Announcements

- Project 1 presentation grades will be out tomorrow
  - Great job, everyone! ☺
- Extra Credit Opportunities today
- Project 1 Design due this Thursday
- Project 2 Test releasing Thursday - related to Project 2
- Please attempt sustainability short course if you haven’t already
- GCP coupons for Project 2
  - 26 ($50) coupons left
  - 2 students from each group will be assigned credits tentatively.
  - I have also reached out to Google for additional credits.
  - More credits to follow if needed

Midterm Feedback

Best Aspect of the course:

- Tools of the trade lectures – has been continuously added/edited based on student suggestions (TA workshop, gcp assignments were new additions this semester)
- Small individual assignments based on tools
- Project – Practicality, teamwork, tools

Things that can be changed

- Recorded Lectures – **Agreed. All lectures will be recorded.**
- Quizizz extra credit should be partial grade – **Disagree**. It is extra credit so it can't be participation. **But more participation-based quizzes/activity coming up.**
- Ed Discussion vs Canvas vs Piazza – Announcements should go to your email directly. We want to keep 1 platform for communication. **Change Settings.** Piazza is not allowed anymore by university.

Midterm Feedback

ONE Change

- More flexibility with frameworks vs step by step guide– Project 2 is for flexibility. Project 1 is to learn 1 set of tools and apply
- Step by step guide for demos – there is already guide for all demos, recording the videos will help for sure
- More prepared demos – Agreed. Taking notes and will do better (I think GCP one could have been done better)

CS3300 Introduction to Software Engineering

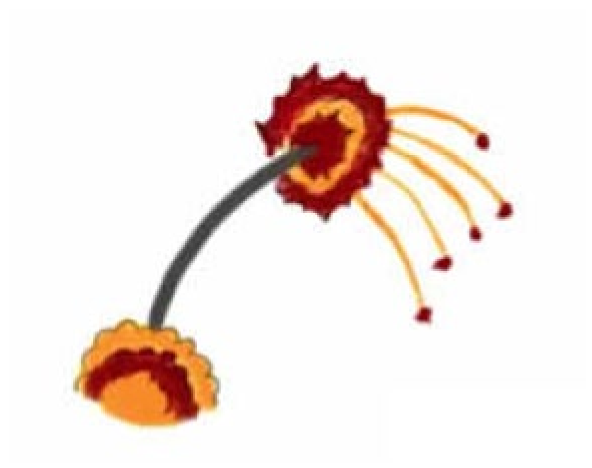
Lecture 13: Project 2 Description and Software Testing

Dr. Nimisha Roy

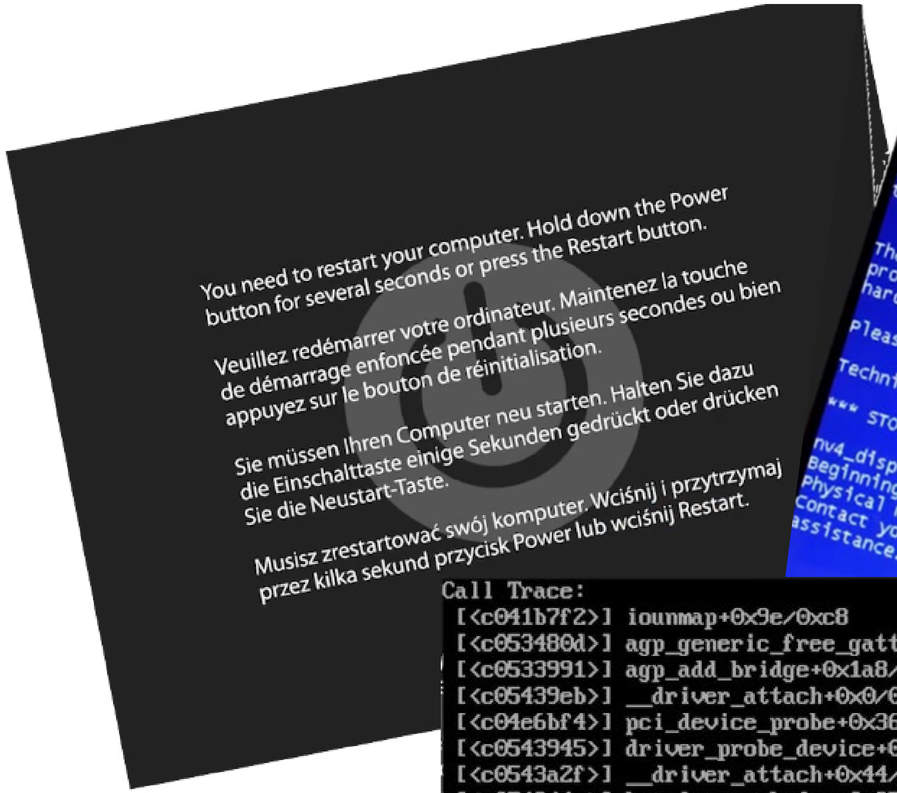
- nroy9@gatech.edu

Slides adapted from Alessandro Orso

Some Examples…



Ariane 5 Failure:
https://www.youtube.com/watch?v=gp_D8r-2hwk

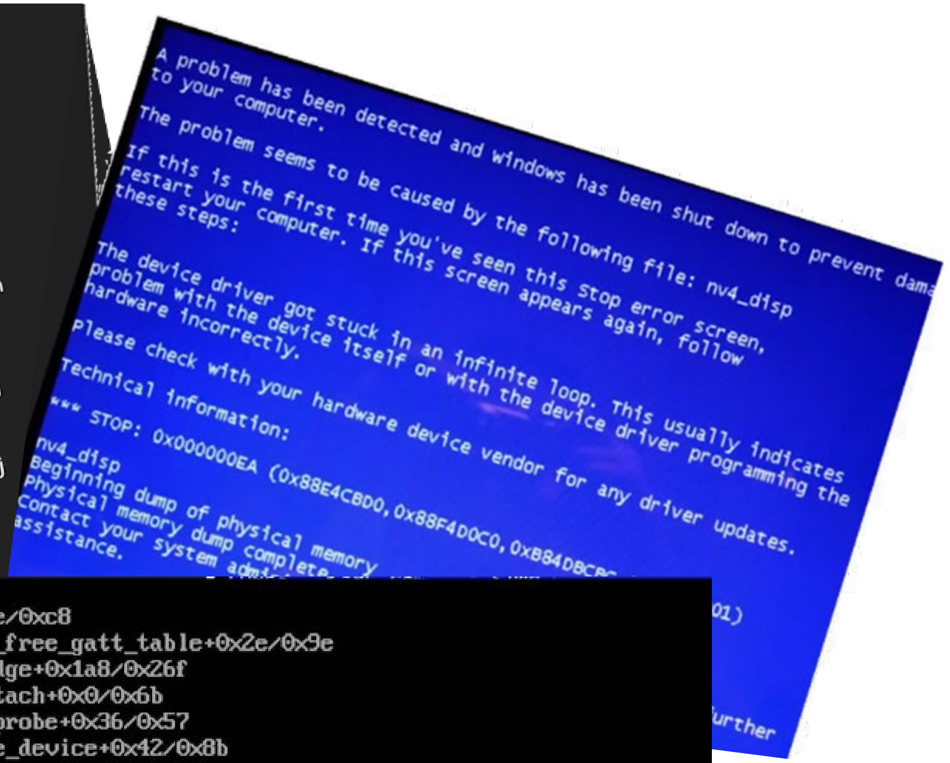


You need to restart your computer. Hold down the Power button for several seconds or press the Restart button.

