

# A chronicle of emulation: Proposed eras for video game emulators

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## ABSTRACT

Most discussions about videogame emulators revolve around their legality or their use in video game history preservation. Little has been written about their cultural influence or their historiography. However, an active member of the emulation community at the time wrote an exhaustive history of emulators up until 2000. Expanding upon this history by Pettus, the following paper proposes five distinct periods in their history based upon pivotal events: the Dawn of Emulation (1964-1988), the Golden Age of Emulation (1989-1998), the Underground Era of Emulation (1999-2008), the Mobile Era of Emulation (2008-2024), and the Modern Age of Emulation (2024-Present). Breaking down the history of emulators into these five eras allows for additional research into the trends, events, and cultural exchanges that happened within the emulation community. Emulators and the community have reacted and adapted to advances in technology, revealing how the planned obsolescence of video game consoles is being rejected.

## Keywords

Video game history, emulation, qualitative, archives, historical analysis

## INTRODUCTION

Likely due to their ethical nature and connections to piracy, emulators and video game emulation are barely mentioned in historical accounts. In fact, there is very little written about them or their history, especially from the academic perspective. Their ephemeral nature comes from a legacy of hobbyist developers being faced with shutdowns and deletions through legal threats. But additionally, similar illicit products and activities have been documented and researched, such as bootleg consoles (Custodio & Iantorno, 2023; Larson, 2022; Svelch, 2023), software piracy (Chandra, 2016; Eve, 2021; Héту et al., 2012), and file sharing (Crisp, 2015; John, 2014; Oberholzer-Gee & Strumpf, 2010). Tangential topics that use emulators such as ROM

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hacking (Iantorno, 2019; Jordan, 2007) and homebrew development (Camper, 2005; Swalwell, 2021) are researched more than emulators, but their documentation and literature is sparse.

If emulators are discussed in the literature, the topics revolve around their legality or their use in video game history preservation. Due to this lack of accounting for the history of emulation, I conducted a historical analysis and compiled a list of over 350 emulators. Through this comprehensive (but not exhaustive) accounting, I want to propose five distinct periods in their history based upon pivotal events: the Dawn of Emulation, the Golden Age of Emulation, the Underground Era of Emulation, the Mobile Era of Emulation, and the Modern Age of Emulation.

## **Emulation and emulators**

Emulation is defined as hardware or software that enables one computer (the host) to behave like another system (the guest). This process allows the host system to run software (video games) or use peripheral devices (controllers) designed for the guest platform. Thus, an emulator is a program that uses emulation to imitate another program or device. Early on, emulation was predominately used with computer systems, but the history presented here incorporates video game emulators as they became dominant. The technologies used for emulation can be divided into three main categories. There are software emulators that rely on translation, firmware emulators that are contained entirely within hardware, and combination emulators that use both.

Software emulators can be considered “true” emulation as they contain no part of the host system (Pettus, 2000). These emulators translate the logic of the guest system for the host system to interpret and rely upon superior hardware in order to carry out this function efficiently. Software emulators have a legacy of shareware and are widely accessible, they provide additional features and quality of life improvements and are available on nearly every platform. But as mentioned previously, their performance demands mean that a poorly optimized emulator (or a less powerful guest device) can result in poor accuracy<sup>1</sup> and high latency.<sup>2</sup>

Second are hardware emulators. Recently, these types of emulators take the form of Field Programmable Gate Array chips (FPGAs). These processors are configured to replicate the hardware logic circuits almost exactly, and when programmed they can become the logic of a specific console. Hardware emulation has high accuracy, low latency, as well as high compatibility with games.<sup>3</sup> In addition, FPGAs preserve the underlying logic of the original console, maintaining its digital blueprint for future generations of historians and gamers.

Third are combination emulators. These emulators incorporate a software component and a hardware component and offer the most flexibility. Usually, the software does the majority of the emulation while the hardware supplements this process. These were the most prevalent form of emulators used prior to the Underground Era (Pettus, 2000) but have since become less common.

## **Games and ROMs**

Coupled with discussions of emulation is the guest software. In relation to video games, this means the digital copies of the games. These game files are often called

ROMs, because they are copies of data from the read-only memory chip. The process of creating these ROMs has been defended by legal precedent if you are creating digital copies of games you own. Called space-shifting or format-shifting, it is a protected right in other media that has been applied to video games. The sharing of these ROMs is illegal though, being a form of media piracy. Thus, owning the tool to play your games on a different format—having an emulator—is ethical and legal, but using that tool to play games is difficult to do legally. Cartridge and memory board dumpers for consoles and arcades are accessible, but expensive and or difficult to acquire.

