Windows Phone Programming in C#

Rob Miles

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Introduction

Welcome

These notes are an introduction to Windows Phone development for anyone learning to program. They assume some knowledge of programming fundamentals, but they will teach you programming concepts in the framework of Windows Phone development.

These notes do not teach programming from first principles. I am going to assume that you already know how to write and run simple C# programs on a Windows PC.

What you need to have before you start

All the development tools that you need can be downloaded for free from here:

http://www.microsoft.com/downloads/en/details.aspx?FamilyID=04704acf-a63a-4f97-952c-8b51b34b00ce

If you have your own Windows Phone device you can use this to run programs if you become a registered Windows Phone developer. This is free for students, and also lets you sell programs that you have written in the Windows Phone Marketplace. However, to get started writing programs you don't need to have a physical device, you can use the emulator that is supplied with the development tools.

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1 Windows Phone 7

In this chapter you are going to find out about the Windows Phone platform as a device for running programs. You will learn the key features of the platform itself, how programs are written and also how you can sell your programs via the Windows Marketplace.

1.1 The Windows Phone hardware

In this section we are going to take a look at the actual hardware that makes up a Windows Phone. This is particularly important as we need to put the abilities of the phone into context and identify the effect of the physical limitations imposed by platform that it uses.

A Windows Phone as a computer

Pretty much everything these days is a computer. Mobile phones are no exception. When you get to the level of the Windows Phone device it is reasonable to think of it as a computer that can make telephone calls rather than a phone that can run programs.

The Windows Phone device has many properties in common with a “proper” computer. It has a powerful processor, local storage, fast 3D graphics and plenty of memory. It also has its own operating system which looks after the device and controls the programs that run on it. If you have used a PC you are used to the Windows 7 operating system which starts running when you turn the computer and even turns the computer off for you when you have finished.

The Windows Phone 7 series is a complete break with previous versions of Windows Mobile devices. You could write programs and run them on earlier versions but you did not use the Silverlight or XNA environments to do this. The number 7 in the name of the product reflects the fact that this is also the 7th incarnation of the Windows Mobile platform. It does not mean that the device shares its underpinnings with desktop PCs running Windows 7. However, as we shall see, it is perfectly possible to take a program you have created for Windows Phone and run it on the Windows desktop, and vice versa.

If you are familiar with computer specifications, then the specifications below are pretty impressive for a portable device. If you are not familiar, then just bear in mind that nobody in the world had a computer like this a few years ago, and now you can carry one around in your pocket.

The Windows Phone hardware platform

Before we start programming we can take a look at the hardware we will be working with. This is not a text about computer hardware, but it is worth putting some of the phone hardware into context. All Windows Phones must have a particular minimum specification, so these are the very least you can expect to find on a device.

It is quite likely that different phone manufacturers will add their particular “take” on the platform, so you will find devices with more memory, faster processors, hardware keyboards and larger screens.

Note that a hardware keyboard is not guaranteed to be present on the device (it might be just a touchscreen based phone) and that if you are an XNA game developer you will be wondering where the gamepad has gone. There are some changes to the hardware that you will have to get used to when writing for this platform, but there are also some very interesting input options (particular for game development) where you can use the accelerometer and the touch screen to good effect. We will look at these later in the text.

The Windows Phone Processor

The Central Processing Unit (CPU) of a computer is the place where all the work gets done. Whenever a program is running the CPU is in charge of fetching data from memory, changing the data and then putting it back (which is really all computers do). The most popular speed measure in a computer is the *clock speed*. A CPU has a clock that ticks when it is running. At each clock tick the processor will do one part of an operation, perhaps fetch an instruction from memory, perform a calculation and so forth.

The faster the clock speed the faster the computer. Modern desktop computers have clocks that tick at around 3 GHz (that is around 3 thousand, million times a second). This is actually incredibly fast. It means that a single clock tick will last a nanosecond. A nanosecond is the time that light takes to travel around 30 cm. If you were wondering why we don't have big computers any more, it is because the time it takes signals to travel around a circuit is a serious limiting factor in performance. Making a computer smaller actually makes it go faster.

A Windows Phone has a clock that ticks at around 1GHz. You might think that this means a Windows Phone will run around a third the speed of a PC, but this turns out not to be the case. This is because of a number of things:

Firstly, clock speed is not directly comparable between processors. The processor in the Windows PC might take five clock ticks to do something that the Windows Phone processor needs ten ticks to perform. The Windows PC processor might be able to do things in hardware (for example floating point arithmetic) which the Windows Phone processor might need to call a software subroutine to perform, which will be much slower. You can regard clock speed as a bit like engine size in cars. A car with a bigger engine might go faster than one with a smaller one, but lots of other factors (weight of car, gearbox, tires) are important too.

Secondly, a Windows PC may well have multiple processors. This doesn't mean a Windows PC can go faster, any more than two motorcycles can go faster than one, but it does mean they can process more data in a given time (two motorcycles can carry twice as many people as one). At some point we will get multiple-processor phones (and the Windows Phone operating system can support this), but at the moment they all have a single processor unit.

Finally, a Windows PC has unlimited mains power. It can run the CPU at full speed all the time if it needs to. The only real problem with doing this is that the processor must be kept cool so that it doesn't melt. The faster a processor runs the more power it consumes. If the phone ran the processor at full speed all the time the battery life would be very short. The phone operating system will speed up and slow down the processor depending on what it needs to do at any given instant. Although the phone has a fast processor this speed is only actually used when the phone has something to do which requires very fast response.

The result of these considerations is that when you are writing a Windows Phone program you cannot regard processing power as an unlimited resource. Desktop PC programmers do not see processor speed as much of an issue but Windows Phone programmers have to remember that poor design can have consequences, both in terms of the experience of the user and the battery life of the phone. The good news for us is that worrying about these things will cause us to turn into better programmers.

The Windows Phone operating system

The operating system in a Windows Phone is called Windows CE (CE stands for "Compact Edition"). It was specially designed to run on portable computer systems and is very good at getting performance and good battery life out of a device. As we shall see later this puts some constraints on your programs, however the good news is that as far as we are concerned the underlying operating system is pretty much irrelevant. Our program will run on the Windows Phone in pretty much the same way as they do on the full sized Windows PC.

Graphical Display

The Windows Phone has a high resolution display made up of a very large number of pixels. This provides good quality graphics and also allows lots of text to be displayed on the screen. The more pixels you have on your screen the higher the quality of image that you can display. However, the more dots you have the greater the amount of memory that you need to store an image, and the more work the computer has to do to change the picture on the screen. This is particularly significant on a mobile device, where more work for the hardware translates to greater power consumption and lower battery life. The display resolution is a compromise between battery life, cost to manufacture and brightness of the display (the smaller the dots the less light each can give out).

The first generation versions of Windows Phone will have a screen resolution of at least 800x480 pixels. This can be used in both landscape (800 wide and 480 high) and portrait (480 wide by 800 high) modes. The phone contains an accelerometer that detects how the phone is being held. The Windows Phone operating system can then adjust the display to match the orientation. Our programs can decide when they run what orientations they can support. If we design our programs to work in both landscape and portrait mode they can be sent messages to allow them to adjust their display when the user changes the orientation of the device.

One problem faced by phone developers is the multitude of different screen sizes that are available. A program would have usually have to be customised for each different sized screen. The Windows Phone screen hardware includes a feature that allows it to scale the screen of an application to fit whatever screen size the device supports. A game can specify that it must have a particular sized screen (say 400x280) and then the display hardware will scale that size to fit whatever physical size is fitted on the device being used. This is very useful and makes it possible to create games that will work on any device including ones with screen sizes that have not been made yet.

The Windows Phone Graphical Processor Unit

In the very first computers all the work was performed by the computer processor itself. This work included putting images on the display. Computer hardware engineers soon decided that they could get faster moving images by creating custom devices to drive the screen. A Graphical Processor Unit (GPU) is given commands by the main processor and takes away all the work involved in drawing the screen. More advanced graphical processors have 3D support and are able to do the floating point and matrix arithmetic needed for three dimensions. They also contain pixel shaders which can be programmed to perform image processing on the each dot of the screen at high speed as it is drawn, adding things such as lighting effects and blur.

Until quite recently only desktop PC systems and video game consoles had graphical processors, but they are now appearing in mobile phones. The Windows Phone platform contains a graphics processing chip which is used to provide 3D animation effects for the phone display and can also be used from within the XNA game development environment to create fast moving 3D games.

Touch input

Older portable devices used *resistive* touch input screens. When the user touches a resistive touch screen the plastic surface bends and makes a connection with the layer below it. A simple circuit then measures the electrical resistance to the point of contact and uses this to determine where on the screen the touch took place. Resistive touch screens are cheap to make and work very well with a stylus. However the way they work makes it very difficult to detect multiple simultaneous touches on the screen. It is also difficult to make a resistive screen out of a very hard material, for example glass, as the screen must bend to make the contact that detects the input point.

A capacitive touch screen works in a different way. An array of conductors underneath the screen surface detects the change in capacitance caused by the presence of a finger on the surface. The touch screen hardware then works out where on the screen that the touch input took place. Capacitive touch screens are more expensive to make as they require extra hardware to process the input signals but the sensor circuits can be printed on the back of a glass screen to make a much tougher display. A capacitive touch screen is not quite as precise as a resistive screen which uses a stylus, but you can build a capacitive screen that can detect multiple inputs on different parts of the display.

All Windows Phone devices have touch input which is capable of tracking at least four input points. This means that if you create a Windows Phone piano program it will be able to detect at least four notes being pressed at the same time.

The move to multi-touch input is an important step in the evolution of mobile devices. The user can control software by using multi-touch *gestures* such as “pinch”. The Windows Phone operating system provides built in support for gesture recognition. Your programs can receive events when the user performs particular types of gesture. We will be using this feature later.

Location Sensors

The Windows Phone device is location aware. It contains a Global Positioning System (GPS) device that receives satellite signals to determine the position of the phone to within a few feet. Since the GPS system only works properly when the phone has a clear view of the sky the phone will also use other techniques to determine position, including the location of the nearest cell phone tower and/or the location of the WIFI connection in use. This is called “assisted” GPS.

The Windows Phone operating system exposes methods our programs can call to determine the physical position of the device, along with the level of confidence and resolution of the result supplied. Our programs can also make use of mapping and search facilities which can be driven by location information. We will be exploring this later.

The actual phone hardware also contains an electronic compass, although there is not a software interface to this in the present version of the Windows Phone operating system.

Accelerometer

The accelerometer is a hardware device that measures acceleration, so no surprises there. You could use it to compare the performance of sports cars if you wish. You can also use the accelerometer to detect when the phone is being shaken or waved around but the thing I like best is that you can also use it to detect how the phone is being held. This is because the accelerometer detects the acceleration due to gravity on the earth. This gives a phone a constant acceleration value which always points downwards. Programs can get the orientation of the phone in three axes, X, Y and Z.

This means we can write programs that respond when the user tips the phone in a particular direction, providing a very useful control mechanism for games. It is very easy for programs to obtain accelerometer readings, as we shall see later.

Camera

All mobile devices have cameras these days, and the Windows Phone is no exception. A phone camera will have at least 5 mega pixels or more. This means that it will take pictures that contain 5 million dots. This equates to a reasonable resolution digital camera (or the best anyone could get around five years ago). A 5 megapixel picture can be printed on a 7”x5” print with extremely good quality.

We can write Windows Phone applications that use the camera, but there are a few things that we need to remember.

Firstly, programs can’t have access to the live video stream from the camera in the current version of the Windows operating system. This means that we can’t make “augmented reality” type applications where the program displays a camera view and then overlays program output onto it. We also can’t make video recorder programs because of this issue (although the Windows Phone camera application can record video).

Secondly, programs are not allowed to take photographs without the user being involved in the process. This is a privacy protection measure, in that it stops programs being distributed that take clandestine pictures without the program user being aware the software is doing anything. When your program wants the user to take a picture this task will be performed by the Windows Phone camera application that will guide the user through framing the picture and taking the shot.

Pictures that are taken by the user are stored as part of the media content on the phone. Our programs can open these images and work with them.

Hardware buttons

All Windows Phone systems share a common user interface. As part of this design there are a number of physical buttons which are fitted to every Windows Phone that will always perform the same function, irrespective of the make or model of the phone.

Start: The start button is pressed to start a new activity. Pressing the start button will always return the user to the program start screen, where they can select a new program and begin to run it. When the user presses the Start button this causes the currently running application to be stopped (we will discuss this more a bit later). However, the Windows Phone operating system “remembers” which application was stopped so that the user may return to it later by pressing the Back button.

Back: The back button is pressed to move back to the previous menu in a particular application. It is also used to stop one application and return to the one that was previously running. The back button makes the phone very easy to work with. A user can start a new application (for example they could decide to send an email message in the middle of browsing the web) and then once the message has been sent they can press Back to return to the browser. Within the mail application the Back button will move the user in and out of the various input screens and menus used to create and send the message. Once the message has been sent the user can press Back at the top menu of the email application and return to the start menu and either run another program or press Back to return to browsing.

Lock:	Pressing the lock button will always lock the phone and turn off the display to save the phone battery. The currently running application will be stopped. When the user presses the lock or start button again the phone will display the lock screen. A phone can be configured to automatically lock after a number of minutes of inactivity.
Search:	Pressing the search button will start a new search. Precisely what happens when search is pressed depends on what the user is doing at the time. If the user presses search during a browsing session they will see a web search menu. If they press Search when the "People" application is active they can search for contacts. A program can get a "user has pressed search" message which will allow it to respond in a useful way.
Camera:	If the user presses the camera button this will stop the currently executing program and start the camera application to take a new picture.

The way these buttons will be used has implications for the programs that we write. A program must be able to cope with the possibility that it will be removed from memory at any time, for example if the user decides to take a photograph while playing our game the game program will be removed from memory. When they have taken their picture they will expect to be able to resume their game just as they left it. The user should not notice that the game was stopped.

Programs that are about to be stopped are given a warning message and the Windows Phone operating system provides a number of ways that a program can store state information. We will explore how to do this later in the text.

Not all Windows Phone devices will have a physical keyboard for entering text but all devices will be able to use the touch screen for text entry.

Memory and Storage

Memory is one of the things that computer owners have been known to brag about. Apparently the more memory a computer has the "better" it is.. Memory actually comes in two flavors. There is the space in the computer itself where programs run and then there is the "mass storage" space that is used to store programs and data on the device. On a desktop computer these are determined by the amount of RAM (Random Access Memory) and the amount of hard disk space. A modern desktop computer will probably have around 2 gigabytes (two thousand megabytes) of RAM and around 500 gigabytes of hard disk storage. A megabyte is a million bytes (1,000,000). A gigabyte is a thousand million bytes (1,000,000,000). As a rough guide, a compressed music track uses around six megabytes, a high quality picture around three megabytes and an hour of good quality video will occupy around a gigabyte.

The minimum specification Windows Phone will have at least 256 megabytes of RAM and 8 gigabytes of storage. This means that a base specification Windows Phone will have an eighth the amount of memory and around a fiftieth of the amount of storage of a desktop machine. The Windows Phone operating system has been optimized to work in slightly smaller amounts of memory (although you must remember that a few years ago this amount of storage would have been regarded as extravagantly large but it does make sure that users always get a responsive device by imposing a few limitations on the way that programs run, of which more later.

Network Connectivity

A mobile phone is actually the most connected device you can get. The one device has a range of networking facilities:

WiFi:	All Windows Phones will support wireless networking. WiFi provides a high speed networking connection, but only works if you are quite near to a network access point. Fortunately these are appearing all over the place now, with many fast food outlets and even city centres being WiFi enabled.
3G:	The next thing down from WiFi in performance is the 3G (Third Generation) mobile phone network. The speed can approach WiFi, but is much more variable. 3G access may also be restricted in terms of the amount of data a mobile device is allowed to transfer, and there may be charges to use this connectivity.
GPRS:	In many areas 3G network coverage is not available. The phone will then fall back to the GPRS mobile network, which is much slower.

The networking abilities are exposed as TCP/IP connections (we will explore what this means later in the text). Unfortunately, as you will have undoubtedly experienced, network coverage is not universal, and so software running on the phone must be able to keep going even when there is no data connection. Ideally the software should also cope with different connectivity speeds.

The Windows Phone also provides support for Bluetooth networking. This is used in the context of connecting external devices such as headsets and car audio systems and is not something our programs are able to access in the present version of Windows Phone.

Platform Challenges

The Windows Phone hardware is very powerful for a mobile device, but it is still constrained by the way that it musts be portable and battery power is limited. To make matters worse, users who are used to working with high speed devices with rich graphical user interfaces expect their phone to give them the same experience.

As software developers our job is to provide as much of that experience as possible, within the constraints of the environment provided by the phone. When we write programs for this device we need to make sure that they work in an efficient way that makes the most of the available platform. I actually see this as a good thing, I am never happy when programmers are allowed to get away with writing inefficient code just because the underlying hardware is very powerful.

Whenever we do something in this course we will consider the implications on the phone. I hope you will see that one effect of this is to make us all into much better programmers.

The Good News

The last few sections read like a list of the bad things, limitations and compromises that surround mobile development. While you have to remember all these issues, it is also the case that writing for mobile devices is actually great fun. The range of features that the device provides and the fact that it is portable make it possible for you to create genuinely new applications that have never been done before.

Also, the tools that we will use to write the program and the built in features provided with the tools make it possible to create really nice looking applications very easily. So don’t give up on Windows Phone development just yet.

1.2 The Windows Phone ecosystem

The Windows Phone is not designed as a device that stands by itself. It is actually part of an *ecosystem* which contains a number of other software systems that work around it to provide the user experience.

The Zune media management software

A Windows Phone device is connected to a Windows PC by means of the Zune software. This provides a way of managing media and transferring it to and from the phone device. The Zune software is also the means by which the firmware of the Windows Phone can be updated as new versions come along. The Zune software also provides the link between the Visual Studio development environment and the phone itself.

The programs that we write can make use of the media loaded onto the phone via the Zune software. It is very easy to write programs that load pictures or playback music and videos stored on the phone.

Windows Live and Xbox Live

The owner of a Windows Phone can register the phone to their Windows Live account. If their Windows Live account is linked to their Xbox Live gamertag their gamer profile is imported onto their device and so they can participate in handheld gaming using the same identity as they use on their console.

A Windows Phone program can use the Windows Live identity of the owner and XNA gamertag information.

Bing Maps

We know that a phone contains hardware that allows it to be aware of its location. The Microsoft Bing maps service provides maps which cover most of the earth. A Windows Phone program can use its network connection to contact the Bing maps service and download maps and aerial views. There is even a Silverlight mapping control that makes it very easy for a program to add location displays. We will do this later in the course.

Windows Notification Server

Although a phone has a wide range of networking technologies available there will still be occasions when the phone is unable to connect to a network. Windows Phone provides a notification service which allows programs to get notifications from the network even when the program is not active. The user is given a notification on the phone that they can use to start the application. Notifications are stored and managed by a notification service which will buffer them if the phone is not connected to the network when the notification is raised.

For example, you might have a sales system that needs to tell a customer when an item they have reserved is in stock. The ordering application on the phone can register with the notification service and then your stock management server has a means of sending a notification to the customer when the item becomes available. This system can also be used in gaming, where one player wants to send a challenge to another. Getting this to work involves a very interesting exploration of some programming issues, and is something we will do later in the course.

Using the Ecosystem

It is important to remember that a phone is not just a phone these days. The connected nature of the application means that it will function in conjunction with remote services which are available over the network connection. Other parts of the phone make use of this connected ability too. The phone has a Facebook client built in and the camera application and picture storage elements can upload your pictures to Windows Live Skydrive or Facebook.

You can also use the network features of the phone to create your own client and server applications. You will need to write two programs to do this, one will run on the Windows Phone and the other can run on any computer connected to the internet, or even on a system in the “cloud”.

1.3 Windows Phone program execution

The Windows phone provides a platform to run programs, some of which can be ones that we have written. It is worth spending some time considering how the programs are made to run on the phone and some of the implications for the way that we write them.

Multi-tasking on Windows Phone

One limitation of the present version of the platform is that it can only run a single program at one time. While the operating system is perfectly capable of executing multiple programs this ability is not enabled for programs that we write. There are a number of sound technical reasons for this, only having a single program active will conserve memory and improve battery life. The limitation might be removed in a later version of the Windows Phone operating system.

In my opinion this is not a huge problem for the user in practice, as long as it is quick and easy to resume an application. Because a phone screen is very small it is unlikely that you would be able to see two applications running at the same time anyway.

However, the implication for developers is that they must live with the possibility that at any point their program might be removed from the system to make way for another. They must also make sure that if a user comes back to an application that was previously suspended in this way it looks exactly as it did when they left.

We will have add behaviours to our programs to give the user the illusion that our program was never stopped and started when they return to it from working with another application. A program is given a message when it is about to be removed and it has access to storage that it can use to retain state information. We will find out how to do this later on.

Windows Phone and Managed Code

In the early days a computer ran a program just by, well, running a program. The file containing the program instructions was loaded into memory and then the computer just obeyed each one in turn. This worked OK, but this simple approach is not without its problems.

The first problem is that if you have a different kind of computer system you have to have a different file of instructions. Each computer manufacturer made hardware that understood a particular set of binary instructions, and it was not possible to take a program created for one hardware type and then run it on another.

The second problem is that if the instructions are stupid/dangerous the computer will obey them anyway. Stupid instructions in the file that is loaded into memory may cause the actual hardware in the computer to get stuck (a bit like asking me to do something in Chinese). Dangerous instructions could cause the program to damage other data in the computer (a bit like asking me to delete all the files on my computer).

The Microsoft Intermediate Language (MSIL)

Microsoft .NET addresses these problems by using an intermediate language to describe what a program wants to do. When a C# program is compiled the compiler will produce a file containing instructions in this intermediate language. When the program actually runs these instructions are compiled again, this time into the low level instructions that are understood by the target hardware in use. During the compilation process the instructions are checked to make sure they don't do anything stupid and when the program runs it is closely monitored to make sure that it doesn't do anything dangerous.

Microsoft .NET programs are made up of individual components called *asssemblies*. An assembly contains MSIL code along with any data resources that the code needs, for example images, sounds and so on. An assembly can either be an executable (something you can run) or a library (something that provides resources for an application). A Windows Phone can run C# executable assemblies and libraries produced from any .NET compatible compiler. This means that you could write some of the library code in your application in another language, for example Visual Basic, C++ or F#. It also means that if you have libraries already written in these languages you can use them in phone applications.

The idea behind .NET was to provide a single framework for executing code which was independent of any particular computer hardware or programming language. The standards for .NET specify what the intermediate language looks like, the form of the data types stored in the system and also includes the designs of the languages C# and Visual Basic .NET.

Just in Time Compilation

When a program actually gets to run something has to convert the MSIL (which is independent of any particular computer hardware) into machine code instructions that the computer processor can actually execute. This compilation process is called *Just In Time* compilation because the actual machine code for the target device is compiled from the intermediate instructions just before it gets to run. The way in which the program runs within a monitored environment is called *managed code*. The compilation happens in the instant before the program runs, i.e. the user of the phone selects a program from the start page, the MSIL is loaded from storage and then compiled at that time.

The downside of this approach is that rather than just run a file of instructions the computer now has to do more work to get things going. It must load the intermediate language, compile it into machine code and then keep an eye on what the program itself does as it runs. Fortunately modern processors (including the one inside the Windows Phone) can achieve this without slowing things down.

The upside is that the same intermediate code file can be loaded and executed on any machine that has the .NET system on it. You can (and I have) run exactly the same compiled program on a mobile device, Windows PC and Xbox 360, even though the machines have completely different operating systems and underlying hardware.

Another advantage is that this loading process can be expanded to ensure that programs are legitimate. .NET provides mechanisms by which programs can be "signed" using cryptographic techniques that make it very difficult for naughty people to modify the program or create “fake” versions of your code. If you become a marketplace developer you will be assigned your own cryptographic key that will be used to sign any applications that you create.

Finally, the use of an intermediate language means that we can use a wide range of programming languages. Although the programming tools for Windows Phone are focused on C# it is possible to use compiled code from any programming language which has a .NET compiler. If you have existing programs in Visual Basic, C++ or even F# you can use intermediate code libraries from these programs in your Windows Phone solutions. Remember though that you will need to use C# for the Silverlight or XNA “front end” for these programs.

Managed Code

Programs that you create on Windows Phone run within the “managed” environment provided by the operating system. You will write your C# programs and then they will run inside a safe area in the phone provided by the operating system. Your program will not be allowed direct access to the hardware. This is good news because it stops people from writing programs that stop the proper operation of the phone itself. As far as the developer is concerned this actually makes no difference. When a program calls a method to put a picture on the screen the underlying systems will cause the picture to appear.

Developer Implications

As far as a developer is concerned there is an element of good news/bad news about all this. The good news is that you only need to learn one programming language (C#) to develop on a range of platforms. Programs that you write will be isolated from potential damage by other programs on a system and you can be sure that software you sell can’t be easily tampered with.

The bad news is that all this comes at the expense of extra work for the system that runs your application. Starting up a program is not just a case of loading it into memory and obeying the instructions it contains. The program must be checked to ensure that it has not been tampered with and then “just in time” compiled into the instructions that will really do the work. The result of all this is that the user might have to wait a little while between selecting the application and getting the first screen displayed.

Fortunately the power of Windows Phone means that these delays are not usually a problem but it does mean that if we have very large programs we might want to break them into smaller chunks, so that not everything is loaded at once. But then again, as sensible developers we would probably want to do this kind of thing anyway.

1.4 Windows Phone application development

You write Windows Phone applications in exactly the same way as you write other applications for the Windows desktop. You use the Visual Studio IDE (Integrated Development Environment). You can debug a program running in a Windows Phone device just as easily as you can debug a program on your PC desktop. You can also create solutions that share components across the desktop, Windows Phone and even Xbox platforms.

You can take all your Windows Desktop development skills in Silverlight and your console skills in XNA and use them on the phone. If you learn how to use the Windows Phone you are also learning how to write code for the desktop (Silverlight) or console (XNA). This is great news for you as it means that you can write (and even sell) programs for Windows Phone without having to learn a lot of new stuff. If you have previously written programs for desktop computers then the move to Windows Phone development will be a lot less painful than you might expect.

The Windows Phone Emulator

The Windows Phone development environment is supplied with an emulator which gives you a Windows Phone you can play with on your PC desktop. If you have a PC system that supports multi-touch input you can even use this with the emulator to test the use of multi-touch gestures with your Windows Phone programs.

While the emulator is feature complete, in that it behaves exactly like a real phone would in response to the requests from your software, it does not mimic the performance of the actual phone hardware. Programs running on the emulator are using the power of your PC, which may well be much greater than the processor in the phone. This means that although you can test the functionality of your programs using the emulator you only really get a feel for how fast the program runs, and what the user experience feels like, when you run your program on a real device.

Accessing Windows Phone facilities

The Windows Phone platform provides a library of software resources that let your programs make use of the features provided by the device itself. Your programs can make use of the camera in the phone, place phone calls and even send SMS messages. They can also make use of the GPS resources of the phone to allow you to create location aware applications. The facilities are divided into *Launchers* which let your program transfer to another application and *Choosers* which use the system to select an item and then return control to your program. We will see how to use these later in this text.

Windows Phone Connectivity

As you might expect, programs on a Windows Phone are extremely well connected. Applications on the phone can make use of the TCP/IP protocol to connect to servers on the internet. Programs can use Web Services and also set up REST based sessions with hosts. The present version of the operating system does not support direct socket connections. If you are not sure what any of this means, don’t worry. We will be exploring the use of network services later in the text.

Silverlight and XNA Development

There are essentially two flavours to Windows Phone development. If you are creating an application (for example a word processor, email client or cheese calculator) then you can use Silverlight. This provides a whole range of features just for creating such programs. If you are creating a game then you can use XNA. XNA provides all the facilities for creating 2D and 3D games with high performance graphics.

You are not forced to work this way. You could create your cheese calculator in XNA or (perhaps more sensibly) you can create simple games (for example word puzzles) very successfully in Silverlight.

You select the type of application you are creating when you make a new project with Visual Studio. It is not possible to make a single program that combines both types of application.

Development Tools

The tools that you need to get started are free. You can download a copy of Visual Studio 2010 Express Edition and be started writing Windows Phone applications literally within minutes. Developers who have more advanced, paid for, copies of Visual Studio 2010 can use all the extra features of their versions in mobile device development by adding the Windows Phone plugin to their systems. We will see in detail how to get started with Visual Studio later in the text.

Windows Marketplace

Windows Marketplace is where you can sell programs that you have created. It is moderated and managed by Microsoft to ensure that applications meet certain minimum standards of behaviour. If you want to sell an application you must be a registered developer and submit your program to an approvals process.

It costs $99 to register as a developer, but students can register for free via the Dreamspark programme. Developers can register their Windows Phone devices as “development” devices. Visual Studio can deploy applications to a developer device and you can even step through programs running in the device itself.

You can distribute free applications as well as paid ones. A registered developer can distribute up to five free applications in any year. If you want to distribute more than five free applications you must pay a $20 fee for each additional free application. You can also create applications that have a “demo” mode which can be converted into a “full” version when the user purchases them. Your program can tell when it runs whether it is operating in full or demo mode.

When you submit an application to be sold in the marketplace it will go through an approvals process to make sure that it doesn’t do anything naughty and that it works in a way that users expect. If the approvals process fails you will be given a diagnostic report. Before you send an application into the system you should read the certification guidelines of the marketplace.

What we have learned

1. Windows Phone is a powerful computing platform.
2. All Windows Phone devices have a core specification. This includes a particular size of display, capacitive touch input that can track at least four points, Global Positioning System support, 3D graphics acceleration, high resolution camera and ample memory for program and data storage.
3. The Windows Phone device is connected to a Windows PC by means of the Zune PC software, which provides a media management system for the PC and also allows media to be synchronised to the phone.
4. Windows Phone systems can make use of network based services to receive notifications, determine their position and perform searches.
5. When developing programs for Windows Phone the Zune software is used to transfer programs into the phone for testing. The Zune software is also used to upgrade the firmware in the phone.
6. The Windows Phone operating system supports full multi-tasking, but to preserve battery life and conserve memory only one user application can be active at one time.
7. The Windows Phone runs programs that have been compiled into Microsoft Intermediate Language (MSIL). This MSIL is compiled inside the phone just before the program runs. The programs

themselves run in a “managed” environment which stops them from interfering with the operating of the phone itself.

8. When developing software for Windows Phone you can create Silverlight and XNA applications. These are written in C# using Visual Studio 2010. Programmers can use a Windows Phone emulator that runs on Windows PC and provides a simulation of the Windows Phone environment.
9. Programs have access to all the phone facilities and can place calls, send SMS messages etc.
10. The free, Express, version of Visual Studio can be used to create Windows Phone applications. However, to deploy applications to a phone device you must be a registered Windows Phone Developer. This costs $99 per year but registration is free to students via the Microsoft Dreamspark initiative. A registered developer can upload their applications to Windows Phone Marketplace for sale.

2 Introduction to Silverlight

A user interface is a posh name for the thing that people actually see when they use your program. It comprises the buttons, text fields, labels and pictures that the user actually works with to get their job done. Part of the job of the programmer is to create this “front end” and then put the appropriate behaviors behind the screen display to allow the user to drive the program and get what they want from it. In this section we are going to find out about Silverlight, and how to use it to create a user interface for our programs.

2.1 Program design with Silverlight

It turns out that most programmers are not that good at designing attractive user interfaces (although I’m sure that you are). In real life a company will employ graphic designers who will create artistic looking front ends. The role of the programmer will then be to put the code behind these displays to get the required job done. Silverlight recognises this process by enforcing a very strong separation between the screen display design and the code that is controlled by it. This makes it easy for a programmer to create an initial user interface which is subsequently changed by a designer into a much more attractive one. It is also possible for a programmer to take a complete user interface design and then fit the behaviours behind each of the display components.

Development Tools

The user interface designer uses the Expression Blend tool and the programmer uses the Visual Studio tool to create the code. The Silverlight system provides a really easy way for combining user interface designs with code. A good way to work is for the programmer to use a “placeholder” design to create the program behaviours and then incorporate the final designs later in the production process.

The Windows Phone SDK (Software Development Kit) includes versions of Visual Studio and Expression Blend that can be used in this way.

The Metro Design Style

From a design point of view a nice thing about Windows Phone is that it brings with it a whole set of design guidelines which are referred to as “Metro”. This sets out how controls are supposed to look and establishes a set of criteria that your applications should meet if they are to be “good looking” Windows Phone applications. This style regime is carried over into the built in components that are provided for you to use in your programs. The happy consequence of this is that if you use the Buttons, TextFields and other components that are supplied with Visual Studio you will be automatically adhering to the style guidelines.

This is a great help those of us who are not very good at design because it means that we are only ever going to use things that look right. Of course you can completely override the properties of the supplied components if you really want purple text on an orange background but I would not really advise this.

There is actually a Metro style document you can read if you really want to know how to make “proper looking” programs. This is well worth a look if you want to publish your programs in the Marketplace, where people will have certain expectations of how things should look and work. You can find the document here:

```
http://download.microsoft.com/download/D/8/6/D869941E-455D-4882-A6B8-
0DBCAA6AF2D4/UI%20Design%20and%20Interaction%20Guide%20for%20Windows%20Phone%207%20
Series.pdf
```

For the purpose of this course we are going to use the Silverlight design tools in Visual Studio. These do not give all the graphical richness that you can achieve with Expression Blend, but for programmers they are more than adequate. This should make sure that our applications adhere to the Metro guidelines and are clean and simple to use.

Silverlight elements and objects

From a programming point of view each of the elements on the screen of a display is actually a software object. We have come across these before. An object is a lump of behaviours and data. If we were creating an application to look after bank accounts we could create a class to hold account information:

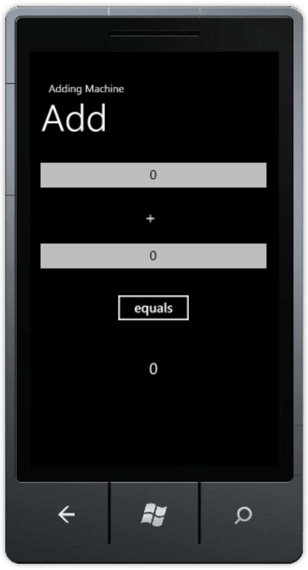
```
public class Account
{
  private decimal balance ;
  private string name ;

  public string GetName ()
  {
     return name;
  }


  public bool SetName (string newName){
  {
    // Final version will validate the name
    name = newName;
    return true;
  }

  // Other get and set methods here

}
```

This class holds the amount of money the account holder has (in the data member called `balance`) and the name of the account holder (in the data member called `Name`). If I want to make a new `Account` instance I can use the new keyword:

```
Account rob = new Account();
rob.SetName("Rob");
```

This makes a new `Account` instance which is referred to by the reference `rob`. It then sets the name member of this `Account` to “Rob”. We are used to creating objects which match things we want to store. When we make games we will invent a `Sprite` class to hold the picture of the sprite on the screen, the position of the sprite and other information. Objects are a great way to represent things we want to work with. It turns out that objects are also great for representing other things too, such as items on a display. If you think about it, a box displaying text on a screen will have properties such as the position on the screen, the colour of the text, the text itself and so on.

Consider the following:



This is a very simple Windows Phone program that I've called an "Adding Machine". You can use to perform very simple sums. You just enter two numbers into the two text boxes at the top and then press the equals button. It then rewards you with the sum of these two numbers. At the moment it is showing us that 0 plus 0 is 0. Each individual item on the screen is called a *UIElement* or User Interface element. I'm going to call these things elements from now on.There are seven of them on the screen above:

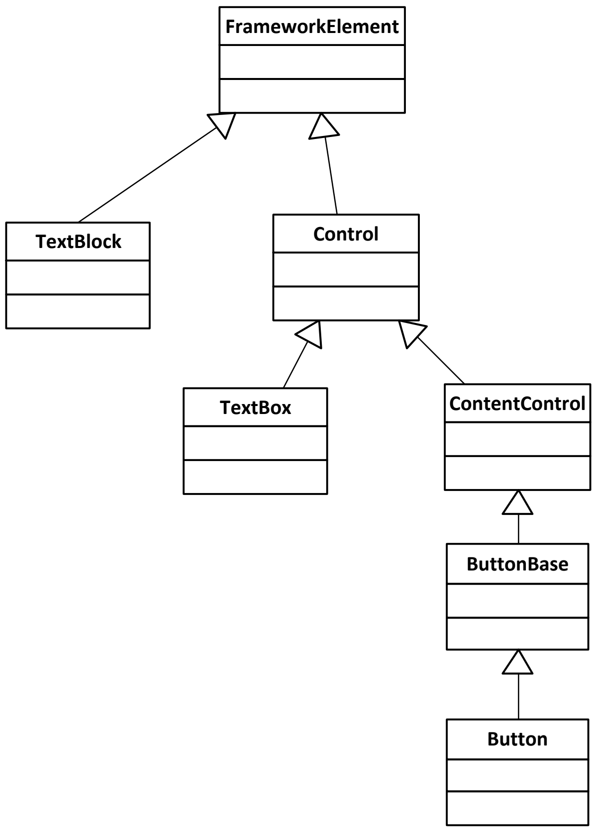
1. The small title "Adding Machine". This is known in the Windows Phone style guidelines as the 'Application Title'.
2. The larger title "Add". This is known as the 'Page Title'.
3. The top textbox, where I can type a number.
4. A text item holding the character +.
5. The bottom textbox, where I can type another number.
6. A button, which we press to perform the sum.
7. A result textbox, which changes to show the result when the button is pressed.

Each of these items has a particular position on the screen, particular size of text and lots of other properties too. We can change the colour of the text in a text box, whether it is aligned to the left, right or centre of the enclosing box and lots of other things too.

There are three different types of element on the screen:

1. `TextBox` – allows the user to enter text into the program.
2. `TextBlock` – a block of text that just conveys information.
3. `Button` – something we can press to cause events in our program.

If you think about it, you can break the properties of each of these elements down into two kinds, those that all the elements need to have, for example position on the screen, and those that are specific to that type of element. For example only a `TextBox` needs to record the position of the cursor where text is being entered. From a software design point of view this is a really good use for a class hierarchy.



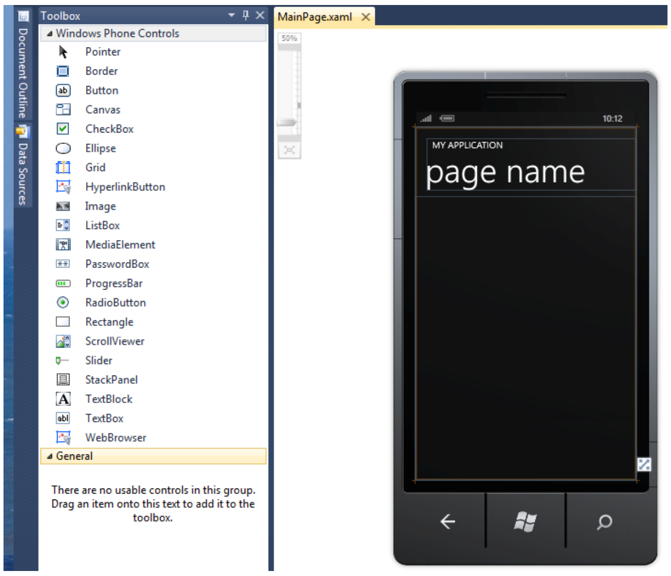
Above you can see part of the hierarchy that the Silverlight designers built. The top class is called `FrameworkElement`. It contains all the information that is common to all controls on the screen. Each of the other classes is a child of this class. Children pick up all the behaviours and properties of their parent class and then add some of their own. Actually the design is a bit more complex than shown above, the `FrameworkElement` class is a child of a class called `UIElement`, but it shows the principles behind the controls.

Creating a class hierarchy like this has a lot of advantages. If we want a custom kind of textbox we can extend the `TextBox` class and add the properties and behaviours that we need. As far as the Silverlight system is concerned it can treat all the controls the same and then ask each control to draw itself in a manner appropriate to that component.

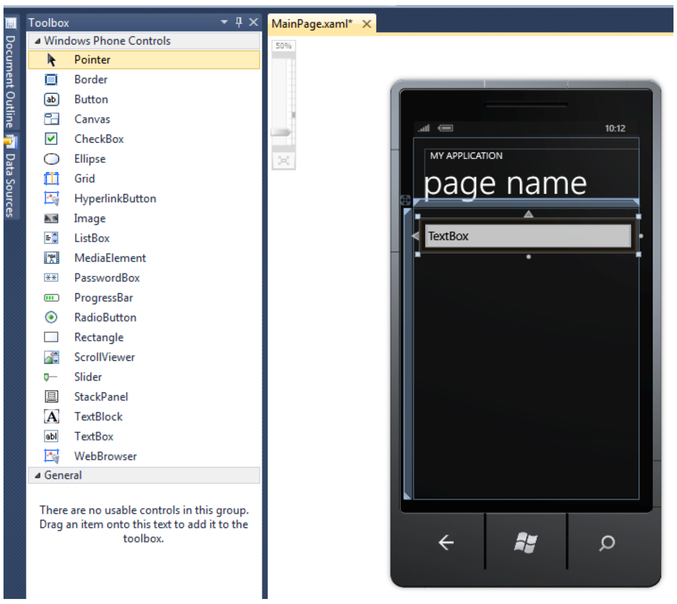
So, remember that when we are adjusting things on a display page and creating and manipulating controls we are really just changing the properties of objects, just as we would change the name and balance values of a bank account object. When we design a Silverlight user interface we set the data inside the display elements to position them on the display. Next we are going to find out how to do this.

The toolbox and design surface

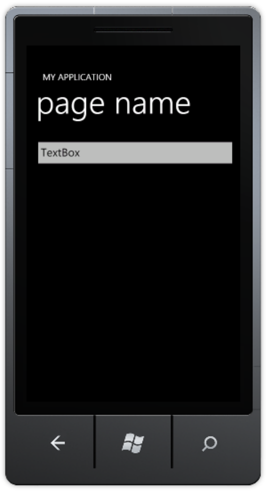
We could start by investigating how the Adding Machine above was created. It turns out to be really easy (we will take a really detailed look at Visual Studio in the next section). When we create a brand new Silverlight project we get an empty page and we can open up a ToolBox which contains all the controls that we might want to add to the page:



We can assemble the user interface by simply dragging the controls out of the toolbox onto the design surface.



Above shows the effect of dragging a `TextBox` out of the Toolbox area and dropping it onto the Windows Phone page. If we run the program now we can see our textbox on the screen:



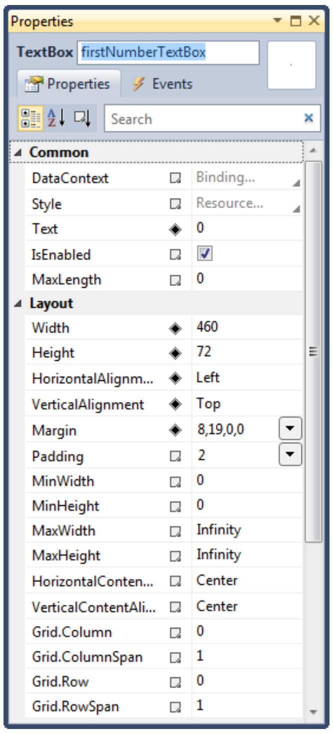
This is the Windows Phone emulator running our program, which is showing the textbox on the screen.

If you have ever done any Windows Forms development (perhaps using earlier versions of .NET) then this will all be very familiar to you. If you haven't then it is a quick and easy way to build up a user interface. Because all the controls are already styled in the Metro style, just like the Windows Phone user interface, you are automatically building an application that looks like a "real" one. The designer has lots of nice features that make it very easy to align your controls too, which is nice.

Managing element names in Visual Studio

Once we have put some elements on the screen we need to set the names of them to sensible values. The designer will give each element a meaningless name like "TextBox1", which I like to change to something which has meaning in the context of the system being created.

We can change the properties of things on the screen by clicking on the item in the designer and then seeking out the Properties pane in Visual Studio for that item.



