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Topic 12: Testing

CITS3403 Agile Web Development

Getting MEAN with Mongo, Express, Angular and Node, Chapter 11

Semester 1, 2023

Verification and Validation

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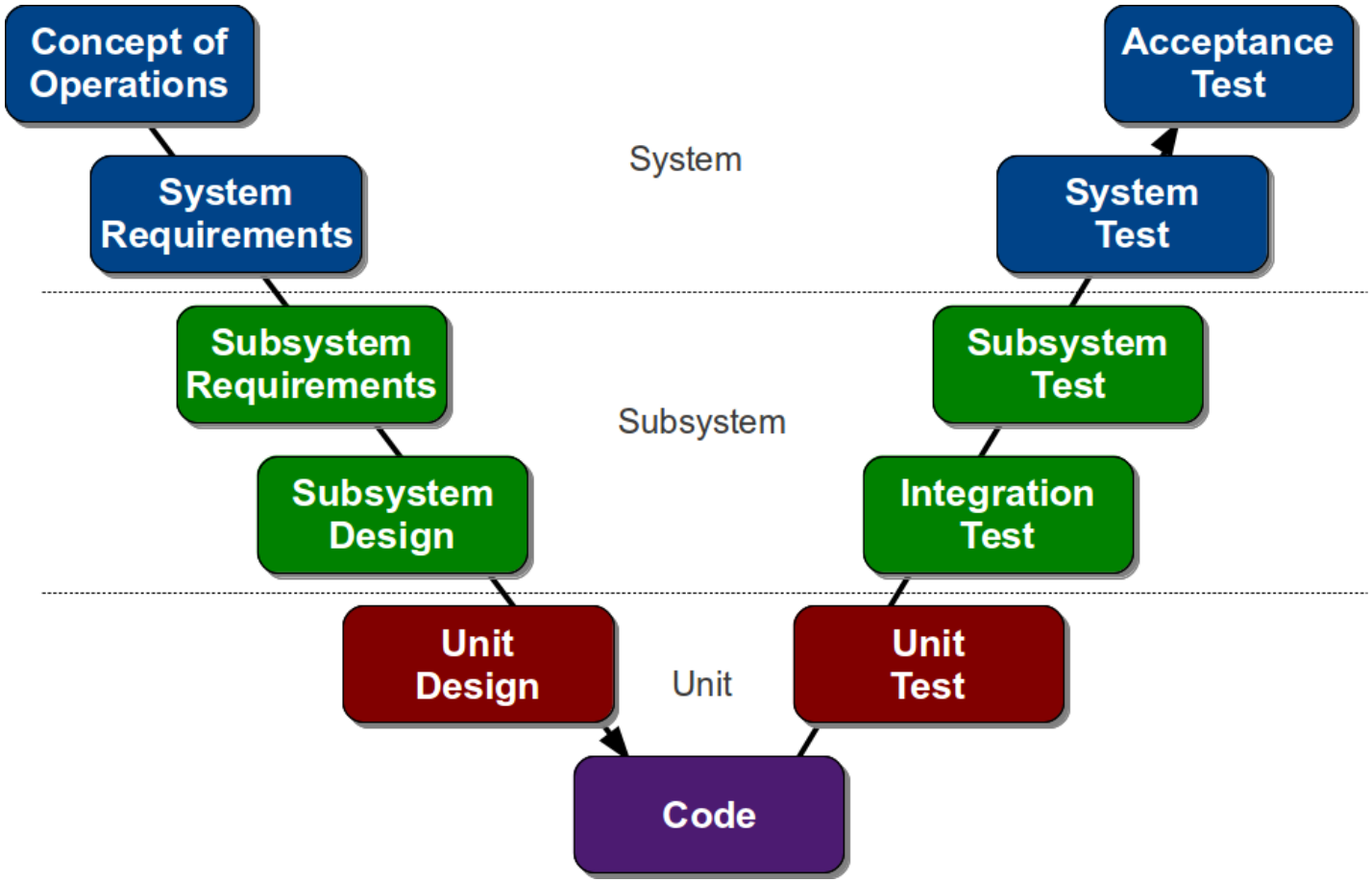
- Writing a bug free application is critical to to success of that application.
- There are various ways to eliminate bugs.
  - Code inspections: having peers critically examine your code and make suggestions.
  - Formal verification: building precise specifications of correctness, and proving the code meets these specs.
  - Testing: Providing test cases of inputs and actions, and expected behaviors.
- Testing is a key activity in any software development, but particularly in agile development, where the test suites are a proxy for requirements documentation.
- *Test Driven Design* specifies that the tests should be written first, and the code designed specifically to pass those tests.
- Agile also relies heavily on test automation, so that every sprint or iteration can be checked against the existing test suite.

