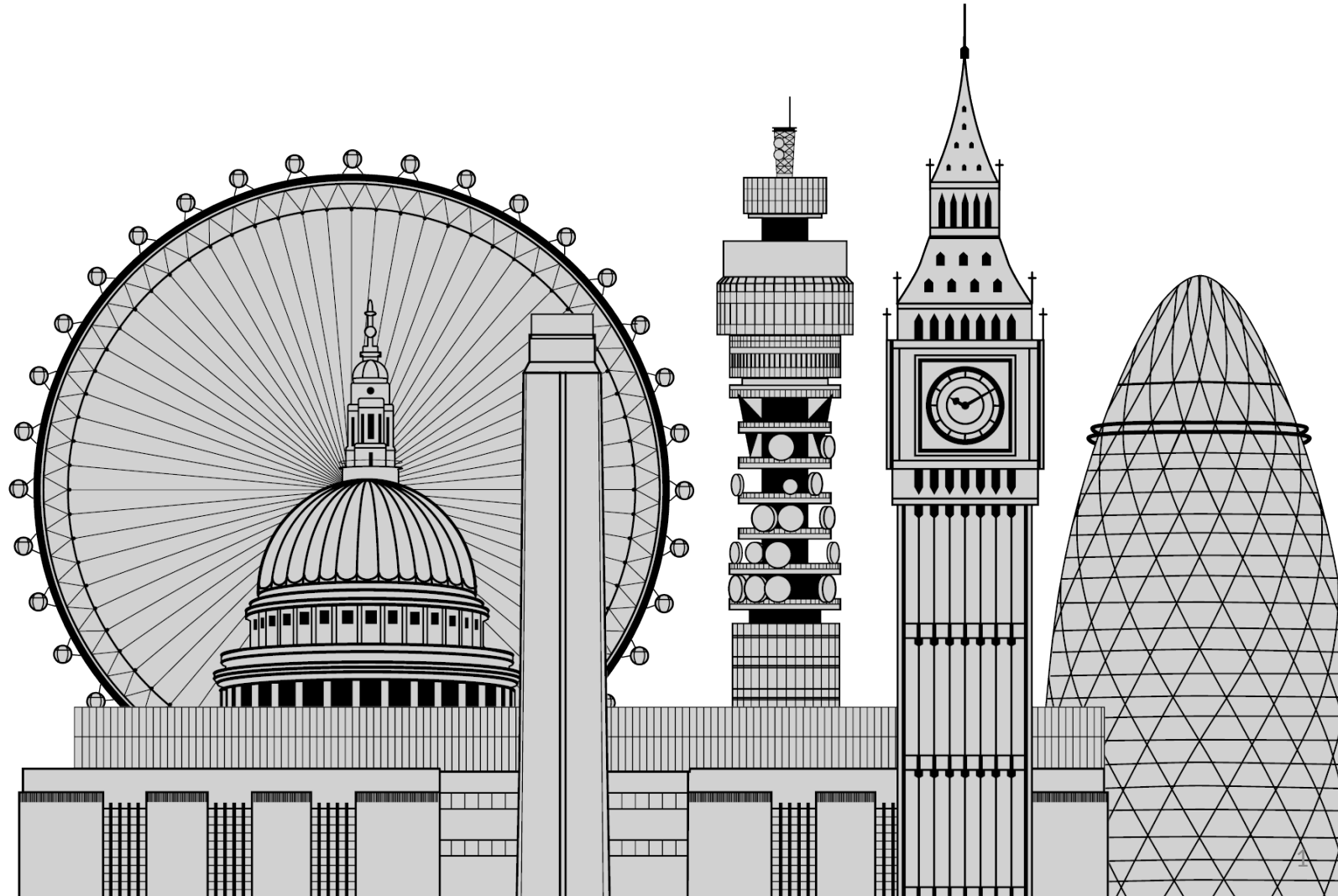


5COSC020W DATABASE SYSTEMS – LECTURE 02

Conceptual Database Design – Enhanced Entity-Relationship Modelling

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Lecture 02 – Outline

- Conceptual Design for Relational Databases: complex relationships
 - Ternary and quaternary relationships.
 - Recursive relationships.
 - Multiple relationships between entities.
- Enhanced Conceptual Design for Relational Databases: generalisations
 - Enhanced Conceptual Entity-Relationship Modelling and EERDs.
 - Generalisation/specialisation.
 - Attribute inheritance and relationship inheritance.
 - Constraints on generalisations/specialisations.
- Redundant Relationships.
- Data Dictionary.

Phases and outputs of Database Design (recap)

Data Requirements

BUSINESS USER'S DATA NEEDS
to support business processes



CONCEPTUAL DESIGN

CONCEPTUAL DATA MODEL OR CONCEPTUAL SCHEMA
of the data required by business users



LOGICAL DESIGN (Mapping)

LOGICAL DATA MODEL OR LOGICAL SCHEMA
based on specific file data organisation (e.g. relational model)



PHYSICAL DESIGN

PHYSICAL OR INTERNAL SCHEMA
storage structures, file organizations, indexes, access paths



DATABASE IMPLEMENTATION & QUERYING

DATABASE IMPLEMENTED & QUERIED IN DBMS
data structures, constraints, data values, data description

Step-by-step approach to Conceptual Design (recap)

I. Identity ENTITIES

- Objects or things with independent existence on which data needs to be stored.

II. Identify RELATIONSHIPS

- Meaningful associations between occurrences of entities.

III. Identify ATTRIBUTES

- Properties of Entities (and sometimes of Relationships) that capture data values.

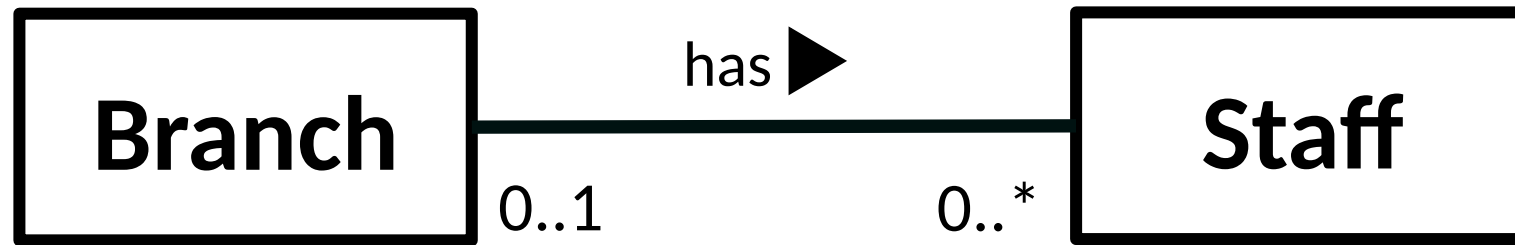
IV. Identify PRIMARY KEYS (PKS)

- Attribute that is a unique identifier, irreducible and selected.

V. Consider enhanced modelling concepts e.g. specialisations/generalisations

VI. Check and remove redundancies

Example of a binary relationship with multiplicities (recap)



- **ONE Branch may have NO Staff assigned to it (Participation is 0)**
 - A branch may be brand new (not staffed yet) or underperforming (cleared out).
- **ONE Branch may have MANY Staff assigned to it (Cardinality is *)**
 - A branch will typically have many staff allocated to work at that specific branch.
- **ONE Staff may NOT BE ASSIGNED TO ANY Branch (Participation is 0)**
 - A staff may be working outside the branch system e.g. Director, Driver, IT support.
- **ONE Staff must be assigned to UP TO ONE Branch (Cardinality is 1)**
 - The structure of the firm says that staff can only be given one branch, no more.

Degree of a relationship

Degree of a relationship: number of participating entities

- **Binary relationship:** relationship between 2 entities (most common).
- **Ternary relationship:** relationship between 3 entities.
- **Quaternary relationship:** relationship between 4 entities.
- **N-nary relationship:** relationship between n entities.

