Dr Greg Wadley

INFO90002 Database Systems & Information Modelling

Week 03

Data Modelling & SQL (1)

The next few weeks: modelling and SQL

Week	Lecture 1	Lecture 2	Lab
3	Modelling 1	SQL 1	Data Modeling
4	Modelling 2	SQL 2	SQL skills lab 1
5	Modelling 3	SQL 3	SQL skills lab 2
6	Normalization	Physical design	SQL skills lab 3

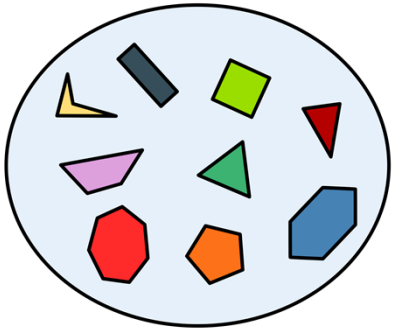
Week 7: assignment one (data modelling) due

Today's session

- Data modelling
  - ER modelling conventions
  - Identifying entities and business rules
  - Conceptual, logical, physical modelling stages
- SQL
  - Overview and history
  - Create tables
  - Insert data into tables
  - Read data from tables

The Entity Relationship (ER) Model

- A database can be thought of as
  - A collection of entity sets, and
  - Relationships between entities
- An entity is an object that exists, or an event that occurred, and can be distinguished from other entities
  - Example: product, order, sale, person, movie, tweet
- Entities have attributes that describe the entity and distinguish it from other entities in the same entity set
  - Example attributes: EmployeeName, Address



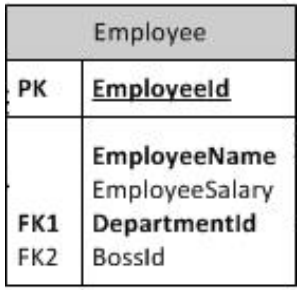
- (reminder – what are “sets”?
  - union, intersection, Cartesian product)

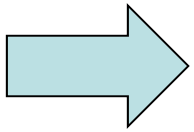
Naming Conventions

- Entities
  - singular nouns
    - Employee, Customer, Sale
- Attributes
  - usually a noun
    - itemColour, quantitySold, employeeID
- Relationships
  - verbs or verb phrases
    - has, wants, manages, performs work for
- Use names meaningful to the domain
  - try not to abbreviate names
    - except num or nbr for number, ID for identifier
  - conventions on case

Mapping ER diagram to database tables

- Entity set
  - Often corresponds to a table in the database
- Entity instance
  - Often corresponds to a row in a table
- Attribute
  - Often corresponds to a column in a table
- Relationship set (link between entity sets)
- Relationship instance (link between entity instances)
  - Foreign Key – Primary Key relationship





EmployeeID	EmployeeName	EmployeeSalary	DepartmentID	BossID
1	Alice	75000.00	1	0
2	Ned	45000.00	11	1
3	Andrew	25000.00	11	2
4	Clare	22000.00	11	2
5	Todd	38000.00	2	1
6	Nancy	22000.00	2	5
7	Brier	43000.00	9	1
8	Sarah	56000.00	9	7
9	Sophie	35000.00	10	1
10	Sanjay	15000.00	6	3

Conceptual data modelling

- Entity

Entity1	
PK	**Identifier**
	Ent1Attribute1 Ent1Attribute2

- Attributes

EntityAttributeExample	
PK PK,FK1	**PartialIdentifier** **PartialIdentifier2**
	Mandatory Optional [Derived] {Multivalued} Composite (item1,Item2)

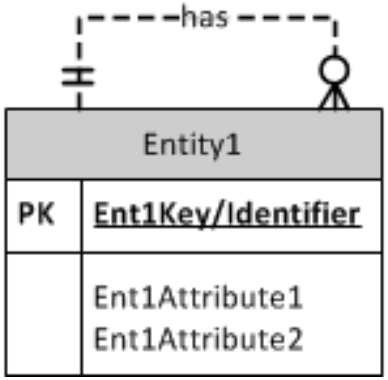
- Key (or Identifier)
  - Fully identifies an instance
- Partial Key
  - Partially identifies an instance
- Attributes
  - Mandatory
  - Optional
  - Derived
    - [YearsEmployed]
  - Multivalued
    - {Skill}
  - Composite
    - Name (First, Middle, Last)

Keys

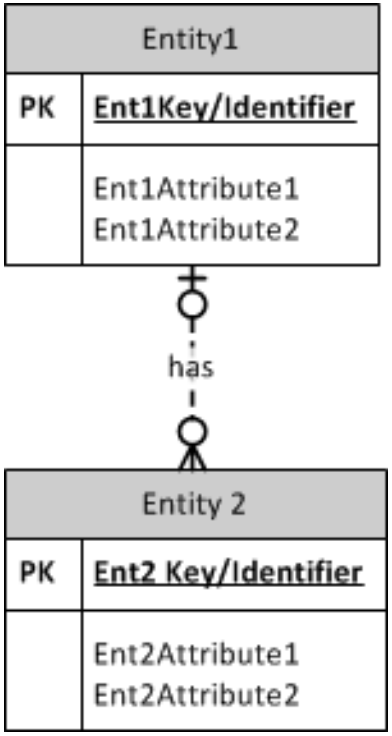
- Keys or Identifiers are used to identify individual entity instances
  - Primary Key
    - (set of) columns, the values in which uniquely identify each instance
    - no column can be removed from the key without losing identification
  - Candidate Key
    - the set of possible primary keys (typically there is only one)
      - We select the primary key from this
  - Composite Key
    - a key which is made up of more than one attribute
      - E.g. For the entity “airline flight” we might use the composite key
        - » FlightNumber + FlightDate
  - Foreign Key
    - The key used to link to a primary key in another table
      - Helps us to join tables in a Select statement
- Keys are
  - Unique
  - Never null
  - Do not change their value

