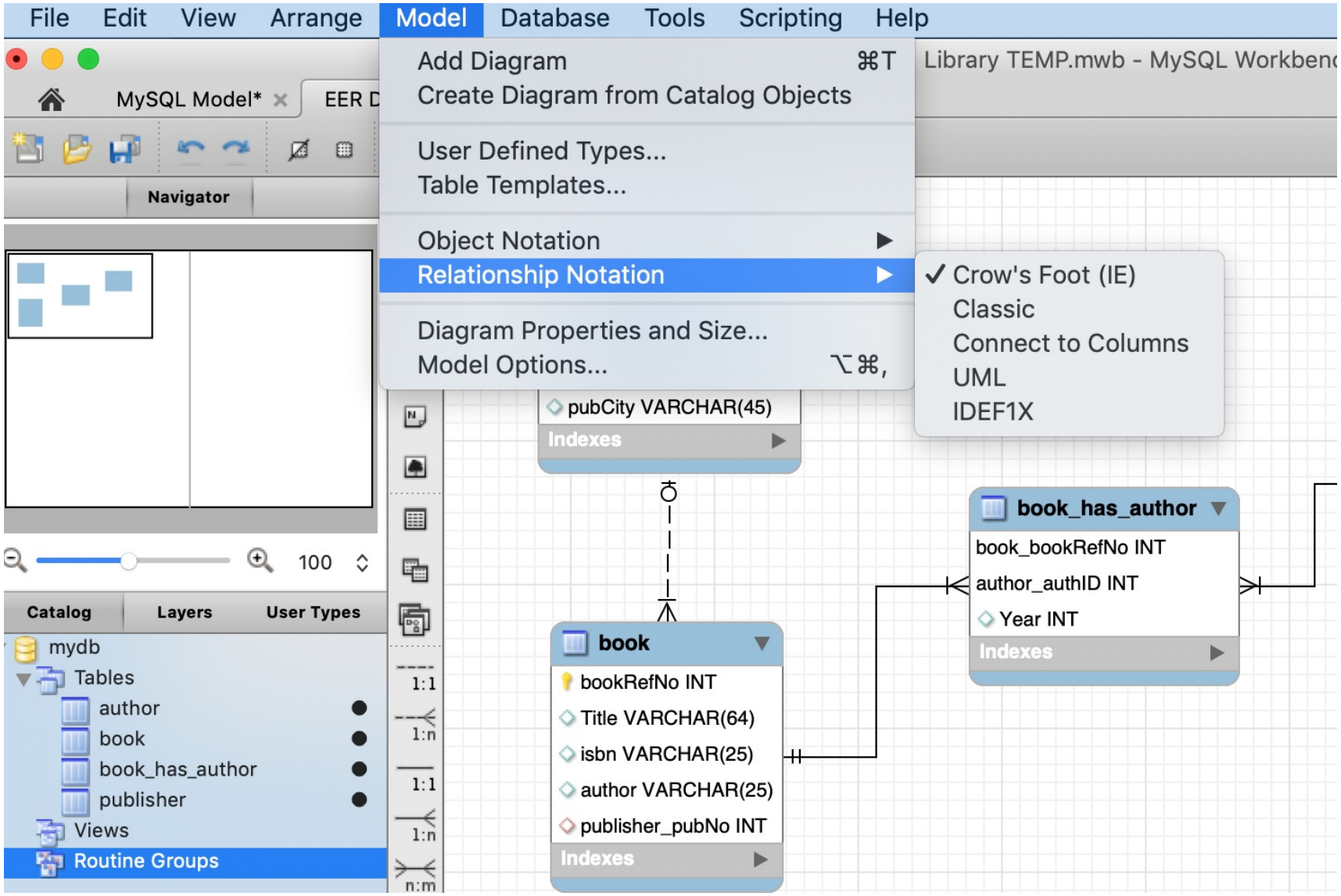
Crow's foot
Chen
UML class
IDE1FX
…



ER – Notations … continued



ER – Notations … continued



Database Design Challenges

- Database designers must often make design compromises that are triggered by conflicting goals
  - Database design must conform to design standards
  - High processing speed may limit the number and complexity of logically desirable relationships
  - Maximum information generation may lead to loss of clean design structures and high transaction speed

Database Design Challenges … continued

FIGURE 4.38 VARIOUS IMPLEMENTATIONS OF THE 1:1 RECURSIVE RELATIONSHIP

Table name: EMPLOYEE_V1 — **Database name: Ch04_PartCo**

EMP_NUM	EMP_LNAME	EMP_FNAME	EMP_SPOUSE
345	Ramirez	James	347
346	Jones	Anne	349
347	Ramirez	Louise	345
348	Delaney	Robert	
349	Shapiro	Anton	346

