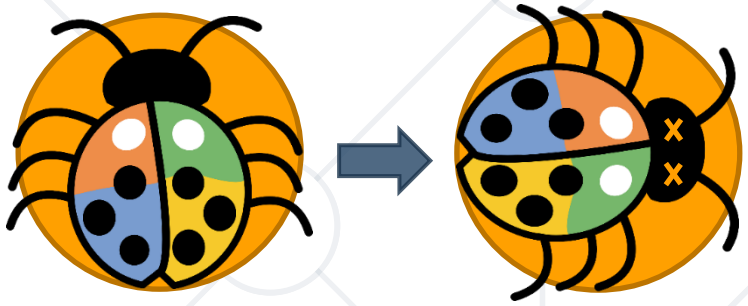
Unit Testing

Building Rock-Solid Software



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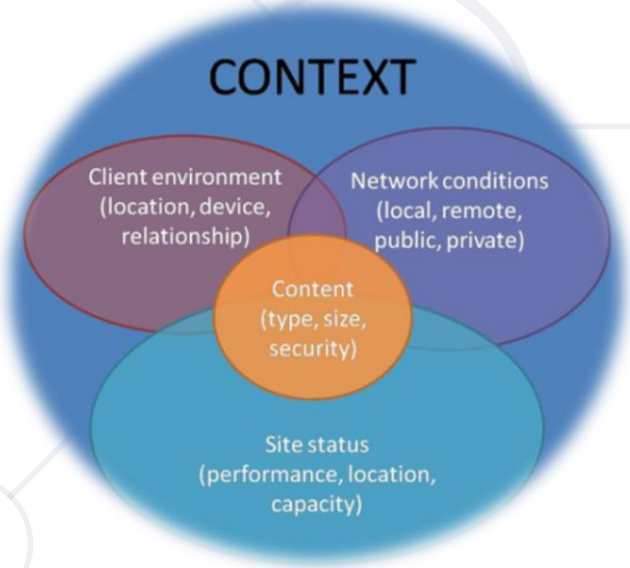
Seven Testing Principles

Seven Testing Principles (1)

- Testing is context dependent
  - Testing is done differently in **different contexts**
- Example:
  - Safety-critical software is tested **differently** from an e-commerce site



Seven Testing Principles (2)

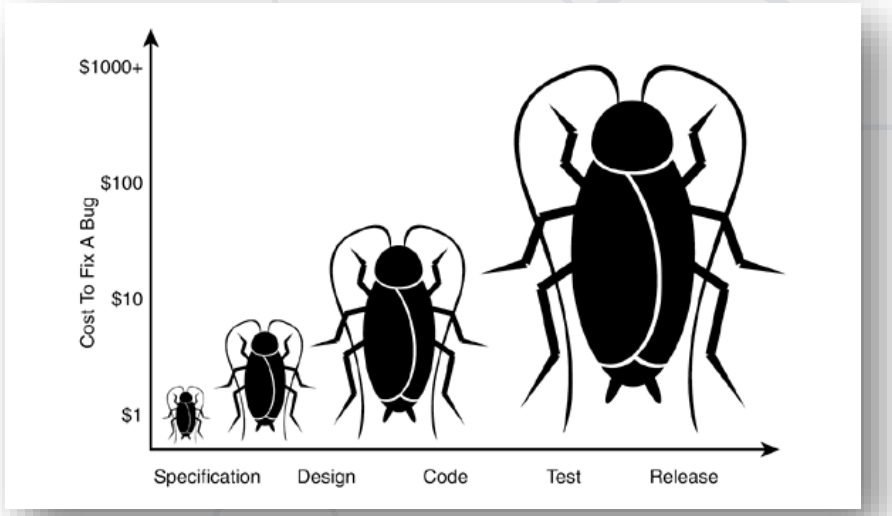
- Exhaustive testing is **impossible**
  - All combinations of inputs and preconditions are usually almost **infinite number**
  - Testing everything is not feasible
    - Except for trivial cases
  - Risk analysis and priorities should be used to focus testing efforts
- E.g.: Big list of naughty strings

A QA Tester walks into a bar:

He orders a beer.
He orders 3 beers.
He orders 2976412836 beers.
He orders 0 beers.
He orders -1 beer.
He orders q beers.
He orders nothing.
Él ordena una cerveza.
He orders a deer.
He tries to leave without paying.
He starts ordering a beer, then throws himself through the window half way through.
He orders a beer, gets his receipt, then tries to go back.

Seven Testing Principles (3)

- Early testing is **always preferred**
  - Testing activities shall be started as early as possible
    - And shall be focused on defined objectives
  - The later a bug is found – the more it costs!



Seven Testing Principles (4)

- Defect clustering
  - Testing effort shall be focused **proportionally**
    - To the expected and later observed defect density of modules
  - A **small number** of modules usually contains **most of the defects** discovered (80/20 principle)
    - Responsible for most of the operational failures

Seven Testing Principles (5)

- Pesticide paradox
  - Same tests repeated **over and over again** tend to **lose their effectiveness**
  - Previously **undetected** defects remain **undiscovered**
  - New and modified test cases should be developed

Seven Testing Principles (6)

- Testing shows presence of defects
  - Testing can **show that defects are present**
  - Cannot prove that there are no defects
  - Appropriate testing **reduces** the probability for defects

Seven Testing Principles (7)

- Absence-of-errors fallacy
  - **Finding** and **fixing** defects itself does not help in these cases:
    - The system built is unusable
    - Does not fulfill the users' needs and expectations

Software Used to Test Software

What is Unit Testing?

Unit Testing

- **Unit test** == a piece of code that **tests specific functionality** in certain software component (unit)

