Engineering, Built Environment and IT
Department of Computer Science

Software Modelling
COS 214

Examination Opportunity 1 (EO1)

9 September 2021

Examiners

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Instructions

1. Read the question paper carefully and answer all the questions.

2. The assessment opportunity comprises of **6** questions on **6** pages.

3. **2** hours have been allocated for you to complete this paper. An additional 30 min have been allocated for you to download the paper and upload your answer document.

4. Write your answers on a separate document (eg. using an editor or handwritten) and submit the document in **PDF format**.

5. Please make sure your **name, student number and a photograph of your student card is clearly visible** in the document you upload. Provide an e-mail address and a phone number on your paper where you can be contacted, should there be any problems.

6. This paper is **take home** and is subject to the University of Pretoria Integrity statement provided below.

   - You are allowed to consult any literature.
   - You are not allowed to discuss the questions with anyone.
   - You may not copy from online resources. All answers must be in your own words.

7. If you have any queries when writing the paper, post them in good time to the COS 214 WhatsApp group or use the chat functionality on the Blackboard Collaborate session for EO1. Make sure your post in general enough as not to give away any answers.

8. An upload slot will be open on the module ClickUP page under the **Tests and EOs** menu option for the duration of the examination opportunity (17:30 to 19:30) and then for an additional 30 min to give enough time to download this paper, create the PDF containing your answers and then upload your PDF. **No late submissions will be accepted.**

Integrity statement:

The University of Pretoria commits itself to produce academic work of integrity. I affirm that I am aware of and have read the Rules and Policies of the University, more specifically the Disciplinary Procedure and the Tests and Examinations Rules, which prohibit any unethical, dishonest or improper conduct during tests, assignments, examinations and/or any other forms of assessment. I am aware that no student or any other person may assist or attempt to assist another student, or obtain help, or attempt to obtain help from another student or any other person during tests, assessments, assignments, examinations and/or any other forms of assessment.

Question:	1	2	3	4	5	6	Total
Marks:	15	5	3	22	10	18	73

Full marks is: 70

Short questions

1. (a) Below is a skeleton of a security system implementation at The Republic of COS 214 presidential office.

```
class BodyGuard
{
        private:
                friend class President;
                BodyGuard() {}
};

class President : private BodyGuard
{
        // ...
};

class Sniper : public President
{
        // ...
};
```

   i. Can `President` be instantiated? (1)
   ii. Give a reason to support your answer in i. (2)
   iii. The programmer observes that `Sniper` doesn't compile. What could be the explanation of this behaviour? (3)

   (b) The COS 214 Presidential Office employs both permanent and temporary employees with different salaries computed based on the number of hours worked. Study the given code extract below and answer the questions that follow.

```
#include <iostream>
#include <string>

using namespace std;

class Employee
{
        protected:
                string name;
                int age;

        public:
                Employee( string n, int a )
                {
                        name = n;
                        age = a;
                }

                int salary()
                {
                        cout << "Employee salary :" <<endl;
                        return 0;
                }

};
```

```cpp
class Permanent : public Employee
{
    public:
        Permanent( string n = "Perm", int a = 23) : Employee(n, a) { }

        int salary ()
        {
            cout << "Permanent employee salary :" <<endl;
            return 450;
        }
};

class Temporary : public Employee
{
    public:
        Temporary( string n = "Temp", int a = 18) : Employee(n, a) { }

        int salary ()
        {
            cout << "Temporary employee salary :" <<endl;
            return 275;
        }
};

// Main function for the program
int main() {
        Employee *emp;
        Permanent perm("James", 31);
        Temporary temp("Larry", 18);

        // store the address of Permanent
        emp = &perm;

        // call Permanent salary.
        emp->salary();

        // store the address of Temporary
        emp = &temp;

        // call Temporary salary.
        emp->salary();

        return 0;
}
```

   i. What will be the output of the program?   (2)

  ii. Provide an explanation of the observed output in i.   (4)

 iii. What modification would you make on the program to provide "better" output?   (1)

 iv. The modification in iii. would ensure that the type of object determines the selection of function   (2)
called at that point in the program. This is called .... or ....!

<div align="right">Total for Question 1: 15</div>

2. (a) The Memento pattern enables an object to be restored to its previous state. Memento can be seen as   (2)
a snapshot of the system at a particular point in time. Why is a direct interface to obtaining the state
of the object not desirable?

