**Q1.**

Employees at a bank use client computers to access data that is stored on a database server.

The database server uses software to query and modify data stored in a database on hard disk drives. It returns the results of these queries to the clients over the bank’s computer network.

The performance of the system is unsatisfactory: the time-delay between a client sending a query to the server and the client receiving the results is unacceptably long.

Explain how the performance of the system might be improved. You should consider the following factors that might be affecting the performance:

•   the hardware of the server

•   the design of the computer network

•   the database and software running on the server.

In your answer you will be assessed on your ability to follow a line of reasoning to produce a coherent, relevant and structured response.

**(Total 12 marks)**

**Q2.**

One characteristic of a data set that might result in it being classified as Big Data is that it contains a variety of different forms of information.

Describe **two other** characteristics that might result in a data set being classified as Big Data.

**Characteristic 1:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Characteristic 2:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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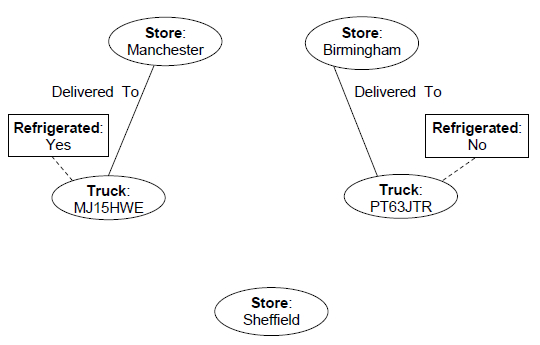
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**(Total 2 marks)**

**Q3.**

In a fact-based model, data is represented as atomic facts, which are immutable (ie will never change). Fact-based models can be represented visually using a graph schema.

The figure below shows part of a graph schema for a data set about deliveries made to stores by trucks.



Complete the graph schema in the figure above to represent the following additional facts.

•   Truck MJ15HWE has made a delivery to the Sheffield store.

•   Truck PT63JTR was last serviced on 10 May 2018 and truck MJ15HWE was last serviced on 18 March 2018.

•   Both of the trucks are owned by a haulage company called Ferguson’s which has 15 employees and has a head office in Bolton.

**(Total 3 marks)**

**Q4.**

The United Kingdom’s National Health Service was created to provide health care to the nation through:

•        hospitals

•        health centres/GPs’ (doctors’) surgeries

•        pharmacies (chemists).

The UK government is proposing to computerise and network the entire National Health Service (NHS) so that it will be possible to have on-line *access to the system at a level of security relevant to their status* for anyone who

•        works for the NHS

•        uses its services

•        works at a branch of government responsible for the NHS.

Patient records will be stored in multi-user distributed relational databases managed by *Database Management* *Systems* (DBMS).

•        Every person in the UK is assigned a unique numeric key, *the patient reference number*, and is assigned for primary health care to a doctor in a health centre or a GPs (General Practitioner’s or doctor’s) surgery located in a single building.

•        A person’s doctor may, if necessary, arrange for the person to see a specialist doctor in a hospital.

•        Drugs prescribed for a person by the person’s GP for the treatment of an illness are obtained from a pharmacy.

•        Every computer in the service of the NHS will be interconnected in *local area networks* (LANS) and the *local area networks* will be interconnected by a *wide area network* (WAN).

Which network type is most appropriate, WAN or LAN, **within** a health centre or GPs (doctor’s) surgery? Justify your choice.

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**(Total 2 marks)**

**Q5.**

A government agency is responsible for storing information about vehicles and their owners. Each vehicle that is driven must be registered with this agency. Vehicles must be insured to be driven, so the agency also keeps a record of vehicle insurance policies.

Details of the vehicles, owners and insurance policies are stored in a relational database using the following three relations:

Vehicle(RegistrationNumber, OwnerID, Manufacturer,  
Model, Colour, EngineSize, DateRegistered)

Owner(OwnerID, Title, Forename, Surname, HouseNumber, Street, Town, Postcode)

Insurance(PolicyNumber, RegistrationNumber, DateStarted, PolicyType, ExcessAmount)

In this system, the following restrictions apply to some attributes:

•        RegistrationNumber: a mixture of exactly 7 letters and numbers, eg MA11FXB

•        EngineSize: a whole number value representing the capacity of the engine, eg 1597

•        PolicyType: can be either ‘Comprehensive’ or ‘Third Party’ and nothing else

•        ExcessAmount: a monetary value, eg 100

(a)     Complete the following Data Definition Language (DDL) statement to create the Insurance table, including the key field.

