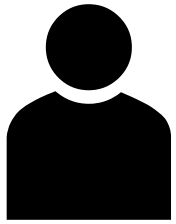
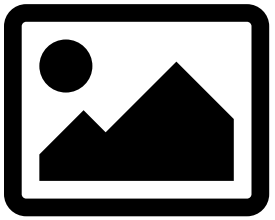
# 2: Foundation Concepts

# conceptual modeling

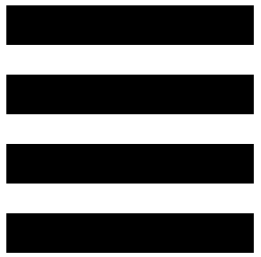
attempt to represent meaning



user participation



big picture and easier maintenance in the long run

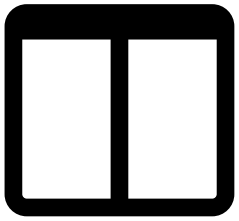


independent from the DBMS

# conceptual modeling

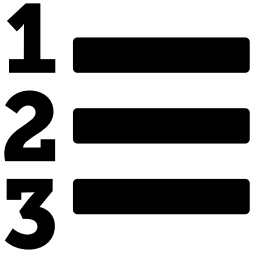
attempt to represent meaning

conceptual model involves:



context (setting)

grammar (defines set of rules)




method (describes how to use the grammar)

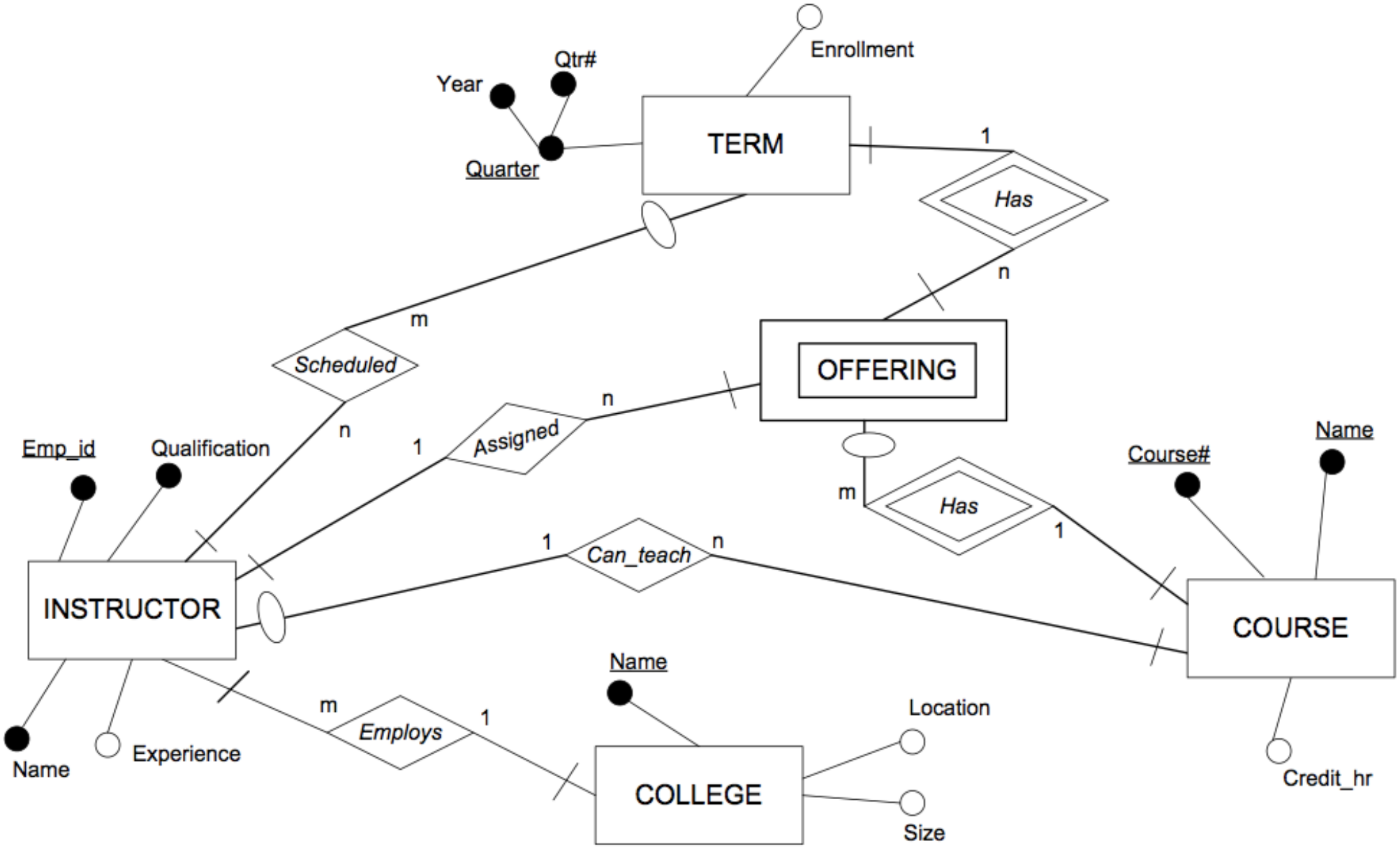
# conceptual modeling

attempt to represent meaning

the output of conceptual modeling is an ER model, the most widely accepted data modeling grammar for conceptual design.

a model can never represent reality in total, but just a portion.

# an ER model




an ER model is more abstract than a logical or physical data model

# entities, attributes, relationships

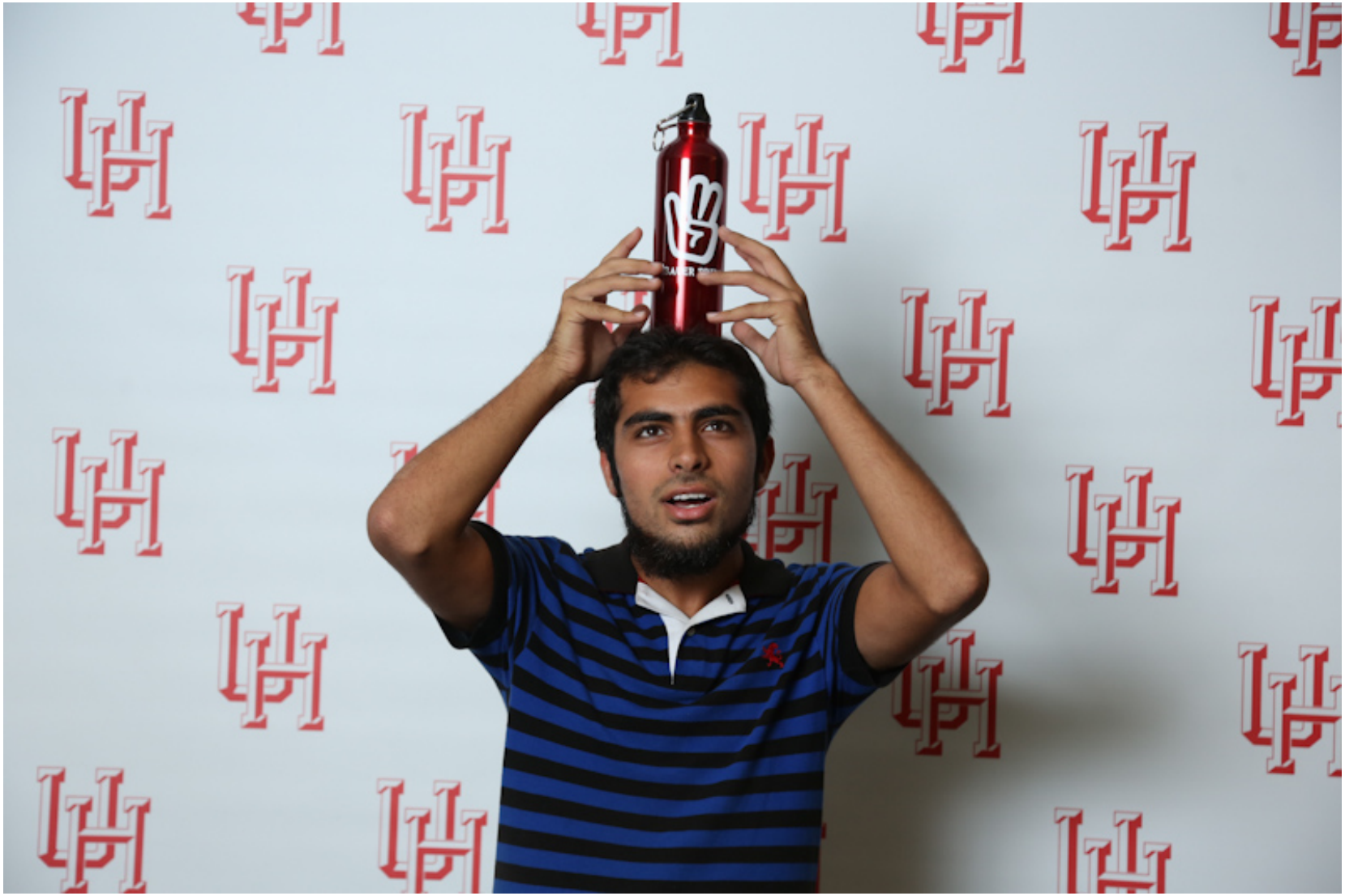
core pieces of the ER modeling grammar

| Real World | Conceptual |
| --- | --- |
| Object {type} | Entit(ies) {type} |
| Object {occurrence} | Entit(ies) {instance} |
| Property | Attribute |
| Fact | Value |
| Association | Relationship |
| Property Value Set | Domain |
| Object Class | Entity Class |

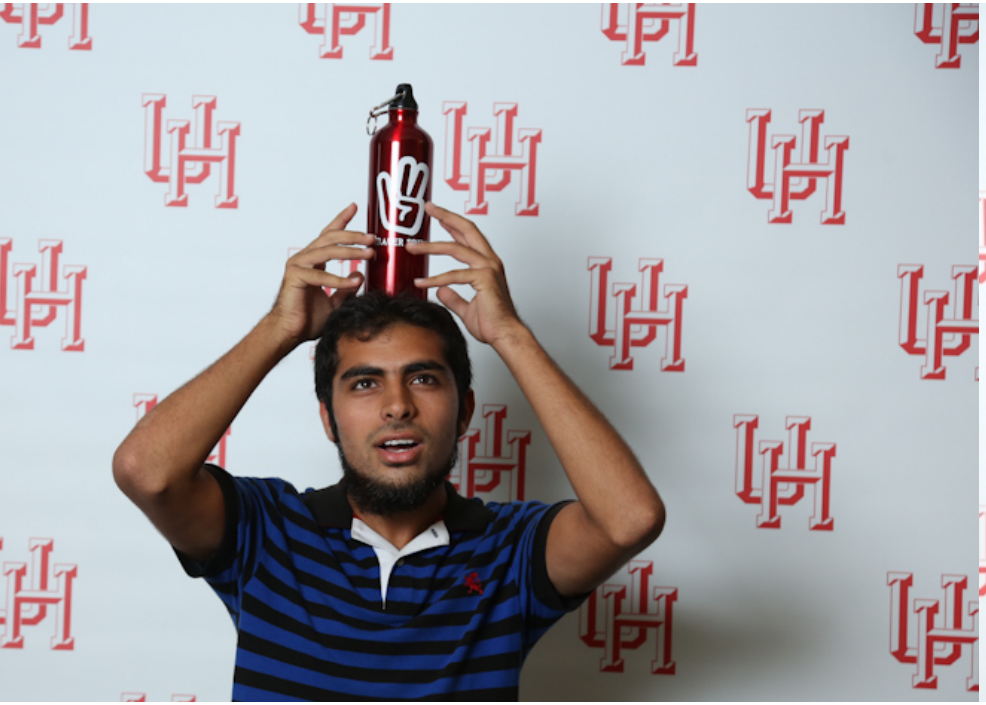
entity type: Bauer student

what are some attributes?

# entity



Joe, an SCM student



# entity set

entity type: Bauer student

entity: Joe, SCM student

entity set: a collection of Bauer students

entity class: students - which includes Bauer students, engineering students, architecture students

# attributes

how we describe entities

**Table 2.2** Characteristics of attributes

| Attribute | Characteristics |
|---|---|
| Name | Standardized naming convention |
| Type | Numeric, alphabetic, alphanumeric, logical, date/time, etc. |
| Classification | Atomic or composite/molecular |
| Category | Single-valued or multi-valued |
| Source | Stored (real) or derived (virtual) |
| Domain* | Property value set—implicit or explicit |
| Value | Conceptual representation of a fact about a property |
| Optionality | Optional value or mandatory value |
| Role | Key (unique identifier) or non-key |

# attributes

how we describe entities

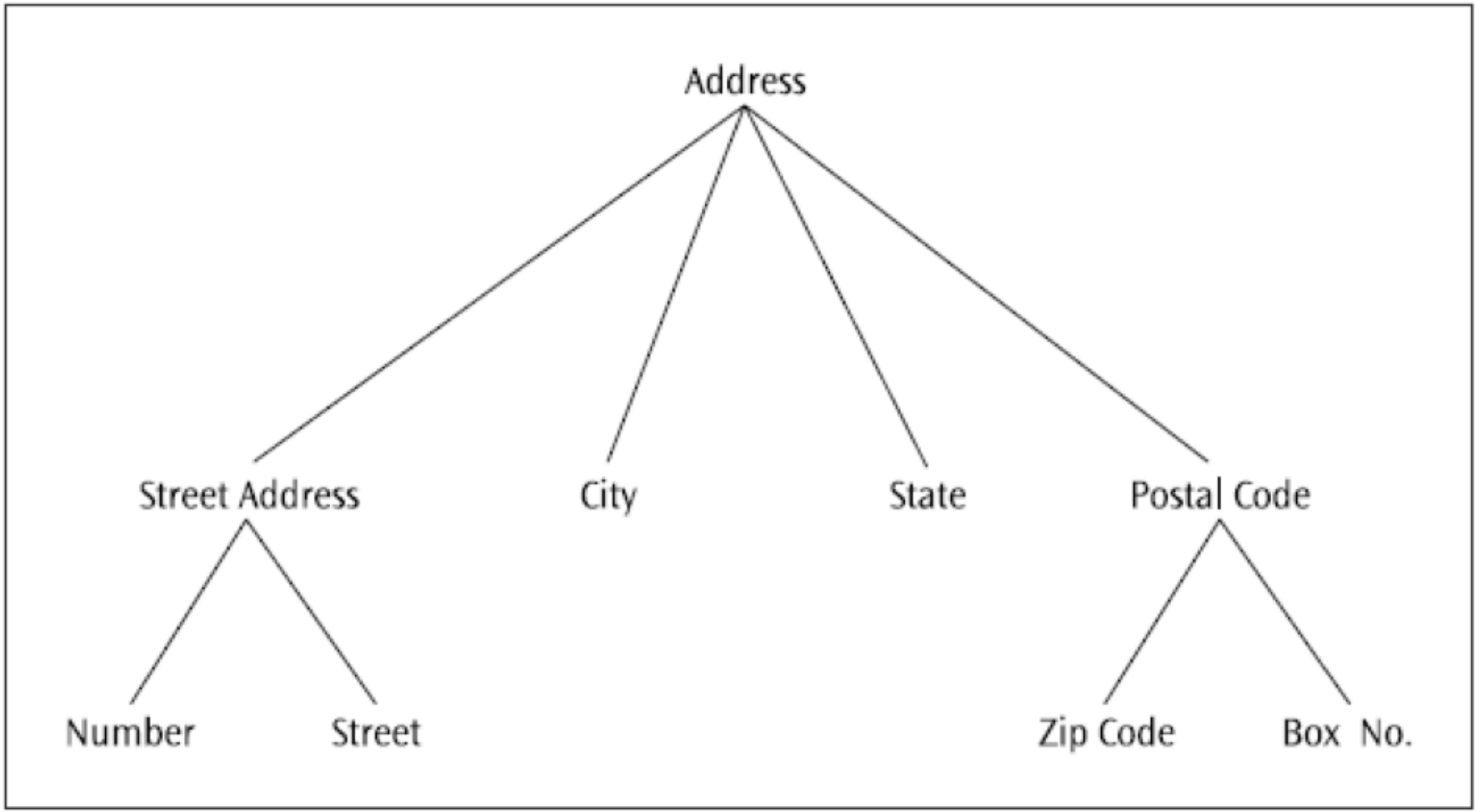



**Figure 2.1** An example of a composite attribute hierarchy

# unique identifiers, key attributes

| Attribute | Value |
|---|---|
| Patient Prefix | X |
| Patient No. | 563345 |

composite attribute of patient ID (unique identifier):

