Monitoring and Tuning the Operational System

Step 7 Consider the Introduction of Controlled Redundancy

Objective: To determine whether introducing redundancy in a controlled manner by relaxing normalisation rules will improve the performance of the system.

Step 7 Consider the Introduction of Controlled Redundancy

- Result of normalisation is a design that is structurally consistent with minimal redundancy.

- However, sometimes a normalised database does not provide maximum processing efficiency.

- May be necessary to accept loss of some benefits of a fully normalised design in favour of performance.

Step 7 Consider the Introduction of Controlled Redundancy

- Also consider that denormalisation:
  - makes implementation more complex;
  - often sacrifices flexibility;
  - may speed up retrievals but it slows down updates.

Step 7 Consider the Introduction of Controlled Redundancy

- Denormalisation refers to a refinement to relational schema such that the degree of normalisation for a modified relation is less than the degree of at least one of the original relations.
- Also use term more loosely to refer to situations where two relations are combined into one new relation, which is still normalised but contains more nulls than original relations.

Step 7 Consider the Introduction of Controlled Redundancy

- Consider the definition of the *Branch* relation:

  Branch(branchNo, street, city, postCode)
  Primary key branchNo

- Strictly speaking, this relation is not in 3NF as postCode → city.

Step 7 Consider the Introduction of Controlled Redundancy

- Hence the relation is only in 2NF, and we split the relation into two:

  PostCodes(postCode, city)
  Primary key postCode

  Branch(branchNo, street, postCode)
  Primary key branchNo
  Foreign key postCode references PostCodes(postCode)

- However, we would rarely wish to access the branch address without the city attribute. This would mean that we would have to perform a join whenever we want a complete address for a branch. As a result, we settle for 2NF and implement the original Branch relation,.

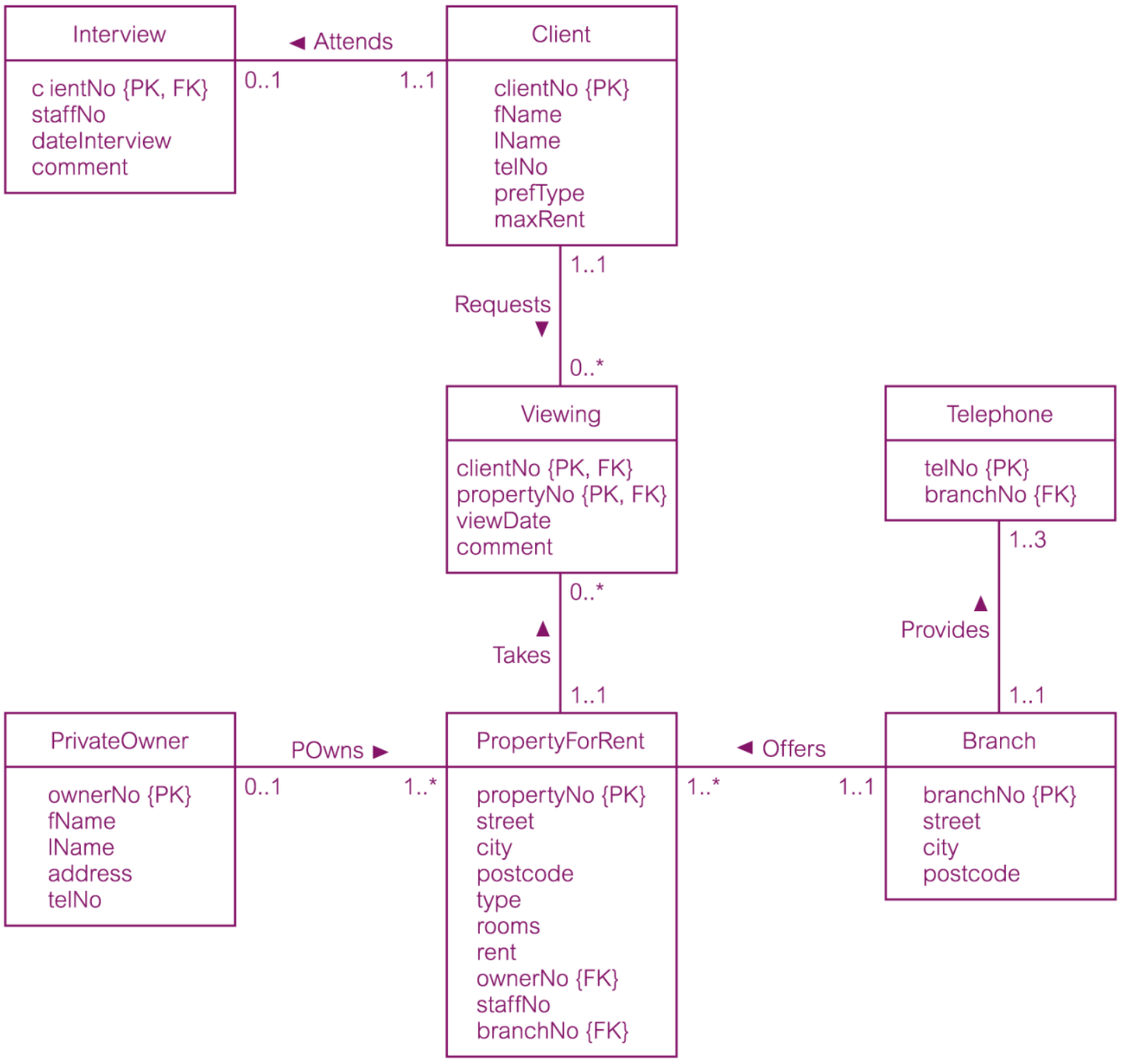
Step 7 Consider the Introduction of Controlled Redundancy

