Chapter 12
Entity-Relationship Modeling

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Objectives

- What is Entity-Relationship modelling?
- How to use Entity–Relationship (ER) modeling in database design.
- Basic concepts associated with ER model.
- Diagrammatic technique for displaying ER model using Unified Modeling Language (UML).

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What is Entity-Relationship modelling?

- Entity–Relationship (ER) modeling is a top-down database design approach.
- Starts with identification of entities and relationships between the entities, which are of interest to the organization.
- Then applies successive top-down refinements to identify lower-level entities, relationships, and the associated attributes.

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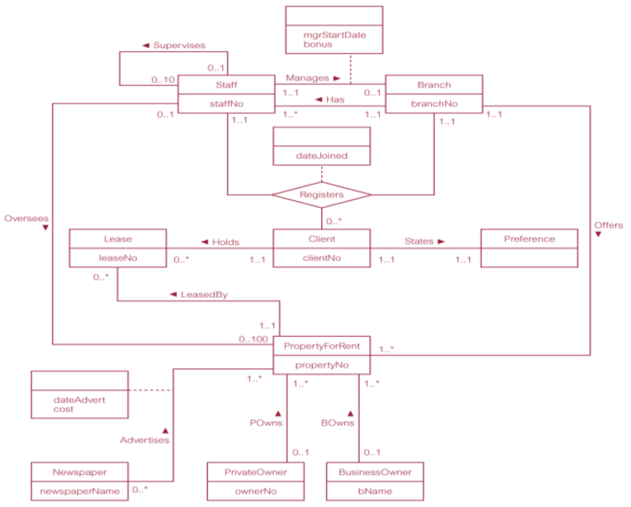
ER diagram of Branch user views of *DreamHome (Fig. 12.1)*



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Concepts of the ER Model

- Entity types
- Relationship types
- Attributes

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Entity Type

- Entity type
  - Group of objects with same properties, identified by enterprise as having an independent existence.
  - The basic concept of ER model.
  - Each uniquely identifiable object of an entity type is referred to as an **entity occurrence** (which is the same as the concept of record in relational model).

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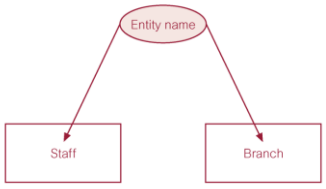
Diagrammatic representation of Staff and Branch entity types

- Each entity type is shown as a rectangle, labeled with the name of the entity, which is usually a singular noun.
- In UML, the first letter of each word in the entity name is uppercase.

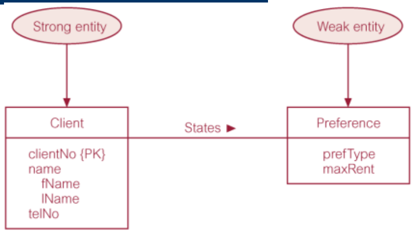


Strong and Weak Entity Types

- Strong Entity Type
  - Entity type that is *not* existence-dependent on some other entity type.
  - A characteristic is that each entity occurrence is uniquely identifiable using the primary key attribute(s) of that entity type.
- Weak Entity Type
  - Entity type that is existence-dependent on some other entity type. It cannot exist without the entity with which it has a relationship.
  - Such weak entity has a primary key that is partially or totally derived from the owner entity in the relationship.
  - A characteristic is that each entity occurrence has a mandatory foreign key — **a foreign key attribute that cannot be null.**

Example on Strong and Weak entity type

- Note that there is no primary key for the Preference entity.
- We can uniquely identify each preference only through the relationship that a preference has with a client.



- We will add clientNo as the foreign key into Preference entity in later stage of database design (logical database design) and here, the foreign key of clientNo cannot be null.
- In the example, the Preference entity is described as having existence dependency for the Client entity, which is referred to as being the owner entity.
- Why not merge the two entities in the design? What reason can you think of?