X563345

patient prefix and patient no. are key attributes

any attribute that is not part (subset) of a unique identifier is a non-key attribute

# an example of an entity type

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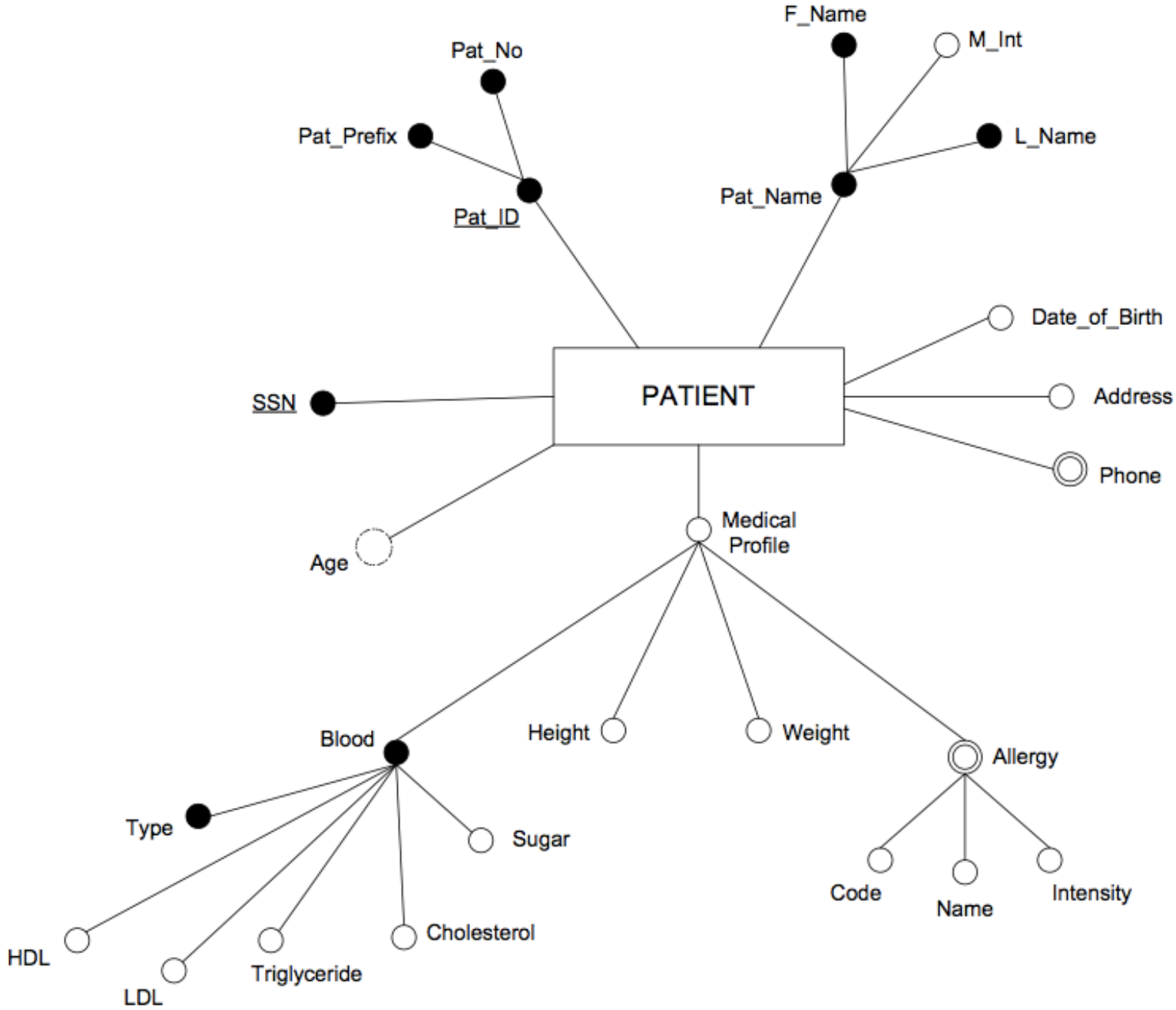
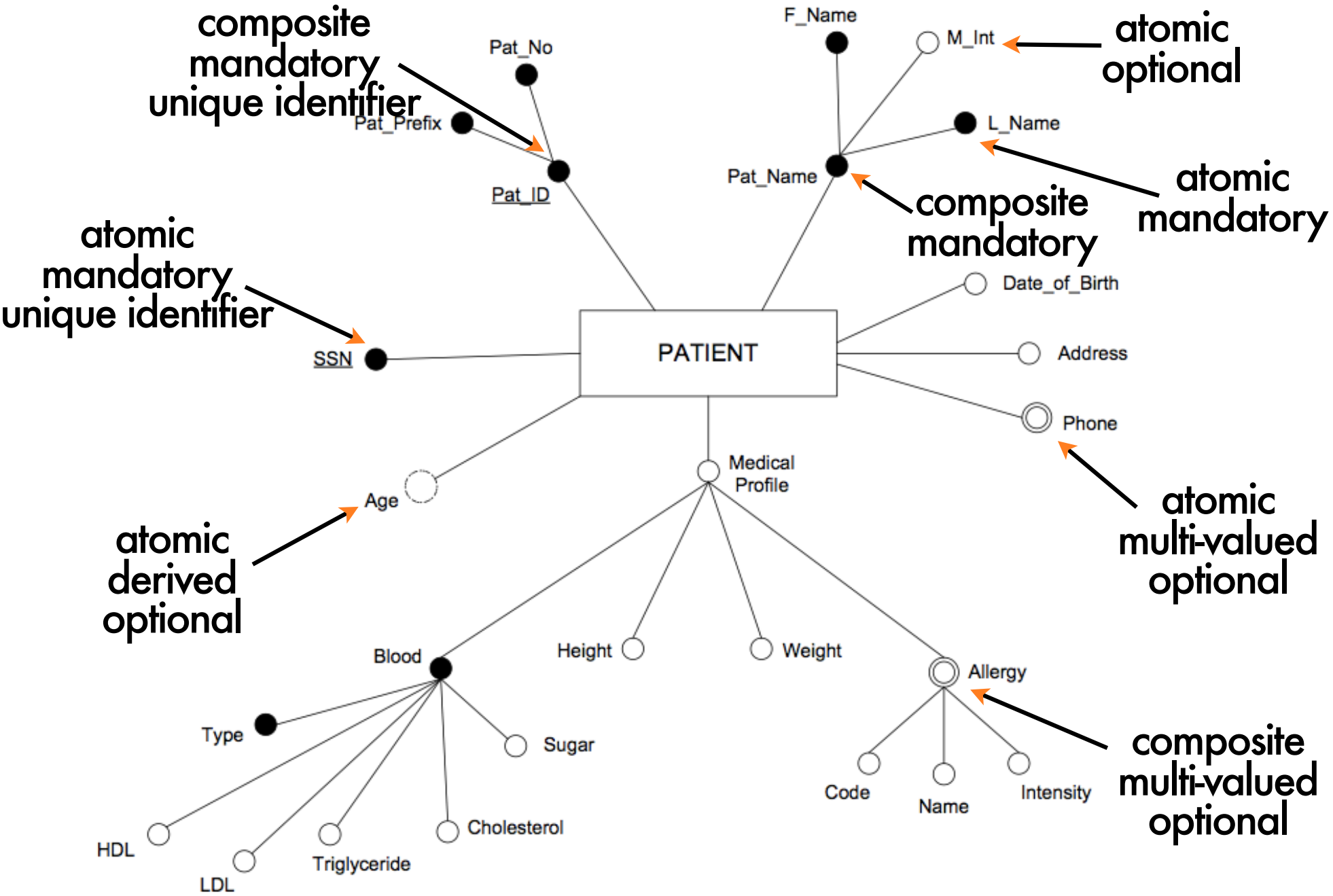


# an example of an entity type

page 34



# integrity constraints

rules that govern behavior of data at all times in a database

technical expressions of business rules
must be preserved through all tiers of modeling

if it cannot be modeled in an ERD, we carry
it over in textual form as a
*semantic integrity constraint*

# integrity constraints

rules that govern behavior of data at all times in a database

domain constraint: ensure that an attribute value is not outside the defined domain

key (uniqueness) constraint: entities of an entity type must be uniquely identifiable

Draw an ER Model for ship:

name

gross tonnage

registration code

year of construction

Ships can be classified as either cargo or passenger

Assume all attributes are mandatory

What are the domain and key constraints?

# step 1. talk to users

gather the business rules

requirements specification

# an example of business rules

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There are several colleges in the university. A college offers many courses and a college term is divided into four quarters - Fall, Winter, Spring, and Summer - during which one or more of these courses may be offered. Let us even say that every quarter at least 23 courses are offered. The college also has several instructors. Often, not all instructors teach during all quarters. Further, instructors are capable of teaching a variety of courses that the college offers.

# an example of business rules

page 31

There are several colleges in the university. A college offers many courses and a college term is divided into four quarters - Fall, Winter, Spring, and Summer - during which one or more of these courses may be offered. Let us even say that every quarter at least 23 courses are offered. The college also has several instructors. Often, not all instructors teach during all quarters. Further, instructors are capable of teaching a variety of courses that the college offers.

- Four quarters: Fall, Winter, Spring, Summer
- A college offers many courses
- At least 23 courses offered per quarter
- A college has several instructors
- Instructors need not teach every quarter
- An instructor is capable of teaching a variety of courses
- An instructor must teach in some quarter
- An instructor must be capable of teaching at least one course that the college offers

# relationships

associations between objects

degree (binary, ternary, n-ary, unary)
cardinality (1:1, 1:n, n:1, m:n)
participation (total, partial)

# binary relationship

degree = 2

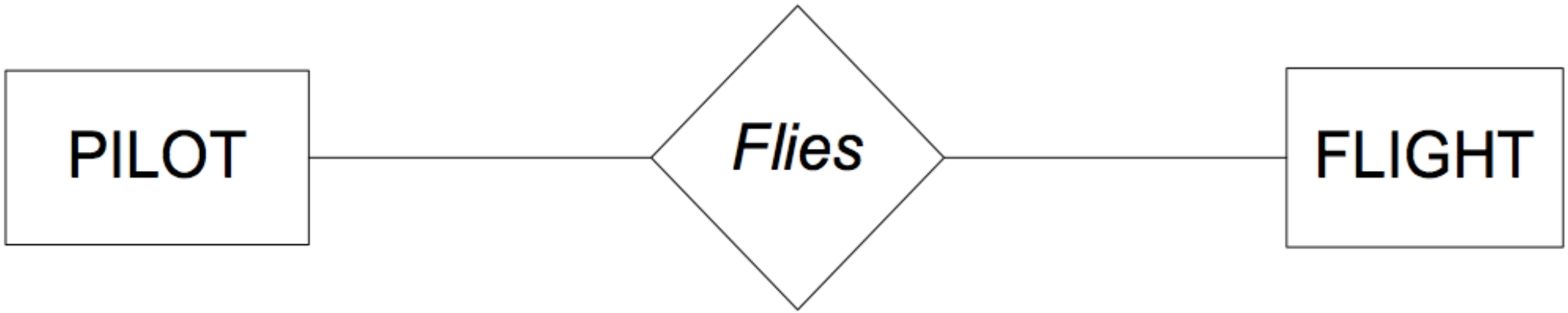



Figure 2.4 A binary relationship

Example: Pilot John flies United Airlines flight 2238

# ternary relationship

degree = 3

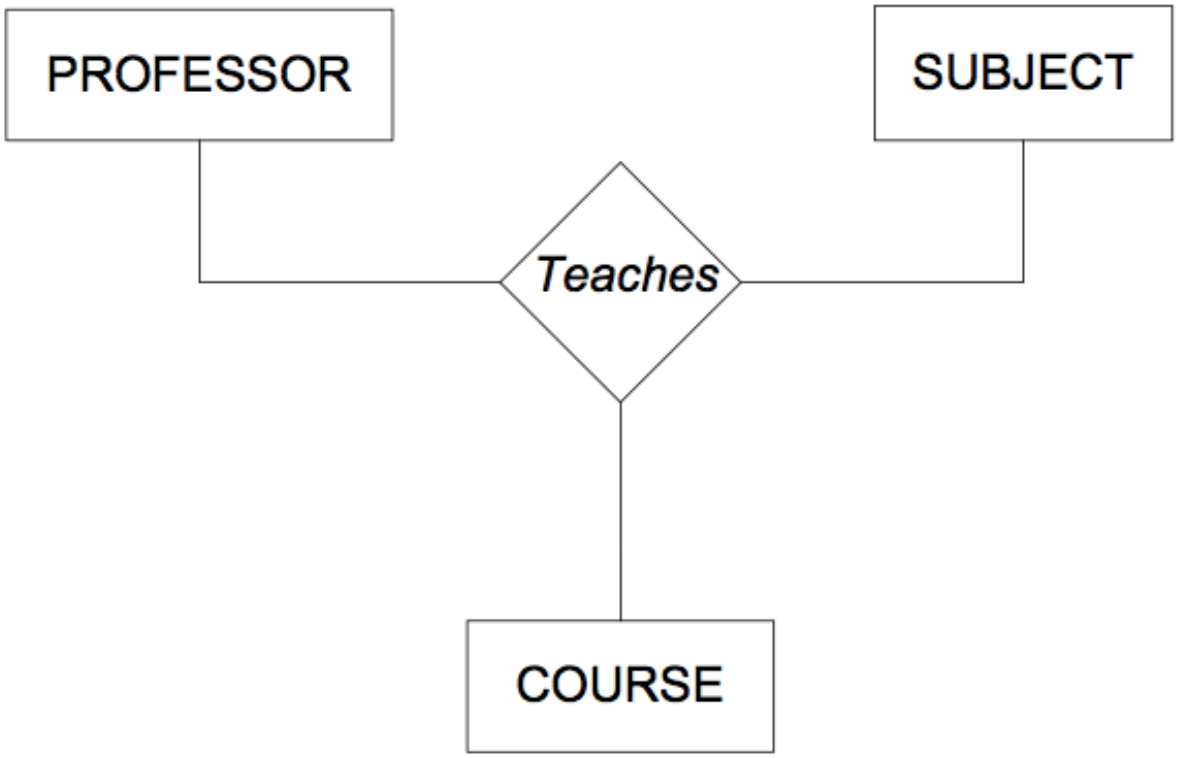



Figure 2.5 A ternary relationship

Example: Professor Einstein teaches physics in the Introduction to Physics course

