Music in Ones and Zeros

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We live in an era of unprecedented musical accessibility. Over the last century, technology has completely transformed the way we create, distribute, and consume music, and there is every reason to assume that similarly transformative practices will occur over the next hundred years. Advancements in technology raise important issues about the nature of music and the music industry; however, the most substantial barriers to innovation are neither technological nor musical, but social, legal, and ethical. Such issues manifest most clearly in three areas: digital sampling, synthesized music, and music distribution.

Composers have borrowed themes, melodies, and ideas from other musicians for centuries. In the twentieth century, the tape recorder made it possible to extract short clips of sound recordings for reuse in other works, a technique known as *sampling.*[1] With the advent of digital recording, sampling can now be performed with no loss in sound quality.[2] Sampling encouraged musicians to reuse music in entirely new ways, not unlike the ways in which composers borrowed musical ideas in past centuries. Hip-hop used sampling extensively, but because hip-hop artists often sampled copyrighted material without obtaining permission, legal concerns began to emerge. Because sampling duplicates a specific realization of a work rather than a musical idea, it was seen as violating copyright. In the early 1990s, legal precedents were established against digital

1. Helga de la Motte-Haber, "Sound Sampling: An Aesthetic Challenge," in *Music and Technology in the Twentieth Century*, ed. Hans-Joachim Braun (Baltimore: The Johns Hopkins University Press, 2002), 202.

2. Digitization, by definition, enables data to be manipulated and copied losslessly, whereas analog technology inherently results in degraded quality because it does not reproduce sound at a discrete level of detail.

sampling, leaving the future of hip-hop and digital sampling in jeopardy.[3]

Synthesizers — electronic keyboard instruments that produced sound via pitch and timbral generation — evolved throughout the twentieth century and became known for their distinctive and adaptable sound. In the 1980s, synthesizers rose to prominence in a genre termed *synth pop*, characterized by conspicuously electronic timbres and mechanical, repetitive rhythms.[4] With the advancement of microprocessing technology, synthesizers began to sound less electronic and more realistic, and as computers became more common and more powerful, they too became capable of synthesizing sound, working in concert with keyboard-style synthesizers to produce music with all types of instrumental sounds. Today, even inexpensive personal computers are capable of synthesizing the sounds of entire orchestras with impressive quality. Moore's Law supports predictions that computers will become tremendously more powerful in a short time, and recent advancements in digital synthesis stand to achieve levels of sonic quality that are indistinguishable from acoustic instruments.[5]Digital music has become more portable and less expensive to maintain than comparable human ensembles; in some cases, musicians have already been replaced by digital recordings and synthesizers.[6] As digital music's convenience and improving realism take on more roles previously occupied by humans, musicians and audiences will need to consider whether the truly human components of music — such as unpredictability, emotion, and physical skill — outweigh the simplicity and convenience of digital music.

In the span of only a few years, the Internet has transformed the music industry, with some online music stores now outpacing sales at brick-and-mortar outlets.[7] Digital music files threaten to render tangible media such as records and CDs obsolete due to their flexibility and portability.

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3. Olufunmilayo B. Arewa, "From J.C. Bach to Hip Hop," *North Carolina Law Review* 84 (2006): 580.

4. Doug Eisengrein, "Renewed Vision," *Remix Magazine*, September 2005, http://remixmag.com/mag/remix_renewed_vision/index.html.

5. "Moore's Law," Intel Corporation, http://www.intel.com/technology/mooreslaw/. Moore's Law implies that the number of transistors on a chip will double about every two years.

6. David Pogue, "Are Digital Orchestras a Sign of the Times?" *The New York Times Online*, June 2008, http://pogue.blogs.nytimes.com/2008/06/05/are-digital-orchestras-a-sign-of-the-times/.

7. Michelle Quinn and Dawn Chmielewski, "Top Music Seller's Store Has No Door," *The Los Angeles Times*, April 2008, http://articles.latimes.com/2008/apr/04/business/fi-itunes4.

The record industry didn't anticipate this change quickly enough, leading to the rise of peer-to-peer file sharing networks; millions of users swapped hundreds of millions of files for free, sending the record industry scrambling. Online music stores, with unmatched convenience and low prices, soon emerged to provide customers with an easy way to purchase music from the convenience of their own homes.[8] But the peer-to-peer movement concerned copyright holders, and online music stores sold music with digital rights management or DRM. DRM sought to prevent unauthorized copying, but also prevented consumers from fully exercising their fair-use rights by restricting the number of times a song could be copied, even for personal use.[9] DRM remains an important issue today, as consumers and copyright holders seek to balance their own interests. Additionally, musicians have begun to question the need for record labels, which consume over 85% of album revenue per performer on average.[10] Technology enables musicians to create, share, and distribute their music on their own, thus leading bands such as Radiohead to sell music without the aid of a record label. Musicians and the record industry continue to seek out new ways to take advantage of these new technological developments.

This thesis will examine the subjects of digital sampling, synthesized music, and music distribution. Each of these affects society, but the issues surrounding these topics will become more significant as computers become more powerful and pervasive. Musicians will find new ways to incorporate technology into their creative works as consumers and the music industry struggle to address concerns of fair use and copyright.

Digital Sampling

For centuries, composers have employed musical borrowing as a technique to enrich their own compositions. Entire books have been devoted to the techniques that composers have employed

8. "Apple Launches the iTunes Music Store," Apple.com, http://www.apple.com/pr/library/2003/apr/28musicstore.html.

9. David Kusek and Gerd Leonhard, *The Future of Music: Manifesto for the Digital Music Revolution* (Boston: Berklee Press, 2005), 149.

10. Eliot Van Buskirk, "Apple Threatens iTunes Shutdown over Royalty Dispute," *Wired Magazine*, October 2008, http://blog.wired.com/music/2008/10/thursdays-copyr.html.

when reusing other material; indeed, borrowed material was "the very *fons et origo* of Western polyphony itself."[11] Even great composers borrowed extensively: Beethoven composed variations on a theme by Mozart; Brahms wrote *Variations on a Theme by Haydn*; Rachmaninoff wrote *Rhapsody on a Theme of Paganini*.[12] Jazz musicians regularly reuse existing harmonic structures and phrases from earlier composers, as in the adaptation of the harmonic changes in George Gershwin's *I Got Rhythm* to Duke Ellington's *Cotton Tail*, Charlie Parker's *Anthropology*, Sonny Rollins's *Oleo*, and Thelonious Monk's *Rhythm-A-Ning*.[13] Before the proliferation of recording technology, composers would borrow certain voices, melodies, or harmonic progressions.[14] While composers could borrow substantial portions of material in this manner, traditional manual borrowing was fundamentally different than musical borrowing employed via digital sampling. Manual borrowing necessarily implies a more abstract notion of copying; the borrower may place an existing melody in a new harmonic context, alter the instrumentation, or change the rhythm. In all cases, however, the borrower would essentially borrow the tune itself rather than a specific performance of that tune.