Binary and ternary relationships

○ Binary Relationship

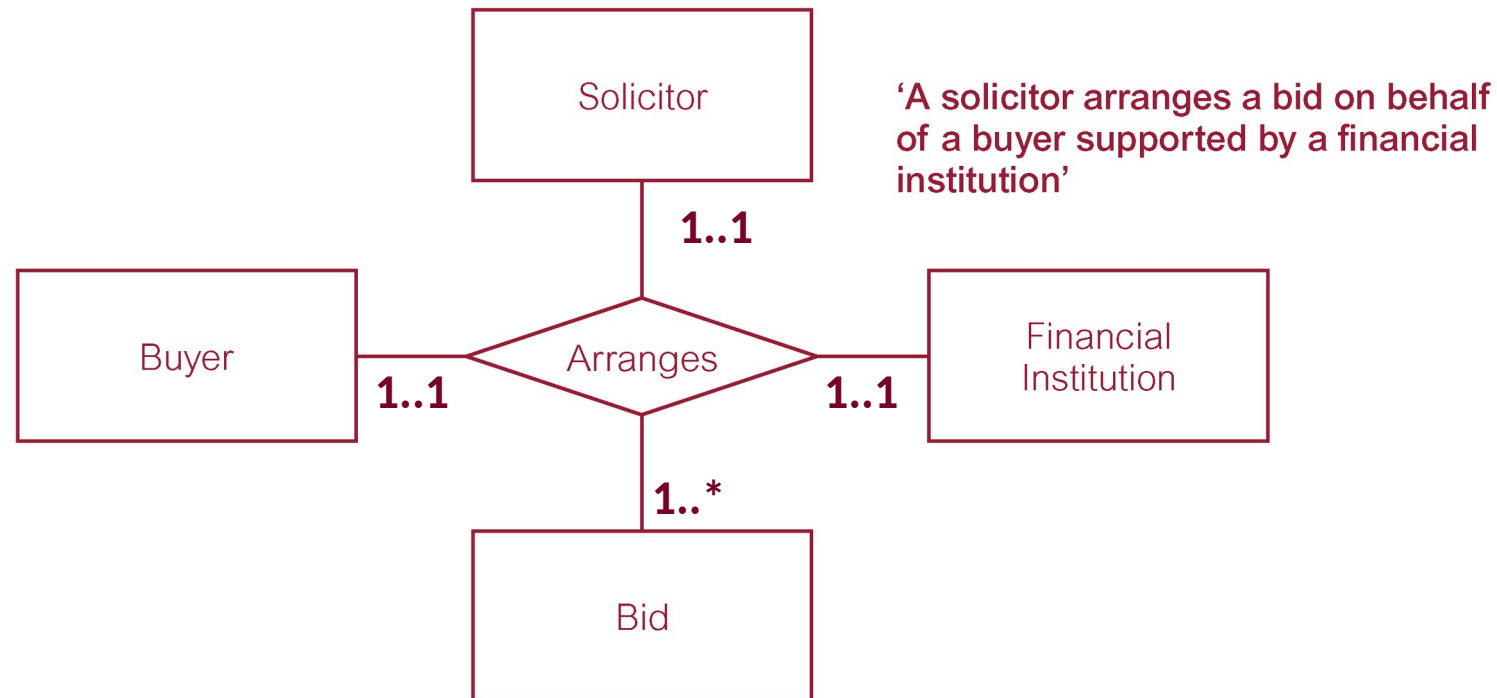


○ Ternary Relationship



Quaternary relationships

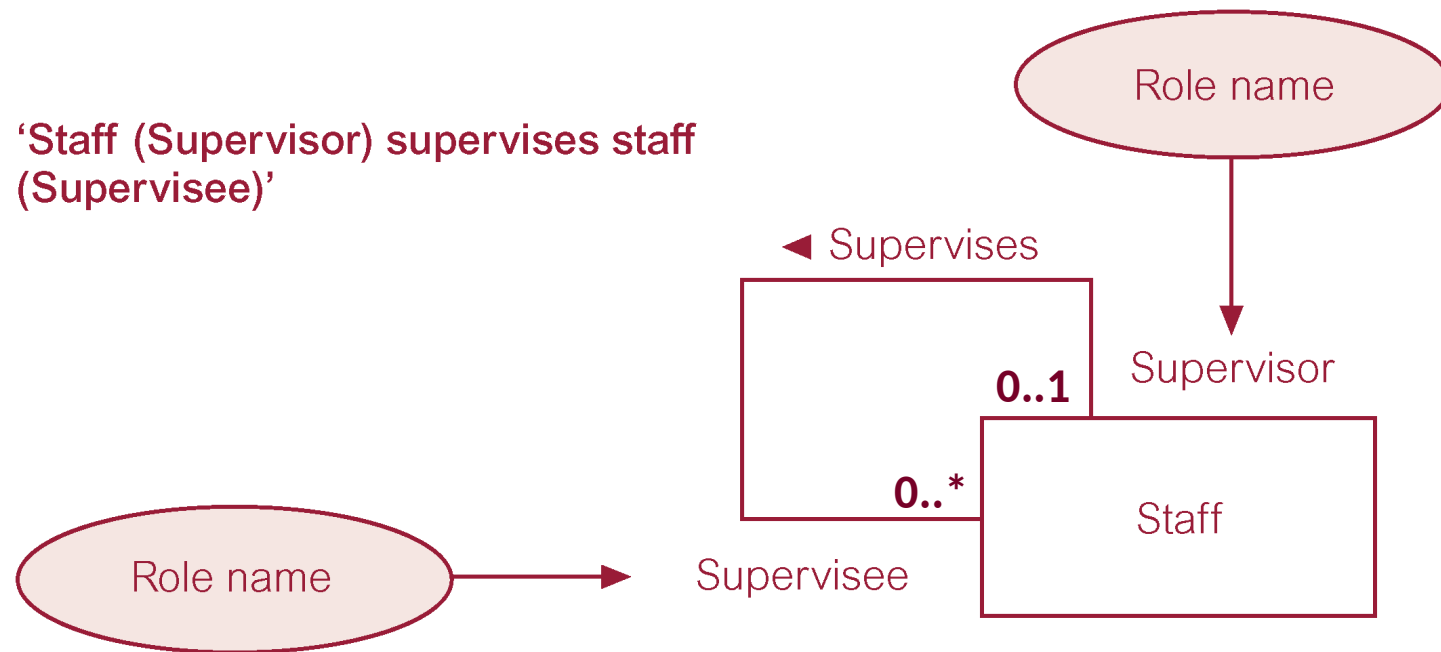
○ Quaternary relationship



Recursive relationships

○ Recursive Relationship

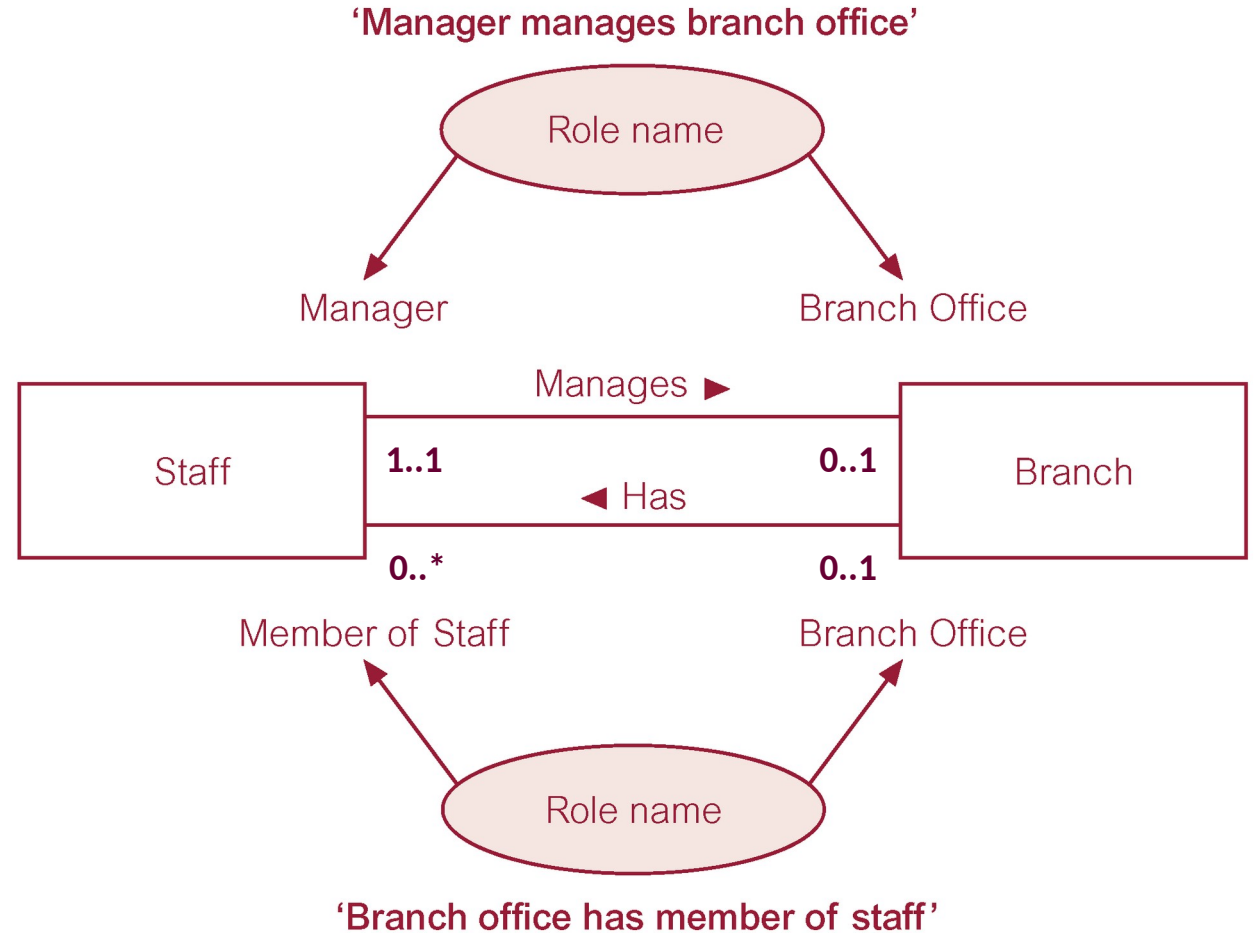
- Same entity participates more than once in relationship with different roles.
- Name roles to indicate roles played by each participating entity in relationship.



