EECS 481 — Software Engineering
Spring 2020 — Exam #2

- There are seven (7) questions in this exam, each with multiple parts. Some questions span multiple pages. If you get stuck on a question, move on and come back to it later.
- Once you download this exam, you have two (2) hours to complete and upload it. If you encounter technical difficulties, email the staff immediately.
- This exam is open book, notes, and Internet. *You may not communicate with others while completing this exam.* You can email the staff, make *private* Piazza posts, or use Slack to send direct messages to staff. We will try to respond during the hours of 11AM to 11PM Eastern time on Saturday and Sunday. Any public posting on course forums or to a third party website will result in an automatic zero.
- You will complete the exam by filling in the accompanying `exam-answers.txt` files. Once complete, submit `exam-answers.txt` alone to the course website: `https://dijkstra.eecs.umich.edu/kleach/eecs481/shibboleth/exam2-submit.php`.
- Solutions will be graded on correctness and clarity. Each problem has a relatively simple and straightforward solution. We may deduct points if your solution is far more complicated than necessary.
- If you leave a non-extra-credit portion of the exam blank or drawn an X through it, **you will receive one-third of the points rounded down (e.g.,** $4/3 = 1$**), for that portion for not wasting time.**

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1 Delta Debugging (13 points)

The Delta Debugging (DD) algorithm makes certain assumptions about its input. It requires that the interesting function be *monotonic*, *unambiguous* and *consistent*. Consider the following snippet of code.

```
1  int macaroni (int s) {
2      int *x = NULL;
3
4      x = (int*)  malloc (s * 1024 * 1024 * 1024 * sizeof(int));
5
6      if ( x == NULL ) {
7          return -1;
8      } else {
9          return 0;
10     }
11 }
```

Say we want to minimize a test suite for this macaroni function.
malloc is a function that asks the system to allocate the specified amount of memory — it returns a pointer if allocation is successful, and NULL if the memory cannot be allocated. (Reminder: 1024 bytes = 1KB, 1024KB = 1MB, etc. Also, what does it mean to allocate negative bytes?).

(a) *(2pts. total)* Assuming your development system has 16GB of memory available to respond to malloc requests, 32-bit integers, that this program is run in complete isolation, AND memory allocation is perfectly optimal, complete the table of test cases and corresponding output.

Test #	**Input (int s)**	**Output of macaroni?**
0	3	
1	2	
2	-2	
3	2048	
4	-3	

(b) *(3pts.)* If we want to minimize this test suite with respect to line coverage, how would you define the interesting function?

(c) *(5pts.)* Below, write the numbers of the test cases that minimize the test suite with respect to line coverage.

(d) *(3pts.)* Now, ignore the assumptions from (a). In two sentences or fewer, explain which Delta Debugging assumption is violated by the code above, and why. Hint: keep in mind the behavior of malloc as described above.

2 Design Patterns (14 points)

Consider a multiplayer computer game. In this game, each player controls the movement of their character. Whenever a player moves their character, all other players see where that player's character moves. Your tragic developer provides the following Java code.

```
1  class Point {
2      public int x, y;
3      public Point (int _x, int _y) {x=_x; y=_y;}
4  }
5  class Game {
6    Player players[32];  // 32 players
7    public startGame() {
8      for (int i=0; i<32; i++)
9        this->players[i]  = new Player();
10
11     while (true) {
12       // main game loop
13       for (int i=0; i<32; i++)
14         players[i].move( random(), random() );
15
16       for (int i=0; i<32; i++) {
17         for (int j=0; j<32; j++)  {
18           if (i==j) continue;
19           players[i].updateOtherPlayer(players[j]);
20         }
21       }
22     }
23   }
24 }
25 class Player {
26   public Point pos; // position
27   public Player () {
28     // constructor
29     pos = new Point(0,0);
30   }
31   public void move( int _x, int _y ) {
32     // move player to new position
33     pos = new Point(_x, _y);
34   }
35   public Point updateOtherPlayer (Player p) {
36     // update information about another player
37     Point otherPos =  p.pos;
38     this.updateGameScreen( p, p.pos);
39   }
40 }
```

You may make the following assumptions about the code.

- `random` is a helper method that returns a random integer.
- `updateGameScreen` is a helper method that updates one player's view of another individual Player's position.

(a) (*6pts.*) Identify two (2) design patterns that might be useful in this program and explain why. (One sentence each).

