M4 (a) – Design for Robustness

Jin L.C. Guo

Objective

- Programming mechanism:

Java Assertions

- Concepts and Principles:

Code style

- Design techniques:

Design by contract, Documentation

Consider the `enroll` method for `Course`

```
public class Course {

    private String aID;
    private int aCap;
    private List<Student> aEnrollment;



    public boolean enroll(Student pStudent) {
        if(aEnrollment.size()<aCap) {
            aEnrollment.add(pStudent);
            return true;
        }
        return false;
    }
    … …
}
```

can be student or Null

Can things go wrong?
(assume that Student is immutable)

enrolling a null student

Consider the `enroll` method for `Course`

```
public class Course {

    private String aID;
    private int aCap;
    private List<Student> aEnrollment;


    public boolean enroll(Student pStudent) {
        if(aEnrollment.size()<aCap) {
            aEnrollment.add(pStudent);
            return true;
        }
        return false;
    }
    … …
}
```

Things can still go wrong!

```
                        student == null

Course comp303 =
        new Course("COMP 303", 200);
comp303.enroll(student);
```

compiler wont error –
null will be added to list

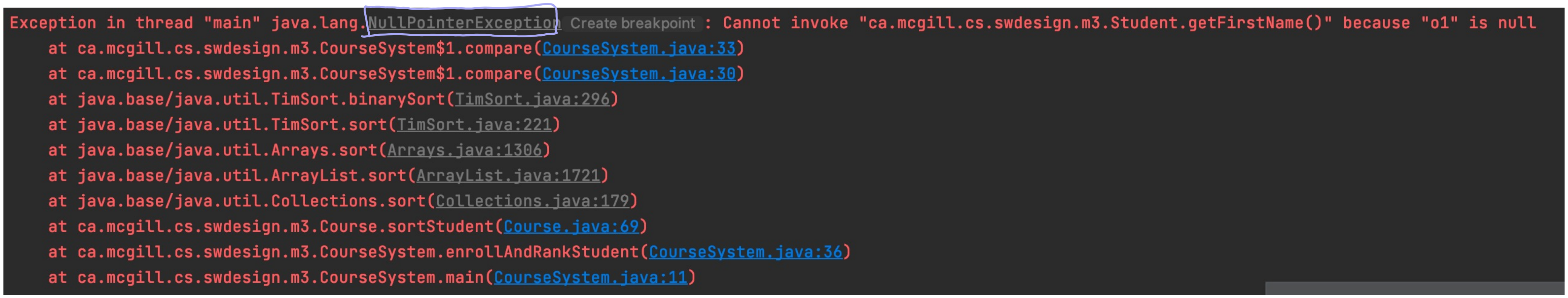
Consider the `enroll` method for `Course`

later

Things can still go wrong!

```
student == null

Course comp303 =
      new Course("COMP 303", 200);
comp303.enroll(student);
```

far from root cause ←
hard to fix



```
Exception in thread "main" java.lang.NullPointerException Create breakpoint : Cannot invoke "ca.mcgill.cs.swdesign.m3.Student.getFirstName()" because "o1" is null
    at ca.mcgill.cs.swdesign.m3.CourseSystem$1.compare(CourseSystem.java:33)
    at ca.mcgill.cs.swdesign.m3.CourseSystem$1.compare(CourseSystem.java:30)
    at java.base/java.util.TimSort.binarySort(TimSort.java:296)
    at java.base/java.util.TimSort.sort(TimSort.java:221)
    at java.base/java.util.Arrays.sort(Arrays.java:1306)
    at java.base/java.util.ArrayList.sort(ArrayList.java:1721)
    at java.base/java.util.Collections.sort(Collections.java:179)
    at ca.mcgill.cs.swdesign.m3.Course.sortStudent(Course.java:69)
    at ca.mcgill.cs.swdesign.m3.CourseSystem.enrollAndRankStudent(CourseSystem.java:36)
    at ca.mcgill.cs.swdesign.m3.CourseSystem.main(CourseSystem.java:11)
```

Fix ideas?

```
public class Course {

    private String aID;
    private int aCap;
    private List<Student> aEnrollment;



    public boolean enroll(Student pStudent) {
        if(aEnrollment.size()<aCap && pStudent!=null) {
            aEnrollment.add(pStudent);
            return true;
        }
        return false;
    }
     ……
}
```

Any drawbacks with this fix?