First implementation

Table name: EMPLOYEE

EMP_NUM	EMP_LNAME	EMP_FNAME
345	Ramirez	James
346	Jones	Anne
347	Ramirez	Louise
348	Delaney	Robert
349	Shapiro	Anton

Table name: MARRIED_V1

EMP_NUM	EMP_SPOUSE
345	347
346	349
347	345
349	346

Second implementation

Table name: MARRIAGE

MAR_NUM	MAR_DATE
1	04-Mar-03
2	02-Feb-99

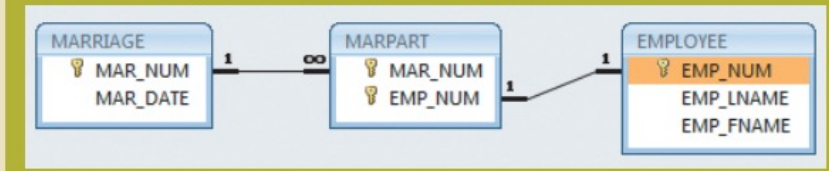
Table name: MARPART

MAR_NUM	EMP_NUM
1	345
1	347
2	346
2	349

Table name: EMPLOYEE

EMP_NUM	EMP_LNAME	EMP_FNAME
345	Ramirez	James
346	Jones	Anne
347	Ramirez	Louise
348	Delaney	Robert
349	Shapiro	Anton

The relational diagram for the third implementation



Third implementation

ER Modeling - Summary

- The ERM uses ERDs to represent the conceptual database as viewed by the end user
- Connectivity describes the relationship classification (1:1, 1:M, or M:N)
- In the ERM, an M:N relationship is valid at the conceptual level
- ERDs may be based on many different ERMs
- Unified Modeling Language (UML) class diagrams are used to represent the static data structures in a data model
- Database designers, no matter how well they can produce designs that conform to all applicable modeling conventions, are often forced to make design compromises

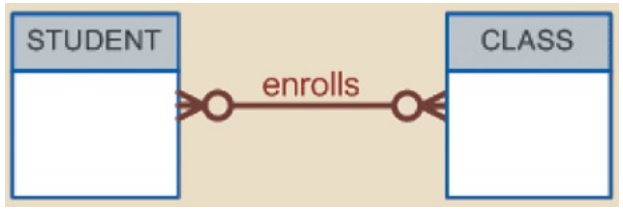
ER Modeling – Review of some of the concepts

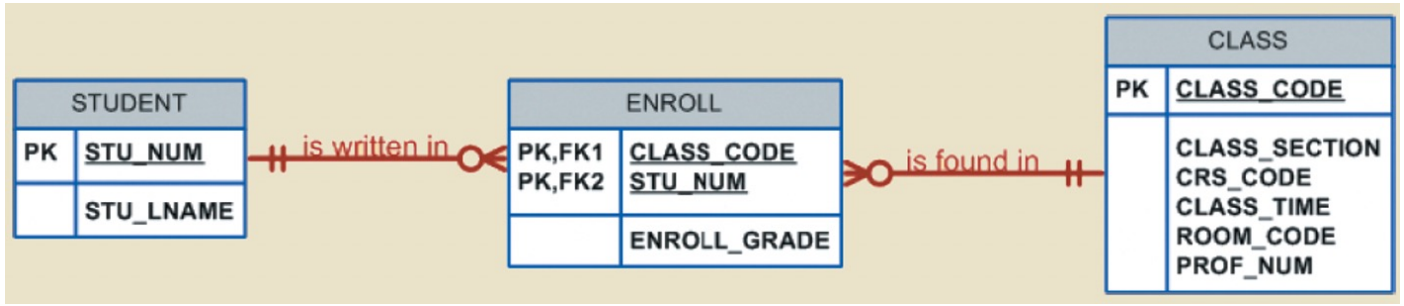
- Many-to-many Relationship and Associative Entity
- Strong/Weak Entities
- Identifying/Non-identifying Relationships