Degree of relationship

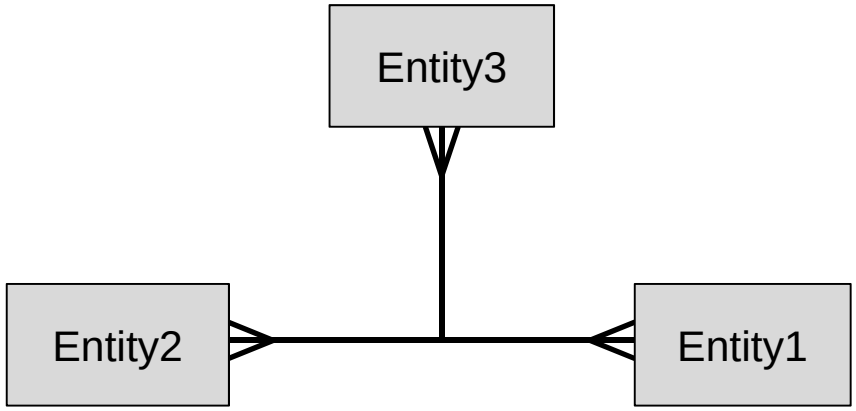
Unary



Binary

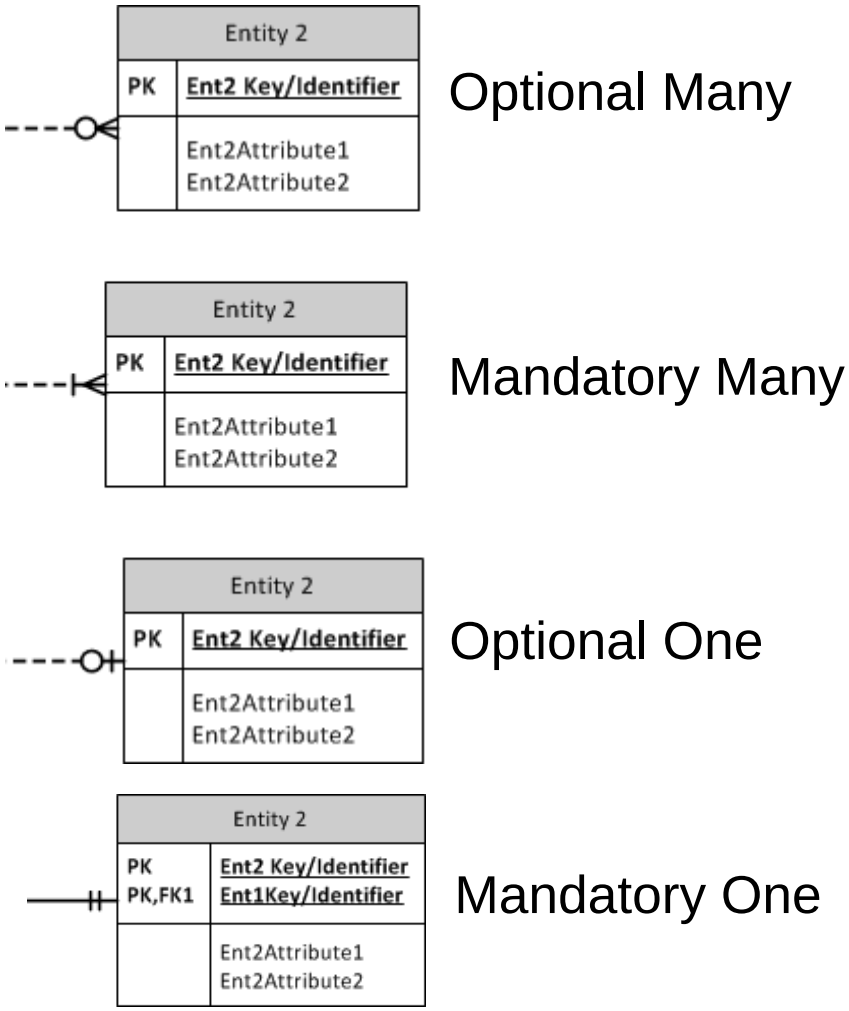


Ternary



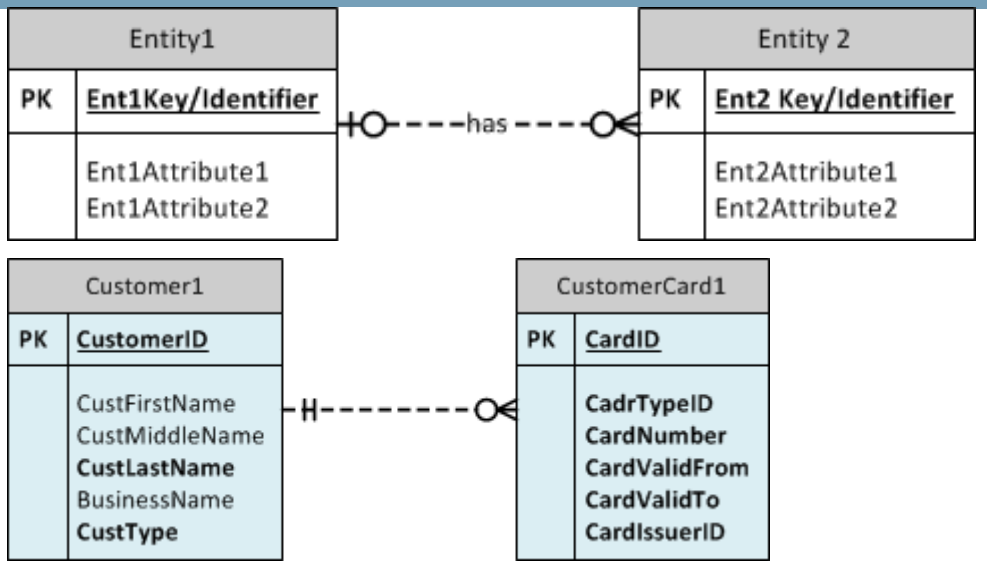
Relationship Cardinality

- One to One
  - Each entity in one set is related to 0 or 1 in the other.
- One to Many
  - Each entity in one set is related to many in the other.
- Many to Many
  - Each entity in either set can be related to many in the other set
  - These require an extra step to implement in a relational database.



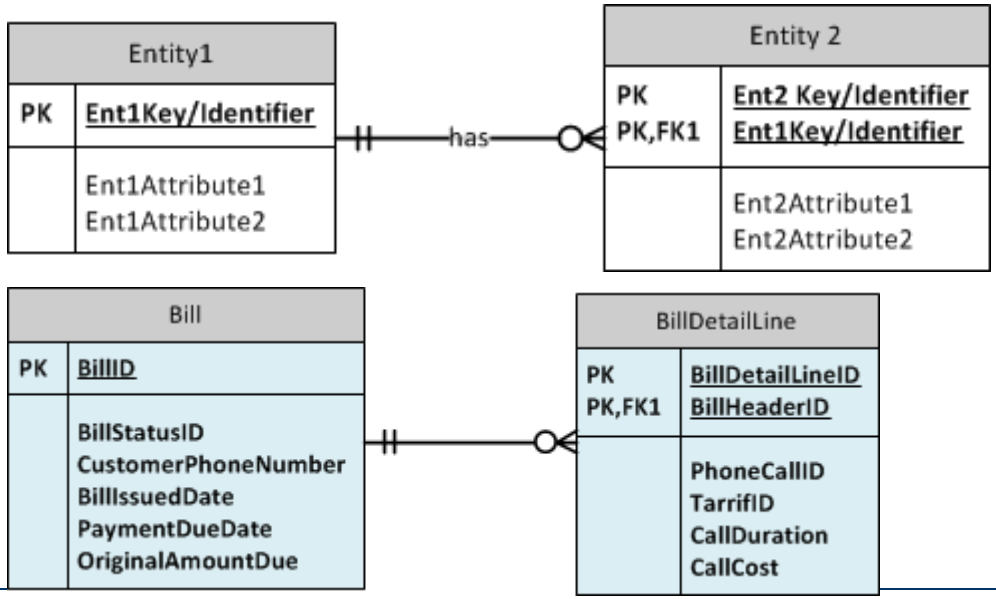
Strong and Weak entities

- Strong Entity
  - Entity 2's identity is independent of the identity of other entities