The V-model

- The V-model links types of tests to stages in the development process.
- We will focus on unit tests and system tests.



Types of test

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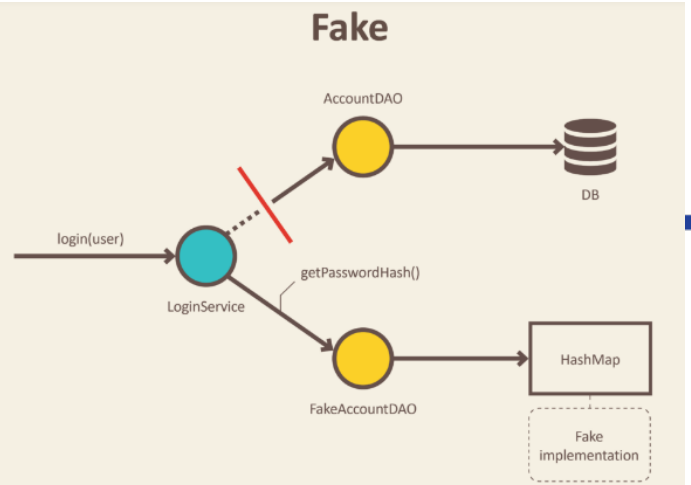
- Unit Tests: test each individual function for to ensure it behaves correctly (2-5 tests per function)
- Integration Test: Execute each scenario to make sure modules integrate correctly.
- System Test: Integrate real hardware platforms.
- Acceptance Test: Run through complete user scenarios via the user interface.

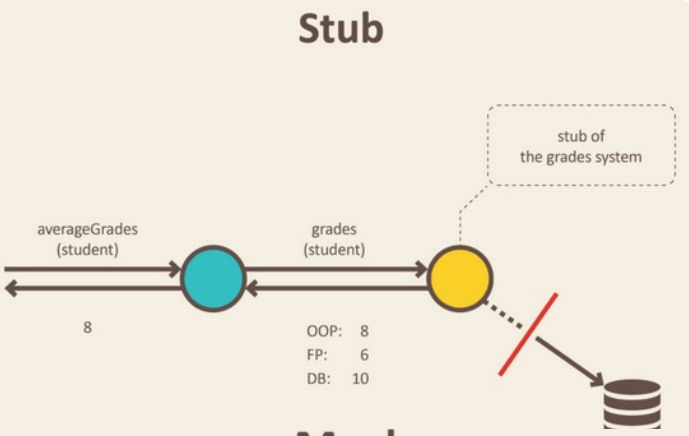
The tests should be repeatable, and should have a clear scope. Any changes to anything outside that scope should not affect whether the test passes.

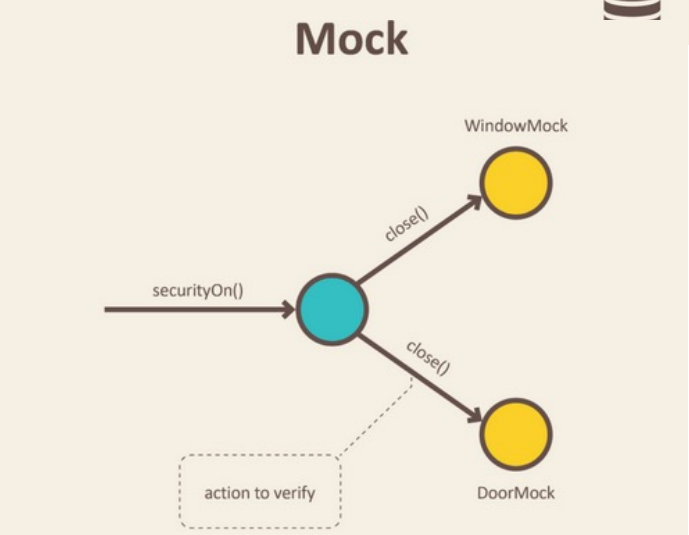
To isolate the *system under test* (SUT) from external systems, we use test doubles: fakes, stubs and mocks.