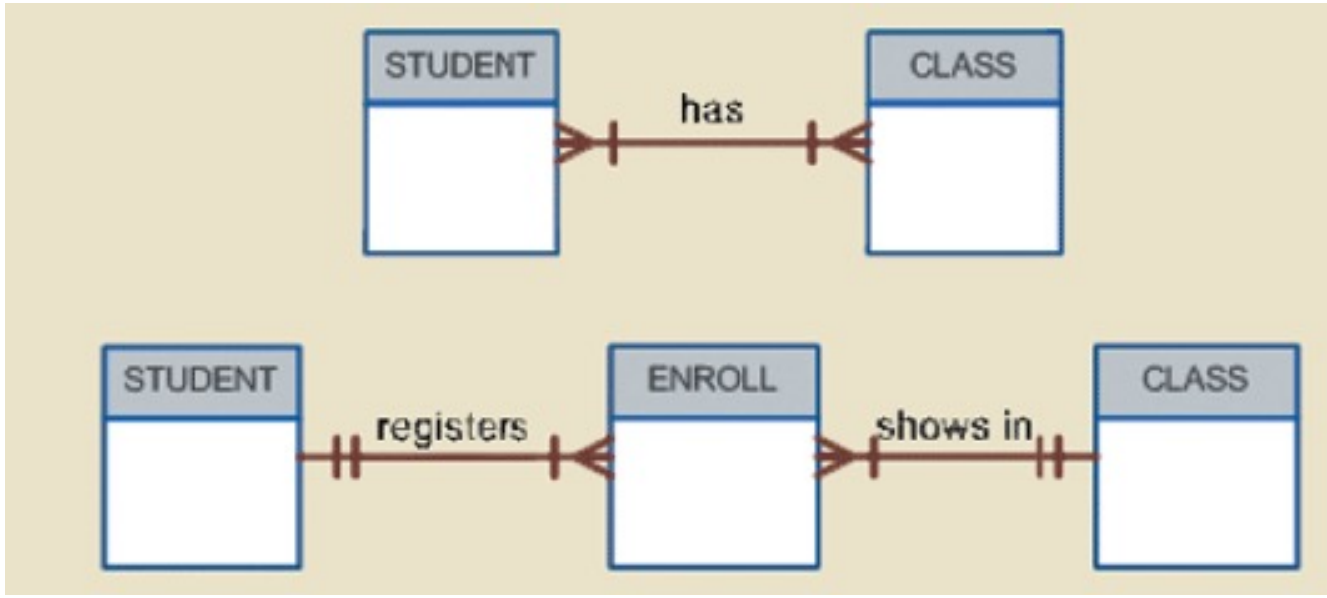
Associative Entities for M-to-N Relationships

- Used to represent an M:N relationship between two or more entities
- Has a 1:M relationship with the parent entities
- Composed of the primary key attributes of each parent entity
- May also contain additional attributes that play no role in connective process

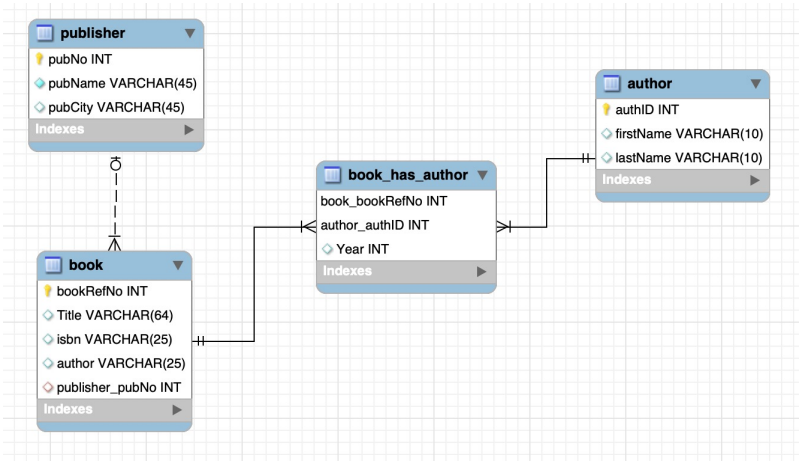
Associative Entities for M-to-N Relationships … continued

