ERD & Normalization

- Degrees of relationship
- Participation constraints

Learning Outcomes

- Differentiate between degrees of relationships.
- Understanding decisions in many-to-many relationships.
- Understand the use of specialization and generalization techniques.

Entity-Relationship Diagram (ERD)

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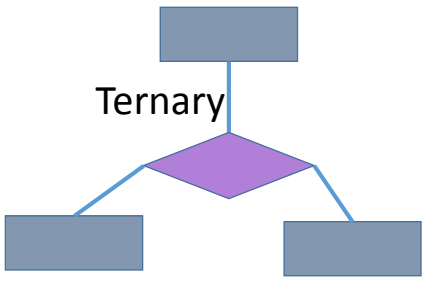
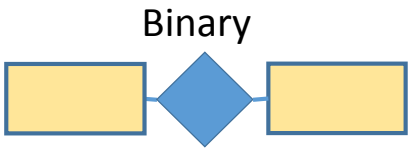
- The ERD module is intended to capture meaning as well as structure of the database.
- The ERD is independent of any DBMS.
- The ERD allows you to express constraints and restrictions on entities or relationships.

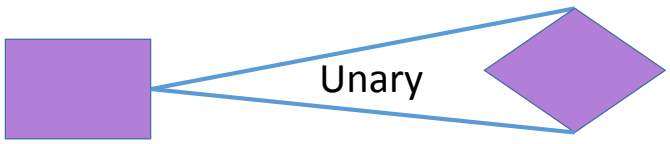
Degrees of relationships

- The degree of relationship is the number of entity sets to which it links

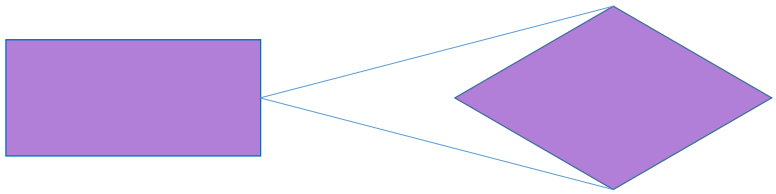
-unary
- binary
- ternary
-n-ary



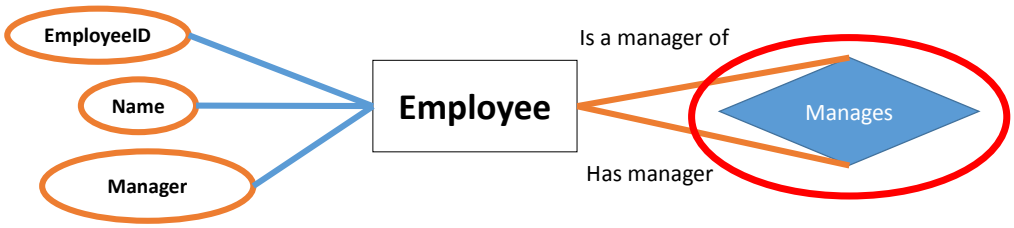




Unary degrees of relationship



Example of unary degrees of relationship (recursive)



Employee

EmployeeID (PK)	Name	Manager
1001	Joe	1005 (Bob)
1002	Tom	1004 (Fred)
1003	Sophie	1005 (Bob)
1004	Fred	1005 (Bob)
1005	Bob	9999

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Example of unary degrees of relationship (recursive)

Manages = {(The employee with Employee ID 1005, The employee with employeeID 1001),

(The employee with Employee ID 1005, The employee with employeeID 1003),

… }

Every set shows that an employee has a manager and a manager is also an employee.

EmployeeID (PK)	Name	Manager
1001	Joe	1005 (Bob)
1002	Tom	1004 (Fred)
1003	Sophie	1005 (Bob)
1004	Fred	1005 (Bob)
1005	Bob	9999

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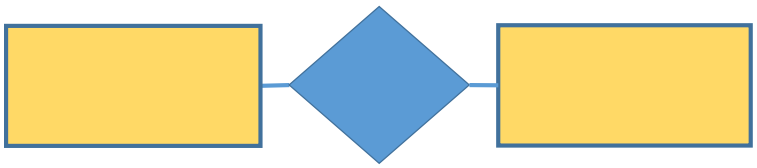
Binary degrees of relationship



Example binary degrees of relationship

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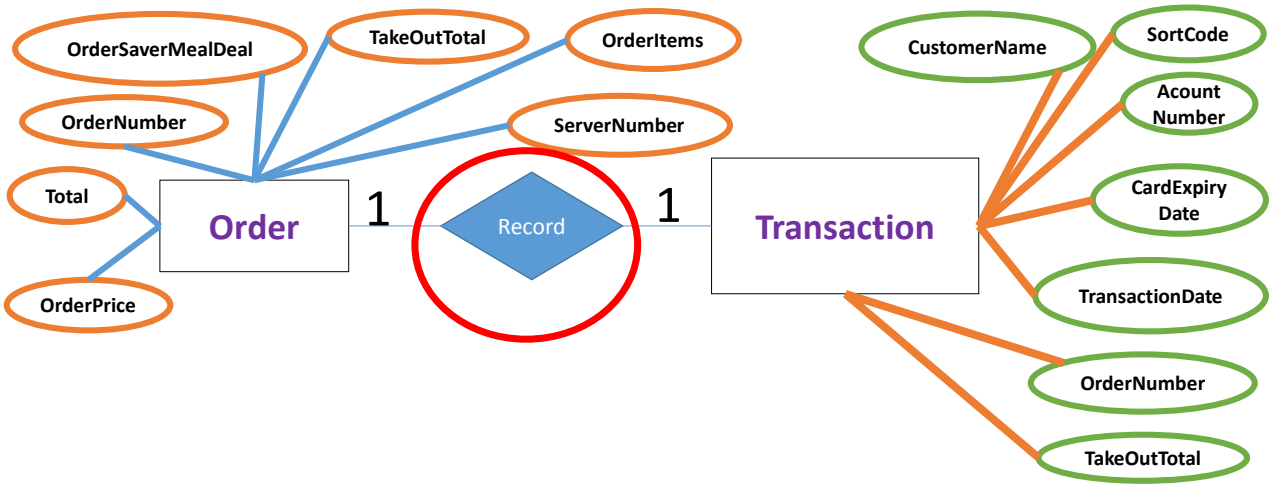
Order

Order Number	OrderItems	OrderPrice	Total	OrderSaverMealDeal	TakeOutTotal	ServerNumber
39	Big Mac	£2.99	7.26	Big Mac Meal Deal	£6.26	#1001
	Large Fries	£1.39				
	Large Chocolate Milkshake	£1.89				
	Mcflurry	£0.99				
56	Chicken Legend with Cool Mayo	£3.59	6.27	Chicken Legen Deal	£5.27	#1002
	Large Fries	£1.39				
	Large Cold Drink	£1.29				
44	Sausage Egg and Cheese Bagal	£2.29	4.18	BreakfastBagalDeal	£3.18	#1001
	Large Cappaccino	£1.89				
69	Chicken Selects 5 Pieces	£4.19	6.87	Chicken Select Deal	£5.87	#1002
	Large Fries	£1.39				
	Large Cold Drink	£1.29				

Transaction

CustomerName	SortCode	AcountNumber	CardExpiryDate	TransactionDate	OrderNumber	TakeOutTotal
B Smith	123456	5149 1234 5678	12/12/21	05/10/17	39	£6.26
R Hussain	171819	9865 6949 1874	01/01/18	06/10/17	56	£5.27
D Tan	262728	6339 5577 9874	01/08/20	07/10/17	44	£3.18
S Sam	293031	1000 2333 1597	01/05/19	07/10/17	69	£5.87

Example of binary degrees of relationship

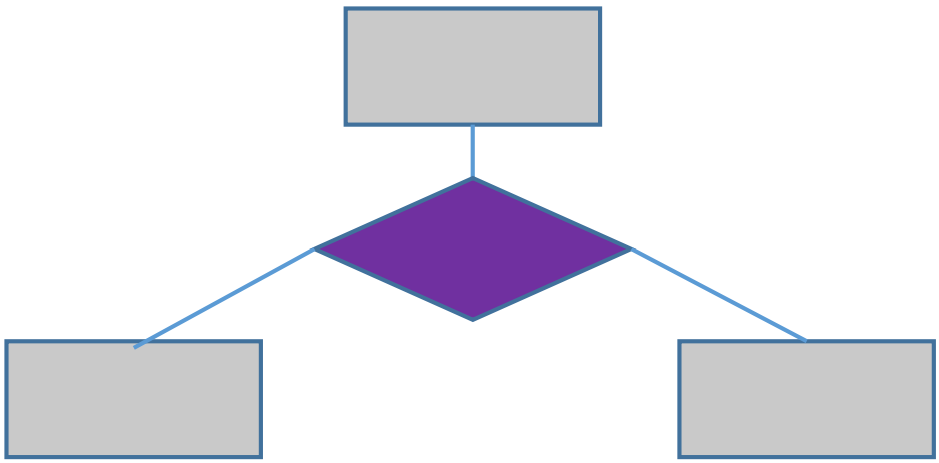


Binary degrees of relationship

Record = {(the order with Number 39, the transaction with customername B Smith),
(the order with Number 56, the transaction with customername R Hussain),
(the order with Number 44, the transaction with customername D Tan),
the order with Number 69, the transaction with the customername S Sam)}

Each ordered pair shows that an order is related to a specific transaction.

