COMP110: Principles of Computing

Software Testing

Today's lecture

Today's lecture has **three parts**

- Software testing and test-driven development
- Introducing COMP110 Coding Task II
- Object composition in C++

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Software testing

In this section

In this section you will learn how to:

- **Discuss** the importance of software testing in game development
- **Identify** the different types and levels of testing
- **Apply** test-driven development practices to your own programming projects

Further reading

- Pressman, R.S. (2009) Software Engineering: A Practitioner's Approach. 7th Edition. McGraw-Hill.

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- There are many ways of measuring the **quality** of a game or piece of software

Quality

Last time:

- There are many ways of measuring the **quality** of a game or piece of software
- **Quality assurance** is important to ensure that the software is of sufficiently high quality to provide benefit to developers and end users

Testing

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- Often takes more time and effort than any other part of development
- ... but letting errors slip into the final product can be even more costly
- Testing $\neq$ quality assurance
    - Testing is an important part of QA, but **not the only part**

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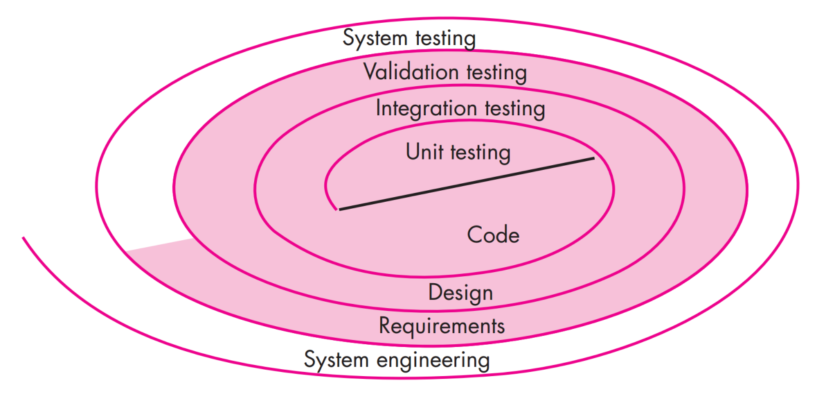
- Who should take responsibility for **testing**?
  - "**Developers** write the code, so they should make sure it works"?
  - "**Everyone** is responsible for quality, so everyone should pitch in"?
  - "Code should be tested by **someone other** than the developer who wrote it"?

Socrative `6E8NSW3IN`

So who should test game software?

- In pairs.
- Discuss for 2-minutes.
- **Suggest** which parties should take responsibility for testing **and justify** your answer.

Testing strategy



(Pressman, 2009) Figure 17.1

Testing strategy

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- **White box testing**: testing the software **with** knowledge of its internal workings
- **Black box testing**: testing the software **without** knowledge of its internal workings

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- E.g. verifies that a function called with invalid parameters throws the expected error

Designing user tests

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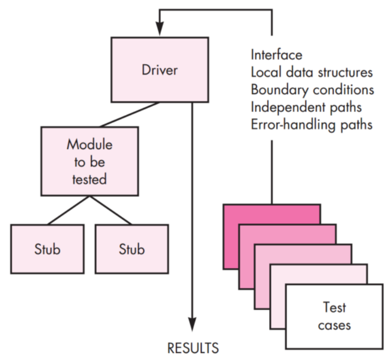
- Aim for high **coverage**
  - Ideally, **every line of code** should be executed in **at least one** unit test

Drivers and stubs



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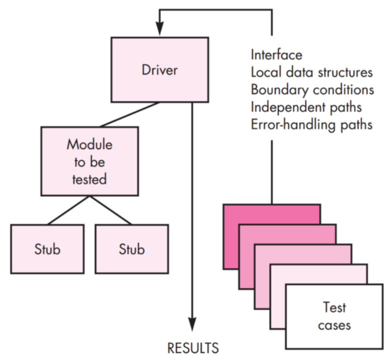

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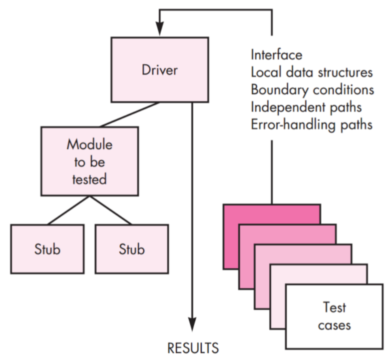

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- Unit testing generally requires extra code to be written
- **Driver** — to set up any required state and run the test
- **Stubs** — to replace any modules upon which the module under test depends

Integration testing

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- Can be done **top-down** or **bottom-up**
- Either way, the idea is to gradually replace stubs and drivers with actual units, testing as you go
- **Regression testing** is important — re-running tests to ensure that recent additions have not broken anything

Socrative `6E8NSW3IN`

If the units have been thoroughly tested individually, why is integration testing needed?

- In pairs.
- Discuss for 2-minutes.
- Give an **example** of a problem that integration testing might uncover, but that unit testing might miss.

