MONASH University

MONASH
INFORMATION
TECHNOLOGY

Week 3 - Database Design I: Conceptual Modelling UML (cont'd)

FIT2094 - FIT3171 Databases
Clayton Campus S1 2019.

GROUP OF EIGHT AUSTRALIA

Overview

- **Hour 1**
  - –UML and Lucidchart
  - –Emphasis for FIT3171
  - –Revisit case study, revisit change in terminology per-level
  - –ERD → Relations (Conceptual → Logical)
  - –Map regular entities
  - –Map weak entities
  - –Map binary relationships

… then COFFEE BREAK!

- **Hour 2**
  - –Map assoc entities
  - –Map unary relationships
  - –Map ternary relationships
  - –Practicalities: SQL Developer Data Modeler and Surrogate Keys

Unified Modeling Language (UML)

- The way that data is organised in a database is very different to the way it is organised in an OO program
  - eg. inheritance
- Use a **subset** of UML notation for database modelling
  - Conceptual
  - Logical
- Several vendors support Database Modelling via UML, some examples:
  - Star UML
  - Altova UModel
- Variety of standards adopted, not widely used in practice

Unified Modeling Language (UML)

- BOTH FIT2094 and FIT3171 have to study this.

- **FIT3171 may be examined more rigorously on UML due to ULO #3…**
  - **e.g. more quality/quantity of Q's...**

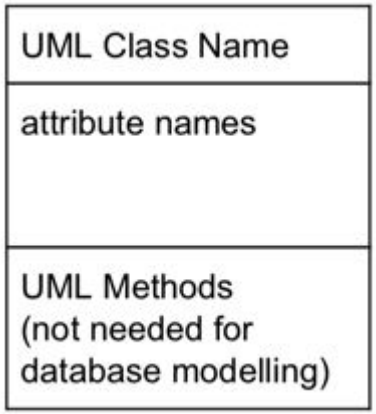
Outcomes

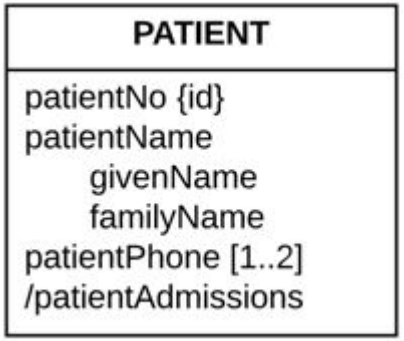
At the completion of this unit, students should be able to:

1. explain the motivations behind the development of database management systems;
2. describe the underlying theoretical basis of the relational database model and apply the theories into practice;
3. critically compared the design constructs of object oriented model and relational model design;

UML Notation for the unit

Standard UML Class Diagram is used as the basic structure:





{id} - indicates KEY
Indentation for composite attribute
[n..m] - multivalued attribute
/ - calculated attribute

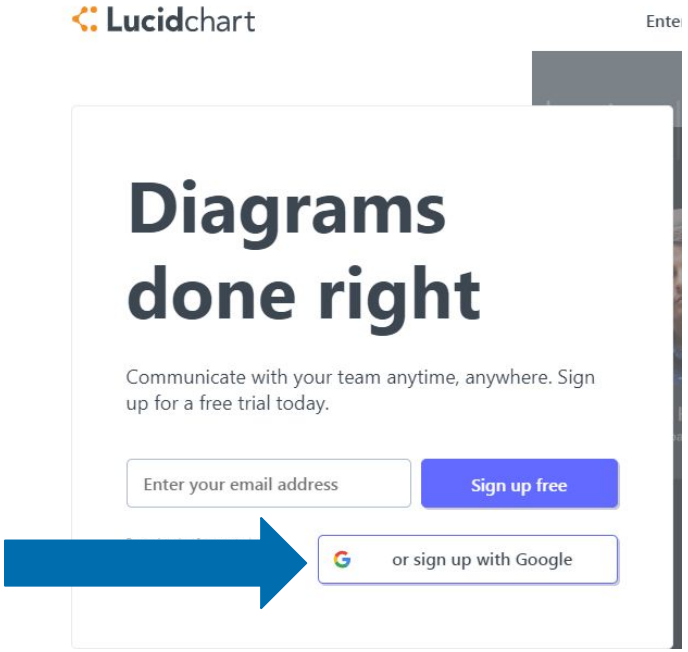
[Clayton]
Quick question - not FLUX.

1. Identify the composite attribute in PATIENT.

2. Why is /patientAdmissions prefixed by a slash? Why EXACTLY?

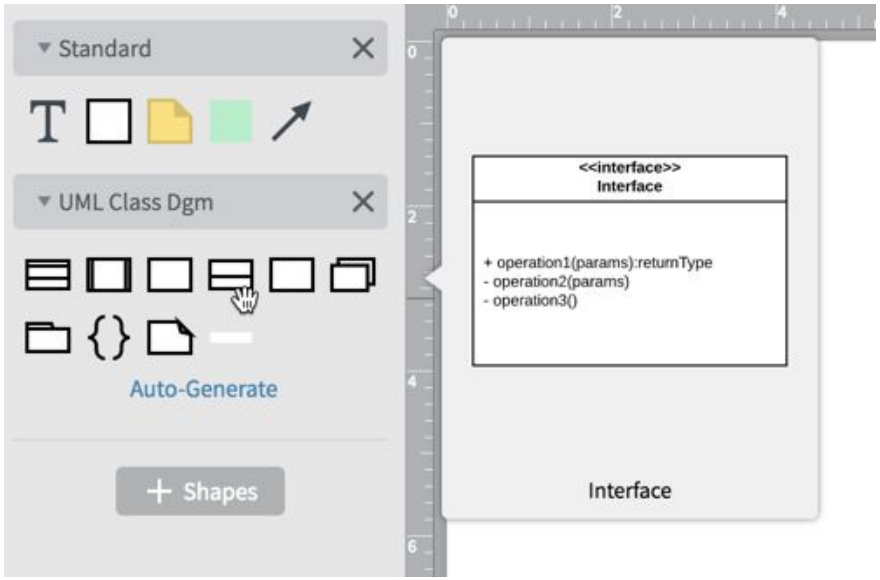
UML - LucidChart

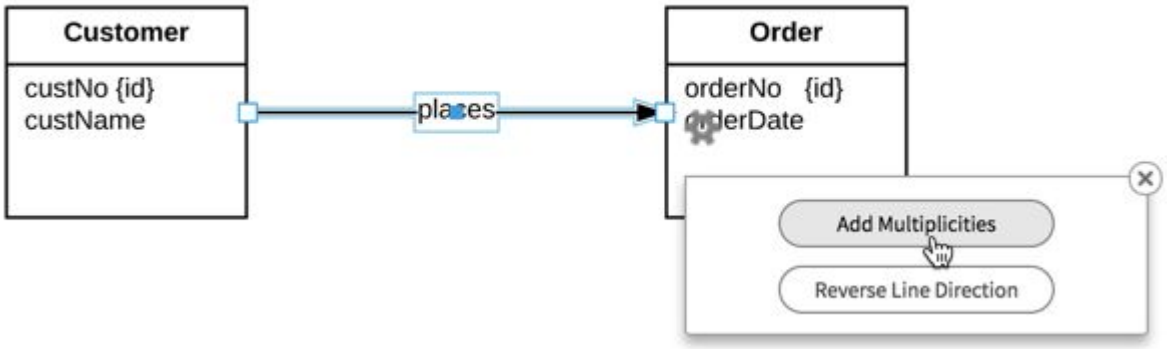
- Recall: Several steps can be used to get an account, as per tute...
- Easiest:
  - go to https://www.lucidchart.com
  - “sign up with Google”
  - USE YOUR MONASH GMAIL: e.g. abcd1234@student.monash.edu
  - Login Okta if needed.
  - Approve permissions if needed.
  - Done!



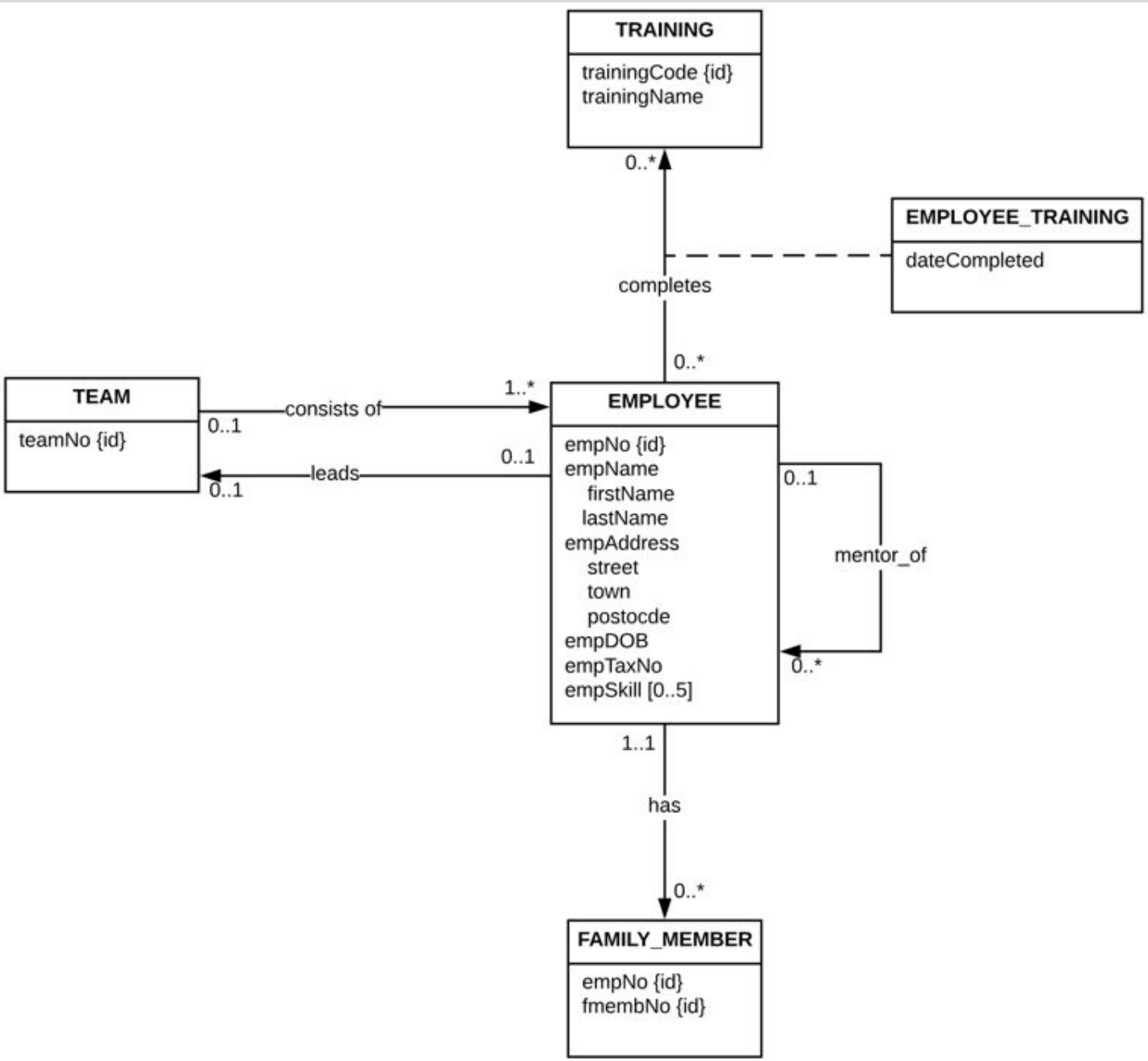
UML - LucidChart

UML Class Diagram - use Interface shape as no methods being added





Relationship lines - directed line, arrow head at M end, add Multiplicities


TRAINING
trainingCode {id}
trainingName
0..*
EMPLOYEE_TRAINING
dateCompleted
completes
0..*
TEAM
teamNo {id}
consists of
1..*
0..1
leads
0..1
0..1
EMPLOYEE
empNo {id}
empName
firstName
lastName
empAddress
street
town
postocde
empDOB
empTaxNo
empSkill [0..5]
0..1
mentor_of
0..*
1..1
has
0..*
FAMILY_MEMBER
empNo {id}
fmembNo {id}

MONASH University

MONASH
INFORMATION
TECHNOLOGY

Week 4 - Database Design II: Logical Modelling

FIT2094 - FIT3171 Databases
Clayton Campus S1 2019.

GROUP OF EIGHT AUSTRALIA

[Clayton] Note from the team

Contents will get tougher.

Some FLUX questions.

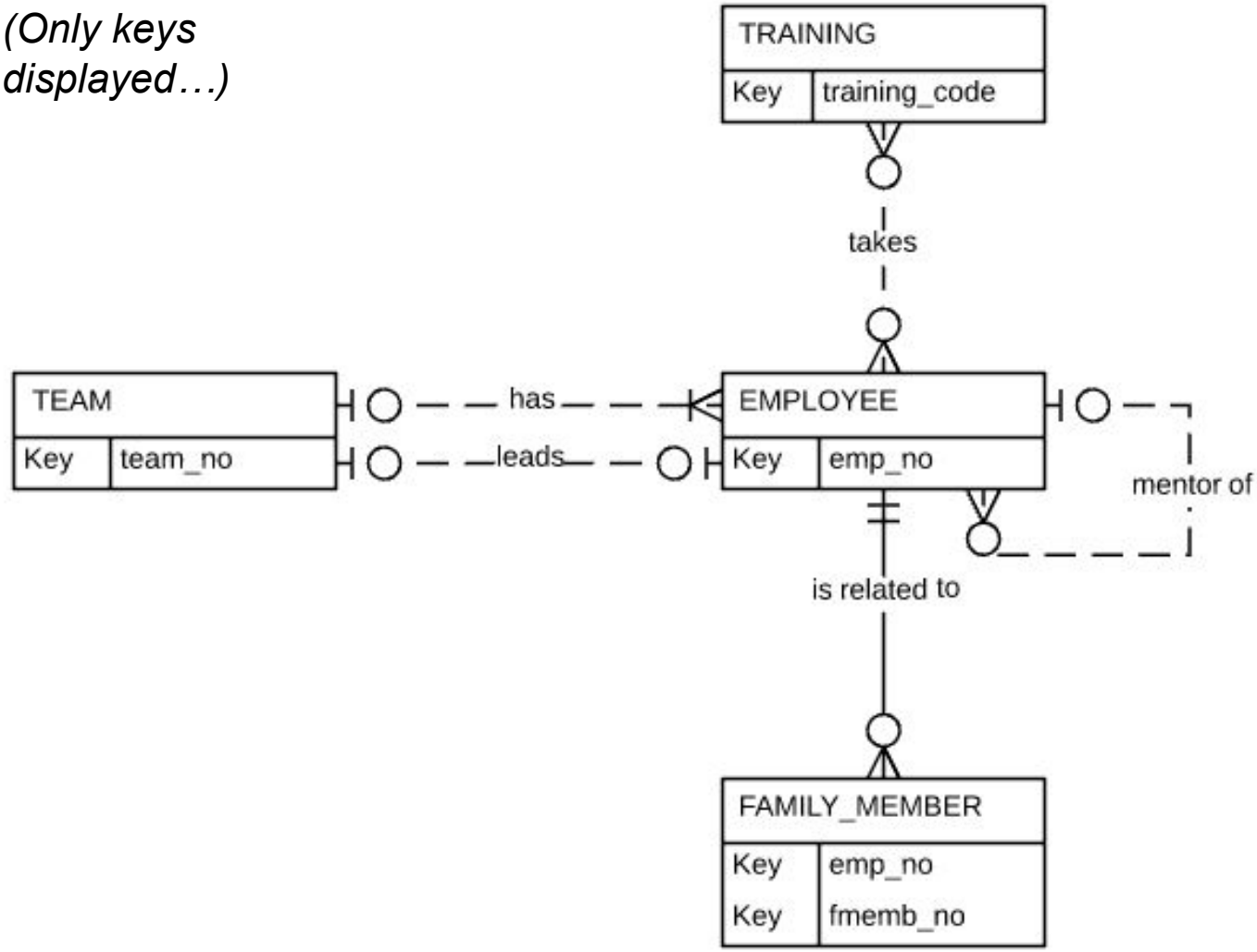
Some Audience Discussion questions.

