MONOGAME

SUCCINCTLY

BY **JIM PERRY**

SUCCINCTLY E-BOOK SERIES

Syncfusion

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MonoGame Succinctly

By
Jim Perry

Foreword by Daniel Jebaraj



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The Story Behind the *Succinctly* Series of Books

Daniel Jebaraj, Vice President
Syncfusion, Inc.

Staying on the cutting edge

As many of you may know, Syncfusion is a provider of software components for the Microsoft platform. This puts us in the exciting but challenging position of always being on the cutting edge.

Whenever platforms or tools are shipping out of Microsoft, which seems to be about every other week these days, we have to educate ourselves, quickly.

Information is plentiful but harder to digest

In reality, this translates into a lot of book orders, blog searches, and Twitter scans.

While more information is becoming available on the Internet and more and more books are being published, even on topics that are relatively new, one aspect that continues to inhibit us is the inability to find concise technology overview books.

We are usually faced with two options: read several 500+ page books or scour the web for relevant blog posts and other articles. Just as everyone else who has a job to do and customers to serve, we find this quite frustrating.

The *Succinctly* series

This frustration translated into a deep desire to produce a series of concise technical books that would be targeted at developers working on the Microsoft platform.

We firmly believe, given the background knowledge such developers have, that most topics can be translated into books that are between 50 and 100 pages.

This is exactly what we resolved to accomplish with the *Succinctly* series. Isn't everything wonderful born out of a deep desire to change things for the better?

The best authors, the best content

Each author was carefully chosen from a pool of talented experts who shared our vision. The book you now hold in your hands, and the others available in this series, are a result of the authors' tireless work. You will find original content that is guaranteed to get you up and running in about the time it takes to drink a few cups of coffee.

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Syncfusion will be working to produce books on several topics. The books will always be free. Any updates we publish will also be free.

Free? What is the catch?

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Let us know what you think

If you have any topics of interest, thoughts, or feedback, please feel free to send them to us at succinctly-series@syncfusion.com.

We sincerely hope you enjoy reading this book and that it helps you better understand the topic of study. Thank you for reading.

Please follow us on Twitter and “Like” us on Face-book to help us spread the word about the *Succinctly* series!





About the Author

Jim Perry has been a software engineer for more than 20 years, and he spent three of those in the game development industry. He's a former multiyear Microsoft XNA MVP and current ID@Xbox MVP. This is his fourth book on game development. When he's not writing code for his day job or his books, he's usually working to create the next hit indie game.

Chapter 1 Introduction

Who this book is for

This book is intended for people interested in game development using C# as your language of choice who want to target multiple platforms, including PC, iOS, Android, MacOS, Linux, PS4, PSVita, Xbox One, and Switch. Since this e-book is only a quick intro to the core information needed to get started, previous experience using C# is ideal, and almost required if you have no experience with another programming language.

If you have previous experience with Microsoft's XNA technology, you'll be very comfortable with MonoGame, and can probably skip most of this book.

A brief history

MonoGame can be thought of as the grandchild of Microsoft's XNA Game Studio technology. Back in 2004, Microsoft announced XNA at the Game Developer's Conference. It took several years, but they eventually released the first version of XNA Game Studio. It consisted of three parts:

- A pipeline for importing game assets – graphics, audio, etc.
- A library of assemblies specifically for game development – graphics, special input handling, sounds, networking
- A custom run-time allowing XNA game to run on several different platforms, including PC, phone, and eventually, the Xbox 360

XNA was the first official major tool to allow anyone to get a game onto a major console. It was updated with a bit more functionality, but Microsoft killed it off not long ago by closing down the Xbox Live Indie Games part of the Xbox for new games. Supposedly, any games that were bought will be playable in the future, but that could change. Even before then, XNA was limited to Microsoft platforms, which made it less than ideal for some indie game developers.

Two different projects spawned from XNA: SilverSprite and XNA Touch. The first was an attempt to make a code-compatible version of the 2D portion of XNA that could be run in a browser using Silverlight. The second was a port of XNA to run on an OpenGL backend on mobile devices. XNA Touch ended up using the 2D code from Silver Sprite, and the two eventually emerged as MonoGame.

MonoGame now is an almost 100 percent complete implementation of XNA 4 that can run on a number of different platforms:

- iOS
- Android
- Mac OS X
- Linux

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- Windows
- PlayStation Vita
- Xbox One
- PlayStation 4

Chapter 2 Installation and Setup

This book will use the Visual Studio version of the software. If you don't have Visual Studio, you can download the Community Edition for free here. Make sure to install Visual Studio before installing MonoGame.

You can find the download page for MonoGame on the MonoGame website. All of the public releases should be listed at the top of that page, with the newest at the top. The newest release at the time of this writing is 3.6.

Once you click a link for a release, you'll see a page that lists the various versions that are available. You'll typically find versions for Windows, Mac OS, and Linux, as well as the source code and pre-compiled assemblies.

After you launch the MonoGame setup, you'll get to a screen that allows you to select the version of Visual Studio for which you would like to install the software.

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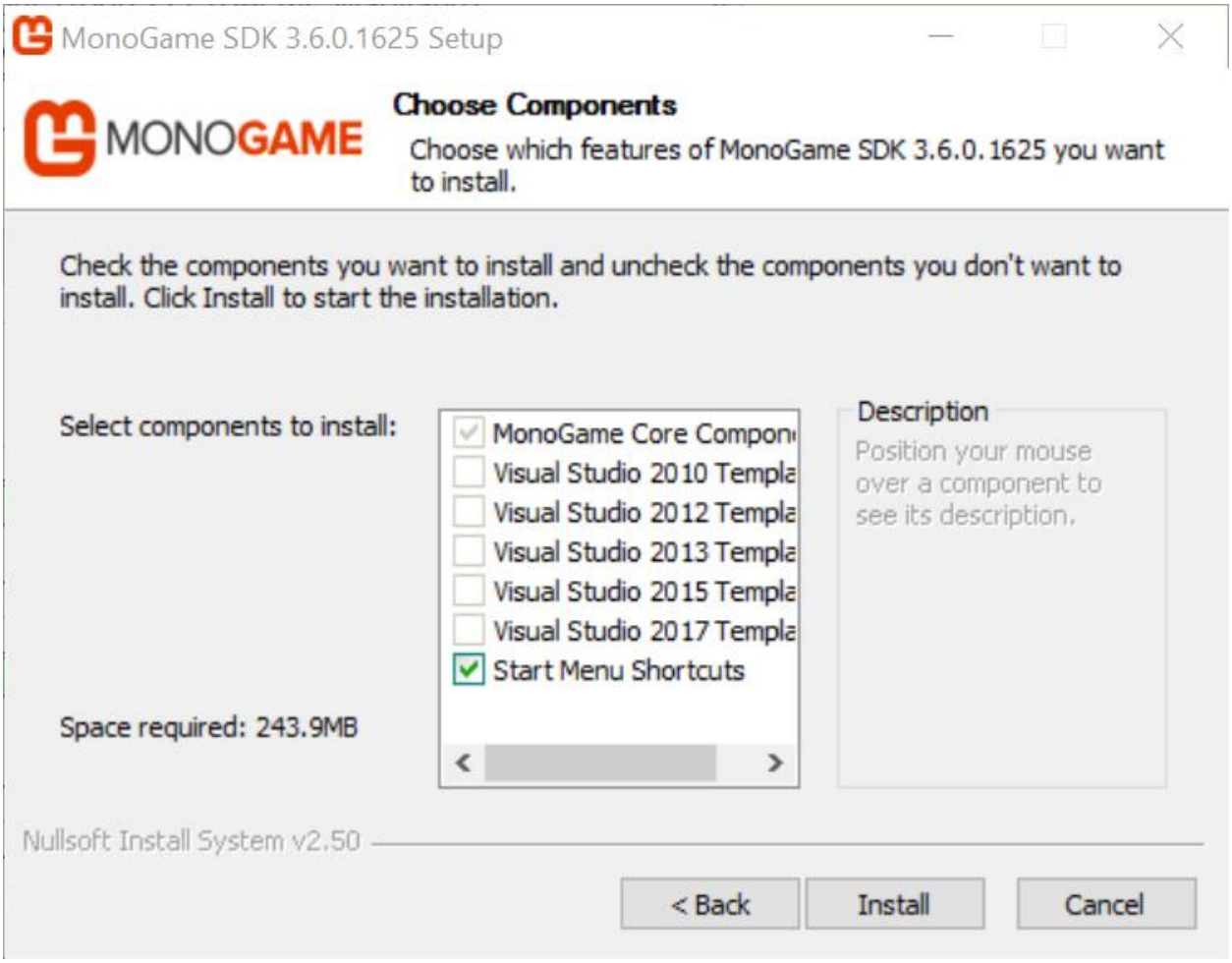


Figure 1 - MonoGame Setup

The install detects which versions of Visual Studio you have installed and disables the options you don't have. You can select one or more of the versions of Visual Studio you have installed, and MonoGame will be made available for whichever ones you select. Since Visual Studio 2017 is the most recent version at the time of writing, that's what we'll use.

Chapter 3 Creating the First Game

Now that we have MonoGame installed, we can get started on the actual game. Open up Visual Studio and select the **New** > **Project** menu item. You'll see a dialog box that looks like the following:

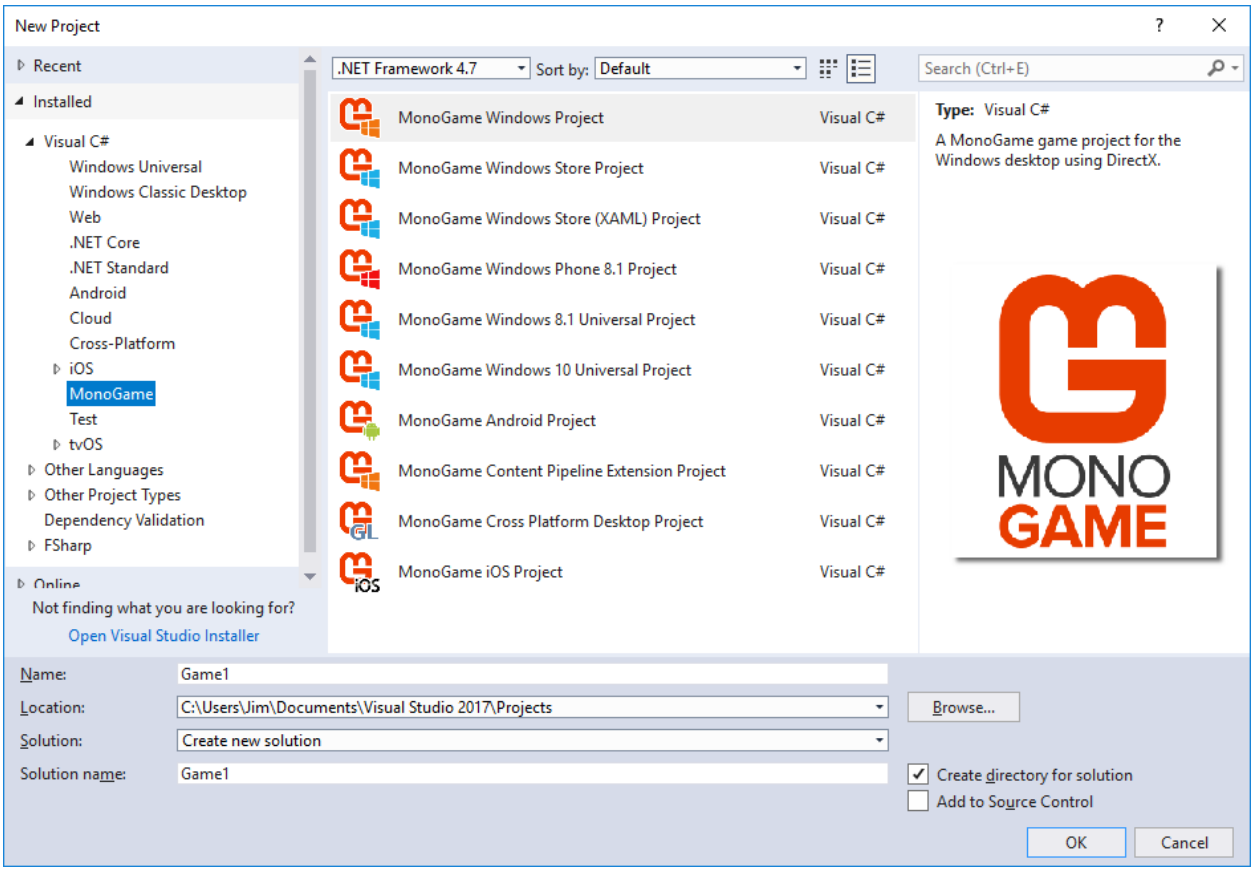


Figure 2 - Visual Studio New Project Dialog

I've selected the **MonoGame** node in the **Installed** list. Note that there are options not just for PC, but for mobile devices as well. If you want to target multiple platforms at once, you would select the MonoGame Cross-Platform Desktop Project option, but we'll only be working in Windows. In particular, we want to create a **MonoGame Windows Project** game. Select this project type, give your project a name (use **Ghost Arena** if you want to match the code available for download or in the book), select a location if you would like, and click **OK**. The Solution Explorer will show the basic skeleton of the game that MonoGame provides:

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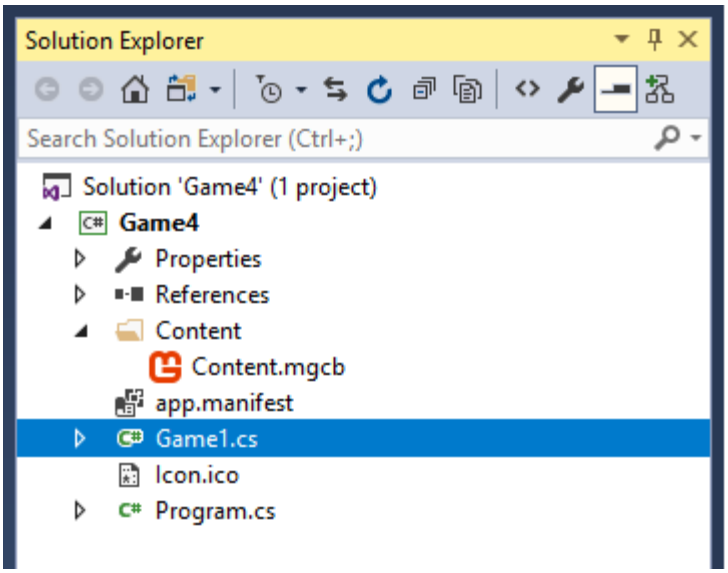


Figure 3 - Default MonoGame Windows Project

The Program.cs file is the entry point for the program:

```
public static class Program
{
    [STAThread]
    static void Main()
    {
        using (var game = new Game1())
            game.Run();
    }
}
```

Code Listing 1 – Program class

The **Main** method creates an instance of the **Game1** class and calls its **Run** method. This starts an internal game loop that allows you to update and draw objects in every frame. It does this by providing methods in the **Game** class. This loop will run until you either close the game window or call the **Exit** method of the **Game** class.

The **Game** class is the backbone of the code for a MonoGame project. It provides a number of methods for performing functionality that all games require, such as loading and unloading content (audio, graphics, etc.), drawing, and updating game objects. All of these methods are declared **protected virtual**, and it's expected that a project that uses MonoGame will contain a class that derives from it, and overrides the methods, implementing functionality that is needed for that specific game. The standard projects do this by providing a **Game1** class:

```
public class Game1 : Game
{
    GraphicsDeviceManager graphics;
```

```
    SpriteBatch spriteBatch;
    public Game1()
    {
        graphics = new GraphicsDeviceManager(this);
        Content.RootDirectory = "Content";
    }

    protected override void Initialize()
    {
        base.Initialize();
    }

    protected override void LoadContent()
    {
        spriteBatch = new SpriteBatch(GraphicsDevice);
    }

    protected override void UnloadContent()
    {
    }

    protected override void Update(GameTime gameTime)
    {
        if (GamePad.GetState(PlayerIndex.One).Buttons.Back ==
ButtonState.Pressed || Keyboard.GetState().IsKeyDown(Keys.Escape))
            Exit();

        base.Update(gameTime);
    }

    protected override void Draw(GameTime gameTime)
    {
        GraphicsDevice.Clear(Color.CornflowerBlue);

        base.Draw(gameTime);
    }
}
```

Code Listing 2 – Basic Game class

The graphics member sets up and controls the graphics system. You can use it to switch between full-screen and windows modes, and to adjust the window size. We'll go more in depth in the next chapter.

The **spriteBatch** member is the object you use to actually draw sprites and text to the screen via the **Draw** and **DrawString** methods.

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The methods are all commented and should be fairly self-explanatory. We'll fill in most of the methods in the next couple of chapters with more explanation. For now, just compile and run the project. You should get the standard filled-in window:

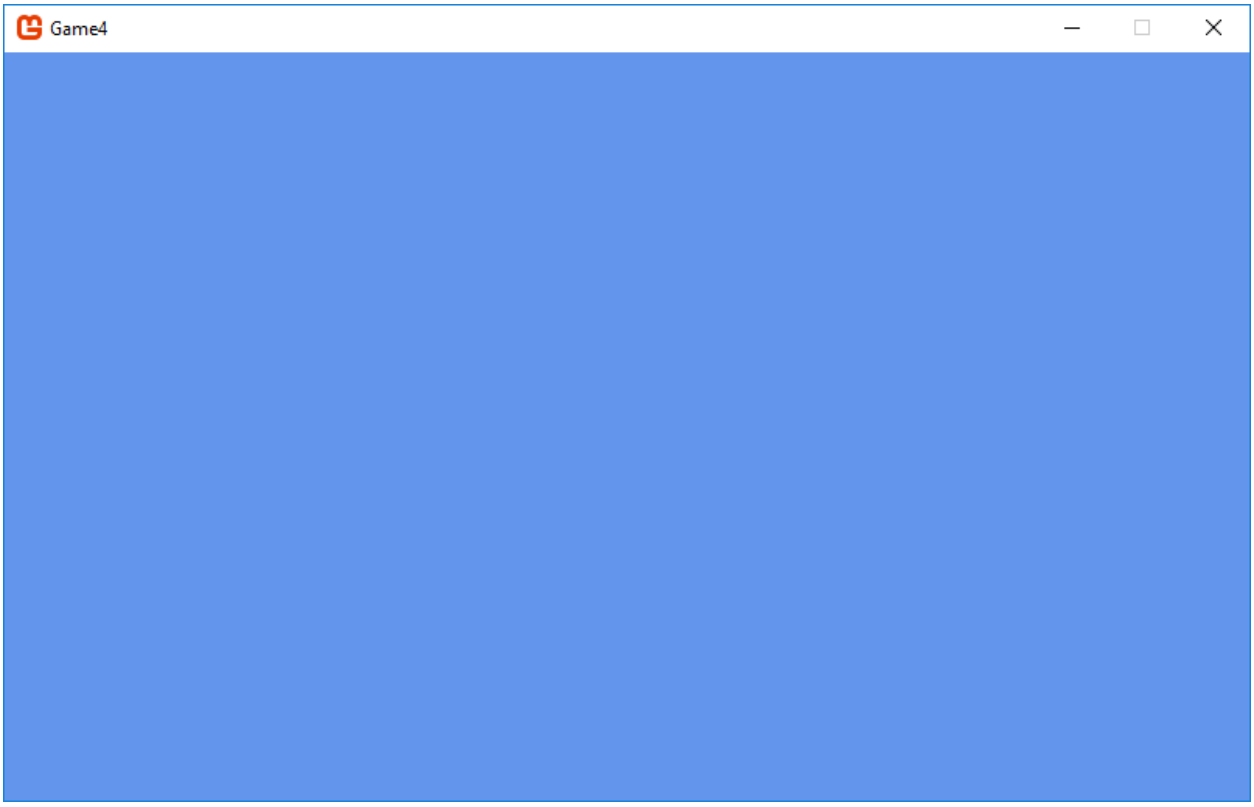


Figure 4 - Default game window

Pressing the Escape key or the Back button on a gamepad will close the window, as you can see in the **`Update`** method. We'll replace this with a more robust input-handling system in a couple of chapters, but for now, it suffices to allow you to cleanly exit the game.

Adjusting the graphics subsystem

Before we move on, let's explore the options available when using the graphics object.

The first thing you'll want to allow players to do is to run your game in either a window or full-screen. This usually takes a good chunk of code, but with MonoGame, it's a simple method call:

```
protected override void Update(GameTime gameTime)
{
    if (GamePad.GetState(PlayerIndex.One).Buttons.Back ==
ButtonState.Pressed || Keyboard.GetState().IsKeyDown(Keys.Escape))
        Exit();

    if (Keyboard.GetState().IsKeyDown(Keys.Enter) && previousState != null
&& previousState.IsKeyUp(Keys.Enter))
```

```
    {
        graphics.ToggleFullScreen();
    }

    previousState = Keyboard.GetState();

    base.Update(gameTime);
}
```

Code Listing 3 – Toggle full-screen mode

While the **ToggleFullScreen** method is what actually does the work, there needs to be a bit of code around it to avoid errors being thrown. We'll get into the **GamePad**, **Keyboard**, and related classes a bit later, but the basic gist of the code is that every time the Enter key is pressed, we flip between the full-screen and windowed modes.

The other main option you will want to give players is the ability to change the resolution of the game window. In order to do this correctly, you'll need to know which resolutions the user's machine supports. You can get this information with the following code:

```
foreach (DisplayMode dm in
GraphicsAdapter.DefaultAdapter.SupportedDisplayModes)
{
    Console.WriteLine("\n width, height(" + dm.Width.ToString() + "," +
dm.Height.ToString() + "), aspect ratio - " + dm.AspectRatio.ToString());
}
```

Code Listing 4 – Supported resolutions

We'll implement this in a later chapter.

There are other options you may want to allow the user to configure, depending on your game. We'll cover input options (such as configuring keys for certain actions) in Chapter 5, and audio options in Chapter 6.

Our game will use a sample that Microsoft provided for developing XNA games, the "Game State Management" sample, which can be found here.

This sample provides a good skeleton for building any game, including menu and game screens, and input handling for keyboard or gamepad. If you don't want to follow along through the book to build the game, you can either download the sample and look at the code, or download the full game code for the game we'll be developing throughout this book.

The game we'll be building is a simple top-down shooter. The player controls a character in an arena where ghosts appear out of 10 different entrances. If a ghost touches the character, it drains some health from him and disappears. The player scores points by killing the ghosts, with the goal of the game being to survive as long as possible and get as high a score as possible. The finished game will look like the following screenshot.

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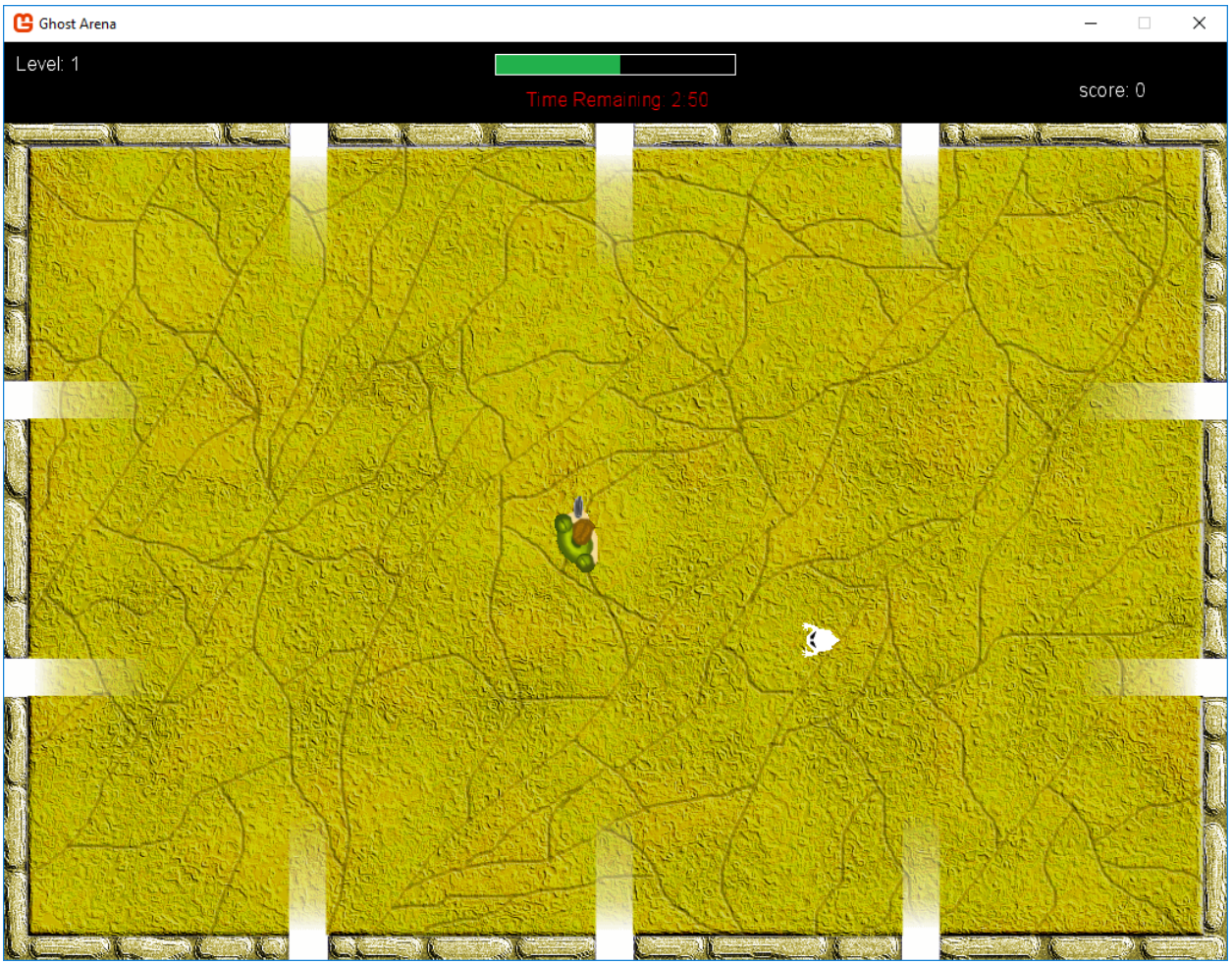


Figure 5 - Finished Game Screenshot

The game will keep track of the player's scores, allowing the highest scores to be displayed. The game will also have achievements that can be earned and displayed. A difficulty system will be implemented to make the game more challenging for skilled players.

