2020-2021

5COSC002W DATABASE SYSTEMS
Lecture 01

CONCEPTUAL DATABASE DESIGN
Entity-Relationship modelling

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Lecture 01 – Outline

- *DB, DBMS, DB Applications & DB System*
- *Conceptual, logical & physical design*
- *Conceptual design & ER modelling*
- *Components of an ER Model*
  - Entities
  - Relationships
  - Multiplicities
  - Attributes
- *Diagrammatic techniques, UML notations*
- *Complex relationships*

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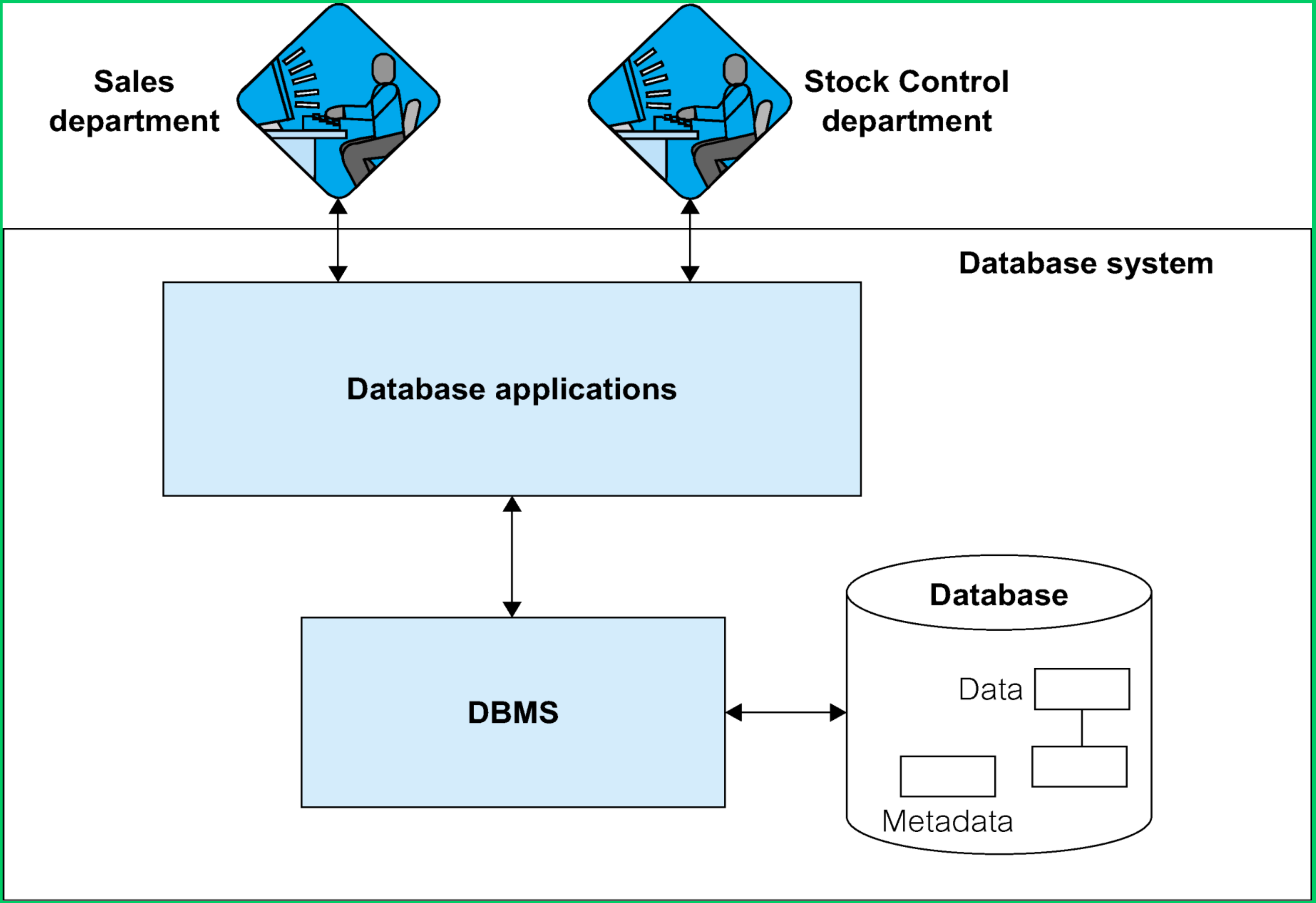
Database System



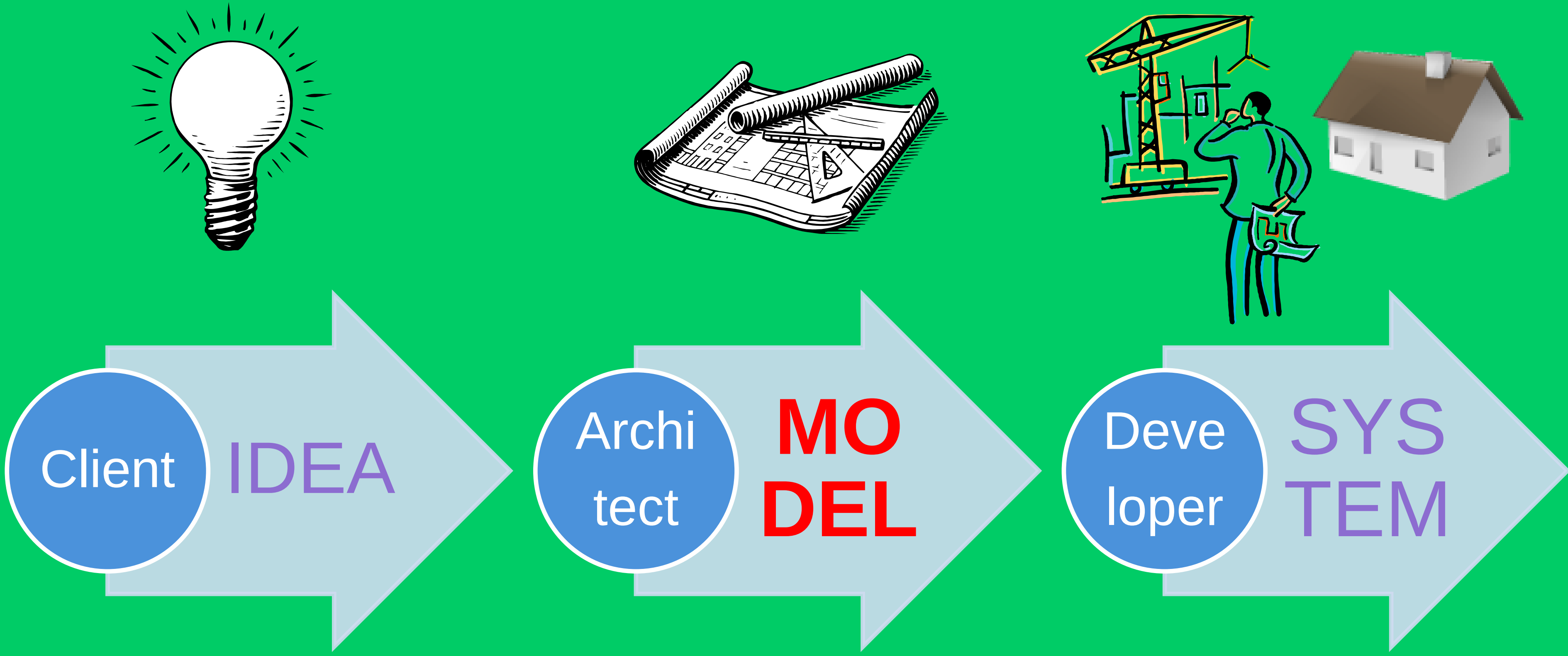
DB, DBMS, DB Applications & DB System

- **Database (DB)**
  - Shared collection of logically related data (& description)
  - Designed to meet information needs of an organization.
- **Database Management Systems (DBMS)** Software
  - enables users to define, create maintain the DB
  - provides controlled access to this DB.

  e.g. Oracle, MS SQL Server, MySQL,SQLite, MongoDB, etc.
- **Database Application.**
  - Computer program that interacts with DB by issuing a request (typically SQL statement) to the DBMS.

  e.g. online retailing system, booking system, stock management system, electronic medical record, etc.
- **DATABASE SYSTEM = DB + DBMS + DB APPLICATIONS**

Database Design: Data Modelling



Client IDEA

Architect MODEL

Developer SYSTEM

3 Phases of Database Design

1. Conceptual database design.

- Construct a model of the data used in a firm, independent of *all* physical considerations.

2. Logical database design.

Construct a model of the data used in a firm:

- based on specific data organisation (e.g. relational schema)
- independent of DBMS & other physical considerations.

3. Physical database design & implementation.

- Produce description of the DB implementation for DBMS
- Create base relations, file organizations and indexes
- Create any integrity constraints and security measures.

Database Design Methodology – Step 1

CONCEPTUAL DESIGN

Produce a Conceptual Data Model

(model of the data used in a firm, independent of physical considerations)

- Step 1.1 Identify entities
- Step 1.2 Identify relationships
- Step 1.3 Identify and associate attributes with entity or relationships
- Step 1.4 Determine attribute domains
- Step 1.5 Determine candidate, primary, and alternate key attributes
- Step 1.6 Consider use of enhanced modelling concepts
- Step 1.7 Check model for redundancy
- Step 1.8 Validate conceptual model against user transactions
- Step 1.9 Review conceptual data model with user

Entity-Relationship Modelling

- **Both for conceptual and logical modelling**

- **Top-down approach to ensure understanding of**
  - the nature of the data
  - how it is used by enterprise.

- **Outcome: series of data models which are**
  - non technical and unambiguous.
  - understandable to both user and IT technologist.
  - Not tied to any technology or business methodology
  - Flexible enough to be used and understood in practically any environment where information is modelled.

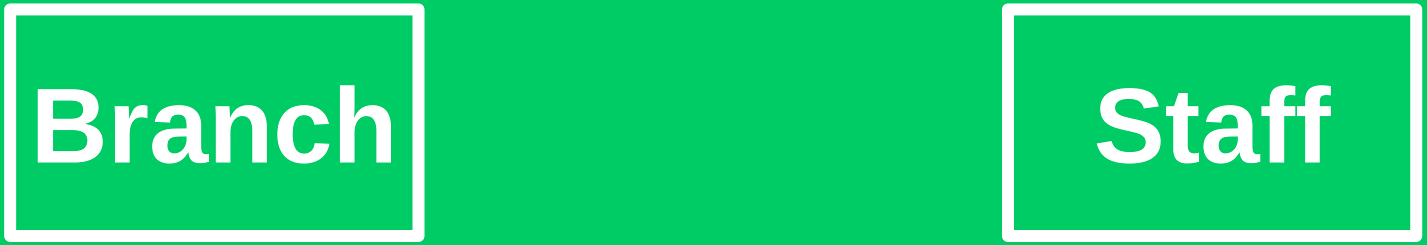
Essential concepts of ER modelling

- Entity
- Relationship
- Attribute

Entity

– Entity

- Building block of ER modelling
- Group of items with same properties, identified having an independent existence in the organisation.