TextBox firstNumberTextBox

Common

Property	Value
DataContext	Binding...
Style	Resource...
Text	0
IsEnabled	✓
MaxLength	0

Layout

Property	Value
Width	460
Height	72
HorizontalAlignm...	Left
VerticalAlignment	Top
Margin	8,19,0,0
Padding	2
MinWidth	0
MinHeight	0
MaxWidth	Infinity
MaxHeight	Infinity
HorizontalConten...	Center
VerticalContentAli...	Center
Grid.Column	0
Grid.ColumnSpan	1
Grid.Row	0
Grid.RowSpan	1

Above you can see the properties window for the top TextBox on the page. The name of an element is given at the very top of the window.

I have changed the name of this textbox to `firstNumberTextBox`. You'll never guess what the second text box is called. Note that the name of a property in this context is actually going to set the name of the variable declared inside the adding machine program. In other words, as a result of what I've done above there will now be the following statement in my program somewhere:

```
TextBox firstNumberTextBox;
```

Visual Studio looks after the declaration of the actual C# variables that represent the display elements that we create and so we don't need to actually worry about where the above statement is. We just have to remember that this is how the program works.

Properties in Silverlight elements

Once we have given our TextBox variable a proper name we can move on to give it all the properties that are required for this application. We can also change lots of properties for the textbox including the width of the textbox, the margin (which sets the position) and so on. The values that you see in the properties windows above are ones that reflect the current position and size of the item on the screen. If I drag the item around the margin values will change. If I change the values in the window above I will see the item move in the design surface. Again, if you are a Windows Forms kind of person you will see nothing strange here. But you must remember that all we are doing is changing the content of an object. The content of the properties window will change depending on what item you select

Silverlight properties and C# properties

When we talk about the "properties" of Silverlight elements on the page (for example the text displayed in a `TextBox`) we are actually talking about property values in the class that implements the `TextBox`. In other words, when a program contains a statement such as:

```
resultTextBlock.Text = "0";
```

- this will cause a `Set` method to run inside the `resultTextBlock` object which sets the text on the `TextBlock` to the appropriate value. At this point it is worth refreshing our understanding of properties in C# so that can get a good understanding of what is happening here.

C# classes and properties

C# classes can contain member data (the name of the person owning a particular bank account) and behaviours (methods called `GetName` and `SetName` that let a program find out this name and change it). Properties provide a way of representing data inside a class that is easier to work with than using `Get` and `Set` methods . They are used extensively in managing Silverlight elements, and therefore worth a refresher at this point.

A property is a member of a class that holds a value. We have seen that we can use a member variable to do this kind of thing, but we need to make the member value public. For example, the bank may ask us to keep track of staff members. One of the items that they may want to hold is the age of the bank account holder. We could do it like this:

```
public class Account
{
   public int Age;
}
```

The class contains a public member. I can get hold of this member in the usual way:

```
Account s = new Account ();
s.Age = 21;
```

I can access a public member of a class directly; just by giving the name of the member. The problem is that we have already decided that this is a bad way to manage our objects. There is nothing to stop things like:

```
s.Age = -100210232;
```

This is very naughty, but because the `Age` member is `public` we cannot stop it.

Creating Get and Set methods

To get control and do useful things we can create get and set methods which are `public`. These provide access to the member in a managed way. We then make the `Age` member `private` and nobody can tamper with it:

```
public class Account
{
   private int age;
   public int GetAge()
   {
      return this.age;
   }
   public void SetAge( int inAge )
   {
      if ( (inAge > 0) && (inAge < 120) )
      {
         this.age = inAge;
      }
   }
}
```

We now have complete control over our property, but we have had to write lots of extra code. Programmers who want to work with the age value now have to call methods:

```
Account s = new Account ();
s.SetAge(21);
Console.WriteLine ( "Age is : " + s.GetAge() );
```

Using Properties

Properties are a way of making the management of data like this slightly easier. An age property for the `StaffMember` class would be created as follows:

```
public class Account
{
   private int ageValue;

   public int Age
   {
      set
      {
         if ( (value > 0) && (value < 120) )
            ageValue = value;
      }
      get
      {
         return ageValue;
      }
   }
}
```

The age value has now been created as a property. Note how there are get and set parts to the property. These equate directly to the bodies of the get and set methods that I wrote earlier. The really nice thing about properties is that they are used just as the class member was:

```
Account s = new Account ();
s.Age = 21;
Console.WriteLine ( "Age is : " + s.Age );
```

When the `Age` property is given a value the `set` code is run. The keyword `value` means “the thing that is being assigned”. When the `Age` property is being read the `get` code is run. This gives us all the advantages of the methods, but they are much easier to use and create.

Data validation in properties

If we set an age value to an invalid one (for example we try to set the age to 150) the set behaviour above will perform validation and reject this value (nobody over 120 is allowed to have an account with our bank), leaving the age as it was before. A program that is using our Age property has no way of knowing whether an assignment to the property has failed unless it actually checks that the assignment worked.

```
Account s = new Account ();
int newAge = 150;
s.Age = newAge;
if (s.Age != newAge )
    Console.WriteLine ( "Age was not set" );
```

The code above sets the age to 150, which is not allowed. However, the code then tests to see if the value has been set. In other words, it is up to the users of your properties to make sure that values have been set correctly. In the case of a Set method the method itself could return false to indicate that the set has failed, here the user of the property has to do a bit more work.

Multiple ways of reading a property

Properties let us do other clever things too:

```
public int AgeInMonths
{
   get
   {
      return this.ageValue*12;
   }
}
```

This is a new property, called `AgeInMonths`. It can only be read, since it does not provide a set behaviour. However, it returns the age in months, based on the same source value as was used by the other property. This means that you can provide several different ways of recovering the same value. You can also provide read-only properties by leaving out the set behaviour. Write only properties are also possible if you leave out the get.

Properties and notifications

You may be asking the question "Why do we use properties in Silverlight elements?" It makes sense to use them in a bank account where I want to be able to protect the data inside my objects but in a Silverlight program, where I can put any text I like inside a `TextBlock`, there seems to be no point in having validation of the incoming value. In fact running this code will slow down the setting process. So, by making the `Text` value a public string we could make the program smaller and faster, which has to be a good thing. Right?

Well, sort of. Except that when we change the text on a `TextBlock` we would like the text on the Silverlight page in front of the user to change as well. This is how our adding machine will display the result. If a program just changed the value of a data member there would be no way the Silverlight system could know that the message on the screen needs to be updated.

However, if the `Text` member is a property when a program updates it the set behaviour in the `TextBlock` will get to run. The code in the set behaviour can update the stored value of the text field and it can also trigger an update of the display to make the new value visible. Properties provide a means by which an object can get control when a value inside the object is being changed, and this is extremely important. The simple statement:

```
resultTextBlock.Text = "0";
```

- may cause many hundreds of C# statements to run as the new value is stored in the TextBlock and an update of the display is triggered to make the screen change.

Page design with Silverlight

We can complete the page of our Adding machine by dragging more elements onto the screen and setting their properties. Remember that the first thing I do after dragging an item onto the page is set the name of that element. One of the first symptoms of a badly written program (for me) is a page that contains lots of elements called "Button1" and "Button2".

From the sequence above I hope you can see that designing a page looks quite easy. You just have to drag the elements onto the page and then set them up by using the properties of each one. If you read up on the Silverlight language you will find that you can give elements graphical properties that can make them transparent, add images to their backgrounds and even animate them around the screen. At this point we have moved well beyond programming and entered the realm of graphic design. And I wish you the best of luck.

2.2 Understanding XAML

In the above section we saw that Silverlight design can be broken down into some element manipulation using the Visual Studio designer and some property setting on the elements that you create. Once you know how to do these things, you can create every user interface you need.

It is perfectly true that you can work this way, and you could even think about making every program you ever need without touching XAML, although I think you would be missing out on some of the most powerful features of Silverlight.

At the moment everything seems quite sensible and we are all quite happy (at least I hope so). So this would seem a good point to confuse everybody and start to talk about XAML. The letters stand for “Extensible Application Markup Language” which I’m sure makes everything clear. Or not. XAML is the language used by Silverlight to describe what a page should look like.

Why have XAML?

You might be wondering why we have XAML. If you have used Windows Forms before you might think that you managed perfectly well without this new language getting in the way. XAML provides a well-defined interface between the look of an application (the properties of the display elements that the user sees) and the behaviour of the application (what happens behind the display to make the application work).

The split is a good idea because, as we have mentioned before, there is no guarantee that a good programmer will be a good graphic designer. If you want to make good looking applications you really have to have both designers and programmers working on your solution. This leads to a problem, in that ideally you want to separate the work of the two, and you don’t want the programmer unable to do anything until the graphical designer has finished creating all the menu screens.

XAML solves both these problems. As soon as the requirements of the user interface have been set out (how many text boxes, how many buttons, what is there on each page etc) then the designer can work on how each should look, while the programmer can focus on what they do. The XAML files contain the description of the user interface components and the designer can work on the appearance and position of these elements to their heart’s content while the programmer gets one with making the code that goes behind them. There is no need for the programmer to give the designer their code files since they are separate from the design, and vice versa.

XAML file content

A XAML file for a given page on the display will contain constructions that describe all the elements on it. Each description will contain a set of named properties. The line of XAML that describes our first `TextBox` is as given below:

```
<TextBox Height="72" HorizontalAlignment="Left"
Margin="8,19,0,0" Name="firstNumberTextBox" Text="0"
VerticalAlignment="Top" Width="460" TextAlignment="Center" />
```

If you compare the information in the Properties pane with the values in the XAML above you will find that they all line up exactly. The name of the `TextBox` is `firstNumberTextBox`, the width is `460` and so on.

If you were wondering how the page and the properties pane kept themselves synchronised it is because they both used the XAML description file for the page. When I move things around the page the editor updates the XAML with the new positions. The properties window reads this file and updates its values accordingly.

XAML is described as a *declarative* language. This means it just tells us about stuff. It is designed to be understandable by humans, which is why all the properties above have sensible names. If you want to, you can edit the text contents of the XAML files within Visual Studio and change both the appearance in the designer and also the property values.

XAML turns out to be very useful. Once you get the hang of the information used to describe components it turns out to be much quicker to add things to a page and move them about by just editing the text in the XAML file, rather than dragging things around or moving between property values. I find it particularly useful when I want a large number of similar elements on the screen. Visual Studio is aware of the syntax used to describe each type of element and will provide Intellisense support help as you go along.

When an application is built the XAML file is converted into a file containing low level instructions that create the actual display components when the program runs. This means that declaring a control inside the XAML file for a page will mean that the control will exist as an object our program can use.

XAML looks a lot like XML, an eXtensible MarkUp language you may have heard of. The way that items and elements are expressed is based on XML syntax and it is quite easy to understand.

Extensible Markup Languages

At this point you may be wondering what an eXtensible Markup Languge actually is. Well, it is a markup language that is extensible. I'm sure that helped. What we mean by this is that you can use the rules of the language to create constructions that describe anything. English is a lot like this. We have letters and punctuation which are the symbols of English text. We also have rules (called grammar) that set out how to make up words and sentences and we have different kinds of words. We have nouns that describe things and verbs that describe actions. When something new comes along we invent a whole new set of word to describe them. Someone had to come up with the word "computer" when the computer was invented, along with phrases like "boot up", "crash" and "too slow".

XML based languages are extensible in that we can invent new words and phrases that fit within the rules of the language and use these new constructions to describe anything we like. They are called *markup* languages because they are often used to describe the arrangement of items on a page. The word markup was originally used in printing when you wanted to say things like "Print the name Rob Miles in very large font". The most famous markup language is probably HTML, HyperText Markup Language, which is used by the World Wide Web to describe the format of web pages.

Programmers frequently invent their own data storage formats using XML. As an example, a snippet of XML that describes a set of high scores might look as follows:

```
<?xml version="1.0" encoding="us-ascii" ?>
<HighScoreRecords count="2">
    <HighScore game="Breakout">
        <playername>Rob Miles</playername>
        <score>1500</score>
    </HighScore>
    <HighScore game="Space Invaders">
        <playername>Rob Miles</playername>
        <score>4500</score>
    </HighScore>
</HighScoreRecords>
```

This is a tiny XML file that describes some high score records for a video game system. The `HighScoreRecords` element contains two `HighScore` items, one for `Breakout` and one for `Space Invaders`. The two high score items are contained within the `HighScoreRecords` item. Each of the items has a property which gives the name of the game and also contains two further elements, the name of the player and the score that was achieved. This is quite easy to us to understand. From the text above it is not hard to work out the high score for the Space Invaders game.

The line at the very top of the file tells whatever wants to read the file the version of the XML standard it is based on and the encoding of the characters in the file itself. XAML takes the rules of an extensible markup language and uses them to create a language that describes components on a page of a display.

```
<TextBox Height="72" HorizontalAlignment="Left"
Margin="8,19,0,0" Name="firstNumberTextBox" Text="0"
VerticalAlignment="Top" Width="460" TextAlignment="Center" />
```

If we now take a look at the description of a TextBox I think we can see that the designers of XAML have just created field names that match their requirements.

XML Schema

The XML standard also contains descriptions how to create a *schema* which describes a particular document format. For example, in the above the schema for the high score information would say that a `HighScore` must contain a `PlayerName` and a `Score` property. It might also say things like the `HighScore` can contain a `Data` value (the date when the high score was achieved) but that this is not required.

This system of standard format and schema means that it is very easy for developers to create data formats for particular purposes. This is helped by the fact that there are a lot of design tools to help create documents and schemas. The .NET framework even provides a way by which a program can save an object as a formatted XML document. In fact the Visual Studio solution file is actually stored as an XML document.

As far as we are concerned, it is worth remembering that XML is useful for this kind of thing, but at the moment I want to keep the focus on XAML itself.

XAML and pages

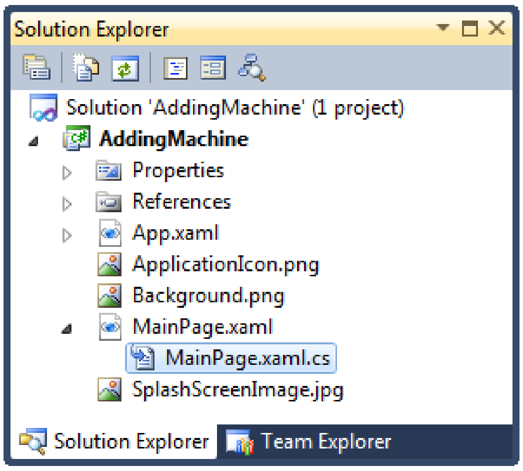
A file of XAML can describe a complete page of the Windows Phone display. When you create a brand new Windows Phone project you get a page that just contains a few elements. As you put more onto the page the file grows as each description is added. Some elements work as *containers* which means that they can hold other components. They are very useful when you want to lay things out, for example there is a Grid element which can hold a set of other elements in a grid arrangement. The XAML code can also contain the descriptions of animations and transitions that can be applied to items on the page to make even more impressive user interfaces.

One thing you need to bear in mind at this point is that XAML has no concept of hierarchy. It is not possible to create an XAML element which is derived from another. We do this in software so that we can create a new object which is similar to an existing one. We know that Silverlight elements are represented in software terms by an object which is part of a class hierarchy. However, when they are written in a XAML file they are all expressed as items which are at the same level.

We are not going to spend too much time on the layout aspects of XAML; suffice it to say that you can create incredibly impressive front ends for your programs using this tool. There is also a special design tool called “Expression Blend” for use by graphical designer. However, it is important to remember that at the end of the day the program is working in terms of objects that expose properties and methods that we can use to work on the data inside them. In the case of our user interface elements, if we change the properties of the element the display the user sees will change to reflect this. The objects represent the items on the screen of our program.

2.3 Creating an application with Silverlight

Now that we know that items on the screen are in fact the graphical realisation of software objects, the next thing we need to know is how to get control of these objects and make them do useful things for us in our application. To do this we will need to add some C# program code that will perform the calculation that the adding machine needs.



Whenever Visual Studio makes a XAML file that describes a page on the Windows Phone display it also makes a program file to go with it. This is where we can put code that will make our application work. If you actually take a look in the file `MainPage.xaml.cs` above you will find that it doesn't actually contain much code:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Net;
using System.Windows;
using System.Windows.Controls;
using System.Windows.Documents;
using System.Windows.Input;
using System.Windows.Media;
using System.Windows.Media.Animation;
using System.Windows.Shapes;
using Microsoft.Phone.Controls;

namespace AddingMachine
{
    public partial class MainPage : PhoneApplicationPage
    {
        // Constructor
        public MainPage()
        {
            InitializeComponent();
        }
    }
}
```

Most of the file is `using` statements which allow our program to make direct use of classes without having to give the fully formed name of each of them. For example, rather than saying `System.Windows.Controls.Button` we can say

`Button`, because the file contains the line `using System.Windows.Controls`.

The only method in the program is the constructor of the `MainPage` class. As we know, the constructor of a class is called when an instance of the class is created.

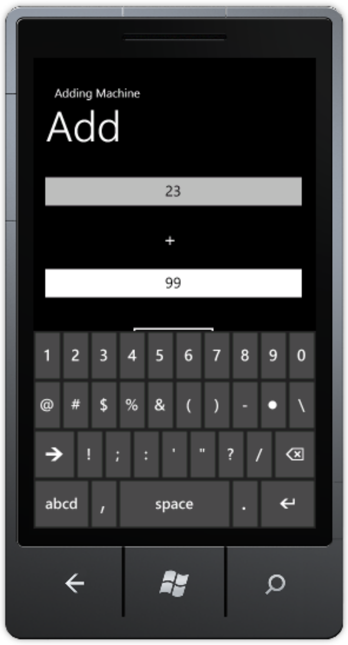
All the constructor does is call the method `InitializeComponent`. If you go take a look inside this method you will find the code that actually creates the instances of the display elements. This code is automatically created for you by Visual Studio, based on the XAML that describes your page. It is important that you leave this call as it is and don't change the content of the method itself as this will most likely break your program.

Note that at this point we are deep in the "engine room" of Silverlight. I'm only really telling you about this so that you can understand that actually there is no magic here. If the only C# programs you have seen so far start with a call of the `Main` method then it is important that you understand that there is nothing particularly special about a Silverlight one. There is a `Main` method at the base of a Silverlight application; it starts the process of building the components and putting them on the screen for the user to interact with.

The nice thing as far as we are concerned is that we don't need to worry about how these objects are created and displayed, we can just use the high level tools or the easy to understand XAML to design and build our display.

Building the application

We can now see how to create the user interface for our number adding program. If we add all the components and then start the application it even looks as though it might do something for us. We can type in the numbers that we want to add, and even press the equals button if we like:



If we touch inside a `TextBox` item the keyboard appears and we can type numbers into the box. If we then touch anywhere else on the screen the keyboard moves out of the way. We seem to have got a lot of behaviour for very little effort, which is nice. However, we need to add some business logic of our own now to get the program to work out the answer and display it.

Calculating the result

At the moment our program looks good, but doesn't actually do anything. We need to create some code which will perform the required calculation and display the result. Something like this.

```
private void calculateResult()
{
    float v1 = float.Parse(firstNumberTextBox.Text);
    float v2 = float.Parse(secondNumberTextBox.Text);

    float result = v1 + v2;

    resultTextBlock.Text = result.ToString();
}
```

The `TextBox` objects expose a property called `Text`. This can be read or written. Setting a value into the `Text` property will change the text in the textbox. Reading the `Text` property allows our program to read what has been typed into the textbox.

The text is given as a string, which must be converted into a numeric value if our program is to do any sums. You may have seen the `Parse` method before. This takes a string and returns the number that the string describes. Each of the numeric types (int, float, double etc) has a `Parse` behaviour which will take a string and return the numeric value that it describes. The adding machine that we are creating can work with floating point numbers, so the method parses the text in each of the input textboxes and then calculates a result by adding them together.

Finally it takes the number that was calculated, converts it into a string and then sets the text of the `resultTextBlock` to this string. `ToString` is the reverse of `Parse`, the "anti-parse" if you like. It provides the text that describes the contents of an object. In the case of the float type, this is the text that describes that value.

Now we have our code that works out the answer, we just have to find a way of getting it to run when the user presses the equals button.

Events and Programs

If you have done any kind of form based programming you will know all about events. If you haven't then don't worry, we now have a nice example of a situation where we need them, and they are not that frightening anyway. In the olden days, before graphical user interfaces and mice, a program would generally start at the beginning, run for a while and then finish.

But now we have complicated and rich user interfaces with lots of buttons and other elements for the user to interact with. The word processor I am using at the moment exposes hundreds of different features via buttons on the screen and menu items. In this situation it would be very hard to write a program which checked every user element in turn to see if the user has attempted to use that. Instead the system waits for these display elements to raise an event when they want attention. Teachers do this all the time. They don't go round the class asking each child in turn if they know the answer. Instead they ask the children to raise their hands. The "hand raising" is treated as an event which the teacher will respond to.

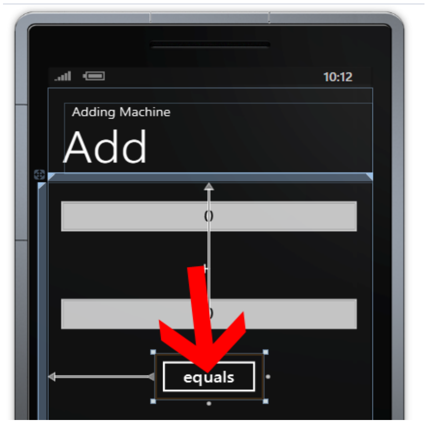
Using events like this makes software design a lot easier. Our program does not have to check every item on the screen to see if the user has done anything with it, instead it just binds to the events that it is interested in.

To make events work a programing language needs a way of expressing a reference to a method in an object. C# provides the *delegate* type which does exactly that. You can create a delegate type that can refer to a particular kind of method and then create instances of that delegate which refer to a method in an object. Delegates are very powerful, but can be a bit tricky to get your head around. Fortunately we don't have to worry about how delegates work just at the moment, because we can get Silverlight and Visual Studio to do all the hard work for us.

Events in Silverlight

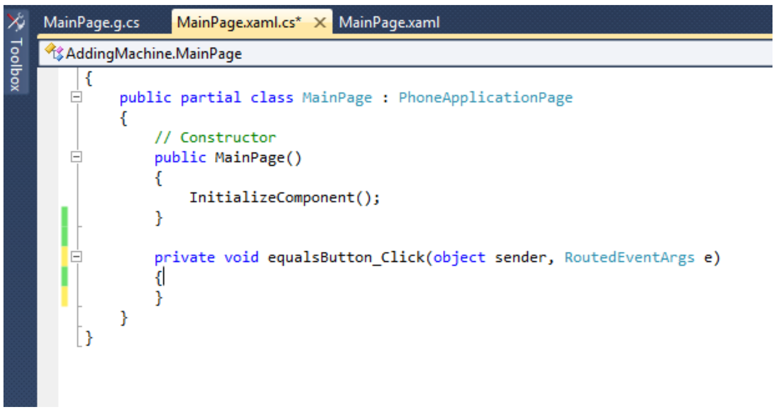
In C# an event is delivered to an object by means of a call to a method in that object. In this respect you can regard an event and a message as the same thing. From the point of view of our adding machine we would like to have a particular method called when the "equals" button is pressed by the user. This is the only event that we are interested in. When the event fires we want it to call the `calculateResult` method above.

We can use the editor in Visual Studio to bind this event for us. This is actually so easy as to appear magical. To connect a method to the click event of a particular button we just have to double click on that button on the editing surface.



The picture above shows where we should double click in Visual Studio. When we double click on the button Visual Studio sets the properties of the button in XAML to connect the button to a method in our page. It also creates an empty version of that method and takes us straight to this method, so that we can start adding the code that must run when the button is clicked.

If we just single click on the button this has the effect of selecting it, so that we can move it around the display and change its size. If you want to connect an event handler it must be a double click. If we do this we will see a display like the one shown below.

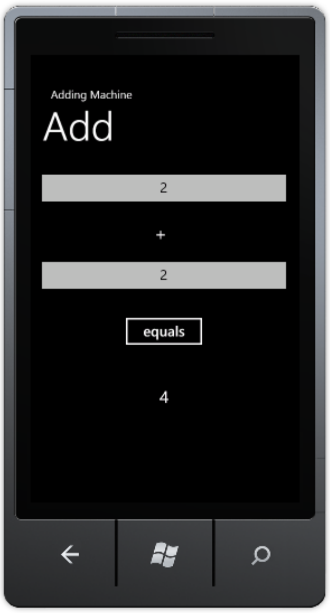


```
{
    public partial class MainPage : PhoneApplicationPage
    {
        // Constructor
        public MainPage()
        {
            InitializeComponent();
        }

        private void equalsButton_Click(object sender, RoutedEventArgs e)
        {
        }
    }
}
```

Now, all we have to do is add the code to make this work.

```
private void calculateResult()
{
    float v1 = float.Parse(firstNumberTextBox.Text);
    float v2 = float.Parse(secondNumberTextBox.Text);

    float result = v1 + v2;

    resultTextBlock.Text = result.ToString();
}

private void equalsButton_Click(object sender,
RoutedEventArgs e)
{
    calculateResult();
}
```

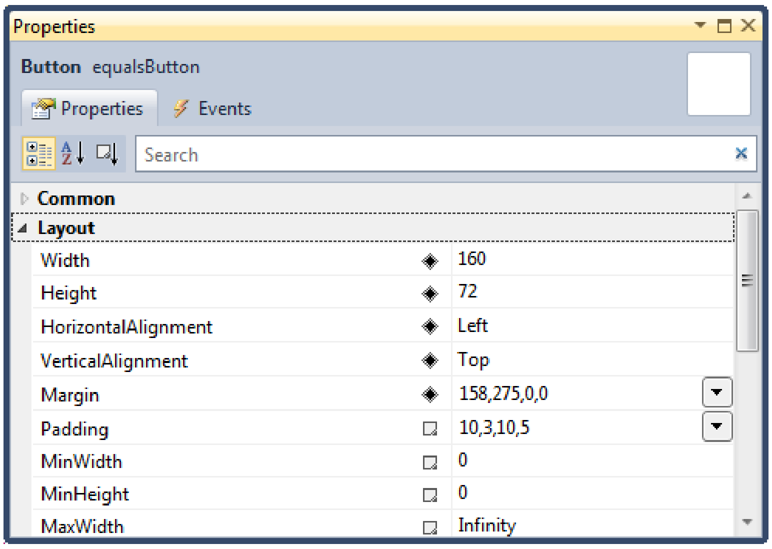
The event handler that is created is automatically given a sensible name by Visual Studio. It takes the name of the element and adds the text "_Click" on the end. This underlines the importance of giving your elements sensible names when you create them, because this name makes it very easy for anyone to understand what is happening.



The program works fine, as you can see above. Of course it is not perfect. If a user types in text rather than a numeric value the program will fail with an exception, but we will deal with this later.

Managing Event Properties

At the moment the process of connecting event handlers to events looks a bit magic. And if there is one thing I'm sure of, it is that computers are not magical. Ever. So now we should really find out how this event process actually works. We can start by taking a look at the properties of the equals button in our application.



Properties

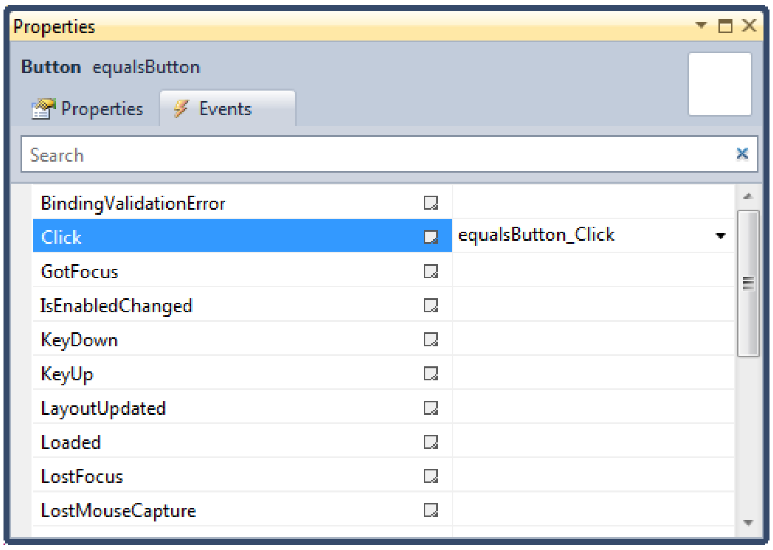
Button equalsButton

Properties | Events

Search

Common		
Layout		
Width	◈	160
Height	◈	72
HorizontalAlignment	◈	Left
VerticalAlignment	◈	Top
Margin	◈	158,275,0,0
Padding	☐	10,3,10,5
MinWidth	☐	0
MinHeight	☐	0
MaxWidth	☐	Infinity

If we single click on the button in the editor and then take a look at the property information in Visual Studio we see something very like the display above. The information here sets out the position of the button on the screen and a bunch of other things too. The property window has two tab panels though. If we look at the top we will find one with the name Events, and a rather scary looking lightning bolt icon. If we click on the Events tab the display changes to display the events that this element can generate, and which are presently connected to code:



Properties

Button equalsButton

Properties | Events

Search

BindingValidationError	☐	
Click	☐	equalsButton_Click
GotFocus	☐	
IsEnabledChanged	☐	
KeyDown	☐	
KeyUp	☐	
LayoutUpdated	☐	
Loaded	☐	
LostFocus	☐	
LostMouseCapture	☐	

The Properties window is now showing us all the events that a button can generate. At the moment only one event has a method connected to it, and that is the Click event. This is linked to the `equalsButton_Click` method. If we wanted to disconnect the Click event from the method we could do this by just deleting the name of the handler from this window. We could cause problems for ourselves by replacing the content of that part of the form with something stupid like “ILikeCheese”. If we do this the program will not work (or even build) any more because the Click event is now connected to something that does not exist.

Events and XAML

Up until now we have worked on the principle that the properties display in Visual Studio is driven by the XAML file which describes the components on the screen. We can prove that this is the case by taking a look at the Button description in the XAML file for the MainPage:

```
Button Content="equals" Height="72"
HorizontalAlignment="Left" Margin="158,275,0,0"
Name="equalsButton" VerticalAlignment="Top" Width="160"
Click="equalsButton_Click" />
```

As you can see; the description of Button now contains an item that connects the Click event with the name of a method.

One important point to note here is that if the XAML file says that a button is connected to a method with a particular name the program will fail to run correctly if that method is not there.

What we have learned

1. Silverlight provides a way of designing graphical user interfaces.
2. A Silverlight user interface is made up of elements which are things such as text boxes and buttons.
3. The Visual Studio integrated development environment provides an editor which can be used to add Silverlight user interface elements onto the pages of an application.
4. From a software point of view each of the user interface elements is represented by a particular type of object in a class hierarchy which is part of Silverlight.
5. Designers can modify the properties of the elements using the design tools in Visual Studio, either by changing them on the design surface or by modifying their properties.
6. The actual properties of Silverlight elements in a project are held in text files in the XAML format. These files are updated by the design tools and used when the program is built to create the software objects that are used in the solution.
7. XAML (eXtensible Application Markup Language) is an XML based language that specifies all the properties of the design elements on a page. It provides a separation between the appearance and properties of the display elements and the program code that sits behind them.
8. XML (eXtensible Markup Language) is a way of creating customised languages that can be used to describe things.
9. Elements can generate events which may be bound to methods inside a C# program. The method name is given in the XML description for the element.
10. The methods that are bound to the events can provide the business logic for a user application.

3 Introduction to Visual Studio 2010

When you write programs for Windows Phone you will be using Visual Studio. In this section we will take a look at the process of creating and managing Windows Phone projects. We will also find out how to run and debug Windows Phone programs using the Windows Phone emulator program. This allows you to test your programs without needing to have a device.

However, this is not just a look at how to use Visual Studio. That would be too easy. We are also going to take a peek underneath the hood and find out how Visual Studio manages the content that makes up our solutions. This will stand us in good stead when we come to create Windows Phone applications.

3.1 Projects and Solutions

The first thing we are going to look at is just how Visual Studio manages the programs that you create.

Creating programs

We know that when we create a program we write a set of instructions in a high level language (which if we are lucky is C#). The *compiler* is a program that takes the high level instructions which the programmer created and converts them into lower level instructions for execution on the computer. We also know now that in Microsoft .NET the compiler produces output in an *intermediate language* (MSIL) which is then "Just In Time" compiled into hardware instructions when the program actually runs.

The bare minimum you need to create a working program is therefore a C# source file (a text file with the language extension .CS) and a compiler. The compiler takes the source file and converts it into an executable file (a binary file with the language extension .EXE) which can then be used by the .NET runtime system for whatever platform you want to execute the program on. The use of MSIL means that I can take exactly the same .EXE file and run it on completely different hardware platforms if I wish.

The .NET SDK

If you just want to create programs for the Windows PC and you don't want to download all of Visual Studio you can actually just get the compiler and runtimes for .NET from here:

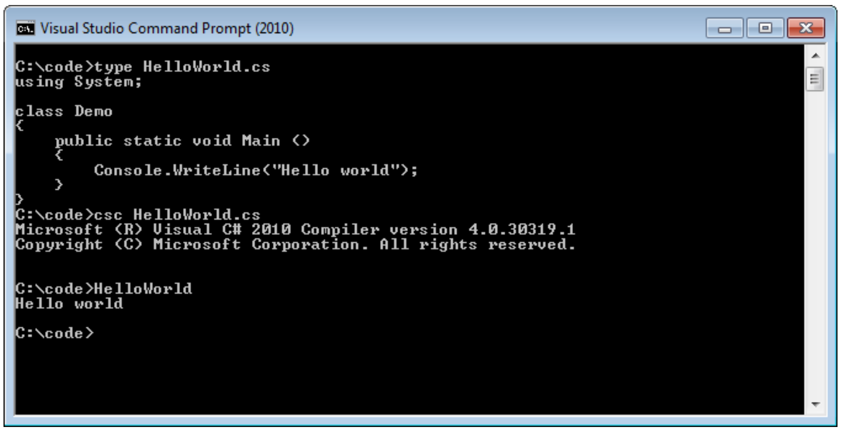
http://msdn.microsoft.com/en-us/netframework/aa569263.aspx

When you install the framework you get a command line compiler which can take C# source files and convert them into executable ones using console commands such as:

```
 csc MyProg.cs
```

This command will compile the file `MyProg.cs` and create a file called `MyProg.exe`.

The command prompt compiler is also available if you have installed Visual Studio.

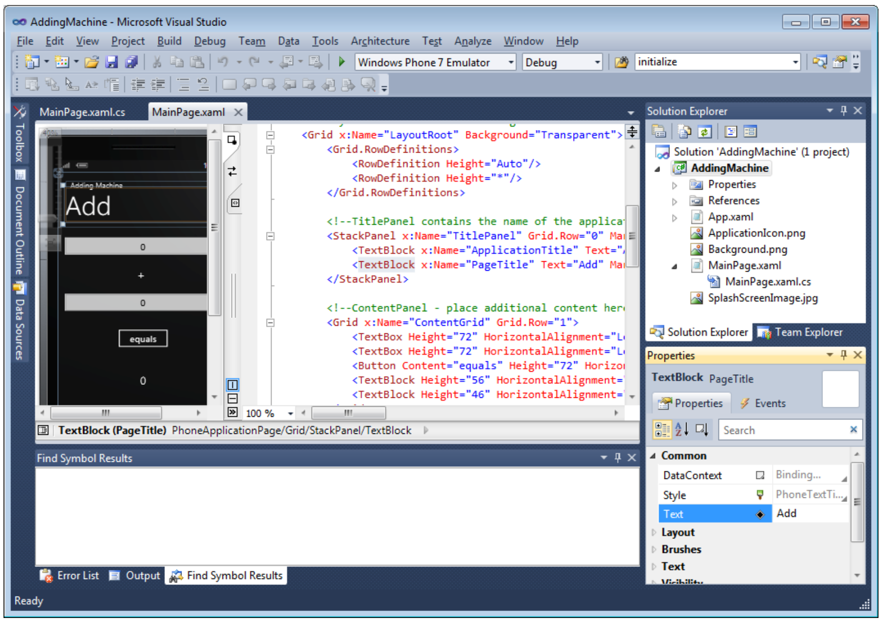


```
C:\code>type HelloWorld.cs
using System;

class Demo
{
    public static void Main ()
    {
        Console.WriteLine("Hello world");
    }
}
C:\code>csc HelloWorld.cs
Microsoft (R) Visual C# 2010 Compiler version 4.0.30319.1
Copyright (C) Microsoft Corporation. All rights reserved.


C:\code>HelloWorld
Hello world

C:\code>
```

It is possible to use these simple tools to create very large programs, but it is also rather hard work. You have to create large, complicated commands for the compiler and you need to make sure that whenever you make a new version of your system that you compile every source file that you need to. Furthermore you have manage and incorporate all the media that your system needs and when it comes to debugging your program all you are going to get is text messages when the program fails.

Visual Studio

Visual Studio addresses all the problems above. It provides a single environment in which you can edit, build and run your programs. It also provides projects and solutions which let you organise your systems and manage what goes into them. Finally, just to make it even more wonderful, it provides a full debugging solution that lets you single step through your program and even execute individual statements and change the values in variables as your program runs. Skill with Visual Studio and an understanding of how it works is very marketable.



```
<Grid x:Name="LayoutRoot" Background="Transparent">
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto"/>
        <RowDefinition Height="*"/>
    </Grid.RowDefinitions>

    <!--TitlePanel contains the name of the applica
    <StackPanel x:Name="TitlePanel" Grid.Row="0" Ma
        <TextBlock x:Name="ApplicationTitle" Text="
        <TextBlock x:Name="PageTitle" Text="Add" Ma
    </StackPanel>

    <!--ContentPanel - place additional content her
    <Grid x:Name="ContentGrid" Grid.Row="1">
        <TextBox Height="72" HorizontalAlignment="L
        <TextBox Height="72" HorizontalAlignment="L
        <Button Content="equals" Height="72" Horizo
        <TextBlock Height="56" HorizontalAlignment=
        <TextBlock Height="46" HorizontalAlignment=
```

The first thing that hits you with Visual Studio is the sheer number of buttons and controls that you have to deal with. If we start opening menus it gets even worse. However, the good news is that you don't have to press all the buttons to get started. We are just going to take a look at the basics of the program. You can pick up more advanced features as we go along.

The first aspect of Visual Studio we are going to take a look at is that of projects and solutions. You will use these to organise any systems that you create. Visual

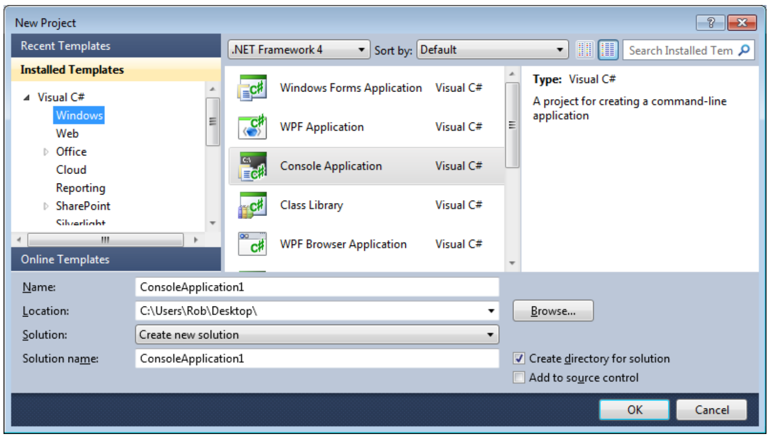
Studio is not able to run any program code which is not in a project or solution. The good news is that to get started you can use one of the templates that provide a starting point for particular project types. We will be using the Windows Phone templates for now. There are many other templates for different kinds of programs.

Visual Studio makes a distinction between a *project* and a *solution* when organising your work. It is important that you understand the difference between these two. Let's start by looking at a project.

A Simple Visual Studio Project

A project is a container for a set of program files and resources which generate a particular *assembly* file. So, what does that mean? Well, the simplest possible project would be one containing a single program file. You can create one of these by asking Visual Studio to create a Console Application. We can do this by using the `File>New>Project` command to open up the New Project dialogue:

The New Project dialogue shows us all the possible project templates that are supplied with Visual Studio. A template is a pre-set collection of files, folders and resources which is used for a particular type of application. We can add to the template once it has been created, and it is even possible to create customised templates of our own. The projects that we saw earlier were created using templates for creating Windows Phone applications.


New Project

Recent Templates
Installed Templates
Visual C#
Windows
Web
Office
Cloud
Reporting
SharePoint
Silverlight
Online Templates

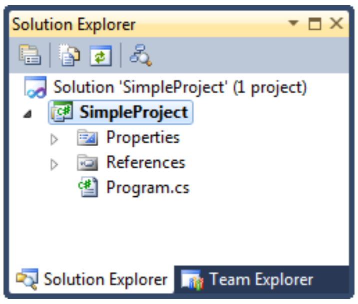
.NET Framework 4 Sort by: Default Search Installed Tem

Windows Forms Application	Visual C#
WPF Application	Visual C#
Console Application	Visual C#
Class Library	Visual C#
WPF Browser Application	Visual C#

Type: Visual C#
A project for creating a command-line application

Name: ConsoleApplication1
Location: C:\Users\Rob\Desktop\ Browse...
Solution: Create new solution
Solution name: ConsoleApplication1
☑ Create directory for solution
☐ Add to source control
OK Cancel

If we select the template for a Windows Console Application as shown above Visual Studio will create the simplest possible project for us. This is what it would look like in Visual Studio Solution explorer.


Solution Explorer
Solution 'SimpleProject' (1 project)
SimpleProject
Properties
References
Program.cs
Solution Explorer
Team Explorer

This project contains a single program file, called `Program.cs`. The program source in this file is very simple too:

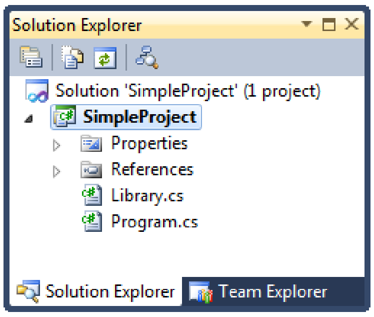
```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

namespace SimpleProject
{
    class Program
    {
        static void Main(string[] args)
        {
        }
    }
}
```

If we ask Visual Studio to run the program it will compile the `Program` class and then run the application by calling the `Main` method. This is how C# programs work. The output of the build process on this program would be a file called `Program.exe` which can be run as a program on a Windows PC.

The program runs in the command window, which will pop up briefly onto the screen when the Main method runs. We will look at running and debugging programs a little later in this section.

Making a program from several source files

It is often sensible to create a program from a number of class files. These can be separate parts written by another programmer or you might use a library of C# code provided by somebody else. You can do this in Visual Studio by adding new a new class to your project. The solution explorer in Visual Studio will show you the new file in the project:



The file `Library.cs` is now part of the project and when Visual Studio builds the project it knows to compile the `Library.cs` source file along with the `Program.cs` one. However, the output of this build will be a single executable file called `Program.exe`. Of course only one of these source files can have a `Main` method, otherwise the compiler will become confused about where the program is supposed to start running. The Library class is presently empty:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

namespace SimpleProject
{
    class Library
    {
    }
}
```

We can create instances of the class in our `Main` method:

```
namespace SimpleProject
{
    class Program
    {
        static void Main(string[] args)
        {
            Library l = new Library();
        }
    }
}
```

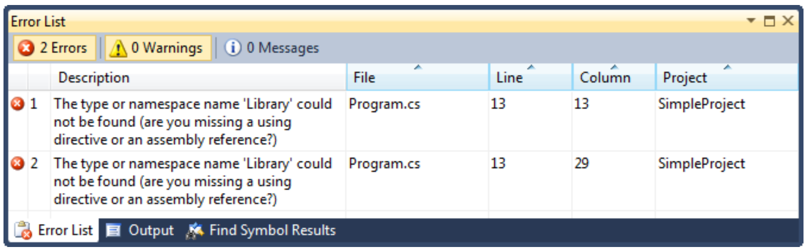
Namespaces and Projects

The Library class and the Program class are in the `SimpleProject` namespace. From a design point of view it is often sensible to have different parts of a system in separate namespaces. This is particularly important if the programs are being built by different people. If the programmer writing the library code decides that the name `Save` is appropriate for a particular method you don't want that clashing with a `Save` method that you want to use.