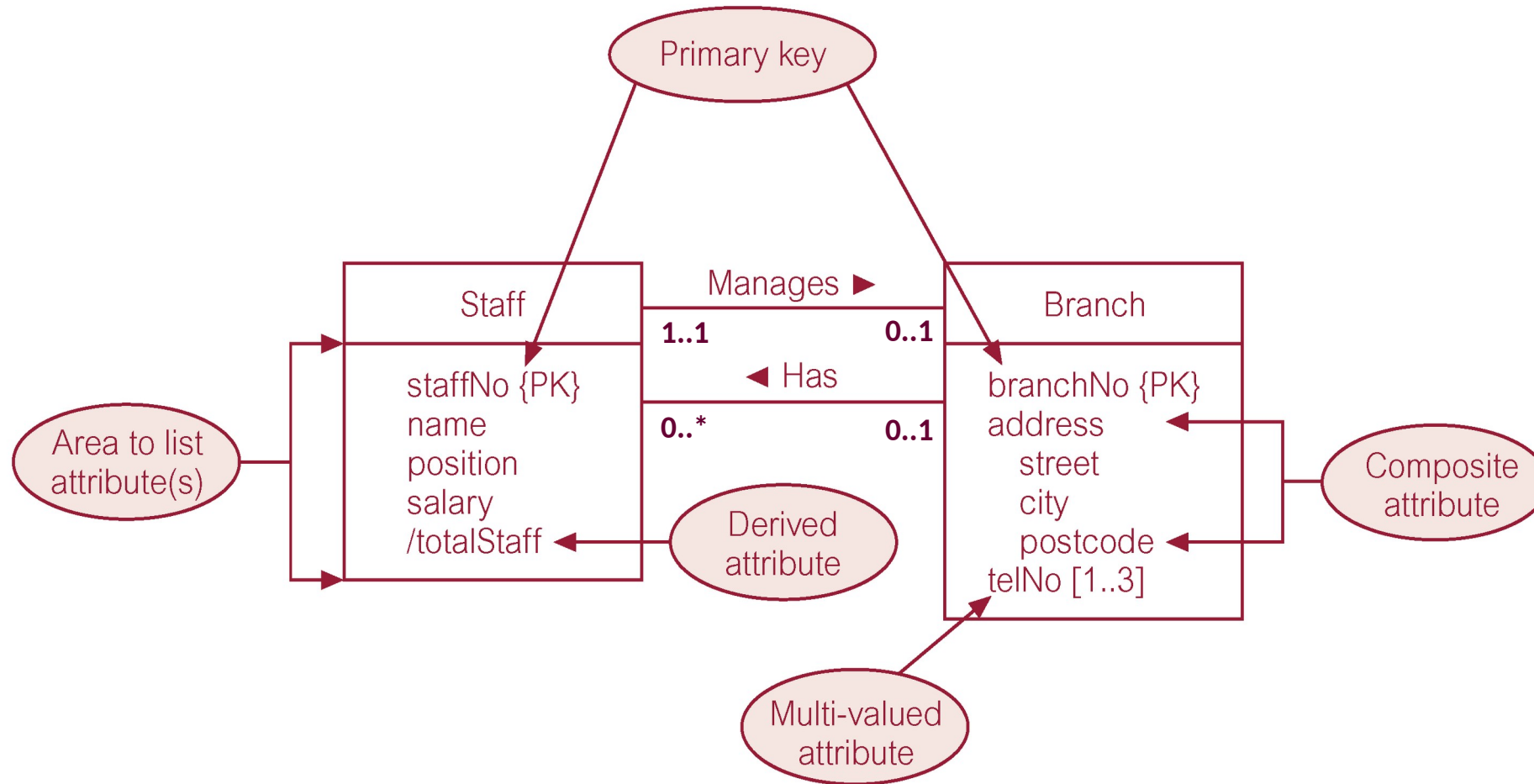
Multiple relationships between entities (1)

○ Multiple Relationships

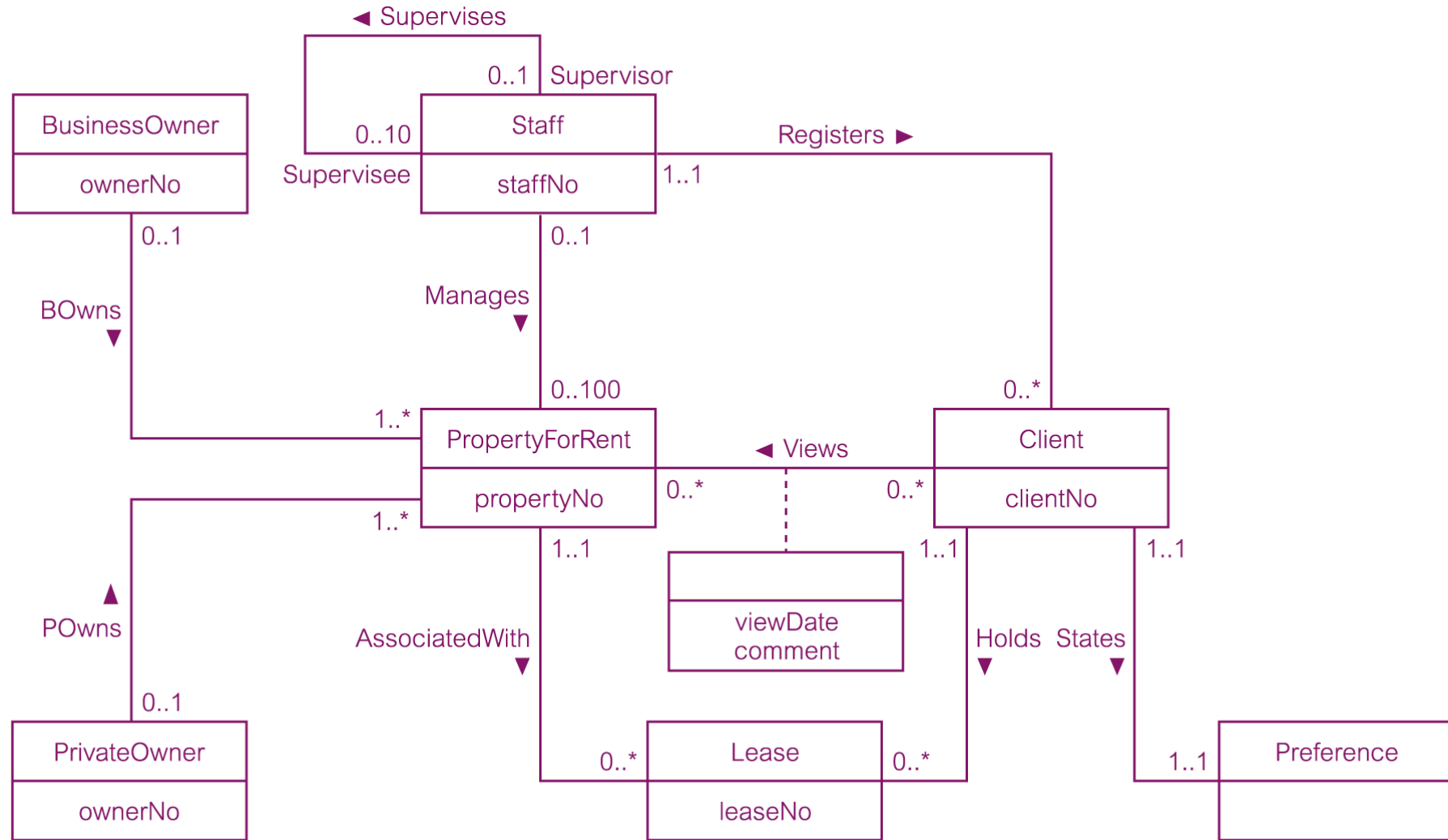
- Occurrences of an entity associated to occurrences of another entity through more than one relationship.
- Name roles to indicate roles played by each participating entity in relationship.



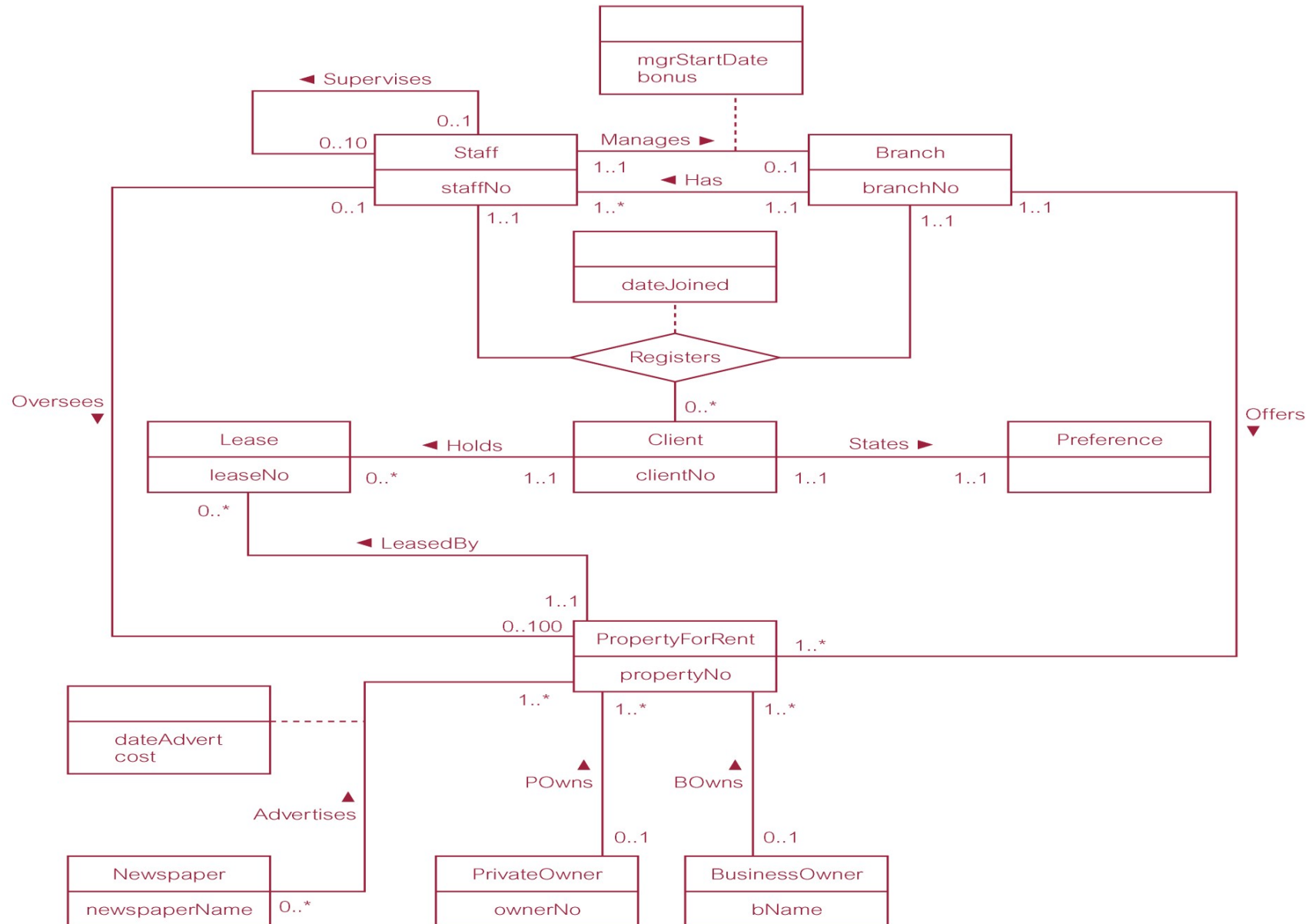
Multiple relationships between entities (2)