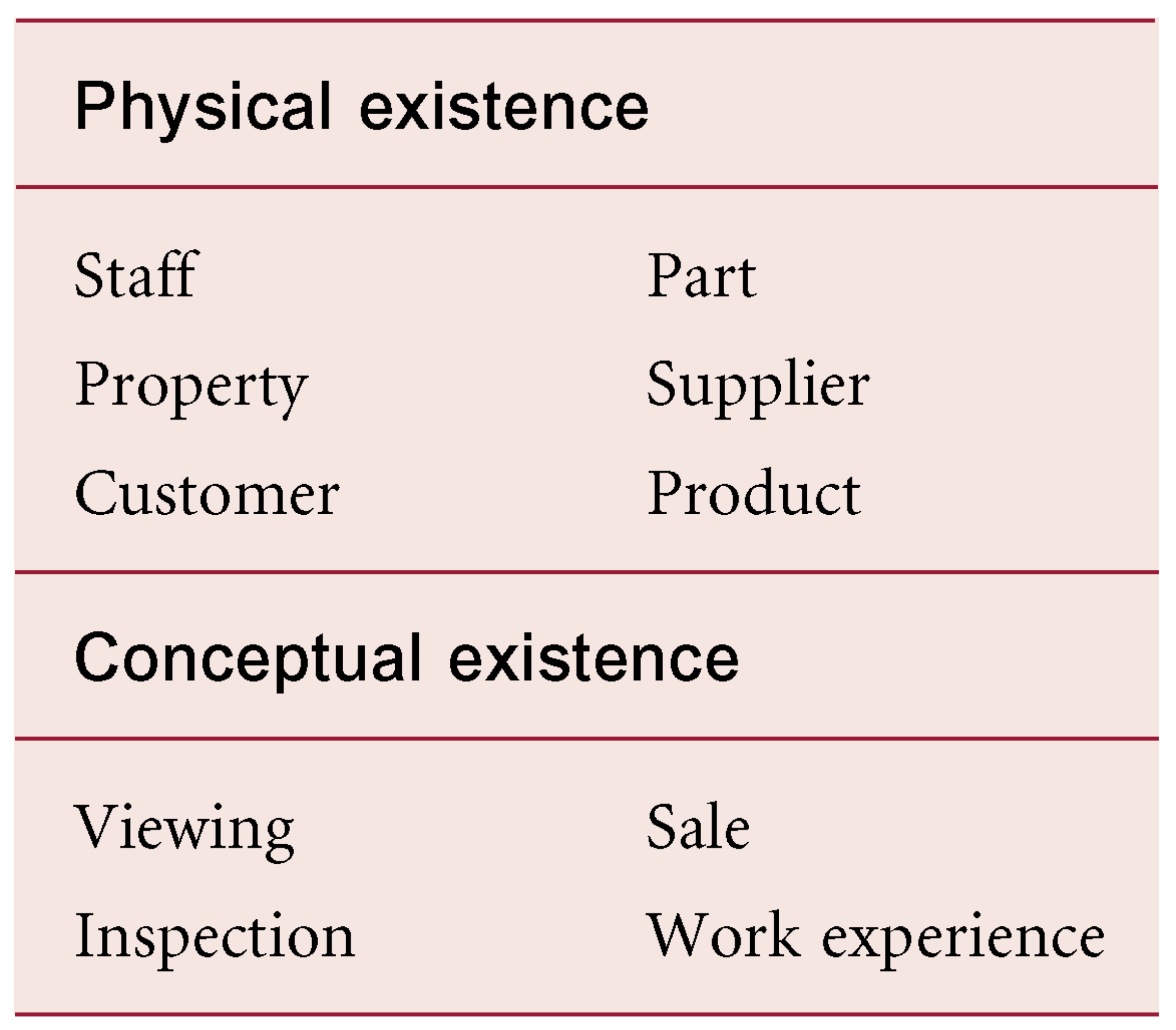
Branch

Staff

– Entity occurrence

- Uniquely identifiable instance of an entity.
- *E.g. Branch – Baker St Branch; Oxford Circus Branch, etc.*
- *E.g. Staff – Joe Bloggs; Kate Green; Raj Pinder, etc.*

Entities: Physical vs. Conceptual

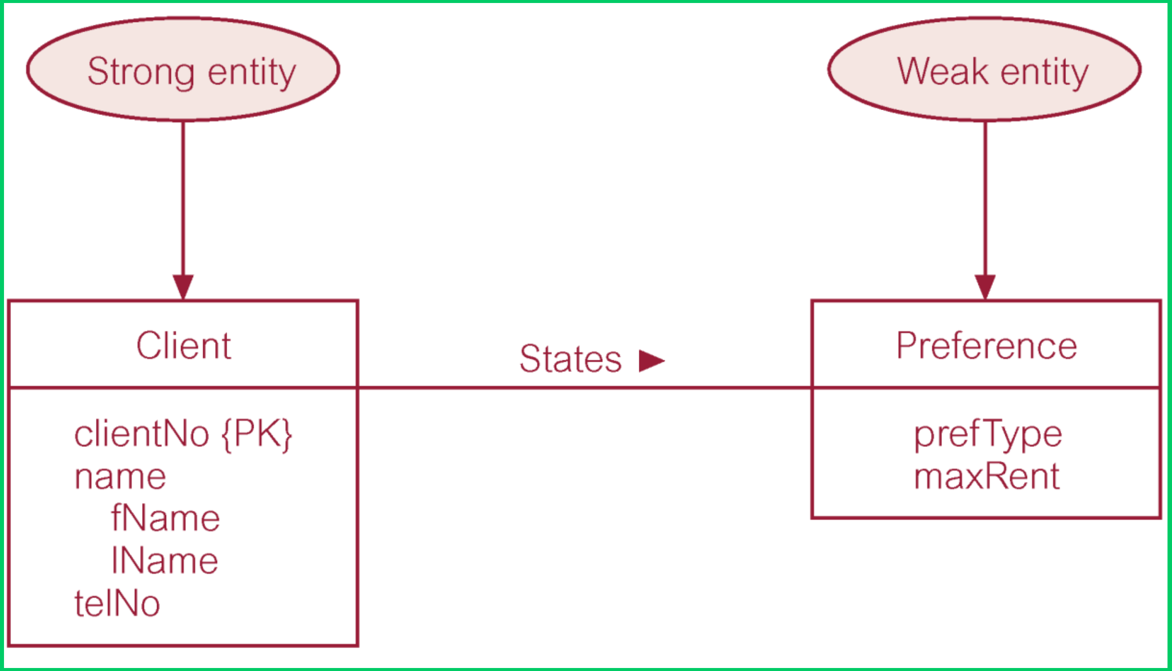


Physical existence	
Staff	Part
Property	Supplier
Customer	Product
Conceptual existence	
Viewing	Sale
Inspection	Work experience

Entities: Strong vs. weak

- **Strong Entity**
  - Entity that is not existence-dependent on some other entity.

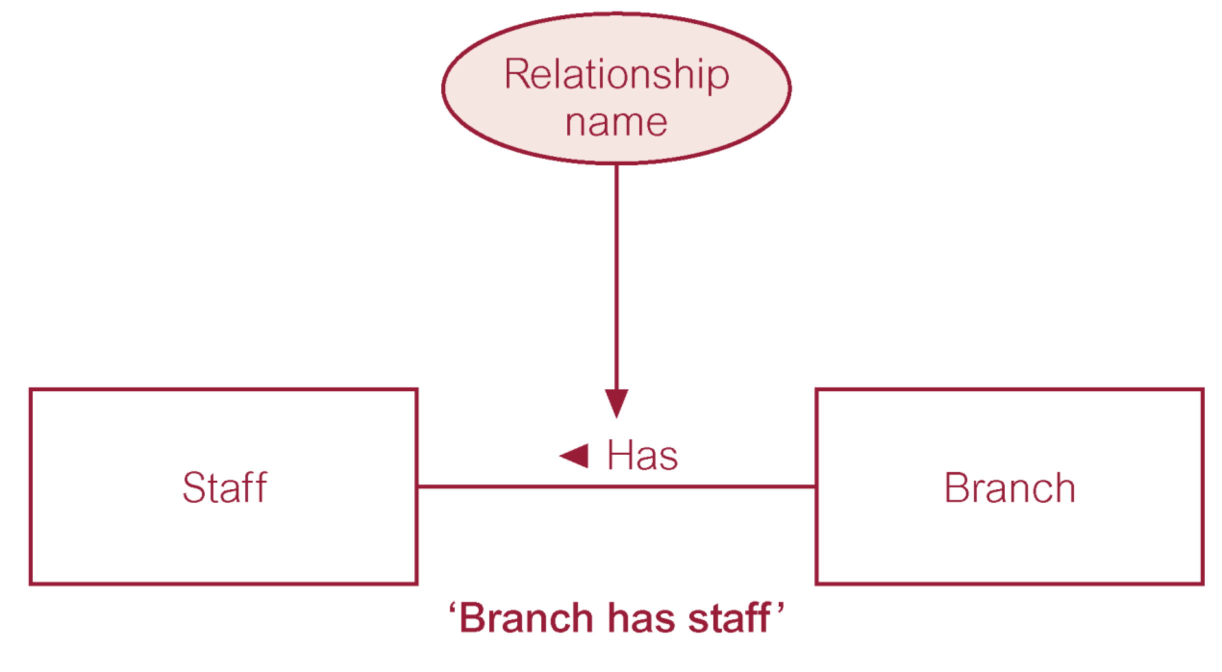
- **Weak Entity**
  - Entity that is existence-dependent on some other entity.



Relationships

– Relationship

- Set of meaningful associations among entities.
- It is given a **meaningful name** (a verb)
- It is given a reading direction ▷ but it is not an arrow!
- The direction helps understand the meaning and can be inverted with a different verb



'Branch has staff'

Degree of a relationship

– **Degree of a Relationship**

- Number of participating entities in relationship.

– **Relationship of degree :**

- two is binary: most common
- three is ternary
- four is quaternary.
- n is n-ary.

Multiplicity

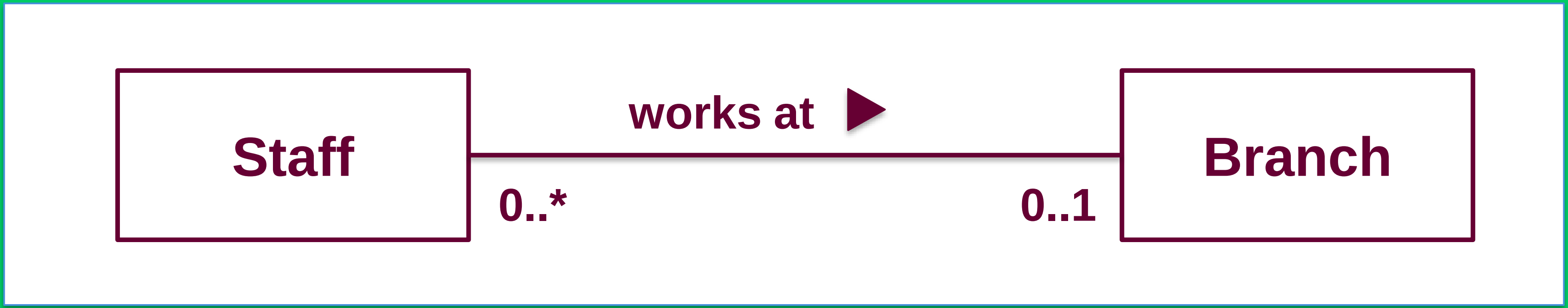
- Main type of constraint on relationships is called *multiplicity*.