Remember that namespaces are a *logical* way of grouping items together. They have no bearing on where the actual code is physically located. We can put the library class into a separate namespace simply by changing the name:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

namespace SimpleLibrary
{
    class Library
    {
    }
}
```

The Library class is now in the `SimpleLibrary` namespace. If we try to build the project we get some errors:



	Description	File	Line	Column	Project
1	The type or namespace name 'Library' could not be found (are you missing a using directive or an assembly reference?)	Program.cs	13	13	SimpleProject
2	The type or namespace name 'Library' could not be found (are you missing a using directive or an assembly reference?)	Program.cs	13	29	SimpleProject

This is because the `Main` method in the `Program` class is trying to create an instance of the `Library` class. This class is no longer in the `SimpleProject` namespace, and so we get the errors. Fortunately the Description field of the error list tries to help by telling us that we might be missing a using directive. This is the case. We can fix the problem by adding a using directory to tell the compiler to look in the `SimpleLibrary` namespace if it needs to find a class:

```
using SimpleLibrary;

namespace SimpleProject
{
    class Program
    {
        static void Main(string[] args)
        {
            Library l = new Library();
        }
    }
}
```

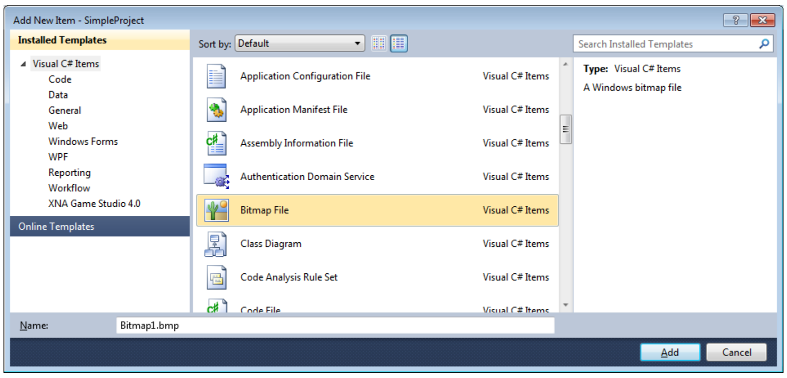
Another way to solve the problem is to use fully qualified names to access the resources in the library:

```
SimpleLibrary.Library l =
    new SimpleLibrary.Library();
```

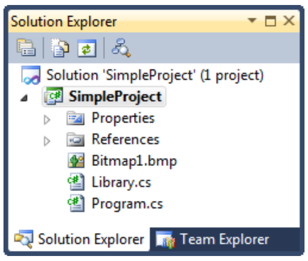
The thing to remember about all this is that we are simply creating names for items in our project; we are not specifying where in the system they are stored. When Visual Studio builds `SimpleProject` it will look in all the source files in the project to find elements that it needs.

Adding Resources to a project

If your program needs to use resources (perhaps an image for splash screen picture) you can add them to a project too. We can add a bitmap image in just the same way as we added the new class.



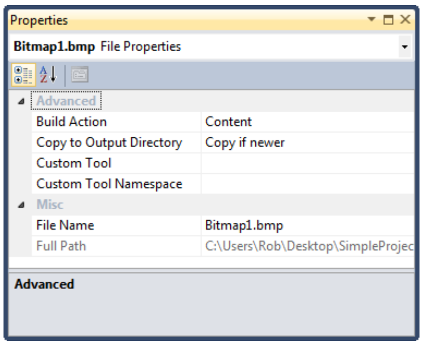
When we have added the bitmap resource it appears in the Solution Explorer for the project.



This solution now contains a bitmap file called `Bitmap1.bmp`. We can now select how Visual Studio manages this content item by modifying the properties of `Bitmap1` in the solution.

Content Properties

Like everything else that Visual Studio manages, the resources added to a project also have properties. We can work with the properties just as we work with the properties of any other item that we add to a project, we use the properties pane.



Properties	
Bitmap1.bmp File Properties	
Advanced	
Build Action	Content
Copy to Output Directory	Copy if newer
Custom Tool	
Custom Tool Namespace	
Misc	
File Name	Bitmap1.bmp
Full Path	C:\Users\Rob\Desktop\SimpleProjec

Advanced

The settings above ask Visual Studio to copy the bitmap into the same directory as the program when it builds the project. The program can then open this file and use it when it runs:

```
Bitmap b = new Bitmap("Bitmap1.bmp");
```

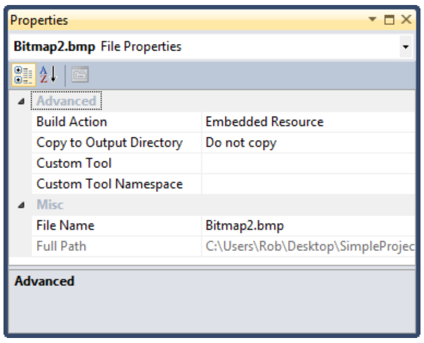
The above code would load the bitmap resource into a bitmap called b.

This is a very good way to add items to a project. Note that the properties above are not the default ones which are set when a new item of content is added. By default (i.e. unless you specify otherwise) the content is not copied into the output directory.

Embedding Content in the Application itself

The above settings ask that the bitmap be stored in the same directory as the program. This works well, but assumes that when we install the program the image files are copied as well as the program binary.

If we want tighter coupling between a program and its resources we can request that this resource be embedded in the program file when the program is built. When the program is built the output executable program will contain the bitmap. We do this by changing the properties of the content item.



Properties	
Bitmap2.bmp File Properties	
Advanced	
Build Action	Embedded Resource
Copy to Output Directory	Do not copy
Custom Tool	
Custom Tool Namespace	
Misc	
File Name	Bitmap2.bmp
Full Path	C:\Users\Rob\Desktop\SimpleProjec

Advanced

The Build Action property of the `Bitmap2.bmp` file is now set to Embedded Resource. Our image is now stored in the actual program file. Getting hold of this is slightly more involved, but guaranteed to work wherever our program is deployed, because there are no extra files:

```
Assembly assembly;
Stream imageStream;

assembly = Assembly.GetExecutingAssembly();
imageStream =
assembly.GetManifestResourceStream("SimpleProject.Bitmap2.bmp
");

Bitmap b = new Bitmap(imageStream);
```

The above code will load a bitmap from an embedded resource and store it in a bitmap called b. Note that when we get a resource from the assembly we have to give the namespace of the project along with the resource name.

One of the design decisions we will have to make later in this text is whether or not to incorporate things like pictures in the program executable file, or as resources which are stored in the same folder as the program itself.

Assembly files and Executable files

At this point you might be starting to wonder about the output file. It seemed simple enough when we were just compiling a simple C# program, but now it contains a picture as well. This is because the output of a Visual Studio build is not just a program; it is in fact an *assembly*. An assembly is a container which can hold a whole range of things, including program code. When a program runs the .NET runtime system will open the assembly and go and find the class in the assembly with the Main method in it. It then starts that method running. The project file tells Visual Studio what to put in the assembly.

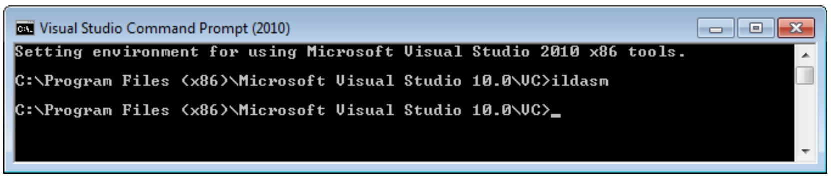
If you are very old, and remember when a file that ends in .exe just contained program instructions, then this is a bit confusing. The good news is that you don't need to worry; Visual Studio does a very good job of managing what goes into a program.

Using ildasm to look inside assembly files

If you've ever wanted to look inside an assembly file and see what makes it tick you can use the program ildasm. This is a program you can start from the Visual Studio Command Line. To open the command line you use the following path through your program files:

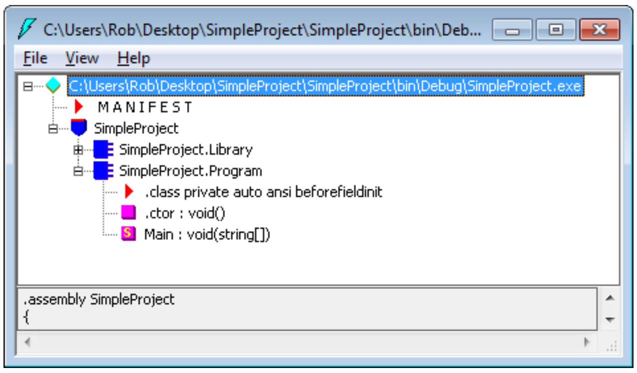
```
All Programs>Microsoft Visual Studio 10>Visual Studio Tools
```

Ildasm lets you can open any assembly and take a look inside. This also lets you see the MSIL (Microsoft Intermediate Language) instructions that the compiler produced. You start the program just by issuing the command `ildasm`:


Visual Studio Command Prompt (2010)

```
Setting environment for using Microsoft Visual Studio 2010 x86 tools.

C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC>ildasm

C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC>_
```

Once the program is running you can find your way to an assembly and open it:

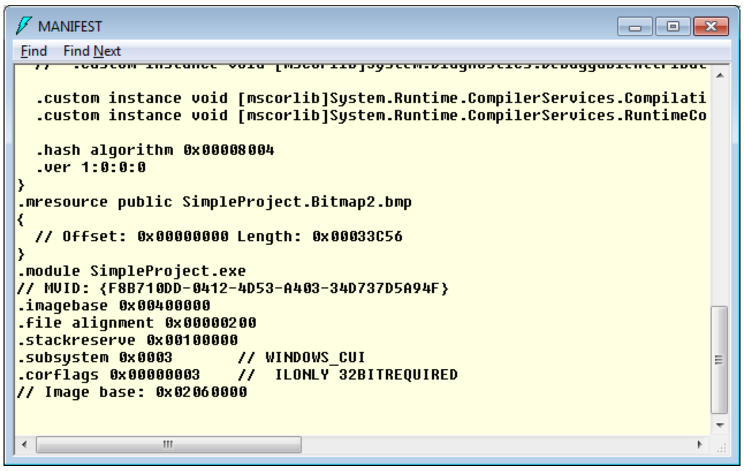


```
C:\Users\Rob\Desktop\SimpleProject\SimpleProject\bin\Debug\SimpleProject.exe
  MANIFEST
  SimpleProject
    SimpleProject.Library
    SimpleProject.Program
      .class private auto ansi beforefieldinit
      .ctor : void()
      Main : void(string[])
```

```
.assembly SimpleProject
{
```

This is the `ildasm` display for the simple project I made above. The assembly contains the compiled classes that make up the program content. You can see that the `SimpleProject.Program` class contains two methods, the `ctor` method (the constructor for the class) and the `Main` method. You can open these and take a look at the code inside them.

The MANIFEST part of the assembly contains a “list of contents” for the assembly.



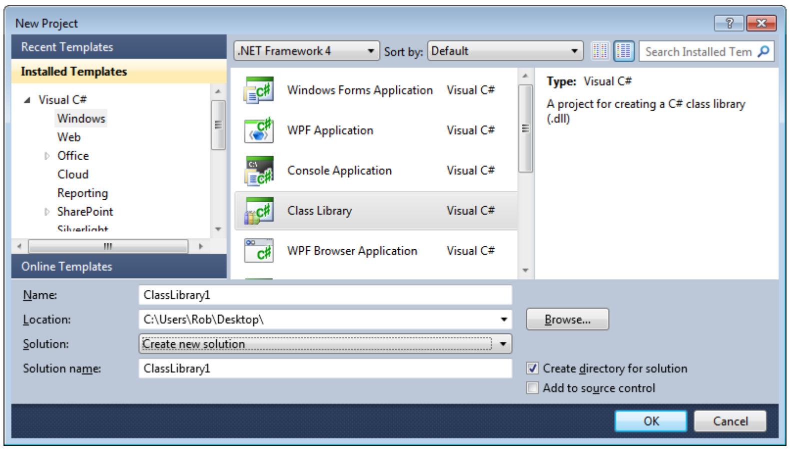
```
  .custom instance void [mscorlib]System.Runtime.CompilerServices.Compilati
  .custom instance void [mscorlib]System.Runtime.CompilerServices.RuntimeCo

  .hash algorithm 0x00008004
  .ver 1:0:0:0
}
.mresource public SimpleProject.Bitmap2.bmp
{
  // Offset: 0x00000000 Length: 0x00033C56
}
.module SimpleProject.exe
// MVID: {F8B710DD-0412-4D53-A403-34D737D5A94F}
.imagebase 0x00400000
.file alignment 0x00000200
.stackreserve 0x00100000
.subsystem 0x0003       // WINDOWS_CUI
.corflags 0x00000003    //  ILONLY 32BITREQUIRED
// Image base: 0x02060000
```

This is the manifest for an assembly that contains an embedded resource. You can see the name of the resource and the size of it.

The `ildasm` program can show us this information because a compiled class contains *metadata* which describes the methods and members and can even include information for Intellisense to use in Visual Studio. If you have ever wondered exactly what a program does and how it gets to run you can have a lot of fun going through the views that `ildasm` provides. However you might not have the same idea about what constitutes fun as I do.

Library Assemblies

There are actually two kinds of assembly; ones that contain a Main method somewhere (the executable ones) and libraries. When you create a new project you can create a library project if you like:



Windows Forms Application	Visual C#
WPF Application	Visual C#
Console Application	Visual C#
Class Library	Visual C#
WPF Browser Application	Visual C#

Type: Visual C#

A project for creating a C# class library (.dll)

Name:	ClassLibrary1
Location:	C:\Users\Rob\Desktop\
Solution:	Create new solution
Solution name:	ClassLibrary1

[✓] Create directory for solution

[ ] Add to source control

This will create a brand new project which will only contain library classes, i.e. none of the classes in the assembly will contain a Main method. If any of them do you will get an error when you try to compile the project. A library assembly compiles to a file with the language extension .dll. This stands for *Dynamic Link Library*. The library word sounds sensible enough; the dynamic link part means that the library classes are loaded dynamically when the program runs.

When the program refers to a method in a class in the library that class will be loaded into memory and the Just In Time compiler will convert the method into machine code so that it can run. If the class is never used, it is never loaded. This is a nice way of saving memory, at the expense of a little more effort when the program runs.

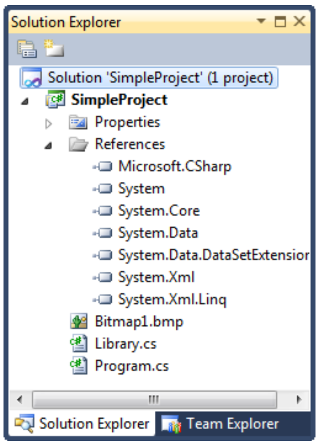
We can give other programmers our dll files and they can use the classes inside them without needing the source code of the program. Even better, the metadata which the libraries contain makes it easy for the programmers to find their way around them.

System Libraries and references

A program running under .NET makes use of system resources as it runs. When the program makes wants to send a message to the console it will call a system method to do this:

```
System.Console.WriteLine("Hello World");
```

These methods are held in the system libraries, which are actually dll files that were created by Microsoft and distributed as part of the .NET system. An assembly file contains references to the library files that it works with. This list of references is maintained in Visual Studio via the Solution Explorer pane.



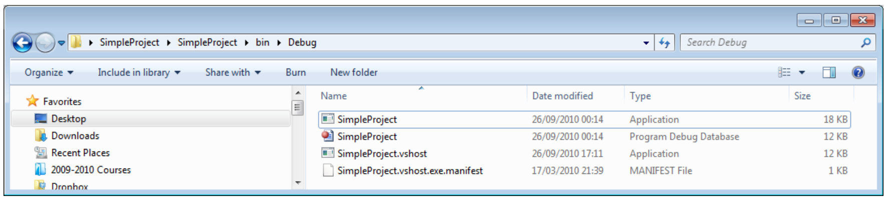
```
Solution Explorer
Solution 'SimpleProject' (1 project)
  SimpleProject
    Properties
    References
      Microsoft.CSharp
      System
      System.Core
      System.Data
      System.Data.DataSetExtensior
      System.Xml
      System.Xml.Linq
    Bitmap1.bmp
    Library.cs
    Program.cs
Solution Explorer | Team Explorer
```

The References section of a project gives a list of all the resources used by an application. When Visual Studio creates a new project of a particular type it will add references to the resources that it things that kind of project needs. Sometimes you will have to manage this list yourself, for example a Windows Phone project does not usually contain a reference to the `Microsoft.Devices.Sensors` component. If you want to use the accelerometer in a Windows Phone application you have to add this reference yourself. We will see how to do this a bit later in the course.

Note that a reference is just that, a reference. If we include a reference to a resource this does not mean that the resource becomes part of our project, rather that the assembly is able to "reach out" to that resource when it runs. If the resource isn't available at run time the program will fail. A given resource has a version number attached to it, so that if a new version of a library is added to a system any older programs will still be able to use the previous version.

The build process

We should now be happy with the idea that a project contains all the content required to create a single assembly. When a program is built Visual Studio will gather together all the elements that are needed to make the assembly and then use them to create the file. The output assembly is stored in a folder created when the project was set up.



Name	Date modified	Type	Size
SimpleProject	26/09/2010 00:14	Application	18 KB
SimpleProject	26/09/2010 00:14	Program Debug Database	12 KB
SimpleProject.vshost	26/09/2010 17:11	Application	12 KB
SimpleProject.vshost.exe.manifest	17/03/2010 21:39	MANIFEST File	1 KB

Here you can see the folder that contains the output from the simple project that we created right at the start. The application file at the top is the executable assembly that runs on the computer. You could give someone this file to run and, virus scanners permitting, they would be able to execute it.

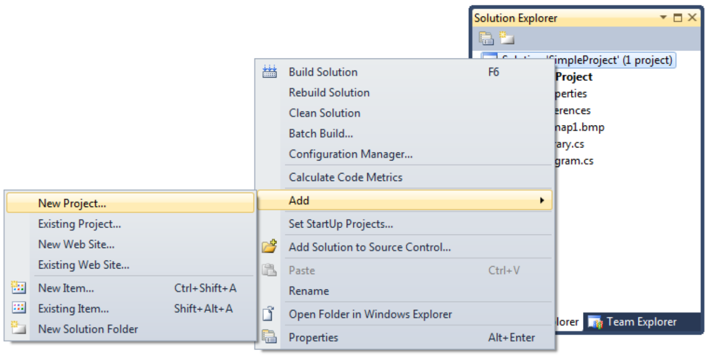
The screenshot above is for the debug version of the program. When Visual Studio makes the debug version if also writes out a database of debug information that provides information about the source when we re debugging.

Visual Studio solutions

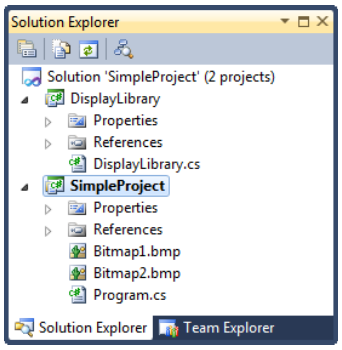
If you only ever want to produce a single executable assembly a project is all you need. However, if you want to create a number of separate assembly files and use this in a single application Visual Studio lets you do this too. A solution file is a container that can hold project files. When you create a new project, as we did with `SimpleProject` earlier, we actually get a solution created for us which encloses the project. The fact that we have been viewing all this content with the Solution Explorer could be considered a clue here…

Creating a multi-project solution

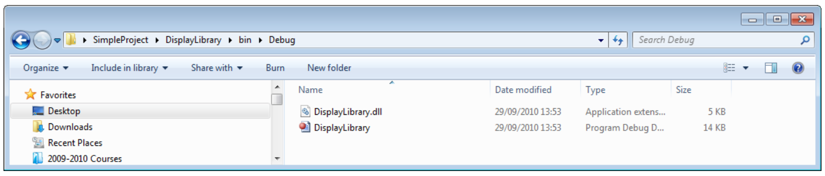
We can add new projects to a solution simply by right clicking the solution and selecting `New Project` from the menu that appears.



We can then pick up any of the project templates and make a new project which is then held as part of the solution:



In the above I made a new library project called `DisplayLibrary`. This will compile to produce a dll file which will be stored in the binary folder for the new project.

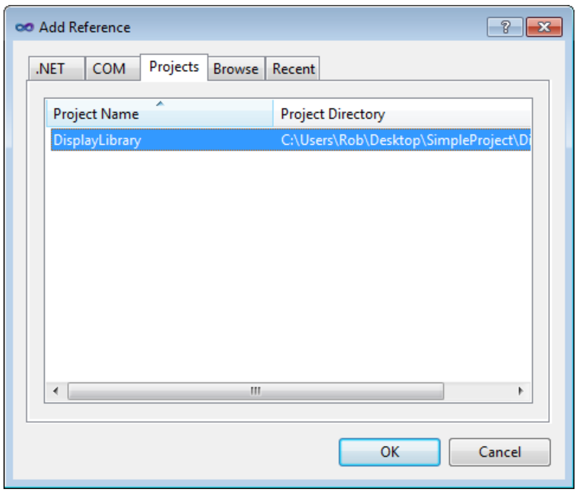


Name	Date modified	Type	Size
DisplayLibrary.dll	29/09/2010 13:53	Application extens...	5 KB
DisplayLibrary	29/09/2010 13:53	Program Debug D...	14 KB

This library can be used by any projects that add a reference to the dll file.

Linking Projects

At the moment the projects in our solution are not connected in any way. If programs in `SimpleProject` want to use resources from `ResourceLibrary` they have to add them as a resource reference:

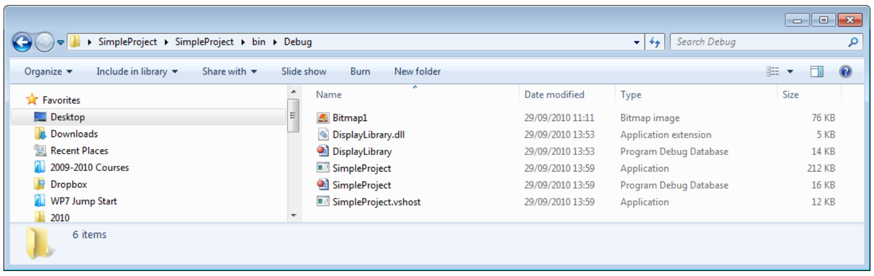


Project Name	Project Directory
DisplayLibrary	C:\Users\Rob\Desktop\SimpleProject\Di

In the dialog above I'm adding a reference to `DisplayLibrary` to the project in `SimpleProject`. To make my programming easier I can add a using directive into the program source file.

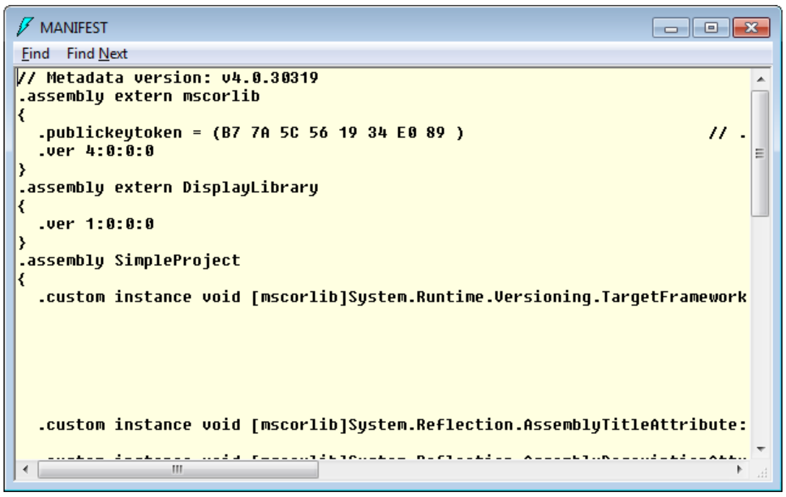
```
using DisplayLibrary;
```

This all helps to remind us that the using directive doesn't actually connect our program to any resources that it wants to use. We only need the using directive to reduce the amount of typing that we have to do when writing programs. When we build the `SimpleProject` we find that the binary directory for this program now contains copies of the `DisplayLibrary` dll files:



Name	Date modified	Type	Size
Bitmap1	29/09/2010 11:11	Bitmap image	76 KB
DisplayLibrary.dll	29/09/2010 13:53	Application extension	5 KB
DisplayLibrary	29/09/2010 13:53	Program Debug Database	14 KB
SimpleProject	29/09/2010 13:59	Application	212 KB
SimpleProject	29/09/2010 13:59	Program Debug Database	16 KB
SimpleProject.vshost	29/09/2010 13:59	Application	12 KB

This is a version of the `SimpleProject` program that uses the `DisplayLibrary` to load and display images. The external resources used by an assembly are listed in the manifest for that assembly.



```
// Metadata version: v4.0.30319
.assembly extern mscorlib
{
  .publickeytoken = (B7 7A 5C 56 19 34 E0 89 )                         // .
  .ver 4:0:0:0
}
.assembly extern DisplayLibrary
{
  .ver 1:0:0:0
}
.assembly SimpleProject
{
  .custom instance void [mscorlib]System.Runtime.Versioning.TargetFramework




  .custom instance void [mscorlib]System.Reflection.AssemblyTitleAttribute:
```

Here you can see the manifest for a version of the `SimpleProject` program that uses a library called `DisplayLibrary`. Note that the version of the library is added to the information so that if a new version of the library is released this assembly will continue to use the old one.

Multi-project solutions

You can put many projects of different types into a single solution. For example you could create an XNA game for Windows Phone, Xbox 360 and Windows PC using a single solution file. Each of the devices could have their own project file, the game engine could be held in a fourth project that was then included by the others.

If you are writing a Silverlight application that connects to a web site that provides services you can put both the Silverlight application project and the web server project inside the same solution.

The projects in your solution and the tasks performed by each of them should be designed at the start of your development.

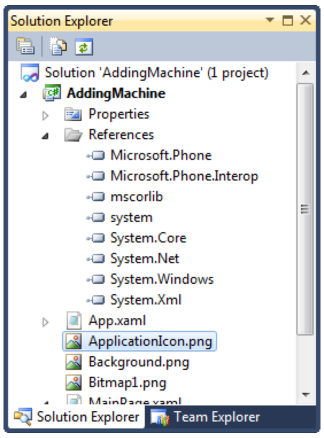
If your solution contains several projects that produce executable outputs you can set one as the “Startup Project” which will be given control when the project is executed.

Windows Phone Solutions

There are essentially two kinds of Windows Phone solutions that can be created using Visual Studio. These are Silverlight application and XNA application. Note that there is no way you can make a single Windows Phone application that uses both systems. While it would be nice to be able to use Silverlight for all the game menus and then XNA for the gameplay this is not at the moment possible.

Silverlight Windows Phone Project

The adding machine that we created in the previous chapter was created as a Silverlight project. If you take a look at Solution for this project you get something like this:



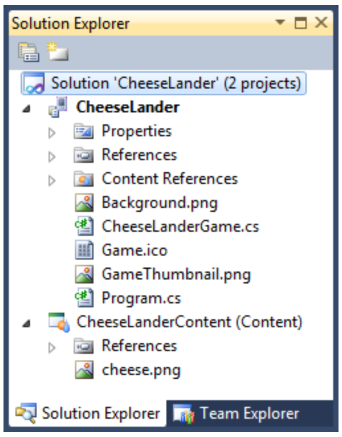
```
Solution Explorer
Solution 'AddingMachine' (1 project)
  AddingMachine
    Properties
    References
      Microsoft.Phone
      Microsoft.Phone.Interop
      mscorlib
      system
      System.Core
      System.Net
      System.Windows
      System.Xml
    App.xaml
    ApplicationIcon.png
    Background.png
    Bitmap1.png
    MainPage.xaml
Solution Explorer | Team Explorer
```

A Windows Phone Silverlight solution contains the `MainPage.xaml` file that describes the appearance of the main screen. It also contains the images that will be used to display the application icon and splash screen when the program rules. If you add new pages to your Silverlight program these will be added to this project as an xaml file and also the code behind file that we saw earlier. Note that the project also includes references to all the system libraries that are used by the phone.

XNA Windows Phone Project

The XNA framework was developed for writing games. It provides a complete game engine into which you can put your game update and draw behaviours. It also provides comprehensive content management so that images, textures and sounds can be easily incorporated into a game.

When you make an XNA solution using the template supplied by Visual Studio you actually get two projects created. One of these contains the executable code. The other will hold all the content the game uses. The idea is that if we want to make a game that runs on multiple platforms we just have to add new projects to the solution. These can share the single resource project.



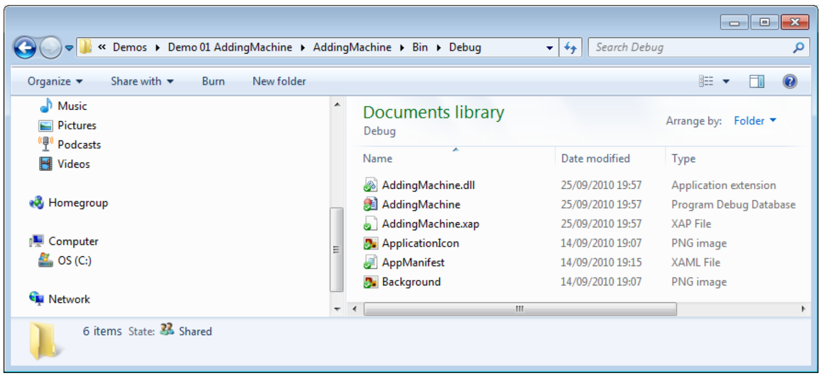
```
Solution Explorer
Solution 'CheeseLander' (2 projects)
  CheeseLander
    Properties
    References
    Content References
    Background.png
    CheeseLanderGame.cs
    Game.ico
    GameThumbnail.png
    Program.cs
  CheeseLanderContent (Content)
    References
    cheese.png
Solution Explorer | Team Explorer
```

Above you can see a solution for a partially completed `CheeseLander` game. The game uses a single item of content, the images of the cheese to be landed. If we add resources such as images to the project these will be stored in the Content project and could be used by any game project in this solution.

Running Windows Phone applications

We know that when you compile and build a Windows PC application the result will be a file with a language extension of .exe which contains a method named `Main` which will be called when the program starts running.

If you create a Windows Phone application things are a little more complicated. The program will not be running inside the PC, instead it must be transferred into the Windows Phone device, or the emulator, before being started. Furthermore, any resources that the program needs (for example content that is not part of the program assembly) must be made available in the target device. This problem is solved by the use of a container file that holds the entire application and all required resources. Below you can see the output directory for the AddingMachine program. It contains all the resources along with the AddingMachine.dll file that contains the program code.

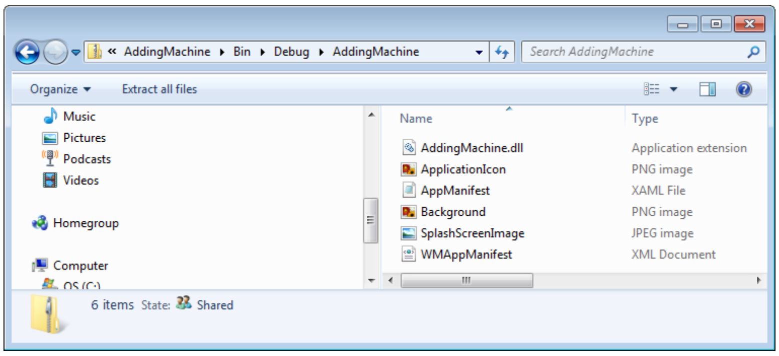


Name	Date modified	Type
AddingMachine.dll	25/09/2010 19:57	Application extension
AddingMachine	25/09/2010 19:57	Program Debug Database
AddingMachine.xap	25/09/2010 19:57	XAP File
ApplicationIcon	14/09/2010 19:07	PNG image
AppManifest	14/09/2010 19:15	XAML File
Background	14/09/2010 19:07	PNG image

There is also a file that has the language extension `.XAP`. This is the *XAP* file. This is the container that holds the entire application.

The XAP file

The XAP file is an archive file (stored in the same format as Zip files) which contains all the files that make up the application. It also contains a manifest file which describes the contents of the XAP.



Name	Type
AddingMachine.dll	Application extension
ApplicationIcon	PNG image
AppManifest	XAML File
Background	PNG image
SplashScreenImage	JPEG image
WMAppManifest	XML Document

Above you can see the contents of the XAP file for the `AddingMachine` application. The XAP file is the file that is transferred into the Windows Phone device and made to run. When you press the run button in Visual Studio this file is created and then sent into the device or emulator. The target device opens the file, reads the manifest and then unpacks the content. Finally the application is executed. If your program is made up of multiple libraries and contains images and sound files these will all placed in the XAP file to be picked up in the target.

When you submit an application to the Windows Phone Marketplace you actually send the XAP file, this is the file that is loaded into the customer's phone if they buy your program.

3.2 Debugging Programs

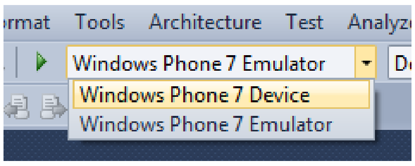
One of the great things about the Windows Phone development environment is the ease with which you can debug programs. We can get a really good idea of what is going on inside a program by single stepping through the code and taking a look at the values in variables. You can debug programs on either the real device or the emulator.

Using the Windows Phone emulator

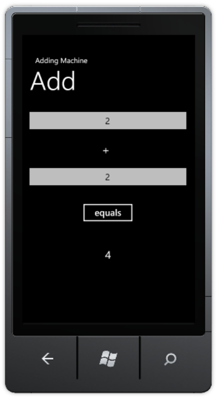
The Windows Phone emulator gives you a chance to try your programs and discover what they look like when they run. The emulator works in just the same way as a real phone. Effectively it is a Windows PC implementation of the Windows Phone platform, running exactly the same source code as the actual phone. You can use the emulator to prove that your program works correctly.

Deploying to the emulator

You can deploy programs to the emulator or a real device. To select the destination when you run a program you use the combo-box to the right of the run button as shown below.



It is possible to select a Windows Phone device even when one is not connected. In this case you will get an error when you try to run the program and Visual Studio detects that a device is not attached.



When the program starts it runs in exactly the same was as it would on the Windows Phone device. You can use the Windows PC mouse to click on items. If you have a multi-touch monitor on your Windows 7 PC you can use multiple touches on the emulator screen to access the multi-touch features of the user interface.

To stop the program you can click the back button (the left pointing arrow) at the base of the emulator or press the stop button in Visual Studio.

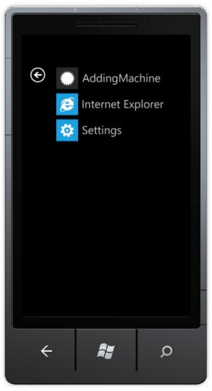
Emulator features

Note that the emulator is not provided with all the built in programs provided with a real device. You can browse the internet using Internet Explorer and you can change some machine settings but lots of things, for example the Calculator, the Calendar and Zune behaviour are all absent. There are some emulations provided to allow you to test your programs however, if you write a program that works with contacts from the address book (something we will do later) you will find that some contacts have been set up inside the phone for you to work with.

Emulator performance

The emulator cannot run at exactly the same speed as the Windows Phone hardware. The actual display speed of an application is restricted on the emulator so that the display will match the real device to a certain extent, but it is important to run your programs on a real device to get an accurate impression of what the user experience will be.

Programs in the emulator



When Visual Studio deploys an application to the Windows Phone emulator it installs it on the emulated device. The application will remain there until the emulator is reset. Above you can see the start menu for the emulator after the `AddingMachine` application had been run on it. We can run this application again just by clicking the icon.

Visual Studio Debugging

The debugging features are integrated into the Visual Studio environment. You can run programs from within Visual Studio. You can add *breakpoints* into your program. When a program reaches a statement nominated as a breakpoint Visual Studio will pause the program and allow you to look at the contents of variables inside the code.

You can add breakpoints to programs running inside the Windows Phone device. You can even set and remove breakpoints as the program itself is running.

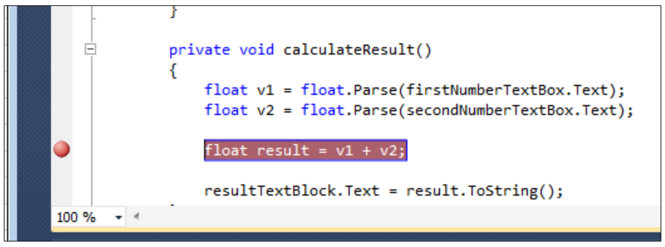
Debugging is an important part of the development process. If you are going to become a successful programmer you are going to have to get used to that feeling in the pit of your stomach that you get when the program doesn’t do what you expected. Fortunately there are some even more powerful tools and techniques that you can use to debug your programs.

Debugging and Programming

However, one important thing to remember here is that I don’t consider it acceptable to debug your programs into life. Every line of code you write should be put there on the basis that you know exactly what the line is going to do, and why it is there. I use debugging to fix an implementation of a solution I have fully thought through. My programs tend to go wrong because I have miss-typed something or because I don’t have the correct understanding of the behaviour of a library I’m using. If you don’t know how to solve the problem it is very unlikely that throwing a few lines together might just solve the problem, any more than throwing a bucket of components at a wall will get you a new Xbox.

Adding a breakpoint at a statement

Breakpoints are added in just the same way as for any program you are working with in Visual Studio. You click in the left margin of the line you want the program to break at.

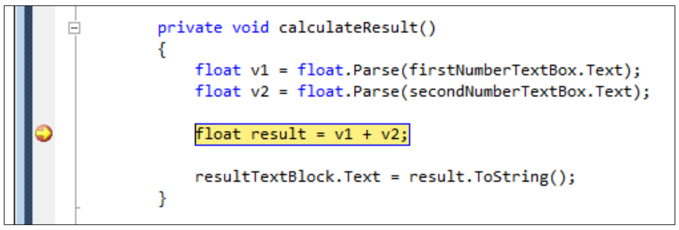


```
}

private void calculateResult()
{
    float v1 = float.Parse(firstNumberTextBox.Text);
    float v2 = float.Parse(secondNumberTextBox.Text);

    float result = v1 + v2;

    resultTextBlock.Text = result.ToString();
```

The line is highlighted as shown above. You can clear a breakpoint by repeating the process. When the program reaches the breakpoint it will stop running and you will be able to take a look at the values of the variables.

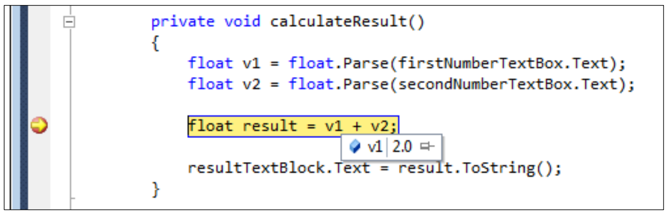
Running the Program

We run the program by clicking the Run button in the Visual Studio menus. The button looks like this: ▶. When you press the button the program is deployed into the target device and starts running. You can use the function key F5 to instead of pressing the button if you prefer. When the program runs, if it reaches this line the execution will pause. Of course, to get to this statement in the adding machine we will have to enter some numbers into the textboxes and then press the enter button.



```
private void calculateResult()
{
    float v1 = float.Parse(firstNumberTextBox.Text);
    float v2 = float.Parse(secondNumberTextBox.Text);

    float result = v1 + v2;

    resultTextBlock.Text = result.ToString();
}
```

The yellow highlight shows the line reached. We can view the contents the variables in the program at this point just by resting the mouse pointer on the variable we want to see:



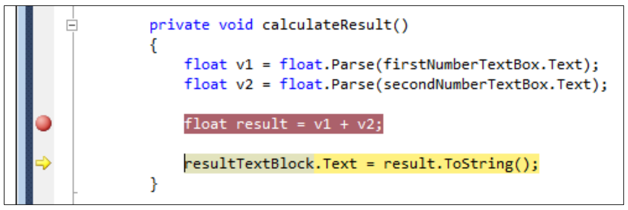
```
private void calculateResult()
{
    float v1 = float.Parse(firstNumberTextBox.Text);
    float v2 = float.Parse(secondNumberTextBox.Text);

    float result = v1 + v2;
                          v1 | 2.0
    resultTextBlock.Text = result.ToString();
}
```

The variable result has not been set to the result of the calculation yet because the line that is highlighted has not been performed. To get the line performed we need to step through the statement.

Single stepping

We can step through a single line of the program by clicking the Single Step button in the Visual Studio menu system. The button looks like this: .

Each time you click this button the program will obey a single statement. Clicking the button once will move the program onto the next statement. The function key F11 will have the same effect.



```
private void calculateResult()
{
    float v1 = float.Parse(firstNumberTextBox.Text);
    float v2 = float.Parse(secondNumberTextBox.Text);

    float result = v1 + v2;

    resultTextBlock.Text = result.ToString();
}
```

There are actually three versions of the Single Step button.

This means obey a single statement. If the single statement is a call of a method this version of single step will step into the method. This is called the "Step into" version of single step. Use F11 to perform this.

This means obey a single statement. If the single statement is a call of a method this version of single step will step over the method call. This is useful if you don't care what happens inside the method. This is called the "Step over" version of single step. Use F10 to perform this.

This means run to the end of the current method and exit from it. Then break. This is very useful if you step into a method by mistake, or you have seen all you need from the method you are stepping through. Use SHIFT+F11 to perform this.

Controlling program execution

Visual Studio maintains contact with the running program in the target device. You can issue commands to stop, pause and resume execution and these will directly affect the program.

Resuming Execution

If you want the program to resume execution after a breakpoint (i.e. you have done all the single stepping you need) then you can press the run button again, or press the F5 function key.

Pausing program execution

Pausing execution is not usually that useful, in that the program might not be at a point where it is doing anything interesting, but you can sometimes use it to find out what a program is doing when it appears to have got "stuck". To pause a running program you click the button. The program stops at the statement that it was running when you pressed pause.

If you want to pause a running program you should remember that you can set breakpoints in the program code even when the program itself is running. We could have put our breakpoint in the `calculateResult` method while the code was running and then pressed the equals button in the emulator to send the program that way.

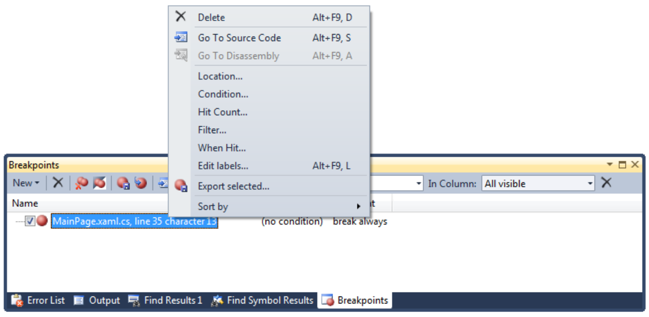
Stopping the program

The button can be used to stop the program from running. When we click this button Visual Studio will stop program after the next statement it obeys. We can use it if the program appears to have got stuck. We need to be a bit careful with this button though.

When a Windows Phone program is stopped properly it is sent a sequence of messages that tell it the end is nigh and to do any tidying up that is required. We will discover how this works later in the course. If the program is stopped using the button above these messages are not sent, and so a program interrupted in this way may lose or corrupt data that it was using when the stop event was fired.

Managing Breakpoints

Visual Studio also has a breakpoint window that you can use to see the breakpoints you have created. You can display this window by going to the Debug>Windows menu in Visual Studio and selecting the Breakpoints option.



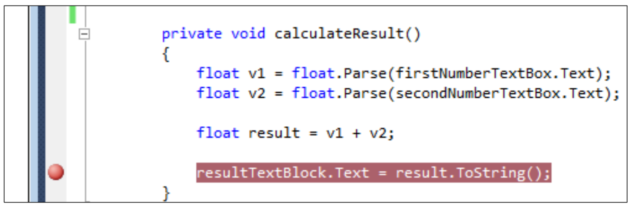
```
MainPage.xaml.cs, line 35 character 13    (no condition)   break always
```

You can use this window to set breakpoint properties. You can request that a breakpoint only fire after a given number of hits, or only fire when a particular condition fires. This is terribly useful. You might have a program that fails after the fiftieth time round a loop. It is very nice to be able to add a counter or a test so that the program skips past the breakpoints you are not interested in.

To open the properties of a breakpoint, either in the code itself or in the Breakpoints window, right click the breakpoint and then select Breakpoint from the context menu that appears.

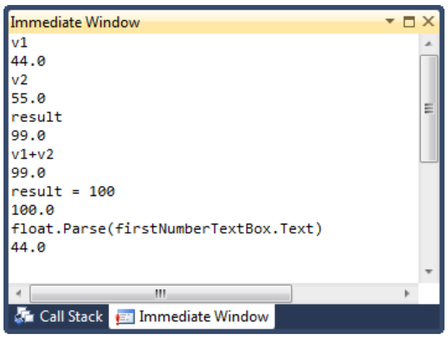
Using the immediate window

The Immediate Window can be displayed by going to the Debug>Windows menu and selecting it. It is where you can view and change the contents of variables. You can also use it to evaluate expressions. As an example of the immediate window in action, we could set a breakpoint just before the `calculateResult` method returns:



```
private void calculateResult()
{
    float v1 = float.Parse(firstNumberTextBox.Text);
    float v2 = float.Parse(secondNumberTextBox.Text);

    float result = v1 + v2;

    resultTextBlock.Text = result.ToString();
}
```

When I run the program and press the equals button the program will hit the breakpoint. I can now move to the Immediate Window and play with the variables in this method.