Veuillez redémarrer votre ordinateur. Maintenez la touche de démarrage enfoncée pendant plusieurs secondes ou bien appuyez sur le bouton de réinitialisation.

Sie müssen Ihren Computer neu starten. Halten Sie dazu die Einschalttaste einige Sekunden gedrückt oder drücken Sie die Neustart-Taste.

Musisz zrestartować swój komputer. Wciśnij i przytrzymaj przez kilka sekund przycisk Power lub wciśnij Restart.



```
A problem has been detected and windows has been shut down to prevent dama
to your computer.
The problem seems to be caused by the following file: nv4_disp
If this is the first time you've seen this Stop error screen,
restart your computer. If this screen appears again, follow
these steps:
The device driver got stuck in an infinite loop. This usually indicates
problem with the device itself or with the device driver programming the
hardware incorrectly.
Please check with your hardware device vendor for any driver updates.
Technical information:
*** STOP: 0x000000EA (0x88E4CBD0,0x88F4D0C0,0xB84DBC
nv4_disp
Beginning dump of physical memory
Physical memory dump complete
Contact your system admi
assistance.
01)
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```
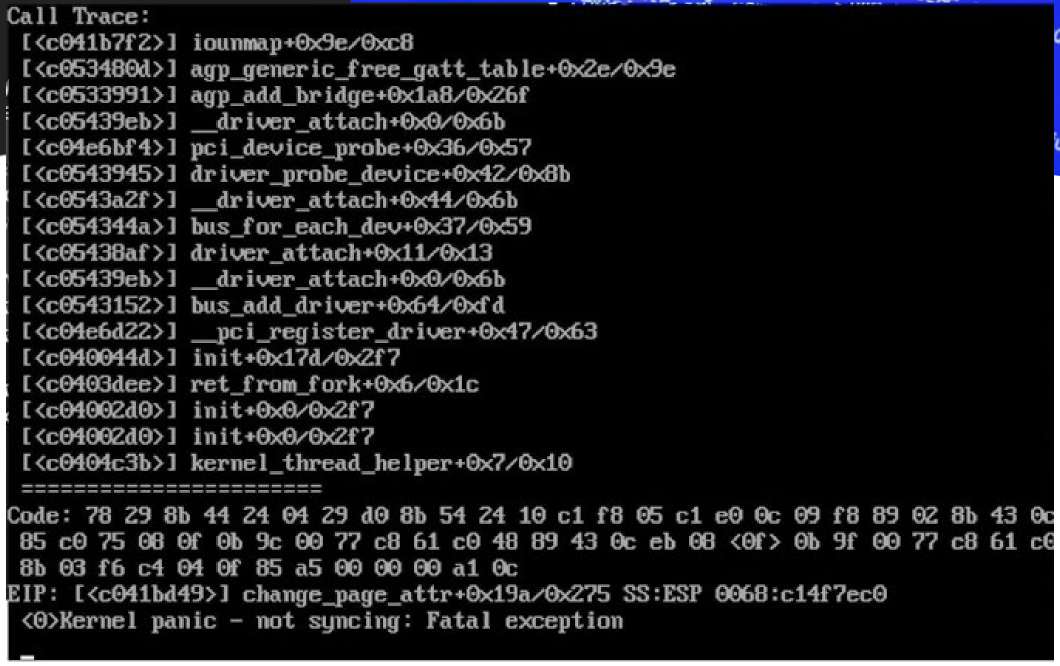
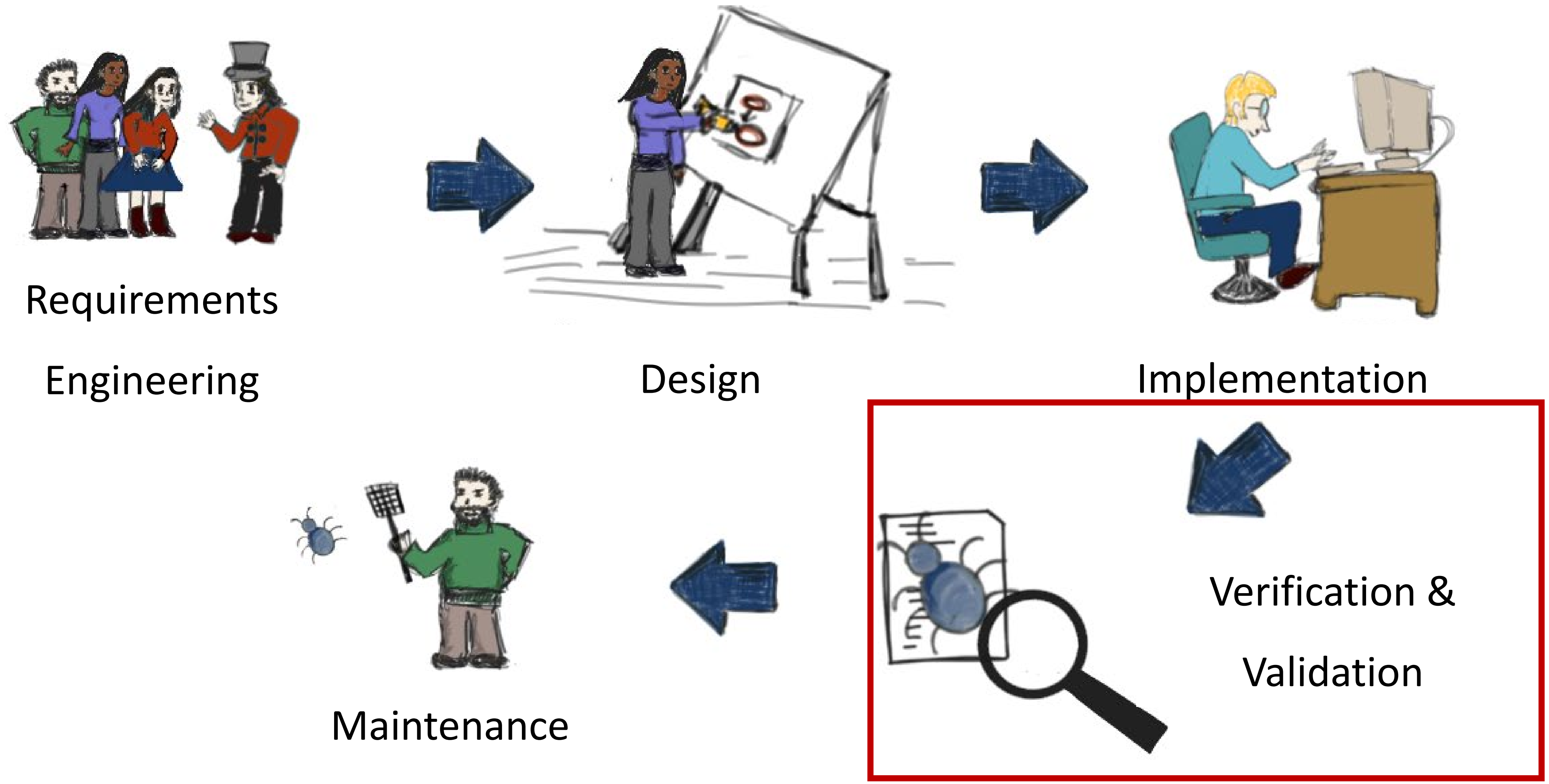