doesn't clearly communicate error to client

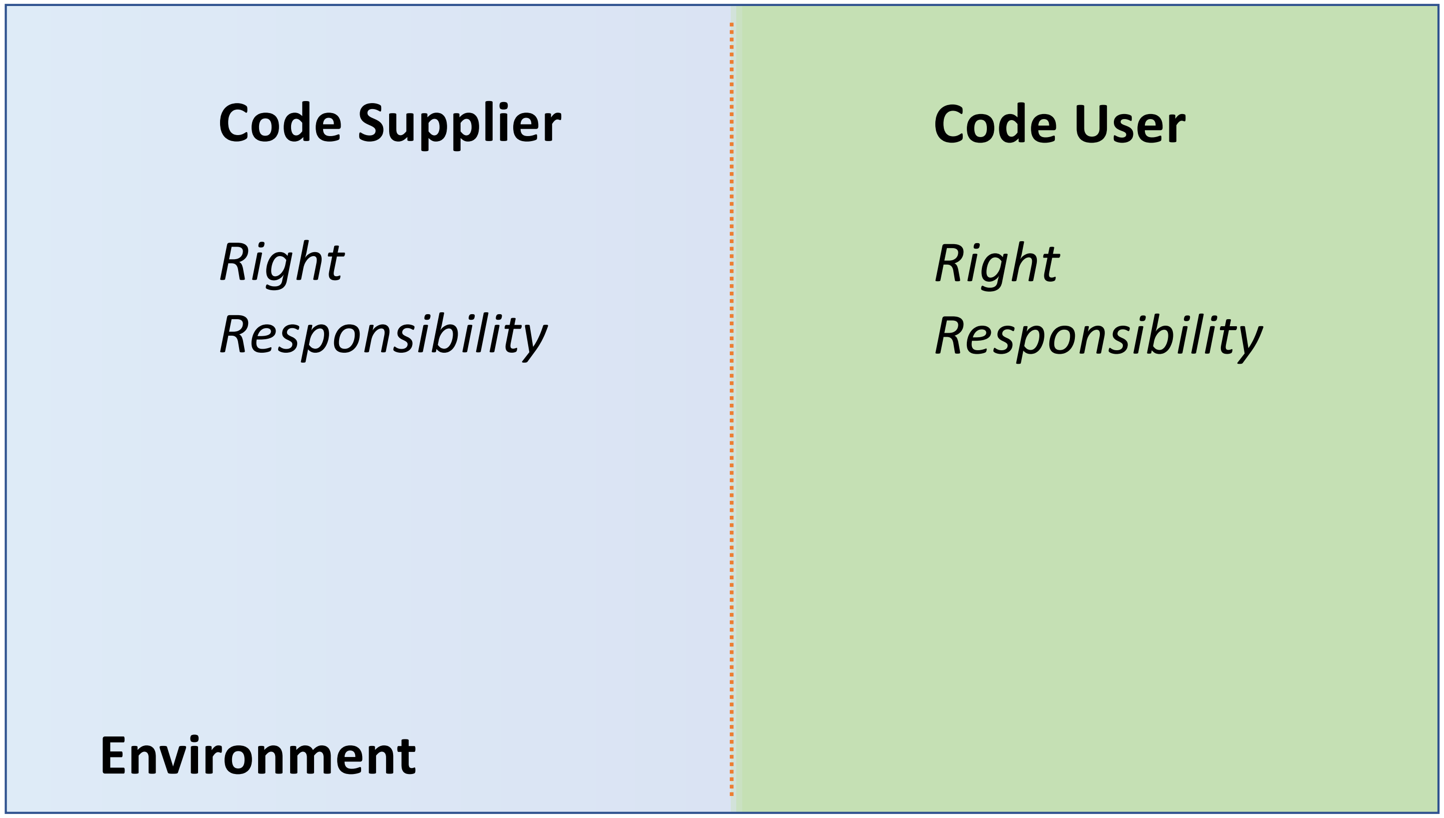
Fix ideas?

```
public class Course {

    private String aID;
    private int aCap;
    private List<Student> aEnrollment;

    public boolean enroll(Student pStudent) {
        if(pStudent == null)
            throw new IllegalArgumentException("The argument cannot be null");
        if(aEnrollment.size()<aCap) {
            aEnrollment.add(pStudent);
            return true;
        }
        return false;
    }

}
```

Defensive programming, more next class

assuming these can happen and are just handled as opposed to not allowing the event to happen at all

Contract (Human Interaction)



Example Contract (Human Interaction)