Weak Entity

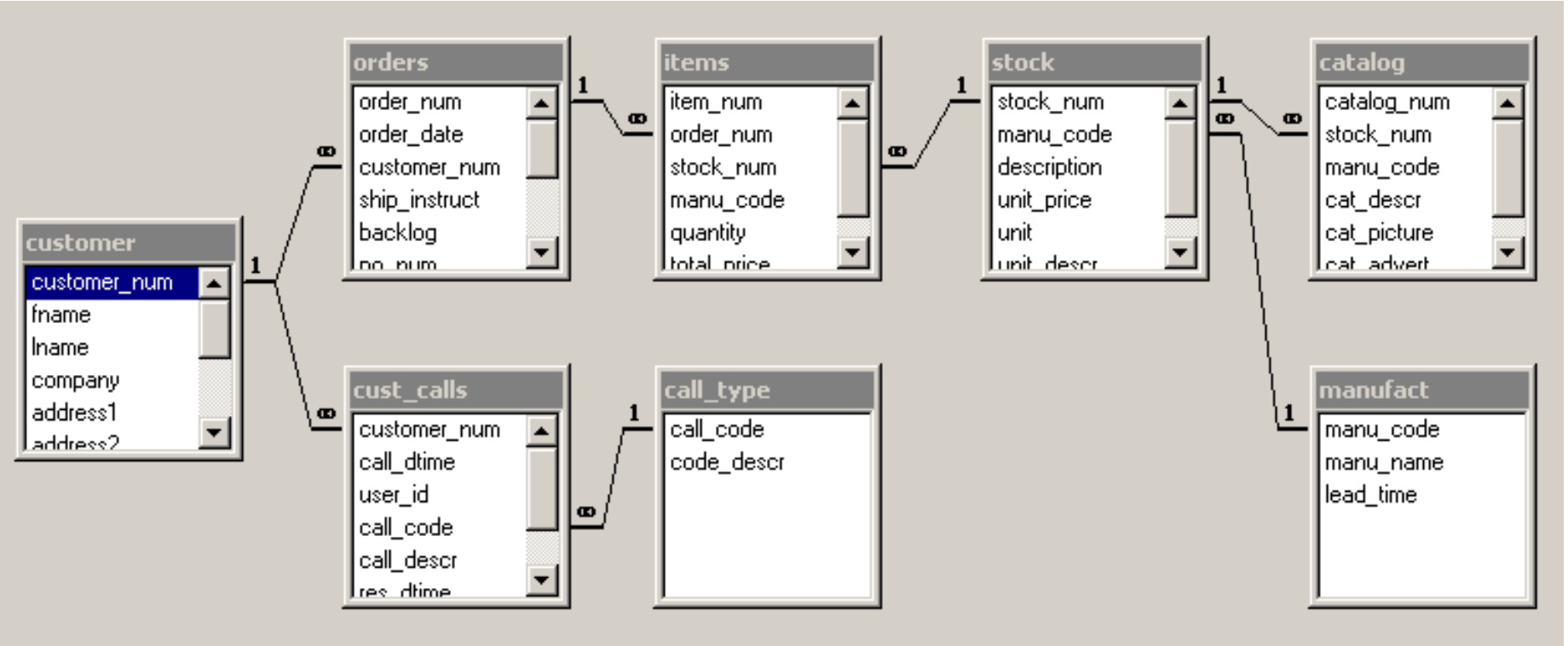
Entity 2's identity depends on (includes) the identity of Entity 1



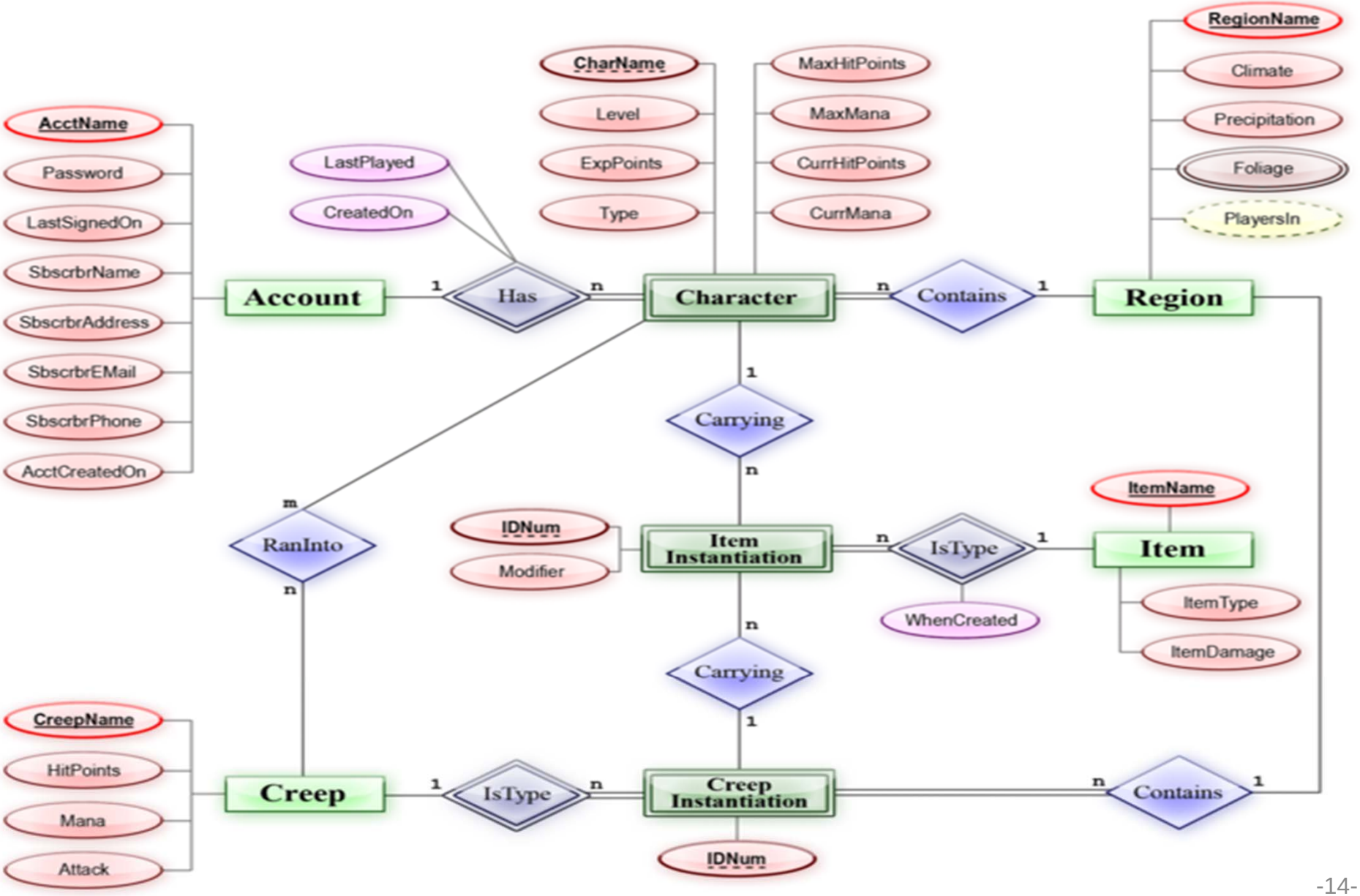
Valid and invalid entities

- An Entity
  - Will have many instances in the database
  - Has several attributes
  - Is necessary for the system to work
- Examples
  - Person: EMPLOYEE, STUDENT, PATIENT
  - Place: STORE, WAREHOUSE, STATE, CITY
  - Object: PRODUCT, MACHINE, BUILDING, VEHICLE
  - Event: SALE, REGISTRATION, BROADCAST
  - Abstract: ACCOUNT, UNI SUBJECT, ROLE
- Entities do not usually include:
  - An output of the system (i.e. a report)
  - The system itself
  - The company that owns the system