With the base game in place, we'll need to add a lot of classes and folders to get to the point where we can start displaying graphics. First, we'll add a couple of folders: ScreenManager and Screens. In the **ScreenManager** folder, add two classes: **`GameScreen.cs`** and **`ScreenManager.cs`**. Replace the code in the **`ScreenManager`** class with the following:

```
using System;
using System.Collections.Generic;
using Microsoft.Xna.Framework;
using Microsoft.Xna.Framework.Graphics;

namespace Ghost_Arena
{
    public class ScreenManager : DrawableGameComponent
    {
        List<GameScreen> _screens = new List<GameScreen>();
```

```
        List<GameScreen> _screensToUpdate = new List<GameScreen>();
        bool _traceEnabled;

        new public Game Game
        {
            get { return base.Game; }
        }

        public bool TraceEnabled
        {
            get { return _traceEnabled; }
            set { _traceEnabled = value; }
        }

        public ScreenManager(Game game, GraphicsDeviceManager
graphicsDeviceManager)
            : base(game)
        {
        }

        protected override void LoadContent()
        {
            foreach (GameScreen screen in _screens)
            {
                screen.LoadContent();
            }
        }

        protected override void UnloadContent()
        {
            foreach (GameScreen screen in _screens)
            {
                screen.UnloadContent();
            }
        }

        public override void Update(GameTime gameTime)
        {
            _screensToUpdate.Clear();

            foreach (GameScreen screen in _screens)
                _screensToUpdate.Add(screen);

            bool otherScreenHasFocus = !Game.IsActive;
            bool coveredByOtherScreen = false;

            while (_screensToUpdate.Count > 0)
            {
                GameScreen screen = _screensToUpdate[_screensToUpdate.Count
- 1];
```


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```
                _screensToUpdate.RemoveAt(_screensToUpdate.Count - 1);
                screen.Update(gameTime, otherScreenHasFocus,
coveredByOtherScreen);

                if (screen.ScreenState == ScreenState.TransitionOn ||
                    screen.ScreenState == ScreenState.Active)
                {
                    if (!otherScreenHasFocus)
                    {
                        screen.HandleInput(_input, gameTime);
                        otherScreenHasFocus = true;
                    }

                    if (!screen.IsPopup)
                        coveredByOtherScreen = true;
                }
            }

            if (_traceEnabled)
                TraceScreens();
        }

        void TraceScreens()
        {
            List<string> screenNames = new List<string>();

            foreach (GameScreen screen in _screens)
                screenNames.Add(screen.GetType().Name);
        }

        public override void Draw(GameTime gameTime)
        {
            foreach (GameScreen screen in _screens)
            {
                if (screen.ScreenState == ScreenState.Hidden)
                    continue;

                screen.Draw(gameTime);
            }
        }

        public void AddScreen(GameScreen screen)
        {
            screen.ScreenManager = this;
            screen.Initialize();
            _screens.Add(screen);
        }

        public void RemoveScreen(GameScreen screen)
        {
```

```
            _screens.Remove(screen);
            _screensToUpdate.Remove(screen);
        }

        public GameScreen[] GetScreens()
        {
            return _screens.ToArray();
        }
    }
}
```

Code Listing 5 – ScreenManager class

Since we'll have about 10 different screens in our game, a nice, clean way to manage them and be able to transition between them is essential. Each screen, whether it's a menu, pause, or gameplay screen, will be a separate class. The **ScreenManager** keeps an array of instances of each screen that's in use, and tells each one to update and draw itself instead of having to figure out which one is the active one and have it draw and update. It does this by inheriting from **DrawableGameComponent**, a framework class that provides a method for loading content and drawing. This class in turn inherits from **GameComponent**, which provides a method for updating itself every frame. The **Draw** method is also called in every frame. The **LoadContent** and **UnloadContent** are only called once, when an instance of the class is created or destroyed.

We'll fill in some of these methods as we go along, but this is all that's needed for now.

We need to create an instance of the **this** class. That will be done in the **Game** class. Add the member and code to initialize it:

```
ScreenManager screenManager;

protected override void Initialize()
{
    screenManager = new ScreenManager(this, graphics);

    screenManager.Initialize();

    // Activate the first screens.
    screenManager.AddScreen(new MainMenuScreen());

    Components.Add(screenManager);

    base.Initialize();
}
```

Code Listing 6 – ScreenManager creation

We'll see the first screen that's displayed when the game starts, the **MainMenuScreen**, shortly.

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The **Components** member that the **ScreenManager** instance is added to is a collection of **GameComponent** (or **DrawableGameComponent**, as it inherits from **GameComponent**) objects. The **GameComponent** class implements four different interfaces that provide some base functionality for objects: **IGameComponent**, **IUpdateable**, **IComparable**, and **IDisposable**.

IGameComponent provides an **Initialize** method, **IUpdateable**:

Properties
Enabled
UpdateOrder
Methods
Update
Events
EnabledChanged
UpdateOrderChanged

Table 1 – IUpdateable Members

IComparable gives us a **CompareTo** method, allowing us to compare two instances and tell us where the two are in relation to each other in the list of **GameComponents**, and **IDisposable** provides a **Dispose** method.

Moving on, replace the code inside the **GameScreen** class with the following:

```
using System;
using Microsoft.Xna.Framework;

namespace Ghost_Arena
{
    public enum ScreenState
    {
        TransitionOn,
        Active,
        TransitionOff,
        Hidden,
```

```
    }

    public abstract class GameScreen
    {
        public bool IsPopup
        {
            get { return _isPopup; }
            protected set { _isPopup = value; }
        }

        protected bool _isPopup = false;

        public TimeSpan TransitionOnTime
        {
            get { return _transitionOnTime; }
            protected set { _transitionOnTime = value; }
        }

        protected TimeSpan _transitionOnTime = TimeSpan.Zero;

        public TimeSpan TransitionOffTime
        {
            get { return _transitionOffTime; }
            protected set { _transitionOffTime = value; }
        }

        protected TimeSpan _transitionOffTime = TimeSpan.Zero;


        public float TransitionPosition
        {
            get { return _transitionPosition; }
            protected set { _transitionPosition = value; }
        }

        protected float _transitionPosition = 1;

        public byte TransitionAlpha
        {
            get { return (byte)(255 - _transitionPosition * 255); }
        }

        public ScreenState ScreenState
        {
            get { return _screenState; }
            protected set { _screenState = value; }
        }

        protected ScreenState _screenState = ScreenState.TransitionOn;
```


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```
        public bool IsExiting
        {
            get { return _isExiting; }
            protected set { _isExiting = value; }
        }

        protected bool _isExiting = false;

        public bool IsActive
        {
            get
            {
                return !_otherScreenHasFocus &&
                       (_screenState == ScreenState.TransitionOn ||
                        _screenState == ScreenState.Active);
            }
        }

        protected bool _otherScreenHasFocus;

        public ScreenManager ScreenManager
        {
            get { return _screenManager; }
            internal set { _screenManager = value; }
        }

        protected ScreenManager _screenManager;
        public virtual void LoadContent() { }
        public virtual void UnloadContent() { }
        public virtual void Initialize() { }
        public virtual void Update(GameTime gameTime, bool
otherScreenHasFocus,
                                                       bool
coveredByOtherScreen)
        {
            _otherScreenHasFocus = otherScreenHasFocus;

            if (_isExiting)
            {
                _screenState = ScreenState.TransitionOff;

                if (!UpdateTransition(gameTime, _transitionOffTime, 1))
                {
                    ScreenManager.RemoveScreen(this);

                    _isExiting = false;
                }
            }
            else if (coveredByOtherScreen)
            {
```

```
                if (UpdateTransition(gameTime, _transitionOffTime, 1))
                {
                    _screenState = ScreenState.TransitionOff;
                }
                else
                {
                    _screenState = ScreenState.Hidden;
                }
            }
            else
            {
                if (UpdateTransition(gameTime, _transitionOnTime, -1))
                {
                    _screenState = ScreenState.TransitionOn;
                }
                else
                {
                    _screenState = ScreenState.Active;
                }
            }
        }

        bool UpdateTransition(GameTime gameTime, TimeSpan time, int
direction)
        {
            float transitionDelta;

            if (time == TimeSpan.Zero)
                transitionDelta = 1;
            else
                transitionDelta =
(float)(gameTime.ElapsedGameTime.TotalMilliseconds /
                                            time.TotalMilliseconds);

            _transitionPosition += transitionDelta * direction;

            if ((_transitionPosition <= 0) || (_transitionPosition >= 1))
            {
                _transitionPosition = MathHelper.Clamp(_transitionPosition,
0, 1);
                return false;
            }

            return true;
        }

        public abstract void Draw(GameTime gameTime);
        public virtual void ExitScreen()
        {
            if (_transitionOffTime <= TimeSpan.Zero)
```


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```
            {
                ScreenManager.RemoveScreen(this);
            }
            else
            {
                _isExiting = true;
            }
        }
    }
}
```

Code Listing 7 – GameScreen class

The **GameScreen** class is the base class for all screens that we'll have in our game. The four **ScreenState** enums show the different states a screen can be in that we'll have to handle. Most of the class is made up of functionality for handling transitions, as menus will slide in and out as well as fade. The Pause screen will be displayed on top of the gameplay screen, so will draw on only part of the screen, with the rest being partly visible behind it.

The **TransitionOnTime** and **TransitionOffTime** members control the how long it takes to perform the transition. Note that for the base class, both are set to **TimeSpan.Zero**, which means the transition is instantaneous.

The **TransitionPosition** and **TransitionAlpha** members control how the transition looks as it occurs. This is more for menu screens, since they slide on and off the monitor. Most of the other members should be pretty obvious.

Since the class is a base class from which others will inherit, there's not much functionality in it except what will be the same in every child class. Classes that inherit from it will be expected to provide the functionality for loading content and drawing (and later, handling input). This is why the methods are abstract or virtual.

The first class that we'll add that will inherit from it will be another base class, **MenuScreen**. Add a new class with this name to the **Screens** folder, and replace the code with the following:

```
using System;
using System.Collections.Generic;
using Microsoft.Xna.Framework;
using Microsoft.Xna.Framework.Input;
using Microsoft.Xna.Framework.Graphics;

namespace Ghost_Arena
{
    abstract class MenuScreen : GameScreen
    {
        protected List<string> _menuEntries = new List<string>();
        int _selectedEntry = 0;

        protected IList<string> MenuEntries
        {
```

```
            get { return _menuEntries; }
        }

        public MenuScreen()
        {
            TransitionOnTime = TimeSpan.FromSeconds(0.5);
            TransitionOffTime = TimeSpan.FromSeconds(0.5);
        }

        public override void Initialize()
        {
            base.Initialize();
        }

        protected abstract void OnSelectEntry(int entryIndex);

        protected virtual void OnNewArrowDown(Keys arrow, int entryIndex)
        {
        }

        protected virtual void OnArrowDown(Keys arrow, int entryIndex,
GameTime gameTime)
        {
        }

        protected virtual void OnArrowUp(Keys arrow, int entryIndex)
        {
        }

        protected abstract void OnCancel();

        public override void Draw(GameTime gameTime)
        {
            Vector2 position = new Vector2(100, 150);

            float transitionOffset = (float)Math.Pow(TransitionPosition,
2);

            if (ScreenState == ScreenState.TransitionOn)
                position.X -= transitionOffset * 256;
            else
                position.X += transitionOffset * 512;

        }
    }
}
```

Code Listing 8 – MenuScreen class

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Our menu screens will be very simple, just strings that are rendered on-screen with the currently selected item being highlighted by being rendered in a different color and growing and shrinking. We'll add the code that actually draws this in the next chapter. Pressing the **Enter** key or **A** button on a gamepad will "click" the menu item.

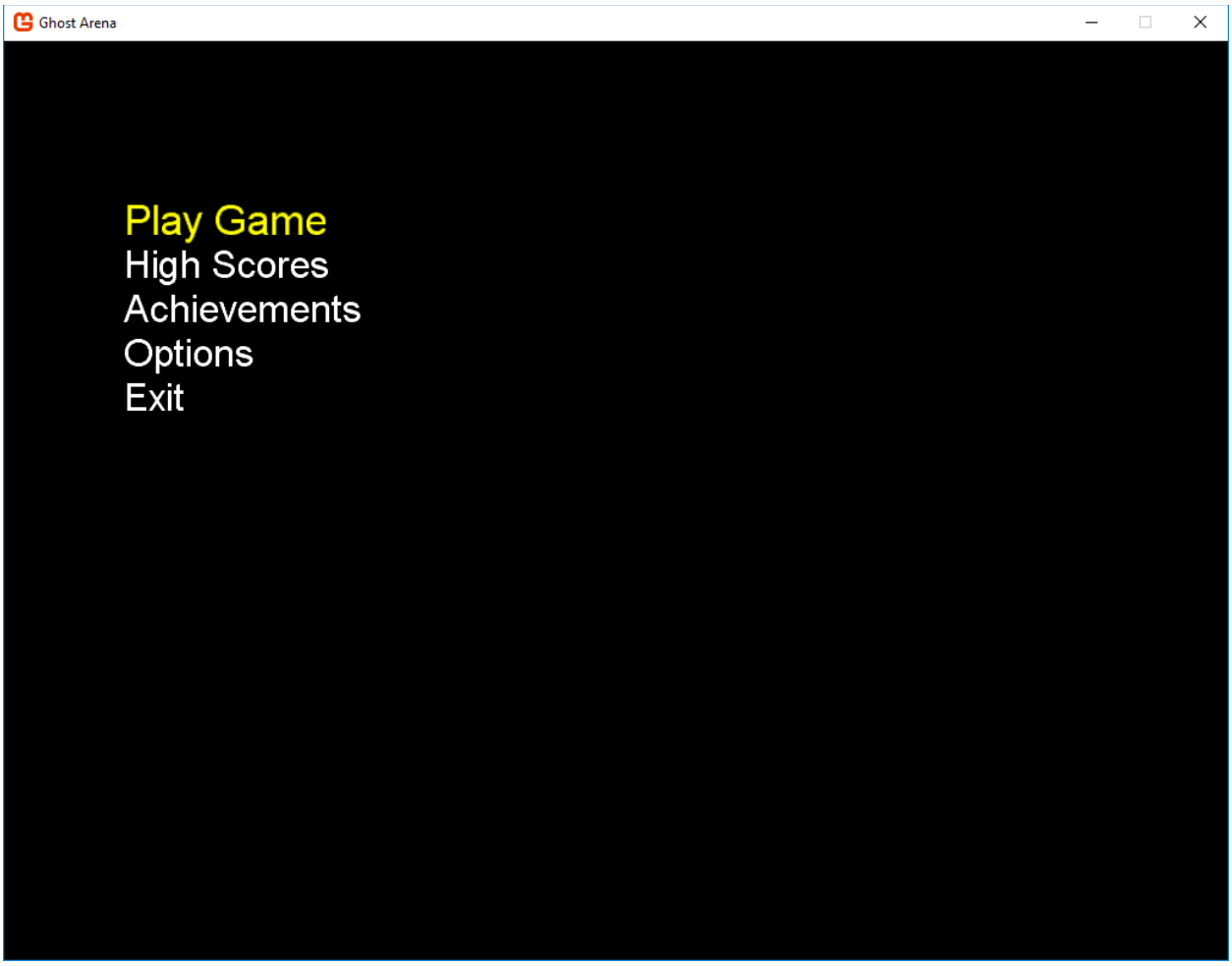


Figure 6 - Main Menu Screen

The **MainMenuScreen** class is very simple since most of the work is done in the base class. Add this class to the **Screens** folder:

```
using System;

namespace Ghost_Arena
{
    class MainMenuScreen : MenuScreen
    {
        public MainMenuScreen()
        {
            _menuEntries.Add("Play Game");
            _menuEntries.Add("High Scores");
            _menuEntries.Add("Achievements");
```

```
            _menuEntries.Add("Options");
            _menuEntries.Add("Exit");
        }

        public override void Initialize()
        {
            base.Initialize();
        }

        protected override void OnSelectEntry(int entryIndex)
        {
            switch (entryIndex)
            {
                case 0:
                    _screenManager.AddScreen(new DifficultyScreen());
                    break;
                case 1:
                    _screenManager.AddScreen(new HighScoreScreen());
                    break;
                case 2:
                    _screenManager.AddScreen(new AchievementsScreen());
                    break;
                case 3:
                    _screenManager.AddScreen(new OptionsMenuScreen());
                    break;
                case 4:
                    OnCancel();
                    break;
            }
        }

        protected override void OnCancel()
        {
            const string message = "Are you sure you want to exit this
game?";

            MessageBoxScreen messageBox = new MessageBoxScreen(message);

            messageBox.Accepted += ExitMessageBoxAccepted;

            _screenManager.AddScreen(messageBox);
        }

        void ExitMessageBoxAccepted(object sender, EventArgs e)
        {
            _screenManager.Game.Exit();
        }
    }
}
```


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Code Listing 9 – MenuScreen class

We add the list of menu items to display in the constructor, override the **`OnSelectEntry`** method to add the applicable screen to the **`ScreenManager`**, and make sure the player really wants to quit when they select the Exit menu item.

We see in this class the first place we'll use the **`MessageBoxScreen`** class. It overlays the existing screen to look like a dialog box.

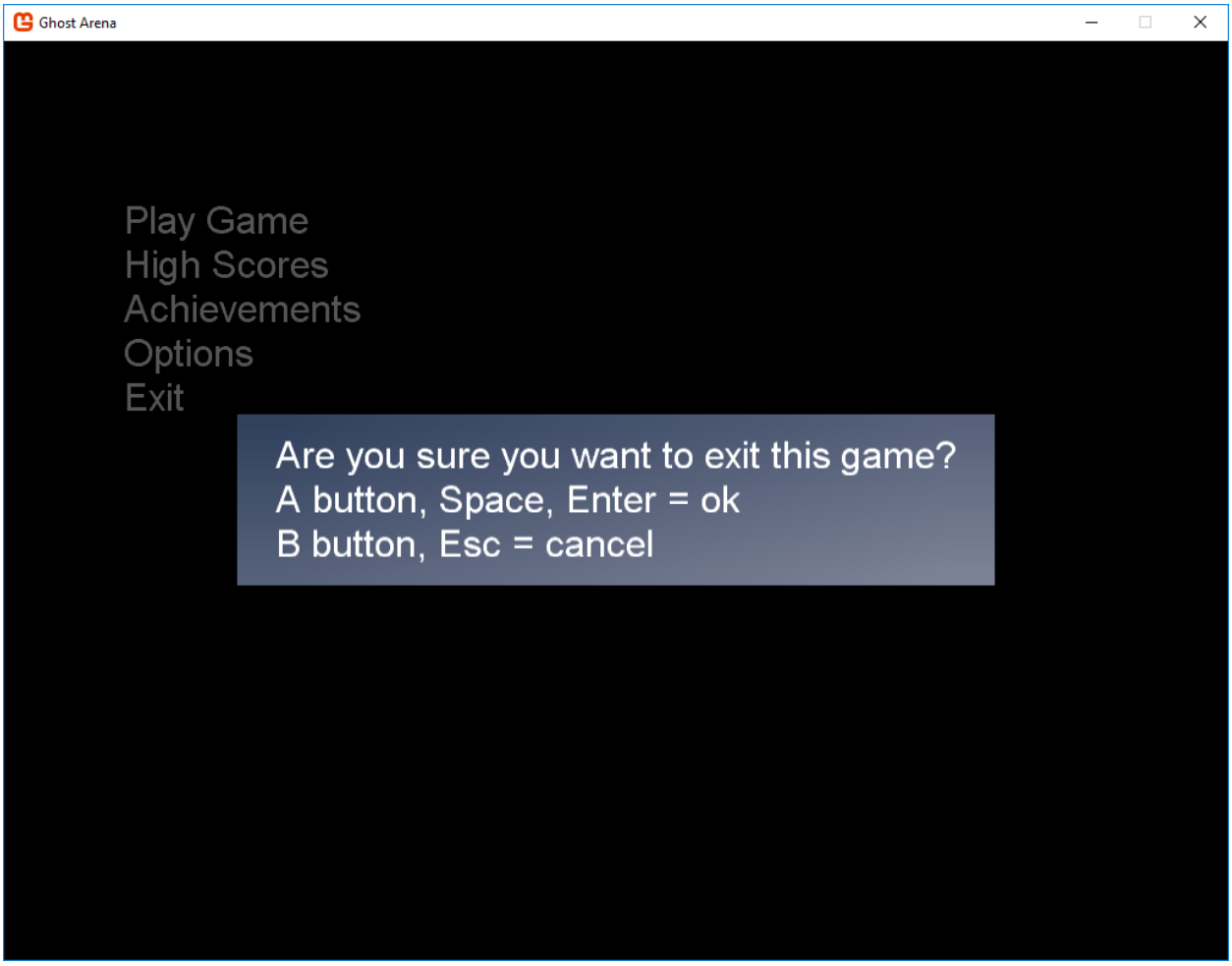


Figure 7 - Message Box Screen

Add this class to the **Screens** folder:

```
using System;
using Microsoft.Xna.Framework;
using Microsoft.Xna.Framework.Graphics;

namespace Ghost_Arena
{
    class MessageBoxScreen : GameScreen
    {
```

```
        string _message;
        Texture2D _gradientTexture;
        public event EventHandler<EventArgs> Accepted;
        public event EventHandler<EventArgs> Cancelled;

        public MessageBoxScreen(string message)
        {
            const string usageText = "\nA button, Space, Enter = ok" +
                                     "\nB button, Esc = cancel";

            _message = message + usageText;

            _isPopup = true;

            _transitionOnTime = TimeSpan.FromSeconds(0.2);
            _transitionOffTime = TimeSpan.FromSeconds(0.2);
        }

        public override void LoadContent()
        {
            _gradientTexture =
Game1.Instance.Content.Load<Texture2D>("gradient");
        }

        public override void Draw(GameTime gameTime)
        {
        }
    }
}
```

Code Listing 10 – MessageBoxScreen class

We'll add a method of input-handling and drawing the dialog in the next few chapters.

The **PauseMenuScreen** class could have been an instance of the **MessageBoxScreen** class, but making it inherit from **MenuScreen** allows you to add functionality to it in the future, such as saving the game. It also uses the **MessageBoxScreen** class as a confirmation selection, so making it inherit from that class would probably look strange. Add the following class to the **Screens** folder:

```
using System;
using Microsoft.Xna.Framework;

namespace Ghost_Arena
{
    class PauseMenuScreen : MenuScreen
    {
        public PauseMenuScreen()
        {
            _menuEntries.Add("Resume Game");
```


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```
            _menuEntries.Add("Quit Game");

            IsPopup = true;
        }

        protected override void OnSelectEntry(int entryIndex)
        {
            switch (entryIndex)
            {
                case 0:
                    ExitScreen();
                    break;

                case 1:
                    const string message = "Are you sure you want to quit
this game?";

                    MessageBoxScreen messageBox = new
MessageBoxScreen(message);

                    messageBox.Accepted += QuitMessageBoxAccepted;

                    _screenManager.AddScreen(messageBox);
                    break;
            }
        }

        protected override void OnCancel()
        {
            ExitScreen();
        }

        void QuitMessageBoxAccepted(object sender, EventArgs e)
        {
            LoadingScreen.Load(_screenManager, LoadMainMenuScreen, false);
        }

        void LoadMainMenuScreen(object sender, EventArgs e)
        {
            _screenManager.AddScreen(new MainMenuScreen());
        }

        public override void Draw(GameTime gameTime)
        {

            base.Draw(gameTime);
        }
    }
}
```

Code Listing 11 – PauseMenuScreen class

We'll add one line to this class in the next chapter when we implement our drawing functionality.

