Practice Final

Final Exam Info

Our regular exam time is Sat June 3rd in Skilling Aud (our regular room) from 3:30-5:30. The alternate will be Fri June 2nd 7:00-9:00 p.m. in Gates b08 in the basement. SITN students may take the exam on campus, or may wait at their site and we will send a copy of the exam which may be taken on Mon the 5th or Tue the 6th.

The final exam will focus on short answer questions and code writing questions. The short answer questions will be +1 for a right answer, 0 if left blank, and -1 for a wrong answer. For the coding questions, We will not be picky about details such as syntax, exact method names, or import directives. However, it will be important that you can write structurally correct code for the topics we have studied...

Swing: components, drawing, event listeners

Threads: creation, synchronization (synchronized), coordination (wait/notify)

RMI: creation, messages, threads

The exam will be 2 hours long and will be open note, open book (but not open computer). I is unlikely I will emphasize questions where you can just look up the answer. The questions will more likely require you to write code the demonstrates understanding of a few concepts at once.

To study for the exam, you should review all the lecture examples, your own homework solution code, and these problems from last year's exam. You can also review the web criteria writeups for the homeworks -- they discuss the key parts of the correct solution. To really study for a code-writing exam, passive review of the solution code is not sufficient. You should get out a blank piece of paper and create solution code from scratch for lecture examples, homework problems, etc. — that's the level of understanding you want to practice for the exam.

(Thanks to Jason Townsend for working up these solutions...)

1) Short Answer (10 points)

Brief answers are fine for these.

a) What is one feature that makes Vector slower than the equivalent new Collection classes?

All Vector methods are synchronized, even if the client is not threaded

b) Why has Thread.stop() been deprecated in Java 2?

Because it's hard to prevent this from interrupting a critical section
and leaving something in an inconsistent state.

c) What is the difference between paint() and repaint()?

paint() is the notification that a component should draw. Repaint is a request by the application that a paint should happen in the future.

d) Remember in HW1, you built a FilteredTableModel that worked by keeping a pointer to another "real" table model that actually stored the data. Could the table model from HW3, the TMClient, act as the "real" table model for a FilteredTableModel? Put another way: could you take the filter table from HW1, add it into HW3, and get a remote table displayed with filtering? (yes or no?)

Yes. Since it only needs a class that implements the TableModel interface, and TMClient is sufficient (neat!).

2) Swing GUI (15 points)

Here is a moderately complex but useless frame which exercises some of the core areas of Swing we've used over the quarter. Write a JFrame subclass with the following features...

- It uses a BorderLayout for its outermost layout
- When the frame closes, its application exits.
- The west contains be a single "Frustration" JButton which disables itself when clicked.
- The east contains a single JLabel containing the text "Spring".
- The center contains a 4 buttons, all with the title "Foo". These buttons are aligned in a single vertical column.
- The south contains 4 buttons, also with the title "Foo". These buttons are aligned in a single horizontal row.
- Write one method with enough parameters that it can be used to create both of the above 4 Foo button groupings. Or put another way: don't repeat the code to create the 4 Foo buttons.
- Clicking any of the 8 Foo buttons switches the Spring label back and forth between being enabled and disabled.
- Since the 8 Foo buttons all do the same thing, they should all use a single listener object. There should not be 8 separate listener objects.

Your code...(constructor first)

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class MyFrame extends JFrame {

   public MyFrame(String name) {
      super(name);
```

```
        getContentPane().setLayout(new BorderLayout());

        final JButton frustration = new JButton("Frustration");
        frustration.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                frustration.setEnabled(false);
            }
        });
        getContentPane().add(frustration,BorderLayout.WEST);

        final JLabel spring = new JLabel("Spring");
        getContentPane().add(spring,BorderLayout.EAST);

        ActionListener springToggle = new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                spring.setEnabled(!spring.isEnabled());
            }
        };

        JPanel centerPanel = new JPanel();
        centerPanel.setLayout(new BoxLayout(centerPanel,BoxLayout.Y_AXIS));
        makeFourFooButtons(centerPanel,springToggle);
        getContentPane().add(centerPanel,BorderLayout.CENTER);