## LITERATURE

As mentioned previously, much of the literature on emulation and emulators discuss their connections to media piracy, the ethics of emulation, and their legality. And while discussions on rethinking media piracy are relevant (Karaganis, 2011; Mirghani, 2011), the research into video game piracy is still being built. It is true, that emulation isn't the initial tool to enable piracy, instead it follows piracy (Fenlon, 2017). Emulators are developed after the host system has been hacked and the software shared.

But the existence—or at the very least the prevalence and popularity—of emulators rests on the market demand for piracy (O'Donnell, 2013). And the video game industry continues to group emulation with piracy, arguing that all of these acts disrupt their sales and infringe upon their copyright (Lextorias, 2024; Wagar, 2017). Several court cases have been settled in the case of emulation and the intellectual property rights of video games, revealing a much more nuanced approach to the legality of emulators (Moon Channel 2023 & 2024). Thus consumers, players, and producers often misunderstand of when emulation is legal and when it isn't, despite the ethics being more or less straightforward (Cifaldi, 2016). Again, almost all literature on emulators and emulation include a discussion on why they are ethical and legal in certain circumstances and argue that the act itself is not illegal. This focus means other discussions—such as the direct effect of emulation, the cultural production of emulators, or the oral histories of their developers—are neglected. And despite the negatives of video game piracy, the effect is that it has preserved parts of gaming history that would have become lost to time (Wagar, 2017).

In many ways emulators are defended for their role in video game preservation and history (Cifaldi, 2019; Scott, 2015). Compared to other media, video game technology has a relatively short shelf life: the hardware produced to play games is often obsolete within 5-7 years, depending upon the lifecycle of the console. This has led to a majority of video games becoming inaccessible to play or to buy. According to the Video Game History Foundation, 87% of all games released in the USA prior to 2010 are no longer commercially available (Orland, 2023). In a similar medium, American movies and television have had a conversion rate of around 16.5% of content released on Blu Ray compared to the content released on DVD (Tribbey, 2025).<sup>4</sup> While not a significant difference between these two comparisons, it is worth noting that DVDs are still being manufactured and sold today, unlike their contemporaries in video game cartridges or discs (the Nintendo 64 or the Sony PlayStation).

This systemic issue of the video game industry means that used console hardware and games have intrinsic value as collectors' items. During COVID the market for retro games exploded, with prices reaching unprecedented heights (Pretl-Drummond,

2021). These prices, fueled in part by millennial nostalgia, means that emulators are enticing to players who are unable to afford used games.

The literature on video game emulators also explores some of the affordances. Playing a game through an emulator is vastly different from playing it on original hardware (Farrand, 2012; Lextorias, 2024; Roth, 2019; Stegner, 2021). Emulators provide accessibility options such as save states, the ability to fast-forward or rewind the game, and more control options for button mapping or using non-traditional controllers (Stegner, 2021). Many emulators also allow for enhanced graphics mods or upscaling to modern resolutions and formats. In contrast, the physical hardware and embodied experience of playing retro games traditionally produces nostalgia and changes how players experience the game (Bowman et al., 2023; Bowman & Wulf, 2023). Many gamers feel that playing on an emulator is an inferior experience in this way (Roth, 2019; Stegner, 2021).

## **METHOD**

To establish this comprehensive accounting of the initial releases of emulators, the author relied heavily upon multiple primary sources. First was Sam Pettus's history, which outlined most emulators up until 2000. To fill in the gaps and extend that history, the author relied upon popular forums from that early time period (1Emulation, EmuTalk, Next Gen Emu, Emulator Zone) which had News boards announcing the releases of emulators. In addition, the popular sites Zophar's Domain and Archaic Ruins were also consulted, which served as databases to compile emulators since the 1990s. And lastly, the EMUGen wiki was also used as a secondary source since it contained dates and links to emulators despite having launched much later than the other sources in 2013.

Thus, each of these forum announcements were cross-referenced across each other and the archives of the Wayback Machine when current hyperlinks were broken. And lastly the documentation of the emulators themselves was frequently analyzed to confirm information through the Readme, About, and License text files. These digital sources and archives reveal a mosaic of information about releases of emulators and some discussion on their cultural impact and the emu-scene itself. The following historical analysis of the records included accounting for thousands of forum posts to be cross-referenced and fact checked.<sup>5</sup> The key information compiled were: the name of the emulator, the release date, the author(s), and its software license. In total, 353 separate emulators were documented across the five different periods (Hansen, 2026). Their attributes were compared to reveal the patterns discussed in this article.