DREAMHOME Conceptual ERD (Staff View with PKs)



DreamHome Conceptual ERD (Branch View with PKs)



Enhanced Entity-Relationship Modelling

- Limitations of basic concepts of ER Modelling
 - Not sufficient to represent requirements of newer & more complex applications.
- **Enhanced Entity-Relationship modelling**
 - Borrowed from UML.
 - Additional semantic modelling concepts incorporated into original ER model.
 - Output:

EERD (Enhanced Entity Relationship Diagram)

= ERD (Entity Relationship Diagram) + additional semantic concepts

- **New Semantic concepts**
 - Specialisation.
 - Generalisation.

Specialisation / Generalisation (1)

○ **Specialisation**

- Breaking down of an entity into several sub-types (Specialised Entities).
- Maximisation of the differences between members of an entity.
- Identification of their distinguishing characteristics.

○ **Generalisation**

- Grouping several entities into one super-type (General Entity).
- Minimisation of the differences between members of an entity.
- Identification of their common characteristics.

Specialisation / Generalisation (2)

- **General Entity (aka superclass in UML)**

- An entity that includes one or more distinct subgroupings of its occurrences.

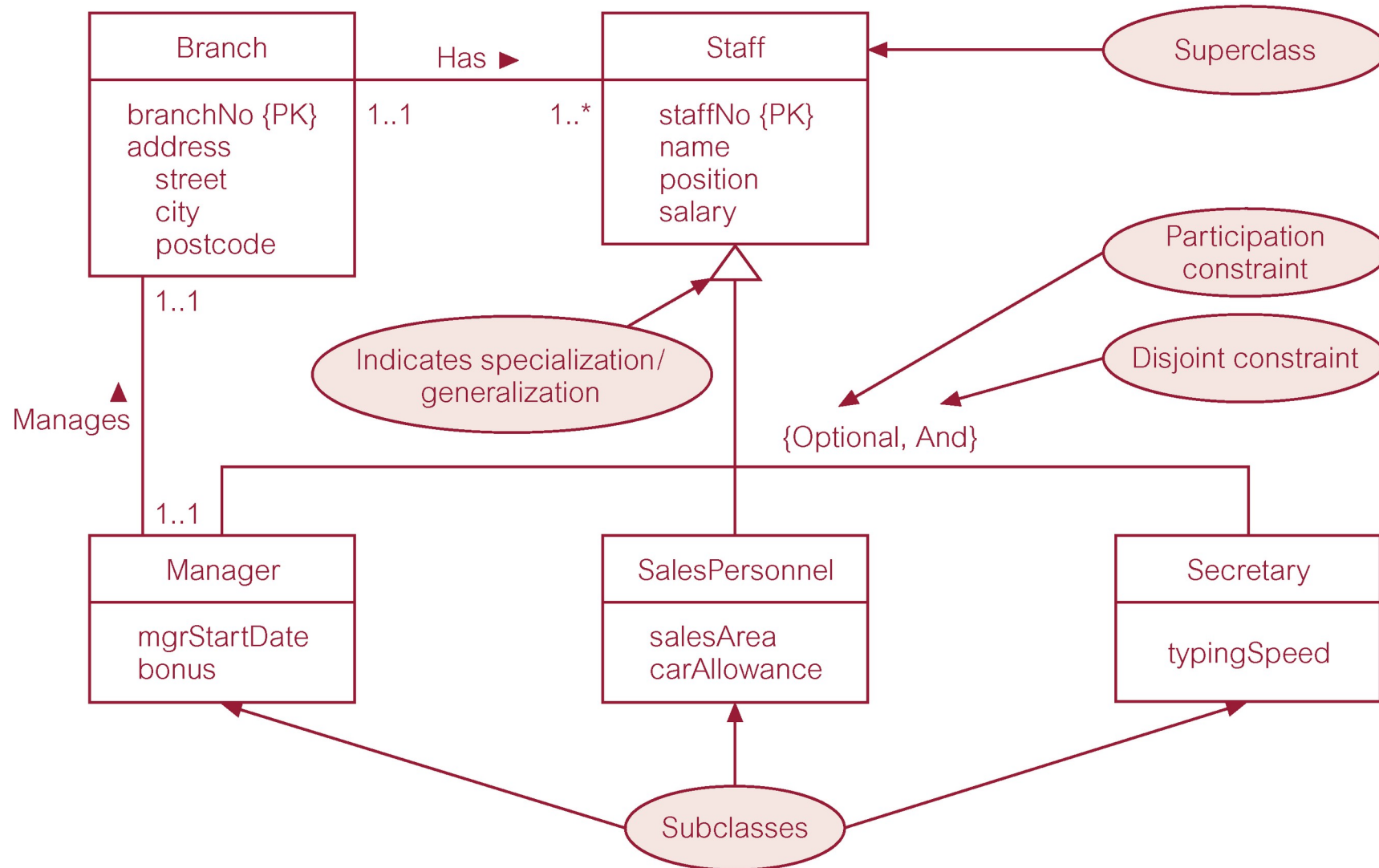
- **Specialised Entity (aka subclass in UML)**

- A distinct subgrouping of occurrences of an entity.

- **Important considerations**

- Relationship between a General Entity and a Specialised Entity is one-to-one.
- Generalised Entity may be broken down into overlapping or distinct Specialised Entities.
- Not all members of a Specialised Entity need to be a member of a General Entity.

EERD with Specialisation / Generalisation



Attribute Inheritance

○ Attribute inheritance

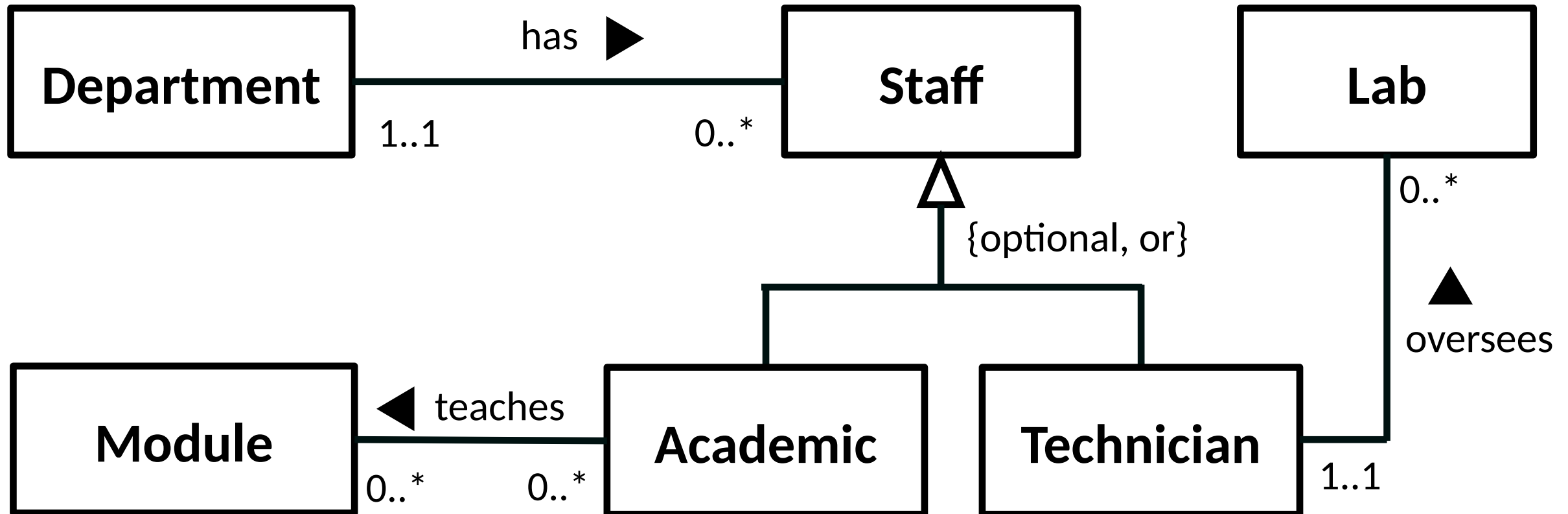
- All the attributes of the General Entity also apply to the Specialised Entity.
- In addition, the Specialised Entity may also have its own specific attributes.

staffNo	name	position	salary	mgrStartDate	bonus	sales Area	car Allowance	typing Speed
SL21	John White	Manager	30000	01/02/95	2000			
SG37	Ann Beech	Assistant	12000					
SG66	Mary Martinez	Sales Manager	27000			SA1A	5000	
SA9	Mary Howe	Assistant	9000					
SL89	Stuart Stern	Secretary	8500					100
SL31	Robert Chin	Snr Sales Asst	17000			SA2B	3700	
SG5	Susan Brand	Manager	24000	01/06/91	2350			

