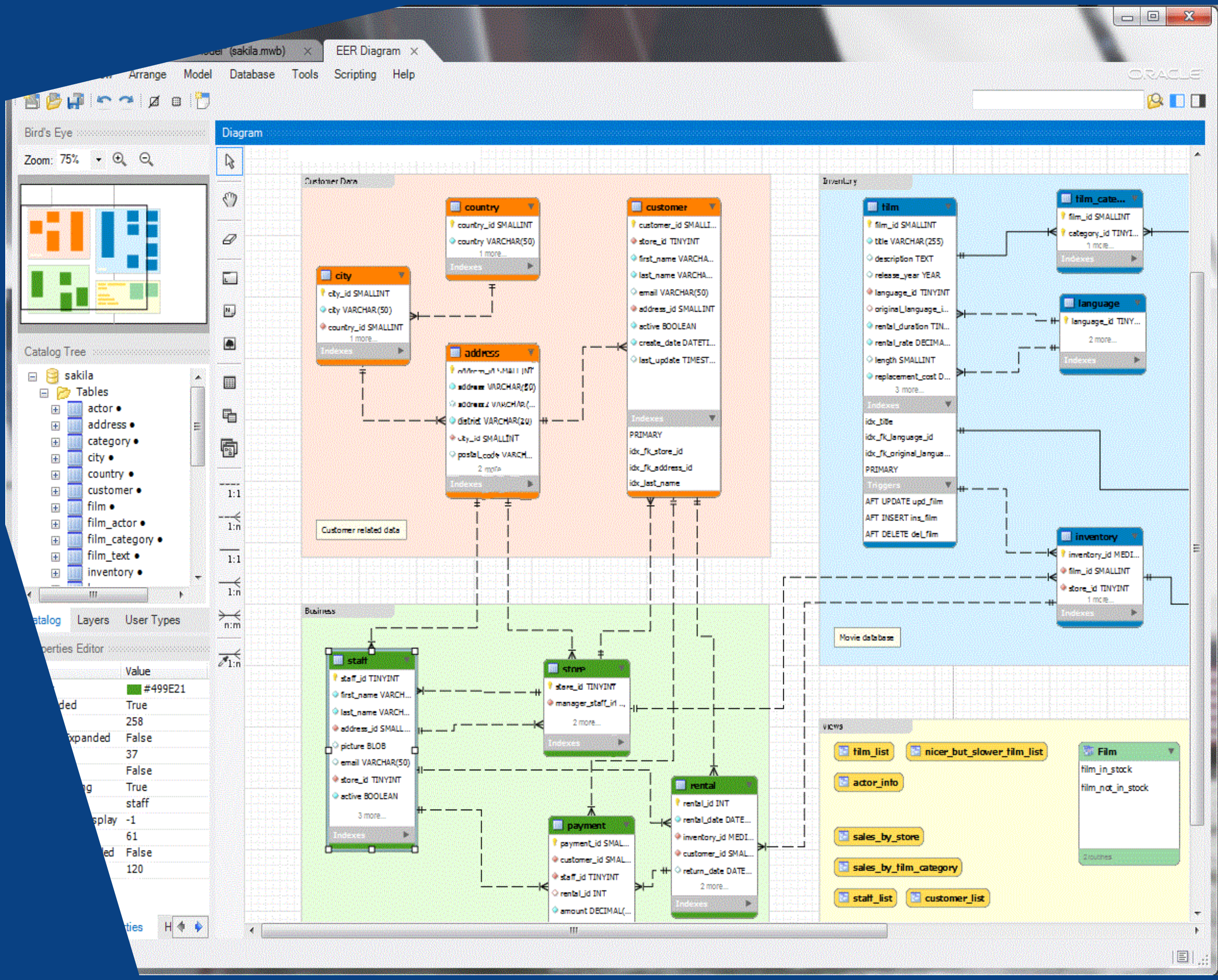
THE UNIVERSITY OF MELBOURNE

Modelling with MySQL Workbench. Data Types



Database Systems & Information Modelling INFO90002

Week 3 – MySQL Workbench
Dr Tanya Linden
Dr Renata Borovica-Gajic
David Eccles

Modelling with Workbench

- Modelling with MySQL Workbench

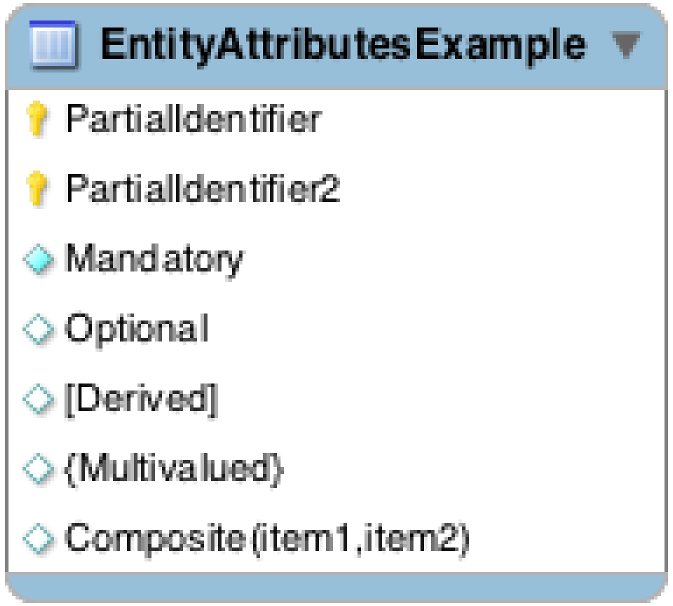
Revision and further design

- Conceptual Design
- Logical Design
- Physical Design
- Data Types

Conventions of ER Modelling (Workbench)

- Entity

- Attribute



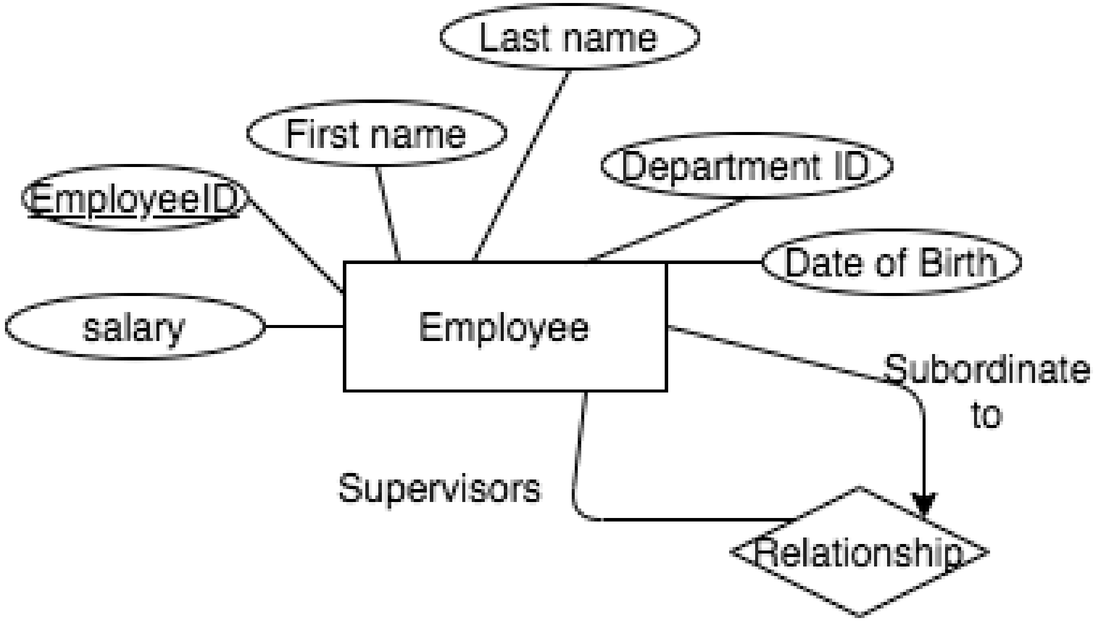
- **Identifier or key:**
  - Fully identifies an instance

Partial Identifier:

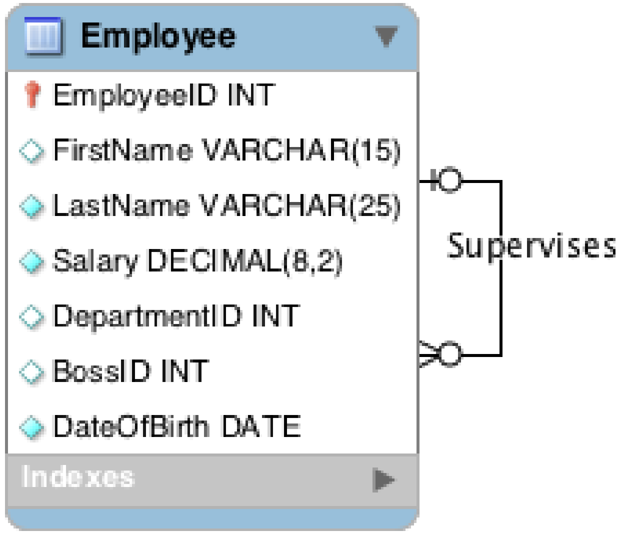
- Identifies an instance in conjunction with one or more partial identifiers
- **Attributes types:**
  - Mandatory (blue diamond)
  - Optional (empty diamond)
  - Derived []
    - [Age]
  - Multivalued {}
    - {CarColour}
  - Composite ()
    - Name (First, Middle, Last)
    - Address (Street, Suburb, Postcode)

Unary relationships

Chen Notation (conceptual)

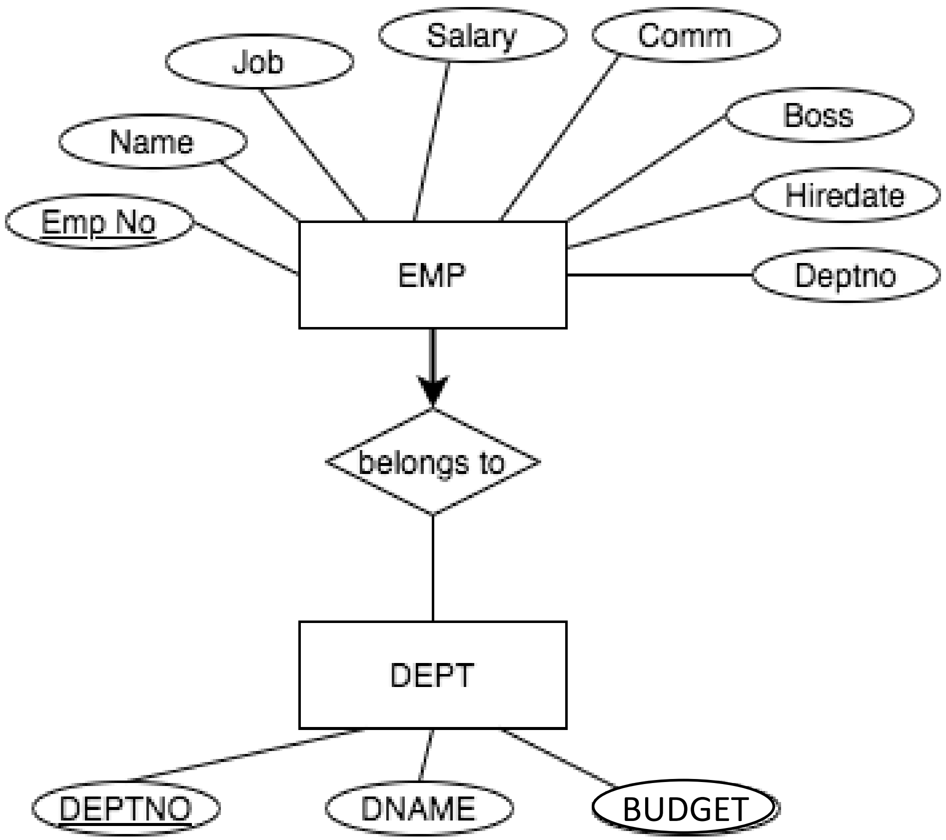


Crows foot notation (logical and physical modelling)