It is important to note that the following history comes from English speaking communities, and the data captured comes mostly from Anglophone emulators. Almost none of the emulators documented mentioned where they were created geographically, having only been released online; though a few were in other languages such as Japanese or French.

## **HISTORY**

Following this accounting of the release of emulators, I propose five periods within the history of emulation. Building upon the framework first established by Pettus, this research finds additional periods that have occurred in the subsequent decades. Each of these periods begin after a seismic event that changed the landscape of the emu-

scene such as legal cases and technological breakthroughs. However, this excludes the pre-history of emulation—prior to 1964—as these advancements have been thoroughly documented in other historiographies of video games (Malliet & Meyer, 2005; Nooney, 2023; Spring, 2015; Wolf, 2007) and of computers (Denley & Hopkin, 1987; Swade, 2022; Mahoney, 2011). The many advances that occurred in computing history set the stage for the birth of emulation.

### **Dawn of emulation: 1964-1988**

The history of emulation on computers extends beyond the introduction of personal computers. The first instance of emulation (1964) is the backwards compatibility of IBM mainframe computers.<sup>6</sup> The System/360 and System/370 computers could read and use the software from previous generations. As IBM was establishing itself and its products, it found that consumers were hesitant to invest in newer computers and abandoning all of their previous software and hardware (Smith & Daum, 2019). Alongside the release of the System/360 line of mainframes was the 7070 Emulator by Larry Moss, which was a combination emulator that worked with the older IBM 7070 products and software.

But the first emulator for a personal computer came in 1980 with Microsoft's first hardware product, the 780 SoftCard. A combination emulator, it had an on-board Zilog Z80 CPU and could run CP/M software (the guest) on the Apple II computer (the host). As two competing operating systems for two different computer systems, this is perhaps the first instance of what is traditionally thought of as emulation. It was also a commercial product and was an instant hit (Pettus, 2000).

This period is dominated by similar commercial products or hardware in the form of bridge cards, mod chips, peripherals, etc. that gave users access to the software library of other platforms. Examples include Baby Blue (a CP/M emulator for the PC-DOS), which was an expansion card, Spartan (an Apple II emulator for the Commodore 64), and the PC Sidecar (a PC-DOS emulator for the Amiga 1000) which were peripherals that plugged into the host.

But in 1984 was the release of the first instance of pure software emulation. Sydex released the 22NICE, which was a multifunction CP/M emulator for IBM PCs. Although it worked by itself, optional hardware was also offered to support all of the various CP/M disk formats which required specialized ports (Pettus, 2000). In 1988 the Sega Genesis/MegaDrive was the first video game console to be backwards compatible through a converter sold separately (hardware emulation). This set a precedent with some hardware manufacturers moving forward, many of which at the time didn't have multiple generations of video game consoles yet.

Also In 1988, Readysoft announced their A-Max product. This was the first time that a fully functional emulator had been commercially released for a proprietary system. The A-max was a bridge board that could allow Amiga computers to emulate Apple Macintosh computers. Apple of course objected to this product—they worked so hard to prevent clones of their hardware and software from succeeding—and many in the emu-scene thought a lawsuit was eminent. This dispute signaled a true shift into opinions about emulation, the creation of the emulation community, and began the connection of emulators to piracy: as the software for the A-Max was leaked and spread among Amiga software pirates prior to its commercial release (Pettus, 2000).

## Golden age of emulation: 1989-1998

But Apple never sued Readysoft after the release of the A-max in 1989. And because Apple didn't seek legal repercussions, this became known as "The A-max Precedent," because it solidified views that emulation was legal. Because the commercial A-max product contained no source code or IP of Apple, it seemed like legally they were protected, and a paradigm shift occurred. Whether correctly or not, the ethical framework became that emulation was fine, so long as the emulator itself did not contain copyrighted material.

While the previous age was dominated by commercial hardware products, the Golden Age was a wave of free software made by individuals. There was an explosion of emulators being developed during the 90's, most of which were hobby projects that weren't very functional and quickly abandoned by their creators. These hobbyists and enthusiasts developed into a community, known as the "emu-scene," and shared their software much like the Warez scene<sup>7</sup> (which overlapped in many cases).