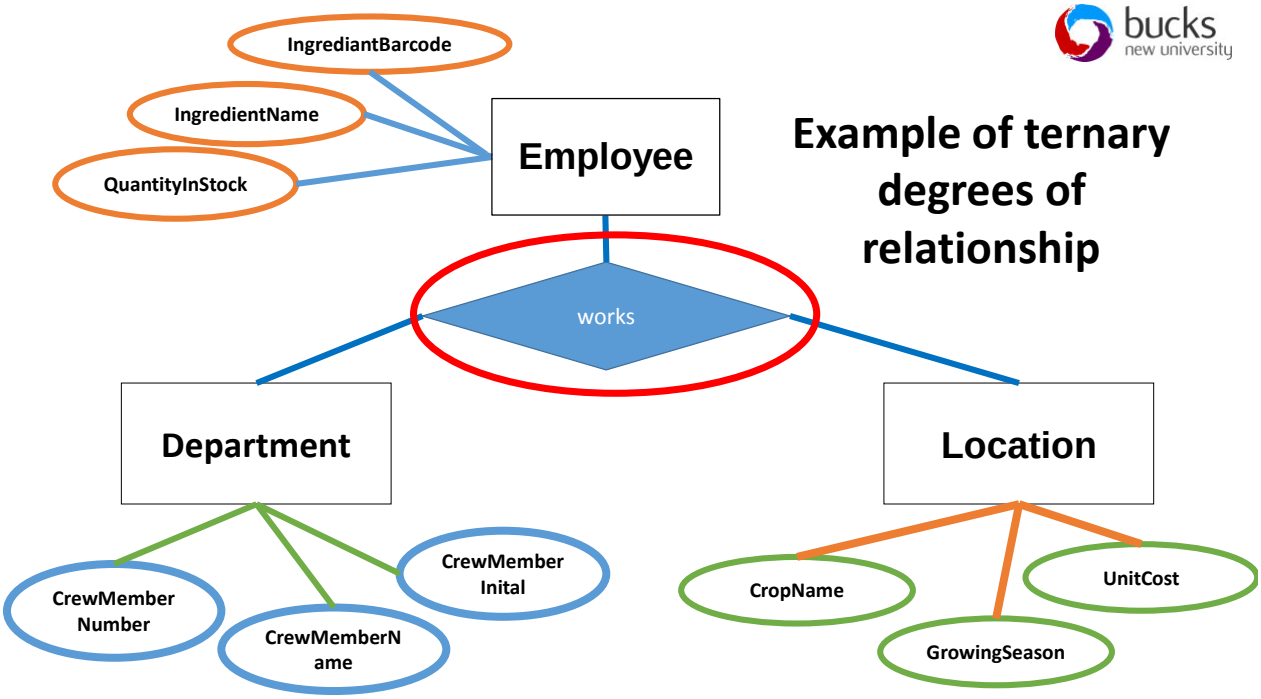
Ternary degrees of relationship



StaffNo (PK)	FirstName	Surname	Position	Salary	DeptD (FK)	dCentreNo (FK)
S1500	Tom	Daniels	Manager	48000	IT	D001
S0003	Sally	Adams	Assistant	30000	IT	D001
S0010	Mary	Martinez	Manager	51000	HR	D002
S3250	Robert	Chin	Assistant	33000	HR	D002
S0415	Art	Peters	Manager	42000	Sales	D003
S2250	Sally	Stern	Manager	48000	Acct&Pay	D004

DeptID (PK)	DpetName	Manager
IT	Information Technology Department	Raza Rizvi
HR	Human Resources Department	Nikki White
Sales	Sales Department	Siama Hussian
Accounts&Payroll	Accounting and Payroll Department	Hannah Grange

dCentre No (PK)	dAddressLine1	Town	Postcode	dTelNo
D001	8 Jefferson Way	High Wycombe	HP11 8TY	503 555 3618
D002	City Centre	Manchester	MD1 1JU	061 852 147
D003	14 Avenue	Slough	SL6 782	015 025 951
D004	West Gate	Oxford	OX7 2QA	023 357 753



Example of ternary degrees of relationship

Ternary degrees of relationship

Works = {(S1500, IT, D001),
(S003, IT, D001),
…}

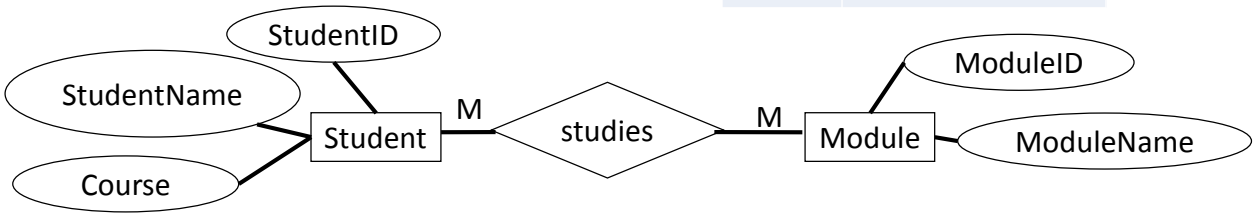
Each ternary set shows that an employee works in a department which is in a specific location

Understanding decisions in many-to-many relationships

Resolving many-to-many relationships

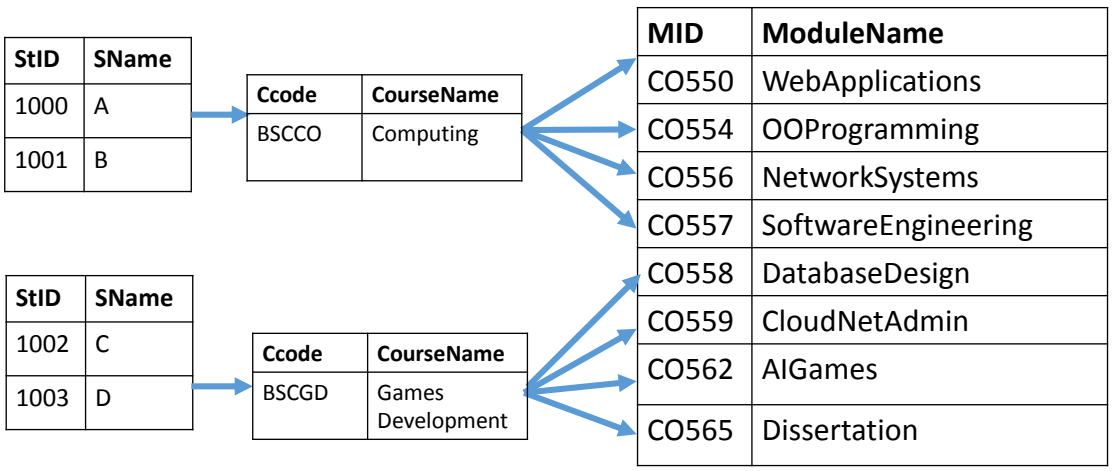
StudentID	StudentName	Course
1000	A	Computing
1001	B	Computing
1002	C	Computing
1003	D	Computing

ModuleID	ModuleName
CO558	Database_Design
CO554	Object_Orientated_Programming
CO556	Network _System
CO562	Artificial_Intelligence for Games

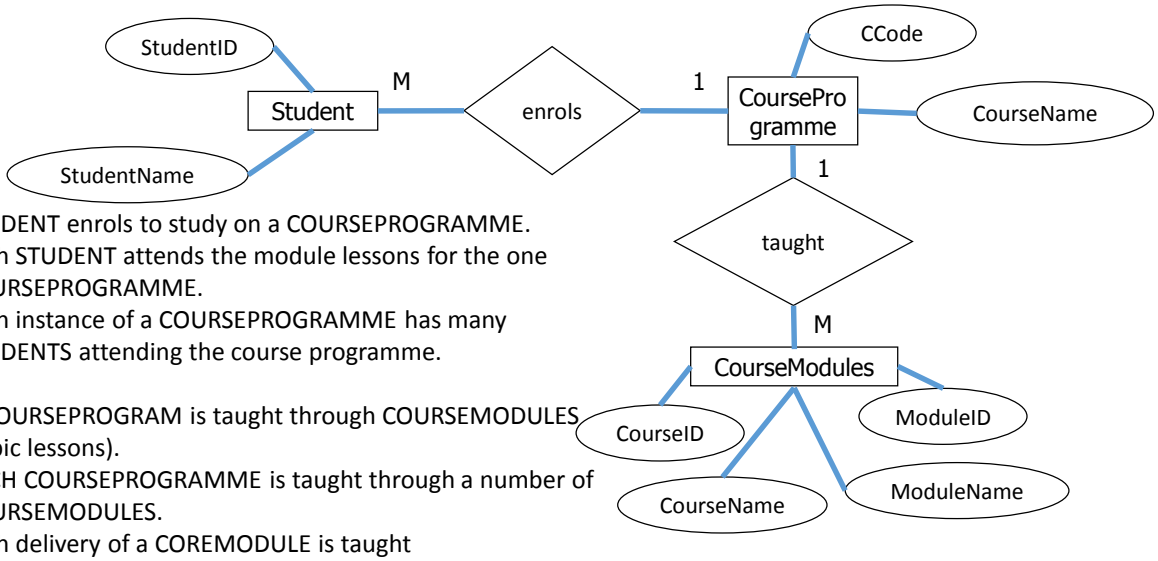


A student studies many modules as part of their course
Modules have many students studying them