Test Doubles

- Fakes are objects with working implementations, but not the same as the production environment. In the diagram, the full database has been replaced by an object wrapping a hashmap.
- A stub is an object that holds predefined data to respond to specific requests. For example, To test the login GUI, we could provide a stub that accepts only the password ‘pw’ regardless of the user.
- Mocks work like stubs but they register the calls they receive, so we can assert that the correct action was performed, or the correct message was sent. In the example, a door mock is used to verify that the close() methoid was called, without interacting with hardware.

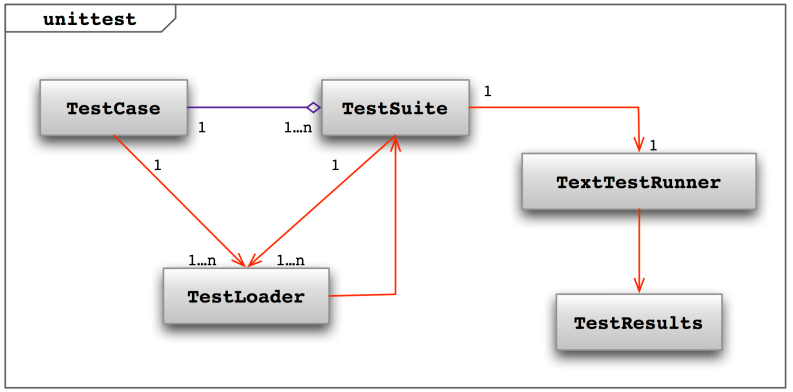






Unit Test Structure

- In python, unit testing is most commonly done with the module unittest.
- This provides a number of classes and functions;
  - Test fixtures: These are the methods to prepare for a test case, called `setUp` and `tearDown`.
  - TestCase: This is the standard class for running a test. It specifies the setUp, tearDown, and a number of functions to execute.
  - TestSuite: Running comprehensive tests is expensive, so often you don't want to run every test case. Test suites allow test cases to be grouped together to be run at once.
  - Test Runners: These run the tests and report the reuslts
- Typically you only have to write the test cases, and the rest is automatic.



Writing some simple tests:

- To write some basic unit tests, we should import unittest, and the modules/classes under test.
- We then subclass `TestCase` for each unit we want to test.
- We specify the `setUp` for each test (e.g. populating a dummy database, or creating instances), and the `tearDown` after each test (e.g. resetting the database).
- Flask has a method test_client() to run a sandboxed version of the app.
- We then specify a set of tests. These must begin with '`test`', and use the assert methods to define whether the test passes
- `python unittest <filename>`

```
1  import unittest, os
2  from app import app, db
3  from app.models import Student, Project, Lab
4
5  class StudentModelCase(unittest.TestCase):
6
7    def setUp(self):
8      basedir = os.path.abspath(os.path.dirname(__file__))
9      app.config['SQLALCHEMY_DATABASE_URI']=\
10         'sqlite:///'+os.path.join(basedir,'test.db')
11     self.app = app.test_client()#creates a virtual test environment
12     db.create_all()
13     s1 = Student(id='00000000',first_name='Test',surname='Case',cits3403=True)
14     s2 = Student(id='11111111',first_name='Unit',surname='Test',cits3403=True)
15     lab = Lab(lab='test-lab',time='now')
16     db.session.add(s1)
17     db.session.add(s2)
18     db.session.add(lab)
19     db.session.commit()
20
21   def tearDown(self):
22     db.session.remove()
23     db.drop_all()
24
25   def test_password_hashing(self):
26     s = Student.query.get('00000000')
27     s.set_password('test')
28     self.assertFalse(s.check_password('case'))
29     self.assertTrue(s.check_password('test'))
30
31   def test_is_committed(self):
32     s = Student.query.get('00000000')
33     self.assertFalse(s.is_committed())
34     s2 = Student.query.get('11111111')
35     lab = Lab.query.first()
36     p = Project(description='test',lab_id=lab.lab_id)
37     db.session.add(p)
38     db.session.flush()
39     s.project_id = p.project_id
40     s2.project_id = p.project_id
41     db.session.commit()
42     self.assertTrue(s.is_committed())
43
44 if __name__ == '__main__':
tests/unittest.py [+]                                    10,9          Top
```

```
(virtual-environment) drtnf@drtnf-ThinkPad:$ python3 -W ignore -m tests.unittest
test_is_committed (__main__.StudentModelCase) ... ok
test_password_hashing (__main__.StudentModelCase) ... ok

----------------------------------------------------------------------
Ran 2 tests in 0.581s

OK
```