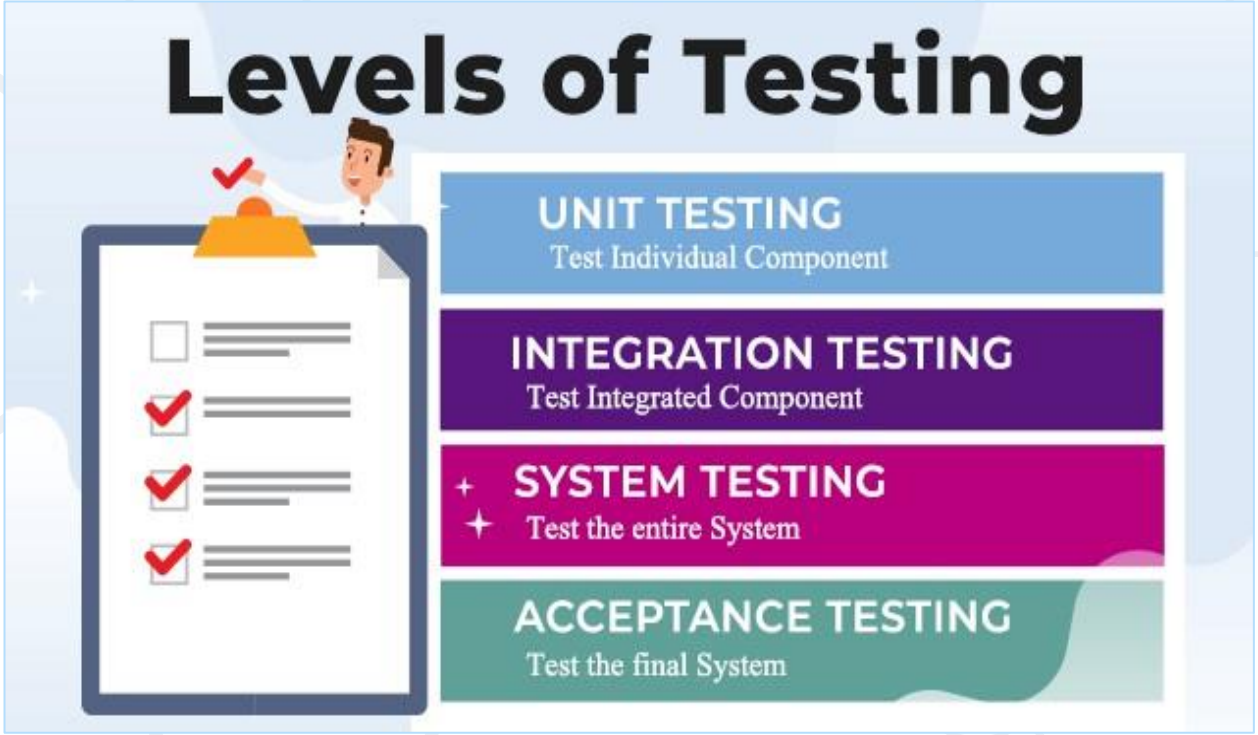

```
int Sum(int[] arr)
{
  int sum = arr[0];
  for (int i=1; i<arr
    .Length; i++)
      sum += arr[i];
  return sum;
}
```

```
void Test_SumTwoNumbers() {
  if (Sum(new int[]{1, 2}) != 3)
    throw new Exception("1+2 != 3");
}
```

```
void Test_SumEmptyArray() {
  if (Sum(new int[]{ }) != 0)
    throw new Exception("sum [] != 0");
}
```

Test Levels

- **Unit tests**
  - Test a **single component** (mocking the dependencies)
  - NUnit, JUnit, PyUnit, Mocha
- **Integration tests**
  - Test an **interaction** between components, e. g. **API tests**



- **System tests / acceptance tests / end-to-end tests**
  - Test the **entire system**, e. g. Selenium, Appium, Cypress, Playwright

Unit Testing Frameworks

Testing Frameworks

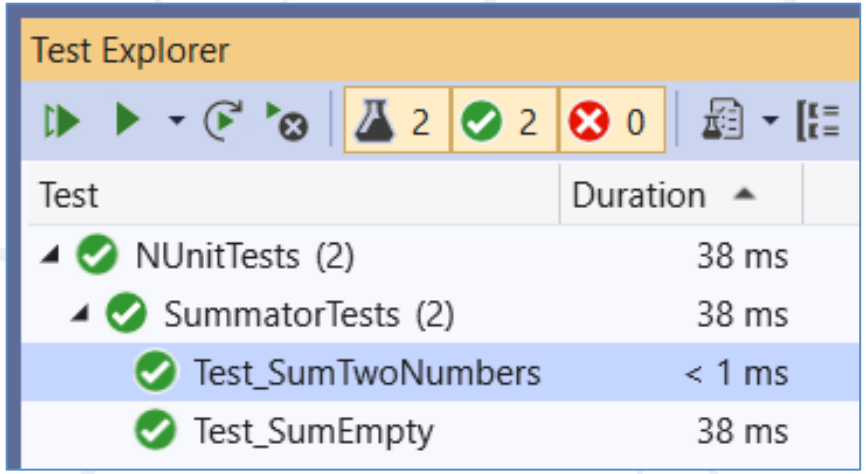
- **Testing frameworks** provide **foundation for test automation**
  - Consists of **libraries**, code **modules** and **tools** for test automation
  - **Structure the tests** into hierarchical or other form
  - **Implement** test cases, **execute the tests** and **generate reports**
  - **Assert** the execution results and exit conditions
  - Perform initialization at **startup** and cleanup at **shut down**
- **Examples** of testing frameworks:
  - NUnit, xUnit, MSTest (C#), JUnit (Java), Mocha (JS), PyUnit (Python)

Testing Framework – Example

- **Testing frameworks** simplify automated testing and reporting
  - Example: **NUnit** testing framework for C#

```
using NUnit.Framework;

public class SummatorTests
{
  [Test]
  public void Test_SumTwoNumbers() {
    var sum = Sum(new int[] { 1, 2 });
    Assert.AreEqual(3, sum);
  }
}
```



Unit Testing Framework vs. Testing Framework

- **Unit testing framework** == **automated testing framework** == **testing framework** == **test framework**
  - Many names for similar concepts → why?
- Testing frameworks like **JUnit** and **NUnit** were initially designed for **unit testing**, but nothing limits them to wider use
- With additional libraries, NUnit and JUnit are used for:
  - **Integration testing**, **API testing**, Web service testing
  - **End-to-end testing**, **Web UI testing**, **mobile testing**, etc.

