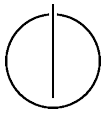


TECHNISCHE UNIVERSITÄT MÜNCHEN

FAKULTÄT FÜR INFORMATIK

Chair of Software Engineering for Business Information Systems Winter 2021/22
IN2309 - Advanced Topics of Software Engineering
Prof. Dr. Florian Matthes, Tri Huynh, Burak Öz

Mock Examination: IN2309 - Advanced Topics of Software Engineering - 11.02.2022

First Name: **Last Name:** **Matr. No.:**

Course of Studies:

I hereby declare that I agree to the above mentioned terms and feel mentally and physically fit to participate in the exam.

(Student Signature)

Question	1	2	3	4	5	6	7	8	9	Sum	Grade
Points											
Max. Points	11	10	11	9	11	16	13	12	7	100	

1 Distributed Systems 11 points

1. Name 4 characteristics of distributed systems. (2 Points)

   - Reliability
   - Availability
   - Security
   - Scalability

2. Briefly explain the differences between horizontal and vertical scaling. (1 Point)

   - Horizontal: add more machines with the same or different computing power.
   - Vertical: in one machine, add more hardware or replace the existing hardware with a more powerful one.

3. Briefly explain the MapReduce algorithm and translate the following SQL statement to a MapReduce function (5 Point)

```
SELECT employee FROM employees WHERE salary_level > 3
```

   (2 points explanation 3 points MapReduce function)

   - A MapReduce program is composed of a map procedure (or method), which performs filtering and sorting (such as sorting students by first name into queues, one queue for each name), and a reduce method, which performs a summary operation (such as counting the number of students in each queue, yielding name frequencies) (Wikipedia)

```
map(key, record):
    if(record.salary_level > 3)
            selection = (record.employee)
            emit(key, selection)
```

4. Briefly explain the differences between Data Marts and Data Cubes. (3 Point)

   - A data mart (DM) is a subset or an aggregation of the data stored to primary warehouse.
   - Data cubes are aggregated facts based on chosen dimensions. Data cubes are three dimensional data structures.

2 Security — 10 points

1. Briefly describe the difference between Security and Safety in software systems. (1 Point)

   - Security — Protection of systems (products, devices) from external hazards
   - Safety — Protection against hazards and risks originating from the operation of a system (product, device)

2. Briefly explain the least privilege principle and give an example for it. (2 Point)

   - Every subject should not have more privileges than necessary to complete its (approved) job.
   - Keys/locks in an office building are mechanism for implementing least privilege: office workers working regular hours only need keys to own office. The janitor has keys to all doors apart from safes.

3. Below you'll find an illustration of a potential attack tree. State the paths for the most expensive and the cheapest attack for opening the the save and state how costly each of the paths is. (3 Point)

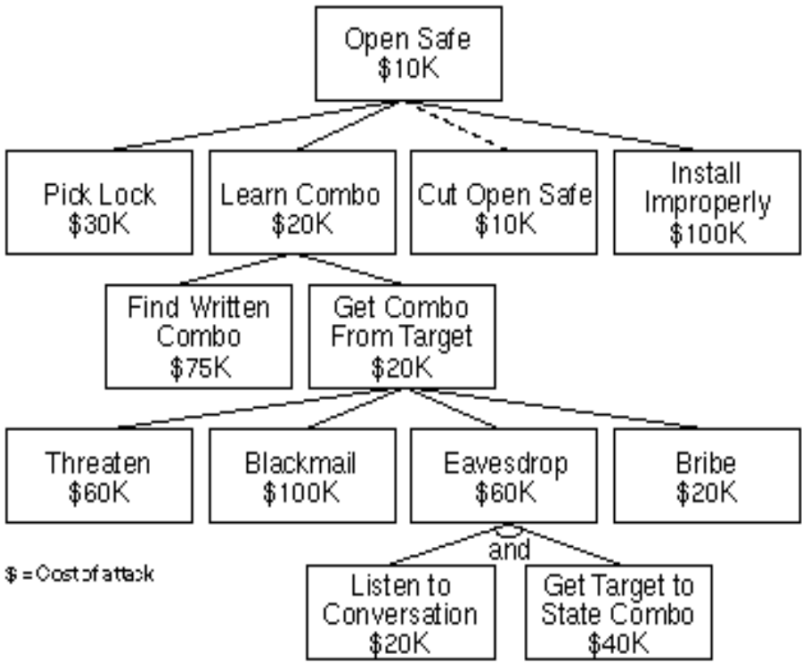


Figure 1: Attack tree

   - Cheapest — Cut Open Safe (10K)
   - Most expensive — Blackmail (100k) LEADS TO Get Combo From Target LEADS TO Open Safe OR Install Improperly LEADS TO Open Safe