```
v1
44.0
v2
55.0
result
99.0
v1+v2
99.0
result = 100
100.0
float.Parse(firstNumberTextBox.Text)
44.0
```

If I just type the name of a variable the window displays the value in that variable. I can also type in expressions (e.g. v1+v2 as shown above) and these are evaluated and displayed. I can also assign a value (e.g. result = 100) and call methods on objects to work out results.

The Immediate pane uses Intellisense to help you write the statements you want to run. It even works when you are debugging a program stored inside the Windows Phone device. It is very powerful, but should be used with care.

Design for debug

Single stepping through code is a great way to find out what it is doing. When you write code it useful to design it so that you can easily step through it and find out what it is doing. The code in the `calculateResult` method could easily be as a single statement.

```
private void calculateResult()
{
    resultTextBlock.Text =
       (float.Parse(firstNumberTextBox.Text) +
        float.Parse(secondNumberTextBox.Text)).ToString();
}
```

However this version is impossible to step through. I am a great believer in spreading my code over a number of statements and even using extra temporary variables when it runs. This makes debugging easier and doesn’t even cost your program more memory since in the “smaller” version of the code above Visual Studio will still have to create some internal temporary variables to perform the calculation. The only difference with the “more efficient” version above is that you can’t take a look at them.

What we have learned

1. Visual Studio is the development environment that is used to create Windows Phone applications. You can obtain a free version of this SDK.
2. Microsoft .NET applications are organised into *assemblies*. An assembly is either an executable program (.exe) or a library (.dll).
3. Visual Studio organises the elements required to produce an assembly into a project. A project brings together the source files and other program resources such as images and sounds required to produce the assembly. When the assembly is created a manifest is added to the project which describes the contents.
4. You can use the ildasm program which is supplied with Visual Studio to view the contents of assemblies.
5. A Visual Studio solution brings together a number of projects which can describe the creation of different elements of an application. This can include the production of completely different components, for example the server and client parts of a large installation.
6. A Windows Phone application can contain a number of assemblies, including library resources. An assembly will contain versioned references to all the resources that it uses.
7. When a Windows Phone application is prepared for deployment to the target device it is packaged into a XAP file which contains a manifest file, program assemblies and any resources that the program uses.
8. The Windows Phone emulator runs on the Windows PC and provides an emulation of the functionality of the device, but does not emulate the performance.

9. Visual Studio provides a means by which a programmer can insert breakpoints into program. These are statements where program execution will stop and the programmer can view the contents of the variables in the program. Breakpoints and single stepping of code can be used on programs executing in the Windows Phone device as well as the emulator.

4 User Interface Design with Silverlight

In section 2 we looked at some of the elements provided with Silverlight. Now we are going to build on our skills and delve a bit more deeply into what Silverlight can do for us. By the end of this section you should be able to create useable, multi-page Silverlight applications that will work on Windows Phone.

4.1 Improving the user experience

At the moment we are able to build user interfaces out of three Silverlight elements:

- TextBlock to display messages and labels
- TextBox to receive input from the user
- Button to receive events

Now we are going to build on these three items to create slightly more interesting places for the user to work. At the same time we are going to learn a bit more about how the Silverlight elements work together to build user interfaces.

Manipulating element properties

We have seen that Silverlight display elements are actually implemented as classes in the code, and that we can change how they appear by modifying the properties in instances of these elements. The properties of a Silverlight element can be set using the Properties pane in Visual Studio or by editing the XAML that describes each element. However, these settings are made when the program is built. We can also set the properties of the elements when the program runs. We have already done this in our `AddingMachine` application, the result is displayed by changing the properties of the `ResultTextBlock`.

```
 resultTextBlock.Text = result.ToString();
```

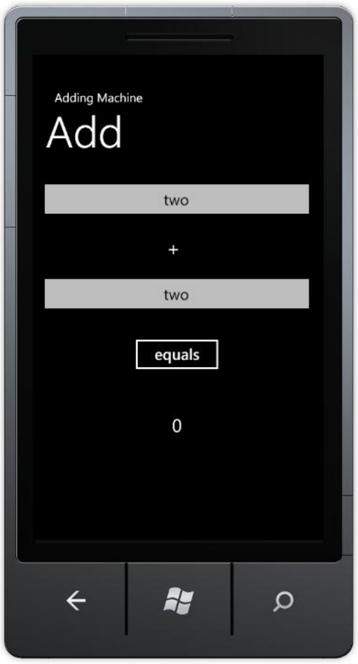
Programs can manipulate any of the properties of a display element. This includes their position on screen, making it possible for us to create moving sprites in games.

We are going to take a look at some other properties that are available. We are going to use further property manipulation to improve the user experience of our `AddingMachine` program. However, we are just going to scratch the surface of what is actually possible. I strongly advise to you spend some time looking at just what you can do with elements. There are some very powerful features available.

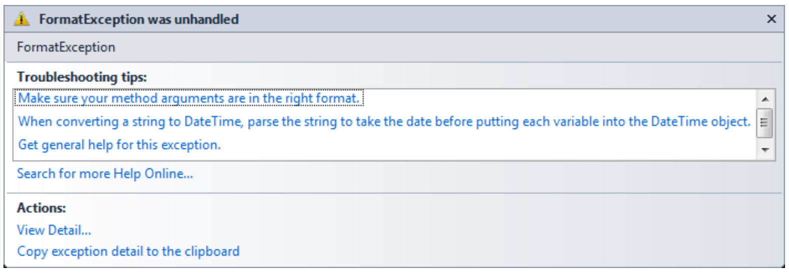
Adding Error Handling

We are going to start by improving the error handing of our `AddingMachine`. In my experience I spend at least as much time writing code to deal with invalid inputs for a system as I do writing programs that deal with the working parts.

At the moment the error handling in our `AddingMachine` program is non-existent. If a user enters text into a `TextBox` the program will try to use the `Parse` method to convert this into a number, and this will fail.



Above you can see trouble brewing for our adding machine program. The user will claim that they just wanted to work out the answer to "two plus two" but the result will not be a successful one:



FormatException was unhandled

FormatException

Troubleshooting tips:

Make sure your method arguments are in the right format.

When converting a string to DateTime, parse the string to take the date before putting each variable into the DateTime object.

Get general help for this exception.

Search for more Help Online...

Actions:

View Detail...

Copy exception detail to the clipboard

This is because this version of the program uses a very simple method to convert the text in the `TextBox` into a number:

```
float v1 = float.Parse(firstNumberTextBox.Text);
```

If `firstNumberTextBox` contains text that cannot be converted into a number (for example "two") it will throw an exception. We can improve on this by using a different version of the `Parse` method:

```
float v1 = 0;
if (!int.TryParse(firstNumberTextBox.Text, out v1))
{
    // Invalid text in textbox
}
```

The code above uses the `TryParse` method which returns `false` if the parse fails. It will obey the statements in the conditional clause if the text in `firstNumberTextBox` contains invalid text. It would be nice to turn the text red in the `TextBox` to indicate there is a problem.

Changing the colour of text

A good way to show an error status is to change the colour of the text. This is a very good way to highlight a problem. Silverlight uses a system of brushes to draw items on the screen. This is a very powerful mechanism. It means that we can draw text using images or textures and get some very impressive effects. In the case of our error display we don't want to do anything quite so interesting, we just want to draw the text with a solid red brush. Silverlight has a set of such colours built in, and so to turn the text in a `TextBox` red we just have to set the foreground brush to a solid red brush:

```
float v1 = 0;

if (!float.TryParse(firstNumberTextBox.Text, out v1))
{
    firstNumberTextBox.Foreground =
                   new SolidColorBrush(Colors.Red);
    return;
}
```

This version of the code works OK. If a user enters an invalid number (i.e. one which contains text) the colour of the foreground for that textbox is set to a solid red brush and the method ends without calculating a result. However, this is not a very good solution. The program should really check more than just the first value when it runs. If the user has typed invalid text into both boxes they would much rather find out in a single message, rather than having to fix one error and then be told later that there was also a second fault item.

There is a more serious fault too, in that the code above will turn the text red when the user enters an invalid item, but it will not turn it back to the original colour when the value is corrected. We must add an else behaviour to put the colour back to the proper brush when the value that is entered is correct. We need to store the "proper" brush so that we can use it for this. A complete version of `calculateResult` looks like this:

```
private SolidColorBrush errorBrush =
                     new SolidColorBrush(Colors.Red);
private Brush correctBrush = null;

private void calculateResult()
{
    bool errorFound = false;

    if (correctBrush == null)
    {
        correctBrush = firstNumberTextBox.Foreground;
    }

    float v1 = 0;

    if (!float.TryParse(firstNumberTextBox.Text, out v1))
    {
        firstNumberTextBox.Foreground = errorBrush;
        errorFound = true;
    }
    else
    {
        firstNumberTextBox.Foreground = correctBrush;
    }

    // Repeat for v2

    if (errorFound)
    {
        resultTextBlock.Text = "Invalid inputs";
    }
    else
    {
        float result = v1 + v2;
        resultTextBlock.Text = result.ToString();
    }
}
```

This code turns the text red if a value is invalid. It also maintains a copy of the correct brush, so that if a value is correct it can be set to the correct colour.

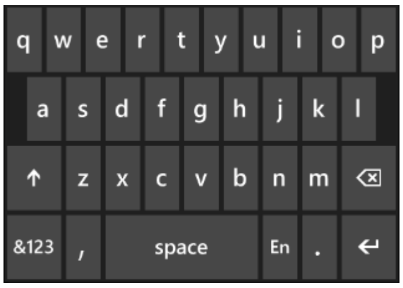
This code works well and provides a reasonable user experience. It also illustrates that when you write a program with a user interface you actually end up writing a lot more code than just the statements that are needed to calculate the result. The code to deal with input errors can greatly increase the amount of code that you have to write.

Editing the XAML for Silverlight elements

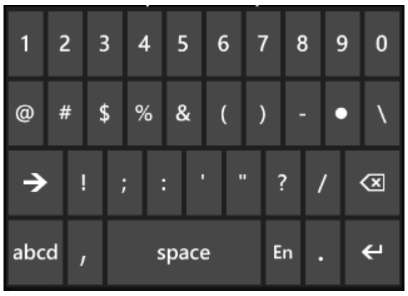
XAML can be described as a 'declarative' language. This means that it doesn't actually describe any behaviour (i.e. it does not tell the computer how to do something). Instead it just tells the computer above stuff. In C# terms we tell the compiler about things we want to use (for example variables) by *declaring* them. The XAML language is only ever used to tell Silverlight about things, hence it is called a declarative language. We will have to get used to putting some aspects of a program into the declaration of the Silverlight elements it uses. One such situation is in the configuration of the input mode for the `TextBox` elements that are used to enter the numbers in our `AddingMachine` program.

Configuring a TextBox to use the numeric keyboard

At the moment the AddingMachine uses the standard keyboard behaviour on the Windows Phone which is to display the text keyboard when the user selects that control. It would make sense to provide the user with a keyboard set to enter numbers, rather than the text one. There are a number of different keyboard configurations for the keyboard that a Windows Phone can display. Below you can see the standard "text" one.



To enter digits the user must press the '&123' key to switch the keyboard into numeric mode.



It would be nice if each `TextBox` in the adding machine could be set for numeric entry when that `TextBox` is opened. We could do this by modifying the properties of the `TextBox` when the program starts running but the best place to put such settings is in the XAML description of the control itself. At the moment the XAML that describes the `secondNumberTextBox` is as follows:

```
<TextBox Height="72" HorizontalAlignment="Left" Margin="8,175,0,0"
Name="secondNumberTextBox" Text="0" VerticalAlignment="Top" Width="460"
TextAlignment="Center" />
```

This tells Silverlight where on the screen to put the element, the size of the element and the name it has. There is also text alignment information.

Each of the values enclosed in `<TextBox .. />` is an *attribute* of the textbox. Attributes are simple items that are not structured and can be expressed as a name – value pair. Above you can see that the `Height` of the element, the `Name` of the element and lots of the other properties are expressed in this way.

The XAML designers could have just added another attribute, perhaps called KeyboardType, to describe the keyboard to be used for input to that textbox, but instead they used a more flexible solution. Instead a `TextBox` can give a list of items that describe the kind of keys that should be used for data input. This is called the `InputScope` of the TextBox.

This list is given as a *property element* which is part of a `TextBox` value. To express this we have to use a slightly more complex version of `TextBox`:

```
<TextBox Height="72" HorizontalAlignment="Left" Margin="8,19,0,0"
Name="firstNumberTextBox" Text="0" VerticalAlignment="Top" Width="460"
TextAlignment="Center">
    <TextBox.InputScope>
        <InputScope>
            <InputScopeName NameValue="Digits" />
        </InputScope>
    </TextBox.InputScope>
</TextBox>
```

Good thing I said “slightly” more complex, eh? If you want a XAML element to contain properties you have to use a different form of the element description. This is a bit confusing in the Silverlight context, so we might want to take a look at something a bit easier to understand.

Element with no properties

We can use the XML format to create a language that will hold information about people. We could start by just storing the name of a person:

```
<Person name="Rob"/>
```

This element is called “Person” and has a single attribute called “Name” which is set to “Rob”. The XAML compiler sees the `/>` at the end of the element definition and knows that it has reached the end of the description of this element.

Element with properties

However, we might want to store more complicated information about a person, such as where they live. Their address will be made up of lots of different elements, and so we should make this address a property of the person.

```
<Person name="Rob">
       <Address addressType="HomeAddress">
              <FirstLine text="18 Pussycat Mews"/>
              <Town text="Seldom"/>
              <County text="Wilts"/>
              <PostCode text="NE1 410S"/>
       </Address>
</Person>
```

This element contains one property, which is the address of the person. The address itself is another element which contains a single attribute (the type of the address) and then four properties. This illustrates an important point with XML based languages. A property is an XML element like any other, which means that it can have attributes and contain properties of its own. Silverlight uses this to good effect with the Grid element, which can hold a collection of Silverlight elements (including Grids) which are to be laid out on the page.

The XAML compiler can tell that an element contains properties because the first line of the element description ends with > rather than ending />. The XAML compiler will regard everything it sees after the first line as a property of the element, until it sees the </ElementName> which rounds things off.

If you find this confusing at first, welcome to the club. The best way to think about this is to consider what is being stored. In the case of the Person above the name is just a single item which can be expressed in a simple attribute. However the address will contain multiple properties of its own and so is best made into a property. There is also the possibility that a Person will have several address values, for example a HomeAddress and a WorkAddress and so the above design makes it possible to add new address types easily.

The type of the address has been made an attribute of the address, which I think is the most appropriate.Whether to make a data item an attribute or a property is something you have to think about when you use XML (eXtensible Markup Language) to describe things.

If we go back to our TextBox we should find that things make a bit more sense now.

```
<TextBox Height="72" HorizontalAlignment="Left" Margin="8,19,0,0"
Name="firstNumberTextBox" Text="0" VerticalAlignment="Top" Width="460"
TextAlignment="Center">
    <TextBox.InputScope>
        <InputScope>
            <InputScopeName NameValue="Digits" />
        </InputScope>
    </TextBox.InputScope>
</TextBox>
```

Simple information about the TextBox is given as attributes, whereas the InputScope value is given as a property. The InputScope itself contains a set of properties, each of which describes a particular input scope. This means that we could if we want ask for an input scope that includes Digits and Text, but not punctuation. However, we don't want anything as complex as that. We just want to ask for Digit input, and so that is the InputScope that we set up. If we use the above description for the two textboxes in the adding machine we get a vastly improved user interface where the user is given the numeric keyboard when they move to those input elements.

This is an example of a situation where just adding text to the XAML is the quickest and easiest way to configure the input behaviour. We could have used the Visual Studio property pane, or even written some complex code to build a collection of InputScopeName values and assign them to the TextBox, but this solution is much neater, and also allowed us to refine our understanding of XAML.

Attributes and Properties – the truth

It turns out that from the point of view of XAML attributes and properties are actually interchangeable

```
<TextBox HorizontalAlignment="Left" Margin="8,175,0,0" Name="secondNumberTextBox"
Text="0" VerticalAlignment="Top" Width="460" TextAlignment="Center">
    <TextBox.Height>
        72
    </TextBox.Height>
</TextBox>
```

In the XAML above the height of the TextBox has been brought out of the attributes and turned into a property. The property name must contain the name of the element type that it is part of. We can't just say Height, we have to put TextBox.Height. This is not a restriction of XML (we didn't have to put this in our Person example above) but is a requirement for XAML.

From the point of view of an XAML writer it doesn't really matter which of these forms we use. For simple name/value pairs we can use attributes, but for more complicated structures we may decide to use properties.

C# Property Setting

If you were wondering what the C# to do the same setting would look like, this is it:

```
// Make a new input scope
InputScope digitScope = new InputScope();

// Make a new input scope name
InputScopeName digits = new InputScopeName();
// Set the new name to Digits
digits.NameValue = InputScopeNameValue.Digits;

// Add the name to the new scope
digitScope.Names.Add(digits);

// Set the scope of the textbox to the new scope
firstNumberTextBox.InputScope = digitScope;
```

If you read carefully through this code you will see that it is actually building up each of the elements in the XAML above.

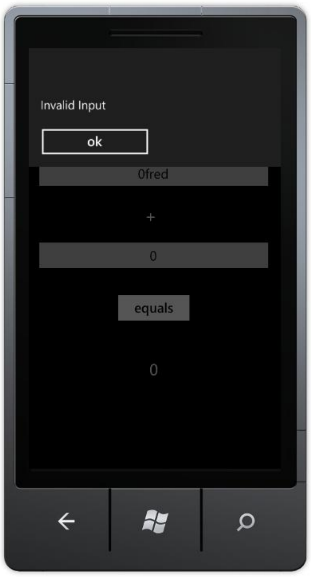
The solution in *Demo 01 AddingMachine with Error Checking* implements a version of the AddingMachine that performs validation and turns invalid entries red. It also sets the input scope of the TextBoxes to numeric.

Displaying a MessageBox

Silverlight provides a `MessageBox` object which you can use to inform the user of errors:

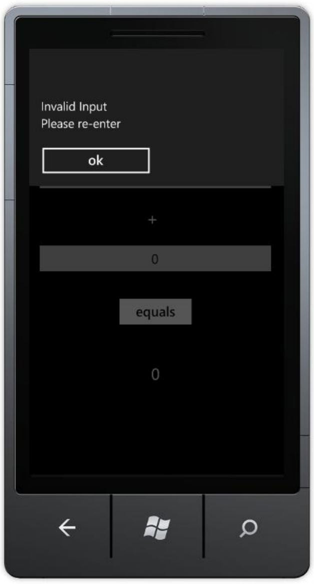
```
 MessageBox.Show("Invalid Input");
```

This will display a message at the top of the phone screen that the user must clear before they can continue. An alert sound is also played.


Invalid Input

If you want to send larger to the user of the phone you can do this by displaying several lines in the message:

```
MessageBox.Show("Invalid Input" +
    System.Environment.NewLine +
    "Please re-enter");
```


Invalid Input
Please re-enter

The element `System.Environment.NewLine` will provide a newline character in a manner appropriate to the target platform. A `MessageBox` is useful if you want to be sure that the user has acknowledged a message before continuing. However, you need to remember that when it is displayed it will stop the program at that point.

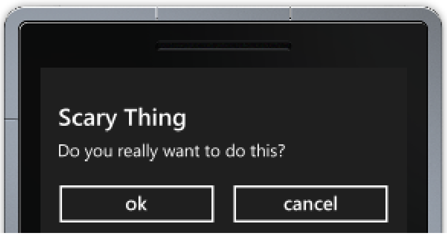
The solution in *Demo 02 AddingMachine with MessageBox* displays a message box when the user enters an invalid value.

Message Box with selection

We can ask the user to make a choice in a `MessageBox`:

```
if (MessageBox.Show("Do you really want to do this?",
                    "Scary Thing", MessageBoxButton.OKCancel)
    == MessageBoxResult.OK)
{
    // do scary thing here
}
else
{
    // do something else
}
```

This version displays a message with a cancel option as shown below.


Scary Thing
Do you really want to do this?

Adding and using assets

In the previous section we saw how Visual Studio manages assets such as images and sounds and adds these to the XAP file for transfer into the target device. Now we are going to see how our applications can add assets of our own and then use it.

A background screen for the Adding Machine

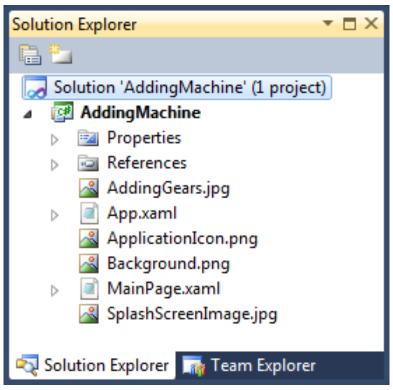
We have been asked by the son of the boss of our customer (who seems to think he is a graphic designer) to add the above image as a background to the adding machine application. This is actually a photograph of some of the gears of Charles Babbage's "Difference Engine" and he thinks that this addition will make the program much better. We're not convinced, but as he is the son of the boss we have to go along.

Assets for Windows Phone

When you add assets such as this it is important to remember that the target device does not have a lot of memory or a particularly high resolution screen. If the above picture was from a high resolution camera it might contain a lot more detail than would be required for a phone application. Remember that the highest resolution for a Windows Phone at the moment is 800x480 pixels. There is no point in using a background image with a higher resolution than this.

Adding Images as Items of Content

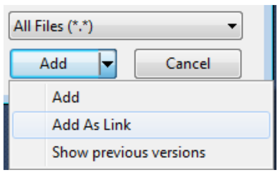
We can add an image as an item of content to the `AddingMachine` project. The boss's son has given us a jpeg image called `AddingGears.jpg` to use. It turns out that the quickest way to add a content item to a project in Visual Studio is just to drag the item out of the folder and drop it onto the project:



This makes a copy of the resource file in the project directory at the appropriate point.

Links to assets

If we want to share an asset amongst a number of different projects (perhaps you have a company logo that is to be used by lots of different programs) then we can add a link to a resource, but to do this we have to add the item using the Add Existing Item dialog and then select "Add as Link":



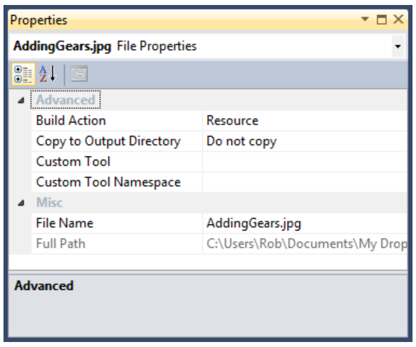
If we change the logo file the new version will be picked up by projects that use it next time they are rebuilt.

The "Build Action" of an Asset

When Visual Studio builds a project there are a number of ways that assets can be added to the completed program. We are going to consider two; adding the asset as an item of content or adding the asset as a resource inside the program assembly. The decision of which to use can have a bearing on the way that programs load and run, so it is worth knowing a bit about how this works.

Adding an asset as Content

When an asset is added to a project it is initially added with a build action of "Resource".



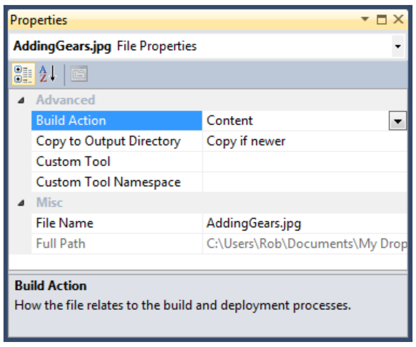
Properties

AddingGears.jpg File Properties

Advanced	
Build Action	Resource
Copy to Output Directory	Do not copy
Custom Tool	
Custom Tool Namespace	
Misc	
File Name	AddingGears.jpg
Full Path	C:\Users\Rob\Documents\My Drop

Advanced

If we want to use the asset as content we need to change its properties so that it is an item of content. We do this by changing the Build Action entry for the item of content.



Properties

AddingGears.jpg File Properties

Advanced	
Build Action	Content
Copy to Output Directory	Copy if newer
Custom Tool	
Custom Tool Namespace	
Misc	
File Name	AddingGears.jpg
Full Path	C:\Users\Rob\Documents\My Drop

Build Action
How the file relates to the build and deployment processes.

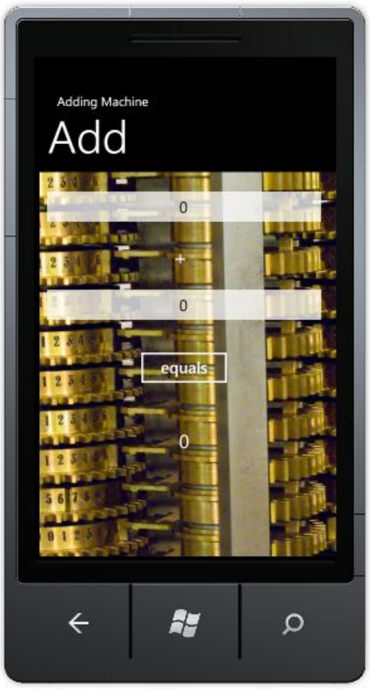
Content assets are copied by Visual Studio into the application directory when the program is built. The "Copy if newer" setting means that Visual Studio will copy a new version of the image into the binary folder if the current image in the project is replaced by a newer file.

Using Image content in a program

An asset of type content is simply made available to the application as a file in the same folder as the program itself. To display an image held as content in our program we just need to add the line of XAML that describes the image file that we want to use:

```
<Image Height="611" HorizontalAlignment="Left" Margin="8,0,0,0"
Name="gearBackgroundImage" Stretch="Fill" VerticalAlignment="Top" Width="472"
Source="AddingGears.jpg" />
```

The `Image` element displays an image on the page. It has a `Source` attribute that identifies the file from which the image is to be loaded. If we enter a filename as the source the image will be loaded from the file. When the program runs the file will be loaded from the file and then drawn on the screen. Silverlight draws the elements on the screen in the order they are defined in the XAML. If this line is put at the top of the Grid containing the elements the image will be drawn in the background:



This is the result of the program. From an artistic point of view we are not convinced, by the choice of picture but the process itself works.

The solution in *Demo 03 AddingMachine with Background Content* displays a background image for the application which is loaded as an item of content.

Adding Images as Resources

There is another way to add an image to a project. This involves creating a new `Image` item from the `ToolBox` in the Visual Studio editor and then selecting the image resource to use for this item by using the Visual Studio the Property pane.

The first step in this process is to drag an image from the Visual Studio Toolbox onto the page. Then open up the `Property` pane for that resource:

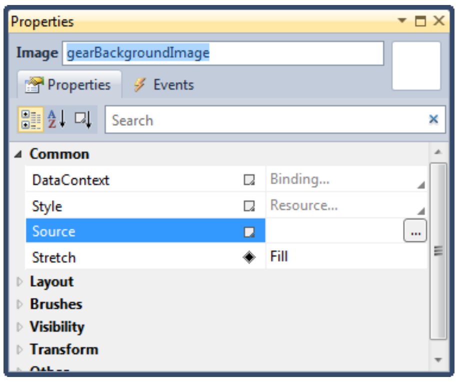
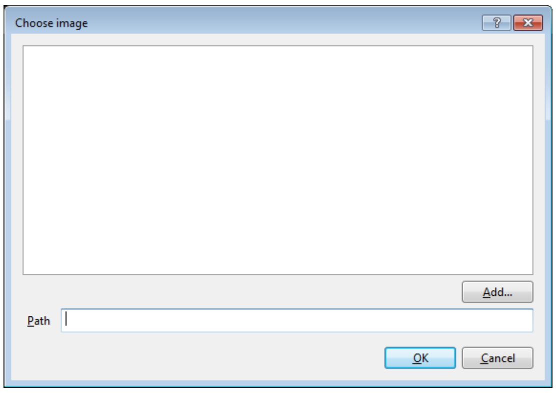
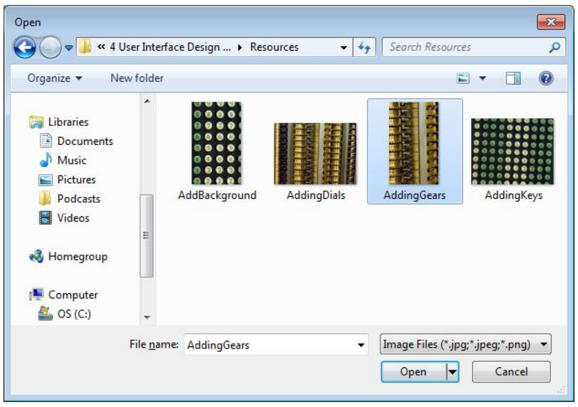


Image gearBackgroundImage
DataContext Binding...
Style Resource...
Source
Stretch Fill

I've changed the name of the image to `gearBackgroundImage` and the next thing to do is to set the source of the image by clicking on the "…" button to the right of the source item. This opens the `Choose Image` dialogue.

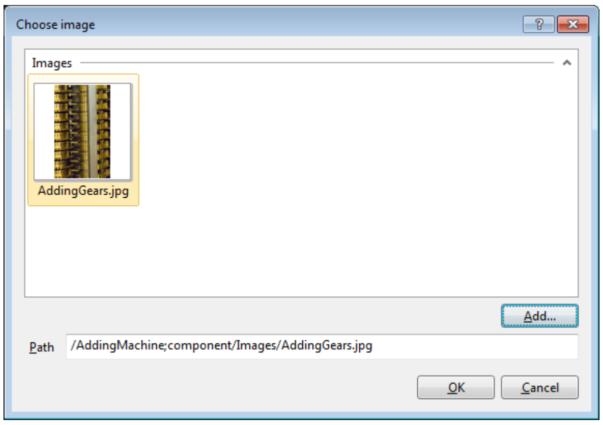


This dialog shows all the images which are presently stored in the application. As we have not added any the dialogue is empty. If we click on `Add` we can open a file browser to look for suitable pictures on the development computer.



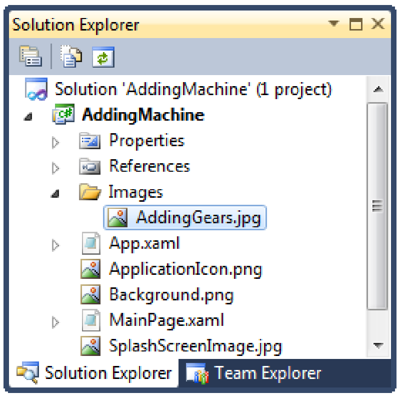
File name: AddingGears
Image Files (*.jpg;*.jpeg;*.png)

This adds the specified image to those available to the project:

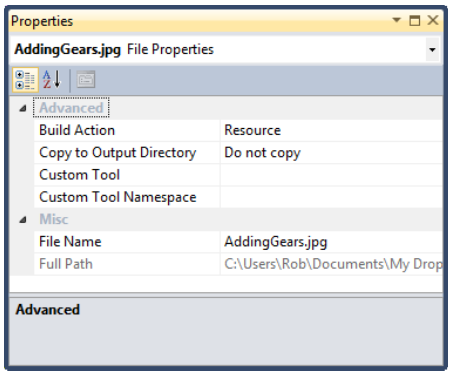


Path /AddingMachine;component/Images/AddingGears.jpg

It also creates the resource item in the project for this item:



Any other images that we add to the project will be added in the folder that Visual Studio created for us. The properties of these images will be set as Resources, not content.



Build Action	Resource
Copy to Output Directory	Do not copy
Custom Tool	
Custom Tool Namespace	
File Name	AddingGears.jpg
Full Path	C:\Users\Rob\Documents\My Drop

The XAML that describes the image contains an image source that refers to the resource in the application:

```
<Image Height="611" HorizontalAlignment="Left" Name="gearBackgrounds" Stretch="Fill"
VerticalAlignment="Top" Width="472"
Source="/AddingMachine;component/Images/AddingGears.jpg" />
```

When the program runs the display is exactly the same, but there is a crucial difference in how the resource is located and used.

The solution in *Demo 04 AddingMachine with Background Resource* displays a background image for the application which is loaded as a resource.

Content vs Resources

When creating Windows Phone applications it is important that we understand the difference between content and resources in an application.

An item of content is simply a file that is stored in the application directory. Our programs can open and use content files when they need them. Adding content has no effect on the size of the program itself, although of course when a program is running and loads content it will use more memory.

A resource item is stored in the program assembly. Adding the gears background image to the assembly above made the program around 317K bytes larger. When a Windows Phone device loads a program it looks through the entire program assembly and does some checks to make sure that it is legal code. These checks take longer if the program is bigger. If your program takes too long to start up when it is loaded it will be killed by the Windows Phone operating system. This means that you should be careful about putting too many things in the program assembly.

Adding our image as an item of content made the program itself smaller, meaning that it starts running more quickly. However, content items take slightly longer to load because they have to be fetched from the filestore when they are used. Adding our image as a resource makes it faster to load when the program tries to fetch it, but makes the program larger and will make the program itself slower to start.

If this is confusing, here are some hints:

- If you have lots of large resources, and you don't need to load all of them into the program at once, use content. An example would be where you allow the user to select from a number of different background images for their screen.
- If you have lots of small resources which are used all the time throughout the program, use resource. An example would be if you had icons that represent particular program setting or options.
- If you find your program is taking too long to get started you should move some of the resources out of the program assembly and add a loading screen of your own to show them being brought into memory when the program starts up. You can also speed up the program startup process by breaking your program into smaller assemblies which are linked together.

4.2 Data manipulation and display

Our adding machine is now quite useable, but the customer is still not completely happy. He doesn't like the way that users have to press the Calculate button each time they want a new answer. What he wants is for the program to detect when the text in the number boxes changes and then update the total automatically. Fortunately for us this turns out to be quite easy to do. We need to revisit events to find out more.

The TextChanged event

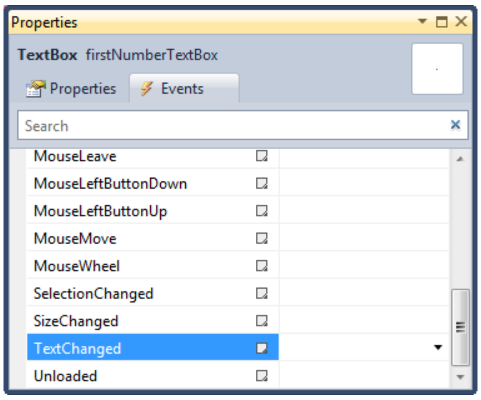
We first saw events when we considered the `Button` element. A `Button` element generates an event when it is activated. From a program point of view an event is a call to a method. We can get Visual Studio to "hook up" a button to an event for us just by double clicking the button in the designer. At the moment the `Calculate` button has a click behaviour that calculates and displays the result. The method to be called is identified in the `Button` description:

```
<Button Content="equals" Height="72" HorizontalAlignment="Left" Margin="158,275,0,0"
Name="equalsButton" VerticalAlignment="Top" Width="160" Click="equalsButton_Click" />
```

When the button is clicked this causes the nominated event handler to run inside the page class. In the case of our `AddingMachine` this will call the `calculateResult` method.

```
private void equalsButton_Click(object sender,
RoutedEventArgs e)
{
    calculateResult();
}
```

We can find out what events a `TextBox` can create by selecting a `TextBox` in the Visual Studio editor and then selecting `Events` in the properties pane.



A `TextBox` can produce a lot of events, including some which seem somewhat meaningless on a Windows Phone. Visual Studio highlights the event that is most useful from a `TextBox`. This is the `TextChanged` event. This is fired each time the text in the `TextBox` is changed. If we double click on `TextChanged` in the Properties pane Visual Studio will create a method and hook it up to this event:

```
private void firstNumberTextBox_TextChanged(object sender,

TextChangedEventArgs e)
{

}
```

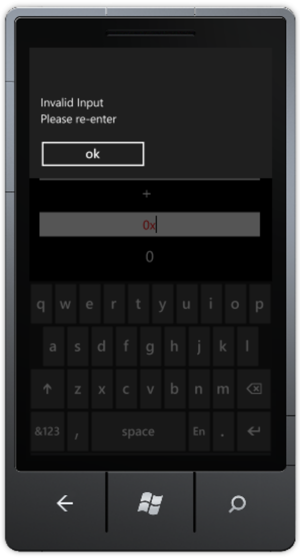
We just need to add a call of `calculateResult` into this method:

```
private void firstNumberTextBox_TextChanged(object sender,

TextChangedEventArgs e)
{
     calculateResult();
}
```

We can do the same thing for the second text box, so that if either of the boxes is changed the sum is updated. This means we can now remove the Calculate button.

Double Changed Events

If we run this program we find that it works quite well. However, we do notice a problem with data validation. If the user types text instead of a number our program will spot this and display a message box:


Invalid Input
Please re-enter

However, this message is displayed twice for each invalid character that is entered. It is as if the `TextChanged` event is firing twice for each character. It turns out that this is the case and it is a known issue with Windows Phone applications. We can get around it by checking for successive changed events with the same data:

```
string oldFirstNumber = "";
private void firstNumberTextBox_TextChanged(object sender,
                                        TextChangedEventArgs e)
{
    if (firstNumberTextBox.Text == oldFirstNumber) return;
    oldFirstNumber = firstNumberTextBox.Text;

    calculateResult();
}
```

This method only calls `calculateResult` if the text in the TextBox has really changed.

The solution in *Demo 05 AddingMachine with no button* implements an adding machine which uses TextChanged events and does not have a calculate button.

Data binding

Data binding is wonderful. Perhaps there are even statues out there to it. Perhaps we should build one, but then again perhaps not. Data binding takes the place of the “glue” code that we are writing to connect display elements to the methods that work on them. It allows us to take a property of a display element and connect it directly to an object. All we have to do is create an object that behaves in a particular way and we can get values in the object transferred into the Silverlight element with no effort on our part.

Data binding can work in either direction. We can bind the text a `TextBox` to our application so that when a user changes the text in the textbox our application is informed of this. We can also bind a `TextBlock` to an object so that when a property in the object is changed the content of the `TextBlock` updates to match. This is “two-way” binding, where a program can both change an element and respond to changes in it. We can do “one way” binding so that a program can display output just by changing properties in an object. Finally we can bind to any of the properties of an object so that a program can move a Silverlight element around the screen by changing X and Y properties in a game object.

Creating an object to bind to

We are going to begin by creating a version of the adding machine which uses data binding. The starting point is a class that will do all the work. This will expose data properties that will be connected to element properties in the display object. There are three things that our object must expose:

- The text in the top TextBox
- The text in the bottom TextBox
- The text in the result TextBlock

We could build an `AdderClass` to express all this:

```
public class AdderClass
{
    private int topValue;
    public int TopValue
    {
        get
        {
            return topValue;
        }
        set
        {
            topValue = value;
        }
    }

    private int bottomValue;
    public int BottomValue
    {
        get
        {
            return bottomValue;
        }
        set
        {
            bottomValue = value;
        }
    }

    public int AnswerValue
    {
        get
        {
            return topValue + bottomValue;
        }
    }
}
```

This class has three properties. Two of them have get and set behaviours so that a user of this class can find out the values of the top and bottom items (the things we are adding together) and set them to new values. The third property is just the answer value (the result of the sum). This is never set to a value; the user of the `AdderClass` will only ever read this property to get the latest answer.

This class does all the "thinking" required to make our adding machine work. A program could make an instance of this, set top and bottom values and then read back the answer. If we wanted to change to a "subtracting" machine we would just have to replace this class with one that worked differently. This would be a good piece of design whether we were using Silverlight or not.

Adding Notification Behaviour

In order for a class to be able to bind to Silverlight objects it must implement the `INotifyPropertyChanged` interface:

```
public interface INotifyPropertyChanged
{
    // Summary:
    //     Occurs when a property value changes.
    event PropertyChangedEventHandler PropertyChanged;
}
```

For a class to implement this interface it must contain the event delegate which will be used by `AdderClass` to tell anything that is interested when a property has changed.

```
public event PropertyChangedEventHandler PropertyChanged;
```

The `PropertyChangedEventHandler` type is used by Silverlight elements to manage event messages. It is described in the `System.ComponentModel` namespace. If a Silverlight component wants to bind to any of the properties in the class it can add delegates to this event.

The `AdderClass` will use this delegate to tell the outside world when one of the properties in the class has changed. This will trigger a display update. Silverlight objects that are connected to our properties bind to this delegate so that they can be notified when required. The final version of the class looks like this:

```
namespace AddingMachine
{
    public class AdderClass : INotifyPropertyChanged
    {
        public event PropertyChangedEventHandler
PropertyChanged;

        private int topValue;

        public int TopValue
        {
            get
            {
                return topValue;
            }
            set
            {
                topValue = value;

                if (PropertyChanged != null)
                {
                    PropertyChanged(this,
                     new
PropertyChangedEventArgs("AnswerValue"));
                }
            }
        }

        // repeat for bottom value

        public int AnswerValue
        {
            get
            {
                return topValue + bottomValue;
            }
        }
    }
}
```

The `AdderClass` now contains a member called `PropertyChanged`. Whenever our class wants to change a property value it must test the value of `PropertyChanged`. If it is not null this means that something has bound to the delegate. You can regard the `PropertyChanged` event as a mailing list. Process can subscribe to the list and be informed of interesting events that occur in the `AdderClass`. If nobody is subscribed to the mailing list (i.e. the `PropertyChanged` value is null) then there is no point in calling a method to describe a change. However, if it is not null this means that we have something out there that wants to know about changes inside our AdderClass.

The format of the method call that delivers our event is as follows:

```
PropertyChanged(this,new
PropertyChangedEventArgs("AnswerValue"));
```

The first parameter to the call is a reference to the object that is generating the event. The second is an argument value loaded with the name of the property that has changed. The Silverlight element will use reflection (i.e. it will look at the public properties exposed by `AdderClass`) to know what properties are available. If it gets a notification that `AnswerValue` has changed it will then update any display element properties that are bound to the property in this class.

Note that this is just a string of text though, if we write “Answervalue” by mistake this will prevent the update message from being picked up correctly.

When the program fires the changed event it will cause the result display to fetch an updated value of `AnswerValue` for display to the user. When the `get` behaviour in `AnswerValue` is called it computes the total and returns it.

```
public int AnswerValue
{
    get
    {
        return topValue + bottomValue;
    }
}
```

If you are finding this confusing, don't worry. Just remember why we are doing this. We are going to connect this object to the user interface. The user interface will tell our `AdderClass` when the values of the two inputs are changed by the user. When the input changes the `AdderClass` instance needs to have a way of telling the user interface that there is now a new total to be displayed.

Adding the Namespace containing our class to MainPage

We now have our object that we want to data bind. The next thing we need to do is link our code to the XAML that describes our user interface. To do this we must add the namespace containing the `AdderClass` to the XAML.