NUnit: First Steps

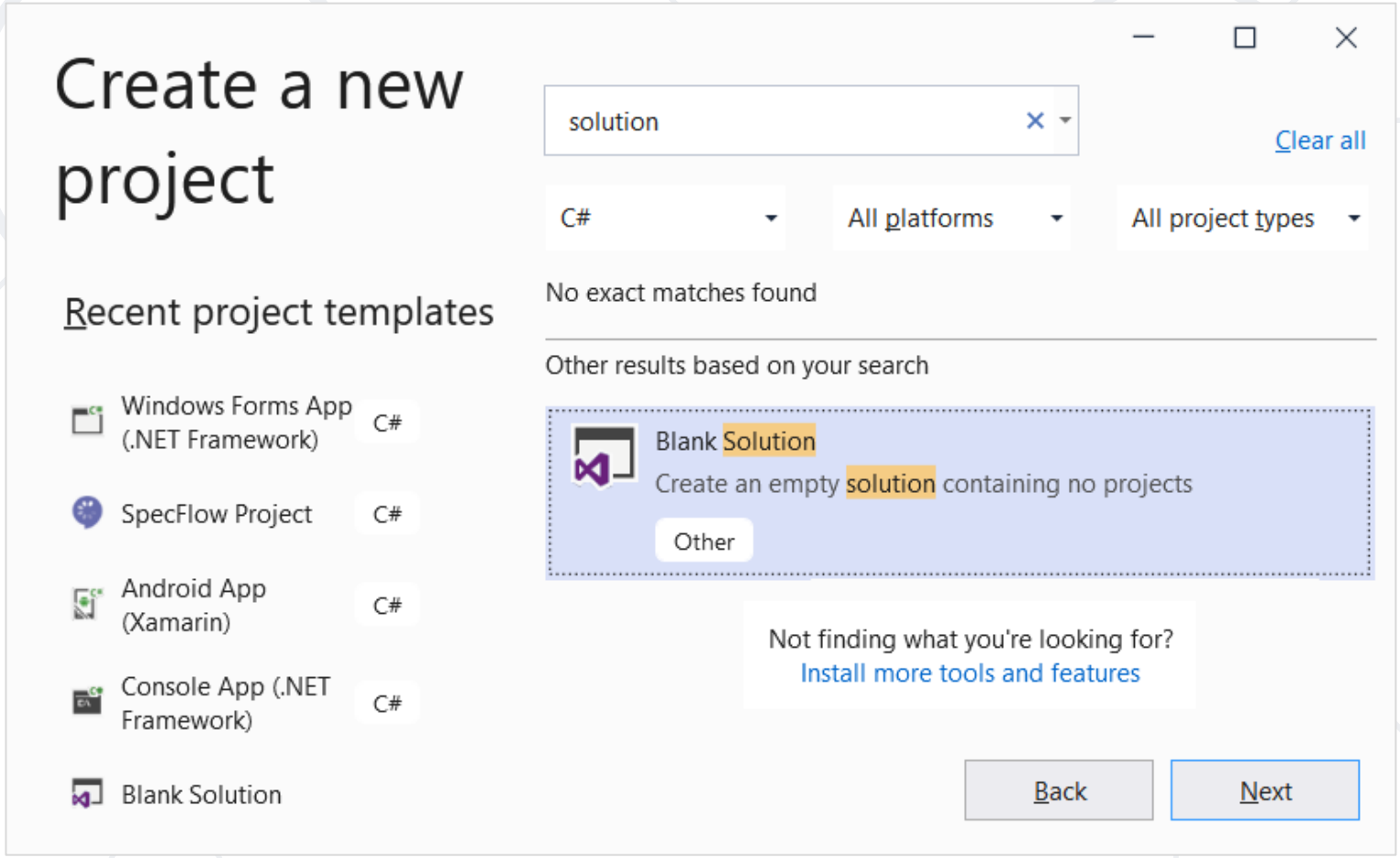
Setup and First Test

NUnit: Overview

- **NUnit** == popular C# testing framework
  - Supports test suites, test cases, before & after code, startup & cleanup code, timeouts, expected errors, …
  - Like **JUnit** (for Java)
  - Free, open-source
  - Powerful and mature
  - Wide community
  - Built-in support in Visual Studio
  - Official site: nunit.org