Resolving Many to Many Relationships



Resolving Many to Many Relationships



STUDENT enrols to study on a COURSEPROGRAMME.
Each STUDENT attends the module lessons for the one COURSEPROGRAMME.
Each instance of a COURSEPROGRAMME has many STUDENTS attending the course programme.

A COURSEPROGRAM is taught through COURSEMODULES (topic lessons).
EACH COURSEPROGRAMME is taught through a number of COURSEMODULES.
Each delivery of a COREMODULE is taught once on a COURSEPROGRAMME.

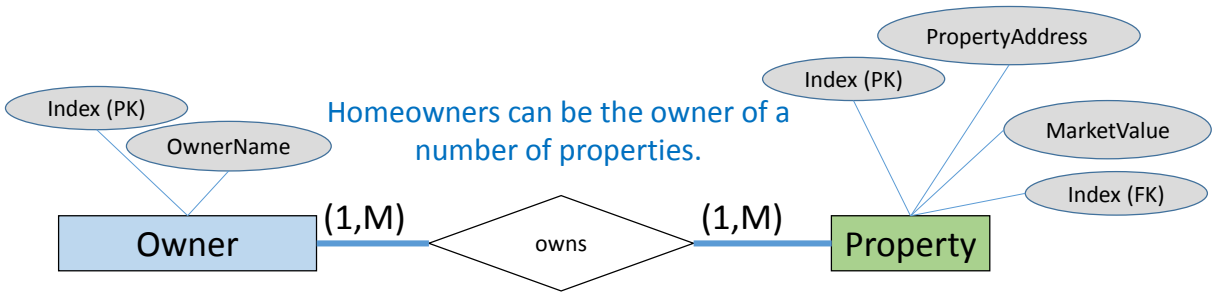
Resolving Many to Many Relationships

Index (PK)	OwnerName
1001	Christopher Arnold
1002	Ben Afflick
1003	Lenny Kravitz
1004	Pam Ferris
1005	Tina Turner
1006	Walter Payton

These tables **"represents"** homeowners and the property they own. A owner can own any number of properties. Also properties can be jointly owned by a number of homeowners.

Index (PK)	PropertyAddress	MarketValue	Index (FK)
101	21 High Street, High Wycombe	£210,000	1001
102	23 High Street, High Wycombe	£250,000	1001
103	25 High Street, High Wycombe	£265,000	1001
104	Apartment 7 Florida	£300,000	1002
105	Penthouse Canary Warf, London	£400,000	1002
106	7 Dudley Drive, Southamption	£199,950	1003
107	15 Writers Block, Birmingham	£500, 000	1004
108	15 Writers Block, Birmingham	£500,000	1005
109	15 Writers Block, Birmingham	£500,000	1006

Resolving Many to Many Relationships



Properties can be jointly owned by a number of homeowners.

Note: we are excluding renters in this example!

Resolving Many to Many Relationships

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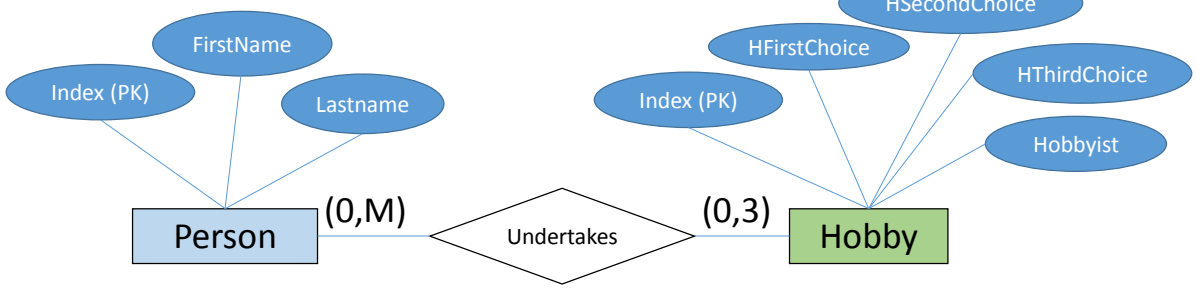
Index (PK)	FirstName	Lastname
1	Christopher	Arnold
2	Bob	Jones
3	Ben	Aflick
4	Lenny	Kravitz
5	Pam	Ferris
6	Tina	Turner
6	Walter	Payton

Index (PK)	HFirstChoice	HSecondChoice	HThirdChoice	Hobbyist
1	Cycling	Running	Tennis	Christopher
2	Running	Archery	Badminton	Bob
3	Archery	Clay Pigeon	Bowling	Ben
4	Singing	Dancing	Swimming	Lenny
5	Swimming	Cycling	Running	Pam
6	Cricket	Bowls	Hockey	Tina
7	Drawing	Pottery	Sculpture	Walter

This table **“represents”** people and their first, second and third choice of hobbies.

Resolving Many to Many Relationships



- A person undertakes hobbies: 1st, 2nd and 3rd choice.
- A hobbyist can undertake any number of hobbies, for which they have a preference, or they can not undertake any hobbies.

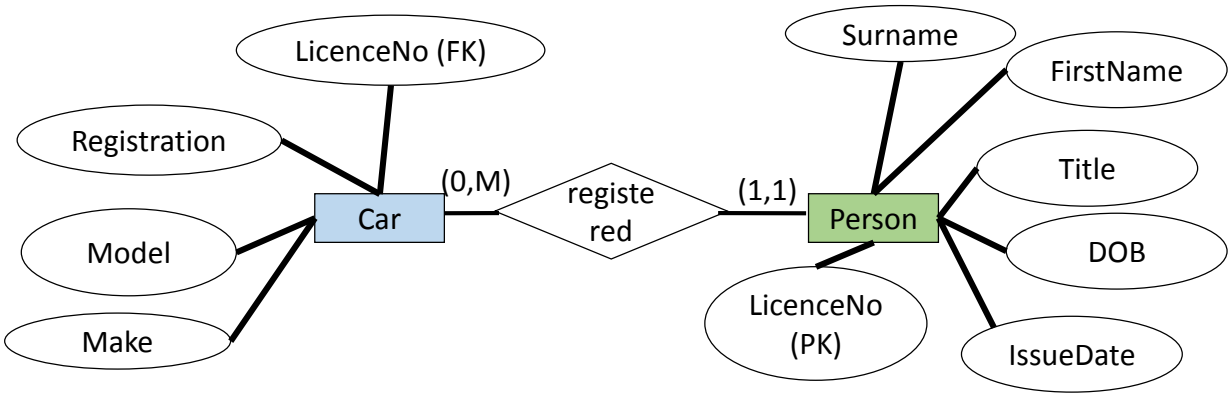
Resolving Many to Many Relationships

Surname	FirstName	Title	DOB	IssueDate	LicenceNo (PK)
Smith	Will	Mr	25/09/1968	30/09/1985	Smith2589651KYBWTYZV
Bean	Mr	Mr	12/12/1975	05/03/1995	Bean85215SBEU5689ZXV

A person can own any number of cars

Index (PK)	Make	Model	Registration	LicenceNo (FK)
1000	Aston Martin	DB9	BD51 SMR	Smith2589651KYBWTYZV
1001	Rolls-Royce	Ghost	GB60 SEP	Smith2589651KYBWTYZV
1002	Lamborghini	Aventador	AN01 C6831	Smith2589651KYBWTYZV
1003	Mini	Cooper	BEAN 123D	Bean85215SBEU5689ZXV

Example of using Index keys



Although, the majority of people own one car, there are no outright limits on the number of cars that can be registered under your name. At the end of March 2017 there were 31.1 million cars licensed for use on the roads in Great Britain.

https://www.gov.uk/government/statistics/vehicle-licensing-statistics-january-to-march-2017 accessed 31/10/2018

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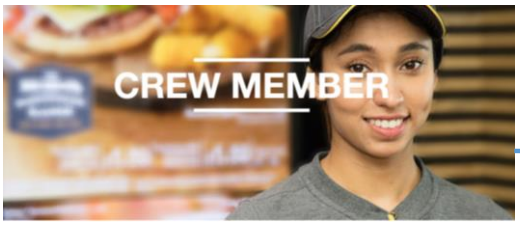
Participation constraints

Specialization

"Not all entities in the membership participate in a relationship"



We want every McDonald's customer to have a brilliant experience, every time they visit. That means hot food in a clean and friendly restaurant. As a Crew Member, you'll make it happen, whether you're preparing food, serving on the till or helping out in the dining areas. We'll train you in our high standards of customer service, food preparation, and cleanliness and hygiene. But the rest is up to you.