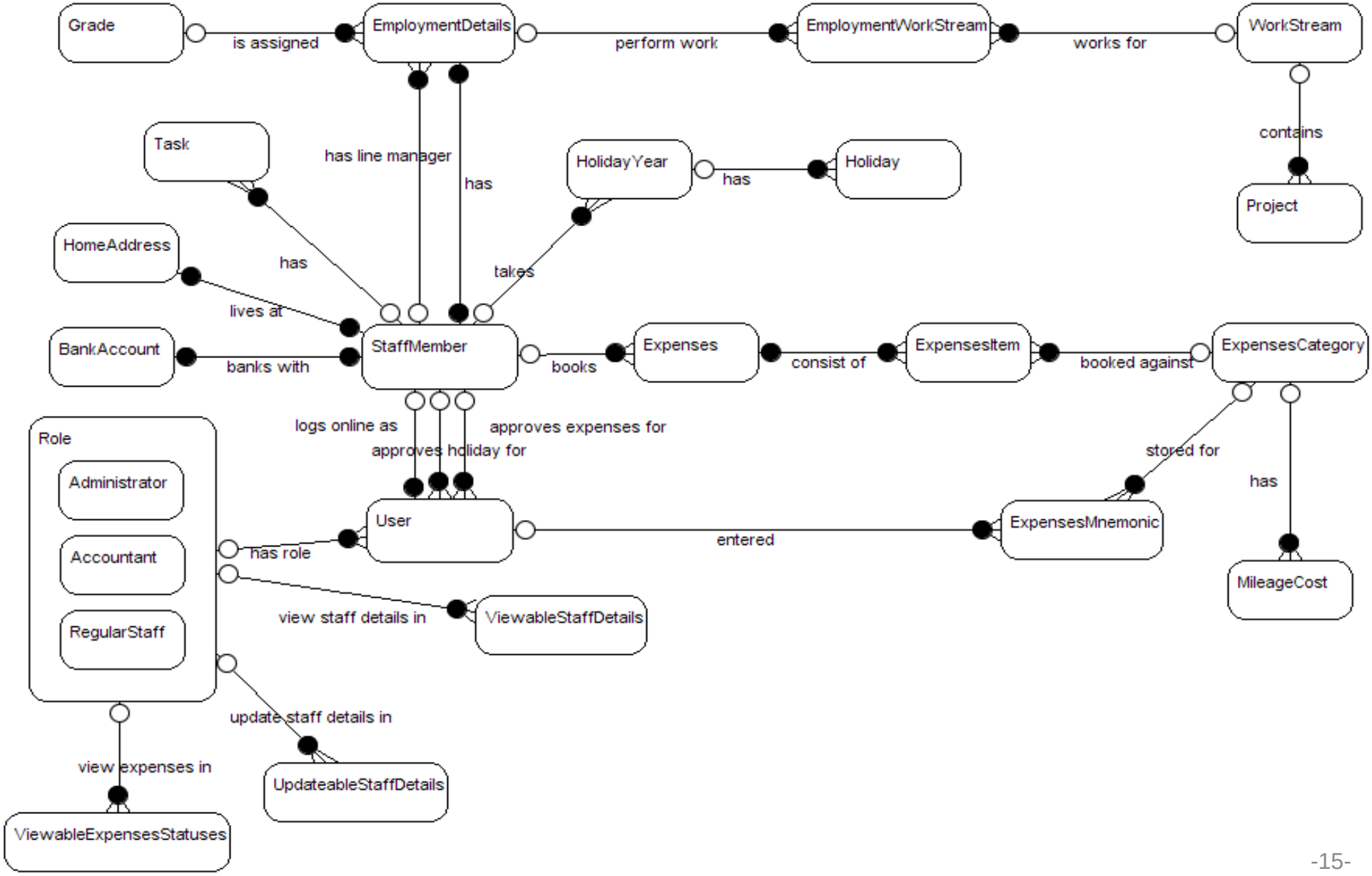
Variation in ER diagram standards



Variation in ER diagram standards



Variation in ER diagram standards



Drawing ER diagrams

- You can use paper or the software of your choice
- Visio is a good (commercial) tool, available in labs
- https://www.lucidchart.com/ and other web apps
- Assignment 1 model should be made in MySQL Workbench
- In the exam you'll need to model on paper
- Diagrams in lecture slides are made in Workbench and Visio
- My suggestion is:
  - Use pen-and-paper or whiteboard for early Conceptual modelling
  - Use paper, Visio or Workbench for subsequent Logical modelling
  - Use Workbench for the final Physical model

Identifying Business Rules

- Business rules are assertions that constrain entities
- Can impact structure and behaviour of the database
- We usually express business rules as assertions about terms
  - “A customer sets up at least one account.” (assertion)
  - customer (term)
  - account (term)
- Entities can often by identified by the terms (nouns) that the business uses in its literature

Modelling a Single Entity

- By searching for nouns in the case we can identify entities

  (for example – Customer)

- What things would we need to record about the Customer
  - these become the customer's Attributes

- How can we identify individual Customers?
  - By name?
  - By address?
- Now we can draw it as an entity in the ER diagram

Conceptual design for single entity

Customer1	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType** **CustAddress(Line1, Line 2, Suburb, Postcode, Country)**

- underline = primary key
- bold = not null
- () = composite attribute

Convert to *logical* design

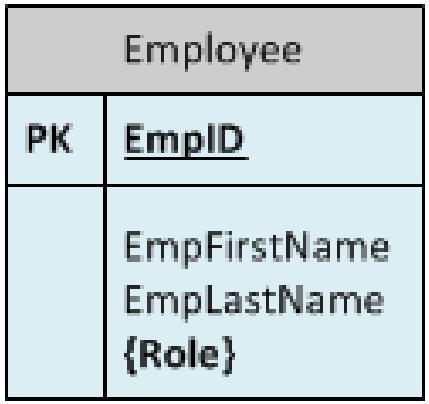
Customer1	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType** **CustAddress(Line1, Line 2, Suburb, Postcode, Country)**

Customer1	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType** **CustAddLine1** **CustAddLine2** **CustSuburb** **CustPostcode** **CustCountry**

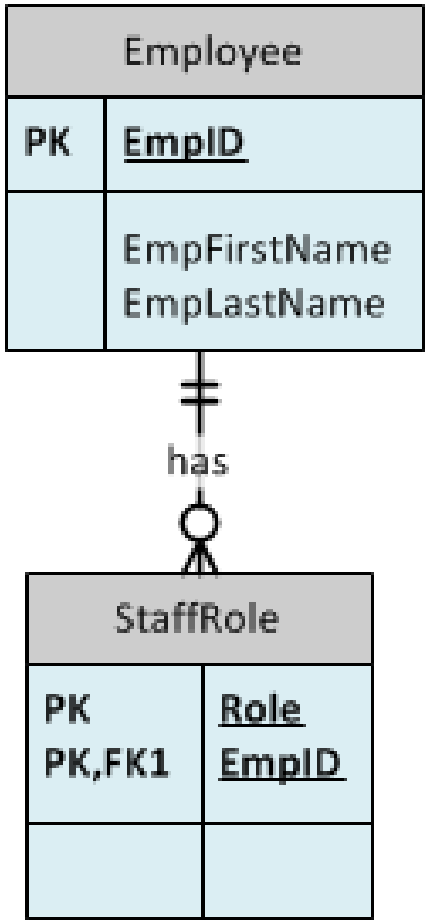
- Composite attributes become individual attributes
- Multi-valued attributes become a new table
- Resolve many-many relationships via a new table
- Add foreign keys at crows foot end of relationships