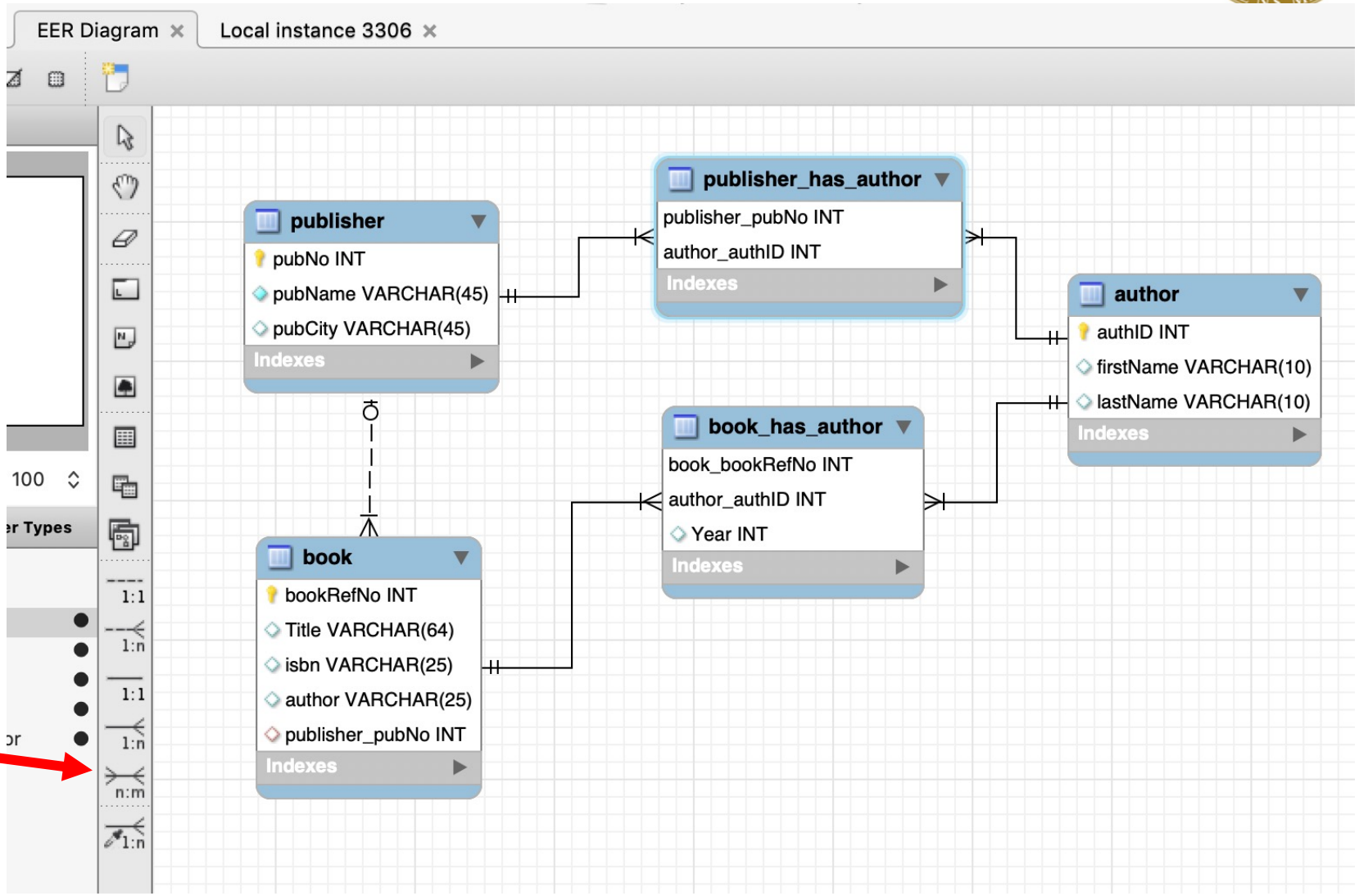






Associative Entities for M-to-N Relationships … continued





Strong/Weak Entities and Identifying/Non-identifying Relationships - Revisited

- Existence and Strong/Weak Entities
  - Dependence - Entity exists in the database only when it is associated with another related entity occurrence
    - **Weak Entity** … usually does not have an attribute(s) that can serve as a primary key
  - Independence - Entity exists apart from all of its related entities
    - Strong entity or **regular entity** … usually has an attribute(s) that can serve as a primary key