Just as a photomontage incorporates existing photographs, sampling involves the reproduction of a specific *sonic* event. Whereas a composer might reuse an existing melody by copying its notation, for instance, sampling enables composers to reproduce a melody as realized at one particular point in time. Sampling — as a process of recording a sound and later incorporating it into another work — began as early as the 1940s, when Pierre Schaeffer experimented with collages of music from tape recordings, which he called *noise études*. Schaeffer's work was among the first examples of *musique concrète*, a form of music that uses recorded sound as a compositional resource.[15] Schaeffer attracted a group of interested young musicians, including

11. Honey Meconi, "Introduction: Borrowing and Early Music," in *Early Musical Borrowing*, ed. Honey Meconi (New York: Routledge, 2004), 1.

12. Miles Hoffman, "Making Music with Tuneful Leftovers," NPR Morning Edition, November 2005, http://www.npr.org/templates/story/story.php?storyId=5021390.

13. Bob Russell, "Rhythm Changes, part 2," Bob Russell's Jazz Guitar, http://people.uncw.edu/russellr/rhythm2.html.

14. Meconi, "Introduction: Borrowing and Early Music," 152-53.

15. Motte-Haber, "Sound Sampling: An Aesthetic Challenge," 202.

Olivier Messiaen, Pierre Boulez, and Karlheinz Stockhausen, who also experimented with musique concrète.[16]

Early sampling technology was primitive and cumbersome, involving large reel-to-reel tape recorders. Composers had to literally cut and splice pieces of magnetic tape, a tedious and time-consuming process. Terry Riley, another pioneer of early sampling, even had to resort to unconventional methods to achieve the effects he desired: "When I started making loops, I had my studio in an old garage, and it wasn't very big. I had to run the loops out into the yard and around wine bottles, so I could get thirty-foot loops. Then I would use scissors and tape. It was really funky."[17] Fortunately, reel-to-reel machines gave rise to tape recorders, which in turn begat digital technology. Digital sampling, unlike tape dubbing, retains the original quality of sampled sound and enables composers to splice together music quickly and easily.

As digital sampling became more accessible and efficient, composers and artists turned to sampling as a new resource. But interest in digital sampling brought forth intellectual property concerns. Herein lies the difference between traditional borrowing and sampling: sampling typically copies a specific, fixed realization of a work, whereas traditional borrowing recasts the borrowed material in new molds. Manual musical borrowing had been employed for ages and was rarely substantial enough to provoke copyright concerns. Sampled material, however, often came from existing, copyrighted recordings. Additionally, the largest market for music was no longer through works intended for live performance; instead, musicians often produced compositions primarily intended for performance in the recording studio.[18] Record companies today profit through the sale of artists' recordings, so when a sample from a copyrighted work comprises part of an album intended for sale, copyright holders take notice.

Digital sampling raises ethical and legal questions regarding the rights of composers and artists. Copyright law varies from nation to nation, and evolves with time; for the sake of this paper, I will focus on copyright in the United States, with the understanding that regulations may

16. Michael Chanan, *Repeated Takes* (London: Verso, 1995), 141.

17. Robert Schwarz, *Minimalists* (London: Phaidon Press, 1996), 34.

18. Chanan, *Repeated Takes*, 142-143.

differ in other countries. Record labels, musicians, and composers may all lay claim to copyright on different aspects of a recording. Under United States copyright law, copyright holders have the exclusive right to determine who can:

- reproduce the work in copies or phonorecords,
- prepare derivative works based upon the work,
- distribute copies or phonorecords of the work to the public by sale or other transfer of ownership, or by rental, lease, or lending,
- perform the work publicly,
- display the work publicly, and
- in the case of sound recordings, perform the work publicly by means of a digital audio transmission.[19]

Those conditions forbid digital sampling in its entirety, but copyright was never intended to give copyright holders unlimited control over their works; rather, copyright was created in order to balance the intellectual property rights of individuals against the needs of the public. Copyright ensures that copyright holders receive credit for their work, while preventing others from stealing and potentially profiting from that work. The argument about copyright in the context of digital sampling derives from whether or not sampling can be considered an exception to copyright law.

The *Copyright Act of 1790* provided the foundation for modern copyright law. It granted copyright holders monopoly control of their work for fourteen years, with an option to renew copyright protection for another fourteen.[20] Today, copyright law extends for 28 years with an optional renewal term of 67 years.[21] Works under copyright law are not completely protected from musical borrowing, however. Marjorie Heins, founder of The Free Expression Policy Project, a non-partisan organization dedicated to research and advocacy of copyright issues, notes: "If copyright owners could control — and effectively ban — every quotation or other use

19. United States Copyright Office, "Copyright Basics," http://www.copyright.gov/circs/circ1.pdf.

20. Marjorie Heins, "The Progress of Science and Useful Arts," http://www.fepproject.org/policyreports/copyright2d.pdf, 4.

21. United States Copyright Office, "Duration of Copyright," http://www.copyright.gov/circs/circ15a.pdf, 1.

of their work, they would exercise a powerful form of censorship."[22] Heins recently compiled a report that highlights four "safety valves" that allow individuals to use copyrighted works such as musical compositions.[23]

"Fair use" is one such safety valve. Fair use allows the use of copyrighted work on a limited basis, taking into account four factors: the purpose and character of the use (including whether such use is commercial or for nonprofit educational purposes), the nature of the copyrighted work, the amount and substantiality of the portion used in relation to the copyrighted work as a whole, and the effect of the use upon the potential market for or value of the copyrighted work.[24]

Courts have ruled that parodies — works which imitate prior works, often in literary, humorous, or satirical ways — are often considered fair use.[25] As explained by the Supreme Court, "the heart of any parodist's claim to quote from existing material is the use of some elements of a prior author's composition to create a new one that, at least in part, comments on that author's work." In *Campbell v. Acuff Rose Music*, the rap group 2 Live Crew parodied a portion of Roy Orbison's "Oh Pretty Woman" in their own song ("Pretty Woman") by incorporating text and melodies from Orbison's version into their own. The Supreme Court ruled that 2 Live Crew's parody was covered under fair use even though "Pretty Woman" was marketed commercially. The Court stated that "the more transformative the new work, the less will be the significance of other factors, like commercialism, that may weigh against a finding of fair use."[26] The Court also made another key point in its ruling: "The cognizable harm is market substitution, not any harm from criticism. As to parody pure and simple, it is unlikely that the work will act as a substitute for the original, since the two works usually serve different market functions."[27] Thus, commercial use does not inherently constitute copyright violation.

Works must demonstrate sufficient originality to receive copyright protection; that is, a

22. Heins, "The Progress of Science and Useful Arts," 9.
23. Ibid.
24. United States Copyright Office, "Fair Use," http://www.copyright.gov/fls/fl102.html.
25. Arewa, "From J.C. Bach to Hip Hop," 575.
26. Campbell v. Acuff-Rose Music, Inc, 510 U.S. 569 (1994)
27. Ibid.

sampler cannot simply create a medley of recordings and still expect to be covered.[28] Yet copyright law remains unclear regarding what constitutes an "original musical work":

> One core element that runs across many definitions is that originality requires an independent creation, which essentially appears to rule out or significantly limit borrowing. As is the case with literary copyright, concepts of originality in music copyright are full of assumptions about the nature and manner of artistic creation that are largely based on an image of a Romantic author.[29]

The Romantic view of intellectual property is based on the assumption that works created by an individual are products of pure inspiration or genius, without taking into account inspirations derived from other influences: "Although courts and legal commentators sometimes acknowledge the existence of borrowing and collaboration in 'original' works, the full implications of such borrowing and collaboration rarely filter through in the application of copyright doctrine."[30] Copyright law, therefore, doesn't fully account for the influence of borrowing in the composition of music through the ages.

