COMP61511 (Fall 2017)

Software Engineering Concepts *In Practice*

Week 2

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(bug reports welcome!)

Intellectual Property

Who Owns Your Code?

- You **wrote** some code!
  - All week!
  - Both systems and tests!
- A key question:
  - Who **owns** that code?
    - Or different bits of it?
  - What **kind** of ownership?

Intellectual Property (IP)

Intellectual property *is any articulable, tangible production of a mind whose physical realisations are restricted by law (in production, distribution, etc.)*

- We don't control what other people think!
- We can control what they **do** with certain thoughts.
- Intellectual Property rights give power to certain people to control what other people do
  - For example, whether they can distribute a book, song, or program

Kinds Of Intellectual Property

Name	Establishment	Enforcement
Copyright	Automatic, immediate	Civil and Criminal
Patent	Application; exposure before application destroys it	Mostly civil
Trademark	Application and vigorous defense	Mostly civil
Trade Secret	Automatic (by not telling people) and NDAs	Mostly civil

Copyright

Copyright *is a licensable monopoly of* ***tangible*** *expression of an idea with respect to reproduction, derivation, display, distribution, and the like.*

- Protects the **expression** not the **idea**
  - Though these **blur** at the limit
    - Some plagiarism is a copyright violation; some is not
- Typically **automatically assigned at creation time**
  - No "notice" or "registration" needed
    - Though these might help with lawsuits

Patents

*A **patent** is a licensable monopoly of the use or sale of a "non-obvious" **invention** (of a process, machine, design (sometimes), mechanism, procedure, etc.*

- A patent is an **incentive** to **disclose**
  - Many patentable inventions **could** be exploited "secretly"
  - Goal is to **add** to our **common** knowledge
- **Prior art** destroys a patent
  - Including **your own**
- **Defensive** patenting "common"
- **Independent** invention no defense

Trade Secret

> *A **trade secret** is an invention which is **not disclosed***

- Persists forever
  - Unless **leaked**
  - Or **re**invented
- Typically protected by **secrecy**
  - Or **specific** contracts
    - "**N**on-**D**isclosure **A**greements" (NDAs)

Who Owns Your Code?

- Copyright **starts** with the **creator**
  - I.e., you!
  - Cheap! (Even to register)
  - Unless you create it as **work-for-hire**
    - Or **otherwise** transfer it
- Patents belong to the **patenter**
  - Expensive(ish) to secure
- Trade secrets belong to the **inventor**

Are You Working For Hire?

- Not **quite**!

3.6. **Student IP Licence to the University**

3.6.1. Each Student grants to the University a licence to use the:

3.6.1.1. IP created by him or her in the course of his/her studies at the University and which they own; and

3.6.1.2. IP in any thesis or dissertation submitted to the University for the award of a degree.

3.6.2. In each case, the licence will take effect upon the creation of the relevant IP.

3.6.3. The licence:

3.6.3.1. is a continuing, non-exclusive, worldwide, irrevocable, royalty-free licence to use the IP in any format (whether existing or future);

3.6.3.2. will last for as long as the relevant IP remains in existence; and

3.6.3.3. is granted so that the University can (i) use such IP for its and its subsidiaries' administrative, promotional, educational and teaching purposes; and (ii) do all such things in relation to such IP which would otherwise be an infringement of such IP.

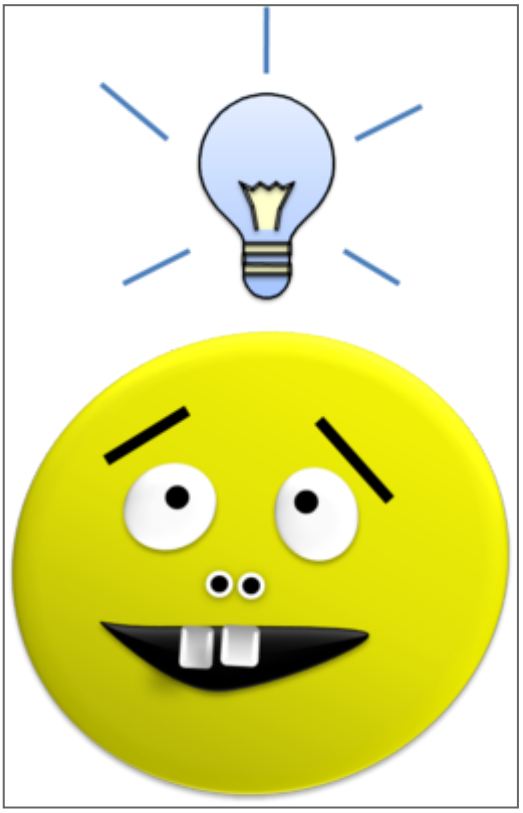
3.6.4. As part of the licence, the University is also permitted to sub-license to others the rights granted to it by Students.

3.6.5. Any thesis or dissertation submitted to the University for the award of a degree may be placed by the University in its institutional repository in electronic or other format.

What To Keep In Mind (Now)

- Software engineers typically **produce** IP
  - Even if not protected, our **output** is "intellectual"
  - Various forms of IP drive
    - **product** value
    - **employee**/**entrepreneur** value
- Software engineers typically **use** IP
  - All sorts and in all ways
  - IP considerations a constraint on the design space

Comprehending Product Qualities



Comprehension?

