Game Engine Programming

GMT Master Program
Utrecht University

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Course code: INFOMGEP
Credits: 7.5 ECTS

Lecture #15

Game Engine Standards

How they did it?

- Engines
  - Ogre 3D
  - XNA platform
  - Unreal, Quake and CryEngine
- Components
  - Global architecture
  - Scene management
  - Input management
  - Resource management

Ogre 3D

- Object-oriented Graphics Rendering Engine
  - a graphics engine, not a game engine...
  - easy plugin of features (python script, ode physics engine, *etc.*)
  - http://www.ogre3d.org

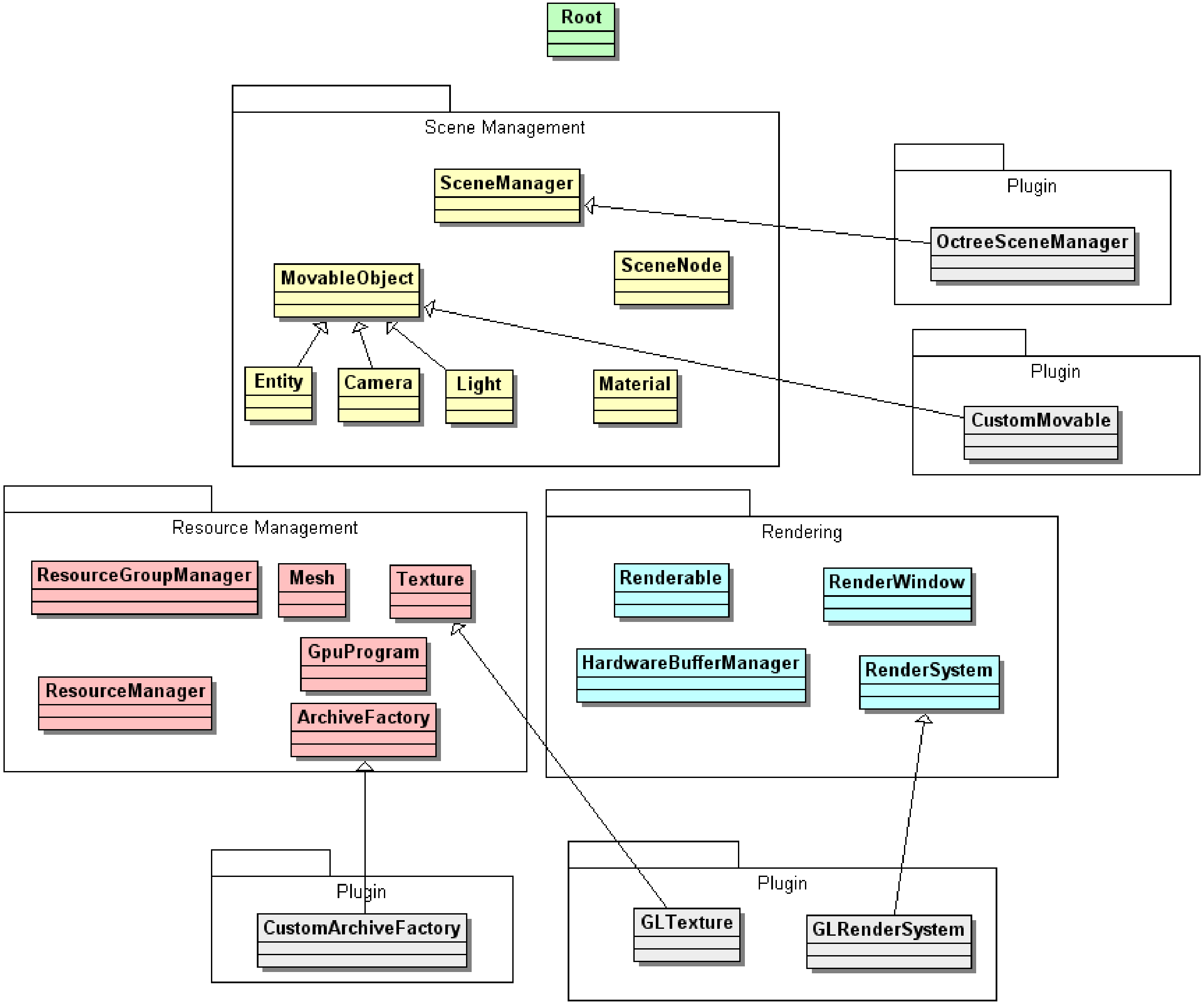
Torchlight
Runic Games

Alien Dominion
Black Fire Games

Ogre features

- Programming
  - OO interface in C++
  - Extensible framework
  - Stable and high performance engine
- Platform
  - Multi-platform
  - Direct3D and OpenGL support
- Content
  - Scene manager
  - Resource manager
    - Material, meshes
  - Animation
  - Renderer
    - Special effects, shader
  - Plugins

Ogre architecture overview



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Ogre

- The ‘Root’ object is the entry point
  - must be the first created object
  - must be the last deleted object
  - enables the configuration of the system
  - has a continuous rendering loop

Ogre

- SceneManager
  - Contains everything that appears on the screen
  - Different managers for terrain (heightmap), exterior and interior scenes
- Entity
  - Type of object you can render in the scene
  - Anything that is being represented by a mesh (player, ground, …)
  - Not an entity: Lights, Billboards, Particles, Cameras, *etc.*

Ogre

- SceneNode
  - Scene nodes keep track of location and orientation for all of the objects attached to it
  - An Entity is only rendered on the screen if it is attached to a SceneNode object
  - A scene node's position is always relative to its parent node
  - A scene manager contains one root node to which all other scene nodes are attached
- The final structure is the scene graph

Ogre

```
// Create Root
Ogre::Root* mRoot = new Ogre::Root();

// Parses resources.cfg
setupResources();

// Shows the Ogre config GUI which configures the render system
// and constructs a render window
configure();

// The scene manager decides what to render
chooseSceneManager();

// We need a camera to render from
createCamera();

// and at least one viewport to render to
createViewports();
```

Ogre

```
// Create any resource listeners (for loading screens)
createResourceListener();

// Now we can load the resources: all systems are on-line
loadResources();

// Now that the system is up and running: create a scene to render
createScene();

// Create any frame listeners (input manager: keyboard, mouse...)
createFrameListener();

// Kick off Ogre loop
mRoot->startRendering();

// Clean up
destroyScene();

// Delete root
delete mRoot;
```

Ogre application design

- Ogre is using a Frame Listener in the game loop to receive notification from the system
  - The game inherits from FrameListener

```
class Game : public Ogre::FrameListener { // ... }
```

  - And register itself to listen to the notifications

```
mRoot->addFrameListener(this);
```

Ogre game loop

- The Root::startRendering method starts the rendering cycle
  - It begins the automatic rendering of the scene
  - It will not return until the rendering cycle is halted
- During rendering, any FrameListener registered will be called back for each frame that is to be rendered
  - These classes can tell Ogre to halt the rendering if required, which will cause this method to return

Ogre game loop

- Ogre notifies the listeners at different time of the game loop

```
// called just before a frame is rendered
virtual bool frameStarted(const FrameEvent& evt);

// called after all render targets have had their rendering commands
// issued, but before the render windows have been asked to swap
// buffers
virtual bool frameRenderingQueued(const FrameEvent& evt);

// called just after a frame has been rendered (buffers swapped)
virtual bool frameEnded(const FrameEvent& evt);
```

  - if return value is false, program exits
  - evt.timeSinceLastFrame contains how long is has been since the last call

Ogre game loop

```
void Root::startRendering(void) {
   // ... Initialization ...
   mQueuedEnd = false;
   while( !mQueuedEnd ) {
         //Pump messages in all registered RenderWindow windows
         WindowEventUtilities::messagePump();
         if (!renderOneFrame()) break;
   }
}

bool Root::renderOneFrame(void) {
   if(!_fireFrameStarted()) return false;

   if (!_updateAllRenderTargets()) // includes _fireFrameRenderingQueued()
    return false;

   return _fireFrameEnded();
}
```

Input management in Ogre

- Ogre allows for both HID managements
  - polling (called unbuffered)
  - interruption (called buffered)

HID unbuffered in Ogre

- Update the user inputs in frameRenderingQueued

```
bool Game::frameRenderingQueued(const Ogre::FrameEvent& evt) {
   // ...
   mMouse->capture();     // to read mouse state
   mKeyboard->capture();  // to read keyboard state
   return processUnbufferedInput(evt);
}
```

  - where mMouse and mKeyboard are defined using the OIS library included in Ogre

- processUnbufferedInput pass the event to user functions according to the updated keyboard and mouse states

```
bool processUnbufferedInput(const Ogre::FrameEvent& evt);
```

HID unbuffered in Ogre

- Example

```
static bool Game::prevLeftMouseDown = false; // if a mouse button was pressed
static Ogre::Real Game::mMove = 0.2;         // the movement increment

bool Game::processUnbufferedInput(const Ogre::FrameEvent& evt) {
    // check if current left mouse button is pressed
    bool leftMouseDown = mMouse->getMouseState().buttonDown(OIS::MB_Left);
    if (leftMouseDown && !prevLeftMouseDown) { // if not pressed before
        // do something when left mouse button pressed, e.g. shoot();
        prevLeftMouseDown = true;
    }
    // check if user is pressing up arrow
    if ( mKeyboard->isKeyDown(OIS::KC_NUMPAD8) ||
        mKeyboard->isKeyDown(OIS::KC_UP)) {
        moveForward(mMove);
    }
    // update scene ...
}
```