Employer

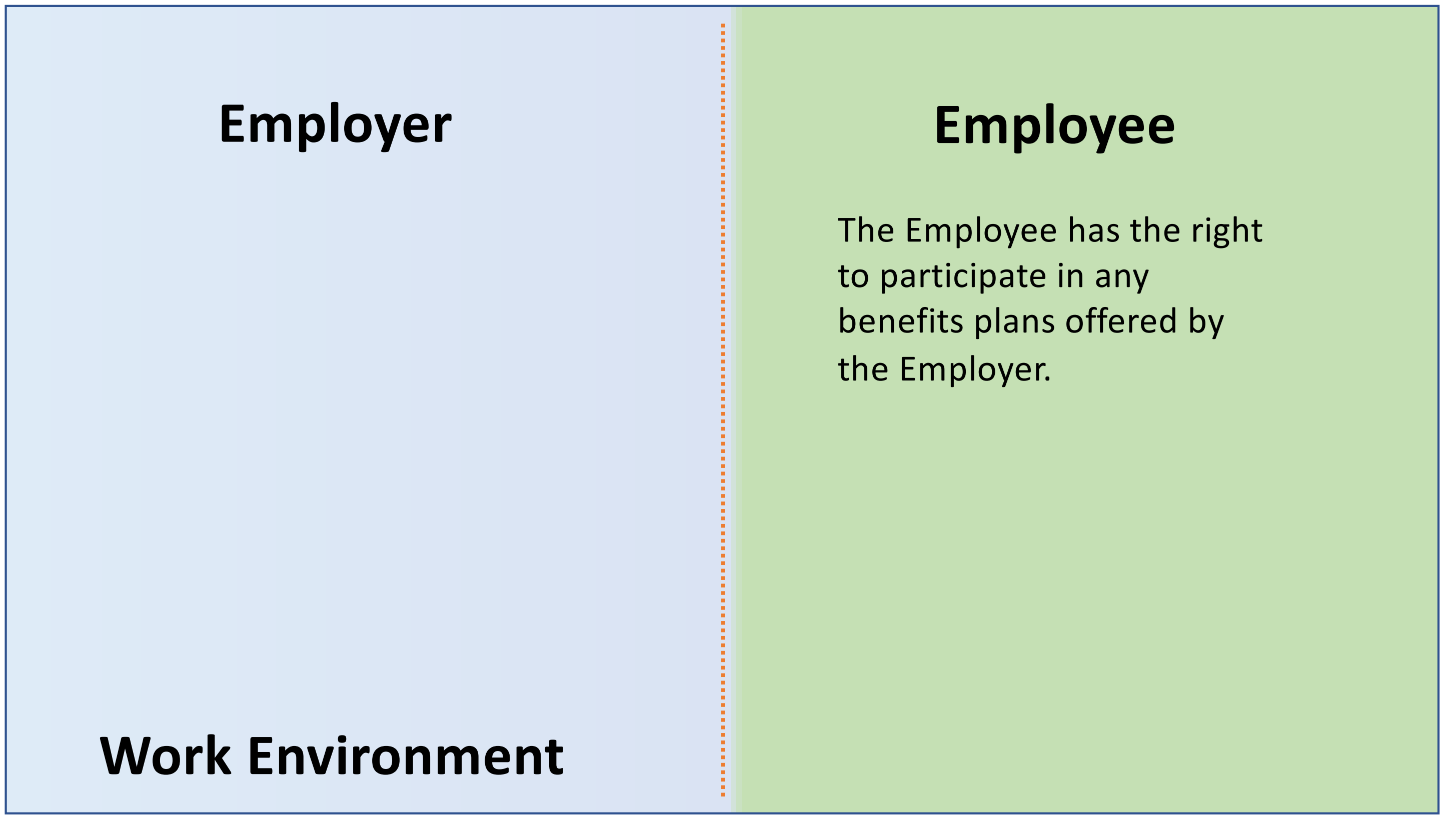
Work Environment

Employee

The Employee agrees that he or she will faithfully and to the best of their ability carry out the duties and responsibilities communicated to them by the Employer. The Employee shall comply with all company policies, rules and procedures at all times.

…

Example Contract (Human Interaction)



The Employee has the right to participate in any benefits plans offered by the Employer.

Example Contract (Human Interaction)

Employer

Provide employees with work, and pay for the work completed

Work Environment

Employee

Example Contract (Human Interaction)

Employer

Use all reasonable precautions to safeguard employees from workplace dangers, whether from the work environment, machinery, or tools;

Work Environment

Employee

Design by Contract

- Documenting rights and responsibilities of software modules to ensure program correctness

documenting during design process

Specify the interface

- Precondition – What must be true in order for the routine to be called.