Assertions:

- Assertions describe the checks the test performs. They can be supplemented with messages to give diagnostic information about the failing cases.
- Each test can have multiple assertions, and the test only passes if every assertion is true.
- We can also assert that an exception or a warning is raised. If the exception is raised, then the test passes.
- There are many other assertion libraries that can be imported and produce more readable test cases,

Method	Checks that	New in
`assertEqual(a, b)`	`a == b`	
`assertNotEqual(a, b)`	`a != b`	
`assertTrue(x)`	`bool(x) is True`	
`assertFalse(x)`	`bool(x) is False`	
`assertIs(a, b)`	`a is b`	3.1
`assertIsNot(a, b)`	`a is not b`	3.1
`assertIsNone(x)`	`x is None`	3.1
`assertIsNotNone(x)`	`x is not None`	3.1
`assertIn(a, b)`	`a in b`	3.1
`assertNotIn(a, b)`	`a not in b`	3.1
`assertIsInstance(a, b)`	`isinstance(a, b)`	3.2
`assertNotIsInstance(a, b)`	`not isinstance(a, b)`	3.2

Method	Checks that	New in
`assertRaises(exc, fun, *args, **kwds)`	`fun(*args, **kwds)` raises *exc*	
`assertRaisesRegex(exc, r, fun, *args, **kwds)`	`fun(*args, **kwds)` raises *exc* and the message matches regex *r*	3.1
`assertWarns(warn, fun, *args, **kwds)`	`fun(*args, **kwds)` raises *warn*	3.2
`assertWarnsRegex(warn, r, fun, *args, **kwds)`	`fun(*args, **kwds)` raises *warn* and the message matches regex *r*	3.2
`assertLogs(logger, level)`	The `with` block logs on *logger* with minimum *level*	3.4

```
from assertpy import assert_that

def test_something():
    assert_that(1 + 2).is_equal_to(3)
    assert_that('foobar').is_length(6).starts_with('foo').ends_with('bar')
    assert_that(['a', 'b', 'c']).contains('a').does_not_contain('x')
```

Code Coverage:

- Testing is essential for reliable software, and we would like to have a set of test cases, where any code that passes the test “works”
- This means that any line of code that does not feature in at least one test case is redundant to your notion of “works”.
- There are different ways of measuring coverage: statement coverage, branch coverage, logic coverage, path coverage. Statement coverage is sufficient for our purposes, but you should always consider the ways your tests may be deficient.
- Coverage can be automatically measured by such tools as Coverage.py, and HtmlTestRunner can be used to give visual feedback on a test run.

Coverage report: 37.59%

Module ↓	statements	missing	excluded	branches	partial	coverage
cogapp/__init__.py	2	0	0	0	0	100.00%
cogapp/__main__.py	3	3	0	0	0	0.00%
cogapp/backward.py	19	8	0	2	1	57.14%
cogapp/cogapp.py	427	197	4	176	26	47.10%
cogapp/makefiles.py	28	20	3	14	0	19.05%
cogapp/test_cogapp.py	704	486	6	6	0	30.99%
cogapp/test_makefiles.py	55	55	0	6	0	0.00%
cogapp/test_whiteutils.py	69	69	0	0	0	0.00%
cogapp/whiteutils.py	45	3	0	32	3	92.21%
Total	**1352**	**841**	**13**	**236**	**30**	**37.59%**