  (b) Study the code snippet below and answer the question that follows: (3)

```cpp
class A
{
    public:
```

```
                    virtual ˜A()
                    \\ ...

                    private:
                    friend class B;
                    A()
                    \\ ...
        };
```

With the few details provided, you determine that this would be an incomplete implementation of the Memento design pattern. Which participants of the pattern can you determine from the code snippet?

Total for Question 2: 5

3. A mobile network operator has two different subnetworks to process voice (normal voice calls) and data (3) (WhatsApp calls, Skype calls, Zoom calls, etc.) calls. The class diagram below shows a model developed by a Wireless Systems Engineer.
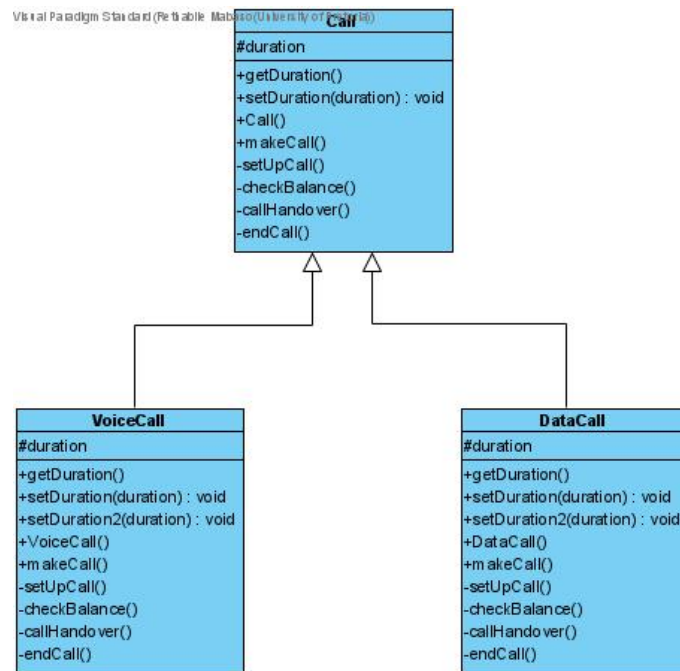
After a careful study of the class diagram, would you say this is an implementation of the Template Method design pattern, or just a close attempt? Explain your answer.

Total for Question 3: 3

Long questions

Scenario
You have been contacted by UP's communications department to help model their telephone management requirements. Initially, all users were allowed to choose one of two push-button type phones. During the demonstrations of the telephone, the latest retro rotary phone was on display - refer to the figure below for an image of a rotary phone. This resulted in a huge uproar as some staff asked if they could have a rotary phone rather than a push-button phone.

Answer the questions below to derive part of the model for UP's phone management requirements. Each question will highlight another aspect of the design.

4. Consider the incomplete `Telephone` hierarchy given below.
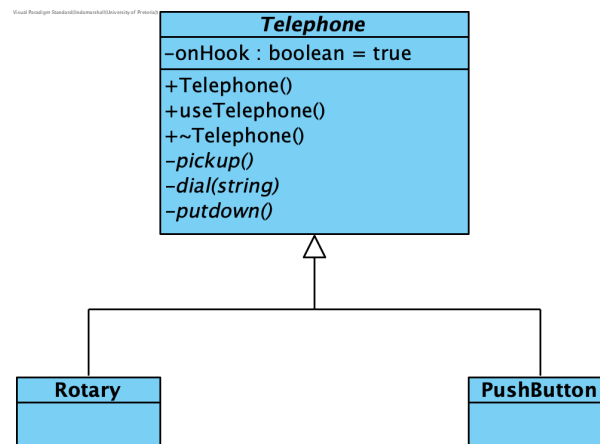
(a) A partial implementation of the `useTelephone` method is given by the following C++ function implementation:

```
void Telephone::useTelephone() {
        string  number = directory.getNumber();
        pickup();
        dial(number);
        while (!done} {
                ...
        }
        putdown();
}
```

   i. Which component does the `useTelephone` function represent? (1)

   ii. Where will `pickup`, `dial` and `putdown` be implemented and why are they private? (2)

   iii. Which design pattern is being represented? (1)