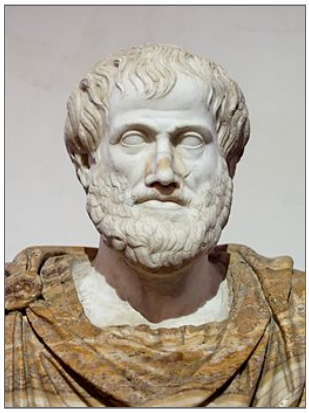
- We can distinguish two forms:
  - Know-that
    - You believe a **true** claim about the software
    - …with appropriate evidence
  - Know-how
    - You have a **competancy** with respect to the software
    - E.g., you know-how to recompile it for a different platform
- They are interrelated
- Both require significant effort!

Quality Levels

- We talked about different kinds of quality
  - But for each kind there can be degrees or **levels** thereof
  - "Easy" example: High vs. Low performance
- Most qualities in principle are **quantifiable**
  - Most things are quantifiable in some sense
- But reasonable quantification isn't always **possible**
  - Or **worth it**
  - Being clear about your vagueness is essential!

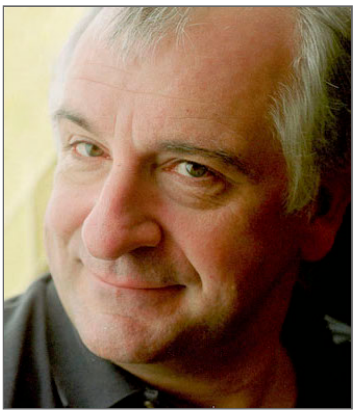
Clarity

Our discussion will be adequate if ***it has as much clearness as the subject-matter admits of****, for precision is not to be sought for alike in all discussions, any more than in all the products of the crafts...for it is the* ***mark of an educated [person]*** *to look for precision in each class of things just so far as the nature of the subject admits...*
— Aristotle, Nicomachaen Ethics, ***Book 1, 3***



Clarity (2)

*We demand **rigidly defined** areas of **doubt** and **uncertainty**!*
— Douglas Adams, The Hitchhiker's Guide to the Galaxy



Defects As Quality Lacks

> *A **defect** in a software system is a **quality level** (for some quality) that is **not acceptable**.*

- Quality levels need to be elicited and negotiated
  - All parties must agree on
    - **what** they are,
    - their **operational definition**
    - their **significance**

What counts as a defect is often determined late in the game!

Question

If your program crashes then it

1. definitely has a bug.
2. is highly likely to have a bug.
3. may or may not have a bug.

Question

If your program crashes, and the cause is in your code, then it

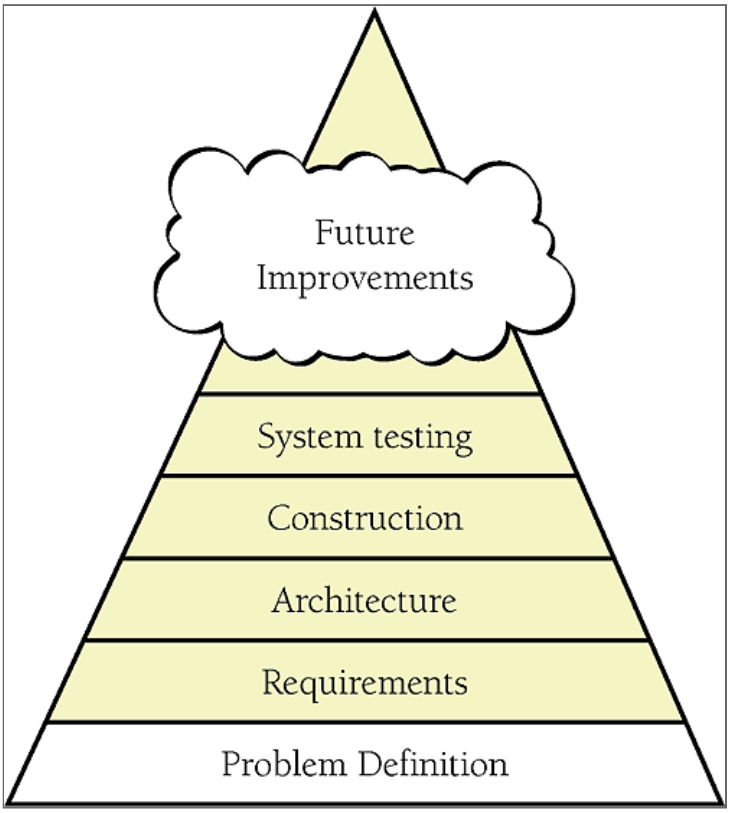
1. definitely has a bug.
2. is highly likely to have a bug.
3. may or may not have a bug.

Bug Or Feature?

(**Does QA hate you?** — scroll for the cartoons as well as the wisdom.)

- Even a **crashing code path** can be a **feature**!
- Contention arises when the stakes are high
  - and sometime the stakes can seem high to some people!
  - defect rectification costs the same
    - whether the defect is **detected**...
    - ...or a feature is **redefined**
- Defects (even redefined features) aren't personal

Problem Definition



This is a logical, not temporal, order.