HID buffered in Ogre

- Mouse and keyboard events are handled immediately instead of once per game loop
- Ogre uses an event mechanism (DP), the game class needs to inherit from

OIS::KeyListener for keyboard

```
#include <OISEvents.h>
#include <OISInputManager.h>
#include <OISKeyboard.h>

class Game : public OIS::KeyListener
```

OIS::MouseListener for mouse

```
#include <OISEvents.h>
#include <OISInputManager.h>
#include <OISMouse.h>

class Game : public OIS::MouseListener
```

HID buffered in Ogre

- The following member functions are inherited

```
// OIS::KeyListener
virtual bool keyPressed( const OIS::KeyEvent& evt );
virtual bool keyReleased( const OIS::KeyEvent& evt );

// OIS::MouseListener
virtual bool mouseMoved( const OIS::MouseEvent& evt );
virtual bool mousePressed( const OIS::MouseEvent& evt, OIS::MouseButtonID id );
virtual bool mouseReleased( const OIS::MouseEvent& evt, OIS::MouseButtonID id );
```

  - when a key is pressed, the keyPressed function is fired
  - when the mouse moves, the mouseMoved function is fired
  - *etc.*

HID buffered in Ogre

- The listening registrations are done during the application setup, typically in a createFrameListener function

```
void Game::createFrameListener () {
    // ...
    mMouse->setEventCallBack(this);
    mKeyboard->setEventCallBack(this);
    // ...
}
```

Resource management in Ogre

- A resource has different states
  - **Unknown**: Ogre is not aware of the resource. Its filename is stored but Ogre has no idea what to do with it
  - **Declared**: Flagged for creation. Ogre knows what type of resource it is, and what to do with it when the time comes to create it
  - **Created**: Ogre has created an empty instance of the resource, and added it to the relevant manager
  - **Loaded**: Created instance has been fully loaded, stage at which the resource's file is accessed

Resource management in Ogre

1. Ogre's native ResourceManagers are created in Root::Root
2. Specify resource locations by calling

```
ResourceGroupManager::addResourceLocation(“name”,“locType”)
```

3. Manually declare resources
   - **Declared** state for declared resources
   - **Unknown** otherwise

Resource management in Ogre

4. Script parsing to automatically declare resources
   - Set these resources as **Declared**
   - Creates the declared resources, now **Created**
5. Resources are loaded when
   - an entity ask for a unloaded resource
   - explicit call to load a resource
   - explicit call to load the declared resources
   - ➢ loaded resources put in **Loaded** state

Resource management in Ogre

- ResourceManager::unload reverts a resource from **Loaded** to **Created**
- ResourceManager::remove removes a resource
  - back to **Unknown** state
- You can get a pointer to the resource with ResourceManager::getByName and unload or remove it manually
- Any existing resources are removed when the resource manager is destroyed

Resource management in Ogre

- Reloading resources is a very useful feature
  - resource is unloaded, and then loaded again
  - moves from **Loaded** to **Created** and then back to **Loaded** again
- ResourceManager::reloadAll reloads all resources of one type
- Resources can be individually reloaded with Resource::reload

Resource management in Ogre

- To extend the resource types

```
class MyResource : public Ogre::Resource {
 protected:
     void loadImpl();                   // load resource (e.g. from file)
     void unloadImpl();                 // unload it
     size_t calculateSize() const;      // get its size
 // ...
}

class MyResourceManager : public Ogre::ResourceManager {
protected:
   Ogre::Resource * createImpl(const Ogre::String &name,
    Ogre::ResourceHandle handle, const Ogre::String &group, bool isManual,
    Ogre::ManualResourceLoader *loader, const Ogre::NameValuePairList
    *createParams); // creates the MyResource instance
public:
   virtual MyResource * load(const Ogre::String &name, const Ogre::String
   &group); // load the resource (and create it if needed)
   // ...
}
```

Resource management in Ogre

- To extend the resource types

```
MyResourceManager * mRM = new MyResourceManager();

ResourceGroupManager::getSingleton().declareResource("resourceName",
   "MyResource");

MyResource* _resource = mRM->load("resourceName",
   ResourceGroupManager::DEFAULT_RESOURCE_GROUP_NAME);

_resource->aFunction(); // you can now use the resource

// ...
_resource->reload();
// ...
mRM->unload("resourceName");
mRM->remove("resourceName");
// ...
```

Ogre

- Ogre uses many different design patterns
  - Factory in
    - MoveableObjectFactory, ParticleEmitterFactory, ...
  - Iterator in
    - ParticleIterator, ...
  - Singleton in
    - Root, OverlayManager, MaterialManager, ...
  - Listener in
    - FrameListener, ResourceGroupListener, ...
- Other commonly appearing structures
  - Events, Buffers, Plugins, Serializers

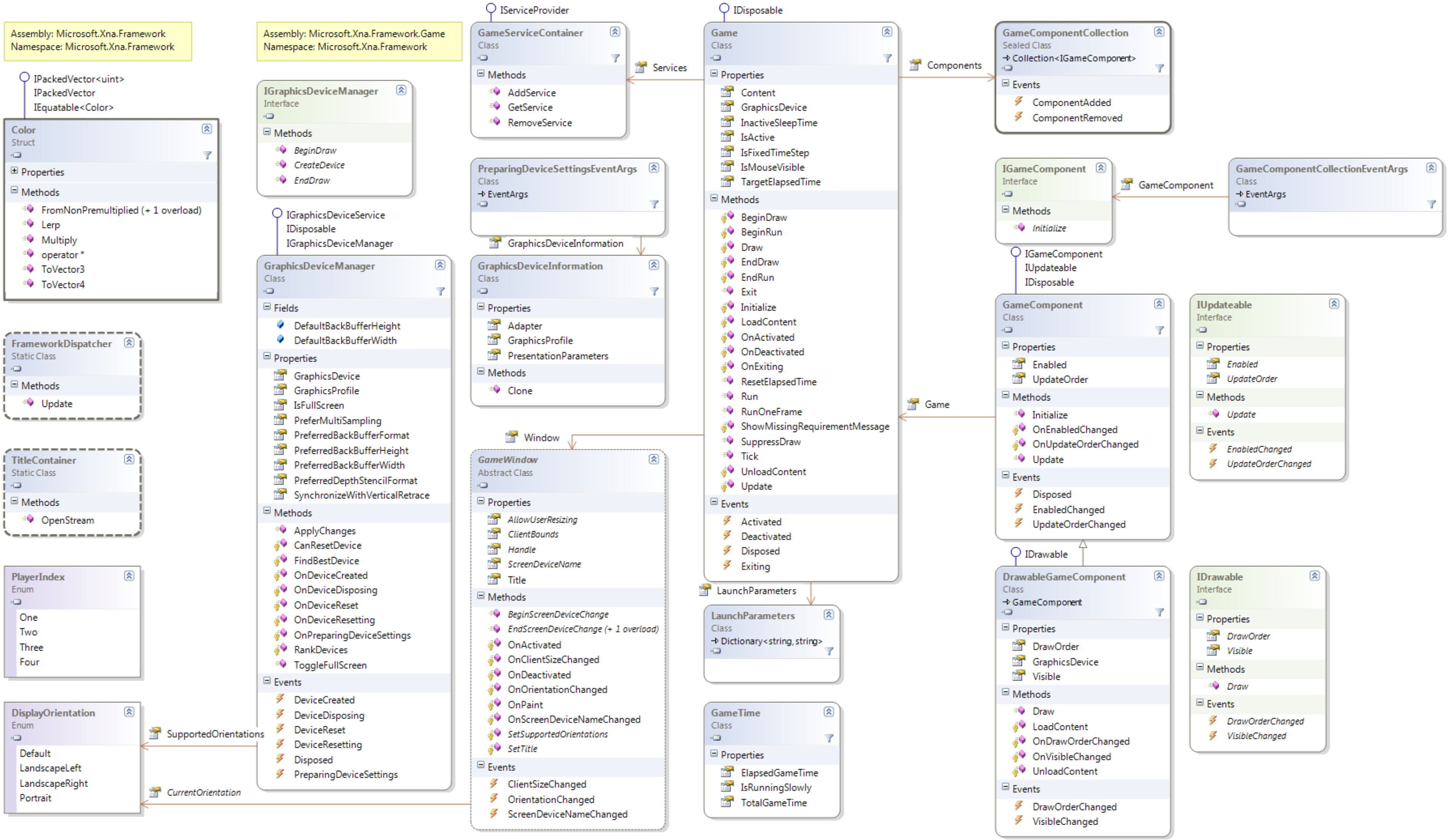
Microsoft XNA Platform

- C# game engine for PC and Xbox 360
  - – Easy programming of DirectX based games
- Documentation on MSDN Library
  - ➢ http://msdn.microsoft.com/en-us/library/
  - ➢ Development Tools and Languages
  - ➢ XNA Game Studio
- Two sets of libraries
  - – XNA Framework
  - – Content Pipeline

XNA Framework architecture

- Library of classes, interfaces and value types
  - Framework
    - commonly used game classes, *e.g.* timer and game loop
  - Framework.Audio
    - audio management
  - Framework.Graphics
    - 2D/3D graphics
  - Framework.Input
    - keyboard, mouse and Xbox 360 controller
  - Framework.Net
    - networking
  - Framework.Storage
    - file manipulation
  - ...