More importantly: we will focus, once again, on Week 3's 'Monash Software' case study.

Img src: me.me

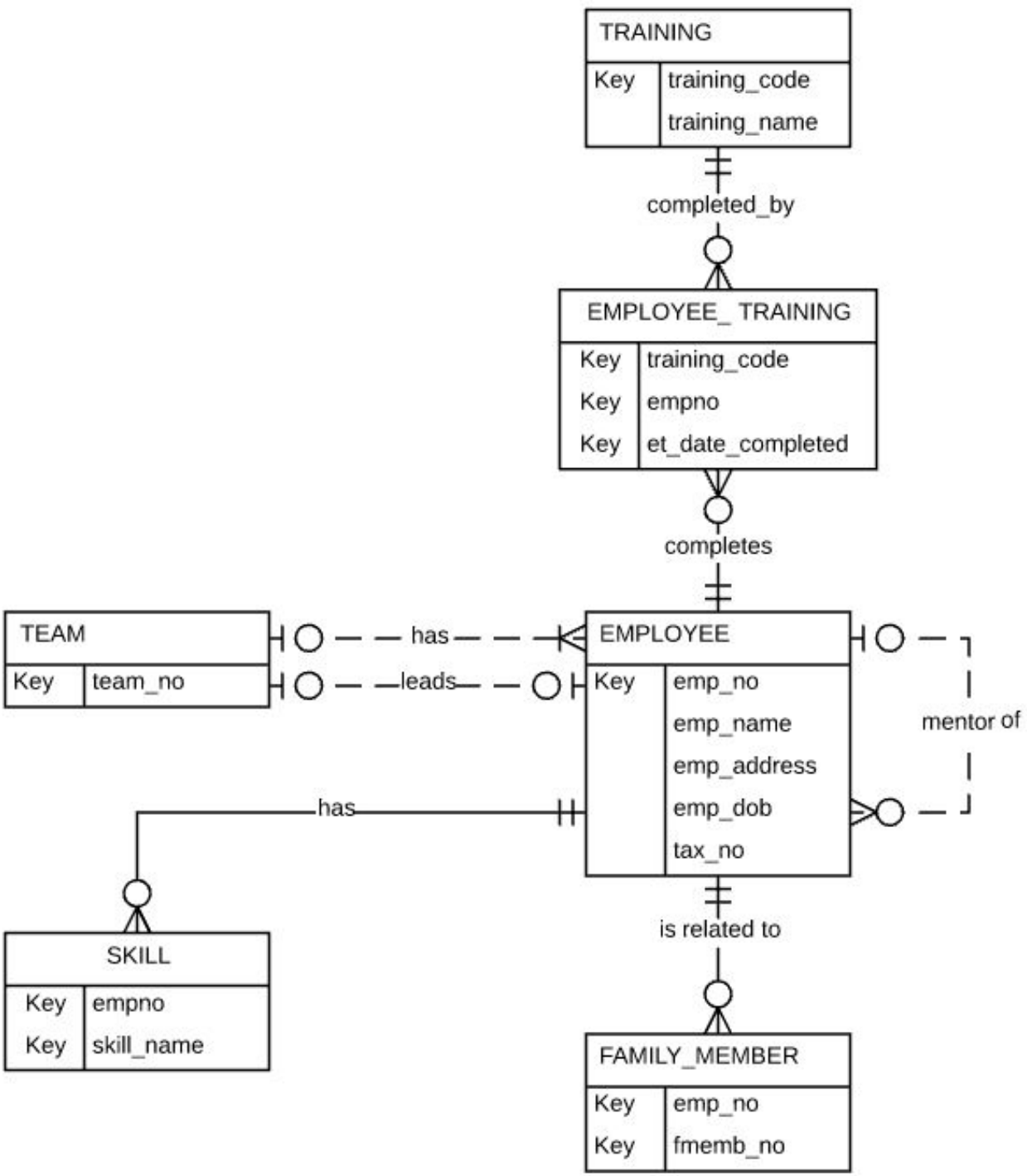
Revisit - Week 3 Conceptual Model

(Only keys displayed…)



Revisit - Week 3 Conceptual Model

(All attributes displayed)



Summary of Terminologies at Different Levels (Courtesy of Lindsay)

Last week… This week… e.g. in Oracle SQLDeveloper

Conceptual	Logical	Physical
Entity	Relation	Table
Attribute	Attribute	Column
Instance	Tuple	Row
Identifier	Primary Key	Primary Key
Relationship	---	---
---	Foreign Key	Foreign Key

NB: Relation (Logical) != RelationSHIP (Conceptual)

Properties of Relations

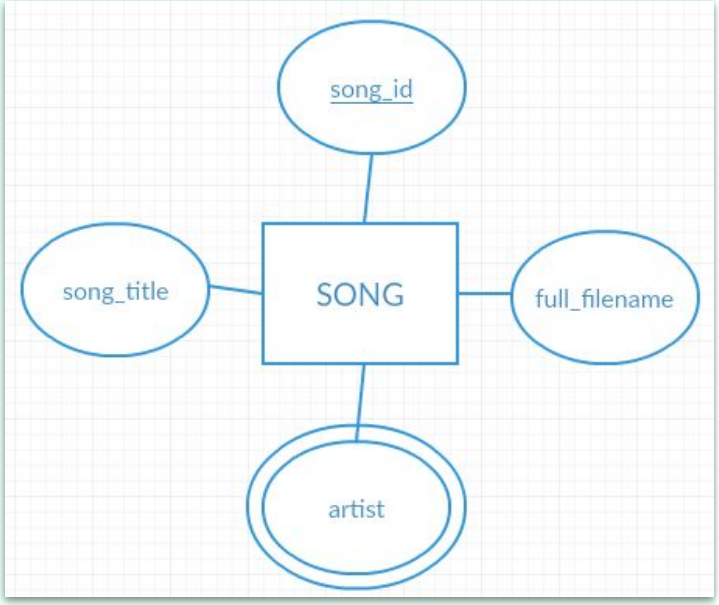
- Some properties to be considered:
  - Each relation has a unique name in the database.
  - Each row is unique - i.e. duplicate tuples are not allowed.
  - Each column has a (meaningful) name.
  - The order of attributes is immaterial.
  - The order of tuples is immaterial.
  - The entries are single-valued **(atomic)** - each cell contains a single entry.
    - **Multi-valued** and **composite attributes**???

RECALL: “Multi-valued can have many values… person may have several college degrees”
RECALL: “Composite can be subdivided into additional attributes… Address into street, city, zip”

[Clayton] Q&A slide: properties of Relations

- *From last slide:* **Multi-valued** and **composite attributes**???
- RECALL:
  - "**Multi-valued** can have **many** values… person may have **several college degrees**" [even ZERO!]
  - "**Composite** can be **subdivided** into additional attributes… **Address** into street, city, zip"

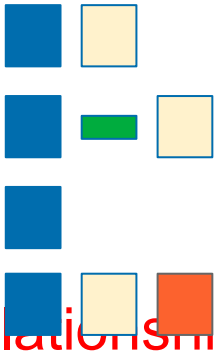
- **Discuss: Refer to the SONG entity for a simple music player (in Chen notation). Identify which is which?**



Transforming ER diagrams into relations (mapping Conceptual level to Logical level)

The steps are:

- Step 1 Map strong (regular) entities
- Step 2 Map weak entities
- Step 3 Map binary relationships
- Step 4 Map associative entities
- Step 5 Map unary relationships
- Step 6 Map ternary relationships
- Step 7 Map supertype/subtype relationships (is not part of this unit).



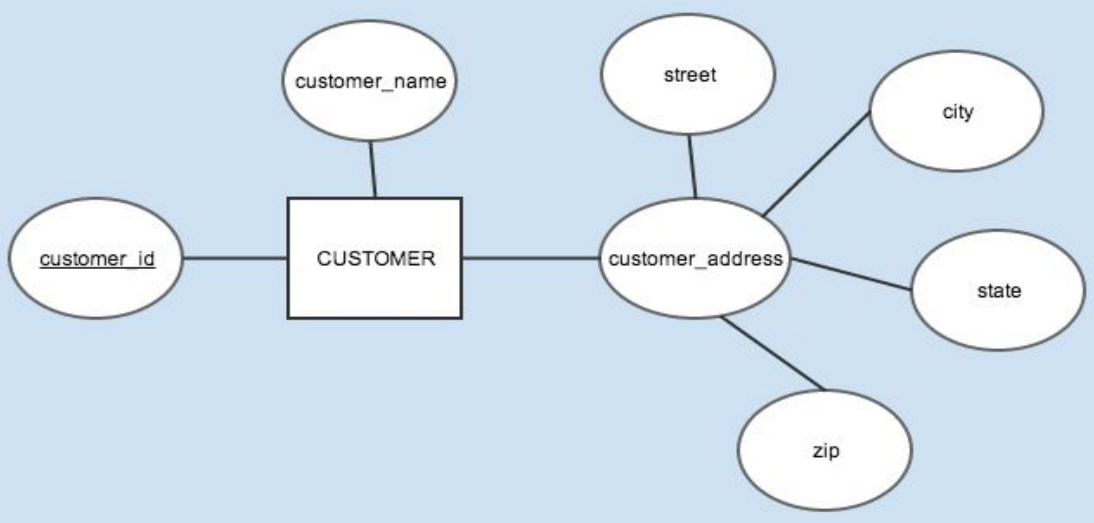
Q1. The relational model requires that each cell in a relation is single-valued (atomic). Considering this requirement, what construct in an ER diagram cannot be implemented directly without adding further entities in the relational model (logical level)?

a. Composite key.
b. Composite attribute.
c. Multi-valued attribute.
d. Dependent attribute. (Trick question!)
e. More than one option is correct.

STEP 1: Map Regular Entities

- **Composite Attributes**
  - When the regular entity type contains a **composite attribute**, only the simple component attributes of the composite attribute are included in the new relation.
  - Compared to composite attributes, simple attributes not only improve data accessibility but also help in maintaining data quality

STEP 1: Map Regular Entities
Mapping a Composite Attribute



CUSTOMER	
P *	cust_id
*	cust_name
*	cust_street
*	cust_city
*	cust_state
*	cust_zip

[Clayton]
Quick question - not FLUX. Which is left out from the original Chen diagram?

Monash Software Case Study

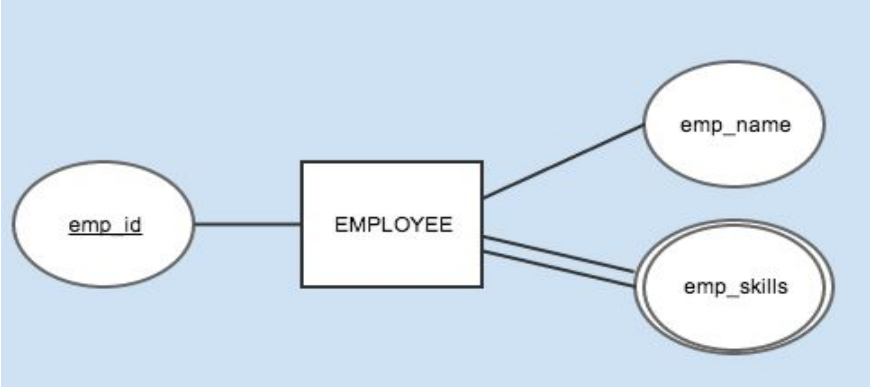
EMPLOYEE	
P *	emp_no
	emp_fname
	emp_lname
*	emp_street
*	emp_town
*	emp_pcode
*	emp_dob
	emp_taxno

NB: * = not null (must have value)

STEP 1: Map Regular Entities

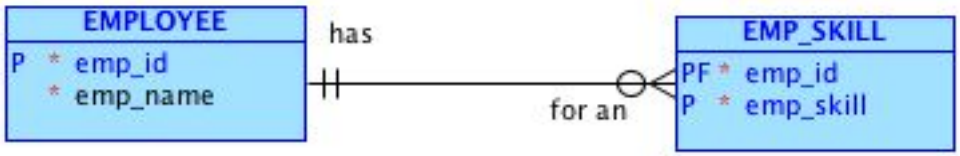
- **Multivalued Attribute**
  - When the regular entity type contains a **multivalued attribute,** two new relations are created.
  - The first relation contains all the attributes of the entity type except the multivalued attribute itself.
  - The second relation contains two attributes that form the PK. One of the attributes is the PK from the first relation, which becomes the FK in the second relation and the other is the multivalued attribute.
  - There can also be non key attributes in the second relation depending upon the data requirements.