# quaternary relationship

degree = 4

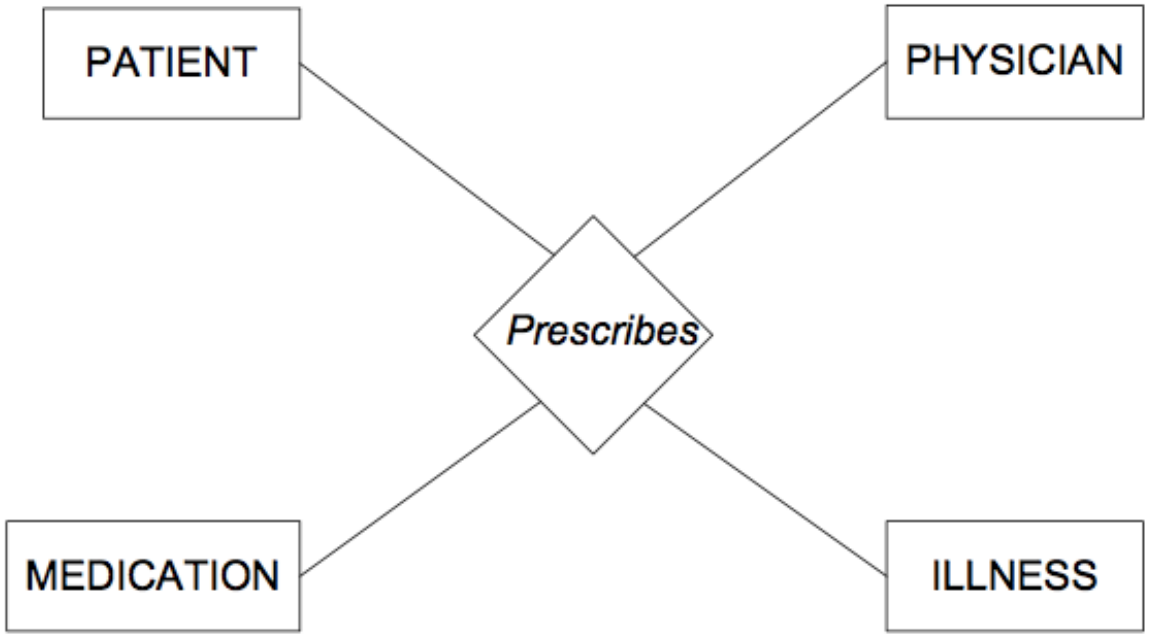



Figure 2.6 A quaternary relationship

Example: Dr. Fields prescribes Advil to treat Sharon Moore for a headache

# unary relationship

degree = 1

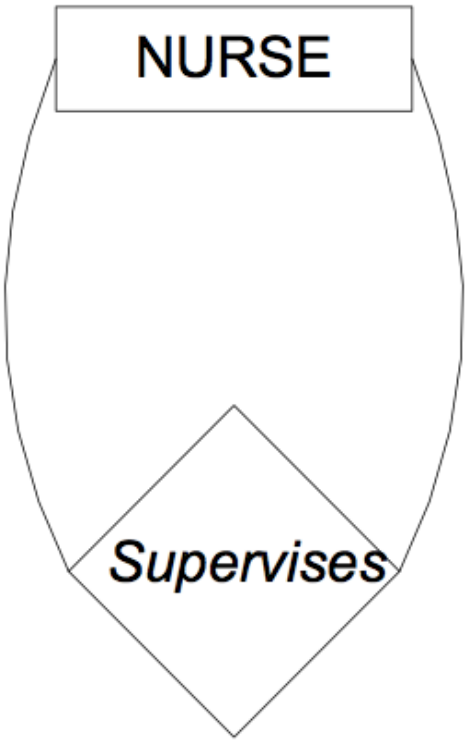



Figure 2.8 A unary relationship

Example: A nurse supervises other nurses

# role names

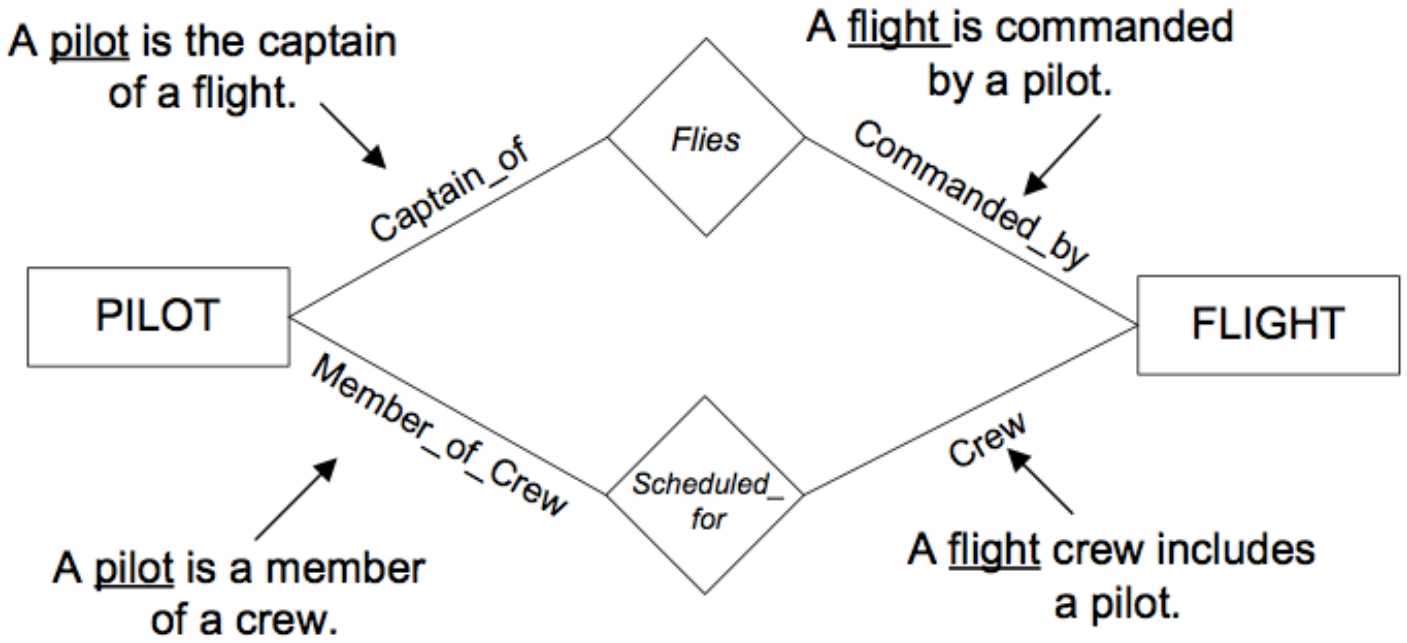



Figure 2.10 Role names in binary relationships

# cardinality constraint/ratio

maximum number of instances that relate to a single instance of an associated entity type

1:1

1:n

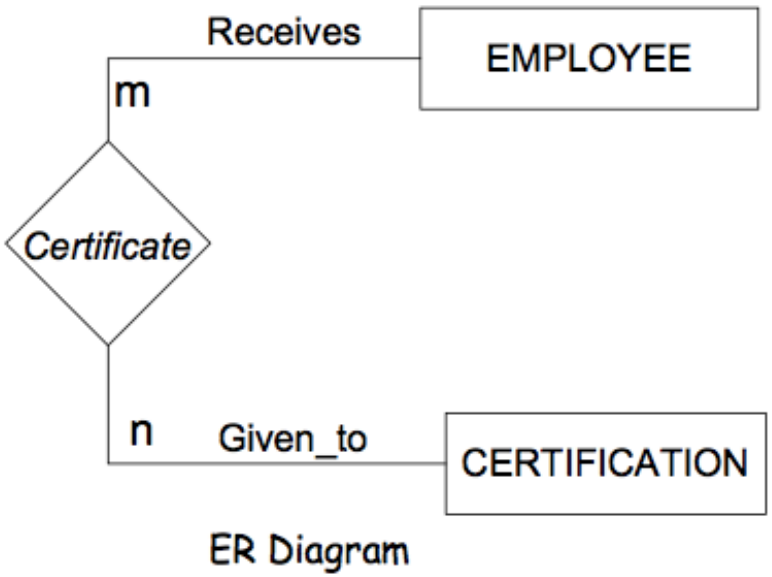
n:1

m:n

"maximum cardinality"

# cardinality constraint/ratio

maximum number of instances that relate to a single instance of an associated entity type



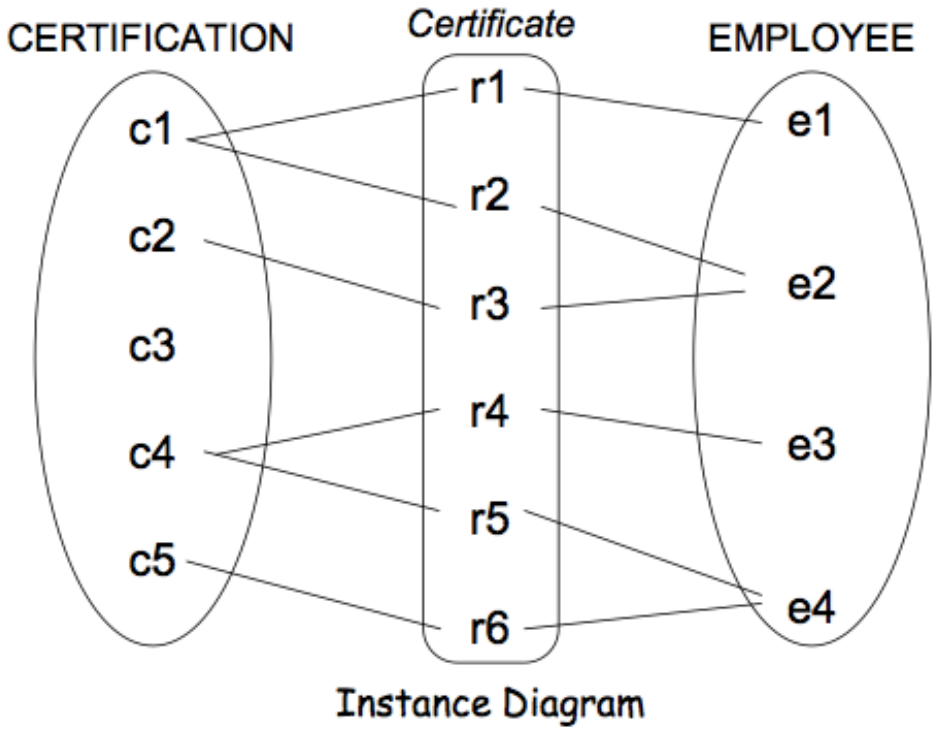
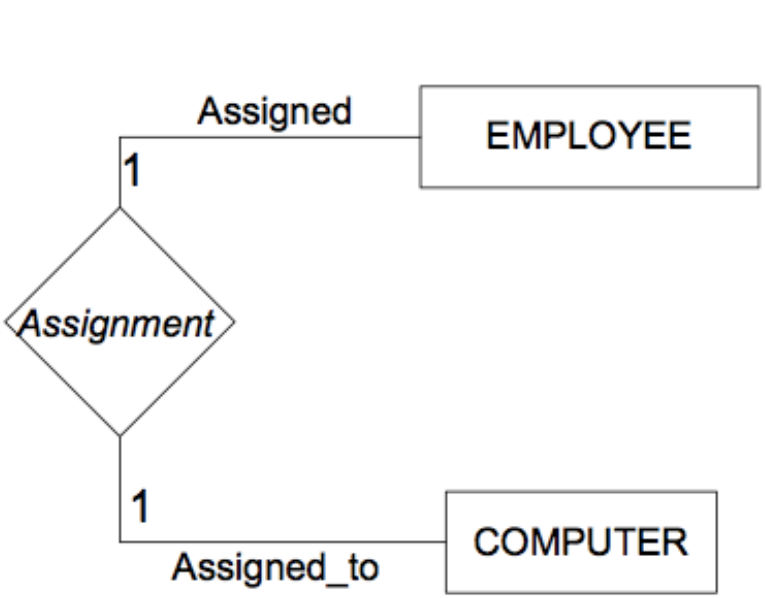



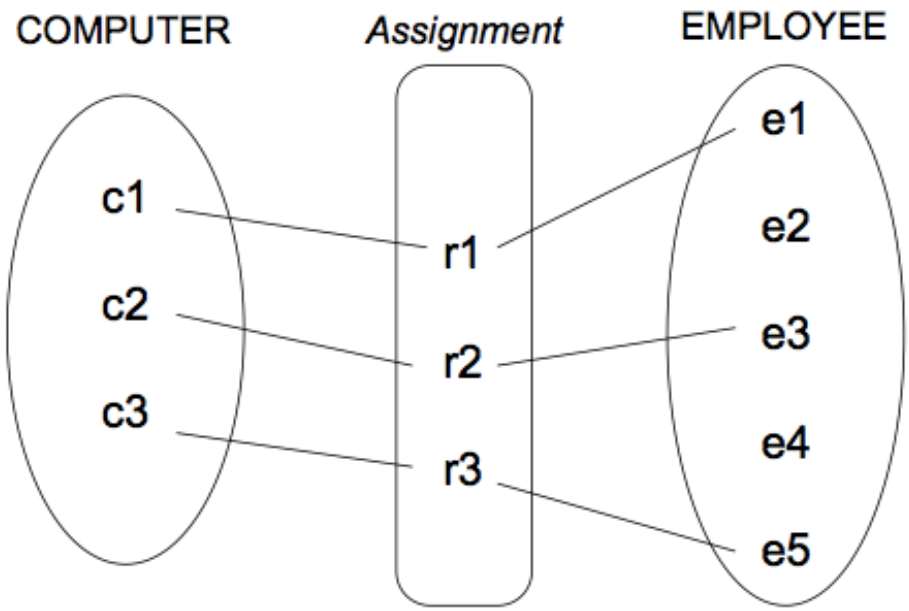

Figure 2.12 Cardinality ratio of m:n

# cardinality constraint/ratio

maximum number of instances that relate to a single instance of an associated entity type




ER Diagram

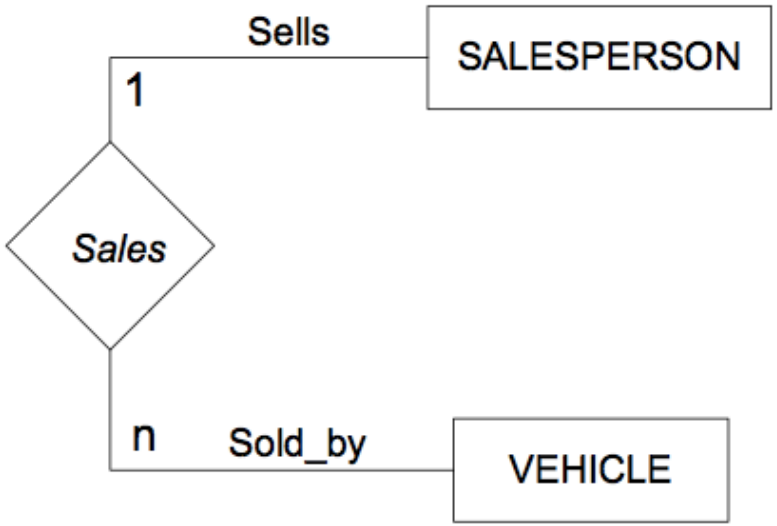



Instance Diagram

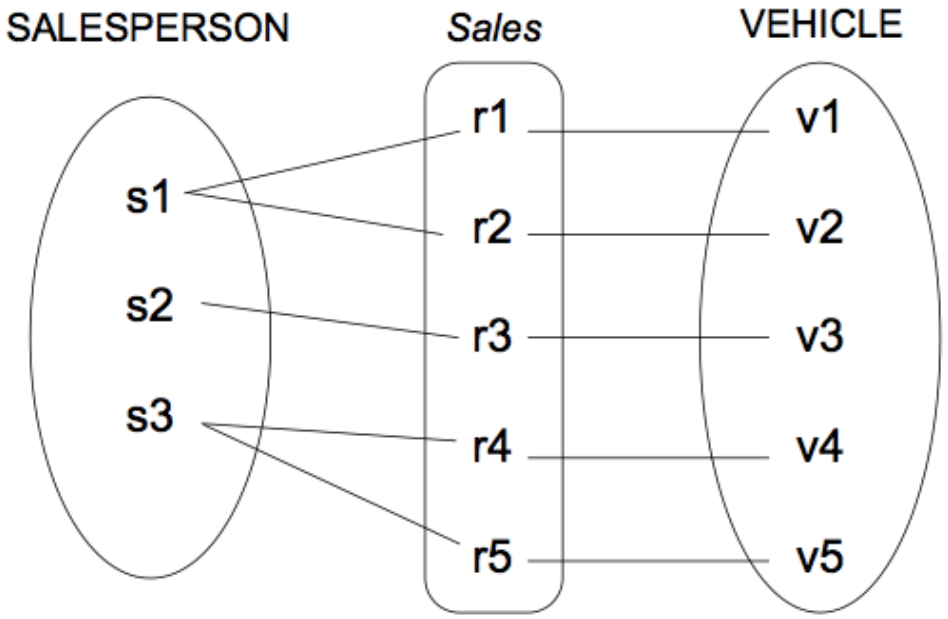
Figure 2.14 Cardinality ratio of 1:1

# cardinality constraint/ratio

maximum number of instances that relate to a single instance of an associated entity type