- Consider denormalisation in the following situations, specifically to speed up frequent or critical transactions:
  - Step 7.1 Combining 1:1 relationships
  - Step 7.2 Duplicating non-key attributes in 1:* relationships to reduce joins
  - Step 7.3 Duplicating foreign key attributes in 1:* relationships to reduce joins

Step 7 Consider the Introduction of Controlled Redundancy

- Step 7.4 Duplicating attributes in *:* relationships to reduce joins
- Step 7.5 Introducing repeating groups
- Step 7.6 Creating extract tables
- Step 7.7 Partitioning relations.

Sample Relation Diagram



Sample Relations

Branch

branchNo	street	city	postcode
B005	22 Deer Rd	London	SW1 4EH
B007	16 Argyll St	Aberdeen	AB2 3SU
B003	163 Main St	Glasgow	G11 9QX
B004	32 Manse Rd	Bristol	BS99 1NZ
B002	56 Clover Dr	London	NW10 6EU

Telephone

telNo	branchNo
0207-886-1212	B005
0207-886-1300	B005
0207-886-4100	B005
01224-67125	B007
0141-339-2178	B003
0141-339-4439	B003
0117-916-1170	B004
0208-963-1030	B002

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

Client

clientNo	fName	lName	telNo	prefType	maxRent
CR76	John	Kay	0207-774-5632	Flat	425
CR56	Aline	Stewart	0141-848-1825	Flat	350
CR74	Mike	Ritchie	01475-392178	House	750
CR62	Mary	Tregear	01224-196720	Flat	600

Interview

clientNo	staffNo	dateInterview	comment
CR56	SG37	11-Apr-00	current lease ends in June
CR62	SA9	7-Mar-00	needs property urgently