4. You were hired by a local software development company as security consultant. As a first task, you should analyze the following programme:

```
1
2 public class UserCount {
```

```
3
4       public static boolean duplicateUser(String username) throws Exception {
5
6           // ...
7           String sqlStatement = "SELECT COUNT(*) FROM user_table where username = " +
                username;
8           // ...
9           int count = jdbcConnection.execute(sqlStatement);
10          if(count <= 1) {
11              return true;
12          }
13          return true;
14      }
15  }
16
17  public class Main {
18
19      public void doSomething() {
20              // ...
21              // POST("ATTRIBUTE_NAME") receives unfiltered HTTP post request from the
                    client
22              String username = POST("username")
23              UserCount.duplicateUser(username);
24              //..
25      }
26
27  }
```

(a) Name the vulnerability and briefly describe how an attacker can potentially exploit the code above (2 points)

- SQL Injection
- An attack can inject some SQL statement into the POST(”username”) variable. For example, ’ ABB” OR 1=1’ –;

(b) Briefly explain how the vulnerability can be fixed (2 points)

- Use prepared statements or escape the user inputs properly before creating the SQL statement string.

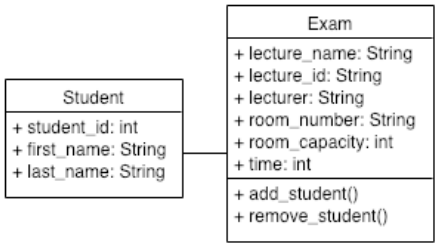
3 Anti Patterns 11 points

1. What are the "7 deadly sins" in software practice? Name **three** of them and describe each with one sentence. (3 points)

   0.5p per name/0.5 per description

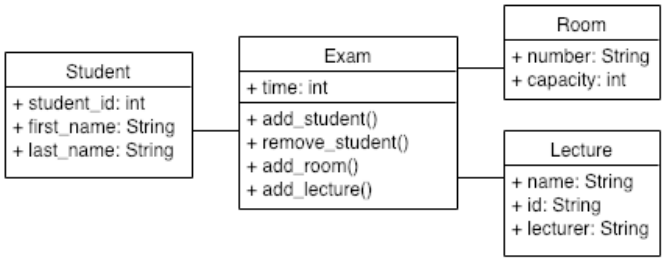
   - Haste — Solutions based on hasty decisions ("time is most important") lead to compromises in software quality
   - Apathy — Not caring about a problem, followed by unwillingness to attempt a solution
   - Narrow-mindedness — The refusal to use solutions that are widely known ("Why reuse? I only have to solve one problem")
   - Sloth — Making poor decisions based on "easy" answers
   - Avarice — No use of abstractions, excessive modeling of details
   - Ignorance — Failure to seek understanding
   - Pride — Not invented here (NIH): Not willing to adopt anything from the outside

2. Analyse the following UML class diagram for an exam management system.



   (a) Which of the anti-patterns discussed in the lecture can you identify? Justify your answer. (1 points)
   0.5p name + 0.5 justification
   The Blob.

(b) Re-factor the design of the system and draw the new UML class diagram without the anti-pattern. (4 points)
1p per class



(c) Name **three** typical causes for the anti-pattern you identified in (a). (3 points)
1p per cause

- Lack of an object-oriented architecture. The designers may not have an adequate understanding of object-oriented principles.
- Lack of (any) architecture. The absence of definition of the system components, their interactions, and the specific use of the selected programming languages.
- Lack of architecture enforcement. Sometimes this Antipattern grows accidentally, even after a reasonable architecture was planned. This may be the result of inadequate architectural review as development takes place.
- Too limited intervention. In iterative projects, developers tend to add little pieces of functionality to existing working classes, rather than add new classes, or revise the class hierarchy for more effective allocation of responsibilities.
- Specified disaster. Sometimes the Blob results from the way requirements are specified. If the requirements dictate a procedural solution, then architectural commitments may be made during requirements analysis that are difficult to change.