```
Call Trace:
 [<c041b7f2>] iounmap+0x9e/0xc8
 [<c053480d>] agp_generic_free_gatt_table+0x2e/0x9e
 [<c0533991>] agp_add_bridge+0x1a8/0x26f
 [<c05439eb>] __driver_attach+0x0/0x6b
 [<c04e6bf4>] pci_device_probe+0x36/0x57
 [<c0543945>] driver_probe_device+0x42/0x8b
 [<c0543a2f>] __driver_attach+0x44/0x6b
 [<c054344a>] bus_for_each_dev+0x37/0x59
 [<c05438af>] driver_attach+0x11/0x13
 [<c05439eb>] __driver_attach+0x0/0x6b
 [<c0543152>] bus_add_driver+0x64/0xfd
 [<c04e6d22>] __pci_register_driver+0x47/0x63
 [<c040044d>] init+0x17d/0x2f7
 [<c0403dee>] ret_from_fork+0x6/0x1c
 [<c04002d0>] init+0x0/0x2f7
 [<c04002d0>] init+0x0/0x2f7
 [<c0404c3b>] kernel_thread_helper+0x7/0x10
 =======================
Code: 78 29 8b 44 24 04 29 d0 8b 54 24 10 c1 f8 05 c1 e0 0c 09 f8 89 02 8b 43 0c
 85 c0 75 08 0f 0b 9c 00 77 c8 61 c0 48 89 43 0c eb 08 <0f> 0b 9f 00 77 c8 61 c0
 8b 03 f6 c4 04 0f 85 a5 00 00 00 a1 0c
EIP: [<c041bd49>] change_page_attr+0x19a/0x275 SS:ESP 0068:c14f7ec0
 <0>Kernel panic - not syncing: Fatal exception
 _
```

Slide adapted from Alessandro Orso

Testing is a part of Verification and Validation…



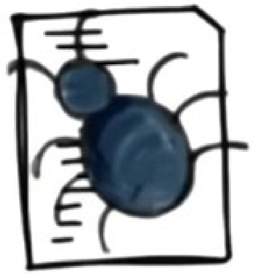
Software is Buggy!

- Cost of bugs: $ 60 B/year
- On average, 1-5 errors per 1K LOC
- Windows 10
  - 50M LOC
  - 63,000 known bugs at the time of release
  - 1.25 per 1,000 lines

- For mass market software 100% correct SW development is infeasible, but