```
xmlns:local="clr-namespace:AddingMachine"
```

If you look at the final version of `AdderClass` above you will find that it is in the `AddingMachine` namespace. By adding this line at the top of the XAML file for `MainPage.xaml` we tell the system that any classes in the `AddingMachine` namespace should be made available for use in our application XAML.

In the same way that a C# program must have all the using directives at the top of the source file a XAML file must have all the namespaces that it uses at the top as well. If you look in the file at the top you will find lots of namespaces being added. These are the classes for the Silverlight elements that make up the user interface.

Once we have added a namespace we now have to create a name for the resources that can be found in this namespace:

```
<phone:PhoneApplicationPage.Resources>
    <local:AdderClass x:Key="AdderClass" />
</phone:PhoneApplicationPage.Resources>
```

If this seems a lot of work then remember that only have to do this once, and that the class that we add can contain many properties that the user interface can interact with.

Adding the Class to an element on the page

Now that the namespace is available we can connect a particular class from this namespace to the elements in our page. The element we are going to add the class to will be the Grid that holds all our display elements. Adding a class to an element automatically makes it available to any elements inside it, and so the `TextBox` and `TextBlock` elements can all use this class.

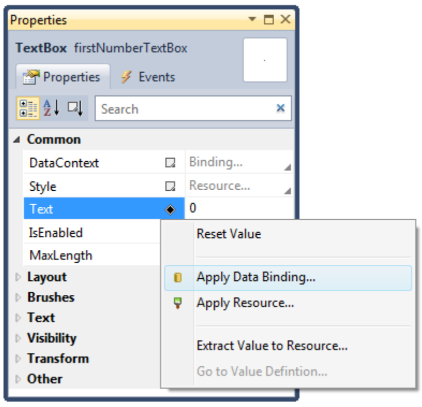
```
<Grid x:Name="LayoutRoot" Background="Transparent" DataContext="{StaticResource
AdderClass}">
```

We get an element to use a particular class by setting a value for the `DataContext` for that component. For our application this will be a static resource, in that it will be part of the program. This might seem a bit over complicated, but it does mean that you can create a test data context that you can use instead of a "real" one.

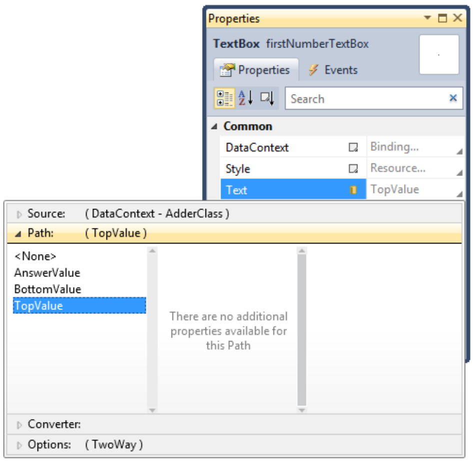
Connecting the Silverlight element to the property

We now have the Adder class available as a data context for elements on a page. This sets up a link between the Silverlight page and an object that is going to provide business behaviours. The next thing we need to do is connect properties of each element to properties that our business object exposes.

We can do this from the Properties pane for each element. Let's start by connecting the text in the `firstNumberTextBox` with the `TopValue` property in our `AdderClass`. If we click on the `TextBox` in the Visual Studio editor we can then open the Property pane for the item. We can then go and find the Text property. At the moment it is just set to a string, we want to apply a Data Binding to our adding machine object:

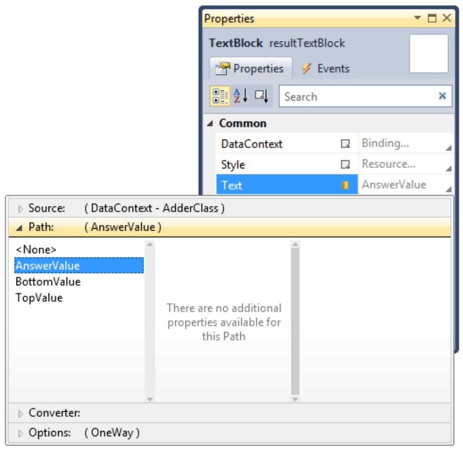


If we click "Apply Data Binding" the next thing we need to do is find the property that is going to be bound. Behind the scenes Visual Studio has gone off and opened the `AdderClass` and used found out what properties it exposes. It can then display a menu of those that are available:



This is where the magic starts to happen. Simply by selecting the required item from the list we can connect the Silverlight element property with my object. Note that the TwoWay option is selected so that when the user changes the value in the `TextBox` my object is informed.

When we bind to the `TextBlock` we are only given the option of `OneWay` binding, as it is not possible to send data from a `TextBlock` into a program.



TextBlock resultTextBlock

DataContext Binding...
Style Resource...
Text AnswerValue

Source: (DataContext - AdderClass)
Path: (AnswerValue)

<None>
AnswerValue
BottomValue
TopValue

There are no additional properties available for this Path

Converter:
Options: (OneWay)

Once we have made these bindings our program will just work. The interesting thing about this is that if you look in the `MainPage.xaml.cs` file for the program code that makes the application work you will find that it is completely empty. All the work is now being done by our tiny little class, which is connected to the display items.

The solution in *Demo 06 AddingMachine with data binding* implements an adding machine which uses data binding to connect the inputs to the AdderClass.

Data Binding using the Data Context

You might be looking at data binding and thinking "This looks OK, and I understand how it works, but you do seem to have to do a lot of work to add the resources and everything" The really good news is that there is a way to sort circuit this process which makes the whole thing really easy. It means adding a statement to our code (one of the interesting things about the solution above is that there is no code in our `MainPage.xaml.cs` file) but I reckon we can live with this.

Setting the Data Binding in XAML

We have seen how the elements in a control can be bound to object properties. We can just bind an object property to an element property and Silverlight will provide the glue to tie these together.

```
<TextBox Height="72" HorizontalAlignment="Left" Margin="8,19,0,0"
Name="firstNumberTextBox" Text="{Binding TopValue, Mode=TwoWay}" VerticalAlignment="Top"
Width="460" TextAlignment="Center" >
```

The XAML above shows how this works. I've highlighted the data binding for the first number textbox in the XAML above. This gives the name of the property that the text will bind to and the mode of the binding.

Setting the DataContext

Now all we have to do is create an `AdderClass` instance and set the `DataContext` of the element that contains the `firstNumberTextbox` to this instance. We can do this in the constructor for the main page.

```
// Constructor
public MainPage()
{
    InitializeComponent();

    AdderClass adder = new AdderClass();
    ContentGrid.DataContext = adder;
}
```

The `DataContext` for a Silverlight element identifies the object that contains all the properties that have been bound to by that control and any that the control contains.

The `ContentGrid` on the page contains our TextBoxes and TextBlocks and now every binding that they contain will be mapped onto the `AdderClass` instance that we created.

In other words we have replaced all the hard work with property panes and resources with a small amount of XAML and a single statement.

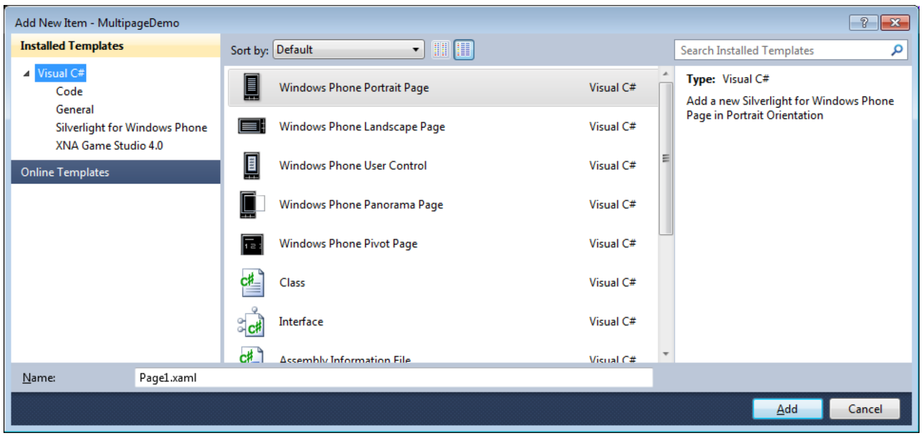
The solution in *Demo 06 AddingMachine with data binding* implements an adding machine which uses data binding to connect the inputs to the AdderClass.

4.3 Pages and Navigation

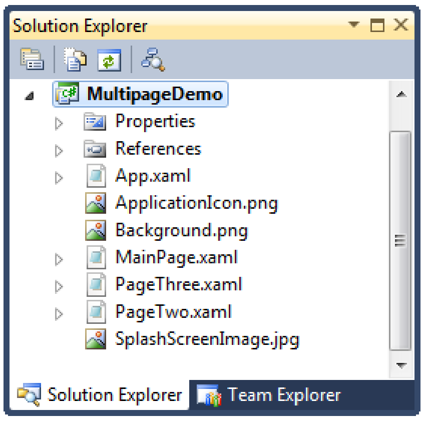
At the moment all the programs we have written have run on a single Silverlight page. However, many applications run over a number of pages. At the very least a program will often have an “options” or “settings” page that the user can navigate to. To do this we will need to have more than one Silverlight page in our application.

Adding a new Page

It is easy to add a new page to an application. If we select `Project>Add New Item` from within Visual Studio we are presented with a menu of possible items that we might like to add.


Add New Item - MultipageDemo
Installed Templates
Visual C#
Code
General
Silverlight for Windows Phone
XNA Game Studio 4.0
Online Templates
Sort by: Default
Search Installed Templates
Windows Phone Portrait Page Visual C#
Windows Phone Landscape Page Visual C#
Windows Phone User Control Visual C#
Windows Phone Panorama Page Visual C#
Windows Phone Pivot Page Visual C#
Class Visual C#
Interface Visual C#
Assembly Information File Visual C#
Type: Visual C#
Add a new Silverlight for Windows Phone Page in Portrait Orientation
Name: Page1.xaml
Add
Cancel

If we select Windows Phone Portrait Page you get a new page added. Before adding a page it is sensible to set the name to something more meaningful than “Page1”. We can change the name of the item later if we like by renaming it. An application can contain as many pages as we need.



This demo contains two new pages, with the original names of PageTwo and PageThree. For each new page we get a file of XAML and the code behind page.

The pages themselves are edited in exactly the same way as MainPage. When the page is open we can drag elements onto it from the Visual Studio ToolBox, we can manipulate their properties and we can edit the XAML directly if we wish.

Navigation between pages

The Silverlight model for moving between pages has more in common with the internet than Windows Forms. If you are used to writing Windows Forms applications you will be familiar with methods such as "`Show`" and "`ShowDialog`" which are used to allow one form to cause the display of another.

Silverlight doesn't work like that. When you think about moving around a Silverlight application you should think in terms of navigating from one page to another. Each page has an address expressed as a `uri` (Uniform Resource Indicator). The `NavigationService` object provides methods that perform the navigation for us.

```
private void page2Button_Click(object sender, RoutedEventArgs
e)
{
    NavigationService.Navigate(new Uri("/PageTwo.xaml",
                                       UriKind.RelativeOrAbsolute));
}
```

Above you can see an event handler for a button. This will cause the program to switch to the page `PageTwo` when the button is pressed. Note that the `Navigate` method is given a uri value which contains the name of the page and also the kind of Uri being used.

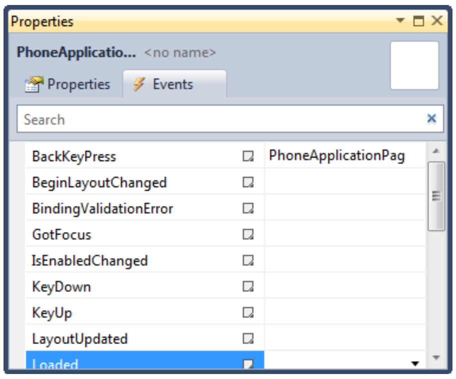
When we create the uri we also need to select what kind of uri it is, we are setting this uri to be `RelativeOrAbsolute`, even though this particular Uri is relative to the present one. We do this to ensure maximum flexibility when loading resources.

When the user clicks on the button the display will switch to the contents of PageTwo. Note that if there is no `PageTwo.xaml` the program will throw an exception if the user tries to navigate there.

Using the Back button

Users will expect the Back button on Windows Phone to return to the previous page. This is exactly what it does. If the user has navigated to `PageTwo` as shown above, and then presses the Back button they will be returned to the page they came from. If the user presses Back when they are at the `MainPage` the application is ended.

Sometimes we want to override this behaviour. We might not want our user to leave the page if they have not saved the data they have entered. We can do this by adding an event handler to the `BackKeyPress` event:



The event handler method can cancel the back behaviour if required.

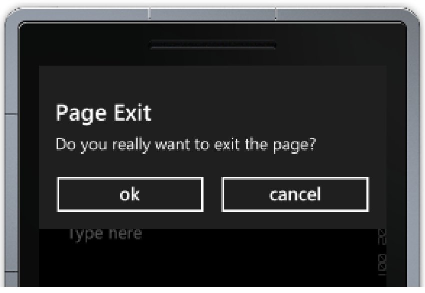
```
private void PhoneApplicationPage_BackKeyPress(object sender,
                              System.ComponentModel.CancelEventArgs
e)
{
    e.Cancel = true;
}
```

If the method above is bound to the `BackKeyPress` event the user will not be able to use the Back key to move away from the page.

Sometimes you want the user to confirm that they want to move away from the page. You can use the `MessageBox` class to do this:

```
private void PhoneApplicationPage_BackKeyPress(object sender,
                             System.ComponentModel.CancelEventArgs e)
{
    if (MessageBox.Show("Do you really want to exit the
page?",
                             "Page Exit",
MessageBoxButton.OKCancel)
       != MessageBoxResult.OK)
    {
        e.Cancel = true;
    }
}
```

This code displays a message box and asks the user if they really want to leave the page. If they don't want to leave the back button is cancelled. This is what the screen looks like when this code runs.



You can use this form of `MessageBox` any time you want to put up a quick question for the user to answer.

Passing Data between Pages

Each Silverlight page is distinct and separate from any other. They do not share data. Sometimes you want to pass data from one page to another. If the data is a simple string of text the easiest way to do this is by adding it to the uri that is passed into the destination page.

```
private void page3Button_Click(object sender, RoutedEventArgs 
e)
{
    NavigationService.Navigate(new 
Uri("/PageThree.xaml?info=" +
                                        infoTextBox.Text, 
                                        UriKind.Relative));
}
```

When the program navigates to Page 3 it passes the contents of a `TextBox` as part of the uri. This information is passed into the page that we are navigating to as part of the uri, what the receiving page will see is something like:

```
PageThree.xaml?info=text message
```

It can then unpack this information to get the text message out of the uri.

Using Page Navigation Events

There are two really important events in the life of a Silverlight page. One is fired when the page is navigated to (`OnNavigatedTo`) and the other is fired when the page is left (`OnNavigatingFrom`). To get control when these events fire we need to override these methods in our page.

When we create a new page the class that controls it is derived from a parent class called `PhoneApplicationPage`:

```
public partial class PageThree : PhoneApplicationPage
{

    // Page 3 methods go here
    // we override the ones that we want to provide
    // our own behaviours for
}
```

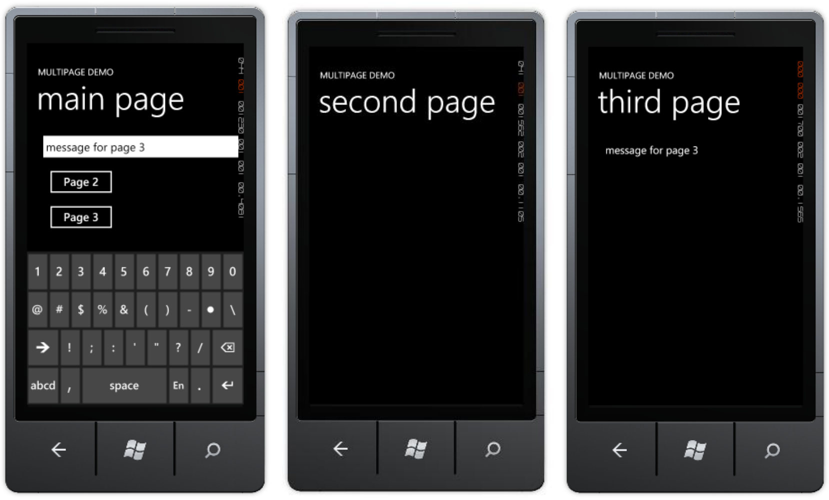
This is the declaration of a page class called `PageThree`. We can add new methods to the page and we can override existing methods and add new behaviours to them. We want our application to get control when the user navigates to the page. This is the point where we want to load information from the uri and display it in a control on the page. Our replacement `OnNavigatedTo` method looks like this:

```
protected override void OnNavigatedTo

(System.Windows.Navigation.NavigationEventArgs e)
{
    string info = "";
    if (NavigationContext.QueryString.TryGetValue("info",
                                                  out info) )
    {
        infoTextBlockFromQuery.Text = info;
    }
}
```

The method uses the `QueryString` in the `NavigationContext` object and tries to get a value out of that string. It asks for the value by name and, if it is recovered, displays it in a text block. Each time the user returns to this page the method runs and puts the latest content onto the page.We can use the OnNavigatedTo event any time we want to set up a page when the user moves to it.

We can use the `OnNavigatingFrom` to get control when the user tries to leave our page. The method can do any tidying up or closing of open resources. The page can also use a Cancel flag to stop the user from leaving the page, just as we did with the Back button earlier.

The `OnNavigatedTo` method can query the `NavigationContext` and try to get data out of it. The above method shows how this is done. The `info` string is copied into a TextBlock on Page3.



The solution in *Demo 08 Multipage Demo* is a three page Silverlight application. You can move to pages 2 and 3 by pressing buttons on the main page. You can return from Page 2 by pressing the back button. If you use the back button on page 3 you need to respond to a confirmation dialog before being moved off the page. Text entered on the main page is transferred into a TextBlock in page 3 via the page uri.

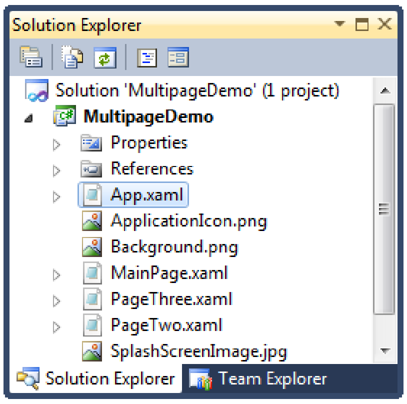
Sharing objects between pages

Passing strings of text between pages is useful, but you often need to share larger items which contain structured data. Often your user will be working with a "thing" of some kind; perhaps a document or a game, and the different pages will provide different views of that object.

What you really want is an object which is common to all the pages and can be accessed by any of them. You could put your shared data into the object and they could all make use of it. Turns out that this is very easy to do, because all Windows Phone Silverlight programs have such a thing as part of the way they work. It is called the App class.

The App.xaml page

When we create a Silverlight application we get a `MainPage.xaml` and an `App.xaml` page.



We can regard `App.xaml` as the container for the phone application. It provides the context in which the pages are displayed. It doesn't actually ever get drawn on the screen, but it is the starting point for the application when it is loaded. The `App.xaml.cs` file contains the methods that start an application running. It also contains handler methods for application lifecycle events which we will be using later.

We can edit the `App.xaml.cs` file and add our own code and data members. If we want to store any global data for use by all the pages in our application we can declare it here.

```
public partial class App : Application
{
    // To be used from all pages in the application
    public string LoginName;
}
```

Here we have added a `LoginName` string that we want to be able to use in all the pages.

Any Silverlight page can obtain a reference to the App which it is part of:

```
App thisApp = Application.Current as App;
LoginTextBox.Text = thisApp.LoginName;
```

The `Current` member of the `Application` class is a reference that can refer to objects of type `Application`. When the application starts it is set to refer to the currently executing application instance.

The `App.xaml.cs` class defines a child class `App` that extends the `Application` parent. To get hold of objects defined in the `App` class we have to make a reference of type `App` and then make this refer to the current application. Above you can see how the as operator is used to convert the reference to one with the correct type.

The code above gets the `LoginName` out of the application and sets the text on a `TextBox` to this. You can use this code in any of the pages in an application.

The solution in *Demo 09 Shared data* is a two page Silverlight application. You can enter a username into the text box on the main page and this is stored in the App class. The application uses the OnNavigatedFrom event on MainPage to trigger the storage of the username in the App class.

What we have learned

1. Programs can manipulate the properties of Silverlight elements to display information to the user of a program. This includes the position and colour of items on the display.

2. Some element properties are best set by editing the XAML directly. The XAML information for an element is structured in terms of properties which can be nested inside each other. The TextBox has a set of properties that give the initial settings for the keyboard to be used to enter data. These can be used to cause a numeric keyboard to be displayed instead of a text one.

3. Windows Phone can display messageboxes to the user. These can display multi-line messags and can also be used to confirm or cancel user actions.

4. Assets such as images can be added to a Windows Phone application as content or resources. An item of content is copied into the application directory as a separate file and can be used from there by the program. A resource item is embedded into the assembly file for an application. Content items do not slow the loading of assemblies but may be slower

to load when the program runs. Resource items are more readily available to a program but they increase the size of the program assembly.

5. Silverlight elements can generate events in response to user actions. One such action is the TextChanged event produced by the TextBox.
6. Silverlight provides data binding support where the properties of an object in the program can be connected to those of a Silverlight display element. The binding can be "one way", where the display element is used to output the value of a program item or "two way" where changes to the item on the page result in an update of the bound property in the class.
7. Silverlight applications can be made up of multiple pages. The navigation between pages is performed by a navigation helper class which is given the uri of the page to be navigated to. Simple items of text can be passed between pages by placing them in a query string attached to the uri.
8. Pages can receive events when they are navigated to and from. The OnNavigatedFrom event provides cancellation option so that a user can be asked to confirm the navigation.
9. Larger data objects can be shared between pages in an application by the use of the App class which is part of a Windows Phone application. Any Silverlight page in an application can obtain a reference to the application object that it is part of.

5 Consuming Data Services

One of the things that make a Windows Phone very useful is the "connectedness" that it has. It allows the user to consume network services wherever they are (as long as they can get a signal). This makes possible some genuinely new kinds of application, particularly if you add in the way that the device is also location aware.

In this section we are going to explore the ways in which C# programs on the device can connect to and use data services provided by the network.

5.1 Connecting to a data service

All Windows Phones support network connectivity via the mobile telephone network and also by means of their built in WIFI. As far as our programs are concerned the two network technologies are interchangeable. The programs we are going to write will initiate connections to a data service and the underlying phone systems will make the connection the best way that they can.

Of course, if there is no mobile signal or WIFI available these connections will fail. Applications that we write must be able to deal with this situation gracefully. At the very least this means displaying a "Sorry we can't connect you just now, please try later" message. A more advanced program may store data locally and then send it later. It is up to you how your program will work in this respect.

Windows Phone applications on a network

Programs running in a Windows Phone can connect to and access servers on the network via a variety of connection mechanisms. They can make web requests and also connect to web services and Windows Communication Foundation (WCF) hosts. However, the present version of the network library in the Windows Phone does not support direct sockets for such things as "session-less" communication.

Networked programs on the Windows Phone Emulator

The Windows phone emulator has the same networking abilities as the real device. It uses the network connectivity of the host PC it is running on. This means that you can test any applications that use the network on your desktop PC. However you should also test your programs on a real device. On a real Windows Phone you can disable network services and test your application to ensure that it performs properly over lower speed connections.

Reading text off a Web Page

We can start exploring the networking ability of the Windows Phone by writing a program that displays the text from a web page. We could use this to "scrape" data off web pages that we want to present to the user in a different format. We can also use this mechanism to read structured data from services such as provided by Twitter, of which more later in this section.

Reading a web page turns out to be very easy indeed. There is only one complication, and that is caused by the way that all the network activities performed by Windows Phone are *asynchronous.*

Synchronous vs Asynchronous operations

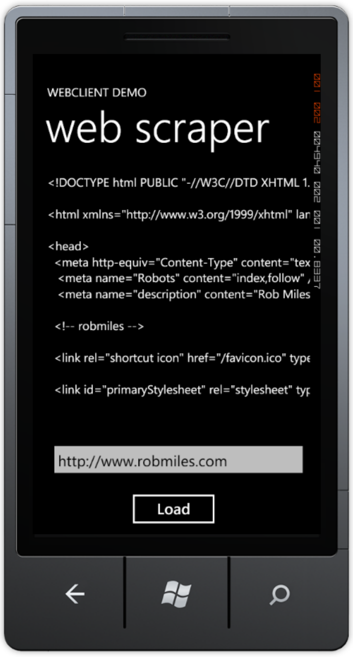
There are two ways you can do things, synchronous and asynchronous. When you do something synchronously what we are really saying is "while you wait". If I have my car serviced "synchronously" it means that I stand in the garage waiting for the "service my car" method to complete, at which point I can take my car and drive home. If I have my car serviced "asynchronously" this means that I go off and do some shopping while the job is being done. At some point the garage will ring me up and deliver a "service complete" event. At which point I go and pick up my car and drive home.

Making asynchronous use of data services is very sensible, particularly on a device such as a Windows Phone. The limitations of the network connection to the phone mean that a network connection may take several seconds to deliver an answer. A program should not be stopped for the time it takes for the server to respond. Furthermore, the whole way that Silverlight works is event based. We are used to writing programs that respond to events generated by display elements. You make a program respond to events from network requests in exactly the same way.

Using the WebClient class

To read text from the web we can use the `WebClient` class. This is provided as part of the Windows .NET networking library, so if you learn how to use it on the Windows Phone you can also use it in your Windows desktop programs. We can use the class to perform an HTTP (Hyper Text Transfer Protocol) interaction with a remote web server. There are a number of different ways we can use a `WebClient`, we are going to look at one of the simplest.

We are going to create a `WebClient` variable in the `MainPage.xaml.cs` of our application. When the user presses the `loadButton` our application will load the url from a `TextBox` and then display the text content of that page.



```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.

<html xmlns="http://www.w3.org/1999/xhtml" lan

<head>
  <meta http-equiv="Content-Type" content="tex
   <meta name="Robots" content="index,follow" ,
   <meta name="description" content="Rob Miles

  <!-- robmiles -->

  <link rel="shortcut icon" href="/favicon.ico" type

  <link id="primaryStylesheet" rel="stylesheet" typ
```

Above you can see the program in action, displaying one of the best pages on the web. Note that this is exactly what a browser does, except that a browser will then take the HTML content received from the server and render it along with any associated graphical content.

The first thing we need to do is declare our `WebClient` as a member of the `MainPage` class. This will be used manage the web requests that we are going to make.

```
WebClient client;
```

At the moment we just have the reference to a `WebClient` object. The next thing we need to do is create an actual instance of a `WebClient`. We can do this in the constructor for the page class:

```
public MainPage()
{
    InitializeComponent();

    client = new WebClient();
    client.DownloadStringCompleted +=
                new DownloadStringCompletedEventHandler(
                    client_DownloadStringCompleted);
}
```

The constructor creates a new `WebClient` and then binds a method to the `DownloadStringCompleted` event that the `WebClient` exposes. The method, called `client_DownloadStringCompleted`, will display the web page text in the in the `pageTextBlock`:

```
void client_DownloadStringCompleted(object sender,
                            DownloadStringCompletedEventArgs
e)
{
    if (e.Error == null)
    {
        pageTextBlock.Text = e.Result;
    }
}
```

When this method is called it tests to see if any errors were reported. If there are no errors the method displays the result of the download in the `pageTextBlock` element.

The last thing we need to add to our program is the event handler for the button that will start the download of a page at the url that the user has typed in:

```
private void loadButton_Click(object sender, RoutedEventArgs
e)
{
    client.DownloadStringAsync(new Uri(urlTextBox.Text));
}
```

When the load button is clicked the following sequence takes place:

1. The text from the `urlTextBox` is used to create a new `Uri` which describes the web site to be loaded.
2. The `DownloadStringAsync` method is called on the `WebClient`. This starts a new web transaction. This method returns immediately, so the button event handler is now completed.
3. Some-time later the `WebClient` will have fetched the string of content at the url. It fires the `DownloadStringCompleted` event to indicate that it has finished, and to deliver the result.
4. The client_`DownloadStringCompleted` method now runs, which checks for errors and displays the received text in the TextBlock.

The solution in *Demo 01 Web Scraper* contains this code. You can type in any url and download the html from that page. The program will work on either the emulator or a real device.

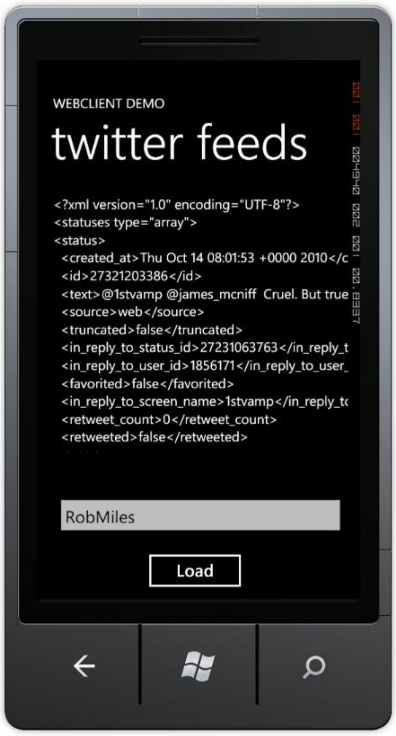
Note that this is a very basic web page reading program (as you might expect for only fifteen or so lines of code). It does not stop the user from pressing the Load button repeatedly and interrupting downloads and it does not provide any form of time out or progress display to the user.

5.2 Using LINQ to read structured data

The ability to read from the web can be used for much more than just loading the text part of a web page. We can also interact with many other data services, for example Twitter. This uses a REST (Representational State Transfer) protocol to expose the activities of Twitter users. REST makes use of the structure of the url being used to denote the required action. As an example, if you point a web browser at the following url:

`http://twitter.com/statuses/user_timeline/robmiles.xml`

- you will be rewarded with an XML document that contains my most recent Twitter posts. By replacing robmiles with the name of another Twitter user you can read their feed.



```
<?xml version="1.0" encoding="UTF-8"?>
<statuses type="array">
<status>
  <created_at>Thu Oct 14 08:01:53 +0000 2010</c
  <id>27321203386</id>
  <text>@1stvamp @james_mcniff  Cruel. But true
  <source>web</source>
  <truncated>false</truncated>
  <in_reply_to_status_id>27231063763</in_reply_t
  <in_reply_to_user_id>1856171</in_reply_to_user_
  <favorited>false</favorited>
  <in_reply_to_screen_name>1stvamp</in_reply_tc
  <retweet_count>0</retweet_count>
  <retweeted>false</retweeted>
```

This makes it very easy to make a slightly modified version of our WebClient program that assembles a web request for the Twitter server and uses that to read feed information from it. The only change we have to make is to the code that produces the web request:

```
private void loadButton_Click(object sender, RoutedEventArgs
e)
{
    string url = "http://twitter.com/statuses/user_timeline/"
+
                 nameTextBox.Text + ".xml";

    client.DownloadStringAsync(new Uri(url));
}
```

The solution in *Demo 02 Twitter Reader* contains this code. You can type in any twitter username and download the feed from that user. The program will work on either the emulator or a real device.

Structured Data and LINQ

Twitter returns status reports in the form of an XML formatted document. XML is something we know and love (a bit). What we want to do now is pull all the information out of the XML content we get from Twitter and display this information properly. As great programmers we could of course write some software to do this. The good news is that we don't have to. We can use LINQ to do this for us. LINQ stands for "Language INtegrated Query". It is really useful. It is designed to provide the "glue" between databases and programs. I don't have space to go into all that LINQ can do for you, but we need to take a look at the problem LINQ was invented to solve before we start using it.

A quick word about databases

To understand what LINQ is used for we have to start by considering how computers manage large amounts of data. They do this by using *databases*. A database is a collection of, well, data, which is organised and managed by a computer program which is often, and rather confusingly, called a database.

Another computer program can ask a database questions and the database will come back with the results. You don't think of a database as part of your program as such, it is the component in your solution that deals with data storage.

We could discover how a database works by taking a quick look at a very simple example. Consider how we would create a database to hold information for an internet shop. We have a large number of customers that will place orders for particular products.

If we hire a database designer they will charge us a huge amount of money and then they will come up with some designs for database tables that will hold the information in our system. Each of the tables will have a set of columns that hold one particular property of an item, and a row across the table will describe a single item.

Name	**Address**	**Bank Details**	**Customer ID**
Rob	18 Pussycat Mews	Nut East Bank	123456
Jim	10 Motor Drive	Big Fall Bank	654322
Ethel	4 Funny Address	Strange bank	111111

This is a **Customers** table that our sales system will use. Each row of the table will hold information about one customer. The table could be a lot larger than this; it might also hold the email address of the customer, their birthday and so on.

Customer ID	**Product ID**	**Order Date**	**Status**
123456	1001	21/10/2010	Shipped
111111	1002	10/10/2010	Shipped
654322	1003	1/09/2010	On order

This is the **Orders** table. Each row of the table describes a particular order that has been placed. It gives the Product ID of the product that was bought, and the Customer ID of the customer that bought it.

Product ID	**Product Name**	**Supplier**	**Price**
1001	Windows Phone 7	Microsoft	200

1002	Cheese grater	Cheese Industries	2
1003	Boat hook	John’s Dockyard	20

This is the **Products** table. Each row of this table describes a single product that the store has in stock. This idea might be extended so that rather than the name of the supplier the system uses a Supplier ID which identifies a row in the Suppliers table.

By combining the tables you can work out that Rob has bought a Windows phone, Ethel has bought a Cheese grater and the Boat hook for Jim is on order.

This is a bit like detective work or puzzle solving. If you look in the Customer table you can find that the customer ID for Rob is 123456. You can then look through the order table and find that customer 123456 ordered something with an ID of 1001. You can then look through the product table and find that product 1001 is a Windows Phone (which is actually not that surprising).

Databases and Queries

You drive a database by asking it questions, or queries. We could build a query that would find all the orders that Rob has placed. The database system would search through the Orders table and return all the rows that have the Customer ID of 123456. We could then use this table to find out just what products had been purchased by searching through the Products table for each of the Product IDs in the orders that have been found. This would return another bunch of results that identify all the things I have bought. If I want to ask the database to give me all the orders from Rob I could create a query like this:

```
SELECT * FROM Orders WHERE CustomerID = "123456"
```

This would return a “mini-table” that just contained rows with the Customer ID of Rob. The commands I’m using above are in a language called SQL or Structured Query Language. This was specifically invented for asking questions of databases.

Companies like Amazon do this all the time. It is how they manage their enormous stocks and huge number of customers. It is also how they create their “Amazon has recommendations for you” part of the site, but we will let that slide for now.

Databases and Classes

Unfortunately object oriented programs do not work in terms of tables, rows and queries. If I was writing a C# program to manage a shop I would create some classes, perhaps starting with one for a `Customer`.

```
public class Customer
{
    public string Name {get; set;}
    public string Address { get; set; }
    string BankDetails { get; set; }
    public int ID { get; set; }
}
```

This contains all the information that you find in a single row of the Customers table. To hold a large number of customer entries I could create a List collection that holds them all:

```
List<Customer> Customers = new List<Customer>();
```

Whenever I add a new customer I add it to the Customers list and to find customers I use the `foreach` loop to work through the customers and locate the one I want. As an example, to find all the orders made by a customer I could do something like this:

```
public List<Order> FindCustomerOrders(int CustomerID)
{
    List<Order> result = new List<Order>();

    foreach ( Order order in Orders )
    {
        if (order.CustomerID == CustomerID)
        {
            result.Add(order);
        }
    }
    return result;
}
```

The method searches through all the orders and builds a new list containing only ones which have the required customer ID. It is a bit more work than the SQL query, but it has the same effect.

Linking Databases and Programs

People like using databases because it is easier to create a query than write the code to perform the work. However, they also like using objects because they are a great way to structure programs. To use databases and object oriented programs together the programmer would have to write lots of "glue" code that transferred data from SQL tables into objects and then back again when they are stored.

This is a big problem in large developments where they may have many data tables and classes based information in them.

LINQ

Language Integrated Query, or LINQ, was the result of an effort to remove the need for all this glue. It is called "Language Integrated" because they actually had to change the design of the C# language to be able to make the feature work. What LINQ lets a programmer do is create objects directly from database queries:

```
var orderQueryResult =
    from order in db.Orders
    where order.CustomerID == "123456"
    select order;
```

This LINQ query is actually C# code that returns a collection of Orders that meet the selection criteria. You can compare it with both the SQL code and the C# above to see how it borrows from both.

One thing that might confuse you is that the `from` construction will return a collection of items, but we don't really know what type these objects will have. This is where the "Language Integrated" bit comes in. The C# language was extended to include a mechanism where the types that hold the results from queries like this (which as a programmer you never actually declare) are created "on the fly" when the query runs. They are given the placeholder type of `var`, which means "a type that works here". The C# compiler and run time system can track the use of `var` types so that programs are still type safe.

In the LINQ query above, which returns a collection of Orders, it would be fine to use the Order Date property on one of the results as this exists in the result. However, you could not use an Address property as this class doesn't hold that property.

If you do any kind of database programming in C# you should find out more about LINQ. It makes it really easy to store and retrieve data.

LINQ on Windows Phone

One piece of bad news to introduce at this point is the fact that the present version of Windows Phone does not have a built in database facility that we can use from C# programs we write. The phone does have database capability, but at the moment this is not exposed to developers. The good news is that this will change in the future. However, it is possible to use the features of LINQ to very good effect when reading other kinds of structured data.

An XML document is very like a database, in that contains a number of elements each of which has property information attached to it. Along with tools to create database queries and get structured information from them, LINQ also contains tools that can create objects from XML data. We are going to use these to read our Twitter feed.

The Twitter feed as a data source

The feed information that you get from Twitter in response to a status request is a structured document that contains attributes and properties that describe the Twitter content. If you have been paying attention during the discussions of XAML and XML you should find this very familiar.

```
<?xml version="1.0" encoding="UTF-8"?>
<statuses type="array">
<status>
  <created_at>Tue Oct 12 11:57:37 +0000 2010</created_at>
  <id>27131245083</id>
  <text>Had 12,000 hits on www.csharpcourse.com for my C# Yellow Book. No idea 
why.</text>
  <source>web</source>
  <truncated>false</truncated>
  <in_reply_to_status_id></in_reply_to_status_id>
  <in_reply_to_user_id></in_reply_to_user_id>
  <favorited>false</favorited>
  <in_reply_to_screen_name></in_reply_to_screen_name>
  <retweet_count>0</retweet_count>
  <retweeted>false</retweeted>
  <user>
    <id>2479801</id>
    <name>Rob Miles</name>
    <screen_name>robmiles</screen_name>
    <location>Hull, UK</location>
    <description>A Computer Science lecturer and Microsoft MVP.</description>

<profile_image_url>http://a3.twimg.com/prof_im/157/me2_normal.jpg</profile_image_url>
    <url>http://www.robmiles.com</url>
    <protected>false</protected>
    <friends_count>21</friends_count>
    <created_at>Tue Mar 27 12:35:28 +0000 2007</created_at>
    <favourites_count>0</favourites_count>
    <utc_offset>0</utc_offset>
    <time_zone>London</time_zone>
    <profile_background_image_url>http://s.twimg.com/a/1286/images/themes/theme1/bg.png
      </profile_background_image_url>
    <notifications>false</notifications>
    <geo_enabled>true</geo_enabled>
    <verified>false</verified>
    <following>true</following>
    <statuses_count>731</statuses_count>
    <lang>en</lang>
    <contributors_enabled>false</contributors_enabled>
    <follow_request_sent>false</follow_request_sent>
    <listed_count>61</listed_count>
    <show_all_inline_media>false</show_all_inline_media>
  </user>
  <geo/>
  <coordinates/>
  <place/>
  <contributors/>
</status>
</statuses>
```

I’ve removed some elements to make it fit nicely on the page, but if you look carefully you can find the text of the tweet itself, along with lots of other stuff. The real document contains a number of status elements. Above I have only shown one.

In the same way as we can ask LINQ to query a database and return a collection of objects it has found we can ask LINQ to create a construction that represents the contents of an XML document:

```
XElement TwitterElement = XElement.Parse(twitterText);
```

The `XElement` class is the part of LINQ that represents an XML element. The `twitterText` string contains the text that we have loaded from the Twitter web site using our `WebClient`. Once this statement has completed we now have an

XElement that contains all the Twitter status information as a structured document. The next thing we need to do is convert this information into a form that we can display. We are going to pull just the status items that we need out of the TwitterElement and use these to create a collection of items that we can display using data binding.

Creating Posts for Display

We know that it is very easy to bind a C# object to display elements on a Silverlight page. So now we have to make some objects that we can use in this way.

The items we are going to create will expose properties that our Silverlight elements will use to display their values. The three things we want to display for each post are the image of the Twitter user making the post, the date of the post and the post text itself. We can make a class that holds this information.

```
public class TwitterPost
{
    public string PostText { get; set; }

    public string DatePosted { get; set; }

    public string UserImage { get; set; }
}
```

These properties are all "one way" in that the TwitterPost object does not want to be informed of changes in them. This means that we can just expose them via properties and all will be well. The UserImage property is a string because it will actually give the uri of the image on the internet.

The next thing we have to do is to use LINQ to get an object collection from the XElement that was built from the Twitter feed we loaded.

```
var postList =
    from tweet in twitterElements.Descendants("status")
        select new TwitterPost
        {
            UserImage =
tweet.Element("user").Element("profile_image_url").Value,
            PostText = tweet.Element("text").Value,
            DatePosted = tweet.Element("created_at").Value
        };
```

This code will do exactly that. It is well worth a close look. The from keyword requests an iteration through a collection of elements in the document. The elements are identified by their name. The program will work through each status element in turn in the document. Each time round the loop the variable tweet will hold the information from the next status element in the XElement.

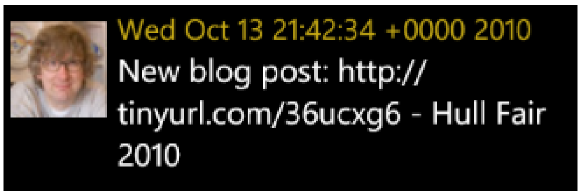
The select keyword identifies what is to be returned from each iteration. For each selected tweet we want to return a new TwitterPost instance with settings pulled from that tweet. The Element method returns an element with a particular name. As you can see we can call the Element method on other elements. That is how we get the image_profile_url out of the user element for a tweet.

The variable postList is set to the result of all this activity. We can make it var type, but actually it is a collection of TwitterPost references. It must be a collection, since the from keyword is going to generate an iteration through something.

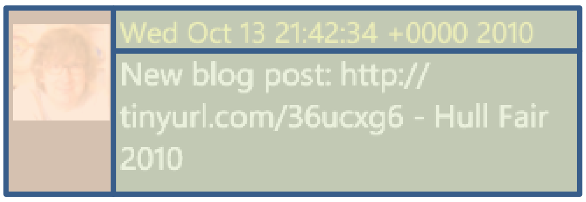
We now have a collection of TwitterPost values that we want to put onto the screen.

Laying out the post display using XAML

We have seen how easy it is to put a Silverlight element on a page and then bind object properties to it. However, we have a little extra complication with our program. We want to display lots of posts, not just one value. Ideally we want to create something that shows the layout for a single item and use that to create lots of display elements, each of which is bound to a different `TwitterPost` value. This turns out to be quite easy.


Wed Oct 13 21:42:34 +0000 2010
New blog post: http://tinyurl.com/36ucxg6 - Hull Fair 2010

Above you can see what I want an individual post to look like. It will have an image on the side, with the date and post text on the right, one above each other.


Wed Oct 13 21:42:34 +0000 2010
New blog post: http://tinyurl.com/36ucxg6 - Hull Fair 2010

From a Silverlight point of view this is three panels, arranged as shown above. We can get Silverlight to do a lot of the work in laying these out for us by using the `StackPanel` container element.

The first `StackPanel` runs horizontally. This contains the user image and then another `StackPanel` that runs vertically and holds the data and time above the post text.