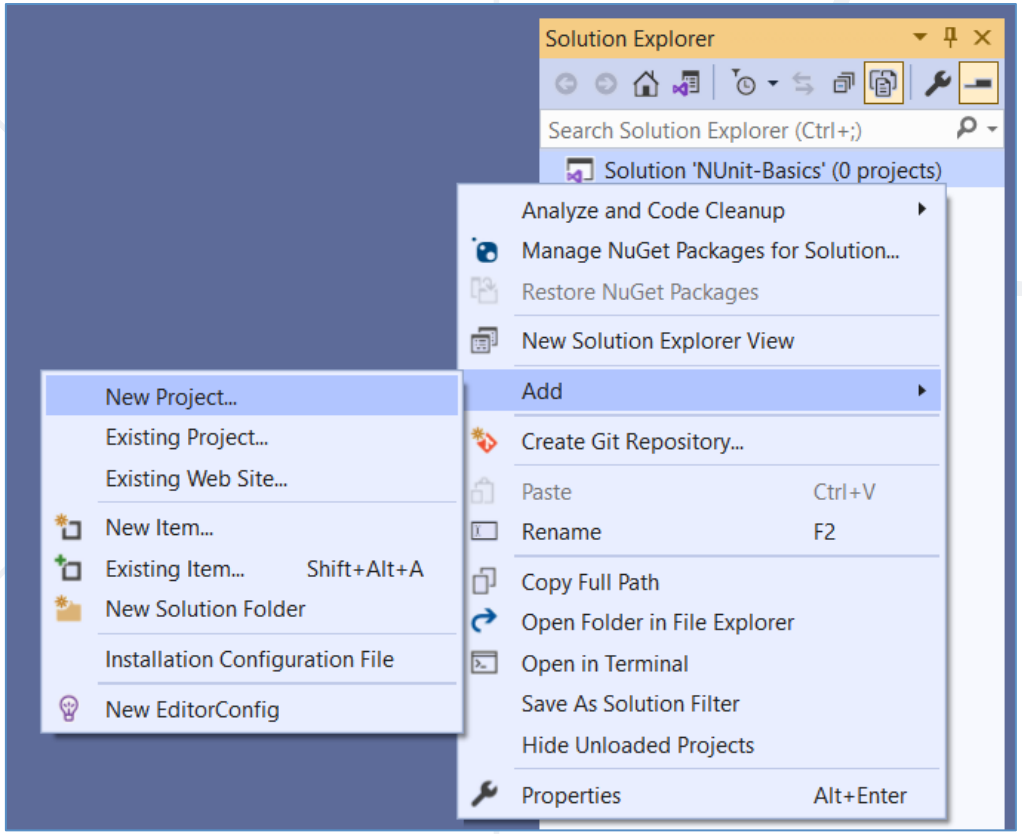
Creating a Blank Solution

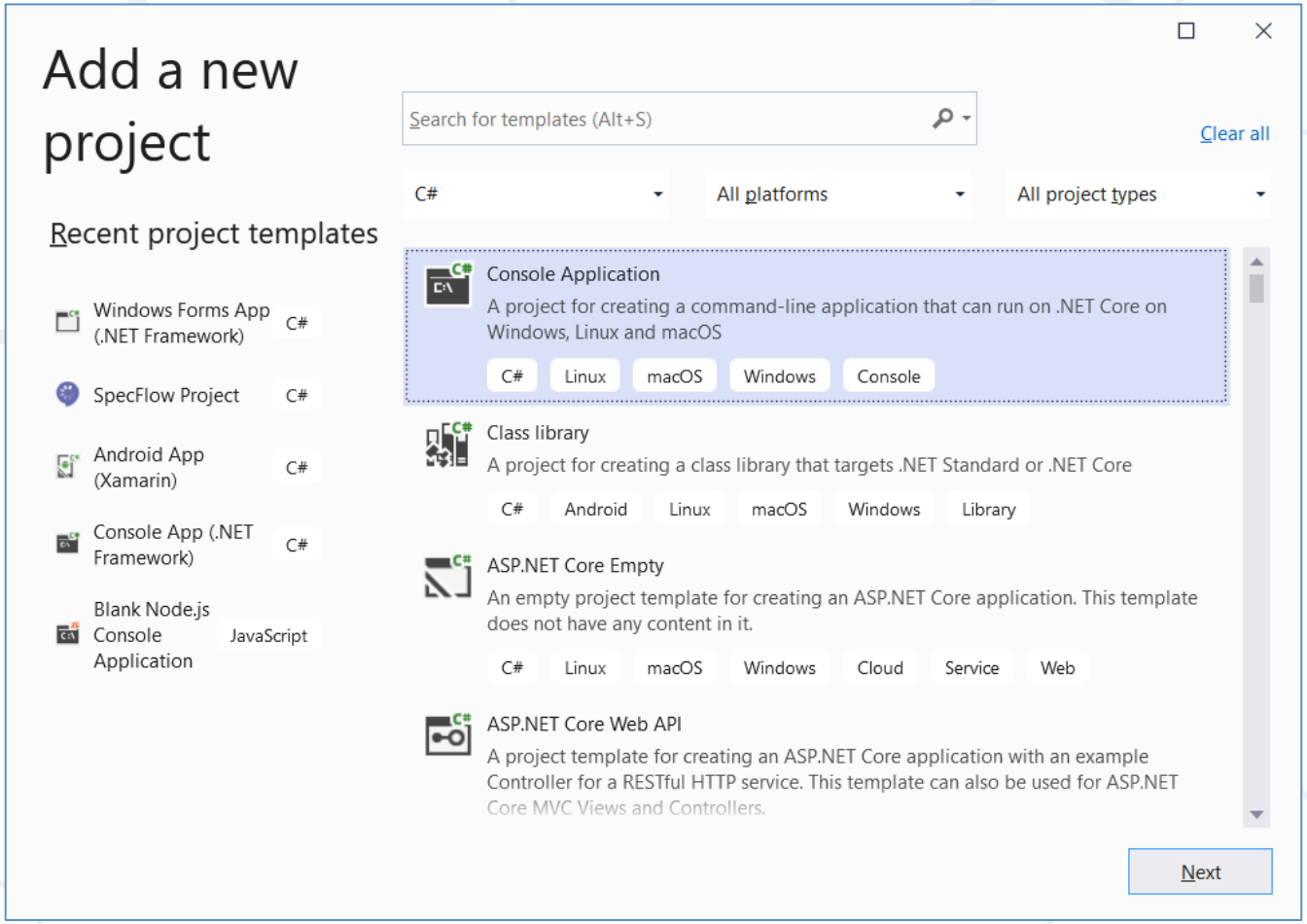
- Create a **blank solution** in Visual Studio
  - It will hold the **project for testing**
  - And the **unit test project** (tests)



Creating a Project for Testing

- Create a **console-based app**, to hold the **code for testing**





Creating a Project for Testing (2)

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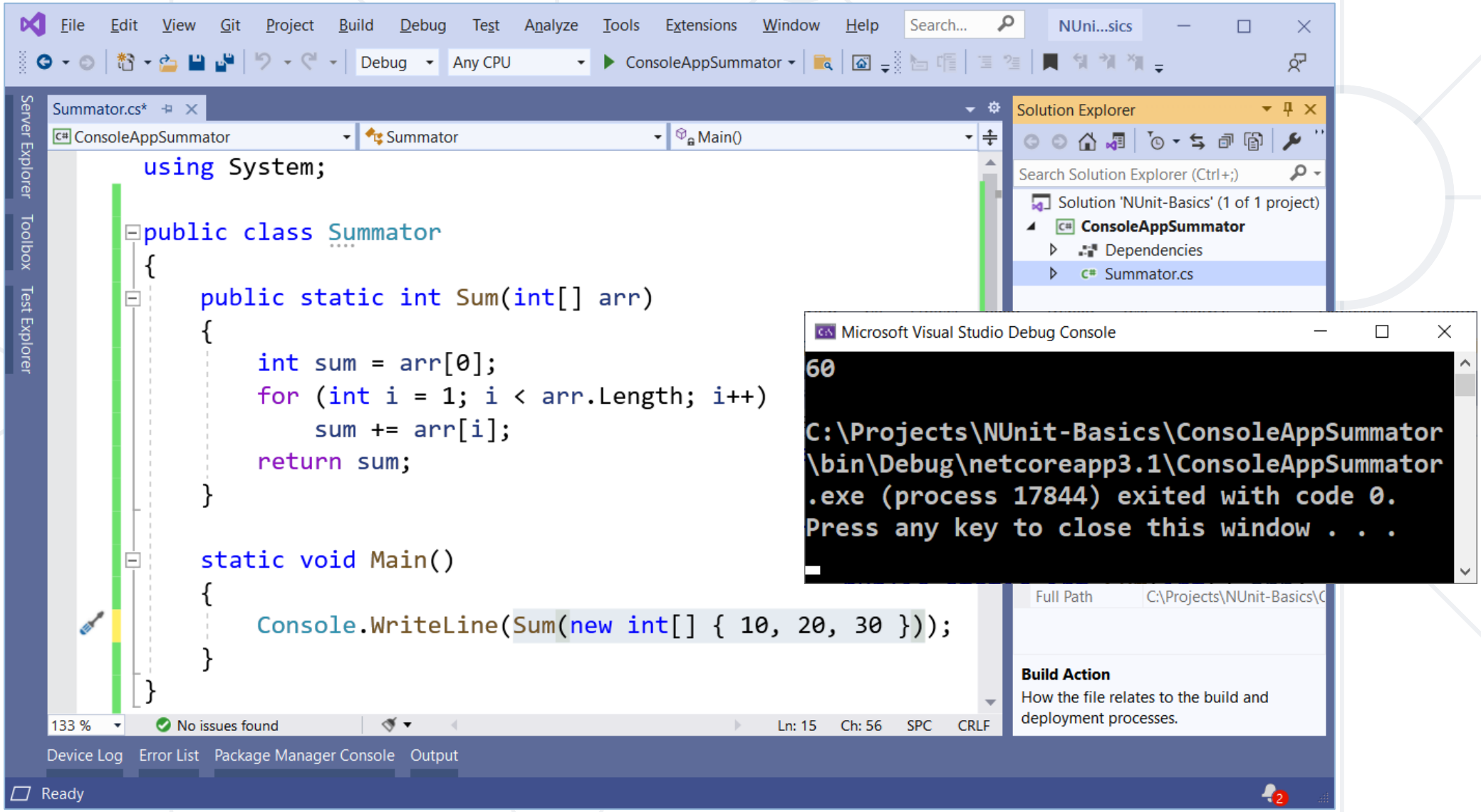