Problem Definition

> *The penalty for failing to define the problem is that you can waste a lot of time solving the wrong problem. This is a double-barreled penalty because you also don't solve the right problem.*
> —***McConnell, 3.3***

Quality Assurance

- Defect **Avoidance** or **Prevention**
  - "Prerequisite" work can help
    - Requirement negotiation
    - Design
    - Tech choice
  - Methodology
- Defect **Detection** & Rectification
  - If a defect exists,
    - Find it
    - Fix it

The Points Of Quality

1. Defect **prevention**
    - Design care, code reviews, etc.
2. Defect **appraisal**
    - Detection, triaging, etc.
3. **Internal** rectification
    - We fix/mitigate before shipping
4. **External** rectification
    - We cope after shipping

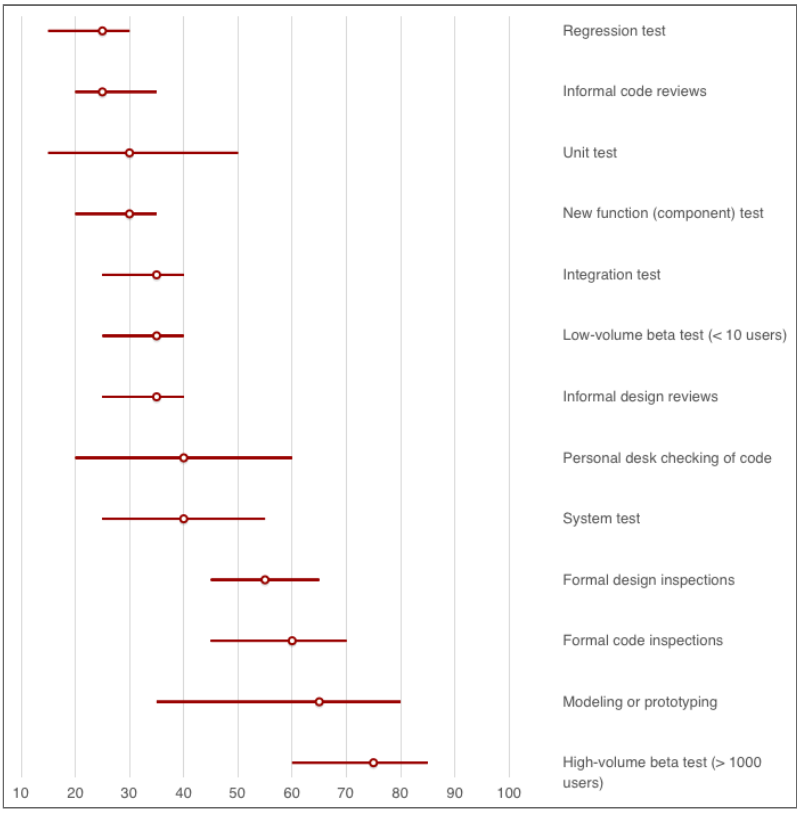
Defect Detection Techniques

Table 20-2. Defect-Detection Rates

Removal Step	Lowest Rate	Modal Rate	Highest Rate
Informal design reviews	25%	35%	40%
Formal design inspections	45%	55%	65%
Informal code reviews	20%	25%	35%
Formal code inspections	45%	60%	70%
Modeling or prototyping	35%	65%	80%
Personal desk-checking of code	20%	40%	60%
Unit test	15%	30%	50%
New function (component) test	20%	30%	35%
Integration test	25%	35%	40%
Regression test	15%	25%	30%
System test	25%	40%	55%
Low-volume beta test (<10 sites)	25%	35%	40%
High-volume beta test (>1,000 sites)	60%	75%	85%

Source: Adapted from *Programming Productivity* (Jones 1986a), "Software Defect-Removal Efficiency" (Jones 1996), and "What We Have Learned About Fighting Defects" (Shull et al. 2002).

Defect Detection Techniques



Experiencing Software

- It's one to know that there are bugs
  - **All** software has bugs!
- It's another to be able to **trigger** a bug
  - Not just a specific bug!
  - If you understand the software
    - You know how to break it.
- Similarly, for **making changes**
  - tweaks, extensions, adaptions, etc.
- The more command, the more modalities of mastery

Forms Of Knowledge (Manifestations)

- **Human interpretable**
  - Comments, design docs, user stories, javadoc
  - **Source code**
    - Both, a written description and a "live" object
    - Also things like demo code, examples, test suites, ec.
  - **Diagrams**
    - "Mere" pictures to semi-formal to formal diagrams: ER docs, UML, etc.
- **Formal specifications**
- **Competencies**
  - I can **make it crash**

Sources Of Knowledge (Modalities)

- **Analytical** knowledge
  - Derived from **inspection** and **reasoning**
  - Can be **automated** using formal methods
- **Experimental** knowledge
  - Derived from the conduct of experiments
  - Typically tests
- **Experiential** knowledge
  - Derived from **personal interaction** with the software
  - Strong "know-how" component