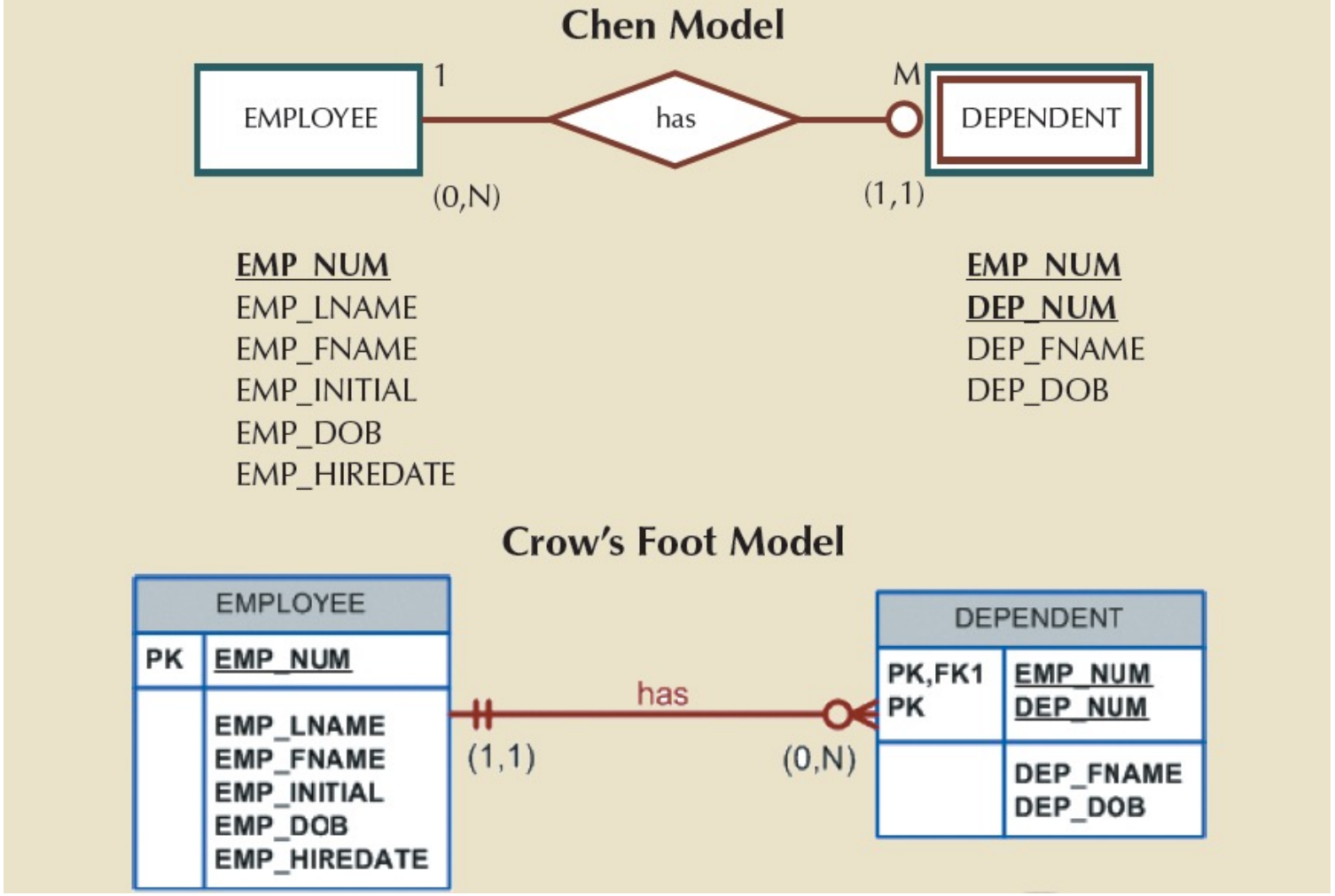
- Conditions of a weak entity
  - Existence-dependent
  - Has a primary key that is partially or totally derived from parent entity in the relationship
  - Database designer determines whether an entity is weak
    - Based on business rules

Strong/Weak Entities and Identifying/Non-identifying Relationships – Revisited … continued

- Weak (non-identifying) and Strong (identifying) Relationships
  - Non-identifying (weak) relationship … Primary key of the related entity does not contain a primary key component of the parent entity
  - Strong (identifying) relationships … Primary key of the related entity contains a primary key component of the parent entity
- Examples
  - Employees and dependants
  - Buildings and rooms
  - Purchase orders and lines

Strong/Weak Entities and Identifying/Non-identifying Relationships – Revisited … continued

FIGURE 4.10 A WEAK ENTITY IN AN ERD



Strong/Weak Entities and Identifying/Non-identifying Relationships – Revisited … continued