CREATE TABLE Insurance (

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**(3)**

(b)     The owner of the vehicle with registration number DF24JUT has had his car repainted so that its colour is now pink.

Complete this SQL statement to update the data in the Vehicle table to reflect this change.

UPDATE\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

SET \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

WHERE \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)     A police officer is following a car with registration number AB72XHC. She wants to use the computerised system to check some details about the car and its owner.

Write an SQL query that could be used to retrieve the Model and Colour of the car and the Forename and Surname of the car’s owner.

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**(4)**

(d)     The police officer requests the information using a hand held terminal that connects to the Internet. She types the vehicle registration number into a form on a secure webpage and the details about the car and owner are then displayed in the web browser on the terminal.

A server-side script is used to search for the required information.

(i)      Explain what a server-side script is.

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**(2)**

(ii)     The server-side script includes the statement:

RegNo = Request("RegistrationNumber")

Explain what this statement does when executed.

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**(2)**

(iii)    The server-side script includes the statement:

Response.Write("Owner is " + Forename + " " + Surname)

Explain what this statement does when executed.

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**(2)**

|  |
| --- |
| The definitions of the three relations in the database are repeated here.  Vehicle(RegistrationNumber, OwnerID, Manufacturer, Model, Colour, EngineSize, DateRegistered)  Owner(OwnerID, Title, Forename, Surname, HouseNumber, Street, Town, Postcode)  Insurance(PolicyNumber, RegistrationNumber, DateStarted, PolicyType, ExcessAmount) |

(e)     The database is to be extended to store information about vehicle safety certificates. Each year, a vehicle must be taken to a garage where it will be tested. If the vehicle passes the test, a certificate will be issued. Each certificate will have a unique Certificate Number. Certificates will last for 12 months so the date that a certificate is issued must be recorded, as must the name of the garage that issued the certificate.

The database must keep a record of all the certificates that have been issued for each vehicle. For a particular vehicle this will include the current certificate together with any certificates that have been issued in the past.

Explain how you would change the design of the database so that the information about safety certificates can be stored.

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**(3)**

**(Total 18 marks)**

Mark schemes

**Q1.**

**All marks AO1 (understanding)**

|  |  |  |
| --- | --- | --- |
| **Level** | **Description** | **Mark Range** |
| 4 | A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. The response covers all three areas indicated in the guidance below and in at least two of these areas there is sufficient detail to show that the student has a good level of understanding. To reach the top of this mark range, a good level of understanding must be shown of all three areas. | 10-12 |
| 3 | A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response which shows a good level of understanding of at least two areas indicated in the guidance below. | 7-9 |
| 2 | A limited attempt has been made to follow a line of reasoning and the response has a mostly logical structure. At least four points have been made. Either a good level of understanding of one area from the guidance has been shown or a limited understanding of two areas. | 4-6 |
| 1 | A few relevant points have been made but there is no evidence that a line of reasoning has been followed. The points may only relate to one or two of the areas from the guidance or may be made in a superficial way with little substantiation. | 1-3 |

**Guidance – Indicative Response**

**For each guidance point, if the student expands on the point to explain in what way the measure will improve performance then this can be considered to be a second point.** For example:

•   “Using a processor with more cores” is one point.

•   “Using a processor with more cores which will be able to execute multiple instructions simultaneously” is two points.

Note that just “faster” is not enough to count as an expansion point without an explanation of why.

**1. Server Hardware**

Replace the processor with one which has more cores

Replace the processor with one which has more cache memory // increase the amount of cache memory

Replace the processor with one which runs at a faster clock speed **NE.** faster processor

Use a parallel processor architecture // use more processors which can work in parallel

Use a processor with a bigger word size

Use a processor that makes (better) use of pipelining

Install more RAM // main memory // primary memory

Use RAM // main memory // primary memory with a faster access time

Replace HDDs with SSDs // Replace HDDS with HDDs that can read data at a faster rate

Defragment the HDD

Replace the motherboard with one which has buses which run at a faster clock speed

Replace the motherboard with one which has more lines in the data bus

Use the Harvard architecture

Distribute the processing across multiple servers

**2. Network**

Replace the network cable with cable that has a higher bandwidth // replace copper cable with fibre-optic cable **A.** Ethernet cable for fibre-optic NE. higher bandwidth network

Replace any wireless / WiFi connections with wired ones

Replace the network cards with ones that can transmit data at a higher bitrate

Consider the overall network design eg how the network is divided into subnets **A.** split the network into subnets

Use a star topology (instead of a bus)