Coursework Recap

Coursework Activities

- Reading
- Q1
  - Mostly related to reading
  - Mostly "Recall"...with some interpretation
    - They will go higher on the Bloom taxonomy!
- SE1
  - Reading and analysing
- CW1
  - **Reverse engineered** a specification
  - **Reengineered** `miniwc` from the spec
    - Program construction

A Note On Marks

- UK marks run from 0-100%
  - <=49 = Failing (<40% **serious** failure)
  - 50-59 = Pass
  - 60-69 = Merit
  - over 70 = Distinction
  - NOTE THE WIDE BAND AT THE TOP AND BOTTOM
- A 65% is a **good mark**
- An 85% is **exceedingly** rare
- Over 70% is **fairly rare**

Q1

- Mean of 3.71 (74%)
  - This is unusual for MCQs
- We will do some "in exam conditions"
- Let's delve

Simplified Problem

- This was a **small** problem
  - With clear boundaries
- Even here:
  - We ended up with **support programs**
    - And corners cut
- Software engineering is (complex) system engineering
  - On both the **product** and **project** sides
  - We use a complex infrastructure!

Challenges

*What were the **challenges** you encountered?*

*What challenges were **inherent** to the problem?*

*What challenges were **environmental**?*

FizzBuzz And Golf!

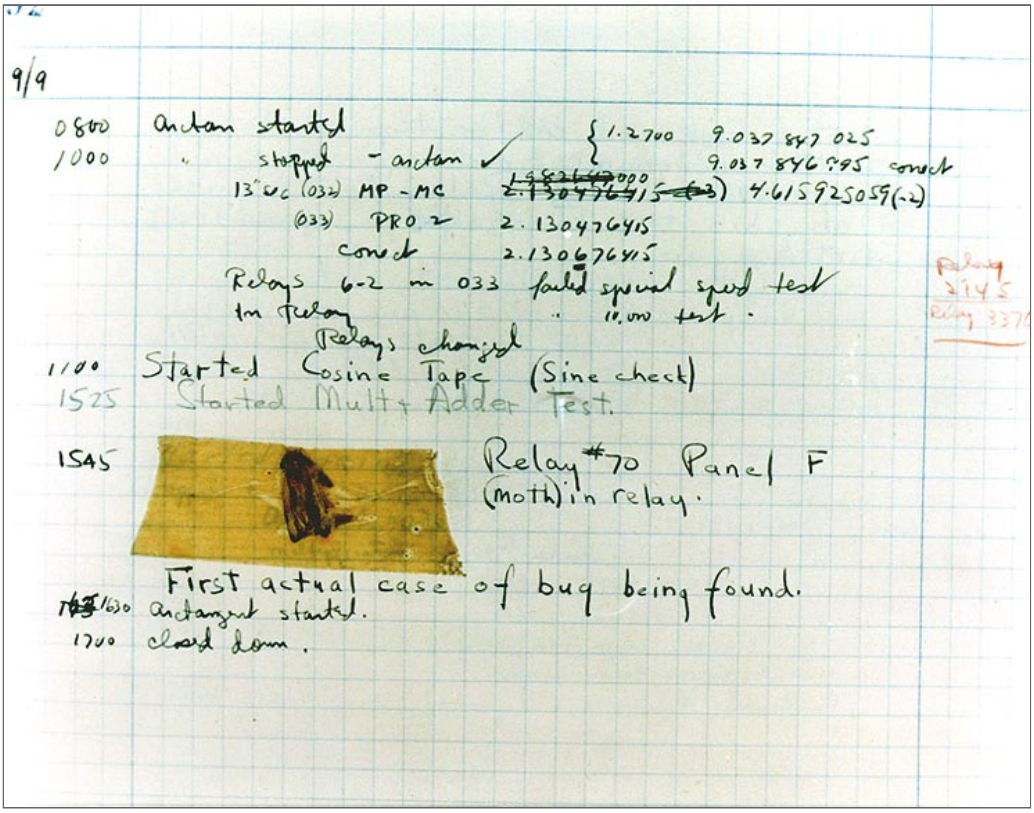
- Will have some more data soon!
- But we have a winner!

ID	Lines	Words	Cha
j02654hg_Lab1	1	8	83
mbax9jc7_Lab1	1	7	94
mbaxtmb3_Lab1	1	13	104
mbaxtod2_Lab1	9	15	134
mbaxtsd2_Lab1ERROR	13	23	155

Testing Correctness

> ***Beware of bugs*** *in the above code; I have only* ***proved*** *it correct, not* ***tried*** *it.*
> *— Don Knuth,* ***Figure 6: page 5 of classroom note***

Really Beware Of Bugs!



—Grace Hopper's **Bug Report**

Developer Testing

- We can distinguish between
  - Testing done by **non-specialists** (McConnell: "Developer testing")
    - For many projects, the only sort!
  - Testing done by (test) **specialists**
- If you **compile** and **run** your code
  - Then you've done a test! (or maybe two!)
    - If only a **"smoke" test**

*Testing is **inescapable**; **good** testing takes **work***

Question Time!

- If you **compile** your code
  - you have tested it for syntactic correctness.
  - you have tested it for semantic correctness.
  - you have tested it for both.
  - you haven't tested it at all.

What Is A Test?