The first court ruling regarding sampling in hip-hop music was *Grand Upright v. Warner Bros. Records* in 1991.[31] Biz Markie, a hip-hop artist for Warner Bros. Records, had sampled portions of Raymond O'Sullivan's "Alone Again (Naturally)" in his own work entitled "Alone Again." Warner attempted to secure permission from O'Sullivan before publishing Biz Markie's album, but they released the album before they received a response.[32] Judge Kevin Duffy ruled pointedly against Warner:

> 'Thou shalt not steal' has been an admonition followed since the dawn of civilization. Unfortunately, in the modern world of business this admonition is not always followed. Indeed, the defendants in this action for copyright infringement would have

28. Arewa, "From J.C. Bach to Hip Hop," 564.
29. Ibid., 565-66.
30. Ibid., 566-67.
31. Ibid., 579.
32. Grand Upright v. Warner, 780 F. Supp. 182 (S.D.N.Y 1991).

> this court believe that stealing is rampant in the music business and, for that reason, their conduct here should be excused. The conduct of the defendants herein, however, violates not only the Seventh Commandment, but also the copyright laws of this country.[33]

The ruling effectively defined borrowing without permission as theft.[34] As a result, would-be samplers must now obtain permission from copyright holders to sample copyrighted works, or face fines of up to $100,000 per violation.[35]

How long does a sample need to be to constitute copyright infringement? Could there be exceptions to the *Grand Upright v. Warner Bros. Records* ruling if a digital sample was brief enough? In 2005, the courts answered that question in *Bridgeport Music, Inc. v. Dimension Films*. In copyright law, the term *de minimis* refers to use of copyrighted material in such a minimal and insignificant manner that it is considered fair use. In determining what can be considered *de minimis*, courts consider factors such as whether or not an average audience would recognize a sample, or how important the sample was to the original composition.[36] In *Bridgeport Music, Inc. v. Dimension Films,* the hip-hop group N.W.A. sampled two seconds of a guitar chord from a song by Funkadelic and repeated the chord five times at a transposed pitch.[37] A federal judge initially ruled that the incident was fair use, but an appeals court later overturned that decision and ruled against N.W.A.: "Get a license or do not sample. We do not see this as stifling creativity in any significant way. It must be remembered that if an artist wants to incorporate a 'riff' from another work in his or her recording, he is free to duplicate the sound of that 'riff' in the studio."[38]

That ruling effectively forbids all types of unlicensed digital sampling of any duration. Olufunmilayo Arewa reflected on the court's decision, noting that it "appears to derive from the

33. Ibid.

34. Arewa, "From J.C. Bach to Hip Hop," 580.

35. Ben Challis, "The Song Remains the Same: A Review of the Legalities of Music Sampling," Music Law Updates, http://www.musiclawupdates.com/articles/ARTICLE%2003thesongremainsthesame.htm.

36. Arewa, "From J.C. Bach to Hip Hop," 573-74.

37. "Bridgeport Music Inc v. Dimension Films," 2005, http://fsnews.findlaw.com/cases/6th/04a0297p.html.

38. Ibid.

court's desire to establish a bright line rule for determining infringement of sound recordings. The court analogized sampling to a physical taking rather than an intellectual one."[39] As of this writing, *Bridgeport Music, Inc. v. Dimension Films* remains the latest ruling on digital sampling.

Digital sampling is only legal when samplers obtain permission from the copyright holders of the sampled works. The current legal state of affairs is ideal for copyright holders, for obvious reasons: copyright holders today have legal assurance that their music will not be sampled without permission. While these rulings don't prohibit musicians from sampling other recordings in their own works, musicians must obtain permission for *every* sample, no matter how brief. Musician Beck Hansen lamented about how sampling's legal status has affected his music:

> It's pretty much impossible to clear samples now. We had to stay away from samples as much as possible. The ones that we did use were just absolutely integral to the feeling or rhythm of the song. But, back then, it was basically me writing chord changes and melodies and stuff, and then endless records being scratched and little sounds coming off the turntable. Now it's prohibitively difficult and expensive to justify your one weird little horn blare that happens for half of a second one time in a song and makes you give away 70 percent of the song and $50,000 ... That's where sampling has gone, and that's why hip-hop sounds the way it does now.[40]

Beck alludes to sampling's influence in hip-hop, implying that hip-hop has been negatively affected by sampling's current legal status. Indeed, hip-hop has changed dramatically since *Grand Upright v. Warner Bros. Records* in 1991. As Public Enemy's Hank Shocklee explained, sampling used to be an integral yet informal part of hip-hop music:

> Back in the day, things was [sic] different. The copyright laws didn't really extend into sampling until the hip-hop artists started getting sued. As a matter of fact, copyright didn't start catching up with us until *Fear of a Black Planet*. That's when

39. Arewa, "From J.C. Bach to Hip Hop," 573-74.

40. Matt Fink, "Beck: Breaking the Narrative," *Paste Magazine*, http://www.pastemagazine.com/articles/2005/06/beck.html.

> the copyrights and everything started becoming stricter because you had a lot of groups doing it and people were taking whole songs. It got so widespread that the record companies started policing the releases before they got out.[41]

Public Enemy used hundreds of samples from existing recordings on the album *It Takes a Nation of Millions*. When asked if it would be possible to create such an album today, Shocklee responded that "it wouldn't be impossible. It would just be very, very costly," explaining that licencing fees rose substantially as publishers discovered that hip-hop music was viable, and the number of samples in *It Takes a Nation* would amplify the cost.[42] Chuck D. also from Public Enemy, noted that the new legal rules for sampling affected the band substantially:

> Public Enemy's music was affected more than anybody's because we were taking thousands of sounds. If you separated the sounds, they wouldn't have been anything–they were unrecognizable. The sounds were all collaged together to make a sonic wall. Public Enemy was affected because it is too expensive to defend against a claim. So we had to change our whole style, the style of *It Takes a Nation* and *Fear of a Black Planet,* by 1991.[43]

Legal regulations drove hip-hop artists to include fewer samples because it was easier to obtain permission for a small number of samples than the hundreds that Public Enemy previously employed.[44] While current legal precedent won't eliminate digital sampling, it certainly decreases sampling's potential as a musical device. Digital sampling fostered the development of hip-hop; Mark Katz argued that sampling "has transformed the very art of composition"[45] and "led to some astonishingly creative works of music."[46] Indeed, just as musical borrowing influenced classical

41. Kembrew McLeod, "How Copyright Law Changed Hip Hop," *Stay Free Magazine*, http : / / www . stayfreemagazine.org/archives/20/public_enemy.html.

42. Ibid.

43. Ibid.

44. Ibid.

45. Mark Katz, *Capturing Sound: How Technology has Changed Music* (Los Angeles: University of California Press, 2004), 157.

46. Ibid., 141. Katz describes Paul Lansky's *Notjustmoreidlechatter* as an exemplary instance of digital sampling.

composers, digital sampling has played an important role in modern music. Unfortunately, limitations on digital sampling will force musicians to employ other means of borrowing instead.

