THE BRITISH COMPUTER SOCIETY

THE BCS PROFESSIONAL EXAMINATION
Diploma

DATABASE SYSTEMS

23rd April 2004, 2.30 p.m.-4.30 p.m.
Answer FOUR questions out of SIX. All questions carry equal marks.
Time: TWO hours.

*The marks given in brackets are **indicative** of the weight given to each part of the question.*

1. *a)* Using your own simple examples, describe and explain the main features and limitations of the file-based approach to data storage in software development.   **(10 marks)**

    b) Using examples to illustrate your answer, describe and explain the main features and benefits of the database approach to data storage in software development.   **(10 marks)**

    c) Draw a single diagram that illustrates how the following concepts are related:
    - Data
    - Database
    - Database Management System (DBMS)
    - Application Logic/Query
    - Results
    - User Interface   **(5 marks)**

2. Using <u>your own SQL code examples</u>, discuss and explain all the relevant concepts that must be addressed by a database developer when implementing the following Data Definition Language (DDL) constructs:

    a) Table creation   **(10 marks)**
    b) Index creation   **(10 marks)**
    c) View creation   **(5 marks)**

3. *a)* List all the Relational Algebra (RA) operators. (Simply itemize the operators - do not describe them or give examples).   **(4 marks)**

    b) For each of the above Relational Algebra (RA) operations, <u>using your own simple examples</u>, describe and explain how the operation works with the relations found in relational theory (include appropriate diagrams to enhance your answer).   **(21 marks)**

4.   **Please refer to Appendix A for Part *a)* and *b)* in this question.**

a)   Explain how a DBMS transaction manager maintains database integrity in a multi-user environment, for example where update requests are received by a centralised DBMS at the same time.   **(12 marks)**

b)   **Refer to Table A1.** Within the context of the application, describe the range of decisions that need to be made if a situation arose whereby a particular action in a Leg failed to commit or was cancelled.

c)   Produce example transaction schedules that show how you would re-organise the transaction schedule in order to recover from a failed or cancelled transaction.   **(13 marks)**

5.   **Refer to Appendix A in this question.**

The haulage company is investigating the possibility of tracking the location of their vehicles whilst Jobs are being undertaken. The company has heard that technologies such as satellite navigation can generate accurate location information (such as latitude and longitude) if tracking equipment is installed on tractors/vehicles. The identity of each tracked vehicle and the location information could be collected and relayed to a central server located at HQ and stored on a traffic database. Transport Operators (TOs) can view this information on client computers allowing them to monitor and interact with the traffic database.

Produce a design for a user interface supporting the information system outlined above. Your design is restricted to the client-side user interface supporting a TO view of the information system.

The following should accompany your answer:
     The design decisions and any assumptions you make. Draft screen shots showing examples of the way that a TO would interact with the information system. The data sources such as tables and views that you would need to support the presentation of information to a TO.   **(25 marks)**

6.   **Refer to Appendix A for Part *b)* in this question.**

a)   Explain the differences between:
       i)   an object id in an Object data model and a Primary Key in a Relational data model.
       ii) a Class in an Object data model and an Entity Type in an Entity Relationship data model.   **(8 marks)**

b)   *i)*   Produce an ER model that models the relationships that exist between the following Entity Types:

             Jobs; Transport Operators; Containers; Products; Legs; Tractors; Trailers; Vehicle Units and Locations.

       ii) Include the relationship degrees and participation constraints in your model. Assign attributes to the Entity and Relationship Types and identify which of these attributes are primary keys.

       iii) State any assumptions that you make and the notation you have used to model the relationship degrees and participation constraints.   **(17 marks)**

Appendix A: Transport Planning System (FOR USE WITH QUESTION 4, 5 AND 6)

1. **INTRODUCTION**
    A haulage company specialises in transporting hazardous chemical products from one location to another over the UK road network. Products are transported in sealed containers owned by the company's customers. The process of transporting a product is called a 'Job'. A Job is created once an order for transport work has been confirmed with a customer.

    The company operates from two sites, the company HQ at Hull and a depot at Felixstowe. About 50 Jobs are undertaken each day and these are handled by a computer system running at company HQ.

2. **INFORMATION SOURCES FOR A JOB**
    Two information sources are needed to support the processing of a Job:
    1. Customer generated:
    *   product details including any handling instructions and the load weight.
    *   Product collection and delivery times.
    2. Company generated, a record of the logistical decisions that meet the customer's requirements, namely:
    *   the allocation of resources to a Job and where these are located .
    *   the timing or staging of a Job so that resources are allocated efficiently.
    A Leg represents a stage of a Job, allowing actions within a Job to be scheduled. Each Leg is assigned an action (such as load a product) undertaken at a particular location. Therefore on completion of a Leg the status of a Job at various times and locations can be recorded allowing the progress of a Job to be monitored. Table A1 on the next page, shows an example of Legs that were undertaken for two completed Jobs, including a Leg that was not originally scheduled (LegID 1061 for example).

3. **USERS**
    Planning and control of a Job requires the support of a Traffic operator (TO). A TO is responsible for allocating resources to each Job under their control. They will plan the route and decide what Legs are needed, producing a schedule of Legs for each Job. A TO tries to ensure a Job is started on time and when it is underway will continue to monitor Jobs over various Legs. A schedule of Legs may need to be changed once a Job has started due to events outside the company's control (for example delays due to traffic conditions, late running ferries, cancellations due to weather conditions etc).