- We must verify the SW as much as possible

Failure, Fault, Error

Failure: Observable incorrect behavior of a program. Conceptually related to the behavior of the program, rather than its code.



Fault (bug): Related to the code. Necessary (not sufficient!) condition for the occurrence of a failure.

Error: Cause of a fault. Usually a human error (conceptual, typo, etc.)

Failure, Fault, Error: Example

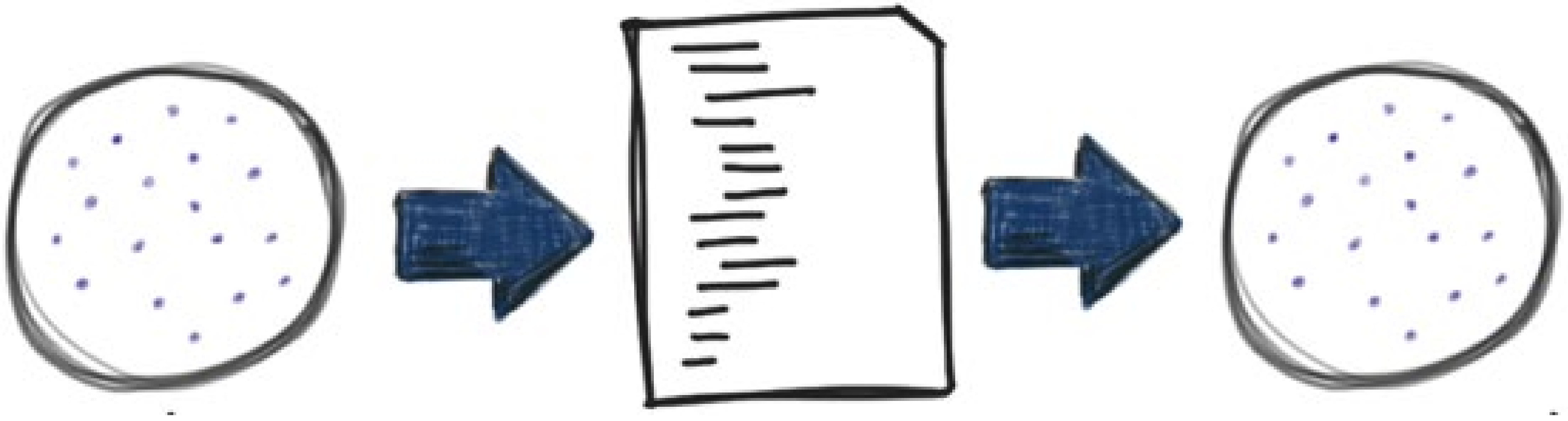
```
1.    double doubleValue(int param) {
2.        double result;
3.        result = (double) param * param;
4.        return(result);
5.    }
```

A call to double(3) returns 9. What is this?	The result 9 is a failure- it is an observable behavior
Where is the fault?	Line 3
What is the error that caused the fault?	N/A. Maybe typo, erroneous copy paste, or conceptual. Only the developer knows.

Approaches to Verification

- **Testing** (dynamic verification): exercising software to try and generate failures
- **Static analysis**: identify (specific) problems statically, that is, considering all possible executions
- **Inspections/reviews/walkthroughs**: systematic group review of program text to detect faults
- **Formal verification** (proof of correctness): proving that the program implements the program specification

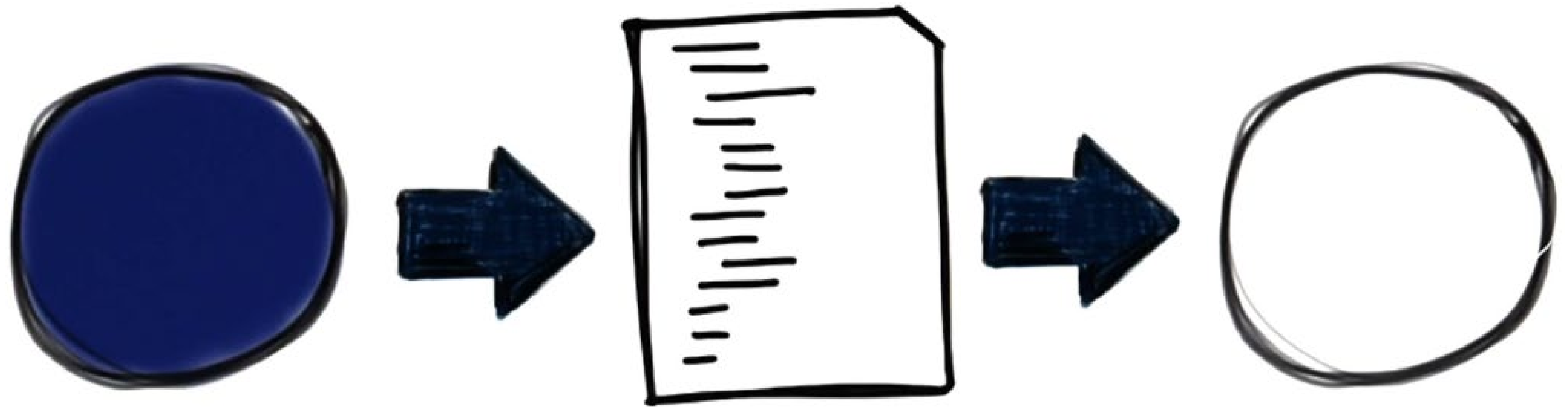
Testing



Test Case: {i ∈ D, o ∈ O}

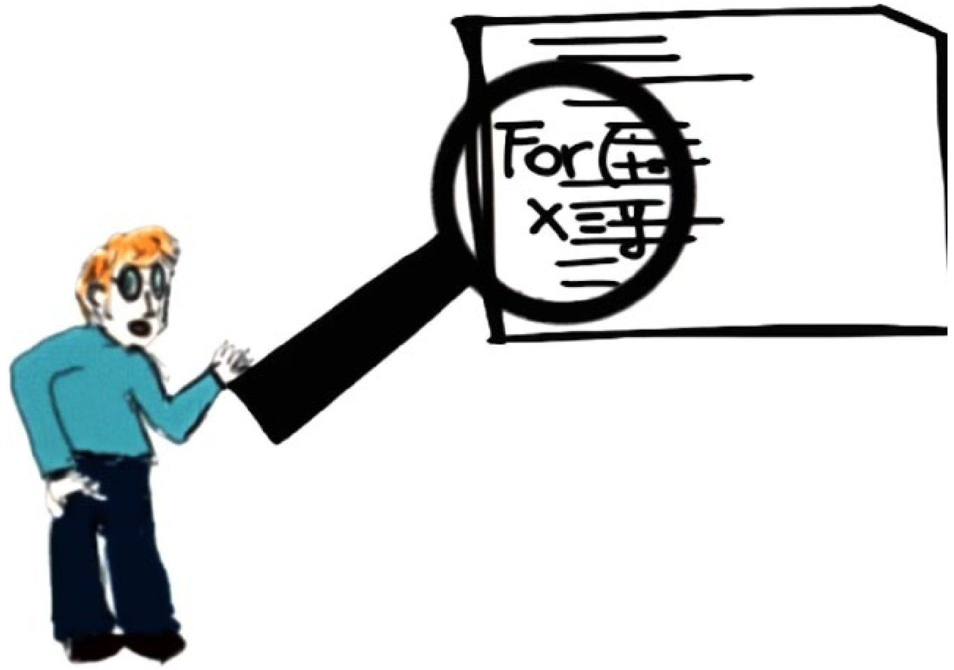
Test Suite: A set of Test Cases