(b) During the conversation with the communications department, someone mentioned they would like the creation of the telephone object to be managed by an/other object(s). They also sketched the following class and handed it to you.
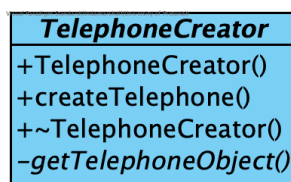
   i. Identify the *factory method* and the *operation* in the given class. (2)

   ii. The class is not complete, nor are the methods 100% correctly defined. Redraw the given class so that it complies with all the requirements for the `Creator` participant of the Factory Method design pattern. (2)

   iii. Assuming the client would like to have a handle on the product produced by a concrete creator of (1)
    the `TelephoneCreator` class, what change needs to be implemented to the given class diagram?

   iv. Taking the answers to the previous questions into account, provide an implementation for the (4)
    `createTelephone` function.

   v. Draw the UML class diagram that includes the concrete creator participants as well as the rela- (4)
    tionships between the classes and client. It is not necessary to include any features (attributes and
    methods) for the classes. The class name and whether it is abstract or not will suffice.

 (c) If multiple types of rotary and push-button telephone objects are to be created, for example, a Nineteen- (5)
   Tens style rotary and Nineteen-Tens style push-button telephone:

- which pattern would need to be implemented?
- which hierarch-y/ies would need to be extended? and
- which hierarchy needs methods added and what will these methods be?

<div align="right">Total for Question 4: 22</div>

5. With reference to the `Telephone` hierarchy (for which an incomplete class diagram was previously given)
and the `TelephoneCreator` hierarchy (which was developed in the previous question), you are required to
model the replication of telephones and the storing of these replicas by answering the questions that follow.

 (a) i. In which class would you first define the *clone* method in order for telephones to be replicated (1)
   (cloned)?

   ii. Provide the visibility and a definition of the *clone* method that will be placed in the class. (2)

   iii. Provide an implementation for the `clone` method for the class representing the Rotary telephone. (4)
    You may assume that the state of the object being cloned is not to be transferred to the clone.
    Clearly write any further assumptions you make in answering this question down.

 (b) The created telephones, whether created using the `TelephoneCreator` hierarchy or by cloning, are
   stored in batches. Once a batch is complete, the batch is processed and the telephones in the batch
   are given a batch number concatenated with a sequence number. The sequence number if the position
   of the phone within the batch.

   i. Which pattern would be used to store batches of newly created telephones, either rotary or push- (1)
    button?

   ii. For the pattern identified in the previous question, which participant has already been defined and (2)
    which class maps to this participant?

<div align="right">Total for Question 5: 10</div>

6. Consider the states a telephone, either rotary or push-button, will go through when a phone call is made.
The following is a description of these states and the events that need to take place to move from one state
to another.

*When the receiver is placed on the hook (`onHook`), the telephone is in an `idle` state. When the receiver
is lifted (`offHook`), a dial tone is heard. If a number is is not dialled within a certain time frame, the
telephone moves back to the `idle` state after issuing a warning. Entering an invalid number will result in
an appropriate message being heard, resulting in an `onHook` event and the telephone returning to the `idle`
state. A valid number will connect through the exchange. If the called phone is in use, it will issue a busy
tone and once the receiver is placed on the hook, to the `idle` state. If the exchange has reached capacity in
terms of the number of calls it can handle, an exchangeBusy event is issued and the appropriate tone given
to the caller until they put down the receiver. If the call is able to go through, the called telephone will ring.
If the call is answered a conversation can take place until the receiver put down and the phone returns to
the `idle` state.*

 (a) Draw the UML State machine diagram to capture the states a telephone object will be in when making (10)
   a call.

 (b) To model the tones emitted when making a connection when a valid telephone number has been
   entered, a design pattern is used. The context of the design pattern will hold a pointer to the derived
   participant of the pattern. A telephone, when making a connection, moves from ConnectTone to either
   BusyTone, ExchangeBusyTone or RingTone, depending on the state the called telephone is in.

   i. Which design pattern(s) would be best to model the functionality of making a connection? Provide (3)
    at least one reason for your answer.

   ii. Draw the class diagram to show how your answer to the previous part of the question integrates (5)
    with the existing classes.

<div align="right">Total for Question 6: 18</div>