  Code User's responsibility

  (provide correct parameters)

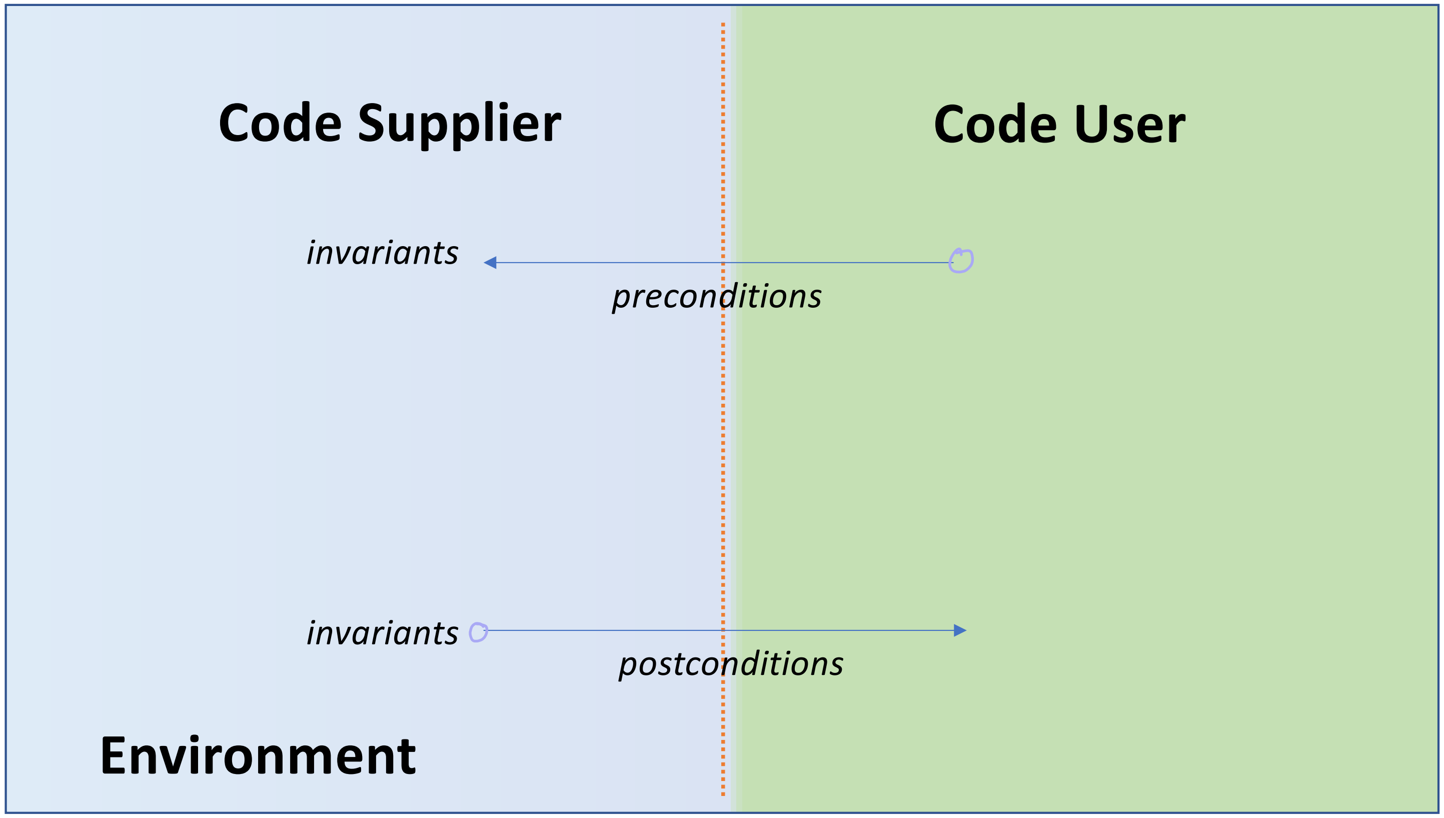
- Postcondition – What the routine is guaranteed to do; the state of the world when the routine is done.

  Code Supplier's responsibility

  compute correct return value

- Class invariants – Conditions that's always true (from the perspective of caller).

Design by Contract



Specify Contract

```
/**
 * @invariant aEnrollment != null && aEnrollment.size() <= aCap
 *
 */


 * … …
 * @pre pStudent != null && !isFull()
 * @post aEnrollment.get(aEnrollment.size()-1) == pStudent
 */

public void enroll(Student pStudent) {
    aEnrollment.add(pStudent);
}

public boolean isFull() {
    return aEnrollment.size() == aCap;
}
```