Crew Member

What attributes for crew member?

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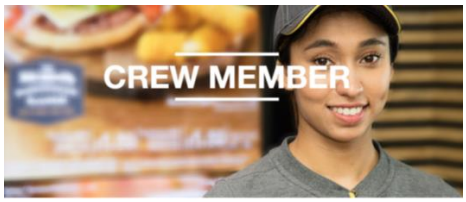
Specialization constraint



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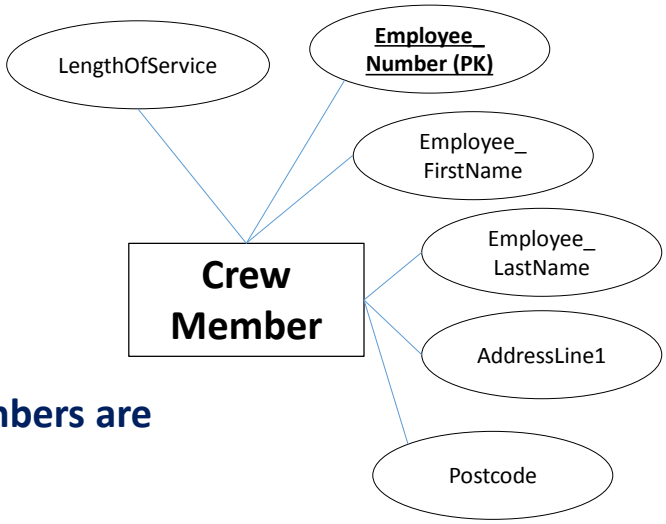
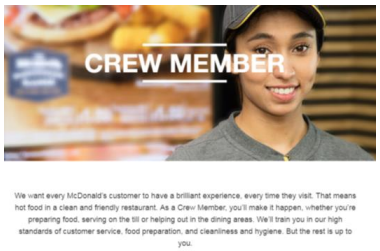


What types of crew members are employed?

Different types of crew members

How do we represent this in our model?



CrewMemberType1
Works weekend shifts and is paid on a hourly rate – national minimum wage

CrewMemberType2
Has been employed for 2 years and is a full time salaried employee

CrewMemberType3
Is a student that is away most of the year studying, but at Christmas is hired as a seasonal contract worker.

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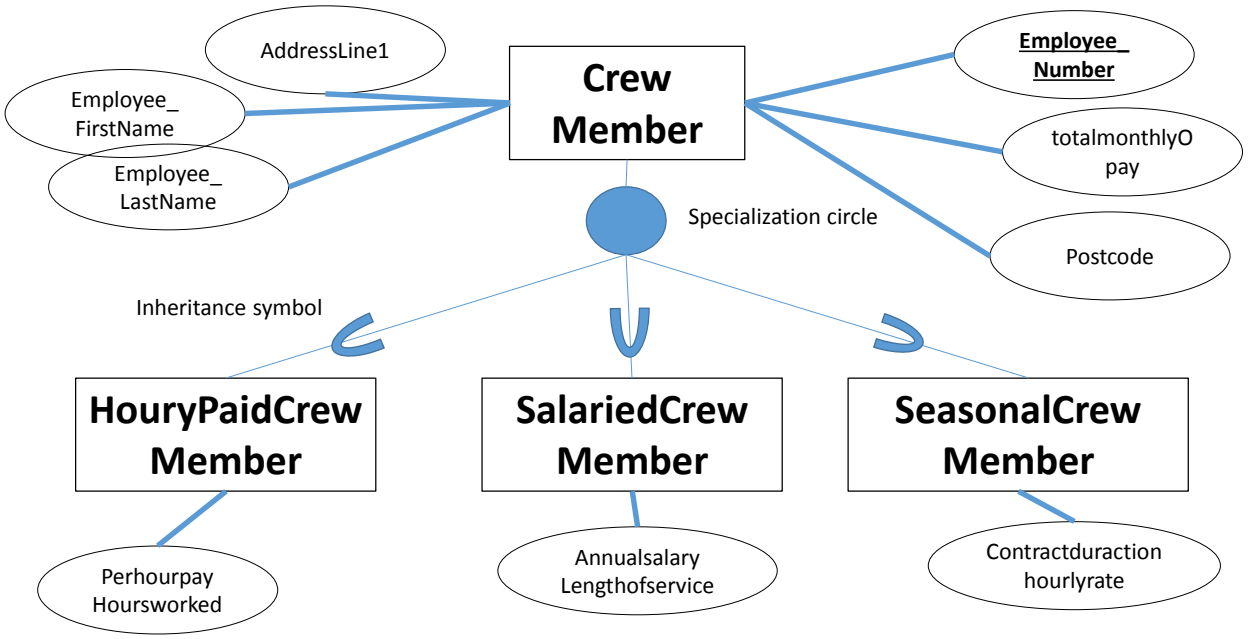


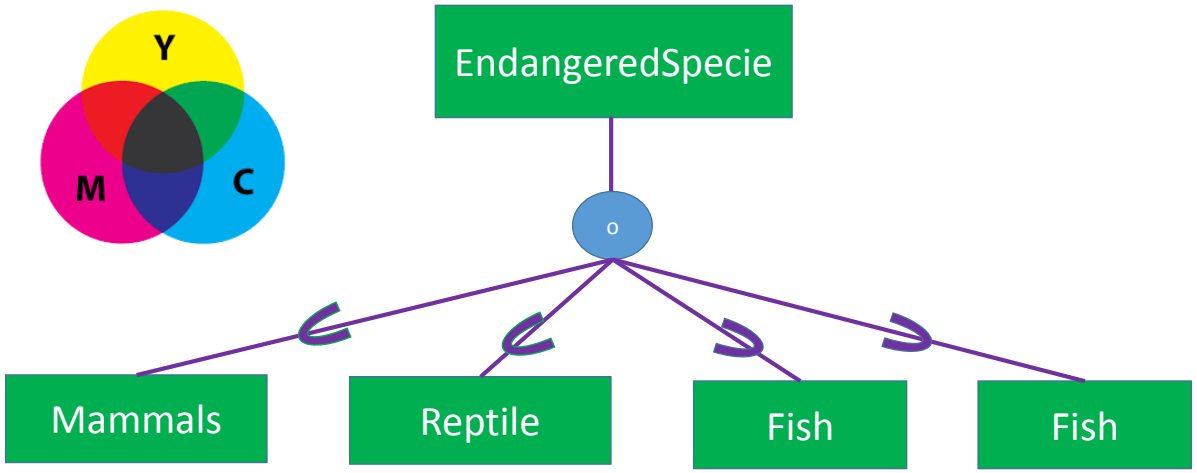
Use of specialization

Generalization

"Entity set contains subsets that have special attributes or special relationships"

Participation Constraints

Generalizaton – overlapping



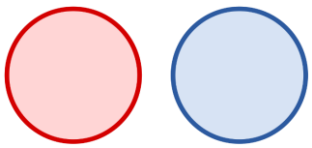
Different species, which are endangered. A mammal is not a reptile, but does have commonality e.g. Legs.

Generalizaton - disjoint

Regular

Large

A milkshake is a regular sized drink or a large sized drink, it cannot be both.



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Modeling data in the organisation: Access control system

Background

- Speedy ISP Ltd is a Internet Service Provider (ISP) and networking solutions provider

- It is a local company and the target customer is small-to-medium enterprises (SME).
- Also the ISP does provide broadband to home users.
- The company employs approximately 100 staff at this site.