STEP 1: Map Regular Entities
Mapping a Multi-Valued Attribute



The first relation contains all the attributes of the entity type **except the multivalued attribute [emp_skills].**

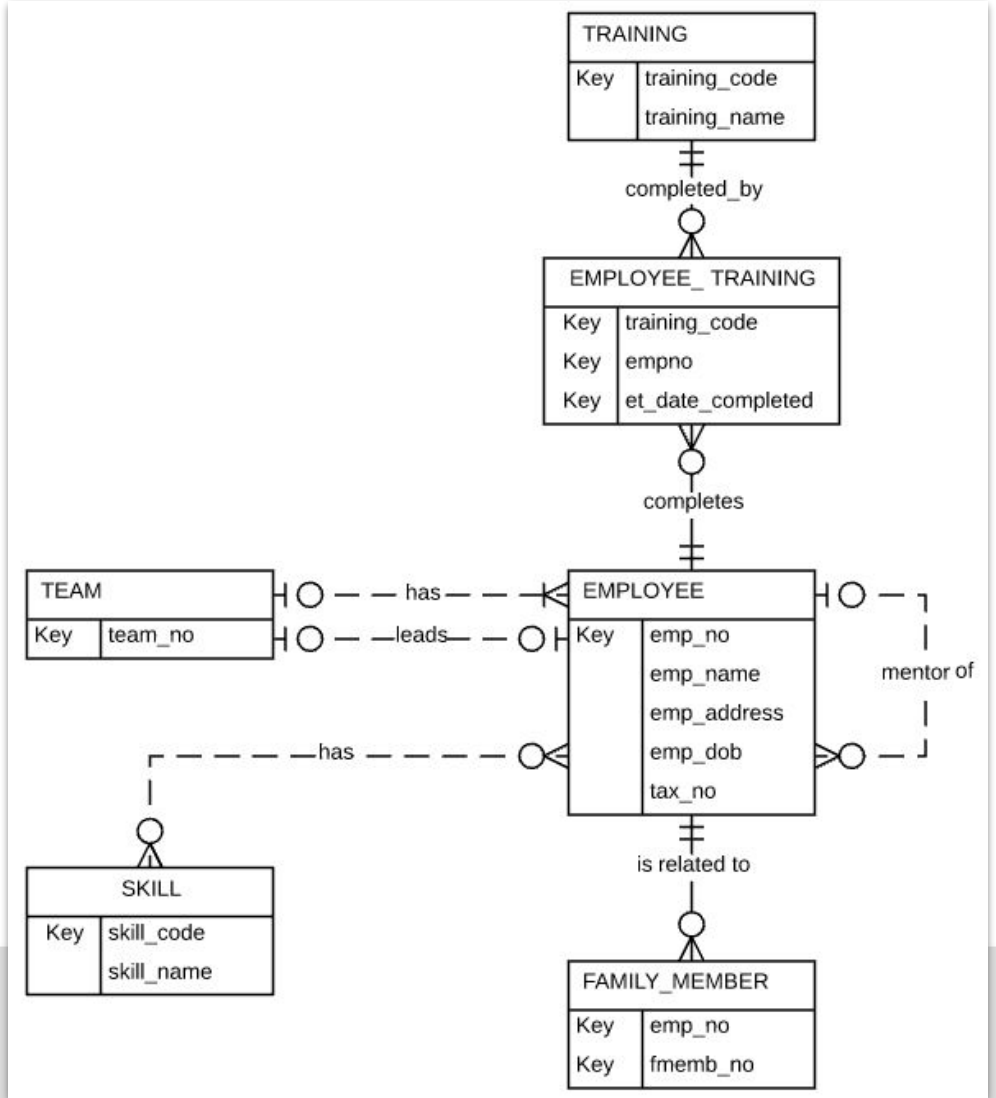
The second relation contains **two attributes that form the PK**.
One of the attributes is the PK from the first relation which becomes the FK in the second relation [**PF emp_id**] …
and the other is the multivalued attribute [**P emp_skill**]



Is there a better solution than the one shown above?

NB: * = not null (must have value)

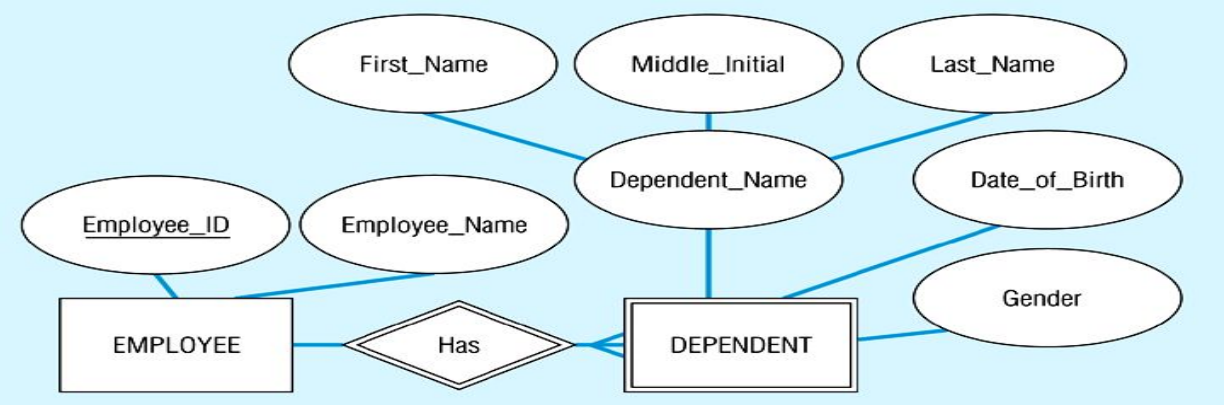
Revisit - Week 3 Conceptual Model - IMPROVED

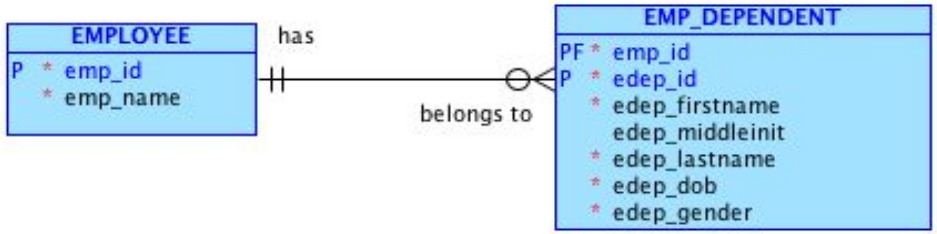


(All attributes shown)

STEP 2: Mapping a Weak Entity

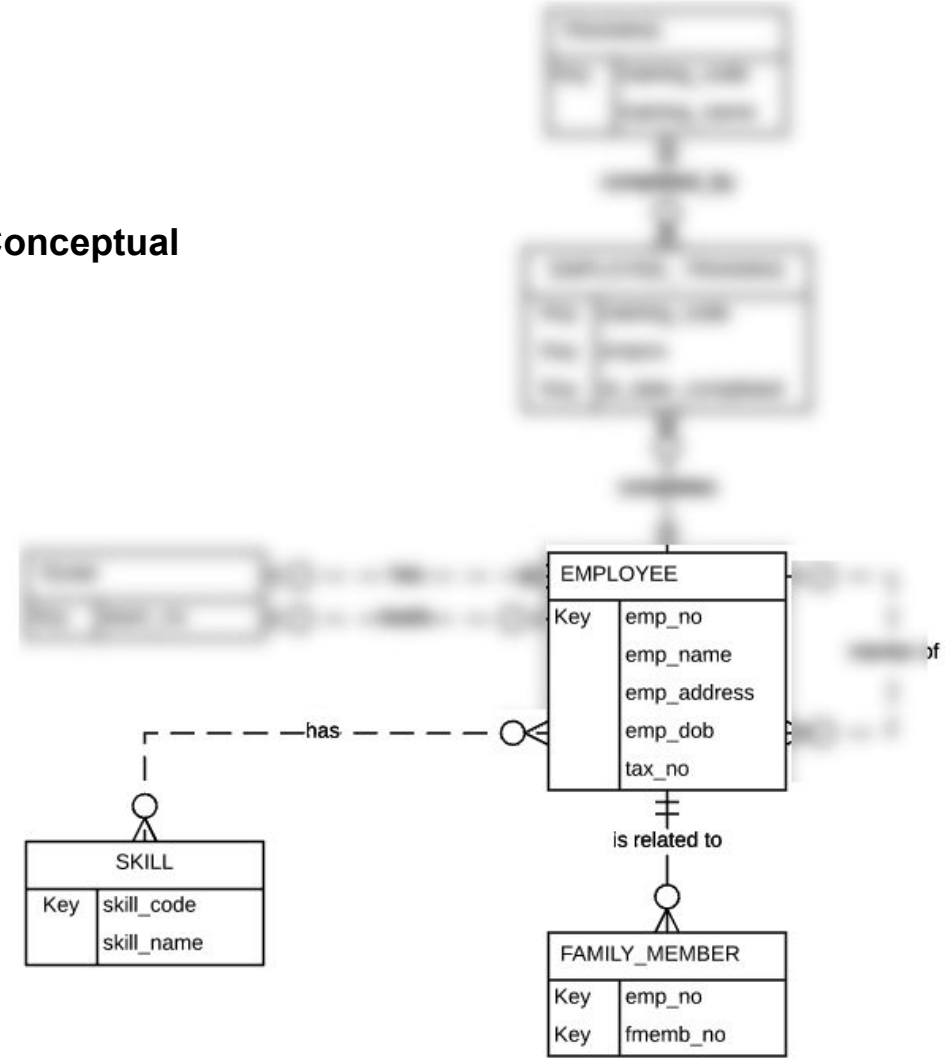
- For each weak entity type, create a **new relation…**
- ...and **include all of the simple attributes** as attributes of this relation.
- The PK of the identifying relation is **also included as the FK in this new relation.**



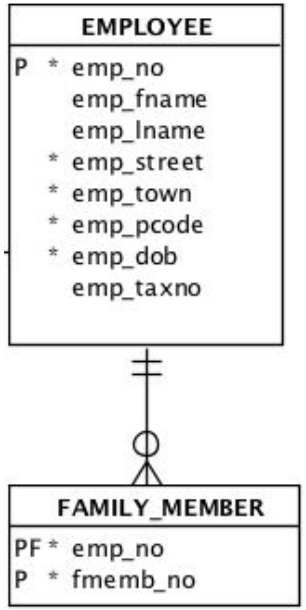


NB: * = not null (must have value)

Conceptual

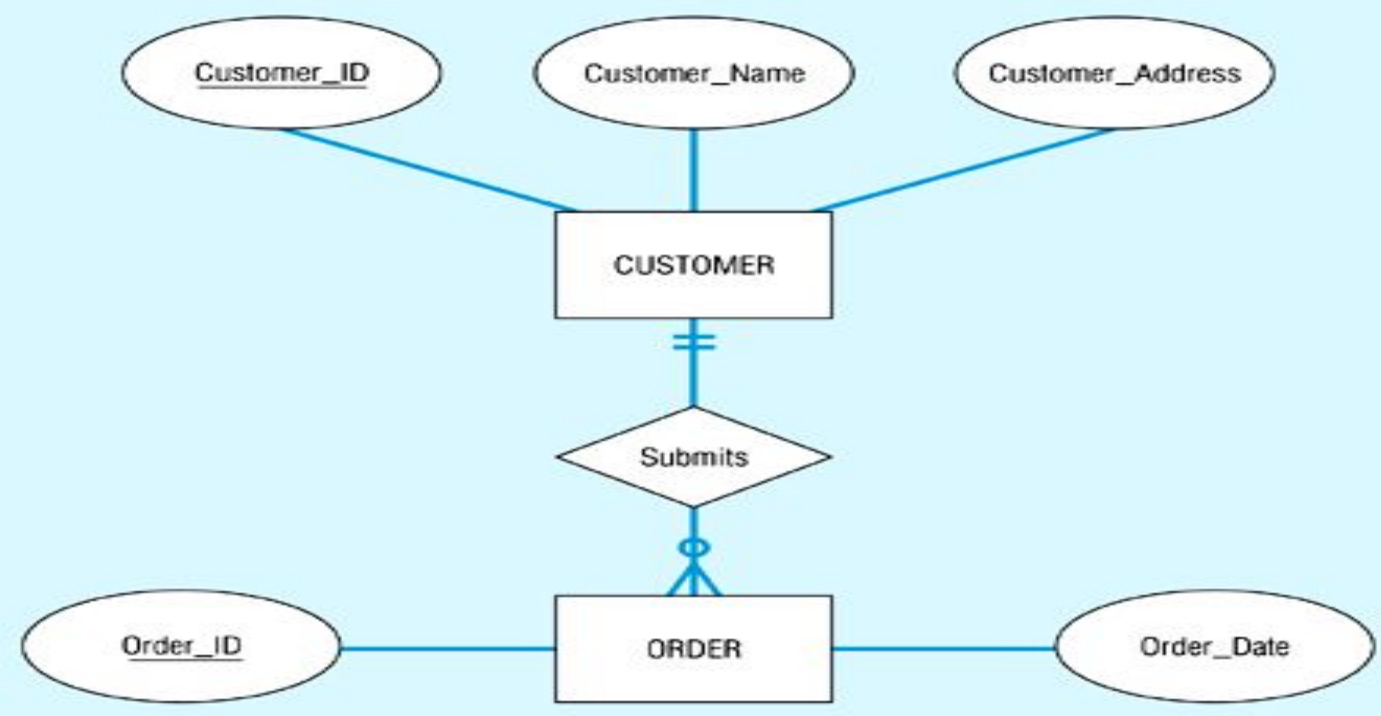


Logical

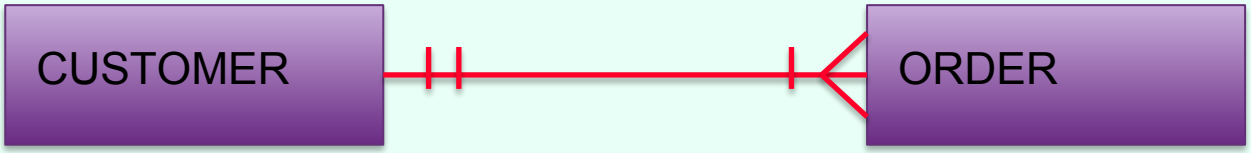


[Clayton Q&A]: **Recall which is the composite attribute (can be broken down)?**
Recall which is the multi-valued attribute (0, 1, or many)?
Recall which is the weak ENTITY?