```
<StackPanel Orientation="Horizontal" Height="132">
    <Image Source="{Binding UserImage}" Height="73" Width="73"
           VerticalAlignment="Top" Margin="0,10,8,0"/>
    <StackPanel Width="370">
        <TextBlock Text="{Binding DatePosted}" Foreground="#FFC8AB14"
FontSize="22" />
        <TextBlock Text="{Binding PostText}" TextWrapping="Wrap" FontSize="24" />
    </StackPanel>
</StackPanel>
```

Above you can see the XAML that expresses all this. The `StackPanel` class is a lovely way of laying out items automatically. We don't have to do lots of calculations about where things should be placed, instead we just give the items and the `StackPanel` puts them all in the right place. You can also see the bindings that link the items to the properties in the `TwitterPost` class. The `UserImage` property in `TwitterPost` is bound to the Source property of the image. If we add the complete XAML above to our main page we have an area that can hold a list of Twitter posts.

Creating a complete layout

```
<ListBox Height="442" HorizontalAlignment="Left" Name="tweetsListBox"
VerticalAlignment="Top"
                                                 Width="468">
  <ListBox.ItemTemplate>
      <DataTemplate>
          <StackPanel Orientation="Horizontal" Height="132">
              <Image Source="{Binding UserImage}" Height="73" Width="73"
                     VerticalAlignment="Top" Margin="0,10,8,0"/>
              <StackPanel Width="370">
                  <TextBlock Text="{Binding DatePosted}" Foreground="#FFC8AB14"
FontSize="22" />
                  <TextBlock Text="{Binding PostText}" TextWrapping="Wrap" FontSize="24" />
              </StackPanel>
          </StackPanel>
      </DataTemplate>
  </ListBox.ItemTemplate>
</ListBox>
```

This is exactly how we do it. This XAML repays a lot of study. The first thing we notice is that this is a `ListBox` element. We've not seem these before but they are, as you might expect, a way of holding a list of boxes. Within a `ListBox` we can put a template that describes what each item in the list will look like. This includes the data binding that will link element properties to our `TwitterPost` instances. It also includes the layout elements that will describe how the post will look.

Creating Posts for Display

The next thing our Twitter reader must do is get the posts data onto the display. Before we do this, it is worth stepping back and considering what we are about to do. This is worth doing because it will help us to understand how Silverlight binds collections to displays.

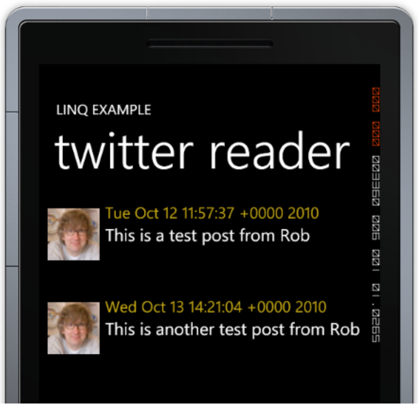
We could write some test code that made us a collection of `TwitterPost` items:

```
TwitterPost p1 = new TwitterPost
{
    DatePosted = "Tue Oct 12 11:57:37 +0000 2010",
    UserImage = "http://a3.twimg.com/profile_images/150108107/me2_normal.jpg",
    PostText = "This is a test post from Rob"
};

TwitterPost p2 = new TwitterPost
{
    DatePosted = "Wed Oct 13 14:21:04 +0000 2010",
    UserImage = "http://a3.twimg.com/profile_images/150108107/me2_normal.jpg",
    PostText = "This is another test post from Rob"
};

List<TwitterPost> posts = new List<TwitterPost>();
posts.Add(p1);
posts.Add(p2);
```

This code creates two `TwitterPost` instances and then adds them to a list of posts. This is not particularly interesting code. It becomes interesting when we do this:

```
tweetsListBox.ItemsSource = posts;
```

The magic of Silverlight data binding takes the list of posts and the template above, and does this with it:



Tue Oct 12 11:57:37 +0000 2010
This is a test post from Rob

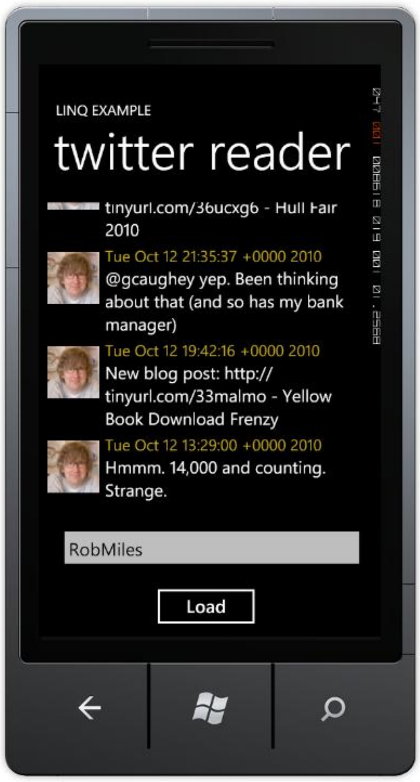
Wed Oct 13 14:21:04 +0000 2010
This is another test post from Rob

This is very nice. It means that you can display any collection of data in a list on the page just by setting them as the source for a `ListBox`. All you have to do is create a data template that binds the properties of each instance to display elements and then assign a list of these instances to the `ItemSource` property of the `ListBox`.

Since we know that we can assign a collection of `TwitterPost` references to a `ListBox` and get this displayed the next statement is not going to come as much of a surprise.

```
tweetsListBox.ItemsSource = postList;
```

At this point our work is done, and the Twitter posts are displayed.



tinyurl.com/36ucxg6 - Hull Fair 2010

Tue Oct 12 21:35:37 +0000 2010
@gcaughey yep. Been thinking about that (and so has my bank manager)

Tue Oct 12 19:42:16 +0000 2010
New blog post: http://tinyurl.com/33malmo - Yellow Book Download Frenzy

Tue Oct 12 13:29:00 +0000 2010
Hmmm. 14,000 and counting. Strange.

RobMiles

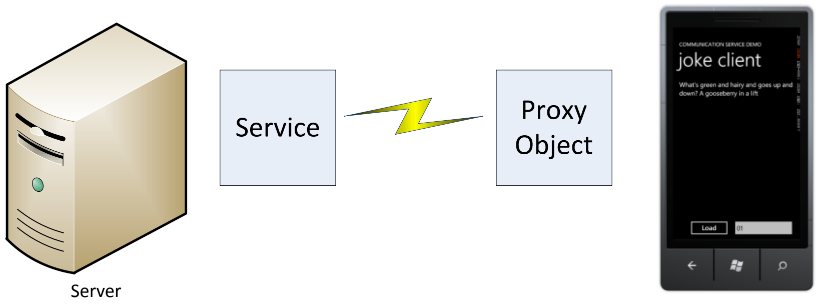
The `ListBox` provides a lot of useful functionality. If you run this program you will find that you can scroll the list up and down by dragging them with your finger. The scroll action will slow down and the items will even "scrunch" and bounce as they move.

The solution in *Demo 03 Complete Twitter Reader* contains this code. You can type in any twitter username and download the feed from that user and display the feed on the screen. When the program starts it is pre-loaded with the test tweets shown above.

5.3 Using Network Services

We can create Windows Phone applications that interact with web servers. If we want to pass data to and from a server using web protocols we can also use the GET and POST elements of HTTP (Hyper Text Transfer Protocol) . In this section we are going to go beyond that and investigate how we can create network based services and then consume them on the Windows Phone device.

WCF (Windows Communication Foundation) services provide a way that two processes can communicate over a network. They take care of all the transfer of messages between two systems and can work over a variety of communication media. The services are exposed by a server and then accessed by a client program. In our case the client program will be running on a Windows Phone.


Server
Service
Proxy Object
COMMUNICATION SERVICE DEMO
joke client
What's green and hairy and goes up and down? A gooseberry in a lift
Load
01

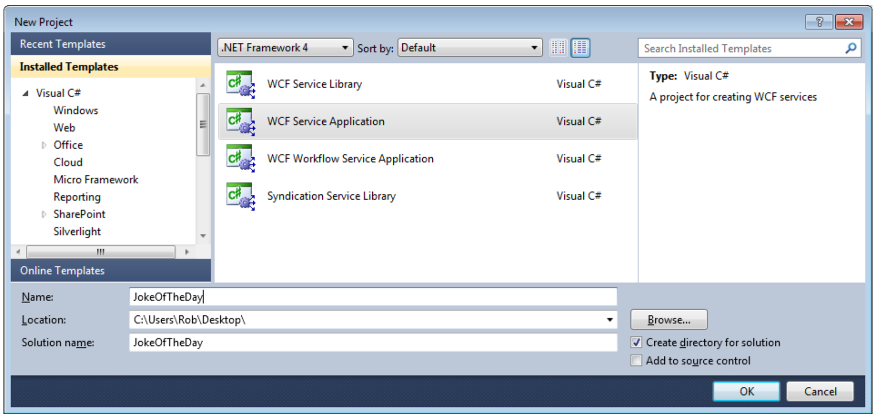
The diagram shows how this works. Software on the phone interacts with a “proxy object” that contains the methods provided by the service. A call to a method on the proxy object will cause a network message to be created that is sent to the service on the server. When the server receives the message it will then call the method code in a server object. The result to be returned by the method will then be packaged up into another network message which is sent back to the client which then sends the return value back to the calling software. We don’t need to worry about how the messages are constructed and transferred. We just have to create our server methods and calls from the client systems.

The service also exposes a description of the methods that it provides. This is used by the development tool (in our case Visual Studio) to actually create the proxy object in the client program. This means that we can create a client application very easily.

Joke of the Day service

To discover how all this works we are going to create a “Joke of the Day” service. This will return a string containing something suitably rib-tickling on request from the client. The user will be able to select the “strength” of the joke, ranging from 0 to 2 where 0 is mildly amusing and 2 is a guaranteed roll on the floor laughing experience.

The application will be made up of two parts, the server program that exports the service and the client program that uses it. The server will be created as a WCF (Windows Communication Foundation) Service application. The client will be a Windows Phone application that connects to the service and requests a joke.



Type: Visual C#
A project for creating WCF services

Name: JokeOfTheDay
Location: C:\Users\Rob\Desktop\
Solution name: JokeOfTheDay
[✓] Create directory for solution
[ ] Add to source control

Services are created as Visual Studio projects. They can run inside Visual Studio in a test environment. After testing the project files would be loaded onto a production server.

Services and Clients

Services and clients look like methods. When we write the server we write a method that does something and returns a result. When we write the client we call a method and something comes back. The communication service underneath the programs takes care of packaging the parameters and the method return value. When we create the service we create an interface that defines the method the service will provide.

```
[ServiceContract]
public interface IJokeOfTheDayService
{

    [OperationContract]
    string GetJoke(int jokeStrength);

}
```

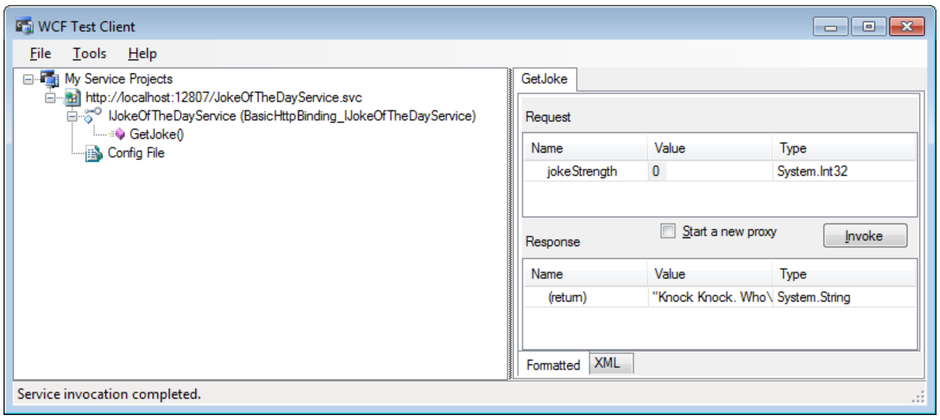
We are only going to create one method in our service, but a service could provide many methods if required. This method only accepts a single parameter and returns a result, but we could create more complex methods if we wish.

Once we have the interface we can now create the method to provide the service that the service describes. The `[ServiceContract]` and `[OperationContract]` attributes on the classes and methods provide the means by which the build process can generate the service descriptions that will be used by clients to discover and bind to these services.

```
public class JokeOfTheDayService : IJokeOfTheDayService
{
    public string GetJoke(int jokeStrength)
    {
        string result = "Invalid strength";
        switch (jokeStrength)
        {
            case 0:
                result =
"Knock Knock. Who's there? Oh, you've heard it";
                break;
            case 1:
                result =
"What's green and hairy and goes up and down? A gooseberry in a
lift";
                break;
            case 2:
                result =
"A horse walks into a bar and the barman asks 'Why the long face?";
                break;
        }
        return result;
    }
}
```

As you can see from above, the method is quite simple. As are the jokes. The input parameter is used to select one of three jokes and return them. If there is no match to the input the message "Invalid strength" is returned.

If we create a service like this we can use the WCF Test Client to invoke the methods and view the results.

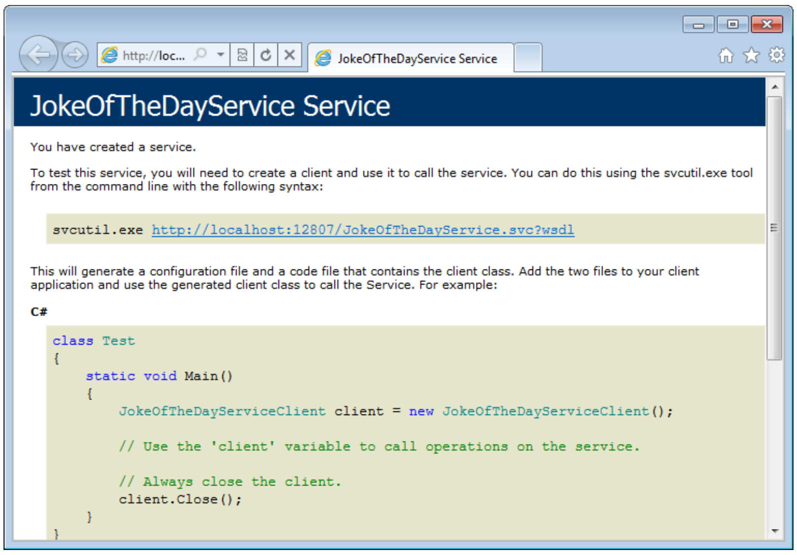


Name	Value	Type
jokeStrength	0	System.Int32

Name	Value	Type
(return)	"Knock Knock. Who\	System.String

Service invocation completed.

This tool lets us call methods in the service and view the results that they return. You can see the results of a call to the method with a parameter of 0. We can also view the service description in a browser:



JokeOfTheDayService Service

You have created a service.

To test this service, you will need to create a client and use it to call the service. You can do this using the svcutil.exe tool from the command line with the following syntax:

```
svcutil.exe http://localhost:12807/JokeOfTheDayService.svc?wsdl
```

This will generate a configuration file and a code file that contains the client class. Add the two files to your client application and use the generated client class to call the Service. For example:

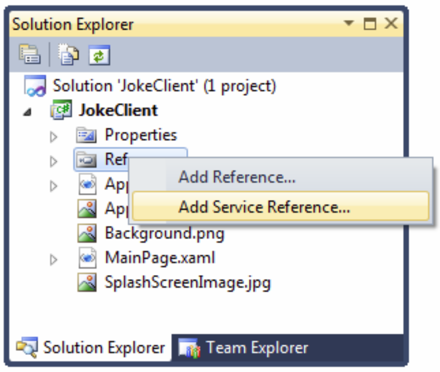
C#

```
class Test
{
    static void Main()
    {
        JokeOfTheDayServiceClient client = new JokeOfTheDayServiceClient();

        // Use the 'client' variable to call operations on the service.

        // Always close the client.
        client.Close();
    }
}
```

This gives a link to the service description, as well some sample code that shows how to use it.

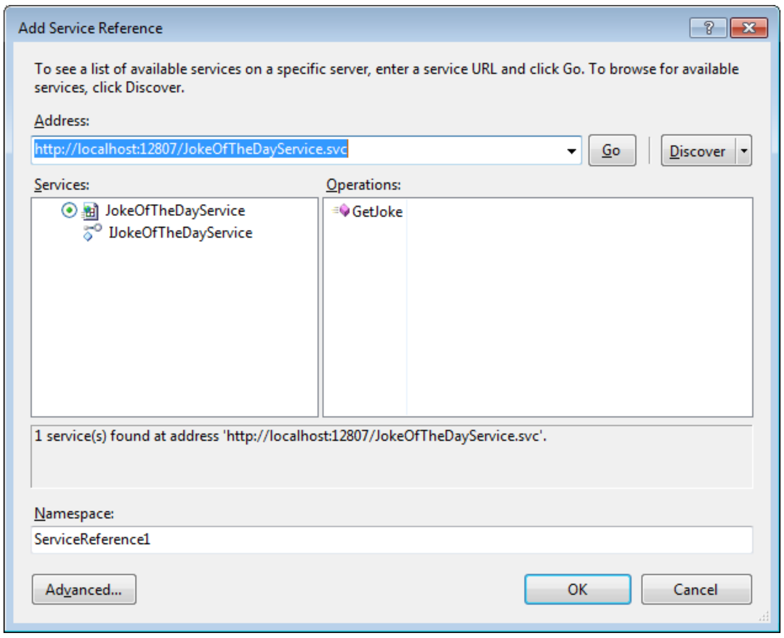
Joke of the Day Client

The client application needs to have a connection to the `JokeOfTheDayService`. This is added as a resource like any other, by using the Solution Explorer pane in Visual Studio:



Rather than being a reference to a library assembly we instead start to create a Service reference. At this point Visual Studio needs to find the description of the service that is to be used. The Add Service Reference dialog lets us type in the network address of a service and it will then read the service description provided by the service.

It is very easy to create and test WCF services as these can be run on your Windows PC using a Development Server which is provided as part of Visual Studio. Once we have the service running and have obtained the url of the service on from the development server we just have to type this into the “Add Service Reference” dialog as shown below.


Add Service Reference

To see a list of available services on a specific server, enter a service URL and click Go. To browse for available services, click Discover.

Address: http://localhost:12807/JokeOfTheDayService.svc

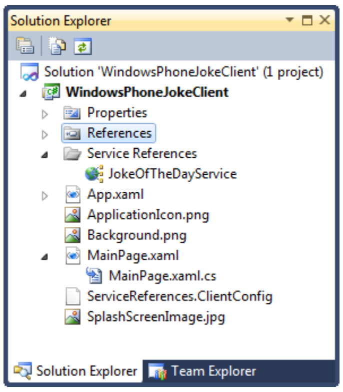
Services:
- JokeOfTheDayService
  - IJokeOfTheDayService

Operations:
- GetJoke

1 service(s) found at address 'http://localhost:12807/JokeOfTheDayService.svc'.

Namespace: ServiceReference1

The Add Service Reference dialog will read the service description and show the operations available from that service. Above you can see that the `JokeOfTheDay` service only provides one method. At the bottom of this dialog you can see the namespace that we want the service to have in our Windows Phone client application. We can change this name to `JokeOfTheDayService`.


Solution Explorer

- Solution 'WindowsPhoneJokeClient' (1 project)
  - WindowsPhoneJokeClient
    - Properties
    - References
    - Service References
      - JokeOfTheDayService
    - App.xaml
    - ApplicationIcon.png
    - Background.png
    - MainPage.xaml
      - MainPage.xaml.cs
    - ServiceReferences.ClientConfig
    - SplashScreenImage.jpg

Once the service has been added it now takes its place in the solution. Our application must now create a proxy object that will be used to invoke the methods in the service. The best place to do this is in the constructor of the main page:

```
JokeOfTheDayService.JokeOfTheDayServiceClient jokeService;

// Constructor
public MainPage()
{
    InitializeComponent();

    jokeService = new
JokeOfTheDayService.JokeOfTheDayServiceClient();

    jokeService.GetJokeCompleted +=
        new
EventHandler<JokeOfTheDayService.GetJokeCompletedEventArgs>
            (jokeService_GetJokeCompleted);
}
```

This code creates a service instance and binds a method to the "completed" event that is fired when a service call returns. You might remember that when we got content from a web server the action was performed asynchronously, in that the program sent off a request to read the service and then another method was called when the data had returned. Calls to WCF methods are exactly the same. When the program wants a new joke it must call the `GetJoke` method. This will not return with the joke, instead it will start off the process of fetching a joke. At some point in the future, when the joke arrives back from the server, a method will be called to indicate this. All the method needs to do is display the joke on the screen:

```
void jokeService_GetJokeCompleted(object sender,
    JokeOfTheDayService.GetJokeCompletedEventArgs e)
{
    if (!e.Cancelled)
    {
        jokeTextBlock.Text = e.Result;
    }
}
```

This method just checks to see if the call was successful and if it was the method takes the result from the call and puts it on the screen.

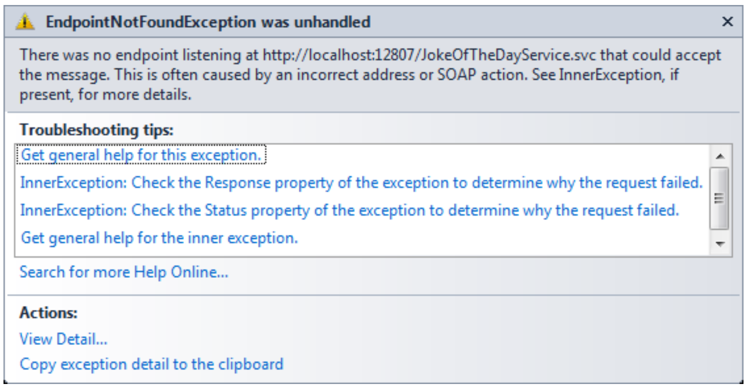
The final piece of code that we need to add is the button event handler that will actually call the WCF method to ask the server to do something:

```
private void getJokeButton_Click(object sender,
RoutedEventArgs e)
{
    int strength = 0;

    if (int.TryParse(strengthTextBox.Text, out strength))
    {
        jokeService.GetJokeAsync(strength);
    }
}
```

This method gets the strength value and then uses this in a call of the `GetJokeAsync` method. Note that `TryParse` will return false if the text in `strengthTextBox` could not be converted into an integer.

Errors and TimeOuts

If the service cannot be accessed the call to `GetJokeAsync` will throw an exception:



EndpointNotFoundException was unhandled

There was no endpoint listening at http://localhost:12807/JokeOfTheDayService.svc that could accept the message. This is often caused by an incorrect address or SOAP action. See InnerException, if present, for more details.

Troubleshooting tips:

Get general help for this exception.
InnerException: Check the Response property of the exception to determine why the request failed.
InnerException: Check the Status property of the exception to determine why the request failed.
Get general help for the inner exception.

Search for more Help Online...

Actions:

View Detail...
Copy exception detail to the clipboard

We know that the connectivity of a Windows Phone is not guaranteed. If they do not have a network signal when they run this program then it will throw the above exception. In production code you must make sure that these exceptions never get passed through to the user. This means that you need to enclose all your attempts to use these facilities in `try` – `catch` constructions and provide appropriate feedback to the user when these events happen.

Using Network Services

For the purpose of the demonstration above I used a network server that runs on the same machine as the client. In reality you will be connecting to different systems on the internet which may be a long way away. This is not a problem. As long as Visual Studio can locate the service and download the service information it can then build the correct proxy objects to use the service correctly. If you want to test a service you can connect to a local service initially and then re-configure the service uri later to connect to the actual service.

The solution in *Demo 04a JokeService* contains a server which provides the joke service as described above. You can run this service on your machine and use the solution in *Demo 04b WindowsPhoneJokeClient* to connect to this service and read jokes from it. When you run the program you need to make sure that the development server url assigned to the service matches that of the service in the client.

We can now create systems that use Windows Phones as clients to servers. A given Windows Phone client can connect to multiple remote services at the same time if required. This is just an introduction to the things you can do with network services. Later we will look at some of the Windows Phone controls that build on these abilities.

What we have learned

1. Windows Phone applications can create and use objects that represent a connection to a network service. The use of these objects is *asynchronous*, in that the results of a request are not returned to that request, but delivered later by a further call made by the network client.
2. Some network calls may return structured data that contains XML describing the content.
3. The LINQ (Language INtegrated Query) library provided for use on the phone can create a representation of structured data which can then be traversed to create structured data for use in a program.
4. LINQ can used be to provide an automatic transfer of data from the rows and tables in a database into objects that can be used in a program.
5. XAML allows the creation of display templates which can be bound to data elements. These templates can include lists, so that a collection of structured data can be bound to a list.
6. Windows Communication Foundation (WCF) provides a means by which servers can be set up that expose methods for clients to call.
7. A client application can read the service description provided by a WCF server and use this to create a *proxy object* that contains the methods provided by the service. When code in the client calls the method in the proxy object a network transaction is performed that transfers the parameters of the call into the server. The server method is then invoked and a further network transaction delivers the result back to the caller.

6 XNA Overview

After all the hard work of the previous sections, now would seem a good place to have some fun and play some games. You can write games in Silverlight, but that is not really what it was designed for. XNA on the other hand was built from the ground up to be an efficient and powerful tool for game creation. In this section we are going to take a look at XNA and how to use it to create games for the Windows Phone device.

6.1 XNA in context

XNA is for creating games. It provides a complete ecosystem for game creation, including Content Management (how you get your sound effects, maps and textures into a game) and the game build process (how you combine all the elements into the single distributable game element). We are not going to delve too deeply into all these aspects of the system, instead we are going to focus on the XNA Framework, which is a library of C# objects that is used to create the games programs themselves. XNA allows game developers to use C# to create high performance games on a variety of platforms, including Windows PC, Xbox 360 and Windows Phone. By careful design of your program structure it is possible to reuse the base majority of your game code across these three platforms.

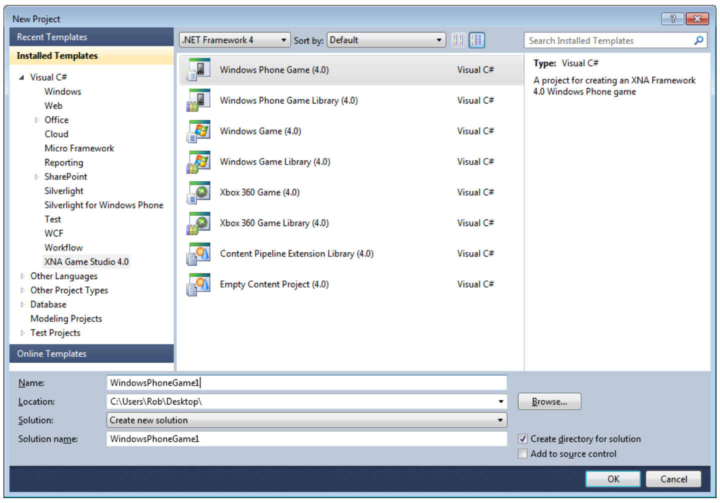
2D and 3D games

Games can be “2D” (flat images that are drawn in a single plane) or “3D” (a visual simulation of a 3D environment). XNA provides support for both kinds of games and the Windows Phone hardware acceleration makes it capable of displaying realistic 3D worlds. For the purpose of this section we are going to focus on 2D, sprite based, games however. We can create a good gameplay experience this way, particularly on a mobile device.

XNA and Silverlight

When we create a Windows Phone project we can create either a Silverlight application or an XNA one. Visual Studio uses the appropriate template and builds the solution with the required elements to make that kind of program. It is not possible to combine these. It would be lovely to think of a system which allowed us to use Silverlight to make the game menus and XNA to provide the gameplay but at the present this is not possible.

6.2 Making an XNA program



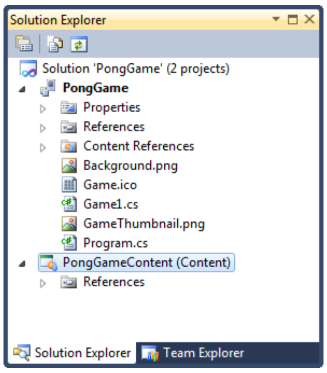
Windows Phone Game (4.0)	Visual C#
Windows Phone Game Library (4.0)	Visual C#
Windows Game (4.0)	Visual C#
Windows Game Library (4.0)	Visual C#
Xbox 360 Game (4.0)	Visual C#
Xbox 360 Game Library (4.0)	Visual C#
Content Pipeline Extension Library (4.0)	Visual C#
Empty Content Project (4.0)	Visual C#

Type: Visual C#

A project for creating an XNA Framework 4.0 Windows Phone game

Name: WindowsPhoneGame1
Location: C:\Users\Rob\Desktop\
Solution: Create new solution
Solution name: WindowsPhoneGame1
[✓] Create directory for solution
[ ] Add to source control

The New Project dialog in Visual Studio lets us select Windows Phone Game as the project type. If we want to make an XNA game for Windows PC or Xbox 360 we can do that here as well. One thing worth bearing in mind is that it is possible to use an existing XNA project as the basis of one for another platform, inside the same solution. Visual Studio will copy a project and make a new version which targets the new device. This means that we can take a Windows Phone XNA game and make a version for the Xbox 360 if we wish.



The Solution for an XNA project looks rather like a Silverlight one, but there are some differences. There is a second project in the solution which is specifically for game content. This is managed by the Content Manager which provides a set of input filters for different types of resources, for example PNG images, WAV sound files etc. These resources are stored within the project and deployed as part of the game onto the target platform. When the game runs the Content Manager loads these resources for use in the game. The result of this is that whatever the platform you are targeting the way that content assets are managed is the same as far as you are concerned.

One thing you need to be aware of though is that Windows Phone has a reduced display size compared to the Windows PC and Xbox 360 platforms. The maximum resolution of a Windows Phone game is 800x480 pixels. To make your XNA games load more quickly and take up less space it is worth resizing your game assets for the Windows Phone platform.

If you run the new game project as created above you will be rewarded by a blue screen. This is not the harbinger of doom that it used to be, but simply means that the initial behaviour of an XNA game is to draw the screen blue.

How an XNA game runs

If you look at a Silverlight application you will find that a lot of the time the program never seems to be doing anything. Actions are only carried out in response to events, for example when a user presses a button, or a network transaction completes, or a new display page is loaded.

XNA programs are quite different. An XNA program is continuously active, updating the game world and drawing the display. Rather than waiting for an input from a device, an XNA game will check devices that may have input and use these to update the game model and then redraw the screen as quickly as possible. In a game context this makes a lot of sense. In a driving game your car will continue moving whether you steer it or not (although this might not end well). The design of XNA recognises that the game world will update all the time around the player, rather than the player initiating actions.

When an XNA game runs it actually does three things:

1. Load all the content required by the game. This includes all the sounds, textures and models that are needed to create the game environment.
2. Repeatedly run the Game Engine
    - Update the game world. Read controller inputs, update the state and position of game elements.
    - Draw the game world. Take the information in the game world and use this to render a display of some kind, which may be 2D or 3D depending on the game type.

These three behaviours are mapped onto three methods in the Game class that is created by Visual Studio as part of a new game project.

```
partial class Game1 : Microsoft.Xna.Framework.Game
{

    protected override void LoadContent
                               (bool loadAllContent)
    {
    }
    protected override void Update(GameTime gameTime)
    {
    }
    protected override void Draw(GameTime gameTime)
    {
    }
}
```

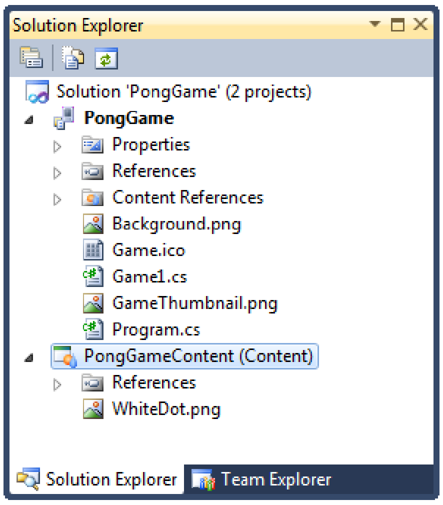
When we write a game we just have to fill in the content of these methods. Note that we never actually call these methods ourselves, they are called by the XNA framework when the game runs. `LoadContent` is called when the game starts. The `Draw` method is called as frequently as possible and `Update` is called thirty times a second. Note that this is not the same as XNA games on the Windows PC or Xbox 360. In order to reduce power consumption a Windows Phone game only updates 30 times a second, rather than the 60 times a second of the desktop or console version of the game. If you want to write a game which will work on all three platforms you will have to bear this in mind.

Before we can start filling in the `Update` and `Draw` methods in our game we need to have something to display on the screen. We are going to start by drawing a white ball. Later we will start to make it bounce around the screen and investigate how we can use this to create a simple bat and ball game.

Game Content

We use the word *content* to refer to all the assets that make a game interesting. This includes all the images on the textures in a game, the sound effects and 3D models. The XNA framework Content Management system can take an item of content from its original source file (perhaps a PNG image) all the way into the memory of the game running on the target device. This is often called a *content pipeline* in that raw resources go into one end and they are then processed appropriately and finally end up in the game itself.

The content management is integrated into Visual Studio. Items of content are managed in the same way as files of program code. We can add them to a project and then browse them and manage their properties.



Above you can see an item of content which has been added to a Content project. The item is a PNG (Portable Network Graphics) image file that contains a White Dot which we could use as a ball in our game. This will have the asset name “WhiteDot” within our XNA game. Once we have our asset as part of the content of the game we can use it in games.

We have seen something that looks a bit like this in the past when we added resources to Silverlight games. Those resources have actually been part of Visual Studio solutions as well. However, it is important that you remember that the Content Manager is specifically for XNA games and is how you should manage XNA game content.

Loading Content

The `LoadContent` method is called to load the content into the game. (the clue is in the name). It is called once when the game starts running.

```
protected override void LoadContent()
{
    // Create a new SpriteBatch, which can be used to
    // draw textures.
    spriteBatch = new SpriteBatch(GraphicsDevice);

}
```

The first thing that `LoadContent` does is actually nothing to do with content at all. It creates a new `SpriteBatch` instance which will be used to draw items on the screen. We will see what the `SpriteBatch` is used for later.

We can add a line to this method that loads image into our game:

```
ballTexture  = Content.Load<Texture2D>("WhiteDot");
```

The `Load` method provided by the content manager is given the type of resource to be loaded (in this case `Texture2D`). The appropriate loader method is called which loads the texture into the game.

```
Texture2D ballTexture;
```

XNA provides a type called `Texture2D` which can hold a single two-dimensional texture in a game. Later in the program we will draw this on the screen. A game may contain many textures. At the moment we are just going to use one.

Creating XNA sprites

In computer gaming terms a sprite is an image that can be positioned and drawn on the display. In XNA terms we can make a sprite from a texture (which gives the picture to be drawn) and a rectangle (which determines the position on the screen). We already have the texture, now we need to create the position information.

XNA uses a coordinate system that puts the origin (0,0) of any drawing operations in the top left hand corner of the screen. This is not same as a conventional graph, where we would expect the origin to be the bottom left hand corner of the graph. In other words, in an XNA game if you increase the value of Y for an object this causes the object to move down the screen.

The units used equate to pixels on the screen itself. Most Windows Phones have a screen resolution of 800 x 480 pixels. If we try to draw objects outside this area XNA will not complain, but it won't draw anything either.

XNA provides a `Rectangle` structure to define the position and size of an area on the screen.

```
Rectangle ballRectangle = new Rectangle(
        0, 0,
        ballTexture.Width, ballTexture.Height);
```

The above code creates a rectangle which is positioned at the top left hand corner of the screen. It is the same width and height as the ball texture.

Drawing objects

Now that we have a sprite the next thing we can do is make the game draw this on the screen. To do this we have to fill in the `Draw` method.

```
protected override void Draw(GameTime gameTime)
{
    GraphicsDevice.Clear(Color.CornflowerBlue);

    base.Draw(gameTime);
}
```

This is the "empty" `Draw` method that is provided by Visual Studio when it creates a new game project. It just clears the screen to blue. We are going to add some code to the method that will draw our ball on the screen. Before we can do this we have to understand a little about how graphics hardware works.

Modern devices have specialised graphics hardware that does all the drawing of the screen. A Windows Phone has a Graphics Processor Unit (GPU) which is given the textures to be drawn, along with their positions, and then renders these for the game player to see. When a program wants to draw something it must send a batch of drawing instructions to the GPU. For maximum efficiency it is best if the draw requests are be batched together so that they can be sent to the GPU in a single transaction. We do this by using the `SpriteBatch` class to do the batching for us.

```
protected override void Draw(GameTime gameTime)
{
    GraphicsDevice.Clear(Color.CornflowerBlue);

    spriteBatch.Begin();

    // Draw operations go here

    spriteBatch.End();

    base.Draw(gameTime);
}
```

When we come to write our game the only thing we have to remember is that our code must start and end a batch of drawing operations, otherwise the drawing will not work.

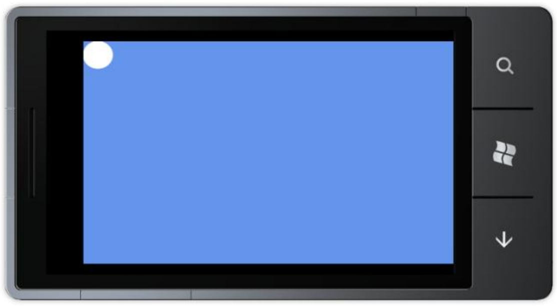
We now have our texture to draw and we know how the draw process will work, the next thing to do is position the draw operation on the screen in the correct place. Once we have done this we will have created a *sprite*. The `SpriteBatch` command that we use to draw on the screen is the `Draw` method:

```
spriteBatch.Draw(ballTexture, ballRectangle, Color.White);
```

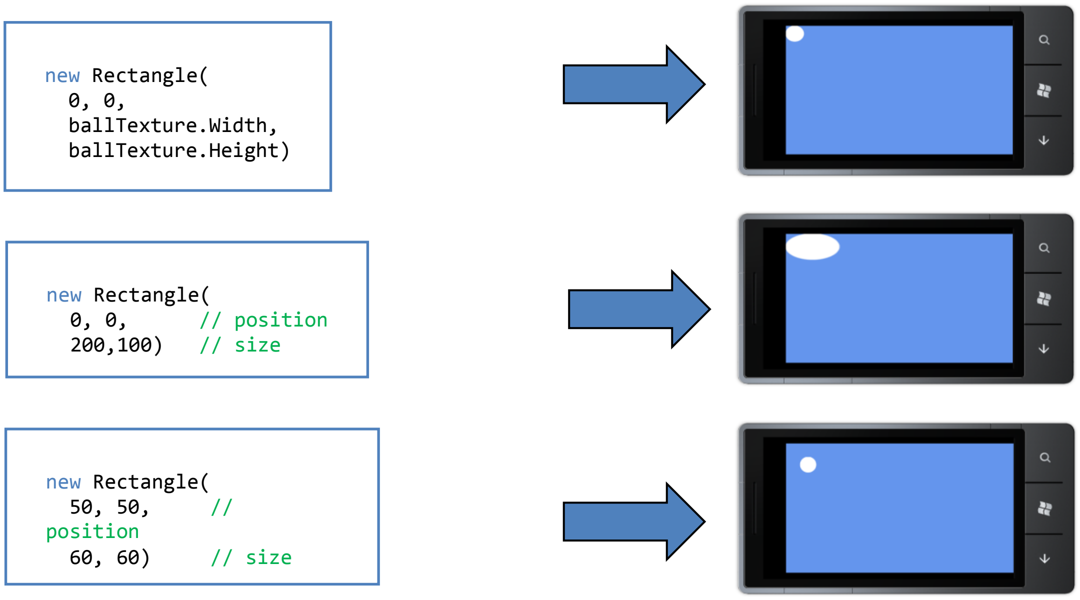
The `Draw` method is given three parameters; the texture to draw, a `Rectangle` value that gives the draw position and the color of the “light” to shine on the texture when it is drawn. The complete `Draw` method looks like this

```
protected override void Draw(GameTime gameTime)
{
    GraphicsDevice.Clear(Color.CornflowerBlue);

    spriteBatch.Begin();

    spriteBatch.Draw(ballTexture, ballRectangle, Color.White);


    spriteBatch.End();

    base.Draw(gameTime);
}
```

When we run this program we find that the ball is drawn in the top left hand corner of the screen on the phone:



Note that, by default, XNA games expect the player to hold the phone horizontally, in “landscape” mode, with the screen towards the left. We will see later that your game can change this arrangement if it needs to.



```
new Rectangle(
  0, 0,
  ballTexture.Width,
  ballTexture.Height)
```

```
new Rectangle(
  0, 0,       // position
  200,100)    // size
```

```
new Rectangle(
  50, 50,      //
position
  60, 60)      // size
```

The first version of our program drew the ball with the same size as the original texture file. However, we can use whatever size and position we like for the drawing process and XNA will scale and move the drawing appropriately, as you can see above.

The solution in *Demo 01White Dot* contains a Windows Phone XNA game that just draws the white dot in the top left hand corner of the display.

Screen Sizes and Scaling

When you make a game it is important that it looks the same whenever it is played, irrespective of the size of the screen on the device used to play it. Windows Phone devices have a particular set of resolutions available to them, as do Windows PC and Xbox 360s. If we want to make a game that looks the same on each device the game must be able to determine the dimensions of the screen in use and then scale the display items appropriately.

An XNA game can obtain the size of the screen from the properties of the viewport used by the graphics adapter.

```
ballRectangle = new Rectangle(
    0, 0,
    GraphicsDevice.Viewport.Width / 20,
    GraphicsDevice.Viewport.Width / 20);
```

This code creates a ball rectangle that will be a 20th of the width of the display, irrespective of the size of the screen that is available.

Updating Gameplay

At the moment the game draws the ball in the same place every time. A game gives movement to the objects in it by changing their position each time they are drawn. The position of objects can be updated in the aptly named `Update` method. This is called thirty times a second when the game is running. We could add some code to update the position of the ball:

```
protected override void Update(GameTime gameTime)
{

    ballRectangle.X++;
    ballRectangle.Y++;

    base.Update(gameTime);
}
```

This version of `Update` just makes the X and Y positions of the ball rectangle one pixel bigger each time it is called. This causes the ball to move down (remember that the Y origin is the top of the screen) and across the screen at a rate of one pixel every thirtieth of a second. After fifteen seconds or so the ball has left the screen and will continue moving (although not visible) until we get bored and stop the game from running.

Using floating point positions

The code above moves the ball one pixel each time `Update` is called. This doesn't give a game very precise control over the movement of objects. We might want a way to move the ball very slowly. We do this by creating floating point variables that will hold the ball position:

```
float ballX;
float ballY;
```

We can update these very precisely and then convert them into pixel coordinates when we position the draw rectangle:

```
ballRectangle.X = (int)(ballX + 0.5f);
ballRectangle.Y = (int)(ballY + 0.5f);
```

The above statements take the floating point values and convert them into the nearest integers, rounding up if required. We can also use floating point values for the speed of the ball:

```
float ballXSpeed = 3;
float ballYSpeed = 3;
```

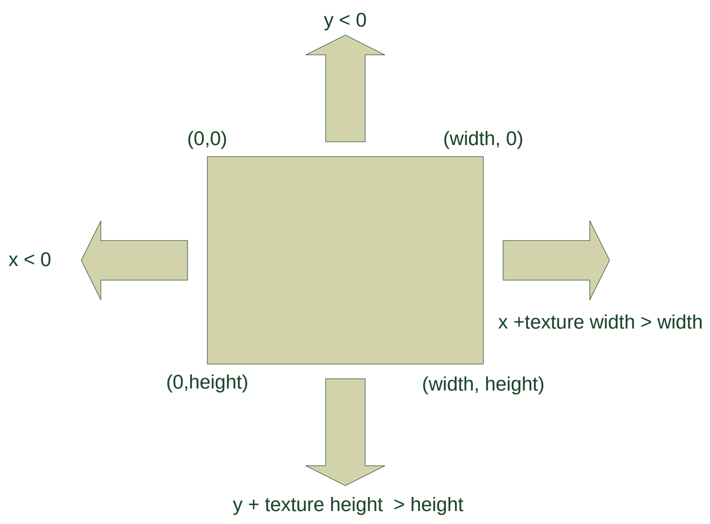
Each time the ball position is updated we now apply the speed values to the ball position:

```
ballX = ballX + ballXSpeed;
ballY = ballY + ballYSpeed;
```

Now that we can position the ball and control the speed very precisely we can think about making it bounce off the edge of the screen.

Making the ball bounce

Our first game just made the ball fly off the screen. If we are creating some kind of bat and ball game we need to make the ball "bounce" when it reaches the screen edges. To do this the game must detect when the ball reaches the edge of the display and update the direction of movement appropriately. If the ball is going off the screen in a horizontal direction the game must reverse the X component of the ball speed. If the ball is going of the top or the bottom of the screen the game must reverse the Y component of the ball speed.



The figure above shows the directions the ball can move off the screen and the conditions that become true when the ball moves in that direction.