Static Verification



Considers all possible inputs
(execution/behaviors)

Inspections/Reviews/Walkthroughs



Human intensive activity
Manual
Group activity
Inspect defects in the artifacts

Formal Proof (Of correctness)

Program

Specification

Given a formal specification, checks that the code corresponds to such specification

Sophisticated mathematical analysis

Comparison among the 4 techniques

	PROS	CONS
Testing	No False Positives	Highly Incomplete
Static Verification	Considers all program behaviors, Complete	False Positives, Expensive
Inspections	Systematic, Thorough	Informal, Subjective
Formal Proofs of Correctness	Strong Guarantees	Complex, Expensive to build/prove a mathematical basis

Today, Quality Assurance (Verification) is mostly Testing

“50% of my company employees are testers, and the rest spend 50% of their time testing”.

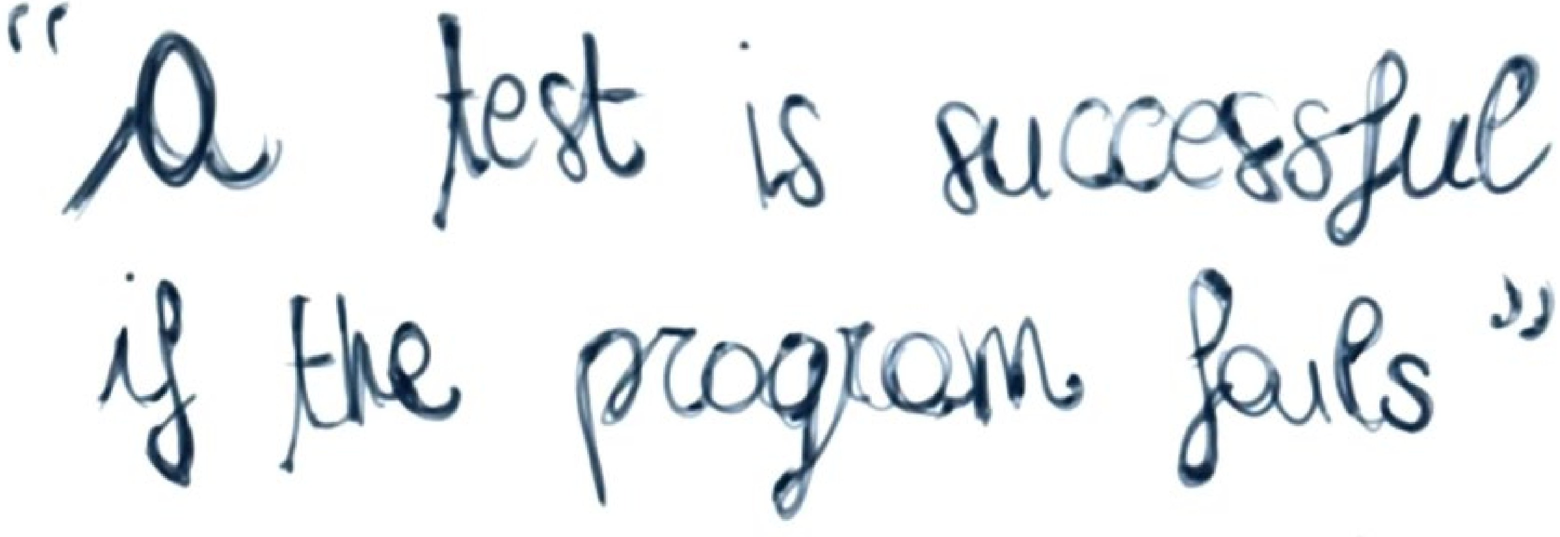
- Bill Gates

What is Testing?

Testing == To execute a program with a sample of the input data

- Dynamic technique: program must be executed
- Optimistic approximation:
  - The program under test is exercised with a (very small) subset of all the possible input data
  - We **assume** that the behavior with any other input is consistent with the behavior shown for the selected subset of input data

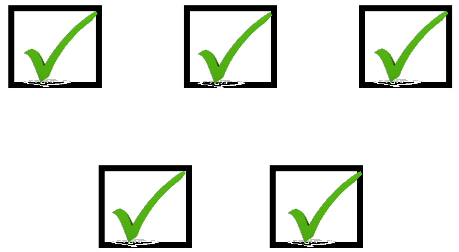
Successful Tests


"A test is successful if the program fails"

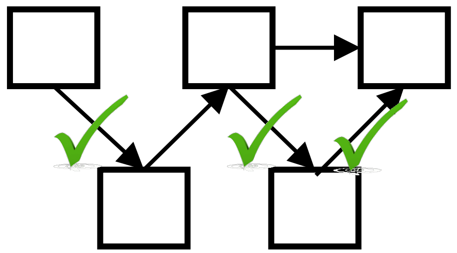