STEP 3:
Mapping a 1:M Binary Relationship

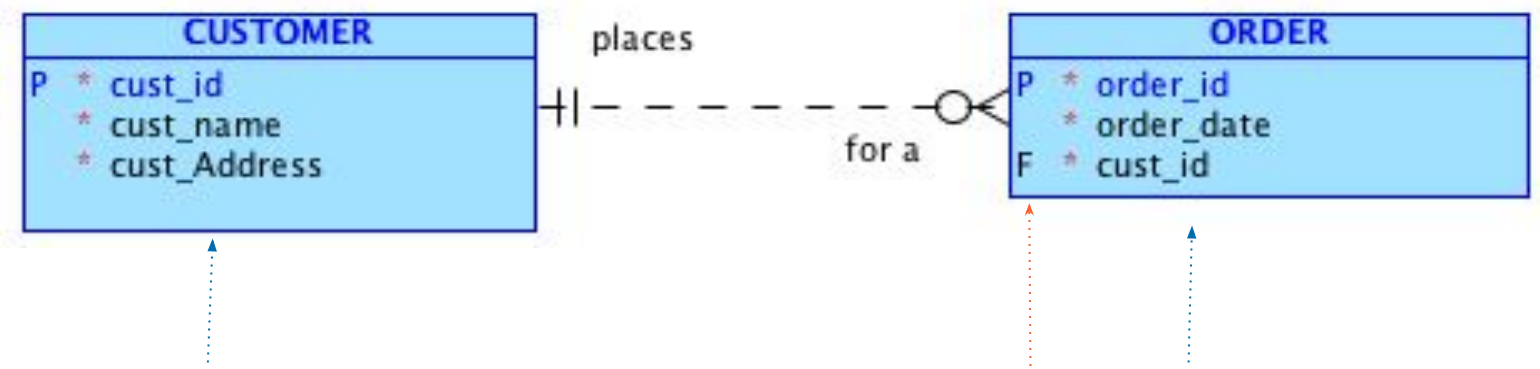


Q2. Where would you place the Foreign Key when you map this ER diagram into the relational model?



a. CUSTOMER
b. ORDER
c. Both CUSTOMER and ORDER.
d. None, no FK is needed.

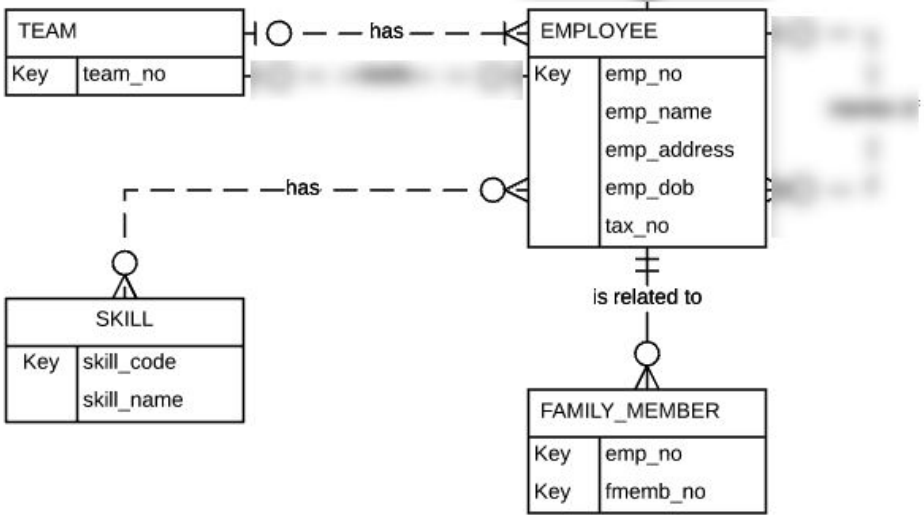
STEP 3: Map Binary Relationships (1:M)



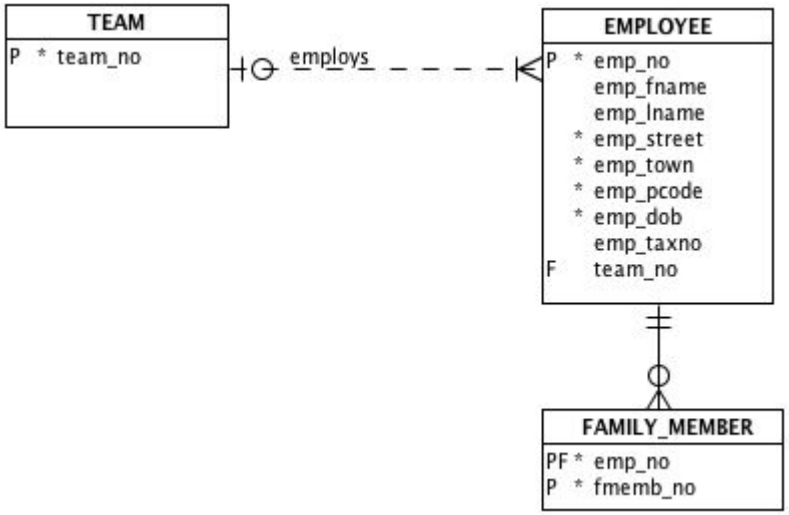
For each 1:M binary relationship, first create **a relation for each of the two entity types** participating in the relationship.

Then include the **PK attribute (or attributes)** of the entity on the one-side of the relationship as the **FK on the many-side [F cust_id]** of the relationship.

Conceptual



Logical



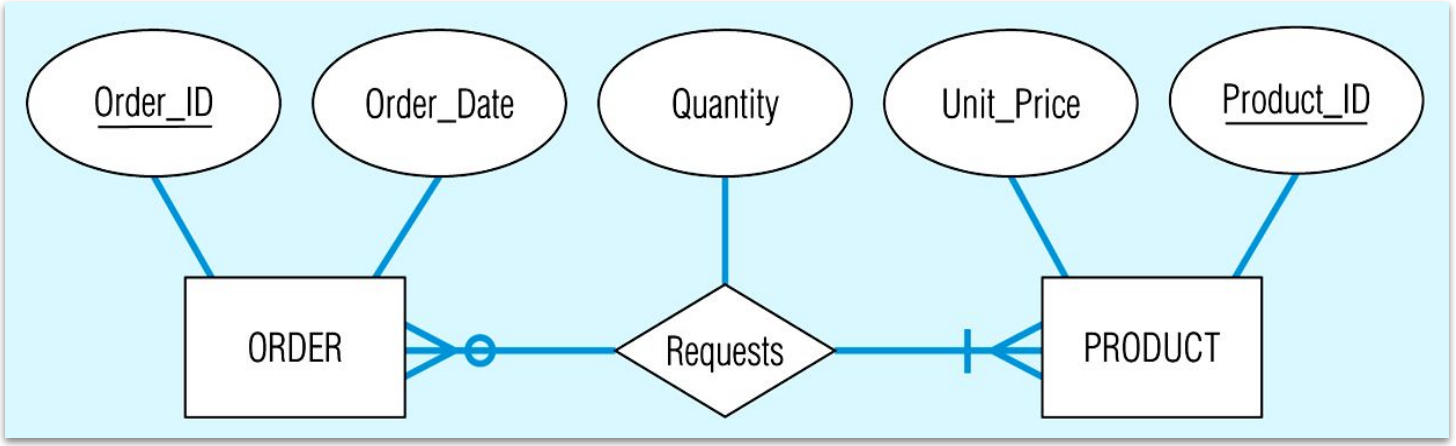
MONASH University

[Clayton Q&A]: **Recall which is the 'ONE-side' and which is the 'MANY-side'? Which attrib appears as P in the 'ONE-side' table and F in the 'MANY-side'?**

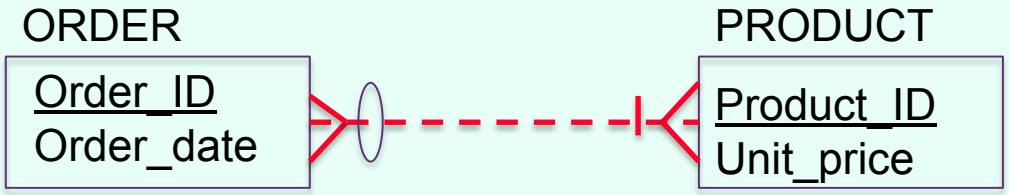
Coffee break - see you in 10 minutes.

Img src: Jazmin Quaynor @jazminantoinette at Unsplash

STEP 3: Mapping a M:N Binary Relationship (STEP 4: Map Associated Entities)

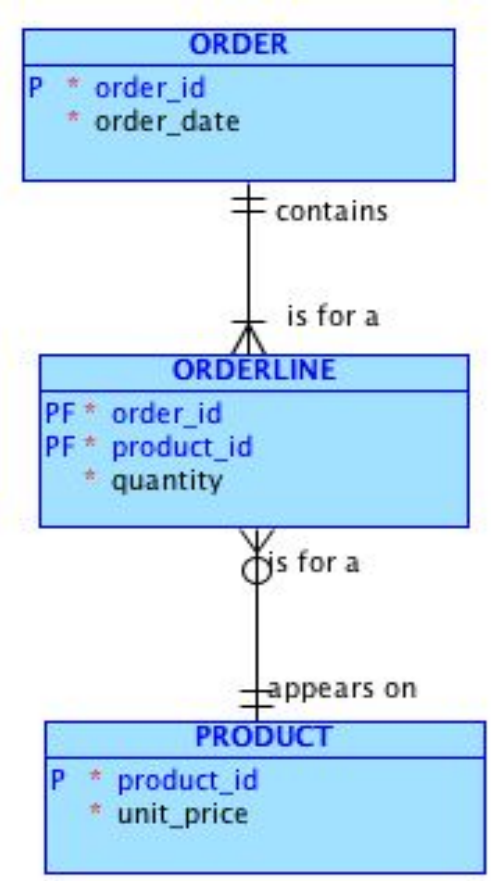


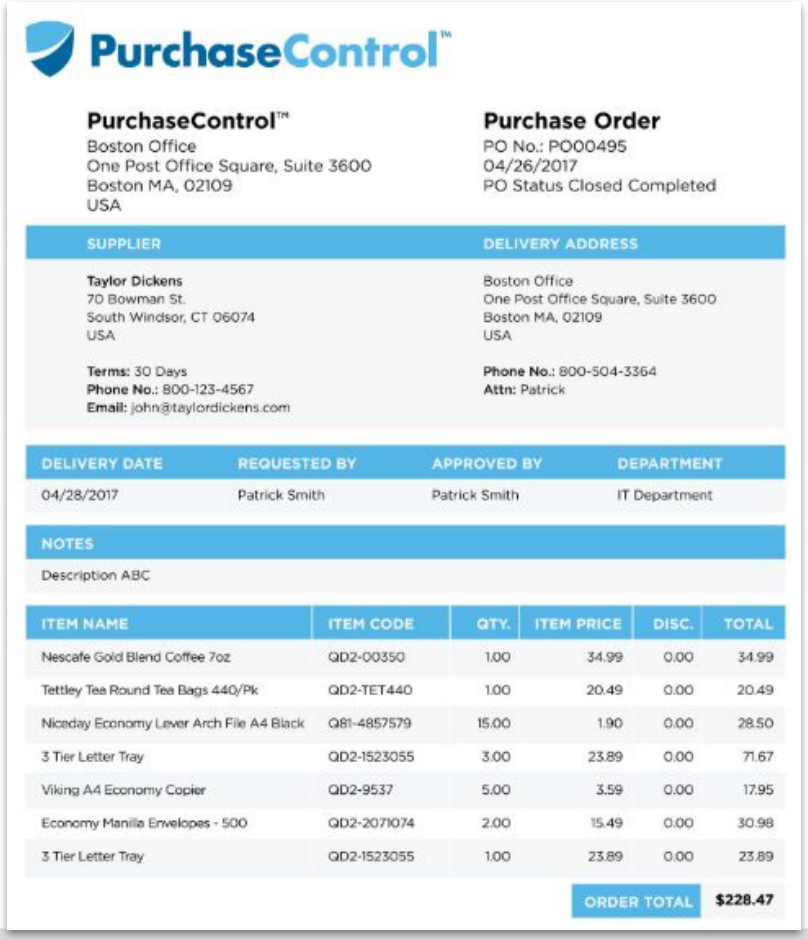
Q3. What will be the Primary Key of the new created relation resulting from mapping this ER model at the conceptual level into a relational model?



a. The primary key of the ORDER table.
b. The primary key of the PRODUCT table.
c. The combination of primary keys of ORDER and PRODUCT.

STEP 3: Mapping a M:N Binary Relationship (STEP 4: Map Associated Entities)





PurchaseControl™

PurchaseControl™
Boston Office
One Post Office Square, Suite 3600
Boston MA, 02109
USA

Purchase Order
PO No.: PO00495
04/26/2017
PO Status Closed Completed

SUPPLIER	DELIVERY ADDRESS
Taylor Dickens 70 Bowman St. South Windsor, CT 06074 USA **Terms:** 30 Days **Phone No.:** 800-123-4567 **Email:** john@taylordickens.com	Boston Office One Post Office Square, Suite 3600 Boston MA, 02109 USA **Phone No.:** 800-504-3364 **Attn:** Patrick

DELIVERY DATE	REQUESTED BY	APPROVED BY	DEPARTMENT
04/28/2017	Patrick Smith	Patrick Smith	IT Department

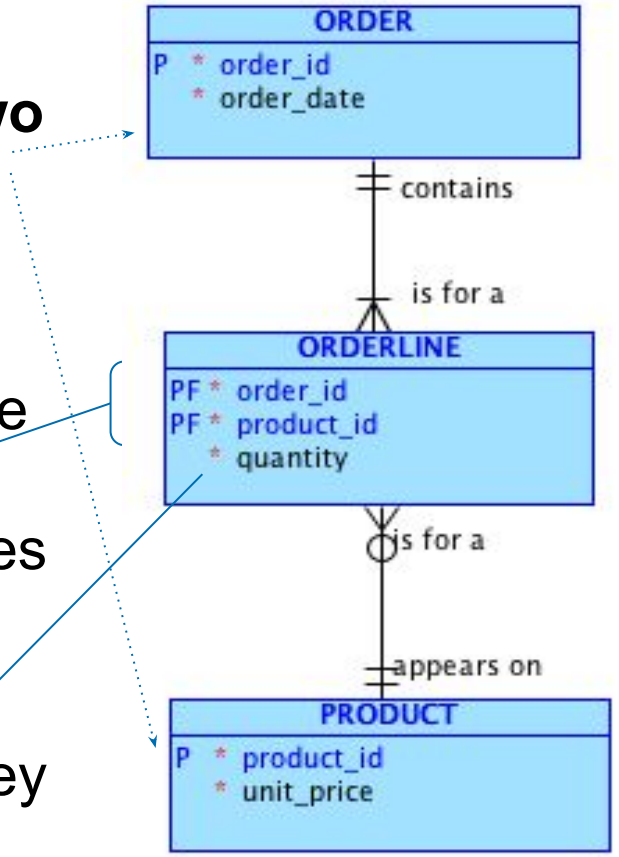
NOTES
Description ABC

ITEM NAME	ITEM CODE	QTY.	ITEM PRICE	DISC.	TOTAL
Nescafe Gold Blend Coffee 7oz	QD2-00350	1.00	34.99	0.00	34.99
Tetley Tea Round Tea Bags 440/Pk	QD2-TET440	1.00	20.49	0.00	20.49
Niceday Economy Lever Arch File A4 Black	Q81-4857579	15.00	1.90	0.00	28.50
3 Tier Letter Tray	QD2-1523055	3.00	23.89	0.00	71.67
Viking A4 Economy Copier	QD2-9537	5.00	3.59	0.00	17.95
Economy Manilla Envelopes - 500	QD2-2071074	2.00	15.49	0.00	30.98
3 Tier Letter Tray	QD2-1523055	1.00	23.89	0.00	23.89
			ORDER TOTAL		$228.47