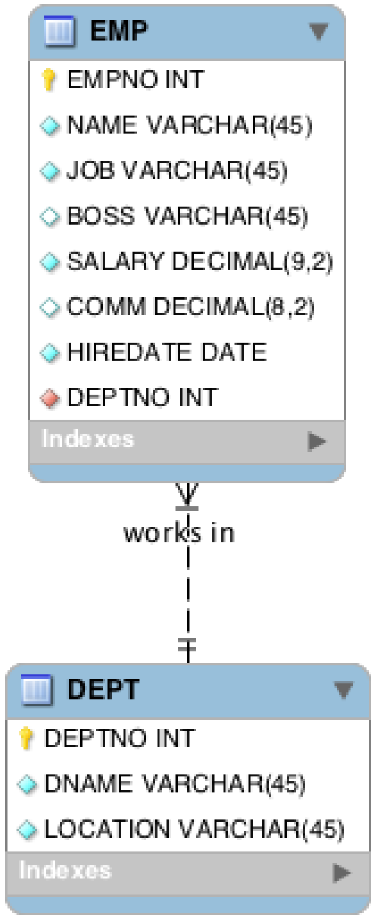


Binary relationships

Chen Notation (conceptual)

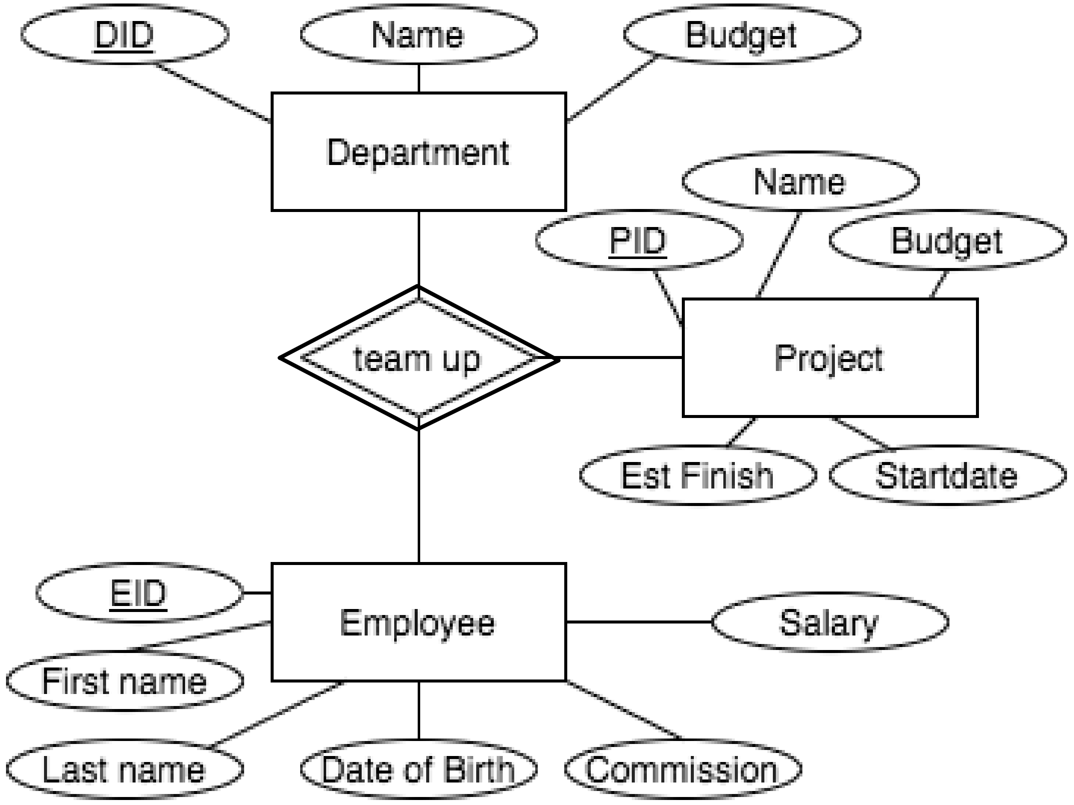


Crows foot notation (logical and physical modelling)

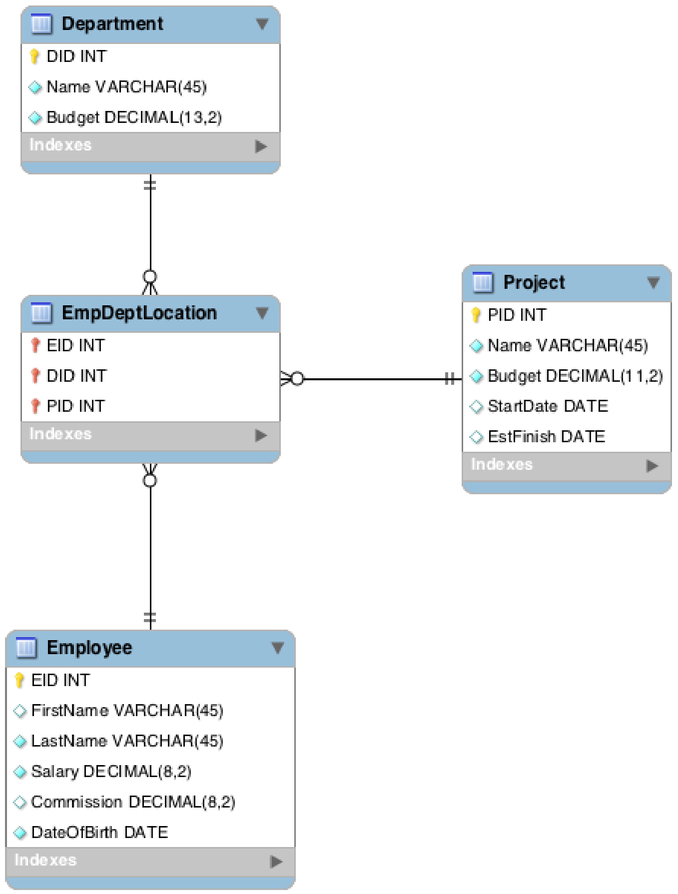


Ternary relationships

Chen Notation (conceptual)

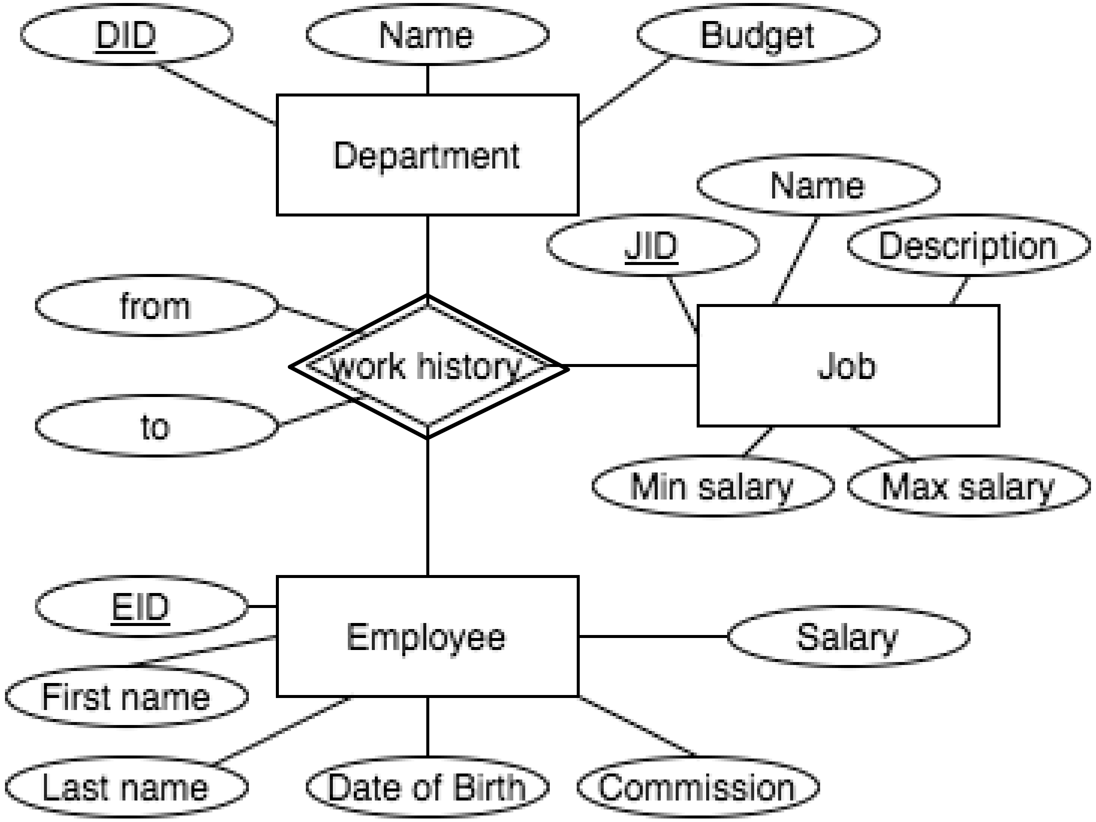


Crows foot notation (logical and physical modelling)

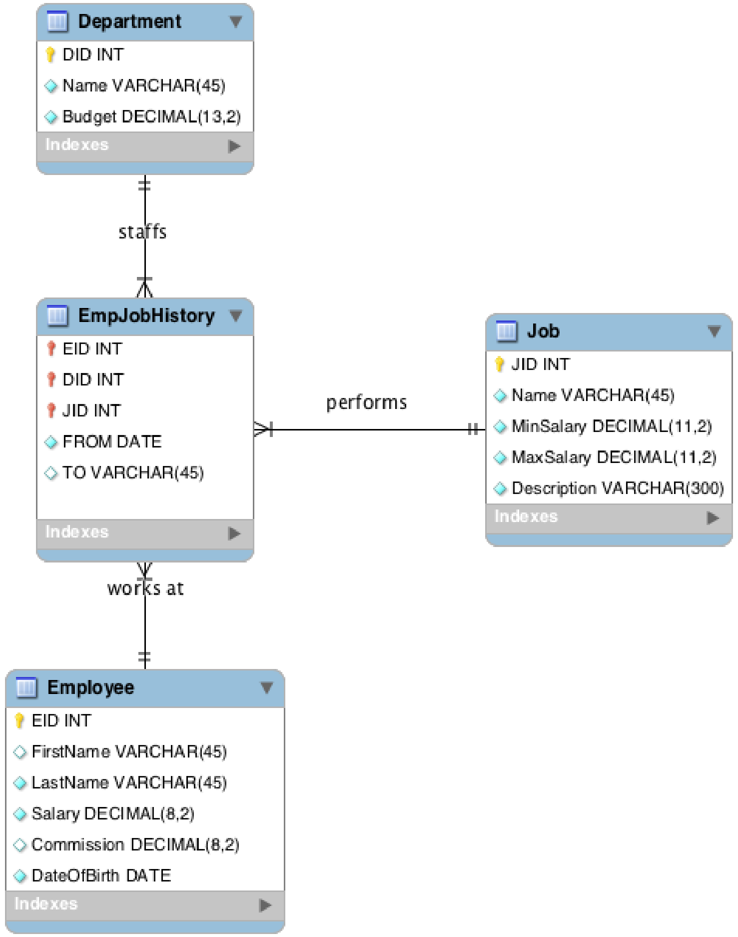


Ternary relationships with attribute

Chen Notation (conceptual)