(b) (*6pts.*) Suppose you want to reorganize the `Game.main` method. Further suppose that you add a method to `Game`:

```
1 ... (other stuff from Game) ...
2 public void updateAllPlayers( Player p ) {
3   for (int i=0; i<32; i++) {
4      if (players[i] == p) continue;
5      this.players[i].updateOtherPlayer( p );
6   }
7 }
8 ... (other stuff) ...
```

If you wanted to call this method from `Player.move`, what change would you need to make to `Player.move`? (One sentence or less).

(c) (*2pts.*) In one word, what property are you increasing by making the change above?

3 Short Answer (21 points)

(a) (*2pts.*) In two sentences or fewer, describe the role of the requirements engineer during elicitation.

(b) (*5pts.*) You are interviewing a customer to gather requirements. They are interested in a 2D graphics program that draws specified polygonal shapes on the screen. They indicate a specific screen resolution and color depth, and say that no more than 3 shapes with 5 sides or fewer each will be drawn on the screen at once, that all shapes are regular (all angles are equal in each shape), and that the shapes must be drawn in under 1 second. You deliver a prototype that you think meets the requirements — however, the customer says that the graphics do not look right.

Specify (1) what might have gone wrong in the prototype you delivered that led the customer to be unhappy, and (2) what might have been done during elicitation to avoid such mistakes from occurring. Use four or fewer sentences.

(c) (*3pts.*) During Chad Spensky's guest lecture, he placed heavy importance on keeping projects open source. Explain why in two sentences or fewer.

(d) (*3pts.*) In class, we discussed how activity in the brain changes based on expertise. Support or refute the claim that measured neural efficiency should be used as a basis for evaluating a software engineering candidate.

(e) (*3pts.*) Explain in your own words a specific scenario that might involve a multi-language project. Use two sentences or fewer.

(f) (*2pts.*) Chad Spensky explained that it was important to "pro up" with various software engineering tools. Describe what this means in one sentence.

(g) (*3pts.*) In Jack Wadden's guest lecture, he explained a scenario in which a difference in a simulation versus real hardware led to a difficult defect to track down. Explain how Delta Debugging might be used to help discern such a difference in compilation tools.

4 Software Engineering Narrative (15 points)

(1 pt. each) Read the following narrative. Fill in each ____ blank with the single *most specific or appropriate* corresponding concept from the answer bank. (Each ____ blank does have *exactly one* corresponding answer.) Each option *can* be used more than once.

A. Conditional Breakpoint	B. Creational Design Pattern	C. Defect	D. Fault
E. Fault Localization	F. Feature Request	G. Priority	H. Profiling
I. Requirements Elicitation	J. Singleton Design Pattern	K. Stakeholder	L. Swiss Cheese Model
M. Traceability	N. Triage	O. Watchpoint	

(a) ____ The video streaming site BiliKan uses a single Video class to encapsulate manipulation of multiple video formats. Each video format has an associated subclass that works with that specific video format.

(b) ____ Your new intern inserts a null pointer dereference in the middle of your team's module.

(c) ____ Your code compiles just fine, but running it against one test case seems to cause accessing memory beyond the boundary of an array, leading to a crash *at runtime*.

(d) ____ The Pizza company Trionomos wants to keep track of their statistics, such as pizzas sold, revenue to date, and number of locations in one centralized location.

(e) ____ In the middle of a sprint, your manager tells you to fix a bug identified in a defect report as soon as possible.

(f) ____ A credit reporting company NutriFax experiences a massive data breach. Upon investigation, it was discovered that multiple failures occurred in sequence: the database did not throttle queries, the front-end allowed requesting millions of records at once, and the authentication mechanism allowed administrative access without valid credentials.

(g) ____ The developers of "Bashing Mealworms" want to add support for different colored in-game Mealworm characters in response to player feedback.

(h) ____ A developer wants to stop a program's execution when the variable `x` equals 5.

(i) ____ You insert time measurements at the beginning of each function to determine which functions of code to optimize by reimplementing in native C.

(j) ____ A defect report related to the Pizza topping "anchovies" is received. However, the report is closed because it is deemed not reproducible.

(k) ____ Hannah approaches a new customer concerning their request for new pharmacy management software. Hannah prepares for interactions with this customer by reading about prescription laws to determine the scope and costs of a pharmacy-related software project.