coverage.py v4.4.2, created at 2017-11-05 07:56

Test Result

Start Time: 2018-08-19 19:57:03

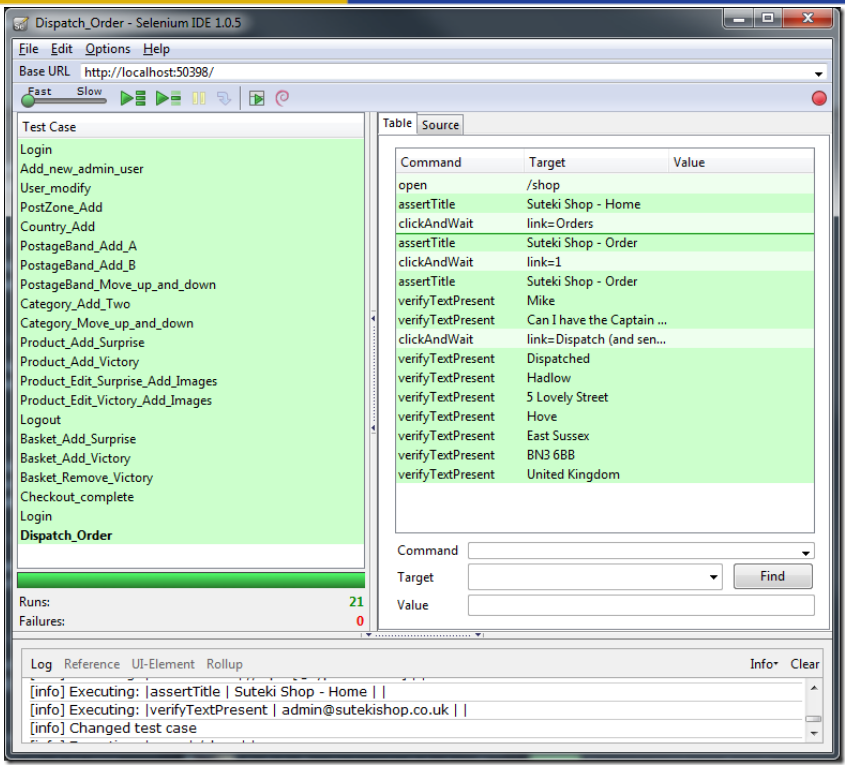
Duration: 0:00:00

Status: Pass: 1, Fail: 1

MyTestExample.MyTestExample	Status
test_function_two (MyTestExample.MyTestExample)	Pass
test_function_one (MyTestExample.MyTestExample)	Fail View
Total Test Runned:	Pass: 1, Fail: 1

