

Lessons from the Game Cartridge

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For most of their history, computer games were the province of the computer engineers. They wrote the first games, they designed the first hardware, and they provided the quirky, fantasy humor that brought so much creative material to the modern games market. It is thus in no way surprising that the adoption of the video game cartridge should appeal to these engineers; it was a solution to a design problem, a solution that only later came to be distorted by imitators and marketing interests. Today, the march of technology has eliminated all but the last vestiges of the video game cartridge from modern game consoles, though it still retains many of the difficult lessons learned by the early game companies.

This history, then, is a history of the game cartridge. Of the Magnavox Odyssey and the beginnings of the game cartridge. Of the Atari 2600, the true classic of the gaming market, whose very popularity caused it to fail. Of the Nintendo Entertainment System, the first console to control, and even abuse, the cartridge system. This is a history of consoles and video games, as told through the game cartridge. It is the story of how a piece of technology drove a market.

The first cartridges: Magnavox Odyssey

Going back to the very beginnings of game cartridges requires a journey to the first game console that supported multiple games: the Magnavox Odyssey. In 1968, Ralph Baer and Lou Etlinger demonstrated a prototype console for Magnavox executives; four years later, in 1972, the Odyssey reached the market [1]. As originally designed, the Odyssey had a set of switches to select one of sixteen games included with the system; however, Magnavox decided to replace these switches with eight replaceable plug-in cards representing sixteen games [1]. This marketing decision has one obvious advantage: the available set of games is a vendor-controlled variable, meaning Magnavox could target one market with the basic consumer (with a few basic cartridges) and derive further income by selling kits containing additional games to more enthusiastic consumers. It also solved an engineering problem: by reducing the complexity of the motherboard for the system itself, Magnavox could save on production costs. Magnavox ultimately sold the system for \$100, containing six cards that could play twelve games; an add-on pack containing a rifle and four more games (two cartridges) sold for an additional \$25 [1]. Unfortunately, the high price of each system and Magnavox's decision to sell the Odyssey only

through Magnavox resellers hindered acceptance of the machine. It derived only moderate profits for Magnavox [1].

The primitive Odyssey cards (fig [2]) contained simple wire jumpers, connections that positioned a player's dot on the screen and controlled a few behavioral aspects, such as collision handling [3]. More importantly, thought was the selection offered by the game cartridges: as Sam Hart notes in his history of early game consoles, “it was a common complaint among consumers that systems with multiple games only had one or two desirable games” (this is in reverence to the Odyssey and its clones) [4]. A consumer had sixteen games to choose from – some were admittedly very boring, but just about everyone should find at least one enjoyable game in that collection. However, the whole idea of a game cartridge was not merely new to consumers. In a historical accident, Magnavox neglected to push their add-on game cartridges at the retail level [1]. This oversight, obvious to modern students of the computer games business, nonetheless illustrates how completely unfathomable the game cartridge was at its initial appearance – what reason beyond mere accident could cause a company to neglect a major subset of its product line?

The lessons from the Magnavox Odyssey's primitive cartridges are both technical and economic. From an engineering standpoint, game cartridges simplified engineering problems and reduced costs. From the marketing side, the cartridge made the Odyssey palatable to a wider range of consumers. The seeds of the game cartridge, then, were planted; future game console manufacturers would quickly release their own improvements that overcame these initial, cumbersome steps.

Atari 2600: Success... and Failure

The seventies saw several additional game consoles, each offering a small selection of games but none differing from the basic premise of altering a few hardware connections. That is... until the programmable cartridge systems arrived. The first, and least notable, was the Fairchild Channel-F system, which permitted the consumer to insert different cartridges to change the game [5]. However, the Channel-F was quickly overshadowed by the now-famous Atari 2600 (or Atari VCS). Containing an 8-bit processor and other expensive hardware, the 2600 shipped in 1977 with nine game cartridges [6]. Perhaps more importantly, these were nine very distinct games. Instead of playing Pong and a dozen Pong clones, consumers could now

play several *Combat*, or other completely separate games that were not merely clones of the earlier ball-and-paddle systems. By the end of the 2600's 10-year sales run, over 500 “official” games existed, plus numerous pirate versions and low-quality clones [7]. The Atari 2600 gave birth to the era of the cartridge game.

The implications of the Atari 2600 cartridge format were much more spectacular than the system itself. Most immediately, the cartridge was a completely open standard [8]. Atari was unpleasantly forced to tolerate legions of imitators producing low-quality games that saturated the market and quickly destroyed the market for Atari. Without some form of quality-control, consumers encountered a classic problem from economics: a lemon market, where the risk of buying junk is so high that the value of the few quality games disappears beneath the low value of the junk. As Nintendo, and the more modern game systems, eventually show, control of the cartridge format is essential for maintaining quality for the consumer.