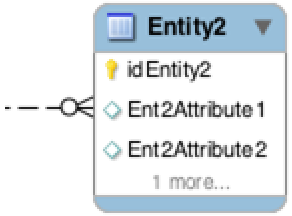


Crows foot notation (logical and physical modelling)

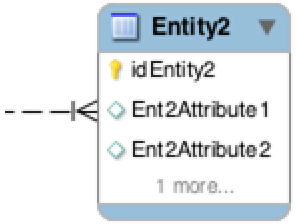


Conventions of ER Modelling

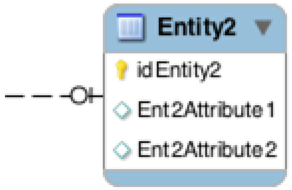
- Cardinality Constraints



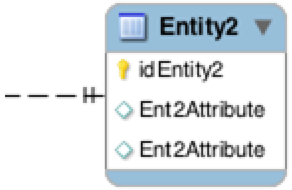
Optional Many
Partial participation
Without key constraint



Mandatory Many
Total participation
Without key constraint



Optional One
Partial participation
Key constraint



Mandatory One
Total participation
Key constraint

- Relationship Cardinality
  - One to One

    Each entity will have exactly 0 or 1 related entity
  - One to Many

    One of the entities will have 0, 1 or *more* related entities, the other will have 0 or 1.
  - Many to Many

    Each of the entities will have 0, 1 or *more* related entities

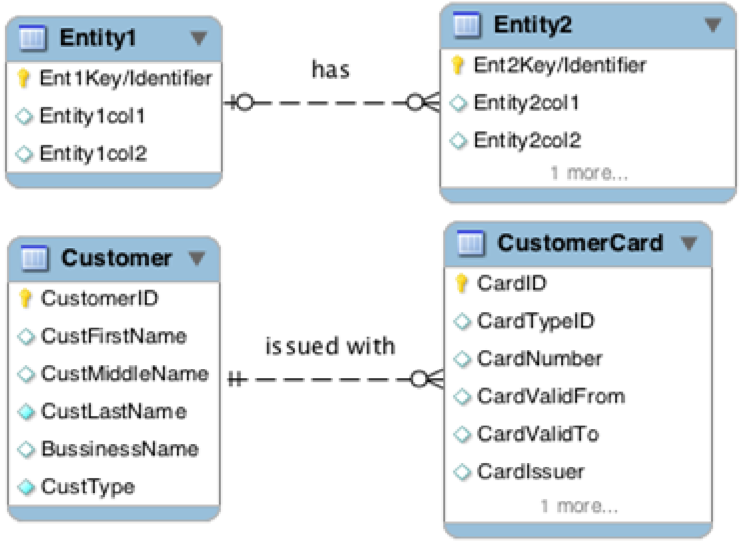
Conventions of ER Modelling

Strong Entity:

Can exist by itself

E.g. Customer Card, Customer

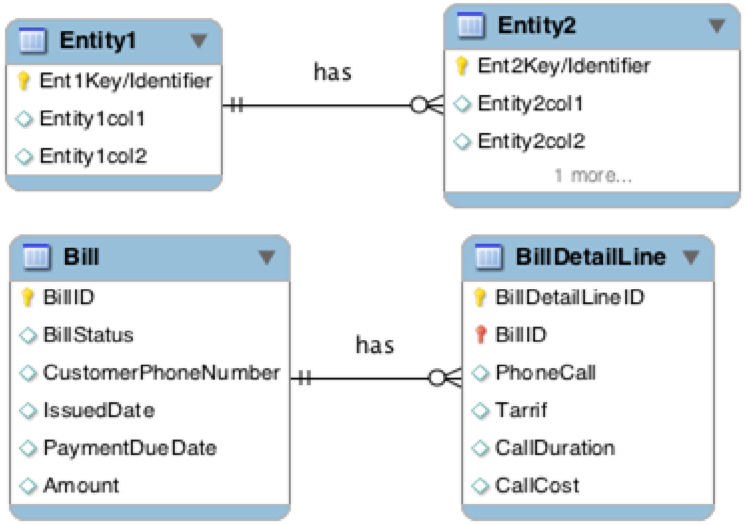
o



Weak Entity

Can't exist without the owner

E.g. BillDetailLine



Good / Bad Entity Selection

- Entity
  - Will have many instances in the database
  - Is composed of many attributes
  - Is something needed for the system to work (something we are trying to model)
- Examples
  - Person: EMPLOYEE, STUDENT, PATIENT
  - Place: STORE, WAREHOUSE, STATE
  - Object: MACHINE, BUILDING, VEHICLE
  - Event: SALE, REGISTRATION, BROADCAST
  - Concept: ACCOUNT, COURSE, ROLE
- An Entity IS NOT
  - A user of the system
  - An output of the system (i.e. a report)

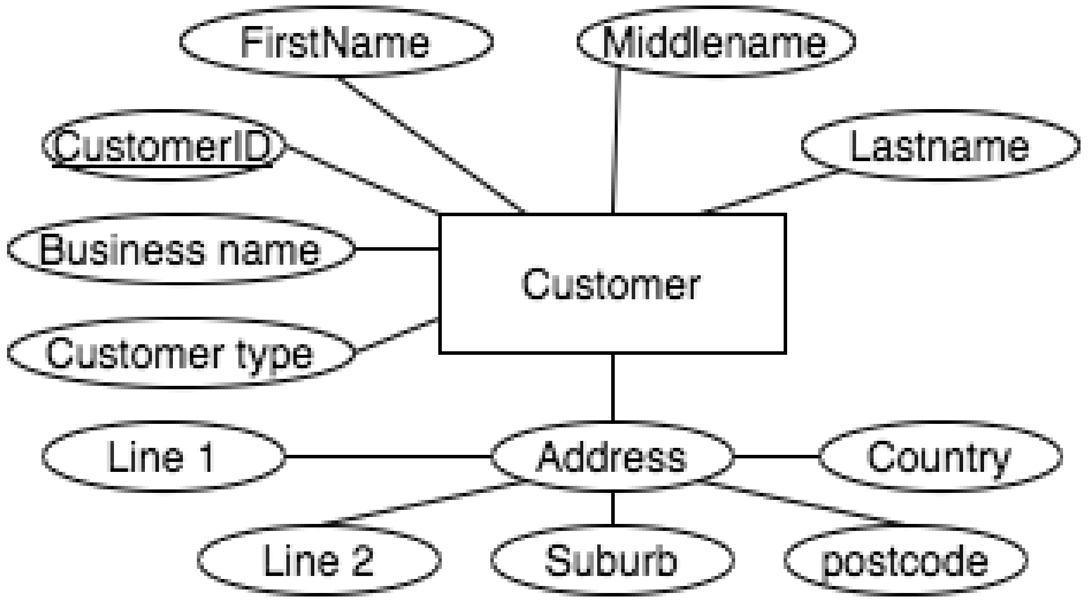
A **Kooyong Road medical practice** needs a database to store details of patients, doctors and appointments.

Questions

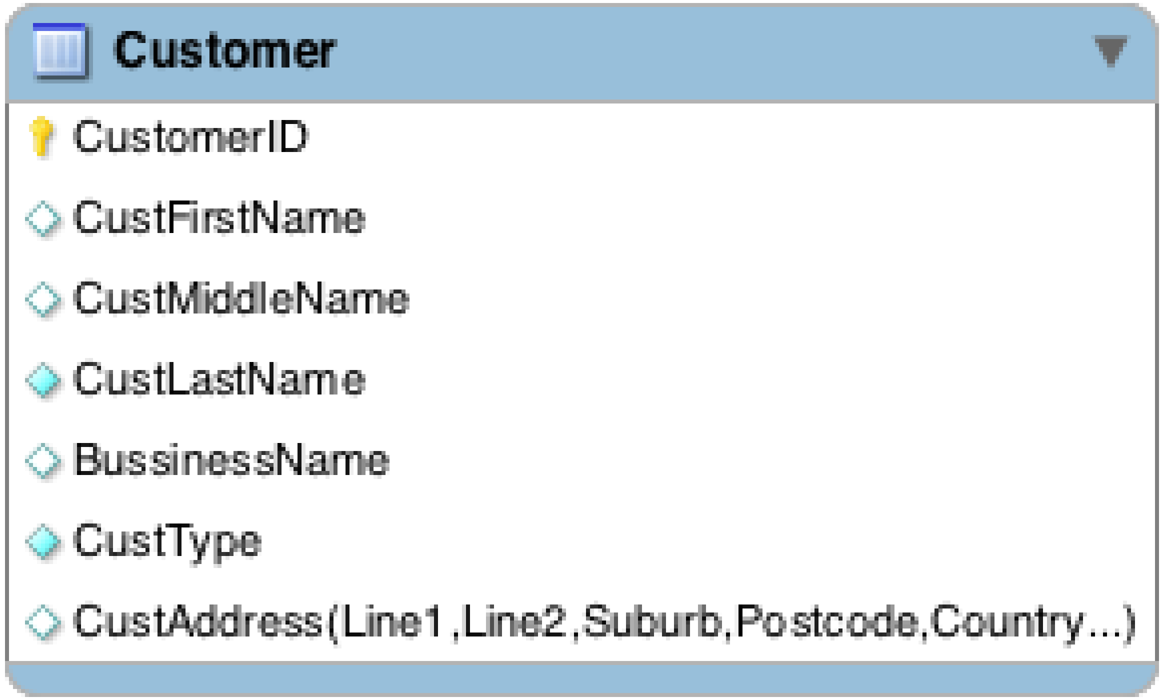
1. Is **Kooyong Road medical practice** an entity in the database?
2. Will a **receptionist** who will be adding patients to the database and recording appointments become an entity in this database?