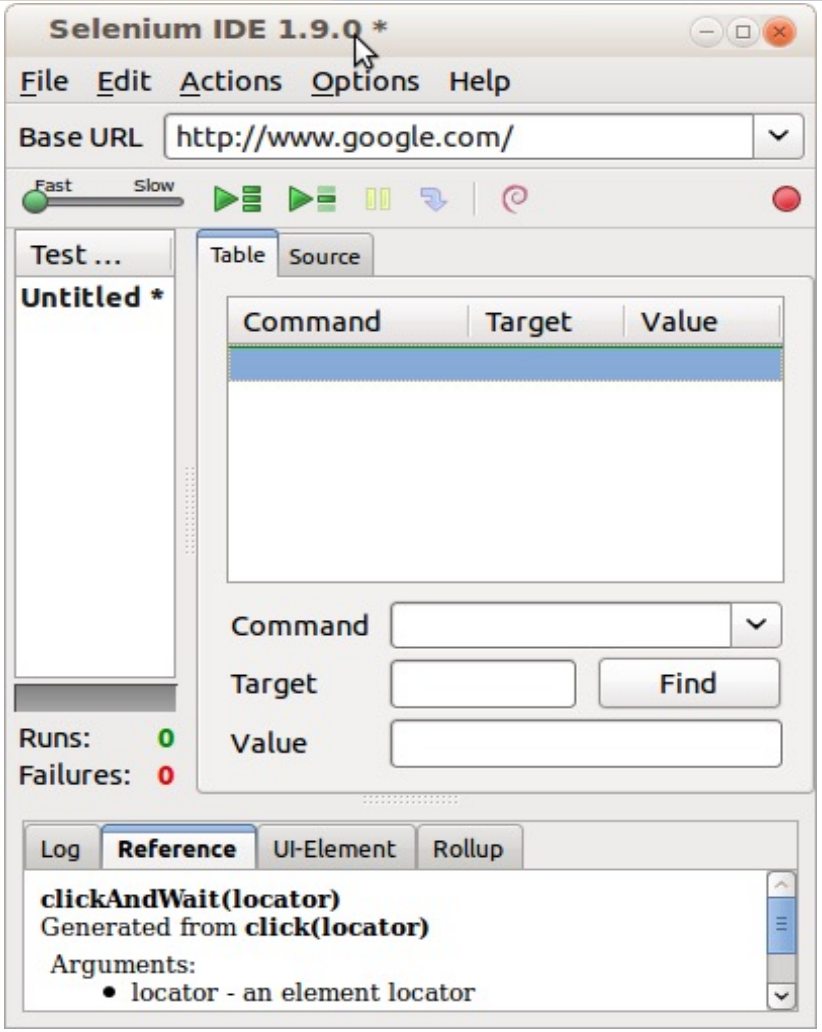
System/User Tests

- User testing is more challenging since it depends on the end user environment.
- Selenium can be used to automate browsers to run test cases.
- PhantomJS is a headless browser that can be used for testing with Selenuim, without the overhead of running a GUI.
- Selenium has two variations: SeleniumIDE is a browser plugin that can record interactions with a web-site and run them back to confirm the outcome remains the same.
- Selenium WebDriver provides a set of tools for scripting User tests.



Selenium IDE

- Firefox/Chrome extension
- Easy record and replay
- Debug and set breakpoints
- Save tests in HTML, WebDriver and other Formats.
- Selenium saves all information in an HTML table format
- Each record consists of:
- **Command** – tells Selenium what to do (e.g. “open”, “type”, “click”, “verifyText”)
- **Target** – tells Selenium which HTML element a command refers to (e.g. textbox, header, table)
- **Value** – used for any command that might need a value of some kind (e.g. type something into a textbox)



How to record/replay with Selenium IDE

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1. Start recording in Selenium IDE

1. Execute scenario on running web application

1. Stop recording in Selenium IDE

1. Verify / Add assertions

1. Replay the test.

... or using webdriver you can integrate selenium with any unit testing scripting language.

You can test functionality, responsiveness and general usability.

Selenium WebDriver

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- Selenium IDE is good for quickly prototyping tests, but is not very good for maintaining tests.
- You can't apply test fixtures easily and, you need a running instance of the application.
- WebDriver provides a set of python classes for interactioning with a browser.
- We require a driver executable for each browser we wish to test (Firefox, Chrome, Edge, PhantomJS).
- The executable needs to be in the path, or the current directory
- We also need to set up our doubles. We want a clean database for testing, so we really need flask to be running in testing configuration.

```
import os
basedir = os.path.abspath(os.path.dirname(__file__))

class Config(object):
    SECRET_KEY = os.environ.get('SECRET_KEY') or 'sshh!'
    SQLALCHEMY_DATABASE_URI = os.environ.get('DATABASE_URL') or '
sqlite:///'+os.path.join(basedir,'app.db')
    SQLALCHEMY_TRACK_MODIFICATIONS = False

class ProductionConfig(Config):
    SECRET_KEY = os.environ.get('SECRET_KEY')
#   SQLALCHEMY_DATABASE_URI = Postgres remote

class DevelopmentConfig(Config):
    DEBUG=True

class TestingConfig(Config):
    SQLALCHEMY_DATABASE_URI = 'sqlite:///'+os.path.join(basedir,'
tests/test.db')
    #SQLALCHEMY_DATABASE_URI = 'sqlite:///:memory:' #in memory da
tabase
~
config.py                                   1,1           All
```

```
from flask import Flask
from config import Config
from flask_sqlalchemy import SQLAlchemy
from flask_migrate import Migrate
from flask_login import LoginManager

app = Flask(__name__)
app.config.from_object('config.TestingConfig')
db = SQLAlchemy(app)
migrate = Migrate(app, db)
login = LoginManager(app)
login.login_view = 'login'

from app import routes,models
~
app/__init__.py                             1,1
```