- Multiplicity:
  - Number (or range) of possible occurrences of an entity type that may relate to a single occurrence of an associated entity through a particular relationship.
  - For ONE occurrence of an entity, determine MIN and MAX numbers of occurrences of other entity participating in the relationship.

- Represents policies (called *business rules*) established by user or company.

Example of multiplicity (1)

Conceptual Entity Relationship Diagram (ERD)



This is a ONE-TO-MANY relationship!!

Work out the Min and the Max!

- One member of staff may be working in no branch.
- One member of staff can only work in up to one branch.
- One branch can have no staff working at it.
- One branch can have many staff working at it.

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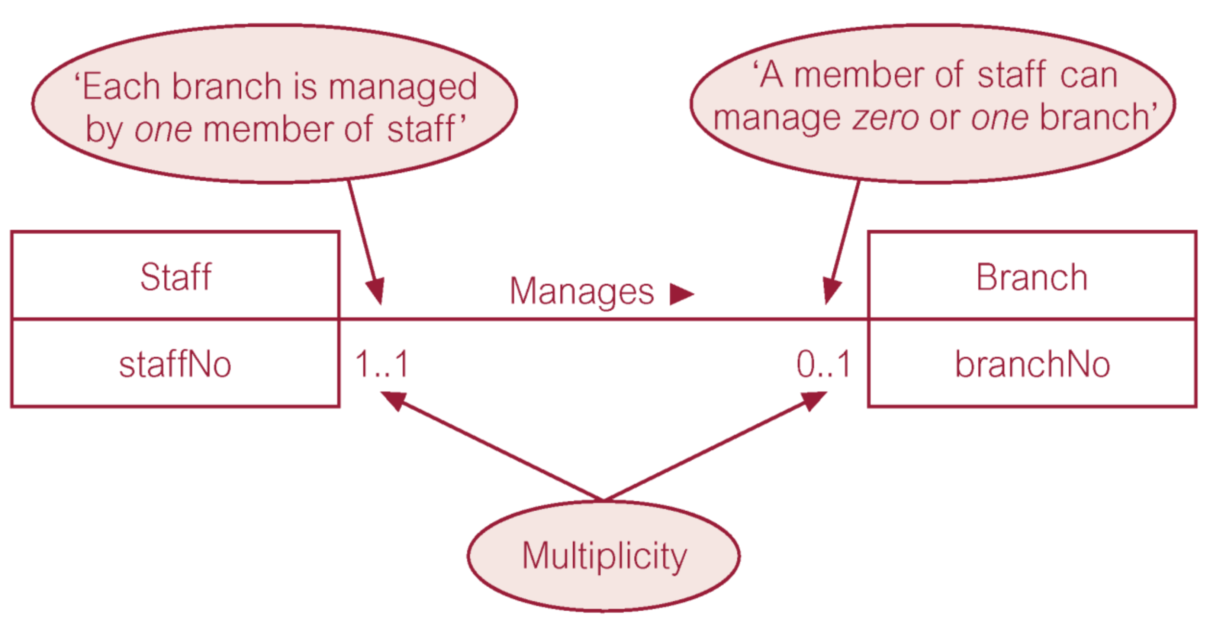
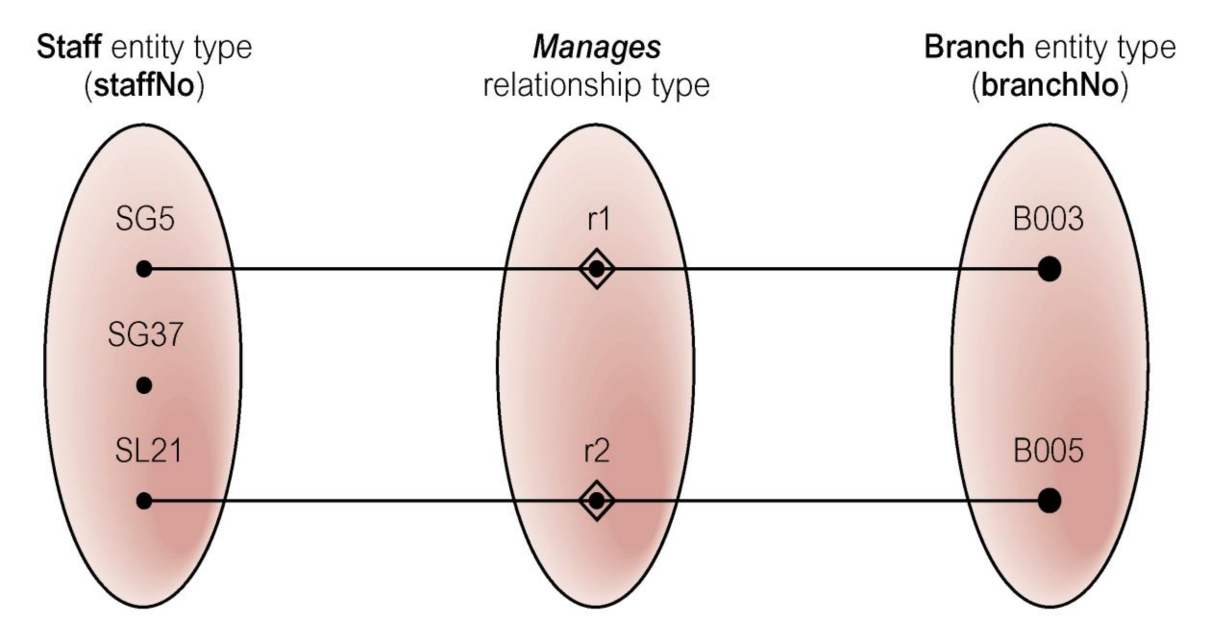
Example of multiplicity (2)

ER Diagram


'Each branch is managed by *one* member of staff'
'A member of staff can manage *zero* or *one* branch'
Staff
staffNo
Manages ▶
Branch
branchNo
1..1
0..1
Multiplicity

Semantic net


Staff entity type (**staffNo**)
Manages relationship type
Branch entity type (**branchNo**)
SG5
SG37
SL21
r1
r2
B003
B005

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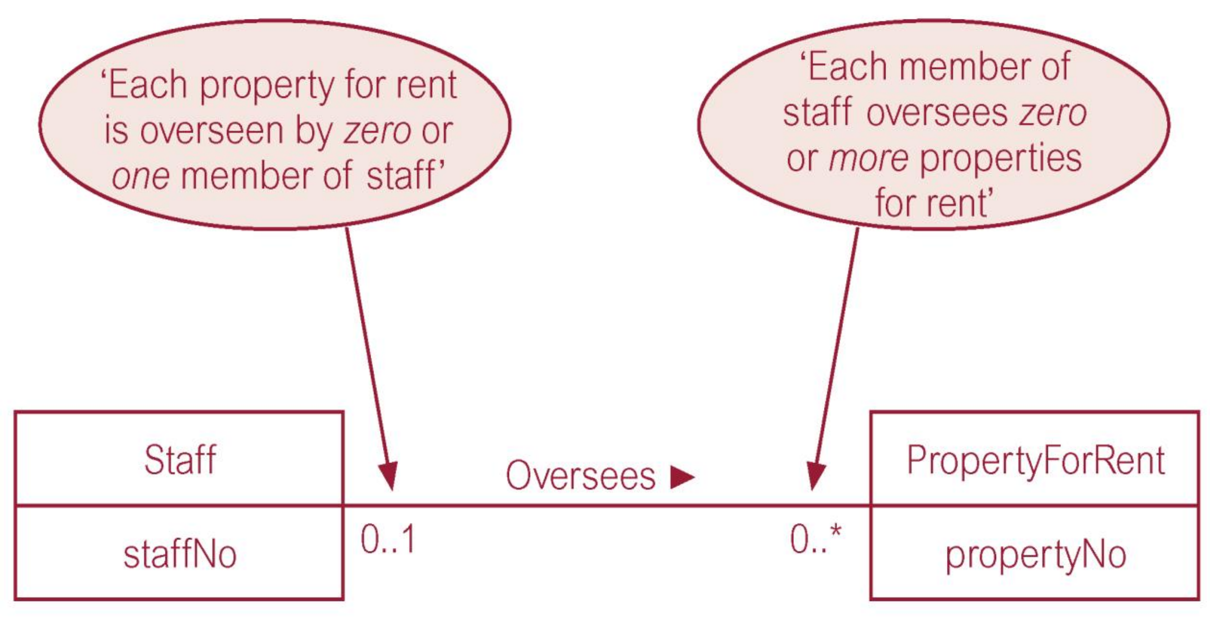
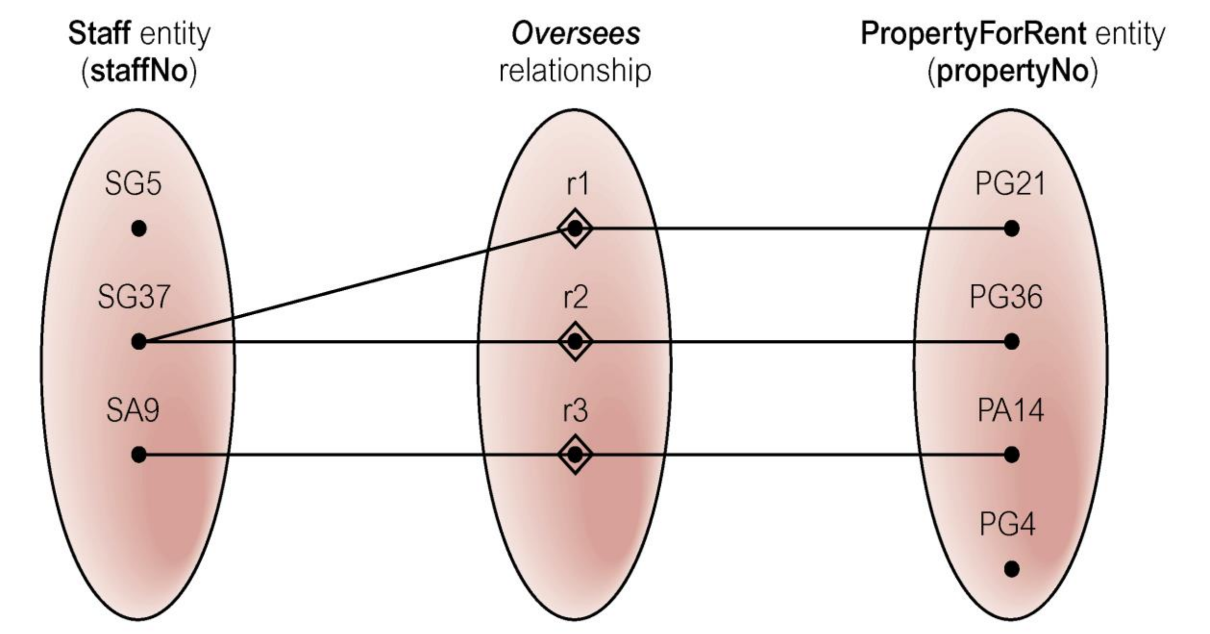
Example of multiplicity (3)