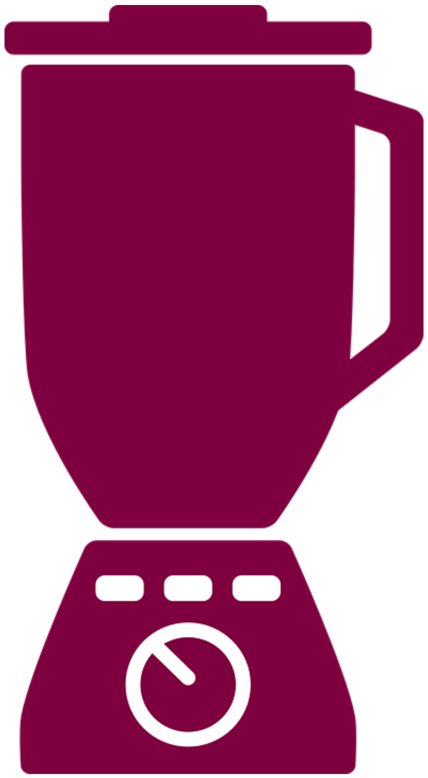
saves
space,

simple

Activity 1

- Design an interface to a kitchen blender. It has ten speed settings (0-9, 0 means off). You can only operate when it's full. You can change the speed only one unit at a time (that is, from 0 to 1, and from 1 to 2, not from 0 to 2). Add appropriate pre- and postconditions and class invariant.

```
int getSpeed()
void setSpeed(int pSpeed) @pre pSeed-getSpeed =abs(1)
                                          post
boolean isFull()
void fill() pre !isFull  post isfull
void empty() pre isFull  post isempty
```



```
/*
* @invariant if(getSpeed() >0) isFull()
* @invariant getSpeed()>=0 && getSpeed()<10
*/


/*
* @pre Math.abs(getSeepd() - pSpeed) == 1
* @pre pSpeed>=0 && pSpeed<10
* @post getSpeed() == pSpeed
*/
void setSpeed(int pSpeed)
```

client must satisfy

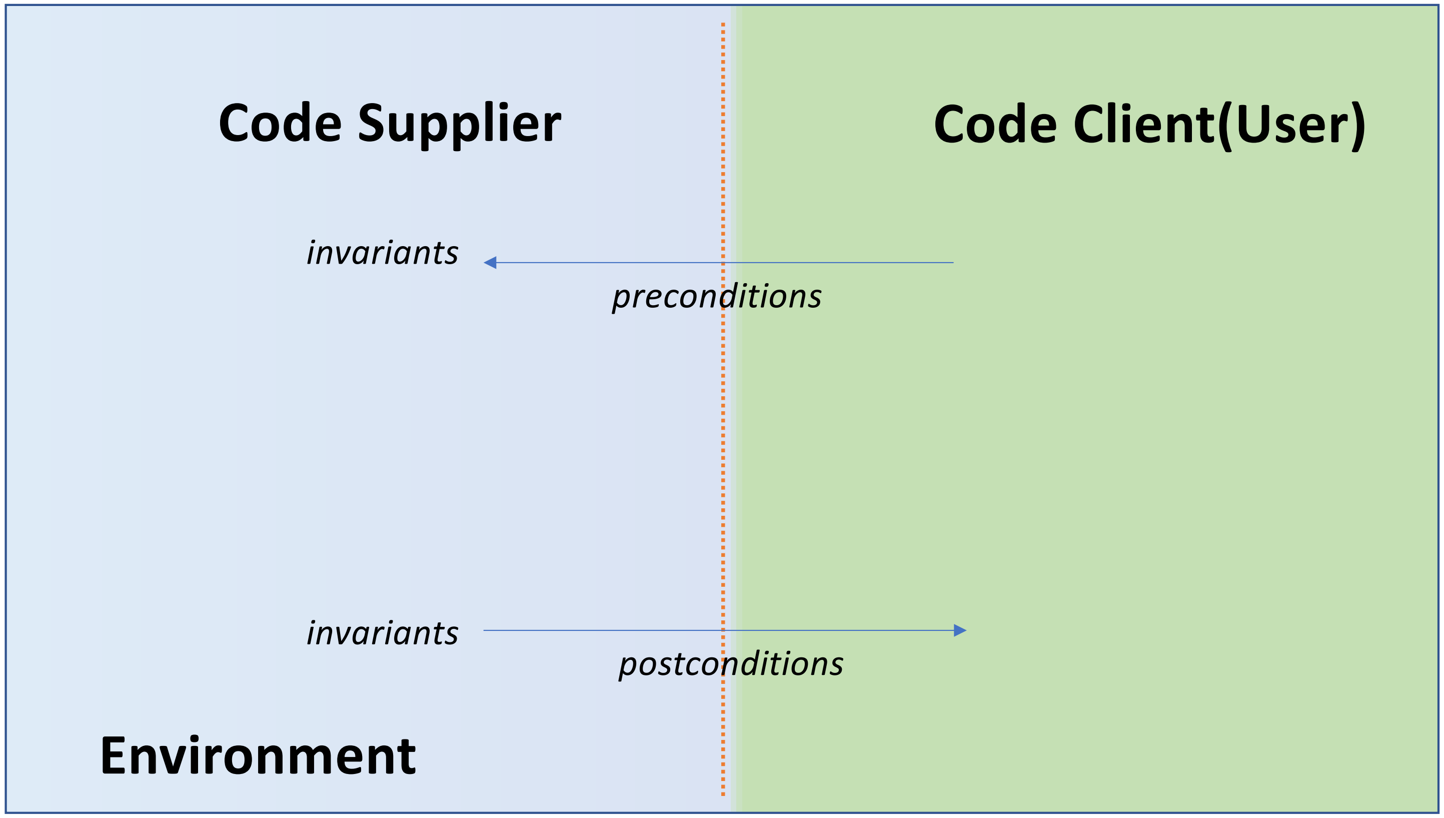
— designer gaurantees field will be properly set

```
/*
* @pre !isFull()
* @post isFull()
*/
void fill()
```