This class uses the **`LoadingScreen`** class in case you want to add functionality, such as saving the game, which might take a few seconds. If the user chooses to end the game and nothing seems to happen, she may think something is wrong with the game. Displaying a screen that lets her know something is going on is a good thing to do. Add this class to the **Screens** folder:

```
using System;
using Microsoft.Xna.Framework;
using Microsoft.Xna.Framework.Graphics;

namespace Ghost_Arena
{
    /// <summary>
    /// The loading screen coordinates transitions between the menu system
and the
    /// game itself. Normally one screen will transition off at the same
time as
    /// the next screen is transitioning on, but for larger transitions
that can
    /// take a longer time to load their data, we want the menu system to
be entirely
    /// gone before we start loading the game. This is done as follows:
    ///
    /// - Tell all the existing screens to transition off.
    /// - Activate a loading screen, which will transition on at the same
time.
    /// - The loading screen watches the state of the previous screens.
    /// - When it sees they have finished transitioning off, it activates
the real
    ///   next screen, which may take a long time to load its data. The
loading
    ///   screen will be the only thing displayed while this load is taking
place.
    /// </summary>
    class LoadingScreen : GameScreen
    {
        bool _loadingIsSlow;
        bool _otherScreensAreGone;
        EventHandler<EventArgs> loadNextScreen;

        public bool LoadingIsSlow
        {
            get { return _loadingIsSlow; }
            set { _loadingIsSlow = value; }
        }

        public bool OtherScreensAreGone
```


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```
        {
            get { return _otherScreensAreGone; }
            set { _otherScreensAreGone = value; }
        }

        private LoadingScreen()
        {
            _transitionOnTime = TimeSpan.FromSeconds(0.5);
        }

        public static void Load(ScreenManager screenManager,
                                EventHandler<EventArgs> loadNextScreen,
                                bool loadingIsSlow)
        {
            foreach (GameScreen screen in screenManager.GetScreens())
                screen.ExitScreen();

            LoadingScreen loadingScreen = new LoadingScreen();

            loadingScreen.LoadingIsSlow = loadingIsSlow;
            loadingScreen.loadNextScreen = loadNextScreen;

            screenManager.AddScreen(loadingScreen);
        }

        public override void Update(GameTime gameTime, bool
otherScreenHasFocus,
                                                        bool
coveredByOtherScreen)
        {
            base.Update(gameTime, otherScreenHasFocus,
coveredByOtherScreen);

            // If all the previous screens have finished transitioning
            // off, it is time to actually perform the load.
            if (_otherScreensAreGone)
            {
                ScreenManager.RemoveScreen(this);

                loadNextScreen(this, EventArgs.Empty);
            }
        }

        public override void Draw(GameTime gameTime)
        {
            // If we are the only active screen, that means all the
previous screens
            // must have finished transitioning off. We check for this in
the Draw
```

```
            // method, rather than in Update, because it isn't enough just
for the
            // screens to be gone: in order for the transition to look good
we must
            // have actually drawn a frame without them before we perform
the load.
            if ((ScreenState == ScreenState.Active) &&
                (ScreenManager.GetScreens().Length == 1))
            {
                _otherScreensAreGone = true;
            }

            // The gameplay screen takes a while to load, so we display a
loading
            // message while that is going on, but the menus load very
quickly, and
            // it would look silly if we flashed this up for just a
fraction of a
            // second while returning from the game to the menus. This
parameter
            // tells us how long the loading is going to take, so we know
whether
            // to bother drawing the message.
            if (_loadingIsSlow)
            {
                const string message = "Loading...";

            }
        }
    }
}
```

Code Listing 12 – LoadingScreen class

I've left the comments in this class, since this is one of the more complicated pieces of code. It stores an event that's called once the code that is being executed (that is causing the pause) in the game completes.

You can customize the text by changing the message variable in the **Draw** method. As with the other classes, there is a lot that we'll add to this method in the next chapter.

Going back to the Main Menu list, we have three other screens left. The first is the **HighScoreScreen**. Add this code to the **Screens** menu:

```
using System;
using System.Collections.Generic;
using System.Text;
using Microsoft.Xna.Framework;
using Microsoft.Xna.Framework.Graphics;
```


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```
namespace Ghost_Arena
{
    class HighScoreScreen : GameScreen
    {
        private HighScoreList _list;

        public HighScoreScreen()
        {
            //load high score list
            _list = new HighScoreList();

            TransitionOnTime = TimeSpan.FromSeconds(1.5);
            TransitionOffTime = TimeSpan.FromSeconds(0.5);
        }

        public override void LoadContent()
        {

            base.LoadContent();
        }

        public override void Draw(GameTime gameTime)
        {
            Vector2 textPosition;



            int count = 0;

            //loop through list and draw each item
            if (_list.Scores != null)
            {
                foreach (HighScore item in _list.Scores)
                {
                    textPosition = new Vector2(50, 150 + 50 * count);



                    count++;
                }
            }
        }
    }
}
```

Code Listing 13 – HighScoreScreen class

The High Score screen will display the date, score, and highest level the player reached for the game:

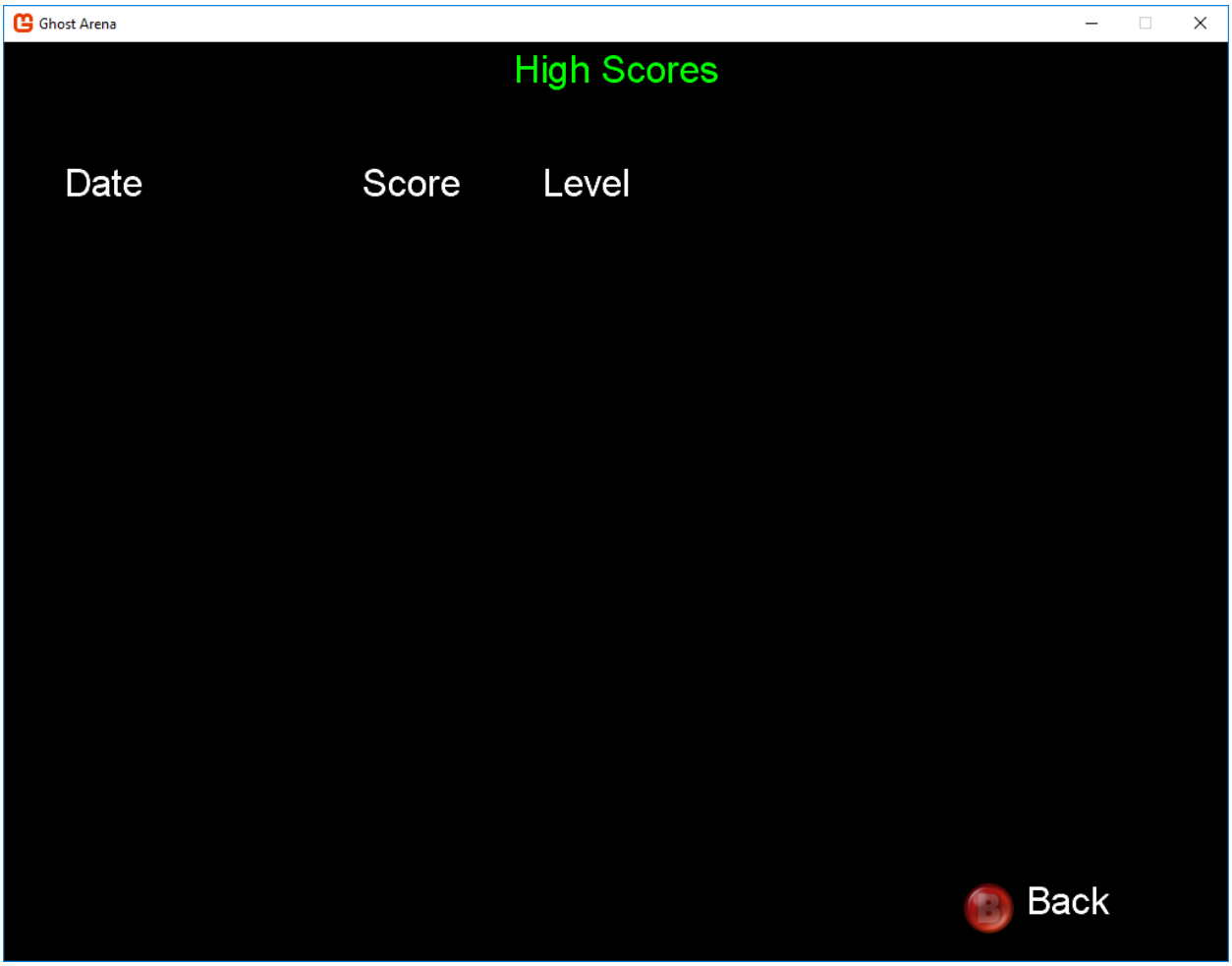


Figure 8 - High Score Screen

The screen uses a class we don't have yet, so let's add a stub so we don't get a compile error. Create a new class in the root folder called **`HighScoreList`** and update it with the following code:

```
public class HighScore
{
    public string Date;
    public int Level;
    public int Score;

    public HighScore()
    {

    }

    public HighScore(string date, int level, int score)
    {
        Date = date;
        Level = level;
```


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```
        Score = score;
    }
}

public class HighScoreList
{
    private List<HighScore> _scores;

    public List<HighScore> Scores
    {
        get {return _scores;}
    }
}
```

Code Listing 14 – HighScoreList class

For every three minutes the player stays alive, the level increases. A countdown timer is displayed at the top of the Game Play screen, below the character's health bar. This can be seen in the finished game screenshot shown earlier in the book. The speed of the ghosts increases a bit each time the level increases. There should come a time when the speed of the ghosts is high enough that the player can't kill them all quick enough to keep his health from reaching 0.

The **OptionsMenuScreen** allows the player to configure whether or not the game runs in full-screen mode and the controls that perform various actions. It's another fairly simple class that inherits from **MenuScreen**:

```
using Microsoft.Xna.Framework;

namespace Ghost_Arena
{
    class OptionsMenuScreen : MenuScreen
    {
        public OptionsMenuScreen()
        {
            _menuEntries.Add("Toggle Full-Screen");
            _menuEntries.Add("Configure Controls");
            _menuEntries.Add("Back");
        }

        public override void Update(GameTime gameTime, bool
otherScreenHasFocus,
                                                        bool
coveredByOtherScreen)
        {
            base.Update(gameTime, otherScreenHasFocus,
coveredByOtherScreen);
        }

        protected override void OnSelectEntry(int entryIndex)
```

```
        {
            switch (entryIndex)
            {
                case 0:

                    break;

                case 1:

                    ScreenManager.AddScreen(new ControlsScreen());
                    break;

                case 2:

                    ExitScreen();
                    break;
            }
        }

        protected override void OnCancel()
        {
            ExitScreen();
        }
    }
}
```

Code Listing 15 – OptionsMenuScreen class

We'll implement the functionality to toggle full-screen mode in the next chapter when we get our graphics system up and running. As we've seen, it's basically one line of code. If the user wants to change the controls used for various actions (move horizontally and vertically, fire, rotate), an instance of the **`ControlsScreen`** is displayed. We'll take a look at this later when we look at MonoGame's functionality for handling input.

Our game will have three difficulty levels, so after the player selects the Play Game item, we display another menu to have them choose the difficulty:

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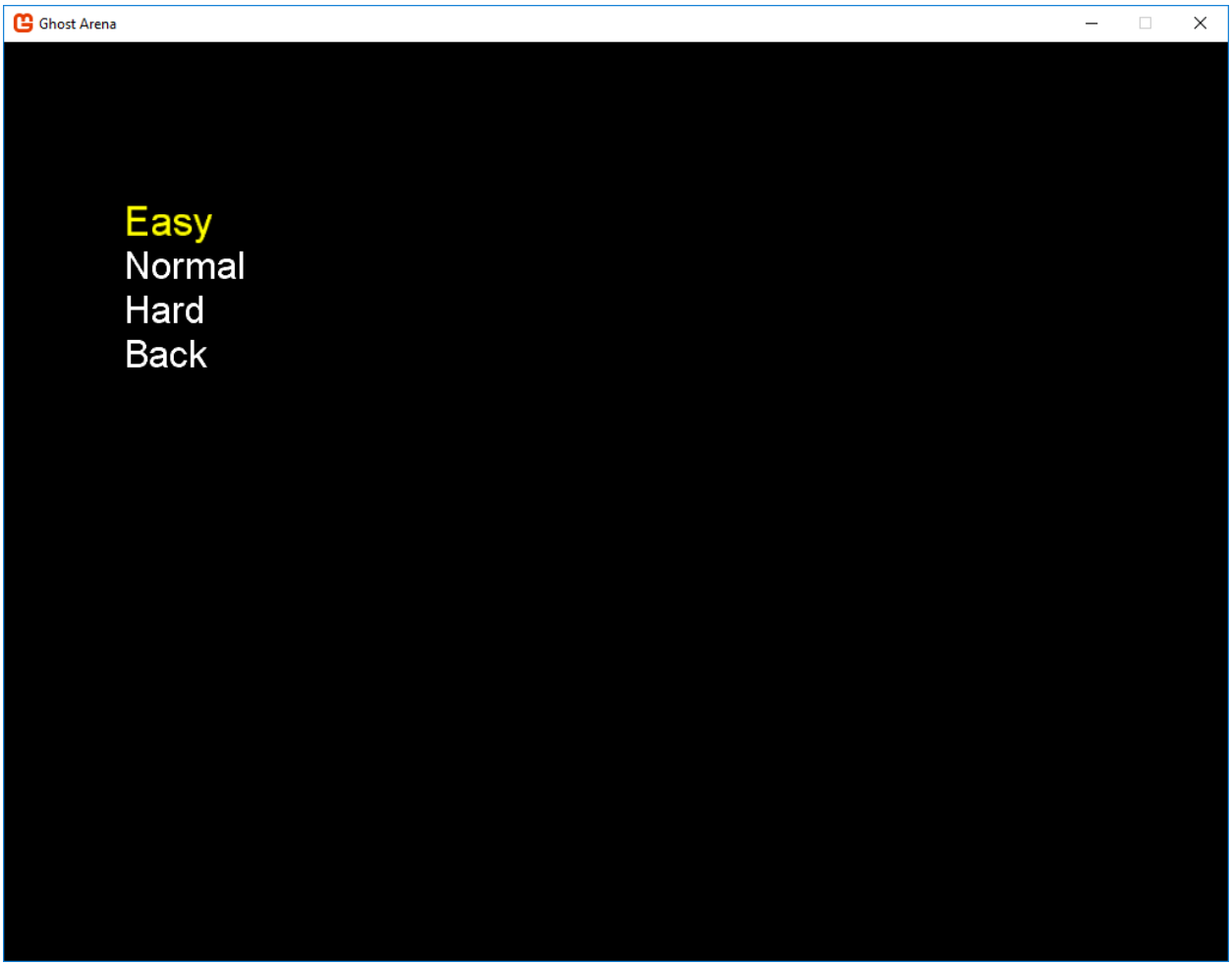


Figure 9 – Difficulty Screen

This class is a very simple version of the **MenuScreen** class:

```
using Microsoft.Xna.Framework;

namespace Ghost_Arena
{
    class DifficultyScreen : MenuScreen
    {
        public override void Initialize()
        {
            string[] names =
((Game1)ScreenManager.Game).Difficulty.GetDifficultyNames();

            foreach (string item in names)
            {
                _menuEntries.Add(item);
            }

            _menuEntries.Add("Back");
```

```
            base.Initialize();
        }

        public override void Update(GameTime gameTime, bool
otherScreenHasFocus,
                                                    bool
coveredByOtherScreen)
        {
            base.Update(gameTime, otherScreenHasFocus,
coveredByOtherScreen);
        }

        protected override void OnSelectEntry(int entryIndex)
        {
            switch (entryIndex)
            {
                case 0:
                case 1:
                case 2:

                    foreach (GameScreen screen in
ScreenManager.GetScreens())
                        screen.ExitScreen();

                    ScreenManager.AddScreen(new
GameplayScreen(entryIndex));

                    break;

                case 3:
                    ExitScreen();
                    break;
            }
        }

        protected override void OnCancel()
        {
            ExitScreen();
        }
    }
}
```

Code Listing 16 – DifficultyScreen class

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You'll notice a line in the **`Initialize`** method that won't compile—we haven't added the **`DifficultySystem`** member to the **`Game`** class yet. We'll get to it shortly. There a several other additions we'll make as well, after we finish adding the rest of our screen classes. For now, if you're creating the game by going along with this book and adding the code, you can comment out the lines in the **`Initialize`** method that cause the error. You won't need this screen until we actually get the Game Play screen up and running, and that won't happen until we get some graphics to display. We'll look at this next.

Chapter 4 2D Graphics

The most important part of a game, usually, is what the user sees. I'm aware of only one game that has no graphics, just audio. Given this, it's pretty important to be able to draw things to the screen. For our game, that will be limited to 2D objects, or sprites.

Since almost all graphics objects are stored as files on a hard drive, we'll need a way to be able to load them into memory in order to draw them. The first step in this process is to compile all of our assets in such a way that they're easier to work with than what most frameworks have to go through. Usually, different types of assets have to be loaded differently because of their format or type. While most frameworks give you a way to load an asset easily, they usually don't offer one way to handle everything. XNA, and thus MonoGame, gave developers the ability to do this by compiling all of their assets into a format that allowed them to be loaded using one class: the **`ContentManager`**. The tool that did this was the content pipeline. XNA handled this behind the scenes when you compiled your game. MonoGame uses a separate application, the MonoGame Pipeline Tool, which is installed along with the main MonoGame bits:

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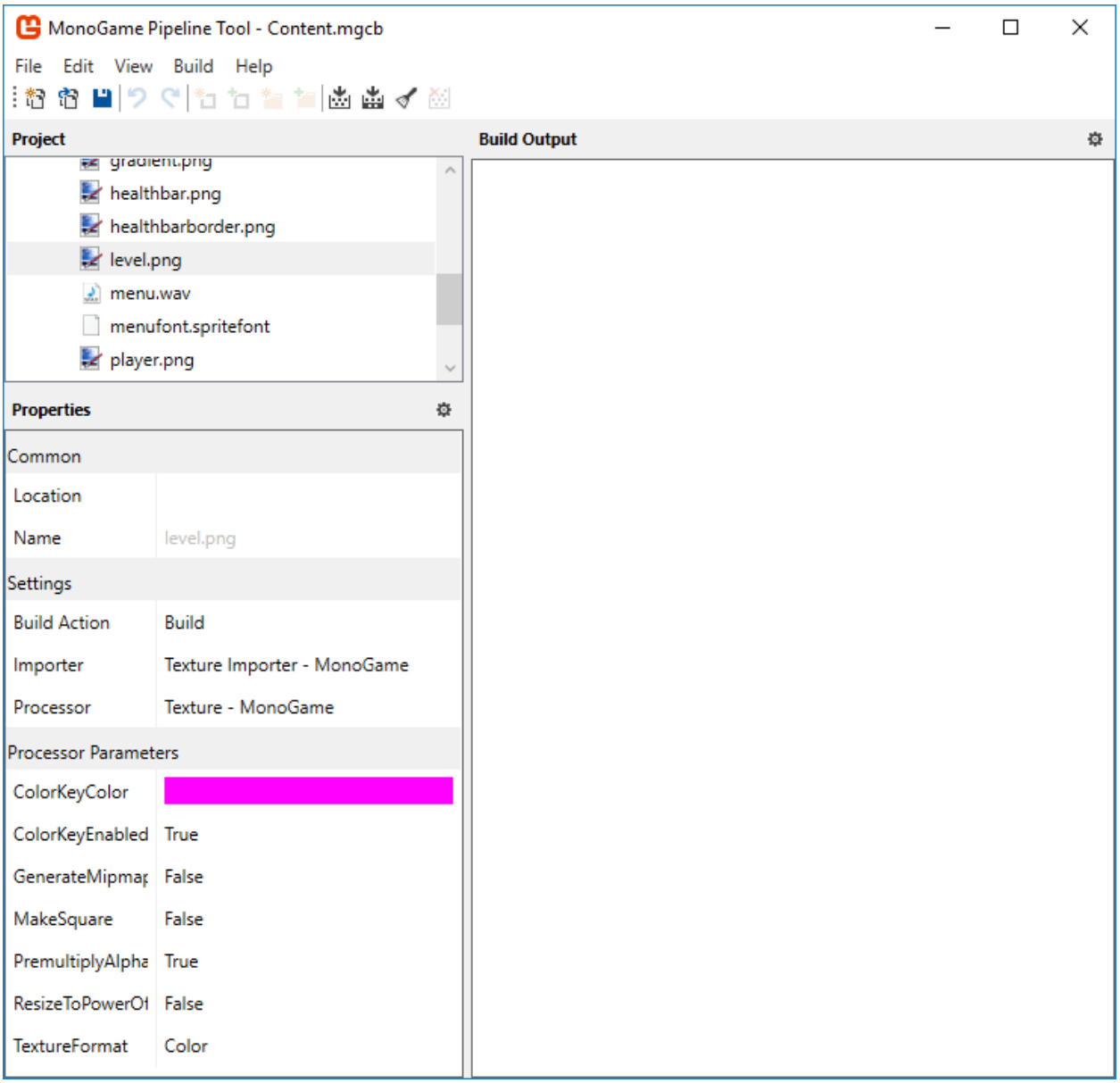


Figure 10 - Pipeline Tool Application

If you have a lot of assets, you may want to organize them into folders of like type or other grouping. Use the **New Folder** toolbar button or **Edit** > **Add** > **New Folder** menu item.

If you're converting an XNA game to MonoGame, you can import your assets using the **File** > **Import** menu. Clicking this menu item opens a dialog box that allows you to select an XNA Content project file.

If you're starting from scratch, use the **New Item** toolbar button or **Edit** > **Add** > **Existing Item** menu to display a dialog box to allow you to select a file to add to the content project, or just drag them into it from a File Explorer window. You can also add an entire folder of assets using the **Add Existing Folder** or **Edit** > **Add** > **Existing Folder** menu item.

Once you've added your assets, click the **Build** toolbar button or menu item. The Build Output section of the application will show the status of each item. The last item should show a successful build message. The screenshot in Figure 11 shows some of the assets in the downloadable project files for this book. You can add them to the project, and should see something similar when you build the assets.

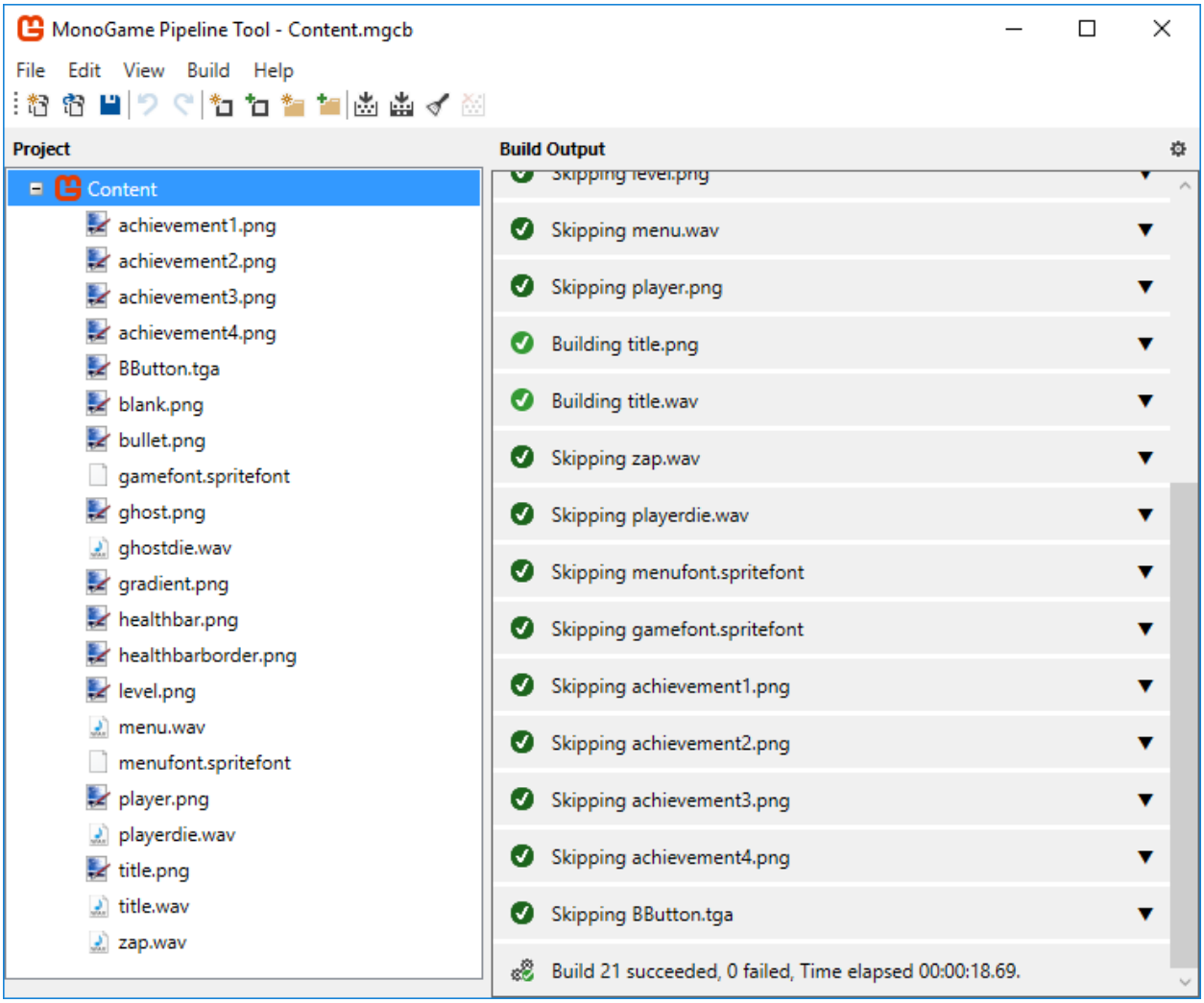


Figure 11 - Successful Build Message

Note that any assets that have already been built will be skipped unless they're changed.

If you get an error message for any item, make sure it's a file type that is supported by the tool. Not all graphics or audio types are supported. While you can use custom file types with the tool, it requires a good bit of work from custom importers and processors that is beyond the scope of this book. For sprites, .bmp, .tga, or .png are suggested. For audio, .wav or .mp3 for sound effects and music will work fine.

Once you have a clean build, you're ready to start loading the assets into objects in memory to use in your game. As I've already mentioned, you do this using the **`ContentManager`** class.

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ContentManager

The **Game** class comes with a **ContentManager** member that you use to load graphics into memory. For most simple games, you'll only need to deal with one property, the **RootDirectory**, and one method, **Load**.

As we saw in Chapter 2, the **RootDirectory** property is set automatically for you in the constructor of the **Game** class instance if you create your project using the built-in template. This will almost always be the Content folder of the project. I've yet to discover a case where you would want to set it to something else.

The **Load** method uses a type parameter to specify what type of content is being loaded. This can be 2D or 3D graphics, audio files, or sprite fonts (for drawing text). For 2D graphics, the file is usually loaded into a **Texture2D** object.

You're usually going to end up needing the **ContentManager** in other places than the **Game** class, so you'll need to either expose the object to over code, or pass it around. I've found it easier and cleaner for me to just expose it through a static instance of the **Game** class. To do this, just add the declaration to the **Game** class code and a line at the end of the constructor of the **Game** class instance code:

```
public static Game1 Instance;

public Game1()
{
    ...