> *A **test case** is a **repeatable** execution situation of a software **system** that produces recordable outcomes. A **test** is a **particular attempt** of a test case*

- The outcomes may be **expected** (i.e., specified in advance)
  - E.g., we expect passing `1+1` to a calculator to return `2`
  - Generally boolean outcomes (**pass** or **fail**)
    - We might have an **error** that prevents completion
- The outcomes may be **measurement** results
  - E.g., we want to find the **time** it takes to compute `1+1`

What Is A Test? (2)

*A **test case** is a **repeatable** execution situation of a software **system** that produces recordable outcomes. A **test** is a **particular attempt** of a test case*

- The outcomes should testify to some software **quality**
  - E.g., correctness, but also efficiency, usability, etc.
- A (single) test specifies a **very particular** quality
  - E.g., correct **for a given input**
  - E.g., uses X amount of memory **for this scenario**

*The **fundamental challenge** of testing is **generalisability***

Generalisability Problem (1)

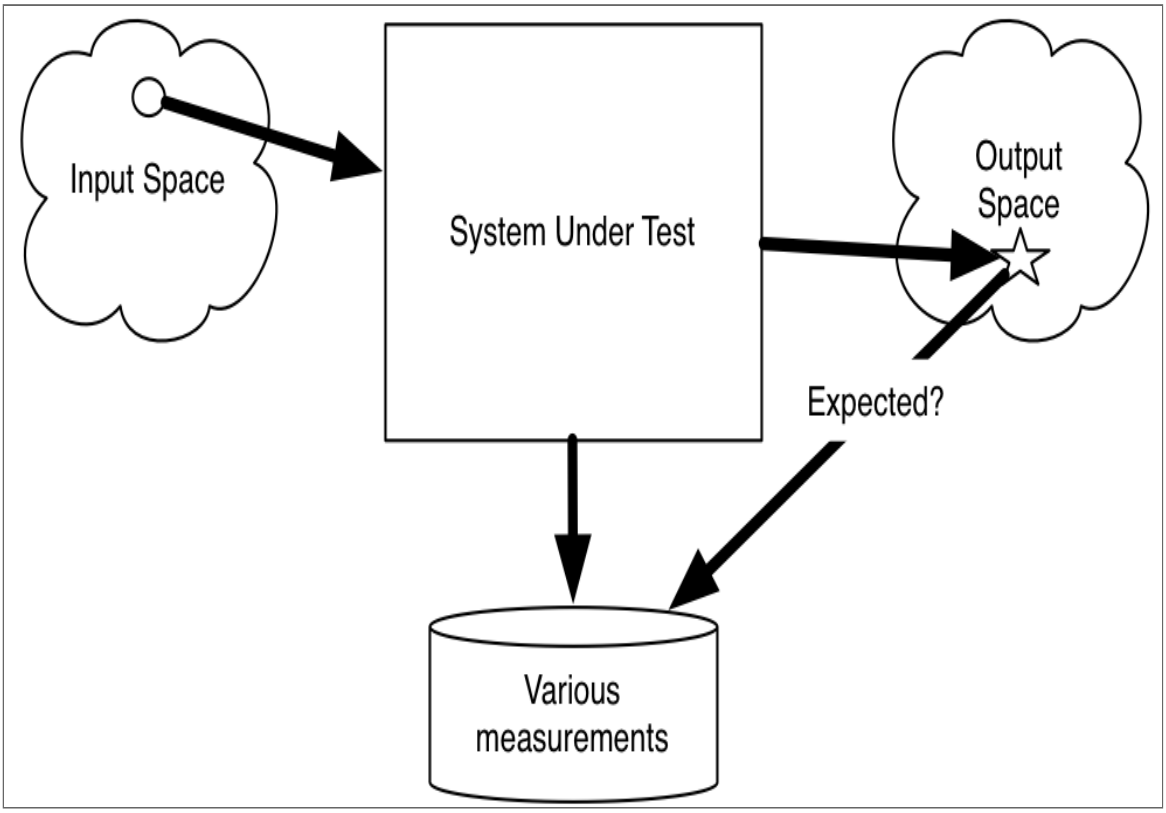
*Testing shows the **presence**, not the **absence** of bugs.*
*—Edsger W. Dijkstra, **Nato Software Engineering Conference, pg 16 1969***

Terminology Note

- **Test** and **test case** are often used interchangeably
  - And in other loose ways
  - Most of the time it doesn't matter because easy to distinguish
- We often talk about a **test suite** or **test set**
  - But this also might be subordinated to a *test*
  - For example,

> *"We used the following **test suite** to **stress test** our application".*

Anatomy Of A Test (1)



Generalisability Threat

- A test case (A):
  - **Goal:** Correctness to the specification
    - **Input:** a pair of integers, `X and Y`
    - **Output:** the integer that is their `sum`
  - **Test Input:**
    - `X=1` and `Y=1`
  - **Expected output:**
    - `2`
- Test result of System S is **pass**
  - What can we conclude?