Single Entity Conceptual

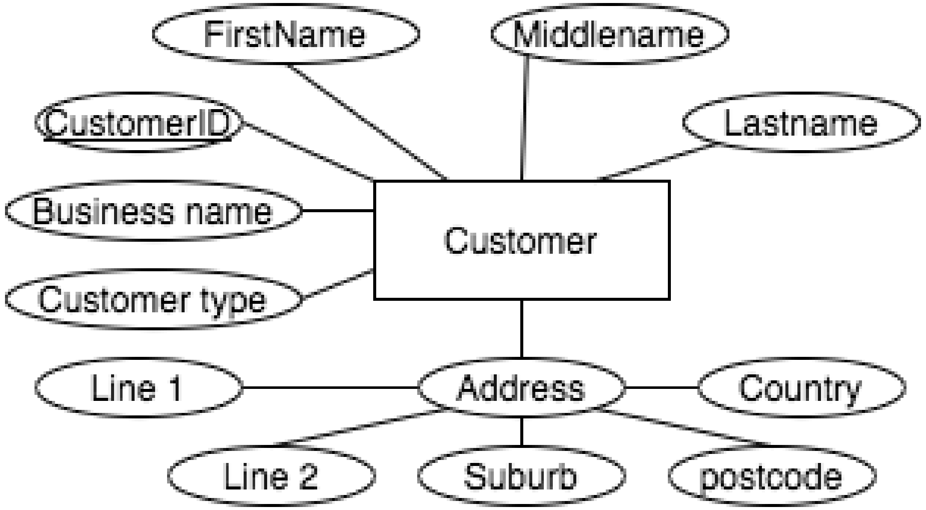
Chen



Crows Foot

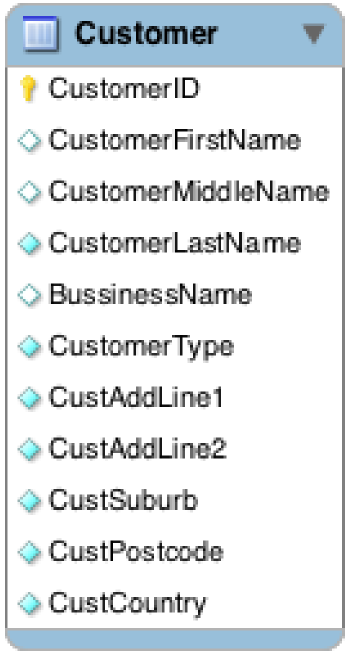


Convert from Conceptual to Logical design (Single Entity)



- Convert the ER into a logical (rel.) model

  Customer=(<u>CustomerID</u>, CustFirstName, CustMiddleName, CustLastName, BusinessName, CustType, CustAddLine1, CustAddLine2, CustSuburb, CustPostcode, CustCountry)



- **Tasks checklist:**
  1. Convert composite and multi-valued attributes
     - Multi-Attribute values can become another table
  2. Resolve many-many relationships
  3. Add foreign keys at crows foot end of relationships (on the many side)

Convert from Logical to Physical Design

Inputs

- Normalised relations
  - (Next lecture)
- Attribute definitions
- Response time expectations
- Data security needs
- Backup / recovery needs
- Integrity expectations
- DBMS technology used

Leads to

Decisions

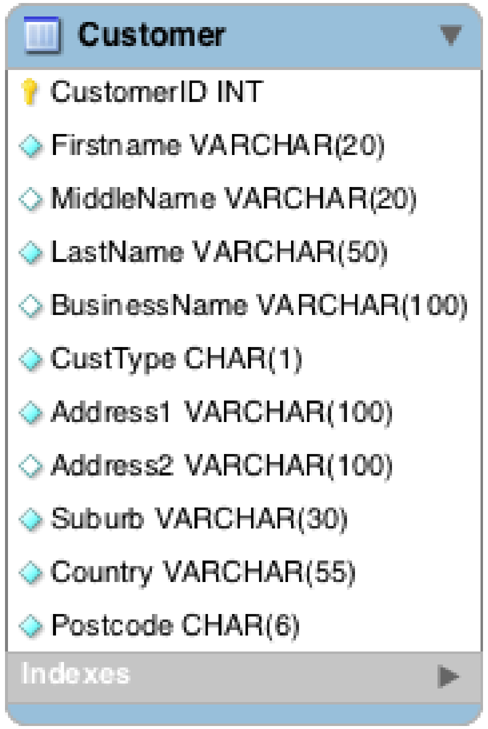
- Attribute data types
- Physical record descriptions
  - These don’t always match the logical design
- File organisations
- Indexes and database architectures
- Query optimisation

The physical record is **a group of fields stored in adjacent memory locations and retrieved together as a unit**.
The design of the physical record can also affect the speed of access to the record and the amount of disk space needed to store the record data.

Convert from Logical to Physical Design

- **Generate attribute data types**

Physical Design:

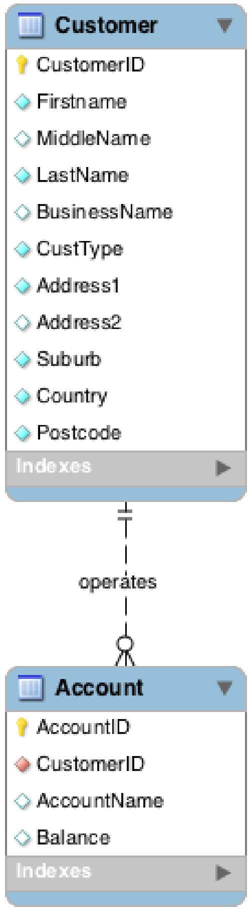


Implementation:

```
CREATE TABLE Customer(
  CustomerID   INT NOT NULL,
  FirstName    VARCHAR(20) NOT NULL,
  MiddleName   VARCHAR(20),
  LastName     VARCHAR(50) NOT NULL,
  BusinessName VARCHAR(100),
  CustType     CHAR(1) NOT NULL,
  Address1     VARCHAR(100) NOT NULL,
  Address2     VARCHAR(100),
  Suburb       VARCHAR(30) NOT NULL,
  Country      VARCHAR(55) NOT NULL,
  Postcode     CHAR(6) NOT NULL,
 PRIMARY KEY (CustomerID));
```

More than One Entity

- A customer can have a number of Accounts
- The tables are linked through a foreign key

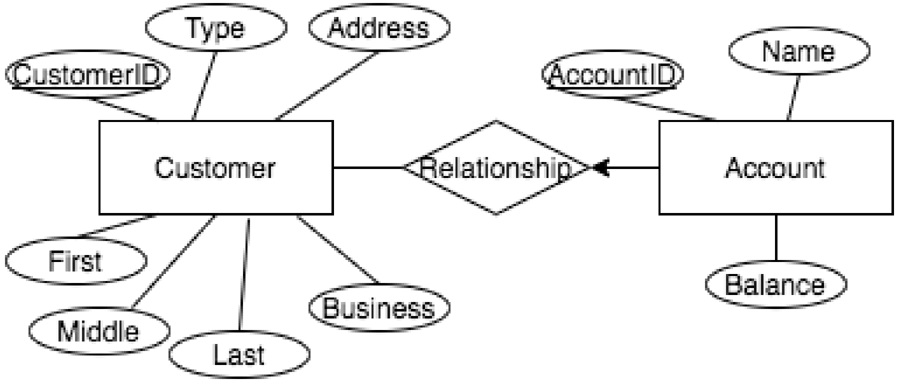


CustomerID	FirstName	MiddleName	LastName	BusinessName	CustType
1	Peter		Smith		Personal
2	James		Jones	JJ Enterprises	Company

AccountID	AccountName	Balance	CustomerID
01	Peter Smith	245.25	1
05	JJ Ent.	552.39	2
06	JJ Ent. Mgr	10.25	2

Conceptual to Logical Design - Account

Conceptual Design:



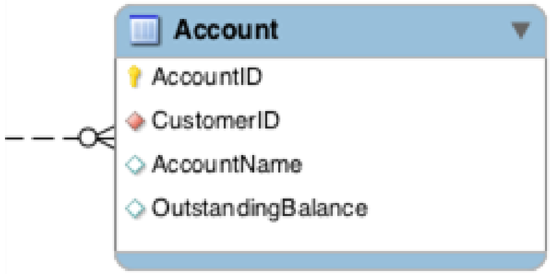
Tasks checklist:

1. Convert composite and multi-valued attributes
2. Resolve many-many relationships
3. Add foreign keys at crows foot end of relationships
   - See FK1 – CustomerID
   - Every row in the account table must have a CustomerID from Customer (referential integrity)

Logical Design:

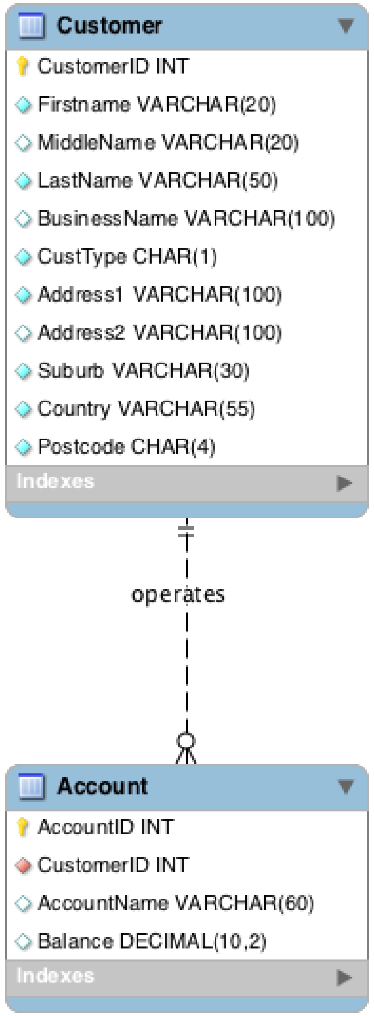
Account=(AccountID, AccountName, OutstandingBalance, *CustomerID*)

Note: Underline = PK,
Italic and underline = FK,
Underline and bold = PFK



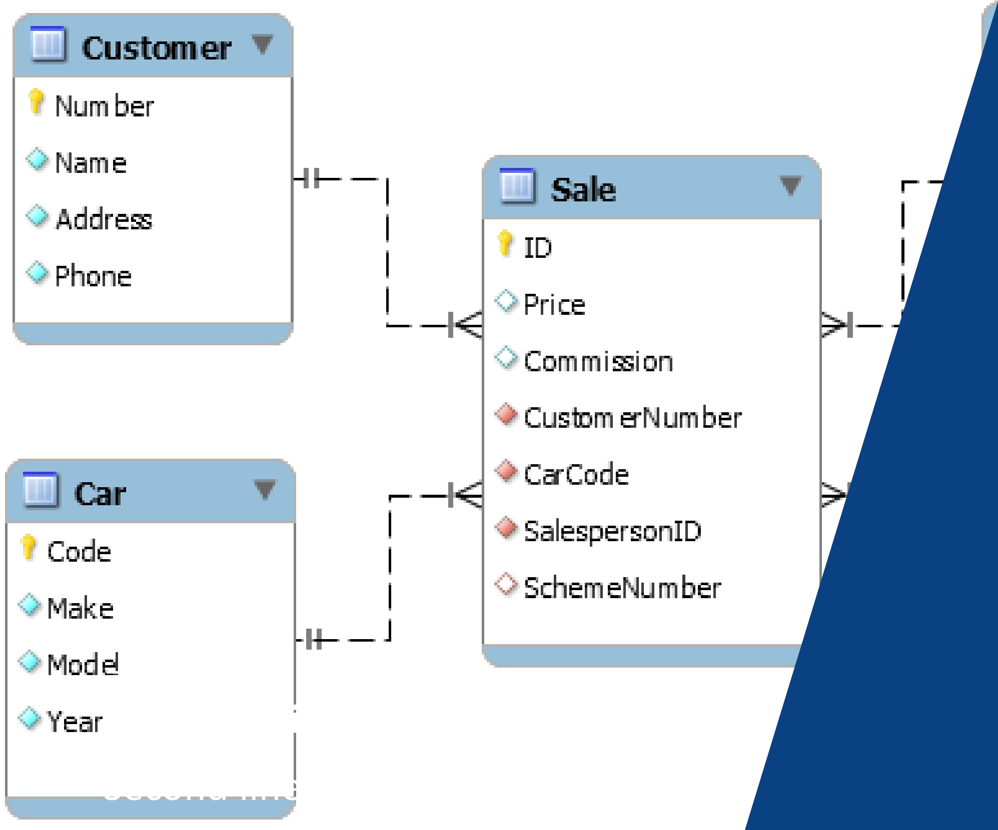
Design and Implementation - Account

Physical design:



Implementation:

```
CREATE TABLE Account (
  AccountID   INTEGER auto_increment,
  CustomerID INTEGER NOT NULL,
  AccountNameVARCHAR(60),
  Balance    DECIMAL(10,2),
  PRIMARY KEY (AccountID),
  FOREIGN KEY (CustomerID) REFERENCES Customer
    ON DELETE RESTRICT
    ON UPDATE CASCADE);
```