Consider using a more efficient protocol for the data across the network

Add additional wireless access points

**3. Database and Software**

Use a more efficient technique for controlling concurrent access to the database // replace record/table locks with serialisation/timestamp ordering/commitment ordering

Replace the database software with software that uses more efficient algorithms for tasks **A.** examples eg replace linear search with binary search

Use the index feature of the database to speed up searching on fields that are commonly used for this purpose

Rewrite the database software in a language that is suitable for concurrent execution // use a functional programming language for the database software

Ensure the software is compiled rather than executed by an interpreter // rewrite the software in assembly language/machine code

Review the conceptual model of the database to see if it contains any inefficiencies such as data redundancy that could be eliminated **A**. normalise the database design

Consider if it would be appropriate to sacrifice normalisation of the conceptual model to improve performance

Use a non-relational database system **A.** examples eg NoSQL

Distribute the data across multiple servers

Try to reduce the amount of other (unrelated) software that might be running on the database server at the same time

Try to reduce the number of database accesses that need to be made simultaneously // run some tasks at quiet times / overnight

Purge / archive data that is no longer necessary / in use

**[12]**

**Q2.**

**All marks AO1 (knowledge)**

There is a lot / high volume of data (to process) // data will not fit on one server;

**NE.** “volume” on its own.

The data is generated / received / must be processed at high velocity / very quickly;

**NE.** “velocity” on its own.

**NE.** high velocity of data

**NE.** speed data sent at

**A.** changed, modified or similar instead of “processed”

**[2]**

**Q3.**

**All marks AO2 (apply)**

**1 mark** for representing “Truck MJ15HWE has made a delivery to the Sheffield store” with a solid line joining the truck and the store labelled “Delivered\_To”.

**A.** alternative labels which clearly have the same meaning eg “Delivery”

**A.** use of directed arrow

**1 mark** for representing “Truck PT63JTR was last serviced on 10/05/2018 and truck MJ15HWE was last serviced on 18/03/2018” by drawing rectangular boxes containing the data, connected to the trucks with dashed lines.

**1 mark** for representing “Both of the trucks are owned by a haulage company called "Ferguson’s" which has 15 employees and has a head office in Bolton” by adding an oval for the haulage company with rectangles connected to it by dashed lines indicating the Head Office and Number of Employees, and joining the oval to the trucks using solid lines with appropriate labels such as “owns”.

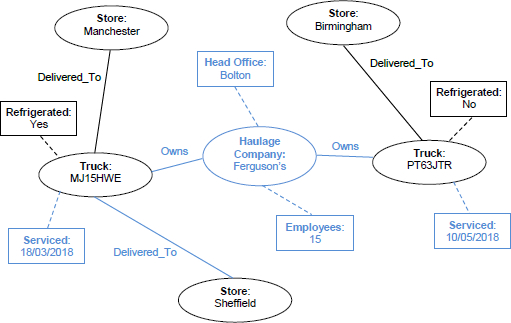
**A.** alternative labels which clearly have the same meaning eg “Belongs To”

**A.** oval only references “Company” not “Haulage” (and possibly but not necessarily additional property added to indicate the type of the company is haulage).

**A.** instead of Head Office Bolton being drawn as a rectangle and joined with a dotted line it can be drawn as an oval and joined with a solid line.

**A.** use of directed arrows

An example fully correct diagram is shown below:



**Max 2 if diagram contains any errors or incorrect additions**

**[3]**

**Q4.**

LAN;

Justification:

Computers in health centre are in close proximity to each

other/geographically close/in same building/on same site;

**R** Computers within health centre on its own

**[2]**

**Q5.**

(a)     *Declaring PolicyNumber as primary key:*

PolicyNumber INT PRIMARY KEY(NOT NULL)

|  |  |
| --- | --- |
| / / PolicyNumber INT PRIMARY KEY(PolicyNumber) |  |

*Declaring RegistrationNumber as foreign key:*

RegistrationNumber CHAR(7) FOREIGN KEY REFERENCES Vehicle(RegistrationNumber)  
/ /  
RegistrationNumber CHAR(7)  
FOREIGN KEY (RegistrationNumber) REFERENCES Vehicle(RegistrationNumber)

*Declaring three other fields:*

DateStarted DATE  
PolicyType VARCHAR(13)  
ExcessAmount SMALLMONEY

**1 mark** for PolicyNumber with sensible type and length (if required), and identified as primary key. Type can be either numeric or text.