FIGURE 4.11 A WEAK ENTITY IN A STRONG RELATIONSHIP

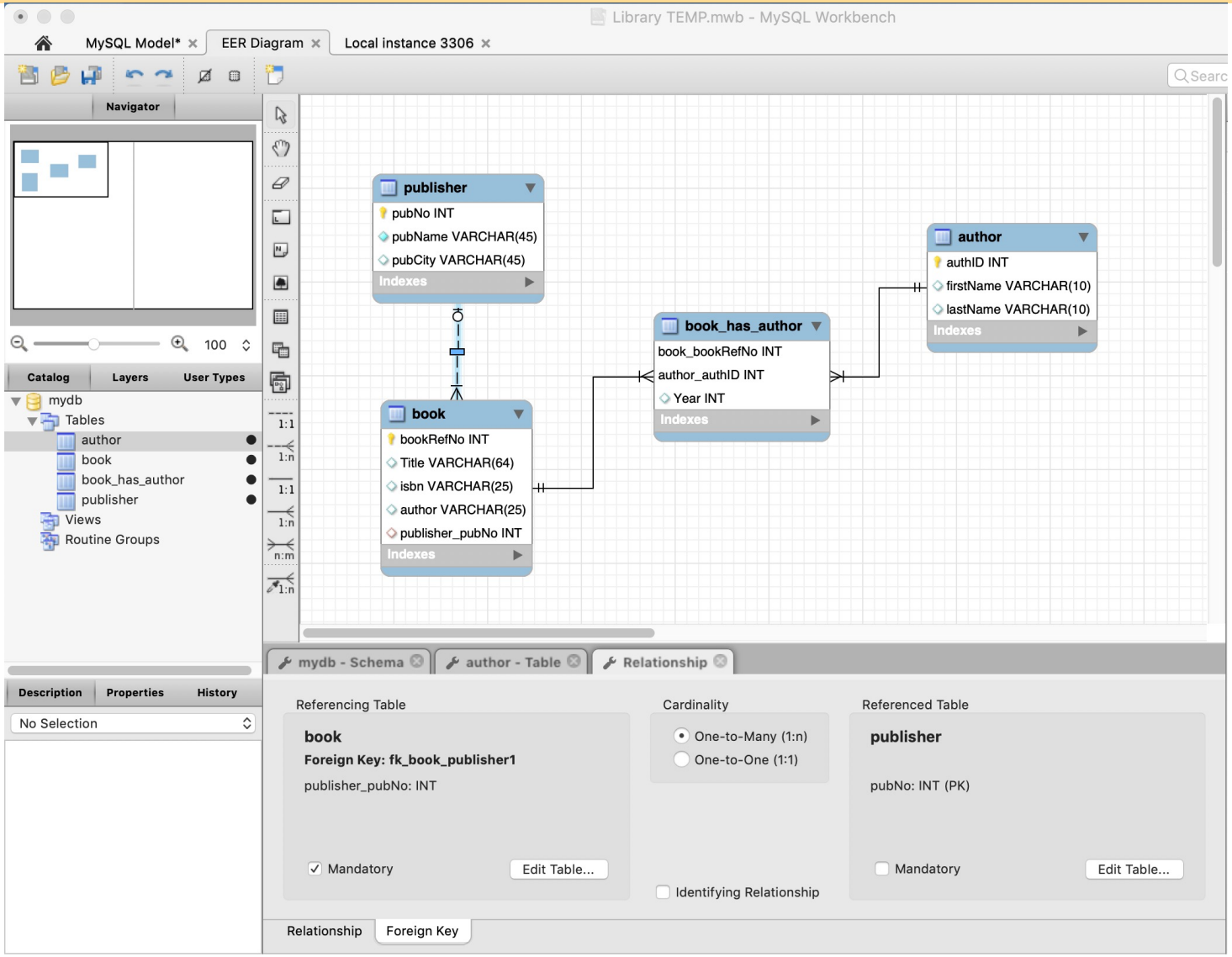
Table name: EMPLOYEE **Database name: Ch04_ShortCo**

EMP_NUM	EMP_LNAME	EMP_FNAME	EMP_INITIAL	EMP_DOB	EMP_HIREDATE
1001	Callifante	Jeanine	J	12-Mar-64	25-May-97
1002	Smithson	William	K	23-Nov-70	28-May-97
1003	Washington	Herman	H	15-Aug-68	28-May-97
1004	Chen	Lydia	B	23-Mar-74	15-Oct-98
1005	Johnson	Melanie		28-Sep-66	20-Dec-98
1006	Ortega	Jorge	G	12-Jul-79	05-Jan-02
1007	O'Donnell	Peter	D	10-Jun-71	23-Jun-02
1008	Brzenski	Barbara	A	12-Feb-70	01-Nov-03