-Goodenough and Gerhart (1985). "Towards a Theory of Test data selection". *IEEE Transactions of Software Engineering*, Jan 1985

Testing Granularity Levels

Unit Testing

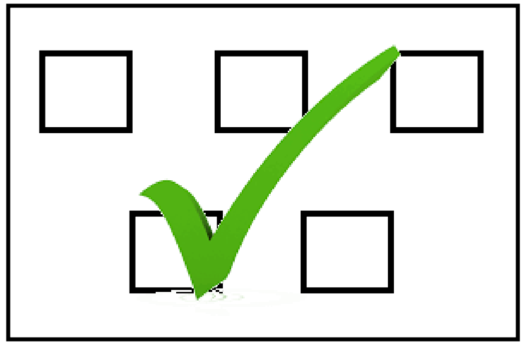


Integration



Big Bang

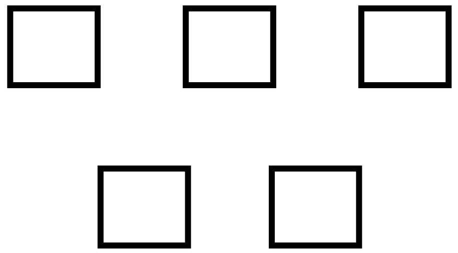
System



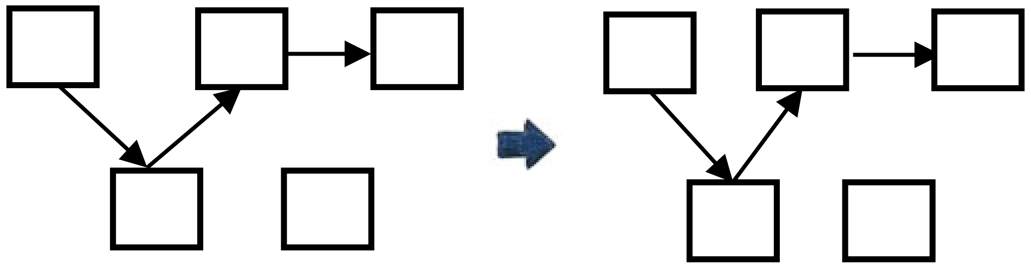
Functional/Non-functional

Customer

Acceptance Testing



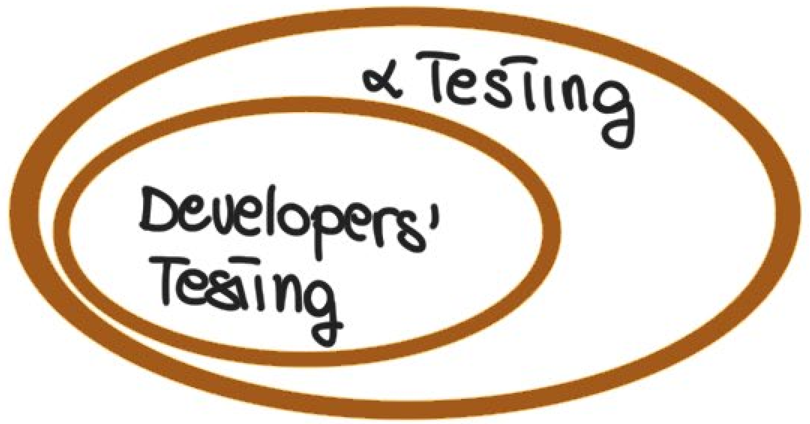
Regression Testing



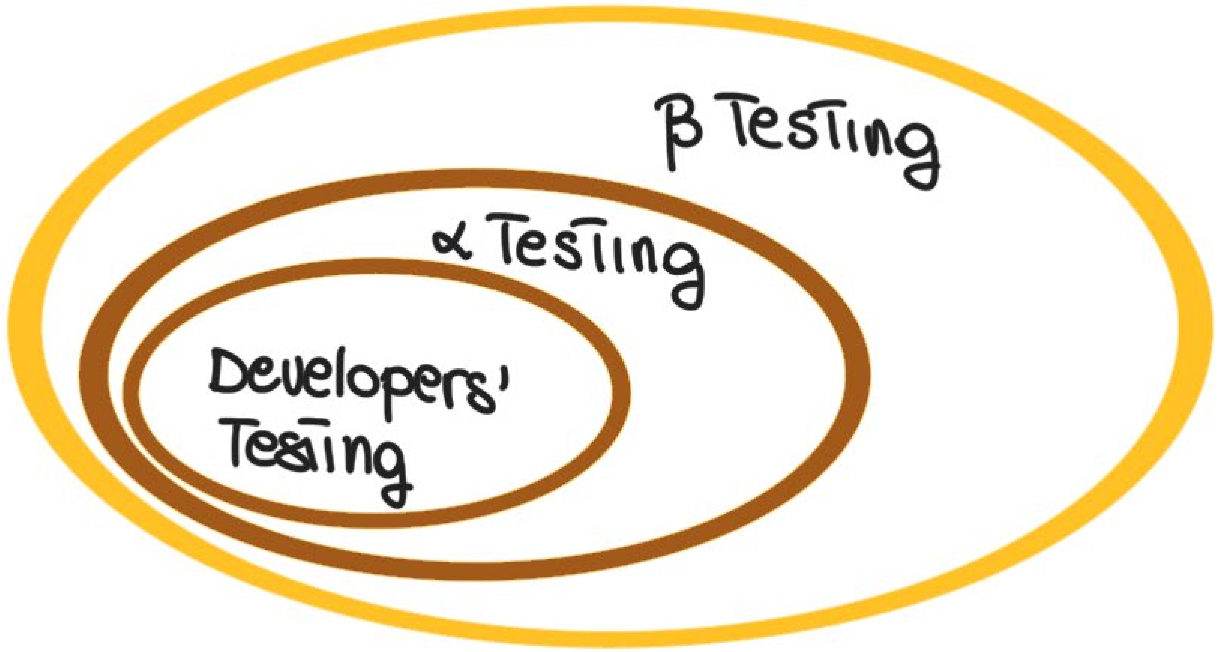
Testing Stages

Developers' Testing

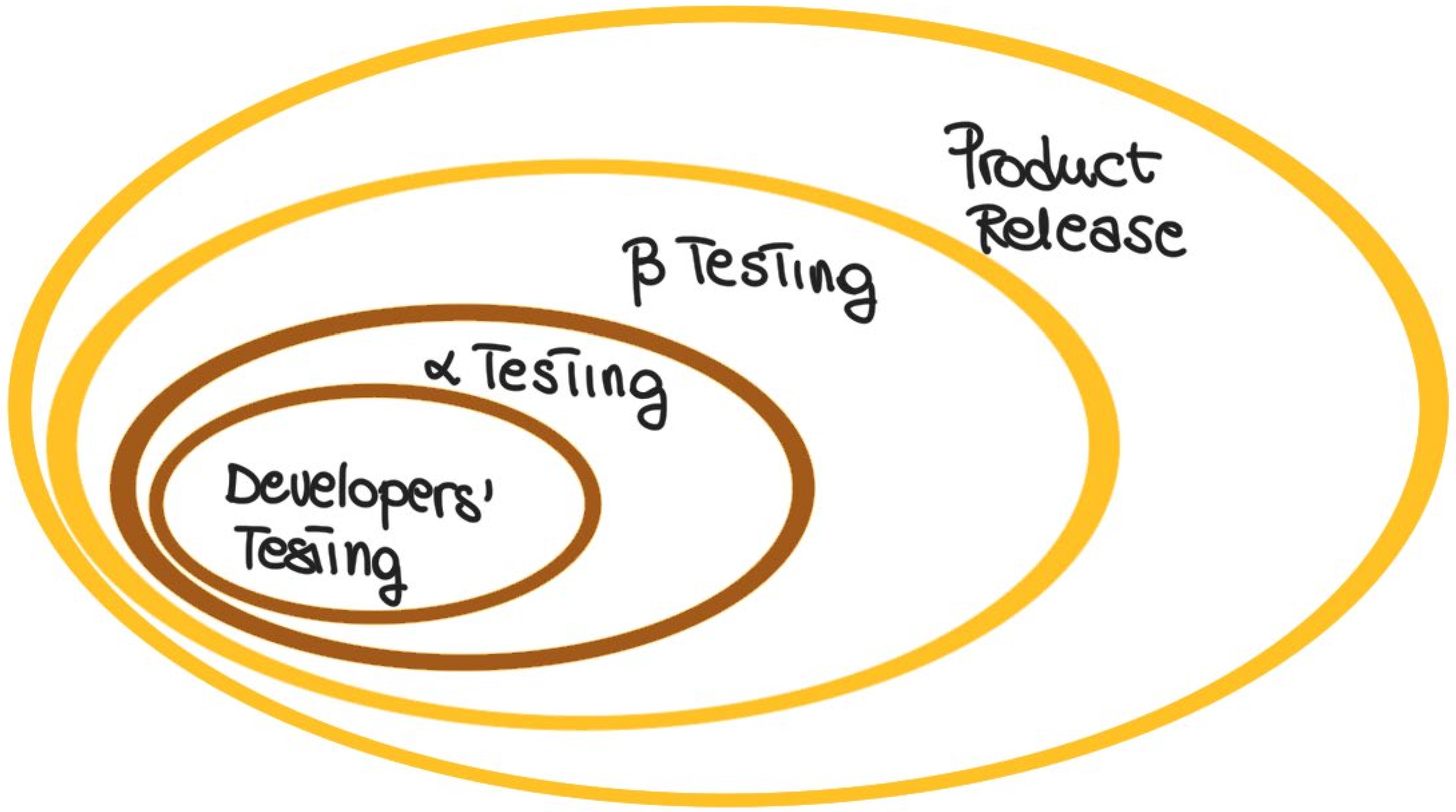
Testing Stages



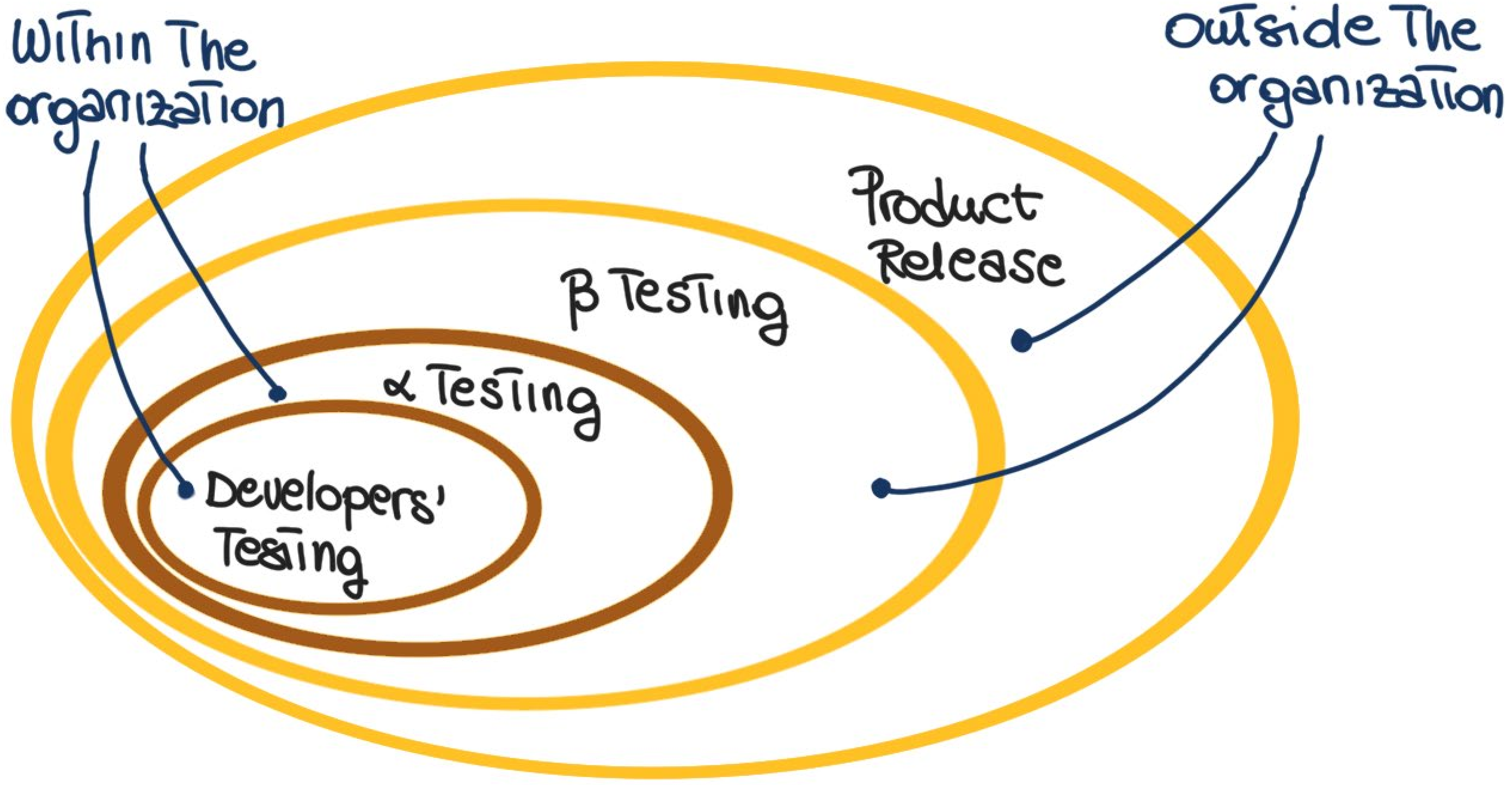
Testing Stages



Testing Stages



Testing Stages



Testing Techniques

There are several techniques

- Different processes
- Different artifacts
- Different approaches

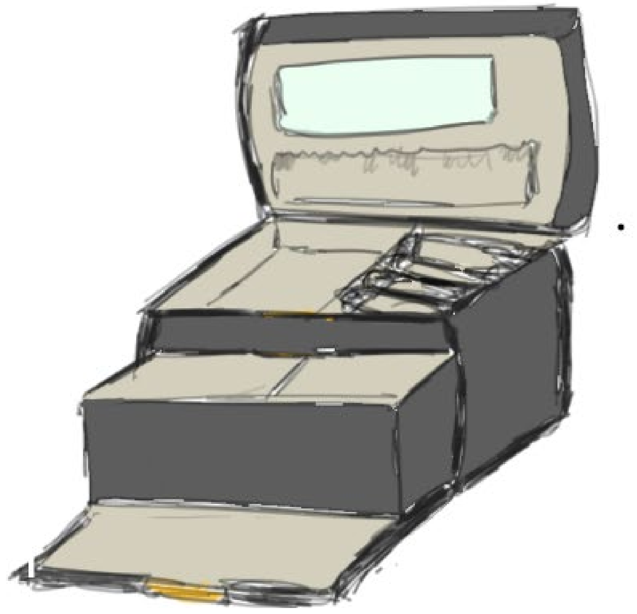
There are no perfect techniques

- Testing is a best-effort activity

There is no best technique

- Different contexts
- Complementary strengths and weaknesses
- Trade-offs

Testing Techniques



BLACK BOX TESTING

- Based on a description of the software (specification)
- Cover as much specified behavior as possible
- Cannot reveal errors due to implementation details

WHITE BOX TESTING

- Based on the code
- Cover as much coded behavior as possible
- Cannot reveal errors due to missing paths

Black-Box Testing Example

Specification: Inputs an integer and prints it

