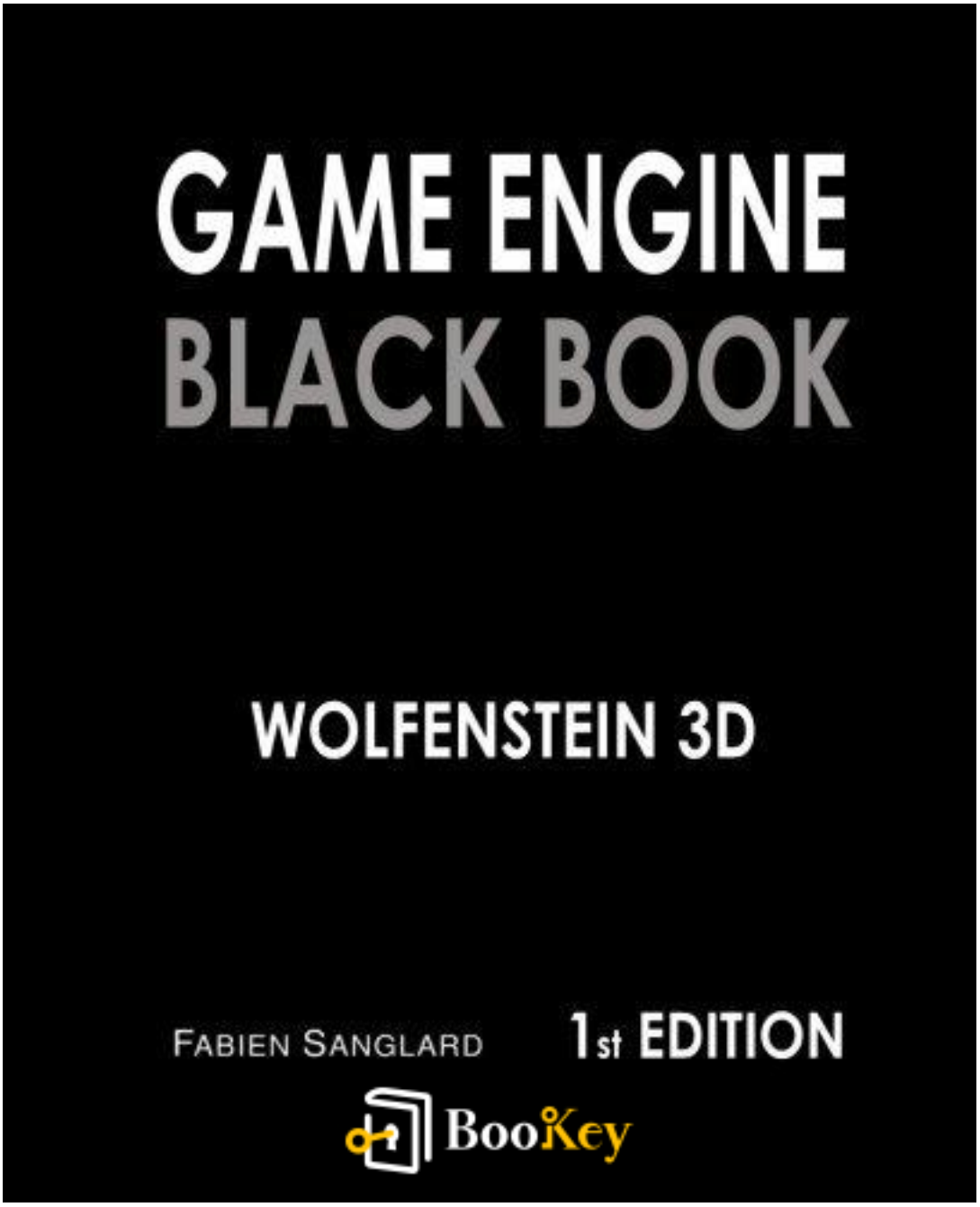
Game Engine Black Book PDF (Limited Copy)

Fabien Sanglard



Game Engine Black Book Summary

Exploring the Secrets of Classic Game Engines

Written by Books OneHub

About the book

Game Engine Black Book by Fabien Sanglard delves into the intricacies of game engine architecture, offering a unique, in-depth exploration of the principles and practices that drive some of the most iconic video game engines. By meticulously dissecting source code and mechanisms of legendary titles, Sanglard invites readers—whether aspiring developers or experienced professionals—to not only understand the technical prowess behind these engines, but also to glean insights into the creative processes that fuel game development. With a blend of technical expertise and engaging storytelling, this book serves as both a hands-on guide and a historical retrospective, captivating anyone passionate about the art and science of building immersive digital worlds.