Other Examples of weak entity types

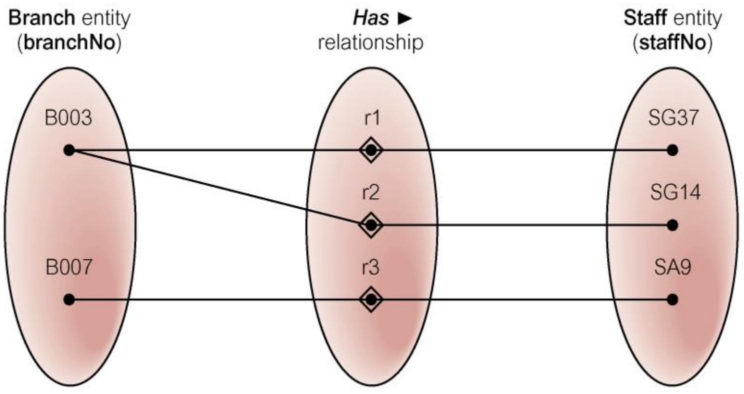
- Can you think of any other examples of weak entities?
  - A company insurance policy insures an employee and any dependents, the DEPENDENT cannot exist without the EMPLOYEE; that is, a person cannot get insurance coverage as a dependent unless the person is a dependent of an employee. DEPENDENT is the weak entity in the relationship "EMPLOYEE has DEPENDENT“.
  - An Order has OrderItems

Relationship Types

- Relationship type
  - Set of meaningful associations among entity types.
  - Each relationship type is given a name that describes its function.
  - A uniquely identifiable association which includes one occurrence from each participating entity type is called **relationship occurrence**.

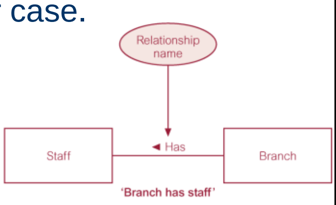
Semantic net of *Has* relationship type

Each line is a **relationship occurrence**



ER diagram of Branch *Has* Staff relationship

- The concepts of ER model can be used to represent the relationships between entities.
- Each relationship type is shown as a line connecting the associated entity types and labeled with the name of the relationship.
- Usually, a relationship name is a verb, with the first letter of each word shown in upper case.
- An arrow symbol is placed beside the relationship name indicating the correct direction.
- Whenever possible, a relationship name should be unique for a given ER model.



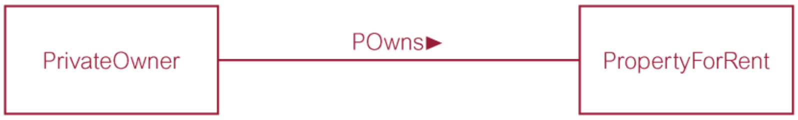
Degree of Relationship Types

- Number of participating entity types (also referred to as **participants**) in a relationship is called the **degree of relationship type**.
- Relationship of degree
  - two is **binary**
  - three is **ternary**

Binary relationship called *POwns*

- Entity types
- Relationship types
- Attributes

‘Private owner owns property for rent’



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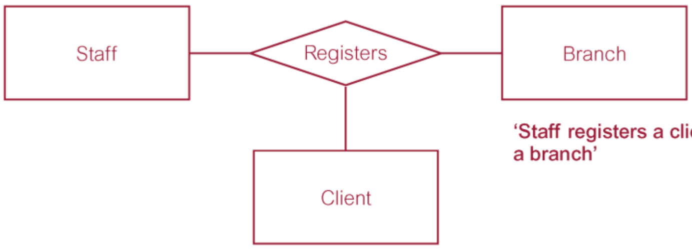
Ternary relationship called *Registers*

- Entity types
- Relationship types
- Attributes



‘Staff registers a client at a branch’

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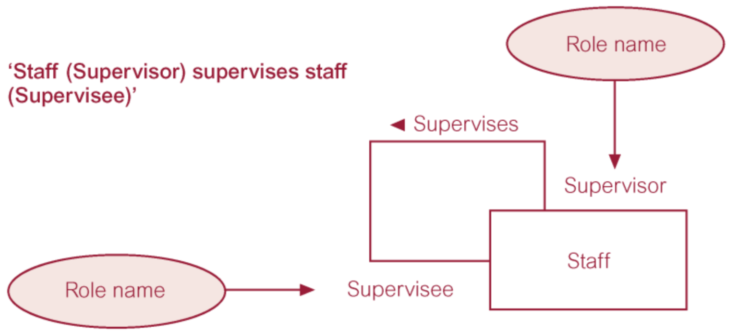
Recursive Relationship