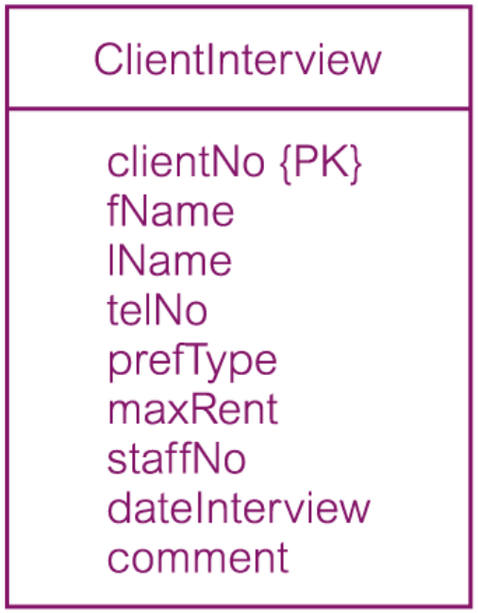
PrivateOwner

ownerNo	fName	lName	address	telNo
CO46	Joe	Keogh	2 Fergus Dr, Aberdeen AB2 7SX	01224-861212
CO87	Carol	Farrel	6 Achray St, Glasgow G32 9DX	0141-357-7419
CO40	Tina	Murphy	63 Well St, Glasgow G42	0141-943-1728
CO93	Tony	Shaw	12 Park Pl, Glasgow G4 0QR	0141-225-7025

Viewing

clientNo	propertyNo	viewDate	comment
CR56	PA14	24-May-01	too small
CR76	PG4	20-Apr-01	too remote
CR56	PG4	26-May-01	
CR62	PA14	14-May-01	
CR56	PG36	28-Apr-01	no dining room

Step 7.1 Combining 1:1 relationships



ClientInterview

clientNo	fName	lName	telNo	prefType	maxRent	staffNo	dateInterview	comment
CR76	John	Kay	0207-774-5632	Flat	425			
CR56	Aline	Stewart	0141-848-1825	Flat	350	SG37	11-Apr-03	current lease ends in June
CR74	Mike	Ritchie	01475-392178	House	750			
CR62	Mary	Tregear	01224-196720	Flat	600	SA9	7-Mar-03	needs property urgently

- Combinations should only be considered for relations that are frequently referenced together.

Step 7.2 Duplicating non-key attributes in 1:* relationships to reduce joins

PropertyForRent

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

- Consider the benefits that may result in duplicating 1 or more non-key attributes of the parent relation in the child relation in a 1:* relationship.
- The benefits that results from this change have to be balanced against the problems that may arise.

Step 7.2 Duplicating non-key attributes in 1:* relationships: Lookup Table

PropertyType

type	description
H	House
F	Flat

PropertyForRent

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

- Reduction in size of child relation.
- If description changes, modify the value once in lookup table.
- Use the lookup table to validate user input.

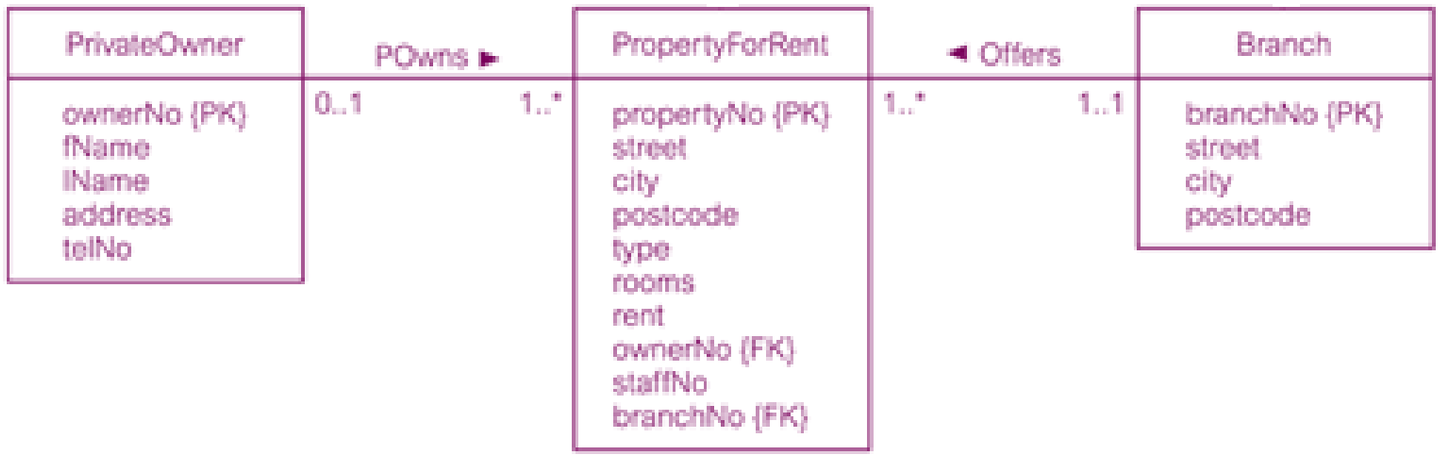
Step 7.2 Duplicating non-key attributes in 1:* relationships: Lookup Table