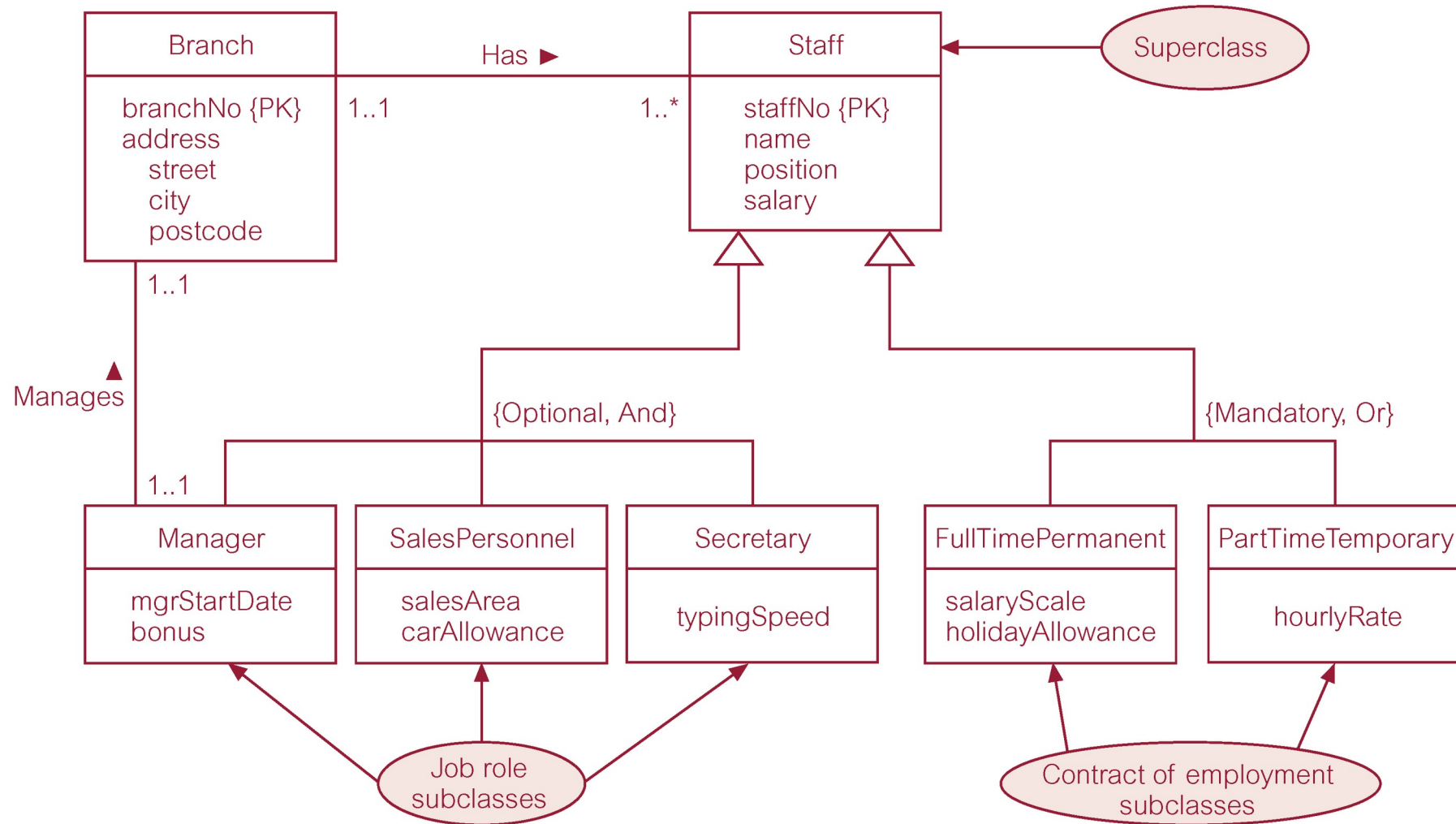
Relationship Inheritance

○ Relationship inheritance

- All the relationships of the General Entity also apply to the Specialised Entity.
- In addition, the Specialised Entity may also have its own specific relationships.



EERD with 2 separate Specialisations / Generalisations



Constraints on Specialisations / Generalisations

○ **Participation Constraint**

- Describes the connection between members of the General Entity and the Specialised entities.
- Determines whether every member in General Entity must participate as a member of a Specialised Entity or whether a member of the General Entity can be something else not represented through the Specialisation.
- May be “Mandatory” or “Optional”.

○ **Disjoint Constraint**

- Describes the connection between members of the Specialised Entities.
- Indicates whether a member of a Specialised Entity can also be a member of one, or more, of the other Specialised Entities.
- May be Disjoint or Non-Disjoint
- Is written as “Or” or “And”.

Four Constraints on Specialisations / Generalisations

○ {Mandatory, Or}

- Mandatory: mandatory participation in specialisation.
- Disjoint: no overlap between members of Specialised Entities.

○ {Mandatory, And}

- Mandatory: mandatory participation in specialisation.
- Non-Disjoint: overlap between members of Specialised Entities is possible.

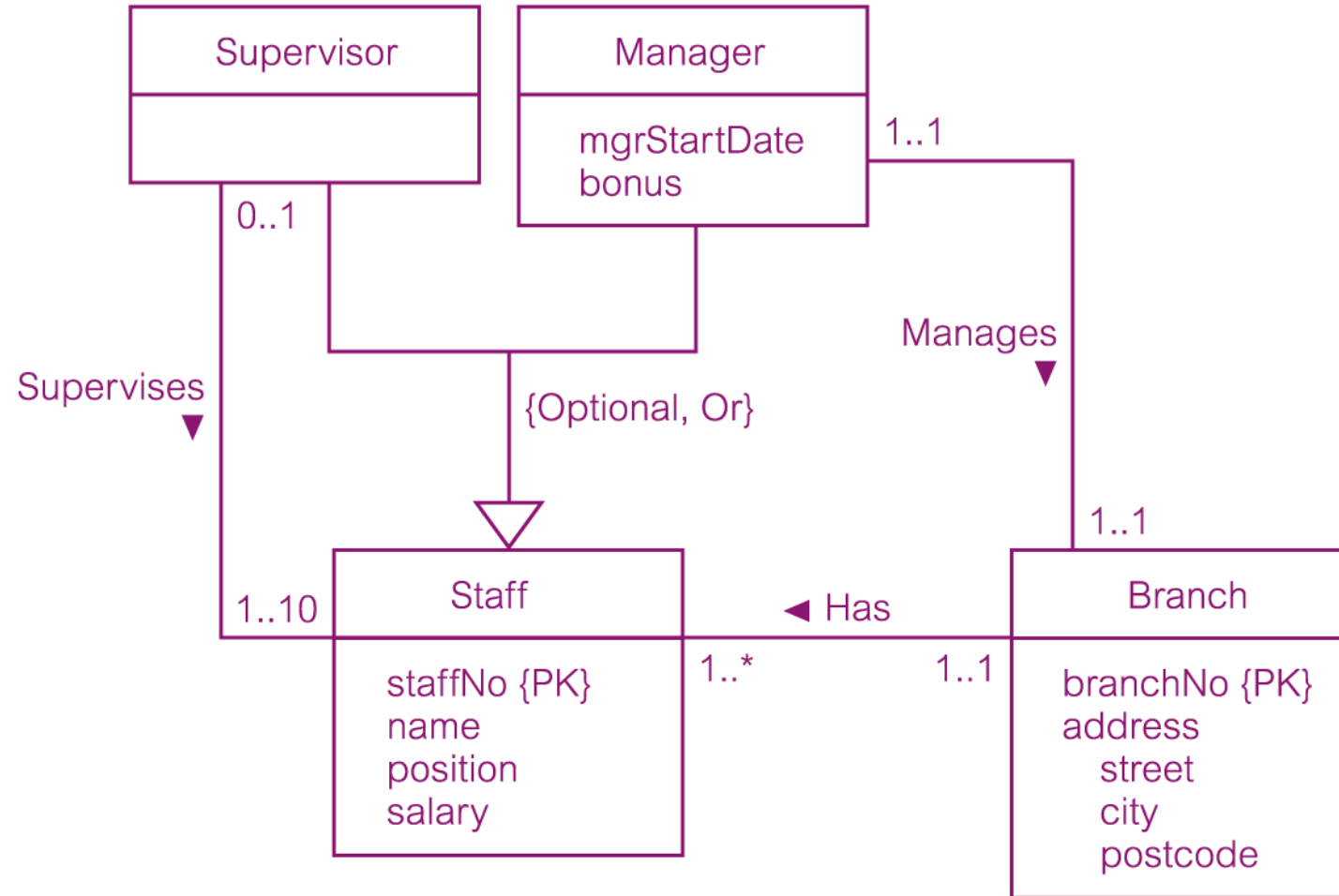
○ {Optional, Or}

- Optional: optional participation in specialisation.
- Disjoint: no overlap between members of Specialised Entities.