Dealing with multi-valued attributes

Conceptual Design



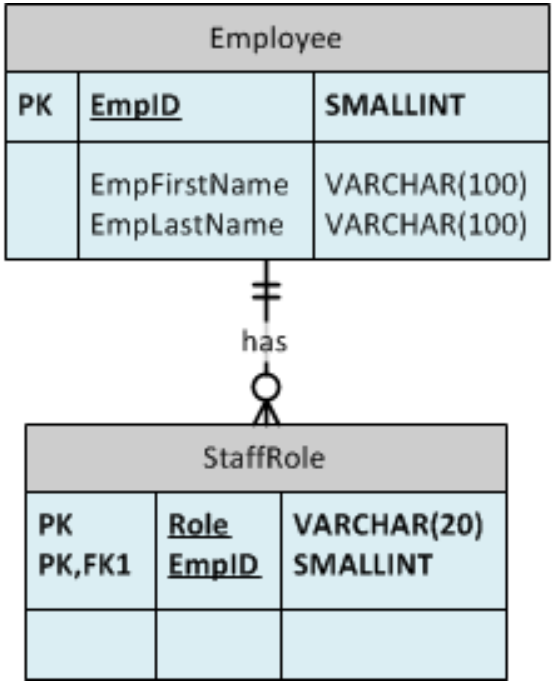
Logical Design



- StaffRole is an example of a weak entity

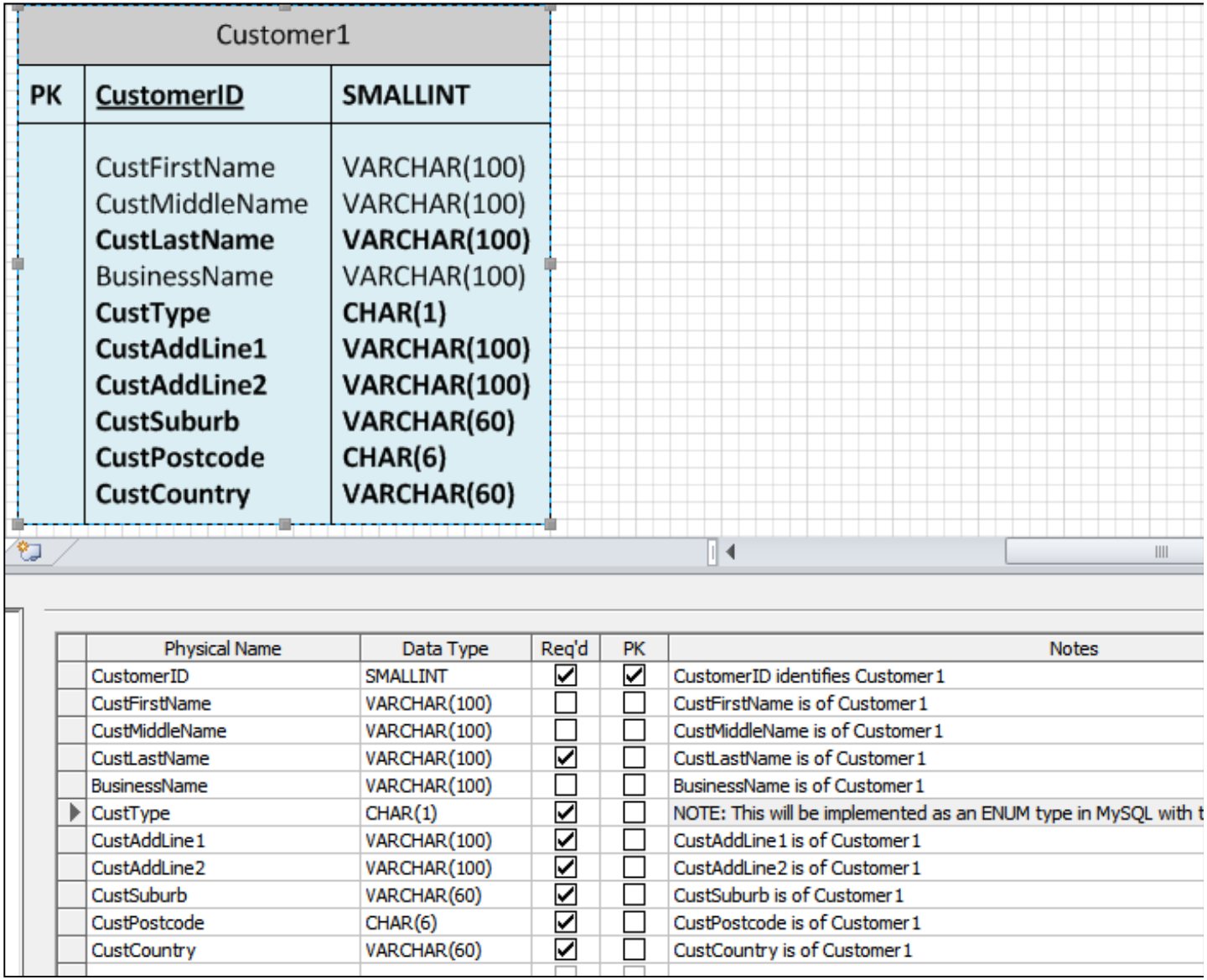
Physical design

- Convert the logical design to a physical design
  - Technical specification for storing the data
  - Dependent on the DBMS chosen
- Design goals
  - Ensure database integrity
  - Provide good performance
  - Ensure database recoverability
  - Ensure database security
- Some of these goals are explained later in the course



Convert from Logical to Physical design

- Determine data types for each attribute
- Key, nullable



Physical Name	Data Type	Req'd	PK	Notes
CustomerID	SMALLINT	☑	☑	CustomerID identifies Customer1
CustFirstName	VARCHAR(100)	☐	☐	CustFirstName is of Customer1
CustMiddleName	VARCHAR(100)	☐	☐	CustMiddleName is of Customer1
CustLastName	VARCHAR(100)	☑	☐	CustLastName is of Customer1
BusinessName	VARCHAR(100)	☐	☐	BusinessName is of Customer1
CustType	CHAR(1)	☑	☐	NOTE: This will be implemented as an ENUM type in MySQL with t
CustAddLine1	VARCHAR(100)	☑	☐	CustAddLine1 is of Customer1
CustAddLine2	VARCHAR(100)	☑	☐	CustAddLine2 is of Customer1
CustSuburb	VARCHAR(60)	☑	☐	CustSuburb is of Customer1
CustPostcode	CHAR(6)	☑	☐	CustPostcode is of Customer1
CustCountry	VARCHAR(60)	☑	☐	CustCountry is of Customer1

Now we can create the table

```
CREATE TABLE Customer (
   CustomerID          smallint                        auto_increment,
   CustFirstName       varchar(100),
   CustMiddleName      varchar(100),
   CustLastName        varchar(100)                    NOT NULL,
   BusinessName        varchar(200),
   CustType            enum('Personal','Company')  NOT NULL,
   PRIMARY KEY  (CustomerID)
) ENGINE=InnoDB;
```