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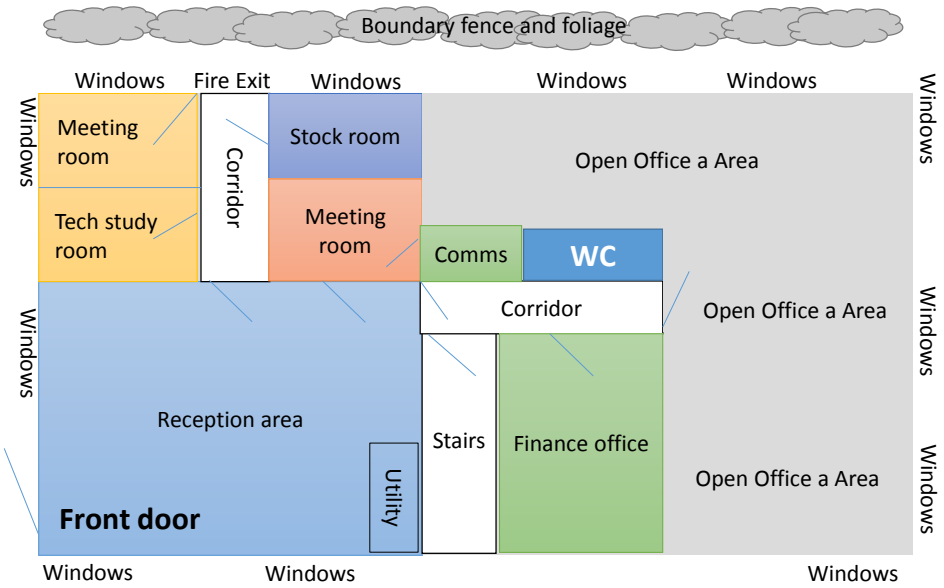
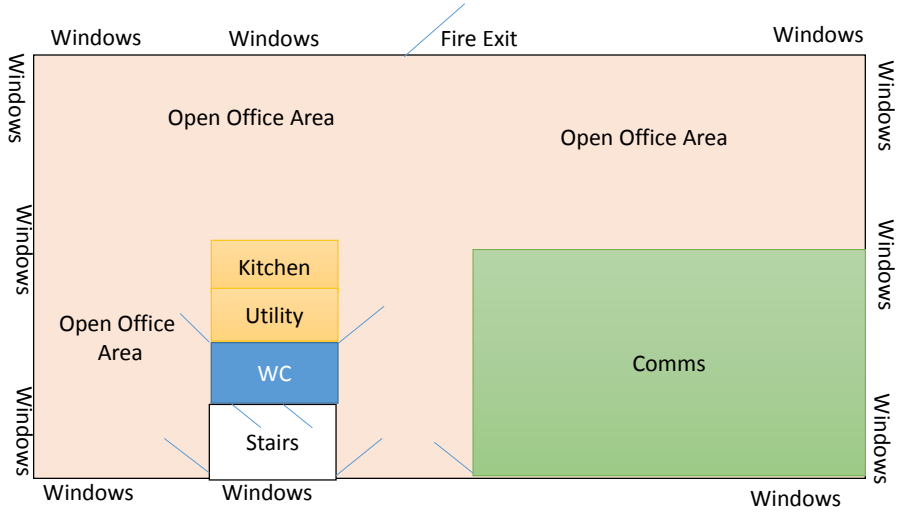
Scenario – THIS IS TRUE!

- One evening armed individuals forced entry into the building via the front door
- On the first floor there were only 10 staff members working the late shift until 8:00pm
- One of the late shift staff members decided to use the washroom facilities on the ground floor and when coming down the stairs spotted the armed intruder!

Floor Plan – Ground Floor



Floor Plan - 1st Floor



My Job

- As duty support manager for that day, I arrived on site at 9:30pm following the late shift staff having initiated the panic button
  - Police were on site getting statements
  - Security were onsite dealing with securing the building
- My job that evening:
  - Ensure the safety and wellbeing of the late shift staff
  - Ensure the building was secured for the night
  - Assess the damage and loss of assets
  - Organise staff working on the ground floor

A few days after the event once all the initial issues were resolved - to assess the long term security of the building – Staff Safety!!

Proposition of access control system

- Increase building security – strengthened doors and locking system – specifically front entrance
- Control entrance to building generally
- Restrict access to certain areas within the building
- Provide a standard for future deployment to other sites

Physical system components

Database

Key Fobs or Access Cards

Readers

Server

Staff Members allocated access tokens

Controllers

Magnetic Locking

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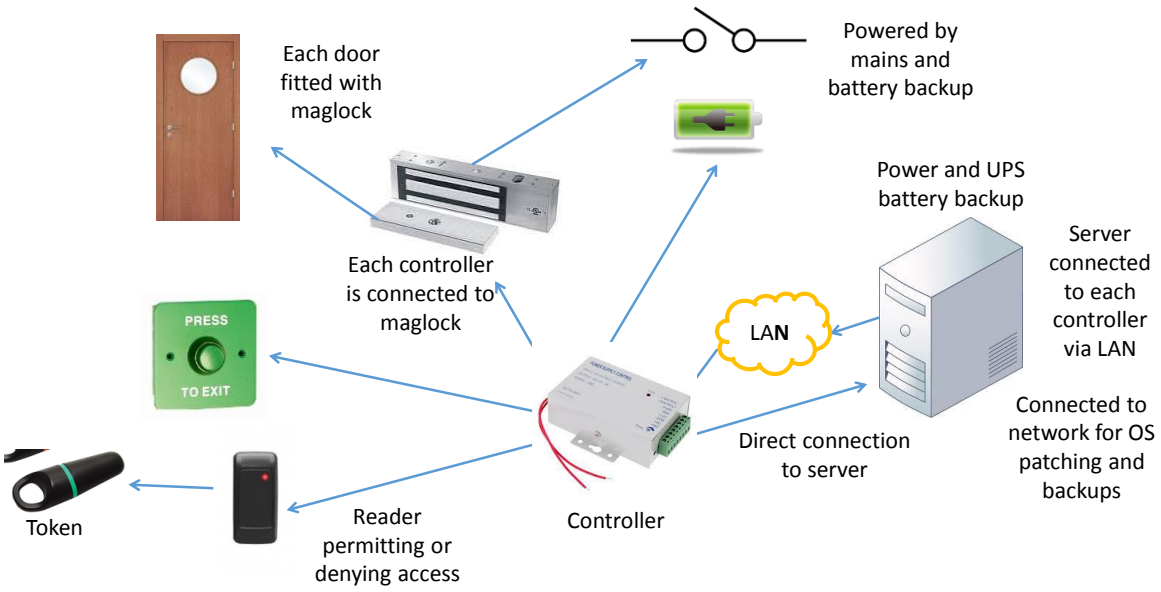
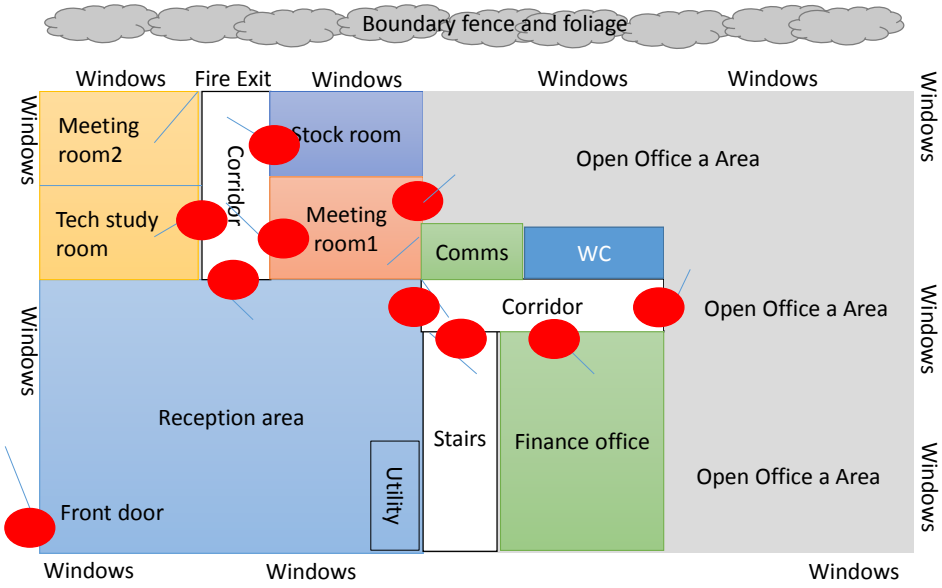
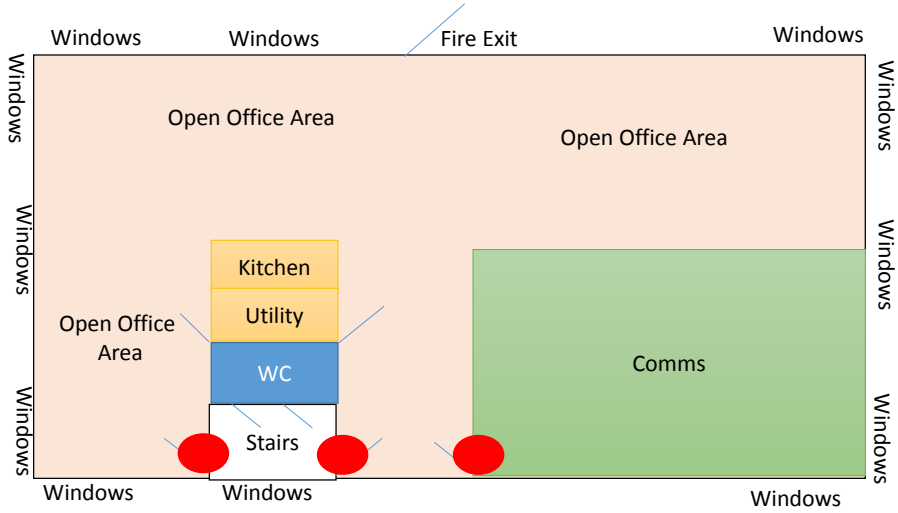
Physical system components