- If the lookup table is used in frequent or critical queries, and the description is unlikely to change, consideration should be given to duplicating the description attribute in the child relation.
- The original lookup table can still be used to validate user input.

PropertyForRent

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

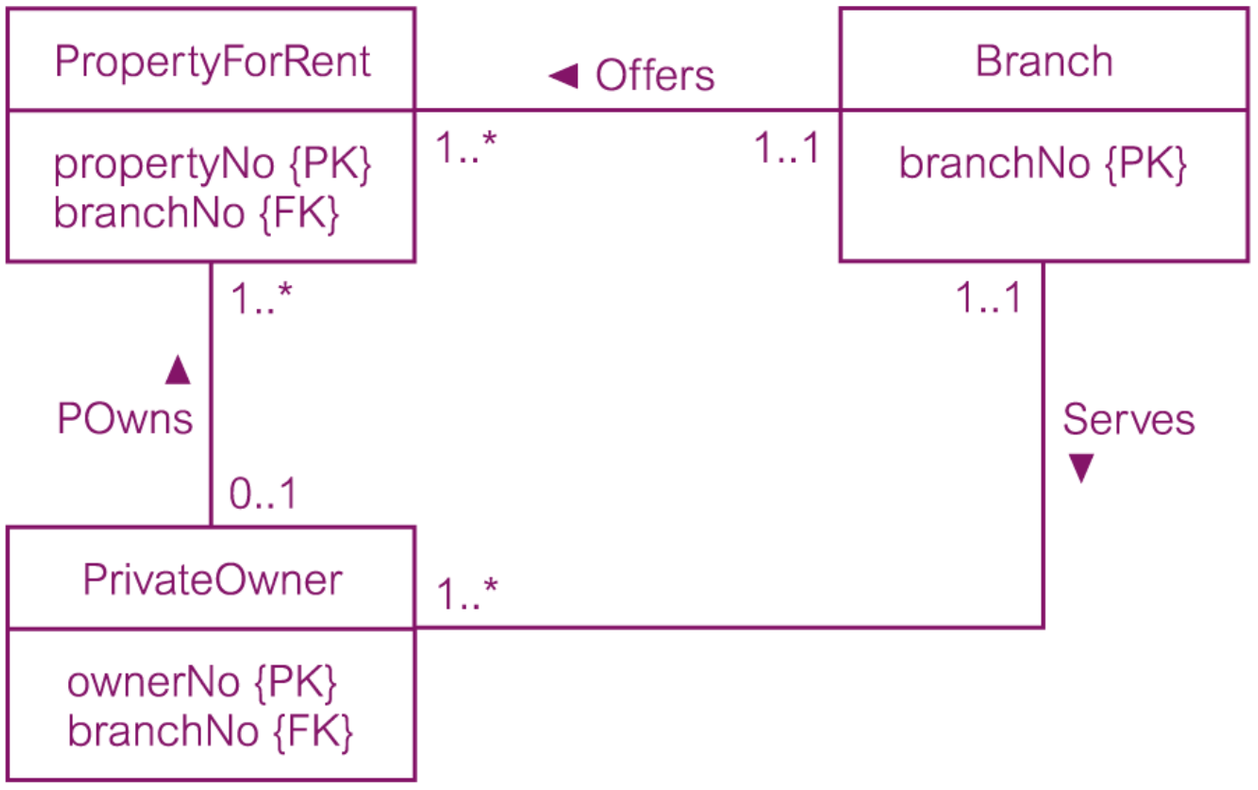
Step 7.3 Duplicating FK attributes in 1:* relationship to reduce joins