Microsoft.Xna.Framework



Assembly: Microsoft.Xna.Framework
Namespace: Microsoft.Xna.Framework

Assembly: Microsoft.Xna.Framework.Game
Namespace: Microsoft.Xna.Framework

IPackedVector<uint>
IPackedVector
IEquatable<Color>

Color Struct
- Properties
- Methods
  - FromNonPremultiplied (+ 1 overload)
  - Lerp
  - Multiply
  - operator *
  - ToVector3
  - ToVector4

FrameworkDispatcher Static Class
- Methods
  - Update

TitleContainer Static Class
- Methods
  - OpenStream

PlayerIndex Enum
- One
- Two
- Three
- Four

DisplayOrientation Enum
- Default
- LandscapeLeft
- LandscapeRight
- Portrait

SupportedOrientations

CurrentOrientation

IGraphicsDeviceManager Interface
- Methods
  - BeginDraw
  - CreateDevice
  - EndDraw

IGraphicsDeviceService
IDisposable
IGraphicsDeviceManager

GraphicsDeviceManager Class
- Fields
  - DefaultBackBufferHeight
  - DefaultBackBufferWidth
- Properties
  - GraphicsDevice
  - GraphicsProfile
  - IsFullScreen
  - PreferMultiSampling
  - PreferredBackBufferFormat
  - PreferredBackBufferHeight
  - PreferredBackBufferWidth
  - PreferredDepthStencilFormat
  - SynchronizeWithVerticalRetrace
- Methods
  - ApplyChanges
  - CanResetDevice
  - FindBestDevice
  - OnDeviceCreated
  - OnDeviceDisposing
  - OnDeviceReset
  - OnDeviceResetting
  - OnPreparingDeviceSettings
  - RankDevices
  - ToggleFullScreen
- Events
  - DeviceCreated
  - DeviceDisposing
  - DeviceReset
  - DeviceResetting
  - Disposed
  - PreparingDeviceSettings

IServiceProvider

GameServiceContainer Class
- Methods
  - AddService
  - GetService
  - RemoveService

Services

PreparingDeviceSettingsEventArgs Class
→ EventArgs

GraphicsDeviceInformation

GraphicsDeviceInformation Class
- Properties
  - Adapter
  - GraphicsProfile
  - PresentationParameters
- Methods
  - Clone

Window

GameWindow Abstract Class
- Properties
  - AllowUserResizing
  - ClientBounds
  - Handle
  - ScreenDeviceName
  - Title
- Methods
  - BeginScreenDeviceChange
  - EndScreenDeviceChange (+ 1 overload)
  - OnActivated
  - OnClientSizeChanged
  - OnDeactivated
  - OnOrientationChanged
  - OnPaint
  - OnScreenDeviceNameChanged
  - SetSupportedOrientations
  - SetTitle
- Events
  - ClientSizeChanged
  - OrientationChanged
  - ScreenDeviceNameChanged

IDisposable

Game Class
- Properties
  - Content
  - GraphicsDevice
  - InactiveSleepTime
  - IsActive
  - IsFixedTimeStep
  - IsMouseVisible
  - TargetElapsedTime
- Methods
  - BeginDraw
  - BeginRun
  - Draw
  - EndDraw
  - EndRun
  - Exit
  - Initialize
  - LoadContent
  - OnActivated
  - OnDeactivated
  - OnExiting
  - ResetElapsedTime
  - Run
  - RunOneFrame
  - ShowMissingRequirementMessage
  - SuppressDraw
  - Tick
  - UnloadContent
  - Update
- Events
  - Activated
  - Deactivated
  - Disposed
  - Exiting

LaunchParameters

LaunchParameters Class
→ Dictionary<string, string>

GameTime Class
- Properties
  - ElapsedGameTime
  - IsRunningSlowly
  - TotalGameTime

Components

GameComponentCollection Sealed Class
→ Collection<IGameComponent>
- Events
  - ComponentAdded
  - ComponentRemoved

IGameComponent Interface
- Methods
  - Initialize

GameComponent

GameComponentCollectionEventArgs Class
→ EventArgs

IGameComponent
IUpdateable
IDisposable

Game

GameComponent Class
- Properties
  - Enabled
  - UpdateOrder
- Methods
  - Initialize
  - OnEnabledChanged
  - OnUpdateOrderChanged
  - Update
- Events
  - Disposed
  - EnabledChanged
  - UpdateOrderChanged

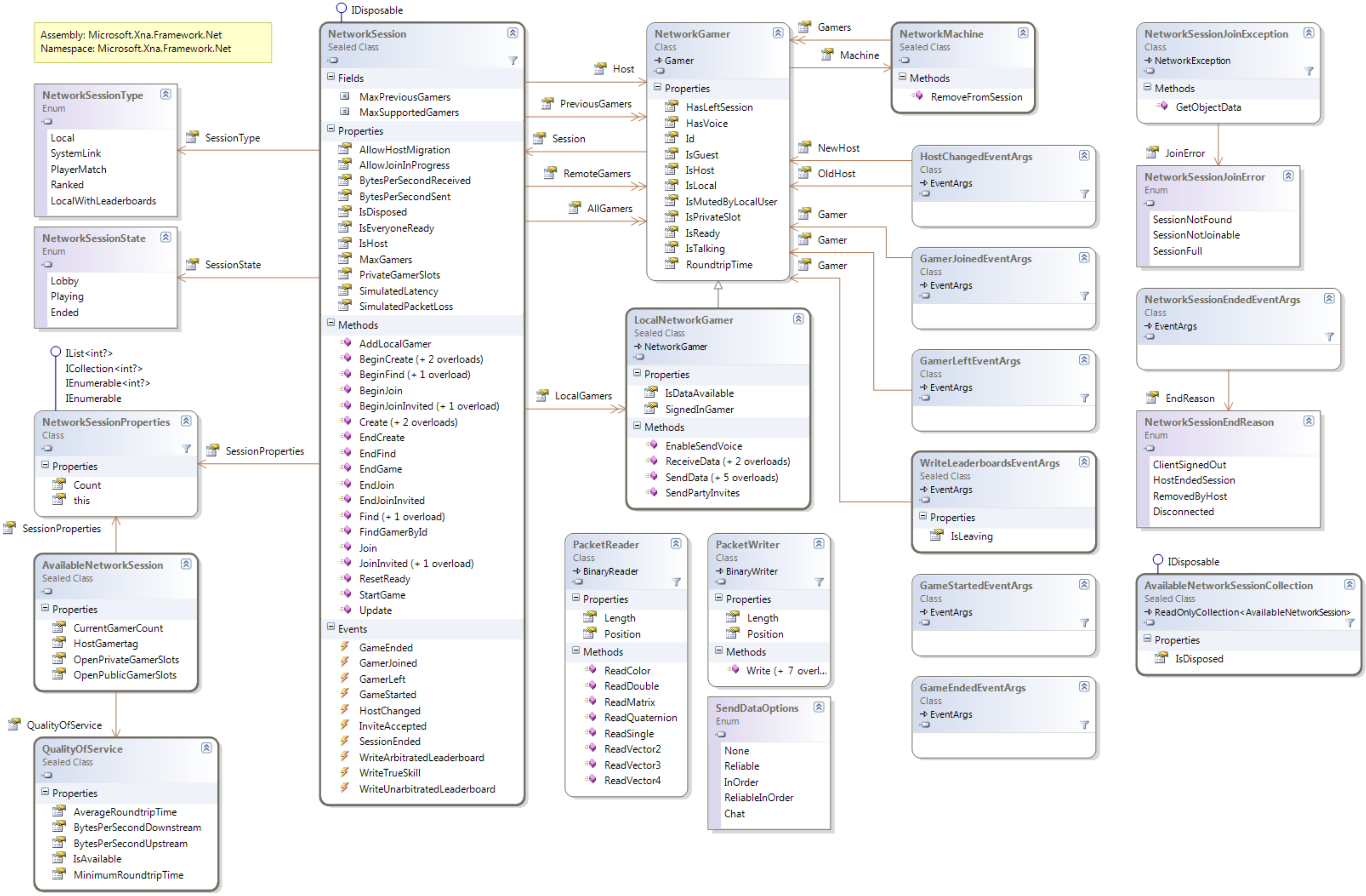
IUpdateable Interface
- Properties
  - Enabled
  - UpdateOrder
- Methods
  - Update
- Events
  - EnabledChanged
  - UpdateOrderChanged

IDrawable

DrawableGameComponent Class
→ GameComponent
- Properties
  - DrawOrder
  - GraphicsDevice
  - Visible
- Methods
  - Draw
  - LoadContent
  - OnDrawOrderChanged
  - OnVisibleChanged
  - UnloadContent
- Events
  - DrawOrderChanged
  - VisibleChanged

IDrawable Interface
- Properties
  - DrawOrder
  - Visible
- Methods
  - Draw
- Events
  - DrawOrderChanged
  - VisibleChanged

Microsoft.Xna.Framework.Net



Assembly: Microsoft.Xna.Framework.Net
Namespace: Microsoft.Xna.Framework.Net

NetworkSessionType
Enum
- Local
- SystemLink
- PlayerMatch
- Ranked
- LocalWithLeaderboards

SessionType

NetworkSessionState
Enum
- Lobby
- Playing
- Ended

SessionState

IList<int?>
ICollection<int?>
IEnumerable<int?>
IEnumerable

NetworkSessionProperties
Class
- Properties
  - Count
  - this

SessionProperties

SessionProperties

AvailableNetworkSession
Sealed Class
- Properties
  - CurrentGamerCount
  - HostGamertag
  - OpenPrivateGamerSlots
  - OpenPublicGamerSlots