4 Blockchain-based architectures 9 points

1. Name **two** characteristics of smart contract platforms. (2 points)
   1p per characteristic
   - Focus on the precise, algorithmic descriptions of the rights and obligations of the contracting parties based on a shared state
   - Trackability of all transactions
   - Use of cryptographic methods
   - Domain-specific languages
   - Decentralized peer-to-peer execution environment

2. Describe the role of a wallet owner in a blockchain network as described in the lecture. (3 points)
   1p per point
   - has private key to unspent transactions
   - owns the money
   - sends money by signing and publishing new transactions

3. Name **two advantages** and **two disadvantages** of blockchain-based systems compared to centralized platforms. (4 points)
   1p per point
   Advantages:
   - Transparency
   - Traceability
   - Trust-free
   - Decentralised and redundant
   - ...

   Disadvantages:
   - Transaction costs
   - Governance
   - Complexity
   - ...

5 Software Architecture 11 points

1. What is the Dependency Structure Matrix ? (2 point)

Answer

Dependency Structure Matrix (DSM) is a compact way to express dependencies in a software project. It helps developers to understand components that belong together and suggests a way to partition a program.

2. Given the following java class.

```
1 public boolean transferMoney(Account sourceAccount, Account targetAccount,
      BigDecimal moneyAmount) {
2     sourceAccount.transfer(targetAccount, moneyAmount);
3     return true;
4 }
```

Under what circumstances might this function fail? Write suitable two pre-conditions and one post- condition for this Java function. (4 points)

Answer

If the amount of the transferred money is less than zero, or the source account has no money at all, or after the transfer the source account will be negative.

```
1 public boolean transferMoney(Account sourceAccount, Account targetAccount,
      BigDecimal moneyAmount) {
2     assert (moneyAmount.compareTo(BigDecimal.ZERO) <= 0);
3     assert (sourceAccount.getBalance().compareTo(BigDecimal.ZERO) <= 0);
4     sourceAccount.transfer(targetAccount, moneyAmount);
5     assert (sourceAccount.getBalance().compareTo(BigDecimal.ZERO) <= 0);
6     return true;
7 }
```

3. You are working as a software developer in GameForLife company. They are developing a new multiplayer online role-playing game (MMORPG) based on real life birds. Your colleague developed the following interface as a base for birds:

```
1 public interface Bird {
2     public boolean eat(){}
3     public boolean fly(){}
4     public boolean breed(){}
5 }
```

Afterwards you finished your implementation for both eagle and penguin and submit it as follows:

```
1 public class Eagle implements Bird {
2     public boolean eat(){
3         ....
4         // Some code
5         ....
6         }
7     public boolean fly(){
8         ....
9         // Some code
```

```
        ....
        }
    public boolean breed(){
        ....
        // Some code
        ....
        }
}

public class Penguin implements Bird {
    public boolean eat(){
        ....
        // Some code
        ....
        }
    public boolean fly(){
        ....
        // Some code
        ....
        }
    public boolean breed(){
        ....
        // Some code
        ....
        }
}
```

Later on your boss came and asked you the following questions:

(a) Is Eagle and Penguin a valid Java implementation of *Bird*? Why/why not? (2 point)

Answer

Yes, it is a valid implementation. Because it implements all the methods of the interface Bird.

(b) Is the implementation consistent with Liskov's substitution principle? If yes, why? If not, how would you make it consistent by writing a correct java implementation? (4 points)

Answer

No, it violates LSP. LSP states that a user should be able to use an implementation transparently. However, *Penguins* can't fly.

Solution: Remove *fly* from the Bird interface. Extend the interface to FlyBird and NonFlyBirds.

```
public interface Bird {
    public boolean eat(){}
    public boolean breed(){}
}
public interface FlyBird extends Bird{
     public boolean fly(){}
}
public interface NonFlyBird extends Bird{
}
```

6 Testing 16 points

1. Explain briefly what is the *testability* of a program. (2 point)

Answer

We will accept definitions from slide 10 or 12 of chapter 2.4.