**1 mark** for two other fields from RegistrationNumber, DateStarted, PolicyType, ExcessAmount with sensible data types and lengths (if required by the type) *OR* **2 marks** for all four other fields with sensible data types and lengths (if required by the type)

•        Length of RegistrationNumber, if specified, must be 7.

•        Length of PolicyType, if specified, must be at least 13.

**1 mark** for identifying RegistrationNumber as a foreign key.

**MAX 3**

**Valid alternative SQL types are:**

•        Alternative types For *PolicyNumber*: smallint, mediumint, integer, any text field type (see below)

•        Alternative types For *DateStarted*: smalldatetime, datetime, datetime2, datetimeoffset

•        Alternative types For *PolicyType*: ENUM('Comprehensive', 'Third Party') - accept any type of quotation marks around values - accept data values in any order - accept if ENUM defined as a type separately first

•        Alternative types for *ExcessAmount*: money, currency, float, real, decimal, double, numeric, int, smallint, mediumint, integer

•        Alternative types for *text fields*: char, varchar, nchar, nvarchar, text, ntext, longvarchar, varchar2, nvarchar2, text, tinytext, mediumtext, longtext

**Sensible non-SQL data types can also be credited but MAX 2 if any non-SQL types used.**

**3**

(b)     UPDATE Vehicle  
SET Colour = "pink"  
WHERE RegistrationNumber = "DF24JUT"

**1 mark** per correct line

**A** double or single quotes around pink and DF24JUT

**A** table names before fieldnames

**A** pink written in any case

**DPT** no quotes

**DPT** for fieldname before table name

**DPT** for unnecessary punctuation – allow one semicolon at the very end of the statement, but not at the end of each clause

**MAX 2**

**2**

(c)     SELECT Model, Colour, Forename, Surname   
FROM Owner, Vehicle  
WHERE RegistrationNumber = "AB72XHC"  
AND Owner.OwnerID = Vehicle.OwnerID

**1 mark** for correct four fields in SELECT clause

**1 mark** for correct two tables in FROM clause

**1 mark** for WHERE RegistrationNumber = "AB72XHC"

**1 mark** for Owner.OwnerID = Vehicle.OwnerID, joined to other condition with AND

--- OR ---

SELECT Model, Colour, Forename, Surname  
FROM Owner INNER JOIN Vehicle ON Owner.OwnerID = Vehicle.OwnerID  
WHERE RegistrationNumber = "AB72XHC"

**1 mark** for correct four fields in SELECT clause

**1 mark** for correct two tables in FROM clause

**1 mark** for INNER JOIN using Owner.OwnerID = Vehicle.OwnerID

**1 mark** for WHERE RegistrationNumber = "AB72XHC"

Marks for SELECT and FROM statements should not be awarded if additional fields / tables included.

Accept table names before fieldnames.

Accept use of Alias / AS command eg FROM Vehicle AS V then use of V as table name.

Accept insertion of spaces into fieldnames

**DPT** for unnecessary punctuation – allow one semicolon at the very end of the statement, but not at the end of each clause.

**DPT** for fieldname before table name.

**Refer responses using nested SQL queries to team leaders.**

**4**

(d)     (i)      Sequence of instructions / program / code;

**NE** programming language

**Note**: Do not award mark for program if candidate clearly means HTML

which is executed / run / interpreted on the server (instead of the client);

executed / run / interpreted when a web page is requested;

to generate a web page (and its contents) / result which the server returns to

the client / / generating of dynamic web pages;

**MAX 2**

**2**

(ii)     **1 mark for this point:**

Retrieve RegistrationNumber / value input by user and store in variable;

**R** responses that suggest the command makes the user input the values at the point in time when the script is run

**MAX 1 point from this list:**

from the web page / web site / form / web server / browser / url / request;

using POST / GET methods;

**2**

(iii)    Output the forename and surname;

Back to the web server / web browser / client / terminal;

**A** display forename and surname on web page (or alternative) for both marks

**R** responses that imply output is made directly to screen

**2**

(e)     Create a new table / / suitable table name given eg

SafetyCertificates;

with CertificateNumber as the primary key ;

Include these fields in new table: CertificateNumber, DateIssued, GarageName;

Add RegistrationNumber into the new table as a foreign key / / as link to Vehicle table;

**A** relation for table

**A** different fieldnames for new fields if meaning the same

**A** adding the extra field ExpiryDate, but not as an alternative to DateIssued

**A** answers by example eg writing out the new table definition, SQL script to achieve changes

**R** a composite key in new table

**Do not award any marks unless it is clear that a new table has been created**

**3**

**[18]**