We can insert data into our tables

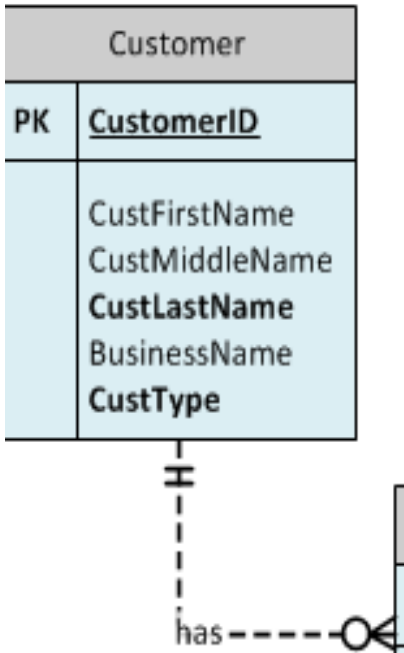
- We added data to the table…

```
INSERT INTO CUSTOMER VALUES (DEFAULT, "Peter", NULL, "Smith", NULL, "Personal");
INSERT INTO CUSTOMER VALUES (DEFAULT, "James", NULL, "Jones", "JJ Enterprises", "Company");
INSERT INTO CUSTOMER VALUES (DEFAULT, "Akin", NULL, "Smithies", "Bay Wart", "Company");
INSERT INTO CUSTOMER VALUES (DEFAULT, "Julie", "Anne", "Smythe", "Konks", "Company");
INSERT INTO CUSTOMER VALUES (DEFAULT, "Jen", NULL, "Smart", "BRU", "Company");
INSERT INTO CUSTOMER VALUES (DEFAULT, "Lim", NULL, "Lam", NULL, "Personal");
INSERT INTO CUSTOMER VALUES (DEFAULT, "Kim", NULL, "Unila", "Saps", "Company");
INSERT INTO CUSTOMER VALUES (DEFAULT, "James", "Jay", "Jones", "JJ's", "Company");
INSERT INTO CUSTOMER VALUES (DEFAULT, "Keith", NULL, "Samson", NULL, "Personal");
```

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType
1	Peter	NULL	Smith	NULL	Personal
2	James	NULL	Jones	JJ Enterprises	Company
3	Akin	NULL	Smithies	Bay Wart	Company
4	Julie	Anne	Smythe	Konks	Company
5	Jen	NULL	Smart	BRU	Company
6	Lim	NULL	Lam	NULL	Personal
7	Kim	NULL	Unila	Saps	Company
8	James	Jay	Jones	JJ's	Company
9	Keith	NULL	Samson	NULL	Personal
NULL	NULL	NULL	NULL	NULL	NULL

Two entities with 1-M relationship

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

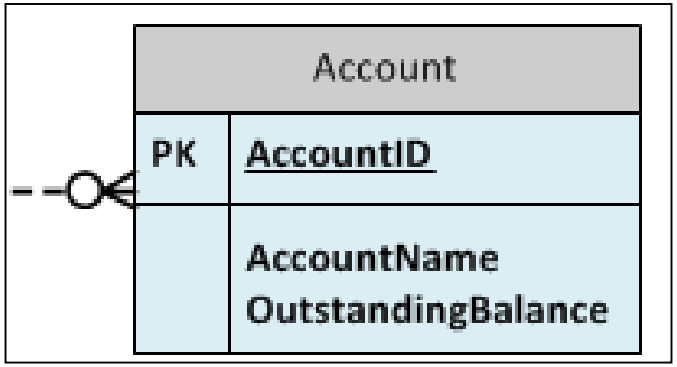


CustID	Customer FirstName	CustMiddle Name	CustLast Name	Business Name	CustType
1	Peter		Smith		Personal
2	James		Jones	JJ Enterprises	Company

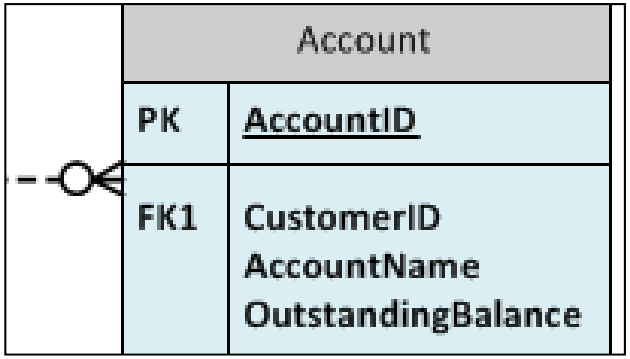
AccountID	AccountName	Outstanding Balance	CustID
01	Peter Smith	245.25	1
05	JJ Ent.	552.39	2
06	JJ Ent. Mgr	10.25	2

Conceptual to logical design – with FK

- Conceptual Design



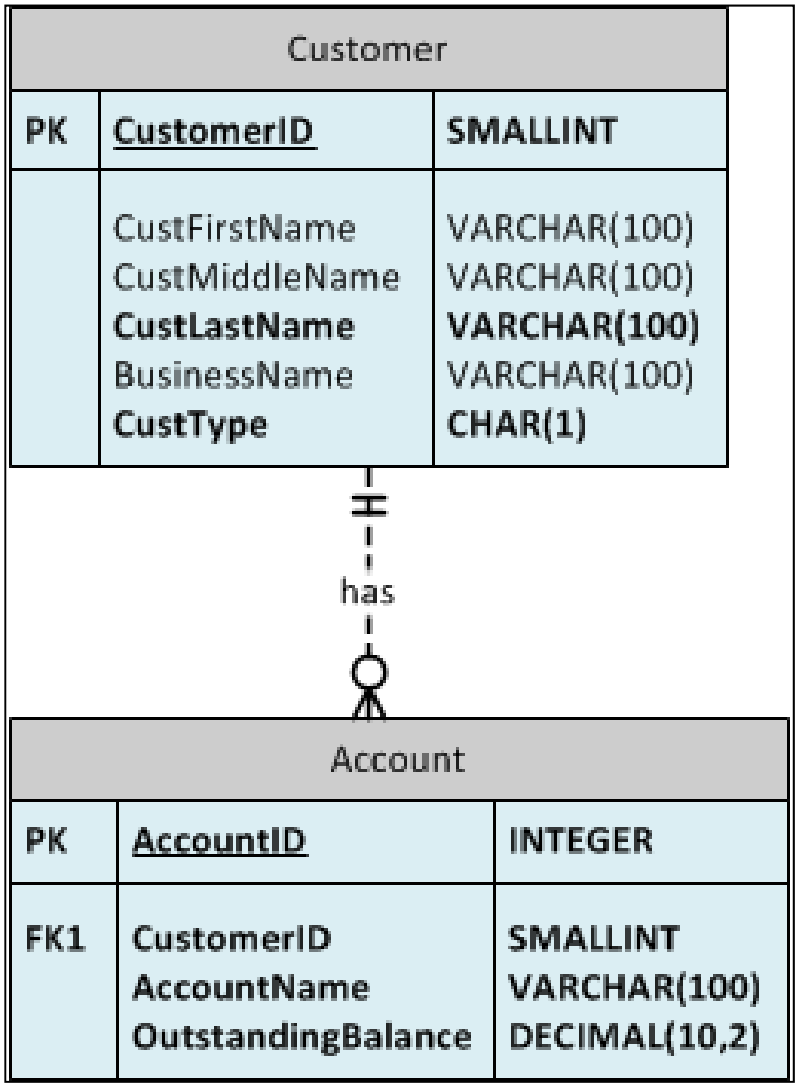
- Logical Design



– Add foreign keys at crows feet end of relationships
  - See FK1 – CustomerID
    – This is the link to the customer table
    – Every row in the account table MUST have a CustomerID
      » Referential integrity