ER Diagram

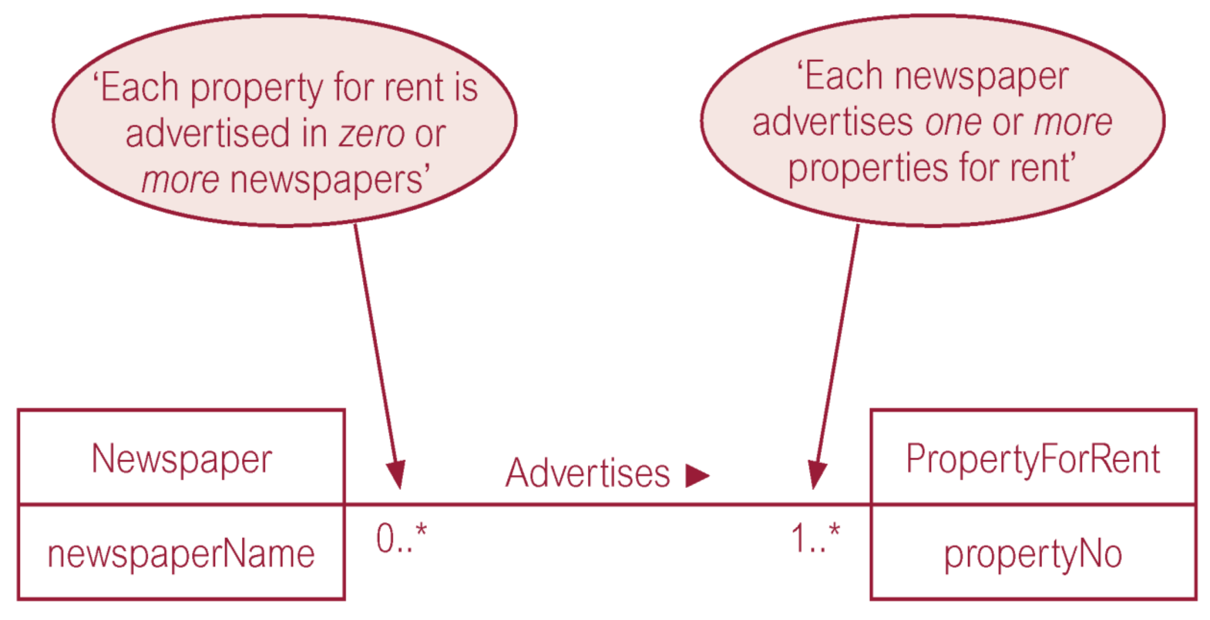

'Each property for rent is overseen by *zero* or *one* member of staff'
'Each member of staff oversees *zero* or *more* properties for rent'
Staff
staffNo
Oversees ▶
0..1
0..*
PropertyForRent
propertyNo

Semantic net


Staff entity (**staffNo**)
Oversees relationship
PropertyForRent entity (**propertyNo**)
SG5
SG37
SA9
r1
r2
r3
PG21
PG36
PA14
PG4

Example of multiplicity (4)

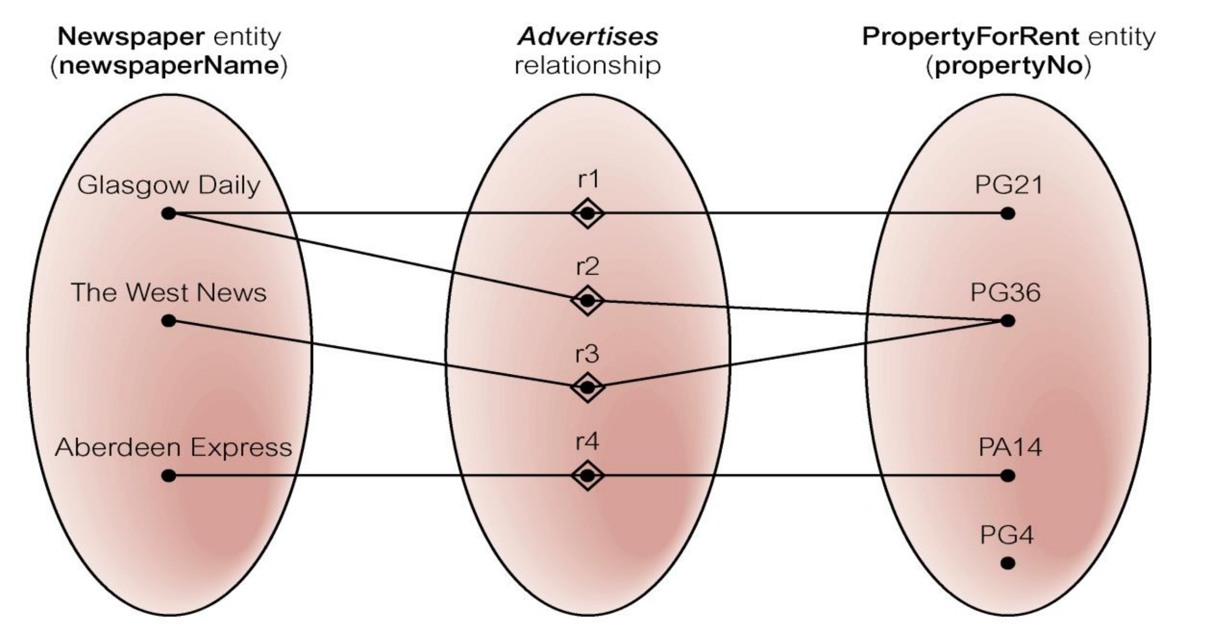
ER Diagram



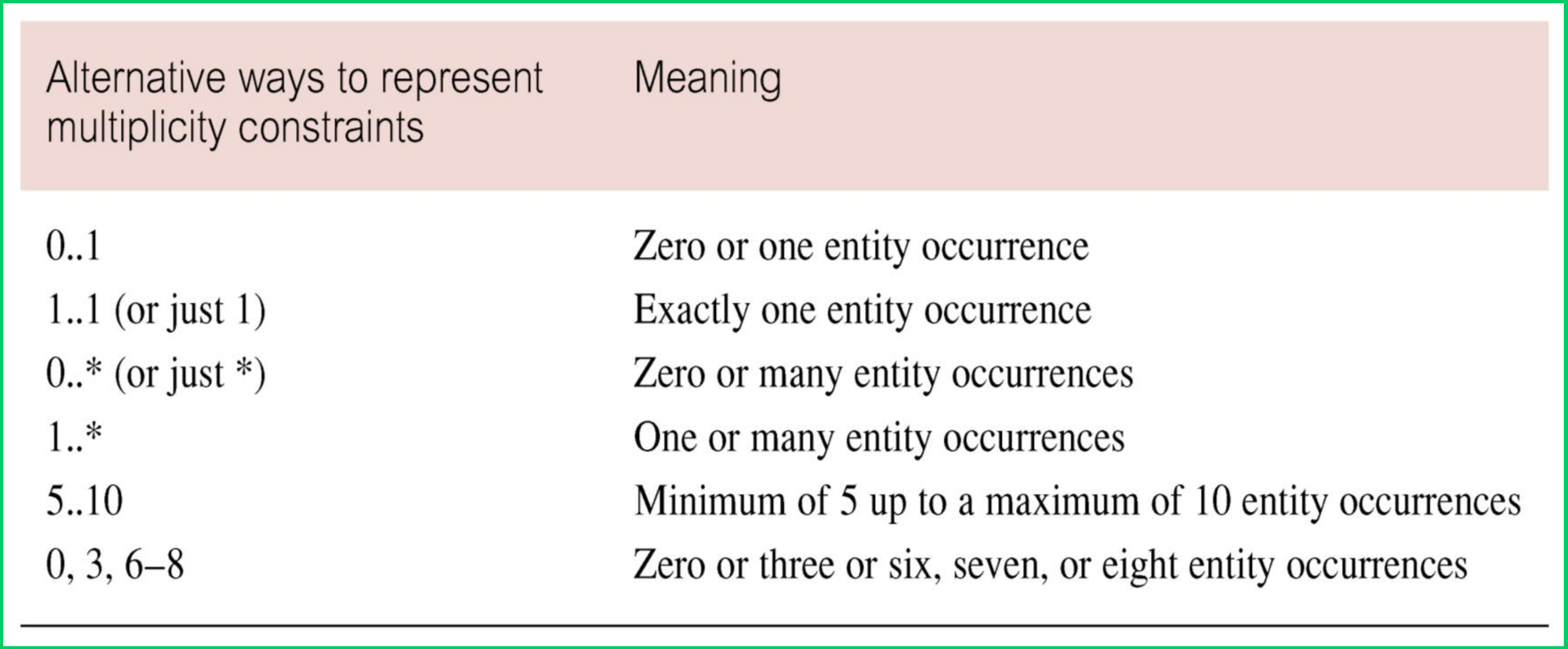
‘Each property for rent is advertised in *zero* or *more* newspapers’

‘Each newspaper advertises *one* or *more* properties for rent’

Semantic net


Newspaper entity (**newspaperName**)
Advertises relationship
PropertyForRent entity (**propertyNo**)
Glasgow Daily
The West News
Aberdeen Express
r1
r2
r3
r4
PG21
PG36
PA14
PG4

Summary of multiplicity constraints



Alternative ways to represent multiplicity constraints	Meaning
0..1	Zero or one entity occurrence
1..1 (or just 1)	Exactly one entity occurrence
0..* (or just *)	Zero or many entity occurrences
1..*	One or many entity occurrences
5..10	Minimum of 5 up to a maximum of 10 entity occurrences
0, 3, 6–8	Zero or three or six, seven, or eight entity occurrences

Multiplicity = cardinality + participation

- **Multiplicity is made up of two types of restrictions on relationships:**

  ***CARDINALITY* and *PARTICIPATION*.**

- **Cardinality**
  - Describes maximum number of possible relationship occurrences for an entity participating in a given relationship.

- **Participation**
  - Determines whether all or only some entity occurrences participate in a relationship.