Areas to protect – ground floor



Areas to protect – 1st Floor



Data gathering - doors

DoorID	Description
MR1	Meeting Room 1 – ground floor
FINOFFICE	Finance office – ground floor
MAROFFICE	Marketing Office – ground floor
FRONTDOOR	FrontDoor – access to building

Note: the doors listed here just some examples

- Doors are the access points to areas
- Depending on job role and hours of work a staff member can gain access through the door or are denied.
- All members of staff of staff permitted through front door according to their hours a work
- Only Finance members of staff permitted entry thought finance door – all other members of staff must wait for access
- Other restricted areas: communication rooms, technical study room

Data gathering - users

CardNumber	First Name	Last Name	Department	Job Role
10000002	Nicola	Smith	Finance team	Finance Assistant
10000003	Kompel	Campion	Technical team	Technical Manager
10000004	Wayne	Palmer	Sales team	Sales Manager

- Job role and working hours of members of staff.

Data gathering – access levels

AccessLevelID	TimeZoneID	DoorID
NormalHours	9-5	FRONTDOOR
AllHoursAllDoors	24hr	FRONTDOOR
LateAccess	7-8	FRONTDOOR

- An access level of Normal hours – assigned to a member of staff that works a 9am-5pm daily working pattern.
- All hours all doors – assigned to a member of staff who is a duty manager – senior level manager
- Late access – assigned to member of staff who work a shift pattern: 7am-3:00pm or 12:00-8:00pm rotation

First attempt conceptual model

- System needs to store information
  - Staff members are permitted access through a door depending on their access level
  - Doors fitted with controlled locking
  - Times access permitted on an individual staff depending on if allowed to enter the area and their hours of work

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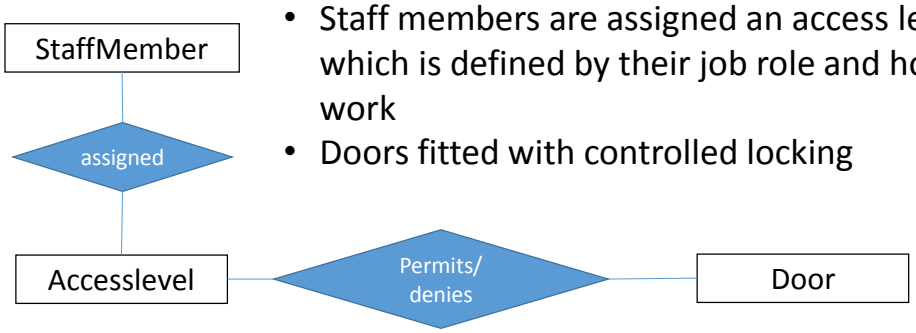
First attempt conceptual model



- Staff members are assigned an access level, which is defined by their job role and hours of work
- Doors fitted with controlled locking

What does a staff member need to gain entry through a door?

Data gathering – access tokens

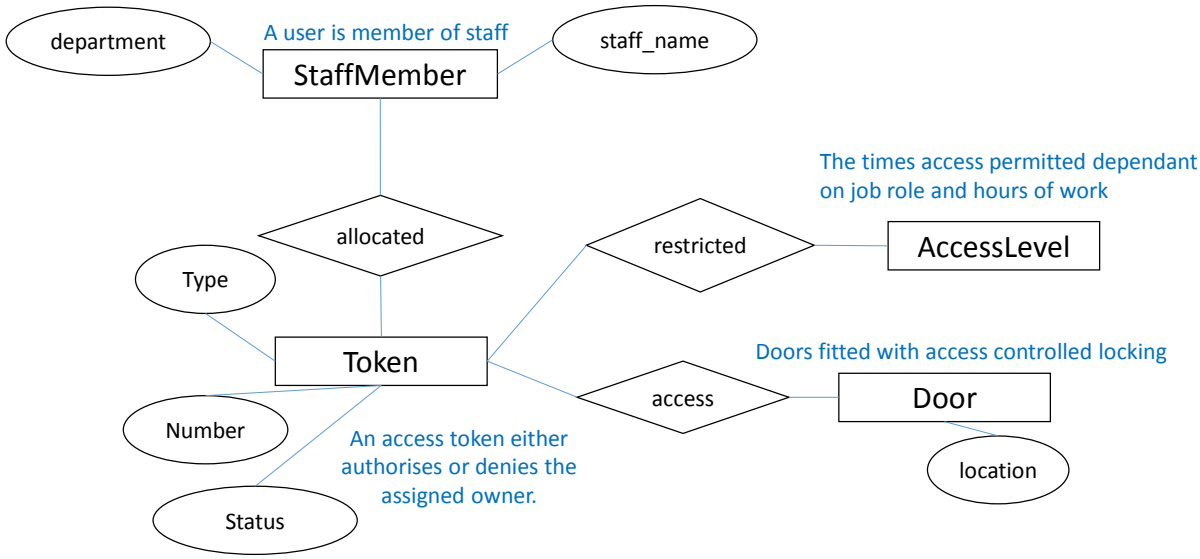
Card Number	Card Type	Card Status
10000002	Key_Fob	Live
10000003	Key_Fob	Live
10000004	Key_Fob	Live

- Each member of staff allocated a key fob, which when presented to the reader will either permit access through the door or deny access.
- The access level dependant on member of staff job role and hours of work
- Restricted areas by job role: technical study room, comms' room and finance office

Example attributes

Attribute	Description	Domain
TokenID	Set of all possible pass ID's based on current stock levels and includes history of lost/stolen and damaged passes.	Integer. 8 digits. 10000053
FirstName	Set of all possible user first names.	Character. 25.
LastName	Set of all possible user names names.	Character. 25.
TimezoneID	A set of access time zones.	Time format. 00:00:00-23:59:59 24hr 08:00:00-20:00:59 8-8 09:00:00-17:00:59 9-5

ERD – Second draft



Cardinality & participation

StaffMember

CardNumber	First Name	Last Name	Department	Job Role	AccessLevelID
10000002	Nicola	Smith	Finance team	Finance Assistant	NormalHours (9-5)
10000003	Kompel	Campion	Technical team	Technical Manager	AllHoursAllDoors (24hrs)
10000004	Wayne	Palmer	Sales team	Sales Manager	LateAccess (8-8)

Token

Card Number	Card Type	Card Status
10000002	Key_Fob	Live
10000003	Key_Fob	Live
10000004	Key_Fob	Live

AccessLevel

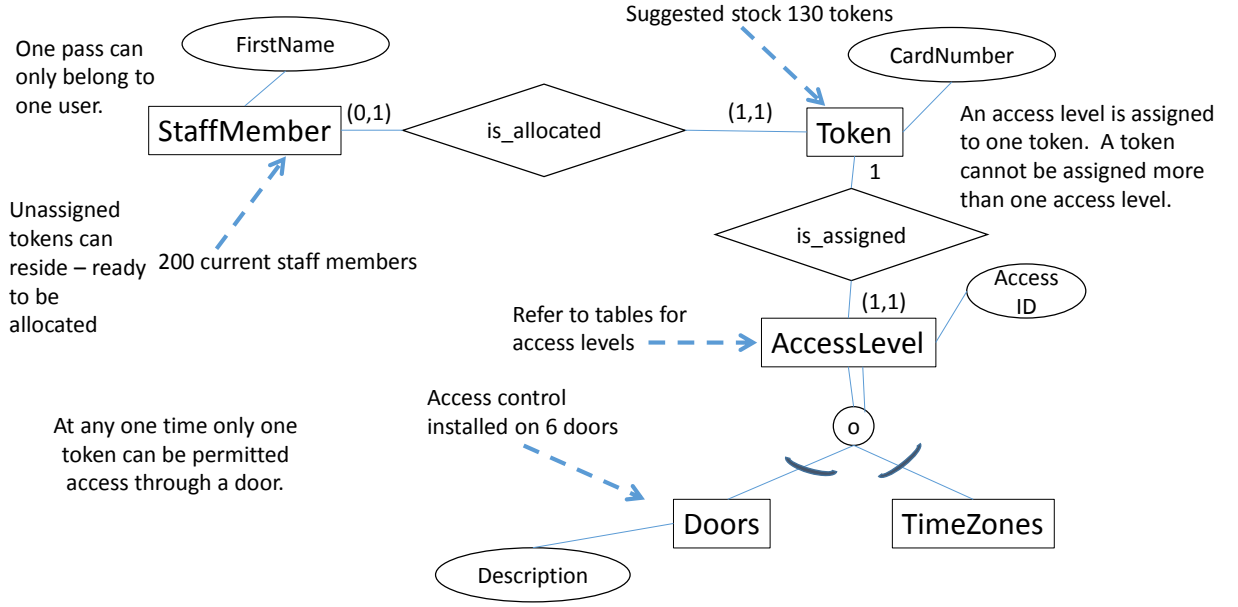
AccessLevelID	TimeZoneID	DoorID
NormalHours	9-5	FRONTDOOR
AllHoursAllDoors	24hr	FRONTDOOR
LateAccess	8-8	FRONTDOOR

Doors

DoorID	Description
MR	Meeting Room
FINOFFICE	Finance office
MAROFFICE	Marketing Office
FRONTDOOR	FrontDoor

ERD

A user can only be allocated one pass.