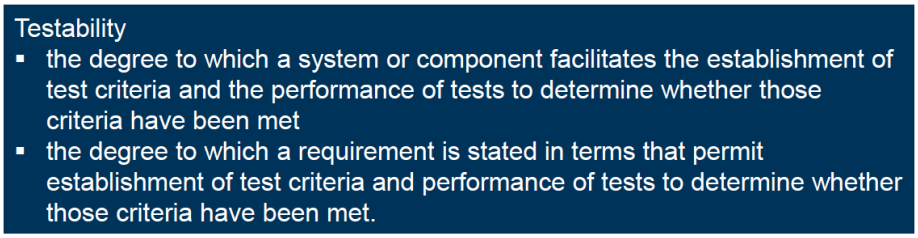


Figure 2: What is testability? (1)

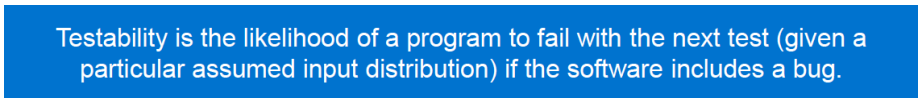


Figure 3: What is testability? (2)

2. The Storage-For-You company provides storage renting rooms for customers in various locations in Germany. As a tester for the company you are given the task of testing their storage processing system. Assume that a storage room record looks like this:

   - ID: int from 1 - 10000.
   - address: String [a-zA-Z0-9\s] with exactly 30 characters.
   - price: float, that varies form 5 euro per day to 20 euro per day. Rates are multiples of 0.5 euro.
   - size: float, that ranges from 1 to 30 meter squares. Sizes are multiples of 1 meter squares.

   (a) How many possible types of records (and thus test cases) are there? (3 point)

   ### Answer

   - ID: 10000
   - address: 63^{30} characters
   - price: 31 daily rates
   - size: 30 possible sizes

   In total we have:

   $$10000 \times 63^{30} \times 31 \times 30 \approx 8.89 \times 10^{60}$$

   (b) Assume the execution of each test case takes 2ms,

   i. Is it feasible to completely test this program? Justify your answer! (1 point)

   ### Answer

   No

   ii. How could you reduce the *input space* test the program without having issues later ? If you have a continues integration server that runs all test cases every night (assume a night lasts 11 hours) can you test all your test cases or do you need more servers ? (4 point)

Answer

As the high number of possibilities for the address has the biggest impact, it makes sense to reduce that number. String handling works in general pretty well, so it usually does not matter if the name is "street" or "str.". It does however make sense to test the *border cases*: Empty String, String with maximum length, String with max length+1 as well as an "average" string. So we could reduce the test set to these 4 test cases: "", "aaaaaaaaaaaaaaaaaaaaaaaaaaaaaa", 'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaz" and "Arcisstraße 21". We, however, have to assume that these Strings are indeed equivalent. If the program somehow uses the address for calculations we might have to change our tests.
This gives us:

$$10000 \times 4 \times 31 \times 30 = 37200000$$

test cases. In 11 hours we can run

$$(11 \times 60 \times 60 \times 1000) \div 2 = 19800000)$$

test cases. As 19800000 is smaller than 37200000 by almost half. We need 2 servers to fully test all test cases. 2 servers will be able to execute 39600000 test cases.

3. Consider the following Java code to find the factorial of a number .

```
static int factorial(int n){
    if (n == 0)
        return 1;
    else
        return(n * factorial(n-1));
}
```

(a) Write the JUnit tests for it "Assuming it should return 0 if there is an error". (2 points)

Answer

```
@Test
public void testFactorial(){
    assertEquals(1, factorial(0)); // Zero Case
    assertEquals(120, factorial(5)); // Normal Case
    assertEquals(0, factorial(-2)); // Negative Case
    assertEquals(0, factorial(Integer.MAX_VALUE)); // Overflaw Case
}
```

(b) Did the code pass all your tests or not ? If yes, why? If no, explain possible fail cases? (1 points)

Answer

No, because the developer didn't take into consideration:

i. Over-flaw problem when the input is integer but the output might need a long variable.

ii. Negative values. There is no factorial for negative values.

(c) Can you completely test this factorial function ? Justify your answer. (1 points)

Answer

In theory you could test all values from 0 to Integer.MAX_VALUE. In practice this is just not feasible, because recursion function is time consuming process and we can't execute all of these checks in reasonable amount of time.