ER Diagram

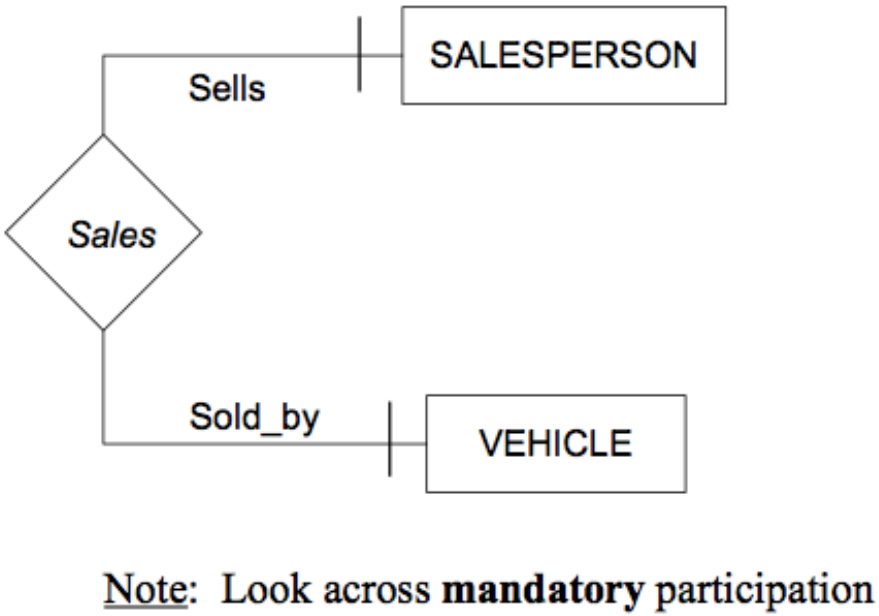



Instance Diagram

Figure 2.13 Cardinality ratio of 1:n or n:1 "look across"

# participation constraint

whether or not an entity needs to be related to an entity of another entity type in a relationship in order to exist - also called “minimum cardinality”



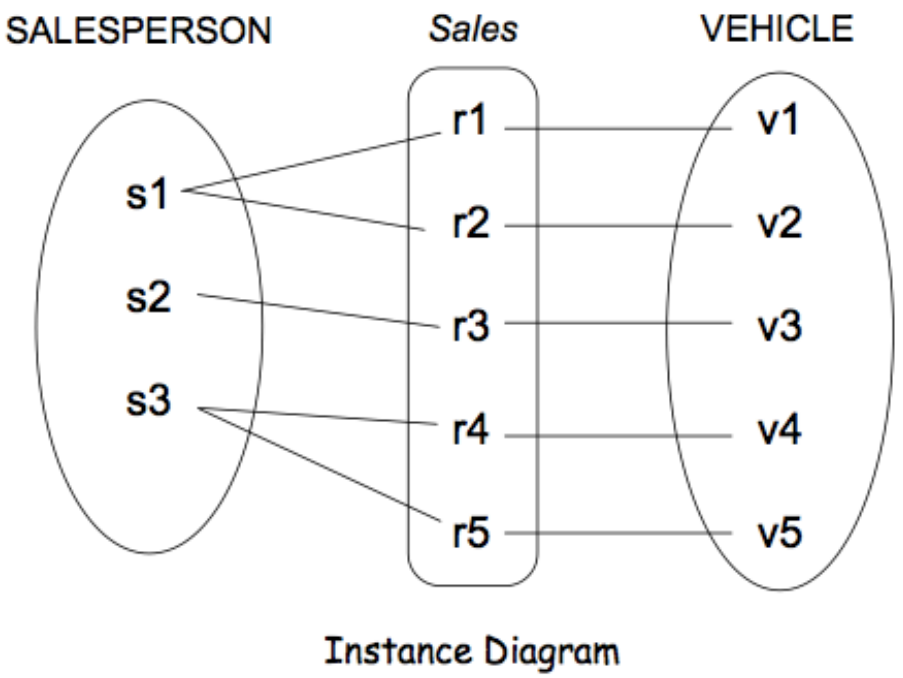
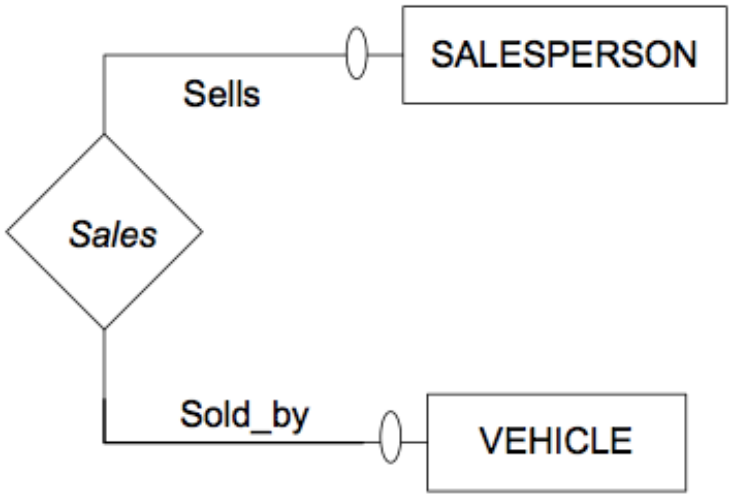




Figure 2.15(a) Total participation

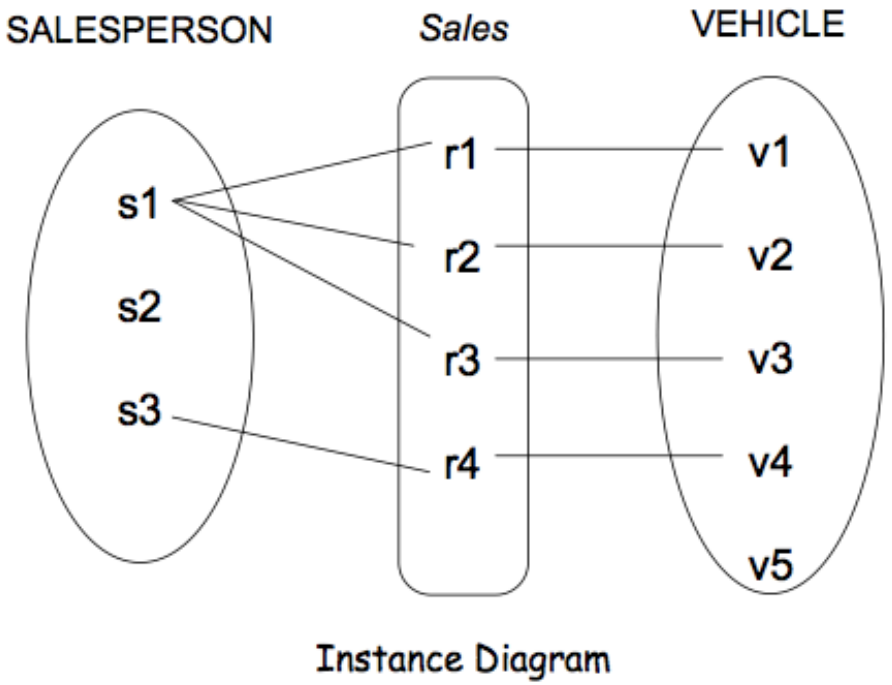
Every salesperson sells at least one vehicle, and every vehicle is sold by at least one salesperson

# participation constraint

whether or not an entity needs to be related to an entity of another entity type in a relationship in order to exist




Note: Look across **optional** participation




Instance Diagram

## Figure 2.15(b) Partial participation

Some salespersons may not sell any vehicles and some vehicles may not be sold by any salesperson

# cardinality and participation

bringing it together

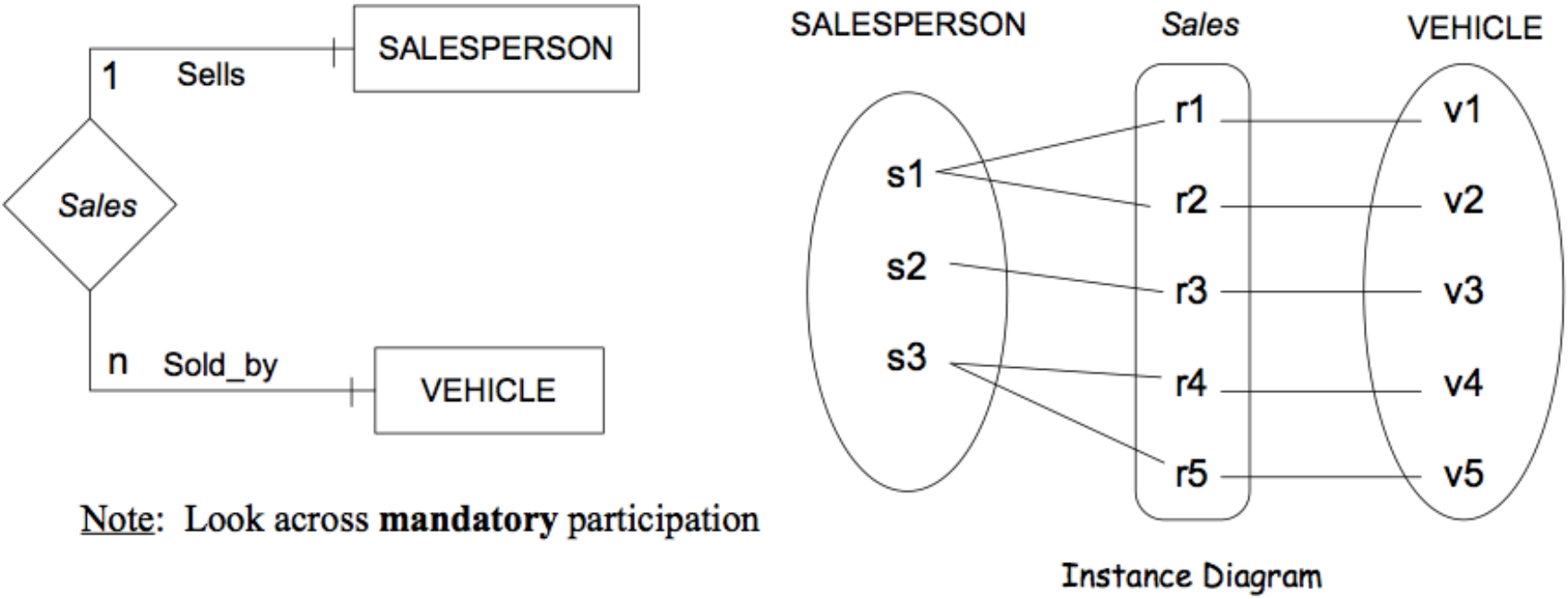
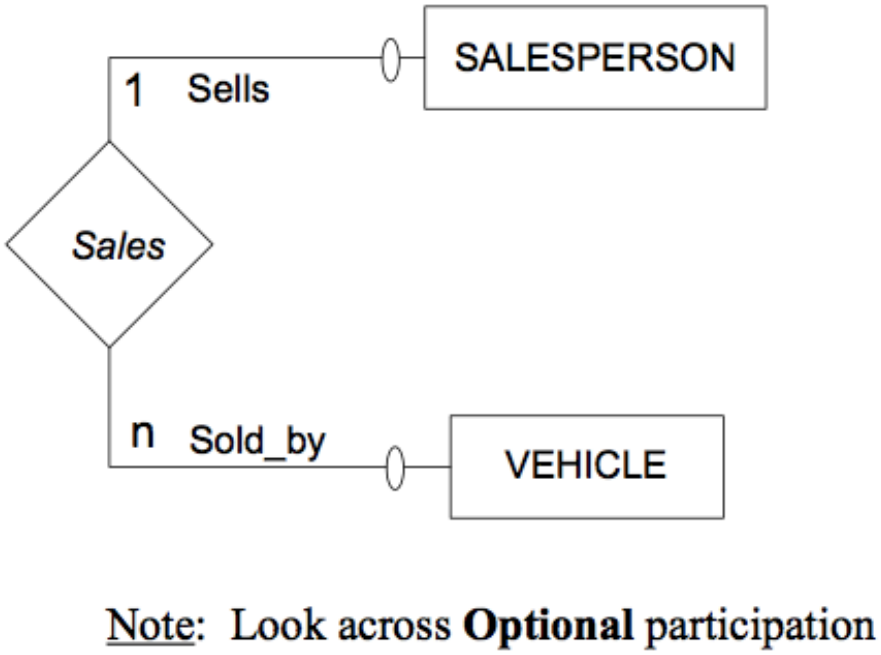



Figure 2.16(a)

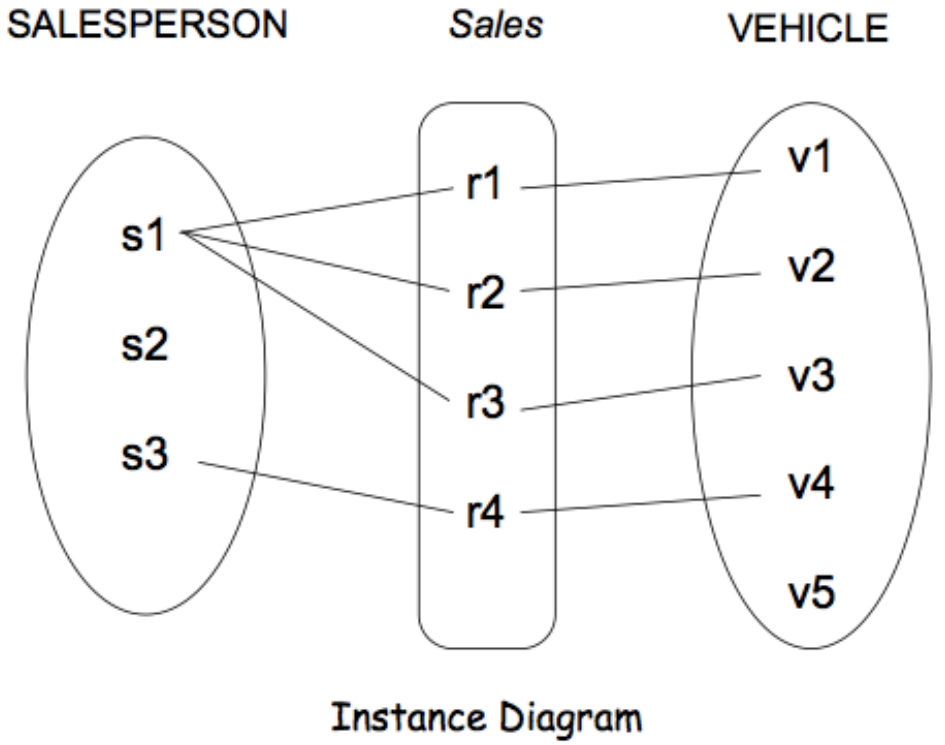
Cardinality ratio of 1:n and total/mandatory participation of VEHICLE and total/mandatory participation of SALESPERSON