Developing emulators that could run at a normal FPS, were compatible with most commercial ROMs, and could play sound at normal speeds was near impossible. Some of the notable emulators from this period include Pasofami (a Nintendo Entertainment System emulator for Windows), Virtual Game Boy (a Game Boy emulator for Windows, Unix, and Mac), and MagiC64 (a Commodore 64 emulator for the Amiga systems). Most of these emulators were software based, as opposed to the previous era's dominance of hardware or combination emulators. The Golden Age of emulation was also a period where video game emulators became possible, and the emu-scene became dominated by them.

According to Pettus, emulators and ROM sites went mainstream and pirated software and games were well known and accessible. Their account labeled this period as the Golden Age for the emu-scene. Sites such as Zophar's Domain and Archaic Ruins were founded, and compiled databases of the breakthrough emulators and ROM files available for them. It was also during this era that the case *Sega v. Accolade (1992)* ruled in favor of reverse engineering and limits the reach of copyright on video game code. This was a win for the emu-scene and codified the A-Max precedent mentioned previously.

This period was also when the SNES emulator war occurred, where developers of opposing SNES emulators had a public falling out and nasty drama (Giannakis, 2021). There was an emulator released (NLKSNEs), that had high latency and was popular for its speed but had low compatibility with the available ROMs (Sneeringer, 1997). The developer of NLKSNEs explicitly called out the other emulators for being inferior, and fans of each side began to "flame" each other (Ibid.). It eventually ended when the developers merged their emulators into SNES9x, which is the leading SNES emulator to this day.

The Golden Age came to an end with a near-extinction event. On March 22, 1998, the Interactive Digital Software Association (IDSA) mounted an all-out attack against ROM sites, threatening legal action for their software piracy. Over the course of six months nearly all ROM sites are shut down, along with many emulation sites. The boom was over, and only the handful of archives remained online were those without any ROM files to share.

## Underground era of emulation: 1999-2008

It took the emu-scene over a year to recover from the IDSA action. This was coupled with the Digital Millennium Copyright Act (DMCA) of 1998, which criminalized the production and dissemination of technology that circumvents copyrighted works. These two major events meant that emulator development and the emu-scene went underground (Pettus, 2000).

Technology progressed so that high-level emulation (HLE) was possible, instead of low-level emulation (LLE) which was the standard at the time. HLE mimics the functionality of a piece of hardware, without getting too deep into the specifics of how the hardware implements it. This means a huge speed boost that uses modern hardware, but the tradeoff is accuracy. On the other hand, LLE aims to emulate the hardware as faithfully as possible, sometimes even going down to emulating the actual logic gates of the processor. It takes more effort to write an LLE emulator, and it is going to be slower, but the result is much closer to hardware. This shift into HLE was signaled by the release of UltraHLE.

In January 1999, UltraHLE was released. It was a Nintendo 64 emulator for Windows and was one of the first video game emulators released for a current console, as the Nintendo 64 was only three years old and still commercially viable. Not only was it the first emulator to use HLE it was also very short lived, as Nintendo threatened legal action in February 1999 and the developers pulled it from the internet.

During this era there were less new emulators released than before. The wave of small hobby projects died down as emulators jockeyed to become the best of their platform. Compatibility again was on the rise, with playable frame rates due to the lower latency.

Two high profile legal cases seem to solidify the legality of emulators in *Sony v. Bleem (2000)* and *Sony v. Connectix (2000)*. First was Bleemcast, a PlayStation emulator for the Dreamcast and Windows released in 1999 by parent company Bleem. It was heavily marketed as a commercial product, and Sony was quick to file legal action. On one count, Bleem won and were allowed to distribute their emulator, but they lost the secondary claim of comparative advertising (Bleem ran ads showing how PlayStation games looked better on their emulator). This along with the appeals and other legal fees meant that Bleem went bankrupt despite their case being a win for emulation.

The second case involved Connectix releasing a PlayStation emulator for the Macintosh called the Virtual Game Station. It mirrored many of the same points as the *Sega v. Accolade* case from before, again solidifying the act of reverse engineering video game BIOS and operating systems as falling under fair use. This was seen as one more win for the legal rights of emulation.

Two major events signaled the end of the Underground Era in 2008: first was the release of the app stores for Android and the iPhone, and second was when the Dolphin emulator went open source. These two events signaled a change in the emu-scene once again as the mobile revolution meant that players were looking for handheld emulators and nostalgic for their video game past. When Dolphin became open source, it signaled its shift into the gold standard for modern emulation in the next age.