Choosing DBMS

Considerations:

- Server type & platform
- Storage format: minimum capacity required for software and database
- Networking requirements
- Backup options
- Ease of administration
- Cost of project
- Timescale for deployment

Paxton

bucks new university

Here is a partial answer to the **company** case study for you to look at in your own time.
Note: You will need to adjust the model as it is not complete and there are errors for you to spot!

Represent all the ER models described in (a), (b), (c), and (d) as a single ER model. Provide any assumptions necessary to support your model.

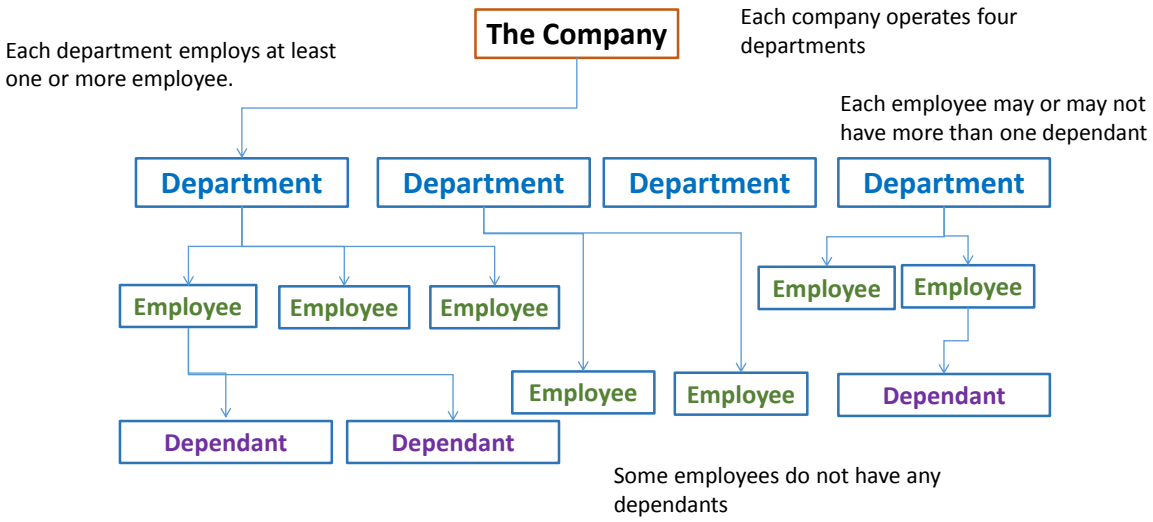
(a) Each company operates four departments, and each department belongs to one company. Each company has a unique name, and each department has a unique number and name.

(b) Each department in part (a) employs one or more employees, and each employee works for one department. Each employee has a number, name (including first and last name), date of birth, and age.

(c) Each of the employees in part (b) may or may not have one or more dependants, and each dependant belongs to one employee. Each dependant has a name, relationship to employee, and contact telephone numbers up to a maximum of three.

(d) Each employee in part (c) may or may not have an employment history. Each employment history has the name of the organization that the employee worked for and in what capacity, the start date and finish date for each employment.

Organisational model & assumptions



What do we need to store information about?

- The details about a company
- The departments and the company it operates under.
- The employees working in a department.
- An employees employment history where they have one.
- A record of an employees dependants if any.
- The type of dependant - NOC

Entities & Example Attributes

Company

CompanyName	TelephoneNumber
Royal Air Force Station - Halton	01296 623535
RAF Air Command – High Wycombe	01494 461461
RAF Benson	01491 837766
RAF Northolt	0208 845 2300

Department

DepartmentName	TelephoneNumber	CompanyName
The Groups	01494 462462	RAF Air Command – High Wycombe
Stations	01494 463463	RAF Air Command – High Wycombe
Squadrons	01494 464464	RAF Air Command – High Wycombe
Expeditionary Air	01494 465465	RAF Air Command – High Wycombe

Entities & Attributes

Employee

Employee Number	FirstName	LastName	DOB	Age	Role	Department
123456	Bob	Smith	07/11/1981	=currentyear-yearofbirth	Weapons Systems Operator	Squadrons
789101	Noor	Hussain	25/12/1975	=currentyear-yearofbirth	Weapons Systems Operator	Squadrons

Dependant

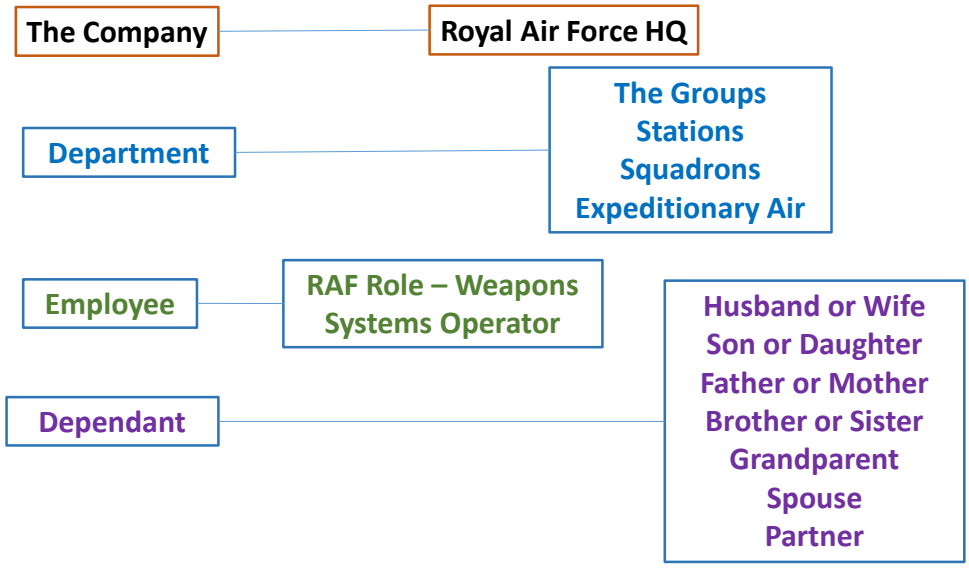
FirstName	LastName	ContactTelephone1	ContactTelephone2	ContactTelephone3	Relationship	Employee Number
Ted	Smith	000000	00000	0000000	Father	123456

Entities & Example Attributes

EmploymentHistory

Employee Number	PreviousEmployeer Name	Role	StartDate	EndDate	LengthofService	Reference
123456	CGI Ltd	Engineer	05/07/2000	21/09/2010	=Startdate-enddate	Ms Green
789101	Nova Ltd	Security	19/02/2008	09/05/2015	=Startdate-enddate	Mr Brown

Determine entities



Defining entities

Entity type: The_Compay
Attributes: Unique_Name CHAR (35)
Instances : RAF_HQ_High_Wycombe

Entity type: Department

Attributes: **Unique_Number** **CHAR (10)**
Unique_Name **CHAR (40)**

Instances of Department: RAF1GRP
ROYAL AIR FORCE NO 1 GROUP

Defining entities

Entity type: Employee		
Attributes:	**Employee_Number**	**STRING (8)**
	Name (Firstname, Lastname)	**CHAR (30)**
	Date_of_Birth	**DATE**
	Age	**INTEGAR**
Instances of Employee:	**447771**	
	John Smith	
	25/12/1904	
	111	

Defining entities

Entity type: Dependant

Attributes:	**Name (Firstname, Lastname)**	**CHAR (30)**
	Relationship to Employee	**CHAR (15)**
	Contact_Number	**STRING (12)**

Instances of dependant :	**Jane Smith**
	Wife
	014948882221
	079515832144

Example Attributes

Company
CompanyName: CHAR (30)
CompanyTelNumber: STRING (12)