Traditional manual borrowing has persisted over time as an effective way to incorporate other composers' ideas into new works. Although digital technology made sampling extremely convenient, sampling is often considered a less creative form of expression than manual borrowing. A photomontage can comprise a great work of art, but its artist remains confined to the material he or she uses to create it; a painting, on the other hand, frees the artist to express his or her ideas without those constraints. Likewise, sampling confines a composer to the specific realization of an existing work. By employing manual borrowing instead, the composer can modify, extend, or reharmonize borrowed material in completely new and different ways. A manually borrowed musical thought can be completely transformed to suit a new work, whereas a sample remains grounded to the sonic context in which it was recorded. Since traditional manual borrowing has been affirmed as a legitimate practice both musically and legally,[47] it still remains a viable alternative to digital sampling, low-tech though it may be.

Synthesized Music

While the courts have placed limits on digital sampling, technology has given musicians the tools to recreate nearly any sound imaginable through the use of *synthesized music*.

Composers create music with a preconceived notion of how they would like to witness their work performed under ideal conditions. For centuries, if a work could not be performed by the composer, it could only be realized through performance by other musicians. Most written notation, in fact, serves primarily to codify composers' intentions for musicians to follow; however, this composer-to-musician transition can be problematic. Musicians, being human, are imperfect. They sometimes miss notes or play incorrect rhythms, or may interpret a piece differently than the composer intended. Ensembles of musicians only multiply the chance of error or miscommunication. Human error cannot be eliminated in traditional ensembles, but

47. Arewa, "From J.C. Bach to Hip Hop," 575.

technology provides new ways for composers to realize their works digitally without the possibility of human error in performance.

The concept of synthesized music existed as early as 1910, when Alexander Dillmann mused about engraving records differently — not from the vibrations produced by physical sound, but rather by tailoring the grooves in a record to match what the composer *wanted* to hear. As Katz explained, "Dillmann was suggesting a pre-electronic form of musical synthesis in which the sound of a voice or instrument is created through artificial means."[48] Due to technological limitations, Dillmann's ideas for record inscription never took hold,[49] but modern digital technology has brought musical synthesis to the masses. Synthesized music enables composers to bypass human error entirely; essentially, composers can create a perfect performance, every time. In 1936, composer Edgard Varèse wrote about another important benefit: machines that could synthesize music need not be limited to mimicking traditional instruments, because synthesizers could create any sound imaginable. "In music we composers are forced to use instruments that have not changed for two centuries," he remarked.[50]

Musicians experimented with digital synthesizers throughout the latter half of the twentieth century, but synthesizers remained prohibitively large and expensive until 1983, with the release of the Yahama DX-7, a programmable digital music synthesizer.[51] Whereas its predecessor, the PDP-11, cost $100,000, the DX-7 only cost two thousand dollars thanks to advancements in microprocessor technology.[52] Prices continued to drop as other companies became interested in digital synthesizers, allowing even amateur musicians to purchase a synthesizer.[53] Many of these early piano-style synthesizers were technically limited. They didn't support touch sensitivity, so pressing a key with any level of force would only result in one dynamic level. Early synthesizers

48. Katz, *Capturing Sound: How Technology has Changed Music*, 104.

49. Ibid., 110.

50. Nick Collins and Julio d'Escriván, eds., *The Cambridge Companion to Electronic Music* (Cambridge: Cambridge University Press, 2007), 22-23.

51. Ibid., 29.

52. Ibid.

53. "Tutorial: History of MIDI," MIDI Manufacturers Association, http://www.midi.org/aboutmidi/tut_history.php.

supported a limited amount of polyphonic activity, in that the keyboard could only produce a certain number of notes at once; additional keypresses would either not produce a sound or would force other keys to stop sounding. Inexpensive synthesizers did not support keyboard pedals. Most notably, synthesizers of the early '80s produced distinctive, but not necessarily realistic, sounds.[54] Despite these limitations, the synthesizer became a staple of the music-making in the 1980s, in both classically and popularly oriented spheres.[55]

While synthesizers were often noted for their distinctive electronic sound, the introduction of the Musical Instrument Digital Interface (MIDI) in 1983 opened the doors of electronic music to the masses.[56] MIDI became a standard format for representing and storing music digitally; it defined a specific representation for pitches, durations, and types of instruments. MIDI became widely adopted, and nearly every modern personal computer now supports MIDI playback and composition; most cell phones even carry support for MIDI ringtones.[57] MIDI's widespread adoption, coupled with the personal computer's accessibility, has placed digital music creation in the hands of the general public. Any computer with MIDI compatibility and suitable software can be used to create digital music, so synthesizers today are primarily used to allow composers to enter notes into a computer using a piano keyboard rather than a computer mouse. Yet synthesizers have become tremendously accessible — entry-level synthesizers can be purchased for less than fifty dollars at Wal-Mart.[58] Quality music editing software can be obtained just as easily; for instance, Apple's GarageBand music composition software comes standard on all Apple computers, providing point-and-click access to a wide array of different instrument sounds and drum loops.[59] With software like GarageBand, composers (even would-be composers) can meld together recorded voices, audio samples, synthesized tracks, and prerecorded loops with a simplicity that Steve Reich could have only dreamt of when composing his first tape pieces in the

54. "Tutorial: History of MIDI."

55. Hugo Fernbom, "The History of Synthpop," December 1995, http://www.synt.nu/history/.

56. "Tutorial: History of MIDI."

57. Ibid.

58. "Wal-Mart Search: Synthesizer," http://www.walmart.com/catalog/product.do?product_id=9904221.

59. "GarageBand Overview," http://www.apple.com/ilife/garageband/.

1970s. With such accessibility and ease of use, even non-musicians can quickly create impressive digital compositions in a wide array of styles, from hip-hop beats to orchestral overtures. In less than half a century, digital synthesis has transformed music creation; tasks that would have been impossible merely twenty years ago can be accomplished almost instantaneously today.

While synthesized instruments have not yet become completely indistinguishable from their physical counterparts,[60] in a span of twenty-five years, digital music has evolved from conspicuously artificial synthesizer sounds to quasi-realistic simulations capable of emulating entire ensembles, even on low-end personal computers. MIDI has remained the primary electronic music standard since its introduction, but new initiatives are underway to advance the realism of digital music. HD-MIDI, a proposed update to the MIDI standard, would enable more precise control of digital sound. At a 2008 conference, Tom White, president of the MIDI Manufacturers Association, noted that "MIDI has worked fantastically for more than 25 years, but with today's computers and embedded microprocessors we can now do much more than MIDI was originally designed to do,"[61] In addition to new protocols, recent research has focused on very detailed aspects of emulating sound. For instance, to more accurately model the sound of a piano, computers may use acoustical models based upon the physical interaction of the piano's strings and soundboard.[62] Just as computer graphics have progressively become more lifelike, digitally generated music will likewise become more realistic.

Synthesized instruments can overcome many undesirable attributes of physical instruments; John Chowning from Stanford University noted these possibilities as early as 1994: "Take the piano, for example. Despite its wonderful sound, it is heavy, hard to maintain and tune, and can't be acoustically isolated. One of CCRMA's [Center for Computer Research in Music and Acoustics] 24 graduate students is currently working on a programmable keyboard, one that can reproduce the feel of the keyboards of different pianos. When this work is combined with

60. William Dougherty, interview by author, Des Moines, IA, December 2007.

61. "MIDI Manufacturers Investigate New HD Protocol," http://www.midi.org/news/hdmidi.php.