QualityOfService

QualityOfService
Sealed Class
- Properties
  - AverageRoundtripTime
  - BytesPerSecondDownstream
  - BytesPerSecondUpstream
  - IsAvailable
  - MinimumRoundtripTime

IDisposable

NetworkSession
Sealed Class
- Fields
  - MaxPreviousGamers
  - MaxSupportedGamers
- Properties
  - AllowHostMigration
  - AllowJoinInProgress
  - BytesPerSecondReceived
  - BytesPerSecondSent
  - IsDisposed
  - IsEveryoneReady
  - IsHost
  - MaxGamers
  - PrivateGamerSlots
  - SimulatedLatency
  - SimulatedPacketLoss
- Methods
  - AddLocalGamer
  - BeginCreate (+ 2 overloads)
  - BeginFind (+ 1 overload)
  - BeginJoin
  - BeginJoinInvited (+ 1 overload)
  - Create (+ 2 overloads)
  - EndCreate
  - EndFind
  - EndGame
  - EndJoin
  - EndJoinInvited
  - Find (+ 1 overload)
  - FindGamerById
  - Join
  - JoinInvited (+ 1 overload)
  - ResetReady
  - StartGame
  - Update
- Events
  - GameEnded
  - GamerJoined
  - GamerLeft
  - GameStarted
  - HostChanged
  - InviteAccepted
  - SessionEnded
  - WriteArbitratedLeaderboard
  - WriteTrueSkill
  - WriteUnarbitratedLeaderboard

Host

PreviousGamers

Session

RemoteGamers

AllGamers

LocalGamers

NetworkGamer
Class
→ Gamer
- Properties
  - HasLeftSession
  - HasVoice
  - Id
  - IsGuest
  - IsHost
  - IsLocal
  - IsMutedByLocalUser
  - IsPrivateSlot
  - IsReady
  - IsTalking
  - RoundtripTime

LocalNetworkGamer
Sealed Class
→ NetworkGamer
- Properties
  - IsDataAvailable
  - SignedInGamer
- Methods
  - EnableSendVoice
  - ReceiveData (+ 2 overloads)
  - SendData (+ 5 overloads)
  - SendPartyInvites

PacketReader
Class
→ BinaryReader
- Properties
  - Length
  - Position
- Methods
  - ReadColor
  - ReadDouble
  - ReadMatrix
  - ReadQuaternion
  - ReadSingle
  - ReadVector2
  - ReadVector3
  - ReadVector4

PacketWriter
Class
→ BinaryWriter
- Properties
  - Length
  - Position
- Methods
  - Write (+ 7 overl...

SendDataOptions
Enum
- None
- Reliable
- InOrder
- ReliableInOrder
- Chat

Gamers

Machine

NetworkMachine
Sealed Class
- Methods
  - RemoveFromSession

NewHost

OldHost

HostChangedEventArgs
Class
→ EventArgs

Gamer

Gamer

Gamer

GamerJoinedEventArgs
Class
→ EventArgs

GamerLeftEventArgs
Class
→ EventArgs

WriteLeaderboardsEventArgs
Sealed Class
→ EventArgs
- Properties
  - IsLeaving

GameStartedEventArgs
Class
→ EventArgs

GameEndedEventArgs
Class
→ EventArgs

NetworkSessionJoinException
Class
→ NetworkException
- Methods
  - GetObjectData

JoinError

NetworkSessionJoinError
Enum
- SessionNotFound
- SessionNotJoinable
- SessionFull

NetworkSessionEndedEventArgs
Class
→ EventArgs

EndReason

NetworkSessionEndReason
Enum
- ClientSignedOut
- HostEndedSession
- RemovedByHost
- Disconnected

IDisposable

AvailableNetworkSessionCollection
Sealed Class
→ ReadOnlyCollection<AvailableNetworkSession>
- Properties
  - IsDisposed

XNA Game

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

class BasicXNAGame : Game {                 // Inherits from XNA Game functionalities
 GraphicsDeviceManager graphics;            // The graphics manager
 SpriteBatch spriteBatch;                   // The sprite batch

 static void Main() {
  BasicXNAGame game = new BasicXNAGame();   // Main program creates a new game ...
  game.Run();                               // ... and runs it
 }

 public BasicXNAGame() {
  Content.RootDirectory = "Content";          // Setup of content directory
  graphics = new GraphicsDeviceManager(this); // Create the graphics manager
 }

 protected override void LoadContent() {
  spriteBatch = new SpriteBatch(GraphicsDevice); // Create the sprite batch
 }

 protected override void Update(GameTime gameTime) { // update code }

 protected override void Draw(GameTime gameTime) { // draw code }
}
```

XNA game loop

- The game loop is started by the function run of the class Game

```
public class MyGame : Microsoft.Xna.Framework.Game { // ... }
```

```
static class Program {
 static void Main(string[] args) {
   MyGame game = new MyGame();
   game.Run();
  }
}
```

- The run method calls the virtual functions to initialize the game, to update and draw the game, and to process events

XNA game loop

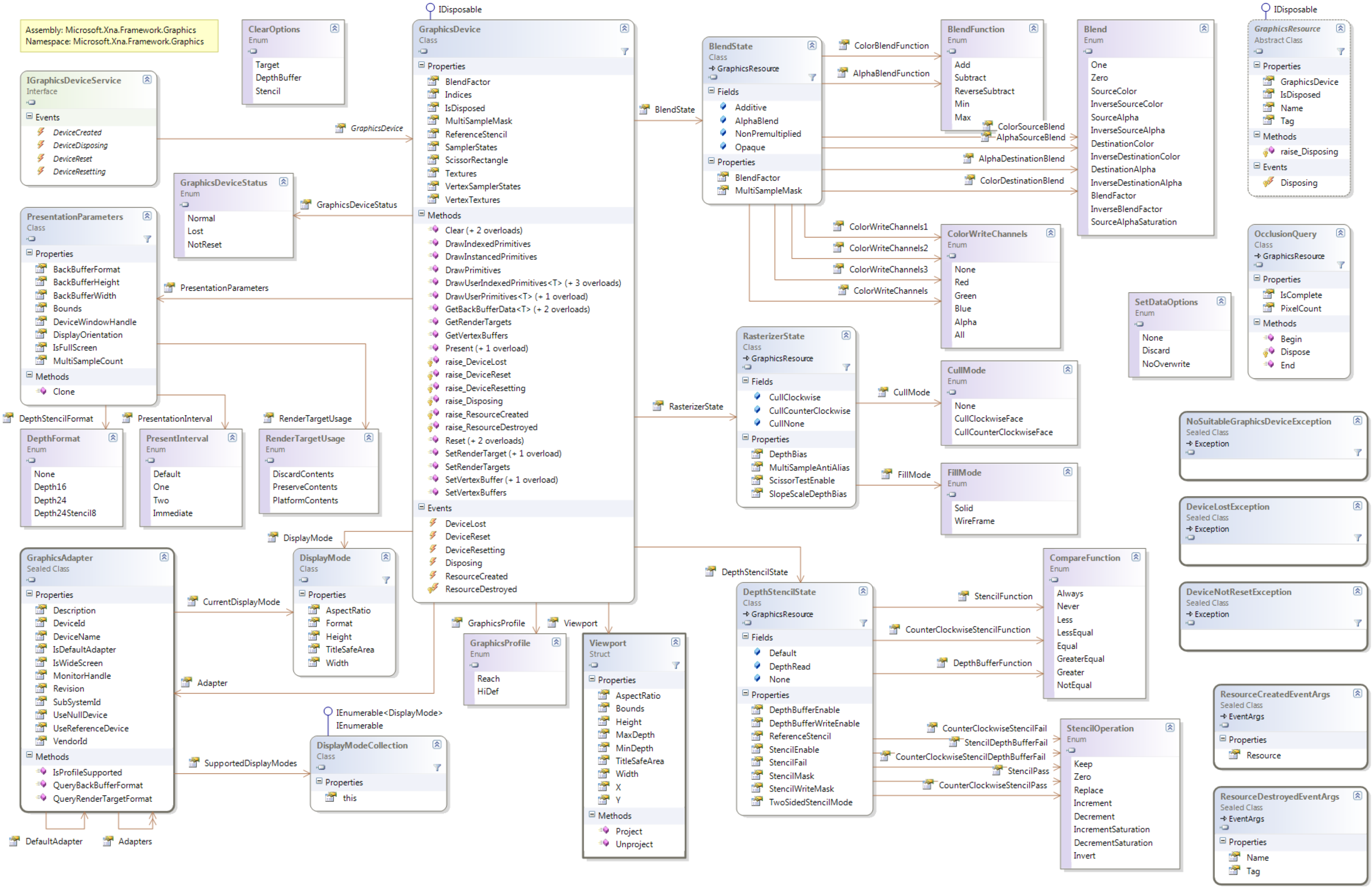
- The game loop is made of calls to the update and draw functions of the game
  - gameTime is the time elapsed since the last game loop call