# cardinality and participation

bringing it together




Note: Look across **Optional** participation



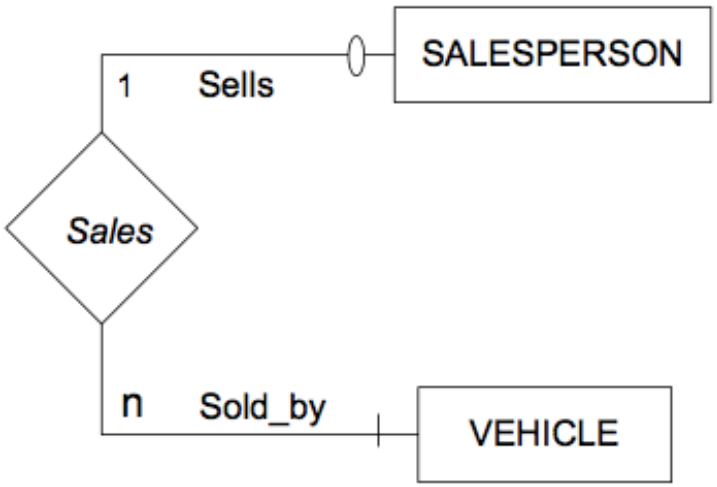

Instance Diagram

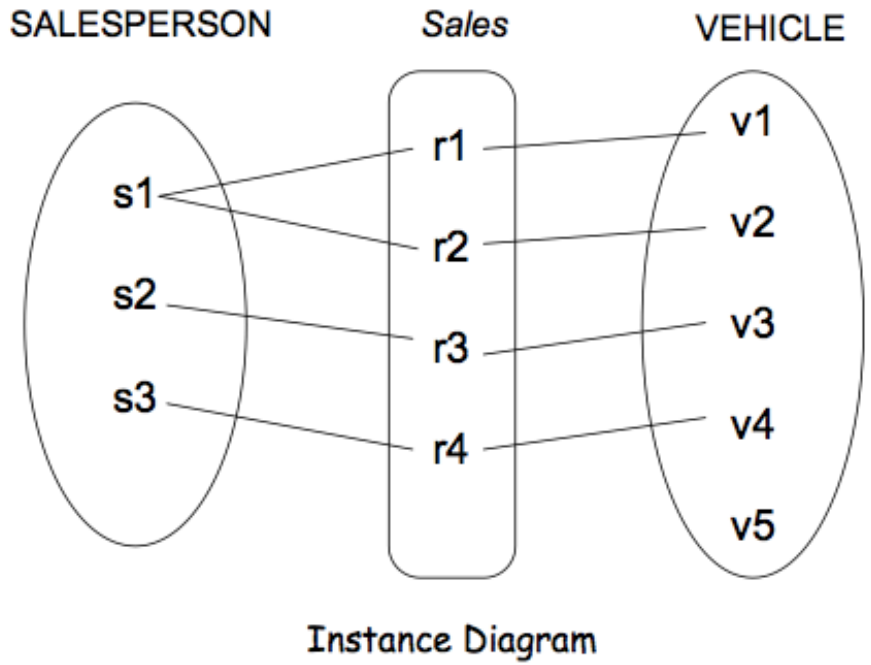
Figure 2.16(b)

Cardinality ratio of 1:n and partial/optional participation of VEHICLE and partial/optional participation of SALESPERSON

# cardinality and participation

bringing it together



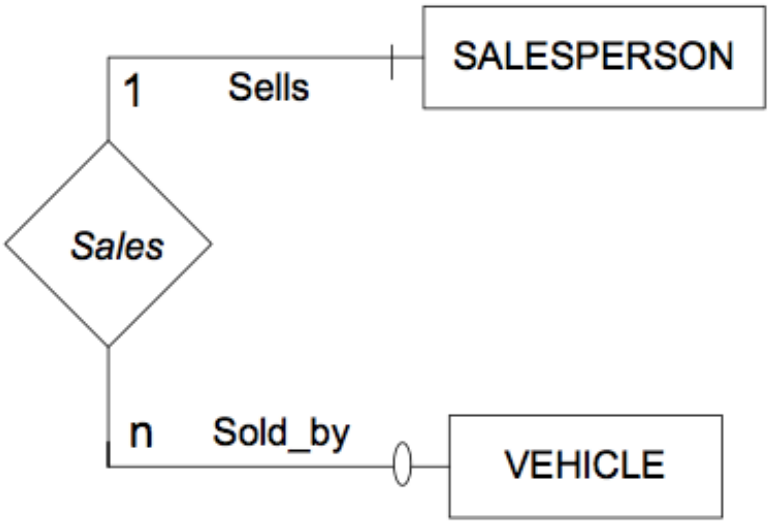

Instance Diagram

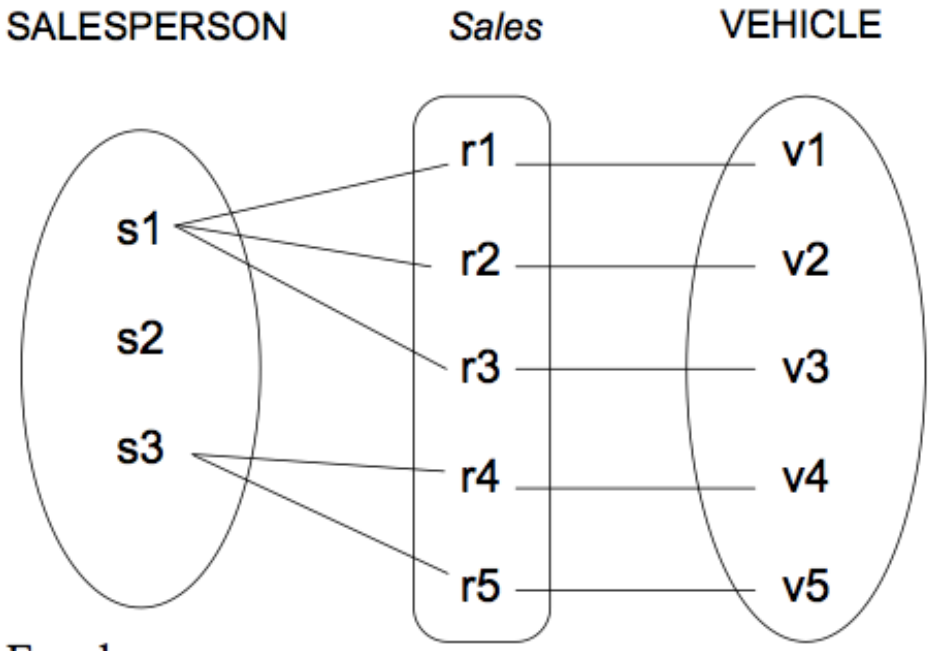
## Figure 2.16(c)

Cardinality ratio of 1:n and optional participation of VEHICLE and mandatory participation of SALESPERSON

# cardinality and participation

bringing it together




Note: Look across **mandatory** participation of VEHICLE and **optional** participation of SALESPERSON in *Sales*

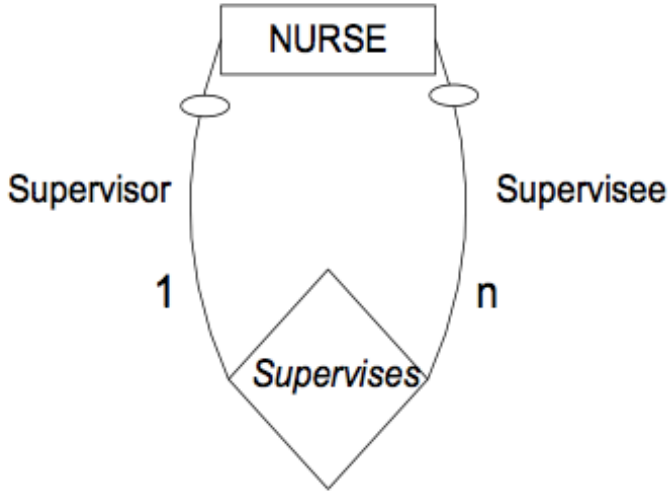
Instance Diagram

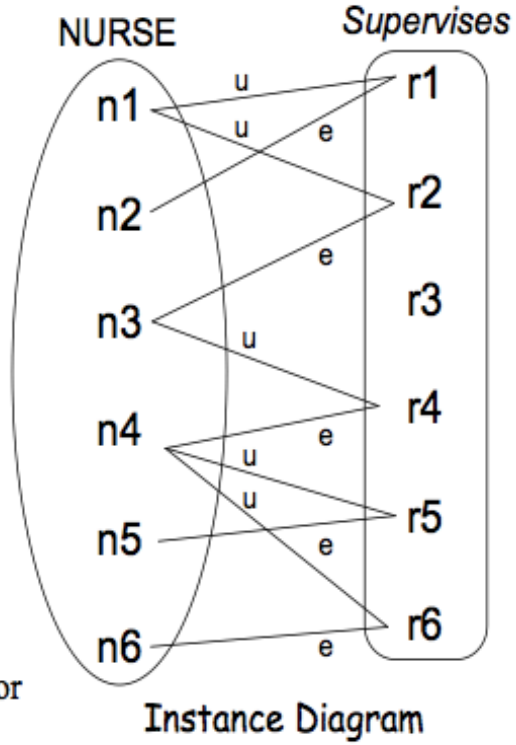
Figure 2.16(d)

Cardinality ratio of 1:n and total participation of VEHICLE and partial participation of SALESPERSON

# cardinality and participation

bringing it together




Note: The symbols **u** and **e** in the instance diagram represent the roles Supervisor and Supervisee respectively in the ER diagram

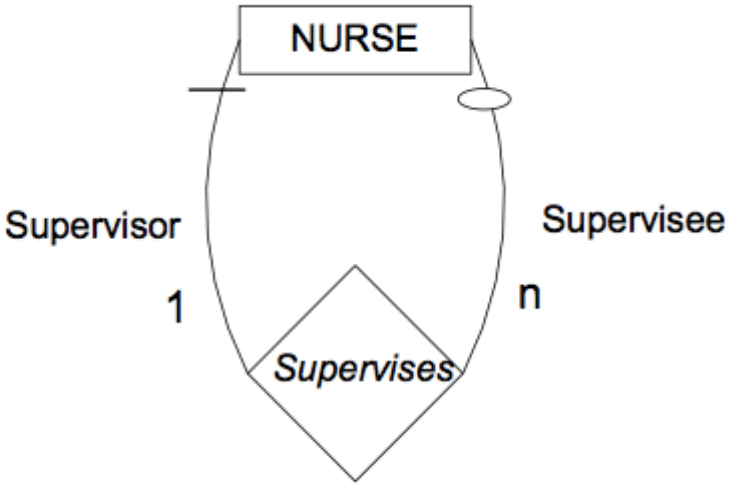
Instance Diagram

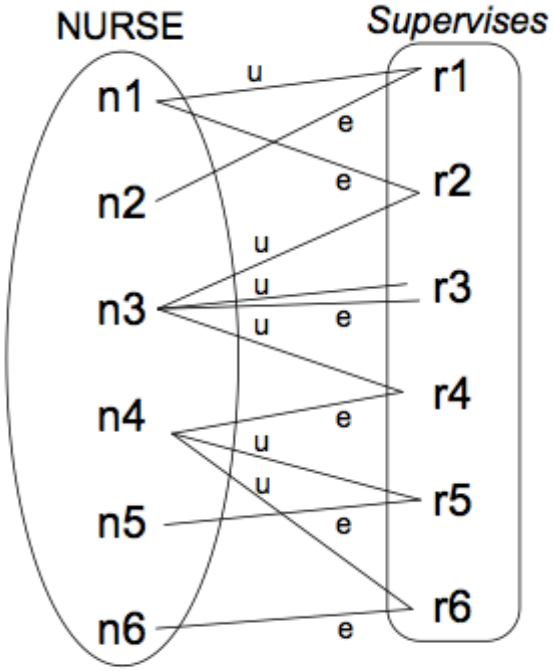
Figure 2.17(a)

Cardinality ratio of 1:n and partial participation of NURSE as supervisor and as supervisee

# cardinality and participation

bringing it together




Note: The symbols **u** and **e** in the instance diagram represent the roles Supervisor and Supervisee respectively in the ER diagram

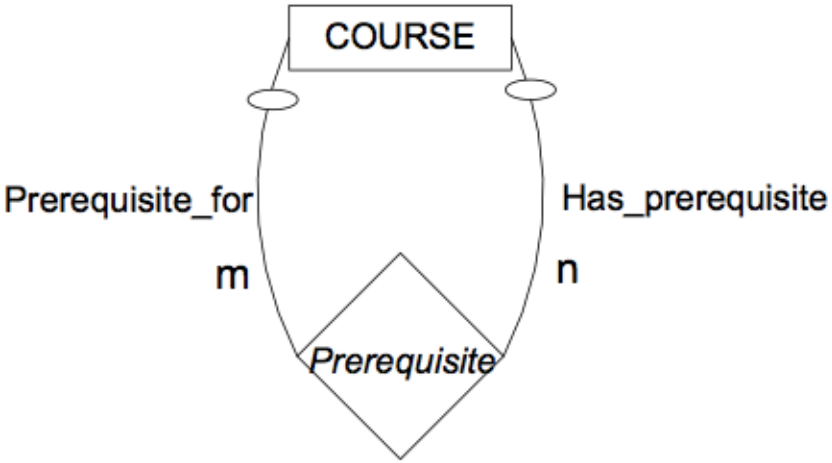
Instance Diagram

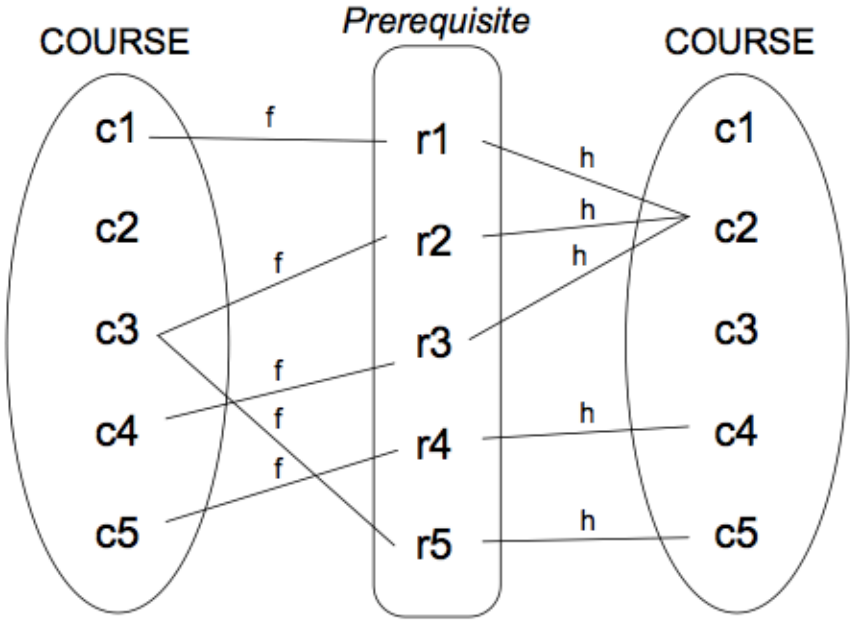
Figure 2.17(b)

Cardinality ratio of 1:n and partial participation of NURSE as supervisor and total participation as supervisee

# cardinality and participation

bringing it together




Note: The symbols **f** and **h** in the instance diagram represent the roles Prerequisite_for and Has_prerequisite respectively in the ER diagram

Instance Diagram

Figure 2.18(a)

Cardinality ratio of m:n and partial participation of COURSE as prerequisite_for and as has_prerequisite

# attributes

attributes can be assigned to relationship types

in 1:1 and 1:n relationship types, an attribute can be placed as an attribute of the relationship type or the participating child entity type

in m:n relationship types, an attribute can only be shown as an attribute of the relationship type

