Source Engine

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1.1 Introduction

The Source engine developed by Valve Corporation is a modular 3D game engine, which is most famous for powering the critically acclaimed Half-Life 2, released on 16th November 2004. Since then it has been the backbone of many other games including Dark Messiah of Might and Magic, SiN Episodes, and Vampire: The Masquerade – Bloodlines. The engine is responsible for all of the rendering, audio and artificial intelligence, while the Havok physics engine which is heavily tweaked and embedded into the Source engine, is responsible for all the of the physics simulations within the game environment.

The Source Software Development Kit (SDK) which contains all of the necessary tools to create a computer game can be licensed for a pre-determined fee from Valve Corporation. For non-commercial uses the Source SDK can be accessed via Steam, a multiplayer gaming and content delivery system also developed by Valve. Although a full copy of Half-Life 2 is needed to run any mod created.

Throughout this document I am going to be discussing the technical achievements of the Source engine; how the Source engine has taken advantage of market trends in technology such as high dynamic lighting; how versatile and compatible the engine is; how the technical advancements of the engine drive and influence gameplay; the history and evolution of the Source engine from its creation; and a comparison with another engine.

1.2 Technical Achievements

The Source engine is at the forefront for industry standard in shader-based rendering, real-world physics, advanced AI and character animation. The renderer was fully developed to give the highest optimisation in visual effects and performance so that the game can look highly detailed, but also run at a high frame rate. It has support for sub-divided surfaces and diffuse and specular bump mapping so that low level geometry can look as detailed and realistic as high level geometry but with improved performance. It can provide water refraction and Fresnel effects for highly realistic water effects, and has full support for large scale environmental effects such as rain and fog for an increased immersion within the game world.

The renderer also supports indoor and outdoor environments, 3D skyboxes (which extends the horizon) and deformable terrain. This allows level designers to create seamless indoor/outdoor levels surrounded by a fully realised 3D skybox and realistic height mapped terrain, without a massive decrease in system performance. All the static meshes and models within the game world support level of detail (LOD) and mip-mapping, which allows for the use of low resolution textures on objects when the player is far-away, and high resolution textures when the player is close-up. This technique allows the graphics processing unit (GPU) to save on memory for loading large resolution textures for every object within sight of the player.

A revolutionary material system has also been developed for the Source engine which replaces the traditional texture system. This system allows for several effects to be applied to a material which will define how the object reacts within the game environment, i.e. its buoyancy, sound effects, and weight. The renderer also supports for the dynamic additions of decals and overlays within the world, i.e. allowing for bullet shots and blood to be shown when the player shoots through a door or hits an enemy. Projected shadows are also used to allow multiple entities to have shadows within the game without impacting on the frame rate, as none of the shadows are dynamically rendered by the engine.

Source also uses a mixture of lighting techniques to improve performance and increase realism. These techniques include light maps and vertex lighting to provide realistic lighting to static objects within the game world, without too much of a drop in frame rate. This lighting is then further enhanced by real time radiosity which provides the lighting with effects such as inter-object reflections and colour bleeding. To further increase realism high dynamic range lighting (HDR) is used to provide lighting effects such as blooming and over-brightening. All of these techniques then combine to provide highly realistic lighting for the game environment.

All of the physic simulations are handled by the Havok physics engine, a middleware physics engine developed by Havok Inc. This allows for an increased interactivity within the world with more realistic interactions, as all of the objects within the game space can be physically simulated. All of the AI characters can interact with the objects, and there is an accurate physics hull collision model to replicate what happens when two physically simulated objects collide. All of the physics is scaleable within the engine, and can be dynamically disabled or enabled using the Input/Output (I/O) system that is present with the world editor Hammer. The physics can also be controlled by custom procedural physics controllers and has full support for rag doll physics.

The artificial intelligence (AI) present within the game can all be controlled using the I/O system in the Hammer editor. All of the characters can navigate complicated terrain and have the ability to run, fly, jump, crouch, and climb stairs and ladders. The AI is very sophisticated and can respond to sight, sound and smell. The non-playable characters can also respond to danger and will move to avoid injuring themselves, i.e. dodging an incoming car. The AI also incorporates a battle AI which allows squads of non-playable characters to work as a team either with or against the player.

The characters in the game also provide highly realistic expressions and body language to increase immersion. All of the expressions are based on Dr Paul Ekman's research regarding the taxonomy of facial expressions, which details which muscles contract and relax when a certain expression is used. All of the characters have a fully rigged skeletal structure to allow for realistic animations, and a fully automatic speech recognition system is used to simulate lip-syncing in the game. Each of the characters

also has a full eye bulge which provides realistic reflections from ambient light sources and follows the characters movement. All of these techniques are created using the development tool Faceposer which is part of the Source SDK.