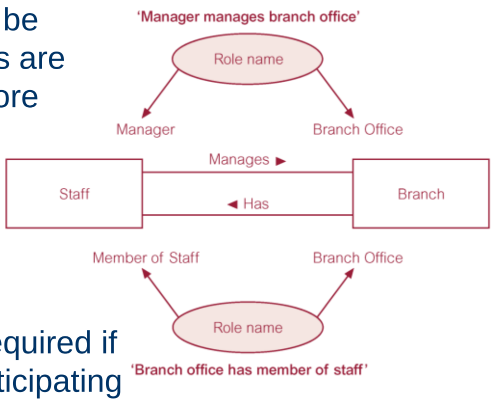
- Recursive Relationship
  - Relationship type where the *same* entity type participates more than once in *different roles*.
  - Sometimes called ***unary*** relationships.
- Relationships may be given **role names** to indicate the purpose that each participating entity type plays in a relationship.

Recursive relationship called *Supervises* with role names



Entities with Role Names

- Role names may also be used when two entities are associated through more than one relationship.
- The use of role names clarifies the purpose of each relationship.
- Role names are not required if the function of the participating entities in a relationship is unambiguous.



Attributes

- Attribute
  - Property of an entity or a relationship type.
- Attribute Domain
  - Data type and set of allowable values for one or more attributes.
- Simple Attribute
  - Attribute composed of a single component with an independent existence. E.g. salary
- Composite Attribute
  - Attribute composed of multiple components, each with an independent existence.
  - For example, address attribute can be subdivided into street, city.

Multi-valued Attributes

- Single-valued Attribute
  - Attribute that holds a single value for each occurrence of an entity type.
  - For example, each occurrence of Branch entity type has a single value for the branch number.
- Multi-valued Attribute
  - Attribute that holds multiple values for each occurrence of an entity type.
  - For example
    - each occurrence of the Branch entity type can have multiple values for the telNo attribute;
    - a person may have several college degrees
  - A multi-valued attribute may have a set of numbers with upper and lower limits.

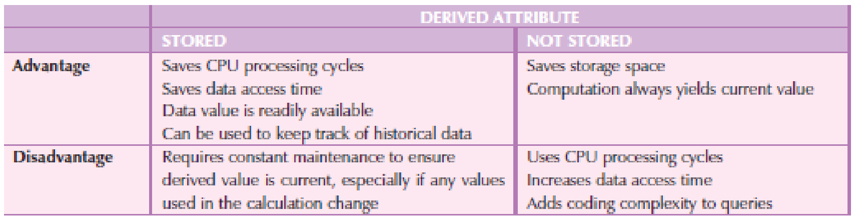
Derived Attributes

- Derived Attribute
  - Attribute that represents a value that is derivable from the value of a related attribute, or set of attributes, not necessarily in the same entity type.
  - For example,
    - the duration attribute of the Lease entity is calculated from the rentStart and rentFinish attributes
    - an employee’s age may be found by computing the integer value of the difference between the current date and employee’s date of birth

- Entity types
- Relationship types
- Attributes

Storing Derived Attributes?

- Should Derived Attribute be stored?
  - The decision to store derived attributes in database tables depends on the processing requirements and the constraints placed on a particular application. The designer should be able to balance the design in accordance with such constraints.