Conceptual to Physical ER Modelling

Multi-value Attributes

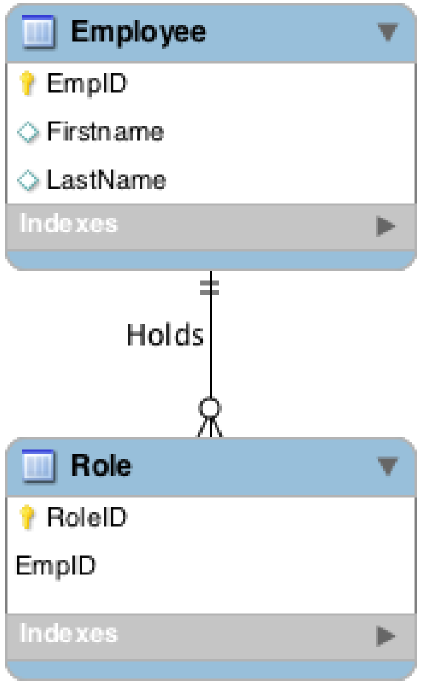
Many to Many (M:M) relations

One to One (1:1) relations

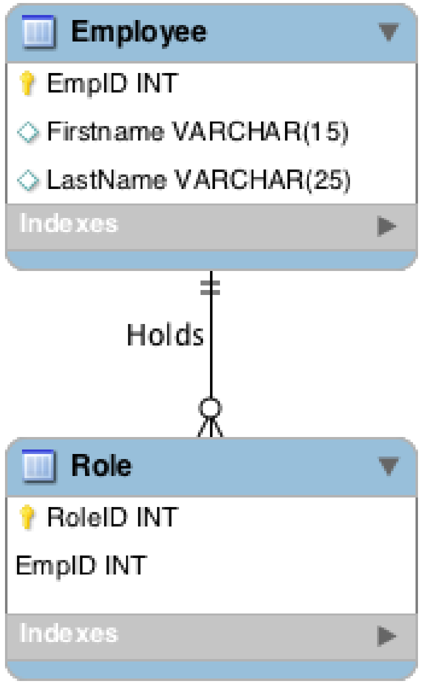
Dealing with Multi-Valued Attributes

Conceptual Design:

Logical Design:



Physical Design:



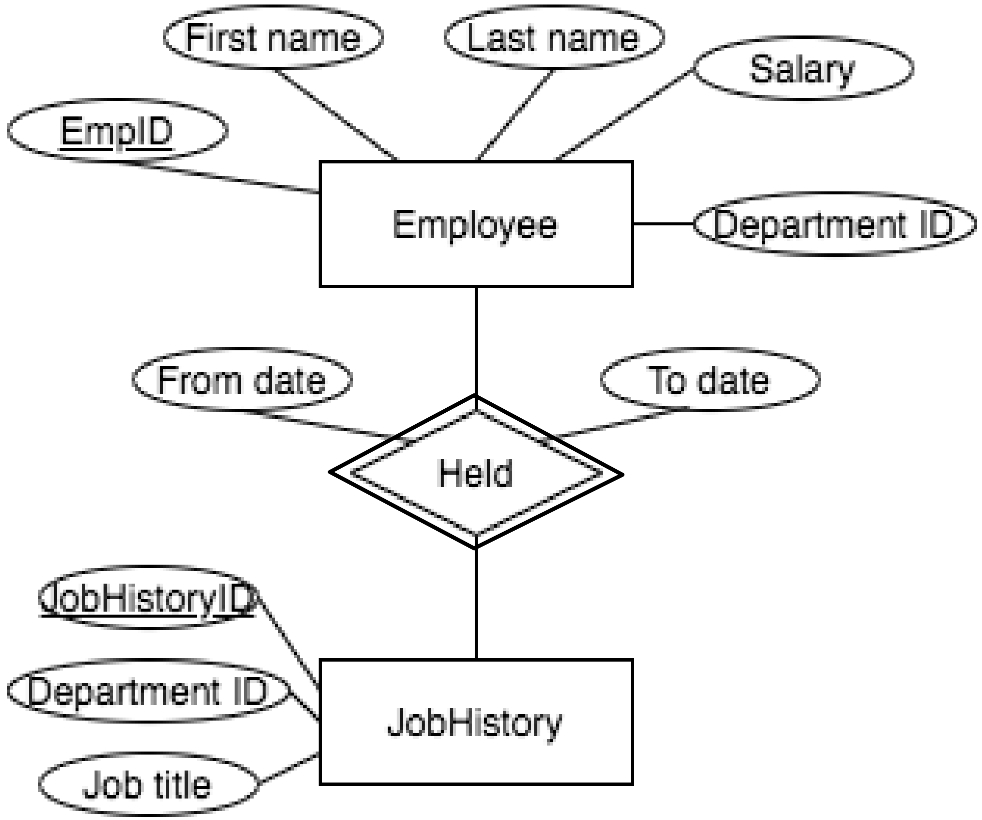
Role is an example of a *multi-value* attribute, denoted by { }

- Convert to several attributes?
- Convert to another entity?

If employees have only 2-3 roles, you may decide to have these within the Employee table at physical design to save on "JOIN" time

Many to Many Relationship

- How to deal with employee jobs/positions…
  - The fact is that employees change jobs within the company
    - AND we probably need to store a history of jobs for employee.
  - At the conceptual level it looks like this:



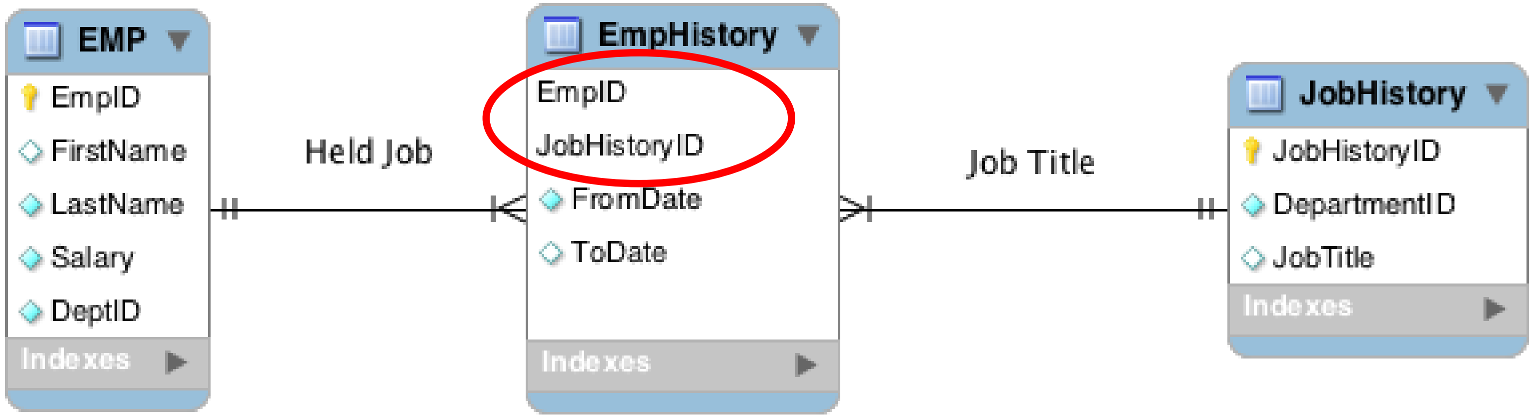
Many to Many - Logical Model

Emp(<u>EmpID</u>, FirstName, LastName, Salary, DeptID)

EmpHistory(<u>**EmpID**</u>, <u>**JobHistoryID**</u>, FromDate, ToDate)

JobHistory(<u>JobHistoryID</u>, DepartmentID, JobTitle)

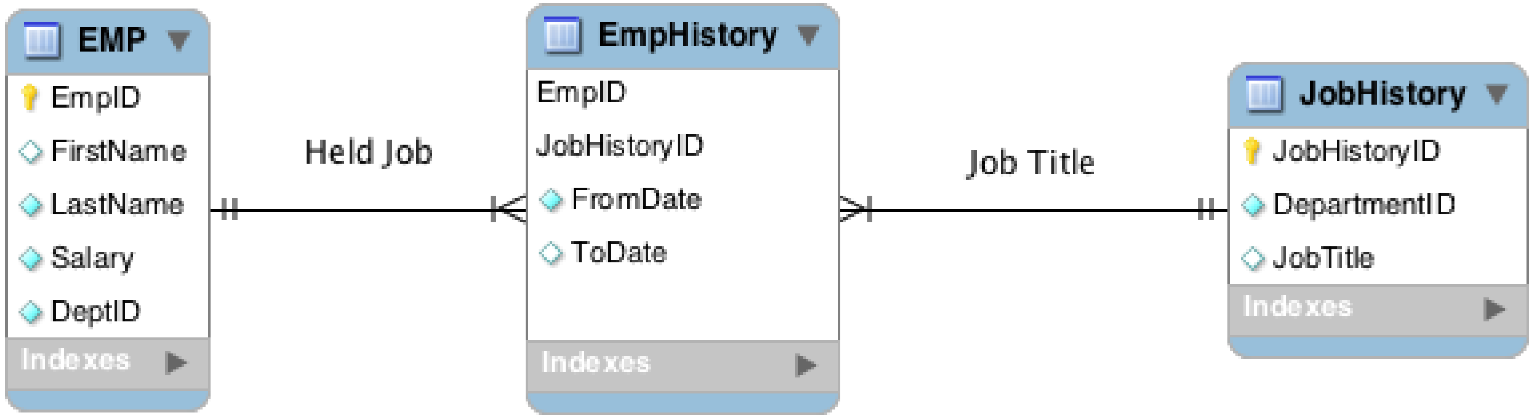
Note: Underline = PK,
Italic and underline = FK,
Underline and bold = PFK



In MySQL Workbench v8.0.x PFKs are displayed like this
They should be a RED KEY:
This is a cosmetic problem and there is a fix published on the LMS
for those who want the red key

Many to Many – Logical design (Workbench)

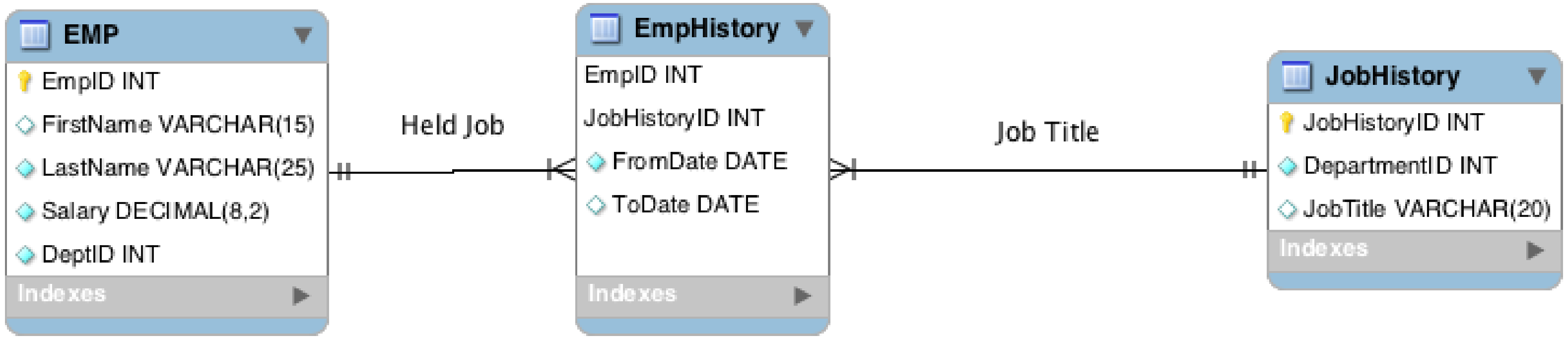
When converting the conceptual to the logical diagram we create an **Associative Entity** between the other 2 entities