```
protected override void Update(GameTime gameTime) { // ... }
protected override void Draw(GameTime gameTime) { // ... }
```

Scene management XNA

- The scene management (*e.g.* scene graph) is up to the user
- The graphics library contains low-level API methods that take advantage of hardware acceleration capabilities to display 2D/3D objects
  - Basically an interface for Direct3D
  - With classes such as Texture2D, ModelMesh and Effect

Microsoft.Xna.Framework.Graphics



Assembly: Microsoft.Xna.Framework.Graphics
Namespace: Microsoft.Xna.Framework.Graphics

ClearOptions
Enum
Target
DepthBuffer
Stencil

IGraphicsDeviceService
Interface
Events
DeviceCreated
DeviceDisposing
DeviceReset
DeviceResetting

GraphicsDevice

GraphicsDeviceStatus
Enum
Normal
Lost
NotReset

GraphicsDeviceStatus

PresentationParameters
Class
Properties
BackBufferFormat
BackBufferHeight
BackBufferWidth
Bounds
DeviceWindowHandle
DisplayOrientation
IsFullScreen
MultiSampleCount
Methods
Clone

PresentationParameters

DepthStencilFormat
PresentationInterval
RenderTargetUsage

DepthFormat
Enum
None
Depth16
Depth24
Depth24Stencil8

PresentInterval
Enum
Default
One
Two
Immediate

RenderTargetUsage
Enum
DiscardContents
PreserveContents
PlatformContents

DisplayMode

GraphicsAdapter
Sealed Class
Properties
Description
DeviceId
DeviceName
IsDefaultAdapter
IsWideScreen
MonitorHandle
Revision
SubSystemId
UseNullDevice
UseReferenceDevice
VendorId
Methods
IsProfileSupported
QueryBackBufferFormat
QueryRenderTargetFormat

DefaultAdapter
Adapters

CurrentDisplayMode

DisplayMode
Class
Properties
AspectRatio
Format
Height
TitleSafeArea
Width

Adapter

IEnumerable<DisplayMode>
IEnumerable

SupportedDisplayModes

DisplayModeCollection
Class
Properties
this

IDisposable

GraphicsDevice
Class
Properties
BlendFactor
Indices
IsDisposed
MultiSampleMask
ReferenceStencil
SamplerStates
ScissorRectangle
Textures
VertexSamplerStates
VertexTextures
Methods
Clear (+ 2 overloads)
DrawIndexedPrimitives
DrawInstancedPrimitives
DrawPrimitives
DrawUserIndexedPrimitives<T> (+ 3 overloads)
DrawUserPrimitives<T> (+ 1 overload)
GetBackBufferData<T> (+ 2 overloads)
GetRenderTargets
GetVertexBuffers
Present (+ 1 overload)
raise_DeviceLost
raise_DeviceReset
raise_DeviceResetting
raise_Disposing
raise_ResourceCreated
raise_ResourceDestroyed
Reset (+ 2 overloads)
SetRenderTarget (+ 1 overload)
SetRenderTargets
SetVertexBuffer (+ 1 overload)
SetVertexBuffers
Events
DeviceLost
DeviceReset
DeviceResetting
Disposing
ResourceCreated
ResourceDestroyed

GraphicsProfile
Viewport

GraphicsProfile
Enum
Reach
HiDef

Viewport
Struct
Properties
AspectRatio
Bounds
Height
MaxDepth
MinDepth
TitleSafeArea
Width
X
Y
Methods
Project
Unproject

BlendState

BlendState
Class
→ GraphicsResource
Fields
Additive
AlphaBlend
NonPremultiplied
Opaque
Properties
BlendFactor
MultiSampleMask

ColorBlendFunction
AlphaBlendFunction

BlendFunction
Enum
Add
Subtract
ReverseSubtract
Min
Max

ColorSourceBlend
AlphaSourceBlend
AlphaDestinationBlend
ColorDestinationBlend

Blend
Enum
One
Zero
SourceColor
InverseSourceColor
SourceAlpha
InverseSourceAlpha
DestinationColor
InverseDestinationColor
DestinationAlpha
InverseDestinationAlpha
BlendFactor
InverseBlendFactor
SourceAlphaSaturation

IDisposable

GraphicsResource
Abstract Class
Properties
GraphicsDevice
IsDisposed
Name
Tag
Methods
raise_Disposing
Events
Disposing

ColorWriteChannels1
ColorWriteChannels2
ColorWriteChannels3
ColorWriteChannels

ColorWriteChannels
Enum
None
Red
Green
Blue
Alpha
All

SetDataOptions
Enum
None
Discard
NoOverwrite

OcclusionQuery
Class
→ GraphicsResource
Properties
IsComplete
PixelCount
Methods
Begin
Dispose
End

RasterizerState

RasterizerState
Class
→ GraphicsResource
Fields
CullClockwise
CullCounterClockwise
CullNone
Properties
DepthBias
MultiSampleAntiAlias
ScissorTestEnable
SlopeScaleDepthBias

CullMode

CullMode
Enum
None
CullClockwiseFace
CullCounterClockwiseFace

FillMode

FillMode
Enum
Solid
WireFrame

NoSuitableGraphicsDeviceException
Sealed Class
→ Exception

DeviceLostException
Sealed Class
→ Exception

DeviceNotResetException
Sealed Class
→ Exception

DepthStencilState

DepthStencilState
Class
→ GraphicsResource
Fields
Default
DepthRead
None
Properties
DepthBufferEnable
DepthBufferWriteEnable
ReferenceStencil
StencilEnable
StencilFail
StencilMask
StencilWriteMask
TwoSidedStencilMode

StencilFunction
CounterClockwiseStencilFunction
DepthBufferFunction

CompareFunction
Enum
Always
Never
Less
LessEqual
Equal
GreaterEqual
Greater
NotEqual

CounterClockwiseStencilFail
StencilDepthBufferFail
CounterClockwiseStencilDepthBufferFail
StencilPass
CounterClockwiseStencilPass

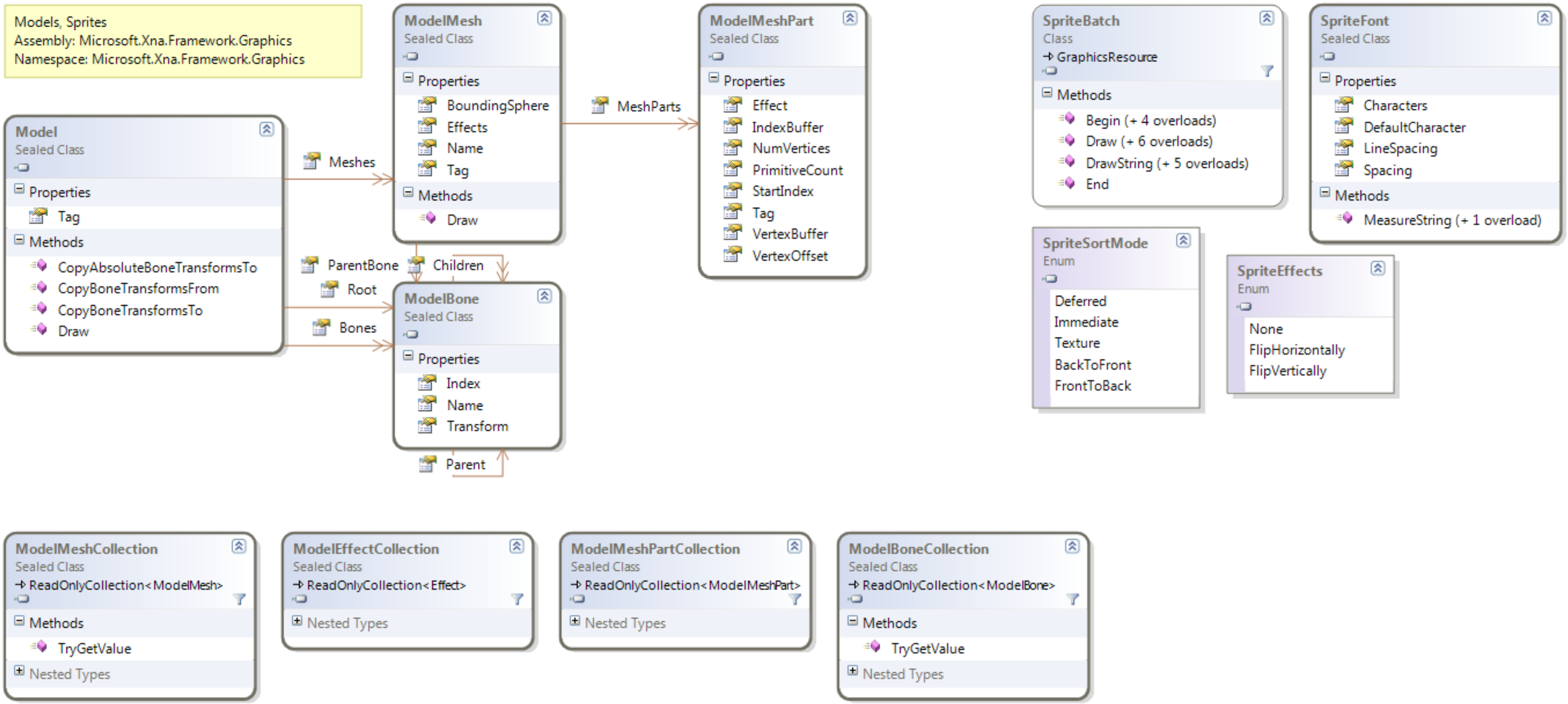
StencilOperation
Enum
Keep
Zero
Replace
Increment
Decrement
IncrementSaturation
DecrementSaturation
Invert

ResourceCreatedEventArgs
Sealed Class
→ EventArgs
Properties
Resource

ResourceDestroyedEventArgs
Sealed Class
→ EventArgs
Properties
Name
Tag

Microsoft.Xna.Framework.Graphics

- Models and Sprites



Models, Sprites
Assembly: Microsoft.Xna.Framework.Graphics
Namespace: Microsoft.Xna.Framework.Graphics

Model
Sealed Class
Properties
- Tag

Methods
- CopyAbsoluteBoneTransformsTo
- CopyBoneTransformsFrom
- CopyBoneTransformsTo
- Draw

ModelMesh
Sealed Class
Properties
- BoundingSphere
- Effects
- Name
- Tag

Methods
- Draw

ModelMeshPart
Sealed Class
Properties
- Effect
- IndexBuffer
- NumVertices
- PrimitiveCount
- StartIndex
- Tag
- VertexBuffer
- VertexOffset

ModelBone
Sealed Class
Properties
- Index
- Name
- Transform

Meshes
MeshParts
ParentBone
Children
Root
Bones
Parent

SpriteBatch
Class
→ GraphicsResource
Methods
- Begin (+ 4 overloads)
- Draw (+ 6 overloads)
- DrawString (+ 5 overloads)
- End

SpriteFont
Sealed Class
Properties
- Characters
- DefaultCharacter
- LineSpacing
- Spacing

Methods
- MeasureString (+ 1 overload)

SpriteSortMode
Enum
- Deferred
- Immediate
- Texture
- BackToFront
- FrontToBack

SpriteEffects
Enum
- None
- FlipHorizontally
- FlipVertically

ModelMeshCollection
Sealed Class
→ ReadOnlyCollection<ModelMesh>
Methods
- TryGetValue

Nested Types

ModelEffectCollection
Sealed Class
→ ReadOnlyCollection<Effect>
Nested Types

ModelMeshPartCollection
Sealed Class
→ ReadOnlyCollection<ModelMeshPart>
Nested Types

ModelBoneCollection
Sealed Class
→ ReadOnlyCollection<ModelBone>
Methods
- TryGetValue

Nested Types

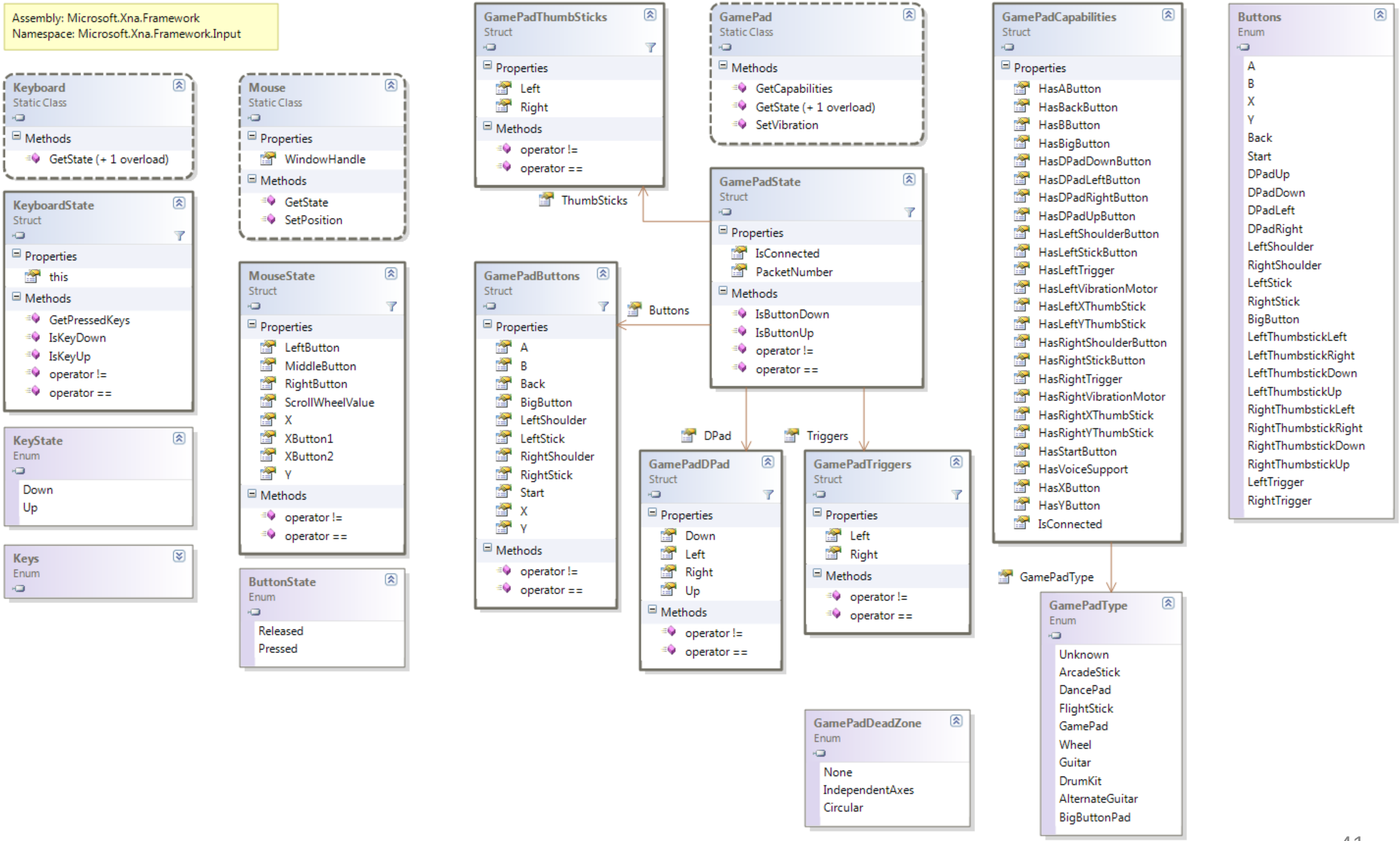
Input management XNA

- On PC, XNA can manage GamePad, Keyboard, Mouse and Microphone
- XNA provides only polling functions