        JPanel southPanel = new JPanel();
        southPanel.setLayout(new BoxLayout(southPanel,BoxLayout.X_AXIS));
        makeFourFooButtons(southPanel,springToggle);
        getContentPane().add(southPanel,BorderLayout.SOUTH);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent we) {
                System.exit(0);
            }
        });
    }

    public void makeFourFooButtons(Container panel, ActionListener listener)
{
        for (int i = 0; i < 4; ++i) {
            JButton foo = new JButton("Foo");
            panel.add(foo);
            foo.addActionListener(listener);
        }
    }

    public static void main(String args[]) {
        JFrame frame = new MyFrame("CS193K");
        frame.pack();
        frame.show();
    }
}
```

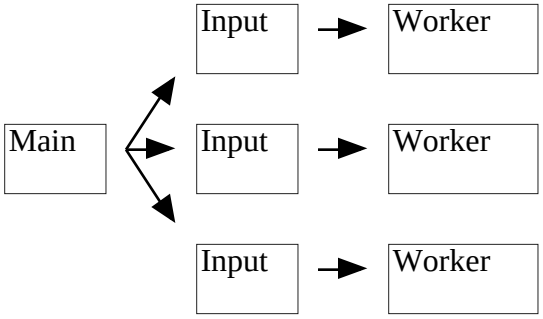
3) Thread Decryption (35 points)

This problem will use several classes and Threads to do decryption in parallel. There are three classes....

- The Main object sets things up, reads lines out of the input file and feeds them to Workers through their Input objects. The input file is made of strings like "w3ena;lkjasdf30924323xzxz" each representing an encryption problem that a Worker is going to try to solve.

- The Input object holds a single string for its Worker. In the homework, the TransactionBlock object could hold an entire array of inputs. In contrast, in this problem, the Input object can only hold one input at a time. Each Worker will have its own Input object.

- Worker thread objects removes an input string from its Input object, does a (slow) decrypt() test on the string, and if the test is successful, prints the string. The decrypt() operation is very slow, so the main thread should have an easy time keeping the Input objects filled with strings.



1) Input

The Input object is the connection between the main thread and each Worker. Each worker has its own Input object. For string storage, each Input should store a single string pointer. If the string pointer is null, the Input is empty, and so has room to contain an incoming string. Input should support a get() method that the Worker uses to get a string out of the Input. Get() should remove the string from the Input, making the Input empty. If the Input is empty at the time of the get(), then the request must block until there is a string in the Input. The Worker cannot proceed without a string to operate on.

On the other hand, when putting string into the Input objects, the Main thread does not need to block if there is not room in the Input. The attempt to add may or may not succeed, but failure does not necessarily lead to blocking. If there is not room for the string in one Input, the main thread can still try to add the string to one of the other Inputs which may have room. The main thread should block when no Input object has room. The main thread should awaken when at least one of the Input objects has room, and then it can try adding to each of them, knowing that at least one of the attempts must succeed. There must be a mechanism by which any of the Workers can alert the main thread that there is room (somewhere) for another string.

(partial credit) If you cannot devise a way for the Workers to notify the main thread that there is room, you could have the main thread loop constantly trying to add to the Input objects. This is inefficient, but it works.

2) Worker

Worker is a simple Thread subclass. Each Worker should get (at least) a pointer to its Input object at construction time. The Worker should repeatedly retrieve a string from its Input and run the boolean Crypt.decrypt(string); method on the string (we're not writing this method, we're just calling it). If decrypt() returns true, then print the string out. The special string "end" marks the end of the input, and the Worker should exit normally. (We are not going to check isInterruped() in this problem.)

3) Main

The Main object should also be a subclass of Thread. It's run() should orchestrate the whole computation. First is should create and start everything: 4 Inputs and 4 Workers. The "4" in this case should just be a constant — Main should use arrays to support an arbitrary number of Input/Worker pairs. Main should then open the file "crypt.txt" which contains problem strings, one per line. Each string should be fed to one Worker for processing through its Input. (as described above) Main should block when there is no Input object with room for another string. When main knows there is room in at least one Input, it's ok for it potentially to try the add operation on all 4 (trying to add to an Input is cheap). When the file is exhausted, main should feed the string "end" to each Input, and then wait for all the Workers to finish.

Solution: the use of setSpace(), getSpace() in main is the trickiest part -- solutions that got everything but that still got most of the points.