Note: FromDate/ToDate are descriptive attributes of the relationship

- They go into the associative entity for M-M

Many to Many – Physical Model and Implementation



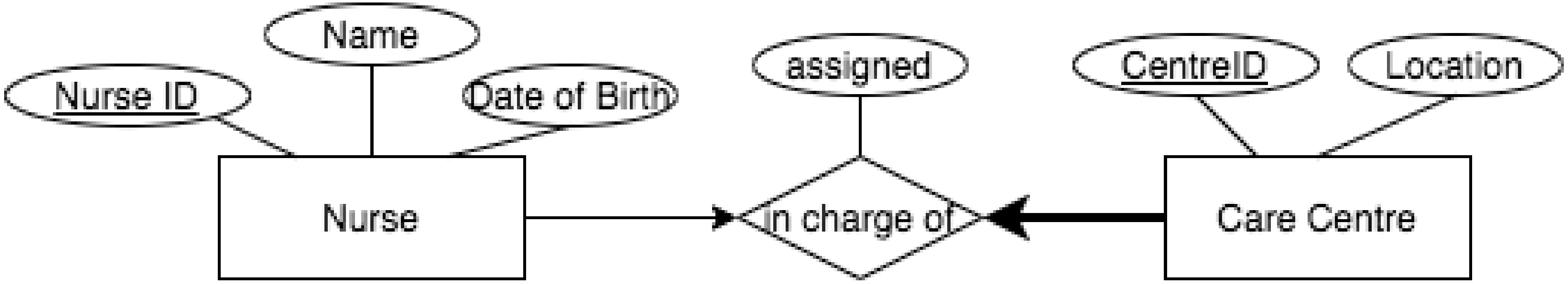

```sql
CREATE TABLE EMP
(EmpID integer,
FirstName varchar(15),
LastName varchar(25) NOT NULL,
Salary decimal (8,2) NOT NULL,
DeptID integer NOT NULL,
PRIMARY KEY (EmpID));
```

```sql
CREATE TABLE JobHistory
(JobHistoryID  integer,
DepartmentID integer NOT NULL,
JobTitle varchar(20),
PRIMARY KEY (JobHistoryID));
```

```sql
CREATE TABLE EmpHistory
(EmpID integer,
 JobHistoryID integer,
 FromDate DATE NOT NULL,
 ToDate DATE,
PRIMARY KEY (EmpID, JobHistoryID)
FOREIGN KEY EmpID REFERENCES EMP(EmpID),
FOREIGN KEY JobHistoryID REFERENCES JobHistory
                                (JobHistoryID));
```

One to One Relationship

- Rule: Move the key from the *one* side to the other side

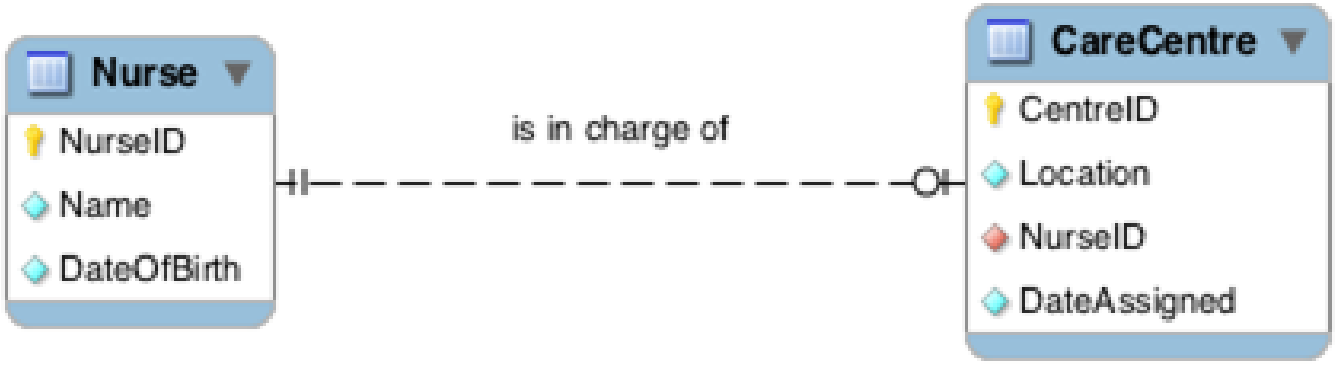


- But we have 2 “one” sides. Which one?

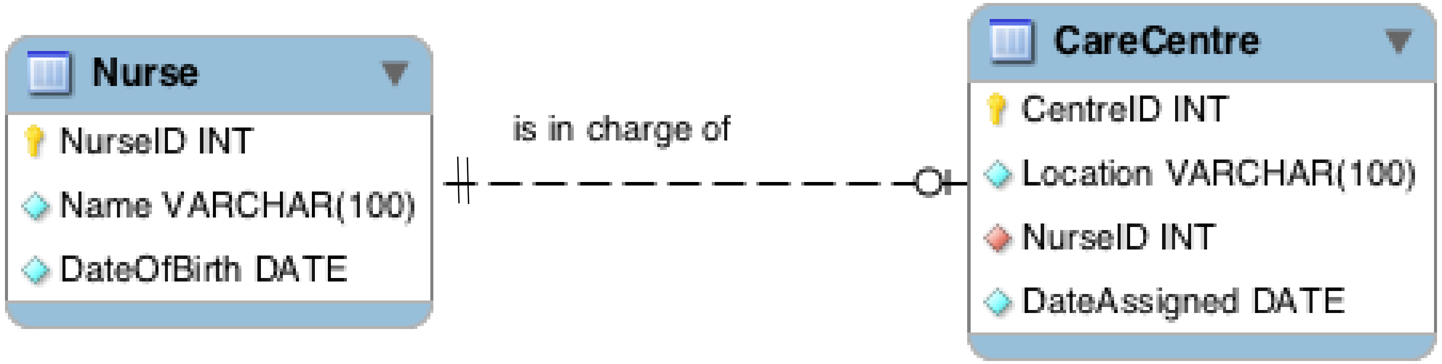
- Need to decide whether to put the foreign key inside Nurse or CareCentre (in which case you would have the Date_Assigned in the same location)
  - Where would the least NULL values be?
  - The rule is the OPTIONAL side of the relationship gets the foreign key

One to One Relationship – Logical and Physical Design

- **Logical**
  - Nurse (<u>NurseID</u>, Name, DateOfBirth)
  - CareCentre (<u>CentreID</u>, Location, *NurseID*, DateAssigned)



- **Physical**

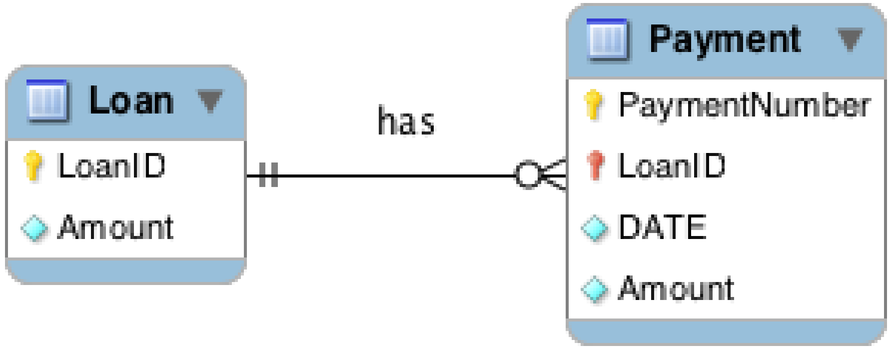


Summary of Binary Relationships

- **One-to-Many**
  - Primary key on the one side becomes a foreign key on the many
- **Many-to-Many**
  - Create an Associative Entity (a new relation) with the primary keys of the two entities it relates to as the combined primary key
- **One-to-One**
  - Need to decide where to put the foreign key
  - The primary key on the mandatory side becomes a foreign key on the optional side
  - If two optional or two mandatory, pick one arbitrarily

Strong and Weak Entity- Identifying Relationship

- How to map an Identifying relationship
  - Map it the same way: Foreign Key goes into the relationship at the crow's foot end.
  - Only Difference is: The Foreign Key becomes **part of the Primary Key**



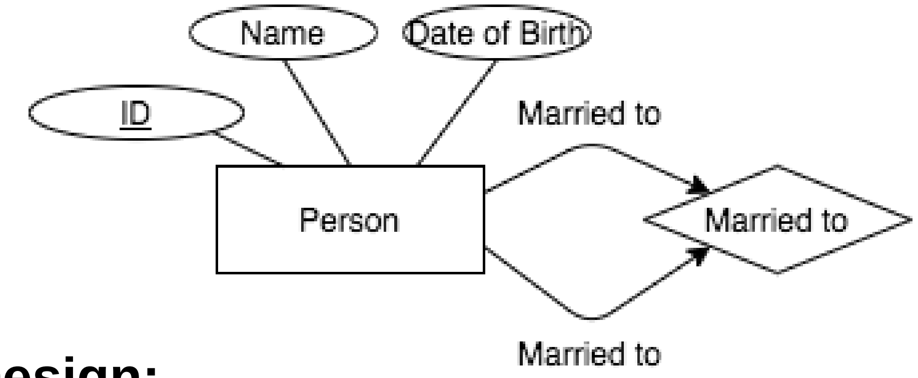
  - Logical Design
    - Loan (<u>LoanID</u>, Amount)
    - Payment (<u>PaymentNumber</u>, **<u>LoanID</u>**, Date, Amount)
  - Physical Design – as per normal one-to-many

Unary Relationships

- A unary relationship is **when both participants in the relationship are the same entity**
- Operate in the same way as binary relationships
  - **One-to-One**
    - Put a Foreign key in the relation
  - **One-to-Many**
    - Put a Foreign key in the relation
  - **Many-to-Many**
    - Generate an Associative Entity
    - Put two Foreign keys in the Associative Entity
      - Need 2 different names for the Foreign keys
      - Both Foreign keys become the *combined* key of the Associative Entity

Unary: One-to-One

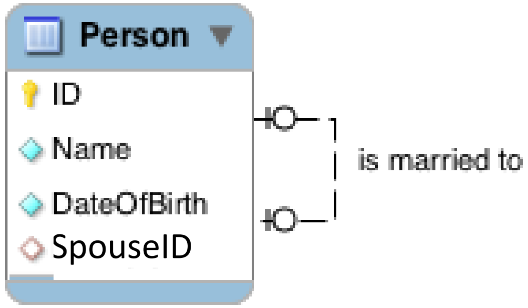
Conceptual Design:



Logical Design:

Person (<u>ID</u>, Name, DateOfBirth, <u>*SpouseID*</u>)

Physical Design:



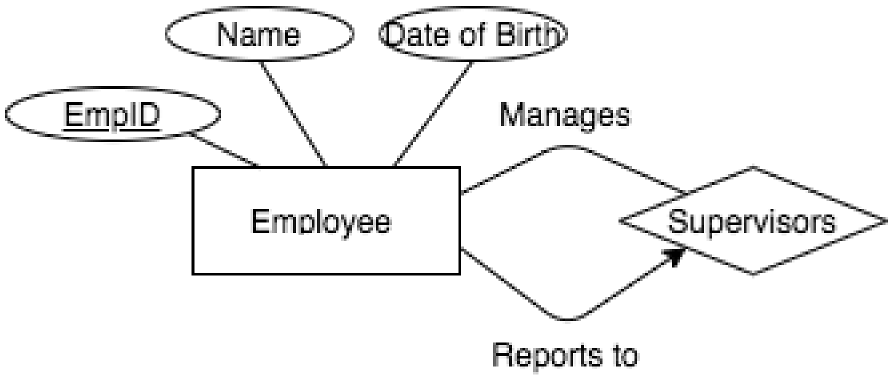
Implementation:

```
CREATE TABLE Person (
  ID INT NOT NULL,
  Name VARCHAR(15) NOT NULL,
  DateOfBirth DATE NOT NULL,
  SpouseID INT,
  PRIMARY KEY (ID),
  FOREIGN KEY (SpouseID)
  REFERENCES Person (ID)
  ON DELETE RESTRICT
  ON UPDATE CASCADE);
```