```
KeyboardState ks = Keyboard.GetState();
if (ks.IsKeyDown(Keys.Space)) { // ... }
```

```
MouseState ms = Mouse.GetState();
if (ms.LeftButton == ButtonState.Pressed) { // ... }
int curMousePos.X = ms.X;
int curMousePos.Y = ms.Y;
```

Microsoft.Xna.Framework.Input



Assembly: Microsoft.Xna.Framework
Namespace: Microsoft.Xna.Framework.Input

Keyboard
Static Class
- Methods
  - GetState (+ 1 overload)

KeyboardState
Struct
- Properties
  - this
- Methods
  - GetPressedKeys
  - IsKeyDown
  - IsKeyUp
  - operator !=
  - operator ==

KeyState
Enum
- Down
- Up

Keys
Enum

Mouse
Static Class
- Properties
  - WindowHandle
- Methods
  - GetState
  - SetPosition

MouseState
Struct
- Properties
  - LeftButton
  - MiddleButton
  - RightButton
  - ScrollWheelValue
  - X
  - XButton1
  - XButton2
  - Y
- Methods
  - operator !=
  - operator ==

ButtonState
Enum
- Released
- Pressed

GamePadThumbSticks
Struct
- Properties
  - Left
  - Right
- Methods
  - operator !=
  - operator ==

ThumbSticks

GamePad
Static Class
- Methods
  - GetCapabilities
  - GetState (+ 1 overload)
  - SetVibration

GamePadState
Struct
- Properties
  - IsConnected
  - PacketNumber
- Methods
  - IsButtonDown
  - IsButtonUp
  - operator !=
  - operator ==

Buttons

GamePadButtons
Struct
- Properties
  - A
  - B
  - Back
  - BigButton
  - LeftShoulder
  - LeftStick
  - RightShoulder
  - RightStick
  - Start
  - X
  - Y
- Methods
  - operator !=
  - operator ==

DPad

Triggers

GamePadDPad
Struct
- Properties
  - Down
  - Left
  - Right
  - Up
- Methods
  - operator !=
  - operator ==

GamePadTriggers
Struct
- Properties
  - Left
  - Right
- Methods
  - operator !=
  - operator ==

GamePadDeadZone
Enum
- None
- IndependentAxes
- Circular

GamePadCapabilities
Struct
- Properties
  - HasAButton
  - HasBackButton
  - HasBButton
  - HasBigButton
  - HasDPadDownButton
  - HasDPadLeftButton
  - HasDPadRightButton
  - HasDPadUpButton
  - HasLeftShoulderButton
  - HasLeftStickButton
  - HasLeftTrigger
  - HasLeftVibrationMotor
  - HasLeftXThumbStick
  - HasLeftYThumbStick
  - HasRightShoulderButton
  - HasRightStickButton
  - HasRightTrigger
  - HasRightVibrationMotor
  - HasRightXThumbStick
  - HasRightYThumbStick
  - HasStartButton
  - HasVoiceSupport
  - HasXButton
  - HasYButton
  - IsConnected

GamePadType

GamePadType
Enum
- Unknown
- ArcadeStick
- DancePad
- FlightStick
- GamePad
- Wheel
- Guitar
- DrumKit
- AlternateGuitar
- BigButtonPad

Buttons
Enum
- A
- B
- X
- Y
- Back
- Start
- DPadUp
- DPadDown
- DPadLeft
- DPadRight
- LeftShoulder
- RightShoulder
- LeftStick
- RightStick
- BigButton
- LeftThumbstickLeft
- LeftThumbstickRight
- LeftThumbstickDown
- LeftThumbstickUp
- RightThumbstickLeft
- RightThumbstickRight
- RightThumbstickDown
- RightThumbstickUp
- LeftTrigger
- RightTrigger

Input management XNA

- You can simulate events by manually checking changes in the state

```
KeyboardState _oldState; // data member

// ...