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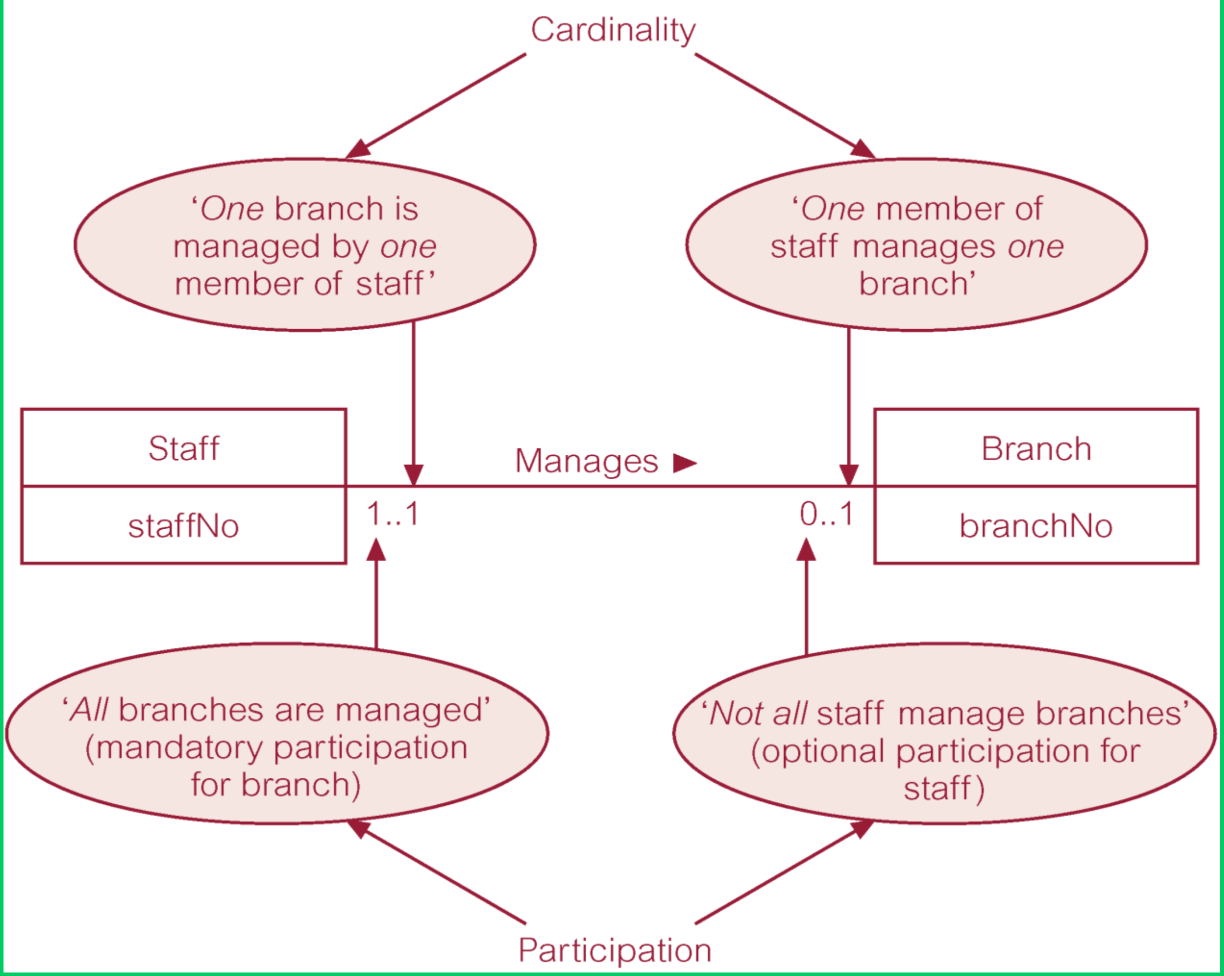
Example of cardinality & participation


Cardinality
'*One* branch is managed by *one* member of staff'
'*One* member of staff manages *one* branch'
Staff
staffNo
Manages ►
1..1
0..1
Branch
branchNo
'*All* branches are managed' (mandatory participation for branch)
'*Not all* staff manage branches' (optional participation for staff)
Participation

Attributes

- **Attribute**
  - Property of an entity or a relationship.

- **Attribute Domain**
  - Set of allowable values for one or more attributes.

- **Simple Attribute**
  - Attribute composed of a single component with an independent existence.

- **Composite Attribute**
  - Attribute composed of multiple components, each with an independent existence.

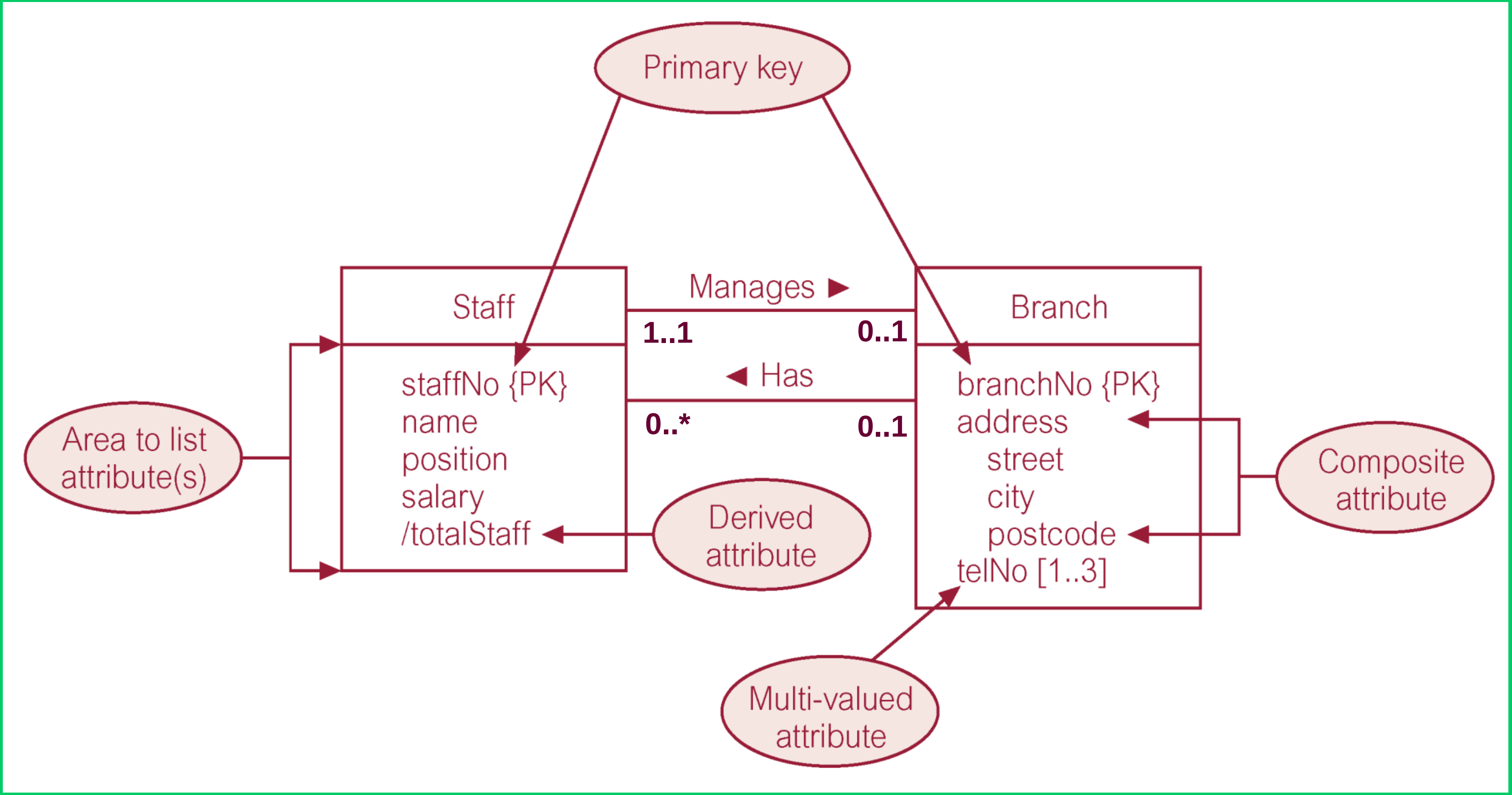
Different types of attributes

- **Single-valued Attribute**
  - Attribute that holds a single value for each occurrence of an entity.
- **Multi-valued Attribute**
  - Attribute that holds multiple values for each occurrence of an entity.
- **Derived Attribute**
  - Attribute that represents a value that is derivable from value of a related attribute, or set of attributes, not necessarily in the same entity.

Keys

- **Candidate Key**
  - Minimal set of attributes that uniquely identifies each occurrence of an entity.
- **Primary Key**
  - Candidate key selected to uniquely identify each occurrence of an entity.
- **Compound Key**
  - A candidate key that consists of two or more attributes.
  - Each attribute that makes up the compound key is a **simple key** in its own right.
- **Composite Key**
  - A candidate key that consists of two or more attributes.
  - At least one attribute that makes up the composite key is not a **simple key** in its own right.

Example of entities and attributes



Degree of a relationship

- **Degree of a Relationship**
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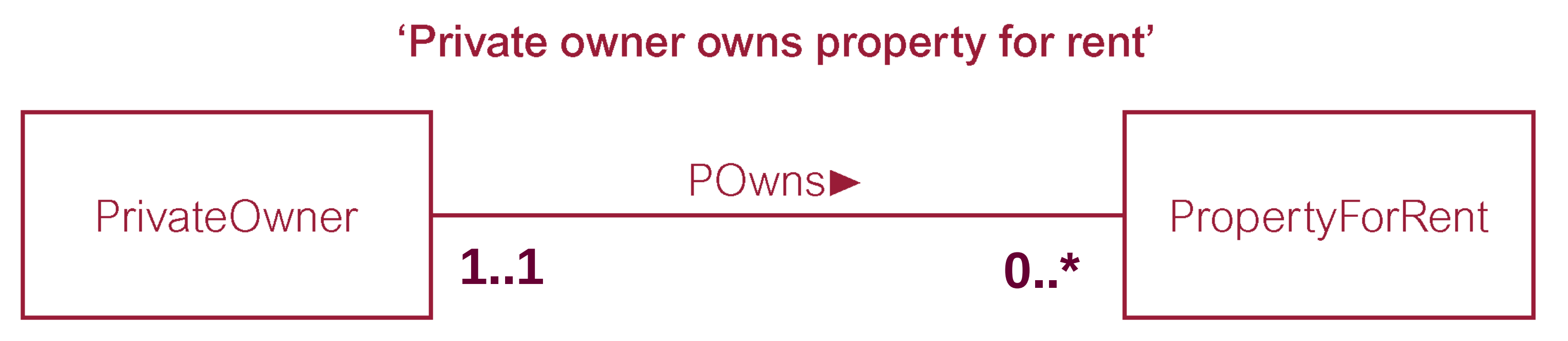
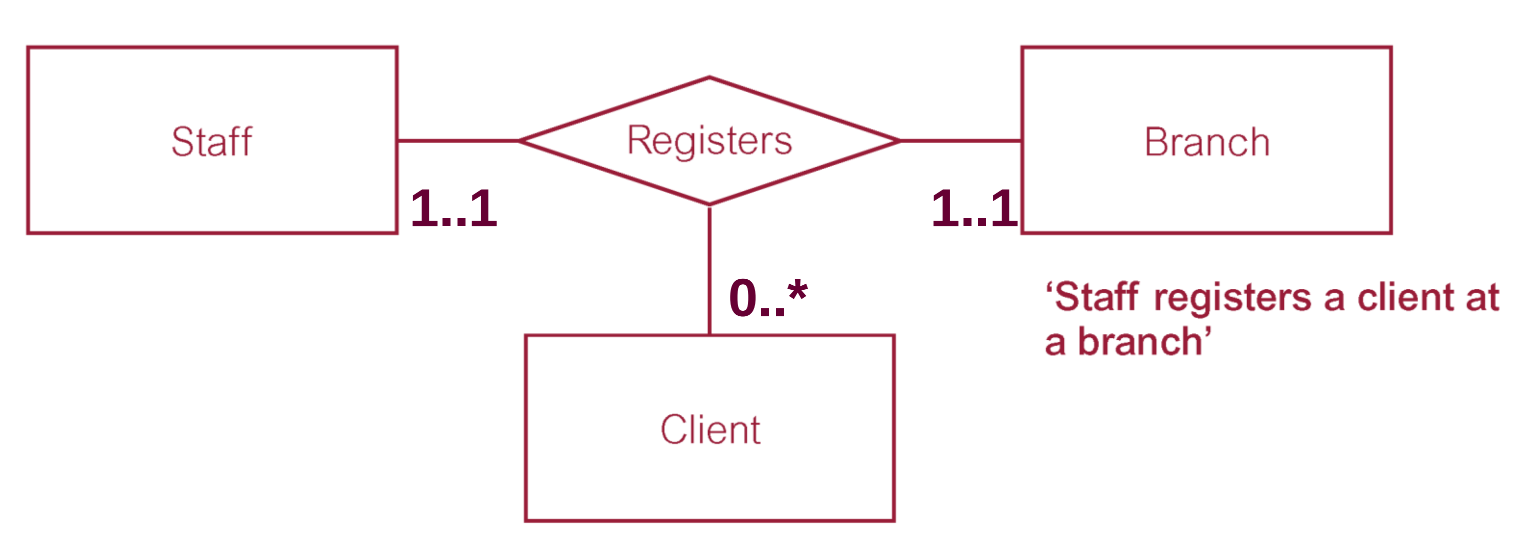
  - four is quaternary
  - n is n-ary.