Creating an NUnit Project

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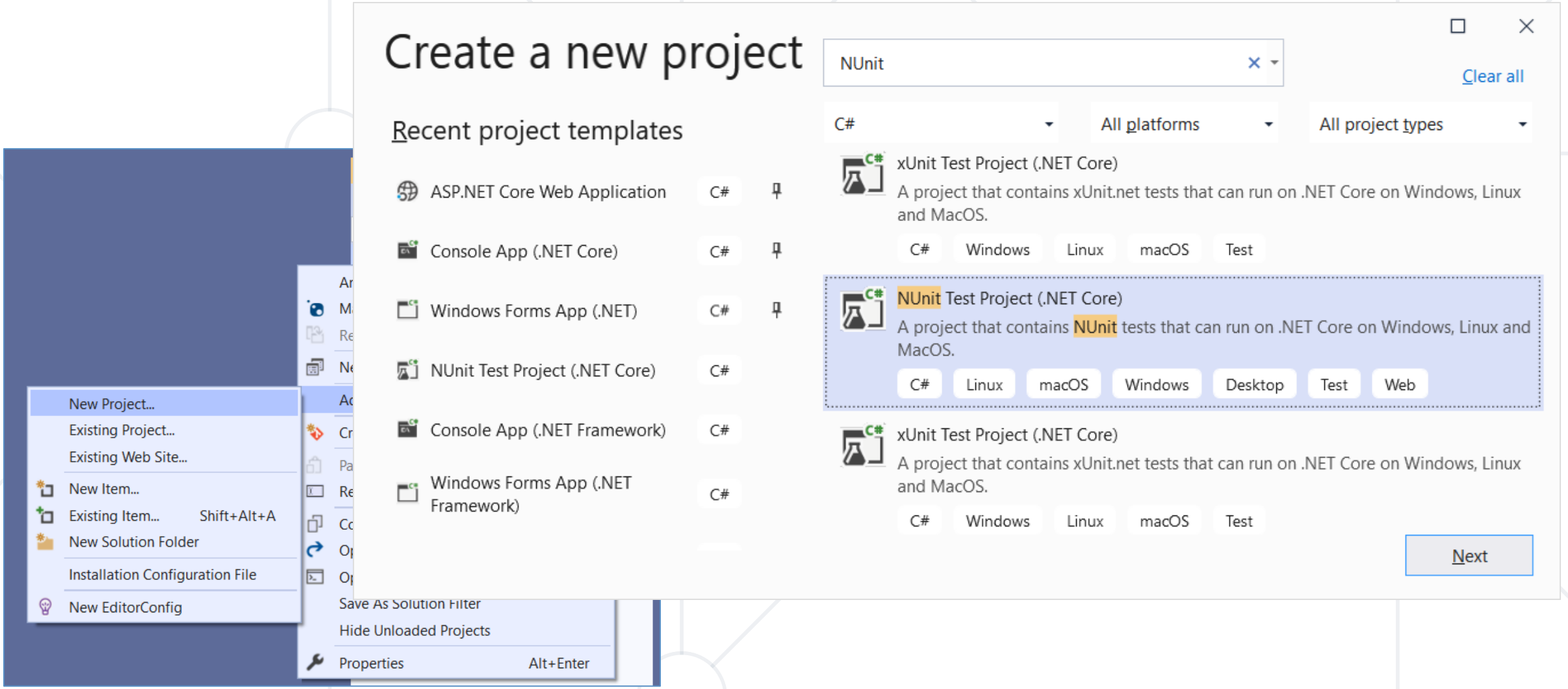
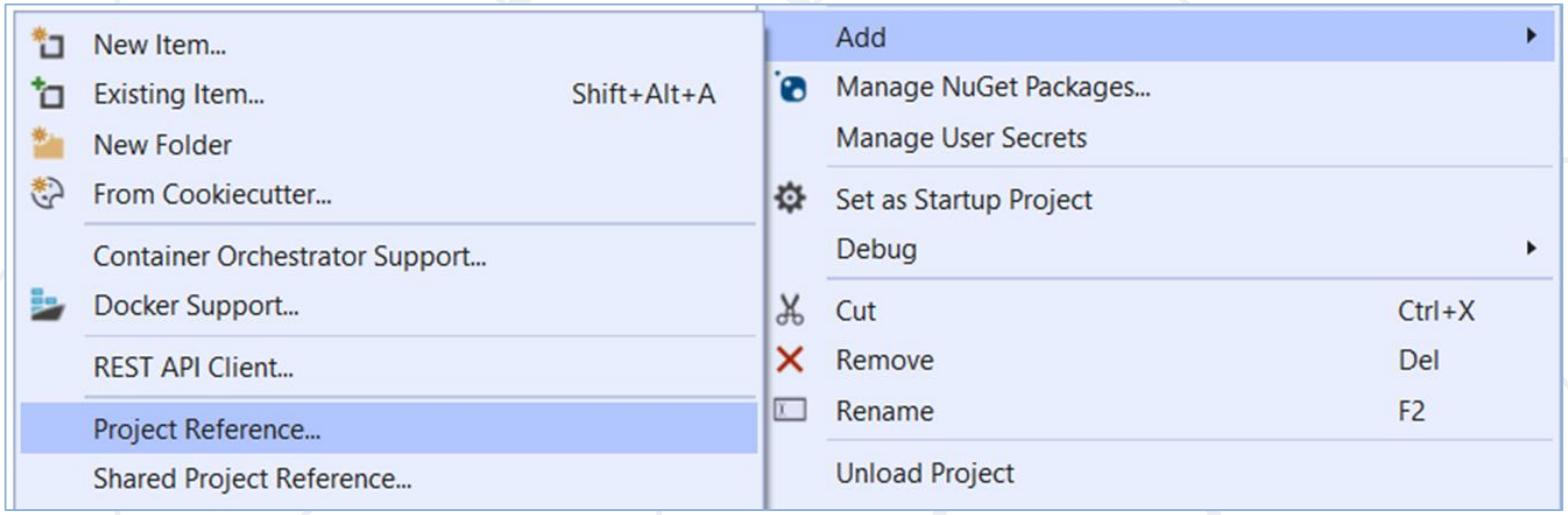
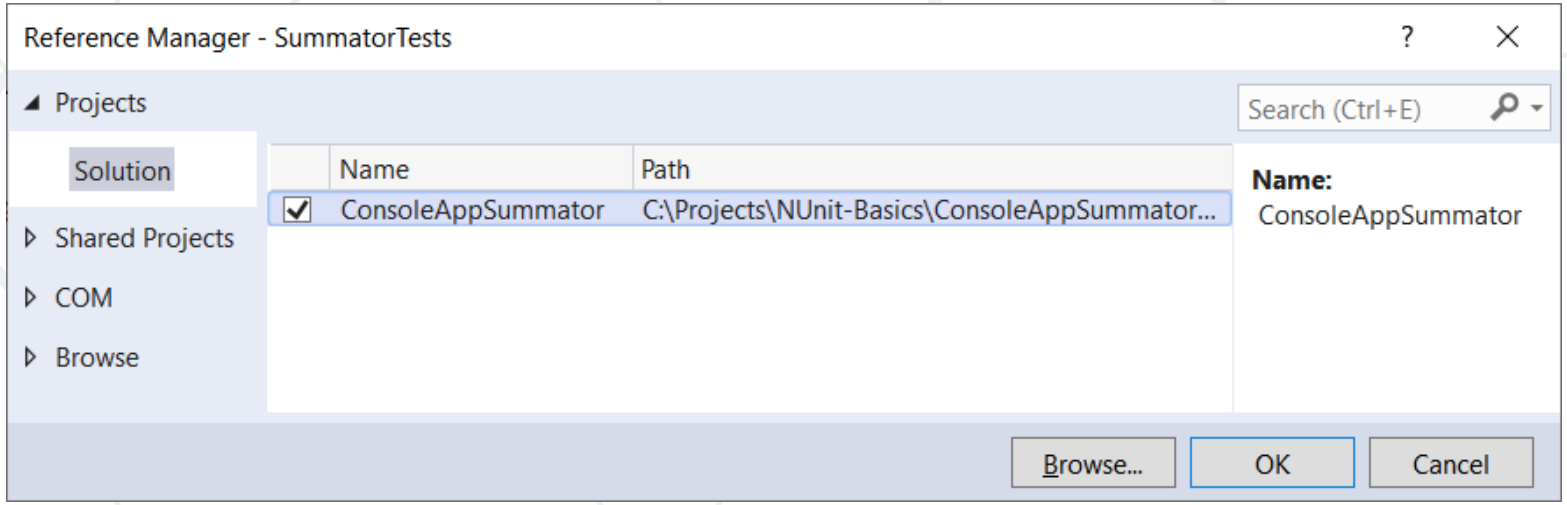