- As we have seen in the sample relation diagram, there is no direct relationship between Branch and PrivateOwner.

- For example, a frequent query may be to list all the private property owners at a branch. So this involves joining the PrivateOwner and PropertyForRent tables.

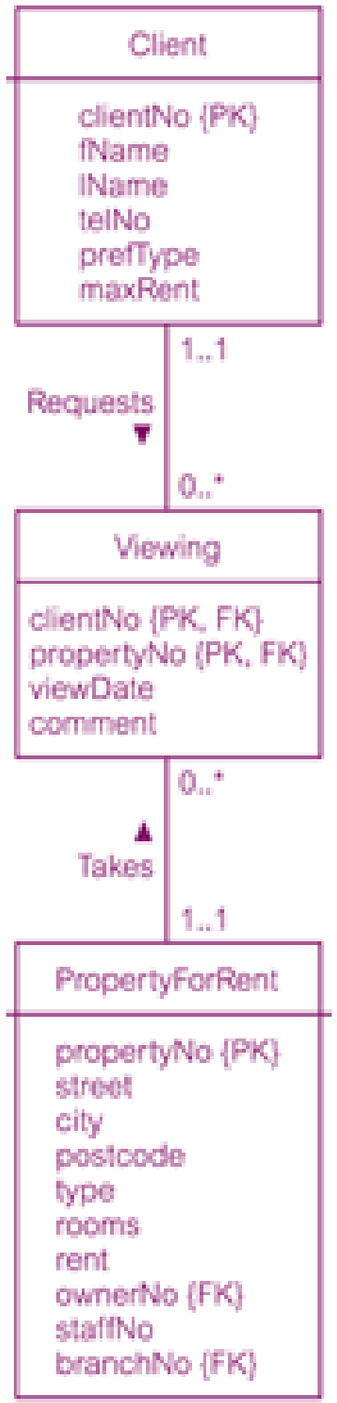
Step 7.3 Duplicating FK attributes in 1:* relationship to reduce joins



PrivateOwner

ownerNo	fName	lName	address	telNo	branchNo
CO46	Joe	Keogh	2 Fergus Dr, Aberdeen AB2 7SX	01224-861212	B007
CO87	Carol	Farrel	6 Achray St, Glasgow G32 9DX	0141-357-7419	B003
CO40	Tina	Murphy	63 Well St, Glasgow G42	0141-943-1728	B003
CO93	Tony	Shaw	12 Park Pl, Glasgow G4 0QR	0141-225-7025	B003

Step 7.4 Duplicating attributes in *:* relationships to reduce joins



- If we wish to produce information from the *:* relationship, we have to join the 3 relations.
- In some circumstances, it may be possible to reduce the number of relations to be joined by duplicating attributes from 1 of the original relations in the intermediate relation.