The engine also fully supports full digital 5.1 surround sound with high quality spatialisation at 16-bit 44 KHz quality. It also features MP3 decompression with the use of Miles audio and supports audio streaming. Another feature of the Source engine is its highly optimised multiplayer network code. It is very reliable and stable and has been tested by millions of gamers online via Counter Strike: Source, and supports both local area networks and online multiplayer. The network code is also highly efficient in predicting collisions between players and is highly optimized for high latency, high packet loss connections; allowing high ping players to compete with low ping players.

1.3 Market Trends

On release of the Source engine in 2004 it was the industry leader in realistic lip-syncing and facial expressions and ultra realistic physics. But since then many new technologies have come along in newer engines i.e. HDR. But the greatest achievement of Source is its modularity, as this allows the engine to continue to be cutting edge as new technologies are being released. With the release of Half-Life 2: Lost Coast, Valve introduced HDR lighting into the engine, which retroactively introduced HDR lighting into all the previous Valve products such as Half-Life 2 and Counter-Strike: Source. Then with the release of Half-Life 2: Episode One, the facial animation system was further upgraded to facial animation 2.0, which improved the detail of the facial expressions at a close range by increasing the number of facial shape targets i.e. muscles in the face.

The two most important additions to the engine though come with the release of Half-Life 2: Episode Two, with an upgrade to the renderer to provide DirectX 10 (DX 10) compatibility and multiprocessing support. With the release of Microsoft Vista and the introduction of DX 10 which will replace DX 9 as the industry standard, the compatibility for DX 10 was crucial. Also following the release of a multi-core processor in the Sony Playstation 3, and dual and quad-core processors for the PC,

multiprocessing support was essential for Valve to continue to provide a high performance engine. Both these additions will allow for an increased visual and frame rate performance, with DX10 providing new stunning effects and multi-threading allowing the use of several processors to run the engine.

Further additions are planned for Episode Two including an update to the current lighting and shadowing system to version 2.0, by adding real-time dynamic lighting which will be affected by all light sources, compared to just the master light in version 1.0. Also models will now dynamically self cast shadows onto other objects instead of using projected shadows for a more realistic look. An introduction of a new soft-particle system is further being implemented, along with the support for large natural environments i.e. large scale forests. Both these additions will allow for more scope and realism within future games. The physics system is also being slightly tweaked to provide cinematic physics which allow objects and large scale geometry to be fully physically simulated to provide a cinematic experience.

1.4 Versatility of the Engine

The Source engine is very flexible, it supports both 32-bit and 64-bit operating systems, and Microsoft Windows, Xbox, Xbox 360 and Sony Playstation 3 platforms. It has full DirectX scalability from DX6 to DX9, and soon to be DX10 with the release of Half-Life 2: Episode Two. Source is also compatible with models created from XSI, Maya and 3D Studio Max which allows developers to use the program of choice to model for their own games.

1.5 How Technology Influences and Drives Gameplay

The physics engine present in Source has a major influence and impact on the gameplay. This is because all of the objects within the world can be physically simulated, therefore the player can use those objects to his advantage, i.e. a player can block an entry way with objects so that enemies can not pass, or use a bin as a shield to cover from enemy fire. Designers can also design gameplay events around the physics engine for the player to solve, i.e. a player must destroy a building to create a

walkway to the other side. Both of these examples show how the physics engine within the game can influence and drive the gameplay. One particular modification of Half-Life 2 named Garry's mod, which is now commercially sold via Steam, is a physics sandbox where players can create anything they can imagine out of the physically simulated objects.

Another aspect of the technology which drives gameplay is the artificial intelligence. The AI provides a realistic output to the player's actions, for example if a player shoots up an alleyway the enemy AI will take cover. This provides realism to the player and forces the player to re-think his actions to overcome certain gameplay situations. This further enhances the gameplay and creates immersion. The AI can also work together with the player in a squad based fashion to simulate other people playing with the player. This allows the player to feel part of team in a single player experience, and again increases immersion within the game. Both these examples enhance the gameplay experience for the player and provide some output reactions from the players input.

1.6 History and Evolution of the Engine

The Source engine was internally developed by Valve for Half-Life 2. It took over 5 years in production before it was ready to be released. Many of its features are very similar to the Goldsource engine, the heavily modified Quake engine that was used for the original Half-Life in 1998; and the Hammer editor which is used as the world editor for Source is an updated version of Worldcraft, the world editor which supported Quake and Quake 2. Since its release the Source engine has received several iterations with the two major updates coming with the release of Half-Life 2: Lost Coast and Half-Life 2: Episode One. Both these expansions provided new features within the Source engine such as HDR and improved facial animation. Further updates are in production with the future releases of Half-Life 2: Episode Two and Episode Three.