62. Julien Bensa, "Analysis and synthesis of piano sounds using physical and signal models," Laboratoire de Mécanique et d'Acoustique, 2003, http://www.lma.cnrs-mrs.fr/~bensa/.

high-quality sound reproduction, it will become possible to have a lightweight piano that plays like a grand piano, always stays in tune and can be heard either over loudspeakers or headphones."[63] Chowning believes that digital synthesis will progressively become more and more realistic until they are indistinguishable from — and perhaps preferred to — traditional instruments.[64]

While completely realistic digital music will be an exciting achievement, advancements in digital music may have adverse affects on the lives of actual musicians. Musicians strive for accuracy, but even the most accomplished musicians are incapable of perfection, and the very best performers are often the most expensive to hire. Coupled with the cost of rehearsal venues, travel expenses, recording sessions, and human resources management, hiring a group to perform a work can be complex, expensive, and time-consuming. Digital music has none of these downsides: composers need only write a score on a computer, and they can then instantly create an error-free digital recording on the first run. They can modify the score as needed, and a new recording is available instantly; changes to a composition that an orchestra has already received would be difficult and time-consuming.

If digital compositions are so advantageous, what has prevented the traditional studio orchestra or band from becoming obsolete? Ethan Winer, who has constructed synthesizers since the 1960s, notes that "for all the advances in modern synthesizers and their popularity, the soundtracks for most movies and TV shows still rely on scores that use real instruments and live players because of the expressiveness real instruments can impart."[65] Richard Ingham, a professor at the University of Aberdeen in Scotland, wrote about the difference between an acoustic piano and today's synthesized version:

> The most interesting teaser is whether a digital grand piano is as good as an acoustic grand piano. Due to curiosities of perception and experience, the general answer is,

63. "Music synthesis approaches sound quality of real instruments," June 1994, http://news-service.stanford.edu/pr/94/940607Arc4222.html, 1. One can see such aims realized in instruments like the Clavinova.

64. Ibid.

65. Ethan Winer, "Add Realism to Your Synthesized Sequences," EthanWiner.com, http://www.ethanwiner.com/realism.html.

> yes it is. This is because most people's experience of a piano sound is from recordings, using either a digital piano or an acoustic piano transformed into electrical signals. Because most of us hear acoustic pianos through a recording process, this destroys many of the acoustic features only available to the ear in a live situation — therefore by the time the sound comes through the speaker it might as well have originated from a digital source. If, however, the listener is placed in a room with an acoustic grand piano and a digital grand piano with amplification, the difference is astonishing — the acoustic piano produces a sound world many times more complex and interesting. The acoustic tone is more interesting because it is more complex, utilising control of finely weighted keys, string overtones, natural resonance from the piano and within the given room acoustic, and pedalling for further overtone control.[66]

Many pianists have echoed Ingham's thoughts. But there is no reason to believe that we have reached the apotheosis of digital music synthesis. Technology evolves at an exponential pace; a completely realistic digital piano may arrive sooner than Ingham might think. Consider the following timeline:

1877 Edison invents the phonograph.

1920 The first musical radio performance is broadcast (Wagner's *Parsifal* opera).

1964 The Moog Synthesizer, the first small, modular synthesizer is created.

1976 The first music synthesizers to offer polyphony begin to appear.

1983 MIDI standardizes the representation of digital music; Yamaha DX-7 makes synthesizers more accessible.

1990s Digital synthesis becomes accessible to the public.

66. Richard Ingham, "The Impact of Digital Music on Composition, Performance and Listening," The University of Aberdeen, http://www.abdn.ac.uk/philosophy/endsandmeans/vol4no2/ingham.shtml.

2000s Synthesized music becomes realistic enough to replace human musicians in certain contexts.

Only thirty years ago, the most advanced music synthesizers had just begun to offer polyphony. It would not be unreasonable to predict that we will have achieved indistinguishable realism in another thirty years. Consider Moore's Law, which states that the number of transistors on a chip will double about every two years.[67] Moore's Law was advanced in 1965, and thus far has held true; computers today are exponentially more powerful than computers ten years ago, which were much more powerful than computers ten years before that. Consider also that computer chips drive musical synthesis; digital music benefits from advancements in computational power. With digital music already replacing pit orchestras in some settings, it may well be inevitable that digital music will become as realistic as acoustic music in a short time. As the *Wall Street Journal* reports:

> Even some experts now find it hard to tell the difference. At the request of a *Wall Street Journal* reporter, David Liptak, chair of the composition department at the Eastman School of Music, listened to a 30-second passage of a Beethoven symphony created on a computer, as well as three versions recorded by live orchestras. On his first try at identifying the computerized version, Mr. Liptak guessed wrong.[68]

When realism is achieved, what would prevent producers from using digital instruments rather than a human ensemble, particularly when a synthesized orchestra would be cheaper, less time-consuming, and flawless? Some productions are already making use of digital music rather than pit orchestras. David Pogue, a technology columnist for the *New York Times*, raved about a performance of *Les Misérables* he attended in 2008 that used a digital orchestra.[69] Pogue explained the role of the company who provided the orchestral music:

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67. "Moore's Law," Intel Corporation, http://www.intel.com/technology/mooreslaw/.

68. Jacob Hale Russell and John Jurgensen, "Fugue for Man and Machine," *The Wall Street Journal*, May 2007, http://online.wsj.com/article/SB117832128175492832.html.

69. Pogue, "Are Digital Orchestras a Sign of the Times?"

> "Today, that same company offers, for rental with your production of its most popular musicals, a full-blown, sampled orchestra, for use at performances. It's not a recording, exactly. While the conductor conducts, an assistant taps away on a strange little plastic keyboard connected to a computer. The tempo of the digital orchestra is actually controlled by this tapping, so there's still an element of real-time control. You can still follow the singer, if you like, or goose the tempo when the energy of the performance is high."[70]

Pogue noted that the company markets that solution as a supplement to an existing orchestra, to substitute a few parts if a production can't find enough instruments. But he pinpoints a very real concern about the future of musicians in the digital age:

> Today's sampled sounds are amazing. Ever greater numbers of theatrical, TV and movie scores are played using these digitized sounds instead of live musicians; so really, this digital orchestra product is just a sign of the times.
>
> I can't help remembering how fonts and laser printers wiped out the entire industry of hand typesetters. Today, we see it as an inevitable replacement of a slow, inefficient process. My question is: in 100 years, will anybody go to the trouble of hiring live musicians to using an equivalent-sounding inexpensive box? And will anyone mind?[71]

David Pogue's question may become relevant sooner than we imagine. His questions strike at the heart of what it means to be human (and creative, in the literal sense), and how society answers these questions will dramatically impact the future of music as we know it. Richard Ingham noted that this moral dilemma is nothing new:

> The aesthetic debate between 'emotionalism' or heteronomous aesthetics and 'formalism' or autonomous aesthetics has continued for centuries since Plato,

70. Pogue, "Are Digital Orchestras a Sign of the Times?"
71. Ibid.

> Aristotle, Aristoxenus and Philodemus propounded their theories. Expression within music is a very powerful factor; while philosophers and aesthetes debate the precise nature of communication and expression, the performer will play, preferring for the most part not to delve too deeply into his/ her own mind for fear of losing the direct contact with sound and its manipulation. The debate has continued through the stages of electronic music development (for instance the problem of recorded sound and its use without a live performer). Synthetic sound production, and its mimetic possibilities, have created a sub-section of debate — not whether music is legitimately imitative of nature, but whether science can produce imitations of music itself, and does emotion remain?[72]

Since the music industry will probably clamor for the cheaper, simpler digital alternative whenever possible, musicians' labor unions will likely object to the wholesale replacement of their livelihood. On paper, comparing digital musicians to human musicians is laughable, since digital music is more efficient and perfect in almost every way. When digital music can emulate not only notes and rhythms, but also the crescendos, changes of timbre, and sonorous qualities that make music sound uniquely *human*, how can musicians compete?