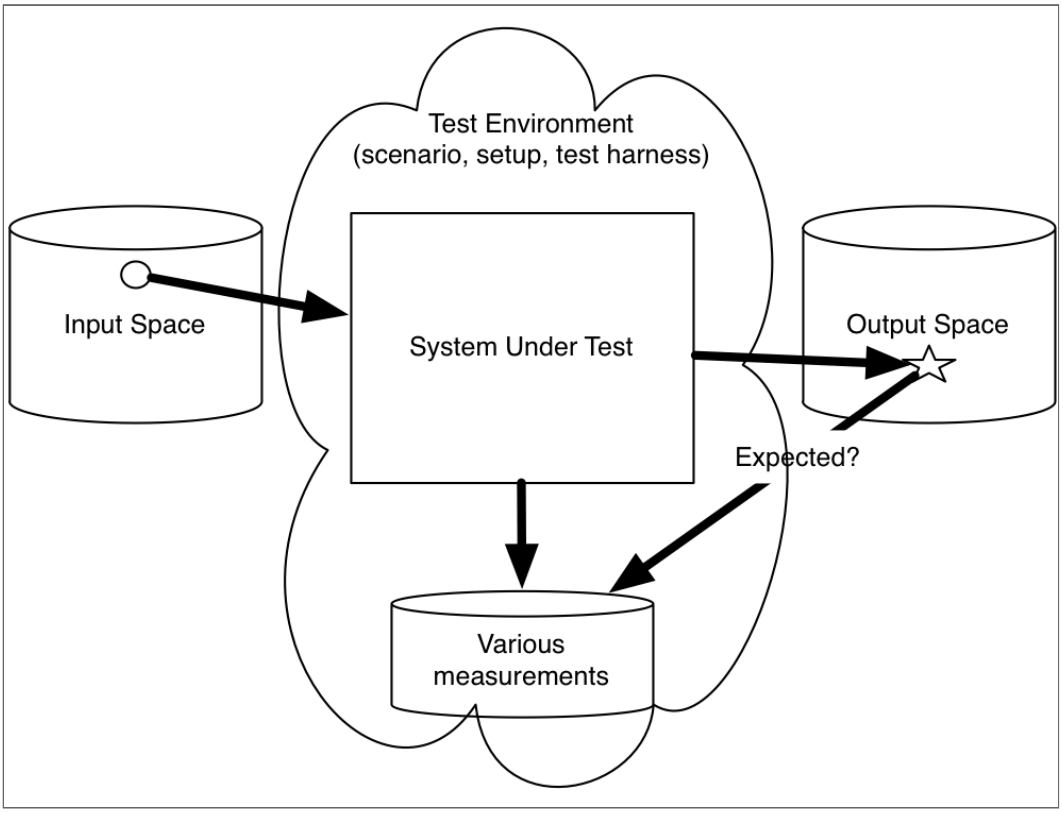
Question Time!

- From the test result **Pass test case A**, we can conclude that:
  1. System S **correctly implements** the specification.
  2. System S **correctly implements** the specification **for this input**
  3. Both 1 and 2
  4. Neither 1 nor 2

Question Time!

- From the test result **Fail test case A**, we can conclude that:
  1. System S **does not correctly implement** the specification.
  2. System S **does not correctly implement** the specification **for this input**
  3. Both 1 and 2
  4. Neither 1 nor 2

Anatomy Of A Test (2)



Environment Matters

The next most significant subset of [Modification Requests (MRs)] were those that ***concern testing*** *(the testing environment and testing categories)—* ***24.8% of the MRs****. ...it is not surprising that a significant number of problems are encountered in testing a large and complex real-time system...First, the* ***testing environment*** *itself is a* ***large and complex system that must be tested****. Second, as the real-time system evolves, so must the* ***laboratory test environment evolve****.*
Making Software, pg. 459.

A Good Test

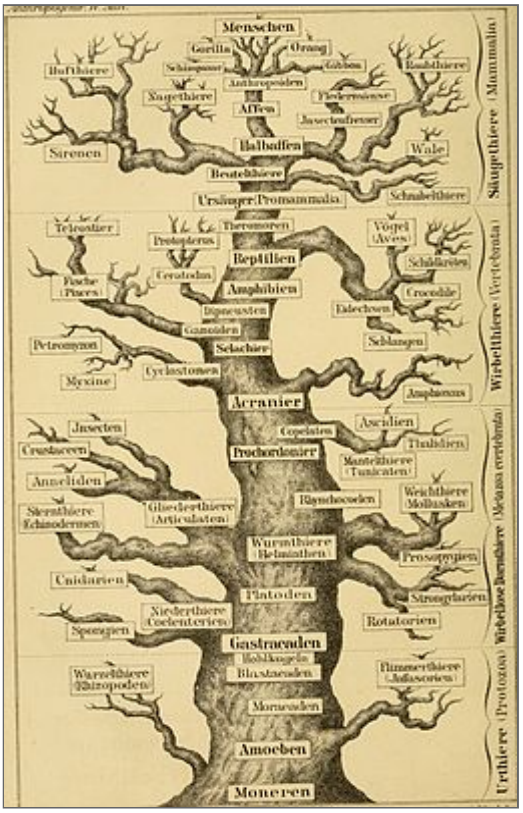
- A good test case is
  - **part** of a suite of test cases
  - **understandable**
    - i.e., you can relate it
      - to the spec
      - to the system behavior
  - **fits in** with the test environment
  - is (given the suite) **informative**