similar with empty()

ok to have post condition and no pre

Verifying Contract



Verifying Contract

- No build-in support in Java
- Partially achieved by assertion

Java Assertions

$\boxed{\text{assert}}$ *Expression1* ;

halts program right away

assert *Expression1* : *Expression2* ;

if *Expression1* is false throws an AssertionError

Safety-net, not enforcement!

Ensure things that shouldn't happened won't happen (correctness)

$\boxed{\textbf{java –ea}}$ runs Java with **a**ssertions **e**nabled (disabled by default)

(Partially) Verifying Contract in Java

```
/**
* … …
* @pre pRank != null && pSuit != null
* @post getRank() == pRank && getSuit() == pSuit
*/
public Card(Rank pRank, Suit pSuit)
{
    assert pRank != null && pSuit != null;
    aRank = pRank;
    aSuit = pSuit;
    assert getRank() == pRank && getSuit() == pSuit;

}
```

(Partially) Verifying Contract in Java

- Evaluate the following contract for a stack class

```
/**
* … …
* @pre pCard != null
* @post pop() == pCard
*/
public void push(Card pCard)
{… …}
```

pop() -> peek()

Heisenbug

a software bug that seems to disappear or alter its behavior when one attempts to study it.

Heisenberg

Design by Contract - Summary

- Purpose: ensure program correctness
- Correct -> does no more and no less than it claims to do
- Being "lazy": be strict in what you will accept before you begin, and promise as little as possible in return

put pressure on client

- Benefit: forces the issue of requirements and guarantees at design time – what your code (doesn't) promise to deliver
- Means: documenting and verifying

Documentation

- Interface
    - a comment block precedes the declaration of a class, data structure, or method.
- Data fields
    - a comment next to the declaration of a static or non-static variable.
- Implementation comments
    - a comment inside a method

Interface Documentation

- Define abstractions
- Information for using a class or method

Interface Documentation

- Define abstractions
- Information for using a class or method

The comment doesn't do any of those!

```
/**
* Returns an Image object by their url
*
* @param url image url
* @param  name image name
* @return      image object
*/
public Image getImage(URL url, String name) {
        try {
            return getImage(new URL(url, name));
        } catch (MalformedURLException e) {
            return null;
        }
}
```

lame

doesnt give info about using it

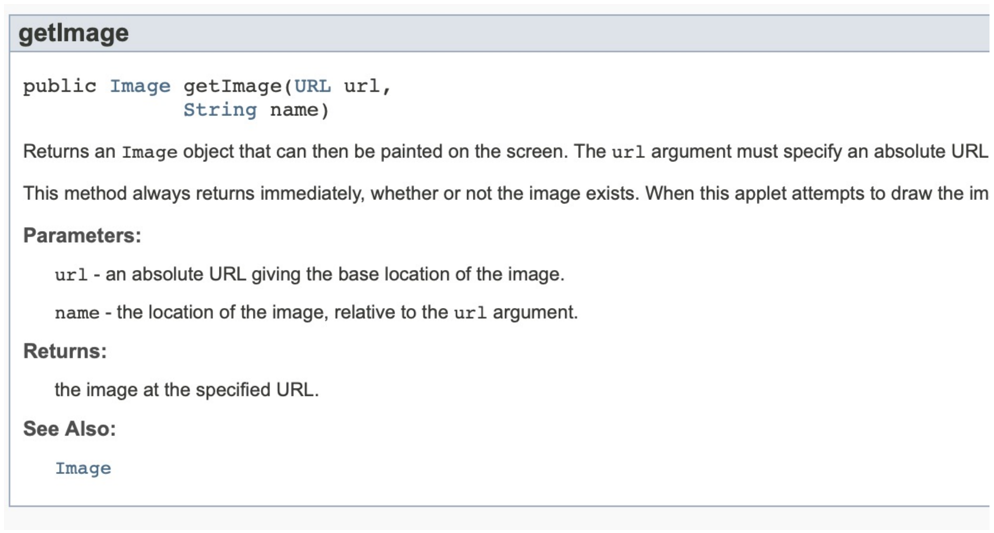
```java
/**
* Returns an Image object that can then be painted on the screen.
* The url argument must specify an absolute {@link URL}. The name
* argument is a specifier that is relative to the url argument.
* <p>
* This method always returns immediately, whether or not the
* image exists. When this applet attempts to draw the image on
* the screen, the data will be loaded. The graphics primitives
* that draw the image will incrementally paint on the screen.
*
* @param url   an absolute URL giving the base location of the image
* @param  name the location of the image, relative to the url argument
* @return      the image at the specified URL
* @see         Image
*/
public Image getImage(URL url, String name) {
        try {
            return getImage(new URL(url, name));
        } catch (MalformedURLException e) {
            return null;
        }
}
```