Certain venues will always require the physical and emotional presence of a human. Performances where the music itself comprises the spectacle — live concerts, recitals, and the like — wouldn't have a reason to exist if the musicians were replaced by synthesizers. Audiences won't visit Carnegie Hall to hear digital music piped through speakers; they can listen to any music they want, digital or human, from the comfort of their own home. Audiences attend concerts to not only hear music, but also to enjoy the human interaction and community experience that only a fellow human on stage can provide. Synthesized instruments may find their way onto the stage, but only when accompanied by human elements. For the foreseeable future, at least, concert musicians will not be replaced by synthesizers.

The real threat to musicians' livelihood can be found in the recording studio and the pit

72. Ingham, "The Impact of Digital Music on Composition, Performance and Listening."

orchestra, where digital music has already begun to replace human musicians. In November of 2005, New York City's Radio City Music Hall was in conflict with the musicians over a dispute about a new contract. The music hall was on the verge of an agreement with the local musicians' union, but pulled out at the last minute when the producers changed their minds. Alan Whyte reported that the producers "replaced the union members with digital pre-recorded music. The producers took this step despite the fact that the musicians showed up in their tuxedos prepared to play for the opening performance. Security guards were posted at the front entrance of the theater to physically prevent the orchestra from entering the hall."[73] A similar incident occurred in 2001 when the orchestra for the New York City Ballet went on strike; rather than cancel the performance, the New York City Ballet performed *The Nutcracker* to a recorded tape instead.

In venues where music is part of a larger spectacle, such as musical theatre, plays, and performances where a pit orchestra would normally be required, production companies will find digital music increasingly attractive.[74] Pit orchestras are designed to stay nearly invisible to the audience; a realistic digital recording would give audiences a stimulating experience just as well as a human orchestra. Recording studios face a similar fate. When synthesized music becomes indistinguishable from human-powered music, a recording will sound the same either way. Popular music already employs synthesized instruments extensively, and vocal modification programs such as AutoTune correct for human imperfections.[75] As digital music becomes more realistic, the recording industry will continue to use digital music extensively for its cost-effectiveness.

The era of realistic digital synthesized music will arrive soon, propelled by the relentless advances predicted by Moore's Law. As it approaches, musicians and audiences will face serious questions about the very nature of human music performance. Musicians must distinguish themselves by providing one quality that digital music will never be able to duplicate: their

73. Alan Whyte, "New York City's Radio City Music Hall locks out musicians for holiday show," November 2005, http://www.wsws.org/articles/2005/nov2005/rcmh-n08.shtml.

74. Russell and Jurgensen, "Fugue for Man and Machine."

75. "Antares Audio Technologies," November 2008, http://www.antarestech.com/.

uniquely human quality, shared with audiences in a collective social experience. Pit orchestras and recording studio musicians may not fare so well against digital music's advantages, but we may be reassured that in the end, all performances and recordings exist for one purpose: human consumption. The audience will forever be human; and it is ultimately the audience, through the laws of supply and demand, will ultimately decide whether digital music can serve as an acceptable alternative to human-produced music.

Music Distribution

The Internet has brought music accessibility to levels unprecedented in human history. In the nineteenth century, non-musicians could only experience music at a live concert. The twentieth century brought music into the home with the invention of the phonograph and radio. In the twenty-first century, nearly anyone can retrieve and listen to any work imaginable in a matter of minutes through the power of the Internet. For less than a dollar per song (or even less, depending on one's ethics) one can find countless recordings of works by classical composers, contemporary composers, and everything in between. From Rossini to Reich, from Bach to Basie, never before has music been so easily acquired. While near-ubiquitous music accessibility provides obvious benefits, the Internet has challenged the music industry and musicians alike to rethink music sales as a business model. In years to come, the Internet may extinguish traditional music stores and CD sales entirely.

While music became more accessible thanks to the proliferation of record stores, record players, and CD players throughout the twentieth century, the Internet has transformed the music industry within the last decade. Until very recently, music recordings were tangible physical objects, meaning piracy on a massive scale was unfeasible; for consumers, purchasing music at a store was the only way to discover new music.

MP3, a technical specification indicating music digitally stored in a compressed format, made digital music compact and easy to acquire. Since audio CDs were playable in CD-ROM drives, consumers could easily store their existing CDs on their computers. At approximately three to

four megabytes per song, computers with thirty gigabytes of free space could store over 8,000 songs.[76] Consumers could store their entire collection of music on a single hard drive, making the physical CD itself redundant. Portable music players such as Apple's iPod, introduced in 2001, enabled consumers to carry thousands of MP3 files at once.[77] Although the MP3 format and computer-based storage introduced tremendous convenience, consumers still needed to purchase music from an online retailer and transfer the CD to their computer and/or iPod in order to take advantage of MP3 portability.

The next logical step would be to enable consumers to purchase songs already in the MP3 format. USB flash drives were not available until 2000, and even the first commercially available drives could only hold eight megabytes of music.[78] Floppy drives, at less than two megabytes per disk, wouldn't even hold a *single* three-and-a-half minute song. Fortunately, broadband Internet distribution was beginning to take hold at the turn of the century; coupled with the compact size of MP3 files, one could transfer songs over the Internet in seconds.

The music industry did not recognize this trend at first, however. In 1999, two college students developed a peer-to-peer software program called Napster, which allowed users to share their MP3 collections with other Napster users over the Internet.[79] Napster became immensely popular, boasting tens of millions of users at its height; together, its users downloaded hundreds of millions of songs.[80] For the first time, consumers could hear a song on the radio, find it through Napster, and add the song to their personal collection in a matter of minutes.

While musicians' music became more accessible than ever before, neither musicians nor record companies made a dime from peer-to-peer music sharing. This angered record companies, because millions of users were copying and distributing copyrighted works without permission or

76. "Introduction to the MP3 Format," Kioskea, October 2008, http://en.kioskea.net/contents/audio/mp3.php3.

77. Leander Kahney, "Straight Dope on the iPod's Birth," October 2006, http://www.wired.com/gadgets/mac/commentary/cultofmac/2006/10/71956.

78. "8MB USB Memory Key," Lenovo Corporation, November 2000, http://www-307.ibm.com/pc/support/site.wss/document.do?sitestyle=lenovo&lndocid=MIGR-4R3GWN.