About the author

Fabien Sanglard is a renowned game developer and author, best known for his work in the field of game engine design and programming. With a strong background in computer science and a passion for video games, Sanglard has contributed significantly to the gaming community through his insightful writings and innovative projects. His expertise encompasses a wide range of topics, from graphics programming to low-level engine architecture, which is reflected in his acclaimed book series, including "Game Engine Black Book." Through rigorous analysis and practical demonstrations, Sanglard empowers both aspiring and seasoned developers to understand the complexities of game engines, fostering a deeper appreciation for the craft of game development.

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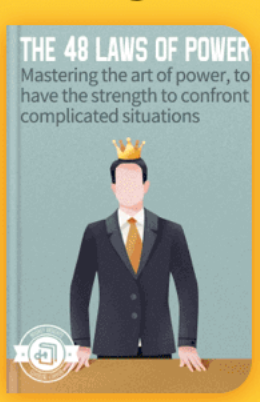

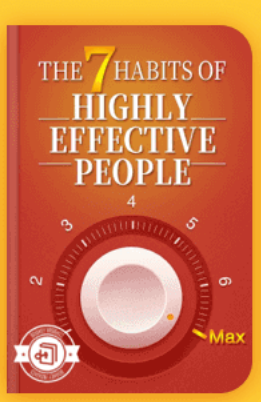

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Summary Content List

Chapter 1 Summary: Hardware

In exploring the evolution of PC hardware, particularly in terms of gaming, we find that the architecture of the IBM PC can be effectively understood through its five fundamental subsystems: Inputs, CPU, RAM, Video, and Audio. This breakdown reveals the inherent challenges posed to developers during the early 1990s, as the quality of components varied significantly, resulting in devices that could range from acceptable to frustratingly inadequate.

1. **CPU Landscape**: By 1991, the performance of PCs was predominantly influenced by the Central Processing Unit (CPU), with Intel's x86 family taking center stage. The terminology used to identify PCs was heavily reliant on the CPU model; hence, systems were commonly referred to by their processor, such as "386" for those using the Intel 80386. The 386's architectural benefits stemmed from its design, which favored backward compatibility while enhancing capabilities through a 32-bit operating mode. This evolution marked a significant leap in processing power and memory management compared to its predecessor, the 80286.

2. **Floating Point Considerations**: When programming games, the absence of a hardware-based Floating Point Unit (FPU) in the 386 processor significantly inhibited performance during tasks that required trigonometric calculations and other complex mathematical functions. Although

floating-point capabilities were essential for 3D graphics, their emulation through software resulted in slow processing speeds, creating a dilemma for game developers who had to balance between speed and accuracy.

3. **RAM Limitations**: The RAM architecture for early Intel CPUs was reflective of the technology's infancy. The 20-bit address bus restricted accessible memory to 1MiB in real mode, although many systems had much more installed. This limitation, compounded by the prevalent DOS operating system, forced developers into archaic programming paradigms, making full utilization of the hardware difficult. As a result, innovations like Extended Memory and various memory management techniques emerged out of necessity to bypass these constraints.

4. **Video Graphic Standards**: The Video Graphics Array (VGA) system represented a significant advancement, but programming against its architecture was notoriously complicated. VGA's design involved using multiple banks for memory access, which, while enhancing throughput, ultimately introduced significant complexities into visual programming. The standardization of VGA created a double-edged sword—streamlining compatibility, yet confining performance optimization.

5. **Audio Challenges**: Audio reigned as another aspect where PC gaming faced hurdles. The reliance on basic internal speakers for sound output limited auditory experiences to simplistic beeps and tones. This paved the

way for third-party sound cards, such as AdLib and SoundBlaster, which offered superior audio capabilities but lacked universal compatibility. Developers were therefore often forced to cater to a fragmented user base.

6. **Device Connectivity via Bus Architecture**: The ISA bus was the cornerstone for connecting the various hardware components in PCs. While its backward compatibility made it versatile, it also constrained bandwidth and performance. Consequently, most games had to carefully manage data transfers to achieve acceptable framerates, often at the cost of visual fidelity.