```
void printNumBytes (param){
    if (param < 1024) printf(“%d”, param);
   else  printf(‘%d KB” ,  param/124);
}
```

Blackbox testing attempts: Inputs +, -, and 0

Will blackbox testing be able to catch the failure? **Most likely Not**

White-Box Testing Example

Specification: inputs an integer param and returns half of its value if even, its value otherwise

```
int  fun(int param){
  int result;
  result = param/2;
  return result;
}
```

Will whitebox testing be able to catch the failure? **No**

Blackbox testing attempts: atleast one odd and one even input – catches failure

Quizizz

Project 2 Topic

Open Ended

Pick your own topic:

You need to justify that the topic is interesting, relevant to the course, and is of suitable difficulty

- Don’t have a project topic very similar to project 1

Should have 3 Minimum Marketable Features

Few examples of project topics from previous year submissions:
Student-Tutor communication apps, personalized music apps, personalized movie recommender, event management app for GaTech events, …

Technologies you are now familiar with

- Google Cloud
- Java Servlet
- REST Platform like Spring Boot
- Frontend development (js,html, css, …)
- Backend testing
- Debugging
- Working efficiently with IDEs, VCs

Technologies for Project 2

Anything you want. Can be web-based or android application.

Backend: Build up your expertise in Java/SpringBoot or go for Node.js/others
Frontend: Keep it simple or try something new. React/Angular
Database: Datastore/FireBase/MySQL/mongo
Testing: More points allotted to testing (blackbox/whitebox) in Project 2

Mandatory: GitHub (PR)
Deployment: Google Cloud services to deploy. Build on your cloud expertise. Big hit among employers.

Bonus Points will be awarded to teams adopting interesting/difficult topics/technologies

Project 2: Requirements

- Should have atleast 3 Minimum Marketable Features

- We will announce bonus points criteria soon
    - 1 is for complying with/analyzing some sustainability based concepts – More on sustainability next class.

- Have to use GitHub
    - PR and readme requirements same as project 1
- Last Assignment - Test is based on Project 2. So focus on thorough testing

Mandatory for Project 2

- 3 MMFs – get approval from mentors in project 2 touchpoint
- Code Review Requirements
- Compliance with 2 design patterns (Which pattern and why applicable?)
  - Applicable to Python, Java, Kotlin, Scala, C#, Ruby, PHP