Adding Project Reference

- Add **Project Reference** to the target project for testing:





Writing the First Test

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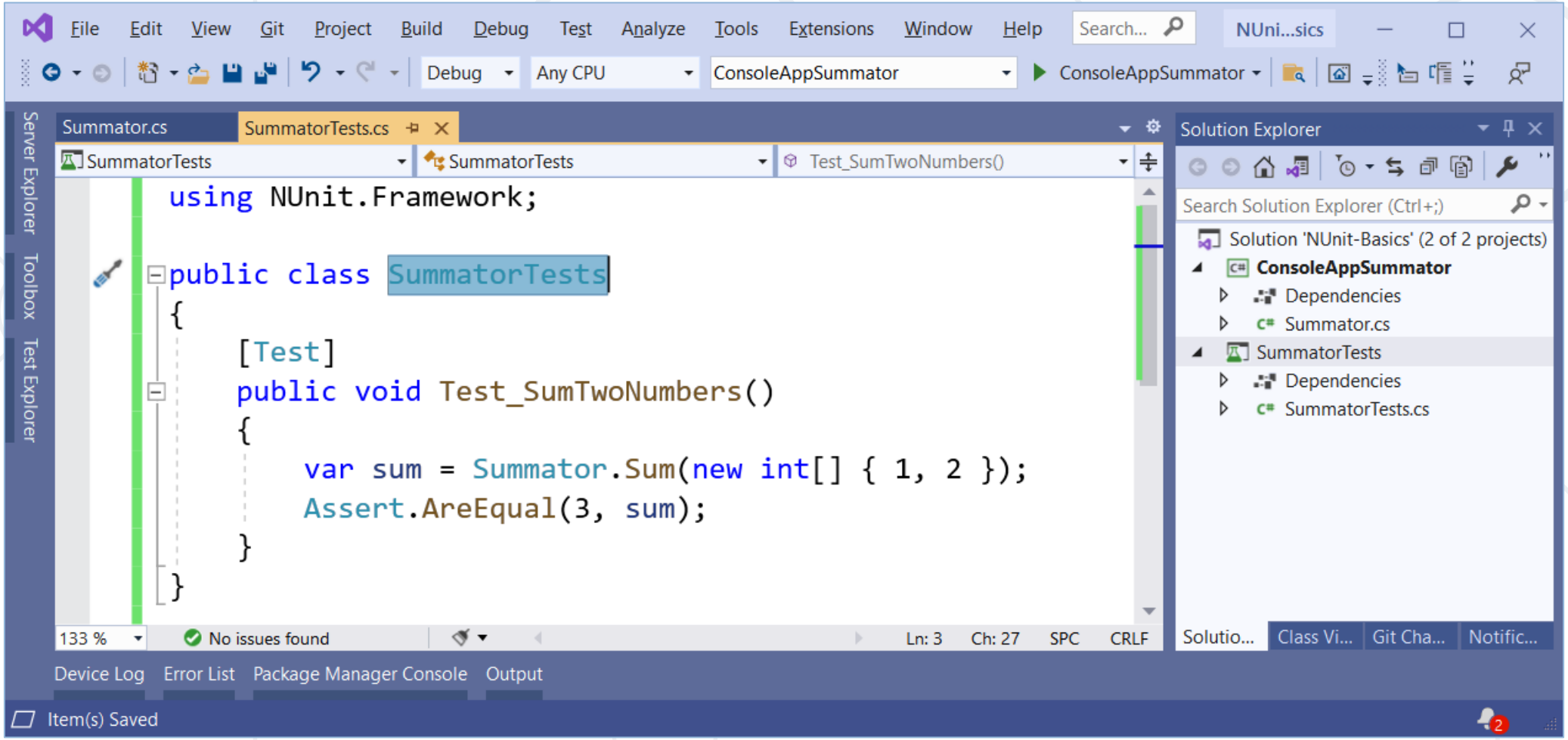
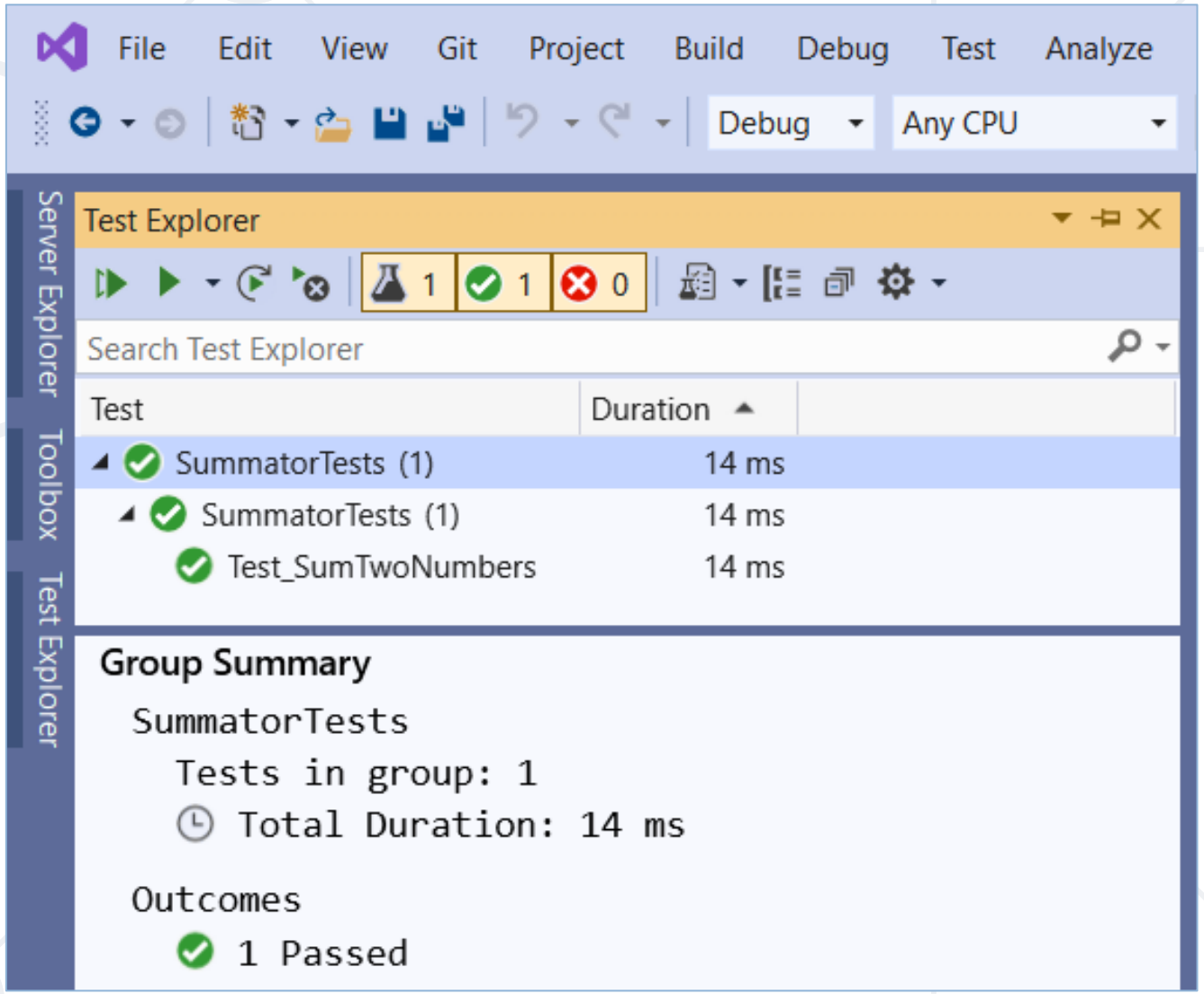
- Writing the first **NUnit test method**:



Running the Tests

- The **[Test Explorer]** tool in Visual Studio
  - Show the [Test Explorer]:
    - **[Ctrl + E] + T**
  - Visualizes the **hierarchy** of tests
  - **Executes** tests
  - **Reports** results



NUnit: Basics

Test Classes and Test Methods

NUnit: NuGet Packages

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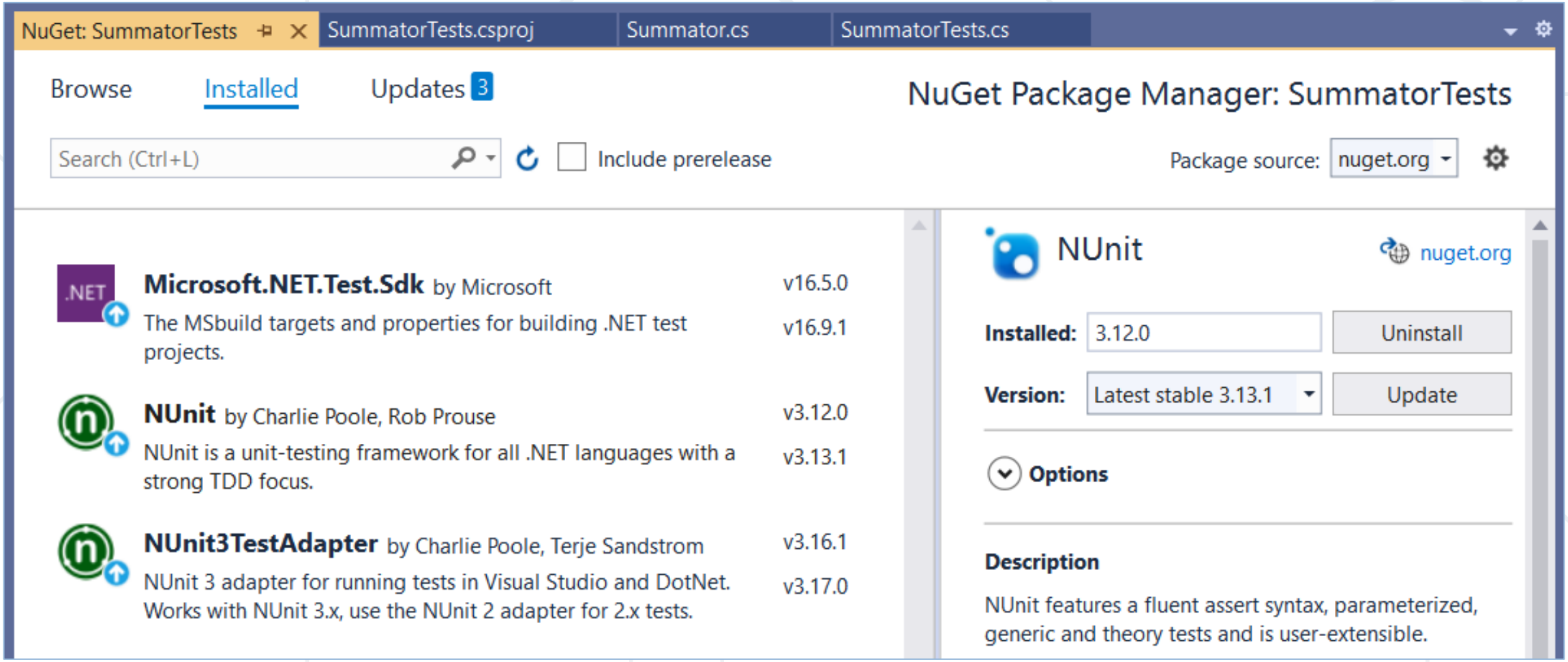
- **NuGet packages**, required to run NUnit tests in Visual Studio



Test Classes and Test Methods

- **Test classes** hold **test methods**:

```
using NUnit.Framework;

[TestFixture]
public class SummatorTests
{
  [Test]
  public void Test_SumTwoNumbers() {
    var sum = Sum(new int[] { 1, 2 });
    Assert.AreEqual(3, sum);
  }
}
```

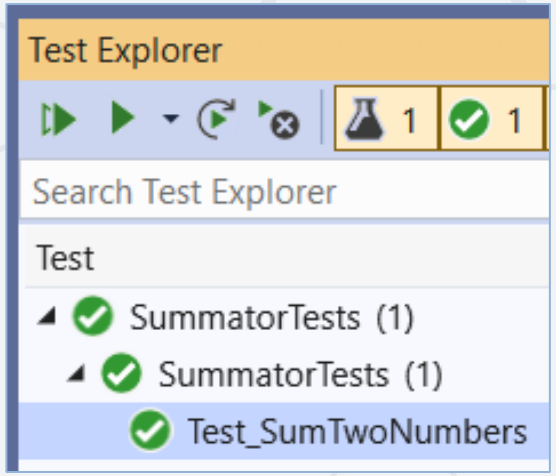
Import NUnit

Optional notation

Test class

Test method

Assertion



Initialization and Cleanup Methods

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```
private Summator summator;

[SetUp] // or [OneTimeSetUp]
public void TestInitialize()
{
  this.summator = new Summator();
}

[TearDown] // or [OneTimeTearDown]
public void TestCleanup()
{
  // …
}
```

Executes before each test

Executes after each test

Problem: NUnit Test

- Create console application project
- Add BankAccount class
- Create NUnit Project
- Test the BankAccount class

Solution: NUnit Test (1)

- Create a console **applicaton**
  - Add BankAccount class for us to test

BankAccount
+Amount : decimal +BankAccount(decimal)

- Create a new **NUnit Test Project**
  - Name it like the project you are testing, but with "**.Tests**" suffix
- Open **Test Explorer** (Ctrl + E, T or Test->Windows->TestExplorer)

Solution: NUnit Test (2)

- Write your first test