```
import java.awt.*;
import java.awt.event.*;
import java.io.*;
import javax.swing.*;

class Input {

	private String myString;
	private Main myMain;

	public Input(Main theMain) {
		myMain = theMain;
	}

	public synchronized String get() {
		while (myString == null) {
			try {
				wait();	// block of no string available
			} catch (InterruptedException ie) {
				ie.printStackTrace();
			}
		}
		String temp = myString;
		myString = null;
		synchronized(myMain) {
			myMain.setSpace(true);		// in case they were waiting
		}
		return temp;
	}

	/**
	 * @return true if the string was successfully put, false
```

```
otherwise
         */
        public synchronized boolean tryPut(String toPut) {
                if (myString == null) {
                        myString = toPut;
                        notify(); // in case our worker is waiting for
this input
                        return true;
                } else {
                        return false;
                }
        }
}

class Worker extends Thread {

        private Input myInput;

        public Worker(Input in) {
                myInput = in;
        }

        public void run() {
                String str = myInput.get();
                while (!str.equals("end")) {
                        if (Crypt.decrypt(str)) {
                                System.out.println(str);
                        }
                }
        }
}

public class Main extends Thread {

        private Input[] inputArray;
        private Worker[] workerArray;
        private static final int NUM_WORKERS = 4;

        private boolean space = true;      // space available for writing

        // Notify if setting that there is space available
        public synchronized void setSpace(boolean value) {
           space = value;
           if (space) notify();
        }

       // Wait until there's space available
       public synchronized void getSpace() {
           if(!space) {
           try {
                        wait();
           }
           catch (InterruptedException) (ignored) {}
        }
```

```
    public Main() {
        inputArray = new Input[NUM_WORKERS];
        workerArray = new Worker[NUM_WORKERS];
        for (int i = 0; i < NUM_WORKERS; ++i) {
            inputArray[i] = new Input(this);
            workerArray[i] = new Worker(inputArray[i]);
        }
    }

    public void run() {
        try {
            BufferedReader inputFile =
                new BufferedReader(new FileReader("crypt.txt"));
            int i;
            for (i = 0; i < NUM_WORKERS; ++i) {
                workerArray[i].start();
            }
            String aLine = inputFile.readLine();
            while (aLine != null) {
                boolean success = false;
                while (!success) {
                    setSpace(false);       // assume there's no space
                    for (i = 0; i < NUM_WORKERS; ++i) {
                        if (inputArray[i].tryPut(aLine)) {
                            success = true;
                            break;
                        }
                    }
                    if (!success) {
                        getSpace();         // check/wait for space
                    }
                }
                aLine = inputFile.readLine();
            }

            for (i = 0; i < NUM_WORKERS; ++i) {
                workerArray[i].join();
            }
        } catch (Exception e) {
            e.printStackTrace();
        }
    }

    public static void main(String args[]) {
        Main theMain = new Main();
        theMain.run();
    }
}

class Crypt {
    public static boolean decrypt(String theString) {
        // some lengthy operation
        return true;
```

```
    }
}
```

4) RMI (40 points)

As usual, the RMI problem will separate a computation into "client" and "server" sides. The basic idea is...

The DBServer exists on the server side, storing a database of a million strings in a single Vector. The DBServer responds to a search(String target) message. The goal of search() is to search through the database on the server side and return to the caller copies of the relatively few strings in the database that contain the target string. The search() message is part of the DBRemote interface that DBServer exposes to remote clients.

DBClient is a simple JFrame subclass with a text field, a search button, an "answer" text area, and a DBRemote connection to the DBServer. When the search button is clicked, the DBClient sends a search() message, and when the answer comes back, it is put in the answer text area.

There is one complication. search() could be written to return a Vector of the matching strings. This is simple, but has the disadvantage that the client needs to wait for the entire search() to complete before getting back the answer. Our approach will be to send an XObjectRemote as a second argument to the search(). The search() can return quickly (with no answers yet). When it gets the search() message, the server can start up a separate thread to do the search, and that thread can use the XObjectRemote to communicate back the string answers as they are found, one at a time. The communication of each string can also be done in a separate thread - there's no reason to make the searching wait for the transmission of each string.

To minimize what you need to write, we will concentrate on search() itself, and ignore most of the rest of the routine RMI code. Your code should catch RemoteException where necessary, but can then ignore the exception silently.

XObjectRemote

Here's the code for XObjectRemote -- you should use these without modification. Your DBServer and DBClient can use the XObjectRemote however they like, so long as they are consistent with each other — it's a private dialog.