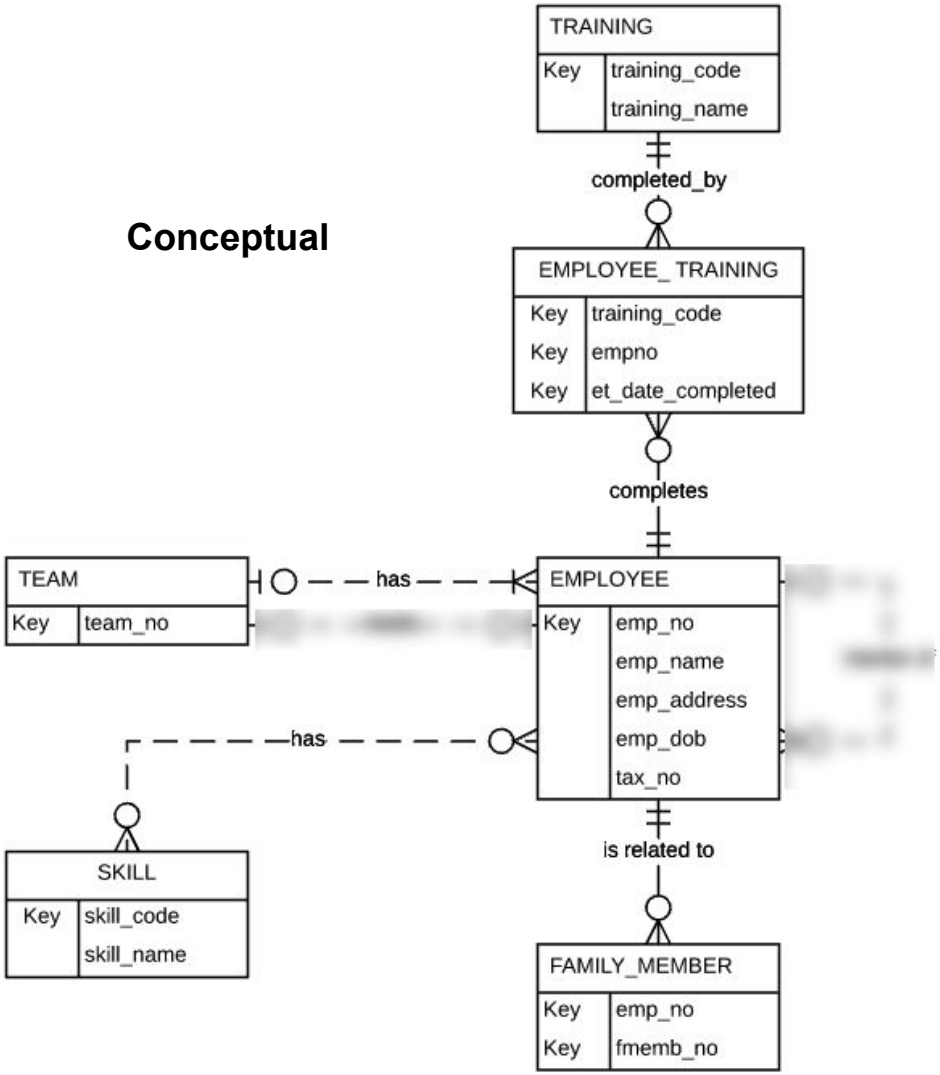
Img src: PurchaseControl

STEP 3: Mapping a M:N Binary Relationship (STEP 4: Map Associated Entities)

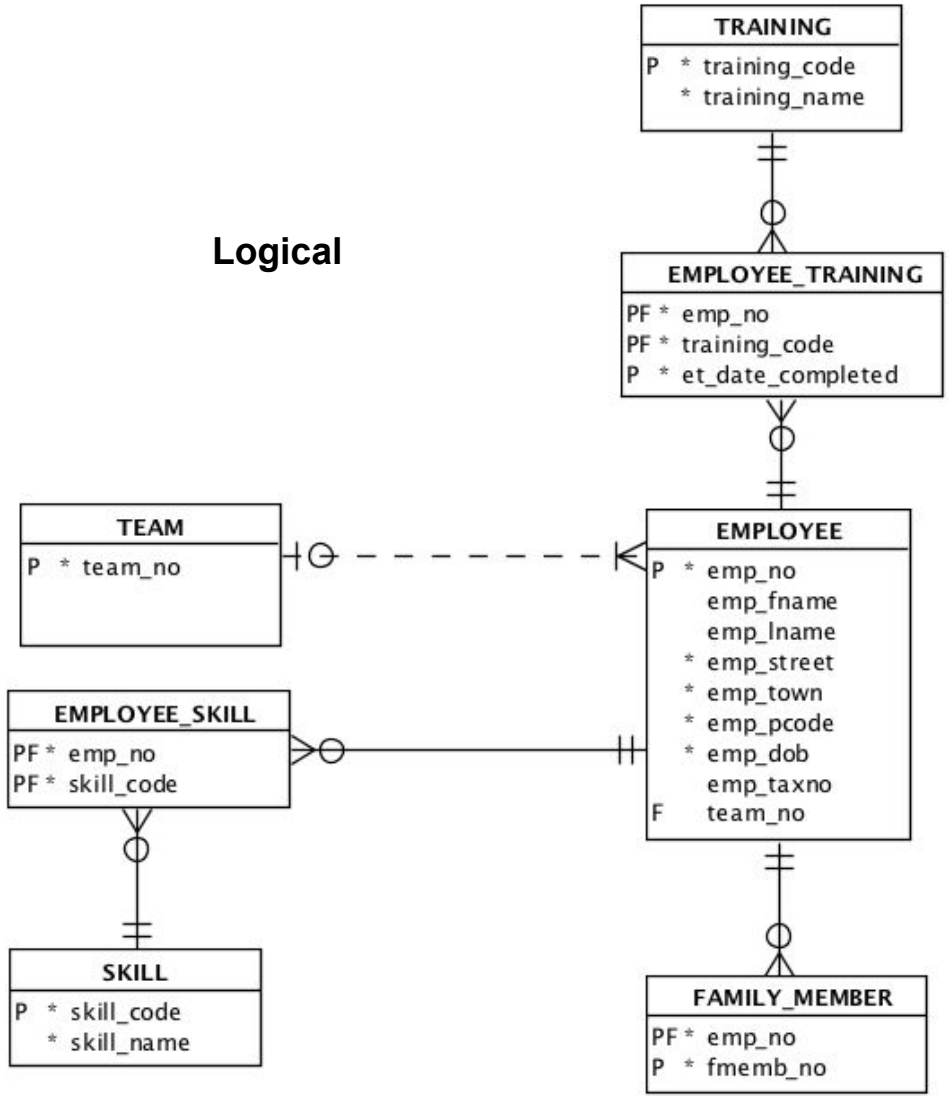
- For a M:N binary relationship
  - First create a relation for **each of the two entity types** participating in the relationship.
  - Then create a **new relation** and include as foreign key attributes, the **PK** attribute (or attributes) for **each of the two** participating entity types. These attributes become the **PK of the new relation.**
  - If there are any **nonkey attributes** associated with the M:N relationship, they are also included in the new relation.



Conceptual

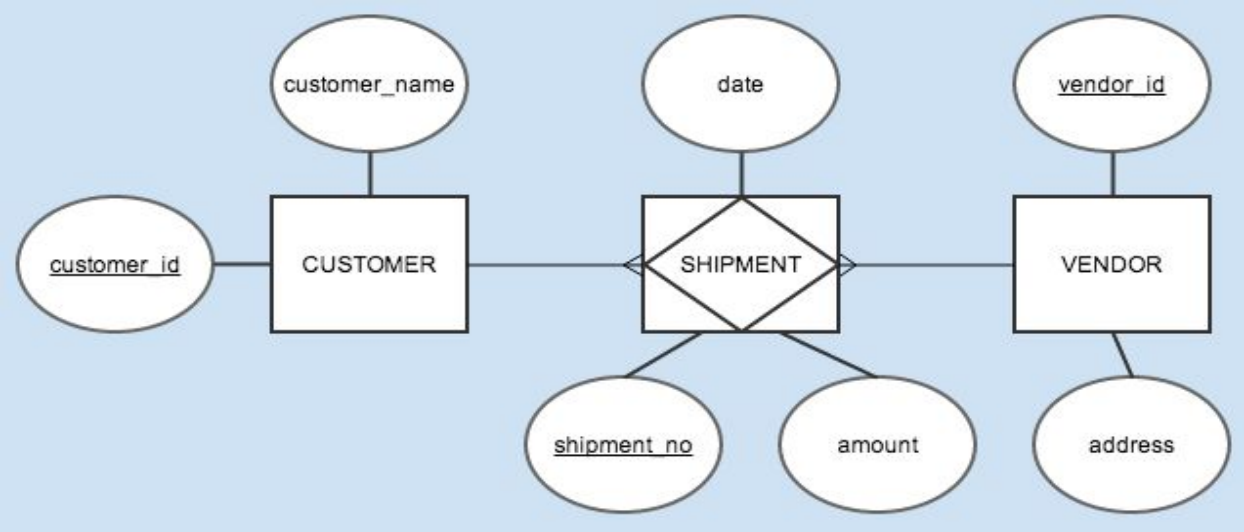


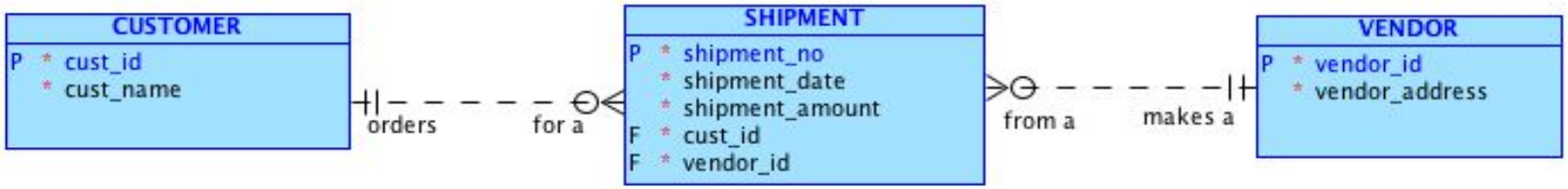
Logical



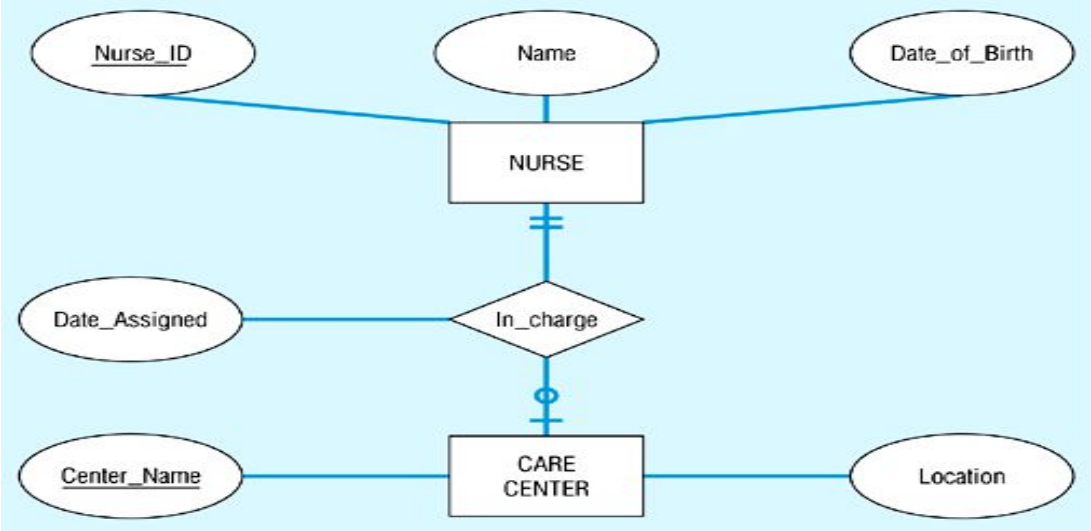
[Clayton Q&A]: **Recall which is the associative entity?**

(STEP 4: Map Associated Entities)
Mapping an associative entity with an Identifier





STEP 3: Mapping a 1:1 Binary Relationship



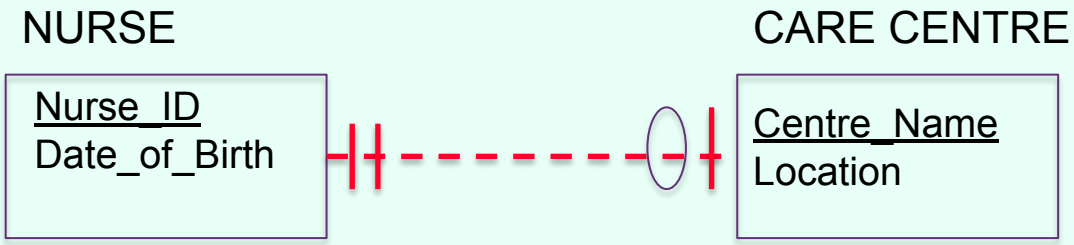
NURSE

Nurse_ID
Date_of_Birth

CARE CENTRE

Centre_Name
Location

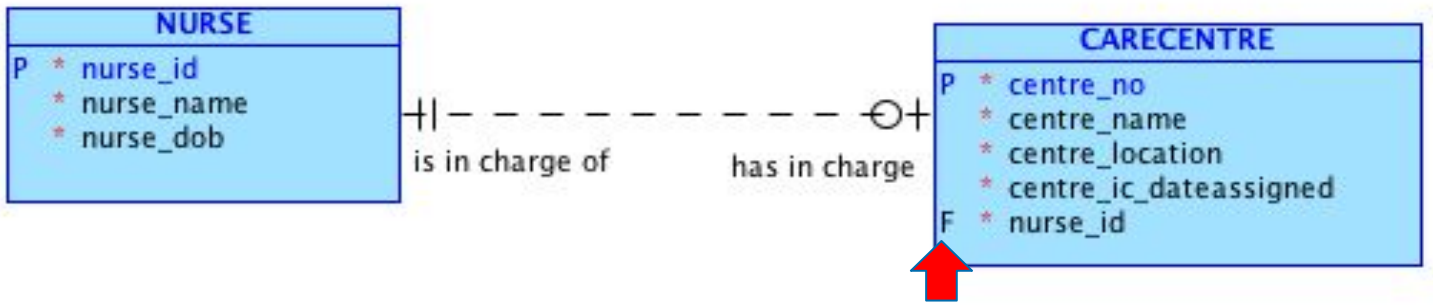
Q4. Where would you place the Foreign Key when mapping this ER diagram into a relational model?