```
if (ballX < 0 ||
    ballX + ballRectangle.Width >
GraphicsDevice.Viewport.Width)
{
    ballXSpeed = -ballXSpeed;
}
```

The code above reverses the direction of the ball in the X axis when the ball moves off either the left or right hand edge of the display. We can use a similar arrangement to deal with movement in the Y direction.

The solution in *Demo 03 Bouncing Ball* contains a Windows Phone XNA game that just draws a ball that bounces around the display.

Adding paddles to make a bat and ball game

We now have a ball that will happily bounce around the screen. The next thing that we need is something to hit the ball with.

The paddle is a rectangular texture which is loaded and drawn in exactly the same way as the ball. The finished game uses two paddles, one for the left hand player and one for the right. In the first version of the game we are going to control the left paddle and the computer will control the right hand one. This means that we have three sprites on the screen. Each will need a texture variable to hold the image on the sprite and a rectangle value to hold the position of the sprite on the screen.

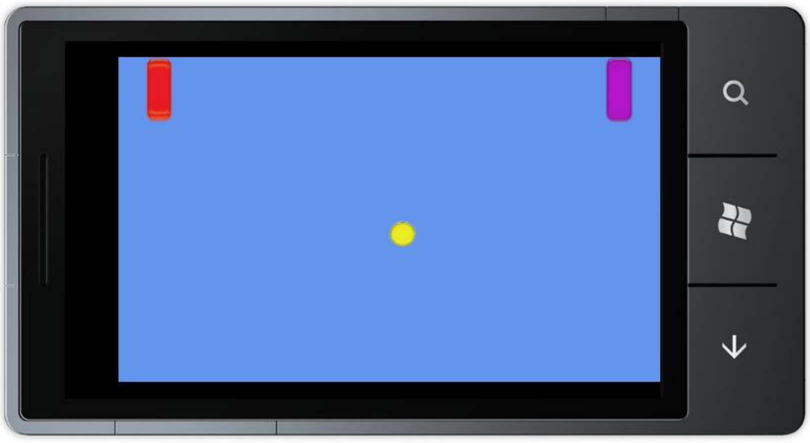
```
// Game World
Texture2D ballTexture;
Rectangle ballRectangle;
float ballX;
float ballY;
float ballXSpeed = 3;
float ballYSpeed = 3;


Texture2D lPaddleTexture;
Rectangle lPaddleRectangle;
float lPaddleSpeed = 4;
float lPaddleY;

Texture2D rPaddleTexture;
Rectangle rPaddleRectangle;
float rPaddleY;

// Distance of paddles from screen edge
int margin;
```

These variables represent our "Game World". The `Update` method will update the variables and the `Draw` method will use their values to draw the paddles and ball on the screen in the correct position.

When the game starts running the `LoadContent` will fetch the images using the Content Manager and then set up the draw rectangles for the items on the screen.

```
protected override void LoadContent()
{
    // Create a new SpriteBatch, which is used to draw
textures.
    spriteBatch = new SpriteBatch(GraphicsDevice);

    ballTexture = Content.Load<Texture2D>("ball");
    lPaddleTexture = Content.Load<Texture2D>("lpaddle");
    rPaddleTexture = Content.Load<Texture2D>("rpaddle");

    ballRectangle = new Rectangle(
        GraphicsDevice.Viewport.Width/2,
        GraphicsDevice.Viewport.Height/2,
        GraphicsDevice.Viewport.Width / 20,
        GraphicsDevice.Viewport.Width / 20);

    margin = GraphicsDevice.Viewport.Width / 20;

    lPaddleRectangle = new Rectangle(
        margin, 0,
        GraphicsDevice.Viewport.Width / 20,
        GraphicsDevice.Viewport.Height / 5);

    rPaddleRectangle = new Rectangle(
        GraphicsDevice.Viewport.Width -
            lPaddleRectangle.Width - margin, 0,
        GraphicsDevice.Viewport.Width / 20,
        GraphicsDevice.Viewport.Height / 5);

    lPaddleY = lPaddleRectangle.Y;
    rPaddleY = rPaddleRectangle.Y;
}
```

This `LoadContent` method repays careful study. It loads all the textures and then positions the paddle draw positions each side of the screen as shown below.



When the game starts the ball will move and the paddles will be controlled by the player.

Controlling paddles using the touch screen

We can use the Windows Phone touch screen to control the movement of a paddle. We can actually get very precise control of items on the screen, but we are going to start very simple. If the player touches the top half of the screen their paddle will move up. If they touch the bottom half of the screen their paddle will move down.

The Touch Panel returns a collection of touch locations for our program to use:

```
TouchCollection touches = TouchPanel.GetState();
```

Each `TouchLocation` value contains a number of properties that tell the game information about the location, including the location on the screen where the touch took place. We can use the Y component of this location to control the movement of a paddle.

```
if (touches.Count > 0)
{
    if (touches[0].Position.Y > GraphicsDevice.Viewport.Height
/ 2)
    {
        lPaddleY = lPaddleY + lPaddleSpeed;
    }
    else
    {
        lPaddleY = lPaddleY - lPaddleSpeed;
    }
}
```

The first statement in this block of code checks to see if there are any touch location values available. If there are it gets the location of the first touch location and checks to see if it is above or below the mid-point of the screen. It then updates the position of the paddle accordingly. If we run this program we find that we can control the position of the left hand paddle.

The solution in *Demo 04 Paddle Control* contains a Windows Phone XNA game that draws a ball that bounces around the display. You can also control the movement of the left hand paddle by touching the top or bottom of the screen area.

You can use the touch panel for much more advanced purposes than the example above. You can track the location and movement of a particular touch event very easily. You can also ask the touch panel to detect gestures that you are interested in.

Detecting Collisions

At the moment the bat and the ball are not “aware” of each other. The ball will pass straight through the bat rather than bounce off it. What we need is a way to determine when two rectangles intersect.

The `Rectangle` structure provides a method called `Intersects` that can do this for us:

```
if (ballRectangle.Intersects(lPaddleRectangle))
{
    ballXSpeed = -ballXSpeed;
}
```

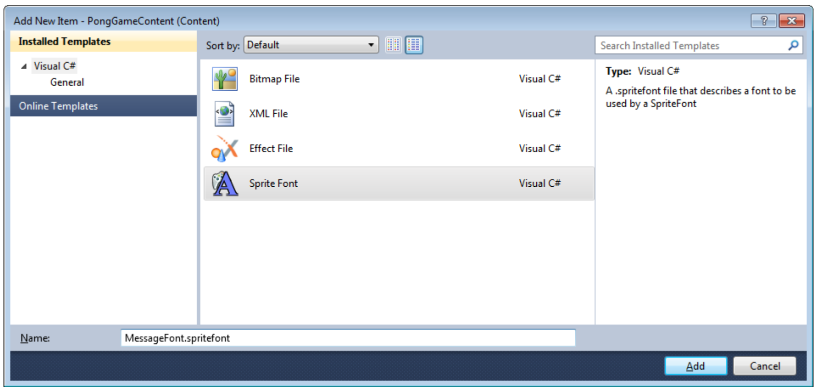
The above code tests to see if the ball has hit the left hand paddle. If it has the direction of movement of the ball is reversed to make the ball bounce off the paddle.

Keeping score

For the game to be worth playing it must also keep a score and display this for the players. Points are scored by hitting the back wall of the opponent player. We already have the code that does this. At the moment it just reverses the direction of movement of the ball, it is a simple matter to add a score variable for each player and increase this each time a “goal” is scored. The final thing we need to be able to do at this point is display the score for the players to see. To do this we need to find out how an XNA game draws text for a player.

Displaying Text

The XNA environment does not provide direct access to text drawing. To write text on the screen a game must load a character font and then use this to draw the characters. The font to be used is an item of game content which we need to add to the game. When the font is added the size and the font design is selected. When the game is built the Content Manager will build a set of character images and add these to the game. The game can then draw the text on the game screen along with the other game items.


Add New Item - PongGameContent (Content)

Installed Templates
Visual C#
General
Online Templates

Sort by: Default

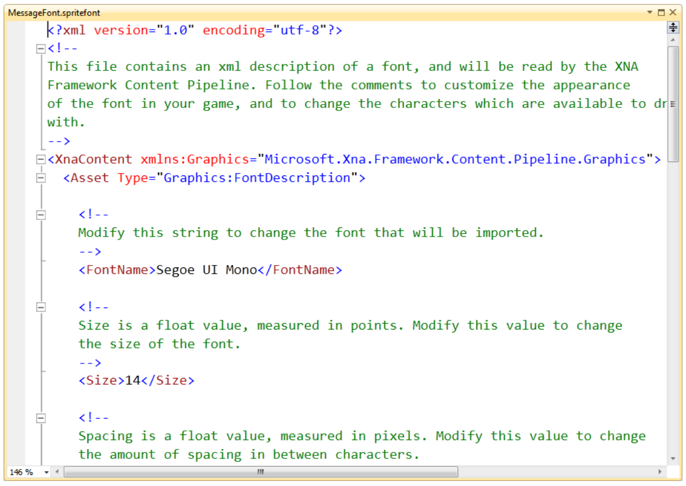
Search Installed Templates

Bitmap File	Visual C#
XML File	Visual C#
Effect File	Visual C#
Sprite Font	Visual C#

Type: Visual C#
A .spritefont file that describes a font to be used by a SpriteFont

Name: MessageFont.spritefont

The font, called a “SpriteFont”, is created as a new item and given a name. The actual font information is held in an XML file which you can edit with Visual Studio:



```
<?xml version="1.0" encoding="utf-8"?>
<!--
This file contains an xml description of a font, and will be read by the XNA
Framework Content Pipeline. Follow the comments to customize the appearance
of the font in your game, and to change the characters which are available to dr
with.
-->
<XnaContent xmlns:Graphics="Microsoft.Xna.Framework.Content.Pipeline.Graphics">
  <Asset Type="Graphics:FontDescription">

    <!--
    Modify this string to change the font that will be imported.
    -->
    <FontName>Segoe UI Mono</FontName>

    <!--
    Size is a float value, measured in points. Modify this value to change
    the size of the font.
    -->
    <Size>14</Size>

    <!--
    Spacing is a float value, measured in pixels. Modify this value to change
    the amount of spacing in between characters.
```

This file is where the font size and the name of the font are selected. Above you can see that the font "Segoe UI Mono" is being used with a font size of 14. Further down the XML file you will find settings for bold and italic versions of the font.

Once the `SpriteFont` has been added to the content in a program it can then be loaded when the program runs:

```
SpriteFont font;


font = Content.Load<SpriteFont>("MessageFont");
```

Note that this is exactly the same format as the Load we used to fetch the textures in our game only this time it is being used to fetch a `SpriteFont` rather than a `Texture2D`.

Once we have the font we can use it to draw text:

```
spriteBatch.DrawString( font, "Hello", new Vector2(50,100),
    Color.White);
```

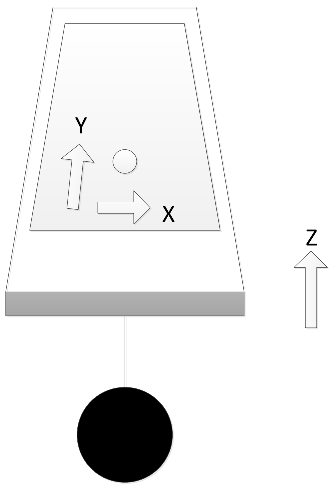
The `DrawString` method is given four parameters. These are the font to use, the string to display, a vector to position the text on the screen and the colour of text to draw. A vector is a way that we can specify a position on the screen, in the example code above the text would be drawn 50 pixels across the screen and 100 pixels down (remember that the origin for Y is at the top of the screen).

The solution in *Demo 05 Complete Pong Game* contains a Windows Phone XNA game that implements a working pong game. The left hand paddle is controlled by the touch panel. The right hand paddle is controlled by an ultra-intelligent AI system that makes it completely unbeatable. Take a look at the code to discover how this top secret technology works. This game is not perfect. Because of the way the ball movement is managed it can sometimes get "stuck" on a paddle or off the edge of the screen. It is up to you to make a completed version of this.

6.3 Using the accelerometer in games

The touch panel is not the only novel input device provided by the Windows Phone. Games can also make use of the accelerometer so that we can create games that are controlled by the tipping of the phone. The accelerometer can measure acceleration in three axes. While it can be used to measure acceleration (you could use your Windows Phone to measure the acceleration of your sports car if you like) it is most often used to measure the orientation of the phone. This is because the accelerometer is acted on by gravity, which gives a constant acceleration of 1 towards the centre of the earth.

You can visualize the accelerometer as a weight on the end of a spring, attached to the back of the phone. The picture below shows us how this might look.



If we hold the phone flat as shown, the weight will hang straight down underneath the phone. If we were to measure the distance in the X, Y and Z directions of the weight relative to the point where it is attached to the phone it would read 0, 0, -1, assuming that the spring is length 1. The value of Z is -1 because at the moment the position of the weight is below the phone and the coordinate system being used has Z, the third dimension, increasing as we move up from the display.

If you tip the bottom of the phone up so that the far edge of the phone is now pointing towards your shoes the weight would swing away from you, increasing the value of Y that it has relative to the point where the string is attached. If you tip the bottom of the phone down, so that the phone tilts towards you and you can see the screen properly, the weight moves the other way, and the value of Y becomes less than 0. If the phone is vertical (looking a bit like a tombstone) the weight is directly below and in line with it. In this situation the value of Z will be 0, and the value of Y will be -1. Twisting the phone will make the weight move left or right, and will cause the value of X to change.

These are the values that we actually get from the accelerometer in the phone itself. So, at the moment the accelerometer seems to be measuring orientation (i.e. the way the phone is being held) not acceleration. If the phone starts to accelerate in other directions you can expect to see the values in the appropriate direction change as well. Our diagram above actually helps us visualise this too. If we push the phone away from us the weight will "lag" behind the phone for a second until it caught up resulting in a brief change in the Y value. We would see exactly the same effect in the readings from the accelerometer if we did move the phone in this way.

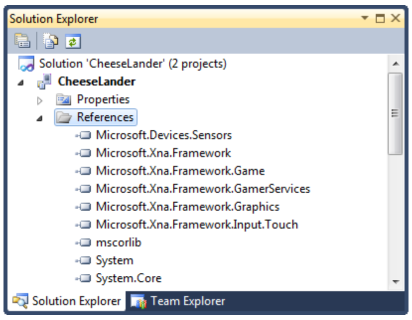
Getting readings from the accelerometer

When we used the touch panel from XNA we found that we just had to ask the panel for a list of active touch locations. It would be nice if we could do the same with the accelerometer but this is not how it works. The accelerometer driver has been written in a way that makes it useable in Silverlight programs as well. In Silverlight we were used to receiving messages from things when we wanted them to tell us something. The elements on a Silverlight page generate events when they are used and web request cause an event when they have data for us to use.

The accelerometer in Windows Phone works the same way. A program must make an instance of the `Accelerometer` class and connect a method to the `ReadingChanged` event that the class provides. Whenever the hardware has a new acceleration reading it will fire the event and deliver some new values for our program to use. If the program is written using Silverlight it can use those values directly and perhaps bind them to properties of elements on the screen. If the program is written using XNA it must make a local copy of the new values so that they used by code in the `Update` method next time it is called.

Using the Accelerometer class

Before we can use the `Accelerometer` class we need to add the system library that contains it.



Solution Explorer
Solution 'CheeseLander' (2 projects)
CheeseLander
Properties
References
Microsoft.Devices.Sensors
Microsoft.Xna.Framework
Microsoft.Xna.Framework.Game
Microsoft.Xna.Framework.GamerServices
Microsoft.Xna.Framework.Graphics
Microsoft.Xna.Framework.Input.Touch
mscorlib
System
System.Core
Solution Explorer
Team Explorer

We can also add the appropriate namespace:

```
using Microsoft.Devices.Sensors;
```

Now the game can create an instance of the accelerometer, connect an event handler to it and then start the accelerometer running.

```
protected override void Initialize()
{
    Accelerometer acc = new Accelerometer();
    acc.ReadingChanged +=
            new EventHandler<AccelerometerReadingEventArgs>

(acc_ReadingChanged);
    acc.Start();
    base.Initialize();
}
```

We can do this work in the `Initialise` method, as shown above. This is another method provided by XNA. It is called when a game starts running. It is a good place to put code to set up elements in our program. Next we have to create our event handler. This will run each time the accelerometer has a new value for the game.

```
Vector3 accelState = Vector3.Zero;

void acc_ReadingChanged
               (object sender, AccelerometerReadingEventArgs
e)
{
    accelState.X = (float)e.X;
    accelState.Y = (float)e.Y;
    accelState.Z = (float)e.Z;
}
```

This method just copies the readings from the arguments to the method call into a `Vector3` value. The `Update` method in our game can then use these values to control the movement of the game paddle:

```
lPaddleY = lPaddleY - (accelState.X * lPaddleSpeed);
```

This code is very simple. It uses the X value of the accelerometer state to control the movement up and down of the left hand side paddle. You might thing we should use the Y value from the accelerometer, but remember that our game is being played in *landscape* mode (with the phone held on its side) and the accelerometer values are always given as if the phone is held in *portrait* mode.

The accelerometer, in association with a very simple physics model, can be used to create "tipping" games, where the player has to guide a ball around a maze or past obstacles.

The solution in *Demo 06 Tipping Pong* contains a Windows Phone XNA game that implements a working pong game. The left hand paddle is controlled by tipping the phone to make the paddle move. You will notice that the further you tip the phone the faster the paddle moves, which is just how it should be.

Threads and Contention

The version of the accelerometer code above will work OK, but code like this can vulnerable to a problem because of the way the program is written. In the case of this version of the game it would not drastically affect gameplay, but this issue is worth exploring because you may fall foul of similar problems when you start writing programs like these. Mistakes like these can give rise to the worst kind of programming bug imaginable, which is where the program works fine 99.999 per cent of the time but fails every now and then.

I hate bugs like these. I'm much happier when a program fails completely every time I run it because I can easily dive in and start looking for problems. If the program only fails once in a blue moon I have to wait around until I see the fault occur.

The problem has to do with the way that accelerometer readings are created and stored. We have two processes running working at the same time.

- The accelerometer is generating readings and storing them
- The Update method is using these readings to move the paddle

However, the Windows Phone only has one computer in it, which means that in reality only one of these processes can ever be active at any given time. The operating system in Windows Phone gives the illusion of multiple computer processors by switching rapidly between each active process. This is the cause of our problem. Consider the following sequence of events:

1. Update runs and reads the X value of the acceleration
2. The Accelerometer event fires and starts running. It generates and stores new values of X, Y and Z
3. Update reads the Y and Z values from the updated values
4. Update now has "scrambled" data made up of a mix of old and new readings.

In the case of our game we don't have much of a problem here, in that it only uses the X value of the accelerometer anyway. But if we had a more advanced game which used all three values the result would be that every now and then the `Update` method would be given information that wasn't correct. In an even larger and more complex program that used multiple processes this could cause huge problems.

Of course the problem will only happen every now and then, when the timing of the two events was very close together, but the longer the program runs the more chance there is of the problem arising.

The way to solve the problem is to recognise that there are some operations in a program that should not be interruptible. We need a way to stop the accelerometer process from being able to interrupt the Update process, and vice versa. The C# language provides a way of doing this. It is called a lock.

A given process can grab a particular lock object and start doing things. While that process has the lock object it is not possible for another process to grab that object. In the program we create a lock object which can be claimed by either the event handler or the code in Update that uses the accelerometer value:

```
object accelLock = new object();

void acc_ReadingChanged
                (object sender, AccelerometerReadingEventArgs
e)
{
    lock (accelLock)
    {
        accelState.X = (float)e.X;
        accelState.Y = (float)e.Y;
        accelState.Z = (float)e.Z;
    }
}
```

The variable accelLock is of the simplest possible type, that of object. We are not actually storing any data in this object at all. Instead we are just using it as a token which can be held by one process or another. This is the new code in Update that uses the accelerometer reading and is also controlled by the same lock object

```
lock (accelLock)
{
    lPaddleY = lPaddleY - (accelState.X * lPaddleSpeed);
}
```

When a process tries to enter a block of code protected by a lock it will try to grab hold of the lock object. If the object is not available the process will be made to wait for the lock to be released. This means that it is now not possible for one method to interrupt another. What will happen instead is that the first process to arrive at the block will get the lock object and the second process will have to wait until the lock is released before it can continue.

Locks provide a way of making sure that processes do not end up fighting over data. It is important that any code protected by a lock will complete quickly, so that other processes do not have to spend a lot of time waiting for access to the lock.

It is also important that we avoid what is called the “Deadly Embrace” problem where process A has obtained lock X and is waiting for lock Y, and process B has obtained lock Y and is waiting for lock X. We can help prevent this by making a process either a “producer” which generates data or a “consumer” which uses data. If no processes are both consumers and producers it is unlikely that they will be stuck waiting for each other.

6.4 Adding sound to a game

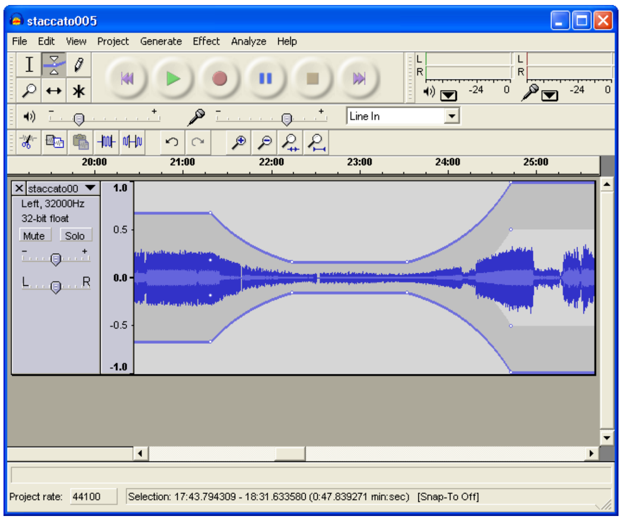
We can make games much more interesting by adding sound effects to them. As far as XNA is concerned a sound in a game is just another form of game resource. There are two kinds of sounds in a game. There are sound effects which will accompany particular game events, for example the sound of a spaceship exploding when it is hit with a missile, and there is background music which plays underneath the gameplay.

Sound effects are loaded into the game as content. They start as WAV files and are stored in memory when the game runs. They are played instantly on request.

Music files can also be supplied as game content but are played by the media player.

Creating Sounds

There are many programs that can be used to prepare sound files for inclusion in games. A good one is the program called Audacity. This provides sound capture and editing facilities. It can also convert sound files between different formats and re-sample sounds to reduce the size of sound files. Audacity is a free download from *http://audacity.sourceforge.net*

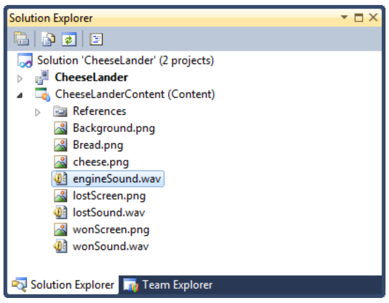


Project rate: 44100   Selection: 17:43.794309 - 18:31.633580 (0:47.839271 min:sec) [Snap-To Off]

This shows a sound sample being edited in Audacity.

Sound samples and content

As far as an XNA game is concerned, a sound is just another item of content. It can be added alongside other content items and stored and managed by the content manager.



Solution Explorer
Solution 'CheeseLander' (2 projects)
CheeseLander
CheeseLanderContent (Content)
References
Background.png
Bread.png
cheese.png
engineSound.wav
lostScreen.png
lostSound.wav
wonScreen.png
wonSound.wav
Solution Explorer Team Explorer

Within the game the `SoundEffect` class is used to hold the sound items:

```
// Sound effects
SoundEffect dingSound;
SoundEffect explodeSound;
```

These are loaded in the `LoadContent` method, as usual:

```
dingSound = Content.Load<SoundEffect>("ding");
explodeSound = Content.Load<SoundEffect>("explode");
```

A `SoundEffect` instance provides a `Play` method that triggers the playback of the sound:

```
if (ballRectangle.Intersects(rPaddleRectangle))
{
    ballXSpeed = -ballXSpeed;
    dingSound.Play();
}
```

This is the code that detects a collision of the bat with the ball. The ding sound effect is played when this happens. This is the simplest form of sound effect playback. The sound is made the instant the method is called. The program will continue running as the sound is played. Windows Phone can play multiple sound effects at the same time; the hardware supports up to 64 simultaneous sound channels.

Using the SoundEffectInstance class

The `SoundEffect` class is very easy to use. It is a great way of playing sounds quickly. A game does not have to worry about the sound once it has started playing. However, sometimes a game needs to do more than just play the sound to completion. Some sound effects have to be made to play repeatedly, change in pitch or move to the left or the right. To get this extra control over a sound a game can create a `SoundEffectInstance` value from a particular sound effect. We can think of this as a handle onto a playing sound. For example we might want to create the sound of a continuously running engine. To do this we start with a `SoundEffect` which contains the sound sample.

```
SoundEffect engineSound;
```

This would be loaded from an item of content which contains the engine sound. Next we need to declare a `SoundEffectInstance` variable:

```
SoundEffectInstance engineInstance;
```

We can ask a `SoundEffect` to give us a playable instance of the sound:

```
engineInstance = engineSound.CreateInstance();
```

Now we can all methods on this to control the sound playback of the sound effect instance:

```
engineInstance.Play();
...
engineInstance.Pause();
...
engineInstance.Stop();
```

Note that the program can stop and start the playback of the sound effect instance, which is not something that is possible with a simple sound effect. A game can also control the volume, pitch and pan of a sound effect instance:

```
engineInstance.Volume = 1; // volume ranges from 0 to 1

engineInstance.Pitch = 0;  // pitch ranges from -1 to +1
                           // -1 – octave lower
                           // +1 – octave higher

engineInstance.Pan = 0;    // pan ranges from -1 to +1
                           // -1 – hard left
                           // +1 – hard right
```

The program can also make a sound loop, i.e. play repeatedly:

```
engineInstance.IsLooped = true;
```

Finally a program can test the state of the sound playback:

```
if (engineInstance.State == SoundState.Stopped)
{
    engineInstance.Play();
}
```

This would start the sound playing again if it was stopped. Using a `SoundEffectInstance` a game can make the pitch of the engine increase in frequency as the engine speeds up and even track the position of the car on the screen.

A `SoundEffectInstance` is implemented as a handle to a particular sound channel on the Windows Phone device itself. We have to be careful that we a game doesn't create a very large number of these because this might cause the phone to run out of sound channels.

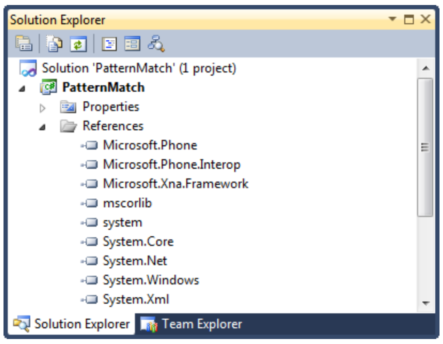
The solution in *Demo 07 Game with Sounds* contains a Windows Phone XNA game that implements a working pong game with sound effects.

6.5 Playing Sound in a Silverlight Program

A Silverlight program can use the XNA sound playback to provide sound effects. To do this it must include the XNA framework in the Silverlight program, load the sound from the project resources and then the sound can be played. Then, once the sound has started playing it must repeatedly update the XNA framework as the program runs so that sound playback is managed correctly.

Loading the XNA Namespace

The XNA namespace is not usually included in a Silverlight program but we can add it as a resource to a Silverlight project.


Solution Explorer

Solution 'PatternMatch' (1 project)
- PatternMatch
  - Properties
  - References
    - Microsoft.Phone
    - Microsoft.Phone.Interop
    - Microsoft.Xna.Framework
    - mscorlib
    - system
    - System.Core
    - System.Net
    - System.Windows
    - System.Xml

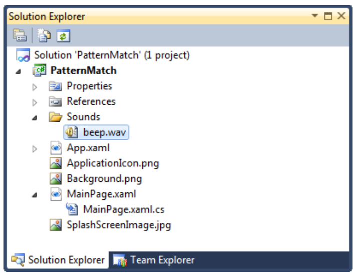
Once we have added the framework we can add using statements to make it easy to use the XNA classes in the Silverlight program:

```
using Microsoft.Xna.Framework;
using Microsoft.Xna.Framework.Audio;
```

Note that we can't use many of the XNA elements, for example it would be impossible to use a `SpriteBatch` or a `Texture2D`, but we can use the audio classes.

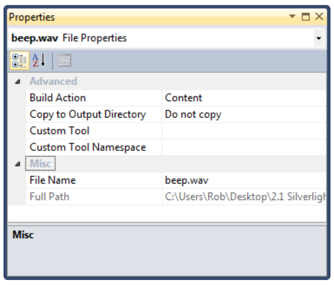
Adding the sound resources

The sound resources are added to our Silverlight project as we would load any other.



```
Solution Explorer
Solution 'PatternMatch' (1 project)
  PatternMatch
    Properties
    References
    Sounds
      beep.wav
    App.xaml
    ApplicationIcon.png
    Background.png
    MainPage.xaml
      MainPage.xaml.cs
    SplashScreenImage.jpg
Solution Explorer | Team Explorer
```

Here you can see that I have created a folder called `Sounds` which is going to hold all the sound samples in the program. The resources themselves must be added as `Content`:



Properties

beep.wav File Properties

Advanced	
Build Action	Content
Copy to Output Directory	Do not copy
Custom Tool	
Custom Tool Namespace	
Misc	
File Name	beep.wav
Full Path	C:\Users\Rob\Desktop\2.1 Silverligh

Misc

Now that the sound sample is part of the project, the next thing that the Silverlight program must do is load the sound data when the program starts running.

Loading a SoundEffect in a Silverlight program

Because there is no content management in a Silverlight program it must use a different way to load the `SoundEffect` value. A `SoundEffect` can be constructed using a method which loads the sound data from a stream. The following statement will do this for us:

```
SoundEffect beep;
...
beep = SoundEffect.FromStream(

TitleContainer.OpenStream("Sounds/beep.wav"));
```

The `TitleContainer` class is part of the Silverlight solution, and can open any of the content items in the project as a stream. The result of this statement is that we now have a `SoundEffect` that we can play in a Silverlight program.

Playing the sound

A Silverlight program plays the sound in exactly the same way as an XNA program.

```
beep.Play();
```

A Silverlight program can also use `SoundEffectInstance` values to play more complicated sounds.

However, there is one important thing that a Silverlight system must do to make sure that sound playback works correctly. You will remember that in an XNA game the `Update` method is called 30 times a second. When an XNA game updates it also updates some of the system elements, including sound playback. A Silverlight program does not have this regular update behaviour, and so we need to add an update call to keep the framework running:

```
FrameworkDispatcher.Update();
```

This must be called around 30 times a second, otherwise sound playback may fail and the program itself may be stopped.

The best way to get this method called regularly is to create a timer to make the call for us. A timer is an object that will generate events at regular intervals. We can bind a method to the timer event and make the method call our despatcher.

Our program can use a `DispatcherTimer`. This is part of the `System.Threading` namespace:

```
using System.Windows.Threading;
```

The code to create the timer and start it ticking is as follows:

```
DispatcherTimer timer = new DispatcherTimer();
timer.Tick += new EventHandler(timer_Tick);
timer.Interval = TimeSpan.FromTicks(333333);
timer.Start();
```

This code creates the timer, connects a method to the `Tick` event, sets the update rate to 30 Hz and then starts the timer running. The `timer_tick` method just has to update the XNA framework.

```
void timer_Tick(object sender, EventArgs e)
{
    FrameworkDispatcher.Update();
}
```

Timers are very useful things. A Silverlight program does have the regular update/draw method calls that an XNA game does, and so you can use a timer to allow you to create moving backgrounds or ticking clocks and the like.

The solution in *Demo 08 Silverlight with Sound* contains a Windows Phone Silverlight adding machine that plays a sound effect each time a new result is displayed.

6.6 Managing screen dimensions and orientation

We have already seen that a Windows Phone program can be used in more than one orientation. By default (i.e. unless we say otherwise) an XNA game is created that is played in landscape mode with the display towards the left. However, sometimes we want to play games in portrait mode. Our games can tell XNA the forms of orientation they can support and then receive events when the player tips the phone into a new orientation.

The graphics class in a game provides a number of properties that games can use to manage orientation and screen size:

```
graphics.SupportedOrientations = DisplayOrientation.Portrait |
    DisplayOrientation.LandscapeLeft |
    DisplayOrientation.LandscapeRight;
```

To allow a particular orientation we just have to add it to the values that are combined using the arithmetic OR operator, as shown above.

If we want our game to get control when the orientation of the screen changes we can bind a method to the event handler as shown below:

```
Window.OrientationChanged +=
       new EventHandler<EventArgs>(Window_OrientationChanged);
```

The `Window_OrientationChanged` method can then resize all the objects on the screen to reflect the new orientation of the game. We have already seen how a program can get the width and height of the display screen. The orientation handler method would use these values to set the new dimensions of the elements in the game.

```
void Window_OrientationChanged(object sender, EventArgs e)
{
    // resize the objects here
}
```

The required orientation is best set in the constructor for the game class.

Selecting a screen size

Games can also select a specific screen size:

```
graphics.PreferredBackBufferWidth = 480;
graphics.PreferredBackBufferHeight = 800;
```

If our game does this it forces the display to run at the requested resolution. It also forces the orientation too. The above width and height values would make the game work on portrait mode because the height of the game is greater than the width.

The clever thing about this is that when we set a particular display resolution the Windows Phone display hardware will make sure that we get that resolution, irrespective of the dimensions of the actual screen. In other words our game can operate as if the screen is that size and the hardware will make sure that it looks correct. This is a way you can make sure that your games will always look correct on the current version, and any new versions, of the Windows Phone hardware. No matter what new devices come along and whatever screen sizes they have the game will always look correct because the display will be scaled to fit the requested size.

We can use this to our advantage to improve the performance of our games:

```
graphics.PreferredBackBufferWidth = 240;
graphics.PreferredBackBufferHeight = 400;
```

The above statements ask for a screen which is smaller than the one fitted to most Windows Phone devices. In fact this screen is a quarter the size of the previous one. However, the hardware scaling in the Windows Phone will ensure that the screen looks correct on a larger display by performing scaling of the image. In a fast moving game this is not usually noticeable and the fact that the display is only a quarter the size of the previous one will make a huge difference to the graphical performance.

Using the Full Screen

At the moment every XNA game that we have produced has been scaled slightly to fit a smaller screen. This is because by default an XNA game does not use the top bar of the phone display. This display area is set aside for status messages. If we want our game to use the entire screen we must explicitly request this:

```
graphics.IsFullScreen = true;
```

A game can set this property to true or false. If it is set to true this means that the game can use the whole of the Windows Phone screen. I always set this to true to give my games the maximum possible amount of display area.

Disabling the screen timeout

The owner of a Windows Phone can set a screen timeout for the device. The idea is that if the phone is left doing nothing for a while it will shut down the screen and lock itself to save battery life. The phone monitors the touch screen to detect user input and if there is no input for the prescribed time it will shut down. The phone does not check the accelerometer however, so if we make a game that is entirely controlled by tipping the phone our customers would become very upset when they played the game. They would just be getting to an interesting part and then find that their screen went blank.

A game can disable the screen timeout function by turning off the screen saver in the XNA Guide:

```
Guide.IsScreenSaverEnabled = false;
```

The XNA Guide is the part of XNA that has conversations with the player about their Xbox Live membership and achievements etc. If we tell it to stop the screen saver from appearing this means that the game can continue until the phone battery goes flat. You should use this option with care. If a user gets bored by your game and puts the phone down it will not shut down if the screensaver has been turned off. This may mean that the phone battery will go flat as the game has been left running.

If you do have a game that is controlled by the accelerometer I would also add some gameplay element where a player has to touch the screen every now and then to keep the phone awake. I would much rather have a game that worked in this way rather than one that ran the risk of flattening the phone battery.

What we have learned

1. The XNA framework provides an environment for creating 2D and 3D games. The games can be created for Windows PC, Xbox 360 or Windows Phone.
2. XNA games operate in a completely different way from Silverlight applications. An XNA game contains methods to load content, update the game world and draw the game world which are called by the XNA framework when a game runs.
3. When Visual Studio creates a new XNA game it makes a class which contains empty LoadContent, Update and Draw methods that are filled in as a game is written. The LoadContent method should load all the required game content. The Update method is called by XNA 30 times a second to update the game content and the Draw method is called to render the game on the screen.
4. Any content (for example images or sounds) added to an XNA game is managed by the Content Management process that provides input filters for different file types and also output processors that prepare the content for deployment to the target device. Within an XNA game the way that content is loaded and used the same irrespective of the target hardware.
5. A sprite is made up of a texture which gives the image to be drawn and a position which determines where to draw the item and its size. The XNA Framework provides objects that can hold this information.
6. When drawing in 2D within the XNA system a given position on the screen is represented by pixel coordinates with the origin at the top left hand corner of the display.
7. The SpriteBatch class is able to batch up drawing commands and send them to the Graphics Processor Unit (GPU).
8. The Windows Phone touch panel can provide a low level array of touch location information which can contain details of at least 4 touch events.
9. XNA games can display text by using spritefonts made from fonts on the host Windows PC

10. XNA and Silverlight programs can play sound effects. For greater control of sound effect playback a program can create a SoundEffectInstance value which is a handle to a playing sound.
11. XNA programs on Windows Phone can select a particular display resolution and orientation. If they select a resolution lower than that supported by the phone display the GPU will automatically scale the selected size to fit the screen of the device.
12. XNA programs on Windows Phone can disable the status bar at the top of the screen so that they can use the entire screen area. They can also disable the screensaver so that they are not timed out by the phone.

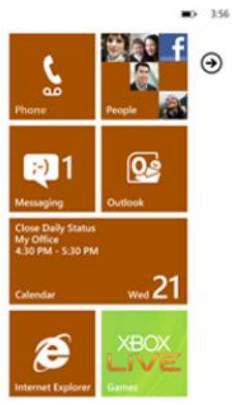
7 Creating Windows Phone Applications

We now know enough to make programs that run on the Windows Phone device. In this section we will to take a look at what takes a program and turns it into a "proper" application. This includes a variety of topics, from how to give your program a custom splash screen and icons to how a program can store data on a phone device.

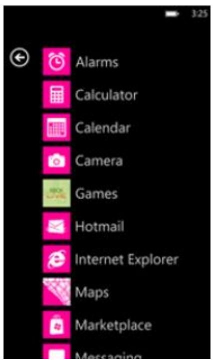
7.1 The Windows Phone icons and Splash Screens

At the moment all the programs that we have written have had the same icon and "splash screen". These have been the "empty" ones that Visual Studio created when it made a new project. There are two images that Windows Phone uses to identify your program when it is stored on the phone. To understand how these are used we have to learn a little about how Windows Phone users find and run programs on the device.

A Windows Phone has a "Start" screen which is displayed whenever the user presses the "Start" button on the device:



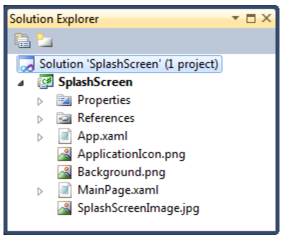
The user can then touch any of the large tiles on the start screen to run the program behind that tile. Alternatively they can slide the start screen to the left (or press the little arrow at the top right of the screen) to move to a list of applications that are installed on the device.



Then the user can scroll up and down the application list and select the program that they want to run. If the user wants to be able to start one of their applications from the Start screen they can "pin" it to the start screen.

Silverlight icons

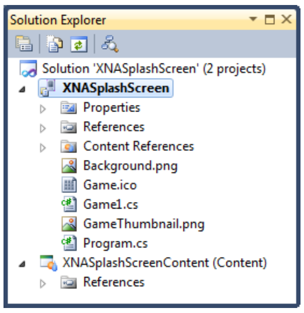
If you create a new Silverlight application Visual Studio will create a project that contains "default" versions of these two icons:



The file `ApplicationIcon.png` holds the image to be used in the application list. The file `Background.png` holds the image to be used when the application has been "pinned" to the Start menu.

XNA icons

If you create a new XNA application Visual Studio will create a slightly different arrangement of programs and the icon files are named differently too:



The file `GameThumbnail.png` holds the image to be used in the application list. The file `Background.png` holds the image to be used when the application has been "pinned" to the Start menu.

Customising Icons

If you want to customise the program icons (and you should) you can open and edit these files with any paint program that you like. Remember that they are stored in the project folder along with all the project files. However, you must make sure that you retain the file type and the image dimensions of the originals.

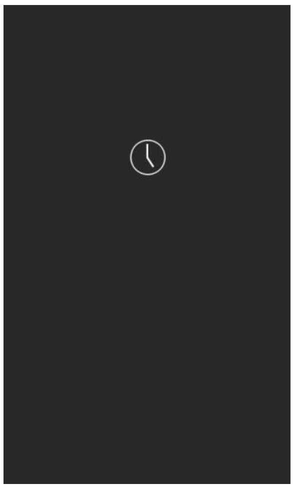
From my experience it turns out that designing icons like this (particularly small ones) is something of an art form. For this reason if you can find an artist to do the design for you this will probably be a good idea. If you have to do the work yourself I would advise you to make the design as simple as possible and make sure that it gives the user a good idea of what your program does. Remember that the icon for your program is also used to promote it in the Marketplace, so the better and slicker the icon looks the more chance there is of people downloading and buying your program.

Splash Screens

A "splash screen" is something that a program "splashes" onto the display as it starts up. These can be used to "brand" your application by showing your company logo when your program starts. Splash screens are also useful to improve the experience of program users when your program starts running. At the very least a splash screen will give them something nice to look at as your program loads.

Silverlight splash screens

The Silverlight run time system has a splash screen behaviour built in. A new Silverlight project actually contains an image file which is displayed during the interval between a program being started and the MainPage being displayed on the screen. If you have run programs on the emulator you may have seen this for a brief instant at the very start of a program run.



If your programs become larger, with more elements on the page and more resources to be loaded, this page may be displayed for more time. You can make your own version by modifying the `SplashScreenImage.jpg` file in your Silverlight project.

XNA splash screens

XNA programs do not have splash screens provided as part of the game project. We have already seen that the way that the display is produced is quite different. When an XNA program starts running the `LoadContent` method is called to fetch assets from storage and make them available to the game. Once the content has been loaded the `Draw` and `Update` methods begin to be called. This can lead to problems. The XNA framework insists on a game displaying something on the screen within five seconds of the program starting. If this does not happen the framework assumes that the game has got stuck and aborts it. This would mean that your game never actually gets to run if the content loading takes too long.

Fortunately an XNA does not have to load all the content at the start. A game can use the content manager to load items at any time. A program can also fire off threads to perform background loading of items while the game runs. The upshot of all this is that for XNA you need to develop a strategy for loading content. Perhaps the game `LoadContent` method could just load a splashscreen texture and this could be displayed while the rest of the content items are fetched.

It turns out that this is a problem common to games on all platforms. A major limiting factor in the development of ever larger console games is the limited access speed and transfer rate of the optical drives used to load information from the storage media.

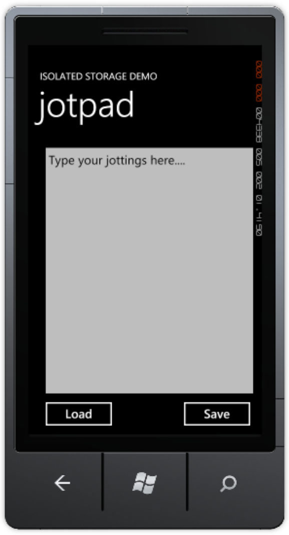
7.2 Persisting data in isolated storage

A proper application will need to store data which it can use each time it runs. A Silverlight application will need to hold settings and information the user is working on and an XNA game will want to store information about the progress of a player through the game along with high score and player settings. Windows Phone programs can use “isolated storage” to hold this kind of information. The storage is called “isolated” because it is not possible for one application to access data stored by another. This is different from a Windows PC where any program can access any file on the system.

Using the Isolated Storage file system

You can use the isolated storage in the same way as you use a file system. The only difference is the way that a program makes a connection to the storage itself. However, once a program has a connection to the file system it can use it as it would any other, creating streams to transfer data to files and even using folders to create a structured filestore. A program can store very large amounts of data in this way.

As an example we could create a simple Silverlight application which gives the user a simple jotter where they store simple messages. This version of the program uses a single file but could easily be extended to provide a note storage system.



The user can type in jottings which are saved when the Save button is pressed. If the Load button is pressed the jottings are loaded from persistent storage.