79. Katz, *Capturing Sound: How Technology has Changed Music*, 161.

80. Ibid.

payment. The record companies pushed back, and in 2001 Napster was shut down.[81] The end of Napster did not stop illegal online music distribution, however, and several other peer-to-peer file sharing programs such as Kazaa and LimeWire stepped up to take its place.[82] Napster's demise was the first casualty in a war between the music industry and peer-to-peer file sharers that continues today. While Napster was successfully shut down, its widespread adoption indicated that the Internet could support widespread distribution of music. But peer-to-peer file sharing was *free* — would consumers be willing to *pay* for music distributed online?

Online music sales faced an uncertain future in an environment where free music could be obtained instantly. But on April 28, 2003, Apple launched the iTunes Music Store, an online music store that integrated with Apple's iPod MP3 player. In addition to selling albums like traditional retailers, the iTunes store sold individual songs for 99 cents each.[83] Peer-to-peer file sharing was convenient, but not without problems; less popular songs were often difficult to find, because fewer users were available to share them. By contrast, consumers who purchased music from the iTunes Music Store had a much more seamless experience. In addition to carrying 200,000 songs at launch, the iTunes Music Store allowed users to transfer music to their iPods with ease.

The iTunes Music Store grew so successful that it began to displace traditional music outlets. In 2008 the iTunes Music Store surpassed Wal-Mart as the number one music retailer in the United States.[84] That same year, fifty million consumers had purchased over four billion songs from the iTunes Music Store as of April 3rd.[85] Clearly, online music was a viable, thriving medium. Other competitors, such as Microsoft and Amazon.com, have since entered the online music market.[86]

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81. Katz, *Capturing Sound: How Technology has Changed Music*, 162.

82. Ibid.

83. "Apple Launches the iTunes Music Store."

84. Quinn and Chmielewski, "Top Music Seller's Store Has No Door."

85. Ibid.

86. Clara O'Brien, "Amazon flows into digital music sales," The Register, April 2007, http://www.theregister.co.uk/2007/04/26/amazon_digital_music/; "The Zune Marketplace," Microsoft Corporation, http://www.zune.net/.

Online music sales have thus begun to affect sales at brick-and-mortar outlets. Some stores have been forced to close due to declining sales, while other independent retailers have emphasized their distinctive features (obscure titles, customer service, or novelty gifts) to try to attract and retain customers.[87] Giant retailers like Best Buy, Wal-Mart, and Target also affect smaller stores because they can afford to sell albums at a lower profit margin.[88] With the rapid growth of online music sales, independent store owners may face difficult times ahead. Online music stores are more accessible, offer high-quality music, and offer prices competitive with traditional stores.

Yet legal online music distribution is not without its own issues. Apple's iTunes store sells most of its music with digital-rights-management (DRM), which limits how often and to which devices consumers may copy purchased music. With DRM, for instance, a song purchased on iTunes can only be copied to Apple's iPod MP3 players, leaving other MP3 players unsupported.[89] To transfer an iTunes DRM-protected song to a computer other than the one the song was purchased on, consumers must "authorize" the computer with Apple. Only a few computers can be authorized simultaneously; once a user has reached his authorization limit, he must deauthorize other computers in order to allow DRM-protected songs to be played on a new computer.[90]

DRM was designed to prohibit unauthorized copying, as seen in peer-to-peer sharing services, but it has been criticized as a violation of the United States fair use doctrine, because DRM can prohibit consumers from copying music in what would otherwise be legal ways (for instance, copying a song purchased on iTunes to a non-iPod digital music player).[91] The record industry advocates DRM technology because it provides protection against illegal copying, but consumers oppose DRM because it prevents them from otherwise legal actions, such as copying songs for

87. Chris Riemenschneider, "CD retailers fighting the tide of online music," StarTribune.com, December 2006, http://www.startribune.com/local/11586091.html.

88. Ibid.

89. "Apple Launches the iTunes Music Store."

90. Ibid.

91. Kusek and Leonhard, *The Future of Music: Manifesto for the Digital Music Revolution*, 149.

personal use on multiple devices. As David Kusek and Gerd Leonhard note, however, technology may not be able to resolve this disparity:

> Ultimately, there is no strictly *technological* solution that can allow the user the full and unrestricted use of content while also maintaining an effective level of control by the creator, owner, or legal representative of the content, since any good technology will always impact and change the underlying business paradigms, as well. This dilemma started the day that computing was invented, and very likely, it can only be solved by some careful and smart economic and/or social engineering — by means of price, value, and ethics.[92]

Kusek and Leonhard note that consumers will always try to circumvent copy protection, especially when it inhibits their right to fair use. In 2003, BMG released a copy-protected disc, but a Princeton University student discovered that one could circumvent the copy protection by holding the "shift" key on the computer keyboard when the disc was inserted. A similar situation occurred when Sony released a disc with copy protection that could be circumvented by drawing on the outside of the disc with a permanent marker.[93] As Kusek and Leonhard opined: "There is no end to human ingenuity and there is always a way to get that chastity belt off, thank goodness."[94]

In response to criticism against DRM, Apple introduced DRM-free music to the iTunes store, though at a higher price. In addition, DRM-free music purchased via iTunes embeds a unique personal identifier into each downloaded song; if a downloader then shares that file over a peer-to-peer file-sharing network, Apple could theoretically discover the source and press charges.[95] Other online music retailers (such as Amazon) now offer DRM-free music as well.[96] These trends indicate that DRM music may be on the way out.

92. Kusek and Leonhard, *The Future of Music: Manifesto for the Digital Music Revolution*, 150.

93. Ibid.

94. Ibid.

95. Ken Fisher, "Apple hides account info in DRM-free music, too," Ars Technica, May 2007, http://arstechnica.com/news.ars/post/20070530-apple-hides-account-info-in-drm-free-music-too.html.

96. O'Brien, "Amazon flows into digital music sales."

The online music revolution has altered the dynamics of music sales and distribution, but the business of music has remained largely the same: musicians are recruited by record companies who manage, promote, and distribute artists' music, traditionally through album sales. Retailers and record labels each receive a portion of the profit, with the artist typically receiving 6–14% of sales.[97] The traditional role of a record label, however — to publicize and distribute artists' music — may not be entirely necessary today. Artists can promote themselves, distribute their own works, and collect profit with relative ease on the Internet. In 2007, the band Radiohead performed an experiment that would challenge the very foundation of the music industry: they released an album, *In Rainbows*, for sale on their own website without any record label. The catch? They asked consumers to name their own price for the album.[98] Radiohead even allowed consumers to download their entire album for free if they so chose. The album was a success:

> In terms of digital income, we've made more money out of this record than out of all the other Radiohead albums put together, forever — in terms of anything on the Net. And that's nuts. It's partly due to the fact that EMI wasn't giving us any money for digital sales. All the contracts signed in a certain era have none of that stuff.[99]

The success of their pay-what-you-want model may be attributed in part to its novelty and publicity, but other artists might benefit from that model as well. At around fifteen dollars per CD, artists today typically receive one to two dollars per sale.[100] If the average consumer pays at least that much per album, artists break even; if consumers pay artists the same amount as they would for a normal album, artists would make ten to fifteen times more than they would with a record contract. Radiohead benefited from having an existing audience and significant publicity, but new artists would not have that advantage; it may be more difficult for new artists to promote

97. Eliot Van Buskirk, "Apple Threatens iTunes Shutdown over Royalty Dispute," *Wired Magazine*, October 2008, http://blog.wired.com/music/2008/10/thursdays-copyr.html.