```
public interface XObjectRemote extends java.rmi.Remote {

   public void send(Object message) throws RemoteException;
}


public class XObjectServer extends UnicastRemoteObject
      implements XObjectRemote {

   XObjectListener listener;

      public XObjectServer(XObjectListener listener) throws RemoteException {
      super();
      this.listener = listener;
   }
```

```
   public void send(Object message) throws RemoteException {
      listener.send(message);
   }
}
```

a) DBRemote

Define the DBRemote interface to specify the prototype for the seach() message that the client can send to the server. The client cannot interrupt or withdraw its search() requests.

b) DBServer

The only code you need to write is search() and any helper methods it needs. We will assume that the DBServer loads its million strings at construction time. We will also assume that all the Naming.rebind() stuff has been done. Use String.indexOf(target) to test if the target is in each string in the database -- it returns -1 if the target is not found.

c) DBFrame

Write the code for the DBFrame constructor which should set up all the components. DBFrame should contain a text field and search button to initiate the search and a JTextArea to show the results. Use getText() to get the target string out of the JTextField. Leave the JTextArea with its default constructed size, and use its convenient append(String) message to append the answer strings as they come in. Beyond the DBFrame constructor, write the code to initiate the search() and get back the results. We will assume that the naming lookup and other setup is written somewhere else.

```
import java.rmi.*;

public interface DBRemote extends java.rmi.Remote {
   // Ask the db to search for the given string
   // and answer back on the given XOR object
   public void search(String searchString, XObjectRemote returnPath) throws
RemoteException;

}

b)
import java.util.*;
import java.rmi.*;
import java.rmi.server.*;

public class DBServer extends UnicastRemoteObject
   implements DBRemote {

   Vector strings;

   public void search(final String searchString, final XObjectRemote
returnPath) {
      if (searchString == null) return;
      Thread searchThread = new Thread() {
         public void run() {
            String tryString;
            for (int i = 0; i < strings.size(); ++i) {
```

```
                tryString = (String)strings.elementAt(i);
                if (tryString != null && tryString.indexOf(searchString) != -1) {
                    // found a match
                    try {
                        returnPath.send(tryString);
                    } catch (RemoteException re) {
                        re.printStackTrace();
                    }
                }
            }
        }
    };
    searchThread.start();
  }

  // not asked for in the question
  public DBServer() throws RemoteException {
    super();
    // do something to load strings
  }

}

c)
import java.awt.*;
import java.awt.event.*;
import java.rmi.*;
import javax.swing.*;


// GUI side of the db/remote question
// We listen to the XOServer object we send to the db

public class DBFrame extends JFrame implements XObjectListener {
  DBRemote dbr; // assume this gets set somehow

  JTextArea textArea;
  JTextField textField;

  public DBFrame(String name) {
    super(name);
    getContentPane().setLayout(new BorderLayout());

    textField = new JTextField();
    getContentPane().add(textField,BorderLayout.NORTH);

    textArea = new JTextArea();
    getContentPane().add(textArea,BorderLayout.CENTER);

    JButton searchButton = new JButton("Search");
    searchButton.addActionListener(new ActionListener() {
      public void actionPerformed(ActionEvent e) {
        try {
          dbr.search(textField.getText(),new
```

```
XObjectServer(DBFrame.this));
                } catch (RemoteException re) {
                    re.printStackTrace();
                }
            }
        });
    }

    // notification on the XObject
    // note: not on Swing thread
    public void send(Object message) {
      SwingUtilities.invokeLater(new Runnable() {
        public void run() {
          textArea.append((String)message);
        }
    }

}
```

d) Interruption

(there is no code writing for this part) Suppose you wanted to have an "Interrupt" button on the DBFrame which can interrupt the search() thread which is running on the server. Write a one paragraph description of how you could build this using XObjectRemote-XObjectServer (XOR-XOS). For your proposal, describe the steps that happen starting with the initiation of the search, the click of the interrupt button on the client side, leading to the interrupt() message being sent to the right Thread object on the server side. Explain which object is keeping the pointer to the correct Thread object to interrupt.

Solution: Create a little server side "stop" object on the server that keeps a pointer to the searching thread object. Pass back to the client a remote copy of the stop object. The client can send a message to the stop object, so that it can do an interrupt() on the real server side thread.