# bringing it together

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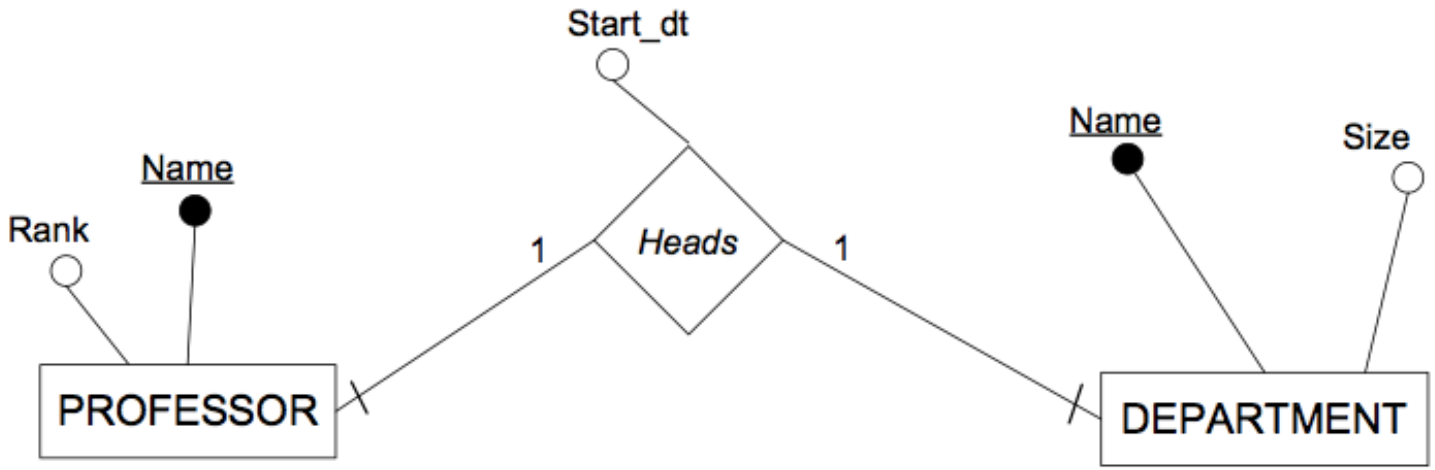



Note: Since the cardinality constraint of *Heads* is 1:1, Start_dt can be an attribute of either PROFESSOR or DEPARTMENT instead of being an attribute of *Heads*

Figure 2.19

An attribute of a relationship in a 1:1 relationship type

# bringing it together

page 48

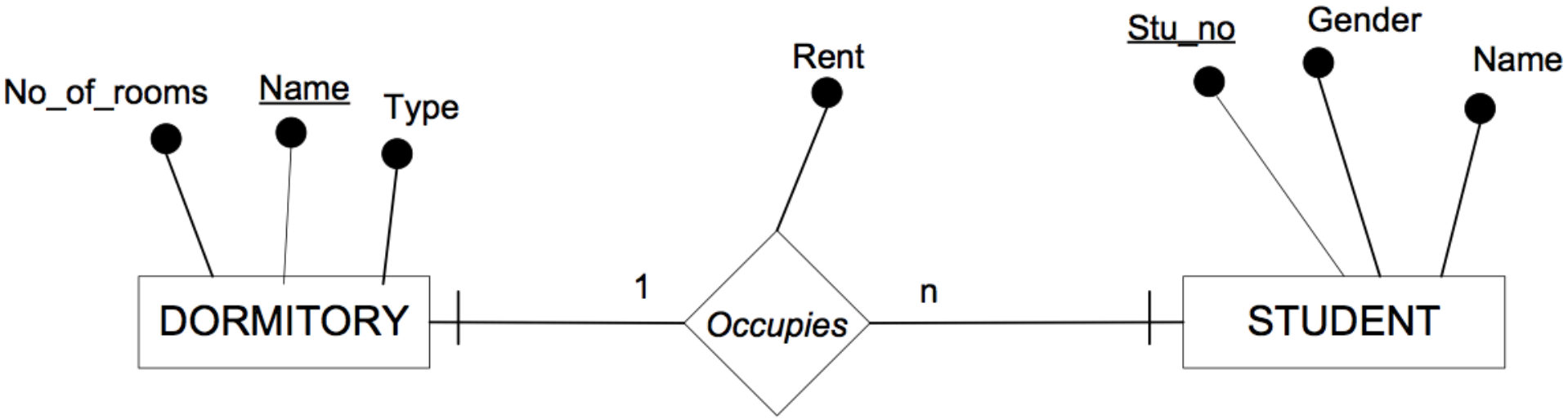



Figure 2.20

An attribute of a relationship in a 1:n relationship type

# bringing it together

page 48

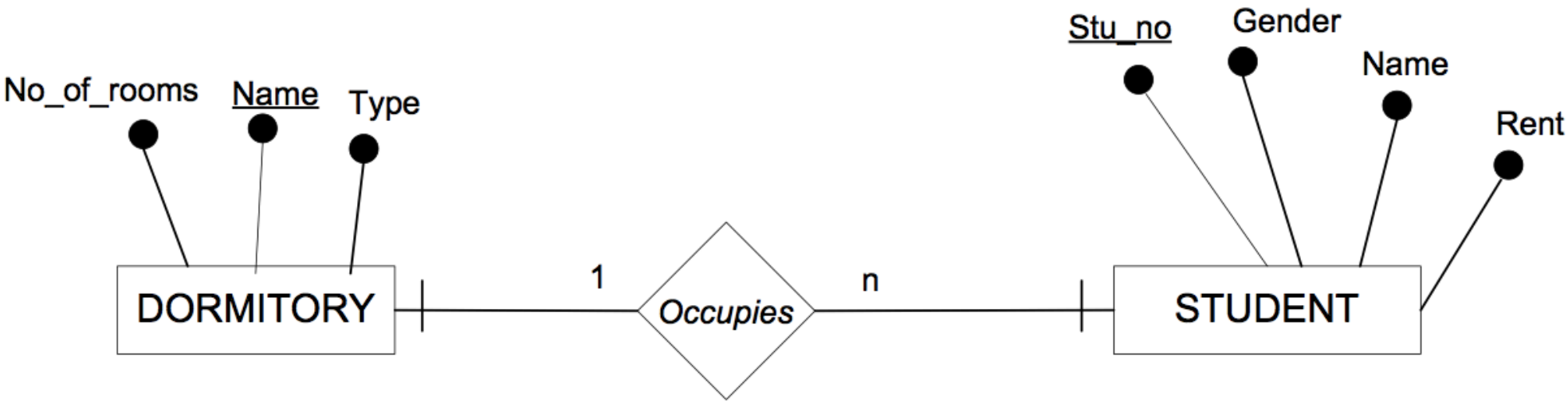



Figure 2.21

An attribute of a relationship in a 1:n relationship type

Why can't rent be an attribute of DORMITORY?

# bringing it together

page 49

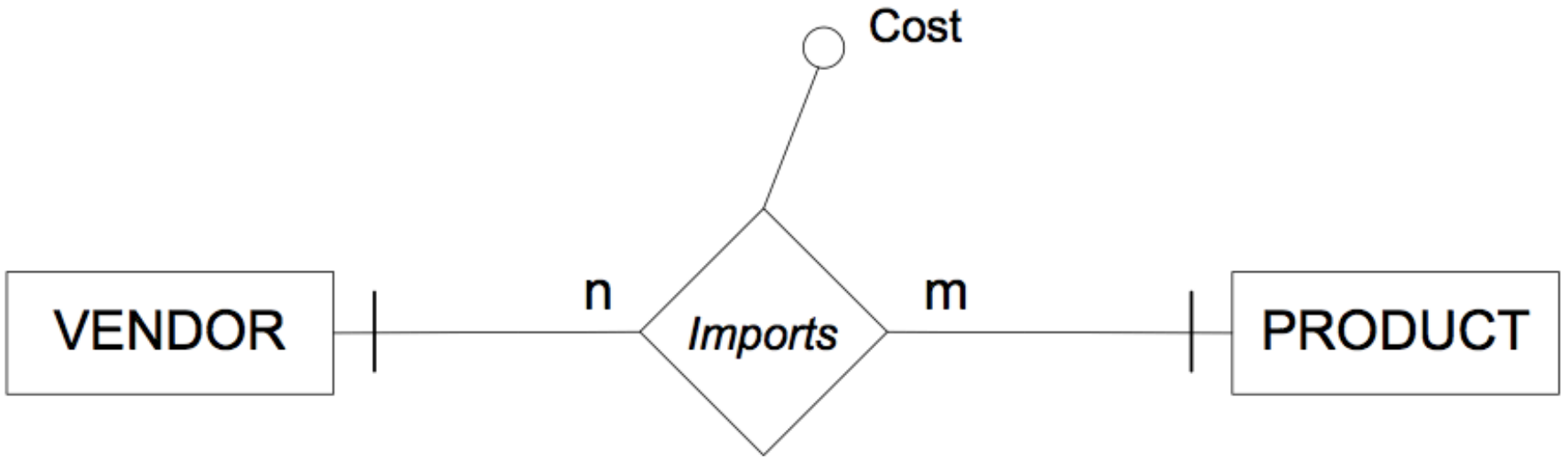



Figure 2.22

An attribute of a relationship in a m:n relationship type

# something to think about

think of each entity type and relationship type as a separate table for now

Vendor

| VenID | VenName |
|---|---|
| 1 | Joe Inc |
| 2 | Bill Inc |

Imports

| VenID | ProdID | Cost |
|---|---|---|
| 2 | 25 | 7 |
| 1 | 24 | 8 |
| 1 | 25 | 7 |

Product

| ProdID | ProdName |
|---|---|
| 23 | Soup |
| 24 | Noodles |
| 25 | Chocolate |

# base vs. weak entity types

the question to ask is: does the entity type have a unique identifier?

a base/strong entity type has a unique identifier

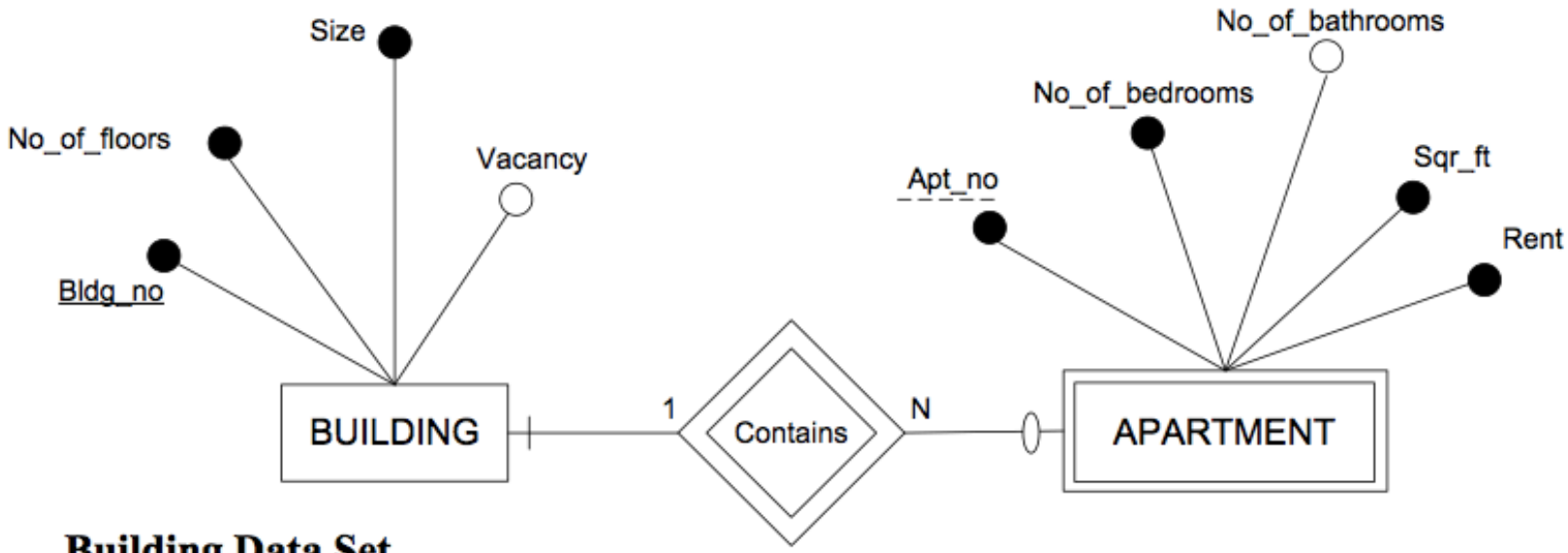
a weak entity type has an identifying relationship with an identifying parent entity type

a weak entity type has a partial key, also known as a discriminator

partial key+unique identifier of the parent = uniquely identify each weak entity

# base vs. weak entity types

page 50




**Building Data Set**

| Bldg_no | #Floors | Size (sq. ft) | Vacancy |
|---|---|---|---|
| S51 | 3 | 15425 | 6 |
| S52 | 1 | 3250 | |
| N51 | 3 | 15425 | 6 |
| N52 | 3 | 16250 | 4 |

**APARTMENT Data Set***

| Apt_no | #bedrooms | #bathrooms | Size (sq. ft) | Rent |
|---|---|---|---|---|
| 11 | 1 | 1 | 600 | 830 |
| 12 | 1 | 1 | 660 | 850 |
| 21 | 2 | | 930 | 985 |
| 22 | 1 | 1 | 600 | 830 |
| 11 | 1 | 1 | 600 | 830 |

*The first four apartments listed are located in Building Number S51 while the fifth apartment is located in Building Number N51.

# data modeling errors

semantic vs. syntactic

semantic errors - misinterpretations of the requirements specifications

syntactic errors - violations of the rules of the ER grammar

# an example of modeling errors

page 54

There are several colleges in the university. Each college has a name, location, and size. A college offers many courses over four college terms or quarters - Fall, Winter, Spring, and Summer - during which one or more of these courses are offered. Course #, name, and credit hours describe a course. No two courses in any college have the same course #; likewise no two courses have the same name. Terms are identified by year and quarter, and contain numbers. Courses are offered during every term. The college also has several instructors. Instructors teach; that is why they are called instructors. Often, not all instructors are scheduled to teach during all terms; but every term has some instructors teaching. Also, the same course is never taught by more than one instructor in a specific term. Further, instructors are capable of teaching a variety of courses offered by the college. Instructors have a unique employee ID and their name, qualification, and experience are also recorded.