7. **Input Complexity**: Before the onset of USB, input methods were convoluted, relying on a myriad of ports such as parallel, serial, PS/2, and game ports. Each port had a unique protocol, complicating the task for developers aiming to provide seamless control across diverse hardware setups.

The environment in which early game developers thrived was nothing short of chaotic, with a myriad of limitations influenced by the hardware's architecture. Nevertheless, fueled by determination and innovation, teams such as id Software emerged, crafting groundbreaking games that ultimately shaped the landscape of modern gaming. Despite the myriad of obstacles presented by the hardware, this era laid the essential groundwork for the future of personal computing and interactive entertainment.

Critical Thinking

Key Point: Embrace Limitations as Opportunities

Critical Interpretation: As you reflect on the journey of early game developers, consider how their creative prowess flourished amidst seemingly insurmountable limitations. The constraints of the 1990s PC hardware landscape—ranging from limited RAM to convoluted input systems—did not stifle innovation; rather, they ignited it. Just as these pioneers harnessed their obstacles into extraordinary gaming experiences, you too can turn the challenges in your life into stepping stones for growth. When faced with restrictions, remember that these are not just barriers but invitations to think outside the box, innovate, and evolve. Embrace your circumstances, push beyond the status quo, and use your creativity to transform adversity into triumph.

Chapter 2 Summary: Team

In the early 1990s, a group of employees from Softdisk, a company based in Shreveport, Louisiana, embarked on a journey to create their own game development powerhouse, founded on the ambition of making a name for themselves in the gaming industry. They pioneered a programming technology called "adaptive tile refresh," which enabled smooth hardware scrolling on PCs, comparable to that of the NES. Their attempt to impress Nintendo by replicating **Super Mario 3** resulted in a clone but failed to secure a contract, as Nintendo preferred to keep its flagship games exclusive to its consoles. Despite this setback, the team members—John Carmack, John Romero, Adrian Carmack, and Tom Hall—realized their talent and decided to establish **id Software** in February 1991.

1. **Initial Successes**: The newly formed company wasted no time leveraging their adaptive tile refresh technology. They rapidly produced several acclaimed titles, including the **Commander Keen** series, which enjoyed significant commercial success. Concurrently, they continued to create games for Softdisk, further cementing their reputation in the gaming community.

2. **Technological Advancements**: As id Software evolved, so did their technology. They introduced **Hovertank One**, which provided immersive

gameplay within a tank, and **Catacomb 3-D**, which marked their first foray into texture mapping, ultimately enhancing player immersion with a first-person perspective. Following the completion of these projects, work commenced on their next significant title: **Wolfenstein 3D**.

3. **Team Expansion and Relocation**: As they transitioned from Softdisk to independent development, the team expanded, attracting more talent and expertise. In September 1991, they relocated to Madison, Wisconsin, where they formed a closely-knit environment conducive to collaboration and creativity. The intense work environment was instrumental during the rigorous four-month development phase of **Wolfenstein 3D**, which was characterized by long hours yet strong camaraderie among team members.

4. **Development Practices**: Utilizing top-of-the-line computers and development tools like Borland C++ 3.1, id Software adopted an unorthodox approach without version control, relying instead on their unique organizational style. The team employed a robust programming methodology characterized by direct asset management and in-house tools for graphic and audio assets.

5. **Graphics and Audio Production**: The graphic assets for **Wolfenstein 3D** were crafted painstakingly by Adrian Carmack using **Deluxe Paint**. Given the constraints of the VGA palette, artist decisions on color selection were

critical. The audio component also required significant effort, supporting various sound cards, and was crafted using tools that ensured quality across platforms. Music compositions were distinctively created by Robert Prince, who adapted to the limitations of the hardware.

6. **Distribution Model**: At the crux of id Software's innovative strategy was their distribution model. In May 1992, they launched **Wolfenstein 3D** as shareware, allowing the first episode to be distributed freely while charging for additional episodes. This approach maximized outreach and engagement, capitalizing on the growing popularity of Bulletin Board Systems (BBS) during that era.

This chapter illustrates the journey of id Software from ambitious beginnings to becoming a pioneering force in the gaming industry. Their commitment to innovation, teamwork, and effective distribution strategies laid the foundation for a legendary legacy in game development.

Chapter 3: Software

Chapter 4 of "Game Engine Black Book" by Fabien Sanglard explores the software foundation and architecture of the game engine behind *Wolfenstein 3D*, detailing its design, source code availability, main components, and the various systems running concurrently to deliver immersive gameplay.