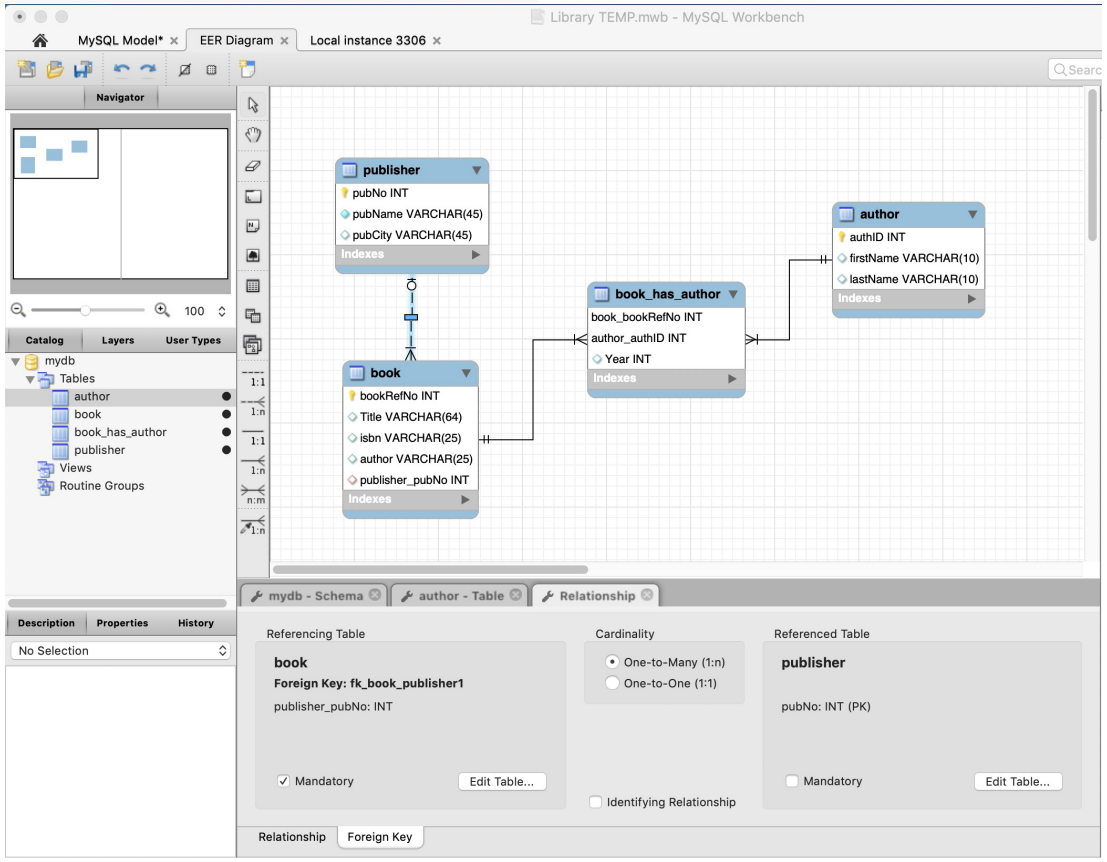
Table name: DEPENDENT

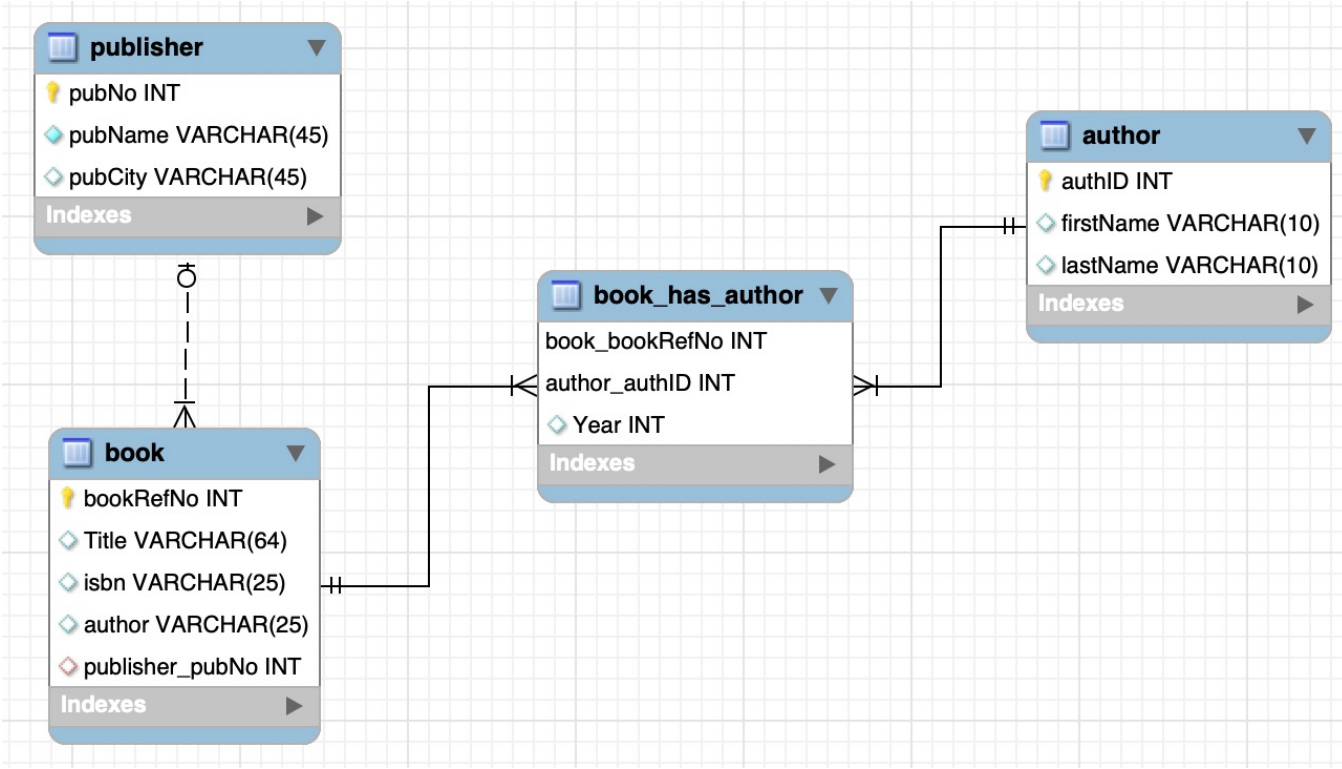
EMP_NUM	DEP_NUM	DEP_FNAME	DEP_DOB
1001	1	Annelise	05-Dec-97
1001	2	Jorge	30-Sep-02
1003	1	Suzanne	25-Jan-04
1006	1	Carlos	25-May-01
1008	1	Michael	19-Feb-95
1008	2	George	27-Jun-98
1008	3	Katherine	18-Aug-03