KeyboardState newState = Keyboard.GetState();
if (newState.IsKeyDown(Keys.Space)) {
  if (!_oldState.IsKeyDown(Keys.Space)) { // Key just pressed }
}
else if (_oldState.IsKeyDown(Keys.Space)) { // Key just released }
_oldState = newState; // Update state
```

Resource management XNA

- Game assets are managed by the XNA Framework Content Pipeline
- It transfers the run-time native loading process to compile time (implemented in Visual Studio)
  - Each asset is imported from its original file format and processed into a managed code object
  - Those objects are then serialized to a file that is included in the game's executable
  - At run time, the game reads the serialized data from the file directly into a managed code object

Resource management XNA

- Default asset importers in XNA
  - Autodesk model: .fbx
  - DirectX effect: .fx
  - Sprite fonts: .spritefonts
  - Texture: .bmp, .jpg, .png, .tga, ...
  - DirectX file: .x
  - Microsoft Audio file: .xap
  - XML file: .xml
- Automatically detected (dedicated project) and added to resource file

Resource management XNA

- To load a resource

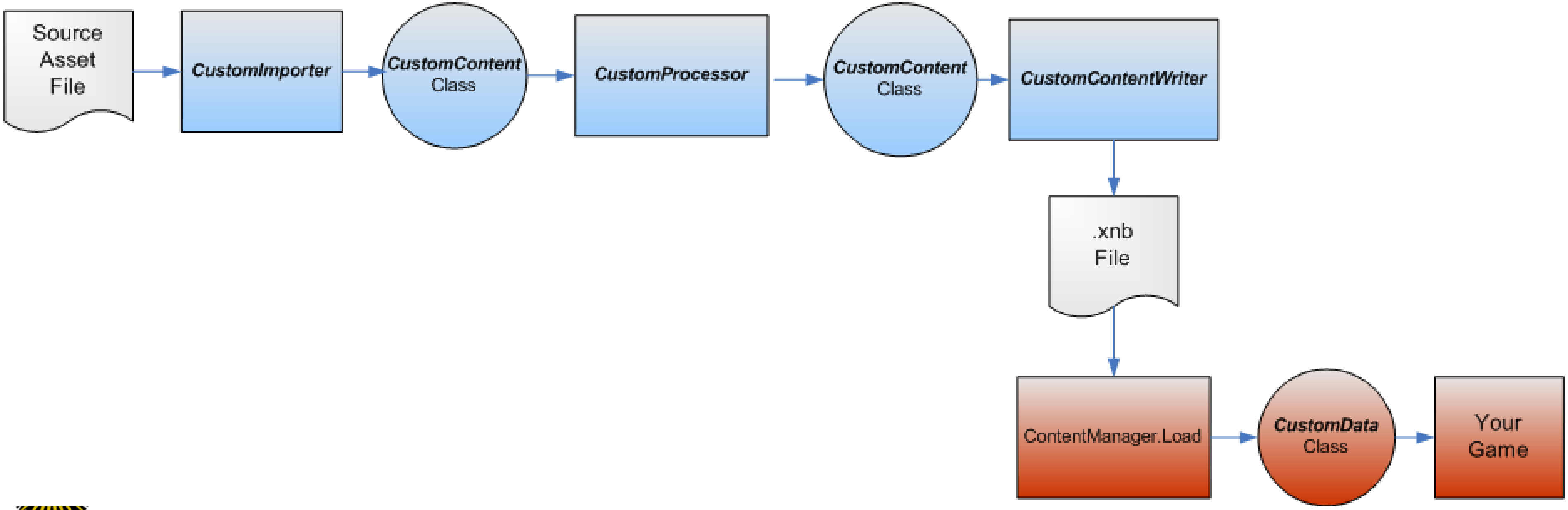
```
SpriteBatch spriteBatch;
Texture2D myTexture; // This is a texture to render

protected override void LoadContent()
{
   spriteBatch = new SpriteBatch(GraphicsDevice);
   myTexture = Content.Load<Texture2D>("mytexture");
}

protected override void UnloadContent()
{
    // ...
}
```

Resource management XNA

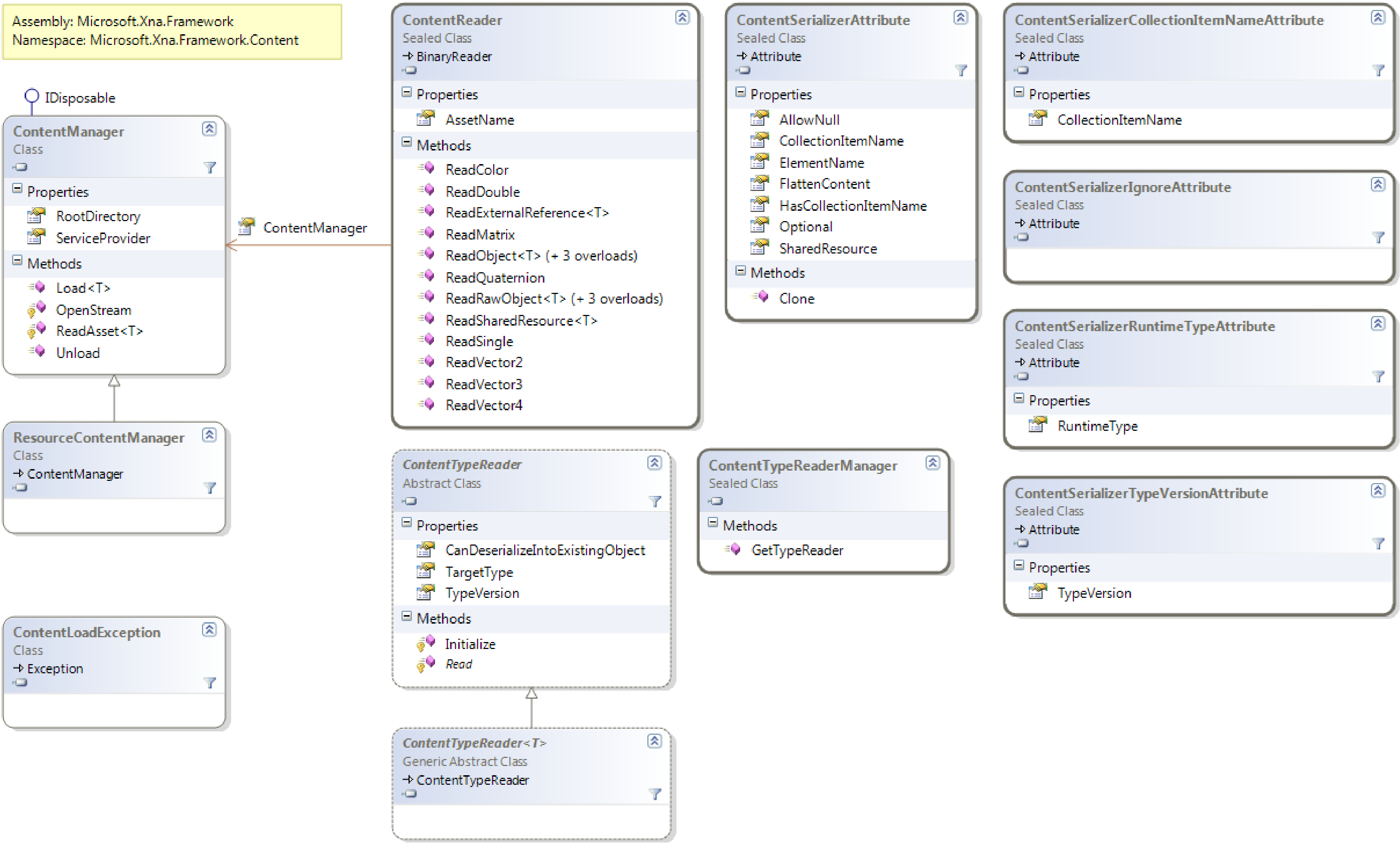
- Custom Content Pipelines can be added to support additional art assets and formats
- Or to derive special-purpose content from another piece of content at the time the game is built
- The asset is added in XNA project and its properties specify the appropriate importer
  - At build time the assigned importer is invoked
  - The asset is built into the game in a form that can be loaded at run time

Resource management XNA

- To manage new asset files
  - A custom importer is required that outputs a CustomContent object
  - A custom content processor is also needed
  - The ContentManager.Load method must be extended to support the custom data object



Microsoft.Xna.Framework.Content



Assembly: Microsoft.Xna.Framework
Namespace: Microsoft.Xna.Framework.Content

IDisposable

ContentManager
Class
- Properties
  - RootDirectory
  - ServiceProvider
- Methods
  - Load<T>
  - OpenStream
  - ReadAsset<T>
  - Unload

ContentManager

ResourceContentManager
Class
→ ContentManager

ContentLoadException
Class
→ Exception

ContentReader
Sealed Class
→ BinaryReader
- Properties
  - AssetName
- Methods
  - ReadColor
  - ReadDouble
  - ReadExternalReference<T>
  - ReadMatrix
  - ReadObject<T> (+ 3 overloads)
  - ReadQuaternion
  - ReadRawObject<T> (+ 3 overloads)
  - ReadSharedResource<T>
  - ReadSingle
  - ReadVector2
  - ReadVector3
  - ReadVector4

ContentTypeReader
Abstract Class
- Properties
  - CanDeserializeIntoExistingObject
  - TargetType
  - TypeVersion
- Methods
  - Initialize
  - *Read*

ContentTypeReader<T>
Generic Abstract Class
→ ContentTypeReader

ContentSerializerAttribute
Sealed Class
→ Attribute
- Properties
  - AllowNull
  - CollectionItemName
  - ElementName
  - FlattenContent
  - HasCollectionItemName
  - Optional
  - SharedResource
- Methods
  - Clone

ContentTypeReaderManager
Sealed Class
- Methods
  - GetTypeReader

ContentSerializerCollectionItemNameAttribute
Sealed Class
→ Attribute
- Properties
  - CollectionItemName

ContentSerializerIgnoreAttribute
Sealed Class
→ Attribute

ContentSerializerRuntimeTypeAttribute
Sealed Class
→ Attribute
- Properties
  - RuntimeType

ContentSerializerTypeVersionAttribute
Sealed Class
→ Attribute
- Properties
  - TypeVersion

Unreal Engine

- Unreal Engine 3 technology is available through UDK: the Unreal Development Kit
  - Main page: http://udk.com/
  - Documentation: http://udn.epicgames.com/Three/
- Features
  - Own editing environment (UnrealEd)
  - Highly dependent on scripts (UnrealScript)
  - Animation manager (AnimTrees)
  - Interface with PhysX engine (Unreal PhAT)
  - Networking, audio, particle, shader, AI managers
  - *and more*

Unreal Game

- UnrealScript is used to create custom classes to form the gameplay for the game
  - Located in a dedicated folder and pointed by a configuration file
- Content is stored within packages stored in a Content directory of the Unreal installation
  - including sub-folders for characters, maps, environments, sounds, *etc.*

Unreal Game

- The scripts are compiled into packages usable by the engine
- Default packages are
  - Core, Engine, GFxUI, GameFramework, UnrealEd, GFxUIEditor, IpDrv, OnlineSubsystemPC, OnlineSubsystemSteamworks, UDKBase, and UTEditor
  - Plus your own MyGame package

UDK Gameplay

- Player's viewpoint is handled in the GetPlayerViewPoint function of the PlayerController class