Validation testing

- Testing the complete software system from the user's point of view

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- E.g. playtesting

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If unit testing and integration testing have been done correctly, why is validation testing needed?

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- Discuss for 2-minutes.
- Give an **example** of a problem that validation testing might uncover, but that unit and integration testing might miss.

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- When the software is (quantitatively or qualitatively) "good enough"
- Testing is never "done" — the burden just shifts onto the users

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- Repeat the following three steps:
  1. **Red**: create a new test case, which should initially **fail**
  2. **Green**: write code to make the new test **succeed** (without causing the other test cases to fail)
  3. **Refactor**: **improve** the code, ensuring that all tests still **succeed**

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- Writing the bare minimum of code to make the test "green" lets you **focus on user stories**, not on **over-generalisation** or **non-essential functionality**
  - **KISS**: Keep It Simple, Stupid
  - **YAGNI**: You Aren't Gonna Need It

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  - Maybe your unit testing code is broken?

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  - (you **did** commit before you started, right?)

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Socrative `6E8NSW3IN`

How suitable is the test driven approach for game development?

- In pairs.
- Discuss for 2-minutes.
- Suggest **one advantage and one disadvantage** of test driven development in the context of game development

Summary

- **Testing** is an important part of software quality assurance (but not the only part)
- There are several different **levels** of testing, which mirror the different levels of software development
  - Unit testing $\leftrightarrow$ Coding
  - Integration testing $\leftrightarrow$ Design
  - Validation testing $\leftrightarrow$ Requirement planning
- **Test driven development** is one possible strategy for testing your software (but not the only strategy)

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COMP110 Coding Task 2

The assignment brief

LearningSpace: COMP110 assignment 4

The task

- Develop a **component**...

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- ... for a **game**
  - BA Digital Games project
  - **or** your COMP150 group project
  - **or** your COMP130 Kivy project

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  - Essentially as a "consultant" to your own team
- Members of the same COMP150 team **must not** target the same component of their COMP150 game

Proposal

- For **next Wednesday's COMP110 lecture (9th March)**
- See assignment brief for details

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Composition in C++

From COMP110 session 7

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- **Has-a**: modelled by **composition**
- **Is-a-type-of**: modelled by **inheritance**

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- Why a **reference**?
- Because that's your only option in Python!

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- "Each instance of class Duck contains **an instance** of class Bill"

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class Bill { ... };

class Duck
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private:
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```

- **Or** "Each instance of class Duck contains **a pointer** to an instance of class Bill"

```
class Bill { ... };

class Duck
{
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    Bill* bill;
};
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- It is usually constructed manually using `new`, and so must be destroyed manually using `delete`

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- They model slightly different types of **has-a** relationship
  - Instance: **has-a** in the sense of "contains"
  - Pointer: **has-a** in the sense of "is associated with"

Circular references

- The following code won't compile:

```
class Bill
{
private:
    Duck* owner;    // Error here
};

class Duck
{
private:
    Bill bill;
};
```

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- Does this make circular referencing impossible? Need to declare `Duck` before `Bill`, but also need to declare `Bill` before `Duck`
    - No...

Forward declarations

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```
class Duck;    // Forward declaration

class Bill
{
private:
    Duck* owner;    // This is OK now
};

class Duck
{
private:
    Bill bill;
};
```

Socrative 6E8NSW3IN

- Different code, same problem:

Bill.h

```
#pragma once

#include "Duck.h"

class Bill
{
private:
    Duck* owner;
};
```

Duck.h

```
#pragma once

#include "Bill.h"

class Duck
{
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};
```

- How to fix it?
- Discuss **in pairs** for 2 minutes and post your answer

Limitations of forward declarations

- Basically all you can do with a forward declared class is declare a **pointer** to it

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Limitations of forward declarations

- Basically all you can do with a forward declared class is declare a **pointer** to it
- E.g. this wouldn't work:

```
class Bill;

class Duck
{
private:
    Bill bill; // Error: undefined class 'Bill'
};

class Bill
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private:
    Duck* owner;
};
```

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- **All pointers have the same size**, so a forward declaration is enough in that case
- Circular references of contained instances are **impossible**
  - At least one of the links in the chain must be a **pointer**

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- The compiler needs to know **how big** (in bytes) an instance of `Bill` is, which the forward declaration doesn't tell it
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  - "Contains-a" relationships in real life can't be circular either
  - Philosophical thought for the day: how big would something have to be, to be big enough to contain itself?

Composition and containers

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- Can cause problems when using certain idioms (e.g. **RAII**)

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- When the `vector` changes size, the instances stay where they are — only the **pointers** are copied
- **However**, managing instances with `new` and `delete` is now your responsibility

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  - If you take ownership of a pointer, `delete`ing it is now your responsibility
- NB: C++ doesn't care about ownership — it's a concept **we** use to write and understand programs

Summary

- **Composition** models **has-a** relationships, which can include **contains-a** and **is-associated-with-a**
- **Circular references** can be set up using pointers, but **forward declarations** are often needed to make the compiler understand them
- **Ownership** is one way of keeping track of instances and understanding when to `delete` them