Department
DeptTelNumber
DeptName

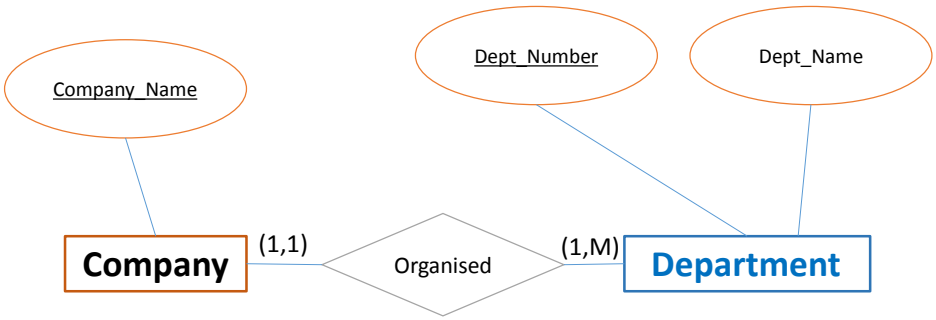
EmployementHistory
EmployeeNumber: STRING (8)
EmployerName
Role
StartDate
EndDate
LengthofService

Employee
EmployeeNumber: STRING (8)
EmployeeName (Firstname, Lastname): CHAR (30)
DateofBirth: DATE
Age: DERIVED INTEGAR

Dependant
DependantName (Firstname, Lastname)
RelationshiptoEmployee
ContactNumber1: STRING (12)
ContactNumber2: STRING (12)
ContactNumber3: STRING (12)
EmployeeNumber

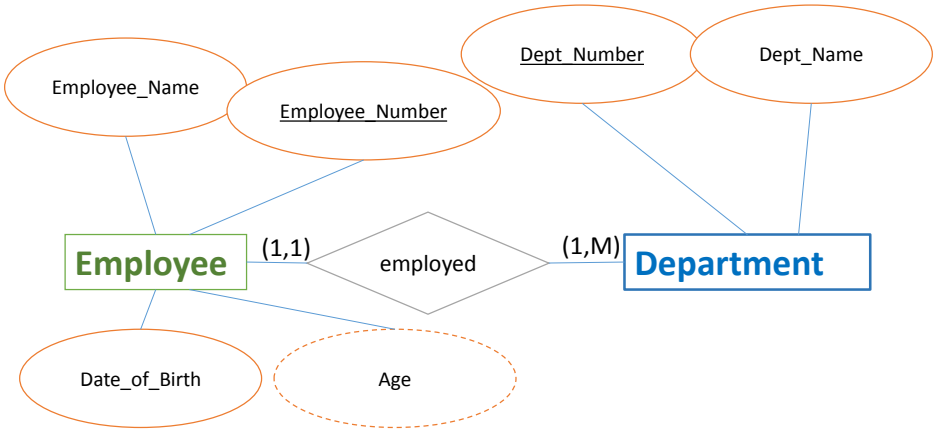
Determining association & cardinality

Company	**Department**	**A Company operates one or more departments** **Each instance of department belongs to exactly one Company**	**(1,M)** **(1,1)**



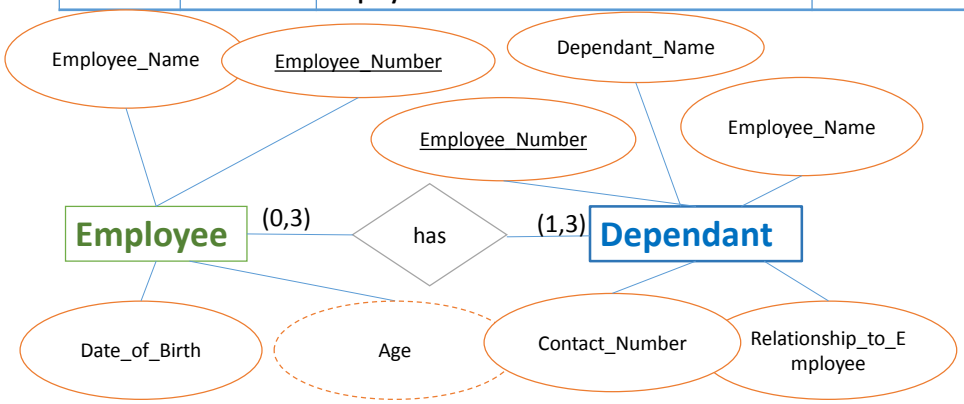
Determining association & cardinality

Department	**Employee**	**Each department employs one or more employees** **One employee is employed by one department**	**(1,M)** **(1,1)**



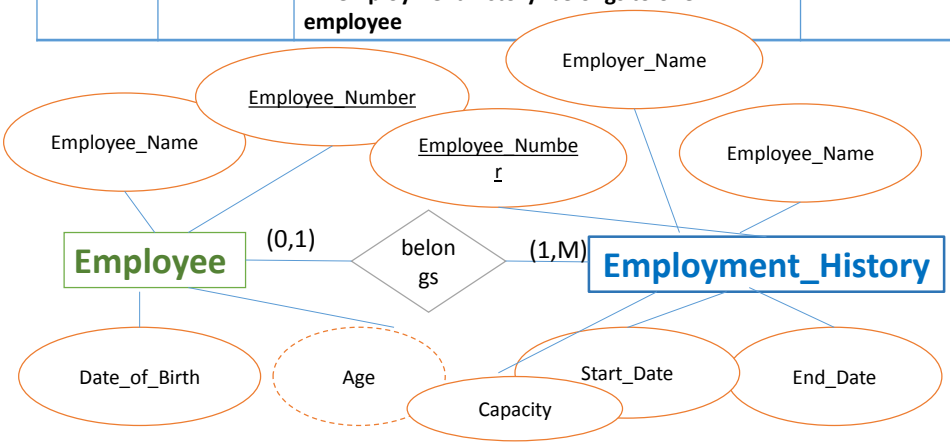
Determining association & cardinality

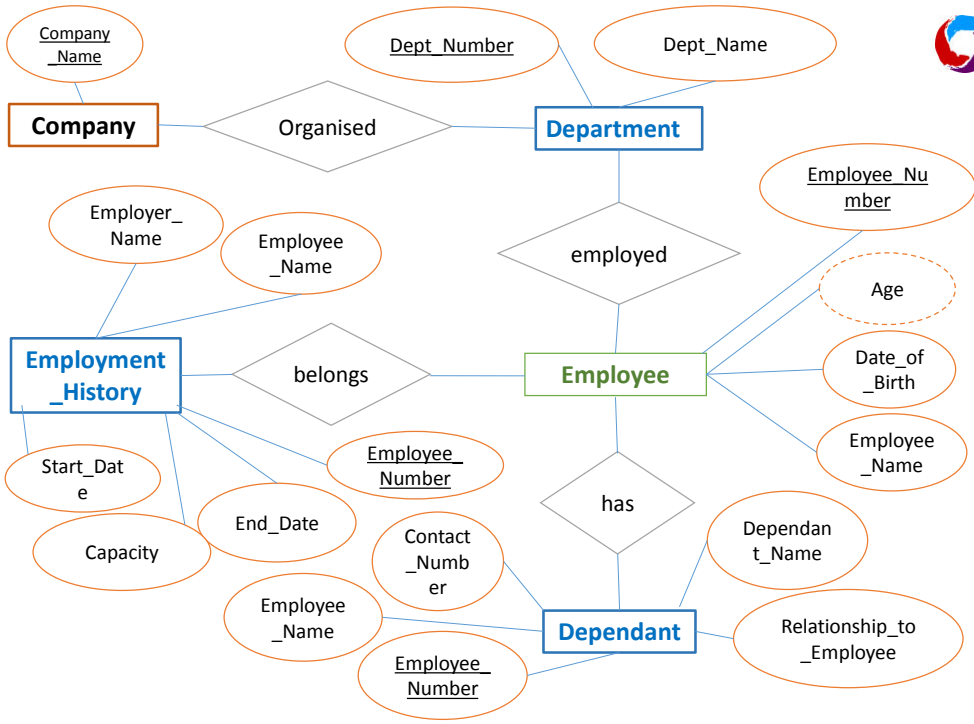
Employee	Dependant		
		Each employee may have one or more dependants a maximum of three. **Each employee may not have any dependants.** **A dependant must be associated to at least one employee : a maximum of three.**	**(1,3)** **(0,3)**



Determining association & cardinality

Employee	**Employee_ History**	**Each employee may have one or more instances of employment history** **An employee may not have a employment history** **An employment history belongs to one employee**	**(1,M)** **(0,1)**




Company_Name
Company
Organised
Dept_Number
Dept_Name
Department
Employer_Name
Employee_Name
Employment_History
belongs
employed
Employee_Number
Employee
Age
Date_of_Birth
Employee_Name
Start_Date
Capacity
End_Date
Employee_Number
has
Contact_Number
Employee_Name
Employee_Number
Dependant
Dependant_Name
Relationship_to_Employee

Can you adapt the model to reflect the types of dependants?

References

- Databases Illuminated (2017) – Catherine Ricardo & Susan Urban