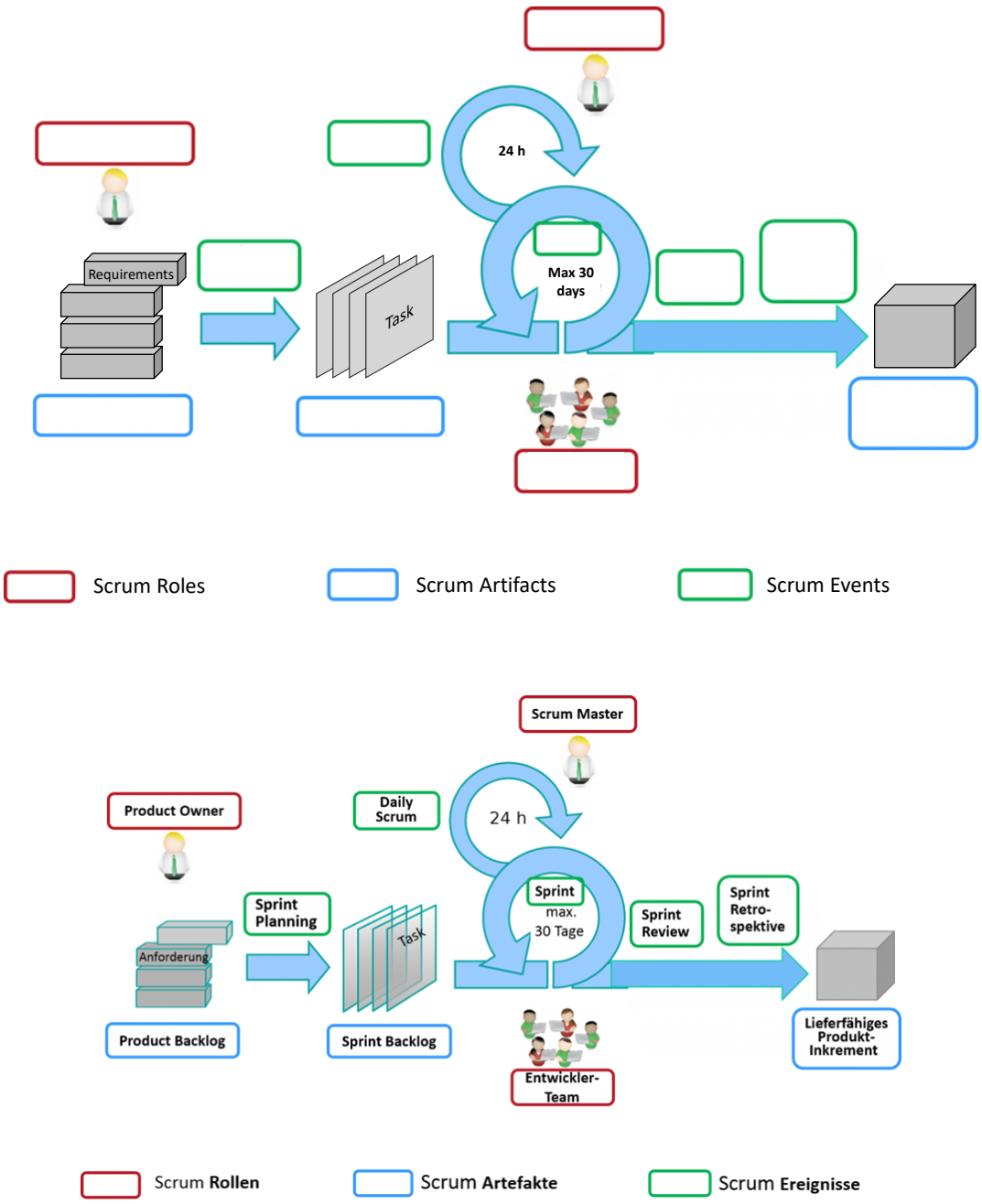
(d) Give two reasons that could cause a system to behave in a non-deterministic way during testing (i.e. flaky tests)? (3 points)

Answer

- Setup/Teardown: Developers are responsible for cleaning up the state and resetting it for consecutive tests. Often this can be difficult as you might want to make use of caching mechanism as setup times (e.g. starting a database server) can be long and costly.
- Concurrency: This can occur when either running tests in parallel, testing multi-threaded or asynchronous functionality.
- Caching: Sometimes due to time manipulation (time travel), cache evictions or stale data, the outcome of the test may become unpredictable.
- Dynamic (Asynchronous) Content: Especially in UI tests where content is loaded dynamically (e.g. AJAX). Tests might run faster than actual human interaction takes.
- Infrastructure Issues: Examples could be bugs in testing framework, network issues, database outages or CI misconfigurations.
- External systems: Integration tests that do not run against a stubbed external environment, inevitably depend on 3rd party systems which could be incorrect or have changed