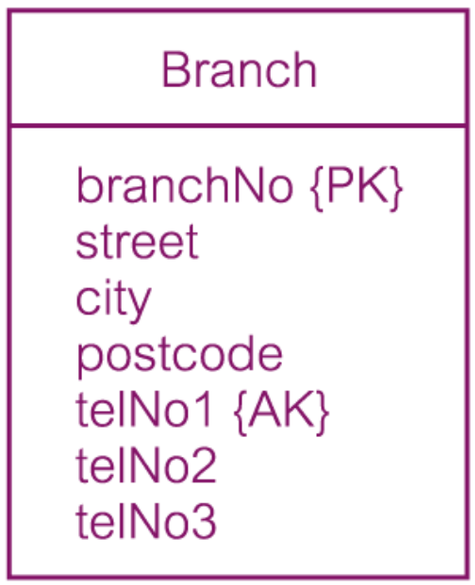
Step 7.4 Duplicating attributes in *:* relationships to reduce joins

Viewing

clientNo	propertyNo	street	viewDate	comment
CR56	PA14	16 Holhead	24-May-04	too small
CR76	PG4	6 Lawrence St	20-Apr-04	too remote
CR56	PG4	6 Lawrence St	26-May-04	
CR62	PA14	16 Holhead	14-May-04	no dining room
CR56	PG36	2 Manor Rd	28-Apr-04	

```
SELECT street, client.*, viewDate
FROM client
JOIN viewing
WHERE comment is null;
```

Step 7.5 Introducing repeating groups



Branch

branchNo	street	city	postcode	telNo1	telNo2	telNo3
B005	22 Deer Rd	London	SW1 4EH	0207-886-1212	0207-886-1300	0207-886-4100
B007	16 Argyll St	Aberdeen	AB2 3SU	01224-67125		
B003	163 Main St	Glasgow	G11 9QX	0141-339-2178	0141-339-4439	
B004	32 Manse Rd	Bristol	BS99 1NZ	0117-916-1170		
B002	56 Clover Dr	London	NW10 6EU	0208-963-1030		

Step 7.6 Creating extract tables

- Reports can access derived data and perform multi-relation joins on same set of base relations. However, data the report is based on may be relatively static or may not have to be current.

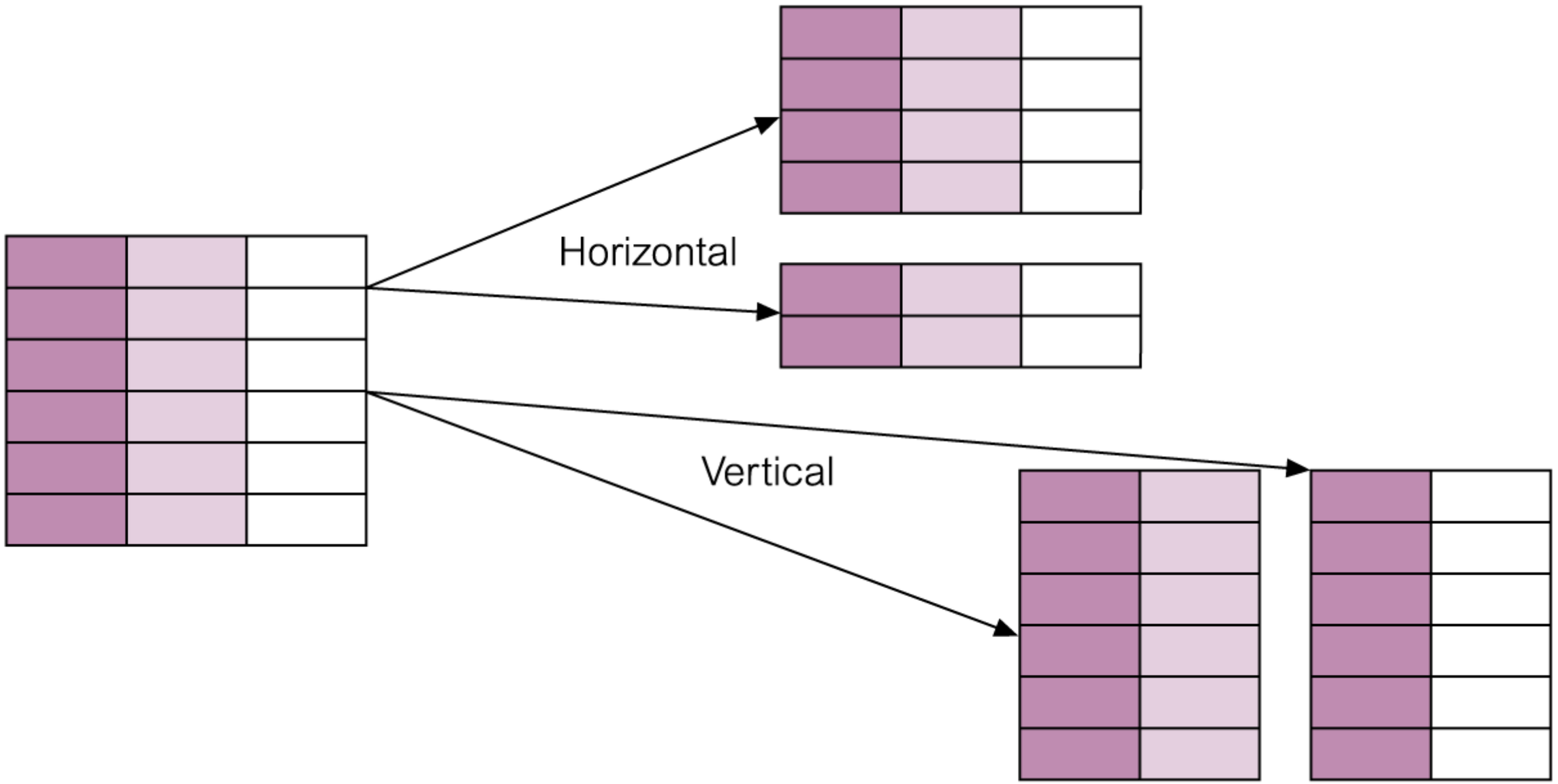
- Possible to create a single, highly denormalised extract table based on relations required by reports, and allow users to access extract table directly instead of base relations.