Not all news was bad, however. The third-most popular game of all time (by cartridges sold), *Pitfall*, appeared in 1982 [9], published by the independent game developer Activision [10]. The most interesting realization here is the date: *Pitfall*, possibly the 2600's most important single game, appeared a full five years after the game console appeared on the market; when the console was developed, nobody even anticipated a game like *Pitfall*, much less designed the system for the game in advance. The second realization is the presence of an independent developer. The independence of the game console and the game itself demonstrate a new feature of the cartridge game: the cartridge is a medium in of itself, developed comparatively independent from the console – even being developed several years after all development work on the console has ceased. The cartridge, a realm of high-profit sales (cartridges that cost mere dollars to make sold for \$20), became independent of the console (selling for hundreds of dollars with minimal profit margins), a low-profit market [11]. This separation, and the desire of entrepreneurial game developers to enter the high-profit market of game development, also marked the beginning of the game developer as a profession distinct from the hardware developer. The Atari 2600 created the fundamental distinctions that still remain in today's game market between the platform and the game development studio.

From a purely technological standpoint, the Atari cartridge introduced a new feature: the cartridge was exclusively memory. Read-only memory, in particular, called ROM in industry parlance, was still an expensive commodity during the Atari's time, but it was drastically cheaper

than designing custom electronics and other hardware to place in each cartridge in the manner of the Odyssey's hard-wired design. The ROM cartridge also shifted the cartridge game much closer to the increasingly popular computer game, which was distributed on floppy disks. Attempting to bridge this gap, Atari eventually produced the Atari 400 and Atari 800, some of the earliest personal computers. In an effort to alleviate the high cost of a mechanical disk drive, the 400/800 included a cartridge reader similar in design to the Atari 2600 game console, though in practice incompatible [12, 13]. Unfortunately for Atari, the magnetic storage of a floppy disk drive was far more economical than ROM chips, and competitor's computers (the Commodore 64 and the Apple II) quickly outpaced Atari in the personal computer market. The ROM cartridge, then, was revealed as an ideal medium for games with low storage memory requirements that did not require a separate data store – that is, for games that did not require a full computer system to play. The cartridge therefore created a division between the console market, where games could run off of ROM on specialized consoles, and the computer game market, which required more advanced (and more expensive) hardware. This division remains, though somewhat blurred by advances in technology, in today's console and computer game market.

During the age of the Atari, the modern console game industry starts to appear. Wide game portfolios, independent game developers, and game distribution in standardized ROM formats are features that still exist today.

Nintendo: Asserting control – and killing the competition

The nascent computer games industry did learn one harsh lesson from the Atari 2600: quality matters. The next iteration of cartridge technology came from Nintendo, and carried one very prominent (and very controversial) feature: a lock-in system that prevented independent publishers from creating games for Nintendo's newest system.

The Nintendo Entertainment System was technically an uninspired piece of hardware. Its contemporary, the Sega Master System, featured hardware twice as fast and four times as capable [14]. However, an extremely expensive and well-targeted marketing drive captured a large market share for Nintendo [15]. At this point, Nintendo could shift from being a follower, copying the trends of the industry and hoping to make a quick buck, to a leader, able to set new trends and bring the games industry into compliance with its enormous market share. Once

again, the vehicle for this re-targeting of the game industry was the game cartridge. Nintendo's executives included a special "key-chip" within the cartridge, the specifications of which were tightly controlled by copyright and patent [15]. Having this chip immediately gave Nintendo a captive market; anyone wishing to produce games for the extremely popular Nintendo Entertainment System had to agree to Nintendo's contractual agreements. Nintendo was quick to exploit this power: typical contracts required game companies to produce games exclusively for the Nintendo platform [15]. This exclusive contract was not necessarily bad for Nintendo games, but did prevent game studios from entering the markets of other console platforms, and thus denied the Sega Master System the selection of games that Nintendo enjoyed. The key-chip lockout, made possible by the game cartridge, allowed Nintendo to exert monopolistic control over the market. This control was not unnoticed; in 1989, all fifty states in the United States successfully sued Nintendo for anticompetitive practices (though the actual punishment was insignificant) [15]. For better or worse, it was Nintendo's wide selection and variety of games that spurred Nintendo's acceptance with the consumer, in direct imitation of the Atari 2600's earlier successes.