1. The source code of *Wolfenstein 3D* was made publicly accessible on July 21, 1995, and is still available today through id Software's FTP and GitHub repositories. The code primarily comprises C and assembly languages; it contains over 27,000 lines of code, primarily in C, with assembly for performance-critical sections. Interestingly, it also includes oddities, like comments regarding spelling mistakes from early coding practices.

2. The engine is structured into three primary systems: a 2D menu engine for configuration, a 3D renderer that handles the bulk of the gameplay, and a sound system that operates alongside the rendering process. Communication

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Chapter 4 Summary: Sequels

Chapter 5 of "Game Engine Black Book" by Fabien Sanglard delves into the sequels that emerged from the monumental success of Wolfenstein 3D. As Tom Hall notes, the game's popularity spurred interest in extending its gameplay experience, leading id Software to engage third-party companies for additional maps and even embark on developing its sequel.

A pivotal release was "Spear of Destiny," which launched on September 18, 1992. This game was developed solely by id Software and utilized the same engine as its predecessor but introduced fresh graphics, music, and levels. Set as a prequel, it followed the heroic exploits of B.J. Blazkowicz and added a significant new episode consisting of 21 levels.

The decision to create a sequel was informed by two key factors: the strong sales performance of Wolfenstein 3D and the opportunity it provided for the engineering team to enhance their technology and tools while keeping the design and graphics personnel actively engaged. Despite relying on the existing engine, "Spear of Destiny" pushed boundaries through innovative design features. It incorporated large transparent sprites to simulate vegetation and adeptly navigated the limitations of orthogonal world design with clever map layouts that made full use of the game environment. The thematic shift away from World War II, exemplified by the game’s boss, the red Angel Of Death, paved the way for id Software's next venture, DOOM,

which would further embrace a “hero fighting demons with big guns” motif.

In a notable departure from its predecessor, "Spear of Destiny" included a copy protection mechanism. While Wolfenstein 3D lacked such features and was easily pirated, the sequel incorporated measures typical of the early 1990s gaming landscape. The game required players to answer specific questions derived from the game manual to launch, a tactic that capitalized on the relative difficulty of photocopying compared to duplicating floppies.

The implementation of this copy protection was not only functional but also incorporated humorous touches, featuring backdoor responses that played on cultural references, such as nods to the 1984 film "WarGames." These clever inclusions reflected a broader trend in the industry at the time, where companies employed increasingly sophisticated paper-based protection methods.

As a result, "Spear of Destiny" stands out as a substantial contributor to the legacy of the Wolfenstein franchise, showcasing id Software's ability to innovate while navigating the challenges and opportunities presented by its predecessor's success.

Chapter 5 Summary: Ports

The chapter explores the various ports of the iconic game *Wolfenstein 3D* across different platforms and the significant challenges faced during their development.

1. **Porting Difficulties**: The engine's close integration with PC hardware made it a challenge to replicate its original performance even on significantly more powerful machines. The complexities of its VGA and audio systems highlighted how tightly coupled the game was to the technology of its time. Most ports, apart from Wolf4SDL and Chocolate Wolfenstein 3D, struggled to capture the authentic *PC DOS* experience.

2. **Super Nintendo**: Id Software's attempt to port *Wolfenstein 3D* to the Super Nintendo (SNES) began in 1992 but faced substantial delays due to inadequate resources and lack of communication with the initial subcontractor. Ultimately, the port was expedited by the entire team, leading to completion within three weeks, notably avoiding financial penalties for late delivery. However, to meet Nintendo's content guidelines, significant alterations were required. Consequently, graphics were altered, blood was replaced with rats, and spikes of WWII-themed content were removed. The technical challenges necessitated the development of new wall span rendering methods to optimize performance, leading to innovations that influenced future games.

3. **Jaguar**: The *Jaguar* port, executed by John Carmack in a brief period, was notable for achieving 60 frames per second, introducing new weaponry such as the Flamethrower and Rocket Launcher. Carmack detailed the system's hardware limitations, especially the inefficient texture mapping and caching mechanics. Still, despite these challenges, the port performed optimally within the confines of the Jaguar's capabilities.