98. Josh Tyrangiel, "Radiohead Says: Pay What You Want," October 2007, http://www.time.com/time/arts/article/0,8599,1666973,00.html.

99. David Byrne and Thom Yorke, "David Byrne and Thom Yorke on the Real Value of Music," *Wired Magazine*, December 2007, http://www.wired.com/entertainment/music/magazine/16-01/ff_yorke?currentPage=all.

100. Van Buskirk, "Apple Threatens iTunes Shutdown over Royalty Dispute."

themselves enough to become commercially successful on their own. Nevertheless, Radiohead's experiment proved that the record industry, once an essential provider of studio time, album production, and marketing, no longer offers the sole path to stardom. *Wired* considers Radiohead's model part of a larger trend:

> While pay-what-you-will worked for Radiohead, though, it's hard to imagine the model paying off for Miley Cyrus — aka chart-topping teenybopper Hannah Montana. Cyrus' label, Walt Disney Records, will stick to selling CDs in Wal-Mart, thank you very much. But the truth is that Radiohead didn't intend *In Rainbows* to start a revolution. The experiment simply proves there is plenty of room for innovation in the music business — this is just one of many new paths.[101]

Other artists have approached this new era in novel ways to attract consumers, as Josh Tyrangiel from *Time Magazine* notes: "Meanwhile, as record sales decline, the concert business is booming. In July, Prince gave away his album *Planet Earth* for free in the U.K. through the downmarket *Mail on Sunday* newspaper. At first he was ridiculed. Then he announced 21 consecutive London concert dates — and sold out every one of them."[102] Several artists have encouraged the online community to create remixes of their music in order to spur interest in their works, including Public Enemy, Radiohead, Bojam, and Nine Inch Nails.[103]

Record labels, distributors, and musicians alike have encountered new challenges as the Internet continues to shape music distribution. But music has not withered in this new environment; rather, it has evolved to the changing technological landscape. These sweeping changes will affect other industries too:

> This type of sea change can influence other mass media as well — which is why all of Hollywood is closely monitoring these developments. The movie studios have

101. Byrne and Yorke, "David Byrne and Thom Yorke on the Real Value of Music."

102. Tyrangiel, "Radiohead Says: Pay What You Want."

103. Sam Dean, "Bojam Applies Open Source Principles to Music," OStatic, September 2008, http://ostatic.com/173515-blog/bojam-applies-open-source-principles-to-music.

> always looked to the music industry as a signpost on piracy and other issues for its own multibillion-dollar business, whose revenues far surpass those of the record labels. Historically, the movie studios have been even more wary of technology than their counterparts in the music industry. They spent years in court trying to block the spread of home video players like Sony's Betamax, only to find later that losing this battle helped drive a huge new business in home video rentals.[104]

Music in Ones and Zeros

Digital sampling, synthesized music, and music distribution have all reshaped music creation and consumption, but technology and music have fused in other ways as well.

Consider Synthogy's *Ivory*, a computer program that synthesizes incredibly realistic piano sounds. Ivory's realism stems from the combination of two technologies previously discussed: sampling and synthesis. Rather than attempting to emulate the sound of a piano through mathematical formulae, Synthogy engineers recorded audio samples from every key of a piano at ten dynamic levels.[105] Ivory then combines those recorded samples as needed to synthesize sound. Since Ivory uses samples from a physical piano, it achieves nearly indistinguishable realism. While Ivory's method may seem like a brute-force way to synthesize instruments, it works well. The piano might be considered an easy candidate for sampling because all notes decay predictably, whereas other instruments such as trumpet or violin can crescendo, decrescendo, and change timbre without releasing the note. However, Ivory's sample-based approach highlights that even if we make no further mathematical advancement in synthesizing a sound digitally, we can use conventional recording technology to artificially generate near-realistic sound. Increasing the quality of such a synthesizer then becomes only a matter of recording more samples at high quality, such that a synthesizer could store and recall sound from an increasingly large library of snippets. Hypothetically, the more samples available, the more

104. John Borland, Evan Hansen, and Mike Yamamoto, "State of the art: A medium reborn," CNET, May 2003, http://news.cnet.com/2009-1027-1009535.html?tag=txt.

105. "Synthology - Ivory - Grand Pianos," Synthology Music, http://www.ilio.com/synthogy/ivory/.

realistic the auditory experience.

But Ivory suffers from the same limitation that has afflicted music playback since its inception: Even the most realistic recording will be limited by the quality of the speakers through which it is played. Quality speakers can produce sound with remarkable quality, but quality is only one measure of a realistic experience; realistic playback must also provide our ears with a physical sense of direction. The first sound recordings were monophonic, and movie soundtracks are often encoded in surround sound for presentation in a theater, but most audio recordings today are encoded stereophonically (for two speakers). Humans hear sound arriving from every direction; a perfect sound reproduction must simulate directionality in order to be truly realistic. Stereophonic recordings remain popular as a compromise between realism and practical concerns, but different types of *surround sound* — technology that simulates sound arriving from multiple directions — have literally brought a new dimension to recordings. In the mid-1970s, Dolby Labs developed a way to encode surround sound within a two-channel signal.[106] This provided compatibility between traditional stereophonic equipment and new surround sound equipment, which stimulated surround sound's growth. As Dolby refined its technology and more manufacturers produced compatible equipment, surround sound has become more realistic and affordable.[107] Coupled with large high-definition televisions, surround sound can provide a powerful, lifelike audiovisual experience.

Digital sampling, synthesized music, and music distribution face continued challenges. Digital sampling remains severely limited due to legal restrictions. Synthesized music will become even more realistic, but its adoption threatens the jobs of human musicians. Online music has turned the music industry on its head and continues to displace traditional music distribution practices. In each of these cases, current barriers are not technological or musical, but rather legal, ethical, and financial. Technology has the potential to enrich the way society creates and consumes music, but it will only be as transformative — or as disruptive — as our legal system

106. Robert Silva, "The History And Basics Of Surround Sound," About.com, http://hometheater.about.com/od/beforeyoubuy/a/surroundsound.htm, 2.

107. Ibid., 3.

and ethical values allow it to be.

Despite those inherent limitations, we have already seen technology transform music. Today, consumers can remix existing music and video in the comfort of their own home. Personal computers are capable of synthesizing entire symphonies, giving young composers tools that are a world ahead of technology available only a generation ago, and the Internet continues to become more ubiquitous, providing high-speed access to music everywhere. Indeed, Mark Katz remains optimistic about the future of music in this new technological world: "From a technological standpoint, we live in very interesting times. Given the daily twists and developments in technology, law, and culture, we can expect musical life to get even more interesting. This is not a curse, as the old saying would have it, but a blessing."[108] While technology brings new challenges to music, it will inevitably march forward — we should embrace it and allow its innovations to enrich our musical lives.

108. Katz, *Capturing Sound: How Technology has Changed Music*, 187.

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