good

everything w/o a special annotation

Use Javadoc for Public APIs

- Documentation -> HTML pages describing the classes, interfaces, constructors, methods, and fields.



getImage

```
public Image getImage(URL url,
                      String name)
```

Returns an `Image` object that can then be painted on the screen. The `url` argument must specify an absolute URL

This method always returns immediately, whether or not the image exists. When this applet attempts to draw the im

Parameters:

`url` - an absolute URL giving the base location of the image.

`name` - the location of the image, relative to the `url` argument.

Returns:

the image at the specified URL.

See Also:

`Image`

Use Javadoc for Public APIs

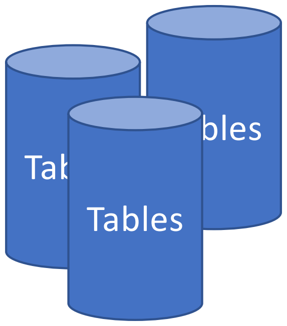
- @param
- @return
- @throws
- @see
- @author
- {@code}

… …

Adding customized tag is also possible
@custom.mytag

Activity 2

- IndexLookup class for distributed storage system.



Object	Name	Age	…
A-1	John	20	…
A-2	Elizabeth	21	…
…	…	…	…

```
IndexLookup query = new IndexLookup(table, index, key1, key2);
Iterator iterator = query.iterator();
while(iterator.hasNext())
{
    object = iterator.next()
    … …
}
```

Activity 2

- Does the user need to know the following:
  1. The format of message that **IndexLookup** class sends to the servers holding indexes and objects. no
  2. The comparison function used to determine whether a particular object falls in the designed range (comparison using integers, floating points, or strings) yes
  3. The data structure used to store indexes on servers 0
  4. Whether **IndexLookup** issues multiple requests to different servers concurrently yes / maybe
  5. The mechanisms for handling server crashes. no

Data field

- Explain, not ~~repeat~~

```
/**
* the horizontal padding of each line in the text
*/
private static final int textHorizontalPadding = 4;
```

Just repeating variable name = not helpful

vs

```
/**
* The amount of blank space to leave on the left and
* right sides of each line of text, in pixels.
*/
private static final int textHorizontalPadding = 4;
```

useful info
(unit)
(left/right)

Data field

- Fill in missing details (that you cannot get from name and type)

```
//Contains all term within the document and their number of
appearances
private TreeMap<String, Integer> termAppearances;
```

VS

```
//Hold the statistics about the term appearances within a
//document in the form of <term, count> where the term is the
//word in its dictionary form, and the count is how many times
//it matches the tokens in the document after preprocessing.
//If a term doesn't match any token in the document, then
//there's no entry for that term.
private TreeMap<String, Integer> termAppearances;
```

Implementation comments

- For understand what the code is doing
  - Add a comment before each major block for abstract description

```
// Compute the standard deviation of list elements that are
// less than the cutoff value.
for (int i = 0; i < n; i++) {
      ...
 }
```

- For understand why the code is written this way.

```
// Arbitrary default value, used to simplify the testing code
private static final int DEFAULT_DIMENSION = 1000;
```