	DERIVED ATTRIBUTE	
	STORED	NOT STORED
Advantage	Saves CPU processing cycles Saves data access time Data value is readily available Can be used to keep track of historical data	Saves storage space Computation always yields current value
Disadvantage	Requires constant maintenance to ensure derived value is current, especially if any values used in the calculation change	Uses CPU processing cycles Increases data access time Adds coding complexity to queries

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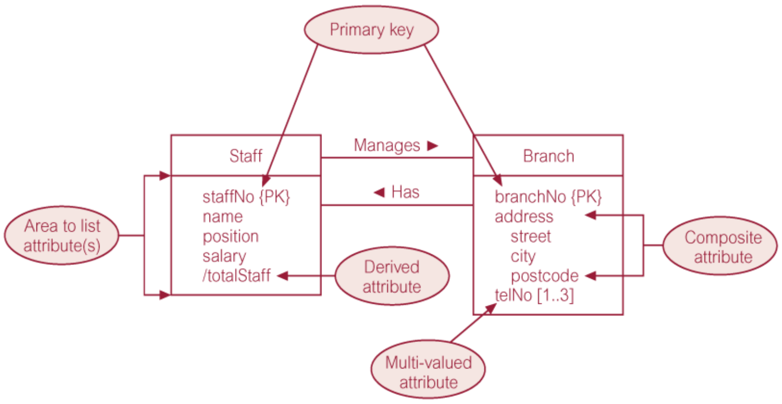
ER diagram of Staff and Branch entities and their attributes



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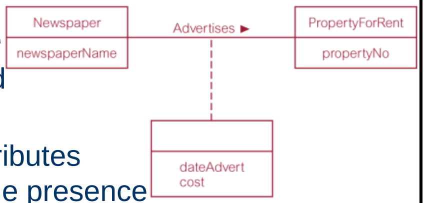
Attributes on Relationships

- The presence of one or more attributes assigned to a relationship may indicate that the relationship conceals an unidentified entity type.
- The diagram shows a relationship called *Advertises* with attributes dateAdvert and cost.
- The presence of these two attributes on the relationship indicates the presence of an entity called Advert.

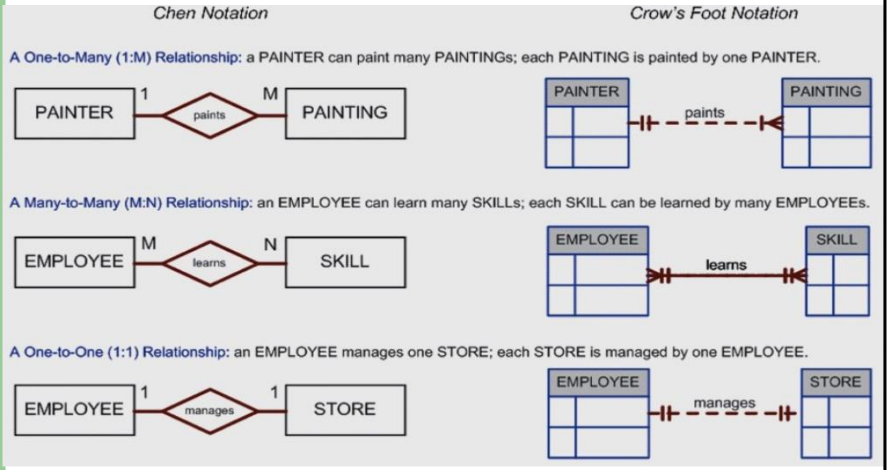
'Newspaper advertises property for rent'



Examples of Attributes on Relationships

- Can you think of any other examples of attributes on relationships?
  - A student enrolls in courses
  - A customer books flight tickets

Different ER notation


Chen Notation
Crow's Foot Notation
A One-to-Many (1:M) Relationship: a PAINTER can paint many PAINTINGs; each PAINTING is painted by one PAINTER.
PAINTER
1
paints
M
PAINTING
PAINTER
paints
PAINTING
A Many-to-Many (M:N) Relationship: an EMPLOYEE can learn many SKILLs; each SKILL can be learned by many EMPLOYEEs.
EMPLOYEE
M
learns
N
SKILL
EMPLOYEE
learns
SKILL
A One-to-One (1:1) Relationship: an EMPLOYEE manages one STORE; each STORE is managed by one EMPLOYEE.
EMPLOYEE
1
manages
1
STORE
EMPLOYEE
manages
STORE

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Structural Constraints

- 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 type through a particular relationship.
  - Represents policies (called *business rules*) established by user or enterprise.