```
class MyGamePlayerCamera extends Camera;
function UpdateViewTarget(out TViewTarget OutVT, float DeltaTime) { // ... }
```

- Input from the player are handled and translated into controlling the game
  - the class responsible for determining how the player controls the game is PlayerController

```
class MyGamePlayerController extends GamePlayerController;
defaultproperties { CameraClass=class'MyGame.MyGamePlayerCamera' }
```

UDK Gameplay

- The visual representation of the player and the logic for determining how it interacts with the physical world is encapsulated in the Pawn class

```
class MyGamePawn extends Pawn;
defaultproperties { // ... }
```

- The HUD class is responsible for displaying information about the game to the player

```
class MyGameHUD extends MobileHUD;
defaultproperties { // ... }
```

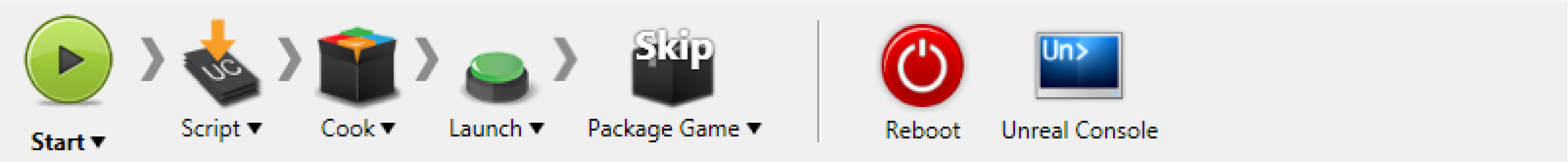
UDK Gameplay

- The gametype determines the rules of the game and the conditions under which the game progresses and ends
- The gametype is also responsible for telling the engine which classes to use for PlayerControllers, Pawns, the HUD, *etc.*

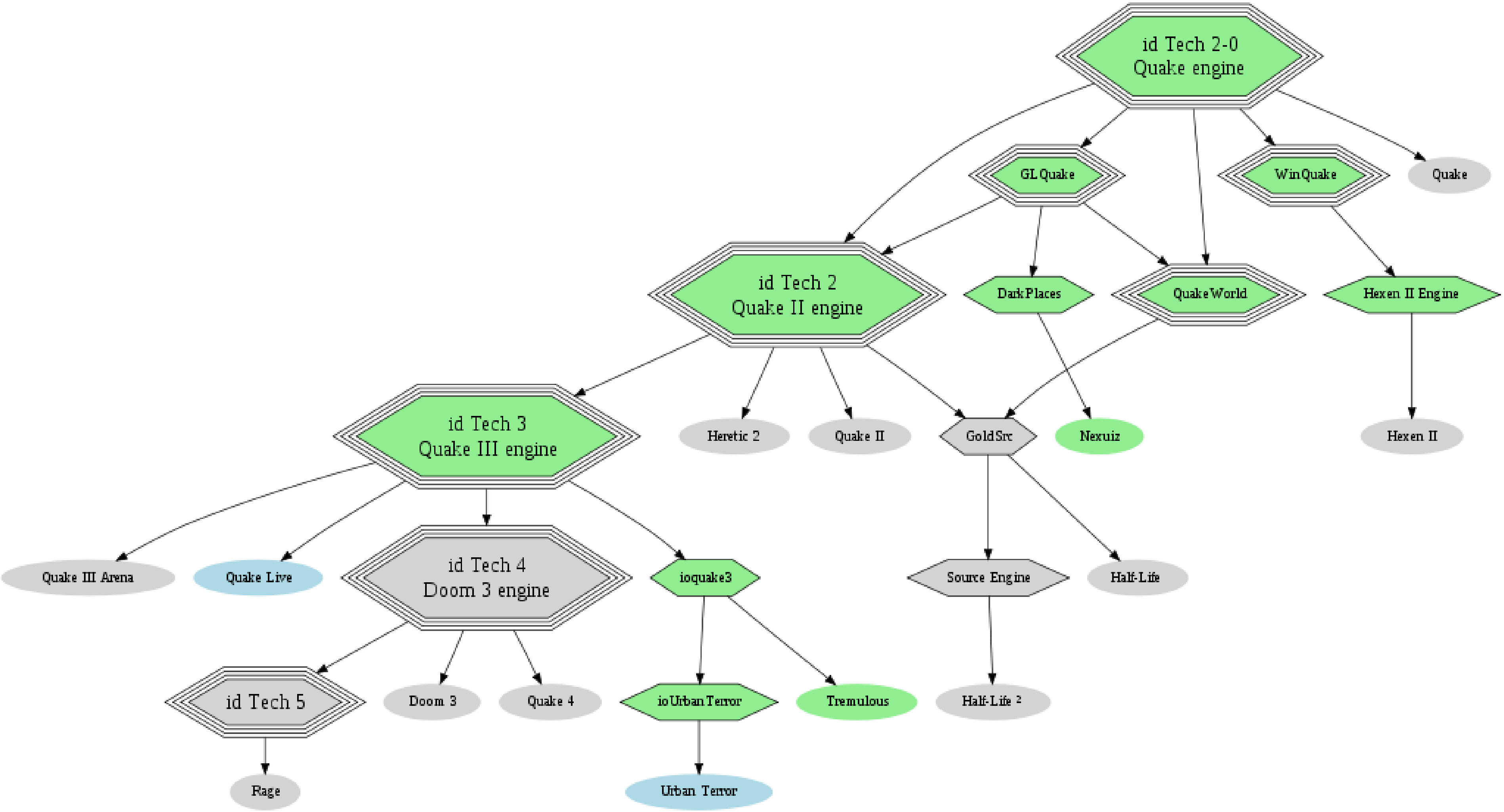
```
class MyGame extends FrameworkGame;

defaultproperties
{
   PlayerControllerClass=class'MyGame.MyGamePlayerController'
   DefaultPawnClass=class'MyGame.MyGamePawn'
   HUDType=class'MyGame.MyGameHUD'
   bDelayedStart=false
}
```

Unreal Game

- The UnrealFrontend application finally provides the ability to build scripts, either as a single operation or as part of a pipeline for building and packaging the game for testing or distribution



Quake engine family



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Quake engine: Id Tech

- Current version is Id Tech 5
  - Used in Rage and Doom 4
- Id Tech 4 SDK download and documentation http://www.iddevnet.com/quake4 (2005)
- Source code released in November 2011
  - ftp://ftp.idsoftware.com/idstuff/source/idtech4-doom3-source-GPL.zip
  - Used in Doom 3, Quake 4, Wolfenstein, Brink

An Id Tech 4 game

- Q4Radiant is the editor used to create the maps
  - To create a game you start by modeling the virtual world (objects, lights, shadows *etc.*)
- Q4Script system is then used to implement the game logic
  - the scripts will be called from the game with triggers activated by conditions defined in the editor

An Id Tech 4 game

- Script to spawn a monster at a location defined in the editor (targetMonster)

```
void spawnMonster() {
 //create a variable to hold the entity handle
 entity newMonster;

 //spawn the monster and store his handle in the variable
 newMonster = sys.spawn("monster_strogg_marine");

 //move it to where that new target lives in the edited map
 newMonster.setWorldOrigin( $targetMonster.getWorldOrigin() );
}
```

And more...

- Another very good free SDK: CryEngine 3
  - SDK download: http://www.crydev.net
  - SDK documentation: http://freesdk.crydev.net/
  - Source released in August 2011
  - Used in Crysis 2, also level design oriented
- Architecture
  - Engine
    - Config, Fonts, Shaders
  - Game
    - Animations, Entities, Levels, Music, Scripts, *etc.*
    - Libs
      - Dialogs, Particles, Sky, SmartObjects, UI, *etc.*
    - Scripts
      - AI, Entities, GameRules, Network, Utils, *etc.*

End of lecture #15

Next lecture

Final lecture