The other advantage of the key-chip lockout was the appearance of licensing agreements. Familiar to modern game developers, these agreements require a game developer to pay a certain royalty to the console manufacturer per game sold. Atari was unable to collect licensing fees for the 2600, as their only leverage was the actual architecture of the 2600 console. In fact, after attempting to sue to block independent publication, the courts decided Atari could not use their intellectual property rights to restrict the creation of Atari game cartridges [16]. Nintendo, however, had a more powerful weapon: their mandatory licensing agreements to gain access to the key-chip could also specify a licensing fee. This finally provided a source of income for the console manufacturer to recoup the expenses of producing a new console without developing a large repertoire of games in-house. The cartridge, and the lockout system provided by the cartridge, provided the console manufacturer with a way to profit from the console hardware sales, previously a low-profit market, and thus gave the console manufacturers the freedom to experiment with different systems.

Nintendo's lockout of independent game studios did have one major advantage for the console market as a whole. Because Nintendo controlled the distribution of games through their contractual agreements, and because Nintendo had watched Atari flounder under the weight of

hundreds of imitation games and clones, Nintendo chose to restrict the sales of game cartridges. From the strictly business perspective, Nintendo chose this tactic to control their resellers with inventory shortages [15]. From a holistic industry perspective, however, this tactic has the advantage of restraining the market, thus ensuring a certain amount of quality among new game releases and preventing consumer fatigue. Nintendo could shamelessly promote individual well-made games into blockbusters while simultaneously blocking imitators from the market, which had the effect of increasing consumer recognition of computer games. One example is the most popular game of all time (by units sold): Super Mario Brothers 3, which sold over 11 million copies during its lifespan [17]. Super Mario Brothers 3 was over-marketed to an extreme: the movie *The Wizard*, released in 1989, is now regarded as a marketing drive exclusively for this one game [18]. Super Mario Brothers 3 was not a particularly innovative game – the later Commander Keen series of computer games was essentially an imitation – but by conscious decision of Nintendo it came out with a unbeatable market branding. The consumer recognition of this game in particular, and of console games in general, fed back into a general consumer acceptance of the console game system. Atari could not achieve this long-term acceptance with the 2600 because Atari was unable to bring quality games and originality to the games market in anywhere near the way Nintendo, with its cartridge and key-chip lockout, could enforce a prosperous business environment.

Though Nintendo's cartridge-manipulation tactics were despicable by modern anti-competitive standards, they undoubtedly helped bring out large-scale consumer awareness of the console game – implicitly (at this time) the cartridge game – as a household technology, moving gaming out of the realm of the technically apt and into the realm of the average consumer.

Modern console games: Vestiges of the cartridge

Today, the console game market no longer depends on the cartridge itself to create a survivable market. Some recent systems, such as the Nintendo64, still use some variant of the game cartridge [19]. An increasingly common method of distribution, however, is the CD/DVD-ROM; the Microsoft Xbox and Sony Playstation 2 use standard DVD drives taken directly from the computer industry [20, 21]. However, the move away from cartridges and towards commodity hardware does not mean the industry has forgotten the lessons of the cartridge. Examining one of these new consoles, the Microsoft Xbox, reveals an involved security system

that stores a secret, encrypted boot code on the CD/DVD for every authorized game [22]. This, then is the modern equivalent of Nintendo's key-code chip, enabling modern console manufacturers to control the availability of games for their systems, allowing these vendors to gain Nintendo-like acceptance for their systems instead of Atari-esque consumer fatigue.

The history of the console game can be retold as the history of the game cartridge in a way that displays the origin of and rationale behind many of the trends in today's game industry. During the time of the Magnavox Odyssey, the cartridge first appeared as a solution to engineering and marketing problems. The later Atari 2600 advanced the idea of a conceptually separate development cycle for the game console and the cartridges that play on it, giving rise to the modern game development studios. Nintendo added copy protection and technological restrictions to control the game retail market in a process that ultimately brought the market from the Atari overabundance of games to the Nintendo mainstream. Each of these earlier advances in game cartridge design and use has a modern equivalent.

Looking forward, two current trends within the game community are the proliferation of "mod-chips" that overcome copy protection technology and the increasing instance of games developed both for a PC platform and a console platform. Examining these two trends in the light of historical development describes how hesitant we should be to accept them. Without copy protection technology, the console market could easily fall into the glut of imitation games that doomed the Atari 2600; abuse of copy protection technology could place the market in the realm of Nintendo's abusive monopoly. Cross-developing games runs the risk of specializing hardware into an unsupportable niche market that doomed the Atari 400 and Atari 800. Neither of these concerns is insurmountable, but history teaches us that there are very good reasons why console games have features left over from game cartridges, and we should not dismiss those reasons without understanding the lessons of history.

Footnotes

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This paper relies completely on online sources. However, the above sources are authoritative in their knowledge presented – though they are fan sites, they are written by serious hobbyists who I treat as experts on the subjects, and are presented in the style of online museums. Some of the sites present their own bibliographies.