ID	Name	DOB	SpouseID
1	Ann	1969-06-12	3
2	Fred	1971-05-09	NULL
3	Chon	1982-02-10	1
4	Nancy	1991-01-01	NULL

Unary: One-to-Many

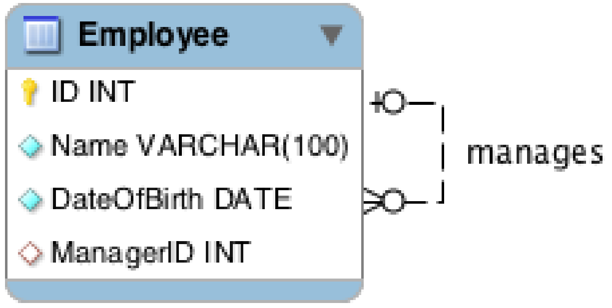
Conceptual Design:



Logical Design:

Employee = (<u>ID</u>, Name, DateOfBirth, <u>*ManagerID*</u>)

Physical Design:



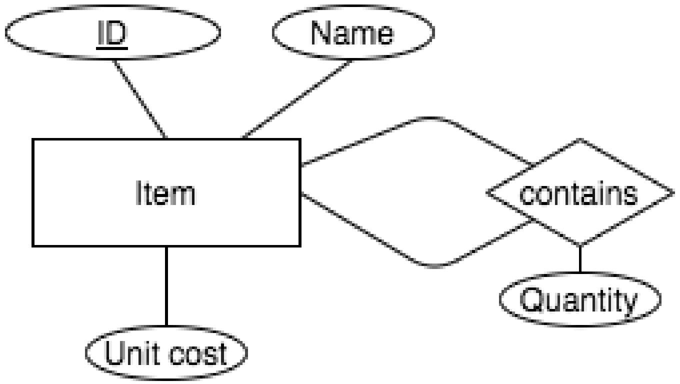
Implementation:

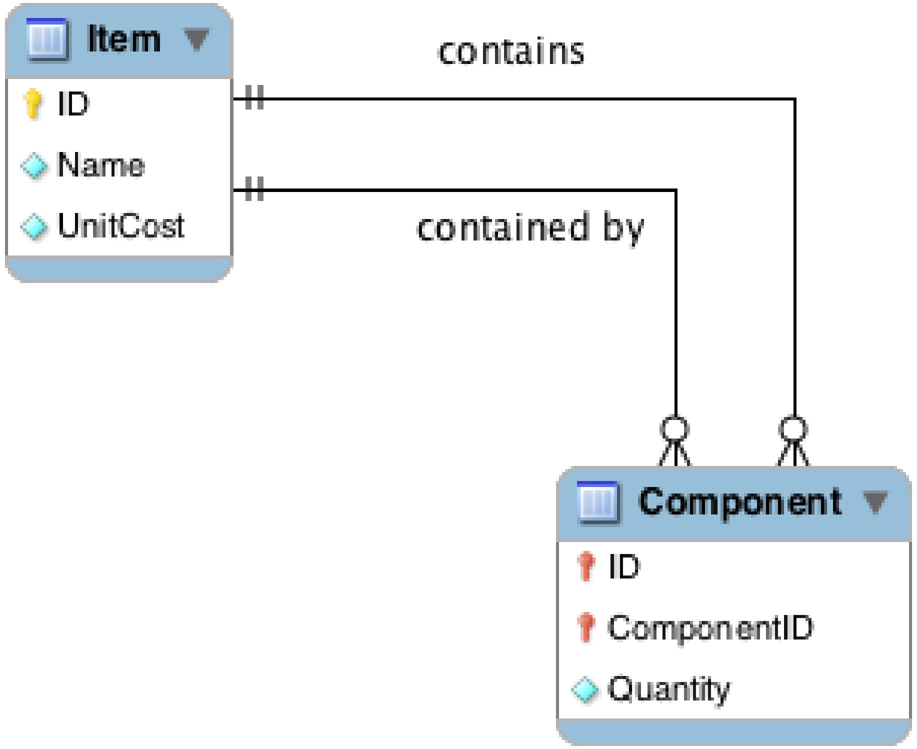
```
CREATE TABLE Employee(
  ID INT NOT NULL,
  Name VARCHAR(12) NOT NULL,
  DateOfBirth DATE NOT NULL,
  ManagerID INT ,
  PRIMARY KEY (ID),
  FOREIGN KEY (ManagerID) REFERENCES Employee(ID)
  ON DELETE RESTRICT
  ON UPDATE CASCADE);
```

ID	Name	DOB	MngrID
1	Ann	1969-06-12	NULL
2	Fred	1971-05-09	1
3	Chon	1982-02-10	1
4	Nancy	1991-01-01	1

Unary: Many-to-Many

Conceptual Design:





Logical Design:

- Create Associative Entity like usual
- Generate logical model

  Item = (<u>ID</u>, Name, UnitCost)

  Component = (**<u>ID, ComponentID</u>**, Quantity)

Unary: Many-to-Many Implementation

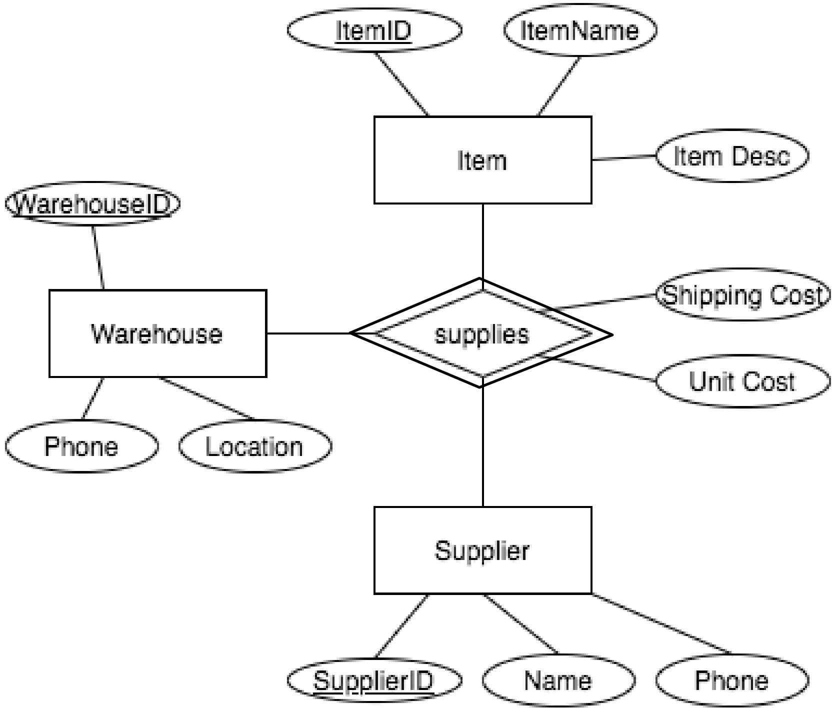
Implementation

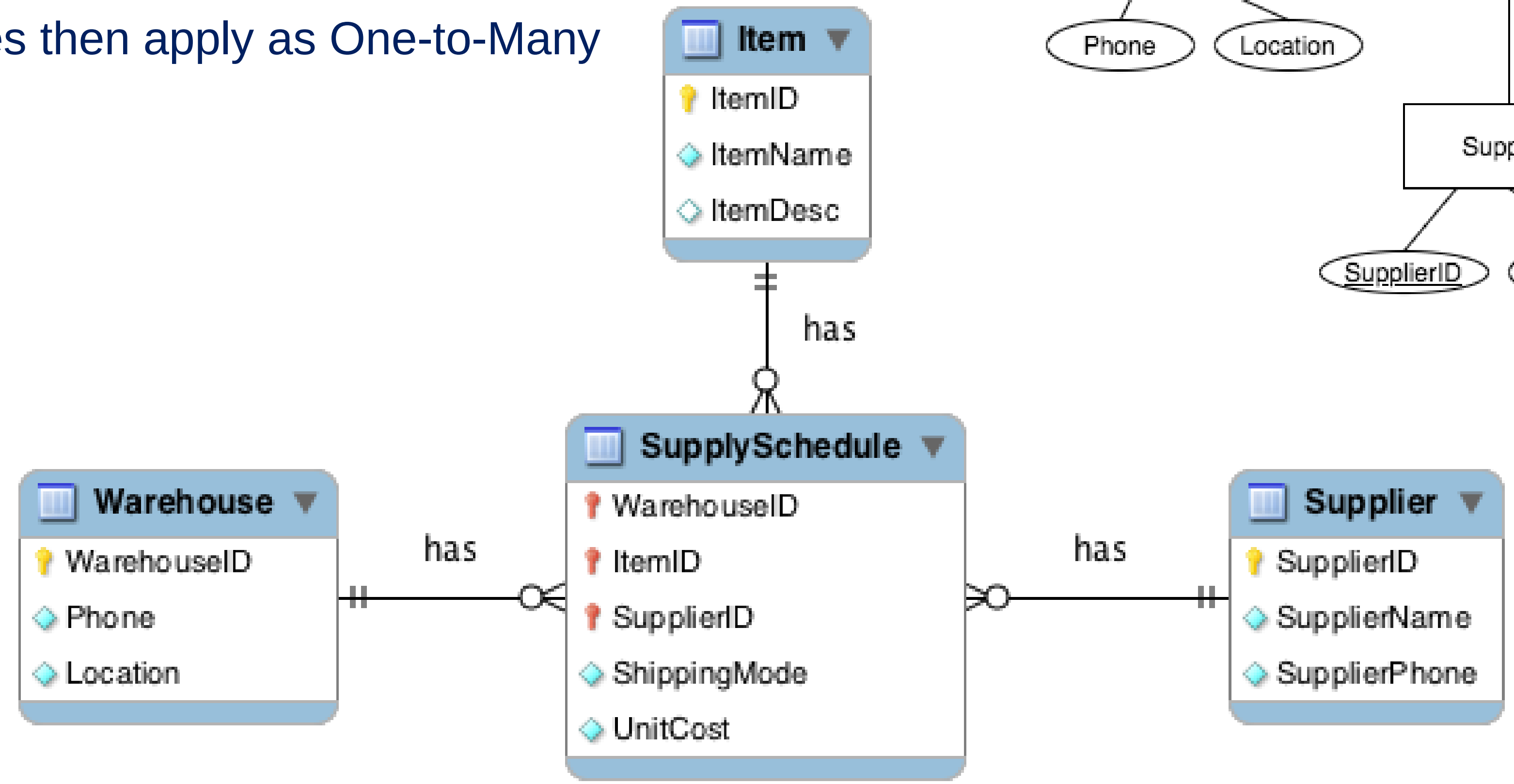
```
CREATE TABLE Item (
  ID         SMALLINT,
  Name       VARCHAR(100)   NOT NULL,
  UnitCost   DECIMAL(6,2)   NOT NULL,
  PRIMARY KEY (ID));
```

```
CREATE TABLE Component (
ID            SMALLINT,
ComponentID   SMALLINT,
Quantity      SMALLINT NOT NULL,
PRIMARY KEY    (ID, ComponentID),
FOREIGN KEY (ID) REFERENCES Item(ID)
  ON DELETE RESTRICT
  ON UPDATE CASCADE,
FOREIGN KEY (ComponentID) REFERENCES Item(ID)
  ON DELETE RESTRICT
  ON UPDATE CASCADE)
```