1.7 Comparison of other Engines

The Source engine is over 2 years old so lets compare it to a brand new engine that has just been released; the Unreal 3.0 engine. When looking at the specifications for both Source and Unreal 3.0 they are both very similar, especially when you take into account the new features being added to the Source engine with Episode Two. Both engines support multithreaded processes, HDR, advanced mapping techniques such as bump/normal mapping, dynamic shadows, and advanced environmental effects such as rain and fog. Although Unreal 3.0 does support up to 4 versions of advanced shadowing techniques and has full support for per-pixel lighting. Regarding audio both engines again are very similar with both supporting full 5.1 surround sound.

Where the engines begin to differ is the physics middleware used by both companies. Valve has used the Havok physics engine, while Epic has used the Ageia PhysX physics engine. Both physics engines are very similar with full physically simulated objects being available in the game world, and physics driven sound and materials. Where Ageia benefit though is the fact they have developed the Ageia PhysX card, which has a dedicated physics processing unit which is fully dedicated to running the physic engine. This allows the core processor to concentrate on running other parts of the Unreal 3.0 engine, therefore giving increased performance.

The animation for both engines again is very similar, although the Source engine has increased facial animation over the Unreal 3.0 engine using faceposer, and still provides very realistic character animation. Both engines come with a development tool dedicated to animation with faceposer being used with Source, and AnimSet Viewer being used with Unreal 3.0. Both provide very similar functionality allowing users to modify the skeletal rigging of the characters to provide realistic animation in-game.

Both engines are very powerful and come packaged with world editing software as standard; Unreal Editor 3.0 for Unreal, and Hammer for Source. But the Unreal 3.0 engine probably provides the most functionality at the moment as Half-Life 2: Episode Two has not been released; therefore some of the features are not available in Source. But that being said the Source engine is 2 years old and still compares very

well against a brand new engine, and it will only get better with its modular updates. Eventually it will probably overtake the Unreal 3.0 engine for newer features as further Half-Life 2: Episodes are released and newer technologies are introduced into the market.

1.8 Conclusion

Source is a very powerful engine and with its modularity has the potential to keep up with newer engines such as Unreal 3.0. The fact that Source is coupled to the Steam content delivery system allows the engine to always be up to date and allows ease-of-use to the developers for re-engineering new features and updates. Another major bonus for Source is the fact that it comes with so many powerful tools including Hammer editor, Faceposer, Studiomdl compiler, and XSI/Maya/3DS max exporters. All of these tools allow users to fully shape and modify the source engine to anything they can imagine.

The only downfall to the engine is that it does have some stability issues with stuttering and looping audio, which occurs when the engines caching system becomes full and performance drops. This only happens on some machines though and can be down to low end hardware. Other than that the engine is very stable and is one of the most advanced engines to date, even compared to some of the more modern engines.

1.9 Bibliography:

1. Valve.,(2006). *The Valve Developer Community.* [online]. Available at: http://developer.valvesoftware.com/ [Accessed 07 May 2007]

2. Valve,.(2006). *Valve Homepage*. [online]. Available at: http://www.valvesoftware.com/ [Accessed 07 May 2007]

3. Wikipedia,.(2007). *Source Engine*. [online]. Available at: http://en.wikipedia.org/wiki/Source_engine [Accessed 08 May 2007]

4. Team Garry,.(2007). *Garry's Mod Homepage*. [online]. Available at: http://www.garrysmod.com/ [Accessed 09 May 2007]

5. HL2World,.(2006). *HL2World Forums*. [online] Available at: http://www.hl2world.com/bbs/new-technology-for-ep2-vt44745.html [Accessed 09 May 2007]

6. Harris, Will,.(2006). *Multi Core in the Source Engine*. [online]. Available at: http://www.bit-tech.net/gaming/2006/11/02/Multi_core_in_the_Source_Engin/1 [Accessed 10 May 2007]

7. McWilliams, Mark,.(2006). *HL2 Stutter.* [online]. Available at: http://www.blep.net/hl2stutter/ [Accessed 10 May 2007]

8. DevMaster,.(2007). *Source Engine*. [online]. Available at: http://www.devmaster.net/engines/engine_details.php?id=34 [Accessed 10 May 2007]

9. Epic Games,.(2007). *Unreal Engine 3.* [online]. Available at: http://www.unrealtechnology.com/html/technology/ue30.shtml [Accessed 10 May 2007]