Binary and Ternary Relationships

Binary Relationship

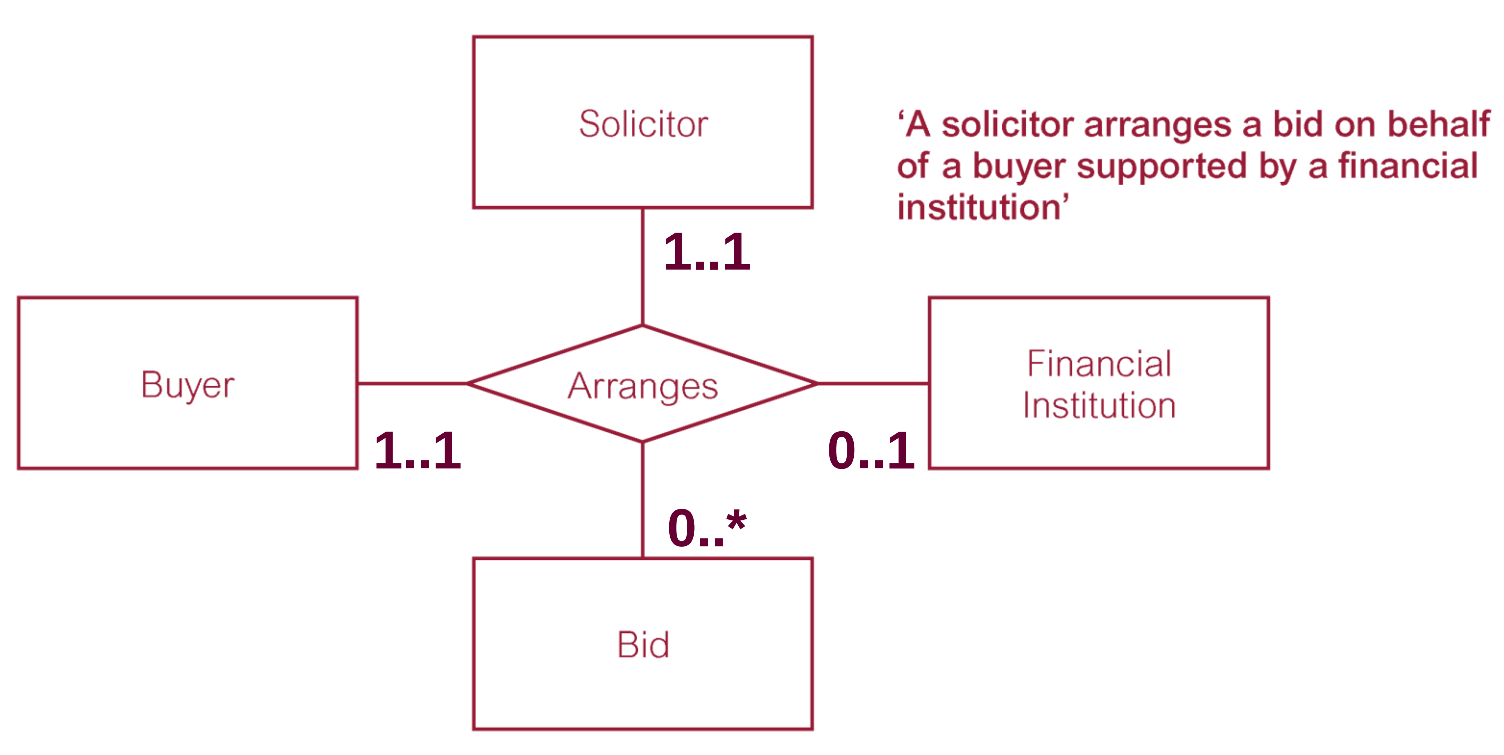


Ternary Relationship



Quaternary Relationships

Quaternary Relationship

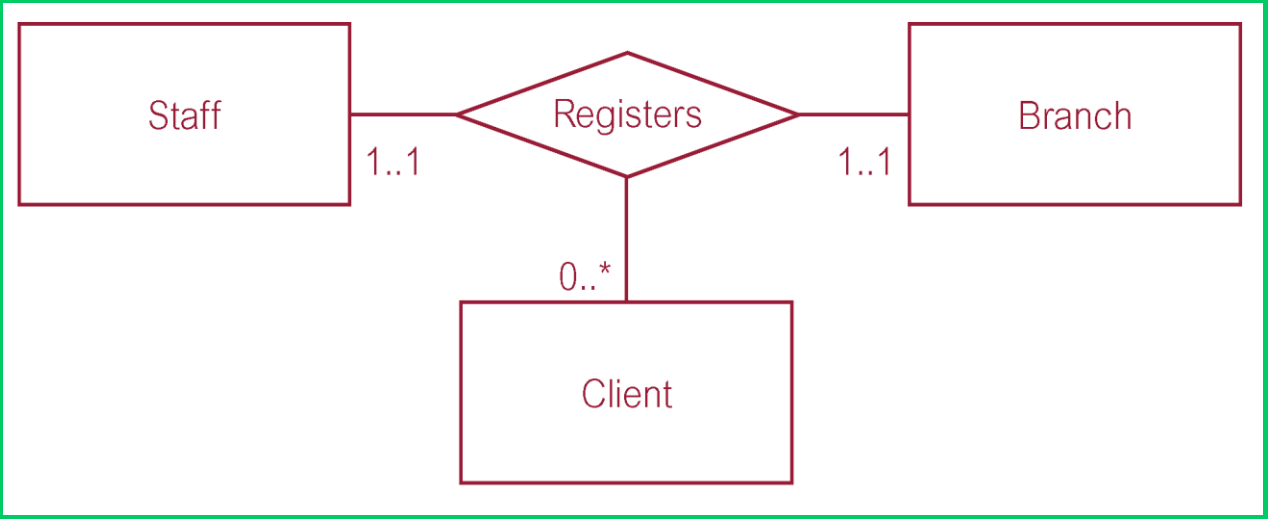


'A solicitor arranges a bid on behalf of a buyer supported by a financial institution'

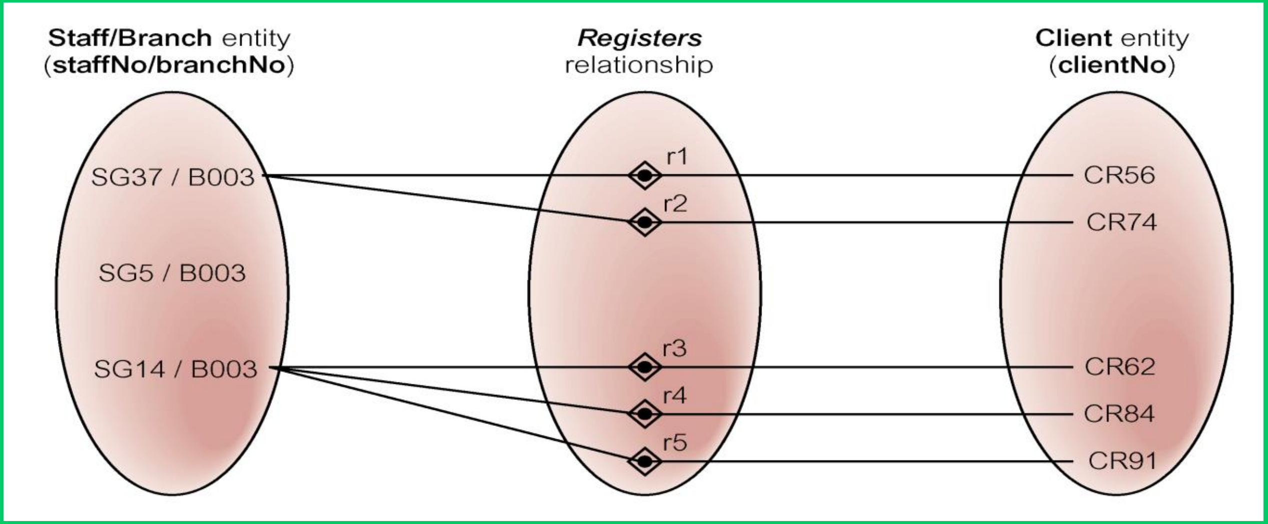
Multiplicities for n-ary relationships

Number (or range) of possible occurrences of an entity in an n-ary relationship when other (n-1) values are fixed.