Physical design - with FK

- Attribute data types



SQL CREATE Statement – with FK

```
CREATE TABLE Account (
   AccountID              smallint         auto_increment,
   AccountName            varchar(100)     NOT NULL,
   OutstandingBalance     DECIMAL(10,2)    NOT NULL,
   CustomerID             smallint         NOT NULL,
   PRIMARY KEY  (AccountID),
   FOREIGN KEY (CustomerID) REFERENCES Customer(CustomerID)
         ON DELETE RESTRICT
         ON UPDATE CASCADE
) ENGINE=InnoDB;
```

Referential Actions
how foreign keys guarantee referential integrity.

Insert - with FK

Current Database

CustID	CustomerFirstName	CustMiddle Name	CustLastName	BusinessName	CustType
1	Peter		Smith		Personal
2	James		Jones	JJ Enterprises	Company

AccountID	AccountName	OutstandingBalance	CustID

Insert a row…

```
INSERT INTO ACCOUNT VALUES (DEFAULT, 'My New Account', 0, 5);
```

What happens?

INSERT INTO ACCOUNT VALUES (DEFAULT, ...	Error Code: 1452. Cannot add or update a child row: a fo

Error Code: 1452. Cannot add or update a child row: a foreign key constraint fails (`db_seanbm/account`, CONSTRAINT `account_ibfk_1` FOREIGN KEY (`CustomerID`) REFERENCES `customer` (`CustomerID`))

Insert - with FK

- Run the Inserts…

```
INSERT INTO ACCOUNT VALUES (DEFAULT, 'Peter Smith', 245.25, 1);
INSERT INTO ACCOUNT VALUES (DEFAULT, 'JJ ENt.', 552.39, 2);
INSERT INTO ACCOUNT VALUES (DEFAULT, 'JJ ENt. Mgr', 10.25, 2);
```

CustID	CustomerFirstName	CustMiddle Name	CustLastName	BusinessName	CustType
1	Peter		Smith		Personal
2	James		Jones	JJ Enterprises	Company
3	Akin		Smithies	Bay Wart	Company

AccountID	AccountName	OutstandingBalance	CustID
01	Peter Smith	245.25	1
02	JJ Ent.	552.39	2
03	JJ Ent. Mgr	10.25	2

Homework for this week

- The PhoneCorp company is an organisation that provides telephony services. They want us to design a database for the Customer Billing Function of their business. The system designed must be able to handle billing (producing bills) and payment of bills. As such, our design must capture information about customers, phone records, accounts, payments and billing details.
- A customer sets up at least one account with PhoneCorp and once approved, is given one or more phone numbers which they nominally own. The customer then uses these phone numbers and usage charges are applied as detail lines against their account. Customers are charged a monthly line fee, a monthly equipment rental fee and for individual phone calls. Each of these charges are governed by different rates for different customers, depending on what the customer negotiated.
- Once a month an invoice is generated and sent to the customer. The customer then pays the invoice (not necessarily in full) using a credit or debit card. Each payment made is applied against their account.

Structured Query Language (SQL)

What is SQL

- SQL – or SEQUEL – is a language used to create, access and maintain relational databases
- Based on relational algebra and relational calculus
- SQL (DML) supports CRUD (Create, Read, Update, Delete)
  - Insert, Select, Update, Delete commands
- You can see the latest SQL 2011 standard at
  - http://www.jtc1sc32.org/doc/N2151-2200/32N2153T-text_for_ballot-FDIS_9075-1.pdf
- Wikipedia has good articles on SQL
  - http://en.wikipedia.org/wiki/SQL
  - http://en.wikipedia.org/wiki/Category:SQL_keywords

Brief history

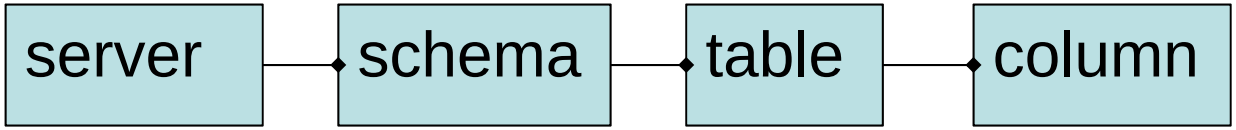
1974	IBM develops SEQUEL (renamed to SQL) based on Codd
1979…	Oracle, IBM etc release RDBMS with SQL language
1986	1st SQL Standard (ANSI)
1989	2nd SQL Standard (ANSI) – includes referential integrity
1992	3rd SQL Standard (ISO) – most widely conformed to by vendors
1997…	dynamic websites enabled by SQL
1999	SQL-1999 – 4th SQL Standard (ISO) – Object support, recursion, procedures and flow control
2003	SQL-2003 – 5th SQL Standard (ISO) – XML support, auto number
2006	SQL-2006 – 6th SQL Standard (ISO) – Defines SQL use with XML
2008	SQL-2008 – 7th SQL Standard (ISO) – FETCH command added
2008	HTML 5 with SQLite built in
2011	SQL-2011 – 8th SQL Standard (ISO) – temporal databases

How we use SQL

- during Implementation of the database
  - Implement tables from physical design using Create Table
- during Production
  - use Select commands to read the data from the tables
  - use Insert, Delete, Update commands to update data
  - use Alter, Drop commands to update the database structure

MySQL

- We are using the MySQL implementation of SQL
  - If you are using other DBMS (such as ORACLE or SQLServer) you will need to check their implementation of SQL.
    - differences can range from valid keywords to data types
- UniMelb MySQL server = version 5.7.9
- You can get the latest version of MySQL (5.7) from
    - http://dev.mysql.com/downloads/
    - Community edition = FOSS
  - Get syntax help for MySQL SQL statements at
    - http://dev.mysql.com/doc/refman/5.7/en/sql-syntax.html
- Explore your server with these commands:
  - show schemas; (alternatively, 'show databases')
  - show tables;
  - describe table;



The SQL Language

- Consists of:
  - Data Definition Language (DDL)
    - To define and set up the database
    - CREATE, ALTER, DROP
      - Also TRUNCATE, RENAME
  - Data Manipulation Language (DML)
    - To manipulate and read data in tables
    - SELECT, INSERT, DELETE, UPDATE
      - MySQL also provides others…. eg REPLACE
  - Data Control Language (DCL)
    - To control access to the database
      - GRANT, REVOKE
  - Other Commands
    - Administer the database
    - Transaction Control

The SELECT Statement in detail

SELECT [ALL | DISTINCT] ***select_expr*** **[,** ***select_expr*** **...]**

List the columns (and expressions) that are returned from the query

[FROM ***table_references***

Indicate the table(s) or view(s) from where the data is obtained

[WHERE ***where_condition*****]**

Indicate the conditions on whether a particular row will be in the result

[GROUP BY {*col_name* **|** ***expr*** **} [ASC | DESC], ...]**

Indicate categorisation of results

[HAVING ***where_condition*****]**

Indicate the conditions under which a particular category (group) is included in the result