4. **RESOURCES**
    A Job requires the following resources:
        A driver (who is employed by the company and works from a depot)
        A tractor (also known as a cab – this is the drive unit)
        A trailer (this is used to attach a container)
        Equipment (this is used to support an action such as heating/loading/unloading a product)

5. **INFORMATION PROCESSING**
    A Use Case Scenario describes how two Jobs were scheduled in such a way that certain vehicle units could be shared. **Please also refer to Tables 1-4 on the next page which show sample data indicative of those that are needed to support the processing of Jobs.**

    5.1 Use Case Scenario
    Job1: *Customer 'FR24' requires Product 'Glycol Hydrate' to be collected from 'ICI Plant No3' any Time after 14:00. It is to be delivered to 'Halton' by 17:00 on the same day.*

    Job2: *Customer 'AB22' requires Product 'Benzyl Acetate' to be collected from 'Bentley' after 14:30 and it is to be delivered to 'Harwich' for loading onto a ship that departs at 21:00.*
    The TO notices it is possible to share resources required for these two Jobs as the collection/delivery times and locations roughly coincide. Therefore Job2 could be scheduled to follow Job1 and the same trailer and container could be used to transport the different products for each Job. But this would mean bringing forward the collection time of the product required for Job1. The delivery time for Job2 cannot be changed because the product must be delivered in time for a ship sailing at 21:00. Following some negotiation, the manufacturer of product *'Benzyl Acetate'* has agreed to make the product available an hour earlier than planned, but it will NOT be heated. Customer 'FR24' had asked the manufacturer to heat the product prior to loading so that it will be easier to use in a production process. The company can hire heating equipment so that the product can be heated whilst in transit. Therefore Job1 can go ahead with an earlier collection time. The schedule is planned and implemented as shown in Table A1 overleaf.

Table A1: TBL_LEGS (for 2 completed Jobs)

LegID	Job No	Unit Number	Location ID	Action	Status	Time
1000	1	U1	Hull	Start Job	Succeeded	09:00
1010	1	U1	Immingham_Dock	Attach Unit	Succeeded but Delayed	10:00
1020	1	U4	Goole	Attach Equipment (Heater)	Succeeded	10:40
1030	1	U4	ICI Plant No3	Load Product	Succeeded	12:45
1040	1	U4	Leeds	Heat Product	Succeeded	14:00
1050	1	U4	Halton	Unload Product	Succeeded	14:35
1060	1	U4	Immingham	Detach Equipment (Heater)	Succeeded	15:10
1061	1	U4	Immingham	Clean Container	Unscheduled-Succeeded	15:10
1070	1	U1	Immingham	Detach Unit	Succeeded	15:15
1080	1	U1	Hull	Finish Job	Succeeded	17:00
1090	2	U3	Felixstowe	Start Job	Succeeded	10:30
1100	2	U3	MQ Services	Driver Status report	Delayed	12:30
1110	2	U3	Immingham	Attach Unit	Succeeded	15:20
1120	2	U9	Goole	Attach Equipment (Hose)	Succeeded	15:50
1130	2	U9	Bentley	Load Product	Succeeded	16:30
1140	2	U9	MQ Services	Driver Status report	On Time	18:30
1150	2	U9	Felixstowe	Detach Equipment (Hose)	Succeeded	20:30
1160	2	U9	Harwich	Detach Container	Succeeded	21:00
1170	2	U8	Felixstowe	Detach Trailer	Succeeded	21:30
1180	2	U3	Felixstowe	Finish Job	Succeeded	21:30

Table A2: TBL_LOCATIONS (example of locations)

Location ID	Address	Post Code	LocationType
Felixstowe	Kedron Industrial Estate	FX 1 6HY	Depot
Harwich	Channel Ferries, Terminal 5	FX2 4GB	Port
Hull	Dacourt Yard, Hessle	HU3 4FB	HQ
Immingham_Dock	The Docks Immingham	IM2 9OP	Port
Immingham	Washbay Services, Immingham	IM2 6KL	Container cleaning plant
Bentley	Marshalls, Doncaster	S45 3NS	Chemical Plant
Halton	Guys Chemicals, Leeds	LS9 9KD	Chemical Plant
ICI Plant No3	Wilton Works , Middlesbro	TS19 9HN	Chemical Plant
Goole	Stig Johnsen Garages, Goole	DR5 6AS	Equipment Hire and Fitting
MQ Services	Murray&Quentin Services, Rugby	CV11 8HT	Motor Café & Services

Table A3: TBL_UNITS (Vehicle Units used during a Job)

Tractor Number	Tractor Name	Trailer Number	Unit Number	Container Number	Maximum Load (tonnes)
a685 jku	Scania 678		U1		
a685 jku	Scania 678	m-jfr-353	U2		35
rwf 781k	Scania 678		U3		
a685 jku	Scania 678	m-jfr-353	U4	1078-056	35
wbt 275m	Foden 768		U5		
wbt 275m	Foden 768	h-ugr-93	U6	1286-8	40
wbt 275m	Foden 768	h-ugr-93	U7		40
rwf 781k	Scania 678	m-jfr-353	U8		35
rwf 781k	Scania 678	m-jfr-353	U9	1078-056	35

Table A4: TBL_ORDERS (Customer Orders)

Order Number	Order Date	Customer Number	Product Name	Job No	Load Weight	Collect Date:Time	Collect From	Delivery Date:time	Deliver To
P-001	10-may-2003	FR24	Benzyl Acetate	1	20	11-05-2003 14:00	ICI Plant No 3	11-05-2003 16:00	Halton
P-002	10-may-2003	AB22	Glycol Hydrate	2	32	11-05-2003 16:00	Bentley	11-05-2003 21:00	Harwich