4. **iPhone**: The port to the iPhone was spearheaded by Carmack in 2009, coinciding with the launch of its App Store. This version featured bilinear filtering but sparked mixed reactions due to the graphical changes, with some players preferring the pixelated aesthetics of the original. The development process was plagued with setbacks and adjustments, eventually leading to a more robust implementation utilizing OpenGL ES for improved rendering. Unique control schemes were tested, and while updates to the gameplay were contemplated, the classic feel remained largely intact.

5. **Wolfenstein 3D-VR**: Aventure into virtual reality was attempted by Alternate World Technologies (AWT) in the early 90s, but the limitations of the technology available hindered the project’s success. Players found it difficult to adapt to controls that did not leverage the full potential of head-tracking. Despite initial enthusiasm, the experience was perceived as premature and did not gain traction.

Overall, the ports of *Wolfenstein 3D* highlight significant technical advancements and the evolution of game design strategies. The persistence of id Software to innovate despite hardware limits laid the groundwork for future gaming technologies while introducing lasting features that would influence the broader gaming landscape. The chapter concludes by recognizing the ongoing legacy of the *Wolfenstein 3D* franchise, with continued adaptations and new iterations being developed even decades later.

Chapter 6: XMS vs EMS

In 1991, accessing memory beyond the first megabyte (MiB) of RAM posed significant challenges, primarily due to the limitations of real mode, characterized by a 20-bit address bus. Developers had to utilize two primary types of RAM drivers to overcome these issues: Expanded Memory Specification (EMS) and eXtended Memory Specification (XMS).

1. EMS or Expanded Memory Specification was conceived in 1985 through the collaboration of Lotus, Intel, and Microsoft. It aimed to enable hardware memory boards that enhanced a computer's RAM capacity. With this system, applications could access additional memory utilizing an EMS driver, where conventional RAM was mapped into "pages." These pages consisted of a page frame of 64 KiB, divided into four 16 KiB portions that acted as windows into the extended memory. At the time, memory boards like the RapidRAM and SUPERAM could be quite expensive, making expansion a costly endeavor. However, the advent of the Intel 386 processor brought a revolutionary change. With its Virtual 8086 Mode, the EMM386 driver enabled DOS to run in a virtual machine environment, allowing the

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Chapter 7 Summary: The 640KB Barrier

The discussion regarding the 640KB barrier highlights the significant limitations imposed by conventional memory management in early computing, particularly in the context of gaming. Initially established by Microsoft with DOS 1.0, this barrier set the maximum accessible memory at 640 kilobytes (KB), known as conventional memory. As technology progressed, although it became possible to access memory beyond this limit, the operating system required programs to execute within this initial segment of memory.

The first key concept revolves around **Conventional Memory**, which spans from 0 to 640 KB. This memory is critical for running DOS and its associated device drivers, as well as TSRs (Terminate and Stay Resident programs). Interestingly, TSRs remain in memory after their execution, affecting the available conventional memory for other programs. A pivotal point emphasized is that regardless of the total RAM installed—be it 1 MB, 8 MB, or even 32 MB—only the first 640 KB is relevant for program execution. Limited availability leads to common "out of memory" errors when attempting to run complex applications.

Following conventional memory, there's **Upper Memory**, which ranges from 640 KB to 1024 KB. Typically occupied by system ROM, video, and hardware components, this memory can be partly utilized for loading certain

TSRs via memory managers, freeing up precious conventional memory for applications. The concept of **Extended Memory (XMS)** comes into play next, which encompasses any addressable memory above 1024 KB. However, this region can only store data, as programs themselves cannot execute from XMS.

The document also highlights **High Memory Area (HMA)**, a designated space used when loading DOS high to reduce conventional memory consumption. Oftentimes, system start-up files such as CONFIG.SYS and AUTOEXEC.BAT dictate which device drivers and TSRs are automatically loaded, further depleting available conventional memory.

Finally, **Expanded Memory (EMS)** is referenced, which, like XMS, is not available for program execution but is designated for data storage in certain MS-DOS applications. Users are advised that memory management programs—like EMM386, QEMM, and 386 MAX—serve as crucial tools for optimizing memory usage. These programs can help shift TSRs to higher memory areas, thereby preserving more conventional memory for essential applications.

In summary, understanding the architecture of memory and the limitations imposed by the 640KB barrier is essential for optimizing the performance of early computer games and applications. Proper management of conventional memory, alongside the strategic use of various memory types and

management tools, plays a vital role in enhancing the functionality and user experience of these software applications.

