Past paper sample solution

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Note

- The sample solution here provides only "key" part of the solution, it may not be the full solution.

- Always write full sentences in exam.

Q1 a) Define the following terms: *data, database* and *database management systems* (DBMS).

Sample solution:

Data: facts and statistics collected together for reference or analysis

Database: a shared collection of logically related data (and a description of this data), designed to meet the information needs of an organization.

DBMS: A software system that enables users to define, create, maintain, and control access to the database.

Q1 b) Define the following terms in a Relational model and give an example of each: 1) *relation,* 2) *foreign key*.

Relation is a table with rows and columns in a relational model.

Foreign key is an attribute, or set of attributes, within one relation that matches candidate(primary) key of another relation.

Q1 c) Sample solution:

i) Produce a relation of all the information for all books.

$$\Pi_{\text{ISBN, title, edition, year}}(\text{Book})$$

Or **Book**

ii) List the titles of all the books published in the year 2017.

$$\Pi_{\text{title}}(\sigma_{\text{year='2017'}}(\text{Book}))$$

iii) List the copy numbers of the book "Lord of the Rings" that are available for borrowing.

$$\Pi_{\text{copyNo}}(\sigma_{\text{available='Y' } \wedge \text{ title='Lord of the Rings'}}(\text{Book} \bowtie \text{BookCopy}))$$

Q1 c) Sample solution:

iv) Give the borrowerNo of borrowers who have borrowed all the books that borrower 123 borrowed between 2nd Feb 2017 and 4th May 2017. (Note: only consider dateOut, no need to consider due date.)

$A = \Pi_{ISBN}(\sigma_{borrowerNo = '123' \wedge dateOut <= '2017-05-04' \wedge dateOut >= '2017-02-02'}$ (BookCopy $\bowtie$ BookLoan))

$B = \Pi_{ISBN, borrowerNo}$ (BookCopy $\bowtie$ BookLoan)

$B \div A$

Q1 d) i)Table 1 below lists sample dentist/patient appointment data. A patient is given an appointment at a specific time and date with a dentist located at particular surgery. The table is susceptible to various anomalies. Provide examples of *deletion* and *modification* anomalies.

Sample solution:

An example of a deletion anomaly is if we delete the details of the dentist called 'Helen Park', we also lose the appointment details of the patient called 'Tom Ford'.

An example of a modification anomaly is if we need to update a patient's name, e.g. patient P105's name, we need to update all tuples involving P105, otherwise P105 may have inconsistent name.

Q1 d)

ii) Relation R(A, B, C, D, E, F, G, H) has functional dependencies of

fd1: A → BCGH, fd2: D → E, fd3: AF → D and fd4: G → H.

Which normal form is relation R in? Describe and illustrate the process of normalization by converting R to Third Normal Form (3NF) relations. (Note: primary keys must be identified for each step.)

Relation R is in 1NF.

The process of normalization from R to 3NF is:

Step 1, identify functional dependencies and primary keys of relation R

Step 2, from 1NF to 2NF, eliminate partial dependencies on primary keys

Step 3, from 2NF to 3NF, eliminate transitive dependencies on primary keys

Primary keys of R is AF.

From 1NF to 2NF, fd1 is partial depencency on primary key, so take the attributes of fd1 out of R and form the following relations:

R1(A, B, C, G, H) primary key: A

R2(A, F, D, E)Primary key: AF

From 2NF to 3NF, fd2, fd4 is transitive dependency on primary key, so take the attributes of fd2 out of R2, attributes of fd4 out of R1, and form the following relations:

R3(A, B, C, G), R4(G, H), R5(A, F, D), R6(D, E)

Q2 a) Briefly explain the four steps to design/implement a relational database.
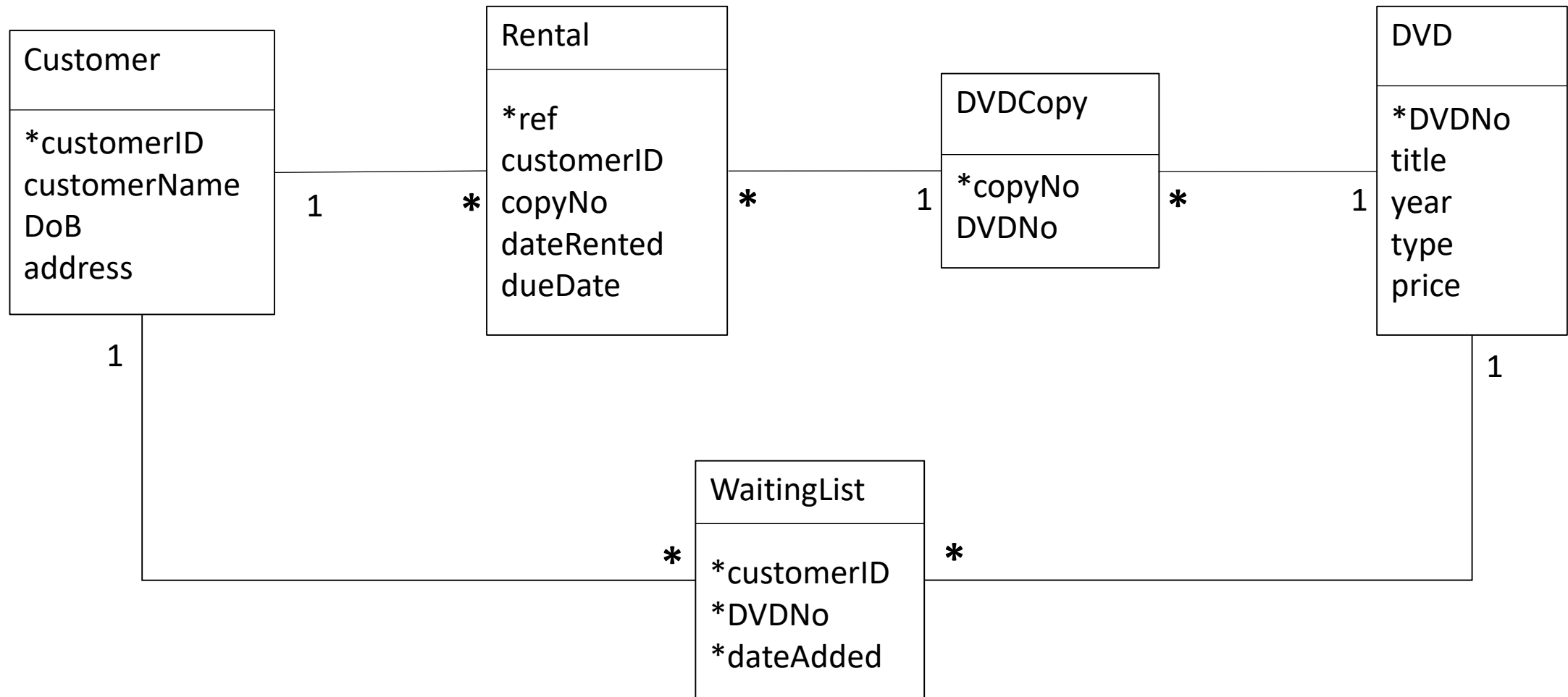
Sample solution:

(Lecture notes 2.4 Database Design Methodology Main phases)

1. Gather requirements
2. Conceptual database design
3. Logical database design
4. Physical database design

Q2 b) Draw an ER diagram for the online DVD rental database. State any assumptions you make about the data if any. Your ER diagram must include details of the entities, attributes and relationships.

Sample solution:

Customer

*customerID
customerName
DoB
address

Rental

*ref
customerID
copyNo
dateRented
dueDate

DVDCopy

*copyNo
DVDNo

DVD

*DVDNo
title
year
type
price

WaitingList

*customerID
*DVDNo
*dateAdded

Customer 1 — * Rental
Rental * — 1 DVDCopy
DVDCopy * — 1 DVD
Customer 1 — * WaitingList
DVD 1 — * WaitingList

Q3 a) Mark "True" or "False" for each of the following statements on **database transaction management**:

- The ACID properties of transaction are *Atomicity, Consistency, Isolation* and *Sequentiality*.

- [False]

- *Concurrency* does not cause problems in ensuring ACID properties.

- [False]

- *Dirty read* occurs when transaction reads several values but the second transaction updates some of them during execution of the first one.

- [True]

- Two basic concurrency control techniques are *locking* and *rolling back*.

- [False]

Q3 b) i) What is the name of the problem that updating like this would cause? Explain it.

Sample solution:

This is Uncommitted Dependency Problem in concurrency.

The Uncommitted Dependency Problem occurs when one transaction can see intermediate results of another transaction before it has committed.

Q3 b) ii) Name a solution to this problem, and rewrite the transactions A and B in Figure 1 using your named solution.

Sample solution:

Two phase locking can be used to solve this problem

Time	A	B
t_1	begin_transaction	
t_2	Write_lock(account)	
t_3	read(account)	
t_4	account = account+100	begin_transaction
t_5	write(account)	Write_lock(account)
t_6	…	WAIT
t_7	Rollback/Unlock(account)	WAIT
t_8		read(account)
t_9		account = account-10
t_{10}		write(account)
t_{11}		Commit/Unlock(account)

Q3 b) iii) What is a deadlock?

Sample solution:

A deadlock is when two (or more) transactions are each waiting for locks held by the other to be released.

Q3 b) iv) Name and explain two techniques that can be used to solve deadlock problems.

- Timeouts and Deadlock prevention.

- Timeout: locks only last a system-defined period of time: the lock will be eliminated after such period.

- Deadlock prevention: the DBMS looks ahead to see if a transaction would cause a deadlock and never allows a deadlock to occur.

Q3 c) Describe and illustrate the elements of a *three-tier client/server architecture*.

Sample solution:

Three-tier includes:

The user interface layer, which runs on the end-user's computer (the client).

The business logic and data processing layer. This middle tier runs on a server and is often called the application server.

A DBMS, which stores the data required by the middle tier. This tier may run on a separate server called the database server.

(diagram – see lecture notes)

Q4 a) i) What does the acronyms *OLTP* and *OLAP* stand for?

Sample solution:

OLTP: Online Transaction processing

OLAP: Online Analytical processing

Q4 a) ii) What is a *data warehouse*?

Data warehouse is a subject-oriented, integrated, time-variant, and non-volatile collection of data in support of management's decision-making process.

Q4 a) iii) Discuss the difference of OLTP systems and Data Warehousing systems in terms of their *main purposes, data age* and *target users*.

Sample solution:

Main Purpose of OLTP Systems is to supports operational processing, for DW systems is to supports analytical processing.

Data age: OLTP system the data is current, DW system the data include historic and current data.

Target Users of OLTP are large number of operational users, target users of DW system are managerial users, and may also serve operational users for analytical requirements.

Q4 b) What is XML? Discuss the difference between XML and the relational model in terms of *structure, schema, queries, ordering* and *implementation*.

Sample solution:

See lecture notes on XML.