Environment Matters

Table 25-1 Summary of faults (modified) *Making Software pg 459*

MR Category	Proportion		
Previous	4.0%		
Requirements	4.9%		
Design	10.6%	**D+C**	**D+C+R**
Coding	18.2%	28.8%	33.7%
Testing Environment	19.1%	**TE+ T**	
Testing	5.7%	24.8%	
Duplicates	13.9%		
No problem	15.9%		
Other	7.8%		

A Classification Of Tests



A Classification Of Tests

- Based on a 5W+H approach by **Ray Sinnema** (archived)
  - **Who** (Programmer vs. customer vs. manager vs…)
  - **What** (Correctness vs. Performance vs. Useability vs…)
  - **When** (Before writing code or after)
    - Or even before architecting!
  - **Where** (Unit vs. Component vs. Integration vs. System)
    - Or lab vs. field
  - **Why** (Verification vs. specification vs. design)
  - **How** (Manual vs. automated)
    - On demand vs. continuous

Who?

- Sinnema: Tests give **confidence** in the system
  - I.e., they are **evidence** of a **quality**
  - **Who** is **getting** the evidence?
    - **Users?** Tests focus on **external** qualities
      - Can I **accept** this software?
    - **Programmers?** Tests focus on **internal** qualities
      - Can I **check in** this code?
    - **Managers?** Both?
      - Are we **ready to release**
- But also, **who** is **writing** the test?
  - A bug report is a (typically partial) test case!

What?

- Which **qualities** am I trying to show?
  - Internal vs. external
  - Functional vs. non-functional?
  - Most **developer testing** is functional (i.e., correctness)
    - And at the unit level
    - Does this class **behave as designed**

When?

- **When** is the test written?
  - **Before** the code is written?
  - **After** the code is written?
- Perhaps a better distinction
  - Tests written with **existing code/design in mind**
  - Test written **without regard** for existing code/design
  - This is related to white vs. black box testing
    - Main difference is whether you **respect the existing API**

Where?

- **Unit**
  - Smallest "chunk" of coherent code
  - Method, routine, sometimes a class
  - **McConnell**: "the execution of a **complete class, routine, or small program** that has been written by a **single programmer or team of programmers**, which is tested **in isolation** from the more complete system"
- **Component** (McConnell specific, I think)
  - "work of **multiple programmers or programming teams**" and **in isolation**

Where? (Ctnd)

- **Integration**
  - Testing the **interaction** of two or more units/components
- **System**
  - Testing the system as a whole
  - In the lab
    - I.e., in a controlled setting
  - In the field
    - I.e., in "natural", uncontrolled settings

Where? (Ctnd Encore)

- **Regression**
  - A bit of a funny one
  - **Backward looking** and **change oriented**
    - Ensure a change **hasn't broken anything**
    - Esp previous fixes.

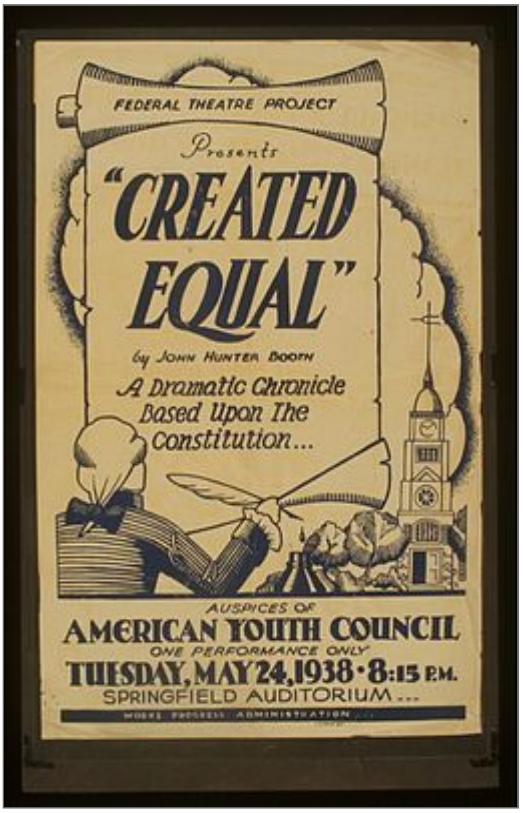
Why?

- Three big reasons
  1. **Verification** (or validation)
     - Does the system possess a quality to a certain degree?
  2. **Design**
     - Impose constraints on the design space
       - Both structure and function
  3. **Comprehension**
     - How does the system work?
       - Reverse engineering
     - How do I work with the system?

How?

- **Manual**
  - Typically interactive
    - Human intervation for more than initiation
  - Expectations **flexible**
- **Automated**
  - The test executes and evaluates on initiation
  - Automatically run (i.e., continuously)

Program Equivalence



Many Equivalences

- Source code equivalent
  - Character equivalent
  - AST equivalent
  - Non-comment/names AST equivalent
- Translation equivalent
  - E.g., after compilation
- All-behavior equivalent
- Bisimilar
- Functionally equivalent

Functionally Equivalent

*Two programs are **functionally equivalent** just in case they implement exactly the same functionality.*

- Functionality is typically characterised by "Input-Output" behaviour
  - Internal structure doesn't matter
    - Programming language, algorithm, etc.
      - FEPs can differ "solely" in execution paths
  - There can be **behaviour** differences (e.g., performance!)
- Strong but not maximally strong!