```
[TestFixture]
public class BankAcountTests
{
  [Test]
  public void AccountInitializeWithPositiveValue() {
    BankAccount account = new BankAccount(2000m);
    Assert.That(account.Amount, Is.EqualTo(2000m));
  }
}
```

Attribute that marks a class that contains tests

Test Method

Assert class comes with NUnit

The "AAA" Testing Pattern

- Automated tests usually follow the **"AAA" pattern**
  - **Arrange**: prepare the **input** data and entrance conditions
  - **Act**: invoke the **action** for testing
  - **Assert**: check the **output** and exit conditions

```
[Test]
public void Test_SumNumbers()
{
    // Arrange
    var nums = new int[] {3, 5};

    // Act
    var sum = Sum(nums);

    // Assert
    Assert.AreEqual(8, sum);
}
```

How to Write Good Tests

Unit Testing Best Practices

Naming the Test Methods

- **Test names** should answer the question "*what's inside?*"
  - Should use **business domain terminology**
  - Should be **descriptive** and **readable**

```
IncrementNumber() {}
Test1() {}
TestTransfer() {}
```

```
Test_DepositAddsMoneyToBalance() {}
Test_DepositNegativeShouldNotAddMoney() {}
Test_TransferSubtractsFromSourceAddsToDestAccount() {}
```

Automated Tests: Good Practices

- Test cases must be **repeatable**
  - Tests should behave the same if you run them many times
  - The expected results must be **consistent** and easily verified
- Test cases should **have no dependencies**
  - The order of test execution should never be important
  - Input data and entrance conditions should be set in the test
  - Test cases may depend on the test initialization only: **[SetUp]**
  - Tests should **cleanup** properly any resources used

Automated Tests: Good Practices (2)

- **Single scenario** per test case, not multiple

```
[Test]
public void Te
{
    var names
    var remove
    Assert.Tha
    var remove
    Assert.Tha
    var removedL
    Assert.That(
    Assert.That(
}
```

```
[Test]
public void Test_Collections_RemoveAtStart()
{
}
```

```
[Test]
public void Test_Collections_RemoveAtEnd()
{
}
```

```
[Test]
public void Test_Collections_RemoveAtMiddle()
{
    var names = new Collection<string>("Peter", "Maria", "Steve", "Mia");
    var removed = names.RemoveAt(1);
    Assert.That(removed, Is.EqualTo("Maria"));
    Assert.That(names.ToString(), Is.EqualTo("[Peter, Steve, Mia]"));
}
```

Testing Private Methods

- **Private methods** should be tested indirectly
  - By testing the **public methods** with certain inputs and entrance conditions, that will invoke the target private methods
  - Check the **code coverage** to ensure all code is tested!
- Example:

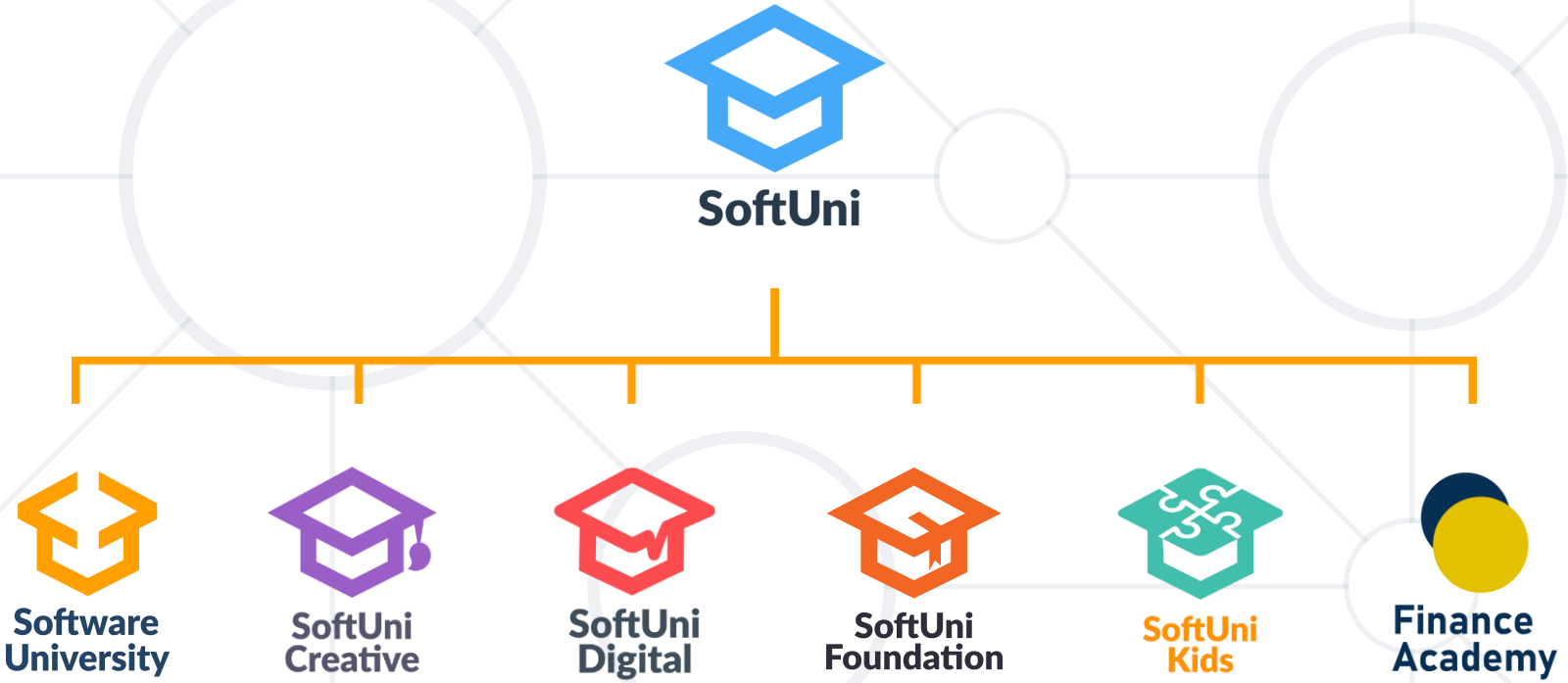
```
public void Add(T item)
{
    this.EnsureCapacity();
    this.items[this.Count] = item;
    this.Count++;
}
```

```
private void EnsureCapacity()
{
    if (this.Count == this.Capacity)
    {
        // Grow the capacity 2 times and move the items
        T[] oldItems = this.items;
        this.items = new T[2 * oldItems.Length];
        for (int i = 0; i < this.Count; i++)
            this.items[i] = oldItems[i];
    }
}
```

Summary

- **Unit testing** == automated testing of single component (unit)
- **Testing framework** == foundation for writing tests
- **NUnit** == automated testing framework for C#
- The **AAA pattern**: Arrange, Act, Assert

Questions?



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