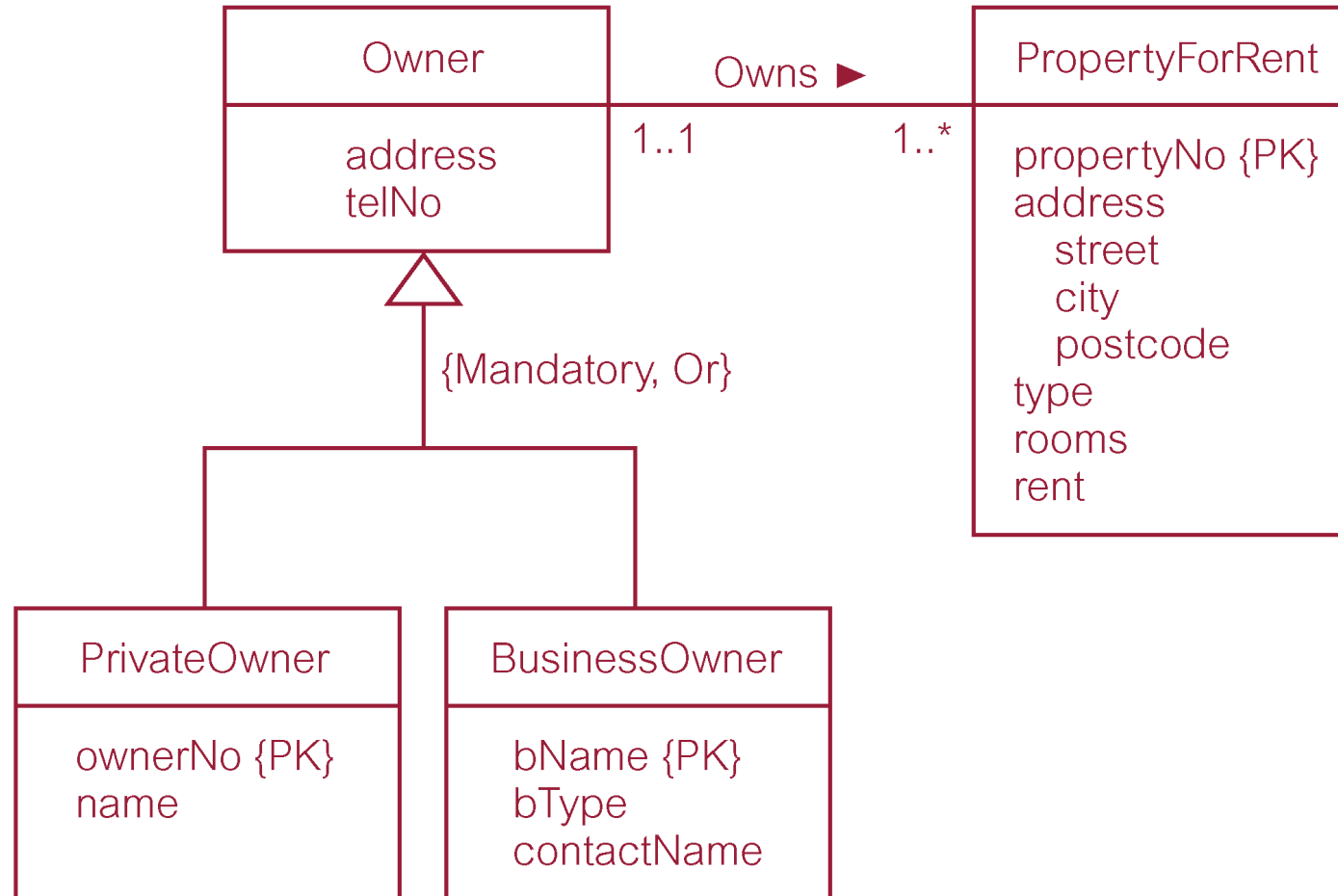
○ {Optional, And}

- Optional: optional participation in specialisation.
- Non-Disjoint: overlap between members of Specialised Entities is possible.