# vignette 1

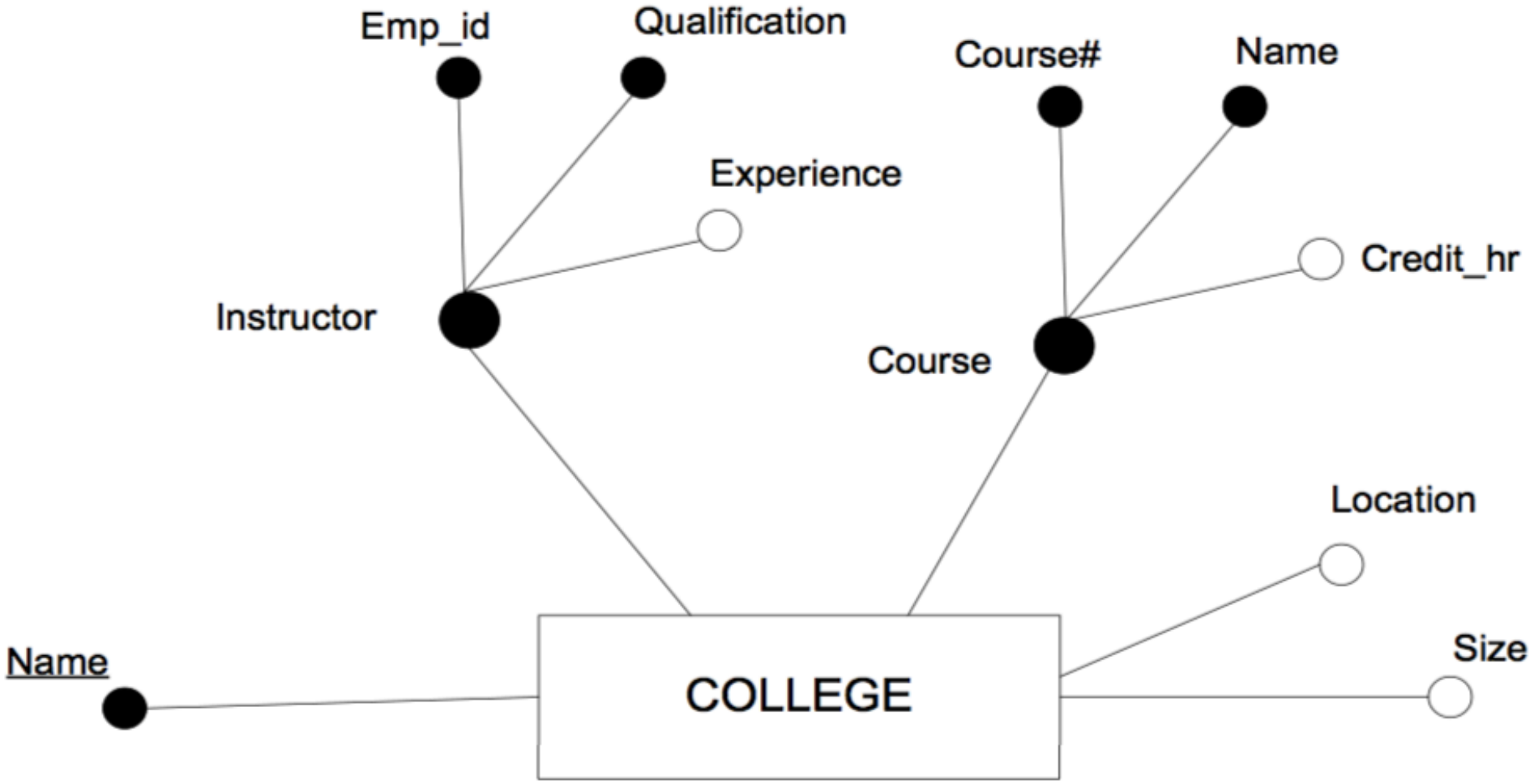



Figure 2.28

The entity type COLLEGE

# vignette 1

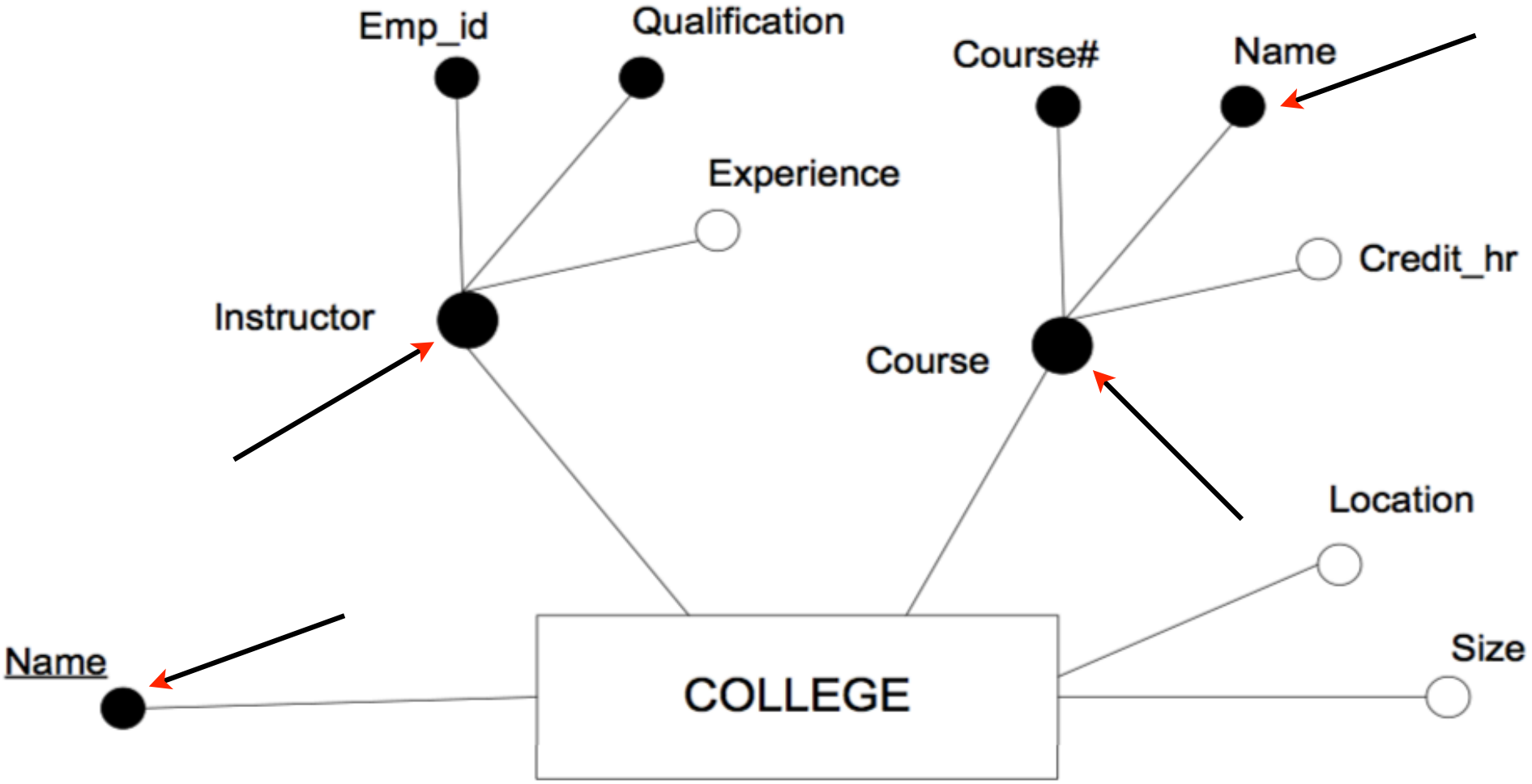



Figure 2.28

The entity type COLLEGE

# vignette 1 - fixing semantic errors

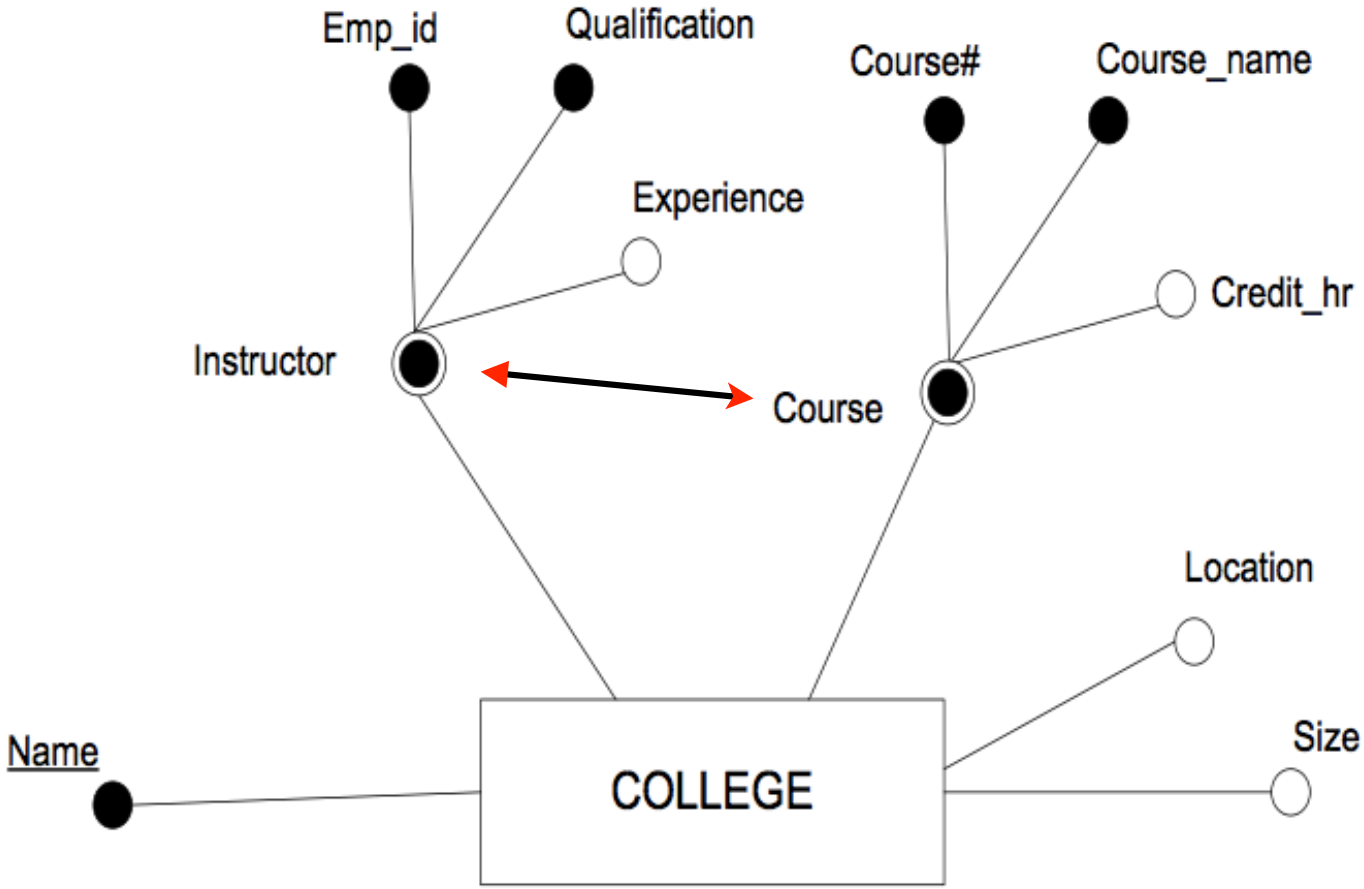



Figure 2.28b

Not shown - an instructor is capable of teaching a variety of courses

# vignette 1 - fixing errors

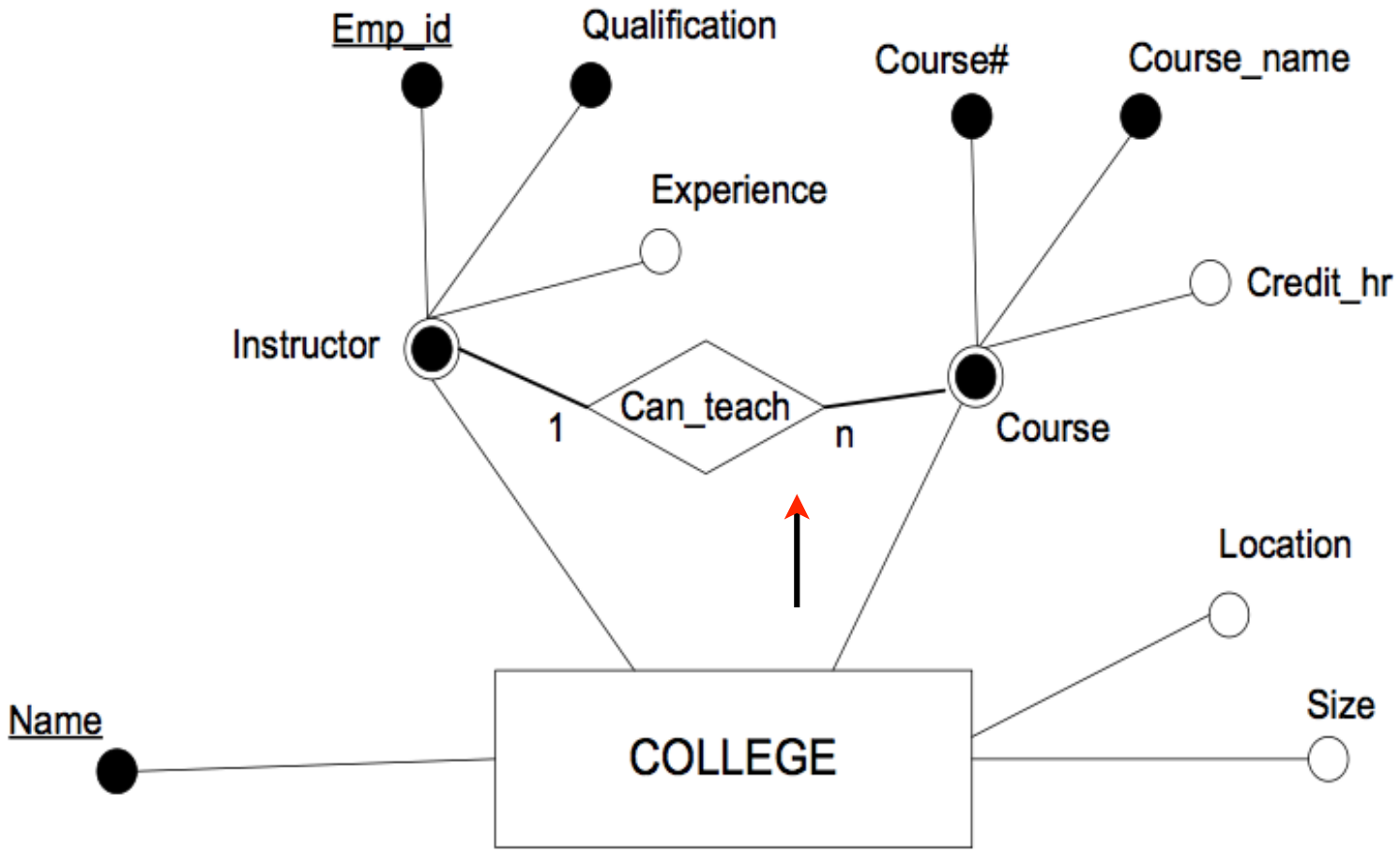



Figure 2.28c

Now we have a syntactic error - cannot have relationships between attributes

# vignette 1 - fixing errors

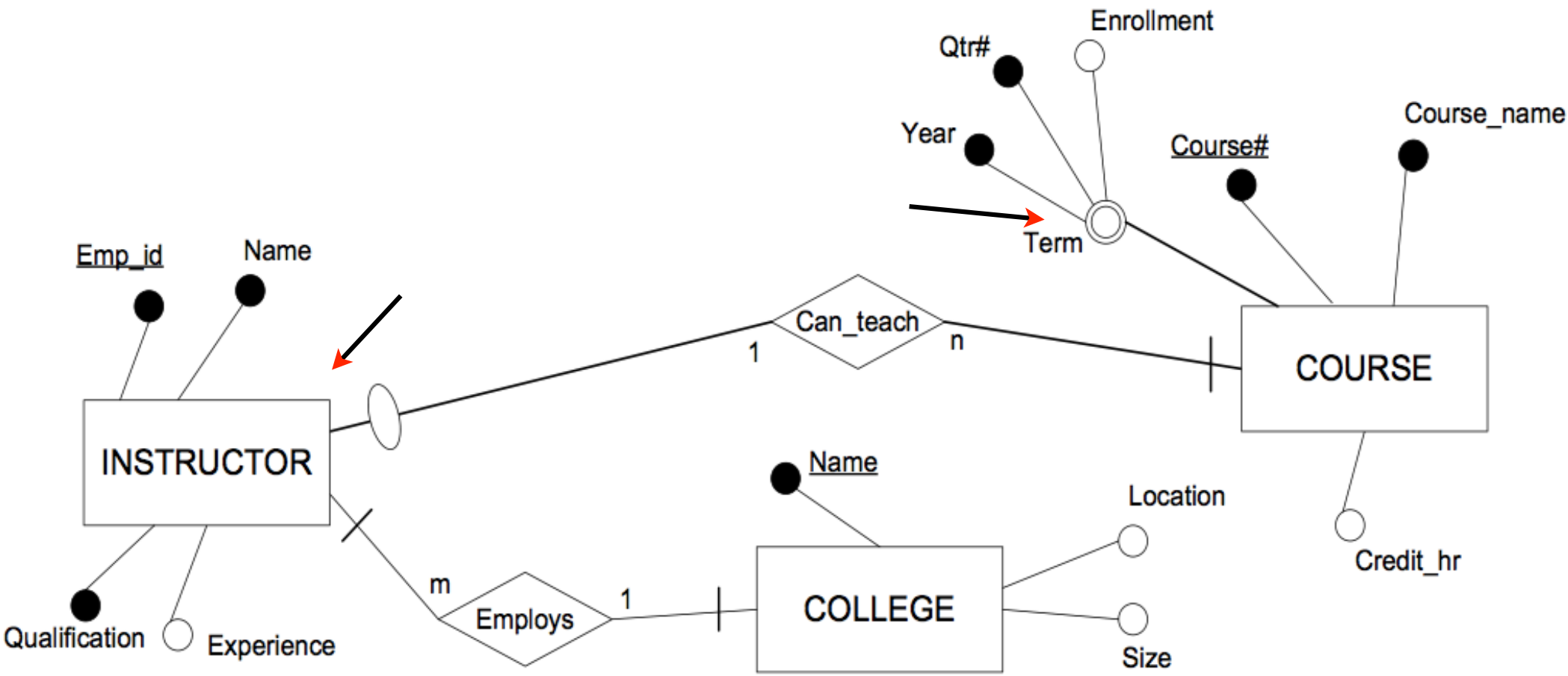



Figure 2.28d

Syntactically correct relationship between INSTRUCTOR and COURSE

# vignette 1 - fixing errors

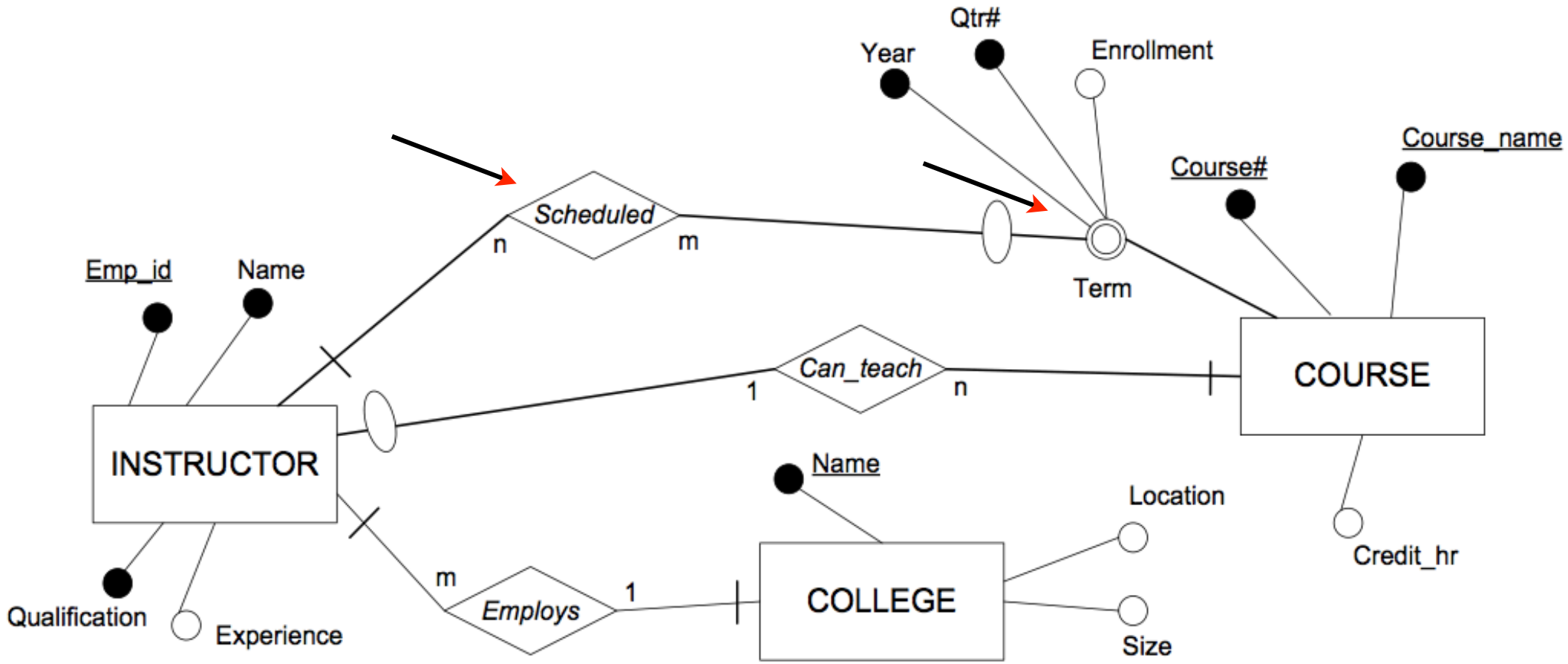