[ORDER BY {*col_name* **|** ***expr*** **|** ***position*****} [ASC | DESC], ...]**

Sort the result based on the criteria

[LIMIT {[*offset*****,] ***row_count*** **|** ***row_count*** **OFFSET** ***offset*****}]**

Limit which rows are returned by their return order (ie 5 rows, 5 rows from row 2)

]

Select entire contents of table

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT * FROM Customer;
```

Edit: Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType
1	Peter	NULL	Smith	NULL	Personal
2	James	NULL	Jones	JJ Enterprises	Company
3	Akin	NULL	Smithies	Bay Wart	Company
4	Julie	Anne	Smythe	Konks	Company
5	Jen	NULL	Smart	BRU	Company
6	Lim	NULL	Lam	NULL	Personal
7	Kim	NULL	Unila	Saps	Company
8	James	Jay	Jones	JJ's	Company
9	Keith	NULL	Samson	NULL	Personal
NULL	NULL	NULL	NULL	NULL	NULL

Select specific columns

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT CustLastName, CustFirstName
    FROM Customer;
```

Export: Autosize:

CustLastName	CustFirstName
Smith	Peter
Jones	James
Smithies	Akin
Smythe	Julie
Smart	Jen
Lam	Lim
Unila	Kim
Jones	James
Samson	Keith

WHERE clause: select specific rows

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT CustLastName FROM Customer
    WHERE CustLastName = "Smith";
```

Export Autosize

CustLastName
Smith

WHERE clause with LIKE

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT CustLastName FROM Customer
    WHERE CustLastName LIKE "Sm%";
```

Export Autosize

CustLastName
Smith
Smithies
Smythe
Smart

Select with ORDER BY

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName;
```

Export:

CustLastName	CustType
Jones	Company
Jones	Company
Lam	Personal
Samson	Personal
Smart	Company
Smith	Personal
Smithies	Company
Smythe	Company
Unila	Company

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName DESC;
```

Export:

CustLastName	CustType
Unila	Company
Smythe	Company
Smithies	Company
Smith	Personal
Smart	Company
Samson	Personal
Lam	Personal
Jones	Company
Jones	Company

Select with LIMIT

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName
    LIMIT 5;
```

Export:

CustLastName	CustType
Jones	Company
Jones	Company
Lam	Personal
Samson	Personal
Smart	Company

```
SELECT CustLastName, CustType
    FROM Customer
    ORDER BY CustLastName
    LIMIT 5
    OFFSET 3;
```

Export:

CustLastName	CustType
Samson	Personal
Smart	Company
Smith	Personal
Smithies	Company
Smythe	Company

CustLastName	CustType
Jones	Company
Jones	Company
Lam	Personal
Samson	Personal
Smart	Company
Smith	Personal
Smithies	Company
Smythe	Company
Unila	Company

(what happens if we Limit without Ordering?)

Select with GROUP BY

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT CustType, Count(CustomerID)
    FROM Customer
    GROUP BY CustType;
```

Export: Autosize:

CustType	Count(CustomerID)
Personal	3
Company	6

```
SELECT CustType, Count(CustomerID) AS Count
    FROM Customer
    GROUP BY CustType;
```

Export: Autosize:

CustType	Count
Personal	3
Company	6

Select with WHERE and GROUP BY

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
SELECT CustType, Count(CustomerID)
    FROM Customer
    WHERE CustLastName LIKE "Sm%"
    GROUP BY CustType;
```

Export: Autosize

CustType	Count(CustomerID)
Personal	1
Company	3

Select with GROUP BY and HAVING

Customer	
PK	**CustomerID**
	CustFirstName CustMiddleName **CustLastName** BusinessName **CustType**

```
1 • select custtype, count(CustomerId) from customer
2   where custlastname like 'Sm%'
3   group by custtype
4   having count(CustomerId) = 3;
```

Result Grid | Filter Rows: | Export: | Wrap Cell Content:

custtype	count(CustomerId)
Company	3

"Having" works on groups
the way "Where" works on individual rows

Inner join, Natural join

- Data about an entity is spread across 2 tables – so join them
- Inner/Equi join - Join rows where FK value = PK value

```
SELECT * FROM Customer INNER JOIN Account
    ON Customer.CustomerID = Account.CustomerID;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2

- Natural Join gives the same result as Inner Join
  - requires PK and FK columns to have the same name

```
SELECT * FROM Customer NATURAL JOIN Account;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25

Outer join

- Outer join
  - Can be left or right (see difference below)
  - Includes records from left/right table that don't have a matching row

```
SELECT * FROM Customer LEFT OUTER JOIN Account
    ON Customer.CustomerID = Account.CustomerID;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleNa	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2
3	Akin	NULL	Smithies	Bay Wart	Company	NULL	NULL	NULL	NULL

```
SELECT * FROM Customer RIGHT OUTER JOIN Account
    ON Customer.CustomerID = Account.CustomerID;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2

Select with JOIN

- What if there is no join condition?

```
SELECT * FROM Customer, Account;
```

Export: Autosize:

CustomerID	CustFirstName	CustMiddleName	CustLastName	BusinessName	CustType	AccountID	AccountName	OutstandingBalance	CustomerID
1	Peter	NULL	Smith	NULL	Personal	1	Peter Smith	245.25	1
2	James	NULL	Jones	JJ Enterprises	Company	1	Peter Smith	245.25	1
3	Akin	NULL	Smithies	Bay Wart	Company	1	Peter Smith	245.25	1
1	Peter	NULL	Smith	NULL	Personal	2	JJ ENt.	552.39	2
2	James	NULL	Jones	JJ Enterprises	Company	2	JJ ENt.	552.39	2
3	Akin	NULL	Smithies	Bay Wart	Company	2	JJ ENt.	552.39	2
1	Peter	NULL	Smith	NULL	Personal	3	JJ ENt. Mgr	10.25	2
2	James	NULL	Jones	JJ Enterprises	Company	3	JJ ENt. Mgr	10.25	2
3	Akin	NULL	Smithies	Bay Wart	Company	3	JJ ENt. Mgr	10.25	2

NOT CORRECT: lack of join conditions -> Cartesian product

(every row in Customer combined with every record in Account)

Summary

- Introduced data modelling & SQL
- Linked data modelling to SQL
  - Conceptual, Logical, Physical Design
  - SQL to create physical database from physical design
  - showed an example of a single entity through these stages
  - used SQL to implement the entity as a database table
- Extended our knowledge on modelling
  - how to model 2 (or more) entities
  - how to link tables together
    - in ER, In SQL
  - how to get data out of tables
- Dealing with multi-valued attributes

Homework: data model

- An insurance company writes policies for drivers. One policy can cover many drivers and also many vehicles, but a vehicle can be related to only one policy. Drivers can share one or more vehicles (e.g. a husband and wife own one vehicle and they both drive the same vehicle or a family can have multiple vehicles). The system needs to store the name and address of each driver.
- The company gets a master list of violations from the Department of Motor Vehicles. These violations are then input into the system and used to determine the price of each insurance policy. A driver may commit more than one violation. One or more drivers can commit the same violation.

- Sample Answer released next week