```
private void saveButton_Click(object sender, RoutedEventArgs
e)
{
    saveText("jot.txt", jotTextBox.Text);
}
```

This is the code for the Save button. It takes the text out of the textbox and passes it into a call of `saveText` along with the name of the file to store it in.

```
private void saveText(string filename, string text)
{
    using (IsolatedStorageFile isf =
                    IsolatedStorageFile.
                        GetUserStoreForApplication())
    {
        using (IsolatedStorageFileStream rawStream =
                            isf.CreateFile(filename))
        {
            StreamWriter writer = new StreamWriter(rawStream);
            writer.Write(text);
            writer.Close();
        }
    }
}
```

The `saveText` method creates a stream connected to the specified file and then writes the text out to it. Note that once we have a stream we can use it like any other. In this case the method creates a `StreamWriter` and then just sends the text out to that stream.

The read button uses a `loadText` method to do the reverse of this operation.

```
private void loadButton_Click(object sender, RoutedEventArgs
e)
{
    string text;

    if ( loadText("jot.txt", out text ) )
    {
        jotTextBox.Text = text;
    }
    else
    {
        jotTextBox.Text = "Type your jottings here....";
    }
}
```

The `loadText` method tries to open a file with the name it has been given. It then tries to read a string from that file. If any part of the read operation fails the `loadText` method returns `false` and `jotTextBox` is set to a starting message.

If the file can be read correctly the `loadText` method returns `true` and sets the output parameter to the contents of the file. This is then used to set the text in `jotTextBox`.

Note that we are using an `out` parameter to allow the `loadText` method to return the string that was read as well as whether it worked or not.

```
private bool loadText(string filename, out string result)
{
    result = "";
    using (IsolatedStorageFile isf =
        IsolatedStorageFile.GetUserStoreForApplication())
    {
        if (isf.FileExists(filename))
        {
            try
            {
                using (IsolatedStorageFileStream rawStream =
                    isf.OpenFile(filename,
                                 System.IO.FileMode.Open))
                {
                    StreamReader reader =
                                new StreamReader(rawStream);
                    result = reader.ReadToEnd();
                    reader.Close();
                }
            }
            catch
            {
                return false;
            }
        }
        else
        {
            return false;
        }
    }
    return true;
}
```

The `loadText` method will return `false` if the input file cannot be found or the read process fails. Note that it uses the `ReadToEnd` method to read from the file so that the program can read multi-line jottings.

The solution in *Demo 1 Jotpad* contains a Windows Phone Silverlight jotter pad that stores text in a file and loads it back. If you stop the program and run it again from the Application list in the emulator you will notice that the stored data is recovered when you press Load. Note that you can expand the save and load methods to store even more data simply by adding extra write and read statements and further parameters. Alternatively you could make the load and save methods work on an object rather than a number of individual items.

Using the Isolated Storage settings storage

Quite often the only thing a program needs to store is a simple settings value. In this case it seems a lot of effort to create files and streams just to store a simple value. To make it easy to store settings a Windows Phone program can use the Isolated Storage settings store. This works like a *Dictionary*, where you can store any number of name/value pairs in the isolated storage area.

An introduction to dictionaries

Dictionaries are a very useful collection mechanism provided as part of the .NET framework. A dictionary is made using two types. One is the type of the key, and the other is the type of the item being stored. For example, we might create a class called `Person` which holds data about, surprise surprise, a person:

```
class Person
{
    public string Name;
    public string Address;
    public string Phone;
}
```

This Person class above only contains three fields, but it could hold many more. We would like to be able to create a system where we can give the name of a Person and the system will then find the Person value with that name. A Dictionary will do this for us very easily:

```
Dictionary<string, Person> Personnel =
                          new Dictionary<string, Person>();
```

When we create a new Dictionary type we give it the type of the key (in this case a string because we are entering the name of the person) and the type of the item being stored (in this case a Person). We can now add things to the dictionary:

```
Person p1 = new Person { Name = "Rob", Address = "His House",
                         Phone = "1234"
                       };

Personnel.Add(p1.Name, p1);
```

This code makes a new Person instance and then stores it in the Personnel dictionary. Note that the code takes the name out of the person that has been created and uses that as the key. The program can now use a string as an indexer to find items in the dictionary:

```
Person findPerson = Personnel["Rob"];
```

The findPerson reference is set to refer to the Person instance with the name Rob. The dictionary does all the hard work of finding that particular entry. This makes it very easy to store large numbers of items and locate them later.

The dictionary will refuse to store an item with the same key as one already present. In other words if I try to add a second person with the name “Rob” the Add operation will throw an exception. A program will also get an exception if it asks the dictionary for a record that doesn’t exist:

```
Person findPerson = Personnel["Jim"];
```

Fortunately there is also a mechanism for determining whether or not a given key is present in the dictionary:

```
if (Personnel.ContainsKey("Jim"))
{
    // If we get here the dictionary contains Jim
}
```

Dictionaries are very useful for storing name-value pairs. They remove the need to write code to search through collections to find things. We can use multiple dictionaries too, for example we could add a second dictionary to our Personnel system that would allow us to find a person from their phone number.

Dictionaries and Isolated Storage

The IsolatedStorageSettings class provides us with a dictionary based storage system for settings that we can use to store setting values. The settings dictionary stores a collection of objects using a string as the key.

Saving text in the isolated storage settings

We could convert our jotter to use the settings class as follows:

```
private void saveText(string filename, string text)
{
    IsolatedStorageSettings isolatedStore =

IsolatedStorageSettings.ApplicationSettings;
    isolatedStore.Remove(filename);
    isolatedStore.Add(filename, text);
    isolatedStore.Save();
}
```

This version of the `saveText` method uses the filename as the key. It removes an existing key with the given filename and then adds the supplied text as a new entry. The `Remove` method can be called to remove an item from a dictionary. It is given the key to the item to be removed. If the key is not present in the dictionary the `Remove` method returns false, but we can ignore this. Once we have made our changes to the store we need to call the `Save` method to persist these changes.

Loading text from the isolated storage settings

The `loadText` method will fetch the value from the settings dictionary:

```
private bool loadText(string filename, out string result)
{
    IsolatedStorageSettings isolatedStore =
              IsolatedStorageSettings.ApplicationSettings;
    result = "";
    try
    {
        result = (string)isolatedStore[filename];
    }
    catch
    {
        return false;
    }
    return true;
}
```

The `loadText` method fetches the requested item from the settings storage. It is made slightly more complicated by the fact that, unlike the `Dictionary` class, the `IsolatedStorageSettings` class does not provide a `ContainsKey` method that we can use to see if a given item is present. The above method simply catches the exception that is thrown when an item cannot be found and returns false to indicate that the item is not present. Note that it must cast to string the value that is loaded from the settings dictionary. This is because the dictionary holds objects (so that we can put any type into it).

We now have two ways to persist data on a Windows Phone device. We can store large amounts of data in a filestore that we can create and structure how we like. Alternatively we can store individual data items by name in a settings dictionary. The isolated storage mechanism can be used by Silverlight programs and XNA games alike.

The solution in *Demo 02 Settings JotPad* contains a Windows Phone Silverlight jotter pad that stores text in the IsolatedSettings dictionary.

7.3 Persisting application state

We now know how an application can store data using the mass storage on the phone. Now we are going to find out how an application can be made to provide a good user experience within the single tasking environment provided on the Windows Phone. This provides a good insight into how programmers often have to make use of systems that are compromised by underlying limitations of the platform and operating system.

Single process operation

The Windows Phone operating system is inherently multi-tasking. This means that it can easily run more than one process at the same time. This is how it can play music using the Zune program while you use the phone to check your email. However, for a number of very sound technical reasons this multi-tasking ability is not extended to applications running on the system. The creators of the Windows Phone system took a deliberate design decision not to allow more than one application to be active at any given time.

In some ways this is a good thing. It stops our programs from looking bad just because another application in the phone is stealing all the memory or processor time. But it does give us some programming challenges that we must address when we write Windows Phone applications.

When we write an application the aim should be to make it appear that the application never stops when a user leaves it and goes off to do something else. This "leaving and going off to do something else" is a behaviour that is strongly encouraged by the design of the Windows Phone user interface.

The Start and Back buttons

While Windows Phone does not have multi-tasking it does have features which have been designed to make it easy for a user to move in and out of programs. These are based on the hardware Back and Start buttons that are fitted to every Windows phonee device.

The **Back** button allows a user to exit a program and return to the one that they were previously running and the **Start** button allows a user to leave a program at any point and go to the Start screen to run another. Used in combination these buttons greatly enhance the user experience. It is easy to press Start to send a quick SMS message and then press Back to return to whatever you were doing before. The Back and Start button allow the user to navigate through a stack of recently used applications.

Application switching

The result of all this is that an application must be adept at saving its state and then restoring itself to the same state when the user returns to it. The Windows Phone system helps us do this by sending an application messages that indicate when it is about to be removed from memory. In this section we are going to explore the situations in which the messages are sent and how we can make our applications and games respond correctly to give the appearance that they are always active.

Understanding tombstoning

If we are going to understand how to make programs that behave properly we are going to have to learn some of the terminology used by the Windows Phone designers to describe what happens when a program runs.

When a program is launched the program files are loaded into memory and executed by the Windows Phone processor. There are two things that the user can do next. The user can exit the program by pressing the Back button at the top level menu of the program or the user can "tombstone" the program by pressing the Start button. A program can also be "tombstoned" if the phone lock screen is displayed because the phone has not been used and has timed out.

If the program is being exited it receives a "Closing" message. If the program is being "tombstoned" it receives a "Deactivated" message. A program is allowed to say “Are you sure?” in response to a closing message. You can see this behaviour in the Microsoft Office Word program, which gives you the chance to save your document before the program closes. However, if a program is being “tombstoned” there is nothing it can do but use the “Deactivated” message as a chance to save its state in case it is resumed “from the grave” later.

However, we must remember that in either case the program is stopped and may be removed from memory. We must not think of “tombstoning” as being a state of suspended animation for our program. This is not the case. A tombstoned program is as dead as one that has been exited. If a tombstoned program is ever restarted it will be loaded into memory and all the objects in the program will be constructed from scratch, just as they would be if the program was loaded for the first time.

At this point we might be forgiven for thinking that being tombstoned is just like being exited. However, this is not quite the case. The great thing about a tombstone is that we can write things on it. The Windows Phone system provides some space in memory where an application can store state information if it receives a tombstone message. This information can then be loaded back into the application if it is ever reactivated. You can see this in action if you “tombstone” a SilverLight application at a particular page. When you return to the application using the Back button you will find that it automatically resumes at the same page you left. The Silverlight system uses the “tombstone” memory to record the active page when it is deactivated.

When an application is being started it will receive either a “Launching” message if it is being launched as new or an “Activated” message if it is being resumed from a previous tombstone.

The Tombstone message methods

The App.xaml.cs file in a Silverlight application contains methods that are called when the various tombstone events occur:

```
// Code to execute when the application is launching (eg, from Start)
// This code will not execute when the application is reactivated
private void Application_Launching(object sender, LaunchingEventArgs e)
{
    System.Diagnostics.Debug.WriteLine("Launching");
}

// Code to execute when the application is activated (brought to foreground)
// This code will not execute when the application is first launched
private void Application_Activated(object sender, ActivatedEventArgs e)
{
    System.Diagnostics.Debug.WriteLine("Activated");
}

// Code to execute when the application is deactivated (sent to background)
// This code will not execute when the application is closing
private void Application_Deactivated(object sender, DeactivatedEventArgs e)
{
    System.Diagnostics.Debug.WriteLine("Deactivated");
}

// Code to execute when the application is closing (eg, user hit Back)
// This code will not execute when the application is deactivated
private void Application_Closing(object sender, ClosingEventArgs e)
{
    System.Diagnostics.Debug.WriteLine("Closing");
}
```

I have added some message printing methods that we can use to see when each event occurs. These messages are shown in the Output window of Visual Studio when the program is run in debug mode. If we want to get control when the events occur we just have to add code to the appropriate method.

We first saw the file `App.xaml.cs` in section 4.3 *Pages and Navigation* when we used it as a place to create variables that can be shared by all the pages in a Silverlight application. It is the class that controls the creation and management of the Silverlight pages. The messages relating to the starting of an application (the Launching and Activating messages) are generated before any of the Silverlight pages have been created, which means that our program can't use these to set up the display, but they can be used to set flags so that the application knows how the program is being started. However, the Closing and Deactivated events can be used to request a form to save data.

A similar set of messages are available to XNA programs so that games can be made to save their state.

The JotPad program and tombstoning

When we create an application we have to decide how it should behave when it is "tombstoned". Should it store all the data in isolated storage each time, or should it only persist things if the user is closing the program? This decision has an impact on the user experience. The user might not expect information to be stored if they "jump out" of an application using the Start button. In fact the user might think they can use Start as a quick way of abandoning data input. When a user presses Start to tombstone an application it might be best if the data is stored as a "work in progress" and not actually committed to main storage. That is how we are going to make the JotPad program work.

Saving Jotpad Data to Isolated Storage on Exit

The user of the JotPad program will expect it to just "remember" the text that they had entered each time. At the moment it doesn't work like this, the user has to press Save and Load buttons to manage the storage of their jottings. We can make a better version of the program by binding a method to the Closing event which stores the data in persistent memory. The event will run in the `App.xaml.cs` class which will then call a method in the page to save the jotter to isolated storage:

```
// Code to execute when the application is closing (eg, user hit Back)
// This code will not execute when the application is deactivated
private void Application_Closing(object sender, ClosingEventArgs e)
{
    MainPage jotPadPage = (MainPage)RootFrame.Content;
    jotPadPage.Save();
}
```

The methods above use the `Content` property of the `RootFrame` member of the `App` class to get hold of the page that holds the JotPad. That sounds a bit confusing, so we'll spend some time thinking about what is happening here.

The `App.xaml` page is the container that holds the page in our application. The page is actually held inside a frame object which is held by `App.xaml`. We can get at the frame by using the `RootFrame` property. And inside the frame there is a `Content` property that holds the Silverlight page which is the main page.

So all our program has to do is get hold of this `Content` item and cast it to a `MainPage` reference. Inside the `MainPage.xaml.cs` we must then put a public save method:

```
public void Save()
{
    saveText("jot.txt", jotTextBox.Text);
}
```

The result of this is that when the program is exited the text is automatically saved in isolated storage.

Saving Jotpad data to state memory on tombstoning

A program can always use isolated storage to hold state information, even when it is being “tombstoned”. However this is not always the best place to store small amounts of data that are needed to hold the state of the user interface. To make it easy and quick to hold this kind of data the Windows Phone system provides a way a program can persist small amounts of data in memory. The phone calls this “state” storage and each program has its own state storage area. This memory is kept intact even if a program is tombstoned.

The JotPad program can use this area to hold data when it is tombstoned rather than back to isolated storage. Then if the program is re-activated it can load the information from this area rather than using isolated storage.

```
// Code to execute when the application is deactivated (sent to background)
// This code will not execute when the application is closing
private void Application_Deactivated(object sender, DeactivatedEventArgs e)
{
    MainPage jotPadPage = (MainPage)RootFrame.Content;
    jotPadPage.SaveState();
}
```

The method above is the one that is called when a program is “tomstoned”. It calls a `SaveState` method in `MainPage.xaml.cs` to save the state of the JotPad program to memory.

```
public void SaveState()
{
    SaveStateText("jot.txt", jotTextBox.Text);
}
```

The `SaveState` method looks remarkably like the Save method, except that it calls a different method. Rather than call `SaveText` it calls `SaveStateText`

```
private void SaveStateText (string filename, string text)
{
    IDictionary<string, object> stateStore =
                   PhoneApplicationService.Current.State;

    stateStore.Remove(filename);

    stateStore.Add(filename,text);
}
```

The state storage dictionary object for each application is stored in the `PhoneApplicationService.Current.State` property. To gain access to this your program must include the `Microsoft.Phone.Shell` namespace:

```
using Microsoft.Phone.Shell;
```

The state storage works like a pure dictionary of objects indexed by a string and so our program to save the data can create a local variable of this type and then just store the new item in it, making sure to remove any existing one first. Loading from the state storage works in exactly the same way too:

```
private bool loadStateText(string filename, out string result)
{
    IDictionary<string, object> stateStore =
                        PhoneApplicationService.Current.State;

    result = "";

    if (!stateStore.ContainsKey(filename)) return false;

    result = (string)stateStore[filename];

    return true;
}
```

This code is virtually identical to the code we wrote to load information from the isolated setting storage in the phone. The only change is that because the state storage is implemented as a pure dictionary we can use the `ContainsKey` method to see if the data was stored by the application when it was tombstoned. The fact that these methods look and function in a very similar way is actually good design.

Loading Stored Data

The next thing to do is to provide a way that the program can load the information from the appropriate place. Unfortunately it is not very easy to use the Launching or Activated events in JotPad, because these are generated before the Silverlight pages are created. Our program must also be able to handle the fact that data stored when an application was tombstoned may not be available when the application restarts. The best way for the program to work is for it to try to use state data first and then use isolated storage if state data is not available. If neither is present it can just display the starting message.

```
public void Load()
{
    string text;

    if (loadStateText("jot.txt", out text))
    {
        jotTextBox.Text = text;
        return;
    }

    if (loadText("jot.txt", out text))
    {
        jotTextBox.Text = text;
    }
    else
    {
        jotTextBox.Text = "Type your jottings here....";
    }
}
```

This `Load` method tries to fetch data from the state object. If this is not found the program looks in the isolated storage. If this is not found it displays a starting message. The best place to put a call of this method is when the page itself is loaded:

```
private void PhoneApplicationPage_Loaded(object sender,
                                        RoutedEventArgs e)
{
    Load();
}
```

If you have a program that needs to behave differently depending on whether it is newly launched or activated from a tombstone event then you can use the event handlers above to set flag variables that can be picked up by your code.

Tombstones and development

We can “tombstone” an application even when it is running via Visual Studio. If the application is restarted any debugging sessions are automatically resumed in the development environment. This works even if the application is being debugged within a Windows Phone device.

You can see this at work if you press the Start button in the emulator while one of your programs is running. Your program is tombstoned but Visual Studio does not end debugging. If you then press the Back button you will find that the program will resume execution after being reactivated.

Note that, rather interestingly, a Silverlight application is not “tombstoned” when a Windows Phone receives a phone call. The application will keep running unless the user does something which starts another application, for example looks up a contact during the call.

Tombstones and applications

It is unfortunate that we have to do so many complicated things to give the user the impression that our application never actually stops. However, it is putting in the effort to make sure that your applications work correctly in this respect as it adds a great deal to the user experience. It is worth spending some time working with this as it is a good way to brush up on your understanding of events and dictionary storage, amongst other things. It is also an interesting way to discover that the road to producing a good user experience is not always a smooth one, particularly if you are writing programs in a constrained environment.

An XNA game can also connect to events that will be generated when it is stopped or tombstoned and you can make games that store game state and high scores when the user moves away from them in exactly the same way.

The solution in *Demo 03 Tombstone JotPad* contains a Windows Phone Silverlight jotter pad that uses both state and persistent storage. State storage is used when the application is tombstoned.

7.4 Launchers and Choosers

The final part of our application development is concerned with how we use the Launchers and Choosers in the phone. These are the built in behaviours that are provided to allow our programs to perform standard actions. A Launcher is means by which our program can fire off a phone feature which does not return any data. A Chooser is where a phone feature is used to select something. Your application can then do something with the item returned.

Launchers and choosers make use of tombstoning in that when a program activates launcher or chooser it is automatically tombstoned. When the launcher or chooser finishes the program is reactivated.

Using a Launcher

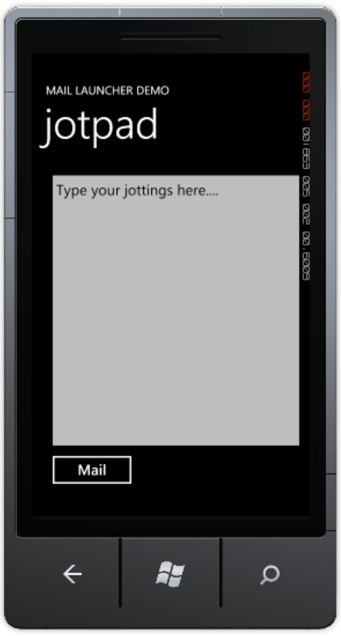
These are all the launchers, along with a brief explanation of what each does:

`PhoneCallTask`	starts the Phone application with a particular phone number and display name selected. Note that the program cannot place the call, the user

	must initiate this
`EmailComposeTask`	your program can set properties on an email and then launch a task to allow the user to send the message.
`SmsComposeTask`	starts the Messaging application and display a new SMS message. Note that the message is not sent automatically.
`SearchTask`	starts the Search application using a query you provide
`WebBrowserTask`	starts the Web browser and displays the URL you provide.
`MediaPlayerLauncher`	starts the Media Player application and play a given media file
`MarketplaceDetailTask`	your program can show details of a particular application in the market place
`MarketplaceHubTask`	starts the Windows Phone Marketplace client
`MarketplaceSearchTask`	your program can search the Windows Phone Marketplace for a particular application and then show search results

Each of these tasks can be started by your application and when the task is complete your application will be re-activated. Of course there is no guarantee that your application will regain control at any point in the future. The user may instead go off and do lots of other things instead of returning to your program.

Adding an email feature to JotPad



We might decide to add a Mail feature to the Jotpad program. By pressing the Mail button a user can send the contents of the jotpad as an email. The image above shows how this might work.

```
private void mailButton_Click(object sender, RoutedEventArgs
e)
{
    sendMail("From JotPad", jotTextBox.Text);
}
```

When the mail button is clicked the event handler takes the text out of the textbox and calls the `sendMail` method to send this. It also adds a `From` message as well. The `sendMail` method is very simple:

```
private void sendMail(string subject, string body)
{
    EmailComposeTask email = new EmailComposeTask();

    email.Body = body;
    email.Subject = subject;
    email.Show();
}
```

This creates an instance of the `EmailComposeTask` class and then sets the `Body` and `Subject` properties to the parameters that were provided. It then calls the `Show` method on the task instance. This is the point at which the JotPad application is tombstoned to make way for the email application. When the user has finished sending the email the JotPad program will resume.

To make use of the tasks a program must include the Tasks namespace:

```
using Microsoft.Phone.Tasks;
```

The solution in *Demo 04 Email JotPad* contains a Windows Phone Silverlight jotter pad that can send the jotting as an email. Note that this will not work properly in the Windows Phone emulator as this does not have an email client set up. However, you can see the tombstoning behaviour in action as the program tries to send an email and displays a warning instead.

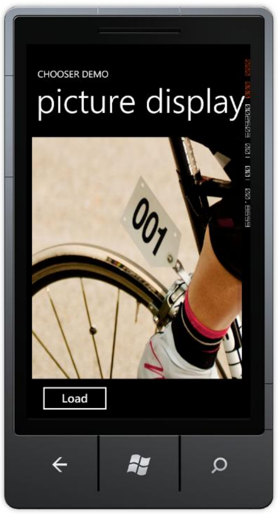
Using a Chooser

These are all the choosers that are available:

`CameraCaptureTask`	starts the Camera application for the user to take a photo
`EmailAddressChooserTask`	starts the Contacts application and allows the user to select a contact's email address
`PhoneNumberChooserTask`	starts the Contacts application and allows the user to select a contact's phone number.
`PhotoChooserTask`	starts the Photo Picker application for the user to choose a photo.
`SaveEmailAddressTask`	saves the provided email address to the Contacts list
`SavePhoneNumberTask`	saves the provided phone number to the Contacts list

A chooser works in exactly the same way as a launcher with just one difference. A chooser can return a result to the application that invoked it. This is done in a manner we are very used to by now; our application binds a handler method to the completed event that the chooser provides.

Picture display



We can explore how this works by creating a simple picture display application this will allow the user to choose a picture from the media library on the phone and then display this on the screen. We must create the chooser in the constructor for the `MainPage` of our application:

```
PhotoChooserTask photoChooser;

// Constructor
public MainPage()
{
    InitializeComponent();

    photoChooser = new PhotoChooserTask();

    photoChooser.Completed +=
          new
EventHandler<PhotoResult>(photoChooser_Completed);
}
```

This constructor creates a new `PhotoChooser` value and binds a handler to the completed even that it generates. The completed event handler uses the result returned by the chooser and displays this in an image.

```
void photoChooser_Completed(object sender, PhotoResult e)
{
    if (e.TaskResult == TaskResult.OK)
    {
        selectedImage.Source =
                new BitmapImage(new Uri(e.OriginalFileName));
    }
}
```

This method sets the source of the image to a new `BitMapImage` that is created using the address of the photo result. Note that the `TaskResult` property of the result allows our program to determine whether or not the use chose something to return.

The final link we need to provide is the event handler for the Load button that starts the process off.

```
private void loadButton_Click(object sender, RoutedEventArgs
e)
{
    photoChooser.Show();
}
```

This method just calls the `Show` method on the chooser to start the choosing process running.

The solution in *Demo 05 PictureDisplay* contains a Windows Phone program that you can use to select an image from the media storage. This program will not work on the Windows Phone emulator which does not have any images in is media store. It will also not work on the Windows Phone device if you use the Zune software to connect the phone to Visual Studio. This is because when the phone is connected to Zune the media content is not available. However, if you disconnect the phone and then run the application it will work correctly.

Choosers and tombstones

It is not guaranteed that an application will get tombstoned when it starts a chooser running but it is best if your application can handle this eventuality if it arises.

What we have learned

1. A Windows Phone application is represented on the device by two icon files. One is used to represent the application in the Application list on the phone and the other, larger, icon is used if the application is pinned to the Start menu on the phone. Good icons are important as they are both used on the phone and in the Windows Phone Marketplace to brand an application.
2. Silverlight applications also have a “splash screen” image that is displayed while the application starts. The default splash screen is provided as part of a new Silverlight project but application writers are advised to customise this. XNA projects do not have a built in splash screen mechanism but game developers are advised to create one if their content takes more than a few seconds to load.
3. A Windows Phone provides a system of isolated storage by which each application on the phone is able to store its own data on the device. Programs can create folders and files in their isolated storage area or make use of a dictionary based mechanism to store name-value pairs such as settings values.
4. The Windows Phone operating system provides a single tasking model of execution for applications. An application may be removed from memory at any time and replaced by another. The Start and Back keys on the phone device allow a user to interrupt one running application and start another by pressing Start, and then return to the original application by pressing Back. The process by which a live application is removed from memory in this way is called “tombstoning”. Tombstoning also occurs when a phone displays its lock screen.
5. There are four events which are produced in an application to help it manage the tombstoning process. They are “Launched” (fired when the application starts), “Closed” (fired when the application is closed), “Deactivated” (fired when the application is tombstoned) and “Activated” (fired when the application is activated from a tombstone).
6. The tombstone events are fired in an application as it is restarted. Tombstoning does not leave an application live in memory. When an applicaton is reactivated from a tombstone all the objects in the application are recreated and the launching and activated events are fired during this process.
7. Windows Phone provides in memory storage mechanism which can be used to store live data when an application is tombstoned. This can be read back if the application is ever reactivated.

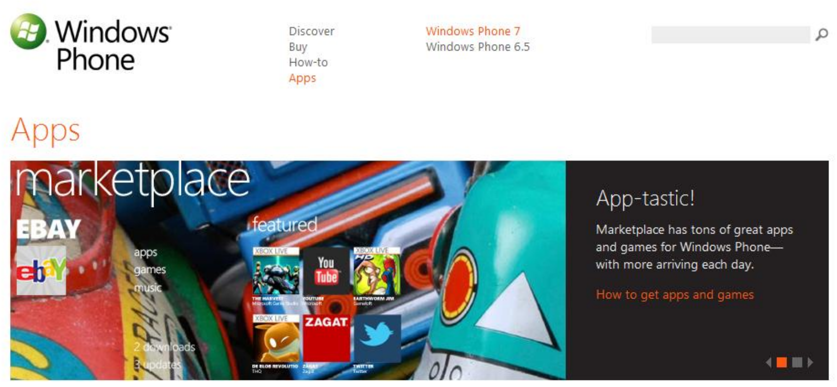
8. Programs can use Launchers and Choosers to interact with phone subsystems. A Launcher starts an external application (for example and email send) and a chooser launches an external application that returns a result (for example selecting a picture from the media store). A program may be tombstoned while the external application runs.

8 Windows Phone Marketplace

We now know enough to make complete applications and games that will work correctly within the Phone environment and use the built-in features of the phone system. Finally we are going to find out how we can take our completed applications and submit them to the Windows Phone marketplace and maybe make some money from them.

8.1 How the Marketplace works

The only way that a Windows Phone owner can get a program onto their device is by downloading it from the Windows Marketplace. Only programs that have been through the Marketplace validation process can be loaded onto a phone.



Marketplace has tons of great apps and games for Windows Phone—with more arriving each day.

A Windows Phone owner can use their Windows Live ID to sign into their phone and gain access to services provided by Windows Live, Zune and Xbox Live along with the Marketplace.

Applications can be loaded direction onto the phone “over the air” using the mobile phone operator or WiFi. They can also be loaded using the Zune software that also provides a media management for the phone as well. Very large applications cannot be downloaded via mobile phone, and must be transferred using WiFi or using the Zune program.

Some applications are free and others are paid. When a phone owner buys a paid application the cost can be added to their phone bill or they can register a credit card to be used to pay for purchases. Many applications have a “trial” mode which is free. This can later be upgraded to a fully featured version. When a program is running it can easily test whether it is being used in “full” or “trial” mode.

A given Windows Live ID can be used on up to five phone devices. If you remove an application from a device you can reload it later without buying it again as the Marketplace keeps a list of everything you have bought.

The marketplace also provides a rating system which allows owners of applications to give ratings and feedback on them.

Marketplace approval

Before an application can be sold in the Marketplace it must first go through an approval process. This makes sure that the application behaves correctly in respect of things like the Start and Back buttons and also that the program doesn’t do anything silly like grab all the memory or take twenty minutes to start running. This process also makes sure that programs that are offensive are not made generally available. Once an application has been approved it is listed in one of the application categories and is available for download. A developer can produce an upgraded version of the application which, once it has been through the approvals process, will be made available as an upgrade to all existing owners.

8.2 Marketplace membership

Before a developer can submit applications to the Marketplace they must first become a member. Membership is keyed to the Windows Live ID of the member. It costs $99 per year to be member of the marketplace. If you stop being a member of the marketplace all your applications are removed. Students who have access to the DreamSpark programme can get free membership of the Windows Phone marketplace.

Members of the marketplace have their identity validated when they join and the Marketplace gives them a unique key which is used to sign their applications. The Marketplace also retains their bank and tax details so that they can be paid for application sales.

Submitting applications

A member of the marketplace can submit up to five free applications for approval and an unlimited number of “paid” ones. If a member wants to submit further free applications these will cost $20 each to be processed.

Members of the Marketplace can set the selling price of their application and receive 70% of the cost paid by the customer. This is paid directly into their bank account once they have reached a threshold of $200 sales.

Trial mode

An application or game can be downloaded as a free demo. A program can easily determine whether or not it is operating in demo mode:

```
LicenseInformation info = new LicenseInformation();

if ( info.IsTrial() )
{
    // running in trial mode
}
```

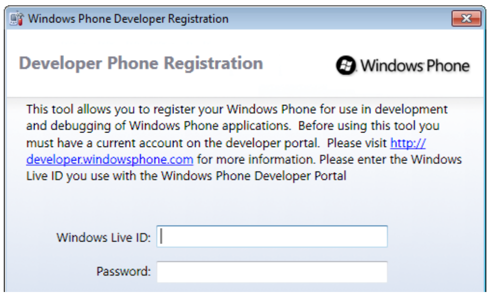
The `LicenseInformation` class is in the `Windows.Phone.Marketplace` namespace. If the program is running in trial mode it can restrict the user actions, for example it could disable certain functions or stop the program running after a time limit. If the user wishes to upgrade the application it can use the Launcher mechanism to direct the user to the marketplace.

8.3 Deploying and testing to hardware

While the emulator provides a faithful representation of the way that Windows Phone works from a software point of view it does not allow us to get much of an idea of how the program feels when in use. This is particularly the case in games where it is very important to be able to test the gameplay on a proper device.

Unlocking devices

A Windows Phone can normally only run programs that have been obtained via the Marketplace. However a marketplace member can unlock a phone so that it can be used to run programs that are loaded into it from Visual Studio. Paid Marketplace members can unlock up to three devices, whereas student members who joined via DreamSpark can only unlock one. The unlocking is performed using an application that is installed as part of the Windows Phone software development kit. This application can lock and unlock phones


Windows Phone Developer Registration

Developer Phone Registration

Windows Phone

This tool allows you to register your Windows Phone for use in development and debugging of Windows Phone applications. Before using this tool you must have a current account on the developer portal. Please visit http://developer.windowsphone.com for more information. Please enter the Windows Live ID you use with the Windows Phone Developer Portal

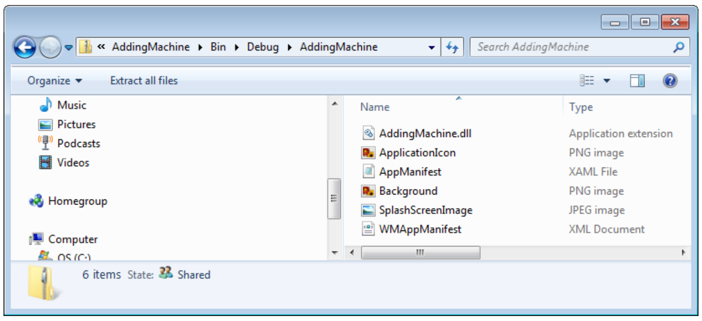
Windows Live ID:

Password:

Applications that are deployed to the phone will stay in the phone memory and can be run from the application or game hubs in the same way as ones obtained from the Marketplace. However, you can only have up to 10 of your own programs on a given device at any time.

The role of the XAP file

We first saw the XAP file in chapter 3 when we were looking at the way that programs are built and deployed by Visual Studio. When Visual Studio builds a Windows Phone application it constructs a XAP file (a file with the extension .xap) which is the actual file that is transferred into the target device for execution.



Name	Type
AddingMachine.dll	Application extension
ApplicationIcon	PNG image
AppManifest	XAML File
Background	PNG image
SplashScreenImage	JPEG image
WMAppManifest	XML Document

6 items State: Shared

This file contains all the program assemblies and resources along with manifest files that describe the application. The WMAppManifest.xml file lists the capabilities of the phone that the application uses and also sets the genre of the application. This determines where on the phone the program is stored. Programs with the Game genre are stored in the game hub, applications are stored in the applications hub.

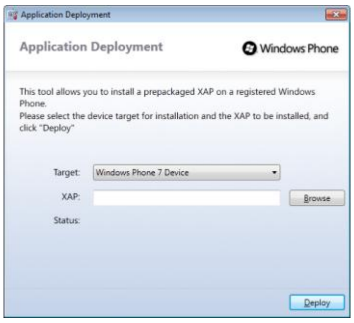
```
<?xml version="1.0" encoding="utf-8"?>

<Deployment xmlns="http://schemas.microsoft.com/windowsphone/2009/deployment"
AppPlatformVersion="7.0">
  <App xmlns="" ProductID="{b92ce770-1b22-4d52-998e-113c2784067a}" Title="PictureDisplay"
RuntimeType="Silverlight" Version="1.0.0.0" Genre="apps.normal"  Author="PictureDisplay
author" Description="Sample description" Publisher="PictureDisplay">
    <IconPath IsRelative="true" IsResource="false">ApplicationIcon.png</IconPath>
    <Capabilities>
      <Capability Name="ID_CAP_GAMERSERVICES"/>
      <Capability Name="ID_CAP_IDENTITY_DEVICE"/>
      <Capability Name="ID_CAP_IDENTITY_USER"/>
      <Capability Name="ID_CAP_LOCATION"/>
      <Capability Name="ID_CAP_MEDIALIB"/>
      <Capability Name="ID_CAP_MICROPHONE"/>
      <Capability Name="ID_CAP_NETWORKING"/>
      <Capability Name="ID_CAP_PHONEDIALER"/>
      <Capability Name="ID_CAP_PUSH_NOTIFICATION"/>
      <Capability Name="ID_CAP_SENSORS"/>
      <Capability Name="ID_CAP_WEBBROWSERCOMPONENT"/>
    </Capabilities>
    <Tasks>
      <DefaultTask  Name ="_default" NavigationPage="MainPage.xaml"/>
    </Tasks>
    <Tokens>
      <PrimaryToken TokenID="PictureDisplayToken" TaskName="_default">
        <TemplateType5>
          <BackgroundImageURI IsRelative="true"
            IsResource="false">Background.png</BackgroundImageURI>
          <Count>0</Count>
          <Title>PictureDisplay</Title>
        </TemplateType5>
      </PrimaryToken>
    </Tokens>
  </App>
</Deployment>
```

Above you can see the default WMAppManifest.xml file that was created for the PictureDisplay application. This version of the file indicates that the application will use all of the phone capabilities. Actually the only feature that it uses is the `ID_CAP_MEDIALIB` one. When an application is submitted to the Marketplace the content of this file is checked against the calls that the application makes. If the application uses resources that are not specified in this file it will fail validation.

When a customer installs a program they are told the features of the phone that it will use and are asked to confirm this. The idea is to stop programs with unexpected behaviours being used by unsuspecting customers, for example a picture display program that also tracks the position of the user.

Local Application Deployment

If you want to send a program to another developer you can send them the XAP file and they can use the Application Deployment program to send the XAP file to their unlocked device or the emulator on their Windows PC.



This tool allows you to install a prepackaged XAP on a registered Windows Phone.
Please select the device target for installation and the XAP to be installed, and click "Deploy"

Target: Windows Phone 7 Device
XAP:
Status:

This allows you to distribute applications for testing before you release the finished product.

The need for obfuscation

If you send someone a XAP file it is very easy for them to open this up and take a look at all things in it, including all the program code that you spend so long writing. Unfortunately it is a simple matter to open an assembly and take a look at how it works. We did this in chapter 3 using the ildasm program. This means that you should be careful when sending out programs that you don't give away all the hard work that you put into making the program. Whenever you send out a program you should take steps to make it more difficult for someone to unpick the contents.

In software development this process is called *obfuscation*. It involves the use of a special tool that you use in the build process to make it very hard for someone looking at your program to deduce how it works and what it does. The tool changes variable names and adds spurious control flow to make a program very hard to understand.

There are a number of free obfuscation tools that you can use to make your program harder to understand. You could use these on your program code before you submit the XAP file. The Windows Phone developer programme also includes access to obfuscation tools from PreEmptive Solutions. These are being provided at very low cost (these systems are usually extremely expensive) and you should consider using them if you are concerned about this issue.

8.4 The Submission and approval process

The submission process for programs is not hard to use. It is all managed from the developer site for Windows Phone and XNA Games:

`http://create.msdn.com`

Visitors to the site can download documentation and the development tools. Members of the Marketplace can use the dashboard pages to view the progress of submissions and submit new programs. There are a number of detailed walkthroughs that will take you through the membership and submission process, you should go through these to make sure you understand what is going on and what is required of you and any programs that you submit.

Windows Phone Application Certification Guidelines

The Windows Phone developer website provides access to a very detailed document that describes how to create applications. It is very important that you read the latest version of this document and follow the guidelines set out in it. It has been through numerous versions as the process has evolved, so you should make sure that you are using the most up to date version of the text.

What we have learned

1. Windows Phone owners get their applications from the Windows Phone Marketplace.
2. Registered developers can submit applications for approval and distribution via the Marketplace.
3. Developers register and track the progress of their applications via the Windows Phone developer website.
4. Registering as a developer costs $99 a year, students can register for free via the Dreamspark programme.
5. Developers can produce free or paid applications, but are limited to submitting only 5 free applications per year. Further submissions of free applications cost $20 each.
6. A registered developer can unlock phones so that they can run programs compiled in Visual Studio.

7. Applications are distributed as XAP files which contain all the resources and content along with a manifest file that describes the content and gives the phone setting information about the application.
8. XAP files can be loaded directly onto unlocked devices by developers.
9. Programmers should obfuscate their programs so that it is not easy for anyone obtaining a XAP file to find out how the code works. There is an obfuscation processor available via the Windows Phone developer web site.
10. A developer must read the Windows Phone Certification guidelines before submitting programs to the approval process.

Program Ideas

We now know how to make programs for Windows Phone. We can create multi-page Silverlight interfaces which match those of the phone itself and we have also had a look at how to create games using XNA. We also know how to create connected applications that make use of data hosted on the internet. We have discovered some of the difficulties encountered by programmers when they write code for small, resource constrained, devices and we now also know how the Windows Phone operating system allows us to create useable applications in spite of these issues. Finally we know how to use the underlying Windows Phone system so that our applications can make use of features in the phone itself.

At this point we have a superb set of tools, next we have to find a problem to solve with them.

Application Ideas

Applications ideas do not always appear fully formed. Quite often you will start with a small idea for a solution and then add features or discover situations where the solution could be made even more useful. This is not a bad way to come up with something original, but you must beware of adding too many feature ideas before you have made something work, otherwise the whole thing might collapse under its own weight before you have built anything.

You can get good ideas for applications by talking to lots of people and trying to find out what would be useful to them. Not everyone is aware of just how much you can do with modern devices and so if you say that you can make something mobile that can track position, take pictures and make use of internet services they might have an idea of a situation where some of that power would be useful to them.

Game Ideas

In some ways game ideas are easier to come by than application ideas. Systems like XNA let you “doodle” with game code to find out what it does. I’ve already mentioned the importance of playtesting. This is where you give your game to other people to find out if the game is playable. Playtesting can also throw up ideas for game development. Often a playtester will suggest changes to the program that will make it more interesting and fun. Don’t be afraid to do silly things in a game (add 10 times as many aliens, invert gravity, make everything bigger/smaller etc etc) and see what happens to the play experience.

The great thing about a game is that rather than hitting a specific problem, as with an application, a game just has to be fun to play.

Fun with Windows Phone

Windows Phone provides an amount of processing power that was unavailable in the world a few years ago, let alone in everyone's pocket. It also provides an amazing level of connectivity, high performance graphics and devices such as cameras and location sensors that make it possible to build truly novel applications.

Personally I reckon that just being able to program for this device, let along sell the results, is inspiring enough. I hope you have learned enough from these notes to get yourself started on the fun you can have with this platform.

Rob Miles
November 2010