Figure 2.28e

Syntactically incorrect relationship between INSTRUCTOR and TERM

# vignette 1 - fixing errors

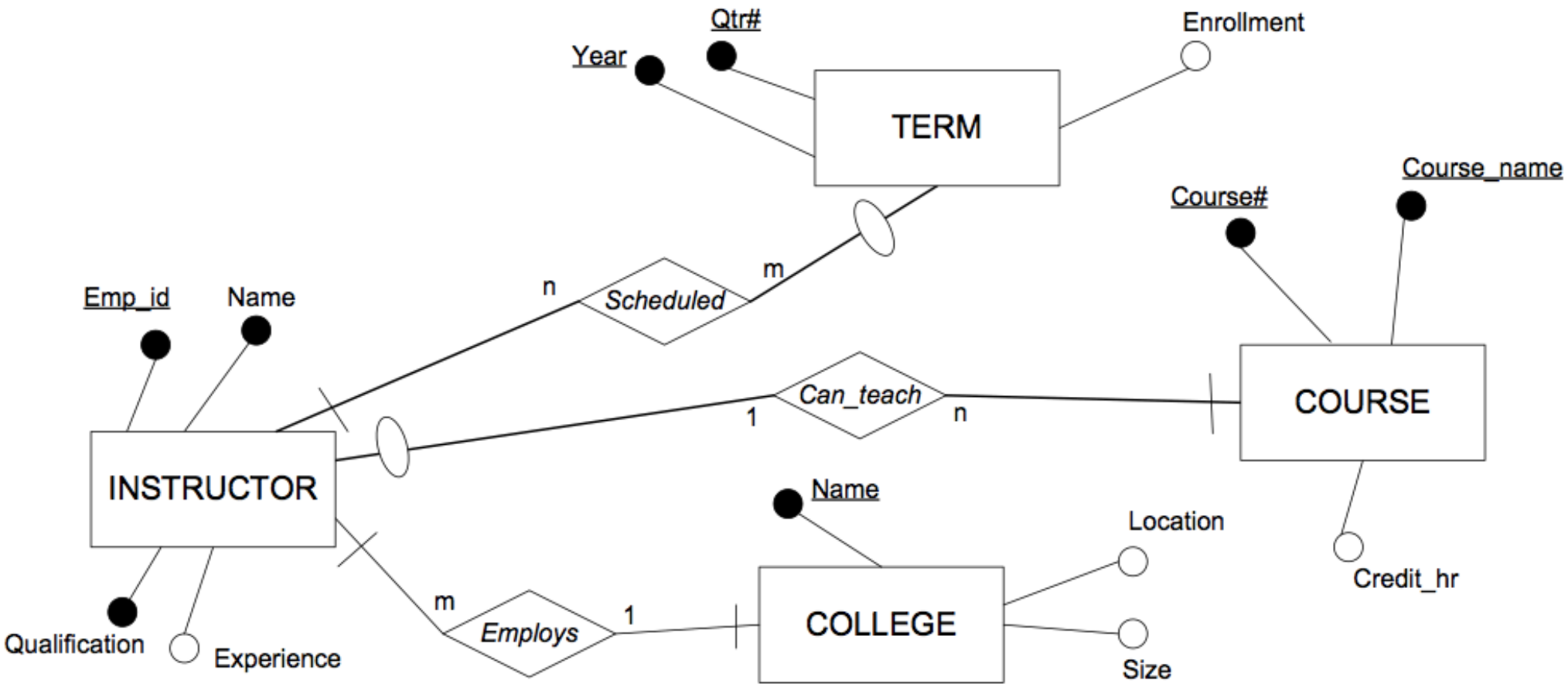



Figure 2.28f

What about the rule that courses are offered over terms? Also, the rule that the same course is never taught by more than one instructor in a specific term is not represented

# vignette 1 - fixing errors

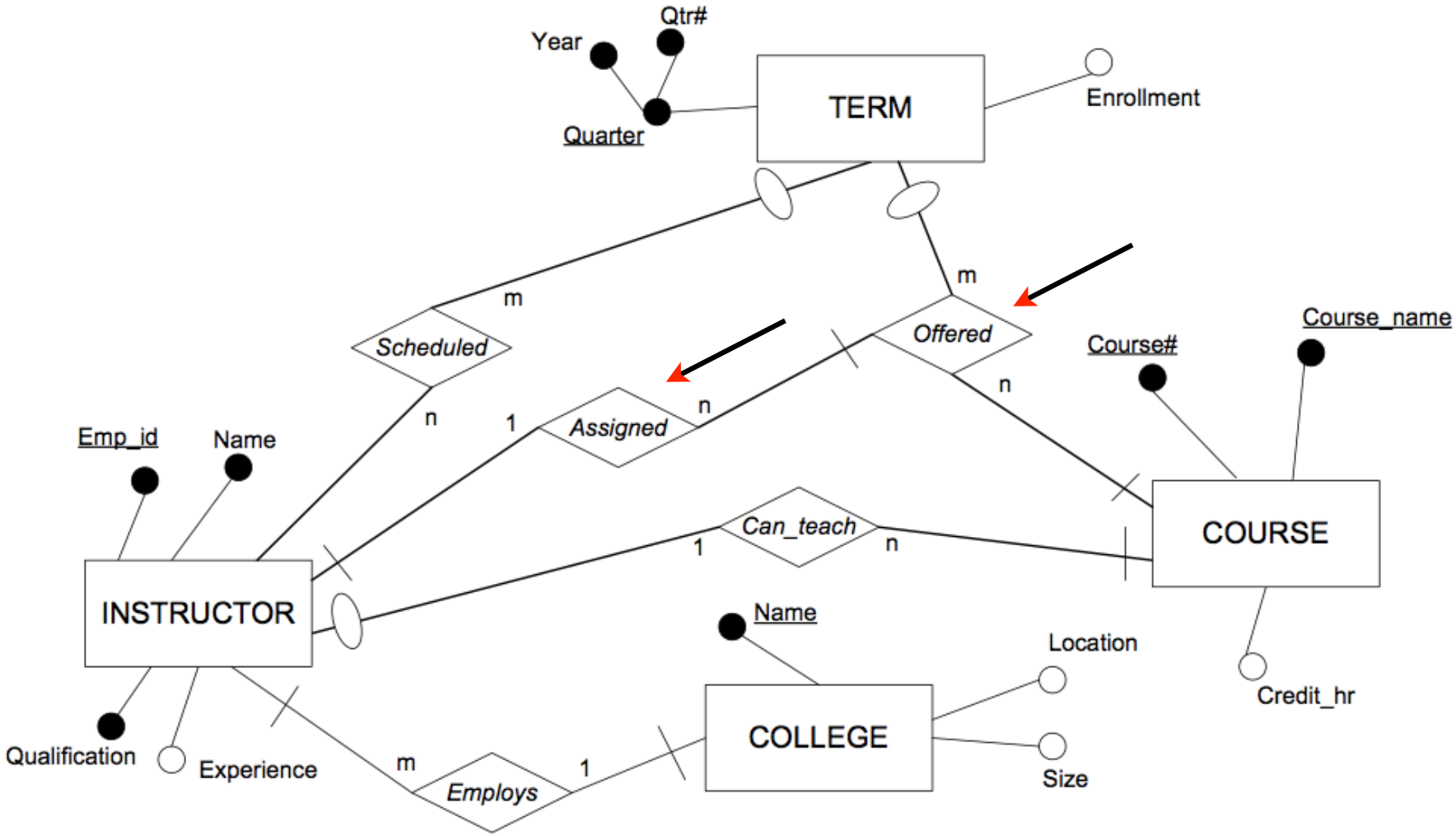



Figure 2.28g

Syntactic error created in the attempt to convey that the same course is never taught by more than one instructor in the same term

# vignette 1 - complete

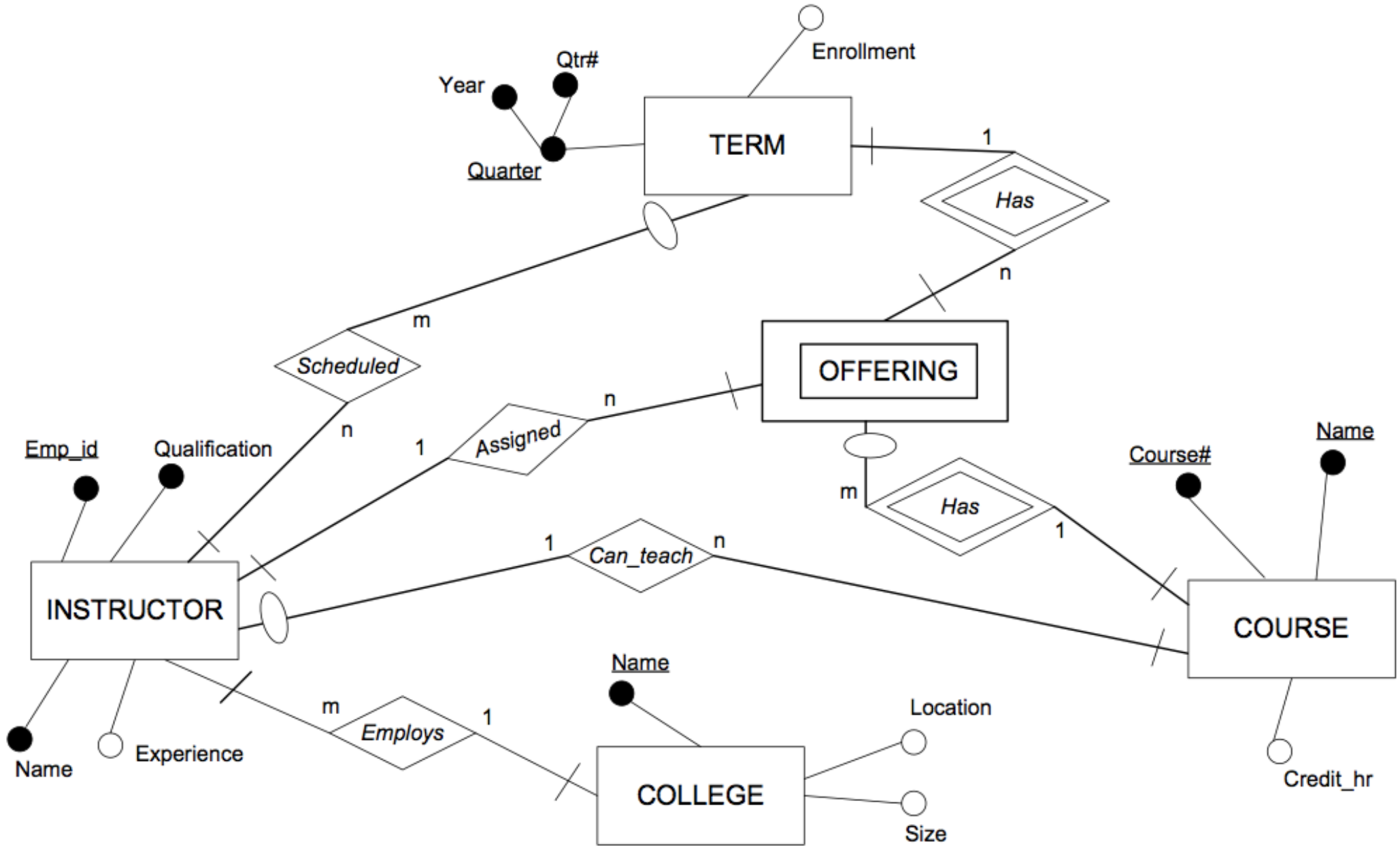



Figure 2.28h

Slide 21: http://www.flickr.com/photos/wwiilego/7720076422/