ER Diagram



Semantic net



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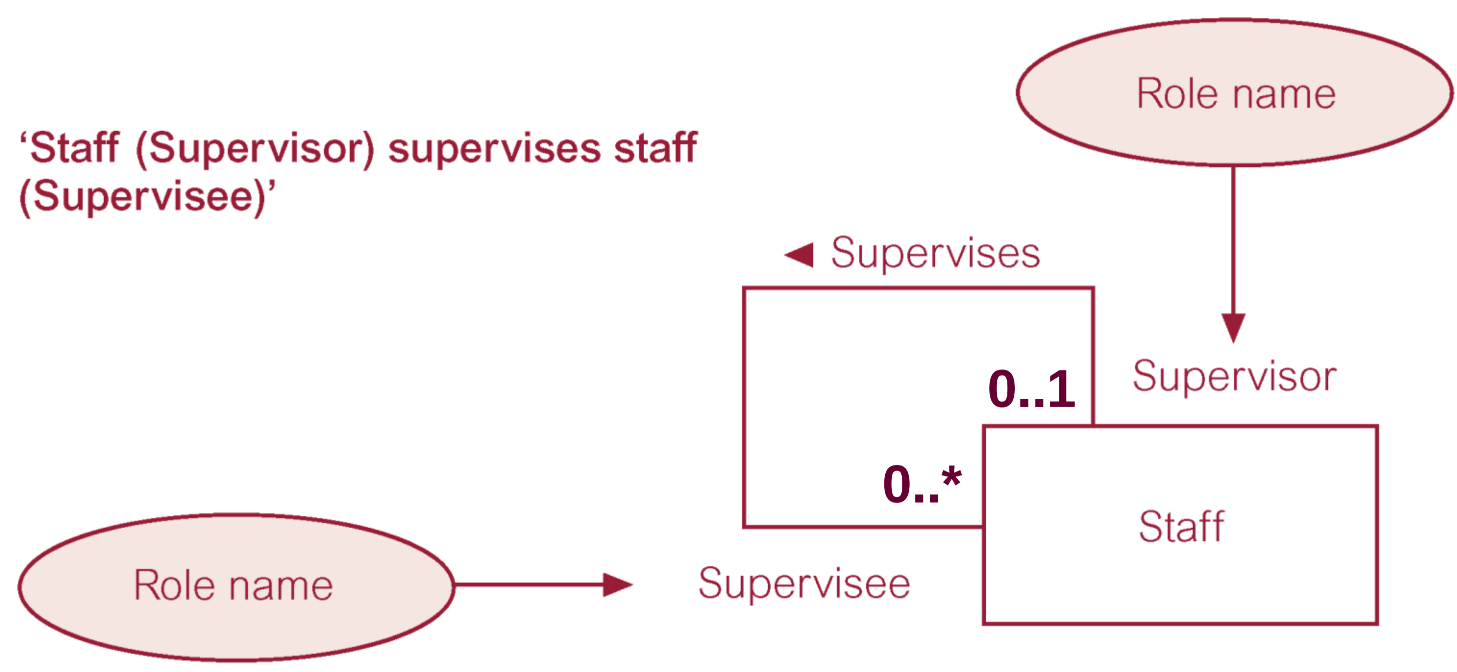
Recursive relationships

– **Recursive Relationship**
  - Relationship where same entity participates more than once in different roles.

– **Relationships may be given role names to indicate purpose that each participating entity plays in a relationship.**



'Staff (Supervisor) supervises staff (Supervisee)'

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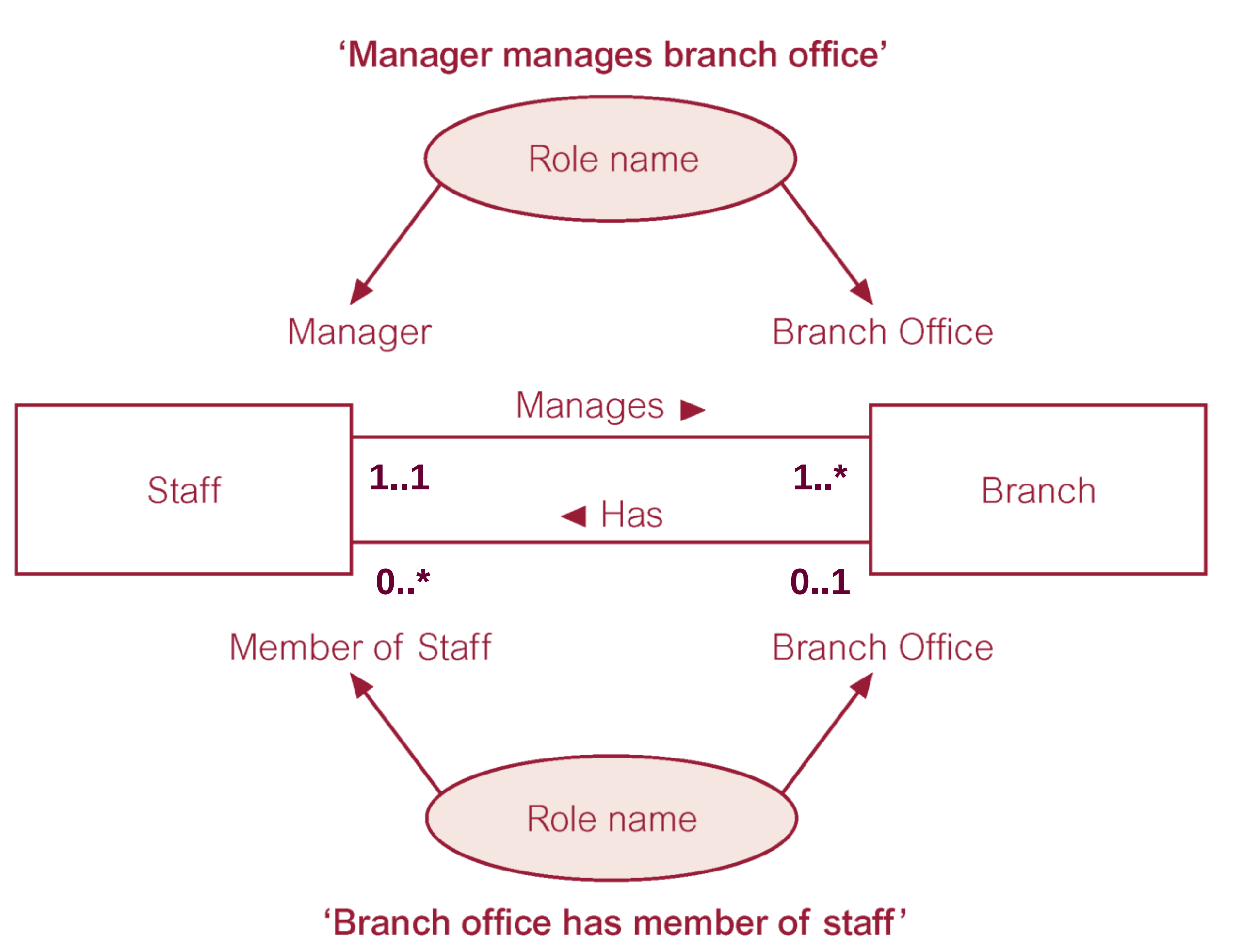
Entities associated through 2 distinct relationships

Occurrences of an entity associated to occurrences of the other entities through more than one relationship



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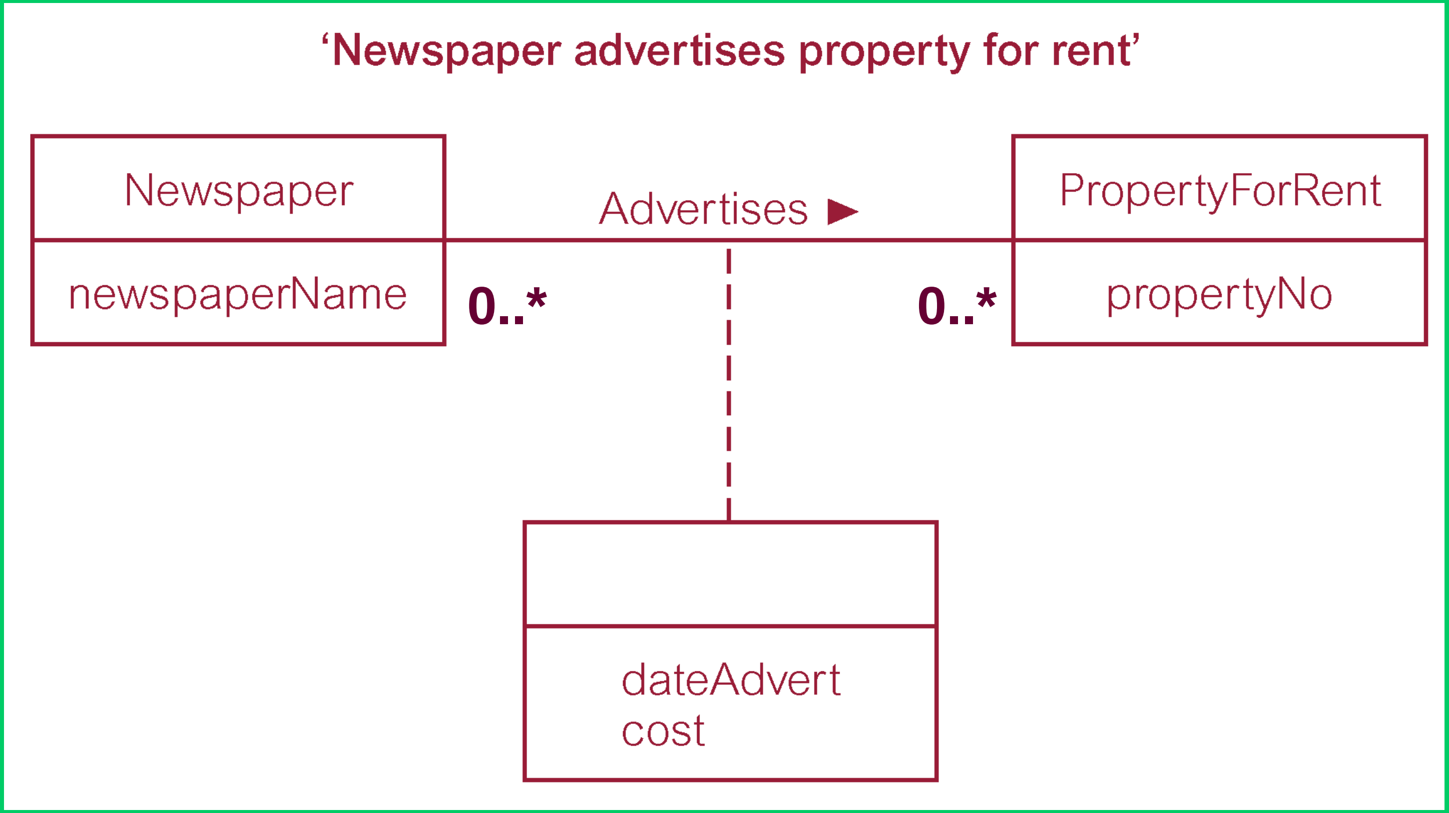
Attributes on relationships

– Attributes on relationship

- In situation where location of attributes not immediately obvious
- May indicate that relationship conceals unidentified entity


‘Newspaper advertises property for rent’