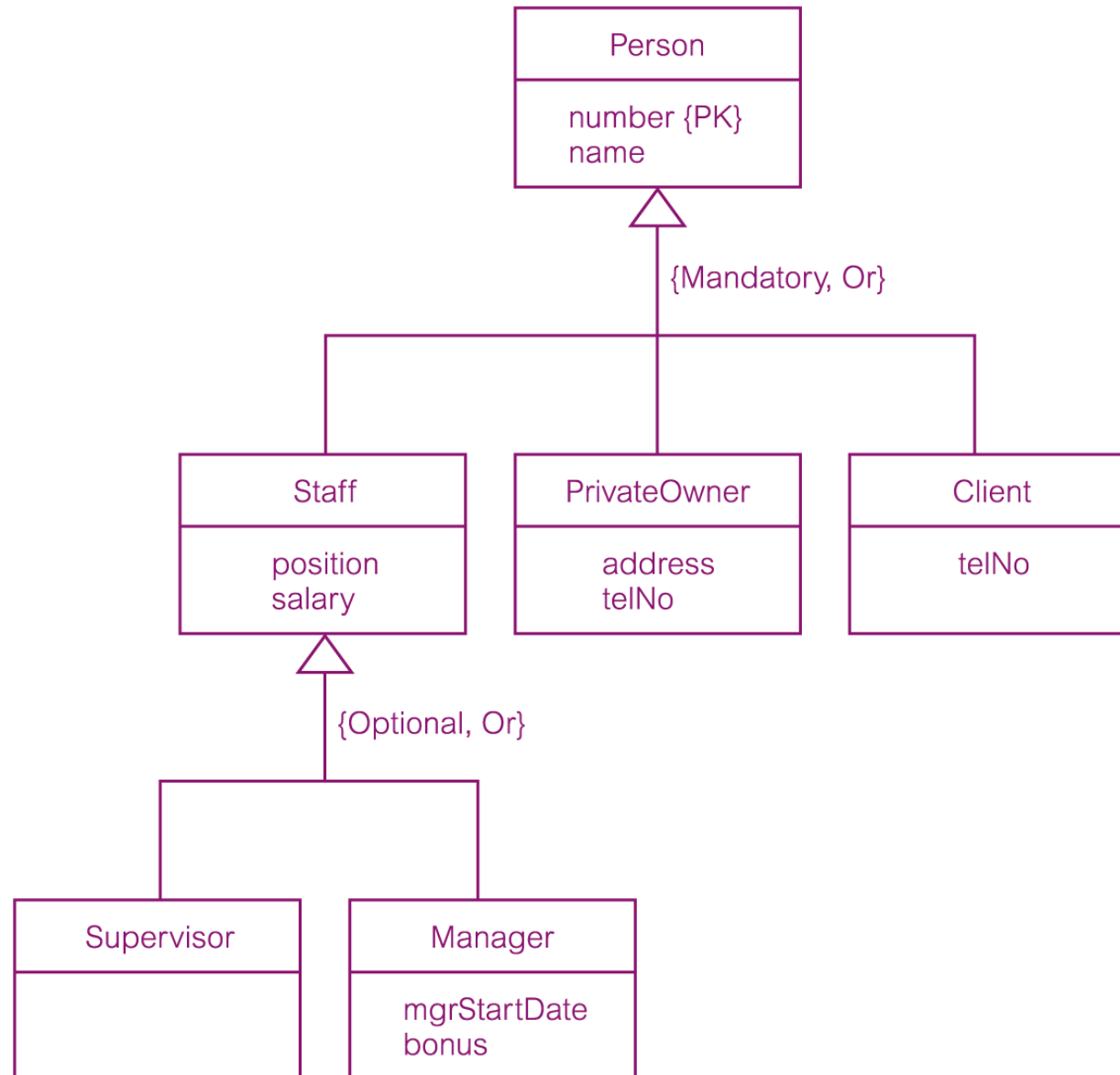
{Optional, Or} Constraint

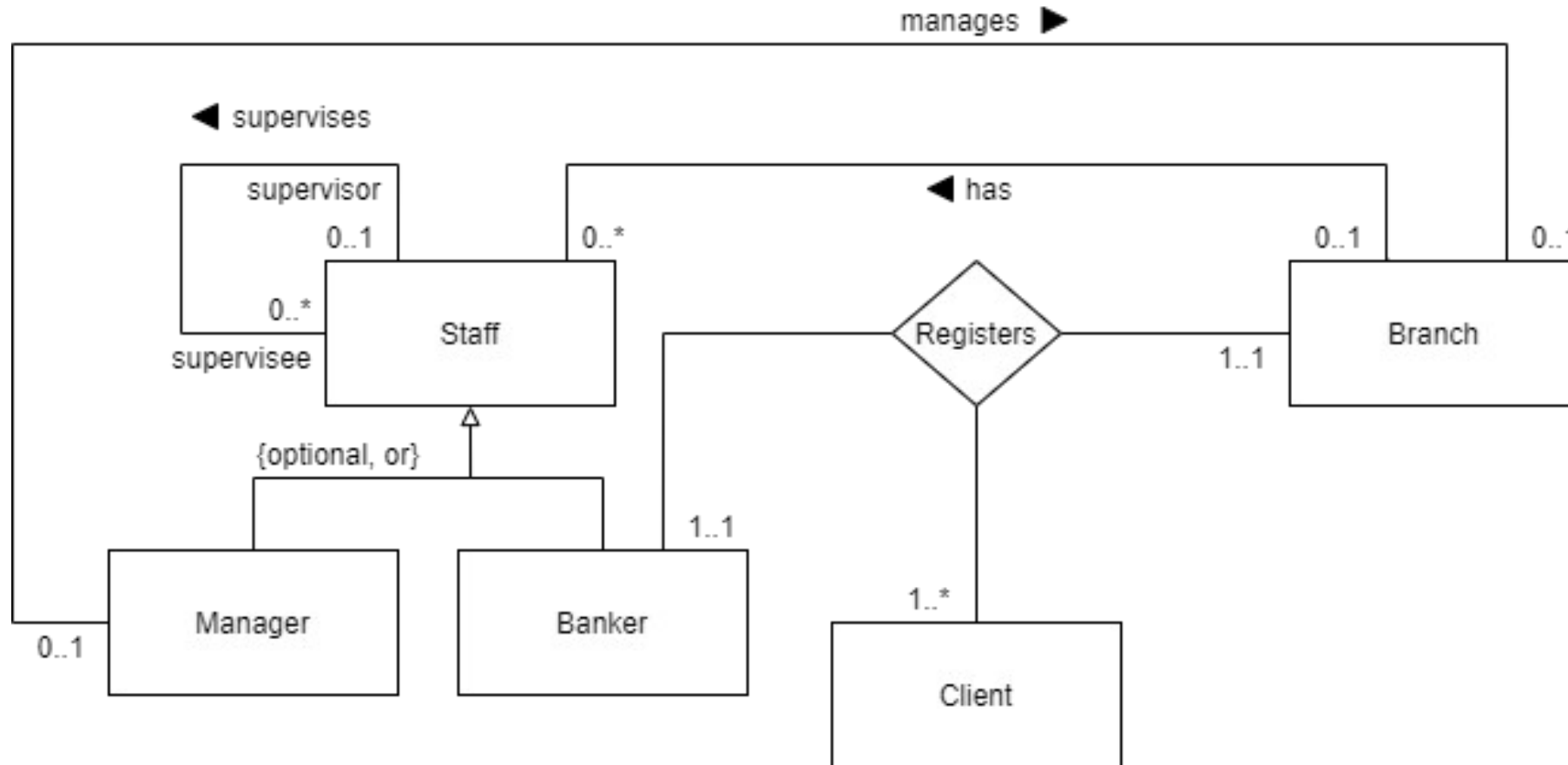


{Mandatory, Or} Constraint

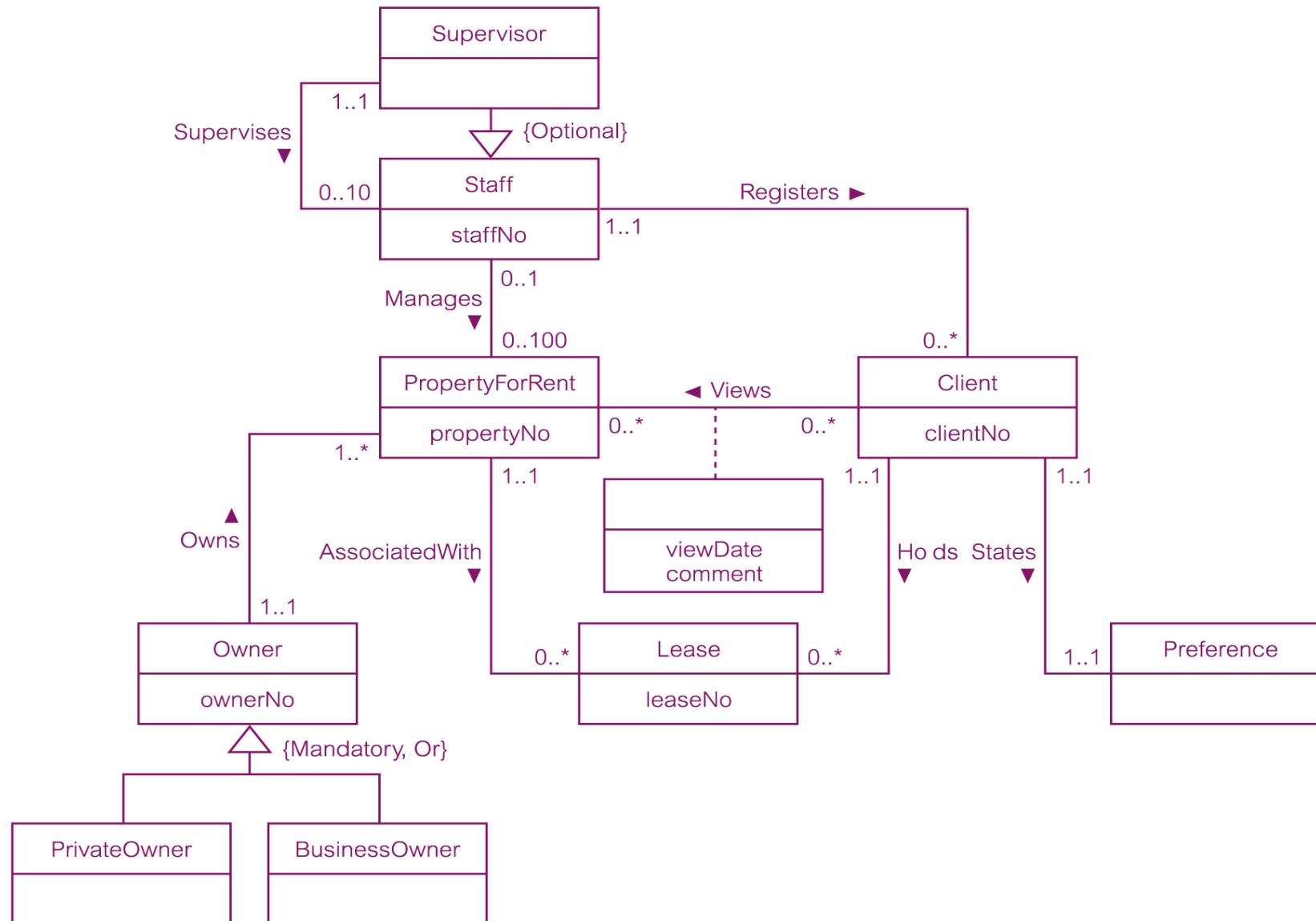


{Mandatory, Or} and {Optional, Or} Constraint

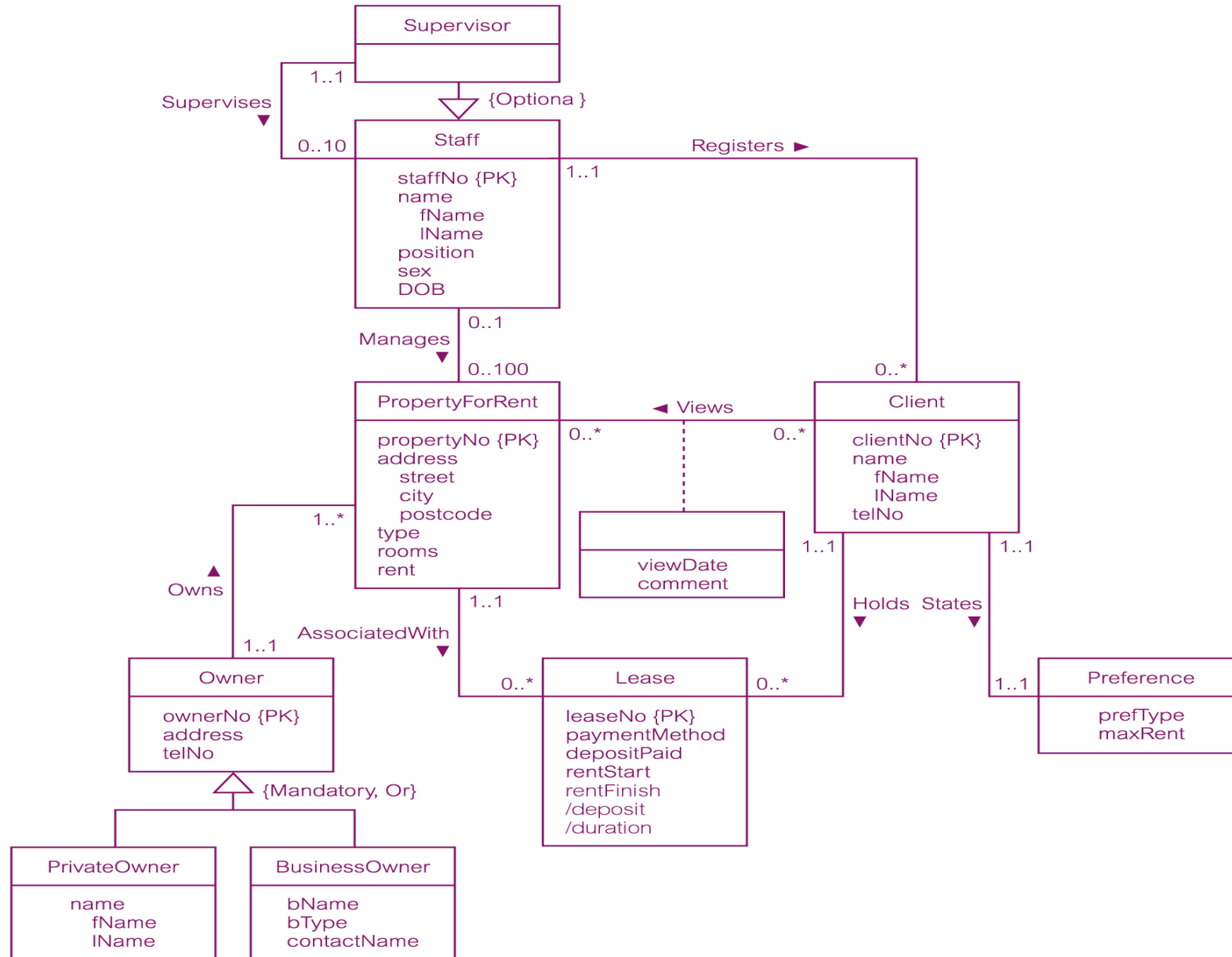




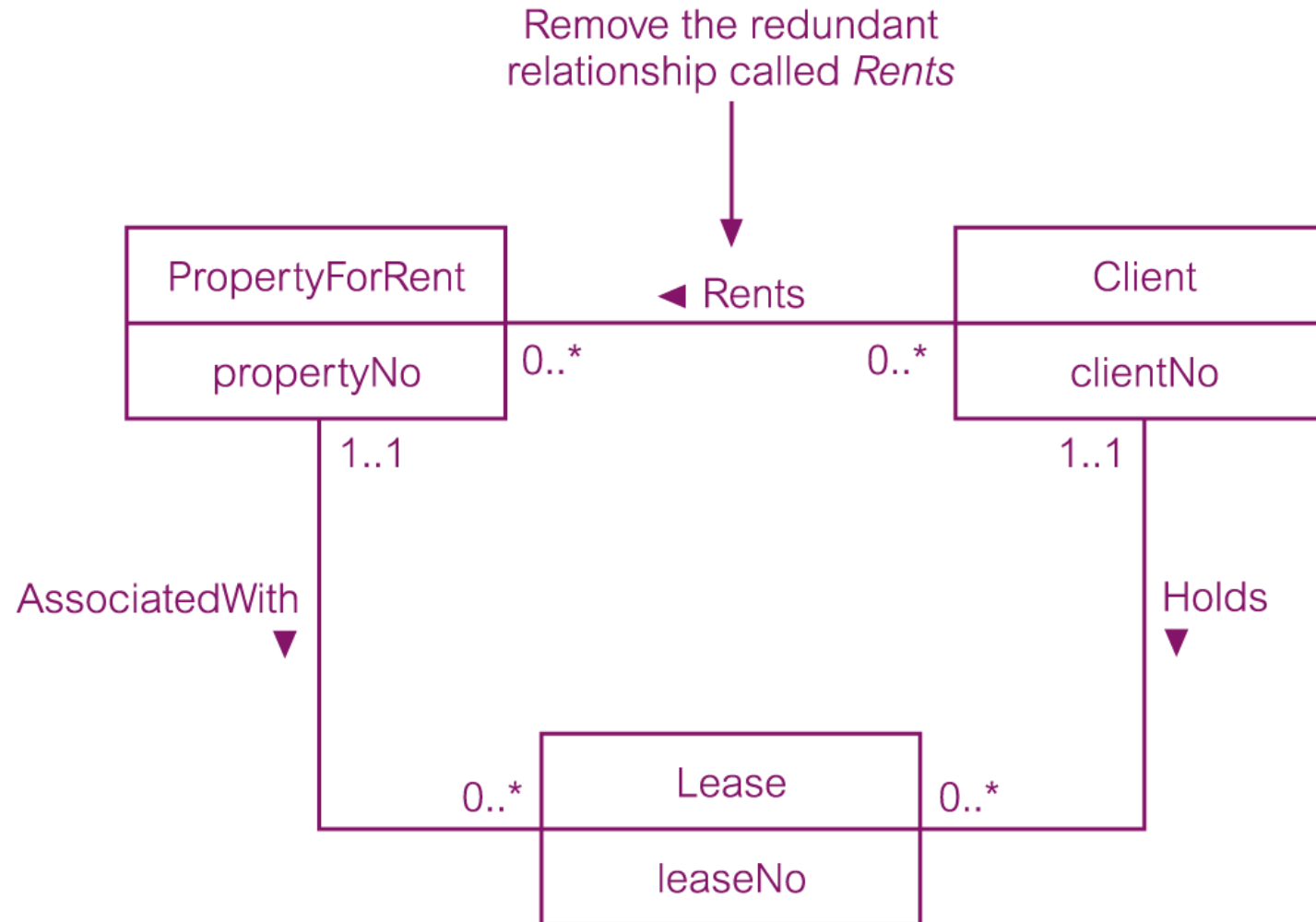
DreamHome Conceptual EERD (Staff View with Specialisations)



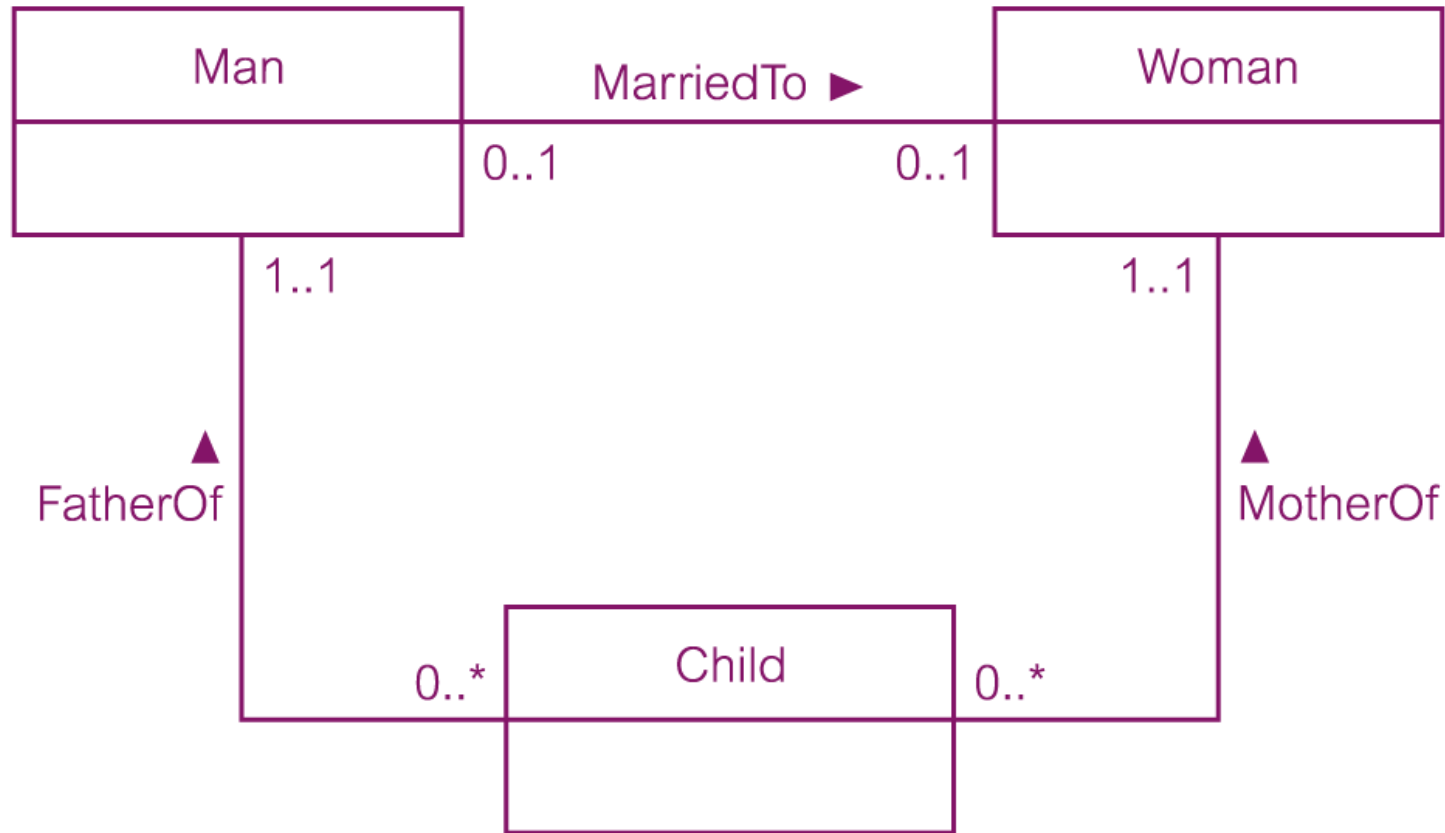
DreamHome Conceptual EERD (Staff View with Specialisations & Attributes)



Redundant relationship: remove!



Non-redundant relationship: do not remove!



Data Dictionary: description of entities

<i>Entity name</i>	<i>Description</i>	<i>Aliases</i>	<i>Occurrence</i>
Staff	General term describing all staff employed by <i>DreamHome</i> .	Employee	Each member of staff works at one particular branch.
PropertyForRent	General term describing all property for rent.	Property	Each property has a single owner and is available at one specific branch, where the property is managed by one member of staff. A property is viewed by many clients and rented by a single client, at any one time.

Data Dictionary: description of relationships & multiplicities

<i>Entity name</i>	<i>Multiplicity</i>	<i>Relationship</i>	<i>Multiplicity</i>	<i>Entity name</i>