    Instance = this;
}
```

Code Listing 17 – Game class instance

This allows you to use the **ContentManager** anywhere simply by doing the following:

```
Texture2D _level;
_level = Game1.Instance.Content.Load<Texture2D>("level");
```

Code Listing 18 *– Accessing the Game class instance*

Texture2D

At its simplest, a **Texture2D** object is what's used to hold a sprite in memory. While the class has a number of overloaded constructors and methods, you'll rarely need them for simple games. You will probably use three of the members: **Bounds**, **Height**, and **Width**.

The **Bounds** member is a rectangle that is useful for drawing and collision detection. One of the overloaded **Draw** methods of the **SpriteBatch** class takes a destination and source rectangle. You could use this to easily scale a sprite. If you're not changing the location of a sprite, say UI elements, using this overloaded method could make your code a bit easier to write and read.

The **Height** and **Width** members will be used for the same things as the **Bounds** member. Which you use will depend somewhat on how you set up your code, and what the sprite is used for. If you're doing a lot of movement of the sprite, you probably don't want to have to recalculate the destination rectangle every frame, so you'll probably use the version of the **Draw** method that takes an X and Y coordinate along with the **Height** and **Width** of the sprite.

GraphicsDeviceManager

The **GraphicsDeviceManager** class is one you'll use mainly for allowing the player to set options pertaining to graphics. You'll also use it for setting defaults for your game.

The template we used to create our game adds an instance of this class to the **Game1** class. The default resolution is not ideal, however. We'll add some code to change the default so it's a little better. Add the two members to the **Game1** class and the two lines of code after the creation of the **GraphicsDeviceManager** in the constructor of the **Game1** class:

```
public static int ScreenWidth = 1024;
public static int ScreenHeight = 768;

graphics.PreferredBackBufferWidth = Game1.ScreenWidth;
graphics.PreferredBackBufferHeight = Game1.ScreenHeight;
```

Code Listing 19 *– Changing the default window resolution*

SpriteBatch

As we saw briefly in the last chapter, the **SpriteBatch** class is used to handle rendering graphics and text to the screen. Instead of having the developer write code to optimize drawing a lot of different objects to the screen in the most efficient manner possible, the **SpriteBatch** class does this for you. It does this through the **Draw** and **DrawText** methods. Each method is overloaded a number of ways to give you flexibility in how things are drawn to the screen based on the information you have to each object:

```
Draw(Texture2D, Nullable<Vector2>, Nullable<Rectangle>, Nullable<Rectangle>,
Nullable<Vector2>, float, Nullable<Vector2>, Nullable<Color>, SpriteEffects, float)
```

```
Draw(Texture2D, Vector2, Nullable<Rectangle>, Color, float, Vector2, Vector2,
SpriteEffects, float)
```


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Draw(Texture2D, Vector2, Nullable<Rectangle>, Color, float, Vector2, float, SpriteEffects, float)
Draw(Texture2D, Rectangle, Nullable<Rectangle>, Color, float, Vector2, SpriteEffects, float)
Draw(Texture2D, Vector2, Nullable<Rectangle>, Color)
Draw(Texture2D, Rectangle, Nullable<Rectangle>, Color)
Draw(Texture2D, Vector2, Color)
Draw(Texture2D, Rectangle, Color)
DrawString(SpriteFont, string, Vector2, Color, float, Vector2, Vector2, SpriteEffects, float)
DrawString(SpriteFont, StringBuilder, Vector2, Color, float, Vector2, Vector2, SpriteEffects, float)
DrawString(SpriteFont, StringBuilder, Vector2, Color, float, Vector2, float, SpriteEffects, float)
DrawString(SpriteFont, string, Vector2, Color)
DrawString(SpriteFont, string, Vector2, Color, float, Vector2, float, SpriteEffects, float)
DrawString(SpriteFont, StringBuilder, Vector2, Color)

Table 2 – SpriteBatch Draw Methods

Sprite drawing

The various **Draw** methods handle drawing sprites. The simplest versions require a **Texture2D** object, a **Vector2** indicating the top-left pixel of the screen to draw the sprite or rectangle indicating the region of the screen, and a color. The color will normally be white. Any other color passed will be blended with the sprite.

If you use a rectangle as the destination, the sprite will be stretched or shrunk as needed to fit the region. This could lead to less-than-ideal results, so ensure you test on multiple displays and resolutions when using this version.

Other versions of the method allow you to rotate the sprite, which we'll be doing, and flip the sprite horizontally or vertically using the **SpriteEffects** enum:

```
public enum SpriteEffects
{
```

```
    None = 0,
    FlipHorizontally = 1,
    FlipVertically = 2
}
```

Code Listing 20 – SpriteEffects Enum

Text drawing

The **DrawString** method draws text. As with the **Draw** method, there are two simple versions and multiple advanced versions for flexibility. The simple versions take a **SpriteFont**, string, **Vector2** or rectangle, and a **Color**. The **Color** draws the text in that color, unlike the sprite version, which blends the sprite with the color.

The **DrawString** method uses the **SpriteEffects** enum as a parameter just like the **Draw** method, although I'm not sure when you'd use it in normal games.

Implementing graphics

Now that we know how to get graphics and text drawn in our game, it's time to implement this functionality.

First, we need something to draw. We'll use a class to represent both the character and the ghosts it'll be fighting that will contain all the information needed to allow both to move and shoot, figure out if they're still alive, etc. Having one class for both will allow us to easily manage them using another class without knowing which is which, to some extent.

```
public class Entity
{
    private static Vector2 vecMin, vecMax;

    private EntityType _type;
    private int _health;

    private Vector2 _location;

    private Direction _moveDirection;
    private Direction _shootDirection;

    private float _speed;

    private int _curFrame;
    private int _numFrames;
    private float _animationDelay;

    private float _frameUpdate;
```


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```
    private int _textureWidth;

    public EntityType Type
    {
        get { return _type; }
    }

    public int Health
    {
        get { return _health; }
    }

    public Vector2 Location
    {
        get { return _location; }
    }

    public Direction MoveDirection
    {
        get { return _moveDirection; }
        set { _moveDirection = value; }
    }

    public Direction ShootDirection
    {
        get { return _shootDirection; }
        set { _shootDirection = value; }
    }

    public float Speed
    {
        get { return _speed; }
        set { _speed = value; }
    }

    public int CurFrame
    {
        get { return _curFrame; }
        set { _curFrame = value; }
    }

    public int NumFrames
    {
        get { return _numFrames; }
        set { _numFrames = value; }
    }

    public Entity(EntityType type, Vector2 location, Direction orientation,
int numFrames, int textureWidth, Game game)
    {
```

```
        _shootDirection = orientation;
        _type = type;
        _location = location;
        _numFrames = numFrames;
        _curFrame = 0;
        _textureWidth = textureWidth;

        _frameUpdate = 0.0f;

        //account for the walls of the level (20) and half the sprite size
(32)
        vecMin = new Vector2(20+32, 88+32);
        vecMax = new Vector2(game.Window.ClientBounds.Width - 20 - 32,
game.Window.ClientBounds.Height - 20 - 32);

        switch (type)
        {
            case EntityType.Ghost:
                _health = ((Game1)game).Difficulty.GhostHealth;
                break;

            case EntityType.Player:
                _health = 100;
                break;
        }

        //ghosts start off moving
        if (_type == EntityType.Ghost)
            _speed = ((Game1)game).Difficulty.GhostSpeed;
    }

    public int CurFrameX
    {
        get { return _curFrame * (_textureWidth / _numFrames); }
    }

    public int FrameWidth
    {
        get {return _textureWidth / _numFrames;}
    }

    public void Update(GameTime gameTime, Vector2 playerLocation)
    {
        //if ghost, change move direction if necessary based on player
location
        if (_type == EntityType.Ghost)
        {
            //figure out if our current direction is greater than 45
degrees to the player. If so, we need to turn
```


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```
            _moveDirection = GetDirectionFromVectors(_location,
playerLocation);
            _shootDirection = _moveDirection;
        }

        if (_speed > 0.0f)
        {
            switch (_moveDirection)
            {

                case Direction.East:
                    _location.X += _speed;

                    break;

                case Direction.North:

                    _location.Y -= _speed;

                    break;

                case Direction.NorthEast:

                    _location.Y -= _speed;
                    _location.X += _speed;

                    break;

                case Direction.NorthWest:

                    _location.Y -= _speed;
                    _location.X -= _speed;

                    break;

                case Direction.South:

                    _location.Y += _speed;
                    break;

                case Direction.SouthEast:

                    _location.Y += _speed;
                    _location.X += _speed;
                    break;

                case Direction.SouthWest:

                    _location.Y += _speed;
                    _location.X -= _speed;
```

```
                    break;

                case Direction.West:

                    _location.X -= _speed;
                    break;
            }

            _location = Vector2.Clamp(_location, vecMin, vecMax);
        }

        if (_type == EntityType.Ghost)
        {
            _frameUpdate += gameTime.ElapsedGameTime.Milliseconds;

            if (_frameUpdate >= 500.0f)
            {
                //increment frame
                _curFrame++;

                if (_curFrame > _numFrames - 1)
                    _curFrame = 0;

                _frameUpdate -= 500.0f;
            }
        }
    }

    public void DrainLife(int amount)
    {
        _health -= amount;
    }
}
```

Code Listing 21 – Entity Class

We'll enhance this class later with functionality for allowing the character to shoot and other necessary gameplay, but for now, this will allow us to get something drawn on the screen.

The first two members are used in the **`Update`** method to ensure the character is never drawn outside of the arena. The values are set in the constructor.

The **`_type`** member allows us to figure out whether we're working with the character or ghost in parts of the class:

```
public enum EntityType
{
    Player,
    Ghost
}
```


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Code Listing 22 – EntityType Enum

The **_location** member is where the character is on screen, although not relative to the arena. We figure that out in the **Update**.

The two **Direction** members tell us where the character is moving and shooting. Since the character can be rotated, he could be moving in a direction other than forward while he's shooting. He could also just spin around in a circle without moving. We'll have eight different directions the character and ghost can face:

```
public enum Direction
{
    North,
    NorthEast,
    East,
    SouthEast,
    South,
    SouthWest,
    West,
    NorthWest
}
```

Code Listing 23 – Direction Enum

The **_speed** gives us some flexibility in controlling how fast the character can move around the screen, in case a modification to the game is added, such as a quickness powerup that modifies how quickly the character moves.

The next four members are used to control which frame the character animation is to be drawn in. Our character and ghost will have four different frames to simulate movement:



Figure 12 - Character Frames



Figure 13 - Ghost Frames

The **_textureWidth** member ensures we're using the correct section of the sprite in drawing the current frame.

The next section of code, from the public accessors to the constructor, are fairly straightforward. The **Update** method is pretty simple at this point. If the entity is a ghost, we update the direction it's moving based on the character's location. We also update the shooting direction member, although it's not being used at this point. We need to add the method we're using to the **Entity** class:

```
public static Direction GetDirectionFromVectors(Vector2 vecFrom, Vector2
vecTo)
{
    float x = vecTo.X - vecFrom.X;
    float y = vecTo.Y - vecFrom.Y;

    float angle = (float)(Math.Atan2(y, x) * 57.2957795);
    Direction dir;

    if (angle < 0)
    {
        if (angle > -23)
            dir = Direction.East;
        else if (angle >= -67)
            dir = Direction.NorthEast;
        else if (angle >= -112)
            dir = Direction.North;
        else if (angle >= -157)
            dir = Direction.NorthWest;
        else
            dir = Direction.West;
    }
    else
    {
        if (angle < 23)
            dir = Direction.East;
        else if (angle <= 67)
            dir = Direction.SouthEast;
        else if (angle <= 112)
            dir = Direction.South;
        else if (angle <= 157)
            dir = Direction.SouthWest;
        else
            dir = Direction.West;
    }

    return dir;
}
```

Code Listing 24 – GetDirectionFromVectors Method

We figure out the angle as a **`float`** value based off the difference between the two vectors, and use that float to determine the **`Direction`** value to return. There's a lot of hard-coded values here, which isn't usually ideal, but since this is a relatively small game, it's not a deal-breaker.

If the entity is moving, we update its location and ensure it doesn't move outside of the arena by calling the **`Clamp`** method.

If the entity is a ghost, we then figure out if enough time has passed to move to the next frame. We also make sure that if the last frame has been reached, we reset to the first one.

Now that we have a class to allow us to create drawable entities, we need to have some code to actually draw them. As I mentioned at the beginning of the section, we'll use a class to manage the entities:

```
public class EntityManager //: DrawableGameComponent
{
    Texture2D _ghostTexture;
    Texture2D _playerTexture;

    Color[][] _ghostData;
    Color[][] _playerData;

    List<Entity> _entities;

    SpriteBatch _sb;

    int _score;

    private float _ghostSpawnTimer;
    private Vector2[] _ghostSpawnPoints;
    private Direction[] _ghostSpawnDirections;
    private Random _rnd;

    private Vector2 _ghostOrigin;
    private Vector2 _playerOrigin;

    public int Score
    {
        get { return _score; }
    }

    public EntityManager()
    {
        _entities= new List<Entity>();
        _score = 0;
        _ghostSpawnTimer = 0.0f;
        _ghostSpawnPoints = new Vector2[10];
        _ghostSpawnDirections = new Direction[10];
        _rnd = new Random();

        _ghostOrigin = new Vector2(16, 16);
        _playerOrigin = new Vector2(32, 32);

        _playerData = new Color[4][];
        _ghostData = new Color[4][];

    }

    public void Initialize()
    {
```

```
        IGraphicsDeviceService graphicsservice =
(IGraphicsDeviceService)Game1.Instance.Services.GetService(typeof(IGraphics
DeviceService));
        _sb = new SpriteBatch(graphicsservice.GraphicsDevice);

        _ghostTexture = Game1.Instance.Content.Load<Texture2D>("ghost");
        _playerTexture = Game1.Instance.Content.Load<Texture2D>("player");

        for (int i = 0; i < 4; i++)
        {
            _playerData[i] = new Color[64 * 64];
            _playerTexture.GetData(0, new Rectangle(i, 0, 64, 64),
_playerData[i], 0, 64 * 64);

            _ghostData[i] = new Color[32 * 32];
            _ghostTexture.GetData(0, new Rectangle(i, 0, 32, 32),
_ghostData[i], 0, 32 * 32);
        }

        //player starts in the middle of the screen
        Entity entity = new Entity(EntityType.Player, new
Vector2((Game1.Instance.Window.ClientBounds.Width / 2) -
((_playerTexture.Width / 4) / 2),
(Game1.Instance.Window.ClientBounds.Height / 2 - _playerTexture.Height / 2)
+ 60), Direction.North, 4, _playerTexture.Width, Game1.Instance);

        _entities.Add(entity);

        _ghostSpawnPoints[0] = new Vector2(240, Game1.LevelTop);
        _ghostSpawnPoints[1] = new Vector2(496, Game1.LevelTop);
        _ghostSpawnPoints[2] = new Vector2(752, Game1.LevelTop);
        _ghostSpawnPoints[3] = new Vector2(1023,284);
        _ghostSpawnPoints[4] = new Vector2(1023,516);
        _ghostSpawnPoints[5] = new Vector2(752,776);
        _ghostSpawnPoints[6] = new Vector2(496,776);
        _ghostSpawnPoints[7] = new Vector2(240,776);
        _ghostSpawnPoints[8] = new Vector2(0,516);
        _ghostSpawnPoints[9] = new Vector2(0,284);

        _ghostSpawnDirections[0]=Direction.South;
        _ghostSpawnDirections[1]=Direction.South;
        _ghostSpawnDirections[2]=Direction.South;
        _ghostSpawnDirections[3]=Direction.West;
        _ghostSpawnDirections[4]=Direction.West;
        _ghostSpawnDirections[5]=Direction.North;
        _ghostSpawnDirections[6]=Direction.North;
        _ghostSpawnDirections[7]=Direction.North;
        _ghostSpawnDirections[8]=Direction.East;
        _ghostSpawnDirections[9]=Direction.East;
```


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```
        //start with 4 ghosts initially
        for (int i = 0; i < 4; i++)
            SpawnGhost();

    }

    protected void Dispose()
    {
        _entities.Clear();
    }

    public void Update(GameTime gameTime)
    {

        //get the ScreenManager and check for paused state
        ScreenManager screenManager =
(ScreenManager)Game1.Instance.Components[0];

        if (screenManager.GetScreens()[0].IsActive)
        {
            //check for ghost spawn
            _ghostSpawnTimer += gameTime.ElapsedGameTime.Milliseconds;

            if (_ghostSpawnTimer >= 3000.0f)
            {
                //get random location
                SpawnGhost();
                _ghostSpawnTimer -= 3000.0f;
            }

            foreach (Entity entity in _entities)
                entity.Update(gameTime, _entities[0].Location);

            for (int i = _entities.Count - 1; i > 0; i--)
            {
                if (CheckEntityCollision(_entities[i]))
                {
                    //drain life

_entities[0].DrainLife(Game1.Instance.Difficulty.HealthDrain);
                    _entities.Remove(_entities[i]);

                    if (_entities.Count == 1)
                        break;
                }
            }

            for (int i = _entities.Count - 1; i > 0; i--)
            {
```

```
                if (_entities[0].CheckBulletCollision(_entities[i]))
                {
                    _entities[i].DrainLife(1);

                    if (_entities[i].State == EntityState.Dead)
                    {
                        _score += Game1.Instance.Difficulty.GhostScore;
                        _entities.Remove(_entities[i]);
                    }

                    if (_entities.Count == 1)
                        break;
                }
            }
        }
    }
    public void Draw(GameTime gameTime)
    {
        //base.Draw(gameTime);

        _sb.Begin();

        Vector2 origin;
        float rot;

        foreach (Entity entity in _entities)
        {
            rot = (int)entity.MoveDirection * MathHelper.ToRadians(45.0f);

            switch (entity.Type)
            {
                case EntityType.Ghost:
                {
                    origin = new Vector2(_ghostTexture.Width /
entity.NumFrames / 2, _ghostTexture.Height / 2);
                    _sb.Draw(_ghostTexture, new
Rectangle((int)entity.Location.X, (int)entity.Location.Y,
entity.FrameWidth, _ghostTexture.Height), new Rectangle(entity.CurFrameX,
0, entity.FrameWidth, _ghostTexture.Height), Color.White, rot, origin,
SpriteEffects.None, 0.0f);
                    break;
                }
                case EntityType.Player:
                {
                    origin = new Vector2(_playerTexture.Width /
entity.NumFrames / 2, _playerTexture.Height / 2);
```


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```
                    _sb.Draw(_playerTexture, new
Rectangle((int)entity.Location.X, (int)entity.Location.Y,
entity.FrameWidth, _playerTexture.Height), new Rectangle(entity.CurFrameX,
0, entity.FrameWidth, _playerTexture.Height), Color.White, rot, origin,
SpriteEffects.None, 0.0f);

                    entity.DrawBullets(_sb);

                    break;
                }
            }
        }

        _sb.End();

    }

    public int GetPlayerHealth()
    {
        if (_entities.Count > 0)
        {
            return _entities[0].Health;
        }
        else
            return 0;
    }

    private void SpawnGhost()
    {
        int num = _rnd.Next(0, 10);
        _entities.Add(new Entity(EntityType.Ghost, _ghostSpawnPoints[num],
_ghostSpawnDirections[num], 4, _ghostTexture.Width, _game));
    }

    public bool CheckEntityCollision(Entity entity)
    {

        Rectangle playerRect;
        Rectangle ghostRect;

        Matrix matrix1, matrix2;

        matrix1 = Matrix.CreateTranslation(new Vector3(-_ghostOrigin,
0.0f)) *

Matrix.CreateRotationZ(GetRotationFromDirection(entity.MoveDirection)) *
            Matrix.CreateTranslation(new Vector3(entity.Location.X,
entity.Location.Y, 0.0f));
```

```
        ghostRect = new Rectangle((int)entity.Location.X,
(int)entity.Location.Y, 32, 32);

        matrix2 = Matrix.CreateTranslation(new Vector3(-_playerOrigin,
0.0f)) *

Matrix.CreateRotationZ(GetRotationFromDirection(_entities[0].MoveDirection)
) *
            Matrix.CreateTranslation(new Vector3(_entities[0].Location.X,
_entities[0].Location.Y, 0.0f));

        playerRect = new Rectangle((int)_entities[0].Location.X,
(int)_entities[0].Location.Y, 64, 64);

        //check for collision using rects first since per-pixel is costly
        if (ghostRect.Intersects(playerRect))
        {
            if (Intersect(matrix1, matrix2, 32, 64, 32, 64,
_ghostData[entity.CurFrame], _playerData[_entities[0].CurFrame]))
                return true;
        }

        return false;
    }

    private float GetRotationFromDirection(Direction dir)
    {
        float ret = 0.0f;

        switch (dir)
        {
            case Direction.North:

                ret = -1.570796f;

                break;

            case Direction.NorthEast:

                ret = -0.785398f;
                break;

            case Direction.East:

                ret = 0.0f;
                break;

            case Direction.SouthEast:

                ret = 0.785398f;
```


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```
                break;

            case Direction.South:

                ret = 1.570796f;
                break;

            case Direction.SouthWest:

                ret = 2.356194f;
                break;

            case Direction.West:

                ret = 3.141593f;
                break;

            case Direction.NorthWest:

                ret = -2.356194f;
                break;
        }

        return ret;
    }
    private bool Intersect(Matrix matrix1, Matrix matrix2, int
spriteWidth1, int spriteWidth2, int spriteHeight1, int spriteHeight2,
Color[] data1, Color[] data2)
    {
        Matrix transform = matrix1 * Matrix.Invert(matrix2);

        Vector2 rowX = Vector2.TransformNormal(Vector2.UnitX, transform);
        Vector2 rowY = Vector2.TransformNormal(Vector2.UnitY, transform);

        Vector2 yPos = Vector2.Transform(Vector2.Zero, transform);

        for (int i = 0; i < spriteHeight1; i++)
        {
            Vector2 pos = yPos;

            for (int j = 0; j < spriteWidth1; j++)
            {
                int i2 = (int)Math.Round(pos.X);
                int j2 = (int)Math.Round(pos.Y);

                if (0 <= i2 && i2 < spriteWidth2 && 0 <= j2 && j2 <
spriteHeight2)
                {
                    Color color1 = data1[i + j * spriteWidth1];
                    Color color2 = data2[i2 + j2 * spriteWidth2];
```

```
                    if (color1.A != 0 && color2.A != 0)
                        return true;
                }
                pos += rowX;
            }
            yPos += rowY;
        }

        return false;
    }
}
```

Code Listing 25 – EntityManager Class

We have our two **Texture2D** objects that hold the graphics file for the character and ghost. As we've seen, this file has the four frames for the animation for each sprite. The two **Color** arrays hold the color of each pixel for each frame. This data is used in the **Intersect** method to determine if two sprites have collided. Since an animation frame has to be rectangular, there will be areas in the frame that aren't part of the actual sprite. If the intersection of two sprites was simply based on the frame rectangle, an inaccurate result would happen:



Figure 14 - Inaccurate Collision Detection

Figure 14 shows the ghost frame intersecting with the player frame, but you can see that the actual sprites aren't touching. This would be very noticeable in the game and lead the player to think the game was slightly broken. Using the color array data, we can see if two non-magenta colors are overlapping, meaning a valid collision has occurred.

In the **_entities** list, the player character will always be the first object, as you'll notice in the **Initialize** method. Since that entity is handled a bit differently, we need to know where it is.

The next four members are used in spawning ghosts, as you can tell by their names. The **_ghostSpawnTimer** value varies by the difficulty level. The **_ghostSpawnPoints** are the doorway areas in the arena graphic:

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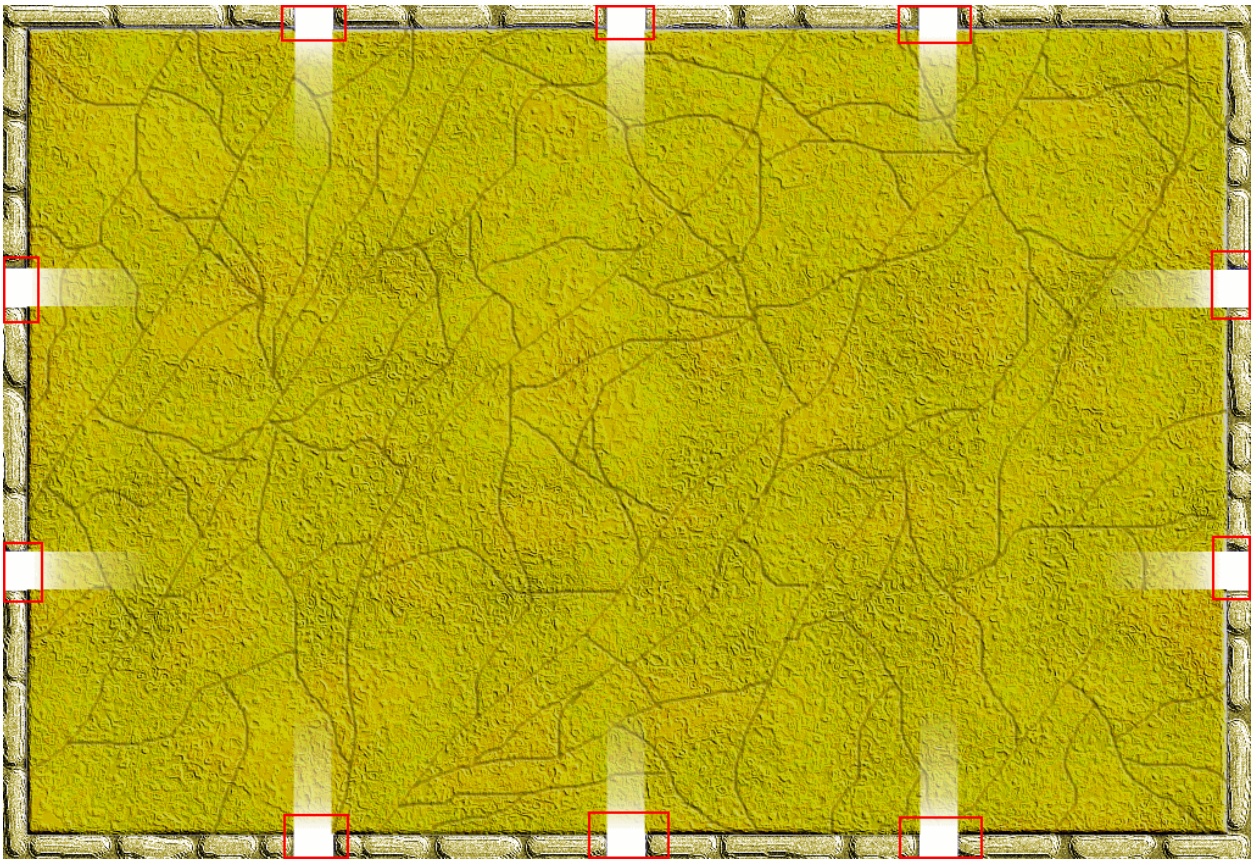


Figure 15 - Ghost Spawn Points

The **_ghostSpawnDirections** match the **_ghostSpawnPoints**—points at the top have a direction of **South**, points at the right have a direction of **West**, etc.