Running Selenium Tests

- In the TestingConfig, we have a new database, test.db, that always starts empty so our tests are repeatable.
- The tests can be run by unittest, even though they're not unit tests.
- In our setUp we create a selenium web driver for Firefox, enter dummy data to our databases, and navigate to the app's page.
- The test is executed by describing the interactions selenium has with the web page.
- This is specified via DOM elements, and selenium offers different methods for simulating events.

```python
import unittest, os, time
from app import app, db
from app.models import Student, Project, Lab
from selenium import webdriver

#To do, find simple way for switching from test context to development to production.


class SystemTest(unittest.TestCase):
  driver = None

  def setUp(self):
    self.driver = webdriver.Firefox(executable_path=r'/home/drtnf/Dropbox/Tim/teaching/2019/CITS3403/pair-up/geckodriver')

    if not self.driver:
      self.skipTest('Web browser not available')
    else:
      db.init_app(app)
      db.create_all()
      s1 = Student(id='22222222',first_name='Test',surname='Case',cits3403=True)
      s2 = Student(id='11111111',first_name='Unit',surname='Test',cits3403=True)
      lab = Lab(lab='test-lab',time='now')
      db.session.add(s1)
      db.session.add(s2)
      db.session.add(lab)
      db.session.commit()
      self.driver.maximize_window()
      self.driver.get('http://localhost:5000/')

  def tearDown(self):
    if self.driver:
      self.driver.close()
      db.session.query(Student).delete()
      db.session.query(Project).delete()
      db.session.query(Lab).delete()
      db.session.commit()
      db.session.remove()

  def test_register(self):
    s = Student.query.get('22222222')
    self.assertEqual(s.first_name,'Test',msg='student exists in db')
    self.driver.get('http://localhost:5000/register')
    self.driver.implicitly_wait(5)
    num_field = self.driver.find_element_by_id('student_number')
    num_field.send_keys('22222222')
    pref_name = self.driver.find_element_by_id('prefered_name')
    pref_name.send_keys('Testy')
    new_pin = self.driver.find_element_by_id('new_pin')
    new_pin.send_keys('0000')
    new_pin2 = self.driver.find_element_by_id('new_pin2')
    new_pin2.send_keys('0000')
    time.sleep(1)
    self.driver.implicitly_wait(5)
    submit = self.driver.find_element_by_id('submit')
    submit.click()
    #check login success
    self.driver.implicitly_wait(5)
    time.sleep(1)
    logout = self.driver.find_element_by_partial_link_text('Logout')
    self.assertEqual(logout.get_attribute('innerHTML'), 'Logout Testy', msg='Logged in')


if __name__=='__main__':
  unittest.main(verbosity=2)
```

tests/systemtest.py

Navigating with Selenium

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- You need to design your web pge so that all elements are accessible. And have a fixed id, so the tests are robust if the page layout changes.
- Selenium can enter information in forms, click on elements and drag and drop etc
- You can extract information by searching for text or accessing the attributes of HTML elements.
- An standard assertion library can be used to confirm that the page behaved as expected.

```
from selenium.webdriver.support.ui import Select
select = Select(driver.find_element_by_name('name'))
select.select_by_index(index)
select.select_by_visible_text("text")
select.select_by_value(value)
```

```
element = driver.find_element_by_name("source")
target = driver.find_element_by_name("target")

from selenium.webdriver import ActionChains
action_chains = ActionChains(driver)
action_chains.drag_and_drop(element, target).perform()
```

- *find_element_by_id*
- *find_element_by_name*
- *find_element_by_xpath*
- *find_element_by_link_text*
- *find_element_by_partial_link_text*
- *find_element_by_tag_name*
- *find_element_by_class_name*
- *find_element_by_css_selector*

```
continue_link = driver.find_element_by_link_text('Continue')
continue_link = driver.find_element_by_partial_link_text('Conti')
```

Running the Selenium Tests

- To run the Selenium tests, you need to have the flask app running in TestingConfig.
- You execute the tests as with unittest
- `python -m tests.systemtest`

```
OK
(virtual-environment) drtnf@drtnf-ThinkPad:$ python3 -W ignore -m tests.systemtest
test_register (__main__.SystemTest) ... 127.0.0.1 - - [01/May/2019 13:21:59] "GET / HTTP/1.1" 200 -
127.0.0.1 - - [01/May/2019 13:21:59] "GET /static/bootstrap.min.css HTTP/1.1" 200 -
127.0.0.1 - - [01/May/2019 13:21:59] "GET /static/bootstrap.min.js HTTP/1.1" 200 -
127.0.0.1 - - [01/May/2019 13:21:59] "GET /static/bootstrap-theme.min.css HTTP/1.1" 200 -
127.0.0.1 - - [01/May/2019 13:22:00] "GET /favicon.ico HTTP/1.1" 404 -
127.0.0.1 - - [01/May/2019 13:22:00] "GET /register HTTP/1.1" 200 -
127.0.0.1 - - [01/May/2019 13:22:01] "POST /register HTTP/1.1" 302 -
127.0.0.1 - - [01/May/2019 13:22:01] "GET /index HTTP/1.1" 200 -
ok

----------------------------------------------------------------------
Ran 1 test in 11.748s

OK
```