A. NURSE
B. CARE CENTRE
C. Both NURSE and CARE CENTRE
D. No FK is needed.

[Clayton Q&A]: **Discuss - Can a CARE CENTRE exist without a supervising nurse? Can a NURSE work without having to supervise any centre?**

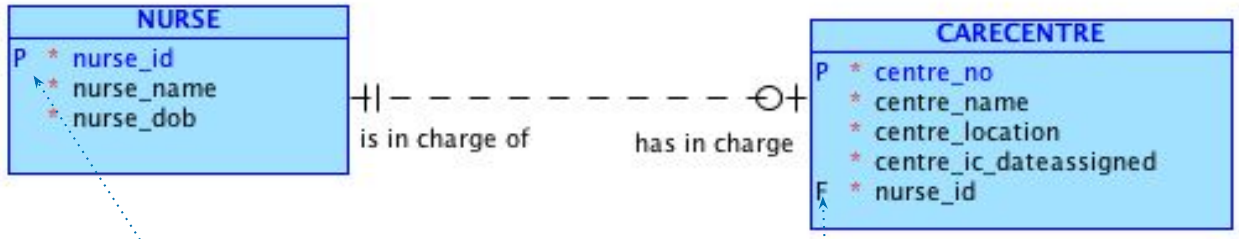
STEP 3: Mapping a 1:1 Binary Relationship



With this setup, each CARECENTRE must reference a NURSE (because it cannot exist without a supervising nurse!)
However, not all NURSEs need to supervise a CARECENTRE (e.g. nurses in emergency medicine or the Royal Flying Doctor program).

NB: However it is “technically” possible, **but NOT the best design**, to put the FK [centre_no] in NURSE, if the “NOT NULL” constraint was relaxed...

STEP 3: Mapping a 1:1 Binary Relationship



- Create two relations, one for each of the participating entity types.
  - The primary key (PK) on the mandatory side of the relationship becomes the foreign key (FK) on the optional side of the relationship.
  - ...where both are optional place the FK on the side which causes the fewest NULLs

[Clayton Q&A]: **Discuss - e.g. in the very simplistic (incomplete) case of:**
GYM_MEMBER [P member_id] - TREADMILL [P treadmill_id] for a Gym's Database.
There are say 1000 members, but only 4 treadmills →
hence it makes sense to put the [F member_id] on the TREADMILL.
(Else, we may have up to 1000 members with NULL if everybody decides to stay home)

STEP 3: Mapping a 1:1 Binary Relationship

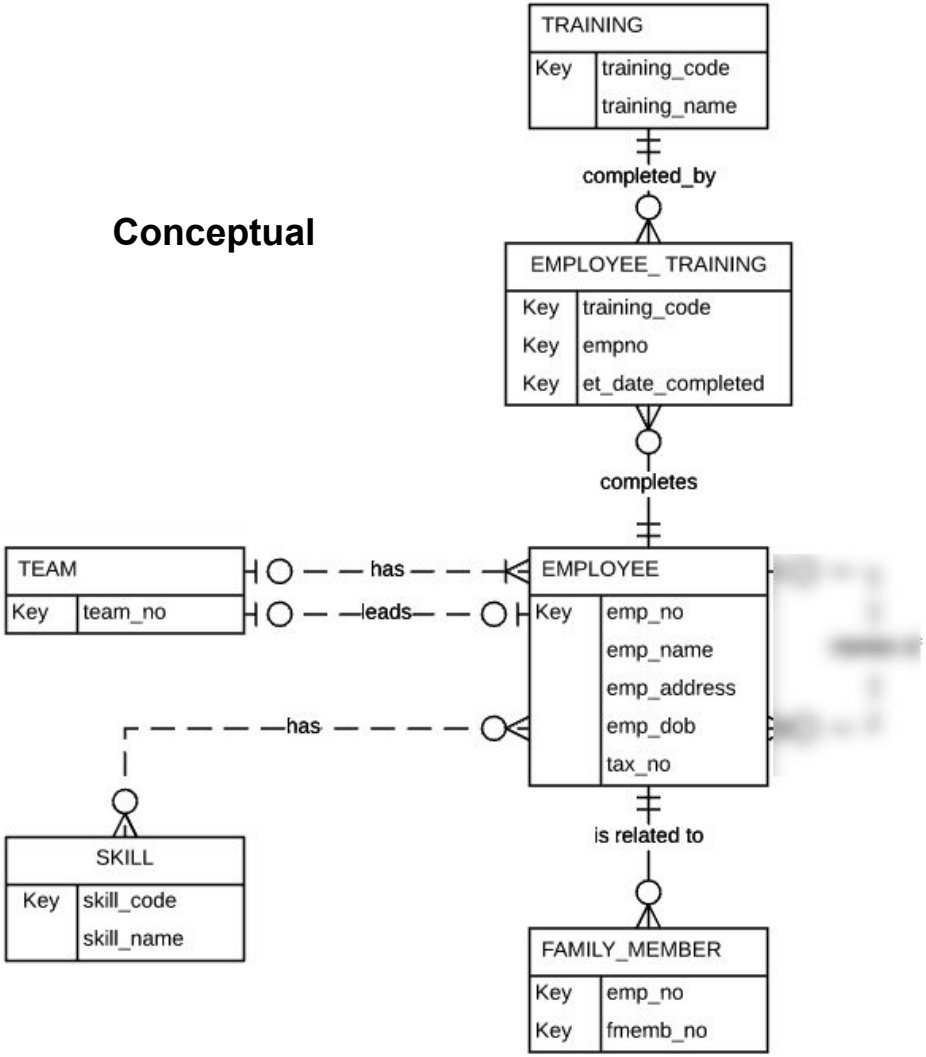
- Create two relations, one for each of the participating entity types. (cont'd)
  - Special case: *1:1 total* relationship (mandatory participation on both sides)
    - Consider consolidating the two entity types into one relation.

[Brendon's Anecdote]

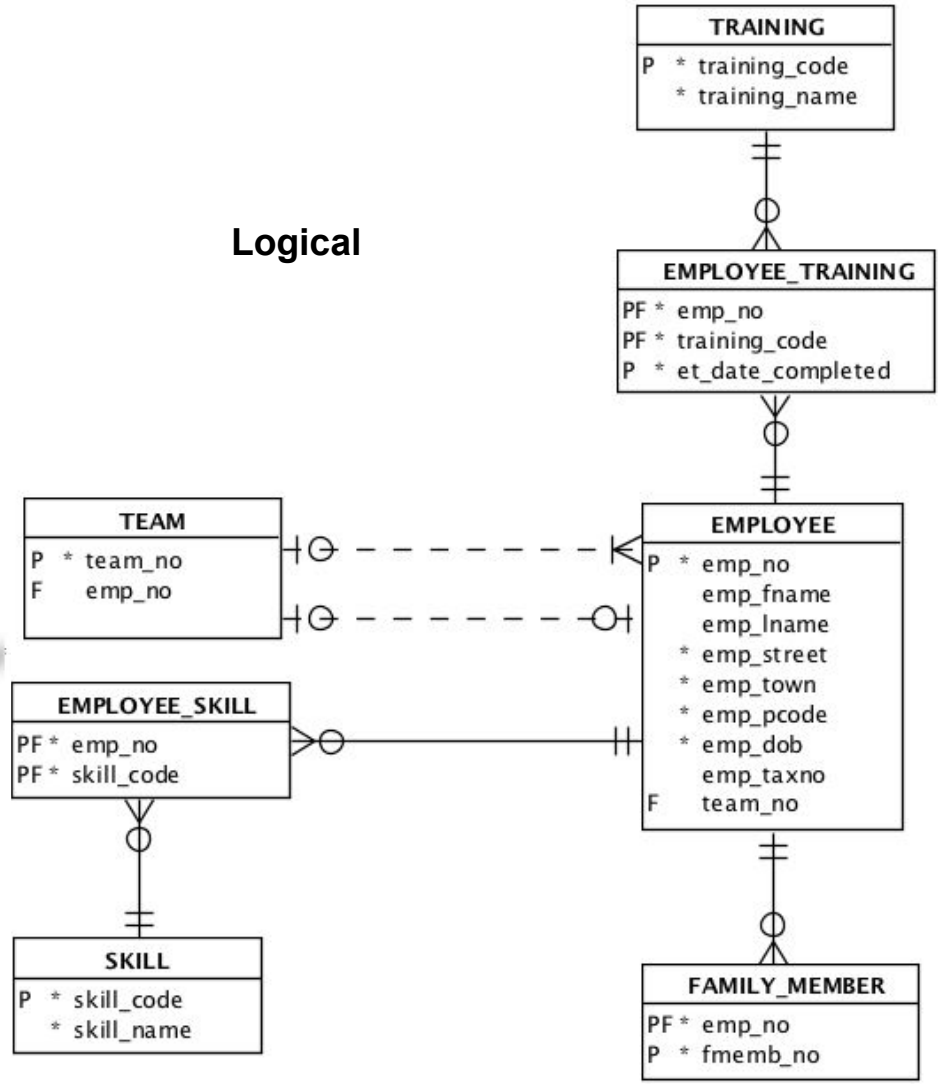
e.g. an example of this is when the conceptual model is not well-designed.
Consider a CUSTOMER table with a strict 1:1 with ADDRESS
(assuming customers must have only one address and people cannot share addresses).

… it's better to consolidate them into CUSTOMER (as seen in our previous case studies).

Conceptual



Logical



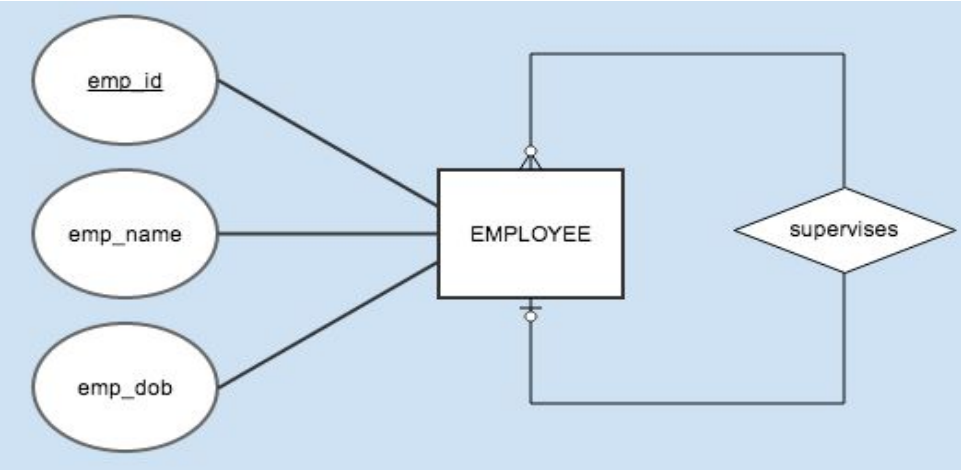
MONASH University

[Clayton Q&A]: **This is a snapshot of our logical model before we move to Step 5 on Unary Relationships.**

STEP 5: Map unary relationships

- Unary Relationship is a relationship between the instances of a **single** entity type.
- **Unary 1:M Relationship** – A relation is created for the entity type. Add a FK within the same relation that references the PK of the relation. A recursive foreign key is a FK in a relation that references the PK values of the same relation.
- **Unary M:N Relationship** – Two relations are created, one for the entity type in the relationship and the other as the associative relation to represent the M:N relationship itself. The PK of the associative relation consists of two attributes (with different names) taking their values from the PK of the other relation.