Concept	Description
Conventional Memory	Spans from 0 to 640 KB, critical for running DOS and its device drivers; limited memory can lead to "out of memory" errors.
Upper Memory	Ranges from 640 KB to 1024 KB; occupied by system ROM and hardware components; can partially be used for TSRs via memory managers.
Extended Memory (XMS)	Any addressable memory above 1024 KB; can store data but programs cannot execute from this memory.
High Memory Area (HMA)	Designated space used for loading DOS high to minimize conventional memory use; affected by startup files like CONFIG.SYS and AUTOEXEC.BAT.
Expanded Memory (EMS)	Not available for program execution; used for data storage in certain MS-DOS applications.
Memory Management Tools	Programs like EMM386, QEMM, and 386 MAX optimize memory usage by shifting TSRs to higher areas, preserving conventional memory.
Key Takeaway	Understanding memory architecture and management is crucial for enhancing performance in early computer games and applications.

Critical Thinking

Key Point: Overcoming Limits Through Resource Management

Critical Interpretation: Just as early developers had to navigate the rigid constraints of the 640KB barrier to optimize performance in gaming, you too can find inspiration in their ingenuity and resourcefulness. Life presents us with various obstacles and limitations—whether they be time, finances, or personal circumstances—that can feel confining. However, remembering the lessons of effective memory management can empower you to recognize that you can achieve more with less. By prioritizing your essential tasks and creatively managing your available resources, you can unleash your true potential, transforming perceived barriers into stepping stones for personal and professional growth. Embrace the challenge, seek innovative solutions, and you'll find that limitations may actually serve as the catalyst for your greatest accomplishments.

Chapter 8 Summary: Good Stuff

In the correspondence shared in Appendix E of "Game Engine Black Book," we witness firsthand accounts illustrating the profound impact that the game "Wolfenstein 3D" has had on players, showcasing the emotional and psychological facets of gaming.

1. The first email, sent by a former POW named Tug Hill, offers a raw and poignant reflection on the game's ability to evoke memories and intense emotions. This individual hesitated to engage with "Wolfenstein 3D" due to fears of triggering traumatic flashbacks from his past experiences in captivity during the Vietnam War. He shares a harrowing narrative of his escape attempt alongside a friend, which underscores the game's capacity to resonate deeply with players. Remarkably, he observes that the game has lessened the frequency of his nightmares, illustrating its therapeutic potential. The chilling moments within the game—particularly the encounters with armed guards—serve as both a reminder of his past and a mechanism for confrontation. His ultimate conclusion is uplifting, suggesting that despite initial fears, facing one's history through the lens of gaming can be a healing experience.

2. The second email from Ty Graham at Microsoft illustrates the cultural influence of "Wolfenstein 3D" within the gaming community. His playful acknowledgment of the game's popularity at Microsoft, evidenced by the

humorous catchphrase “Mein Leben” echoing through the halls, reflects the game's significant presence. Here, we see a blend of admiration and business acumen, as Graham inquires about potential collaborations with Id Software, expressing keen interest in the company's direction. His suggestion for a port of the game's engine to facilitate multi-user experiences under Windows for Workgroups reveals a forward-looking approach to gaming development, emphasizing the emerging opportunities in the Windows gaming market.

Through these emails, the reader gains insight into the varied and powerful reactions elicited by "Wolfenstein 3D." Not only does the game serve as a source of entertainment, it also offers a platform for players to confront their pasts and fosters a sense of community and interest surrounding gaming innovation in the burgeoning tech landscape of the early 1990s. The emotional resonance and cultural relevance of the game illustrate its significance beyond mere pixels and code, marking a pivotal moment in gaming history.

Critical Thinking

Key Point: Confronting the Past

Critical Interpretation: Imagine finding a way to face your deepest fears and past traumas—could a video game really aid in this journey? The revelations shared by Tug Hill in the chapter remind you that engaging with your history, even through a medium as unconventional as a game, can foster healing. Whether it's reminiscing about moments that once brought you pain or reliving experiences that shaped who you are, this act of confrontation becomes a powerful catalyst for emotional growth. You might not be a former POW, but like Tug, you may find that embracing your past, rather than shying away from it, creates pathways to understanding, acceptance, and ultimately, peace. Let this insight inspire you to confront your own narratives, recognizing that facing them—whether through creative expression, conversation, or yes, even gaming—can be a profound step towards personal healing.