## Mobile era of emulation: 2008-2024

This period began with the mobile revolution, which upended other forms of media as well. First came a wave of Android emulators during 2008 and 2009, most of which were ports of older emulators from retro consoles. Later came a wave of unofficial iPhone emulators as Apple took a stance against emulation. But all of these emulators for both mobile platforms signaled a shift into handheld emulation which was later carried out by dedicated emulator devices in the late 2000s.

While there were some emulators ported to consoles in the previous age, the Mobile Era especially became a period of multi-platform-ability for emulators. Current generation consoles could emulate and play retro games, and almost any platform received a port of SNES9x or VisualBoy Advance. This era saw the options for host systems grow alongside the options for guest systems.

Front ends for emulation also became popular during this period. A successful front end of this era was RetroArch, which consolidated many emulators into one. Front ends were especially important during this period for handheld emulators mentioned previously (Retroid Pocket series, Anbernic RG series, Miyoo Mini series, and Powkiddy RGB series).<sup>8</sup> RetroPie was another popular front end as many players made use of the Raspberry Pi to build emulation devices.

Notable emulators from this period include Cemu (a Wii U emulator for Windows), Citra (a 3DS emulator for Windows), and Mednafen (a multi-console emulator for Windows and Linux). These three emulators followed Dolphin and were open-source projects that excelled by crowdsourcing their production. Previous eras such as the Golden Age and Underground Era were dominated by shareware and freeware, which are different licenses to open-source (Hansen, 2026). Also notable were the “oid” series of emulators such as Gameboid and Snesoid, which were available on Android and part of the evolution toward mobile emulation.

As mentioned previously, during this period the Dolphin emulator became the standard for emulation broadly. Its team of developers pushed the emulator above and beyond what the GameCube or Wii could previously accomplish due to the emulator going open source. The community around Dolphin development were constantly refining the emulator to not only have near perfect compatibility but also added quality of life improvements that are now common with other emulators such as graphical hacks, multiplayer capabilities, and improved performance.

And as this emulator led the emu-scene and set the standard for what a good emulator could do, it was also part of what ended the Mobile Era. On May 27, 2023, the Dolphin team announced that they were no longer going to publish the emulator on the Steam store. Prior to this, the Dolphin emulator was going to come to the Steam platform, which of course would mean it gained visibility and accreditation. But Valve reached out to Nintendo in anticipation and sided with them after Nintendo voiced their opposition. This of course coupled with the announcement of the *Nintendo vs. Yuzu* lawsuit to signal a seismic shift in the legality and ethics of emulation.

The Mobile Era ended with the announcement of the *Nintendo vs. Yuzu* lawsuit filed in North America in 2024. This case was settled out of court, but the legal argument from Nintendo signaled a nearly iron-clad approach that skirted previous legal precedent (Moon Channel, 2024). While other cases protected emulators as long as

they did not use the source code or infringed on intellectual property, the Yuzu lawsuit from Nintendo instead argued against the breaking of digital rights management (DRM). Because of modern digital copy protection on console operating systems—such as the Switch—and on their games, it is impossible for modern emulators to function without cracking the DRM of both. Cracking digital protection and distributing services to do so is unquestionably illegal and highly enforced by other laws and acts, meaning Nintendo would likely win with their legal argument. As such, this signaled a new approach to lawsuits from game corporations against emulation that are stronger and more likely to be won.

## **Modern age of emulation: 2024-Present**

In April 2024, Apple changed their stance on emulators and allowed them on their App Store. This embrace of emulators has the potential to change the emu-scene and represent an acceptance of emulation by the large technology companies that have previously fought it. The fallout of *Nintendo vs. Yuzu* was another seismic shift in the emulation community. Due to this threat many emulators pre-emptively shut down or were taken offline by their creators. This self-censoring could have a chilling effect and undermine any other successes (such as the approval of Apple).

The legality of emulators is called into question once again. In hindsight, many of the legal "victories" for emulation and emulators still ended in defeat: Accolade, the Bleem company, and Connectix all went bankrupt not long after their legal battles (Moon Channel 2023 & 2024). And while these cases set a precedent, they were also made by lesser courts over two decades ago. This means the legal defense of emulators is actually in a grey zone, where game corporations like Nintendo don't want to take emulators to court for fear of codifying the legality anymore, but at the same time they threaten legal action to any emulator they see as a threat (Ibid.).