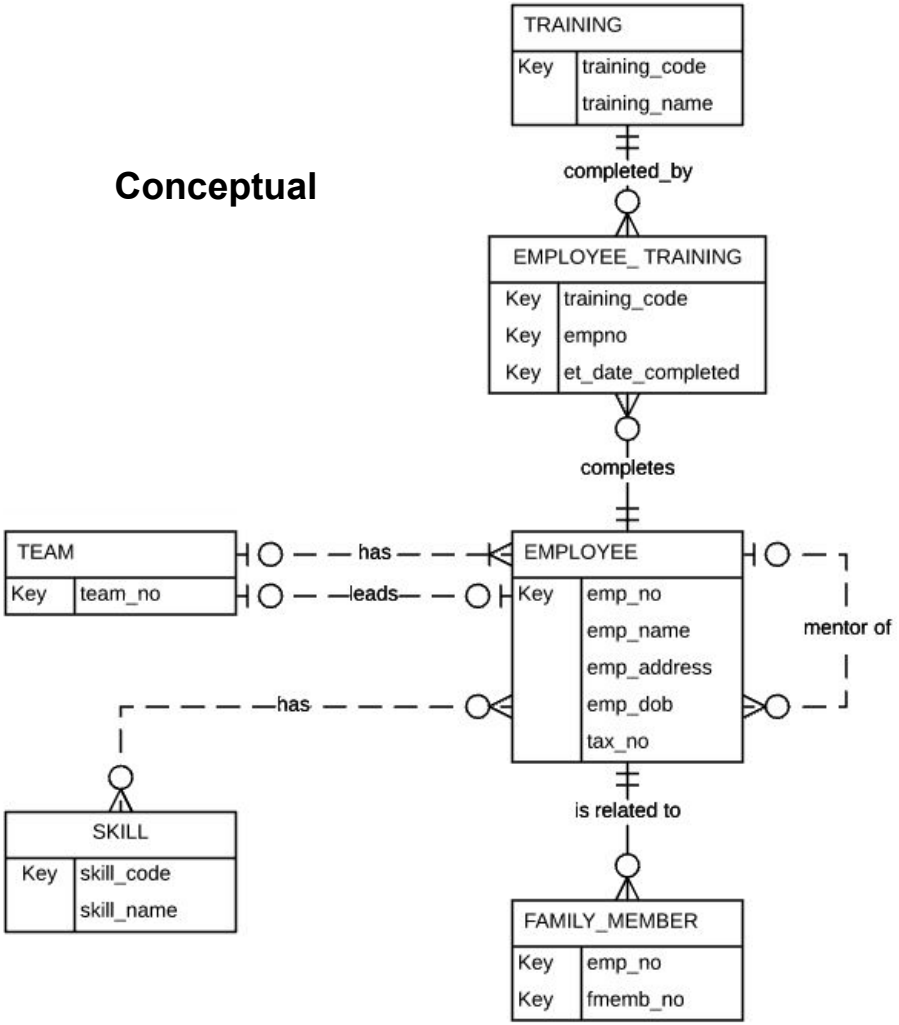
STEP 5: Map unary relationships
Mapping a 1:M Unary Relationship



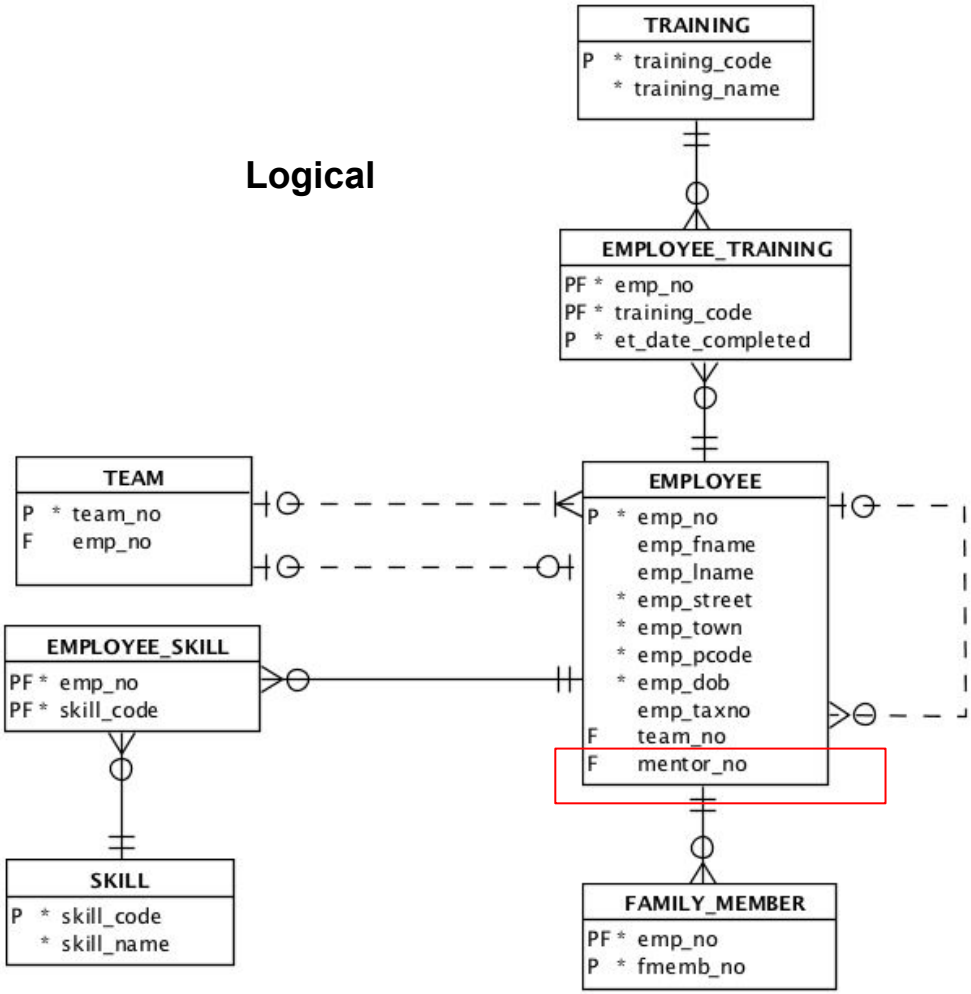
Unary 1:M Relationship – A relation is created for the entity type **[EMPLOYEE]**.
Add a FK within the same relation **[F mentor_no]** that references the PK of the relation (Recall: **[P emp_no]**).

As our case study says that there can be 0 or 1 supervisor per employee (say the CEO doesn't even need to be supervised!) therefore note that the "non null" asterisk (*****) is not required.

Conceptual

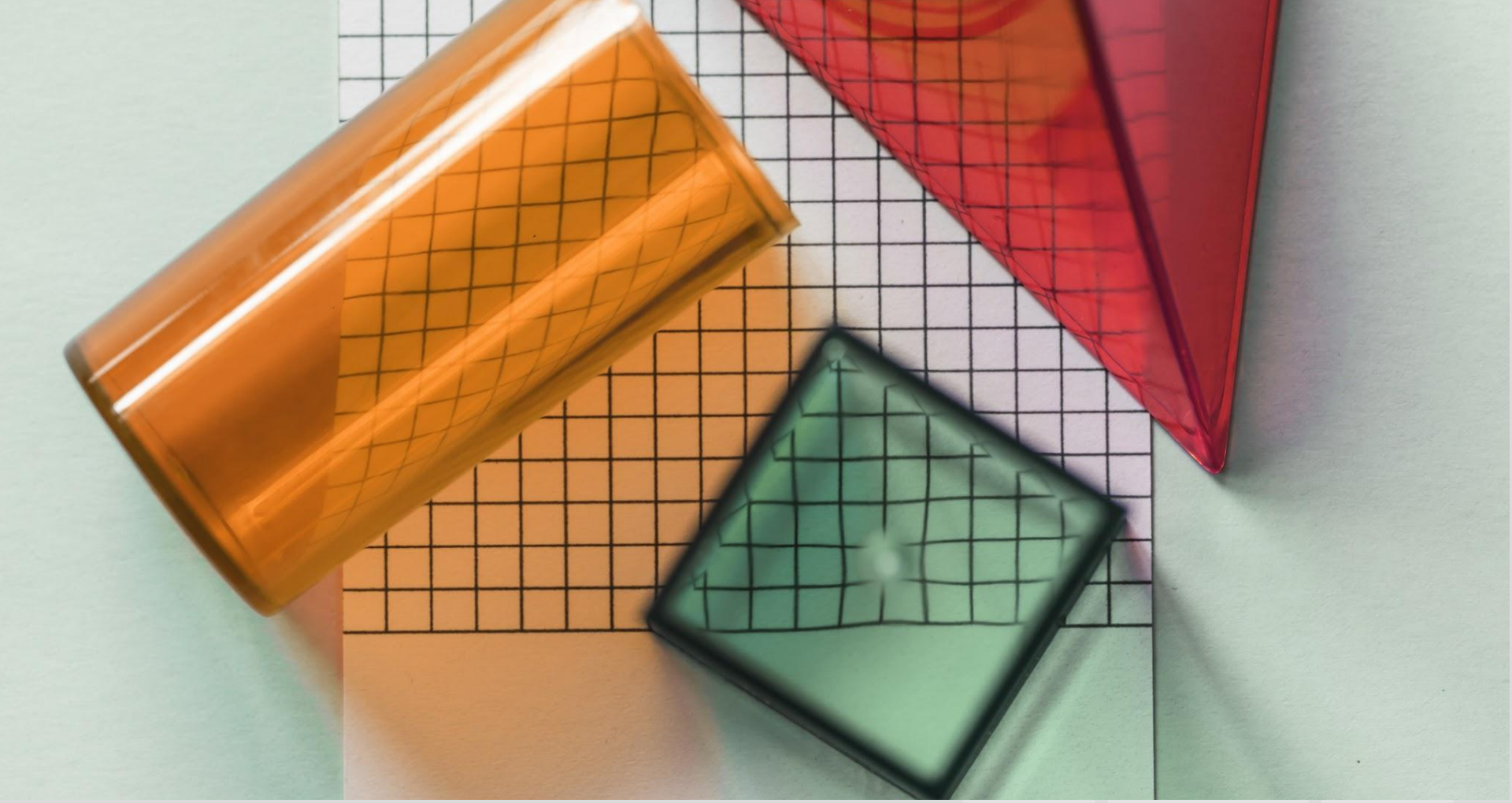


Logical



MONASH University

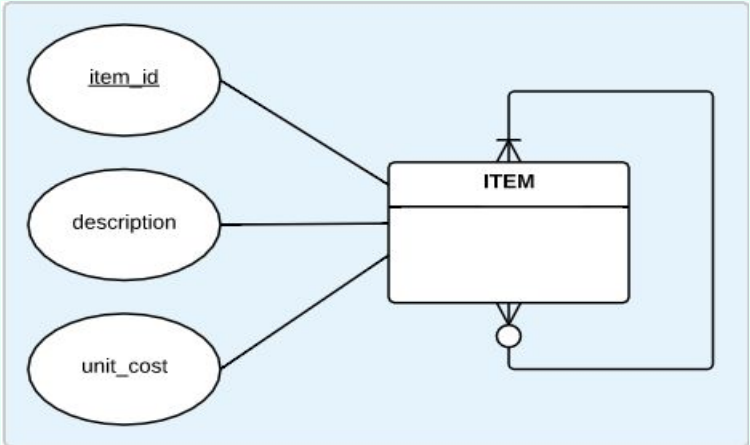
[Clayton Q&A]: **Note mentor_no is an F, but has no asterisk (*).**



Pause: few more slides to go…
Things will be complex so hang on!

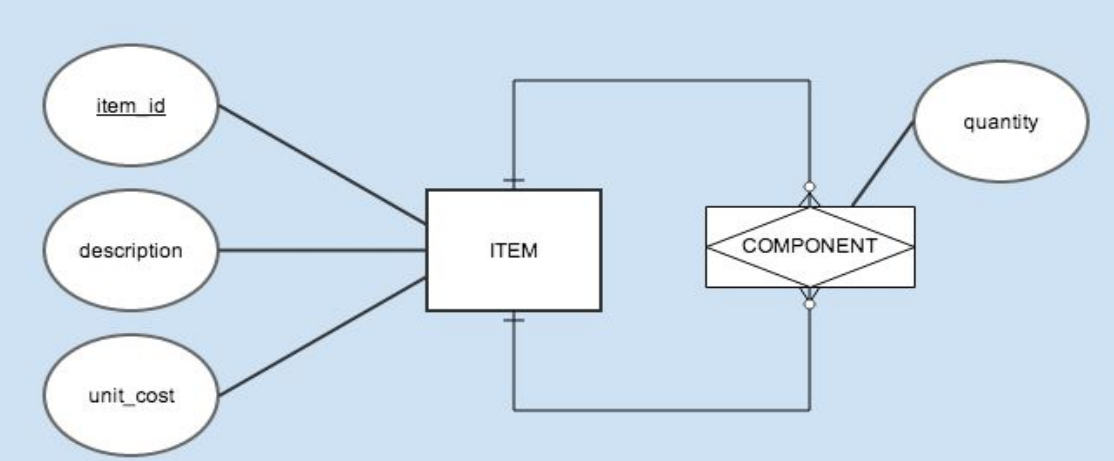
Img src: RawPixel @rawpixel at Unsplash

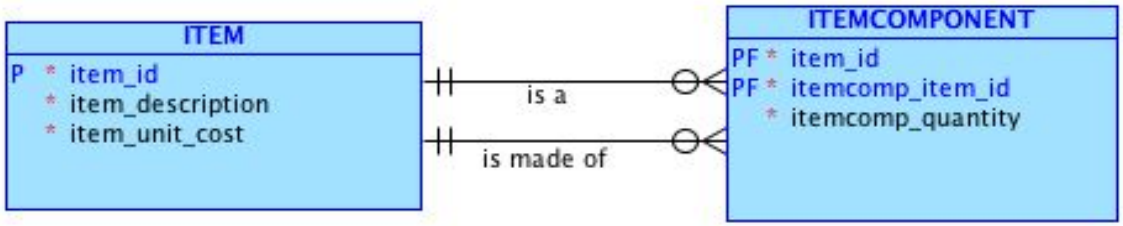
Q5. How many relations/tables and relationships do we need to implement the model below into a relational model?



a. 2 tables, 1 relationship
b. 2 tables, 2 relationships
c. 3 tables, 2 relationships
d. 4 tables, 3 relationships