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Structural Constraints (cont'd)

- The most common degree for relationships is binary.
- Binary relationships are generally referred to as being:
  - one-to-one (1:1)
  - one-to-many (1:*)
  - many-to-many (*:*)
- Examples:
  - A member of staff manages a branch (1:1)
  - A member of staff oversees properties for rent (1:*)
  - Newspapers advertise properties for rent (*:*)

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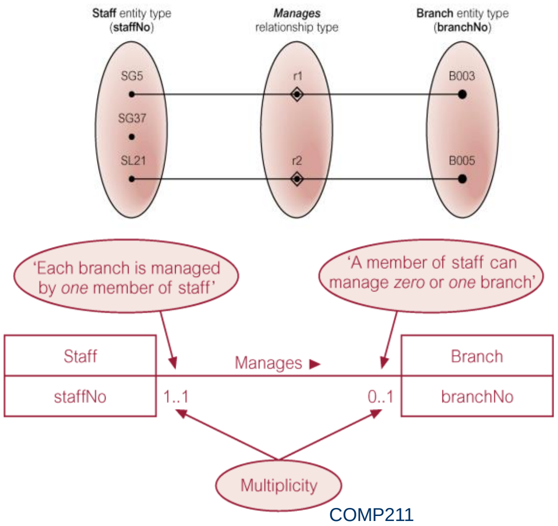
One-to-One (1:1) Relationships



Staff entity type (staffNo)
Manages relationship type
Branch entity type (branchNo)
SG5
SG37
SL21
r1
r2
B003
B005
'Each branch is managed by one member of staff'
'A member of staff can manage zero or one branch'
Staff
staffNo
Manages ►
1..1
0..1
Branch
branchNo
Multiplicity

ER diagram showing the multiplicity of the Staff *Manages* Branch one-to-one (1:1) relationship.

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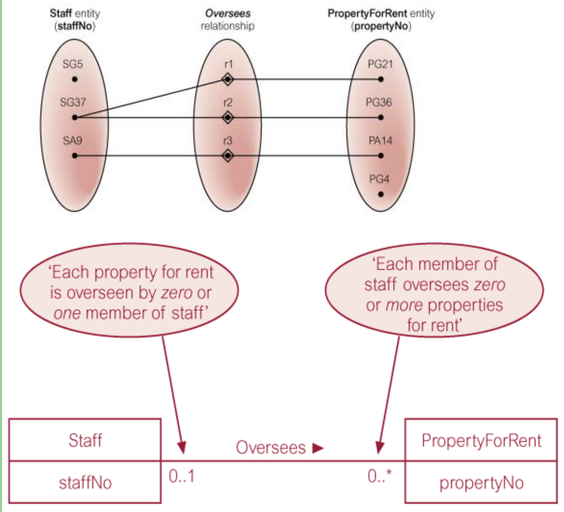
One-to-Many (1:*) Relationships


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

ER diagram showing the multiplicity of the Staff *Oversees* PropertyForRent one-to-many (1:*) relationship.

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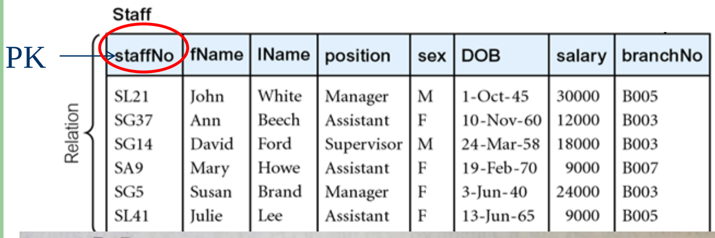
One-to-Many (1:*) Relationships