Staff	0..1	<i>Manages</i>	0..100	PropertyForRent
	0..1	<i>Supervises</i>	0..10	Staff
PropertyForRent	1..1	<i>AssociatedWith</i>	0..*	Lease

Data Dictionary: description of attributes

<i>Entity name</i>	<i>Attributes</i>	<i>Description</i>	<i>Data Type & Length</i>	<i>Nulls</i>	<i>Multi-valued</i>	<i>...</i>
Staff	staffNo	Uniquely identifies a member of staff	5 variable characters	No	No	
	name					
	fName	First name of staff	15 variable characters	No	No	
	lName	Last name of staff	15 variable characters	No	No	
	position	Job title of member of staff	10 variable characters	No	No	
	sex	Gender of member of staff	1 character (M or F)	Yes	No	
	DOB	Date of birth of member of staff	Date	Yes	No	
PropertyForRent	propertyNo	Uniquely identifies a property for rent	5 variable characters	No	No	

References and Essential Readings

- Module Reading List:

- <https://rl.talis.com/3/westminster/lists/2CAA7D6B-DCAD-AB71-C97B-7FEFCB499C28.html>

- Connolly, T. & Begg, C. E. (2015). Database systems: a practical approach to design, implementation and management. 6th Edition (Global Edition). Pearson Education. Ch. 1, 12, 13, 16.
- Elmasri, R. & Navathe, S. (2017). Fundamentals of Database Systems. 7th Edition (Global Edition). Pearson Education. Ch. 1, 2, 4.