- The most common technique for producing extract tables is to create and populate the tables in an overnight batch run when the system is lightly loaded.

Step 7.7 Partitioning relations

- Rather than combining relations together, alternative approach is to decompose them into a number of smaller and more manageable *partitions*.
- Two main types of partitioning: horizontal and vertical.

Step 7.7 Partitioning relations



Advantages and disadvantages of denormalisation

- Advantages:
  - Can improve performance by:
    - precomputing derived data;
    - minimising the need for joins;
    - reducing the number of foreign keys in relations;
    - reducing the number of indexes;
    - reducing the number of relations.

Advantages and disadvantages of denormalisation

- Disadvantages:
  - May speed up retrieval but slow down updates.
  - Always application specific and needs to be re-evaluated if the application changes.
  - Can increase the size of relations.
  - May simplify implementation in some cases but may make it more complex in others.
  - Sacrifices flexibility.

Step 8 Monitor & Tune Operational System

Objective: To monitor operational system and improve performance of system to correct inappropriate design decisions or reflect changing requirements.

Step 8 Monitor & Tune Operational System

- Number of factors may be used to measure efficiency:
  - *Transaction throughput:* number of transactions processed in given time interval.
  - *Response time:* elapsed time for completion of a single transaction.
  - *Disk storage:* amount of disk space required to store database files.

- No one factor is always correct. Have to trade each off against another to achieve reasonable balance.

- Need to understand how the various hardware components interact and affect database performance.

Step 8 Monitor & Tune Operational System

- Many DBMSs provide the Database Administrator (DBA) with utilities to monitor and tune the operation of the system.

- Benefits of tuning include:
  - Tuning can avoid the procurement of additional hardware.
  - It may be possible to downsize the hardware configuration. This results in less and cheaper hardware and consequently less expensive maintenance.
  - A well-tuned system produces faster response times and better throughput.
  - Improved response times can improve staff morale.
  - Improved response times can increase customer satisfaction.