(l) ____ The music software VeggieLoops has an individual test case for each individual requirement.

(m) ____ The printer company Cannon is considering developing software that optimally conserves ink in their consumer printers. However, the CEO is concerned that this will

overly diminish ink cartridge sales, and so cancels the project. The developers on the customer success team were very surprised by this move, given the interests expressed by customers.

(n) ____ A developer on your team ranks lines of code by suspiciousness to identify a buggy "if" statement in their code.

(o) ____ A developer wants to stop execution to step through instructions every time the address `0xdeadbeef` is written to.

5 Interviewing (17 points)

You are a hiring manager considering three candidates. You have given each candidate the following prompt:
Given an array of integers of size $N+1$, each integer from 1 to N is in the array *once* except for one integer, which appears twice. Find the value of the integer that appears twice. If no pair exists, report an error.

(a) (*4pts.*) List 4 test cases that you would expect a good candidate to provide, and why.

Candidate 1 provides the following code.

```
def findDuplicate(nums):
    for i in range(len(nums)):
        for j in range(len(i)):
            # consider each pair of numbers
            if nums[j] == nums[i]:
                # bail on the first match
                return nums[i]
    return None
```

Candidate 2 provides the following code.

```
def findDuplicate(nums):
    nums.sort()
    for i in range(len(nums)):
        if nums[i] == nums[i + 1]:
            return nums[i]
    raise Exception('No pairing')
```

Candidate 3 provides the following code.

```
def findDuplicate(nums):
    for i in range(len(nums)):
        for j in range(len(nums)):
            if nums[j] == nums[i]:
                return nums[i]
    return None
```

(b) (*10pts.*) In the table below, mark with a X the candidate that performed the best with respect to each property listed and explain why briefly.

	C 1	**C 2**	**C 3**	**Explanation**
Correctness				
Error Handling				
Maintainability				
Runtime Complexity				
Space Complexity				

(c) (*3pts.*) Support or refute the claim that you, as the interviewer, must detect and guard against defective code from candidates. Use two sentences or fewer.

6 Fault Localization (20 points)

The following code attempts to determine if, given a list of integers and strings, the strings follow the same pattern as the integers. For example, the input `pattern="1 1 2", string="fish fish dog"` would return *true*, but `pattern="1 2", string="cat cat"` would return *false*.

```
1
2  def wordPattern ( pattern , string ):
3    pattern = pattern.strip ()
4    pattern = pattern.split (' ')
5    string = string.strip ()
6    string = string.split (' ')
7
8    if len ( string ) != len ( pattern ):
9      return False
10
11   match = {}
12
13   for i in range ( len ( pattern )):
14     if pattern[i] in match:
15       if match[ pattern[ i ]] != string [i]:
16         return False
17
18     else :
19       if string [ i ] != match.values() ():
20         match [ pattern [ i ] ] = string [ i ]
21       else :
22         return False
23
24   return True
```

(a) (*15pts.*) Given the five test cases below, identify the *actual* output (produced by the program above) and the *expected* output (based on the problem specification). *Then*, for each test case, specify which lines are *not* covered by that test case. Note the spaces in inputs.

pattern	string	Actual	Expected	Lines *not* covered
`''`	`'dog dog'`			
`' '`	`'dog dog'`			
`'1 2 3 2 '`	`''`			
`' 1 2 2 1 '`	`' dog cat cat dog '`			
`'1 1 1 1'`	`'dog cat dog'`			

(b) (*2pts.*) Identify any defect(s) in the code above including line number(s) and how to fix it/them. If none are present, explain why.

(c) (*3pts.*) Support or refute the claim that and automated program repair tool could easily apply to the program above with the given fault localization and test suite.

7 Extra Credit **(1 pt each; we are tough on reading questions)**

(a) *(Feedback)* What advice would you give to future students in this class?

(b) *(Feedback)* What was your least favorite topic covered in the course?

(c) *(Feedback)* What was your most favorite topic covered in the course?

(d) *(Psychology)* Explain the illusory truth effect in your own words.

(e) *(Your Choice Reading)* Identify any **optional** reading. Write a sentence about it that convinces us that you read it critically. (Our subjective judgment applies here!).

(f) *(Your Choice Reading 2)* Identify any different **optional** reading. Write a sentence about it that convinces us that you read it critically. (Our subjective judgment applies here!).