The **_rnd** member is used to pick a random spawn point when a ghost spawns.

The two **origin** members are used for collision detection between the ghosts and character. Since they can rotate, we need to do some calculations before we can accurately detect a collision between the two.

When the **EntityManager** object is initialized, the sprite for the player character and ghosts are loaded and the color data for each frame of each sprite is obtained. The player **Entity** object is then created and placed in the middle of the screen. The spawn points for the ghosts is then set. The x and y coordinates for each spawn point are hard-coded except for the y coordinate of the three spawn points at the top of the arena, since that location is known and will not change as the area above that location is used for displaying game information. The last thing that happens is that the initial four ghosts are spawned.

The **Update** method is pretty simple—if the gameplay screen is active, we update the time check for spawning ghosts first. Note that the index into the screen array is hard-coded; not the best thing to do, but for a fairly simple game, we know this will always be correct. If you implement functionality before the gameplay that keeps a screen loaded when the gameplay screen starts, this will cause problems. A way to fix this would be to search the loaded screens for the **GameplayScreen** instance and use that object. We then update each entity by calling its Update method. After this, we check for collisions between the player character and the ghosts, then between ghosts and bullets.

The **Draw** method is also pretty straightforward. The entity array is gone through, and each entity is drawn based on its movement direction. If the entity is the player character, the active bullets are also drawn.

While we're not at the point yet where we have bullets flying around the screen, we'll add a stub method to the **Enity** class so we don't get a compile error:

```
public void DrawBullets(SpriteBatch sb)
{

}
```

Code Listing 26 – DrawBullets Stub Method

There's a static member in the **Game** class that needs to be added:

```
public class Game1 : Game
{
    public static int LevelTop = 68;
}
```

Code Listing 27 – Game Class Static Member

The **EntityManager** is used by the **GameplayScreen**. A number of other sprites and text are drawn in the **GameplayScreen** as well. We'll add the skeleton code for that screen now and enhance it in later chapters so that we can at least get the sprites drawing on the screen.

```
class GameplayScreen : GameScreen
{
    Texture2D _level;
    Texture2D _healthbar;
    Texture2D _healthbarBorder;

    Rectangle _rectHealthBorder;

    Vector2 _levelLocation;
    Vector2 _scoreLocation;

    SpriteFont _scoreFont;

    EntityManager _entityManager;
```


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```
    Vector2 _curLevelLoc;

    public GameplayScreen()
    {
        TransitionOnTime = TimeSpan.FromSeconds(1.5);
        TransitionOffTime = TimeSpan.FromSeconds(0.5);
    }

    public override void Initialize()
    {
        _entityManager = new EntityManager();
        _entityManager.Initialize();

        _levelLocation = new Vector2(0, Game1.LevelTop);
        _scoreLocation = new Vector2(900, 32);

        _curLevelLoc = new Vector2(10, 10);

        _rectHealthBorder = new
Rectangle(ScreenManager.Game.Window.ClientBounds.Width / 2 - 101, 10, 202,
18);

    }

    public override void LoadContent()
    {
        _level = Game1.Instance.Content.Load<Texture2D>("level");
        _scoreFont = Game1.Instance.Content.Load<SpriteFont>("gamefont");
        _healthbar = Game1.Instance.Content.Load<Texture2D>("healthbar");
        _healthbarBorder =
Game1.Instance.Content.Load<Texture2D>("healthbarborder");
    }

    public override void Update(GameTime gameTime, bool
otherScreenHasFocus,
                                                bool
coveredByOtherScreen)
    {
        base.Update(gameTime, otherScreenHasFocus, coveredByOtherScreen);
    }

    public override void Draw(GameTime gameTime)
    {
        ScreenManager.GraphicsDevice.Clear(ClearOptions.Target,
Color.Black, 0, 0);

        Vector2 timeLoc = new
Vector2(ScreenManager.GraphicsManager.PreferredBackBufferWidth / 2 -
                                        _scoreFont.MeasureString("Time
Remaining: " + _remainingTime.ToString()).X / 2, 40.0f);
```

```
        ScreenManager.SpriteBatch.Begin();
        ScreenManager.SpriteBatch.Draw(_level, _levelLocation,
Color.White);
        ScreenManager.SpriteBatch.Draw(_healthbarBorder, _rectHealthBorder,
Color.White);
        ScreenManager.SpriteBatch.Draw(_healthbar, new
Rectangle(_rectHealthBorder.Left + 1, _rectHealthBorder.Top + 1,
_entityManager.GetPlayerHealth() * 2, 16), Color.White);
        ScreenManager.SpriteBatch.DrawString(_scoreFont, "score: " +
_entityManager.Score.ToString(), _scoreLocation, Color.White);

        ScreenManager.SpriteBatch.End();

        _entityManager.Draw(gameTime);

        // If the game is transitioning on or off, fade it out to black.
        if (TransitionPosition > 0)
            ScreenManager.FadeBackBufferToBlack(255 - TransitionAlpha);
    }
}
```

Code Listing 28 – GameplayScreen Class

The **GameplayScreen** draws the level graphic, the graphic that shows the health of the character, and the player's score. Later on we'll add drawing the timer for the game that's used in conjuction with the game difficulty, but we don't need that for now.

The character's health is divided into two pieces: the border, and a rectangle that is scaled from filling the border to nothing based on the amount of health remaining to the character. If you looked earlier when we added the graphics files to the content pipeline tool, you would have seen that the healthbar graphic is just a single green pixel. The overloaded version of the **Draw** method that we're using to draw the inner part of the healthbar takes a rectangle parameter, with which the method automatically scales whatever **Texture2D** object you pass to fill the rectangle. This can lead to unexpected results on the screen, depending on the graphic file you load into the **Texture2D** object. A graphic containing multiple colors for an image of some object could display less than ideally, depending on how you scale the object. Drawing the object much larger than the original image could lead to a pixelated image onscreen. Drawing the character sprite several times larger than the original image, for example, would make the character look something like the following:

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Figure 16 - Scaled Character

The pixels in the scaled character are very noticeable in the stretched image. There is a way to deal with this using mipmaps, but that's beyond the scope of this book. If you really need to display a graphic at multiple size where stretching the image would lead to pixilation, feel free to research mipmaps.

Now that we have some drawing functionality, we need to modify some of the screens to add this functionality. The **`ScreenManager`** class needs some new members:

```
IGraphicsDeviceService _graphicsDeviceService;

GraphicsDeviceManager _graphicsDeviceManager;

SpriteBatch _spriteBatch;
SpriteFont _font;
Texture2D _blankTexture;
```

Code Listing 29 – ScreenManager Class graphics members

```

/// <summary>
/// Expose access to our graphics device (this is protected in the
/// default DrawableGameComponent, but we want to make it public).
/// </summary>
new public GraphicsDevice GraphicsDevice
{
    get { return base.GraphicsDevice; }
}
public SpriteBatch SpriteBatch
{
    get { return _spriteBatch; }
}
```

```
public SpriteFont Font
{
    get { return _font; }
}

public GraphicsDeviceManager GraphicsManager
{
    get { return _graphicsDeviceManager; }
}

public ScreenManager(Game game, GraphicsDeviceManager
graphicsDeviceManager)
    : base(game)
{

    _graphicsDeviceManager = graphicsDeviceManager;

    _graphicsDeviceService =
(IGraphicsDeviceService)game.Services.GetService(

typeof(IGraphicsDeviceService));

    if (_graphicsDeviceService == null)
        throw new InvalidOperationException("No graphics device service.");
}

public void FadeBackBufferToBlack(int alpha)
{
    Viewport viewport = GraphicsDevice.Viewport;

    _spriteBatch.Begin();

    _spriteBatch.Draw(_blankTexture,
                      new Rectangle(0, 0, viewport.Width,
viewport.Height),
                      new Microsoft.Xna.Framework.Color((byte)0, (byte)0,
(byte)0, (byte)alpha));

    _spriteBatch.End();
}
```

Code Listing 30 – ScreenManager Class Graphics Methods

We also need to update some of the existing methods to add drawing functionality:

```
protected override void LoadContent()
{
    // Load content belonging to the screen manager.
    _spriteBatch = new SpriteBatch(GraphicsDevice);
```


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```
    _font = Game1.Instance.Content.Load<SpriteFont>("menufont");
    _blankTexture = Game1.Instance.Content.Load<Texture2D>("blank");
}

public void AddScreen(GameScreen screen)
{
. . .

    if ((_graphicsDeviceService != null) &&
        (_graphicsDeviceService.GraphicsDevice != null))
    {
        screen.LoadContent();
    }

}

public void RemoveScreen(GameScreen screen)
{
. . .

    if ((_graphicsDeviceService != null) &&
        (_graphicsDeviceService.GraphicsDevice != null))
    {
        screen.UnloadContent();
    }

}
```

Code Listing 31 – ScreenManager Class Updated Methods

In the **GameplayScreen** class, we're not yet drawing the time remaining or level, so let's add that. The following code should be placed right before the **ScreenManager.SpriteBatch.End();** line:

```
_displayMinutes = _remainingTime >= 60 ? ((int)(_remainingTime /
60)).ToString() : "";

ScreenManager.SpriteBatch.DrawString(_scoreFont, "Time Remaining: " +
_displayMinutes + ":" + ((int)(_remainingTime % 60)).ToString("00"),
timeLoc, Color.Red);

ScreenManager.SpriteBatch.DrawString(_scoreFont, "Level: " +
_curLevel.ToString(), _curLevelLoc, Color.White);
```

Code Listing 32 – GameplayScreen Class Draw Method Code

The **MenuScreen** class gets some additional code to add a pulse effect to the selected menu item:

```
public override void Draw(GameTime gameTime)
```

```
{
. . .

    // Draw each menu entry in turn.
    ScreenManager.SpriteBatch.Begin();

    for (int i = 0; i < _menuEntries.Count; i++)
    {
        Color color;
        float scale;

        if (IsActive && (i == _selectedEntry))
        {
            // The selected entry is yellow, and has an animating size.
            double time = gameTime.TotalGameTime.TotalSeconds;

            float pulsate = (float)Math.Sin(time * 6) + 1;

            color = Color.Yellow;
            scale = 1 + pulsate * 0.05f;
        }
        else
        {
            // Other entries are white.
            color = Color.White;
            scale = 1;
        }

        // Modify the alpha to fade text out during transitions.
        color = new Color(color.R, color.G, color.B, TransitionAlpha);

        // Draw text, centered on the middle of each line.
        Vector2 origin = new Vector2(0, ScreenManager.Font.LineSpacing /
2);

        ScreenManager.SpriteBatch.DrawString(ScreenManager.Font,
_menuEntries[i],
                                              position, color, 0, origin,
scale,
                                              SpriteEffects.None, 0);

        position.Y += ScreenManager.Font.LineSpacing;
    }

    ScreenManager.SpriteBatch.End();
}
```

Code Listing 33 – MenuScreen Class Updated Method

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The **MessageBoxScreen** class needs some updating to make the portion of the screen not covered by the message box:

```
public override void Draw(GameTime gameTime)
{
    // Darken down any other screens that were drawn beneath the popup.
    _screenManager.FadeBackBufferToBlack(TransitionAlpha * 2 / 3);

    // Center the message text in the viewport.
    Viewport viewport = _screenManager.GraphicsDevice.Viewport;
    Vector2 viewportSize = new Vector2(viewport.Width, viewport.Height);
    Vector2 textSize = _screenManager.Font.MeasureString(_message);
    Vector2 textPosition = (viewportSize - textSize) / 2;

    // The background includes a border somewhat larger than the text
itself.
    const int hPad = 32;
    const int vPad = 16;

    Rectangle backgroundRectangle = new Rectangle((int)textPosition.X -
hPad,
                                                  (int)textPosition.Y -
vPad,
                                                  (int)textSize.X + hPad
* 2,
                                                  (int)textSize.Y + vPad
* 2);

    // Fade the popup alpha during transitions.
    Microsoft.Xna.Framework.Color color = new
Microsoft.Xna.Framework.Color((byte)255, (byte)255, (byte)255,
TransitionAlpha);

    _screenManager.SpriteBatch.Begin();

    // Draw the background rectangle.
    _screenManager.SpriteBatch.Draw(_gradientTexture, backgroundRectangle,
color);

    // Draw the message box text.
    _screenManager.SpriteBatch.DrawString(_screenManager.Font, _message,
textPosition, color);

    _screenManager.SpriteBatch.End();
}
```

Code Listing 34 – MessageBoxScreen Class Updated Method

The **OptionsMenuScreen** needs an additional line to toggle the screen between full-screen and windowed mode. Add this line in the **case 0** section in the **OnSelectEntry** method:

```
ScreenManager.GraphicsManager.ToggleFullScreen();
```

Code Listing 35 – OptionsMenuScreen Class Toggle Full-Screen Code

The **LoadingScreen** gets some code added to the **if(_loadingIsSlow)** block in the **Draw** method:

```
Viewport viewport = ScreenManager.GraphicsDevice.Viewport;
Vector2 viewportSize = new Vector2(viewport.Width, viewport.Height);
Vector2 textSize = ScreenManager.Font.MeasureString(message);
Vector2 textPosition = (viewportSize - textSize) / 2;

Microsoft.Xna.Framework.Color color = new
Microsoft.Xna.Framework.Color((byte)255, (byte)255, (byte)255,
TransitionAlpha);

// Draw the text.
ScreenManager.SpriteBatch.Begin();

ScreenManager.SpriteBatch.DrawString(ScreenManager.Font, message,
                                     textPosition, color);

ScreenManager.SpriteBatch.End();
```

Code Listing 36 – LoadingScreen Update Draw Method Code

We can now add the missing drawing functionality to the **HighScoreScreen** class, along with the graphics:

```
private SpriteFont _titleFont;
private Texture2D _buttonB;

public override void LoadContent()
{
    _titleFont = Game1.Instance.Content.Load<SpriteFont>("menufont");
    _buttonB = Game1.Instance.Content.Load<Texture2D>("BButton");

. . .
}


public override void Draw(GameTime gameTime)
{
    Vector2 textPosition;
```


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```
    ScreenManager.GraphicsDevice.Clear(ClearOptions.Target, Color.Black, 0,
0);

    Microsoft.Xna.Framework.Color color = new
Microsoft.Xna.Framework.Color((byte)0, (byte)255, (byte)0,
TransitionAlpha);

    ScreenManager.SpriteBatch.Begin();

    //draw title
    Vector2 titleSize = _titleFont.MeasureString("High Scores");
    textPosition = new Vector2(ScreenManager.GraphicsDevice.Viewport.Width
/ 2 - titleSize.X / 2, 5);

    ScreenManager.SpriteBatch.DrawString(_titleFont, "High Scores",
textPosition, color);

    color = new Microsoft.Xna.Framework.Color((byte)255, (byte)255,
(byte)255, TransitionAlpha);

    //draw header
    textPosition = new Vector2(50, 100);
    ScreenManager.SpriteBatch.DrawString(ScreenManager.Font, "Date",
textPosition, color);
    ScreenManager.SpriteBatch.DrawString(ScreenManager.Font, "Score",
textPosition + new Vector2(250,0), color);
    ScreenManager.SpriteBatch.DrawString(ScreenManager.Font, "Level",
textPosition + new Vector2(400, 0), color);

    int count = 0;

    //loop through list and draw each item
    if (_list.Scores != null)
    {
        foreach (HighScore item in _list.Scores)
        {
            textPosition = new Vector2(50, 150 + 50 * count);

            ScreenManager.SpriteBatch.DrawString(ScreenManager.Font,
item.Date, textPosition, color);
            ScreenManager.SpriteBatch.DrawString(ScreenManager.Font,
item.Score.ToString(), textPosition + new Vector2(250, 0), color);
            ScreenManager.SpriteBatch.DrawString(ScreenManager.Font,
item.Level.ToString(), textPosition + new Vector2(400, 0), color);

            count++;
        }
    }
```

```
    ScreenManager.SpriteBatch.Draw(_buttonB, new Rectangle(800, 700, 48,
48), Color.White);
    ScreenManager.SpriteBatch.DrawString(ScreenManager.Font, "Back", new
Vector2(855, 700), Color.White);

    ScreenManager.SpriteBatch.End();

    if (TransitionPosition > 0)
        ScreenManager.FadeBackBufferToBlack(255 - TransitionAlpha);
}
```

Code Listing 37 – HighScoreScreen Class Draw Method

The **PauseMenuScreen** needs just one line to fade the screen:

```
public override void Draw(GameTime gameTime)
{
    _screenManager.FadeBackBufferToBlack(TransitionAlpha * 2 / 3);

. . .
}
```

Code Listing 38 – PauseMenuScreen Class Updated Draw Method

At this point we have just about everything being drawn to the screen to allow us to play the game. Unfortunately, we don't have a way of moving the character around the screen, so it would quickly die. It's time to fix that by implementing an input system.

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Chapter 5 Input

Until voice-controlled games become the standard, game developers will have to give players a way to control their games. Fortunately, MonoGame makes it easy to hook input devices into your game. In this chapter, we'll build an input system that recognizes the player using these devices that you can reuse in all of your games. We'll take a look at the three devices that are typically used in PC and console games. Mobile devices have additional functionality in the form of touch that is the main source of input, but we're only concentrating on the first two platforms. If you want to port your games to mobile platforms, you'll have to add touch capability into the input system we'll develop here.

Gamepad

The gamepad is a combination of mouse and keyboard for consoles, since most gamers don't want nor have these devices in their living room or other rooms in which consoles are normally used. Gamepads are also much smaller and easier to store when not in use. They don't have quite as much flexibility as a mouse and keyboard due to the limited number of types of input, so you may have to get creative with how you use them in your game. One method (as seen in the RPG genre) is using on-screen UI elements such as dialogs, menus, and toolbars that the player can bring up or toggle to from controlling their character.

Input devices can have two kinds of controls: digital and analog. Digital controls can be in only one of two states: on or off. Keys on a keyboard are examples of digital controls, as are the buttons on the mouse, and the buttons and DPad on the Xbox 360 controller. Analog controls can have a value within a specific range. The sticks and triggers on the Xbox 360 controller and movements of the mouse return values within a range. The Xbox 360 controller sticks return a floating-point value between −1.0 and 1.0, and the triggers return a value between 0.0 and 1.0. For the mouse, mouse cursor values are returned in pixels.

Each input device has specific advantages and disadvantages. The following table shows a brief comparison:

Input Device	Digital Buttons	Analog Controls	Vibration Effects	Supported on Windows	Supported on Xbox	# Allowed on System
Xbox Controller	14	4	Yes	Yes	Yes	4
Keyboard	> 100	0	No	Yes	Yes	1

Input Device	Digital Buttons	Analog Controls	Vibration Effects	Supported on Windows	Supported on Xbox	# Allowed on System
Mouse	5	3	No	Yes	No	1

Table 3 – Input Device Platform Comparison

Since you can't assume that a player on a PC is using a specific type of gamepad (or even an actual gamepad), the **`GamePad`** class provides two methods called **`GetCapabilities`** for getting the controls on the device that is being used. One method takes an **`int`** parameter, the other a **`PlayerIndex`** parameter.

The methods return a **`GamePadCapabilities`** structure with the following properties:

Name	Description
`DisplayName`	Gets the gamepad display name.
`GamePadType`	Gets the type of the controller
`HasAButton`	Gets a value indicating whether the controller has the button A
`HasBButton`	Gets a value indicating whether the controller has the button B
`HasBackButton`	Gets a value indicating whether the controller has the button Back
`HasBigButton`	Gets a value indicating whether the controller has the guide button
`HasDPadDownButton`	Gets a value indicating whether the controller has the directional pad down button
`HasDPadLeftButton`	Gets a value indicating whether the controller has the directional pad left button

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Name	Description
HasDPadRightButton	Gets a value indicating whether the controller has the directional pad right button
HasDPadUpButton	Gets a value indicating whether the controller has the directional pad up button
HasLeftShoulderButton	Gets a value indicating whether the controller has the left shoulder button
HasLeftStickButton	Gets a value indicating whether the controller has the left stick button
HasLeftTrigger	Gets a value indicating whether the controller has the left trigger button
HasLeftVibrationMotor	Gets a value indicating whether the controller has the left vibration motor
HasLeftXThumbStick	Gets a value indicating whether the controller has X axis for the left stick (thumbstick) button
HasLeftYThumbStick	Gets a value indicating whether the controller has Y axis for the left stick (thumbstick) button
HasRightShoulderButton	Gets a value indicating whether the controller has the right shoulder button
HasRightStickButton	Gets a value indicating whether the controller has the right stick button
HasRightTrigger	Gets a value indicating whether the controller has the right trigger button
HasRightVibrationMotor	Gets a value indicating whether the controller has the right vibration motor

Name	Description
`HasRightXThumbStick`	Gets a value indicating whether the controller has X axis for the right stick (thumbstick) button
`HasRightYThumbStick`	Gets a value indicating whether the controller has Y axis for the right stick (thumbstick) button
`HasStartButton`	Gets a value indicating whether the controller has the button Start
`HasVoiceSupport`	Gets a value indicating whether the controller has a microphone
`HasXButton`	Gets a value indicating whether the controller has the button X
`HasYButton`	Gets a value indicating whether the controller has the button Y
`Identifier`	Gets the unique identifier of the gamepad.
`IsConnected`	Gets a value indicating if the controller is connected

Table 4 – GamePadCapabilities Structure Properties

If you're going to support any type of controller, you'll want to check the **`GamePadType`** property to make sure whatever controls you want to use are supported on the controller the player is using. You'll also want to check this if your game is in a genre that needs a specific type of controller, such as a music or rhythm game, or an aircraft simulator or flight game where the player could use a flight stick. The possible values for the **`GamePadType`** are:

Name	Description
`AlternateGuitar`	GamePad is an alternate guitar
`ArcadeStick`	GamePad is an arcade stick
`BigButtonPad`	GamePad is a big button pad

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Name	Description
`DancePad`	GamePad is a dance pad
`DrumKit`	GamePad is a drum kit
`FlightStick`	GamePad is a flight stick
`GamePad`	GamePad is the XBOX controller
`Guitar`	GamePad is a guitar
`Unknown`	Unknown
`Wheel`	GamePad is a wheel

Table 5 – GamePadType Fields

The **`BigButtonPad`** is a specific type of controller Microsoft introduced with the “Scene It?” games that is useful for quiz-type games. It has a large button at the top that acts as a buzzer and four smaller buttons for answering multiple-choice questions.

If your game uses the vibration motors you’ll use the two **`SetVibration`** methods to control them. The methods take three parameters, with the first being either a **`PlayerIndex`** or **`int`**, and the other two being floats.

There are four **`GetState`** methods, although you’ll probably only use the two that take either a **`PlayerIndex`** or **`int`** parameter. The other two take a **`GamePadDeadZone`** parameter that is useful for analog stick controllers.

GamePadState

Every frame, the state of the available input devices is updated and made available through various structures. The first we’ll look at is the structure that contains data for a gamepad. The **`GamePadState`** structure gives us the state of the following controls and methods for getting some of them:

Properties
Buttons
DPad
IsConnected
ThumbSticks
Triggers
Methods
IsButtonDown
IsButtonUp

Table 6 – GamePadState Structure Properties and Methods

The structure offers a few more properties and methods than this, but these are the ones that will be used most often.

The properties representing the various controls on the gamepad are themselves structures that contains properties for the various options for that property. Buttons contains all basic controls: A/B/X/Y buttons, Back/Start buttons, and Shoulders/Sticks. Each property in that structure is an enum with a value of **`Pressed`** or **`Released`**.

`DPad` has **`Left`**, **`Right`**, **`Up`**, and **`Down`** properties that are either **`Pressed`** or **`Released`**.

`Triggers` and **`ThumbSticks`** use a **`float`** and **`Vector2`** data type for the **`Left`** and **`Right`** controls, respectively, since they do not have to be completely pressed or released. These provide detail that the **`Button`** properties do not have. If you're using either in such a way that you only need to know if they're pressed or not, use the **`Buttons`** properties. This could be for something like navigating UI, for example. You don't need to know how far the control is pressed, just whether or not it is. If it is, you might move to the next UI element that can be selected. If you're using the thumbsticks to control a character, you will need to know in what direction and possibly how much it's being moved.

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The **IsButtonUp** and **IsButtonDown** methods take a **Buttons** enum parameter and return a Boolean to indicate if the button or buttons (the parameter can be a bitwise OR to check multiple buttons at once) is pressed or released. This is useful if you have a game that uses combinations of buttons to perform actions, and is easier than checking each button individually.

Keyboard

The **Keyboard** class contains just two methods, which are used for getting the state of the keyboard(s). The first takes no parameter and returns the state of the current keyboard. The second takes a **PlayerIndex** parameter and returns the state of the keyboard for a specific player. This method is obsolete, however, so should be avoided.

KeyboardState

The **KeyboardState** structure has three properties, which you probably won't use a lot, and three methods, which will probably be what you'll rely on most often.

Properties	Description
CapsLock	Returns the current state of the CapsLock key
Item	Returns the current state of a specific key
NumLock	Returns the current state of the NumLock key
Methods	**Description**
GetPressedKeys	Returns an array of the keys that are currently pressed
IsKeyDown	Returns a Boolean that indicates if the specified key is pressed
IsKeyUp	Returns a Boolean that indicates if the specified key is not pressed

Table 7 – KeyboardState Structure Properties and Methods

The **GetPressedKeys** method is useful if you need to check a lot of keys at the same time without calling the **IsKey** methods multiple times. This is handy for games that use key combinations. If you only want to check whether a key is pressed or not, the **IsKey** methods are what you'll want to use.

Mouse

Like the **`Keyboard`** class, **`the`** Mouse class is mainly used for getting the state of the mouse. There are two other methods, **`SetCursor`** and **`SetPosition`**, that you might find useful in certain situations, however.

Instead of drawing your own cursor, you can call the **`SetCursor`** method to use the Windows cursor and change it to one of the supplied cursors:

Name	Description
`Arrow`	Gets the default arrow cursor
`Crosshair`	Gets the crosshair (“+”) cursor
`Hand`	Gets the hand cursor
`Handle`	n/a
`IBeam`	Gets the cursor that appears when the mouse is over text editing regions
`No`	Gets the cursor that points that something is invalid, usually a cross
`SizeAll`	Gets the cursor which points in all directions
`SizeNESW`	Gets the northeast/southwest (“/”) cursor
`SizeNS`	Gets the vertical north/south (“|”) cursor
`SizeNWSE`	Gets the northwest/southeast (“\”) cursor
`SizeWE`	Gets the horizontal (“-“) cursor
`Wait`	Gets the waiting cursor that appears while the application/system is busy

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Name	Description
`WaitArrow`	Gets the cross between `Arrow` and `Wait` cursors

Table 8 – KeyboardState Structure Properties and Methods

You would have to ensure the cursor is visible by setting the the **`Game.IsMouseVisible`** member to **`true`**.

The **`Crosshair`** cursor would be useful as an aiming reticle, the **`Hand`** for indicating that something can be picked up, etc.

The **`SetPosition`** method takes two int parameters for the x and y position of the mouse cursor. This could be useful if you're using the Windows cursor and want to lock it into a certain area or point.

MouseState

The **`MouseState`** structure contains the following properties:

Name	Description
`HorizontalScrollWheelValue`	Returns the cumulative horizontal scroll wheel value since the game start
`LeftButton`	n/a
`MiddleButton`	n/a
`Position`	n/a
`RightButton`	n/a
`ScrollWheelValue`	Returns cumulative scroll wheel value since the game start
`X`	n/a

Name	Description
XButton1	n/a
XButton2	n/a
Y	n/a

Table 9 – MouseState Structure Properties

Most of the properties are fairly obvious. I've noted the two that could be misleading. The scroll wheel properties are tracked since the start of the game, not since the last frame. If you want frame-based values, you'll have to track them yourself.

Implementing input

There are quite a few modifications necessary to our game to get a nice input system up and running. First, add a class to the **ScreenManager** folder called **`InputState`**, and add the following code to it:

```
using Microsoft.Xna.Framework;
using Microsoft.Xna.Framework.Input;

public class InputState
{
    public KeyboardState CurrentKeyboardState;
    public GamePadState CurrentGamePadState;

    public KeyboardState LastKeyboardState;
    public GamePadState LastGamePadState;

    public bool MenuUp
    {
        get
        {
            return IsNewKeyPress(Keys.Up) ||
                   (CurrentGamePadState.DPad.Up == ButtonState.Pressed &&
                   LastGamePadState.DPad.Up == ButtonState.Released) ||
                   (CurrentGamePadState.ThumbSticks.Left.Y > 0 &&
                   LastGamePadState.ThumbSticks.Left.Y <= 0);
        }
    }

    public bool MenuDown
```


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```
    {
        get
        {
            return IsNewKeyPress(Keys.Down) ||
                   (CurrentGamePadState.DPad.Down == ButtonState.Pressed
&&
                   LastGamePadState.DPad.Down == ButtonState.Released) ||
                   (CurrentGamePadState.ThumbSticks.Left.Y < 0 &&
                   LastGamePadState.ThumbSticks.Left.Y >= 0);
        }
    }

    public bool MenuSelect
    {
        get
        {
            return IsNewKeyPress(Keys.Space) ||
                   IsNewKeyPress(Keys.Enter) ||
                   (CurrentGamePadState.Buttons.A == ButtonState.Pressed
&&
                   LastGamePadState.Buttons.A == ButtonState.Released) ||
                   (CurrentGamePadState.Buttons.Start ==
ButtonState.Pressed &&
                   LastGamePadState.Buttons.Start ==
ButtonState.Released);
        }
    }

    public bool MenuCancel
    {
        get
        {
            return IsNewKeyPress(Keys.Escape) ||
                   (CurrentGamePadState.Buttons.B == ButtonState.Pressed
&&
                   LastGamePadState.Buttons.B == ButtonState.Released) ||
                   (CurrentGamePadState.Buttons.Back ==
ButtonState.Pressed &&
                   LastGamePadState.Buttons.Back == ButtonState.Released);
        }
    }

    public bool PauseGame
    {
        get
        {
            return IsNewKeyPress(Keys.Escape) ||
                   (CurrentGamePadState.Buttons.Back ==
ButtonState.Pressed &&
```

```
                    LastGamePadState.Buttons.Back == ButtonState.Released)
||
                    (CurrentGamePadState.Buttons.Start ==
ButtonState.Pressed &&
                    LastGamePadState.Buttons.Start ==
ButtonState.Released);
        }
    }

    public void Update()
    {
        LastKeyboardState = CurrentKeyboardState;
        LastGamePadState = CurrentGamePadState;

        CurrentKeyboardState = Keyboard.GetState();
        CurrentGamePadState = GamePad.GetState(PlayerIndex.One);
    }

    public bool IsNewKeyPress(Keys key)
    {
        return (CurrentKeyboardState.IsKeyDown(key) &&
                LastKeyboardState.IsKeyUp(key));
    }
    public bool IsKeyDown(Keys key)
    {
        return (CurrentKeyboardState.IsKeyDown(key));
    }

    public bool IsNewKeyUp(Keys key)
    {
        return (CurrentKeyboardState.IsKeyUp(key) &&
                LastKeyboardState.IsKeyDown(key));
    }
}
```

Code Listing 39 – InputState class

The class holds the state of the keyboard and gamepad for the current frame and the previous frame. This is necessary because examining only the current frame would give false results. If the player holds down the control to fire, for example, even for only a fraction of a second, the game would process that as multiple fire actions if the code only examines the current input state. We need to detect the first frame in which the player initiates a fire action, and this can only be done by comparing the previous frame's data with the current frame.

The **`Update`** method copies what it has as the current frame input data to the previous frame's input data before obtaining the actual current frame input data via the **`GetState`** methods for the keyboard and gamepad.

The **Menu**… and **Pause** members check all the various controls that can be used to navigate a menu and return the appropriate value, depending on whether or not the control for that action was used.

The **Is**…members check the current keyboard state or the current and previous keyboard state for the key passed and return the appropriate value if the key was pressed, up, or down that frame.

As every screen will use this class, we'll add a virtual method to the **GameScreen** class that each instance will override:

```
public virtual void HandleInput(InputState input, GameTime gameTime) { }
```

Code Listing 40 – GameScreen HandleInput Method

This class is only used for the non-gameplay input. We'll need something a little more robust and flexible for controlling our character in the actual game.

Our input system will use an interface and class to create a system that will map a specific control to a specific action. We'll have seven different possible actions the player can take:

- Fire
- Move
- Move backward
- Move forward
- Move left
- Move right
- Rotate

The interface looks fairly simple, but allows a lot of flexibility. Create a file call **IInputSystem** in the root project folder and add the following code to it:

```
using System.Collections.Generic;

interface IInputSystem
{
    List<MappedAction> MappedActions { get; set; }
    void SetActionFunction(string name, ActionDelegate function);
    void Enable();
}
```

Code Listing 41 – IInputSystem Interface

The **MappedAction** class is what will allow us to associate a control with an action.

The **SetActionFunction** is basically what its name says—it allows us to add a function for an action that's associated with a user-friendly name. The implementation of this method will be done in the **InputSystem** class we'll add soon that implements this interface.

The **Enable** method lets us disable the input system until we get into the actual game. We set up the input system when the game starts and allow the user to configure the controls for actions, but we don't want the system to actually run until the gameplay starts, since we have a different system that controls the menu system.

It's time to add the **MappedAction** class that this interface references. Add this class file to the root folder, and fill it with the following code:

```
class MappedAction
{
    private string _name;
    private Control _control;
    private ActionType _action;
    private ActionDelegate _function;

    public MappedAction(string name, Control control, ActionType action,
ActionDelegate function)
    {
        _name = name;
        _control = control;
        _action = action;
        _function = function;
    }

    public string Name
    {
        get { return _name; }
        set { _name = value; }
    }

    public Control ActionControl
    {
        get { return _control; }
        set { _control = value; }
    }

    public ActionType Action
    {
        get { return _action; }
        set { _action = value; }
    }

    public ActionDelegate Function
    {
        get { return (ActionDelegate) _function; }
        set { _function = value; }
    }
}
```

Code Listing 42 – MappedAction Class

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The **Name** member allows us to show the user actions as correct English. Since enums cannot have spaces between the different words and might not be named exactly as what you would want to show the user, we have a member that can be set to exactly what we want to show the user.

The **Control** and **ActionType** members are enums. We'll define them now. Add a file called **InputSystem** to the root folder and add the enums for these two members:

```
public enum ActionType
{
    Move,
    MoveForward,
    MoveBackward,
    MoveLeft,
    MoveRight,
    Rotate,
    Fire
}

public enum Control
{
    AButton,
    BButton,
    XButton,
    YButton,
    StartButton,
    BackButton,
    LeftTrigger,
    RightTrigger,
    LeftShoulder,
    RightShoulder,
    LeftStick,
    RightStick,
    DPadUp,
    DPadDown,
    DPadLeft,
    DPadRight,
    None,
    Back,
    Tab,
    Enter,
    CapsLock,
    Escape,
    Space,
    PageUp,
    PageDown,
    End,
    Home,
    Left,
    Up,
```

```
    Right,
    Down,
    Select,
    Print,
    Execute,
    PrintScreen,
    Insert,
    Delete,
    Help,
    D0,
    D1,
    D2,
    D3,
    D4,
    D5,
    D6,
    D7,
    D8,
    D9,
    A,
    B,
    C,
    D,
    E,
    F,
    G,
    H,
    I,
    J,
    K,
    L,
    M,
    N,
    O,
    P,
    Q,
    R,
    S,
    T,
    U,
    V,
    W,
    X,
    Y,
    Z,
    LeftWindows,
    RightWindows,
    Apps,
    Sleep,
    NumPad0,
```


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```
    NumPad1,
    NumPad2,
    NumPad3,
    NumPad4,
    NumPad5,
    NumPad6,
    NumPad7,
    NumPad8,
    NumPad9,
    Multiply,
    Add,
    Separator,
    Subtract,
    Decimal,
    Divide,
    F1,
    F2,
    F3,
    F4,
    F5,
    F6,
    F7,
    F8,
    F9,
    F10,
    F11,
    F12,
    F13,
    F14,
    F15,
    F16,
    F17,
    F18,
    F19,
    F20,
    F21,
    F22,
    F23,
    F24,
    NumLock,
    Scroll,
    LeftShift,
    RightShift,
    LeftControl,
    RightControl,
    LeftAlt,
    RightAlt,
    BrowserBack,
    BrowserForward,
    BrowserRefresh,
```

```
    BrowserStop,
    BrowserSearch,
    BrowserFavorites,
    BrowserHome,
    VolumeMute,
    VolumeDown,
    VolumeUp,
    MediaNextTrack,
    MediaPreviousTrack,
    MediaStop,
    MediaPlayPause,
    LaunchMail,
    SelectMedia,
    LaunchApplication1,
    LaunchApplication2,
    OemSemicolon,
    OemPlus,
    OemComma,
    OemMinus,
    OemPeriod,
    OemQuestion,
    OemTilde,
    OemOpenBrackets,
    OemPipe,
    OemCloseBrackets,
    OemQuotes,
    Oem8,
    OemBackslash,
    ProcessKey,
    Attn,
    Crsel,
    Exsel,
    EraseEof,
    Play,
    Zoom,
    Pa1,
    OemClear,
    LeftMouseButton,
    MiddleMouseButton,
    RightMouseButton,
    MouseButton1,
    MouseButton2
}
```

Code Listing 43 – Input System Enums

The **`Control`** enum has all possible gamepad, keyboard, and mouse input controls. Many of them you wouldn't ever consider using for controls for an action, but they're including for future expansion for any other functionality you might want to add.

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The **ActionDelegate** function is defined as follows:

```
public delegate void ActionDelegate(object value, GameTime gameTime);
```

Code Listing 44 – ActionDelegate Defintion

If you're not familiar with delegates, we're using them here to define the parameters that are passed for events for each type of action the user can have the character perform. These events will be in the **InputSystem** class that we'll define now. Add this to the **InputSystem** file:

```
class InputSystem : GameComponent, IInputSystem
{
    public event ActionDelegate Move;
    public event ActionDelegate MoveForward;
    public event ActionDelegate MoveBackward;
    public event ActionDelegate MoveLeft;
    public event ActionDelegate MoveRight;
    public event ActionDelegate Stop;
    public event ActionDelegate Rotate;
    public event ActionDelegate Fire;

    private GamePadState _lastGamePadState;
    private KeyboardState _lastKeyboardState;
    private GamePadState _curGamePadState;
    private KeyboardState _curKeyboardState;
    private MouseState _curMouseState;
    private MouseState _lastMouseState;

    private List<MappedAction> _mappedActions;

    public List<MappedAction> MappedActions
    {
        get { return _mappedActions; }
        set { _mappedActions = value; }
    }

    public InputSystem(Game game)
        : base(game)
    {
        _mappedActions = new List<MappedAction>();
    }

    public override void Initialize()
    {
    }

    public void Enable()
```

```
    {
        this.Enabled = true;
    }

    public void AddAction(string name, Control control, ActionType type,
ActionDelegate function)
    {
        MappedAction action = new MappedAction(name, control, type,
function);
        _mappedActions.Add(action);
    }

    public void SetActionControl(string name, Control control)
    {
        foreach (MappedAction action in _mappedActions)
        {
            if (action.Name == name)
            {
                action.ActionControl = control;
                break;
            }
        }
    }

    public void SetActionFunction(string name, ActionDelegate function)
    {
        if (name == "Stop")
            this.Stop += function;

        foreach (MappedAction action in _mappedActions)
        {
            if (action.Name == name)
            {
                action.Function = function;
                break;
            }
        }
    }

    public override void Update(GameTime gameTime)
    {
        _curGamePadState = GamePad.GetState(PlayerIndex.One);
        _curKeyboardState = Keyboard.GetState();
        _curMouseState = Mouse.GetState();

        int dir = -1;
        bool moving = false;

        //we only need to look at the controls mapped to actions
            if (Enabled)
```


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```
            {
                foreach (MappedAction action in _mappedActions)
                {
                    switch (action.ActionControl)
                    {
                        case Control.AButton:

                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curGamePadState.Buttons.A,
gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Buttons.A ==
ButtonState.Pressed && _lastGamePadState.Buttons.A == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }
                            break;

                        case Control.BButton:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curGamePadState.Buttons.B,
gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Buttons.B ==
ButtonState.Pressed && _lastGamePadState.Buttons.B == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.XButton:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curGamePadState.Buttons.X,
gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Buttons.X ==
ButtonState.Pressed && _lastGamePadState.Buttons.X == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;
```

```
                        case Control.YButton:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curGamePadState.Buttons.Y,
gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Buttons.Y ==
ButtonState.Pressed && _lastGamePadState.Buttons.Y == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.StartButton:
                            if (action.Action < ActionType.Fire)
                            {

action.Function(_curGamePadState.Buttons.Start, gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Buttons.Start ==
ButtonState.Pressed && _lastGamePadState.Buttons.Start ==
ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.BackButton:
                            if (action.Action < ActionType.Fire)
                            {

action.Function(_curGamePadState.Buttons.Back, gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Buttons.Back ==
ButtonState.Pressed && _lastGamePadState.Buttons.Back ==
ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.LeftTrigger:
                            if (action.Action < ActionType.Fire)
                            {
```


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```
action.Function(_curGamePadState.Triggers.Left, gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Triggers.Left == 1.0f
&& _lastGamePadState.Triggers.Left < 1.0f)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.RightTrigger:
                            if (action.Action < ActionType.Fire)
                            {

action.Function(_curGamePadState.Triggers.Right, gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Triggers.Right == 1.0f
&& _lastGamePadState.Triggers.Right < 1.0f)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.LeftShoulder:
                            if (action.Action < ActionType.Fire)
                            {

action.Function(_curGamePadState.Buttons.LeftShoulder, gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.Buttons.LeftShoulder
== ButtonState.Pressed && _lastGamePadState.Buttons.LeftShoulder ==
ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.RightShoulder:
                            if (action.Action < ActionType.Fire)
                            {

action.Function(_curGamePadState.Buttons.RightShoulder, gameTime);
                            }
                            else
```

```
                            {
                                if (_curGamePadState.Buttons.RightShoulder
== ButtonState.Pressed && _lastGamePadState.Buttons.RightShoulder ==
ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.LeftStick:
                            if (action.Action < ActionType.Fire)
                            {
                                //convert to a direction
                                if (_curGamePadState.ThumbSticks.Left !=
Vector2.Zero)
                                {
                                    float degrees =
((float)(Math.Atan2(_curGamePadState.ThumbSticks.Left.X,
_curGamePadState.ThumbSticks.Left.Y) * 57.2957795));

                                    if (degrees < 0)
                                    {
                                        if (degrees >= -67)
                                            dir = (int)Direction.NorthWest;
                                        else if (degrees >= -112)
                                            dir = (int)Direction.West;
                                        else if (degrees >= -157)
                                            dir = (int)Direction.SouthWest;
                                        else
                                            dir = (int)Direction.South;
                                    }
                                    else
                                    {
                                        dir = (int)((int)(degrees / 45));
                                    }
                                    action.Function((Direction)dir,
gameTime);

                                    if (action.Action < ActionType.Rotate)
                                        moving = true;
                                }
                                else if (action.Action < ActionType.Rotate)
                                    moving = false;
                            }
                            else
                            {
                                if (_curGamePadState.ThumbSticks.Left !=
Vector2.Zero && _lastGamePadState.ThumbSticks.Left == Vector2.Zero)

action.Function(_curGamePadState.ThumbSticks.Left, gameTime);
```


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```
                            }

                            break;

                        case Control.RightStick:
                            if (action.Action < ActionType.Fire)
                            {
                                //convert to a direction
                                if (_curGamePadState.ThumbSticks.Right !=
Vector2.Zero)
                                {
                                    float degrees =
((float)(Math.Atan2(_curGamePadState.ThumbSticks.Right.X,
_curGamePadState.ThumbSticks.Right.Y) * 57.2957795));

                                    if (degrees < 0)
                                    {
                                        if (degrees >= -67)
                                            dir = (int)Direction.NorthWest;
                                        else if (degrees >= -112)
                                            dir = (int)Direction.West;
                                        else if (degrees >= -157)
                                            dir = (int)Direction.SouthWest;
                                        else
                                            dir = (int)Direction.South;
                                    }
                                    else
                                    {
                                        dir = (int)((int)(degrees / 45));
                                    }
                                    action.Function((Direction)dir,
gameTime);

                                    if (action.Action < ActionType.Rotate)
                                        moving = true;
                                }
                                else if (action.Action < ActionType.Rotate)
                                    moving = false;
                            }
                            else
                            {
                                if (_curGamePadState.ThumbSticks.Right !=
Vector2.Zero && _lastGamePadState.ThumbSticks.Right == Vector2.Zero)

action.Function(_curGamePadState.ThumbSticks.Right, gameTime);
                            }

                            break;

                        case Control.DPadUp:
```

```
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curGamePadState.DPad.Up,
gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.DPad.Up ==
ButtonState.Pressed && _lastGamePadState.DPad.Up == ButtonState.Released)

action.Function(_curGamePadState.DPad.Up, gameTime);
                            }

                            break;

                        case Control.DPadDown:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curGamePadState.DPad.Down,
gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.DPad.Down ==
ButtonState.Pressed && _lastGamePadState.DPad.Down == ButtonState.Released)

action.Function(_curGamePadState.DPad.Down, gameTime);
                            }

                            break;

                        case Control.DPadLeft:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curGamePadState.DPad.Left,
gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.DPad.Left ==
ButtonState.Pressed && _lastGamePadState.DPad.Left == ButtonState.Released)

action.Function(_curGamePadState.DPad.Left, gameTime);
                            }

                            break;

                        case Control.DPadRight:
                            if (action.Action < ActionType.Fire)
                            {
```


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```
action.Function(_curGamePadState.DPad.Right, gameTime);
                            }
                            else
                            {
                                if (_curGamePadState.DPad.Right ==
ButtonState.Pressed && _lastGamePadState.DPad.Right ==
ButtonState.Released)

action.Function(_curGamePadState.DPad.Right, gameTime);
                            }

                            break;

                        case Control.Back:
                        case Control.Tab:
                        case Control.Enter:
                        case Control.CapsLock:
                        case Control.Escape:
                        case Control.Space:
                        case Control.PageUp:
                        case Control.PageDown:
                        case Control.End:
                        case Control.Home:
                        case Control.Left:
                        case Control.Up:
                        case Control.Right:
                        case Control.Down:
                        case Control.Select:
                        case Control.Print:
                        case Control.Execute:
                        case Control.PrintScreen:
                        case Control.Insert:
                        case Control.Delete:
                        case Control.Help:
                        case Control.D0:
                        case Control.D1:
                        case Control.D2:
                        case Control.D3:
                        case Control.D4:
                        case Control.D5:
                        case Control.D6:
                        case Control.D7:
                        case Control.D8:
                        case Control.D9:
                        case Control.A:
                        case Control.B:
                        case Control.C:
                        case Control.D:
                        case Control.E:
```

```
                        case Control.F:
                        case Control.G:
                        case Control.H:
                        case Control.I:
                        case Control.J:
                        case Control.K:
                        case Control.L:
                        case Control.M:
                        case Control.N:
                        case Control.O:
                        case Control.P:
                        case Control.Q:
                        case Control.R:
                        case Control.S:
                        case Control.T:
                        case Control.U:
                        case Control.V:
                        case Control.W:
                        case Control.X:
                        case Control.Y:
                        case Control.Z:
                        case Control.LeftWindows:
                        case Control.RightWindows:
                        case Control.Apps:
                        case Control.Sleep:
                        case Control.NumPad0:
                        case Control.NumPad1:
                        case Control.NumPad2:
                        case Control.NumPad3:
                        case Control.NumPad4:
                        case Control.NumPad5:
                        case Control.NumPad6:
                        case Control.NumPad7:
                        case Control.NumPad8:
                        case Control.NumPad9:
                        case Control.Multiply:
                        case Control.Add:
                        case Control.Separator:
                        case Control.Subtract:
                        case Control.Decimal:
                        case Control.Divide:
                        case Control.F1:
                        case Control.F2:
                        case Control.F3:
                        case Control.F4:
                        case Control.F5:
                        case Control.F6:
                        case Control.F7:
                        case Control.F8:
                        case Control.F9:
```


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```
                        case Control.F10:
                        case Control.F11:
                        case Control.F12:
                        case Control.F13:
                        case Control.F14:
                        case Control.F15:
                        case Control.F16:
                        case Control.F17:
                        case Control.F18:
                        case Control.F19:
                        case Control.F20:
                        case Control.F21:
                        case Control.F22:
                        case Control.F23:
                        case Control.F24:
                        case Control.NumLock:
                        case Control.Scroll:
                        case Control.LeftShift:
                        case Control.RightShift:
                        case Control.LeftControl:
                        case Control.RightControl:
                        case Control.LeftAlt:
                        case Control.RightAlt:
                        case Control.BrowserBack:
                        case Control.BrowserForward:
                        case Control.BrowserRefresh:
                        case Control.BrowserStop:
                        case Control.BrowserSearch:
                        case Control.BrowserFavorites:
                        case Control.BrowserHome:
                        case Control.VolumeMute:
                        case Control.VolumeDown:
                        case Control.VolumeUp:
                        case Control.MediaNextTrack:
                        case Control.MediaPreviousTrack:
                        case Control.MediaStop:
                        case Control.MediaPlayPause:
                        case Control.LaunchMail:
                        case Control.SelectMedia:
                        case Control.LaunchApplication1:
                        case Control.LaunchApplication2:
                        case Control.OemSemicolon:
                        case Control.OemPlus:
                        case Control.OemComma:
                        case Control.OemMinus:
                        case Control.OemPeriod:
                        case Control.OemQuestion:
                        case Control.OemTilde:
                        case Control.OemOpenBrackets:
                        case Control.OemPipe:
```

```
                        case Control.OemCloseBrackets:
                        case Control.OemQuotes:
                        case Control.Oem8:
                        case Control.OemBackslash:
                        case Control.ProcessKey:
                        case Control.Attn:
                        case Control.Crsel:
                        case Control.Exsel:
                        case Control.EraseEof:
                        case Control.Play:
                        case Control.Zoom:
                        case Control.Pa1:
                        case Control.OemClear:

                            //we can use one case here
                            if (action.Action < ActionType.Fire)
                            {

action.Function(_curKeyboardState.IsKeyDown((Keys)(action.ActionControl -
(action.ActionControl - 1))), gameTime);
                            }
                            else
                            {
                                if
(_curKeyboardState.IsKeyDown((Keys)(action.ActionControl -
(action.ActionControl - 1))) &&
_lastKeyboardState.IsKeyUp((Keys)(action.ActionControl -
(action.ActionControl - 1))))
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.LeftMouseButton:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curMouseState.LeftButton,
gameTime);
                            }
                            else
                            {
                                if (_curMouseState.LeftButton ==
ButtonState.Pressed && _lastMouseState.LeftButton == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.MiddleMouseButton:
                            if (action.Action < ActionType.Fire)
```