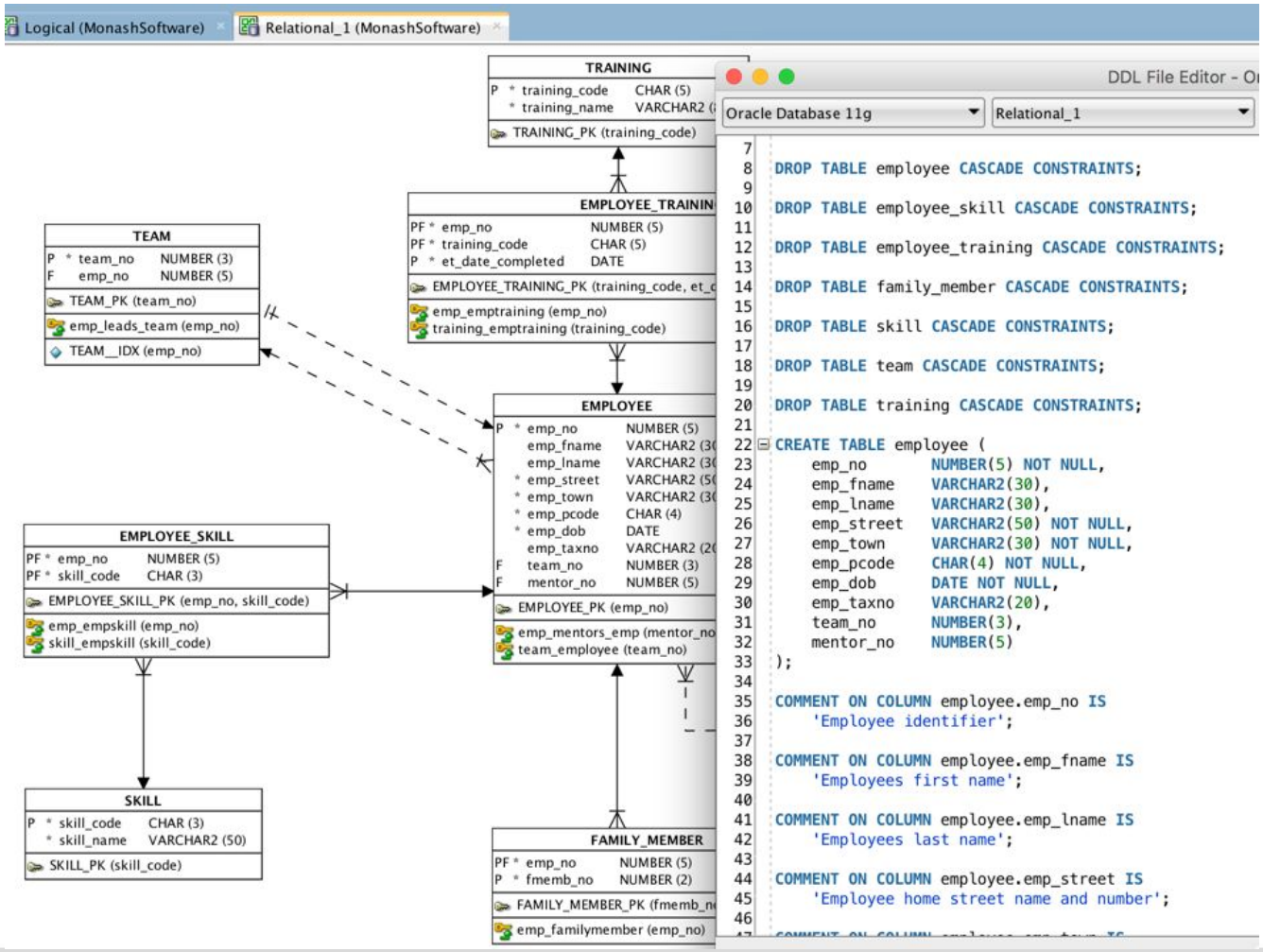
STEP 5: Map unary relationships
Mapping a M:N Unary Relationship



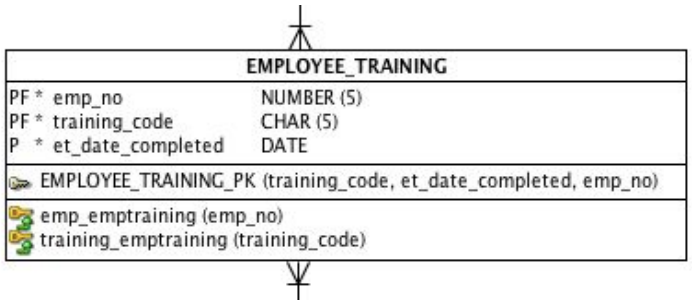


[Clayton Q&A]: **Thankfully our case study doesn't have this!**
This example simulates a situation in a hardware store (e.g. Bunnings) where...
an Item (e.g. "Wooden Stool") is made of other Items ("Nail 70x3.1", "Wood 500mm", "Cushion A12"), or
an Item (e.g. "1000 pack Nails 70x3.1") is another Item ("Nail 70x3.1") with qty = 1000.

Practicalities: SQL Developer Data Modeler



Practicalities: Adding surrogate keys



Surrogate PK's may be added **ONLY** on the logical model provided they are justified (include in documentation / assumptions)

Potential problem:

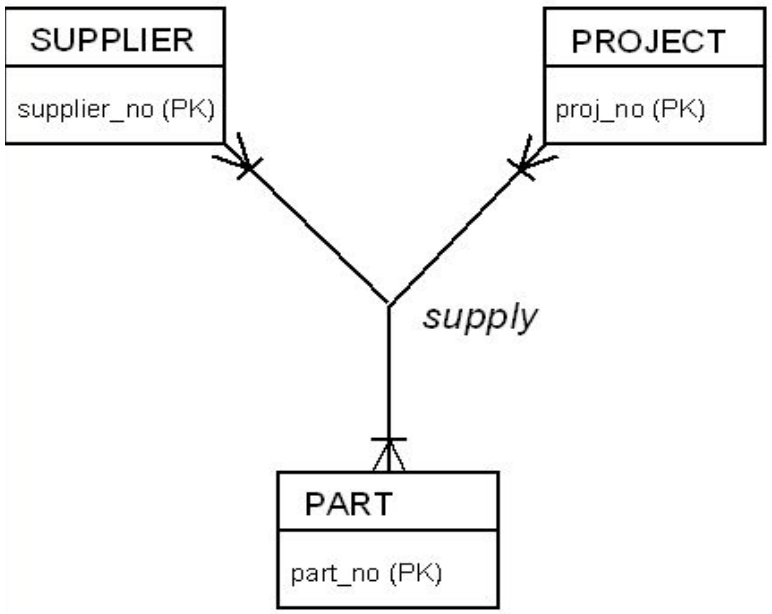
Need to ensure that the identified key from the conceptual model (emp_no, training_code, et_date_completed) will still remain unique

- define a unique index on attributes of key
- Example Business Rule: we need to itemise each and every attempt at training by an employee for a given code and date (say if an employee fails a test and is required by HR to redo the training up to X times in a day)

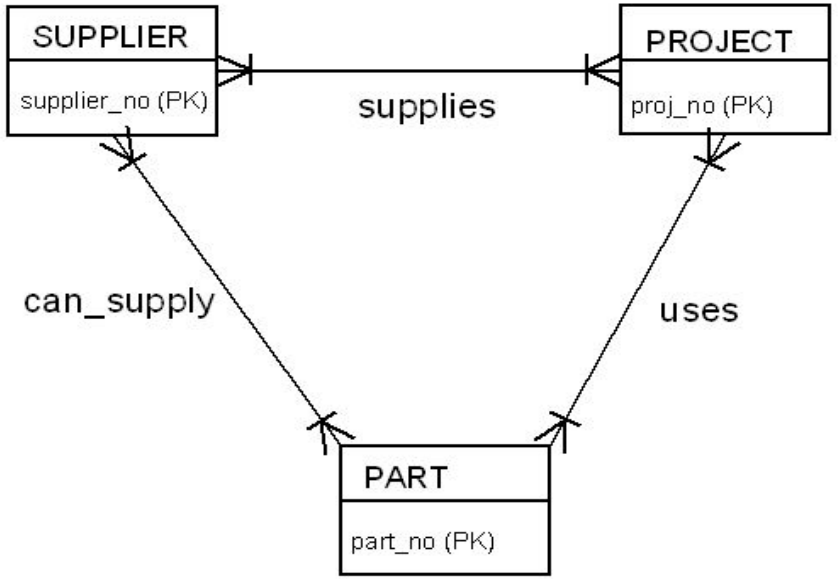
et_no	emp_no	training_code	et_date_completed
1	101	ORA01	1-Oct-2016
2	101	ORA01	1-Oct-2016
3	101	ORA01	1-Oct-2016

STEP 6: Ternary Relationships

Ternary



modelled as binary:



STEP 6: Ternary Relationships
Can we model as binary relationships?

- Ternary represents more information than three binary relationships
- For example - Supplier 1 (Bunnings Warehouse) supplies Project 2 (Clayton Apartments) with Part 3 (Heaters) -
  - ternary:
    instance (Bunnings Warehouse, Clayton Apartments, Heaters) exists
  - binaries
    - instances
      - (Bunnings Warehouse, Clayton Apartments)
      - (Clayton Apartments, Heaters)
      - (Bunnings Warehouse, Heaters)
    - **BUT does not imply (Bunnings Warehouse, Clayton Apartments, Heaters)**

[Clayton Q&A] Counterarguments: Bunnings can supply the Clayton Apts with Plywood only? Bob's Tools can supply the Clayton Apts with heaters? Bunnings can supply Notting Hill Hotel with heaters?

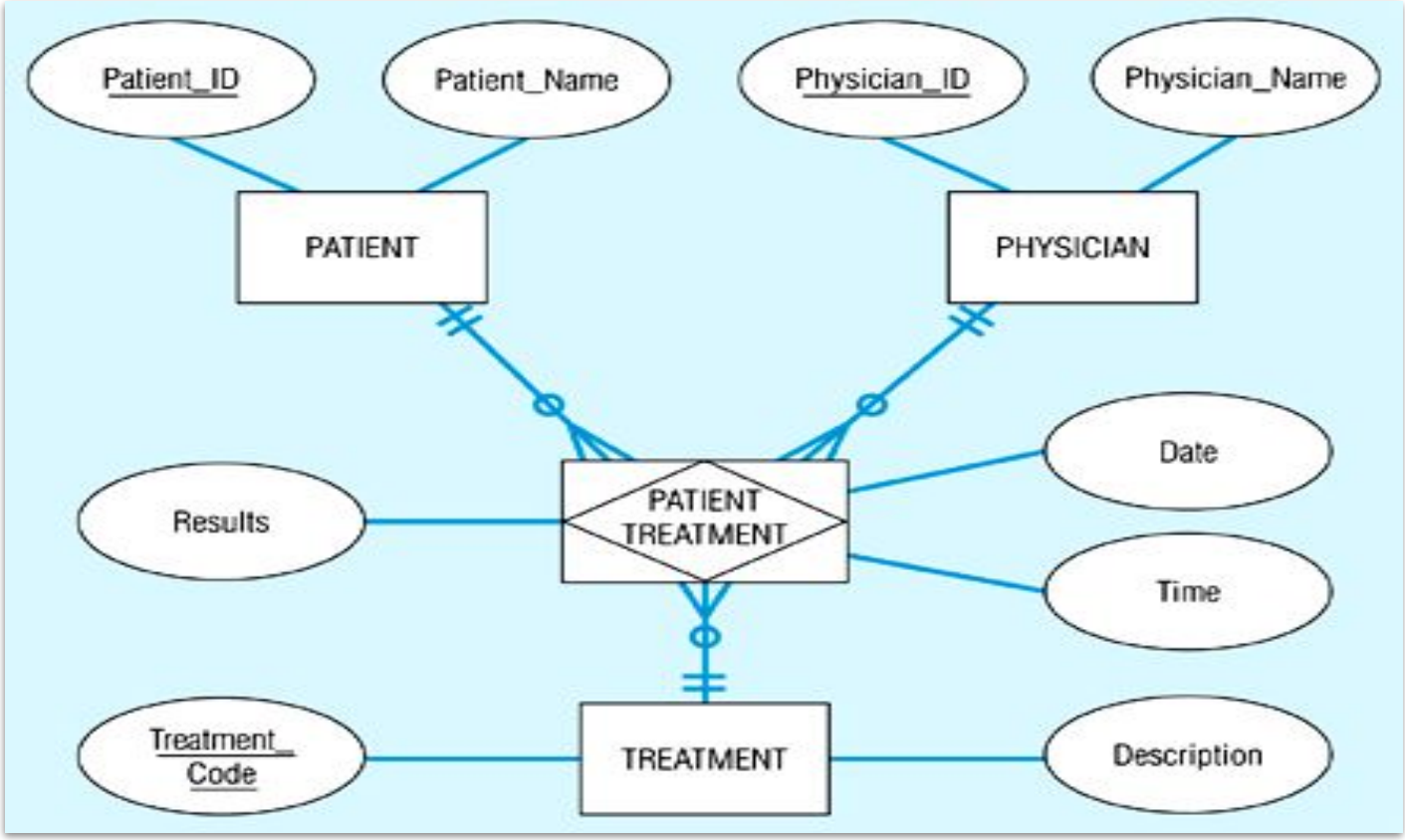
[Marc's Anecdote]
Can we model as binary relationships?

- According to Coronel & Morris (2018), 13th Ed.
  - "Ternary … implies an association between three different entities"

- Business case application: DOCTOR, PATIENT, PRESCRIPTION.
  - A ternary relationship allows all transactions to be 'accountable' especially in the above business case!
  - (Else, we will have to use [SQL] JOINs to combine 3x binary relationships to query…)

- How then do we map such relationships?

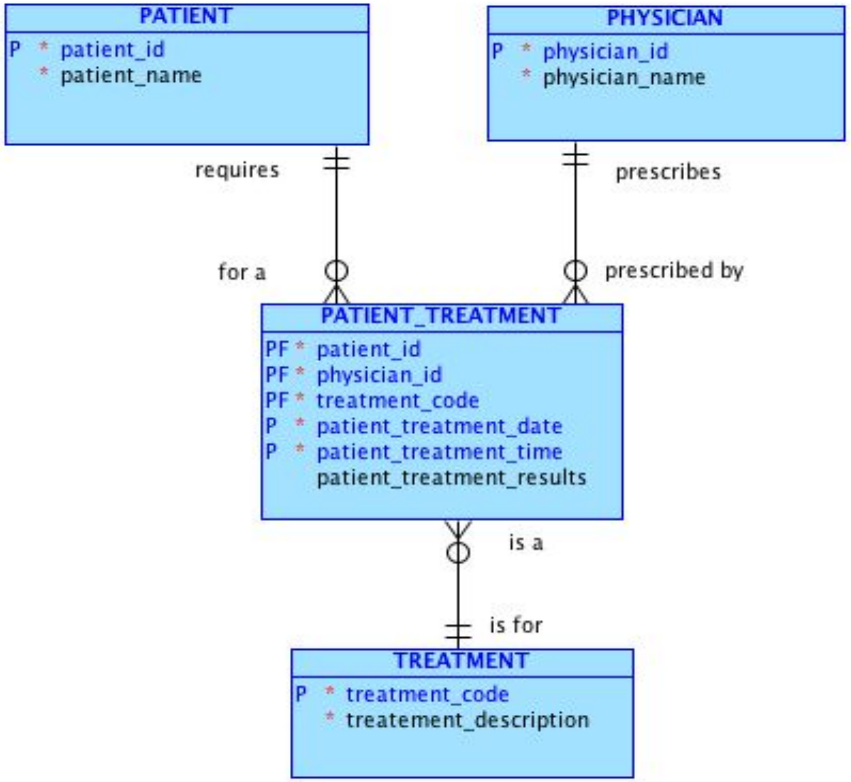
STEP 5: Mapping a Ternary Relationship



STEP 6: Ternary Relationships
Map Ternary (and n-ary) Relationships

- Ternary relationship should be converted to an **associative entity.**
  - To map an associative entity type that links three regular entity types, an associative relation is created.
  - The default PK of this relation consists of **the three PK attributes for the participating entity types.**
  - Any attributes of the associative entity type become attributes of the new relation.

STEP 5: Mapping a Ternary Relationship



Reference

Hoffer, J. A. , Prescott, M. B. & McFadden, F. R.
“Modern Database Management”