Strong/Weak Entities and Identifying/Non-identifying Relationships – Revisited … continued

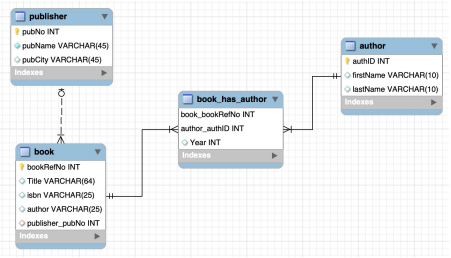


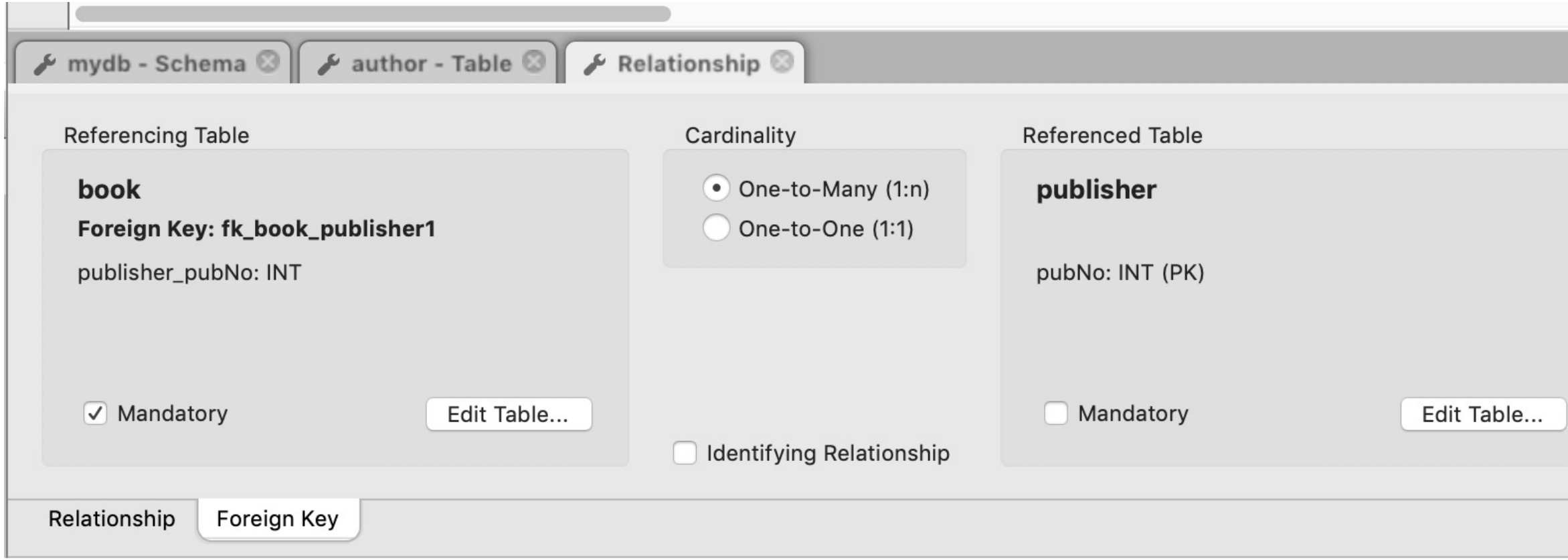
Strong/Weak Entities and Identifying/Non-identifying Relationships – Revisited … continued





Strong/Weak Entities and Identifying/Non-identifying Relationships – Revisited … continued





Questions and Answers (Q/A)