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```
                            {

action.Function(_curMouseState.MiddleButton, gameTime);
                            }
                            else
                            {
                                if (_curMouseState.MiddleButton ==
ButtonState.Pressed && _lastMouseState.MiddleButton ==
ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.RightMouseButton:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curMouseState.RightButton,
gameTime);
                            }
                            else
                            {
                                if (_curMouseState.RightButton ==
ButtonState.Pressed && _lastMouseState.RightButton == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.MouseButton1:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curMouseState.XButton1,
gameTime);
                            }
                            else
                            {
                                if (_curMouseState.XButton1 ==
ButtonState.Pressed && _lastMouseState.XButton1 == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;

                        case Control.MouseButton2:
                            if (action.Action < ActionType.Fire)
                            {
                                action.Function(_curMouseState.XButton2,
gameTime);
                            }
```

```
                            else
                            {
                                if (_curMouseState.XButton2 ==
ButtonState.Pressed && _lastMouseState.XButton2 == ButtonState.Released)
                                    action.Function(null, gameTime);
                            }

                            break;
                        }
                    }

                    if (!moving)
                    {
                        Stop(null, gameTime);
                    }
                }

            _lastGamePadState = _curGamePadState;
            _lastKeyboardState = _curKeyboardState;
            _lastMouseState=_curMouseState;

        }
    }
```

Code Listing 45 – InputSystem class

There's a lot going on here, so let's take a closer look.

The first thing we see is the implementation of the **`ActionDelegate`** delegate. We have the eight types of actions for which we'll do something. Notice that there's an **`ActionDelegate`** for **`Stop`**. If the player isn't doing one of the actions related to moving that we mentioned before, we stop the character from moving.

The next members are the current and previous states of the input devices we'll handle.

After this, we have the implementation of our interface. We also provide a variety of methods for allowing the modification of mapped actions.

The **`Update`** method is the largest chunk of code in the class, as you would expect. After getting the current state of the input devices, if the input system is enabled, we go through all of our mapped actions, examining the current input to see if the conditions match to fire the function associated with that action.

If, after evaluating all the actions, it's determined that the character is not moving, the **`Stop`** action function is called. We then set the current input states to the last input states.

The **`InputSystem`** instance is created in the **`Game`** class:

```
InputSystem input;

protected override void Initialize()
```


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```
{
. . .


    input = new InputSystem(this);

    //we don't want to use this until we play the game or configure the
controls
    input.Enabled = false;

    input.AddAction("Move", Control.LeftStick, ActionType.Move, null);
    input.AddAction("Move Foward", Control.DPadUp, ActionType.MoveForward,
null);
    input.AddAction("Move Backward", Control.DPadDown,
ActionType.MoveBackward, null);
    input.AddAction("Move Left", Control.DPadLeft, ActionType.MoveLeft,
null);
    input.AddAction("Move Right", Control.DPadRight, ActionType.MoveRight,
null);
    input.AddAction("Fire", Control.RightTrigger, ActionType.Fire, null);
    input.AddAction("Rotate", Control.RightStick, ActionType.Rotate, null);

    Components.Add(input);

    this.Services.AddService(typeof(IInputSystem), input);
}
```

Code Listing 46 – Input System Activation

The input system is enabled only when the player has started the actual gameplay. This happens in the **`Initialize`** method of the **`GameplayScreen`** class:

```
IInputSystem input =
((IInputSystem)ScreenManager.Game.Services.GetService(typeof(IInputSystem))
);

input.SetActionFunction("Move", Move);
input.SetActionFunction("Move Foward", MoveForward);
input.SetActionFunction("Move Backward", MoveBackward);
input.SetActionFunction("Move Left", MoveLeft);
input.SetActionFunction("Move Right", MoveRight);
input.SetActionFunction("Fire", Fire);
input.SetActionFunction("Rotate", Rotate);
input.SetActionFunction("Stop", Stop);

input.Enable();
```

Code Listing 47 – Input System Activation

The **ActionDelegate** parameter for the **SetActionFunction** method calls are methods in the **GameplayScreen** class:

```
private void Move(object value, GameTime gameTime)
{
    _entityManager.MovePlayer((Direction)value);
}

private void MoveForward(object value, GameTime gameTime)
{
    if (value != null)
    {
        if ((ButtonState)value == ButtonState.Pressed)
        {
            _entityManager.MovePlayer(_entityManager.GetPlayerDirection());
        }
    }
}

private void MoveBackward(object value, GameTime gameTime)
{
    if (value != null)
    {
        if ((ButtonState)value == ButtonState.Pressed)
        {
            Direction dir = _entityManager.GetPlayerDirection();

            if (dir < Direction.South)
                dir += 4;
            else
                dir = (Direction)((int)Direction.NorthWest - (int)dir);

            _entityManager.MovePlayer(dir);
        }
    }
}

private void MoveLeft(object value, GameTime gameTime)
{
    if (value != null)
    {
        if ((ButtonState)value == ButtonState.Pressed)
        {
            Direction dir = _entityManager.GetPlayerDirection();

            if (dir < Direction.East)
                dir += 6;
            else
                dir = (Direction)((int)Direction.NorthWest - (int)dir);
```


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```
            _entityManager.MovePlayer(dir);
        }
    }
}

private void MoveRight(object value, GameTime gameTime)
{
    if (value != null)
    {
        if ((ButtonState)value == ButtonState.Pressed)
        {
            Direction dir = _entityManager.GetPlayerDirection();

            if (dir < Direction.West)
                dir += 2;
            else
                dir = (Direction)((int)Direction.NorthWest - (int)dir);

            _entityManager.MovePlayer(dir);
        }
    }
}

private void Rotate(object value, GameTime gameTime)
{
    if (value != null)
    {
        _entityManager.SetPlayerDirection((Direction)value);
    }
}

private void Stop(object value, GameTime gameTime)
{
    _entityManager.StopPlayer();
}

private void Fire(object value, GameTime gameTime)
{
    _entityManager.PlayerFire();
}
```

Code Listing 48 – Input System Action Methods

The **EntityManager** class takes care of resolving all the actions that the player takes. We have a bit of the **EntityManager** started already, and we'll continue fleshing it out with the methods called here:

```
public void SetPlayerDirection(Direction dir)
{
    if (_entities.Count > 0)
```

```
    {
        _entities[0].MoveDirection = dir;
    }
}

public void StopPlayer()
{
    if (_entities.Count > 0)
    {
        _entities[0].Speed = 0.0f;
    }
}

public Direction GetPlayerDirection()
{
    if (_entities.Count > 0)
    {
        return _entities[0].MoveDirection;
    }
    else
        return Direction.North;
}

public void MovePlayer(Direction dir)
{
    if (_entities.Count > 0)
    {
        _entities[0].MoveDirection = dir;
        _entities[0].Speed = 3.0f;
    }
}

public void PlayerFire()
{
    if (_entities.Count > 0)
    {

    }
}
```

Code Listing 49 – EntityManager Action Methods

The methods include a sanity check to ensure we're not attempting to set properties of a null object. This should never happen, but such validation is good practice.

If we move the character, we ensure his speed is set to the default. You could use a constant here, with other constants that could be used for a character that has had his speed enhanced to be faster or slower than normal. This could be done if you put powerups into the game.

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Notice the empty **`if`** statement in the **`PlayerFire`** method. We'll implement audio in the next chapter.

The last piece we need to implement is the **`InputState`** instance. That goes in the **`ScreenManager`** class, where it's also updated and passed to the screens:

```
InputState _input = new InputState();

public override void Update(GameTime gameTime)
{
    // Read the keyboard and gamepad.
    _input.Update();

. . .

    while (_screensToUpdate.Count > 0)
    {
        // Pop the topmost screen off the waiting list.
        GameScreen screen = _screensToUpdate[_screensToUpdate.Count - 1];

        _screensToUpdate.RemoveAt(_screensToUpdate.Count - 1);

        // Update the screen.
        screen.Update(gameTime, otherScreenHasFocus, coveredByOtherScreen);

        if (screen.ScreenState == ScreenState.TransitionOn ||
            screen.ScreenState == ScreenState.Active)
        {
            // If this is the first active screen we came across,
            // give it a chance to handle input.
            if (!otherScreenHasFocus)
            {
                screen.HandleInput(_input, gameTime);

                otherScreenHasFocus = true;
            }

            // If this is an active non-popup, inform any subsequent
            // screens that they are covered by it.
            if (!screen.IsPopup)
                coveredByOtherScreen = true;
        }
    }

    if (_traceEnabled)
        TraceScreens();
}
```

Code Listing 50 – ScreenManager Updated Update Method

We need to add input handling to a few classes, starting with the the **HighScoreScreen** class:

```
public override void HandleInput(InputState input, GameTime gameTime)
{
    if ((input.CurrentGamePadState.Buttons.B ==
Microsoft.Xna.Framework.Input.ButtonState.Pressed &&
input.LastGamePadState.Buttons.B ==
Microsoft.Xna.Framework.Input.ButtonState.Released) ||

(input.CurrentKeyboardState.IsKeyDown(Microsoft.Xna.Framework.Input.Keys.Es
cape) &&
input.LastKeyboardState.IsKeyUp(Microsoft.Xna.Framework.Input.Keys.Escape))
)
        this.ExitScreen();

    base.HandleInput(input, gameTime);
}
```

Code Listing 51 – HighScoreScreen HandleInput Method

The **MessageBoxScreen** class:

```
public override void HandleInput(InputState input, GameTime gameTime)
{
    if (input.MenuSelect)
    {
        // Raise the accepted event, then exit the message box.
        if (Accepted != null)
            Accepted(this, EventArgs.Empty);

        ExitScreen();
    }
    else if (input.MenuCancel)
    {
        // Raise the cancelled event, then exit the message box.
        if (Cancelled != null)
            Cancelled(this, EventArgs.Empty);

        ExitScreen();
    }
}
```

Code Listing 52 – MessageBoxScreen HandleInput Method

The **GameplayScreen** class:

```
public override void HandleInput(InputState input, GameTime gameTime)
{
    if (input == null)
        throw new ArgumentNullException("input");
```


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```
    if (input.PauseGame)
    {
        ScreenManager.AddScreen(new PauseMenuScreen());
    }
}
```

Code Listing 53 – GameplayScreen HandleInput Method

The **MenuScreen** class:

```
public override void HandleInput(InputState input, GameTime gameTime)
{
    // Move to the previous menu entry?
    if (input.MenuUp)
    {
        _selectedEntry--;

        if (_selectedEntry < 0)
            _selectedEntry = _menuEntries.Count - 1;
    }

    // Move to the next menu entry?
    if (input.MenuDown)
    {
        _selectedEntry++;

        if (_selectedEntry >= _menuEntries.Count)
            _selectedEntry = 0;
    }

    // Accept or cancel the menu?
    if (input.MenuSelect)
    {
        OnSelectEntry(_selectedEntry);

    }
    else if (input.MenuCancel)
    {
        OnCancel();
    }

    if (input.IsNewKeyPress(Keys.Left))
        OnNewArrowDown(Keys.Left, _selectedEntry);
    else if (input.IsKeyDown(Keys.Left))
        OnArrowDown(Keys.Left, _selectedEntry, gameTime);


    if (input.IsNewKeyUp(Keys.Left))
        OnArrowUp(Keys.Left, _selectedEntry);
```

```
    if (input.IsNewKeyPress(Keys.Right))
        OnNewArrowDown(Keys.Right, _selectedEntry);
    else if (input.IsKeyDown(Keys.Right))
        OnArrowDown(Keys.Right,_selectedEntry, gameTime);

    if (input.IsNewKeyUp(Keys.Right))
        OnArrowUp(Keys.Right, _selectedEntry);

}
```

Code Listing 54 – MenuScreen HandleInput Method

Now that we have an input system, we need to give the player a way to change which controls map to the actions we've defined. We'll add a new screen to allow this. Create a new class in the **Screens** folder and add the following:

```
class ControlsScreen : MenuScreen
{
    private string[] _items;
    private int[] _selectedIndices;

    private bool _leftArrowDown = false;
    private bool _rightArrowDown = false;

    private float _leftArrowDownTime = 0.0f;
    private float _rightArrowDownTime = 0.0f;

    private List<MappedAction> _actions;

    public ControlsScreen()
    {
    }

    public override void Initialize()
    {
        base.Initialize();

        //get the current configuration and load the menu
        _actions =
((IInputSystem)ScreenManager.Game.Services.GetService(typeof(IInputSystem))
).MappedActions;

        _selectedIndices = new int[_actions.Count];

        int count = 0;

        foreach (MappedAction action in _actions)
        {
            _menuEntries.Add(action.Name + ": ");
```


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```
            _selectedIndices[count] = (int)action.ActionControl;
            count++;
        }

        _menuEntries.Add("Back");

        //populate items array with all available controls
        _items = new string[System.Enum.GetNames(typeof(Control)).Length];

        count = 0;

        //Loop through Keys enum
        foreach (int value in System.Enum.GetValues(typeof(Control)))
        {
            _items[count] = System.Enum.GetName(typeof(Control), value);
            count++;
        }

    }

    public override void Update(GameTime gameTime, bool
otherScreenHasFocus,
                                                    bool
coveredByOtherScreen)
    {
        base.Update(gameTime, otherScreenHasFocus, coveredByOtherScreen);

        int count = 0;
        string entry;

        for (count = 0; count < _actions.Count;count++ )
        {
            entry = _actions[count].Name + ": " +
_items[_selectedIndices[count]];
            _menuEntries[count] = entry;
        }
    }

    protected override void OnSelectEntry(int entryIndex)
    {
        //increment and check item
        if (entryIndex == 7)
        {
            // Go back to the main menu.
            ExitScreen();
        }
    }

    protected override void OnArrowUp(Keys arrow, int entryIndex)
    {
```

```
        int index = _selectedIndices[entryIndex]++;

        switch (arrow)
        {
            case Keys.Left:

                index--;

                if (index < 0)
                    index = _items.Length - 1;

                break;

            case Keys.Right:
                index++;

                if (index > _items.Length - 1)
                    index = 0;

                break;
        }

        _selectedIndices[entryIndex] = index;

    }

    protected override void OnArrowDown(Keys arrow, int entryIndex,
GameTime gameTime)
    {
        int index = _selectedIndices[entryIndex]++;

        switch (arrow)
        {

            case Keys.Left:

                if (_leftArrowDown)
                {
                    _leftArrowDownTime +=
gameTime.ElapsedGameTime.Milliseconds;

                    if (_leftArrowDownTime > 250.0f)
                    {
                        index--;
                        _leftArrowDownTime = 0.0f;
                    }
                }
                else
                {
                    _leftArrowDown = true;
```


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```
                    _leftArrowDownTime = 0.0f;
                }

                break;

            case Keys.Right:

                if (_rightArrowDown)
                {
                    _rightArrowDownTime +=
gameTime.ElapsedGameTime.Milliseconds;

                    if (_rightArrowDownTime > 250.0f)
                    {
                        index++;
                        _rightArrowDownTime = 0.0f;
                    }
                }
                else
                {
                    _rightArrowDown = true;
                    _rightArrowDownTime = 0.0f;
                }

                break;

        }

        if (index < 0)
            index = _items.Length - 1;
        else if (index == _items.Length)
            index=0;

        _selectedIndices[entryIndex] = index;

    }

    protected override void OnCancel()
    {
        ExitScreen();
    }

    public override void ExitScreen()
    {
        //save the controls configuration
        MappedAction action;

        for (int count = 0; count < _actions.Count; count++)
        {
            action = _actions[count];
```

```
            action.ActionControl = (Control)_selectedIndices[count];
        }

((IInputSystem)ScreenManager.Game.Services.GetService(typeof(IInputSystem))
).MappedActions = _actions;

        base.ExitScreen();
    }
}
```

Code Listing 55 – ControlsScreen Class

We now have a way to control our character. The last system we'll be adding is audio to handle sounds and music.

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Chapter 6 Audio

There aren't many games that won't benefit from good sound effects and music. Even board games can use sound to enhance the play experience. Playing sounds for tokens moving around the board and landing on special areas, cards flipping or moving, etc. can be used to enhance the game. Many games make the sound portion of the game development process the lowest priority, unless it's a game in the music genre.

As with most other areas of the game development process, getting audio into your game is fairly easy with MonoGame. The object-oriented nature of the framework makes it easy to work with your audio files. At the most basic level, you need just two lines of code to play a sound (assuming you already have a **`ContentManager`** object, which by this point you do):

```
SoundEffect se = Content.Load<SoundEffect>("soundname");

se.Play();
```

Code Listing 56 – SoundEffectInstance State Enum

If you need to control the volume, pitch, or panning of a sound, you can call the overloaded **`Play`** method that takes these three parameters:

```
se.Play(1.0f, 0.0f, 0.0f);
```

Code Listing 57 – SoundEffectInstance State Enum

The parameters' possibilities are shown in the following table:

`Volume`	Ranges from 0.0 (silence) to 1.0 (full volume)
`Pitch`	Ranges from -1.0 (down an octave) to 0.0 (no change) to 1.0 (up an octave)
`Pan`	Range from -1.0 (left speaker) to 0.0 (centered), 1.0 (right speaker)

Table 10 – Play Method Parameters

Both methods return a **`SoundEffectInstance`** object, which you can keep around if you need to work with the sound after you start playing it, including adjusting the previously mentioned properties or playing it as a 3D sound using AudioListener and AudioEmitter objects.

If you're working with a **SoundEffectInstance** object, you may need to know what state it's in at some point. If the object is currently playing, you probably don't want to try playing it again. If, for some reason, you've paused the sound in one section of code, you may need to know in another section if it's still paused. You can use the **State** property of the **SoundEffectInstance** class to find out the state of the object. It will return one of three states:

```
public enum SoundState
{
    Paused,
    Playing,
    Stopped
}
```

Code Listing 58 – SoundEffectInstance State Enum

Our sound system will not use instances, as it's extremely simple. We'll keep a collection of sounds in the **Game** class and load the collection in the **Initialize** method:

```
public enum Sounds
{
    GhostDie,
    Menu,
    PlayerDie,
    Title,
    Zap
}

public Dictionary<Sounds, SoundEffect> GameSounds;

protected override void Initialize()
{
    GameSounds = new Dictionary<Ghost_Arena.Sounds, SoundEffect>();

    GameSounds.Add(Sounds.GhostDie, Content.Load<SoundEffect>("ghostdie"));
    GameSounds.Add(Sounds.Zap, Content.Load<SoundEffect>("zap"));
    GameSounds.Add(Sounds.Menu, Content.Load<SoundEffect>("menu"));
    GameSounds.Add(Sounds.PlayerDie,
Content.Load<SoundEffect>("playerdie"));
    GameSounds.Add(Sounds.Title, Content.Load<SoundEffect>("title"));

. . .
```

Code Listing 59 – SoundEffectInstance State Enum

The sounds will be used in the **EntityManager**, **MainMenuScreen**, and **MenuScreen** classes. In the **MenuScreen**'s **HandleInput** method, we'll add one line after the **OnSelectEntry(_selectedEntry);** line:

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```
((Game1)ScreenManager.Game).GameSounds[Sounds.Menu].Play();
```

Code Listing 60 – MenuScreen Item Selected Sound

We have three places in the **EntityManager** where we play sounds. In the **Update** method, the following code goes after the **_entities.Remove(_entities[i]);** line. The other two existing methods should be replaced with the following.

```
public void Update(GameTime gameTime)
{
. . .
    if (_entities[0].Health <= 0)
    {
        Game1.Instance.GameSounds[Sounds.PlayerDie].Play();
    }
. . .
}

public void PlayerFire()
{
    if (_entities.Count > 0)
    {
        if (_entities[0].SpawnBullet())
            Game1.Instance.GameSounds[Sounds.Zap].Play();
    }
}

private void SpawnGhost()
{
    int num = _rnd.Next(0, 10);
    _entities.Add(new Entity(EntityType.Ghost, _ghostSpawnPoints[num],
_ghostSpawnDirections[num], 4, _ghostTexture.Width, Game1.Instance));
    Game1.Instance.GameSounds[Sounds.GhostDie].Play();
}
```

Code Listing 61 – EntityManager Sound Code

When the game starts we'll play the **Title** sound. Add the following line as the first line in the **Initialize** method:

```
((Game1)ScreenManager.Game).GameSounds[Sounds.Title].Play();
```

Code Listing 62 – MainMenuScreen Sound Code

That's all there is to sound in our game. For most simple games, there probably won't be much more than this. Larger games could do things like use 3D sound or distort sounds.

We just have a bit more to add to make our game complete. This is the last stretch—take a deep breath and dive in.

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Chapter 7 Completing the Game

Bullets flying everywhere

We stubbed out the functionality for having the character fire bullets, and now we'll flesh it out. We'll start with a standard manager class:

```
public class Bullet
{
    private Direction _direction;
    private Vector2 _location;
    private bool _alive;

    public Vector2 Location
    {
        get { return _location; }
    }

    public Direction BulletDirection
    {
        get { return _direction; }
    }

    public bool IsAlive
    {
        get { return _alive; }
    }

    public Bullet(Direction dir,Vector2 location)
    {
        _direction = dir;
        _location = location;
        _alive = true;
    }

    public void Update()
    {
        if (_alive)
        {
            switch (_direction)
            {
                case Direction.East:
                    _location.X += 4.0f;

                    break;

                case Direction.North:
```

```
                    _location.Y -= 4.0f;

                    break;

                case Direction.NorthEast:

                    _location.Y -= 3.0f;
                    _location.X += 3.0f;

                    break;

                case Direction.NorthWest:

                    _location.Y -= 3.0f;
                    _location.X -= 3.0f;

                    break;

                case Direction.South:

                    _location.Y += 4.0f;
                    break;

                case Direction.SouthEast:

                    _location.Y += 3.0f;
                    _location.X += 3.0f;
                    break;

                case Direction.SouthWest:

                    _location.Y += 3.0f;
                    _location.X -= 3.0f;
                    break;

                case Direction.West:

                    _location.X -= 4.0f;
                    break;
            }
        }

        if (_location.X < 20 || _location.X > Game1.ScreenWidth - 20 ||
_location.Y < 88 || _location.Y > Game1.ScreenHeight - 20)
            _alive = false;

    }

    public void Kill()
```


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```
    {
        _alive = false;
        _location = Vector2.Zero;
    }

    public void Spawn(Direction dir, Vector2 loc)
    {
        _direction = dir;
        _location = loc;
        _alive = true;
    }
}

public class BulletManager : List<Bullet>
{
    private static Vector2[] _bulletOffset;

    private Texture2D _bulletTexture;

    private Rectangle _bulletRect;

    private float _lastBulletSpawnTime;

    private int _shotsFired;
    private int _shotsHit;

    public int ShotsFired
    {
        get { return _shotsFired; }
    }

    public int ShotsHit
    {
        get { return _shotsHit; }
    }

    public BulletManager(Game game)
        : base(5)
    {
        _bulletOffset = new Vector2[8];
        _bulletOffset[0] = new Vector2(0,-33);
        _bulletOffset[1] = new Vector2(24,-25);
        _bulletOffset[2] = new Vector2(33,0);
        _bulletOffset[3] = new Vector2(24,25);
        _bulletOffset[4] = new Vector2(0,33);
        _bulletOffset[5] = new Vector2(-24,25);
        _bulletOffset[6] = new Vector2(-33,0);
        _bulletOffset[7] = new Vector2(-24,-25);

        ContentManager content = new ContentManager(game.Services);
```

```
        _bulletTexture = content.Load<Texture2D>("Content/bullet");

        _bulletRect = new Rectangle(0, 0, 2, 6);

        _lastBulletSpawnTime = 1.0f;

        _shotsFired = 0;
        _shotsHit = 0;

    }

    public bool Spawn(Direction dir, Vector2 location)
    {
        bool bRet = false;

        if (this.Count < 5)
        {
            this.Add(new Bullet(dir, location + _bulletOffset[(int)dir]));
            bRet = true;
        }
        else
        {
            //check to see if any bullet is no longer alive
            foreach (Bullet bullet in this)
                if (bullet.IsAlive == false)
                {
                    bullet.Spawn(dir, location + _bulletOffset[(int)dir]);
                    bRet = true;
                    break;
                }
        }

        if (bRet)
            _shotsFired++;

        return bRet;
    }

    public void Update()
    {
        foreach (Bullet bullet in this)
            bullet.Update();
    }

    public void Draw(SpriteBatch sb)
    {
        Vector2 origin = new Vector2(_bulletTexture.Width / 2,
_bulletTexture.Height / 2);
        float rot;
```


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```
        foreach (Bullet bullet in this)
        {
            if (bullet.IsAlive)
            {
                rot = (int)bullet.BulletDirection *
MathHelper.ToRadians(45.0f);

                sb.Draw(_bulletTexture, new
Rectangle((int)bullet.Location.X, (int)bullet.Location.Y, 2, 6),
_bulletRect, Color.White, rot, origin, SpriteEffects.None, 0.0f);
            }
        }
    }

    public bool CheckCollision(Entity entity)
    {
        bool ret = false;

        BoundingBox entityBox = new BoundingBox(new
Vector3(entity.Location.X, entity.Location.Y, 0),
            new Vector3(entity.Location.X + entity.FrameWidth,
entity.Location.Y + entity.FrameWidth, 0));

        foreach (Bullet bullet in this)
        {
            BoundingBox bulletBox = new BoundingBox(new
Vector3(bullet.Location.X, bullet.Location.Y, 0),
                new Vector3(bullet.Location.X + 2, bullet.Location.Y + 6,
0));

            if (entityBox.Intersects(bulletBox))
            {
                bullet.Kill();

                _shotsHit++;

                ret = true;
                break;
            }
        }

        return ret;
    }
}
```

Code Listing 63 – *BulletManager Class*

The **Bullet** class handles updating its location based on the direction it was fired. It's a hard-coded value, which isn't ideal, but for a small game, it does the job. Ideally you'd ensure the value diagonally is the same over time as it is horizontally and vertically. It's close with the values here, but not perfect. Players may not even notice, but if you want to clean it up a bit, feel free.

The **BulletManager** holds a collection of offsets so the bullet appears correctly based on the direction the character is facing when firing. It initializes the collection of bullets it manages to **5**, which is all the player can have on screen at once to avoid overpowering the ghosts. If the player could just fire a bullet a second, he could probably just spin in place and never get touched. This way, he has to have a bit of skill and actually aim.

The **CheckCollision** method calls the **Kill** method of the **Bullet** class when it touches a ghost, which sets the **_alive** member to **false**. This member is also set to **false** if the bullet has gone offscreen. This is done in the **Update** method of the **Bullet** class.

When the player fires, the **Spawn** method is called, and we check to see if there are fewer than five bullets in the collection. If so, we add a new one. If not, we check the **_alive** member of each bullet to see if we can reuse that object.

The **BulletManager** is used in the **Entity** class:

```
private BulletManager _bulletManager;

public int ShotsFired
{
    get { return _bulletManager.ShotsFired; }
}

public int ShotsHit
{
    get { return _bulletManager.ShotsHit; }
}

public Entity(EntityType type, Vector2 location, Direction orientation, int
numFrames, int textureWidth, Game game)
{
. . .
    _bulletManager = new BulletManager(game);
}

public void Update(GameTime gameTime, Vector2 playerLocation)
{
. . .
    _bulletManager.Update();
}

public bool SpawnBullet()
{
    return _bulletManager.Spawn(this.ShootDirection, this.Location);
```


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```
}

public void DrawBullets(SpriteBatch sb)
{
    _bulletManager.Draw(sb);
}

public bool CheckBulletCollision(Entity entity)
{
    if (_bulletManager.CheckCollision(entity))
        return true;

    return false;
}

public void Dispose()
{
    _bulletManager.Clear();
}
```

Code Listing 64 – Entity Class Bullet Code

We add a couple of helper methods that we'll use in our achievements system. We add other methods to handle initializing, updating, and cleaning up the object, as well as adding, drawing, and checking for collision with a ghost. Pretty basic at this point.