  - Inform the Instruction team on Ed if your team is attempting functional programming (Haskell, Erlang, F#) or procedural programming (C, Pascal, in which case this requirement for your team will be revised accordingly
  - Even if you are only using JS, TypeScript and ES6 classes support classic OOP patterns
- Good testing done – blackbox and whitebox.
  - Relevant to testing assignment and project 2 ppt
- GitHub
- GCP

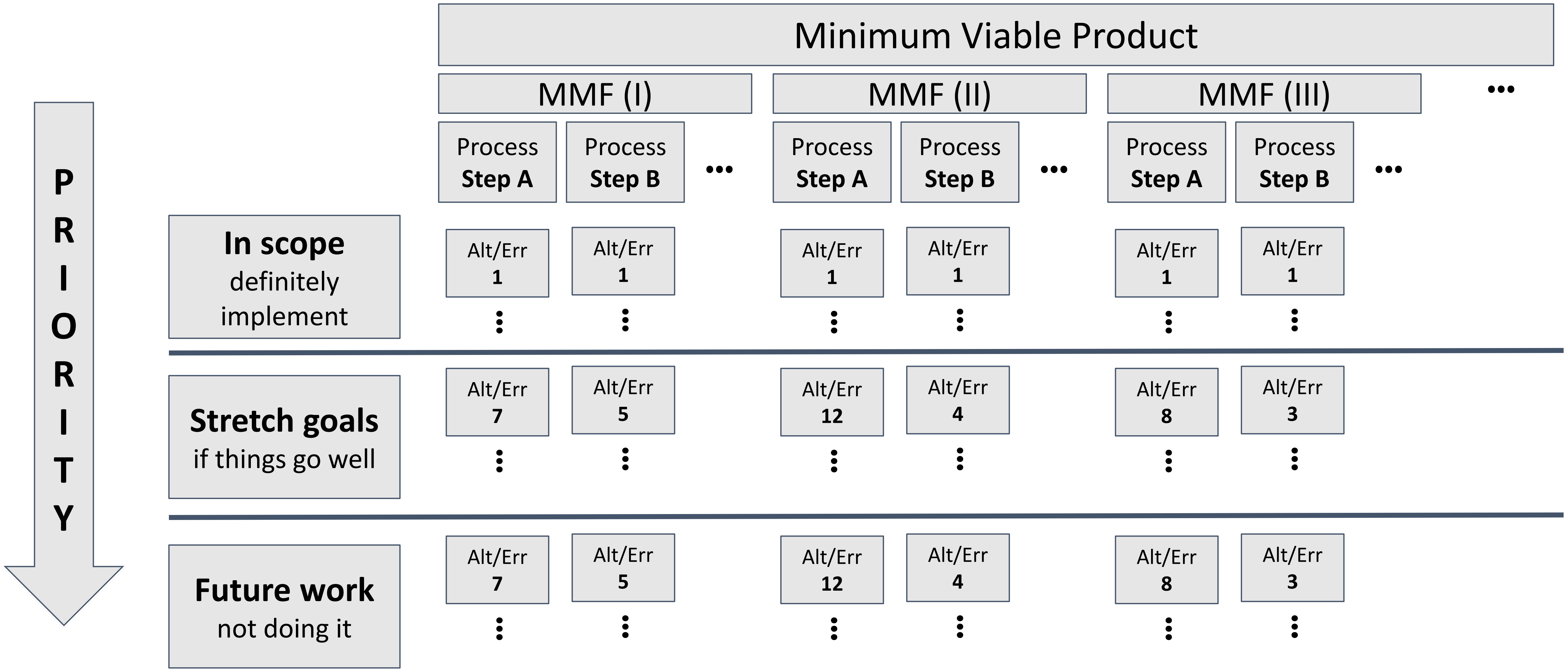
GitHub

- Make sure to have your GitHub for this project
- Ensure it is private
- It is important for your future reference
- Add it to your resume
- GitHub page can be very compelling for employers
  - You will use GitHub pages to create your Project Report

MMF and MVP

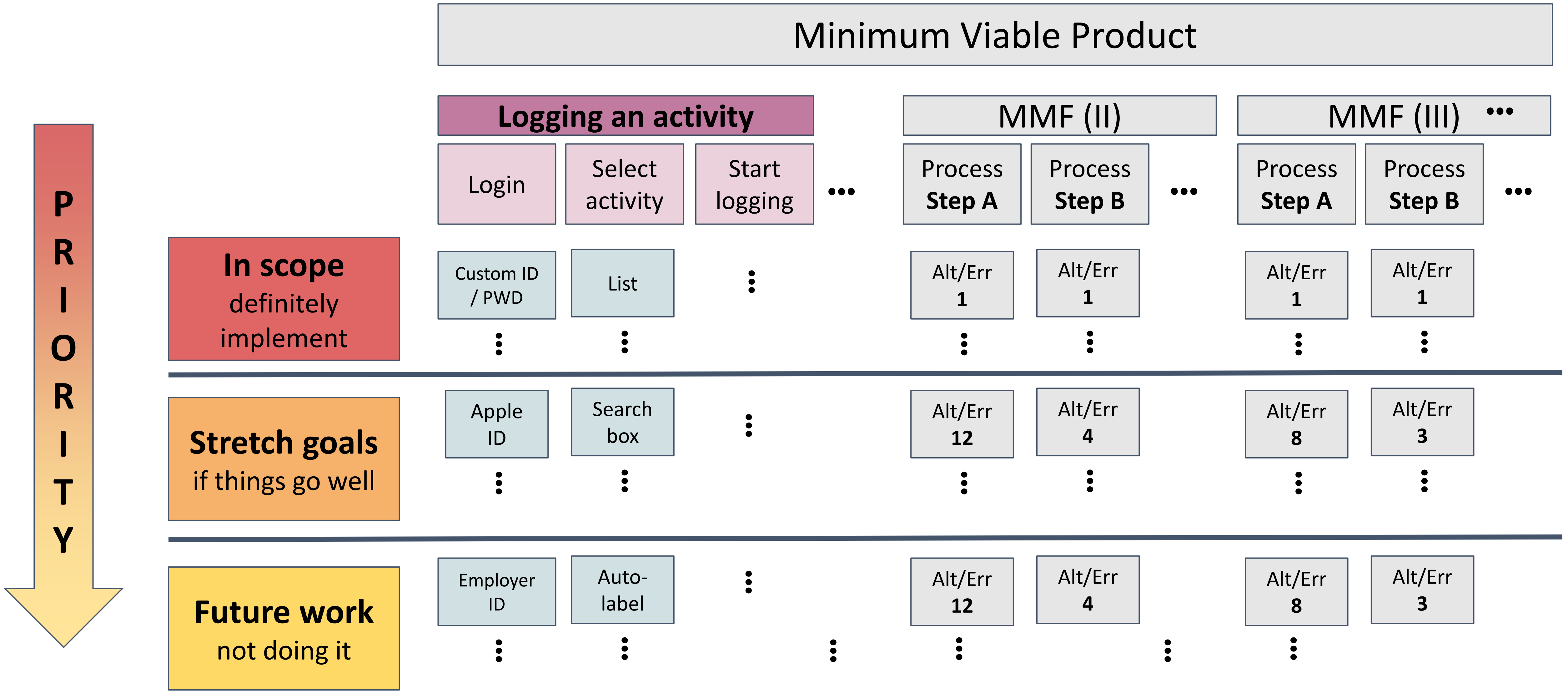
- Substantial piece of functionality that delivers business value to customers
    - Should comprise multiple small user stories
- An MVP comprises several MMFs
- For Sustainable Commute Finder, MMFs could be:
    - Basic Route Finder based on different modes of transportation
    - Carbon Emission Estimation and Environmental Impact for each Route
    - Personalized Commute Profiles and best route recommender

MMF and MVP



Minimum Viable Product
MMF (I)
MMF (II)
MMF (III)
•••
Process Step A
Process Step B
•••
PRIORITY
In scope definitely implement
Stretch goals if things go well
Future work not doing it
Alt/Err 1
Alt/Err 7
Alt/Err 5
Alt/Err 12
Alt/Err 4
Alt/Err 8
Alt/Err 3

Example: Fitness app



Submission Deliverables & Announcements

- Project Progress Report (pdf submission) - 5% grade
  - Rubric same as Project 1 Progress Report Rubric
  - On the class website
- Project Presentation in class (with Demo) – 10% grade
- Project Report (GitHub Page Link)- 15% grade
- Project Codes (share your private GitHub repo) – 5% grade
- Project 2 Rubric will be uploaded on class website sometime this week for your reference
- Project 2 Touchpoint on 11/8 during class hours with your mentors
  - Ask questions about the feasibility, technologies, any other issues. Share your progress
  - Verify that your topic is valid/ has 3 valid MMFs

Slide adapted from Alessandro Orso

Presentation

- 14 Groups
- 2 days of presentation
- Each Team will have 10 minutes time
- + 1 minute Q&A
- 7 Teams per day
- **Make sure to have a demo**

Project Report

- Explain All phases of Software Development in your project (Refer your assignments for details)
- Should be deployed as a GitHub page
- Team Contributions
- Technologies
- Rubric will be up on Canvas soon