What Behaviour Is "Functionality"?

> *The **functionality** of a software system is the **required** behaviour of the system*

Not ideal, as non-functional behaviour may be required

> *The **functionality** of a software system is the behaviour of the system that performs some user task*

In either cause, the functionality is a **subset** of all behaviour

Functionality Equivalent (Reprise)

*Two programs are **functionally equivalent** just in case they implement exactly the **same functionality***

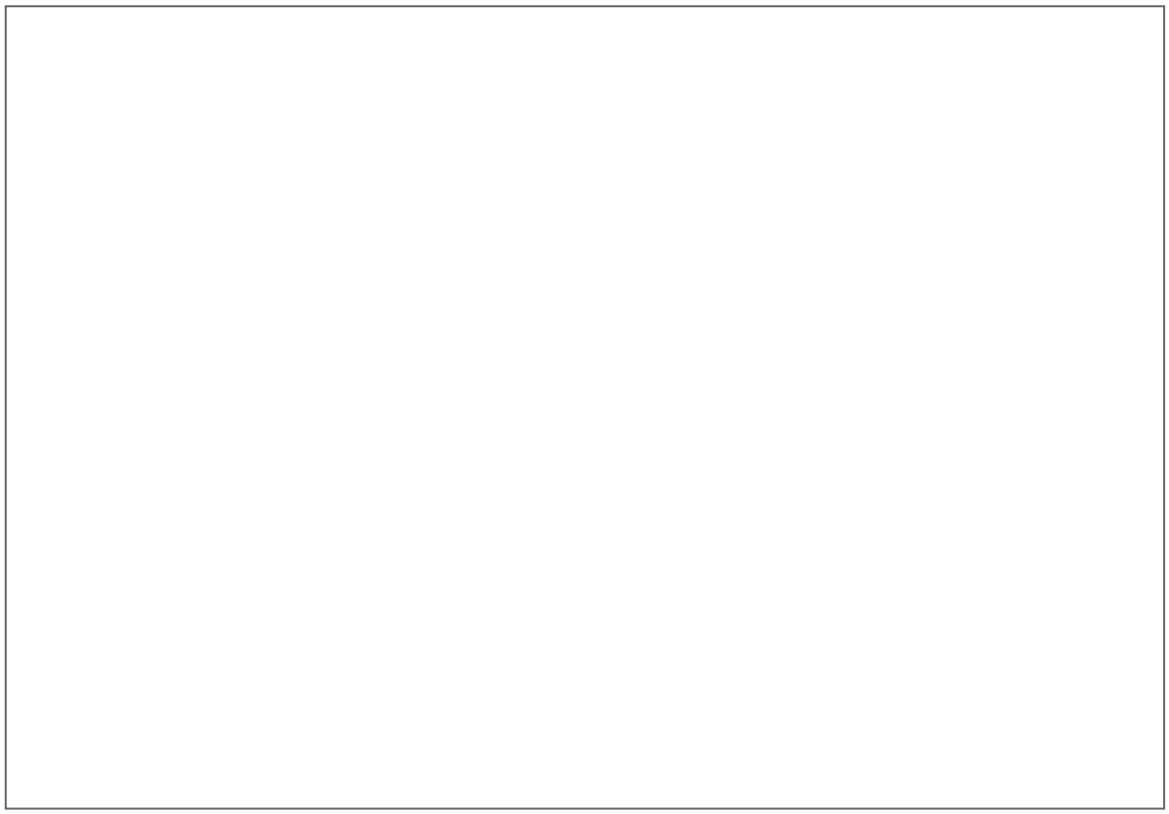
*The **functionality** of a program are those behaviours which performs a user task*

Functionality may be changing, unknown, or misunderstood

The set of functionally equivalent programs **depends on the functionality parameter**

FizzBuzz Example (8

Compare a "normal" FizzBuzz solution with a golf version:



Functionally Equivalent

Given a set of ***required functionalities*** *F, and* ***two systems****, S1 & S2, S1 is* ***functionality equivalen****t (with respect to F) to S2 if S1 and S2 enact F.*

So, if two programs are **behaviourly equivalent** then they are **functionally equivalent**.

What happens if S1 and S2 don't **quite** enact the same F?

"Sufficiently" Functionally Equivalent

*Given a set of **required functionalities** F, and **two systems**, S1 & S2, which enact functionality sets F1 & F2 (respectively), where, F1 ≠ F2 ≠ F, S1 is **sufficiently functionally equivalent** to S2 wrt F if F1 and F2 share **"enough"** of an overlap with F.*

Obviously, "enough" is a **parameter**!

`wc` Example!

- GNU `wc` has more functionality (and user-notable behaviour) than `miniwc.py`
  - Or other `wc`s!
  - Different flag options, find longest line, etc.
- Some behaviour is user visible but not "functional" (or interesting)
  - `wc --help --version` vs. `wc --version --help`
    - Non-equivalent in GNU `wc`
    - Do we care to preserve this?!
- How about spacing?!

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