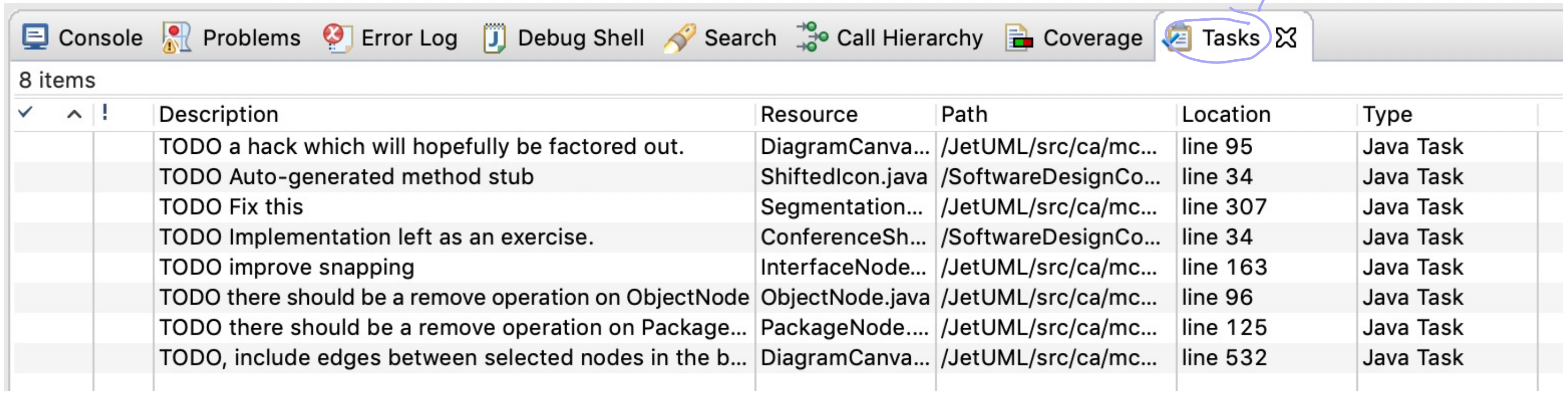
explain why 1000

More Informative Comments

- *Record Assumptions*
- *Record Limitations*
- *TODO comments* organize work

……

TODO



8 items

✓	^	!	Description	Resource	Path	Location	Type
			TODO a hack which will hopefully be factored out.	DiagramCanva...	/JetUML/src/ca/mc...	line 95	Java Task
			TODO Auto-generated method stub	ShiftedIcon.java	/SoftwareDesignCo...	line 34	Java Task
			TODO Fix this	Segmentation...	/JetUML/src/ca/mc...	line 307	Java Task
			TODO Implementation left as an exercise.	ConferenceSh...	/SoftwareDesignCo...	line 34	Java Task
			TODO improve snapping	InterfaceNode...	/JetUML/src/ca/mc...	line 163	Java Task
			TODO there should be a remove operation on ObjectNode	ObjectNode.java	/JetUML/src/ca/mc...	line 96	Java Task
			TODO there should be a remove operation on Package...	PackageNode....	/JetUML/src/ca/mc...	line 125	Java Task
			TODO, include edges between selected nodes in the b...	DiagramCanva...	/JetUML/src/ca/mc...	line 532	Java Task

Smells in Comments = bad

- Repeat the code
- About the implementation details too much / not necessary
- Journal comments recording progress / changes → use git instead
- Misleading comments
- Outdated comments – big / common problem
- … …

Comments As a Design Tool

Write comments first:

helpful

- Capture the abstraction before implementation
- Reveal potential problem of design (complexity)
- Improve quality of documentation

think abstractly

make it a habit

Code Style

- Goal: reduce complexity
  - to understand the code
  - to make future changes

when working with a team

eg google has a code style guide

Naming Entities

- Packages
- Classes/Enums
- Interfaces/Annotations
- Members of Reference types
- Parameters
- Local variables

Naming Entities

- Principle
  - Be clear and descriptive
  - Reveal your intention
  - Follow conventions
    - [Java Naming Conventions]
    - EJ3: 68

```
int d; // elapsed time in days
```

↓

```
int elapsedTimeInDays;
```

Formatting

- Braces
- Indentation
- Spacing

…

```
public class CommentWidget extends TextWidget
{
  public static final String REGEXP = "^#[^\r\n]*(?:(?:\r\n)|\n|\r)?";
  public CommentWidget(ParentWidget parent, String text){super(parent, text);}
  public String render() throws Exception {return “”; }
}
```

Not Easy to read…

long lines of code = bad

Formatting

- Braces
- Indentation
- Spacing

…

```java
return new MyClass() {
  @Override public void method() {
    if (condition()) {
      try {
        something();
      } catch (ProblemException e) {
        recover();
      }
    } else if (otherCondition()) {
      somethingElse();
    } else {
      lastThing();
    }
  }
};
```

Easy to read

Consistent

Acknowledgement

- Some examples are from the following resources:
  - *COMP 303 Lecture note* by Martin Robillard.
  - *The Pragmatic Programmer* by Andrew Hunt and David Thomas, 2000.
  - *Effective Java* by Joshua Bloch, 3rd ed., 2018.
  - *Clean Code* by Robert C. Martin, 2009
  - *A Philosophy of software design* by John Ousterhout, 2018