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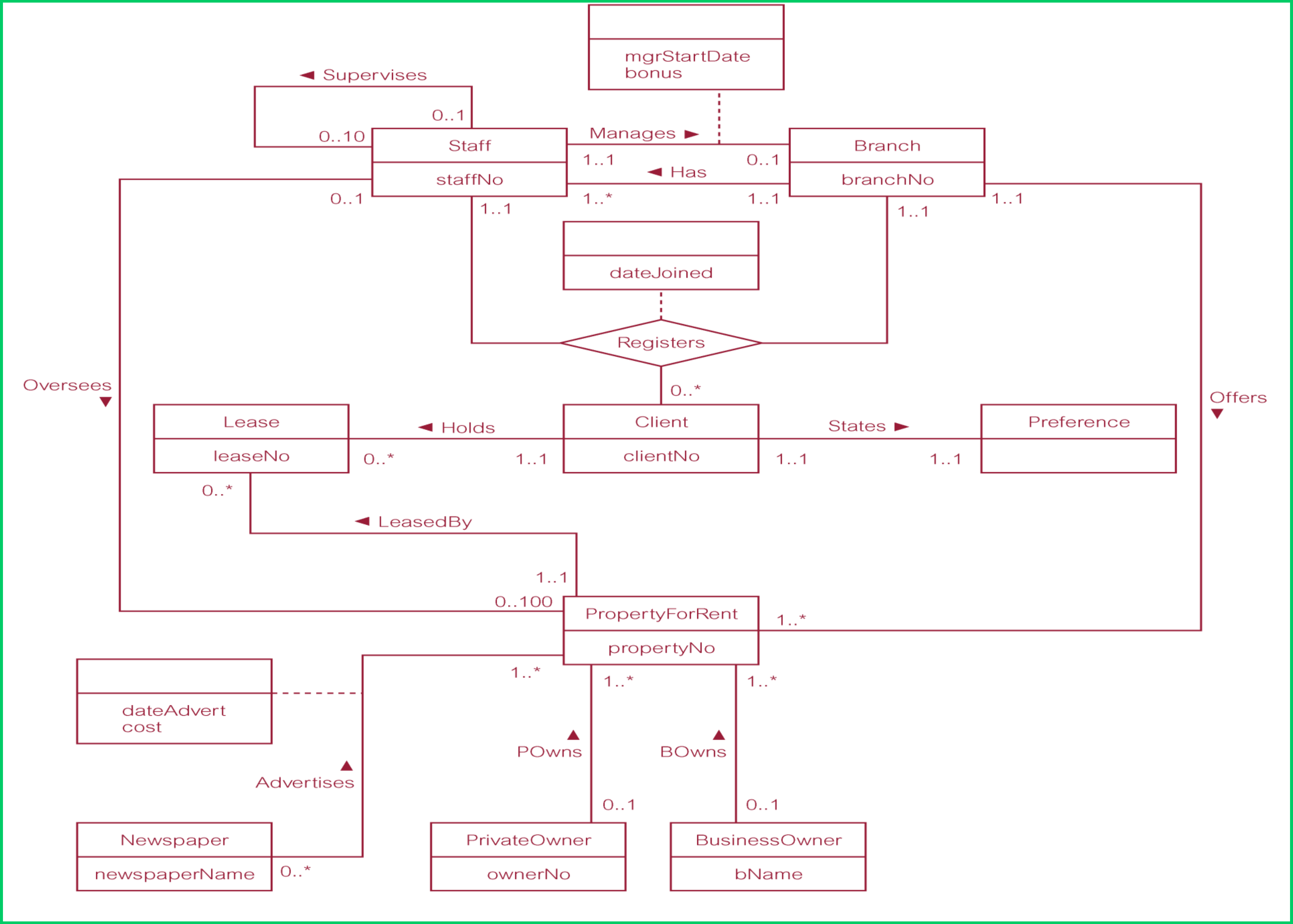
DreamHome Conceptual ERD (branch view)



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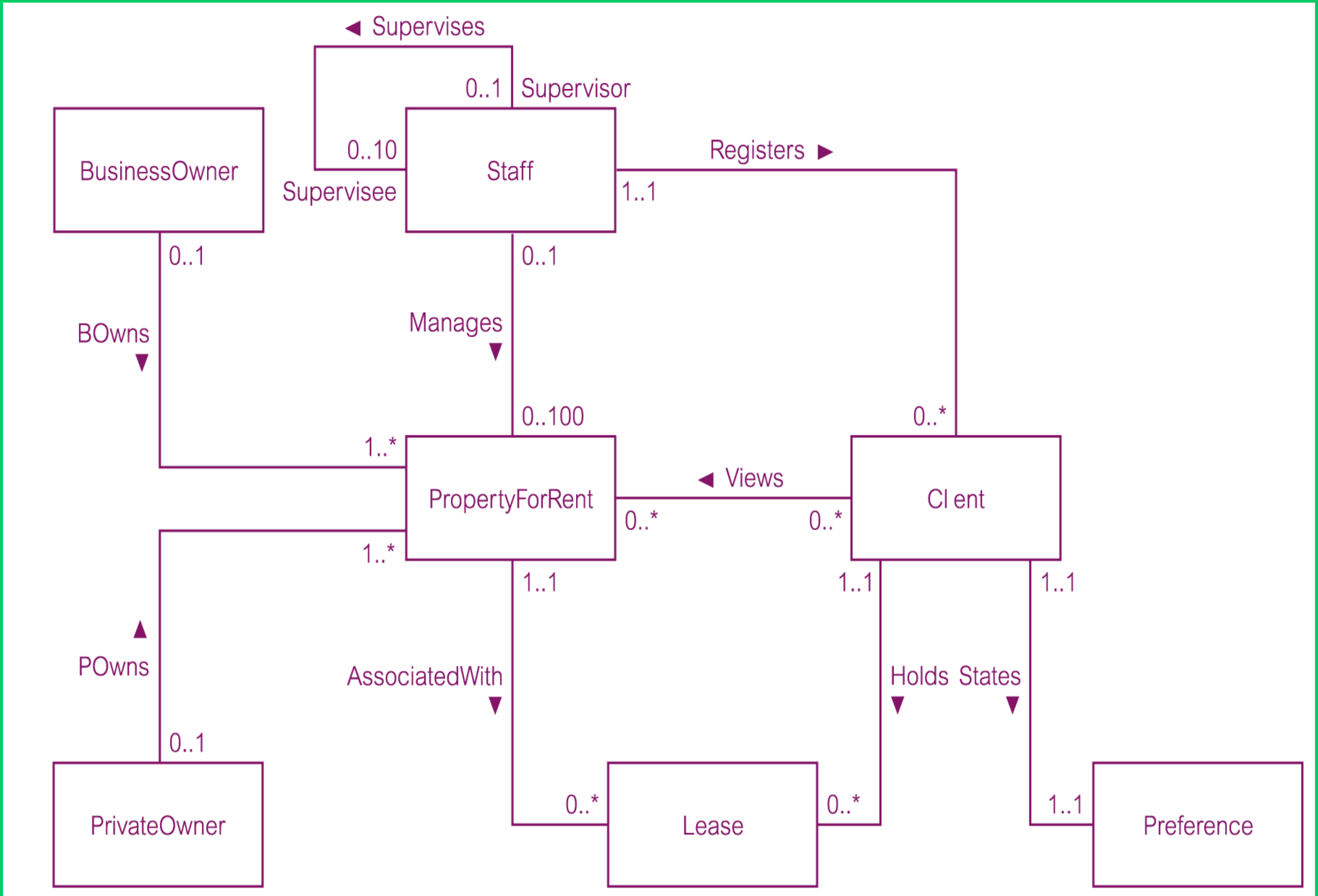
DreamHome Conceptual ERD (staff view)



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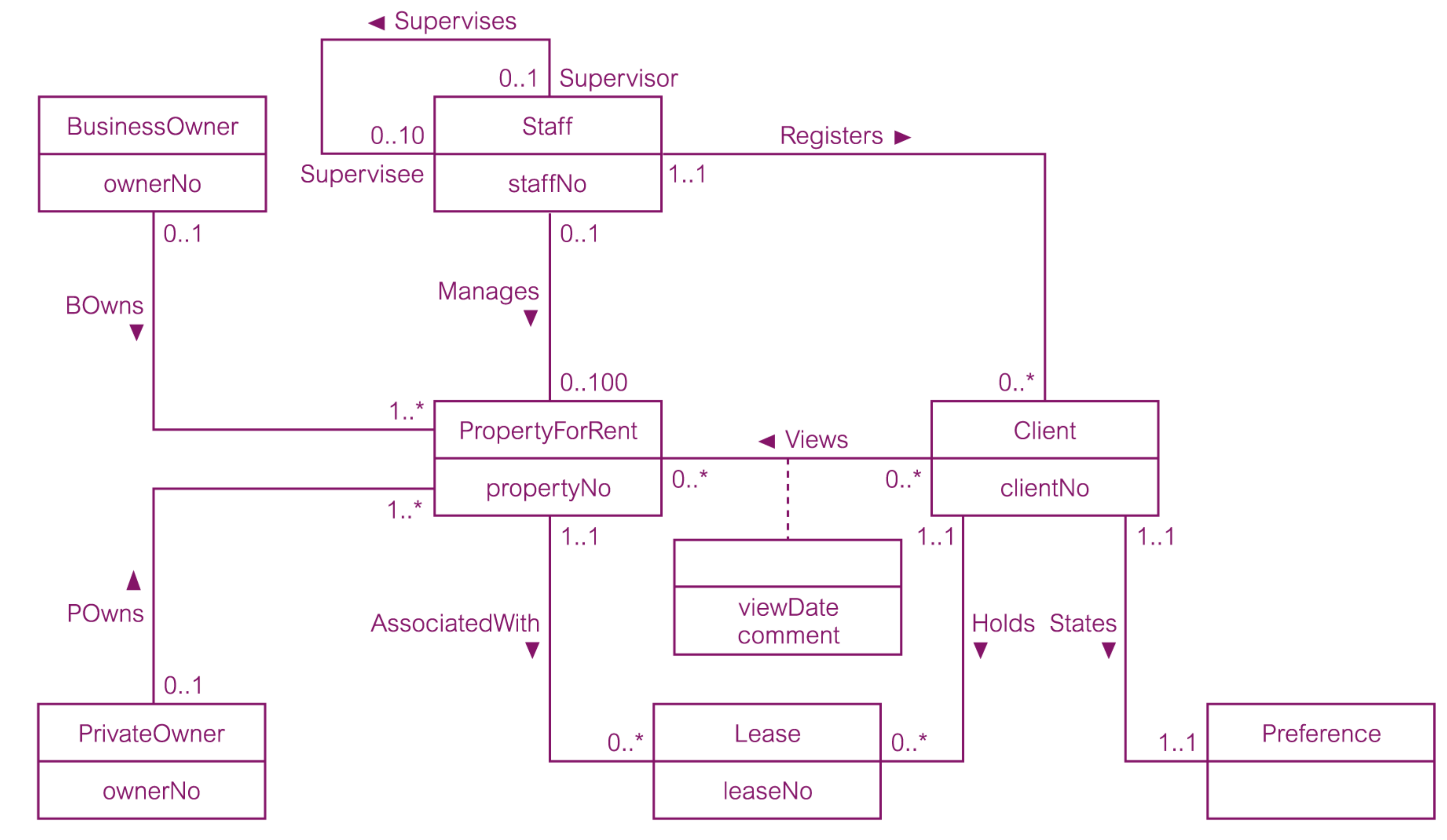
DreamHome Conceptual ERD (staff view with PKs)


◄ Supervises
0..1
Supervisor
0..10
Supervisee
BusinessOwner
ownerNo
Staff
staffNo
Registers ►
1..1
0..1
0..1
BOwns ▼
Manages ▼
0..100
0..*
1..*
PropertyForRent
propertyNo
◄ Views
Client
clientNo
0..*
0..*
1..*
1..1
1..1
1..1
viewDate
comment
▲ POwns
AssociatedWith ▼
Holds ▼
States ▼
0..1
PrivateOwner
ownerNo
0..*
Lease
leaseNo
0..*
1..1
Preference