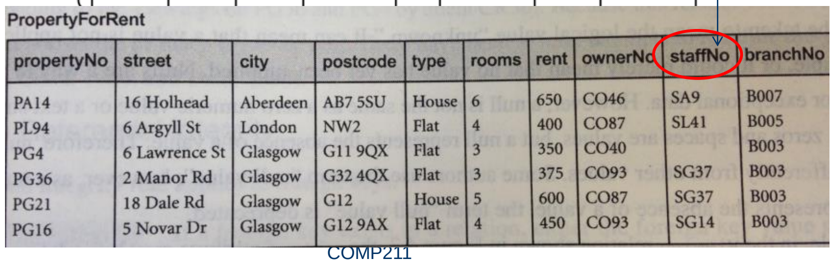
- Staff oversees PropertyForRent


PK
Relation

Staff

staffNo	fName	lName	position	sex	DOB	salary	branchNo
SL21	John	White	Manager	M	1-Oct-45	30000	B005
SG37	Ann	Beech	Assistant	F	10-Nov-60	12000	B003
SG14	David	Ford	Supervisor	M	24-Mar-58	18000	B003
SA9	Mary	Howe	Assistant	F	19-Feb-70	9000	B007
SG5	Susan	Brand	Manager	F	3-Jun-40	24000	B003
SL41	Julie	Lee	Assistant	F	13-Jun-65	9000	B005

Foreign key implementation of "***each property is overseen by 0..1 staff***", thus allowing nulls to exist.



PropertyForRent

propertyNo	street	city	postcode	type	rooms	rent	ownerNo	staffNo	branchNo
PA14	16 Holhead	Aberdeen	AB7 5SU	House	6	650	CO46	SA9	B007
PL94	6 Argyll St	London	NW2	Flat	4	400	CO87	SL41	B005
PG4	6 Lawrence St	Glasgow	G11 9QX	Flat	3	350	CO40		B003
PG36	2 Manor Rd	Glasgow	G32 4QX	Flat	3	375	CO93	SG37	B003
PG21	18 Dale Rd	Glasgow	G12	House	5	600	CO87	SG37	B003
PG16	5 Novar Dr	Glasgow	G12 9AX	Flat	4	450	CO93	SG14	B003

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One-to-Many (1:*) Relationships (cont'd)

- If we know the actual minimum and maximum values for the multiplicity, we can display these instead.
- For example, if a member of staff oversees a minimum of zero and a maximum of 100 properties for rent, we can write "0..*" with "0..100"

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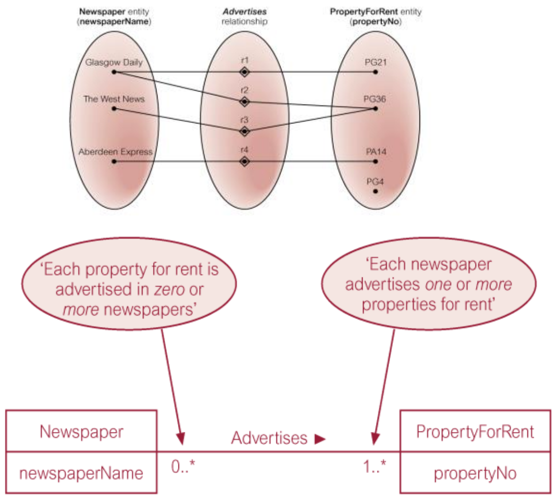
Many-to-Many (*:*) Relationships


Newspaper entity (newspaperName)
Advertises relationship
PropertyForRent entity (propertyNo)
Glasgow Daily
The West News
Aberdeen Express
r1
r2
r3
r4
PG21
PG36
PA14
PG4
'Each property for rent is advertised in zero or more newspapers'
'Each newspaper advertises one or more properties for rent'
Newspaper
newspaperName
Advertises ▶
0..*
1..*
PropertyForRent
propertyNo

ER diagram showing the multiplicity of the Newspaper *Advertises* PropertyForRent many-to-many (*:*) relationship.

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Question to Reflect on

- Compare the difference between the two models we have discussed:
  - Relational model
  - Entity-relationship model

Summary

We have covered the following:

- Binary relationships
  - One-to-one (1:1)
  - One-to-many(1:*)
  - Many-to-many (*:*)
- **Terms:**
  - Composite attribute, Multi-valued attribute, Derived attribute