Adding difficulty settings

As we've seen, we'll have three difficulty settings for our game. The difficulty affects five different things: ghost health, ghost speed, the health drained from the character when touched by a ghost, the spawn time for ghosts, and the score for destroying a ghost. This data is kept in an XML file. Add a file called **DifficultySettings.xml** to the root of the project, and add the following to it:

```
<?xml version="1.0" encoding="utf-8" ?>
<ArrayOfDifficultySetting xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema">>
  <DifficultySetting>
    <Name>Easy</Name>
                <GhostHealth>1</GhostHealth>
                <GhostSpeed>3.0</GhostSpeed>
                <HealthDrain>2</HealthDrain>
                <GhostSpawnTime>3</GhostSpawnTime>
                <GhostScore>1</GhostScore>
          </DifficultySetting>
  <DifficultySetting>
    <Name>Normal</Name>
                <GhostHealth>2</GhostHealth>
                <GhostSpeed>3.5</GhostSpeed>
```

```
                <HealthDrain>4</HealthDrain>
                <GhostSpawnTime>2</GhostSpawnTime>
                <GhostScore>2</GhostScore>
            </DifficultySetting>
  <DifficultySetting>
      <Name>Hard</Name>
                <GhostHealth>3</GhostHealth>
                <GhostSpeed>4.0</GhostSpeed>
                <HealthDrain>8</HealthDrain>
                <GhostSpawnTime>1</GhostSpawnTime>
                <GhostScore>3</GhostScore>
            </DifficultySetting>
</ArrayOfDifficultySetting>
```

Code Listing 65 – DifficultySystem XML File

This data will be stored in a simple class. Create a **`DifficultySystem`** class and add the following class before it:

```
public class DifficultySetting
{
    public string Name;
    public short HealthDrain;
    public float GhostSpeed;
    public short GhostHealth;
    public float GhostSpawnTime;
    public short GhostScore;
}
```

Code Listing 66 – DifficultySetting Class

This class will be used in our **`DifficultySystem`** class:

```
public class DifficultySystem
{
    private int _difficulty;
    private float _levelSpeed;

    private List<DifficultySetting> _settings;

    public DifficultySystem()
    {
        GetDifficultySettings();
        _levelSpeed = 0.0f;
    }

    private void GetDifficultySettings()
    {
        try
```


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```
        {
            FileStream stream =
File.Open("DifficultySettings.xml",FileMode.Open);
            XmlSerializer serializer = new
XmlSerializer(typeof(List<DifficultySetting>));

            _settings =
(List<DifficultySetting>)serializer.Deserialize(stream);

        }
        catch (Exception e)
        {
            Console.WriteLine(e.Message);
        }
    }

    public int HealthDrain
    {
        get { return _settings[_difficulty].HealthDrain; }
    }

    public float GhostSpeed
    {
        get { return _settings[_difficulty].GhostSpeed + _levelSpeed; }
    }

    public int GhostHealth
    {
        get { return _settings[_difficulty].GhostHealth; }
    }

    public float GhostSpawnTime
    {
        get { return _settings[_difficulty].GhostSpawnTime; }
    }

    public short GhostScore
    {
        get { return _settings[_difficulty].GhostScore; }
    }

    public void SetDifficulty(int difficulty)
    {
        _difficulty = difficulty;
    }

    public string[] GetDifficultyNames()
    {
        List<string>names = new List<string>();
```

```
        foreach (DifficultySetting setting in _settings)
            names.Add(setting.Name);

        return names.ToArray();
    }

    public void IncreaseGhostSpeed()
    {
        _levelSpeed += .2f;
    }
}
```

Code Listing 67 – DifficultySystem Class

With the **DifficultySystem** in place we can add an instance of it to our **Game** class and initialize it, as well as add the method to all the difficulty levels to be set:

```
public DifficultySystem Difficulty;

protected override void Initialize()
{
. . .

    Difficulty = new DifficultySystem();

    base.Initialize();
}

public void SetDifficulty(int difficulty)
{
    Difficulty.SetDifficulty(difficulty);
}
```

Code Listing 688 – Game Class Difficulty Code

After adding this, the lines in the **DifficultyScreen Initialize** method can be uncommented. We can now select a difficulty level when we start the game and set it in the **GameplayScreen**, adding the necessary members to the class:

```
int _remainingTime;
float _timeCounter;

int _difficulty;
int _curLevel;


public GameplayScreen(int difficulty)
{
    TransitionOnTime = TimeSpan.FromSeconds(1.5);
    TransitionOffTime = TimeSpan.FromSeconds(0.5);
```


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```
    _timeCounter = 0.0f;

    _remainingTime = 180;

    _difficulty = difficulty;

    _curLevel = 1;
}

public override void Initialize()
{
. . .
    ((Game1)ScreenManager.Game).SetDifficulty(_difficulty);
}
```

Code Listing 69 – Game Class Difficulty Code

Remaining Gameplay Logic

There's a bit of code we haven't added for handling increasing the level of the game over time, and handling what happens when the player dies. It's not a lot of code, but the game would be broken without it, so let's take care of that.

Everything goes in the **`GameplayScreen`** class:

```
string _displayMinutes;

public override void Update(GameTime gameTime, bool otherScreenHasFocus,
                                                bool coveredByOtherScreen)
{
    base.Update(gameTime, otherScreenHasFocus, coveredByOtherScreen);
    if (IsActive)
    {
        _entityManager.Update(gameTime);

        if (_entityManager.IsPlayerDead())
            DoGameOver();

        _timeCounter += gameTime.ElapsedGameTime.Milliseconds;

        if (_timeCounter >= 1000.0f)
        {
            _remainingTime--;
            _timeCounter -= 1000.0f;

            if (_remainingTime == 0)
                DoNextLevel();
```

```
        }
    }
}

void DoGameOver()
{
    MessageBoxScreen messageBox = new MessageBoxScreen("Game Over. Final
score: " + _entityManager.Score.ToString());

    messageBox.Accepted += GameOverMessageBoxAccepted;

    ScreenManager.AddScreen(messageBox);
}

void DoNextLevel()
{
    _curLevel++;
    _remainingTime = 180;

    ((Game1)ScreenManager.Game).Difficulty.IncreaseGhostSpeed();
}

void GameOverMessageBoxAccepted(object sender, EventArgs e)
{
    LoadingScreen.Load(ScreenManager, LoadMainMenuScreen, false);
}

void LoadMainMenuScreen(object sender, EventArgs e)
{
    ScreenManager.AddScreen(new MainMenuScreen());
}
```

Code Listing 70 – GameplayScreen Class Gameplay Logic Code

We update the time to determine if the level of the game should be increased. If so, we speed up the ghosts a bit. When the player dies we display a message box to show the final score and allow the player to go back to the main menu. You could update this to allow the player to play again with the same difficulty. In this case, you'd have to clear out everything gameplay related.

High score list

There's a bit of code left to add a new score to the high score list when the game is over. This goes in the **DoGameOver** method in the **GameplayScreen** class:

```
void DoGameOver()
{
. . .
    HighScoreList scores = new HighScoreList();
```


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```
    scores.AddScore(new HighScore(DateTime.Now.ToString("mm/dd/yyyy"),
_curLevel, _entityManager.Score));
    scores.Save();
}
```

Code Listing 71 – GameplayScreen Class High Score Logic Code

We also need to finish fleshing out the HighScoreList class to actually load and save the scores:

```
public HighScoreList()
{
    GetHighScores();
}

private async void GetHighScores()
{
    try
    {
        //StorageFile file = await
storageFolder.GetFileAsync("scores.xml");
        //Stream s = await file.OpenStreamForReadAsync();

        //XmlSerializer serializer = new
XmlSerializer(typeof(List<HighScore>));

        //_scores = (List<HighScore>)serializer.Deserialize(s);
    }
    catch (Exception ex)
    {
        throw new Exception("Error getting achievements file");
    }

}
public async void Save()
{
    //StorageFile file = await storageFolder.GetFileAsync("scores.xml");
    //Stream s = await file.OpenStreamForWriteAsync();

    //XmlSerializer serializer = new
XmlSerializer(typeof(List<HighScore>));

    //serializer.Serialize(s, _scores);
}

public void Save(FileStream stream)
{
    XmlSerializer serializer = new XmlSerializer(typeof(List<HighScore>));
    serializer.Serialize(stream, _scores);
}
```

```
public void Load(FileStream stream)
{
    XmlSerializer serializer = new XmlSerializer(typeof(List<HighScore>));
    _scores = (List<HighScore>)serializer.Deserialize(stream);
}

public void AddScore(HighScore score)
{
    if (_scores == null)
        _scores = new List<HighScore>();

    bool scoreAdded = false;

    for (int i = 0; i < _scores.Count; i++)
    {
        if (_scores[i].Score < score.Score)
        {
            _scores.Insert(i, score);
            scoreAdded = true;

            if (_scores.Count > 10)
                _scores.RemoveAt(10);

            break;
        }
    }

    if (!scoreAdded && _scores.Count < 10)
        _scores.Add(score);
}
```

Code Listing 72 – HighScoreList Class Updated Code

I've left in the old XNA code that loaded the data so you can compare it with standard file I/O type loading. The list by default only keeps the 10 highest scores. Feel free to expand this if you implement global high scores.

Achievements

One thing that will keep players coming back to your game is a goal to achieve. Players love a challenge, and having unearned achievements in your game is a sure way to get players to keep playing your game.

We'll add four achievements to the game:

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Figure 17 - Achievements Screen

As with the difficulty levels, the data for the achievements is kept in an XML file, where you can see a description of what needs to be done to earn the achievement. Add a file called **achievements.xml** to the root of the project, and add the following:

```
<?xml version="1.0"?>
<ArrayOfAchievement xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <Achievement>
    <ID>1</ID>
    <Name>Dodger</Name>
    <Points>5</Points>
    <Description>Do not get touched by a ghost once during a
level</Description>
  </Achievement>
  <Achievement>
    <ID>2</ID>
    <Name>Unstoppable</Name>
    <Points>10</Points>
    <Description>Do not die once in a level</Description>
```

```
  </Achievement>
  <Achievement>
    <ID>3</ID>
    <Name>The Quick and the Dead</Name>
    <Points>5</Points>
    <Description>Defeat a level under par time</Description>
  </Achievement>
  <Achievement>
    <ID>4</ID>
    <Name>Eagle Eye</Name>
    <Points>10</Points>
    <Description>Get 95% or greater hit/miss ratio in a level</Description>
  </Achievement>
</ArrayOfAchievement>
```

Code Listing 73 – Achievements Data

Again, as with the difficulties, we'll keep the data in a class and have a manager for the data. Add a file to the project with the following:

```
//this enum must be synced with the order in the XML file
public enum Achievements
{
    Dodger,
    Unstoppable,
    QuickDead,
    EagleEye
}

public class Achievement
{
    public int ID;
    public string Name;
    public int Points;
    public string Description;
}

public class PlayerAchievement
{
    public int ID;
    public DateTime DateUnlocked;
}

//used in AchievementScreen
public class AchievementDisplay
{
    public Texture2D Icon;
    public string Name;
    public string Points;
    public string DateUnlocked;
```


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```
}

public class AchievementManager
{
    private List<PlayerAchievement> _playerAchievements;
    private List<Achievement> _achievements;

    private Game _game;

    public AchievementManager(Game game)
    {
        _achievements = new List<Achievement>();

        LoadAchievements();
        LoadPlayerAchievements();

        _game = game;
    }

    private void LoadAchievements()
    {
        try
        {
            FileStream stream = File.Open("achievements.xml",
FileMode.Open);
            XmlSerializer serializer = new
XmlSerializer(typeof(List<Achievement>));

            _achievements =
(List<Achievement>)serializer.Deserialize(stream);
        }
        catch (Exception ex)
        {
            throw new Exception("Error getting achievements file");
        }
    }

    private void LoadPlayerAchievements()
    {
        try
        {
            FileStream stream = File.Open("achievements.xml",
FileMode.Open);

            if (stream != null)
            {
                XmlSerializer serializer = new
XmlSerializer(typeof(List<PlayerAchievement>));
```

```
                _playerAchievements =
(List<PlayerAchievement>)serializer.Deserialize(stream);
            }
        }
        catch (Exception ex)
        {
            _playerAchievements = new List<PlayerAchievement>();
        }
    }

    public void Save()
    {
        try
        {
            FileStream stream = File.Open("achievements.xml",
FileMode.OpenOrCreate);
            XmlSerializer serializer = new
XmlSerializer(typeof(List<PlayerAchievement>));
            serializer.Serialize(stream, _playerAchievements);
        }
        catch (Exception ex)
        {
            throw new Exception("Error getting player achievements file");
        }
    }

    public bool PlayerHasAchievements()
    {
        if (_playerAchievements != null)
            return (_playerAchievements.Count > 0);
        else
            return false;
    }

    public int PlayerAchievementCount()
    {
        if (_playerAchievements != null)
            return _playerAchievements.Count;
        else
            return 0;
    }

    public List<AchievementDisplay> Achievements()
    {
        List<AchievementDisplay> achievements = new
List<AchievementDisplay>();

        AchievementDisplay display;

        foreach (Achievement achievement in _achievements)
```


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```
        {
            display = new AchievementDisplay();

            display.Icon =
Game1.Instance.Content.Load<Texture2D>("achievement" +
achievement.ID.ToString());
            display.Name = achievement.Name;
            display.Points = achievement.Points.ToString();
            display.DateUnlocked = GetDateUnlocked(achievement.ID);

            achievements.Add(display);
        }

        return achievements;
    }

    private string GetDateUnlocked(int id)
    {
        if (_playerAchievements != null)
        {
            foreach (PlayerAchievement achievement in _playerAchievements)
                if (achievement.ID == id)
                    return achievement.DateUnlocked.ToString();
        }

        return "";
    }

    public void AddAchievement(Achievements type)
    {
        PlayerAchievement achievement = new PlayerAchievement();

        achievement.DateUnlocked = DateTime.Now;
        achievement.ID = _achievements[(int)type].ID;

        if (_playerAchievements == null)
            _playerAchievements = new List<PlayerAchievement>();

        _playerAchievements.Add(achievement);
    }

    public bool IsAchievementEarned(Achievements type)
    {
        if (_playerAchievements != null)
        {
            for (int i = 0; i < _playerAchievements.Count; i++)
                if (_playerAchievements[i].ID ==
_achievements[(int)type].ID)
                    return true;
        }
```

```
            return false;

        }
    }
```

Code Listing 74 – Achievements Code

Note that the enum for the achievement names is not in alphabetical order. If you want it to be, you'll need to reorder the items in the XML file. If you're really organized, this would mean you would want to update the **`ID`** property for each item to reflect the new order, which would also require changing the file names of the achievement icons.

The **`AchievementsScreen`** class is used to display the achievements. Add the file for this class to the **Screens** folder and update it with the following:

```
class AchievementsScreen : GameScreen
{
    private List<AchievementDisplay> _achievements;
    private SpriteFont _titleFont;
    private Texture2D _buttonB;

    private SpriteFont _textFont;

    private Vector2 _iconLoc;
    private Vector2 _nameLoc;
    private Vector2 _pointsLoc;
    private Vector2 _dateLoc;

    private int _topIndex;

    private const int MaxAchievementsDisplayed = 6;

    public AchievementsScreen()
    {
        TransitionOnTime = TimeSpan.FromSeconds(1.5);
        TransitionOffTime = TimeSpan.FromSeconds(0.5);

        _iconLoc = new Vector2(10, 100);
        _nameLoc = new Vector2(90, 100);
        _pointsLoc = new Vector2(525, 100);
        _dateLoc = new Vector2(675, 100);

        _topIndex = 0;
    }

    public override void LoadContent()
    {
        _titleFont = Game1.Instance.Content.Load<SpriteFont>("menufont");
        _textFont = Game1.Instance.Content.Load<SpriteFont>("menufont");
```


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```
        _buttonB = Game1.Instance.Content.Load<Texture2D>("BButton");

        base.LoadContent();
    }

    public override void Initialize()
    {
        _achievements = new
AchievementManager(ScreenManager.Game).Achievements();

        base.Initialize();
    }

    public override void HandleInput(InputState input, GameTime gameTime)
    {
        if ((input.CurrentGamePadState.Buttons.B ==
Microsoft.Xna.Framework.Input.ButtonState.Pressed &&
input.LastGamePadState.Buttons.B ==
Microsoft.Xna.Framework.Input.ButtonState.Released) ||

(input.CurrentKeyboardState.IsKeyDown(Microsoft.Xna.Framework.Input.Keys.Es
cape) &&
input.LastKeyboardState.IsKeyUp(Microsoft.Xna.Framework.Input.Keys.Escape))
)
            this.ExitScreen();

        base.HandleInput(input, gameTime);
    }

    public override void Draw(GameTime gameTime)
    {
        Vector2 textPosition;

        ScreenManager.GraphicsDevice.Clear(ClearOptions.Target,
Color.Black, 0, 0);

        Microsoft.Xna.Framework.Color color = new
Microsoft.Xna.Framework.Color((byte)0, (byte)255, (byte)0,
TransitionAlpha);

        ScreenManager.SpriteBatch.Begin();
        Vector2 titleSize = _titleFont.MeasureString("Achievements");
        textPosition = new
Vector2(ScreenManager.GraphicsDevice.Viewport.Width / 2 - titleSize.X / 2,
5);

        ScreenManager.SpriteBatch.DrawString(_titleFont, "Achievements",
textPosition, color);
```

```
        color = new Microsoft.Xna.Framework.Color((byte)255, (byte)255,
(byte)255, TransitionAlpha);

        int numDisplayed = (int)MathHelper.Clamp(_achievements.Count, 0,
MaxAchievementsDisplayed);

        //draw headers
        ScreenManager.SpriteBatch.DrawString(_textFont, "Name", _nameLoc,
Color.White);
        ScreenManager.SpriteBatch.DrawString(_textFont, "Points",
_pointsLoc, Color.White);
        ScreenManager.SpriteBatch.DrawString(_textFont, "Date Unlocked",
_dateLoc, Color.White);

        //loop through list and draw each item
        for (int i = _topIndex; i < numDisplayed; i++)
        {
            ScreenManager.SpriteBatch.Draw(_achievements[i].Icon, _iconLoc
+ new Vector2(0, (i + 1) * 75), Color.White);
            ScreenManager.SpriteBatch.DrawString(_textFont,
_achievements[i].Name, _nameLoc + new Vector2(0, (i + 1) * 75),
Color.White);
            ScreenManager.SpriteBatch.DrawString(_textFont,
_achievements[i].Points, _pointsLoc + new Vector2(0, (i + 1) * 75),
Color.White);
            ScreenManager.SpriteBatch.DrawString(_textFont,
_achievements[i].DateUnlocked, _dateLoc + new Vector2(0, (i + 1) * 75),
Color.White);
        }

        ScreenManager.SpriteBatch.Draw(_buttonB, new Rectangle(800, 700,
48, 48), Color.White);
        ScreenManager.SpriteBatch.DrawString(ScreenManager.Font, "Back",
new Vector2(855, 700), Color.White);

        ScreenManager.SpriteBatch.End();

        if (TransitionPosition > 0)
            ScreenManager.FadeBackBufferToBlack(255 - TransitionAlpha);
    }
}
```

Code Listing 75 – AchievementsScreen Class

Some updates to the **GameplayScreen** will be necessary to track when an achievement is earned:

```
private AchievementManager _achievementManager;
```


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```
void DoGameOver()
{
    CheckAchievements();

. . .
    if (_achievementManager != null)
        _achievementManager.Save();
}

void CheckAchievements()
{
    //check for level-based achievements
    if (_achievementManager == null)
        _achievementManager = new AchievementManager(ScreenManager.Game);

    //touched
    if (!_entityManager.PlayerTouched)
    {
        if (!_achievementManager.IsAchievementEarned(Achievements.Dodger))
            _achievementManager.AddAchievement(Achievements.Dodger);
    }

    //died
    if (!_entityManager.PlayerDied)
    {
        if
(!_achievementManager.IsAchievementEarned(Achievements.Unstoppable))
            _achievementManager.AddAchievement(Achievements.Unstoppable);
    }

    //par time - right now just 2 1/2 minutes, could be changed to less
time for higher levels
    if (_remainingTime >= 150)
    {
        if
(!_achievementManager.IsAchievementEarned(Achievements.QuickDead))
            _achievementManager.AddAchievement(Achievements.QuickDead);
    }

    //hit/miss ratio
    float ratio = _entityManager.GetPlayerHitMissRatio();

    //just 95% right now, could be changed for higher levels
    if (ratio >= 0.95f)
    {
        if
(!_achievementManager.IsAchievementEarned(Achievements.EagleEye))
            _achievementManager.AddAchievement(Achievements.EagleEye);
    }
}
```

```
void DoNextLevel()
{
    CheckAchievements();

. . .

}
```

Code Listing 76 – GameplayScreen Achievements Code

You'll notice some new members and methods in the **`EntityManager`** class being queried. Now it's time to update that class. In the **`Update`** method, replace the existing **`if (CheckEntityCollision(_entities[i]))`** block with the following.:

```
private bool _touched;
private bool _died;

public bool PlayerTouched
{
    get { return _touched; }
}

public bool PlayerDied
{
    get { return _died; }
}


public EntityManager()
{

. . .

    _touched = false;
    _died = false;
}

public void Update(GameTime gameTime)
{
. . .
    if (CheckEntityCollision(_entities[i]))
    {
        _touched = true;

        _entities[0].DrainLife(Game1.Instance.Difficulty.HealthDrain);
        _entities.Remove(_entities[i]);

        if (_entities[0].Health <= 0)
```


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```
        {
            Game1.Instance.GameSounds[Sounds.PlayerDie].Play();
            _died = true;
        }

        if (_entities.Count == 1)
            break;
    }
. . .
}

public bool IsPlayerDead()
{
    if (_entities.Count > 0)
    {
        return _entities[0].State == EntityState.Dead;
    }
    else
        return true;
}

public float GetPlayerHitMissRatio()
{
    if (_entities[0].ShotsFired > 0)
        return _entities[0].ShotsHit / _entities[0].ShotsFired;
    else
        return 0.0f;
}
```

Code Listing 77 – EntityManager Achievements Code

The **EntityManager** uses some new code in the **Entity** class:

```
public enum EntityState
{
    Alive,
    Dying,
    Dead
}

public class Entity
{
    private EntityState _state;

    public EntityState State
    {
        get { return _state; }
    }

    public void DrainLife(int amount)
```

```
    {
. . .
        if (_health <= 0)
            _state = EntityState.Dead;
    }
}
```

Code Listing 78 – EntityManager Achievements Code

There's really nothing new here that hasn't been done before. Any new achievements you might add would just require updates to these three chunks of code and data added to the XML file, as well as an icon to display in the achievements screen. Note that if you add more than a couple more, the screen will not be able to display them all at once. You'll have to add code to enable scrolling or paging of the achievements.

That wraps up everything that's needed to make a playable game. Playable doesn't always mean the best game that you can create, of course. There is always room for improvement in any game. The following are a couple of things that you can add to make the game more attractive and enjoyable—not just for this game, but any game you create.

Enhancements

Achievement notification

When an achievement is earned, there is currently no way for the player to know. Adding a notification that displays for several seconds on the screen would be a good enhancement to make your game more player friendly.

If you do this, I would recommend making a class that inherits from **`DrawableGameComponent`** that would become a member of the **`GameplayScreen`** class. A method called **`ShowNotification`** could be used to initialize the component, setting a switch that's checked in the **`Draw`** method of the **`GameplayScreen`** to determine whether or not to draw the notification. You could pass the achievement information in this method.

Global leaderboards

The high scores in the game are currently local to the machine that the game is played on. To make the game more attractive to players, you might want to have the scores be seen by other players. This would mean you would have to either use a service that allows players to see scores from other players, or implement this functionality yourself. The latter would be a huge task.

There are a number of services that you could use for this. Here are a few:

- Gamesparks
- Microsoft Azure
- Parse

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- Scoreoid
- App42
- Buddy