The popularity of FPGAs continues to grow. While introduced in the Mobile Era with the MiSTER project, they were complex to set up and expensive to buy. FPGAs in the Mobile Era were predominately used by enthusiasts with the expertise and knowledge to seek near-perfect emulation. But their popularity will likely happen in the Modern Era more than before, as they become more accessible and more affordable. New clone consoles are using FPGAs in order to emulate through hardware such as the products of Analog, the upcoming M64, and the upcoming SuperStation<sup>one</sup>.

During this age it is apparent that there is a "Cold War," between game publishers and developers of emulators. The nuclear big red button of legal action would likely disrupt the tension between the two, and neither party really wants to press it. However, this looming threat is only getting closer and someday soon it will be pressed and the emu-scene—and by extension all of video games—will be changed forever.

## **CONCLUSION**

In conclusion, why study the history of emulators? It's important to track when these software programs were released, how they changed the video game community, and how they were influenced by the current culture. Despite their connections to piracy, they serve a vital role in video game preservation. They are the tools for ensuring the history of video games is accessible to future historians. This exploratory research then lays the foundation for additional historical analysis of emulators, emulation, and their role in video game culture.

Trends in the types of emulators produced and the types of emulators used by players, consumers, and collectors form a backbone for the history discussed above. While originally dominated by combination and hardware-based emulators, the emu-scene eventually adopted software emulators that are still dominant today. Today, casual gamers typically use the straightforward software emulators and collectors typically use the more accurate hardware emulators. However, as FPGAs continue to advance and are becoming more accessible in price, they are being adopted by more than just enthusiasts and purists. And these trends are likely to change in the future as they have changed from the past.

These eras also represented differences in the approach to emulation by the community: first were a wave of hobbyist projects released as shareware, next was a refinement and adoption of HLE, next was the adoption of open-source projects, and last is the modern era. These proposed eras arose out of a cultural analysis of patterns found in some of the many factors related to the releases of emulators.

Some limitations of this study include its breadth instead of depth: it sought to chronicle macro-level trends and provide a foundation for future historians. Further research should be done into the nuances and historiography of these emulators. While this study only looked at initial releases, it is also worth analyzing those emulators that received periodic updates and were maintained overtime. Additional research should also be done by interviewing the developers of these emulators, whose oral histories could provide insight into their cultural production.

Thus, a greater cultural study on emulators, emulation, and the emu-scene is needed and could build off these proposed five eras. More can and should be written about the pivotal emulators that have shaped the medium of video games. The adoption of handheld emulation devices in the Mobile Era continues into the Modern Age and mirrors the success of the hybrid console. The Steam Deck and Nintendo Switch and Switch 2 were not designed to be emulation devices, but their success has led to imitators that are.

Emulation is a medium like others worthy of its own history and analysis despite its ethical quandaries and DMCA threats. Studying emulation is not condoning copyright theft and would benefit the field of game studies. As the video game industry continues to grow with new generations of consoles, their predecessors are increasingly made obsolete by publishers and developers. Emulators and the community have reacted and adapted to these advances, revealing how the planned obsolescence of video game consoles is being rejected.

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## ENDNOTES

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- <sup>1</sup> Accuracy is defined as the system recognizing inputs from the player.
- <sup>2</sup> Latency is the time between the input from the player and when the instructions are processed by the system. Having a high latency means a longer input lag which is noticeable in certain types of games.
- <sup>3</sup> As hardware emulation captures all of the logic of the guest system, any game that works on the guest will work on the host.
- <sup>4</sup> As of February 2025, in the USA there were 351,823 releases on DVD, and 57,934 releases on Blu Ray. There are also only 2,343 releases on 4K Ultra HD.
- <sup>5</sup> Worth mentioning that almost 90% of posts in these news forums are updates to previous releases. After a while you see that many emulators got frequent updates announced while most did not. Big names like MAME were updated almost weekly.
- <sup>6</sup> Backwards compatibility is a common form of emulation with video game consoles, allowing for players to keep their libraries of games for the past generation.
- <sup>7</sup> The Warez scene was a community of software pirates that bypassed digital rights management and shared their cracked software via online message boards and eventually peer-to-peer networks.
- <sup>8</sup> Linux and Windows-powered handhelds such as Ayn Odin/Loki, and of course Valve's Steam Deck, have their own OS and often don't use Front Ends or specialized software to consolidate emulators. But they are worth mentioning at least, Windows-powered handhelds are another market that gained popularity during this period.