7 Scrum and Software Quality 12 points

1. Fill in the missing artifacts in the schema of the Scrum Agile Methodology process. (6 points)



2. Name and briefly explain the scrum roles. (3 points)

- The **product owner** specifies firmly the common goal and prioritizes the tasks in the product backlog
- The **team / team members** estimates the efforts and benefits of the tasks in the backlog and chooses what it wants to achieve by the end of the next sprint

- The **scrum master** is responsible for the scrum process. He is neither a member of the team nor the product owner. He oversees the division of roles and the rights of other stakeholders. His goal is to achieve a smooth process.

3. Name and explain four software quality factors. (4 points)

8 Coupling and Cohesion 12 points

1. Explain the difference between coupling and cohesion. (2 points)

   - coupling: Measures the dependencies between subsystems
   - cohesion: Measures the dependencies among classes within a subsystem

2. Explain the relationship of coupling and cohesion of a bad system architecture. (2 points)

   - Low cohesion and high coupling
   - The subsystems are not independent of each other. The subsystems contain classes that do not depend on each other

3. Consider you are a software architect in a car manufactoring company. Look at the design of a car driving behavior analyzer, *iCarBehave*, and its related components in Fig. 4.

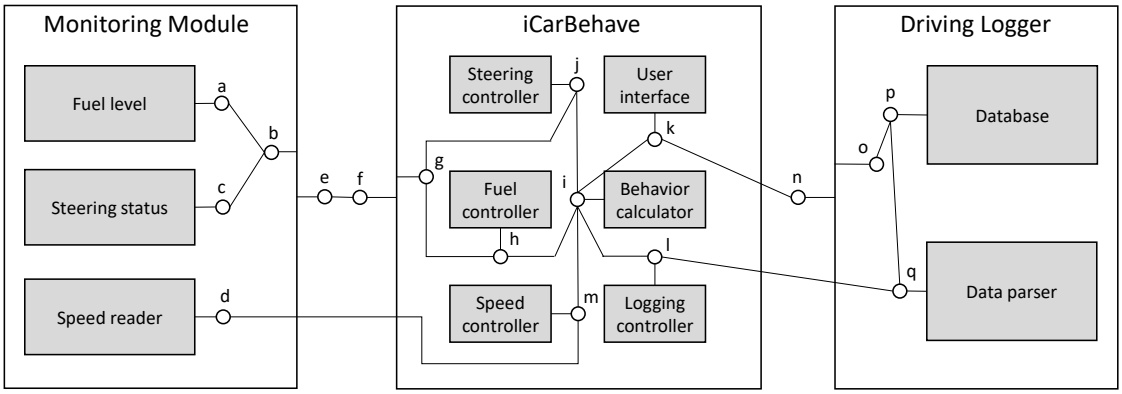


Figure 4: Car driving behavior analyzer, iCarBehave

Answer questions on the next page related to this design.

(a) Briefly explain 2 lowest coupling levels. (4 points)

Solution

1 point for correct naming, 1 point for correct explanation

i. Stamp: Complete data structures are passed from one component to another
ii. Data: Component passes data (not data structures) to another component

(b) List at-least *4 changes* that you can make in this system's design to decrease the coupling factor. (2 points)
Note: Example of one change may be removing a connection or adding a connection.

Solution

Examples of changes

i. Remove dm
ii. Connect dc
iii. Remove kn
iv. Remove lq
v. Connect lk

(0.5p for a correct change.)

(c) Name and explain the architecture principle that is violated on this example. (2 points)

Solution

Information hiding: A calling module (class, subsystem) does not need to know anything about the internals of the called module

9 Quiz 7 points

1. Evaluate the following statements (correct answers + 1 point, incorrect answers -1 point, you can not get less than 0 points overall): (7 Points)

Statement	**True**	**False**
Smart contracts guarantee correctness of code.		X
An embedded system is an information system integrated into a physical thing.	X	
Product Line Engineering increases development costs.		X
Continuous integration makes it more difficult to detect integration bugs.		X
Stateless EJBs persist over multiple sessions.		X
REST is language agnostic..	X	
In Autonomous Vehicle Testing, Acceptance Test verifies if the implementation meets business or functional requirements.	X	