Ternary relationships

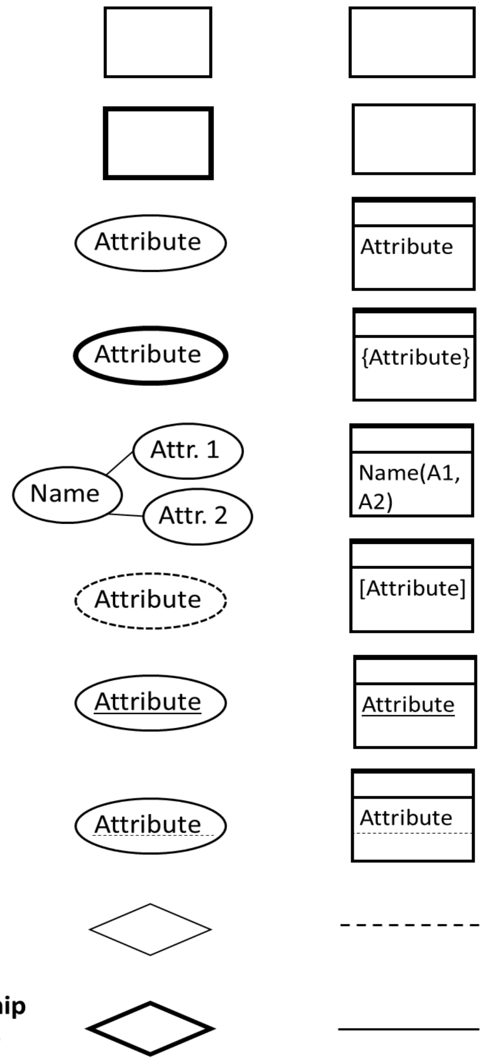
- Relationships between three entities
- Logical Design:
  - Generate an Associative Entity
  - Three One-to-Many relationships
  - Same rules then apply as One-to-Many





Conceptual Model Mapping

Concept	Chen's	Crow's foot
Entity		
Weak Entity		
Attribute		
Multi-valued A.		
Composite A.		
Derived A.		
Key A.		
Weak Key A.		
Relationship		
Weak relationship (Identifying rel.)		



Relationship cardinalities and constraints

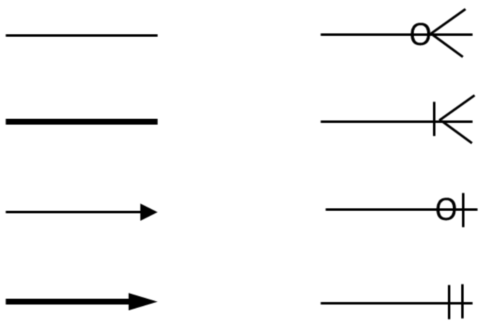
Chen's notation — Crow's foot notation

Optional Many
0..m

Mandatory Many
1..m

Optional One
0..1

Mandatory One
1..1



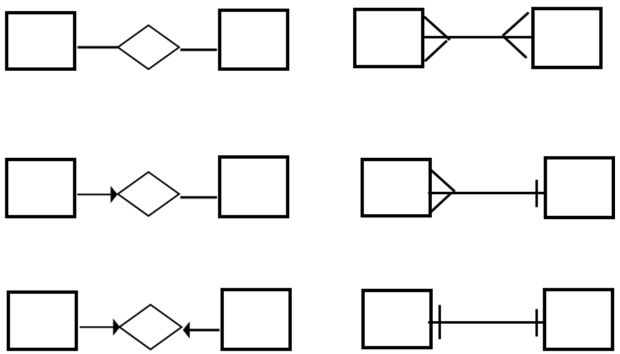
BINARY Relationship Cardinalities

Here we just looked at cardinalities and omitted participation constraints (optional/mandatory) for clarity

Many to Many

One to Many

One to One



Conceptual to Physical checklist

	Many to Many resolved?	Database type (RDBMS, NoSQL)	Datatypes & DB brand (e.g. MySQL)	Key Name
Conceptual	NO	NO	NO	Key Attribute
Logical	YES	YES	NO	Primary Key + Foreign Key
Physical	YES	YES	YES	Primary Key + Foreign Key

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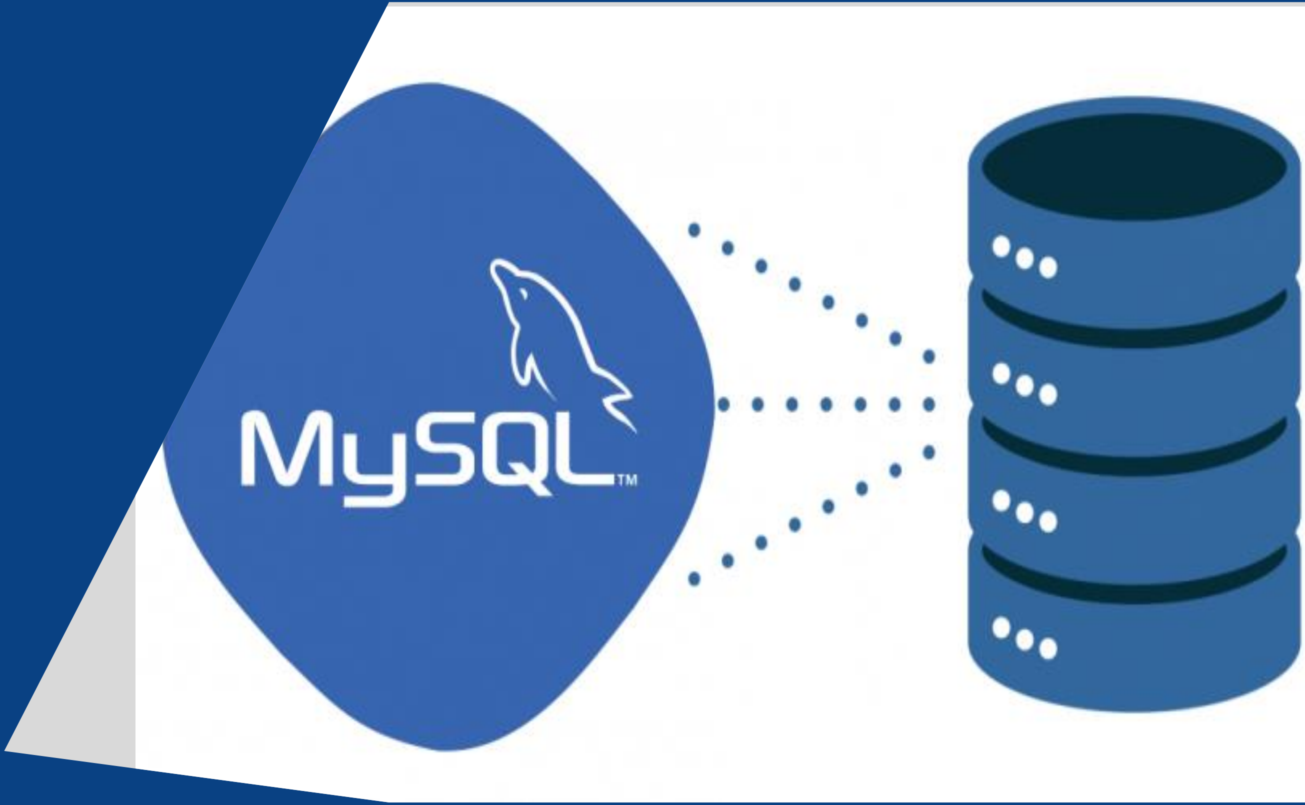
MySQL Data Types



Choosing data types

Column: smallest unit of data in database

Data types help DBMS to store and use information efficiently

You should choose data types that:

- enforce data integrity (quality)
- can represent all possible values
- support all required data manipulations
- minimize storage space
- maximize performance (e.g. fixed or variable length)

The major data types categories are:

- Text/string or character
- Number
  - Integer
  - Decimal
  - Float, Double
- Date and time

Character types (MySQL)

CHAR(M): A fixed-length string that is always right-padded with spaces to the specified length when stored on disc.
The range of M is 1 to 255.

CHAR: Synonym for CHAR(1).

VARCHAR(M): A variable-length string.
Only the characters inserted are stored – no padding.
The range of M is 1 to 65535 characters.

BLOB, TEXT: A binary or text object with a maximum length of 65535 (2^16) bytes (blob) or characters (text).
Not stored inline with row data.

LONGBLOB, LONGTEXT: A BLOB or TEXT column with a maximum length of 4,294,967,295 (2^32 - 1) characters.

ENUM (‘value1’,’value2’,…) up to 65,535 members.

Number types (MySQL)

Integers

- **TINYINT**: Signed (-128 to 127), Unsigned (0 to 255)
- **BIT, BOOL:** synonyms for TINYINT
- **SMALLINT**:
  Signed (-32,768 to 32,767), Unsigned (0 to 65,535 – 2^16 or 64k)
- **MEDIUMINT**:
  Signed (-8388608 to 8388607), Unsigned (0 to 16777215 –16M)
- **INT / INTEGER**:
  Signed (-2,147,483,648 to 2,147,483,647),
  Unsigned (0 to 4,294,967,295 – 2^32 or 4G)
- **BIGINT**:
  Signed (-9223372036854775808 to 9223372036854775807),
  Unsigned (0 to 18,446,744,073,709,551,615 - 2^64)
- **Don't** use the "(M)" number for integers

Number types (MySQL)

Real numbers (fractions)

- **FLOAT**: single-precision floating point, allowable values: -3.402823466E+38 to -1.175494351E-38, 0, and 1.175494351E-38 to 3.402823466E+38.

- **DOUBLE / REAL**: double-precision, allowable values: -1.7976931348623157E+308 to -2.2250738585072014E-308, 0,
  and 2.2250738585072014E-308 to 1.7976931348623157E+308.
- optional M = number of digits stored, D = number of decimals.
- Float and Double are often used for scientific data.

- **DECIMAL**[(M[,D])]: fixed-point type. Good for money values.
- M = precision (total number of digits stored), D = number of decimals (within M)

Date Time types

DATE used for values with a date part but no time part.
MySQL retrieves and displays DATE values in 'YYYY-MM-DD' format; 1000-01-01 to 9999-12-31

TIME retrieves and displays TIME values in 'hh:mm:ss' format; -838:59:59 to 838:59:59
(time of day or elapsed time)

DATETIME used for values that contain both date and time parts.
MySQL retrieves and displays DATETIME values in 'YYYY-MM-DD hh:mm:ss' format;
1000-01-01 00:00:00 to 9999-12-31 23:59:59
Stored in local time

TIMESTAMP 1970-01-01 00:00:00 - '2038-01-19 03:14:07'
used for values that contain both date and time parts.
Stored in UTC, converted to local when retrieved, which allows to use a different time zone when you connect to MySQL Server.

YEAR 1901 to 2155

By default, the current time zone for each connection is the server's time.

If the time zone setting remains constant, you get back the same value you store.

If you store a TIMESTAMP value, and then change the time zone and retrieve the value, the retrieved value is different from the value you stored.

What’s examinable

Ability to draw conceptual, logical and physical diagrams

Assignment 1: Conceptual Chen’s pen and paper or draw.io or any tool that can draw Chen conceptual model shapes

Physical Crow’s foot with MySQL Workbench

CREATE TABLE SQL statements

Thank you

Subtitle

Identifier first line

Second line